INTERNATIONAL WILDLIFE REHABILITATION COUNCIL

Volume 37, Number 3, 2018

JOURNAL OF WILDLIFE REHABILITATION

IN THIS ISSUE:

ABOUT THE JOURNAL

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:

Common snapping turtles *(Chelydra serpentina),* catching midday sun in Fairfax County, Virginia.

Left:
North American puma *(Puma concolor),* a genetic relative of the the eastern puma, *Puma concolor couguar.* Long thought extirpated from its eastern range, the latter was declared extinct January 2018.

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IWRC

Providing science-based education and resources on wildlife rehabilitation to promote wildlife conservation and welfare worldwide.

The *Journal of Wildlife Rehabilitation* is published by the International Wildlife Rehabilitation Council (IWRC), PO Box 3197, Eugene, OR 97403 USA. (ISSN: 2166-9198).

JOURNAL OF WILDLIFE REHABILITATION

Volume 37(3)

CONTENTS

PEER-REVIEWED PAPERS

DEPARTMENTS

EDITORIAL

Sustaining focus while welcoming change

by Susan Wylie

Many of you have seen firsthand how the field of wildlife rehabilitation continues to change because of experience, research, and different professional approaches. With more knowledge and information at hand, as well as a change in the public's perception of wildlife rehabilitation, we have a responsibility as wildlife rehabilitators to continue to contribute to this growing field.

Our responsibilities as rehabilitators are also changing. With the public interest in our work, some of us are finding ourselves more involved in education and finding solutions to human–wildlife conflicts. There is an increasing need for our services due to declining wildlife populations, growth of urban wildlife, and changing temperatures that are altering the behavior of wildlife.

The field is evolving not only through the way we care for animals but also by branching into different actions beyond wildlife rehabilitation. So, what does this mean for wildlife rehabilitation?

At the organization I work for, it recently meant changing our name from a wild bird rehabilitation center to a wild bird conservation center. Our vision has not changed but rather the way we pursue it. Though rehabilitation remains the core foundation of the organization, the increase in demand for education has us pursuing our vision in different ways. As an IWRC board member for the last nine years, I have seen these changes firsthand at IWRC as well. Our perception of rehabilitation has branched out into domains that include not only rehabilitation but education and research. With all three domains complementing one another, I think it is time we see each other as not only rehabilitators but overall as conservationists.

In Canada, a Canadian Wildlife Service study indicated that wild bird mortality is linked to 28 human-related causes, with the most common being due to feral and domestic cat predation (70%). How often have you spoken to a member of the public who lets their cat outdoors and thinks they are natural predators? For a rehabilitator it can be heart-wrenching and frustrating to see these situations reoccur almost on a daily basis at some facilities. The importance of education is significant in situations like this. If you are able to educate an individual to keep their cats indoors it means that you will not have to rehabilitate anymore animals brought in by this individual.

As conservationists, we should always be open to information and looking for new practices to improve the care we offer. We can no longer find justification in saying we are doing the right thing because we have always done it that way. As a rehabilitator for 15 years, I am constantly looking for information either to modify my practices or reconfirm that my current practices are appropriate. It is important that we are open to change with the animals' best interests in mind.

The recent growth in wildlife rehabilitation will result in more resources being available to rehabilitators, as well as support, which includes IWRC's focus on further developing its courses and responding to its members' needs. I am confident that we will continue to see positive change and that our community will continue to focus on saving wildlife in need.

—Susan Wylie
IWRC President

IFAW Deploys to Dominica After Hurricane Maria

DOMINICA (October 20)—The island nation of Dominica suffered terribly after hurricane Maria tore through the Caribbean last month. The International Fund for Animal Welfare is sending food, supplies, and an expert team of disaster responders to help the community, their animals, and wildlife. IFAW has partnered with Jake Levenson of the Dominica Sea Turtle Conservation Organization and Shane Gero of the Dominica Sperm Whale Project, two organizations with extensive ties to the island, to complete this essential mission.

"It broke my heart to see my home so devastated by this hurricane," said Kelvin Alie, Executive Vice President at IFAW, who hails from the island. "Dominica was hit so hard, with every community severely impacted by Hurricane Maria. Gaining access to the island has been a challenge and only recently were the lines of communication restored. A number of communities are still without water and electricity. Thankfully we can now deliver much needed supplies, and put boots on the ground, to help people and their animals."

The Government of Dominica's Division of Forestry, Wildlife, and National Parks invited IFAW's disaster responders to bring food and other supplies, as well as perform an in-depth assessment of the needs of community animals and wildlife on the island.

"Dominica is a very special place, with a huge amount of biological diversity," said Shannon Walajtys, Disaster Response Manager at IFAW. "We'll be helping dogs, cats, and farm animals, but also determining the best approach to protect the island's endangered species in the face of such terrible destruction."

Iconic species such as the imperial amazon parrot and the hawksbill sea turtle make their homes on the island. With trees uprooted and foliage ripped from the forest canopy, birds, lizards, and other wildlife are struggling to survive. Sea turtle nesting grounds have also been disturbed, imperiling the next generation of these endangered animals. IFAW, their partners, and the Government of Dominica are committed to assisting these animals in these extraordinary circumstances.

"The homes and livelihoods of our close friends and colleagues have been destroyed," said Shane Gero of the Dominica Sperm Whale Project. "The recovery is a long term project but we are determined to be there and assist the individuals and organizations we have worked with so closely over the years."

California Wildfire Affects Wildlife Centers

FAIRFIELD, CA (October 15)—The Atlas fire in California hit International Bird Rescue close to home. Their San Francisco Bay-Delta wildlife center, which is also their headquarters, is located in Fairfield, California, not far from the path of the fires.

They kept birds-in-care at the facility as long as possible before the poor air quality and the looming possibility of evacuation rose beyond their acceptable threshold. For the well-being of the birds, International Bird Rescue made the decision on

OBITUARY

SUZIE SUTTON

February, 1942—June, 2017

Suzie "Wildlife" Sutton passed away peacefully on June 30th at her home in Kirkwood, Missouri, after a challenging year battling cancer.

She is survived by sons Andy of StL, George (Kathy) of MN; sister Molly (David) Avan of Miami; and grandchildren Erik, Connor, Sydney and Cassidy.

A ferocious champion for wildlife and a bushwacker in a fledgling field, Suzie founded the Missouri Wildlife Rescue Center in 1979, one of the first in the US. In 20 years, she grew the center from a kitchen table to one of the largest in the country. A regular in St. Louis media, she gained the field and the center national attention during the massive floods of 1993. She developed early protocol for many species, and her hit-by-car methods for the Virginia opossum are still used. She authored center management guides and newsletters, developed a volunteer force, mentored rehabilitators around the country, cultivated donors, and oversaw the design of the current facility, never leaving the trenches of wildlife care.

After leaving MWRC, she took her skills to the City of Crestwood as the first animal control officer, developing an active and progressive shelter. Aware of the dangers faced by wildlife, she successfully convinced the city to enact a leash law for cats. She continued to write and educate the public until her retirement in 2011.

Throughout her years, she loved to garden and to cook for her friends from her house by Kirkwood Park, where whe lived with her beloved rescued pets. She saved the lives of thousands of animals in her career and made an indelible contribution to wildlife rehabilitation as the profession it is today. —Nancy Hawekotte, JWR art director, friend.

Wednesday October 11th to release those that were healthy enough to go, and to transfer the remaining patients to partner centers outside the fire zone.

Preparing aquatic birds to be transferred to any outside facility (especially those not specialized in aquatic care) takes a tremendous amount of energy, and International Bird Rescue reports that its team stepped up to the challenge. From exit examinations to preparing the birds' medications, food, and paperwork and arranging transport, the process is extremely time-consuming and tedious.

International Bird Rescue was supported by partner centers WildCare (San Rafael), Peninsula Humane Society & SPCA (San Mateo), The SPCA for Monterey County (Monterey), and Pacific Wildlife Care (San Luis Obispo) who received the evacuated patients.

In their 46-year history, International Bird Rescue never before needed to evacuate all of the birds from the facility. They have been through floods, handled numerous oil spill emergencies, felt earthquakes, endured other extreme weather, and yet this evacuation was unique for their SF Bay-Delta wildlife center. Their flight aviary may be motionless at the moment, but the center staff and volunteers are thankful they can see the uncharred hill behind the center through the smoke.

Neotropical Migratory Bird Act Introduced for Reauthorization Under New nName

WASHINGTON, DC (July 12, 2017)—U.S. Senator Ben Cardin (D-Md.), a senior member of the Senate Environment and Public Works Committee, and U.S. Senator Rob Portman (R-Ohio), a member of the Senate Energy and Natural Resources Committee, have introduced legislation (S. 1537) to reauthorize the Neotropical Migratory Bird Conservation Act, which would help sustain populations of migratory birds that face threats to their health and habitats. Their bill, reintroduced as the Migratory Birds of the Americas Conservation Act, promotes long-term conservation, education, research, monitoring, and habitat protection for more than 350 species of migratory birds including Maryland's state bird, the Baltimore oriole, and Ohio's state bird, the northern cardinal. The bill furthers investment in critical conservation programs that have demonstrated marked successes through public-private partnerships and innovative granting and conservation strategies.

"Our goal is to continue to sustain healthy populations of migratory birds that are not only aesthetically beautiful, but also critical to our farmers through consuming billions of harmful insects and rodent pests, pollinating crops, and dispersing seeds," said Senator Cardin. "This simple legislation reauthorizes a cost-effective, budget-friendly, and highly successful federal program to protect birds, including the Baltimore oriole that have seen a steady decline in their populations despite being protected by federal and state laws."

"Hundreds of bird species migrate through Ohio each year, making Lake Erie one of the most popular destinations for birdwatching," Senator Portman said. "Birding contributes more than $20 million to Ohio's tourism industry and attracts visitors from across the world each year. I am proud to work with my colleagues on the Migratory Birds of the Americas Conservation Act to protect and conserve these bird populations so that they may be enjoyed by future generations."

For nearly a decade, federal investment in habitat protection, education, research, and monitoring of neotropical migratory birds has been vital to the well-being of our economy. Nationwide, bird watchers include more than 47 million Americans who are part of a larger wildlife watching community that spends $30 billion annually.

The S. 1537, Migratory Birds of the Americas Conservation Act, formerly the Neotropical Migratory Bird Conservation Act, has a proven track record of reversing habitat loss and advancing conservation strategies for the hundreds of species of birds considered neotropical migrants—birds that spend summers in the United States and winter in Latin America.

Since 2002, more than $58.5 million in grants have been awarded, supporting 510 projects in 36 countries. Partners have contributed an additional $222 million, and more than 4.2 million acres of habitat have been improved. In 2016, the grants totaled $4 million, with nearly $17 million in matching funds across 17 countries. However, migratory birds continue to face threats from pesticide pollution, deforestation, sprawl, and invasive species that degrade their habitats.

Rehabilitated Rhino Births Second Wild Calf

ASSAM, INDIA (September 5)—"Jamuna," a female rhino that had been rehabilitated into the wild by the International Fund for Animal Welfare (IFAW), Wildlife Trust of India (WTI) and the Assam Forest Department in 2010, gave birth to her second calf in Manas National Park, the UNESCO World Heritage Site, September 5.

The calf was first seen by frontline forest staff of the Bansbari Range during their early morning patrol. Its presence was later confirmed by a field team of IFAW-WTI's Greater Manas Conservation Project, comprising Dr Bhaskar Choudhury, WTI's Head Veterinarian (North East) and the project-in-charge, and animal keeper Debajit Saikia.

"This is the sixth calf born to the rhinos rehabilitated under our project and marks another significant milestone in our collective efforts to restore Manas to its former glory," said Dr Choudhury. "It is a matter of great pride for IFAW-WTI, the Assam Forest Department and the Bodoland Territorial Council (BTC). Our thanks also to WWF-India, which had translocated the rhino that fathered this calf from Kaziranga to Manas, and to the local community for their continuing tolerance towards rhinos despite instances of crop raiding."

