JOURNAL OF WILDLIFE REHABILITATION

Volume 41, Number 3, 2021



INTERNATIONAL WILDLIFE REHABILITATION COUNCIL

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



ON THE COVER:

Eastern cottontail (*Sylvilagus floridanus*) seen in the wild, apparently considering its options.

PHOTO ©JANE SCHNELKER. USED WITH PERMISSION.

LEFT:

Juvenile California condor (*Gymnogyps californianus*), the largest North American land bird, near the South Rim of Grand Canyon National Park.

PHOTO © GRAND CANYON NPS, MARK LELLOUCH. CC BY 2.0 LICENSE.

IWRC

International Wildlife Rehabilitation Council
PO Box 3197
Eugene, OR 97403 USA
Phone: 866.871.1869
Fax: 408.876.6153
Toll free: 866.871.1869
Email: office@theiwrc.org
director@theiwrc.org
www.theiwrc.org

IWRC

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

Editor
Kieran J. Lindsey, PhD
Center for Leadership in Global Sustainability
Virginia Tech University
JWR Editorial office: St. Louis, Missouri, USA

Art Director
Nancy Hawekotte
Cumulus Creative
Art offices: Omaha, Nebraska, USA

The *Journal of Wildlife Rehabilitation* is published by the International Wildlife Rehabilitation Council (IWRC), PO Box 3197, Eugene, OR 97403 USA. ©2021 (ISSN: 2166-9198). All rights reserved.

JOURNAL OF WILDLIFE REHABILITATION

Volume 41(3)

CONTENTS

PEER-REVIEWED PAPERS

7

Aggressive treatment of young cottontail rabbits (*Sylvilagus* spp.) for coccidiosis resulted in large reduction in gastrointestinal disease mortality from all causes (Colorado, USA)
Gabriele C. Paul and Daniel G. Friend

13

Survival of infant eastern cottontails (*Sylvilagus floridanus*) rehabilitated using a rabbit-specific and non-specific milk replacer: a retrospective study
Pauline Kosmal

18

A case study of complicated Horner's syndrome in a fledgling wild naturalized lilac-crowned parrot
Patricia J. Latas, Brooke Durham, Sarah Mansfield, and Rebecca L. Miller

23

Fostering orphaned pups of endangered San Joaquin kit foxes (*Vulpes macrotis mutica*): three case studies
Brian L. Cypher, Tory L. Westall, Erica C. Kelly, Nicole A. Deatherage, Gregory D. Warrick, and Linda Spiegel

DEPARTMENTS

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

IWRC

BOARD OF DIRECTORS

President
Adam Grogan
RSPCA
Horsham, West Sussex, UK

Vice President
Mandy Kamps
State of Wisconsin
Wausau, Wisconsin, USA

Secretary
Kristen Heitman, CWR
Providence Wildlife Rehabilitation
Westfield, Indiana, USA

Treasurer
Dani Nicholson
Willow Tree Wildlife
Cayucos, California, USA

President-Elect
Suzanne Pugh
RSPCA Branch
Isle of Wight, United Kingdom

Brooke Durham
Rep4Wildlife
San Diego, California, USA

Deborah Galle
Cornell University Veterinary Specialists
Greenwich, Connecticut, USA

Ashley Ihrke
Hudson, WI, USA

Lindsay Jones
Victor, Idaho, USA

Jayanthi Kallam
Avian and Reptile Rehabilitation Centre
Bangalore, India

Patricia Latas, DVM
Tucson, Arizona, USA

Max Lipman
International Wildlife Rescue Response
California, USA

Kai Williams
Executive Director

Julissa Favela
Program Manager

Micayla Harland
Bookkeeper

Katie McInnis
International Programs Supervisor

Aya Cockram
Program Coordinator

EDITORIAL

The Patient's Perspective

When I started attending IWRC conferences, exactly 20 years ago, I was interested in the differences between how wildlife rehabilitation was perceived in the U.K. and the U.S. In the U.S., it seemed to me that the focus was on the role of wildlife rehabilitation in wildlife conservation. I heard very few mentions of animal welfare. This was of interest to me because I work for an organization that rehabilitates over 15,000 wild animals a year (and rescues many more), all in the name of animal welfare. Roll forward 20 years and the situation has changed dramatically: the latest edition of the Standards for Wildlife Rehabilitation (formerly Minimum Standards) focuses on welfare, and the 2nd edition of Comprehensive includes a chapter on animal welfare.

