INTERNATIONAL WILDLIFE REHABILITATION COUNCIL

Volume 39, Number 1, 2019

JOURNAL OF WILDLIFE REHABILITATION

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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:
Koala *(Phascolarctos cinereus).*

Left:
American bison *(Bison bison)* on a ridge in Theodore Roosevelt National Park, part of their historic range.

IWRC

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

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JOURNAL OF WILDLIFE REHABILITATION

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EDITORIAL

Sharing the Wealth for Wildlife

When Kai Williams asked me to write a guest editorial for the *Journal of Wildlife Rehabilitation*, I was initially struggling, but my uncertainty was short-lived. For those of you who may not have met me at an IWRC conference, Effects of Oil on Wildlife conference, or elsewhere, I have worked for the Royal Society for the Prevention of Cruelty to Animals (RSPCA) in the UK for over 18 years, the first 15 as the wildlife rehabilitation coordinator, and the past three years as head of the wildlife department, part of the Science and Policy team. Prior to working at the RSPCA, I worked at a Wildlife Conservation Research Unit (WildCRU) in Oxford, UK, for a variety of research projects on mammals, including ways of reducing roadkill in otters and bovine TB in badgers, and the impact of the American mink on a native UK rodent, the water vole. I have also served two terms as a trustee of the Mammal Society of the British Isles, an organization dedicated to the study and conservation of mammals.

You may have detected a theme in all this—science and research. That theme was one of the main reasons for my coming to work for the RSPCA: to promote research in the field of wildlife rehabilitation. It was a slow start, but between 2000 and 2010, we undertook many research programs on a variety of the species that we rehabilitate. Some of this work was the subject of a review published in 2013.[1]

I believe that we as rehabilitators have a responsibility to understand the effects we have on the wild animals we treat and whether our interventions have a positive effect. This requires research, even if it is just doing the basics by banding birds to assess survival, or collaborating with universities in implementing well-designed projects that investigate the survival or the effects of captivity on the species we have in our care. While I understand that many rehabilitators may not be trained in the sciences and may be wary of involvement in these types of studies, there are many graduate students out there who may be looking for interesting projects, and who would willingly accept an opportunity to work with our community.

We, as rehabilitators, have much to offer when it comes to understanding wild animals and the factors that affect them, such as disease, climate change, interactions with humans, and others. Rehabilitators often have an empathy with their animals that shows far more understanding than many scientists provide. I cite reintroductions as one example: some reintroduction programs use rehabilitation methods, if not rehabilitators themselves, to rear the animals they wish to release.

Of course, all these research results are only as good as how we communicate them. We may learn something important—something important enough to change what we do with regards to that species with that condition—but if we tell no one else, that knowledge will only benefit *our* animals. If, however, we use journals like the *Journal of Wildlife Rehabilitation*, we can inform others and they too can learn and change what they do. The result: the successful rehabilitation of more animals.

As President of the IWRC, I want to continue to encourage research in the rehabilitation community and the publication of those research results in the *Journal of Wildlife Rehabilitation*, so that other rehabilitators can learn from what you have learnt, so more animals can benefit.

—Adam Grogan, President

[1]Grogan A, Kelly A. A review of RSPCA research into wildlife rehabilitation. *Veterinary Record.* 2013. doi:10.1136/vr.101139.

Historic Transnational Buffalo Summit

DENVER, Colorado, USA (November 1, 2018)—The first Tribal Buffalo Conservation Summit was held in November 2018, bringing together tribal leaders, tribal wildlife and cultural representatives, and conservation experts to share their management strategies and discuss the important ecological, cultural, and economic benefits of bison restoration. In the last six years, tribes have led the way by bringing back hundreds of wild buffalo to western tribal lands in Montana, Wyoming, and other states, and celebrating the birth of dozens of calves.

Conference participants include the World Wildlife Fund, Fort Belnap Tribes, National Wildlife Federation, Defenders of Wildlife, Fort Peck Tribes, and the InterTribal Buffalo Council (ITBC). The latter is a collection of over 63 federally recognized tribes from 20 different states, whose mission is to restore buffalo to Indian Country in order to preserve their historical, cultural, traditional, and spiritual relationship for future generations.

"To re-establish healthy buffalo populations on tribal lands is to re-establish hope for Indian people," says Ervin Carlson, President of the InterTribal Buffalo Council. "By returning the buffalo to tribal lands, we will help heal the land, the animal, and the spirit of the Indian people."

A National Bison Day Celebration on November 3rd at the Rocky Mountain Arsenal National Wildlife Refuge showcased speeches by tribal leaders and elders about the importance of buffalo to tribes, native singing and drumming performances, and viewing opportunities of the refuge's bison herd.

Subadult and adult common zebras (*Equus quagga*), Tanzania.
PHOTO © DANY STERNFELD. CC-BY-2.0 LICENSE.

Twenty-four Zebras Reintroduced to Kitulo National Park

DAR ES SALAAM, Tanzania (October 19, 2018)—Conservationists from Wildlife Conservation Society (WCS), Tanzania National Parks (TANAPA), and the Tanzania Wildlife Research Institute (TAWIRI) announced the reintroduction of 24 zebras into Tanzania's Kitulo National Park in the Southern Highlands region in October as part of a bold effort to re-wild this once pristine landscape. The release process was caught on video.

Half a century ago, zebras were hunted to extinction or otherwise removed from this region for state-run sheep ranching and dairy farming, which have since been abandoned. The zebras—which include 16 adult/subadult females, six adult/subadult males, and two juvenile males—were translocated from Mikumi National Park, some 700 kilometers (434 miles) away from Kitulo in eastern Tanzania. Four of the animals have been equipped with satellite collars so conservationists can track their movements in real time.

Dr. Tim Davenport, Director of WCS Tanzania Program, who designed the reintroduction, says, "It was thrilling to see the zebras moving across the plateau as they had for untold centuries. This collaboration proves that we can restore wildlife in once-degraded landscapes, provided there is political will and good science behind these efforts."

Lead TANAPA veterinarian Dr. Emmanuel Macha explains, "Some people were skeptical, but we achieved it. It is great to see zebras once again enjoying this beautiful landscape. Perhaps we can re-introduce impala, waterbuck, or eland next."

The release, which took place on October 12th and 13th, is part of a long-term effort by WCS to re-wild key habitats in the Southern Highlands. WCS has already planted some 4 million indigenous trees so far to restore woodlands and corridors for duikers and the kipunji, a new species of monkey WCS discovered in the region in 2003.

The Kitulo plateau where the zebras were released contains the best remaining example of one of eastern Africa's rarest biomes: montane grassland. WCS helped establish a national park here in 2002. These high-altitude habitats need to be burned every five years and must be grazed to prevent a monoculture of grasses outcompeting the native terrestrial orchids. Due to conservation in the last decade,

southern reedbuck and steenbok (two midsize antelope species) have come back in numbers, and now zebras will join them.

The zebra release has been in the works for two years as WCS carried out feasibility studies, ecological surveys—especially for grasses, forage, and food availability—an EIA (environmental impact assessment), sensitization program, and education in all villages around the park. Noah Mpunga and Sophy Machaga from WCS led the field work and coordinated logistics, along with Vicky Mbofu and Anthony Minazi from the WCS education team, who spent a year in local villages familiarizing the communities with the idea. WCS worked closely with TANAPA at crucial stages, especially with their veterinarians—most notably, Dr. Emmanuel Macha.

Female black bear *(Ursus americanus)*, frequent urban visitor in the Tahoe-Truckee region of the Sierra Nevada range.

Bear Conservation Success Has Effects Beyond Ursine Health

CARSON CITY, Nevada, USA (October 26, 2018)—A new study by Wildlife Conservation Society (WCS), American Museum of Natural History, and other partners uses long-term data on bear mortality to map high-probability hot spots for human–bear conflicts. The authors say this is a critical tool for wildlife managers to reduce mortality of bears as they recolonize their former range in the Great Basin and in other parts of the country.

The study, which appears in the latest issue of *Global Ecology and Conservation*, represents the latest information from the first and longest running effort to understand the impact of an increasing human footprint on American black bears at the wildland–urban interface.

The authors looked at expanding bear populations in the Lake Tahoe Basin and Western Great Basin Desert in Nevada, examining 382 bear deaths between 1997 and 2013. They found that the largest causes of mortality were vehicle collisions (160) and management removal of bears (132) due to animals breaking into people's homes, causing property damage, or both, or other threats to human safety.

The authors say that by understanding the causes and consequences of mortality on bears using long-term data, wildlife managers will be able to reduce bear deaths in urban interface areas where bears could otherwise be killed more frequently.

The study's co-author, Jon Beckmann, Science Director of WCS's Rocky Mountain West Program, says, "Ultimately, the goal of conservation is to have more individuals of species like bears and other carnivores on landscapes like we have accomplished in the Great Basin, but we then have to understand how to limit their mortality that results from conflicts with humans."

Lead author Rae Wynn-Grant from the Museum's Center for Biodiversity and Conservation suggests, "This approach to understanding local drivers of bear mortality can be replicated in other areas where human influence varies across the landscape. We were surprised to find subtle indicators of human activity were important drivers of bear mortality risk, an important finding for wildlife recovery efforts."

Wildlife Conservation Society and Nevada Department of Wildlife (NDOW) currently use this information to try and reduce mortality of bears in areas where bears already occur, and to predict hot spots of human–bear conflict as they currently recolonize their historical range in the state of Nevada. In the Great Basin, bears are returning after an absence of 80-plus years, due to recovering habitats and WCS/NDOW conservation efforts, such as the Bear Aware Campaign, regulation changes, policies prohibiting the feeding of wildlife, and ordinances requiring bear-proof dumpsters in many regions of western Nevada. These efforts have led to the bear population expanding in number and geography over the past several years, resulting in bears showing up in areas of central and eastern Nevada.

The authors say that these conservation successes can be a model for other places, including New York, New Jersey, and areas throughout the US that are dealing with increasing human–bear conflicts at the wildland–urban interface. In addition, the authors say there are lessons for other regions of the globe where large carnivores occur in these wildland–urban interface areas, such as lions at the wildland–urban interface of Nairobi, Kenya.

Research Underway in Face of Virulent PPR Virus

NEW YORK (October 15, 2018)—A team of conservationists from the Royal Veterinary College, WCS, Food and Agricultural Organization of the United Nations,

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Case study: Rehabilitation of a red-tailed hawk (*Buteo jamaicensis*) with a severe neurological disorder

Nefris Xel Herrera-Cuamatzin[1], Álvaro Oidor-Méndez[1], Andrés Estay-Stange[1,2]

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ABSTRACT: We present the rehabilitation of a red-tailed hawk (*Buteo jamaicensis*) which showed a lack of motor coordination, involuntary movements, inability to stand, abnormal head movements, excess body fat and general injuries in plumage. A nutritional rehabilitation program with a specific rat diet (supply of calcium and vitamin B) was established, complementing the treatment with vitamin B12. After six months of rehabilitation the specimen showed a remarkable improvement, keeping itself upright and coordinating its movements, without any relapse. It is necessary to test this methodology in a greater number of raptors with similar nutritional problems to ensure the effectiveness and enrich the development of specific protocols for effective nutritional rehabilitation in raptors.

KEYWORDS: *Buteo jamaicensis*, nervous alteration, nutritional rehabilitation, vitamin B.

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Introduction

Main problems in captive birds

One of the main problems of birds in captivity is non-specific diseases.[1] Many birds of prey kept in captivity have strongly bent upper beaks and long, sharp and curved claws. Large hallux and beaks commonly develop due to the use of soft and inadequate coat surfaces and the lack of a natural diet. The most severe cases indicate malnutrition which often leads to molting disorders, such as: delayed molting, sudden molting of a large number of feathers of a particular area, twisted feathers, stress or fret bars, and "pin" and "pinched" feathers. Feather molting disorders may be the result of endoparasitism, trauma, follicular infection, or the use of certain pharmacological agents during molting, but more often they are the result of nutritional deficiencies.[2]

Correct nutrition is fundamental for good health as well as for efficient captivity care of birds. A lack of detailed nutritional data and data on the nutritional needs of each species generate a challenge to wildlife rehabilitation centers in trying to provide a diet as similar as possible to that which the birds get in the wild.[3] Nutritional and metabolic disorders in birds can be categorized mainly as hypoglycemia, vitamin B1 (thiamine) deficiency, hypocalcemia and "liver disease", and can cause seizures, incoordination, coma or even death.[4]

J. Wildlife Rehab. 39(1): 7–10.

Most scientific research on avian nutrition has been carried out on poultry, which gives us a reference to begin with; however, research on avian nutrition continues, both in poultry and wildlife, after 100 years of work.[5]

Movement and coordination problems

In contrast to the situation of free-living birds, information on the nutrition of raptors in captivity is very scarce, documented studies are limited in terms of the species involved—mainly zoo species, and there are few scattered reports of diseases considered to have a nutritional origin.[6]

Hypovitaminosis B1 (thiamine), B2 (riboflavin), B6 (pyridoxine), and B12 (cyanocobalamin) have been reported to cause neuropathies in raptors[7,8] and other birds. The lesions in the nervous system are variable depending on the species, age, and chronicity of the deficiency, and can affect the central nervous system (CNS) causing polioencephalomalacia and peripheral nerve myelin degeneration.

Riboflavin deficiency (vitamin B2) has been extensively studied in chickens[9] and pigeons[10] and leads to myelin degeneration of the peripheral nerves, resulting in clinical signs that include toes curled outward and leg and wing paralysis. Birds with riboflavin deficiency have weakness and atrophy of the leg muscles, and are seen walking on their hocks with the toes curved inward, although this does not always happen because death can occur first. Riboflavin deficiency causes a demyelinating peripheral neuritis.[2] Treatment involves the administration of oral or parenteral riboflavin and correction of the diet.