Jamuna was the third rhino rehabilitated under the Greater Manas Conservation Project. She had been rescued by the Assam Forest Department during the 2004 monsoon floods in Kaziranga National Park and brought to the Centre for Wildlife Rehabilitation and Conservation–IFAW-WTI and the Assam Forest

CONTINUED ON PAGE 22

Effects of traumatic shell fracture on hematology values in chelonians

Sonja Ahlberg

Spotted turtle *(Clemmys guttata).*

ABSTRACT: Many chelonians are admitted to wildlife rehabilitation centers suffering from traumatic shell injury caused by motor vehicle collisions. The incidence and severity of infection as they heal from shell injuries are currently unknown. To determine if there is a correlation between the severity of traumatic shell injury and the severity of infection in turtle patients, total white blood cell counts (WBCs) and white blood cell differentials were measured in common snapping turtles *(Chelydra serpentina)*, painted turtles (*Chrysemys picta)*, a Blanding's turtle *(Emydoidea blandingii)*, and a spotted turtle *(Clemmys guttata)*. WBCs were not significantly different between severity classes; however, WBCs decreased significantly over time for Severity Class III, and basophil counts for all severity classes were significantly different from one another. The data suggest that severity of injury may not be a proper indicator of susceptibility of turtles to infection after shell trauma. Hematology parameters may not be suitable indicators of infection, and the criteria for administering prophylactic antibiotics to turtles with traumatic shell injury remains unknown.

KEYWORDS: Chelonians, hematology, infection, motor vehicle collision, rehabilitation, shell fracture, turtles, wildlife rehabilitation.

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Introduction

Chelonians are often admitted to wildlife rehabilitation centers with traumatic carapace and/or plastron fractures from motor vehicle collisions. Rehabilitation centers offer medical care to wildlife that are ill, injured, or have been orphaned, with the ultimate goal of release back into the wild.[73] Treatment of these turtles can be extensive, and length of hospitalization can be many months depending on severity of fracture. The incidence of infection and the health status of turtles as they heal from shell injuries are currently unknown.

Road mortality is considered one of many threats to turtle populations.[11] Motor vehicle collisions have been identified as the number one unnatural cause of mortality

J. Wildlife Rehab. 37(3): 7-16.

for vertebrate species on protected lands, with the majority of mortalities being amphibians and reptiles.[4,6,27] Studies conducted in rehabilitation centers have shown that trauma associated with motor vehicle collisions is the most common reason for reptile admissions.[32,70,72] In addition, studies indicate that mortality from motor vehicle collisions is one of the greatest threats to New England populations of both the endangered Blanding's turtle (*Emydoidea blandingii*) and the threatened spotted turtle (*Clemmys guttata*)— two species that are often admitted into rehabilitation centers.[7,48] Roads are frequently built through wetland areas where turtle populations are highest, and turtles take advantage of the roads for transport and basking, as well as the shoulders for nesting.[4-7] Gravid females and hatchlings often cross roads as they move between their nesting uplands and water source.[42] These segments of the population are vital to recruitment and are susceptible to mortality during this seasonal movement.[4]

Consequently, successful rehabilitation and release of wild turtles that have been hit by cars can be important to local populations.[32] Chelonians are generally long-lived, have delayed sexual maturity, and require both wetland and terrestrial environments for successful reproduction.[43] Age structure and sex ratios of species with these life histories can have profound effects on population persistence.[11,31] Therefore, the removal of adult female and juvenile members from their populations due to anthropogenic causes can mean the difference between local extinction and survival.

To ensure successful rehabilitation from shell fractures, immediate broad spectrum antibiotic therapy is recommended by many practitioners.[21,35,76] The administration of prophylactic antibiotics could possibly prevent undue infection and subsequent suffering and consequently lead to faster and more complete healing of shell fractures. However, no studies have been done to establish criteria for when antibiotic treatment is necessary. Some literature suggests administering antibiotics if injury is severe but offers no guidelines or measurements for severity.[21] Very few experiments have been conducted on the efficacy of medicines, including antibiotics, on turtle health and healing. Most chelonian studies have focused on therapeutic blood levels of antibiotics or sensitivities but not on clinical responses.[13,24-26,30,38-39,41,44,47,51-52,55,62,64-66,78-79] Thus, the effects of antibiotic use are largely unknown in most turtles, leading many rehabilitators to put off treatment with antibiotics until symptoms of infection are readily apparent.[54]

Some practitioners have been leery of placing chelonians on systemic antibiotic therapy for a few reasons. Turtles often are host to both commensal and pathogenic organisms, and antibiotics could upset sensitive gut flora in those turtles that rely heavily on microbial fermentation for digestion.[16,47,56] Nephrotoxicity from antibiotic administration has been documented in many reptiles; however, recent studies have shed more light on appropriate doses for various species.[30,39,44,47] Another consideration is that isolates of reptilian bacteria have been shown to be very resistant to antibiotics as a result of environmental pollution.[42,47] Also, because reptilian metabolic processes are dependent on environmental conditions, the effectiveness of antibiotics can vary greatly.[13,23]

Despite these challenges, assessing the health status and occurrence of infection in turtles undergoing rehabilitation for shell injury is important to evaluating and adjusting medical care. Health of convalescing chelonians may be appraised by studying hematology and chemistry values.[17,19,56,80-82] In particular, total white blood cell counts (WBC) and white blood cell differentials can be used to evaluate immune response, including the presence and severity of infection.[12,71,80] Both leukocytosis and leucopenia can be indicators of infection, and the type of infection can be characterized according to the percentage of different leukocytes in the blood.[14,69] To date, only one study has been conducted to investigate the correlation between shell disease and hematology in turtles.[34] This study found no correlation between hematology parameters and shell disease; however, only lesions, not fractures, were studied.

Among the health status data, little has been published on blood values of wild turtles that have been injured and are undergoing medical rehabilitation in captivity. Studies of hawksbill (*Eretmochelys imbricata*) and loggerhead sea turtles examined blood samples of patients with varying presentations.[12,14,] Knotkova et al. used hematology data to assess the rehabilitation of Bornean river turtles (*Orlitia borneensis*) with blood parasites and shell necrosis.[46] Research on the desert tortoise concluded that some white blood cell abnormalities and anemia were correlated with the observance of infection.[17] Clearly, more research needs to focus on applying hematology values to clinical assessment of turtle rehabilitation patients.

The objective of this study was to determine if there is a correlation between the severity of injury and hematological parameters that could be indicative of infection in turtles that have been admitted for rehabilitation due to traumatic shell fracture. Understanding the presence and pattern of infection in turtles can lead to improved medical treatment, shortened healing times, and eventual successful rehabilitation and release of patients. Results of this study suggest that severity of injury may not be a good predictor of infection. Hematology parameters may not be appropriate indicators of infectious disease in turtles, and the criteria for placing turtles with traumatic shell injury on prophylactic antibiotics remains unknown.

Methods

Medical treatment

From 2013–2014, common snapping turtles (*Chelydra serpentina*), painted turtles (*Chrysemys picta*), a Blanding's turtle, and a spotted turtle were admitted to the Center for Wildlife in Cape Neddick, Maine, for medical treatment for shell trauma from motor vehicle collision. The turtles were treated by permitted wildlife rehabilitators and an accompanying veterinarian in accordance with protocols employed at the facility. All turtles underwent a complete medical examination within one hour of admission. Patients were stabilized, and lactated Ringer's solution was administered subcutaneously for dehydration and blood loss as needed, at a rate of 15 ml/kg/day in subjects over 1 kg in

weight and 25 ml/kg/day in subjects less than 1 kg in weight.[61] All fracture wounds were flushed with sterile 0.9% sodium chloride and cleaned of debris using sterile materials as indicated and available.[9,59] Additional injuries were treated. Plastron and carapace fractures were temporarily taped together and lightly coated with silver sulfadiazine cream, and wet to dry bandages were applied to the fracture lines.[76-77] Next, small hooks, as used in hook and eye closures in sewing, were strategically superglued onto the shell. They were placed as close to the fracture as possible, facing parallel to each other and perpendicular to the fracture. Tiny hash marks were superficially scratched onto the shell with a large gauge needle to provide a better surface for adhesion. After the glue set (usually within 24 hours), bandages were removed and wounds were flushed again. Wire was strung between the brackets and tightened with pliers until the fractures were reduced and there was bone-to-bone contact between shell fragments.[33,76]

At admission, all turtles were assigned to a fracture severity class as follows: 1) nondisplaced fractures of the plastron and/or carapace; 2) fractures with displaced segments of plastron and/or carapace; and 3) fractures with displaced and/or missing segments with additional injuries (i.e., lacerations, limb fractures) or any fractures with exposure of the coelomic cavity.[17,21,61] After initial examination, treatment, and blood collection, turtles were drydocked (kept out of water) for the duration of their blood draws to allow the shell to fuse enough to be waterproof.[77] Turtles were examined or weighed daily to assess hydration status, whereupon they were soaked or given fluid therapy as needed.[61] Turtles were provided with necessary supportive care and husbandry while fracture sites healed.[56] In addition, a fecal flotation test and a direct wet mount were performed on turtles as soon as samples were available after admission.

Wound management varied depending on the severity of injury and the occurrence of complications. Fracture sites were coated with topical silver sulfadiazine cream or triple antibiotic ointment to prevent further local introduction of bacteria to the wound and were covered with DuoDERM® or Tegaderm® dressing as needed for added wound protection.[50,58-59] Dressings were changed and wounds flushed and debrided every 3 days or as needed as the wounds healed.[45,59,76-77]

Hematology

Blood parameters were evaluated four times throughout the convalescence of the turtle. The first blood sample was taken within 24 hours of admission, the second at 3 weeks, the third at 6 weeks, and the fourth at 9 weeks post-admission, for a total of four blood draws. Turtles were safely restrained by a trained handler.[23,49,60,75]

A 1-cc syringe with a 25-gauge, 1-inch needle was used for blood collection.[49] Blood was drawn from the jugular vein in painted, spotted, and Blanding's turtles and from the dorsal coccygeal vein in common snapping turtles.[37,53,75] Approximately 0.2 ml of blood was drawn from each turtle, being careful not to exceed the maximum blood volume of 0.6% of the turtle's body weight.[49,75]

Immediately after blood collection, whole blood was used to make two blood smears, using the bevel-edge slide technique.[63] Slides were air dried and then stained with a modified Wright's stain (Jorgensen Labs, Loveland, Colorado, USA).[75] The remaining blood was placed in a blood collection tube containing lithium heparin (Sarsted Ad & Co., Germany).[18,75] Using the stained blood smears, a white blood cell differential was performed on 100 cells.[18] Cells were classified as heterophils, lymphocytes, basophils, eosinophils, and monocytes.[1,50,74,81] White blood cell and red blood cell morphology were evaluated. Thrombocytes were examined (increased, adequate, low, clumped), and hemoparasites were identified.

A WBC was manually estimated using anticoagulated blood. If counts were not performed within 60 minutes of collection, blood was refrigerated and examined within 24 hours.[17-18] Counts were made by the semidirect method, using an Eopette™ Kit (Exotic Animal Solutions, Hueytown, Alabama, USA) and an Improved Neubauer Hemocytometer (Becton Dickinson, Sparks, Maryland, USA).[18,75] WBC was calculated as outlined in the Eopette™ instruction manual, using heterophil and eosinophil percentages from the differential count.

Two untreated microhematocrit tubes (Iris Sample Processing, Westwood, Massachusetts, USA) were filled with anti-coagulated blood and centrifuged.[81] Using a card-style reader (Jorgensen Labs, Loveland, Colorado, USA), packed cell volume (PCV) and buffy coat were read as a percentage. A handheld refractometer (Jorgensen Labs, Loveland, Colorado, USA) was used to measure estimated total protein in g/dl.