Some may think that conservation and animal welfare are easy bedfellows, but this is not always the case. Conservation has historically been more concerned with populations of animals, so methods may be used that may harm individuals of one species to protect another. This is changing. Initiatives like Compassionate Conservation recognise the need to understand how individuals function within a population to best conserve that population—how individual traits can impact an individual's ability to survive, breed, or find new territories—important attributes for an animal we want to survive in the wild.

Wildlife rehabilitators receive individuals that need specialist care if they are to be rehabilitated successfully and released to integrate into the wild population. This process requires an understanding of an animal's welfare to assess its progress through the care regime, but consideration of how the animal feels about the situation has been lacking in our approach. We like to think we know, but we are prone to anthropomorphize and often decide an animal is "happy" without truly considering how it feels.

Consider amputation and permanent captivity. We've kept animals alive because we could, and then sought homes for them, rather than asking if this animal *should* be kept alive and caged for the rest of its life.

Advances in how we assess animal welfare have provided us with a tool—the five domains model—to evaluate an animal's mental state—how it feels —by measuring things we can see, such as diet, accommodation, behaviour, and health, and considering how they affect that individual's mental state. Such tools force us to rethink how we look after animals in our care, to consider if we are acting in an animal's best interests or our own, and, importantly, to help us develop better decision-making protocols that are focused on the animal.

Consideration of animal welfare goes beyond the interests of animals currently in care. Many rehabilitators are also educators. When planning education programs, we should start by asking what is it we want to teach our audience (whether children, adults, or particular communities). We can use the 3 Rs—replace, reduce, refine—as a framework to plan such programs:

Replace. Do we need to use captive animals? What alternatives are there? (like directly observing the animal in the wild doing what they have evolved to do);

Reduce. If we do need to use captive animals, how many, and of what species?

Refine. How can we deliver our messages in a way that minimises the impact on the welfare of the animals involved?

More recently, the Fish and Wildlife Service in the U.S. has started to ask more questions about animal welfare and exploring how to provide better welfare to animals under human care. I welcome this new approach. The IWRC is involved in this process, along with many partner organizations, as an advocate for animal welfare. I am pleased to see this progress as my tenure as President comes to an end. I will continue to be involved, as the development of wildlife rehabilitation standards and regulations in the U.S. is important to promote better standards for animal welfare in wildlife rehabilitation worldwide.

—Adam Grogan, *President*

First Test of Wildlife Morbidity and Mortality Event Alert System

LOWER LAKE, CALIFORNIA *(July 14, 2021)*—A study describing the first test of the Wildlife Morbidity and Mortality Event Alert System was published this summer in the open access journal *Proceedings of the Royal Society B*. The project is a collaboration of University of California Davis, School of Veterinary Medicine, California Department of Fish and Wildlife, and Wild Neighbors Database Project.

"Human-induced disturbances are contributing to a wide range of threats—habitat loss, invasive species introductions, pollution, disease, wildfires," said co-lead author Terra Kelly, a wildlife epidemiologist at the UC Davis One Health Institute and its Karen C. Drayer Wildlife Health Center within the School of Veterinary Medicine. "It speaks to the need for a system like this where we can better understand the threats facing wildlife populations and respond to them in a timely way so there's less harm to wildlife."

UC Davis explains that wildlife rehabilitation workers are the front-line responders of the free-ranging animal world. They are the first to receive and tend to sick and injured wild animals. Their clinical reports carry a wealth of information that, when shared, can indicate broader patterns.

"I'm thrilled that WRMD is not only useful for thousands of wildlife rehabilitators but that the data collected by them is used for morbidity and mortality monitoring," co-author Devin Dombrowski said. "To witness the WMME Alert System identifying data anomalies and alerting investigators is incredible."