Pyridoxine deficiency (vitamin B6) in chickens has also been studied. The affected birds showed neurologic clinical signs that included ataxia, head tilt, and death without histopathological abnormalities in the nervous system.[11] Pyridoxine deficiency causes characteristic spasms, nervous walking, running, and wings flapping.[2]

Vitamin E deficiency can cause encephalomalacia that results in tremors, ataxia, head tilt, cycling and/or recumbency. It is mostly a disease of captive piscivorous birds,[12] but has been reported in chickens,[13] turkeys,[14] emus,[15] raptors,[12] and rarely in psittacines.[16]

Greenwood[17] divided the raptors' nervous diseases into five groups: nutritional, infectious, poisoning, central nervous system lesions, and peripheral nervous system lesions. In the Middle East, raptors commonly have central nervous system disorders that include moderate to severe head tilt or opisthotonos. In severe cases, raptors can even fall backwards from the perch when disturbed.[2]

Severe torticollis can cause raptors to fall off the perch due to loss of balance. It is believed that the etiology of this condition is the result of vitamin B complex deficiency. Thiamine deficiency (vitamin B1) includes ataxia, ascending paralysis and opisthotonos. A response to treatment provides a presumptive diagnosis, since affected birds usually respond within a few hours to oral or parenteral administration of vitamin B1.[6]

Studies on thiamine (vitamin B1) deficiency in a peregrine falcon (*Falco peregrinus*) in the United States included clinical signs of opisthotonos followed by seizures that showed no response to antibiotics or small doses of a mixture of vitamins, minerals or drugs, but responded with a slow recovery after the administration of thiamine.

Clinical signs observed in nerve diseases vary considerably but may include general signs, such as seizures, or local signs, such as paralysis. The most common physical signs include lack of coordination, inability to use pelvic limbs, and absent-looking appearance. The head usually presents a lateral inclination, with the mouth slightly open, and accelerated and pronounced breathing; in some cases, food regurgitation may occur. There may be a variety of other clinical signs in birds of prey and it is often unclear if these represent different syndromes or other manifestations of a disease. Muscle fasciculation is common and there may be weakness or paralysis of the extremities. In some cases there are opisthotonos, and the bird may scream as if in pain. The bird can stand and walk, but sometimes keeps its head tilted or upside down. A variety of neurological clinical features can be found in birds of prey, generally, but not exclusively, when kept in captivity.[6]

Possible solutions to nervous system problems through the diet

Patients with nervous system problems require rapid intervention, frequent assessment, and often, very intensive care. Although serial neurologic examinations may be the most important aspect of determining and modifying treatment and prognosis, the neurologic examination itself can be one of the most challenging aspects of this process.[18] Birds with deficient or unbalanced diets in minerals, vitamins, and fatty acids are more likely to develop metabolic or nutritional diseases that affect the neurologic system. Physical examination might reveal seizures, paresis, paralysis, ataxia, head tilt, nystagmus, intention tremor, dysmetria, and visual or hearing deficits that should be evaluated in further detail. Nonspecific findings like low body condition, integumentary or musculoskeletal system abnormalities, and gastrointestinal or respiratory signs might add information regarding possible etiology.[19]

Cases where general signs of incoordination or nervous disturbance are present might be a result of a thiamine deficiency; the effect of such deficiency in birds and mammals has been recognized for a long time. Benzodiazepine midazolam soluble in water has been shown to be useful in raptors and can be administered intramuscularly or intravenously.[6] Similarly, thiamine can be administered to birds orally or by injection. Not all cases respond; some remain with residual signs. Another possible cause of nervous signs in birds of prey is hypocalcemia after nutritional osteodystrophy and hyperparathyroidism, as originally postulated by Wallach and Flieg.[20]

It is often difficult to distinguish different syndromes, so a general therapy is necessary. According to Cooper et al.,[6] oral administration of glucose with calcium boragluconate and thiamin (or vitamin B complex) by injection is an effective solution

to these problems.

General treatment of central nervous signs may be multifactorial according to the etiology, but deficiencies of the vitamin B complex and vitamin E have been implicated. In such cases, it is preferred to administer 1 ml/kg IM of a multivitamin preparation (which provides 15,000 IU of vitamin A, 25 µg of vitamin D3, 20 mg of vitamin E, 10 mg of vitamin B1, 5 mg of vitamin B2, 25 µg of vitamin B12, nicotinamide 35 mg, 25 mg D-panthenol).[2]

FIGURE 1. Red-tailed hawk on the first day of admission, unable to stand.

FIGURE 2. Red-tailed hawk with deep torticollis.

Case study

A red-tailed hawk (*Buteo jamaicensis*) was received at the UMA Konkon facilities on December 23rd of 2015. A significant lack of motor coordination was detected, as well as involuntary movements, inability to stand, abnormal head movements, general injuries in plumage, and excess fat in the abdominal area (Figs. 1 and 2). It was reported that the bird had been in captivity for fifteen years, since it was a juvenile, in a confined area of 3 x 2 meters without access to direct sunlight, and fed exclusively with chicken viscera. Lack of motor coordination, involuntary movements and abnormal head movements had been happening for several years, but the inability to stand up was a recent symptom. All the birds in the contiguous cages were healthy and did not show any nervous system problems. Contagious viral infections were ruled out. The red-tailed hawk was kept in quarantine to monitor its health status, and a rat-specific diet was assigned.

After the quarantine period the condition had not increased or decreased. Due to the information received about the bird's diet of the last 15 years, and based on bibliographic reviews of case studies and diseases in raptors, we assumed that the nervous system problem was caused by poor nutrition.

Thiamine deficiency (vitamin B1) was consistent with the main symptoms present in the bird and the nutritional information related to the feeding of raptors. According to Forbes,[21] a chicken diet contributes approximately 0.06 mg/100 g of thiamine, while a rat diet provides approximately 1.33 mg/100 g.

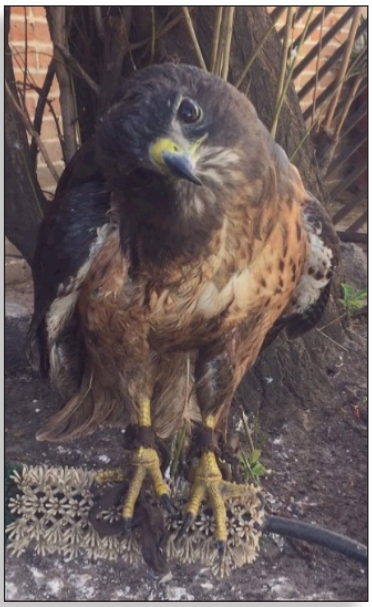

FIGURE 3. Red-tailed hawk with a lateral rotation of the head and body in the medial plane, on a perch taking sun baths freely.

FIGURE 4. Red-tailed hawk with head and body rotation corrected and maintaining a more upright posture, able to adequately coordinate its movements to remain perched.

Nutritional rehabilitation

An ad libitum rat-specific diet was established for its high calcium contribution (2286 mg/100 g) and vitamin B1 (1.33 mg/100 g)[21] and the bird was kept in a perch with access to sun baths. The bird ate an average of 135 g of rat every day.

For six months the bird was kept under constant evaluation. By the third month of the specific nutrition program the bird showed a remarkable improvement in posture, managing to stay perched for several hours, but with a marked inclination of the head towards the right side (Fig. 3). In the first three months, the bird showed the greatest improvement in body posture correction and movement coordination.

In the fourth month, the established diet was complemented with Catosal® 10% treatment consisting of Buthaphosphan (10 g), vitamin B12 (0.005 g) and excipient csp 100ml, 2.5 ml/kg, two times per week for two weeks with a break of two weeks, for a total of two months.

In the sixth month the bird showed remarkable improvement. It could keep upright and coordinate its movements adequately to feed by itself, as well as respond correctly to aversive stimuli. In this evaluation, the lateral rotation of the head and body in the medial plane decreased (Fig. 4).

Motor and body rotation evaluation continued for six months to evaluate any recidivism. The bird did not show any recidivism.

Conclusions

After a six months' period of nutritional rehabilitation, the bird showed considerable recovery in its body posture and in the coordination of movements. The improvement achieved by the Catosal® application was remarkable, allowing a greater recovery in the inclination of the head. It is necessary to test the present methodology in a greater number of raptors with similar nutritional status to corroborate the effectiveness of this method and to detail and enrich the process of nutritional rehabilitation due to vitamin B deficiency. Although relatively little is known about nervous diseases in the birds of prey, it is of great importance to continue working and providing information for their treatment.

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Andrés Eduardo Estay-Stange graduated in 2008 in Biology from the Autonomous University of Puebla; he received his Masters (2011) and PhD (2016) degrees in Biological Science from the Autonomous University of Tlaxcala. Currently he is a research professor at the Faculty of Biological Science at the Autonomous University of Puebla.

He has been Director of the Wildlife Conservation Centre "Konkon" since 2015, and President of Wildlife Rescue Civil Association "Koruma" since 2018. He collaborated on the project "Scientific Station La Malinche: Integrative research for conservation and environmental education," winner of the Volkswagen Prize "Por amor al Planeta," seventh edition.

Álvaro Oidor Méndez, DVM graduated in 1986 from the School of Veterinary Medicine and Zootechnics. He was responsible for the Animal Hospital 1987–2007, and Coordinator of the Veterinary Hospital for 7 years. He was president of the College of Veterinary Medicine Professionals of the State of Puebla (2009–2011), and a member of the National Assembly of the Council for Veterinary Education, 2010–2012. Currently he is a research professor and Head of Medicine and Surgery of the Veterinary Hospital for Small Species of the Autonomous University of Puebla.

Nefris Xel Herrera Cuamatzin is a senior student in Biology at the Autonomous University of Puebla, and has been a volunteer in the rehabilitation and rescue of raptors since 2017 at the Conservation Centre "Konkon."

Case study: Cattle-associated traumatic injuries in koalas *(Phascolarctos cinereus)*, 2010–2016.

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ABSTRACT: Trauma among koalas dispersing through urban areas is common; however, injuries in agricultural landscapes are under-reported. The morbidity and mortality of koalas admitted to Currumbin Wildlife Hospital following trauma from cows between 2010 and 2016 are presented. Three of eight cases presented were treated successfully for injuries to the head, chest and abdomen. The most common region of injury was the abdomen (75%), followed by the chest (62.5%), head (50%), and peripheral limbs (25%). Hemoabdomen was present in all abdominal injuries, while injuries to the chest included hemothorax and rib fractures. Head injuries included brain trauma, mandible fracture, hyphema and ocular prolapse. Rapid stabilisation, imaging, and consideration of early surgical intervention should be a minimum requirement for any koala with a history of interactions with cattle.

KEYWORDS: Cow, injury, koala, livestock, trauma, wildlife.

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Introduction

The koala is an arboreal marsupial, endemic to eastern Australian sclerophyll forests and woodlands, which feeds almost exclusively on a limited range of *Eucalyptus* sp. foliage.[1,2] It has a widespread distribution and areas of local abundance; however, distribution is largely fragmented by unsuitable habitat or cleared land.[1,3] Populations in southeast Queensland are subject to a range of threatening processes including habitat loss through land-clearing, urban expansion associated with an increase in road-associated deaths and exposure to attack by dogs, and chlamydial disease.[1]

Home ranges of koalas in agricultural landscapes in southeast Queensland vary from 5.2 ha to 91.4 ha, and koala movement paths outside of their spatial range describe linear patterns, leading to exposure of koalas to a range of agricultural or urban hazards.[2] Encroachment of urban and agricultural land into remnant koala habitat has further increased koalas' exposure to a range of novel hazards, including vehicle collisions and predation by dogs, and also injuries caused by cows.[4] Multiple publications describe human injuries and fatalities caused by cattle, but few describe injuries to other animals.[5-11] Koalas injured by cows in New South Wales (NSW) and Victoria (VIC) have instead been reported in the media; however, details of their injuries, treatment and outcomes are lacking.

J. Wildlife Rehab. 39(1): 11–15.

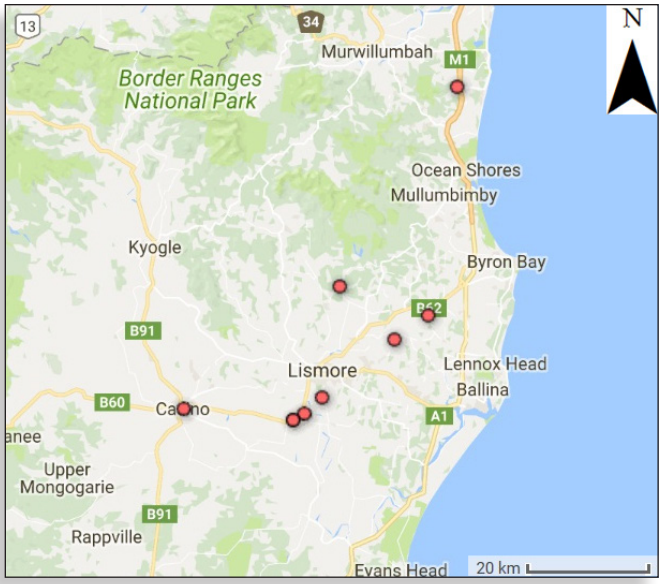

FIGURE 1. Locations of eight koalas with traumatic injuries found in cow paddocks in New South Wales between 2010 and 2016.

Currumbin Wildlife Hospital (CWH), located in southeast Queensland (QLD), receives sick and injured koalas from a catchment extending southwards to Grafton, New South Wales (NSW) and northwards to Brisbane, QLD. This paper reports on the injuries and outcomes of koalas presented to CWH following interactions with cows for the period 2010–2016. Additional field data of koalas which died prior to receiving medical attention are also presented.

Materials and methods

The CWH admissions database was examined for koalas that presented following an observed interaction with cows, or having been found injured in a cow paddock, for the period 2010–2016. Admission date, age, sex, reason for admission, veterinary notes and outcome were extracted. All koala admissions received a standardised workup including physical exam under anaesthesia, radiographs, ultrasonography, hematology, abdominocentesis, bone marrow cytology and testing for chlamydia using PCR.

Selected large Australian wildlife hospitals and volunteer wildlife rehabilitation groups in QLD, NSW, VIC and South Australia (SA) were contacted to determine if further cases had occurred over a larger geographic area for the same period.

Results

Currumbin Wildlife hospital admitted 1,806 koalas between 2010 and 2016. Ten koalas (0.55%) were admitted to CWH from cow paddocks during the study period. Five koalas were confirmed as having been attacked by cows and three were found in a cow paddock with injuries but were not witnessed to have been attacked (Table 1). Two cases presented with chlamydia in the absence of trauma (C1–C2) and were excluded from further analysis, as no evidence was present to indicate contact with cows had actually occurred. All cases presented within a 35 kilometre radius between Casino and Cudgera Creek in northern NSW (Fig. 1).