Statistical Analysis

The effect of traumatic shell fracture on hematology values was determined. Statistical analysis was performed using Microsoft Office Excel 2013 with Descriptive Statistics and PHStat4 Add-Ins (Microsoft Corporation, Andover, Massachusetts, USA). All hematological data from individual draws was binned into its assigned fracture severity class. Using the Descriptive Statistics Add-In, basic descriptive statistics were run for PCV, total protein, buffy coat, heterophils, lymphocytes, basophils, eosinophils, monocytes, and WBC (Microsoft Corporation, Andover, Massachusetts, USA). Each parameter was tested for statistical significance ($P < 0.05$) across severity class by running a Type I analysis of variance (ANOVA).[17-18,28] WBC was also binned for each severity class according to time of draw and these values were compared over time using a Type 1 ANOVA. If statistical significance was indicated, multiple comparisons were determined using the Tukey–Kramer method within the PHStat4 Add-In.[67]

Results

Hematology assessments were conducted on 10 turtles from Maine and New Hampshire that were hit by cars from 2013–2014. Admitted into the study were two male and two female common snapping turtles, three male painted turtles, one female painted turtle, a male Blanding's turtle, and a female spotted turtle. All

TABLE 1. Hematology values for four painted turtles *(Chrysemys picta)*, four common snapping turtles *(Chelydra serpentine)*, a Blanding's turtle *(Emydoidea blandingii)*, and a spotted turtle *(Clemmys guttata)* with three severities of traumatic shell fracture from Maine and New Hampshire, 2013–2014.

	Severity I			Severity II			Severity III			
Measurement[a]	*n*[b]	Mean±SE	Reference Range (95% CI)	*n*	Mean±SE	Reference Range (95% CI)	*n*	Mean±SE	Reference Range (95% CI)	*p* -value
PCV (%)	20	19.7±1.3	17.0-22.3	11	17.2±1.7	13.4-20.9	8	15.4±1.2	12.4-18.3	nsd[c]
Total Protein (mg/dl)	20	4.51±0.28	3.92-5.10	11	4.48±0.24	3.94-5.02	8	4.95±0.60	3.53-6.37	nsd
Buffy Coat (%)	20	1.2±0.1	1.0-1.3	11	1.2±0.1	0.9-1.5	8	1.4±0.2	0.9-1.8	nsd
Heterophils (%)	20	30.3±3.1	23.8-36.7	11	38.5±3.8	30.2-46.9	8	31.4±2.7	24.9-37.8	nsd
Lymphocytes (%)	20	43.8±3.0	37.5-50.0	11	43.6±5.5	31.3-56.0	8	30.9±2.9	23.9-37.8	nsd
Basophils (%)	20	19.4±2.5	14.2-24.6	11	7.1±2.3	2.0-12.2	8	32.8±3.7	23.9-41.6	0.00002
Eosinophils (%)	20	1.2±0.4	0.4-1.9	11	0.5±0.2	0.0-0.9	8	0.1±0.1	0-0.4	nsd
Monocytes (%)	20	5.4±0.4	4.5-6.3	11	10.1±2.8	3.7-16.4	8	5.0±1.1	2.4-7.6	nsd
WBC (/µl)	20	11359.0±1133.5	8986.5-13731.4	11	12678.6±2721.1	6615.7-18741.6	8	16832.1±3333.8	8948.9-24715.4	nsd

[a] PCV= packed cell volume, WBC= total white blood cell count.
[b] Total number of blood draws from all turtles in severity group over 9 week period.
[c] nsd= no significant difference.

TABLE 2. WBC values over time for four painted turtles *(Chrysemys picta)*, four common snapping turtles *(Chelydra serpentine)*, a Blanding's turtle *(Emydoidea blandingii)*, and a spotted turtle *(Clemmys guttata)* with three severities of traumatic shell fracture over a 9-week period, 2013–2014.

	Severity I[a]			Severity II[b]			Severity III[c]		
WBC[d] (/µl)	*n*[e]	Mean±SE	Reference Range (95% CI)	*n*	Mean±SE	Reference Range (95% CI)	*n*	Mean±SE	Reference Range (95% CI)
Time 0 weeks	5	9617.2±1257.8	6124.9-13109.5	3	20160.7±7831.3	0-53856.0	2	28305.5±231.5	25364.0-31247.0
Time 3 weeks	5	10717.6±2792.5	2964.3-18470.9	2	10306.0±197.0	7802.9-12809.1	2	20998.5±4794.5	0-81918.4
Time 6 weeks	5	1313.2±2032.5	7489.5-18775.7	3	9793.3±4558.8	0-29408.2	2	11892.0±354.0	7394.0-16390.0
Time 9 weeks	5	11968.4±3026.5	3565.6-20371.2	3	9663.7±3878.9	0-26353.4	2	6132.5±393.5	1132.6-11132.4

[a] $p = 0.748$; no significant difference.
[b] $p = 0.476$; no significant difference
[c] $p = 0.010$; significant difference.
[d] WBC= total white blood cell count.
[e] Total number of blood draws from all turtles in severity group at that time.

turtles were adults and varied in overall health and reproductive status. Five turtles were classified into Severity Class I, three turtles into Severity Class II, and two turtles into Severity Class III.

Of the nine hematology parameters analyzed, there were significant differences ($P < 0.05$) between all severity classes for basophils (Table 1). The basophil count for Severity Class I was significantly higher than Severity Class II but lower than Severity Class III (I 19.4 ± 2.5 %; II 7.1 ± 2.3 %; III 32.8 ± 3.7 %). Severity Class II was significantly lower than both Severity Class I and III, and Severity Class III was higher than both Severity Class I and II. All other hematology values were not significantly different from one another across severity class.

WBCs were significantly different over time for Severity Class III, as presented in Table 2. The admission blood draw at Time 0 weeks was significantly higher than Time 6 weeks and Time 9 weeks (Time 0 28305.5 ± 231.5 /µl; Time 6 11892.0 ± 354.0 / µl; Time 9 6132.5 ± 393.5 /µl). WBC at Time 3 weeks was also significantly higher than at Time 9 weeks (Time 3 20998.5 ± 4794.5 /µl; Time 9 6132.5 ± 393.5 /µl).

Parasite loads were evaluated by performing blood smears for hemoparasites and fecal floatation and direct wet mount for intestinal parasites. Three snapping turtles and one painted turtle were positive for sporozoan hemoparasites of the family *Haemogregorinidae*, referred to as hemogregarines.[1,23,50] One of these snapping turtles was also positive for *Trypanosoma sp*., a flagellate protozoan. Fecal analyses were performed on all but one painted turtle, which did not produce a sample during the collection period. Two painted turtle patients were positive for one unknown ovum. One snapping turtle was positive for one cestode and another for multiple nematode ova. The Blanding's turtle was positive for 1–7 strongyle ova per high power field and was treated with fenbendazole 50 mg/kg PO once daily for 5 days. Follow-up fecal analyses were negative. The other patients were asymptomatic or negative and were not treated with parasiticides.

Most patients were successfully treated and did not develop complications or require systemic antibiotic therapy for their injuries during the sampling period. One snapping turtle with Severity Class III injuries was removed from the study due to deep tissue necrosis and started on antibiotics. The turtle was not included in any hematology analyses. The spotted turtle in Severity Class

II also had an esophageal feeding tube placed shortly before its Time 9 blood draw, so later values may have been affected, including an elevated WBC for Time 9. Fracture sites and associated wounds for the remaining turtles healed satisfactorily to meet criteria for release. Five of the turtles were released back into the wild in the fall of 2013, four were released during 2014, and one was euthanized post-study in the fall of 2014 due to complications from the aforementioned esophageal feeding tube.

Discussion

Aside from their traumatic injuries, all patients appeared to be in good physical condition upon admission to the wildlife hospital. All blood draws were completed according to the set timeline with the exception of Time 3 in the spotted turtle, as blood collection was unsuccessful despite multiple attempts. Blood collection and processing protocols were conducted consistently throughout the study. The only variation from typical industry standards was the use of a general purpose whole blood centrifuge for spinning microhematocrit tubes. The wildlife rehabilitation facility where the study was conducted did not have a designated microhematocrit centrifuge. During pre-study troubleshooting and the first five blood draws of this study, microhematocrit tubes were spun in both a general purpose blood centrifuge (approximately 6,000 revolutions per minute for 3 minutes) and in a designated hematocrit centrifuge at another location (15,800 revolutions per minute for 2 minutes) (Iris Sample Processing, Westwood, Massachusetts, USA). PCV, total protein, and buffy coat were comparable between methods, so the on-site general-purpose blood centrifuge was used for processing the remainder of the samples.

Many of the hematology values were consistent with previous documentation in semiaquatic and terrestrial turtles. Total protein and buffy coat were within the normal ranges for published values.[19,36,50] Red blood cell morphology and thrombocyte numbers appeared normal, although smears occasionally contained artifacts or were poorly stained.

PCVs for many of the turtles were lower than previously published ranges. Snapping turtles were generally lower than the accepted range of 20–40%, some of the painted turtle values were lower than the 20–25% range, and the spotted turtle was lower than the 20–30% range.[15,19,22,60,74] The Blanding's turtle was within normal PCV ranges of 20–30%.[22] Low PCV values could have been caused by hemodilution during blood collection or may have been in response to hemogregarine parasites in those infected.[46,68,74-75] Blood loss from initial injury may have also caused the low values seen in most patients, but one would expect to see numbers increase after initial blood draw, which was not consistently the case.

According to Frye, many of the heterophil counts seen in this study were within the normal limits of 30–40% for healthy reptiles.[23] Stacy et al. cited normal values near 50%.[74] The spotted turtle (Severity Class II) and one painted turtle (Severity Class I) had higher counts in the 60s at Time 0, which decreased with subsequent draws, but values were not significant. It was expected

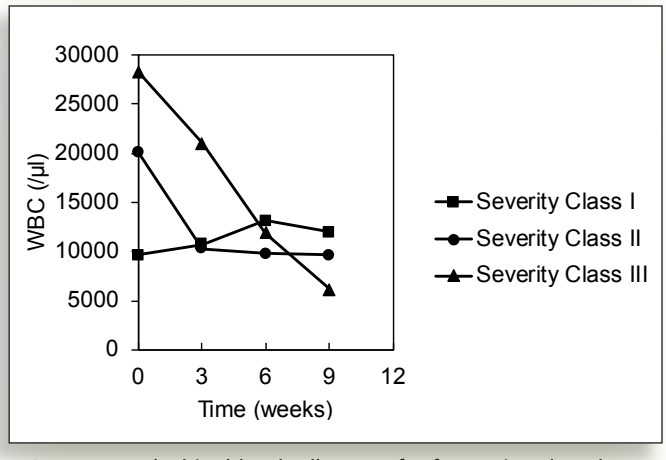

FIGURE 1. Total white blood cell counts for four painted turtles *(Chrysemys picta)*, four common snapping turtles *(Chelydra serpentine)*, a Blanding's turtle *(Emydoidea blandingii)*, and a spotted turtle *(Clemmys guttata)* with three severities of traumatic shell fracture over a 9-week period, 2013–2014. WBCs in Severity Class III were significantly different from Time 0 to Time 6, Time 0 to Time 9, and Time 3 to Time 9. Data are mean values.

that heterophil values would be elevated in response to tissue injury, inflammation, and infection at the injury site, especially during early draws.[23,50,68,74] In Severity Class I, one snapping turtle and one painted turtle exhibited heteropenia (<30%).[74] Heterophil values in the snapping turtle were low during the first draw but were normal in subsequent blood draws. The painted turtle had consistently low values. This could have been in response to acute bacterial infection, as in the snapping turtle, or chronic infection in the painted turtle.[74]

Lymphocyte counts in the literature are variable in reptiles; therefore, the numbers seen here appear to be within normal limits.[23,50,74] Increased lymphocytes are usually correlated with wounds, infection, and inflammation, so higher lymphocyte values were expected with higher severity classes.[74] This was not reflected in the results as Severity Class I and II shared similar lymphocyte averages that were higher than Severity Class III. One explanation for this may be that both turtles in Severity Class III were snapping turtles, which have been documented with greater than 50% basophils.[57] This would result in other white blood cell percentages, such as lymphocytes, to be lower than other species. Lymphocyte numbers can also be affected by many variables such as age, sex, nutritional state, seasonal status, reproductive status, and preexisting parasitism or disease.[15,18,20,23,74] According to these variables, the patients in the differing severity groups were well mixed, and no trends could be positively identified. Hemodilution from lymphatic fluid has also been shown to increase lymphocyte numbers; therefore, this could be a factor if sample collection was more compromised in Severity Class I and II.[74] This is unlikely, however, since many of the blood draws in these classes were from the jugular vein, which is known to result in less lymphatic contamination than more peripheral veins.[53,75]