The California Department of Fish and Wildlife is using the system to help identify and prioritize wildlife needs and conservation efforts. "The near real-time information this system provides has allowed us to quickly follow up with diagnostic testing to identify the problem," said Krysta Rogers, senior environmental scientist at the CDFW's Wildlife Health Laboratory. "This system also has been instrumental in determining the geographic range and severity of the threat."

Kelly notes that being able to monitor and rapidly detect wildlife morbidity and mortality events is important for all species, humans included. The alert system combines machine-learning algorithms, natural language processing, and statistical methods used for classifying cases and establishing thresholds for alerts with the ecology and distribution of wildlife within the test area of California, said co-leading author Pranav Pandit, a researcher in the UC Davis One Health Institute and its EpiCenter for Disease Dynamics.

"The wildlife rehabilitation organizations' data is making such valuable contributions," Pandit said. "That's all coming together in this highly adaptable surveillance system."

Organizations across 19 countries use the related Wildlife Rehabilitators Medical Database (WRMD).

Sources: Press release by UCDavis and personal conversation with Wild Neighbors Database Project co-founder Rachel Avilla.



PHOTO © ANDREAS KAY. CC BY 2.0 LICENSE.

Harlequin frog *Atelopus spumarius* (commonly called the Pebas stubfoot toad) from the Amazon rainforest of Ecuador.

Protecting Harlequin Toads from Chytrid Fungus

AUSTIN, TEXAS *(Aug 25, 2021)*—Atelopus Survival Initiative (ASI) is a new alliance of more than 40 organizations from 13 countries formed specifically to support the genus *Atelopus*.

While amphibian researchers and conservationists have worked for many years to save harlequin toads (which make up the *Atelopus* genus) and groups of species in individual countries, the ASI is bringing them together for the first time to pool the resources, decades of experience and knowledge necessary to prevent the extinction of the entire genus of harlequin toads across the region where these species still survive.

"As an incredibly diverse group of amphibians facing a number of threats, harlequin toads require innovative solutions coming from a diverse group of individuals and organizations with different expertise, knowledge and capacities," said Lina Valencia, ASI founder, co-coordinator of the IUCN SSC Amphibian Specialist Group Atelopus Task Force and Andean countries coordinator for Re:wild,

one of the primary ASI conveners. "More than ever before, we need a constellation of champions working together to bring harlequin toads back from the brink of extinction. The ASI underscores the vital need to implement on-the-ground conservation actions that will mitigate the main threats to this beautiful group of amphibians."

The fungus *Batrachochytrium dendrobatidis* (Bd) causes the lethal disease chytridiomycosis, which has resulted in amphibian declines all around the world, including in Australia and the western United States. Although Bd may likely be the primary driver of these declines, a number of other threats are exacerbating the precipitous drops in population numbers. This includes habit destruction and degradation (as the result of animal agriculture, logging, mining and infrastructure development), the introduction of invasive species such as the rainbow trout that prey on harlequin toad tadpoles, pollution, illegal collection for the pet trade, and the effects of climate change.

The ASI and its members, including governments, local communities and Indigenous peoples, will collaboratively address each of these threats—and new ones as they arise—across the genus's full range, taking into account the social, political and cultural realities of each of the 11 countries where harlequin toads are found.

"With their beautiful songs and unique lifestyles, amphibians are among the most extraordinary animals on Earth, and among them, harlequin toads stand out for their amazing colors," said Luis Fernando Marin da Fonte, coordinator of the ASI and director of partnerships and communications for the Amphibian Survival Alliance. "But these colorful and delicate jewels are becoming increasingly rarer. Harlequin toads must be protected not only because of their beauty and uniqueness, but also because of their intrinsic value and biological, ecological and even cultural importance."