The histories of affected koalas admitted to CWH included direct reports of cow attacks (5), being actively licked by cows (1) and being found in a cow paddock (10). Five adult males and three adult females were affected. The majority of affected koalas (5) were presented in spring, including three dependant koalas that would likely have been travelling with their mothers. Three of the eight cases with documented injuries occurred in 2016, with two in 2017, two in 2014 and one in 2013 (Table 1).

All affected koalas sustained multiple injuries, with five of eight koalas receiving injuries to multiple regions. The most common region of injury was the abdomen (6), followed by chest (5), head (4) and peripheral limbs (2). Hemoabdomen was present in all abdominal injuries, while injuries to the chest included hemothorax (3) and rib fractures (2). Head injuries included concussion (1), mandible fracture (1), hyphema (1) and ocular prolapse (1).

Three of eight koalas admitted to CWH following cow-induced injury were treated successfully, with each sustaining multiple injuries of the head, chest and abdomen. Successful cases received intravenous fluids, ceftazidime 20mg/kg (Fortum, 100mg/ml, Aspen Pharmacare Australia Pty Ltd, St Leonards, NSW 2065; three times daily for 5 days), carprofen 2mg/kg (Carprieve 50mg/ml, Norbrook Laboratories Australia Pty Ltd, Tullamarine, VIC 3043; once daily for 3 days), and methadone 3mg/kg (Methadone 10mg/ml, Troy Laboratories Pty Ltd, Glendenning, NSW 2761; every 6 hours as needed) or buprenorphine 0.03mg/kg (Temvet 300ug/ml, Troy Laboratories Pty Ltd, Glendenning, NSW 2761; every 12 hours as needed) during stabilisation followed by oral codeine 1mg/kg (Actacide 5mg/ml, Arrow Pharma Pty Ltd, Cremorne, VIC 3121; twice daily for 3 days) as required during hospitalisation.

All wildlife hospitals and rehabilitation organisations responded to requests for case information on koalas; however, the low incidence made retrieving case data challenging. The University of Sydney Wildlife Health and Conservation Clinic (Cobbitty NSW), RSPCA Brisbane (Wacol QLD), and Australia Zoo (Beerwah QLD) provided anecdotal confirmation that rare cases of koalas injured by cattle had been admitted, but numbers were not quantified (*pers. comm.* Hamish Baron, Claude Lacasse, Rosemary Booth). Healesville Sanctuary Wildlife Hospital (VIC), Adelaide Koala and Wildlife Hospital (SA), and Koala Hospital Port Macquarie (NSW) reported no known cases. Anecdotal reports of cases among carers and farmers were received from Taree (NSW) (*pers. comm.* Christeen McLeod, Koalas in Care Inc.) and Gunnedah (*pers. comm.* Angela Baker, North West Local Land Services). Wildcare (QLD) reported no cases in 2016, and WIRES (NSW) responded without identifying further documented cases. Volunteer koala rescue group Friends of Koala Inc. (Lismore, NSW) presented all eight affected koalas to CWH and reported a further three cases which were not presented to CWH. These were found dead or were presented to a local vet for euthanasia (Table 1).

TABLE 1. Admission details, injuries and survival of koalas found in cow paddocks between 2010 and 2017 from northern New South Wales. (F F = female, M = male, U = unknown).

KOALA	MONTH	YEAR	SEX	AGE	HISTORY	REGION OF INJURY	INJURY	OUTCOME	SOURCE
1	Oct	2013	F	Adult	Found being licked by cows	chest, head, abdomen	Haemothorax, haemoabdomen hyphema, ocular prolapse, anaemia	Died	CWH
2	Jan	2014	M	Adult	Attacked by cows	abdomen	Haemoabdomen	Died	CWH
3	Nov	2014	F	Adult	Attacked by cows	chest, abdomen, head	Cerebellar injury, stridor, anaemia	Survived	CWH
4	Sep	2016	F	Adult	Trampled by cows	head	Moribund, open mandible fracture	Euthanised	CWH
5	Sep	2016	M	Baby	Trampled by cows	head, chest, abdomen, limbs	Lacerations to ear and penis, radius and fibula fractures, haemothorax, haemoabdomen	Survived	CWH
6	Oct	2016	F	Juvenile	Found in cow paddock	chest, abdomen	Haemoabdomen, haemothorax, rib fractures	Died	CWH
7	Apr	2017	M	Adult	Trampled by cows	abdomen	Multiple abdominal hernias, haemoabdomen	Survived	CWH
8	Apr	2017	F	Adult	Found in cow paddock	limb, chest	Fractured tibia and fibula, rib fractures, concurrent pyelonephritis	Died	CWH
9	Jul	2016	F	Juvenile	Attacked by cows	head, abdomen	Skull fracture, abdominal trauma	Died	FOK
10	Sep	2016	M	Adult	Found in cow paddock	spine, abdomen	Hindlimb paralysis, treated at local veterinarian	Died	FOK
11	May	2016	U	Adult	Found in cow paddock	n/a	Found decomposed	Found dead	FOK
C1	Jun	2016	U	Adult	Found in cow paddock	no injury	Chlamydia	Died	CWH
C2	Dec	2016	F	Adult	Found in cow paddock	no injury	Chlamydia	Euthanised	CWH

Discussion

The increased frequency of admission of koalas injured by cows in 2016 appears to be associated with a defined geographic area and requires further investigation; however, difficulties in the retrieval of medical and rehabilitation records suggest wider under-reporting. The cause of cow-associated injuries is likely to be multifactorial, including proximity to agricultural land, positive relationships with rescue groups, and transition of land use in northern NSW.

As most wildlife hospitals and volunteer rescue groups are situated in urban areas, koalas injured by cows in regional areas are presumably less likely to be presented following trauma. Rural veterinary clinics are also more likely to receive such cases than dedicated wildlife hospitals, leading to an underreporting of cases. Friends of Koala Inc. is a koala-specific rescue group with an active ambulance service and long-standing relationships with the rural community and CWH. It is possible that their large response range, combined with recent media attention to threats to koalas in this region, has contributed to the identification of the presented cases. The presence of a major highway through this regional area may have allowed the presented cases to reach CWH in more a timely manner than could be replicated over similar distances elsewhere.

Procurement of records with sufficient data to identify cases was challenging for veterinary hospitals and rehabilitators alike, resulting in the anecdotal reports presented rather than a more detailed survey. The absence of records, exclusive use of paper records, and absence of centralised record keeping by volunteer rescue and rehabilitation groups make tracking such cases extremely difficult and needs to be improved. Veterinary hospitals all employed digital record keeping, but reported difficulty in searching for rare or unusual cases retrospectively, which prevented the analysis of a wider cohort for comparison.

It was presumed that the dispersal of males in spring would

lead to an increased risk of exposure to cattle, but this gender bias was not evident in the current admissions. It is possible that cattle are more cautious with larger male koalas, making them less likely to be injured. The majority of cases presented in spring (Sept–Nov) after the northern NSW calving season, coinciding with the seasonal peak period of koala activity when trauma admissions to southeast Queensland wildlife hospitals are highest. Statistical analysis was not pursued due to the small sample size of presented cases.

Koalas are hindgut fermenters dependent on a large and thin-walled caecum which is prone to developing ileus following abdominal trauma or surgery. They also possess a relatively small thorax with limited respiratory reserve. The majority of koalas presented with significant abdominal trauma followed by chest injuries, making prognosis following such interactions poor. The nature of thoracic injuries in koalas were similar to those experienced by humans following cattle attacks, in which all chest injuries included fractured ribs and most developed flail chest, hemothorax or pneumothorax.[12] In a study of 35 cattle-associated human fatalities between 1996 and 2010, most cases suffered hemopneumothorax and lung injury (71.4%), followed by skull fractures and brain injury (11.4%).[9]

The region of injury caused by cattle is an important factor in outcome among human cases, with all fatalities in one study being caused by injuries to the head or chest.[12] Region of injury is directly related to the mechanism of trauma; head butting is likely to cause head and chest trauma with internal injuries, goring to produce puncture wounds, and trampling to result in multiple fractures.[13] The most common injuries in humans were located in the chest (71.4%), followed by the head (11.4%) and abdomen (11.4%), with less severe injuries in the extremities.[9,14] Bulls caused 54% of cattle-related human fatalities, and were more likely to involve the abdomen (60.1%) and chest (39.1%).[12,15] In one study, 14 of 23 bull attack injuries involved the abdomen and all required surgical treatment.[12] Abdominal injuries included intestinal perforation, intra-abdominal haemorrhage and splenic laceration.[12] Chest trauma was a common cause of fatality, resulting in injuries more likely to lead to a rapid death prior to provision of medical intervention.[12] Of all bull-related human fatalities, 74% died on the day of trauma, with 40% sustaining trauma to multiple organs.[15] Recommendations for management included rapid assessment and treatment similar to high-velocity motor vehicle accidents, immediate attention to head and chest injuries, and early surgical intervention of injuries to the abdominal region.[12,16,17]

The mechanisms of injuries caused by large animals to humans include kicking, head-butting, crushing and trampling (in order of decreasing frequency), which often result in open soft tissue injury or fractures.[11,17-20] Trampling was associated with the most severe injuries to humans, and kicking the least.[17] Due to the position of koala close to the ground, trampling and head-butting are the most likely mechanisms of injury, both of which inflict a greater transfer of force, result in more severe injuries, and require more urgent and extensive medical intervention.[17]

Fraser-Williams et al. identified maternal defensive aggression and fear in the presence of dogs as key factors in attacks by cattle on humans walking through paddocks. Dogs were present in 72% of 54 cattle attacks on walkers in the UK from 1993 to 2013.[19] Dogs appeared to be more threatening than unfamiliar humans, and cattle were exceptionally vigilant when moved to new locations.[19] It is unclear if cows demonstrate an innate behavioural response to wolves or a generalised learned response to all canids; they do show markedly stronger responses to wolf stimuli than non-canid predators.[22] It is possible that koala may induce an active anti-predator response, but lack the speed and agility on the ground to escape injury.

Conclusions

Direct contact between cattle and wildlife are few, and while interactions between koalas and livestock likely have a long history where paddocks intersect eucalypt forest, the encroachment of agriculture and urbanisation on current koala habitat is likely to bring increasing levels of contact.[23] Fragmentation of habitat, requiring koalas to traverse modified land seeking food or as part of the natural dispersal of males, will increase such interactions. Alongside other hazards such as vehicles and dogs, this will provide an ever more hazardous environment for this already-threatened species.

Cattle are large, strong animals weighing in excess of 400kg and capable of causing serious injury to humans and koalas alike.[24] Koalas injured by cattle are likely to present after some delay with life-threatening injuries to the head, chest and abdomen, with fractures and internal injuries. Rapid stabilisation, imaging and consideration of surgical intervention should be a minimum requirement for any koala with a history of interaction with cattle.

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Susannah Keogh, the care coordinator of Friends of the Koala Inc., is an experienced koala rehabilitator who personally rescued many of the koalas described in this paper and was instrumental in the successful rehabilitation of the survivors.

Bethany Anderson volunteered with the Currumbin Wildlife Sanctuary Hospital as an intern of Sydney University, providing valuable clinical assistance and developing a keen interest in koala medicine and surgery.

Rehabilitation of greater one-horned rhinoceros calves in Manas National Park, a World Heritage Site in India

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ABSTRACT: For the first time in the history of rhinoceros conservation in India, three rescued orphan greater one-horned rhino calves have been rehabilitated in an area that in the recent past was a good habitat for rhinos. The calves were rescued in Kaziranga National Park (NP) when they were about one to five months old when they were swept away by flood waters. The calves were hand reared and nursed at the Centre for Wildlife Rehabilitation and Conservation (CWRC) with the aim of releasing them into their natural habitat. They were fed human baby formula until they reached two years of age, and then with concentrates and greens in paddocks in CWRC. At the age of about three years the calves were translocated to Manas NP, about 500 km away from Kaziranga, and placed in a pre-release area measuring 600 acres. This pre-release area is enclosed with an electric fence and the calves were free to roam and forage within it. After spending about two years in this area the calves were released into Manas NP. The calves were radio monitored for two years; they all survived and created their own home ranges.

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Introduction

Rehabilitated animals are now seen as useful scientific resources not limited to the classical theories of individual animal welfare or endangered species conservation.[1] When a population is threatened, either globally or locally, released rehabilitated individuals can have a positive effect on the population. Until the early nineties, *Rhinoceros unicornis* had a healthy population in Manas National Park (NP) (26°30′N–27°00′N to 90°50′E–92°00′E), a World Heritage Site in India (Fig. 1). Assam Forest Department[2] revealed in their internal documents that this population was, however, wiped out due to civil unrest during the late nineties. The civil unrest ended in 2004 following political agreements that led to the formation of the Bodoland Territorial Council (BTC). Thanks to the efforts of BTC and the local autonomous civil administration authority and support from communities around Manas, this important global biodiversity hot spot has regained its protection status. BTC proposed adding an area measuring 950 km^2 to the eastern boundary of Manas

Reprint: *Pachyderm* 2014 (January–June), 55:79–89. (Creative Commons License)