Basophil counts were lower than most documented values, ranging on average from 7–33%.[57,74] Basophil percentages in the

Painted turtle *(Chrysemys picta)* found in the wild with shell fracture repair.

literature are quite variable but can account for up to 65% of cells.[50,74] Hematology studies on turtle species that live in New England have indicated that basophil percentages are uncommonly high in both the snapping and painted turtle and become more numerous as immune responses are excited.[57,71] In this study, each severity class was significantly different from the others. The basophil count for Severity Class II was significantly lower than both Severity Class I and III, with the highest levels in Severity Class III. Of the three patients in Severity Class II, one was a Blanding's turtle and one a spotted turtle. Both of these individuals had very low basophil counts, which may be a characteristic of their species, as normal ranges for these species are not published. As previously mentioned, the high basophil counts in Severity Class III may be a result of both patients being snapping turtles, which are known for their elevated basophil numbers.[57] The role of basophils in reptiles is poorly understood, but they have been shown to release histamine and antibodies in snapping turtles.[74] It is possible that the increase in basophils in Severity Class III could be a species response to greater bacteria numbers from more severe wounds. Increases in basophil percentages have also been correlated with blood parasites and viral infections.[50,74] This may not be the cause of the differences seen here, as only one out of the two patients in Severity Class III had hemoparasites, and multiple individuals in the other severity groups were also infected. Although statistical analyses on basophil levels over time were not conducted, the two patients in Severity Class III had consistent increases in basophils from Time 0 through Time 9.[57]

Eosinophils, which averaged 0–1% of total white blood cells, were below the published range of 6–20% in chelonians.[23,50,68,74] Eosinophil levels often increase in response to intestinal parasites; however, most reptile species may be infected without showing clinical symptoms or changes in hematology values.[50] This was confirmed in this study, as many of the patients had low levels of parasites but did not demonstrate any significant difference in eosinophil levels. In fact, the Blanding's turtle, which was medically treated for nematodes, had only 0–1% basophils, while the turtle with the highest levels (2–6%) was negative for intestinal parasites. This is opposite of expected values. It has been suggested that diet may play a role in eosinophil counts, and it is likely that the anorexia that accompanied the convalescing turtles could have led to lower eosinophil numbers in all severity groups.[74] Low eosinophil numbers have also been correlated with the active season in chelonians.[20]

Monocyte values fell within the normal published range of 0–10% for reptiles.[23,50,74] Increased monocyte values can occur in cases of severe tissue damage, chronic inflammation, and bacterial or parasitic infection. Therefore, one would expect more monocytes in turtles with greater injury severity.[23,50,68,74] Monocyte values between severity classes in this study were not significantly different and did not follow this trend. Severity Class II had a higher average than that of Severity Class I and III. The monocyte values of the spotted turtle in Severity Class II ranged 20–25%, which elevated the overall average for the class. As there is little published data on spotted turtles, it is unclear whether this elevation in monocyte percentages was due to injury and subsequent infection or whether it was a normal value for this species.

White blood cell counts were not significantly different between severity classes, and average counts were similar to the sparse data that currently exists for freshwater and terrestrial turtle species. Previous studies have suggested that normal values are variable but may typically range from 2,000 to 30,000 /µl.[3,15,50,60] Although no significant difference was found between severity classes, the average WBC was increased in those with greater severity (I 10,580/µl; II 12,679/µl; III 16,832/µl) (Figure 1). These counts still lie within published normal limits for a healthy turtle; however, the preexisting data is not robust. This lack of statistical significance suggests that severity may not be an adequate indicator for whether turtles may develop systemic infection and if they should be placed on prophylactic antibiotic therapy at the time of admission. This is consistent with other studies that have examined hematology parameters in relation to infection.[17,34] For instance, desert tortoises (*Gopherus agassizii*) with notable injuries and infection did not have differing hematology values.[17] In another study involving map turtles (*Graptemys spp.*) and shell disease, no correlations between hematology and severity of disease were found.[34] This suggests that hematology parameters may not be sensitive enough to be good predictors or indicators of disease.[17]

WBCs were significantly different over time for Severity Class III, as presented in Table 2. Admission blood draw at Time 0 weeks was significantly higher than Time 6 weeks and Time 9 weeks (Time 0 28305.5 ± 231.5 /µl; Time 6 11892.0 ± 354.0 /

µl; Time 9 6132.5 ± 393.5 /µl). WBC at Time 3 weeks was also significantly higher than at Time 9 weeks (Time 3 20998.5 ± 4794.5 /µl; Time 9 6132.5 ± 393.5 /µl). This suggests that WBC levels in the most severely injured turtles increased in response to trauma and decreased over time as healing progressed and infection was fought off.

Due to the inability to draw successfully from other sites and also to maintain the safety of the handler and venipuncturist, the use of the dorsal coccygeal tail vein likely created variation in hematology values. Contamination from lymphatic or other extravascular fluid was grossly obvious for many snapping turtle blood draws and could have also been present in jugular draws from the painted turtles, although this is less likely.[49,53] This hemodilution may have resulted in lower than normal PCV, total protein, and WBC values.[10,29,68,74-75]

White blood cell differentials of reptiles can be very difficult to read objectively. One challenge is differentiating lymphocytes from thrombocytes, as they can appear very similar. Another variable is how well the cells pick up stain and the amount of artifact that is present. If smears were not perfectly stained, it was difficult to identify lymphocytes and basophils. To limit this variation, blood smears were prepared by only two people, and all differentials were read by one person. All smears from each individual were read within one session in order to increase consistency in cell identification. Anecdotally, it was observed that cell appearance was variable between species, between individuals within the same species, and also between draw times from the same individual. This could greatly affect the outcomes for all white blood cell parameters and will continue to be a source of error in all manual reptile hematology studies.

It should be noted that the sample size for Severity Class III (two patients) was likely lower than the other classes because the injuries were life-threatening. Many Severity Class III patients were not entered into the study because they died or were euthanized on admission or during the study time period. As previously mentioned, one snapping turtle patient was also pulled from the study because its wounds were healing poorly and it was started on antibiotics. Because of these factors, the quantity of data is likely biased toward Severity Class I and II.

Data suggest that severity of injury may not be a proper indicator of susceptibility of turtles to infection after shell trauma. Turtles of all injury severities had WBCs within normal limits, although more studies should be conducted to establish reliable hematology normals for all turtle species. WBC averages increased with increasing severity of trauma; however these values were not significantly different. Results also suggest that hematology parameters may not be good indicators of infection, perhaps due to variability between and among species and due to likelihood of hemodilution. The criteria for placing turtles with traumatic shell injury on prophylactic antibiotics remains unknown, as severity of injury may not be an accurate indicator. I recommend repeating this study over a longer period of time, as nine weeks may not be long enough to capture trends. It could be beneficial to sample from a greater number of facilities in order to increase sample size. This larger sample size could enable separation of statistical analyses by species, sex, age, seasonal status, reproductive status, and parasite presence, creating more meaningful results. Repeating the study using an alternate venipuncture site in snapping turtles may produce more accurate hematology results for this species.

Further investigation in this field includes examining the effects of antibiotic therapy on hematological parameters, examining the effects of wound management on hematological parameters, and examining culture and sensitivity tests taken from wound sites and blood to identify bacteria and to monitor degree of infection over time.

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About the Author

Sonja Ahlberg has a M.S. in Biology from the University of Nebraska and a B.S. in Environmental Conservation from the University of New Hampshire. She spent many years traveling all over the western U.S. conducting wildlife surveys with the National Parks and Forest Services, collecting data that would inform wildlife, habitat management, and conservation decisions. Beyond an extensive knowledge of native wildlife ecology and physiology, she has a strong veterinary background and has worked in the field of wildlife conservation medicine for almost 10 years. She has also been involved in the creation of a Veterinary Technology program at her local community college, where she serves as a faculty member.

Acknowledgements

This study was conducted with permission from the State of Maine Department of Inland Fisheries and Wildlife, Wildlife Scientific Collection Permit #2013-414 and 2014-414, and the New Hampshire Department of Fish and Game. Methodologies were approved by the University of Nebraska Kearney (UNK) Institutional Animal Care and Use Committee (IACUC), IACUC #031113 and were conducted in compliance with the Institute for Laboratory Research (2011).

Funding was provided by the UNK Biology Department and the Center for Wildlife.

Thank you to Dr. Thomas Freeman, Dr. John Means, the staff at North Hampton Animal Hospital, Dr. Charles Innis, Brendan Clifford, and Chris Bogard. Special thanks to the staff and volunteers at the Center for Wildlife for providing medical treatment and restraint, with venipuncture assistance by Erin Burns.

Physiotherapy in tibiotarsal fracture rehabilitation in raptors

Andrés Estay-Stange, Álvaro Oidor-Méndez, and Sandra José-Ramírez

Roadside hawk *(Rupornis magnirostris)*.

ABSTRACT: Manage of fractures in birds of prey most of the times require surgical intervention, which has been adequately documented in various studies; however, the rehabilitation to achieve the best recovery of the functionality of the injured limb is not well documented; such information is scarce and imprecise. Most rehabilitation processes take several months before achieving the limb to be highly functional, which in raptors is a strong constraint to achieve a successful release. In this paper we present two case studies, both birds with a transverse fracture, of the right tibiotarsus (black hawk-eagle), and left tibiotarsus (roadside hawk). After the fourth week of physiotherapy, an overall assessment of the extremities was performed comparing the speed and accuracy of both limbs and reviewing in detail the body position and found that the affected limbs were fully functional and used to move, perch, and feed accurately. It is necessary to test this methodology in a larger number of raptors with similar injuries, to ensure the effectiveness and to establish a physiotherapy protocol for effective rehabilitation.

KEYWORDS: black hawk-eagle, fractured limbs, raptors rehabilitation, roadside hawk, tibiotarsal fracture

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Introduction

Fractures in the extremities of birds are common in free living and in captivity[10, 3, 7], a large number of cases have been documented on the surgical management and the necessary immobilization to restore fractures of different types, achieving, in most cases, a high success rate.[10, 1, 17, 4, 5]

In contrast, the post-surgical rehabilitation processes have not been analyzed, in most articles only the surgical process is recorded, usually; the bird is kept in a cage where it begins to gradually move the injured limb. Such rehabilitation in most cases takes several

J. Wildlife Rehab. 37(3): 17-21.

FIGURE 1. Loss of continuity of the right tibia in its proximal third in black hawk-eagle

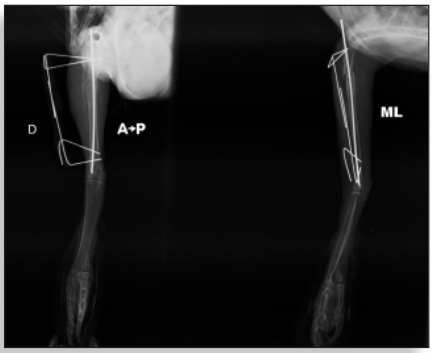

FIGURE 2. Medullary implant and external fixator in black hawk-eagle

FIGURE 3. Tibiotarsal fracture in roadside hawk

FIGURE 4. Roadside hawk immobilization with a cotton splint

months and may not fully recover mobility.[4]

The articulations of birds are especially susceptible to ankylosis as a result of the implants used and the immobilization of the limbs.[1] Physiotherapy rehabilitation procedures in humans have shown to be definitive in the recovery of fractured limbs, facilitating a faster recovery and preventing secondary complications.[14]

The surgical and rehabilitation processes in birds with the possibility of being released must be carried out carefully, in order to achieve a successful release; the injured limb must recover the maximum possible mobility to guarantee the well-being of the bird.[6]

The present study was carried out with a black hawk-eagle *(Spizaetus tyrannus)* and a roadside hawk *(Rupornis magnirostris).* Both birds were received at the Wildlife Conservation Centre UMA–Konkon; the delivery of both birds to Konkon was carried out by the Federal Attorney for Environmental Protection (PROFEPA). Both birds presented a tibiotarsal fracture. A physiotherapeutic program was established to reduce, in the shortest possible time, the effects produced by the injury and the effects derived from the immobilization. The physiotherapy program included contrast therapies, passive and active range of motion (ROM), range of joint movement, stimulation of joint movement, strength training, posture correction, and proprioceptive neuromuscular therapy.[14]

The black hawk-eagle is a bird of prey considered endangered in Mexico.[16] The population of this species outside Mexico varies from moderately small to large, so it does not approach the category of "Vulnerable."[8] Within Mexico, there is no detailed information about the state of its free-living population.[2]

Rupornis magnirostris is a species of bird of prey that is not considered in a risk category within international national lists NOM–059[16] and IUCN.[8]

Case studies

The black hawk-eagle was received at the Konkon facility; crepitation and pain were detected in the right tibia. X-rays were taken, confirming the loss of continuity of the right tibia in its proximal third (Fig. 1). The surgery was performed at the Veterinary Hospital for Small Species of the Autonomous University of Puebla (BUAP), as part of a collaboration for Wildlife rehabilitation and conservation between the UMA Konkon, Faculty of Biological Sciences and Faculty of Veterinary Medicine and Zootechnics (BUAP), Ministry of the Environment and Natural Resources (SEMARNAT), and the Federal Attorney for Environmental Protection (PROFEPA). The tibiotarsal fracture was reduced through an open procedure. A medullary implant was inserted through the distal segment of the tibiotarsus and slipped through the fracture site to the proximal segment. Subsequently an external fixator was implanted to prevent bone rotation and to facilitate adequate alignment of the fracture. We determined that the intramedullary pin allowed adequate movement of the joints (Fig. 2).