The initiative's newly developed Harlequin Toad (*Atelopus*) Conservation Action

CONTINUED ON PAGE 30

Letter to the Editor

March 21, 2021

Dear Editor,

We were dismayed to read the article "Raccoon roundworm as an occupational hazard to caregivers of captive wildlife" in a recent issue of the *Journal of Wildlife Rehabilitation* (Vol. 41(1), pp. 7–14, 2021). The research described in this article included the trapping and killing of 50 native wild animals. The research justification for this trapping and killing is questionable, despite the approval of institutional review boards. Much of the information gleaned from the carcasses is already known and available in the published literature. The authors further suggest that the trapping and killing represented an attempt at "lethal raccoon removal" (i.e., killing of "nuisance" animals). These practices and research methods are antithetical to the Wildlife Rehabilitator's Code of Ethics[1] as well as to the mission of the IWRC ("promotes wildlife conservation and welfare"). In our opinion, this article does not belong in a journal that represents the field of wildlife rehabilitation. We are concerned that publication of articles using methods such as these may be seen as condoning them.

The IWRC treatise on Wildlife Rehabilitation notes that "One of the guiding principles in any wildlife research should be that collecting the information should never compromise the animals."[2] Similar data to that obtained from killing 50 healthy animals could have been gathered through non-lethal means.

An interesting perspective from Field et al.[3] states that "publication of methods that contravenes animal welfare principles risks perpetuating inhumane approaches and bad science." We suggest that the IWRC consider establishing explicit ethical guidelines for wildlife research associated with rehabilitation, and require adherence to these guidelines for all of their publications and supported research projects. At minimum, authors must abide by the Wildlife Rehabilitator's Code of Ethics as a prerequisite for publication in the *Journal of Wildlife Rehabilitation.* This would give JWR the opportunity to play a leadership role in advancing wildlife research ethics.

1. Wildlife Rehabilitator's Code of Ethics. 2021. https://www.nwrawildlife.org/page/Code_of_Ethics_Rehab. Accessed 20 Mar 2021.
2. Grogan A. Research. In: Poisson K, Weiss R, editors. Wildlife rehabilitation: A comprehensive approach. Eugene (OR): The IWRC; 2016. p. 333.
3. Field KA, Paquet PC, Artelle K, Proulx G, Brook RK, Darimont CT. Publication reform to safeguard wildlife from researcher harm [published correction appears in *PLoS Biol.* 2020 May 18;18(5):e3000752]. *PLoS Biol.* 2019;17(4):e3000193.

Sincerely,

Gabriele Paul and Daniel Friend
Colorado Wild Rabbit Foundation

Reply from the IWRC:

Dear Gabriele Paul and Daniel Friend,

Thank you for your letter in regards to "Raccoon roundworm as an occupational hazard to caregivers of captive wildlife" published in Volume 41(1). Your feedback has prompted a board-level discussion regarding a review of the *JWR* research standards, considering both animal welfare and benefits to practice, amongst ourselves and the *Journal of Wildlife Rehabilitation* editorial team.

Many thanks for the references you provided, which we will be considering as part of our review. In addition to the texts referenced in your letter we will also consider the article, "Journal Editorial Policies, Animal Welfare, and the 3Rs," by N. Osborne, D. Payne, and M. Newman in *The American Journal of Bioethics.* (2009 December; 9(12): 55–59. DOI: 10.1080/15265160903318343.)

Sincerely,

Kai Williams, *Executive Director*
Adam Grogan, *President*
Kieran J. Lindsey, *Editor*

Aggressive treatment of young cottontail rabbits (*Sylvilagus* spp.) for coccidiosis resulted in large reduction in gastrointestinal disease mortality from all causes (Colorado, USA)

Gabriele C. Paul[1] **and Daniel G. Friend**[1]

PHOTO PROVIDED BY AUTHOR.



A juvenile desert cottontail rabbit (*Sylvilagus audubonii)* undergoing rehabilitation at the Colorado Wild Rabbit Foundation.

AUTHOR AFFILIATIONS
[1]Colorado Wild Rabbit Foundation, Erie, CO, USA.