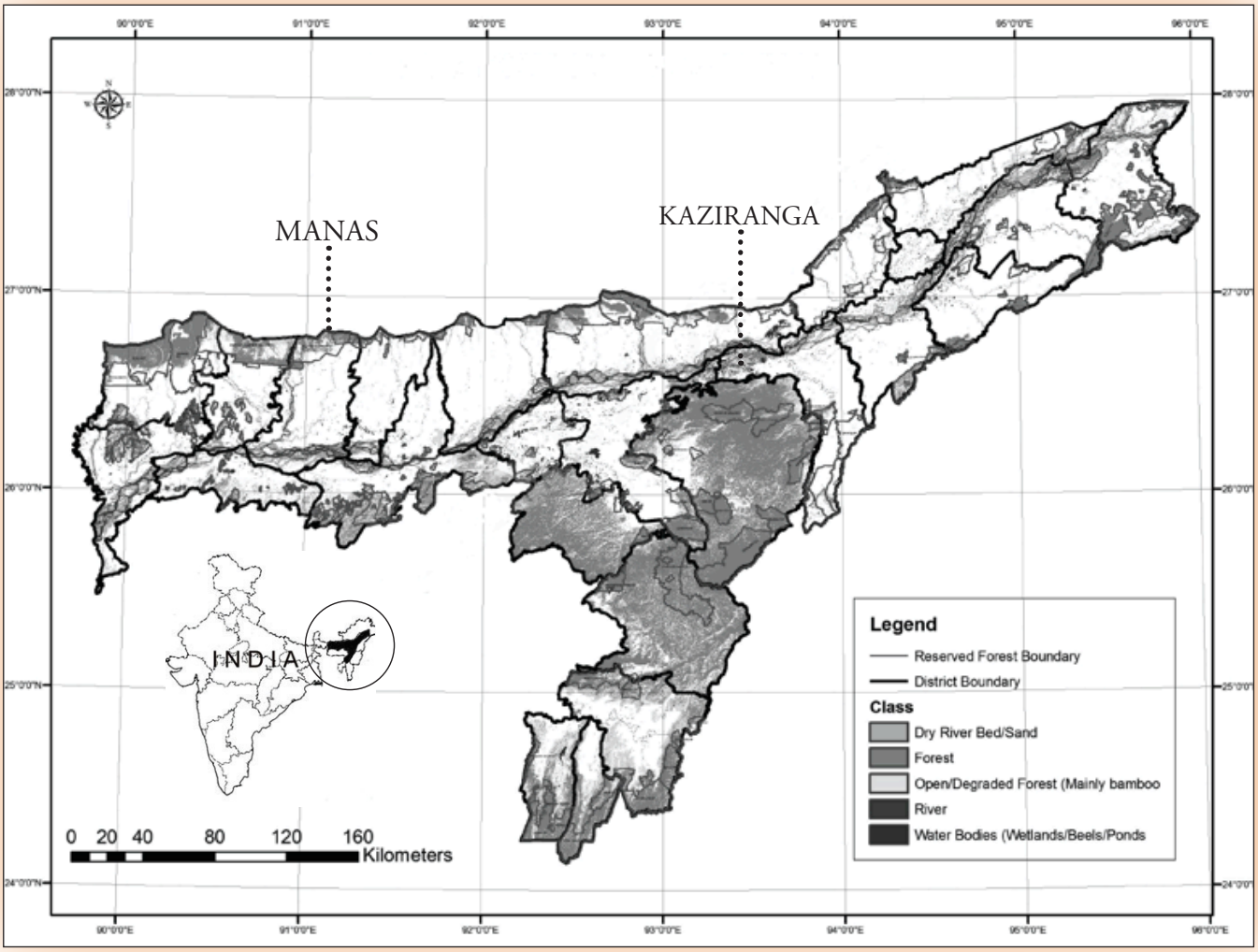

FIGURE 1. State of Assam showing Manas and Kaziranga NPs.

NP. The legislative council has endorsed the proposal and this much larger landscape is to be called the Greater Manas; it awaits final endorsement by the State Board of Wildlife, Assam, a statutory body of the government of Assam. This new conservation initiative in Manas is banking on community conservation efforts, a new approach in India. With civil societies collaborating to protect these rhinos, conservation communities asked for them to be urgently reintroduced in Manas NP.

Kaziranga NP (26°33′N–26°45′N and 93°9′E–93°36′E), another World Heritage Site in the northeast Indian state of Assam, has a population of about 2,000 wild greater one-horned rhinos: more than two-thirds of their global population (Fig. 1). As Kaziranga NP is situated on the bank of River Brahmaputra, flooding is a natural phenomenon and almost every year about 90% of the park is under flood.3 During each flood, a number of wild animals are dispersed, separated from their mother populations and their land in civil areas. These animals are injured or killed in different circumstances such as in road accidents, by humans or by poachers. To minimize mortality and to have a proper scientific rescue and rehabilitation programme, the Assam Forest Department in collaboration with the Wildlife Trust of India (WTI) and the International Fund for Animal Welfare (IFAW) established the Centre for Wildlife Rehabilitation and Conservation (CWRC) in 2002 at Kaziranga. With two biologists, two veterinarians and 12 animal keepers, CWRC has been providing all rescue and rehabilitation needs of wild animals in distress in Kaziranga for the last 12 years. In the last 10 years, CWRC has handled more than 3,500 animal rescue cases; more than 50% of these animals were successfully released into the wild. CWRC is a major facility for hand-raising orphaned large wild mammals, especially rhino, elephant and wild buffalo calves in northeast India. At this centre, orphan animals spend their time in different housing facilities from nursery to big paddocks, depending on their age at rescue. They are bottle-fed human baby milk formula until they are weaned at different ages, depending on the species. In 2002 and 2004, three rhino calves aged less than five months were rescued in Kaziranga NP after they were separated from their mothers by high flood waters. They were shifted to CWRC for further care and treatment. These animals were later released into Manas NP. This is the first time in the history of rhino conservation in India that rescued rhino calves have been rehabilitated and reintroduced into a natural habitat. Before that, all rescued calves were placed in a zoo and many died while being hand-raised in captivity (pers. comm., Office of the Park Director, Kaziranga NP).

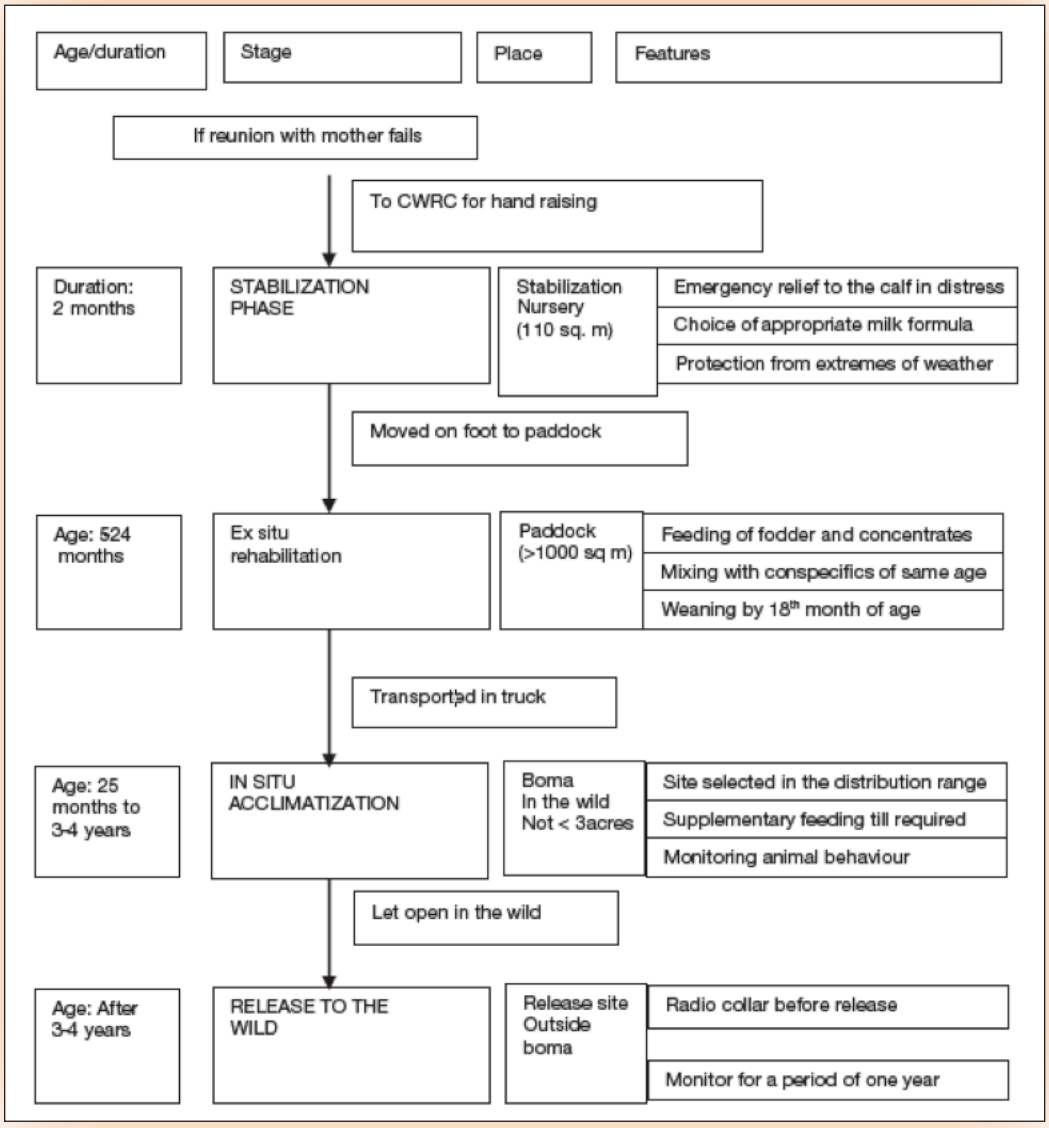

FIGURE 2. Rhino rehabilitation protocol flow chart.

Materials and methods

The process

Wildlife rehabilitation is still in its infancy and a professional and scientific wildlife rescue and rehabilitation programme is lacking in India.[5] The best way to reintroduce a hand-raised rhino to the wild is still debated and doing so needs consultation and inputs from various experts. A wildlife rehabilitation consultative workshop was organized at CWRC in 2005 to get expert suggestions and inputs, to share Africa's experiences, and to formulate a protocol for reintroducing these rescued rhino calves (Fig. 2). This forum discussed a protocol drafted by a WTI–IFAW team and incorporated expert inputs. This protocol to rehabilitate large mammals in Assam[6] was later adopted by the Assam Forest Department–WTI–IFAW-run CWRC. It was tested with the rhino calves rescued and admitted at CWRC that were later released in Manas NP.

Rhino calves admitted to CWRC

The first rhino calf was rescued in July 2002 after it was separated from its mother during the floods. It was weak and less than a month old. Two calves estimated to be less than six months old were rescued in July 2004 in similar conditions. CWRC rescued 21 other rhino calves under various circumstances. Flooding is the major cause of displacement of rhino calves in Kaziranga NP. In a few cases, calves were found alone in the forest for unknown reasons; a few were orphans after poachers killed their mothers, others were failed predation attempts. CRWC took in all these rhinos for treatment and care. While five of the 24 rhinos brought to the CWRC were injured, due largely to predation, four cases could be attributed solely to floods. Interestingly, almost all the rhino calves with serious injuries were encountered outside the peak monsoon season (July–September). In spite of medical care, all calves that survived predation died from the serious injuries. Critics consider 'rescuing' such calves as disrupting normal ecological processes. Field staff in the park realized that these cases were predation attempts only after taking the animals captive. Park authorities have been advised to adopt a wait-and-watch policy when they encounter rhino calves as they could be cases of predation attempts. Of the 10 calves that died, six died within 48 hours of admission, three within two weeks and one inside the boma at Manas. CWRC veterinarians have found it much easier to hand-raise rhino calves than elephant calves; however, their condition on arrival determines whether they will survive. A healthy rhino calf, even when very young, has greater survival chances than an elephant calf of the same age group. Besides the four rhinos that were relocated to Manas in 2006, 2007 and 2008, CWRC at present has five rhino calves, all males (Table 1).

At CWRC, the calves were placed in a nursery enclosure (~5 m × 5 m), observed for injuries and stabilized. Generally, calves are accompanied round the clock by an animal keeper. Calves were fed diluted human baby milk formula that was available in the market (brand name: Nestogen, make: Néstle) with a special

TABLE 1. List of rhino calves admitted at CWRC for various reasons since 2002.

SL NO.	DATE OF ADMISSION	PLACE OF RESCUE	STAGE/SEX	CAUSE OF DISPLACEMENT	OUTCOME	DATE OF OUTCOME
1	21/01/2013	Kaziranga	Infant female	unknown (found alone)	died in captivity	31/01/2013
2	23/09/2012	Haldibari	Neonate female	flood/river-induced	died in captivity	19/11/2012
3	01/07/2012	Baghmari	Infant male	unknown (found alone)	alive	N/A
4	27/10/2011	Burapahar	Infant female	unknown (found alone)	died in captivity	27/10/2012
5	10/03/2011	Hathikhuli	Neonate male	injury (unknown)	died in captivity	22/03/2011
6	15/02/2011	Karetapu	Infant female	unknown (found alone)	died in captivity	04/03/2011
7	19/12/2010	Agoratuli	Neonate male	orphan (parent killed)	alive	N/A
8	08/03/2010	Kathpora, Kohora	Infant female	stuck in mud	died in captivity	15/03/2010
9	10/09/2009	Baghmari, Baguri	Infant male	unknown (found alone)	alive	N/A
10	21/08/2009	Haldibari	Neonate male	unknown (found alone)	alive	N/A
11	13/03/2009	Baruntika Camp, Baguri	Infant male	unknown (found alone)	alive	N/A
12	09/02/2009	Bokhpora	Infant male	orphan (parent killed)	alive	N/A
13	31/01/2008	Gerakati, Baguri	Infant male	unknown (found alone)	alive	N/A
14	22/09/2007	Hatikuli, Kohara	Neonate female	orphan (parent killed)	died in captivity	06/10/2008
15	11/09/2007	Deopani, Baguri	Infant male	injury (unknown)	died in captivity	12/09/2007
16	16/10/2006	Japoripothar	Neonate male	injury (predation)	died in captivity	16/10/2006
17	20/06/2005	Baguri	Neonate female	injury (unknown)	died in captivity	20/06/2005
18	09/01/2005	Ajagar camp	Infant female	unknown (found alone)	died in captivity	27/01/2005
19	09/12/2004	Dumjan	Infant male	injury (predation)	died in captivity	28/12/2004
20	22/07/2004	Harmoti, Baguri	Infant female	flood/river-induced	released	27/11/2008
21	14/07/2004	Baghmari	Infant female	flood/river-induced	released	27/11/2008
22	06/03/2003	Kaziranga	Infant male	injury (predation)	died in captivity	06/03/2003
23	06/08/2002	Kaziranga	Infant female	flood/river-induced	died in captivity	07/08/2002
24	28/07/2002	Kaziranga	Infant female	flood/river-induced	released	27/11/2008

2-litre bottle with a long rubber nipple. For the first three to four days, they were given milk at one-hour intervals, although this frequency was reduced during the night. Once they were accustomed to drinking this milk, were less stressed and had stabilized, they were allowed to use a paddock (~10 m × 10 m) next to the nursery (Fig. 6, right). After three to four months, varying with the individual, the calves were fed concentrates with mineral supplements and vitamins. From the age of six months, they were introduced to fresh greens, mainly grass, and continued with concentrates and milk. They were weaned at two years and fed a diet of greens from then on. Veterinary doctors treated the calves and prescribed appropriate medicines for injuries. At any time, there were two vets at CWRC, ready to handle any emergency with medical interventions.