The roadside hawk *(Rupornis magnirostris)* was received with a loss of continuity in the left tibia in its proximal third (Fig. 3), the fracture could be aligned through a closed procedure and the limb was immobilized with a cotton splint (Fig. 4). Both birds remained in reduced mobility conditions.[15]

A physiotherapy rehabilitation program was established under the schemes developed to rehabilitate fractures in humans and have been used in other animal species. Under this scheme, immobilization of a limb results in reduced joint mobility, muscle atrophy, and joint pain in immobilized structures[9]. Therefore, an evaluation was made of possible joint and muscle injuries, as well as postural and behavioral changes generated by limb immobilization, and a rehabilitation program was established.

Both birds were wildlife individuals, the physiotherapy rehabilitation procedures were performed in the reduced mobility cages, without any restraining or anesthetics, falconry hood was discarded as a method to keep the birds calm due to the crest of the black hawk-eagle.

Both birds were fed by the same person every time, to reduce stress and aggressiveness when the rehabilitation program was carried out, and the same person that fed them was in charge of applying the direct rehabilitation exercises.

Establishment of the physiotherapy rehabilitation program

In the second week after surgery and immobilization, an analysis was carried out to establish the appropriate rehabilitation program scheme for both individuals. Initially the deficiency, functional limitation, and disability related to the mobility of the toes were analyzed and mobility deterioration was verified at different levels. In both cases, the mobility of the toes was analyzed thru distant observation and direct manipulation, first we observed if the birds opened and closed the toes voluntarily, and then each toe was manually forced to open and close to prove if there was any resistance. In the case of the black hawk-eagle, toes 1 and 4 were disabled and had muscle stiffness, and toes 2 and 3 had no mobility. However, all toes were sensitive (Fig. 5). All the injured limb toes of roadside hawk showed sensitivity and range of motion, but lack of strength compared to the other leg; the toes 2 and 4 had the greatest limitation in mobility. Both birds presented muscle weakness, limited range of motion, and reduction of physical resistance in the affected limbs.

Based on the initial diagnosis, the following rehabilitation program was established for the toes of both species.

Contrast therapy, passive mobility and range of motion (ROM)

The reduced blood supply of the extremities of raptors, the poor musculature of the tarsus-metatarsus, along with a prolonged periods of immobility can lead to irreversible muscular and articular atrophy. It was decided, in the third week after alignment of the fracture in both birds, to initiate contrast therapies (3x3) to stimulate blood supply thru a "pumping mechanism" resulting from vasodilation and vasoconstriction.[12] These therapies consisted in the application, in the 4 toes, of hot water packs (Fig. 5) and alternating with cold water packs wrapped around the toes (Fig. 6). This therapy was applied in sequences of 3 minutes cold, 3 minutes hot and rest 3 minutes, to achieve 5 sequences, 4 times a week, for 2 weeks (Fig.5).

In the analysis of mobility of the toes of both species, in the black hawk-eagle a loss of voluntary mobility in two toes and decreased mobility of the other two toes was observed, and in the roadside hawk a decrease in mobility was found in all the toes of the injured limb. Simultaneously with the contrast therapies, a protocol of passive stretching and joint mobilization was established to avoid ankylosis, which consisted in holding firmly the injured leg by the tarsometatarsus in its distal third and manually forcing the movement of the joints in the affected toes by stretching and folding each toe fully, sliding the articular surfaces imitating the joint natural movement involved in the mechanics of locomotion and hunting. When each toe was fully stretched, horizontal figure-8 movements were performed for 10 seconds, then the toe was held fully extended for 10 seconds and left to rest and continued the sequence with the next toe. Each sequence was repeated 4 times in each toe, 4 times a week for 4 weeks.

During the third week after surgery, both birds stopped lying on the floor, low perches (15 cm) lined with astroturf to avoid bumblefoot were incorporated in the reduced mobility cages (Fig. 7). In the fourth week the soft splint was removed and callus formation was verified in the fractures of both birds and a new evaluation of each bird was made to analyze the mobility of the pelvic-femoral, femoro-tibio-tarsal, and tibio-tarsus-metatarsal. Due to the immobilization of the injured limbs in each bird, the three joints presented reduced mobility and lack of coordination; the posture of both birds was notoriously affected, approximately 10º of inclination (Fig. 7) in comparison with their natural posture.

Isometric resistance exercises and stabilization exercises

At the same time that the contrast therapies were maintained on the toes of the injured limbs, a protocol of passive mobility and joint mobility involving the pelvic-femoral, femoro-tibio-tarsal, and tibio-tarsus-metatarsal. For this therapy, these joints were stretched and folded slowly following the natural movement, with each stretching and flexing the posture was maintained for 10 seconds and the opposite muscular posture was performed. This procedure was repeated 4 times per week for 4 weeks.

In the sixth week, the physiotherapy protocol was supplemented with

FIGURE 5. Black hawk-eagle with hot water pack therapy

FIGURE 6. Black hawk-eagle with cold water pack therapy

FIGURE 7. Low perch lined with astroturf to avoid bumblefoot and posture affected due to the injury and immobilization.

FIGURE 8A. Rotation of the perch with round metal plate base.

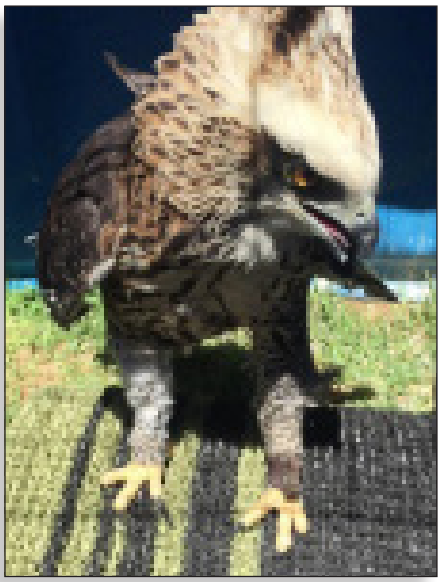

FIGURE 8B. Inflatable plastic cushion with astrotourf mat on top.

isometric resistance exercises to develop muscle strength, manually putting resistance on the movement of the injured limb joints, gradually increasing the resistance as the limbs strength increased. These resistances were applied at different states of joint mobilization by stretching and folding the limb, and putting resistance when the birds were folding or stretching the limb by its own, and were applied for 10 seconds at 4 different joint positions, 3 times a week, because such therapy may be exhaustive and may cause some pain. This protocol was carried out between the sixth and eighth week.

At the same time, a program of stabilization exercises was established to improve the posture of the individuals and the proprioceptive afferent. A perch lined with astroturf, with a base of round metal plate was incorporated in the reduced mobility cages and while the birds were perched, it was rotated in favor and against the clock (Fig. 8), to cause an imbalance in the bird and to force the injured limb to be used to reestablish the axis of the bird and maintain balance. This procedure was performed for 30 seconds and then 30 seconds in the opposite direction and the perch was balanced from right to left for 15 seconds. After completing the exercises on perch, an inflatable plastic cushion was incorporated and an astroturf mat (Fig.9) was placed on top to allow the birds to perch in it and slide smoothly in front to back movements. This movement generated the greatest discomfort in both birds, and was tried to maintain it for 30 seconds.

In the eighth week after immobilization and fracture intervention in both birds, a general evaluation was performed, which included muscle strength, grip strength, grip accuracy, and body axis of both birds. The functionality of the limb in activities like feeding, coordination when walking and its use when perching were analyzed through remote observation to avoid interfering with these behaviors. The angle of body inclination was analyzed through distance photographs; these photographs were analyzed in computer. Grip strength, range of motion at both extremities, and muscle strength were compared through direct manipulation. As a result of this overall evaluation, we checked for a full improvement of the injured limbs (Fig. 9 and 10).

Conclusion

We conclude that after a period of 8 weeks, with 6 weeks of physiotherapeutic work, both birds showed a full recovery of the functionality of the limb, as well as the body axis. Recovery time was considerably reduced compared to other investigations that recorded several months of recovery.[4, 11, 13] Despite the risk of fractures due to their proximity to the tibio-femoro-tarsal joint, adequate alignment, either through surgery or closed alignment,

FIGURE 9. Black hawk-eagle after rehabilitation

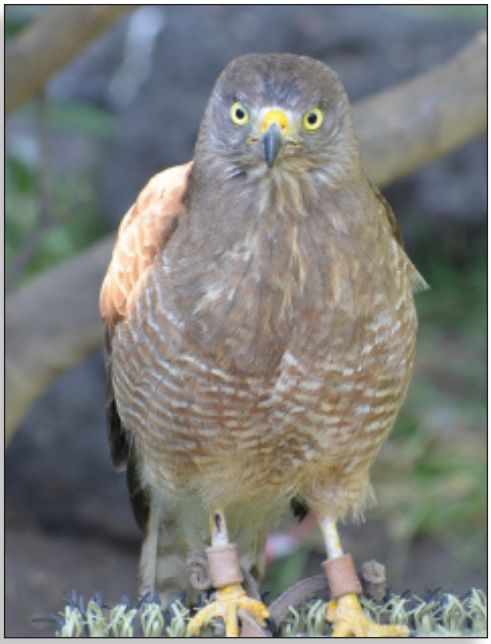

FIGURE 10. Roadside hawk after rehabilitation

together with the application of a physiotherapeutic protocol, allowed a full rehabilitation in a short period of time.

It is necessary to test the present methodology on a greater number of birds of prey with similar lesions, to corroborate the effectiveness of this method and to detail and enrich the process of physiotherapeutic rehabilitation.

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NEWS CONTINUED FROM PAGE 6

Department's wildlife rescue, treatment, and rehabilitation facility near Kaziranga —where she was hand-raised. She was transported to Manas and released into the wild in November 2010. She birthed her first calf, a female, in 2014.

"I'm extremely pleased to received this news," said HK Sarma, IFS Field Director, Manas National Park. "This is the first rhino calf born in Manas in nearly 20 months. My congratulations to IFAW-WTI, BTC and other stakeholders on this happy occasion."

Persian Leopard Rehab Success

TEHRAN, IRAN (July 11, 2017)—A rare female Persian leopard that had undergone spinal surgery in February is recovering so well that authorities plan to move her to a bigger area before releasing her back into the wild.