FIGURE 6. A calf under rehabilitation at CWRC is bottle-fed milk.

While the calves were being hand raised at CWRC, procedures had started to select sites where they could be rehabilitated. Though Kukrakata near Kaziranga NP was identified as a possible site for release, the CWRC governing council recommended moving them to Manas NP for rehabilitation and release. Rehabilitation is isolated from the holistic conservation effort when it is not linked to an active conservation programme. Here was an opportunity to link rehabilitation efforts with an active conservation programme. Using rehabilitated animals in reintroduction programmes for establishing new free-ranging populations has greater conservation value than releasing them in areas like Kaziranga where there is already a healthy rhino population.

Two important issues were considered while selecting Manas as the release site. The IUCN Guidelines on re-introduction (1998) stipulate that the reintroduction area should have assured long-term protection, and the causes of the species' decline should be identified and eliminated or reduced to a significant level. Cessation of political unrest in the region, formation of the autonomous BTC and resumption of park protection and management activities assured that the project had political support and that poaching in the park has been reduced to insignificant levels.

Following the governing council's recommendation, a site selection committee visited Kokilabari and Bansbari areas in 2005 to assess the area. This committee consisted of the chief wildlife warden of Assam, the directors of Manas and Kaziranga NPs, all range officers of Manas NP and representatives from WTI. Site selection criteria were developed based on the IUCN guidelines on re-introduction[7] that had the following set of suitability criteria: the site falling within the rhino distribution range; availability of adequate cover, food and water; minimal presence of human settlements in the area; reports of minimal livestock grazing and human trespassing; habitat suitability in terms of vegetation composition; accessibility of the site for monitoring; reports of livestock diseases reported from the area; how prone the site is to flooding during the monsoon; and availability of reports of hunting, poaching and insurgency in the area. Three sites within Manas were selected: Kuribeel, Uchila and Kokilabari. The

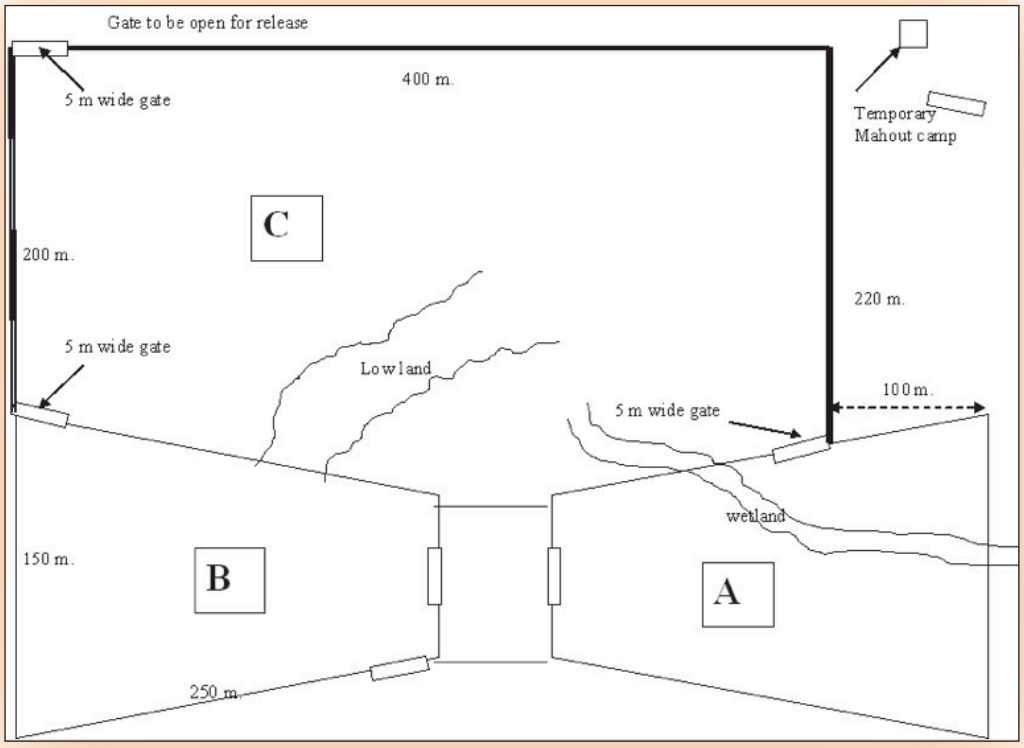

FIGURE 3. Schematic diagram of the boma used for rhino rehabilitation.

committee considered the advantages and disadvantages of each site, and the Kuribeel area of Bansbari Range in Manas NP was chosen as the site in which to establish the rehabilitation station. Kokilabari has less grassland area, few perennial water bodies and high human intervention; Uchia is located deep in the park and it was likely there would be problems with regular monitoring of the area. The presence of a few watchtowers around Kuribeel area ensured 24-hour rhino security. As the plan was to move the rhinos in trucks, it was also important to have the pre-release area located along an existing forest camp road.

The boma: pre-release area

The pre-release area in Kuribeel—called a "boma", as this is what a similar enclosure is called in Africa—was surrounded by a solar-powered electric fence. It had three compartments: compartment A was ready when the first rhino was moved, and as soon as compartment B was completed, the rhino was allowed to use both areas (Fig. 3). The boma also included part of a perennial stream because rhinos need water bodies to wallow in during the hot hours of the day. Hume pipes (large cemented pipes) were placed below the fence to facilitate the free flow of stream water through the boma. The nine-strand power fence had a twin role: to keep the rhinos confined in a large area for at least two years and at the same time keep away wild elephants and large carnivores like tigers. A corridor measuring 20 m × 70 m was created between sections A and B in case the rhinos needed to be confined for medical intervention. Two more rhinos were relocated to the boma in 2006 and another rhino calf was rescued in September 2007. The boma was expanded to double its existing size. Accordingly, 19 acres were added as compartment C in January 2008, just before the fourth rhino was relocated. All three compartments together measure 33.35 ha and were sufficient to accommodate the four rhinos until they were released.

Relocating rhinos to Manas NP

Early in 2006 WTI partnered with BTC to reintroduce rhinos into Manas NP from Kaziranga. IUCN guidelines[8,9] were used to plan and translocate the hand-raised rhinos. The first rhino, a three and a half-year-old female christened Maino by BTC, was moved to the boma on 21 February 2006. Maino thus got the distinction of being the first rhino to reach Manas after the resident population of rhinos had been wiped out during the decade of political instability in the region. On 28 January 2007, two more female rhinos, Rose and Manasi, were relocated from CWRC to the same boma. After a month of habituation at CWRC the rhinos were each lured into a crate, and a long-acting tranquilizer, Azaperon (Stressnil), was administered intramuscularly to reduce aggression and minimize damage to the crate. With the use of a crane the crates were loaded onto individual trucks that travelled by road overnight for about 400 km.

On 23 February 2008 a female rhino calf about two years old was translocated from CWRC to Manas NP, raising to four the number of rhinos inside the boma. This rhino had been rescued from Hatikhuli Tea Estate near Kohora after poachers killed its mother. While the rhinos that had been moved to Manas earlier were all hand raised, this calf was already two years old and was therefore considered to have been already weaned off milk. Consequently, luring this calf into the transportation crate was not considered an appropriate option for trapping it. We used a combination of Meditomidine and Ketamine hydrochlorides to restrain it before placing it on the sledge and dragging it into the crate. To give the rhinos a sense of familiarity to the new area, bags of their fresh and old dung had been taken to Manas from CWRC the previous day and scattered on the ground. The next morning after the trucks reached Manas, the young rhinos were let out of their crates into the boma (Fig. 7). All four rhinos have been radio-collared to enable post release monitoring. Within two months of relocating the fourth rhino to Manas, two male rhinos from Pabitora Wildlife Sanctuary (WLS) were hard-released (caught in the wild and directly released in Manas without using a pre-release boma) in Manas as part of the Indian Rhino Vision 2020 (IRV 2020) rhino translocation programme of the government of Assam. The female rhinos translocated from CWRC to Manas have a chance to choose mates while they are rehabilitating in Manas NP.

FIGURE 7. Releasing a rhino from CRWC into Manas National Park.

Rhinos at the boma

The rhino calves admitted to CWRC were hand-raised for about 18 months. Unlike elephant calves, they were held in large stockades at the centre until they were considered fit enough to be relocated to the

boma at the release site. Since rhino calves begin nibbling grass blades by the age of 2–3 months, grass and browse were made available to them by the time they were four months old.

A "soft-release" strategy was adopted after holding the rhinos in captivity at the release site for two to four years, depending on the age of the rhino at the time of its relocation. All rhinos were given supplementary feeding, a concentrate mix, for a week following their relocation. Supplementary feeding stopped as soon as they became accustomed to the grazing area inside the boma.

The fourth rhino was much younger and she was held initially in a small paddock specially created within compartment A, before she was allowed free access to the entire compartment. The plan was to restrict the calf to this compartment until the other three adult or subadult rhinos occupying compartments B and C were released. However, one of the male IRV 2020 rhinos strayed more than 100 km from Manas, creating panic among people, and had to be captured and released into the boma. The second male rhino, possibly lured by the three females inside, had already forced his way into the boma by disrupting the power fence on 10 June 2008. Fortunately, this happened on the side harbouring compartments B and C where the adult rhinos were held, and not in compartment A. However, releasing the straying rhino into the boma through compartment A had serious consequences. The standard operating procedures were overlooked and the calf was left among adult and subadult rhinos with all compartments interconnected. On 14 September 2008 the young female calf was found dead. The carcass was discovered only after a couple of days by which time putrefaction had started and scavengers had devoured the carcass considerably. Mandibular fracture and other circumstantial evidence pointed to death due to traumatic injury caused by the adult rhinos. Though fingers were pointed at the wild captured rhinos, there was no clear evidence to support this.

Data were collected on rhinos' use of habitat within the boma, and rhino behaviour towards caretakers, strangers, conspecifics and other wildlife was recorded anecdotally. Initially, the animals were seen following the caretaker whenever he inspected the fence for repairs. A month later the monsoon set in and tall grass grew inside the boma that soon cut down the visibility of the rhinos from outside. Three months after they were released, the rhinos showed little concern for people patrolling around the fence, though they were at times heard vocalizing on noticing human presence.

The tall grass was cut to encourage the growth of fresh blades of grass. The rhinos were moved from one compartment to another and the grass was trimmed close to the ground. Burning the grass would have been a better option but was not done as the fire might have gone out of control and spread into the other compartments holding the rhinos.

Release and post-release monitoring

On 27 November 2008, the park authority and WTI representatives visited the pre-release site at Bansbari to assess whether it was feasible to release three female rhinos from the boma. The

FIGURE 8. Female (rehabilitated) and male (hard release) rhinos graze in Manas National Park.

Rhino Task Force meeting of the government of Assam held in September 2008 had proposed that these rhinos be released. The team found all conditions favourable and released the rhinos from the pre-release site. On 27 November 2008, the gate of the boma at the northern-most boundary was opened and two female rhinos came out immediately. The third female rhino only ventured out the next day. At the time of release, one of the females was over six years old and the other two nearly five years. Meanwhile, the two male rhinos continued being held in the boma till 3 May 2009 when the younger forced his way out, once again by breaking through the power fence. The reason was said to be persecution by the other male inside. Once part of the southern boundary of the park was power fenced, the other male rhino was also let out, on 25 November 2009. This was exactly one year after the three rehabilitated rhinos had been released from the boma. Soon, the male and female rhinos were seen grazing together, often occupying the same habitat.

The rehabilitation protocol emphasized that the rhinos be monitored intensively for one year post-release.[6,8] But the rhinos were monitored for more than this designated period. In spite of collaring them as early as 2006 and 2007 respectively, the collars continued to give signals till the end of 2009 and beginning of 2010. Collars therefore provided range-use data for more than the stipulated period of one year post-release. Manasi's collar fell in October 2009, and Maino's in February 2010. Rose's collar is on the verge of falling due to normal wear and tear. The collar stopped functioning, but not before providing the tracking team with information on her movement patterns for more than a year. All rhinos were intensively monitored till 31 March 2010.

Radio-tracking was done largely using a vehicle, but sometimes on foot and rarely on elephant back. Temporary watchtowers were erected at strategic locations, especially near the southern park boundary towards the village site, to facilitate easy tracking.

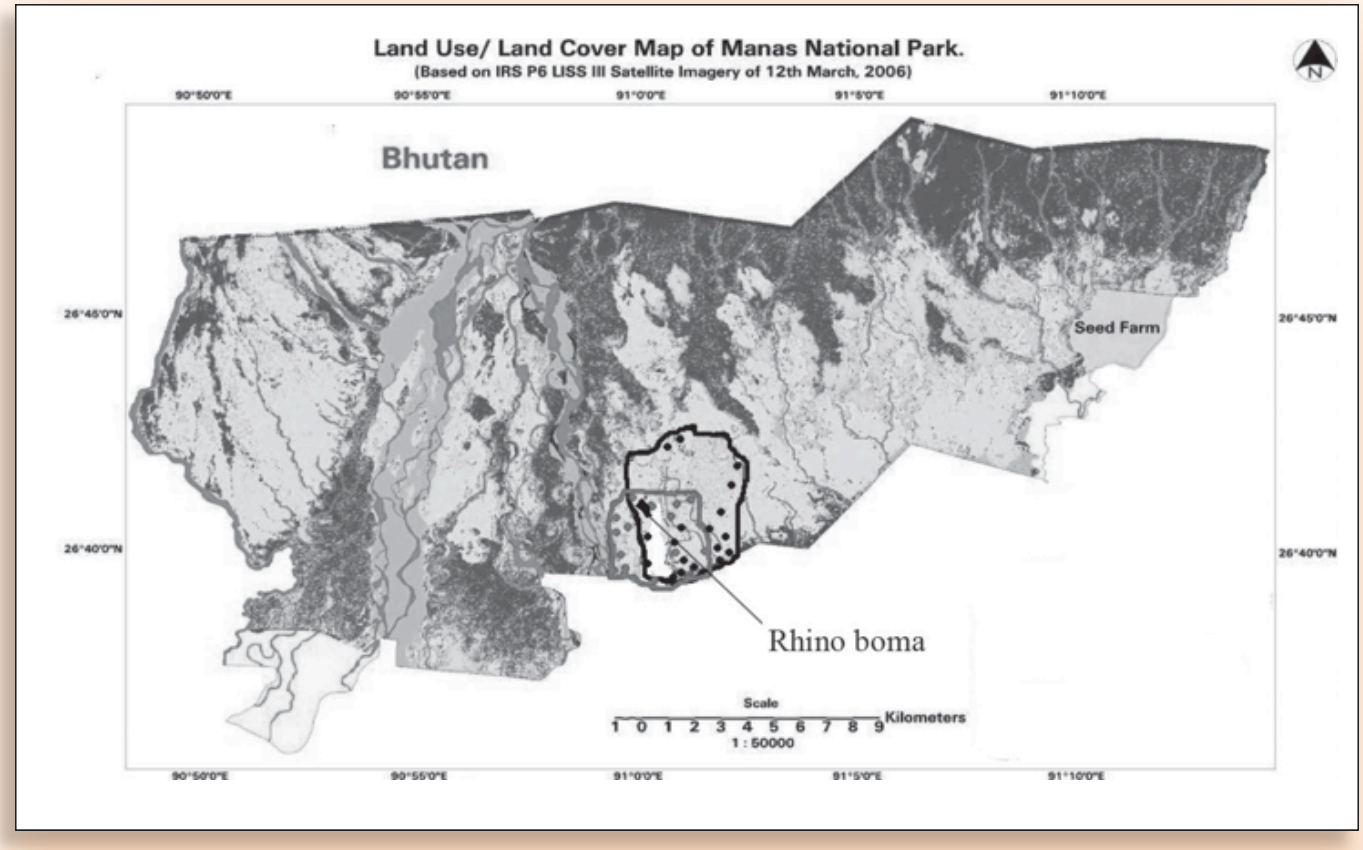

FIGURE 4. Home range of rehabilitation rhinos in the Manas National Park.
Key: solid line = Maino; broken line = Manasi and Rose

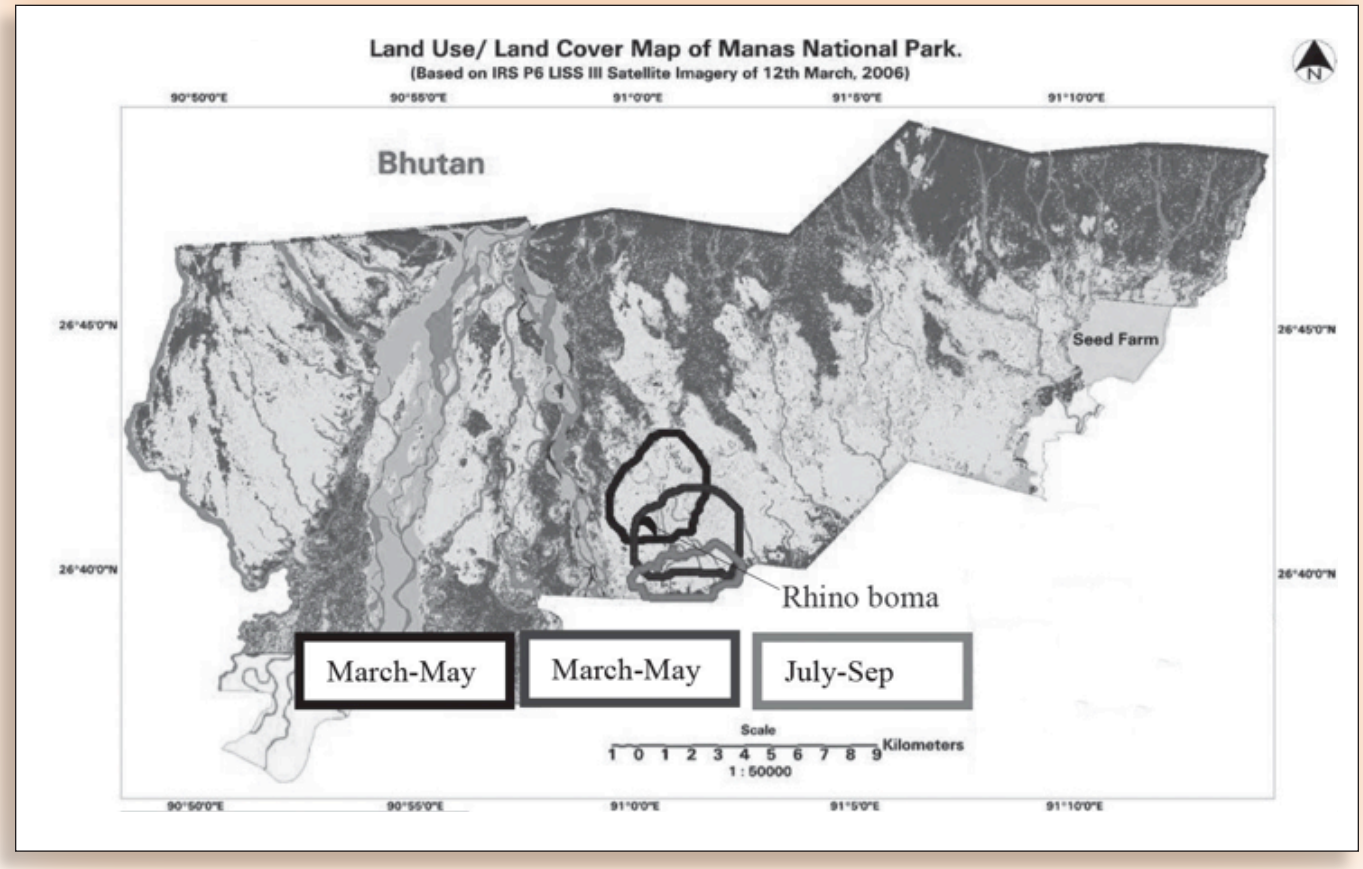

FIGURE 5. Shift of home ranges in different seasons.

Having been held in captivity in the boma for more than two years, the rhinos had developed site fidelity and as a result did not wander long distances after their release, unlike the hard-released males. Tracking these animals was therefore much easier as they rarely went beyond the coverage area of the radio-transmitter. As they were also habituated to the caretakers, watching them from close quarters did not hamper their normal behaviour. However, they were never seen to approach humans as was the case during the first six months of being released into the boma in 2006 and 2007 respectively.

Results

Range extension and habitat use: first six months post-release

The rhinos did not have a chance to re-enter the boma as the gates had to be closed for the two male rhinos to be held captive till the southern boundary of the park was power-fenced. However, true to the nature of soft-released animals, the initial range utilization of all the three rhinos had a close association with the boma. The two younger females (Rose and Manasi) were confined to the perimeter of the power fence for the first two months after their release. Within six months, Maino had established a home range of about 15 km^2 and Rose and Manasi a considerably small home range of 7–8 km^2 (Fig. 4). Maino extended her range towards the south and southeast of the boma up to the fringe areas of the southern boundary. The farthest distance she travelled from the park boundary was 1.5 km up to Barengabari village. From the boma the northern limit was 2.5 km and movement towards east during the first six months of release varied from 2 to 5 km. It was apparent that the movement to the south and southeast of the boma was for the aquatic vegetation on the Giati River and short grassland in the fringe areas where livestock grazing and other biotic pressure is high. In May 2009, her movement pattern almost coincided with that of the male rhino that had escaped from the boma on 3 May 2009. By September 2009, all three rhinos not only showed a general increase in their range use, but also a shift in habitat use pattern, which was possibly determined by the physiognomic changes in ground vegetation. Because of her frequent association with the male rhinos, Maino's range use often coincided with the movement pattern of the males. As a result, she also strayed out of the park repeatedly during the day and up to four or five times during May 2009. By placing an animal tracker solely for guarding against this at the Palsiguri beat of the southern boundary of the park, the situation could be brought under control. However, after the power fence was erected on the Bansbari side of the southern boundary, incidents of straying have not been reported.

Maino avoided the tall grasslands being routinely burned in January 2010 and instead used swampy grasslands more. As soon as new blades of grass emerged in the burnt areas, the rhino began frequenting these patches. In January, Maino was associated with one of the IRV 2020 male rhinos and both disappeared from the scene for nearly a week. With no signal being received from Maino for five days, intensive search led to her being spotted in the Tower camp, northeast of the boma.

Range extension and habitat use: the last six months (October 2009–March 2010)

By March 2010, Maino had extended her range further to the northeast of the boma (Fig. 5). The animal was no longer sighted frequently in and around anti-poaching camps. This could be because short grasses and aquatic vegetation were abundant everywhere. The rhinos in Manas most frequented areas with short grass and aquatic vegetation. Unlike Rose and Manasi, Maino explored newer areas that are also used by the adult male rhinos. For instance in March, she was sighted with a male rhino in Bangale Hatdhua area, long after her collar had dropped.

While Maino had her own range-use pattern, often associating with the males, Rose and Manasi were always found moving together. In March 2010, both rhinos were seen using the elephant training camp, boma and Bathan areas. However, it was not uncommon to see all three in one location for a brief period.

The one year of radiotracking rehabilitated rhinos ended, and intensive tracking formally came to an end on 31 March 2010. The rhinos are still physically tracked and their GPS locations, habitat use, association with conspecifics and activity recorded anecdotally. By April 2010, the home ranges of Maino and the other two females were almost equal, each occupying 15–20 km^2. It will be interesting to compare the home ranges of these rhinos with those of the wild-caught males hard-released in Manas.

Discussion

Lessons for the future

Transportation age: All three rhinos (except the fourth, which died in the boma) were relocated to Manas when they were about three and a half to four years of age. It would be better to move them much earlier, say by two years, as this would shorten the time caretakers would be needed at CSRC. It is also much easier to move younger rhinos.

Protecting offspring: Experience in Dudhwa NP has shown that reintroduced rhinos have little chance of protecting their calves from tiger attacks. In Kaziranga NP, rhinos lose a considerable number of their calves to tigers. The 2,000 odd rhinos in Kaziranga can withstand this occasional removal of individuals from the population, but this may not be the case in Manas. The rhinos with newly born calves may have to be confined to the boma to protect their calves till they are about two years old.

Relocating the boma: In a soft-release programme, animals tend to establish their home range close to the area of their acclimatization. To spread out the distribution of the rhinos in the park and to reduce pressure on the southern boundary, future releases might have to be deep inside the park in areas like Uchila and beyond. The boma might have to be relocated to ensure that this happens next time when orphan rhinos are moved to Manas.

Time of collaring rhinos: Since a considerable amount of battery life is lost by collaring the rhinos before their relocation, in the future the animals should be collared only when they are about to be released from the boma. Experience has shown that the rehabilitated rhinos do not break the fence and venture outside. They can always be captured and returned to the boma should an emergency of this sort happen.

From rescue to release: the success of rehabilitation

The successful rehabilitation of rhinos in Manas NP can be recapitulated in the following stages:

1. Rescuing the calf from distress: When attempts to reunite calf with mother fail, the calf is taken to CWRC for hand-raising. In the last 10 years of experience at Kaziranga NP, not a single rhino calf has been reunited with the mother. This is in contrast to elephants wherein at least seven calves have been successfully reunited.

2. Hand-raising: All calves are stabilized upon arrival in captivity. Depending upon their hydration levels, fluid therapy is given where necessary. A standard milk formula is employed. The calves are weaned by 18 months of age and unlike elephant calves, rhino calves begin nibbling blades of grass even before they turn two months of age.

3. Translocating: Weaned calves spend another one year held in a 2–3-acre bamboo paddock reinforced with live wire at CWRC. Husbandry practices include providing adequate fodder (largely grass) and a suitable concentrate mix of gram, cereal, vitamins and mineral supplements. At the time of translocating them, they are either habituated to a crate or chemically restrained and dragged into it, and moved to the release site in a truck after their radio collars have been placed.

4. Acclimatizing to the release site: Following translocation, the rhinos are held in the boma for a minimum of two years to acclimatize to the local conditions. Apart from managing the habitat within the enclosure, no other husbandry practice is followed here. Such a soft-release programme also helps the animals become loyal to the site.

5. Release and monitoring: The boma gates are opened and the rhinos released into the wild after the period of acclimatization is over. They are then radiotracked for one year post-release and valuable data on their habitat use, range extension, social interactions with conspecifics is collected. The collars either drop on their own or are made to drop using a preprogrammed device.

Conclusions

The project has demonstrated that hand-raised rhinos can successfully contribute to the reintroduction of rhinos to Manas NP. With five more orphaned rhino calves waiting to be moved to Manas in the next two years and more wild rhinos being planned for addition to Manas as part of the IRV 2020 programme, the conservation scenario looks bright as far as the return of rhinos to the park is concerned.

All IUCN guidelines have been adhered to, not only in formulating the rhino rehabilitation protocol,[6,8] but also during the implementation of the project. All the required permissions from the chief wildlife warden of the state, from the Ministry of Environment and Forests and from the Central Zoo Authority were obtained in advance. All rhinos were also screened for infectious diseases before they were moved to Manas NP following the appropriate protocol.[10] The rehabilitated rhinos have contributed to the return of this species to the once-renowned Manas National Park.

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Working Together for Wildlife:

How the Partners for Wildlife initiative will empower rehabilitators

By Molly O'Bryan

In last quarter's issue of the IWRC newsletter, the world-renowned Raptor Center at the University of Minnesota introduced Partners for Wildlife (P4W), a groundbreaking three-year initiative aimed at raising the bar for wildlife rehabilitation care across all species, starting in a pilot region that includes seven states (Wisconsin, Minnesota, North Dakota, Montana, Idaho, Washington, and Arkansas). At the heart of P4W is the desire to improve animal welfare in wildlife rehabilitation so that animals are rehabilitated more quickly and have greater chances of release back into the wild, in addition to improving and standardizing the decision-making processes for euthanasia or placement. Animal welfare is a concept that encompasses multiple domains: nutrition, environment, health, behavior, and mental state. Even though rehabilitation is often a high-stress environment, there are many ways to mitigate the impact of stress by ensuring good practices across multiple welfare domains.

P4W's three-pronged approach to achieving its objectives includes building community between rehabilitators and veterinarians and building the capacity of veterinarians to provide skilled care for wildlife. The cornerstone of this three-pronged approach, however, is all about reaching out and building sustainable partnerships between and among wildlife rehabilitators and rehabilitation organizations.