Ali Teymouri, director of the Hunting and Fishing Office at the Department of Environment, said if the leopard continues to show physical improvements, she will be released into her natural habitat, ISNA reported.

The leopard is being looked after at a wildlife facility in western Tehran. However, barring unforeseen circumstances, the animal will be transferred to a facility in Qazvin (143 km northwest of Tehran), where a 600-square-meter plot of land at a local facility has been prepared for her.

Teymouri said the four-year-old leopard spent her formative years with her mother, learning how to hunt and survive in the wild. "So we're not particularly worried about how she'll fare in nature once we release her; we know she has the necessary skills," he said. "We just have to make sure the leopard is physically and mentally capable of fending for herself."

The Persian leopard was found on February 5 caught in a boar trap in Roudsar, Gilan Province. The severity of her injuries compelled environment officials to bring her to Tehran's Pardisan Park where one of Iran's most well-equipped wildlife rehabilitation facilities is located. CT scans revealed a lesion on her spine, which experts said was untreatable and recommended euthanizing the animal and freezing her ovaries. But Teymouri's office insisted that she be operated on.

On Feb. 10, she underwent surgery at Dr. Hamidreza Fattahian's veterinary clinic in Tehran.

To many people's surprise, the Persian leopard began walking only seven days after the operation and has continued her miraculous recovery.

Persian leopards are among the most threatened animals in the world, with Iran among their last remaining habitat. They are classified as "endangered" species by the International Union for Conservation of Nature.

Studies have shown that 71% of all Persian leopard fatalities in Iran are attributed to illegal hunting or poisoning by shepherds trying to protect their livestock. Furthermore, road accidents accounted for 27% of leopard deaths between 2007 and 2014. Over the past eight years, 166 leopards have died across the country.

Measures, including fencing of roads that run through leopard's habitats and ensuring the animal to compensate those (such as shepherds) who suffer damages by the leopard, have helped reduce fatalities.

Efforts to protect the Persian leopard will not only help the species, but other wildlife as well, making the leopard a so-called umbrella species. Due to its wide distribution, protecting the endangered species will also help conserve the populations of other animals that share the same habitat.

Human/wildlife experts study 'the Potter effect'

OXFORD, UK (June 29, 2017)—Researchers at Oxford Brookes University have investigated whether or not there is a 'Harry Potter effect' on owl keeping in countries where keeping wild birds as pets is considered commonplace.

This week marked 20 years since Harry Potter and the Philosopher's Stone was first published. In the years following the release of Harry Potter novels, there have been some suggestions that countries like the UK and India have seen an increase in owl keeping. JK Rowling has previously spoken out against keeping owls as pets stating: "If anybody has been influenced by my books to think an owl would be happiest shut in a small cage and kept in a house, I would like to say as forcefully as I can, you are wrong."

In the recently published study, Professors Vincent Nijman and Anna Nekaris at Oxford Brookes University turned their attention to Indonesia, where a wide range of species can be bought at bird markets in most major cities.

By comparing data from market surveys from 1979 to 2016, thus including the period before and after the release of the Harry Potter novels, the researchers were able to show that there has been an increase in the owl trade. Furthermore, they have highlighted that where owls used to be called Burung hantu, which translates as ghost birds, now they are referred to as Burung Harry Potter (Harry Potter birds).

Professor Nijman said: "In the 1990s, when surveying the bird markets I would typically see one or two owls for sale amongst the thousands of wild-caught birds on offer but equally often not a single owl was on display.

"Now, returning to those same markets we can see dozens of owls for sale of a wide range of species and owls are always present, all taken from the wild."

While at least in Indonesia, Harry Potter may have had some effect on the normalization of keeping owls as pets, blaming the increase of the owls trade solely on the little wizard or its creator paints too simplistic a picture. "What we have seen in Indonesia is a massive increase in popularity of owls in general and pet owl lovers organise themselves on social media to exchange information on how to keep owls, what owls are available as pets, and where to obtain them", added Prof Nijman.

"Only a year prior to the publication of Harry Potter the first public Internet café opened in Indonesia and the increase in use of social media coincided with the rise of Harry Potter as a phenomenon."

Professor Anna Nekaris said: "It is particularly heart breaking to see nocturnal animals like owls in the markets. Look-

ing stunned and stressed under the bright sun, they are often only fed water and rice, making the situation all the more pitiful.

"About half of the 2,000 or so owls we encountered in the markets were downy chicks, taken from their nests, and we expect the majority of them to die within weeks; this does not appear to be a sustainable trade."

With limited information available on the status of wild owls in Indonesia it is difficult to gauge the effect of the increase of owl trade. "Few researchers venture out at night making it possible that the trade affects some species very negatively without us knowing" added Prof Nekaris.

Eight species of owl in Indonesia are listed a globally threatened, and with traders offering a wide range of species, these are the ones that need to be monitored to ensure the unsustainable trade is not an impediment to their conservation.

The paper, entitled The Harry Potter effect: The rise in trade of owls as pets in Java, Bali and Indonesia, is published in the open access journal *Global Ecology and Conservation.*

Lead Poisoning Cases in Bald Eagles

HARRISBURG, PA (October 14)—An increasing number of bald eagles have been admitted to wildlife-rehabilitation centers across Pennsylvania exhibiting signs of illness such as weakness, lethargy, emaciation, labored respiration, and drooping wings. Blood tests often reveal that the eagles are suffering from lead toxicity.

Lead poisoning occurs when toxic levels of lead are absorbed into the body. Raptors are particularly susceptible to lead poisoning because when they ingest lead particles, the acidic nature of their stomach causes rapid absorption of the metal, said Pennsylvania Game Commission Wildlife Veterinarian Justin Brown.

"Lead poisoning is a debilitating disease in bald eagles," said Brown. "You have this powerful bird and you find it in the field – limp and weak. You can pick it up and it doesn't even know you are there. "

After a blood test reveals that a bald eagle has lead toxicity, intensive treatments can begin. Drugs treatments can take the metal out of the body's tissue and blood. And if metal is detected in an eagle's digestive system, it can be flushed out and removed. But treatment often is unsuccessful because the eagles have already absorbed too much lead.

In the past year, wildlife rehabilitation centers statewide have treated 12 bald eagles with lead toxicity, and only one of them survived, said Red Creek Wildlife Center director Peggy Hentz

"As there are more eagles in the wild, we are getting more eagles in the wildlife rehabilitation centers and the problem has become evident," Hentz said.

Since 2006, the Game Commission has been conducting necropsies on bald eagles that die to monitor causes of death and potential diseases. The data from 2006 to 2016 reveals that approximately one-third of the state's known bald eagle mortalities are associated with a toxin, with lead being the most common. In fact, lead toxicity is a significant cause of death in all raptors, not just eagles.

Lead is a heavy, relatively inexpensive, malleable metal, which often is used in fishing lures, ammunition, and other materials. Research has shown that fragments of lead can be found as far as 18 inches from a bullet's point of impact. In addition, 30 to 40 percent of the lead can remain in the target after the bullet has passed through. Small-game carcasses and big-game entrails that remain in the field could contain lead that might be ingested by opportunistic scavenging eagles and other wildlife.

Moose calves in rehab

SMITHERS, BC, CANADA (July 14, 2017)—In the early morning of May 20th Northern Lights Wildlife Society (NLWS) received notice of two orphaned moose calves in Prince George. They had just recently formed an alliance with Roy Rea from UNBC to create moose rescue teams. Orphaned moose calves are either highly mobile (outrunning humans with great ease) or hunkered down somewhere (basically making themselves invisible). It takes manpower and patience to capture these youngsters.

Moose calves *(Alces alces)* in rehab at Northern Lights Wildlife Society.
PHOTO © NORTHERN LIGHTS WILDLIFE.

By mid-afternoon the Centre got word that Roy was now in possession of both calves. After a short stop at Ospica Veterinarian Service (for a physical exam and to administer fluids) the calves traveled to Smithers where they arrived in the evening.

As of July the calves have settled in well and are growing at a rapid rate. Along with four other moose calves, they will stay at NLWS until spring of 2018.

—contributed by Angelika Langen.

Banding Together for Bears

WARDSBORO, VT (April 24, 2017)—The Vermont Fish & Wildlife Department has worked with multiple conservation partners to rescue several bear cubs this spring. These cubs, who were born during a particularly high birth year last spring, are showing up malnourished in residential areas due to a shortage of wild food supplies in some regions this past fall.

Working in partnership with New Hampshire Fish & Game, the cubs have been delivered to bear rehabilitator Ben Kilham in Lyme, New Hampshire.

Recently a Wardsboro resident contacted the Vermont Fish & Wildlife Department after finding a cub under her porch. Department biologists and game wardens evaluated the situation and determined the bear was a rare candidate for rehabilitation. Its health was so poor that it would have died within a few days if they did not intervene.

"We are grateful when concerned

Black bear cub *(Ursa americanus).*

citizens report these bears to their local warden, rather than attempting to handle the animal themselves," said Forrest Hammond, Vermont Fish & Wildlife's lead bear biologist. "Many people mistakenly think that young animals are in distress and in need of rescue and they sometimes intervene directly, putting their safety and that of the animal at risk. In most situations, animals do best when they remain in the wild," said Hammond. "However, in rare instances we do come across a bear that trained wildlife professionals are able to help. After a brief period, these bears are quickly and successfully returned to the wild in Vermont."

Ben Kilham is an internationally recognized bear rehabilitator who has been researching wild bears and caring for them for decades along with his sister and wife. "We are fortunate to have such an experienced and proven bear rehabilitator in the region, and to have a special agreement with the New Hampshire Fish & Game to be able to transport cubs into that state for care by Kilham," said Hammond. "Without his expertise, rehabilitation may not be an option for us."

The cubs will be returned to remote areas in Vermont once fully recovered and at a time when more natural foods are available.

Neighborhood Eagle Rescue

KENOSHA, WI (July 10, 2017)—An injured juvenile bald eagle turned up in a Kenosha backyard, sparking a rescue effort by the neighborhood.

The young eagle landed on a house in the 1500 block of 25th Street, startling residents who aren't used to seeing birds much bigger than a robin hanging out on the block.

The eagle stayed on the roof for about two hours before flying into the yard behind the house, trying to drink out of a birdbath and knocking it over in the process. The man who lived in the house refilled the birdbath on the ground, and the eagle went over to get a drink.

Meanwhile, the eagle drew a crowd of people from the neighborhood, who became increasingly concerned as it became clear that that the eagle was too weak to leave the yard.

"He tried to fly, he'd open his wings and hop around the yard a little bit," Jecevicus said. "He got up on a chair, he got up on a table, at one point he tried to get up and he crashed into a fence. You could just tell he was distressed." Among the people watching were Nick Counterman and his brother Ben, who called Fellow Mortals Wildlife Hospital in Lake Geneva, describing the eagle's actions and sending a photo. The wildlife rehab facility gave the brothers tips on how to capture the bird using a blanket to herd the eagle into a dog crate. They then drove him to Fellow Mortals.

Bald eagles were once critically endangered but their populations have been rebounding since the banning of the pesticide DDT in 1972. According to state data, there were 1,500 confirmed eagle nests in Wisconsin last year, 15 times the number in the state in the '70s. As their population has grown, eagles' range has expanded south. In April, the DNR announced there was an active eagle's nest in Kenosha County for the first time in 45 years.

According to Fellow Mortals, the injured eagle was likely born this year, possibly nearby. The eagle had a cracked lower mandible or beak, and his mouth and throat were full of blood. He was severely dehydrated and weak, infested with mites, and weighed in at less than 5 pounds when his weight should have been around 9 pounds.

"If you had not acted, he quite possibly would have died last night," a hospital representative wrote.

Meyer said the close encounter with the eagle and watching people work together to do the rescue was a once-in-a-lifetime experience, and brought together neighbors who had never met.—*Source: Deneen Smith, Kenosha News. Edited.*

A New Approach to Conservation

ABINGDON, UK (January 18, 2018)—

Conservationists use a basic set of underlying values to guide their decision-making and action. The safeguarding or promotion of biodiversity, it is believed, is the means by which nature is best protected.