A shared passion

A common experience shared by wildlife rehabilitators is a chronic shortage of resources at a time when their services are more than ever in demand. A single rehabilitator may serve a catchment area of hundreds of square miles, with little to no support due to long distances, poor communication networks, and a sheer lack of time to reach out for advice and assistance. Isolation, combined with ever-increasing caseloads and subsequent demands for additional space, supplies, feed, and expensive veterinary care, can all lead to burnout, compassion fatigue, and poor outcomes for the animals. P4W wants to change this challenge.

Gail Buhl is P4W's Partnership Coordinator. She has been a rehabilitator for more than 30 years, holds a master rehabilitator permit in the state of Minnesota, and is an experienced trainer of ambassador animals. She explains, "I am singularly passionate about this: wildlife rehabilitation is important work. There is nothing I love more than helping others who share my passion feel more supported and empowered."

Buhl's primary role in P4W is to reach out to rehabilitators in the program's seven-state region and offer a listening ear and a voice of experience. "I'll be visiting rehabilitators all over the program area; I just returned from three weeks in Alaska, where I met the most amazing group of people, who are eager to make connections with other rehabilitators and excited about *us* coming to *them* to listen and help them improve animal welfare." Buhl hopes to work one-on-one with rehabilitators, to get an idea of their needs and capacity in order to strategize opportunities for improvements and upgrades, while also becoming a trusted resource for rehabilitators to call on and facilitate connections between and among rehabilitators. "If a rehabilitator in remote eastern Washington that generally works with small mammals receives an injured turtle, he or she may not feel confident enough to treat the animal appropriately. That is where I can help—either by using my own knowledge and experience to guide people where appropriate, connecting them to someone else who has that knowledge and experience, or getting them connected to the already-existing networks like NWRA (National Wildlife Rehabilitators Association), IWRC, and other local organizations. No single person can be an expert in all aspects of wildlife rehabilitation; strengthening networks is one of the best practices in wildlife rehabilitation."

Transformative change

After connecting with wildlife rehabilitators in the program region, visiting their sites, and assessing their needs, P4W will be able to facilitate access to resources and small grants to enact the improvements that will have the biggest impact on animal welfare. "For some facilities, that could mean improved caging or equipment. For others, it might be a computer and an internet connection, so that patient data can be logged and shared more effectively, and communication can be improved. Specialized trainings or workshops could be another possibility. We really want to know what rehabilitators need to make significantly improved conditions for the wildlife in their care. And then we want to help them acquire the resources to make those changes," Buhl says.

Wildlife rehabilitators sometimes feel invisible. As a rehabilitator herself, Buhl understands this: "Most of us get very little support and make great personal sacrifices in order to do what we do. The potential for P4W to have a positive impact is incredibly exciting." In the next issue of the IWRC newsletter, we will showcase the role that veterinarians will play in helping to achieve P4W's objectives, and how building community among veterinarians and rehabilitators is key to improving animal welfare in wildlife rehabilitation. ■

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

SELECTED ABSTRACTS

How do wombats make cubed poo?

PJ Yang, M Chan, S Carver, DL Hu. Presentation: 71st Annual Meeting of the APS Division of Fluid Dynamics. Nov 2018; Atlanta, Georgia.

Wombats are fossorial herbivorous Australian marsupials with the distinctive feature of producing cubic feces, which is unique in the animal kingdom. In the built world, cubic structures are created by extrusion or injection molding, but there are few examples of this feat in nature. We investigate how wombats produce cubic feces, through investigation of the structure and mechanics of two dissected alimentary systems of wombats--derived from veterinary euthanized individuals following motor vehicle collisions in Tasmania, Australia. In the final 8 percent of the intestine, feces changed from a liquid-like state into a solid state composed of separated cubes of length 2 cm. This shape change was due to the azimuthally varying elastic properties of the intestinal wall. By emptying the intestine and inflating it with a long balloon, we found that the local strain varies from 20 percent at the cube's corners to 75 percent at its edges. Thus, the intestine stretches preferentially at the walls to facilitate cube formation. This study addresses the long-standing mystery of cubic scat formation and provides insight into new manufacturing techniques for non-axisymmetric structures using soft tissues.

Top: The Australian wombat *Vombatidae*, a native marsupial. PHOTO © DREW DOUGLAS. CC 2.0 LICENSE. Above: Wombat scat, unique in its cubic form. PHOTO ©THE POO MUSEUM. USED WITH PERMISSION.

Giant tortoise genomes provide insights into longevity and age-related disease

V Quesada, S Freitas-Rodríguez, and C López-Otín. *Nature Ecology & Evolution.* 2019;(3):87–95.

Giant tortoises are among the longest-lived vertebrate animals and, as such, provide an excellent model to study traits like longevity and age-related diseases. However, genomic and molecular evolutionary information on giant tortoises is scarce. Here, we describe a global analysis of the genomes of Lonesome George—the iconic last member of *Chelonoidis abingdonii*—and the Aldabra giant tortoise *(Aldabrachelys gigantea)*. Comparison of these genomes with those of related species, using both unsupervised and supervised analyses, led us to detect lineage-specific variants affecting DNA repair genes, inflammatory mediators and genes related to cancer development. Our study also hints at specific evolutionary strategies linked to increased lifespan, and expands our understanding of the genomic determinants of ageing. These new genome sequences also provide important resources to help the efforts for restoration of giant tortoise populations.

Variation in inbreeding rates across the range of northern spotted owls *(Strix occidentalis caurina)*: Insights from over 30 years of monitoring data

MP Miller, SM Haig, ED Forsman, RG Anthony, L Diller, KM Dugger, AB Franklin, TL Fleming, S Gremel, DB Lesmeister, et al. *The Auk.* 2018;135(4):821-833. doi.org/10.1642/AUK-18-1.1

Inbreeding has been difficult to quantify in wild populations because of incomplete parentage information. We applied and extended a recently developed framework for addressing this problem to infer inbreeding rates in northern spotted owls *(Strix occidentalis caurina)* across the Pacific Northwest, USA. Using pedigrees from 14,187 northern spotted owls, we inferred inbreeding rates for 14 types of matings among relatives that produce pedigree inbreeding coefficients of F = 0.25 or F

= 0.125. Inbreeding was most common in the Washington Cascades, where an estimated 15% of individuals are inbred. Inbreeding was lowest in western Oregon (3.5%) and northern California (2.7%), and intermediate for the Olympic Peninsula of Washington (6.1%). Estimates from the Olympic Peninsula were likely underestimates because of small sample sizes and the presence of few pedigrees capable of resolving inbreeding events. Most inbreeding resulted from matings between full siblings or half siblings, although a high rate of inbreeding from mother–son pairs was identified in the Olympic Peninsula. Geographic variation in inbreeding rates may reflect population declines and bottlenecks that have been detected in prior investigations. We show that there is strong selection against inbred birds. Only 3 of 44 inbred birds were later identified as parents (6.8%), whereas 2,823 of 10,380 birds that represented a comparable cross section of the data were later seen as reproducing parents (27.2%). Habitat loss and competition with barred owls *(S. varia)* remain primary threats to northern spotted owls. However, given the negative consequences of inbreeding, spotted owl populations in Washington with suitable habitat and manageable numbers of barred owls may benefit from translocations of individuals from Oregon and California to introduce new genetic variation and reduce future inbreeding events.

Intrinsic anti-inflammatory properties in the serum of two species of deep-diving seal

A Bagchi, AJ Batten, M Levin, KN Allen, ML Fitzgerald, LA Hückstädt, DP Costa, ES Buys, and AG Hindle. *Journal of Experimental Biology.* 2018;221(jeb1784910. doi: 10.1242/jeb.178491

Weddell and elephant seals are deep-diving mammals, which rely on lung collapse to limit nitrogen absorption and prevent decompression injury. Repeated collapse and re-expansion exposes the lungs to multiple stressors, including ischemia–reperfusion, alveolar shear stress and inflammation. There is no evidence, however, that diving damages pulmonary function in these species. To investigate potential protective strategies in deep-diving seals, we examined the inflammatory response of seal whole blood exposed to lipopolysaccharide (LPS), a potent endotoxin. Interleukin-6 (IL6) cytokine production elicited by LPS exposure was 50 to 500 times lower in blood of healthy northern elephant seals and Weddell seals compared with that of healthy human blood. In contrast to the ~6× increased production of IL6 protein from LPS-exposed Weddell seal whole blood, isolated Weddell seal peripheral blood mononuclear cells, under standard cell culture conditions using medium supplemented with fetal bovine serum (FBS), produced a robust LPS response (~300×). Induction of Il6 mRNA expression as well as production of IL6, IL8, IL10, KC-like and TNFα were reduced by substituting FBS with an equivalent amount of autologous seal serum. Weddell seal serum also attenuated the inflammatory response of RAW 267.4 mouse macrophage cells exposed to LPS. Cortisol level and the addition of serum lipids did not impact the cytokine response in cultured cells. These data suggest that seal serum possesses anti-inflammatory properties, which may protect deep divers from naturally occurring inflammatory challenges such as dive-induced hypoxia–reoxygenation and lung collapse.

Kill, incarcerate, or liberate? Ethics and alternatives to orangutan rehabilitation

A Palmer. *Biological Conservation.* November 2018;227:181-88. doi.org/10.1016/j.biocon.2018.09.012

Despite its high cost and debatable conservation value, orangutan rehabilitation and reintroduction (R&R) continues. Drawing on qualitative research with orangutan conservationists, this paper argues that a central reason why R&R practitioners undertake this activity is a view that the alternatives, killing orangutan orphans or keeping them in captivity, are practically or ethically unacceptable. However, questions remain over whether orphans might be better off in captivity than in the wild, and why orphans appear to attract more attention and support than wild orangutans. In evaluating these questions, practitioners must weigh up obligations to individuals and larger units, displaced and wild orangutans (the former visible, and the latter abstract), and properties of orangutans such as their wildness, welfare, and autonomy. As advocates of compassionate conservation have highlighted, similar ethical dilemmas arise in the conservation of other species.

Categorical perception of colour signals in a songbird

EM Caves, PA Green, MN Zipple, S Peters, S Johnsen, and S Nowicki. *Nature.* 2018;560: p 365–67.

In many contexts, animals assess each other using signals that vary continuously across individuals and, on average, reflect variation in the quality of the signaller. It is often assumed that signal receivers perceive and respond continuously to continuous variation in the signal. Alternatively, perception and response may be discontinuous, owing to limitations in discrimination, categorization or both. Discrimination is the ability to tell two stimuli apart (for example, whether one can tell apart colours close to each other in hue). Categorization concerns whether stimuli are grouped based on similarities (for example, identifying colours with qualitative similarities in hue as similar even if they can be distinguished). Categorical perception is a mechanism by which perceptual systems categorize continuously varying stimuli, making specific predictions about discrimination relative to category boundaries. Here we show that female zebra finches *(Taeniopygia guttata)* categorically perceive a continuously variable assessment signal: the orange to red spectrum of male beak colour. Both predictions of categorical perception were supported: females (1) categorized colour stimuli that varied along a continuum and (2) showed increased discrimination between colours from opposite sides of a category boundary compared to equally different colours from within a category. To our knowledge, this is the first demonstration of categorical perception of

signal-based colouration in a bird, with implications for understanding avian colour perception and signal evolution in general.

The impact of human activities on Australian wildlife

A Taylor-Brown, R Booth, A Gillett, E Meally, S Ogbourne, A Polkinghorne, G Conroy. *bioRxiv*. Oct 2018;452409. In-press. doi.org/10.1101/452409

Increasing human population size and the concomitant expansion of urbanisation significantly impact natural ecosystems and native fauna globally. Successful conservation management relies on precise information on the factors associated with wildlife population decline, which are challenging to acquire from natural populations. Wildlife Rehabilitation Centres (WRC) provide a rich source of this information. However, few researchers have conducted large-scale longitudinal studies, with most focussing on narrow taxonomic ranges, suggesting that WRC-associated data remains an underutilised resource, and may provide a fuller understanding of the anthropogenic threats facing native fauna. We analysed admissions and outcomes data from a WRC in Queensland, Australia Zoo Wildlife Hospital, to determine the major factors driving admissions and morbidity of native animals in a region experiencing rapid and prolonged urban expansion. We studied 31,626 admissions of 83 different species of native birds, reptiles, amphibians, marsupials and eutherian mammals from 2006 to 2017. While marsupial admissions were highest (41.3%), admissions increased over time for all species and exhibited seasonal variation (highest in Spring to Summer), consistent with known breeding seasons. Causes for admission typically associated with human influenced activities were dominant and exhibited the highest mortality rates. Car strikes were the most common reason for admission (34.7%), with dog attacks (9.2%), entanglements (7.2%), and cat attacks (5.3%) also high. Admissions of orphaned young and overt signs of disease were significant at 24.6% and 9.7%, respectively. Mortality rates were highest following dog attacks (72.7%) and car strikes (69.1%) and lowest in orphaned animals (22.1%). Our results show that WRC databases offer rich opportunities for wildlife monitoring and provide quantification of the negative impacts of human activities on ecosystem stability and wildlife health. The imminent need for urgent, proactive conservation management to ameliorate the negative impacts of human activities on wildlife is clearly evident from our results.

Mycoplasmosis of house finches (Haemorhous mexicanus) and California scrub-jays *(Aphelocoma californica)* in a wildlife rehabilitation facility with probable nosocomial transmission

KH Rogers, DH Ley, and LW Woods. 2018. *Journal of Wildlife Diseases.* In-press. doi.org/10.7589/2018-06-162

We describe an investigation of an outbreak of conjunctivitis in juvenile House Finches (*Haemorhous mexicanus*) and California Scrub-jays (*Aphelocoma californica*) at a central California wildlife rehabilitation facility. In late May 2015, the facility began admitting juvenile finches, the majority with normal eyes at intake. In June, with juvenile finches already present, the facility admitted additional juvenile scrub-jays, again all with normal eyes at intake. In July, after conjunctivitis was observed in increasing numbers of juvenile finches and scrub-jays, carcasses were submitted for postmortem examination. Histopathology of five finches and three scrub-jays identified lymphocytic infiltrates in the ocular tissues. Conjunctival swabs from 87% (13/15) finches and 33% (4/12) scrub-jays were PCR-positive for *Mycoplasma gallisepticum*. One finch and two scrub-jays were PCR-positive for *Mycoplasma synoviae.* Additionally, gene sequencing (16S rRNA and 16S-23S intergenic spacer region) identified *Mycoplasma sturni* from 33% (3/9) scrub-jays. This outbreak of conjunctivitis suggested that M. gallisepticum-infected juvenile finches admitted to and maintained in a multispecies nursery likely resulted in transmission within the facility to healthy juvenile finches and scrub-jays. Evidence of other Mycoplasma spp. in finches and scrub-jays indicates that these species are susceptible to infection and may act as carriers. This outbreak highlighted the need for effective triage and biosecurity measures within wildlife rehabilitation facilities.

A headache from our past? Intracranial abscess disease, virulence factors of *trueperella pyogenes*, and a legacy of translocating white-tailed deer *(Odocoileus virginianus)*

BS Cohen, EH Belser, SP Keeler, MJ Yabsley, and KV Miller. *Journal of Wildlife Diseases.* Oct 2018;54(4):671-79. doi.org/10.7589/2017-09-216

Trueperella pyogenes, a bacterial opportunistic pathogen residing along the skin layer of apparently healthy animals, is the etiologic agent of intracranial abscessation-suppurative meningoencephalitis, a cause of mortality for male white-tailed deer *(Odocoileus virginianus)*. Occurrence of this disease has been speculated to be influenced by virulence of *T. pyogenes* residing on white-tailed deer in geographically distinct metapopulations. To determine if differences in virulence potential of *T. pyogenes* could affect occurrence of disease across populations, we examined if frequency of seven virulence genes of *T. pyogenes* from forehead swabs of 186 apparently healthy white-tailed deer differed between sites in the state of Georgia, US, where ≥1 male tested positive for a cranial abscess and sites where no individuals tested positive for a cranial abscess. We detected six of seven virulence genes more frequently at sites where we detected ≥1 male with a cranial abscess compared to sites where we did not detect any individuals with a cranial abscess (nanH, $P<0.001$; nanP, $P=0.007$; fimA, $P<0.001$; fimC, $P=0.037$; fimE, $P<0.009$; fimG, $P<0.001$; and cbpA, $P=0.872$). Our findings suggest differences in the pathogenic potential of *T. pyogenes* at individual sites may help to explain spatial variability of this disease. Anecdotally, the incidence of cranial abscess disease in Georgia seems to be associated with areas that were restocked with white-tailed deer from a high-fenced property in Wisconsin, US. Given the spatial distribution of this disease, we speculate that these genetic differences in *T. pyogenes* may have arisen from white-tailed deer restocking efforts, and our observations may be a legacy of an introduced disease manifesting itself generations later.

Raccoon roundworm *(Baylisascaris procyonis)* as an occupational hazard: Knowledge of *B. procyonis* and attitudes towards it and other zoonoses among wildlife rehabilitators

S. G. H. Sapp B. A. Murray E. R. Hoover G. T. Green M. J. Yabsley. *Zoonose*s. Feb 2018;65(1):e130-42.

Wildlife rehabilitators are at risk of zoonotic diseases because they often have prolonged contact with many species of wildlife and their bodily fluids. Raccoon roundworm *(Baylisascaris procyonis)* is a common zoonotic parasite of raccoons that has the potential to cause severe or fatal neurologic disease in a broad variety of hosts if the eggs within raccoon faeces are ingested. We administered an online survey to wildlife rehabilitators to assess their knowledge regarding aspects of transmission, biology and disease caused by *B. procyonis*, and also to evaluate attitudes towards wildlife diseases and *B. procyonis* as an occupational hazard. Knowledge was assessed using multiple choice and true–false questions; attitudes were measured using Likert-type items. A total of 659 complete or near-complete responses (missing fewer than three knowledge or attitudes items and/or non-response to some demographic fields) were collected. The median knowledge score was 7/14 questions correct (range: 0–14 correct). Generally, individuals with higher levels of education and rehabilitation experience, veterinary professionals and those who are members of professional wildlife rehabilitation groups scored above the median significantly more often ($p < .01$). Significantly more rehabilitators who were located in the south-east and those with part-time or infrequent commitments scored below the median overall knowledge score. There was general agreement that *B. procyonis* is a health risk of rehabilitators and that measures should be taken to control transmission to people and animals. Some factors explaining differences in attitudes include setting of rehabilitation (home versus animal care facility), veterinary profession, region, membership in a wildlife rehabilitation group and rehabilitation of raccoons. Findings emphasize the importance of awareness and mentorship to inform rehabilitators on the potential risks of *B. procyonis* and other potential zoonoses within captive wildlife settings, and the important role of professional wildlife rehabilitator groups in disseminating educational materials.

Use of blood clotting assays to assess potential anticoagulant rodenticide exposure and effects in free-ranging birds of prey

S Hindmarch, BA Rattner, JE Elliott. *Science of The Total Environment.* Mar 2018;657(20):1205-16. doi.org/10.1016/j.scitotenv.2018.11.485

Non-target wildlife, particularly birds of prey, are widely exposed to and acutely poisoned by anticoagulant rodenticides (ARs). An unresolved issue surrounding such exposure, however, is the potential for sublethal effects. In particular, the consequences of AR exposure and resulting coagulopathy on health and survival of unintentionally exposed animals, which often encounter a multitude of anthropogenic stressors, are understudied. In a wildlife rehabilitation setting, AR intoxication may be masked by more obvious injuries related to collision with vehicles or electrocution, thereby obfuscating proximate from ultimate cause of mortality. An assessment of coagulation function of admitted wildlife may provide a means of identifying animals exhibiting sublethal coagulopathy, and ultimately ensuring provision of appropriate and swift treatment. In conjunction with routine diagnostics for injury and disease, we performed two blood clotting assays (prothrombin time, Russell's viper venom time) affected by vitamin K-dependent coagulopathy of samples from six species of live raptors admitted to a rehabilitation facility. We also measured clotting time in pre-fledgling barn owl chicks (*Tyto furcata*) from 10 nest sites in Lower Mainland Canada. Prolonged clotting time or failure to form a clot altogether was observed in 23.0% of 61 sampled raptors admitted to the rehabilitation facility. This is a biologically significant proportion of individuals given the fortuitous and likely biased nature by which raptors are found and admitted to rehabilitation facilities. In contrast, there was little evidence of coagulopathy in 19 pre-fledgling barn owl chicks. The utility of avian coagulation tests for diagnosing AR exposure is promising, yet there remains a need to establish species specific reference values and standardize assay methodologies among testing facilities.

Barred owl *(Strix varia)*.

Longevity of the barred owl, *Strix varia* Barton, 1799 from captivity

AB Orfinger, D Helsel, and SF Breeding *The Wilson Journal of Ornithology.* 2018. In-Press.

Surprisingly little is known about the basic biology of many large raptor species. Zoos and wildlife rehabilitation centers can help remedy this knowledge gap by providing a wealth of data on species whose in situ counterparts are difficult to study. We present one such example here by recording multiple new longevity records for the barred owl (*Strix varia* Barton, 1799). At 34 years and 1 month of age, the longest-lived new record surpasses the previous oldest known individual by a decade. Along with the additional new and already available longevity data we reviewed, the information provided here will prove useful for those working on many aspects of owl biology. ■

CONTINUED FROM PAGE 6

and University of Veterinary Medicine, Vienna published a letter in this week's edition of the journal *Science* on the threat of the virus peste des petits ruminants (PPR) to conservation.

The Mongolian saiga *(Saiga tatarica)*.

Peste des petits ruminants is a viral disease of sheep and goats and is of great significance to the livelihood of rural communities, biodiversity conservation, and national and global economies. Repeated mass mortality events in wild steppe and mountain ungulates of the Middle East and eastern Asia are raising significant concerns about the conservation impact of this virus.

The mass mortality of over two-thirds of the critically endangered Mongolian saiga in 2017 is a dramatic illustration of the threat of PPR to wildlife. The situation is particularly bleak for the saiga antelope, as this is the second known mass mortality event due to infectious disease in less than two years—effectively reversing decades of conservation efforts to limit the impact of other threats, such as poaching for horn and meat.

Mass mortality events in saiga are linked to changes in climate, spillover of pathogens from livestock, and resource scarcity due to increasing competition with livestock for forage. The impact of livestock diseases on other wild ungulates is likely underappreciated, due to a lack of systematic surveillance.

The authors say there is an urgent need to explicitly include wildlife protection as an objective of the PPR global eradication campaign.

Growing human and livestock populations put increasing pressure on natural resources; a better integration of rural development and conservation strategies is a critical challenge of our time.

To better understand this disease, Science for Nature and People Partnership (SNAPP Steppe Health) is gathering a diverse group of animal health and conservation professionals to measure and mitigate the impact of pathogens, such as PPR virus, at the livestock–wildlife interface.

2018 Neotropical Migratory Bird Treaty Act Funding Supports 16 Countries

WASHINGTON, DC (August 8, 2018)—Each spring, the air fills with the calls of millions of migratory birds making their annual journeys from wintering grounds in the Southern Hemisphere to breeding grounds in North America. Yet populations of many birds are in decline as a result of habitat loss and degradation. Thanks to the Neotropical Migratory Bird Conservation Act (NMBCA) grants program, however, these long-distance travelers will benefit from $18 million in federal and matching funds.

The NMBCA provides critical funding each year for bird conservation and research throughout the Western Hemisphere and is the only source of federal funding solely dedicated to the conservation of our shared migratory bird heritage. This year, more than $3.8 million in federal funds will be matched by more than $14.2 million in partner contributions, going to 29 collaborative conservation projects in 16 countries across the Americas.

"Birds add billions of dollars to the economy each year by controlling crop pests, pollinating plants, and dispersing seeds. Our national passion for birdwatching adds billions more through our purchases of bird food, binoculars, and travel to see our favorite birds," says Service Principal Deputy Director Greg Sheehan. "These projects will not only have a positive impact in local communities, but will ensure these birds come back to us year after year, helping keep our agricultural and recreational economies strong."

The NMBCA grants will fund projects to conserve migratory bird habitats, engage local communities in bird habitat protection, and strengthen international relations, while raising awareness of the importance of bird conservation.

There are 386 species of neotropical migratory birds that migrate to and from the United States each year, including songbirds, shorebirds, and birds of prey. In addition to their role as pollinators, seed dispersers, and pest controllers, they also provide early warnings of environmental contamination.

The NMBCA program is specifically designed to send at least 75% of its funding to projects in Latin America and the Caribbean, where habitat loss and other threats to migratory birds that spend part of their lives in the United States are significant and conservation funding is scarce. Because the program works throughout the Western Hemisphere, it is able to support the full life-cycle needs of the birds. For instance, the NMBCA funds work for Canada warbler and wood thrush on their breeding grounds as well as key stopover and wintering sites in Central America and South America.

Since 2002, the NMBCA has provided more than $66 million in grants to support 570 projects in 36 countries. These projects have positively affected more than 4.5 million acres of bird habitats and have spurred partnerships on multiple levels, contributing an additional $250 million. This year's project highlights include:

■ *Saving the Golden-Cheeked Warbler Wintering Habitat*

This project will implement a conservation plan for the endangered golden-cheeked warbler through the restoration of the pine-oak forest in Honduras, sustainable forest management in Mexico, and through conducting field surveys on the wintering habitat.

■ *Steele Family Ltd. Partnership Acquisition Project*

The Steele Family Limited Partnership acquisition will preserve and buffer tallgrass prairie, which is an important breeding and migration habitat in the Little Sioux River watershed of northwest Iowa. It will ultimately expand the Iowa Department of Natural Resources' 1,834-acre Waterman Prairie Wildlife Management Area.

■ *Conserving Bicknell's Thrush on Canadian Breeding Grounds*

The grantees will partner with timber companies and management agencies to implement best practices to reduce mortality and habitat loss, conduct research to improve long-term protection of Bicknell's thrush, and continue regional and range-wide surveys to evaluate the success of conservation actions over the medium- and long-term.

PHOTO © NICHOLAS PETERSON. CC BY-NC-ND 2.0 LICENSE.

Golden-cheeked warbler *(Setophaga chrysoparia)*.

USFWS Supports WNS Research with $1 million in Grants

WASHINGTON, DC (September 5, 2018)—The US Fish and Wildlife Service (USFWS) is providing much-needed support in the fight against the bat-killing fungal disease white-nose syndrome (WNS) through an additional $1 million in grants to 39 states and the District of Columbia. White-nose syndrome has killed millions of North American bats in recent years, decimating many populations and putting several species at additional risk of extinction.

Bats are crucial to our nation's farmers and foresters, helping control pest insects, such as beetles and locusts, and significantly reducing the amount of toxic pesticides that would otherwise be needed. Studies estimate bats save farmers at least $3.7 billion per year in lost crop revenue and pesticide savings.

Funds will help states support a national strategy for the disease, which includes increasing bat survival rates, preventing further spread, and preparing for the potential arrival of the disease in new areas.

This year's grants bring the total funding to states for WNS response over the last eight years to $8 million. This financial support is part of a USFWS-led, cooperative, international effort involving more than 100 state, federal, tribal, academic, and nonprofit partners.

"These grants are critical to helping states respond to white-nose syndrome," says Jeremy Coleman, National White-Nose Syndrome Coordinator for the USFWS. "We've seen so much collaboration and innovative work from states engaged in the international response."

For example, last year, the Maine Department of Inland Fisheries used funds to search for bats hibernating in rock rubble, because Maine has only a handful of caves and mines where bats hibernate. This year, they plan to expand the search to wells, after talking with their counterparts to the northeast on Prince Edward Island, where bats commonly hibernate in wells. Several other states across the country will also look for bats in places other than caves and mines, where the impacts of the fungus that causes white-nose syndrome have not been thoroughly documented.

First discovered in New York in the winter of 2006 through 2007, the WNS fungus has now spread to at least 36 states and seven Canadian provinces and infects nine of the top ten agricultural producing states.

"Without the grants, many states would be limited in the amount of work they can do to help bats," says Coleman. Funds may be used to support activities addressing WNS, including response planning, population monitoring, sample collection for disease surveillance, containment, and outreach and support of research, such as experimental treatment research funded by the National Fish and Wildlife Foundation's Bats for the Future Fund. ■

TAIL END

Gene always dressed for success, and a quick 18-holes mid-afternoon.

Fox squirrel *(Sciurus niger)*, Ontario, Canada

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

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

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

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

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

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California scrub-jay (*Aphelocoma californica*). See Abstracts, page 30.

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