Gill Aitken's new book, "A New Approach to Conservation: The Importance of the Individual through Wildlife Rehabilitation," examines and challenges these long-held conservation assumptions. While reinforcing the need to halt extinc-

tion and value biodiversity, Aitkin argues that biodiversity needs to be more clearly understood, perhaps being replaced by the notion of "wildness."

Published by Routledge, the book examines biodiversity as a holistic term, and the ways in which individual species and their own contribution to wildness need to be recognized and assessed.

Aitkin proposes a new approach to conservation—one that makes more room for neglected, rather than endangered or rare species. He also asserts that wildness is not incompatible with certain kinds of human intervention.

Federal Register Releases Eastern Puma Extinction Rule Issuance

WASHINGTON, DC (January 30, 2018)—The U.S. Fish and Wildlife Service has issued a final rule that declared the eastern puma (*Puma concolor couguar*) extinct. This review process began in July 2015, when the USFWS initiated the standard five-year status review of this species. This subspecies was endemic to the eastern half of the United States and is genetically similar to the Florida panther (*Puma concolor coryi*) and the western subspecies of the North American cougar (*Puma concolor*). The last confirmed sighting of an individual was reported in 1938.

See the official ruling on this case in the Federal Register or read more about the eastern puma from Yale Environment 360.

Emergency Responders Train to Rescue Wildlife Caught in Oil Spills

TORRANCE, CA (February 7, 2018)—A rescue team from the Pacific Marine Mammal Center (PMMC) reacted instantly when they found a sea lion covered in oil on a San Clemente beach in 2015.

They photographed him, took samples of the oil, assessed his health for a wash and then went to work to remove as much oil as possible.

The sea lion was treated for dehydration and began eating, showing signs of improvement. But two weeks later, he developed severe lung congestion and died.

"This animal was rescued before the big Santa Barbara oil spill," said Krysta Higuchi, referring to the Refugio spill in May 2015, when nearly 143,000 gallons of crude oil dumped into the ocean after a corroded pipeline burst harming hundreds of sea lions, seals and birds. "It goes to show you, even when an event or crisis hasn't occurred, it's important to be properly trained in such instances."

PMMC is one of 41 organizations statewide — including rehabilitation groups, universities and aquariums — that comprise the Oiled Wildlife Care Network. The network was established in 1994 by the California Department of Fish and Wildlife's Office of Spill Prevention and Response after spills by the Exxon Valdez in Alaska (about 11 million gallons spilled) and the American Trader in Huntington Beach (more than 400,000 gallons). It is administered by the UC Davis Wildlife Health Center in the School of Veterinary Medicine.

Nineteen groups in the network participated in an annual drill, a response to a mock spill involving the collision of an oil tanker and barge off the San Diego coast.

The exercise placed participants at the beach doing rescues, into animal transportation, and at triage at SeaWorld's Oiled Wildlife Care Center — a 2,600-square-foot building with outdoor pools — where the affected birds and marine mammals were taken for their initial workups. In 2015, SeaWorld treated 62 live sea lions and seals affected by oil spills — the most at the park in a single year, said Jody Westberg, who has worked with stranded animals at SeaWorld for 20 years. Ultimately, 24 were rehabilitated. Sea birds were taken to International Bird Rescue in San Pedro, a network member, for care.

"We have more than 3,000 spills a year," said Michael Ziccardi, director of OWCN. "We don't respond to all of these but if there's an oil spill that affects waters of the state, California Department of Fish and Wildlife would activate the network and we would deploy. Even in a situation of a light sheen, we've mobilized because a dime-sized drop of oil on a sea bird can cause it to die."

For Lisa Peronne and Sheila Eberly, who work with sea birds at Huntington Beach's Wetlands & Wildlife Care Center, the new system was eye-opening. Eberly worked at the beach and in transport during the drill, Peronne was in the pre-wash station.

"We put in the information on what the species was, if it was oiled or non-oiled and what injuries it had," Peronne said. "That way we could track the animals through the entire process, from intake to rehabilitation."

Julie Skoglund, operations manager at the International Bird Rescue Center, said working with others from the network is critical.

"Getting to test my own knowledge for a spill response was really important," she said. "The most important thing with wildlife during a spill is to respond quickly. It's important to be familiar with what other team member skill-sets are." ■

SELECTED ABSTRACTS

Border walls and biodiversity: New barriers, new horizons

LE Ogden. BioScience, 2017;67(6):498–505. https://doi.org/10.1093/biosci/bix044.

Can a wall impede a bird capable of flying? It seems illogical. But the ferruginous pygmy owl is not a high flier. In the Sonoran Desert in southern Arizona, these owls do not even readily fly over trees. "They fly really low," with an average flight height of 1.4 meters (m) above ground, explains the University of Arizona's Aaron Flesch. Flesch's telemetry work suggests that habitat use by these low-flying birds is profoundly curtailed.

Further evidence for bats as the evolutionary source of Middle East respiratory syndrome coronavirus

SJ Anthonya, K Gilardid, VD Menacherye, T Goldsteind, B Ssebidef, R Mbabazif, I Navarrete-Maciasa, E Lianga, H Wellsa, A Hicksa, et al. *mBio.* 2017;8:e00373-17. https://doi.org/10.1128/mBio.00373-17.

The evolutionary origins of Middle East respiratory syndrome (MERS) coronavirus (MERS-CoV) are unknown. Current evidence suggests that insectivorous bats are likely to be the original source, as several 2c CoVs have been described from various species in the family Vespertilionidae. Here, we describe a MERS-like CoV identified from a *Pipistrellus cf. hesperidus* bat sampled in Uganda (strain PREDICT/PDF-2180), further supporting the hypothesis that bats are the evolutionary source of MERS-CoV. Phylogenetic analysis showed that PREDICT/PDF-2180 is closely related to MERS-CoV across much of its genome, consistent with a common ancestry; however, the spike protein was highly divergent (46% amino acid identity), suggesting that the two viruses may have different receptor binding properties. Indeed, several amino acid substitutions were identified in key binding residues that were predicted to block PREDICT/PDF-2180 from attaching to the MERS-CoV DPP4 receptor. To experimentally test this hypothesis, an infectious MERS-CoV clone expressing the PREDICT/PDF-2180 spike protein was generated. Recombinant viruses derived from the clone were replication competent but unable to spread and establish new infections in Vero cells or primary human airway epithelial cells. Our findings suggest that PREDICT/PDF-2180 is unlikely to pose a zoonotic threat. Recombination in the S1 subunit of the spike gene was identified as the primary mechanism driving variation in the spike phenotype and was likely one of the critical steps in the evolution and emergence of MERS-CoV in humans.

The importance of the altricial–precocial spectrum for social complexity in mammals and birds: a review

IBR Scheiber, BM Weiß, SA Kingma, and J Komdeur. *Frontiers in Zoology.* 2017;14:3. https://doi.org/10.1186/s12983-016-0185-6.

Various types of long-term stable relationships that individuals uphold, including cooperation and competition between group members, define social complexity in vertebrates. Numerous life history, physiological, and cognitive traits have been shown to affect, or to be affected by, such social relationships. As such, differences in developmental modes, i.e. the 'altricial-precocial' spectrum, may play an important role in understanding the interspecific variation in occurrence of social interactions, but to what extent this is the case is unclear because the role of the developmental mode has not been studied directly in across-species studies of sociality. In other words, although there are studies on the effects of developmental mode on brain size, on the effects of brain size on cognition, and on the effects of cognition on social complexity, there are no studies directly investigating the link between developmental mode and social complexity. This is surprising because developmental differences play a significant role in the evolution of, for example, brain size, which is in turn considered an essential building block with respect to social complexity. Here, we compiled an overview of studies on various aspects of the complexity of social systems in altricial and precocial mammals and birds. Although systematic studies are scarce and do not allow for a quantitative comparison, we show that several forms of social relationships and cognitive abilities occur in species along the entire developmental spectrum. Based on the existing evidence it seems that differences in developmental modes play a minor role in whether or not individuals or species are able to meet the cognitive capabilities and requirements for maintaining complex social relationships. Given the scarcity of comparative studies and potential subtle differences, however, we suggest that future studies should consider developmental differences to determine whether our finding is general or whether some of the vast variation in social complexity across species can be explained by developmental mode. This would allow a more detailed assessment of the relative importance of developmental mode in the evolution of vertebrate social systems.

Rehabilitating sea otters: Feeling good versus being effective

JA Estes and MT Tinker. In: Effective Conservation Science: Data Not Dogma. P Kareiva, M Marvier, and B Silliman, eds. Oxford University Press; 2017. Ch 20. https://doi.org/10.1093/oso/9780198808978.003.0020

This chapter examines the complexities of assessing the merits and drawbacks of wildlife rehabilitation. Wildlife rehabilitation is often costly, and the resulting benefits differ depending on whether one's interest is in the welfare of individual animals or conserving populations. Two examples of this dilemma include the rehabilitation of oiled sea otters following the Exxon Valdez spill in Prince William Sound, Alaska, and the rehabilitation of stranded sea otter pups in central California. In the first example, substantial financial investment resulted in little or no benefits for population conservation. In the second example, the potential for population-level benefits is context dependent: in populations near carrying capacity the conservation impacts are negligible, whereas in isolated, low-density populations rehabilitation and release can be an effective conservation tool. Wildlife rehabilitation is valued by people for various reasons, but recognizing

and acknowledging the difference between individual and population welfare is an important step toward effective wildlife conservation.

Management of gastrointestinal parasites in wildlife rehabilitation centers in Brazil

M Bomon. (2018). Dissertação de mestrado. Universidade de Lisboa, Faculdade de Medicina veterinária, Lisboa.

Parasites are essential and inevitable part of ecosystems, but simultaneously harm their individual host. This duality leads to dilemmas regarding the best approach to these symbionts when conservation medicine is concerned, such as in wildlife rehabilitation centers. In Brazil, tens of thousands of wildlife specimens are admitted in these centers every year. An online survey was sent to wildlife rehabilitation centers throughout the country, addressing topics like diagnostic testing, deworming, and biosecurity. Additionally, a detailed case study of the gastrointestinal parasite profile at one rehabilitation center was performed. This resulted in an exhaustive characterization of gastrointestinal (GI) parasite management in these centers, with some notorious and returning findings: a) Overcrowding and/or understaffing, making time one of the most precious resources in these centers. Veterinarians receive 4 to 18 cases a day, having a total time of 26 to 104 minutes to dedicate to a case from beginning to end, which is virtually impossible. b) Lack of resources (equipment and funding); c) A worryingly high percentage of inefective treatments. 15 to 47% of the organizations perform treatments without considering diagnostic results. From the organizations that check treatment efficacy, 74% already encountered inefective results, 40% frequently. Only 60% of the treatments performed by the author were efective. Based on the collected information, guidelines were written for diagnosis and treatment of GI parasites in wildlife rehabilitation centers, in order to optimize time and resources. A diagnostic protocol was proposed with prioritization of certain patients: a) those with clinical signs suggestive of GI parasitism, such as diarrhea and anemia; b) older animals; c) animals under permanent human care; and d) animals under a high amount of stress (e.g. polytraumatized patients). One should test the efficacy of all treatments and keep extensive records. The use of alternative methods for parasite control, such as fungi and plants, is suggested as a measure with a lot of potential and advantages in wildlife medicine.

Precision wildlife medicine: applications of the human-centered precision medicine revolution to species conservation

J Whilde, MQ Martindale, and DJ Duffy. *Glob Change Biol*. 2017;23:1792–1805. doi:10.1111/gcb.13548

The current species extinction crisis is being exacerbated by an increased rate of emergence of epizootic disease. Human-induced factors including habitat degradation, loss of biodiversity and wildlife population reductions resulting in reduced genetic variation are accelerating disease emergence. Novel, efficient, and effective approaches are required to combat these epizootic events. Here, we present the case for the application of human precision medicine approaches to wildlife medicine in order to enhance species conservation efforts. We consider how the precision medicine revolution, coupled with the advances made in genomics, may provide a powerful and feasible approach to identifying and treating wildlife diseases in a targeted, effective, and streamlined manner. A number of case studies of threatened species are presented which demonstrate the applicability of precision medicine to wildlife conservation, including sea turtles, amphibians, and Tasmanian devils. These examples show how species conservation could be improved by using precision medicine techniques to determine novel treatments and management strategies for the specific medical conditions hampering efforts to restore population levels. Additionally, a precision medicine approach to wildlife health has in turn the potential to provide deeper insights into human health and the possibility of stemming and alleviating the impacts of zoonotic diseases. The integration of the currently emerging Precision Medicine Initiative with the concepts of EcoHealth (aiming for sustainable health of people, animals, and ecosystems through transdisciplinary action research) and One Health (recognizing the intimate connection of humans, animal, and ecosystem health and addressing a wide range of risks at the animal–human–ecosystem interface through a coordinated, collaborative, interdisciplinary approach) has great potential to deliver a deeper and broader interdisciplinary-based understanding of both wildlife and human diseases.

The implications of significant adenovirus infection in UK captive red squirrel *(Sciurus vulgaris)* collections: How histological screening can aid applied conservation management

DJ Everest, CM Shuttleworth, SS Grierson, A Dastjerdi, MF Stidworthy, JP Duff, RJ Higgins, A Mill, and J Chantrey. *Mammalian Biology.* 2018;88:123-129. https://doi.org/10.1016/j.mambio.2017.10.003.

Conservation translocation using captive bred red squirrels *(Sciurus vulgaris)* is increasing in the United Kingdom (UK). However, project managers are often unaware of the risk of pathological adenovirus (ADV) infection. In this study we illuminate the viral threat using transmission electron microscopy (TEM) and polymerase chain reaction (PCR) assays. Both techniques were used to screen samples collected from 26 English and Welsh captive red squirrel collections. Of 181 carcasses received between 2002 and 2016, 129 (71%) were suitable for routine surveillance post mortem examination (PME). A range of tissues were examined with ADV identified from a variety of samples by PCR and TEM in 92 (72%) cases encompassing 23 of the 26 study collections (89%). ADV enteritis was histologically confirmed in two deaths (2%) with another 39 (30%) through both laboratory and clinical findings, considered as likely clinically-significant ADV cases, but advanced autolysis precluded accurate assessment and confirmatory histological diagnosis. Other positive cases were more indicative of sub-clinical

infection. Clusters of ADV red squirrel deaths were recorded with circumstantial evidence suggesting inter-collection movement of presumed ADV infected donated animals had triggered mortality in recipient collections. During the study, several collections intermittently experienced ADV-associated deaths. Definitive cause of death was not determined in most cases, but a diverse range of diagnoses were recorded in 25 (19%) animals. Implications of these findings for captive United Kingdom (UK) red squirrel husbandry are discussed. It is recommended that protocols be drawn up to minimise potential intra-species ADV infection and highlight the danger of contact with ADV infected wood mice *(Apodemus sylvaticus).*

Augmenting the conservation value of rehabilitated wildlife by integrating genetics and population modeling in the post-rehabilitation decision process

C Pacioni, C Rafferty, K Morley, S Stevenson, A Chapman, M Wickins, T Verney, G Deegan, S Trocini, and PBS Spencer. *Current Zoology.* zox065. https://doi.org/10.1093/cz/zox065

Insular populations are particularly vulnerable to the effects of stochastic events, epidemics, and loss of genetic diversity due to inbreeding and genetic drift. The development of successful management options will require accurate baseline data, establishment of clear objectives, and finally monitoring and implementation of corrective measures, if and when required. This study assessed management options for the genetic rehabilitation of highly inbred woylies obtained from wildlife rehabilitation centers. The study generated genetic data for the woylie *Bettongia penicillata* from a conservation reserve and calculated measures of genetic diversity and individual relatedness. These data were fed into a population viability analysis (PVA) to test genetic outcomes in relation to different management actions. We demonstrated that a careful selection of the founder cohort produced a population with an expected heterozygosity of ~70% for a window of approximately 10 years. A proposal to increase the size of the reserve available to the colony was shown to almost double the time at which the colony would retain heterozygosity levels of ≥ 70%. Additionally, developing a regular program of supplementation of unrelated woylies would result in a further improvement in their genetic value. This study demonstrated how the application of molecular techniques in combination with PVA can be beneficial for the management of rehabilitated wildlife otherwise considered of little conservation value. This approach can be applied to the management of breeding programs, but also to small, closed populations such as those found on islands, fenced enclosures, insurance populations, and in zoological collections.

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

RA Molina-López, S Mañosa, A Torres-Riera, M Pomarol, and L Darwich. *PLoS ONE.* 2017;12(7):e0181331. https://doi.org/10.1371/journal.pone.0181331

Background: There are few studies of careful examination of wildlife casualties in Wildlife Rehabilitation Centers. These studies are essential for detecting menaces to wild species and providing objective criteria about cost-benefit of treatments in those centers. The release rate is considered the main outcome indicator, but other parameters such as length of stay at the center and a cost-benefit index expressed as number of released animals per euro and day, could be used as reliable estimators of the rehabilitation costs.

Methodology: A retrospective study based on 54772 admissions recorded from 1995–2013 in the database of the Wildlife Rehabilitation Center of Torreferrussa (Catalonia, NW Spain) assessed the morbidity, outcomes, and cost-benefits of the rehabilitation practices.

Results: Three hundred and two species were included: 232 birds (n = 48633), 37 mammals (n = 3293), 20 reptiles (n = 2705) and 13 amphibians (n = 141). The most frequent causes of admission were: 39.8% confiscation of protected species (89.4% passerines), 31.8% orphaned young animals (35.3% swifts, 21.7% diurnal raptors and owls), and 17.4% trauma casualties (46.7% raptors and owls). The highest proportion of releases was found in the captivity confiscation category [87.4% passerines (median time of stay: 12 days)], followed by the orphaned category [78% owls (66 days), 76.5% diurnal birds of prey (43 days), 75.6% hedgehogs (49 days), 52.7% swifts (19 days), and 52% bats (55 days)]. For the trauma group, 46.8% of releases were hedgehogs (44 days) and 25.6% owls (103 days). As regards the cost-benefit index, the trauma casualties and infectious diseases had the 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, particulary in amphibian, reptiles, and passerines.

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

A wet-tolerant adhesive patch inspired by protuberances in suction cups of octopi

S Baik, Da Wan Kim, Youngjin Park, Tae-Jin Lee, Suk Ho Bhang and Changhyun Pang. *Nature.* 2017;546:396–400. doi:10.1038/nature22382

Adhesion strategies that rely on mechanical interlocking or molecular attractions between surfaces can suffer when coming into contact with liquids. Thus far, artificial wet and dry adhesives have included hierarchical mushroom-shaped or porous structures that allow suction or capillarity, supramolecular structures comprising nanoparticles, and chemistry-based attractants that use various protein polyelectrolytes. However, it is challenging to develop adhesives that are simple to make and also perform well—and repeatedly—under both wet and dry conditions, while avoiding non-chemical contamination on the adhered surfaces. Here we present an artificial, biologically inspired, reversible wet/dry adhesion system that is based on the dome-like protuberances found in the suction cups of octopi. To mimic

the architecture of these protuberances, we use a simple, solution-based, air-trap technique that involves fabricating a patterned structure as a polymeric master, and using it to produce a reversed architecture, without any sophisticated chemical syntheses or surface modifications. The micrometre-scale domes in our artificial adhesive enhance the suction stress. This octopus-inspired system exhibits strong, reversible, highly repeatable adhesion to silicon wafers, glass, and rough skin surfaces under various conditions (dry, moist, under water and under oil). To demonstrate a potential application, we also used our adhesive to transport a large silicon wafer in air and under water without any resulting surface contamination.

Body condition as a quantitative tool to guide hand-rearing decisions in an endangered seabird

JM Morten, NJ Parsons, C Schwitzer, MW Holderied, and RB Sherley. Anim Conserv. 2017;20:471–479. doi:10.1111/acv.12338

The use of wildlife rehabilitation for conservation is growing, but quantitative criteria are rarely used to guide whether and when to remove animals from the wild. Since 2006, large numbers of African penguin (*Spheniscus demersus)* chicks have been abandoned annually when adults enter moult with dependent young still in the nest. As part of conservation initiatives for this endangered species, these chicks were collected and hand reared to fledging age. Post-release survival has been well documented; in this study we develop models to predict survival of individuals during rehabilitation with the aim of improving hand-rearing success and guiding the use of scarce resources. For 1455 chicks abandoned between 2008 and 2013, we assessed whether a chick body condition index (BCI) could predict outcome (death or release) and time spent in rearing. In addition, for a subset of 173 chicks in 2012, we assessed whether BCI at admission influenced chick growth rates during rehabilitation and examined whether the use of additional structural measurements and sex provided additional power to predict outcome. Models predicted an 82.9% (95% confidence interval: 73.3–89.5%) release rate for chicks admitted with a BCI >0, the proposed guideline for removal from colonies. This fell below 50% for BCIs < –1.05; 66% of chicks were admitted with BCIs between these thresholds. Adding bill length to BCI improved the relative model fit, but in both cases only ~70% of rehabilitation outcomes were correctly predicted. Chicks that grew more quickly were more likely to be released and, for those that were released, had lower BCI at admission suggesting compensatory growth. Chicks were generally removed at an appropriate time to ensure successful hand-rearing. However, 32% were admitted in good condition, highlighting the importance of using adaptive management to guide wildlife rehabilitation and the allocation of conservation resources.

Everyday green space and experienced well-being: the significance of wildlife encounters

SL Bell, M Westley, R Lovell, and BW Wheeler. *Landscape Research.* 2017;43(1):8-19. https://doi.org/10.1080/01426397.2016.1267721

A broad and growing evidence base suggests the potential for time spent in natural environments to promote human health and well-being. Whilst evidence of such benefits is rapidly accumulating, we still know relatively little about the role of wildlife encounters in shaping the well-being potential of people's routine green/blue space interactions, particularly amongst non-specialists. This article addresses this conceptual gap, drawing on the findings of a three-stage, qualitative, interpretive study which sought to understand and situate people's natural environment well-being experiences within their everyday lives. Wildlife encounters were emphasised by study participants in the context of four types of well-being experience: social, immersive, symbolic, and achievement oriented. These are explored within this paper, before discussing the influence of past experiences and current life circumstances on participants' wildlife relationships. Consideration is also given to how environmental managers might focus activity and investment to balance opportunities for such wildlife experiences with the ongoing priorities of delivering socially inclusive, ecologically rich, and climate change–resilient green spaces.

Assessment of releases of translocated and rehabilitated Yucatán black howler monkeys *(Alouatta pigra)* in Belize to determine factors influencing survivorship

F Tricone. *Primates.* 2018;59:69. https://doi.org/10.1007/s10329-017-0628-5.

Rehabilitation and reintroduction have become important to the management and welfare of primates worldwide. However, the suitability and success of these practices must be evaluated to determine their effectiveness as well as to improve programs and methods, as little is known about the factors influencing survival of released individuals. Between 2011 and 2014, 28 howler monkeys (*Alouatta pigra*) were released at Fireburn Reserve, northern Belize by the Primate Rehabilitation Centre of Belize: Wildtracks. From March to August 2015, field trips were made to determine the number and identity of surviving individuals to assess whether differences in individual outcomes (survived or disappeared) could be associated with specific characteristics or backgrounds of the monkeys. Fourteen of the twenty rehabilitated monkeys and seven of the eight translocated monkeys were found alive. The proportion of surviving individuals was not significantly different between rehabilitants and translocated animals, males and females, former pets and wild animals, short- and long-term rehabilitants, or different ages at release or intake. As mortality was low and none of the general factors analyzed influenced survivorship, it is suggested that chance or individual traits may be important in the outcomes of releases. This study provides an example of successful population reintroduction from both rehabilitation and translocation programs, and the first analyses of characteristics impacting the success of releases of howler monkeys. ■

TAIL END

You have *got* to stop sneaking up on me like that!

Red Squirrel *(Sciurus vulgaris).*

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:

Kieran Lindsey, Editor
jwr.editor@theiwrc.org

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.

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African penguin *(Spheniscus demersus).*

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