ABSTRACT: Gastrointestinal diseases are major causes of mortality in young cottontail rabbits (*Sylvilagus* spp.) undergoing rehabilitation. During the four-year period from 2017 through 2020, the Colorado Wild Rabbit Foundation implemented increasingly aggressive protocols for the treatment and prophylaxis of coccidiosis. This resulted in a large (75%) decrease in gastrointestinal disease mortality from all causes.

KEYWORDS: Coccidiosis, cottontail, gastrointestinal disease, *Sylvilagus*, wildlife rehabilitation.

Introduction

Gastrointestinal (GI) diseases are major causes of morbidity and mortality in young cottontail rabbits (*Sylvilagus* spp.),[1] with coccidiosis, acquired in the wild or during rehabilitation, being a significant component.[2] During the four-year period from 2017 through 2020, the Colorado Wild Rabbit Foundation implemented increasingly aggressive protocols for the treatment and prophylaxis of coccidiosis. Prior to 2019, we had been successful in treating most clinical cases of coccidiosis with toltrazuril 5% solution (Baycox, Bayer Inc., Mississauga, ON, Canada). However, we had not been as successful in treating bacterial enteropathies, especially clostridial enterotoxemia,

CORRESPONDING AUTHOR
Gabriele C. Paul
Colorado Wild Rabbit Foundation
PO Box 1253
Erie, CO 80516 USA
E: cowildrabbit@yahoo.com

J. Wildlife Rehab. 41(3): 7–12. © 2021 International Wildlife Rehabilitation Council.

which often accompany coccidial infections; additionally, we frequently missed cases of coccidiosis. Therefore, GI disease was still a major cause of death in our patients. Beginning in 2019, we adopted a more proactive approach to the treatment and prophylaxis of coccidiosis, which resulted in a large reduction in GI disease mortality from all causes. The results of our retrospective study are consistent with a suggestion of Lenz,[3] who implied a broad benefit from prophylactic treatment for coccidiosis in cottontail rabbits using a coccidiostat.

Methods

For this retrospective study, we included all immature cottontail rabbits received at our facility from 2017 through 2020 that had survived 24 hours after intake, i.e. had not been euthanized or died on arrival. Rehabilitation outcomes were categorized as released, mortality from GI disease, or death from all other causes. A presumptive diagnosis of gastrointestinal disease was established from clinical signs prior to death and through gross necropsy analysis; only individuals with clear post-mortem evidence of GI disease were assigned GID (gastrointestinal disease) as the cause of death. (See Figs. 1 and 2 for characteristic necropsy signs of coccidiosis and clostridial enterotoxemia. During our initial research into GI diseases in our patients[2], we submitted numerous samples for histopathology, culture, and PCR to confirm our diagnoses and rule out other pathogens. We found the lesions depicted to be indicative of the respective diseases and easily identifiable on gross necropsy.) Other causes of death included injuries and infections from domestic cat (*Felis catus*) predation (the largest category), neurologic disease, trauma, emaciation, etc. All animals considered in this study either died in our care or were released to the wild according to consistent criteria. Below, we outline three different protocols that were evaluated through their outcomes. The first protocol (I) spans two years (2017 through 2018). The second (II) and third (III) protocols were used in 2019 and 2020, respectively.

In 2017 through 2018 (I), we only treated cases of suspected coccidiosis based on clinical signs, e.g., diarrhea and/or abnormally shaped feces (Fig. 3) and presence of oocysts in feces (Fig. 4). In 2019, we implemented a more aggressive approach (II) that involved treating all patients exhibiting clinical signs suggestive of GI disease, including those with only mild or only behavioral signs (primarily agitation and posture, as in Fig. 5). In 2020 (III), we began prophylactically treating all young cottontail rabbits, beginning at intake (or when their eyes opened and they began eating solids), and continuing until release. The typical stay for these patients ranged from two to four wks.

Toltrazuril (5% solution) was the sole drug considered in this study. The dose of toltrazuril we used for *treating clinical disease* was 25 mg/kg, given orally once per day for up to five days, until clinical signs subsided. We used this same dose (orally once per day) for *prophylaxis,* following a schedule of two days on and five days off.

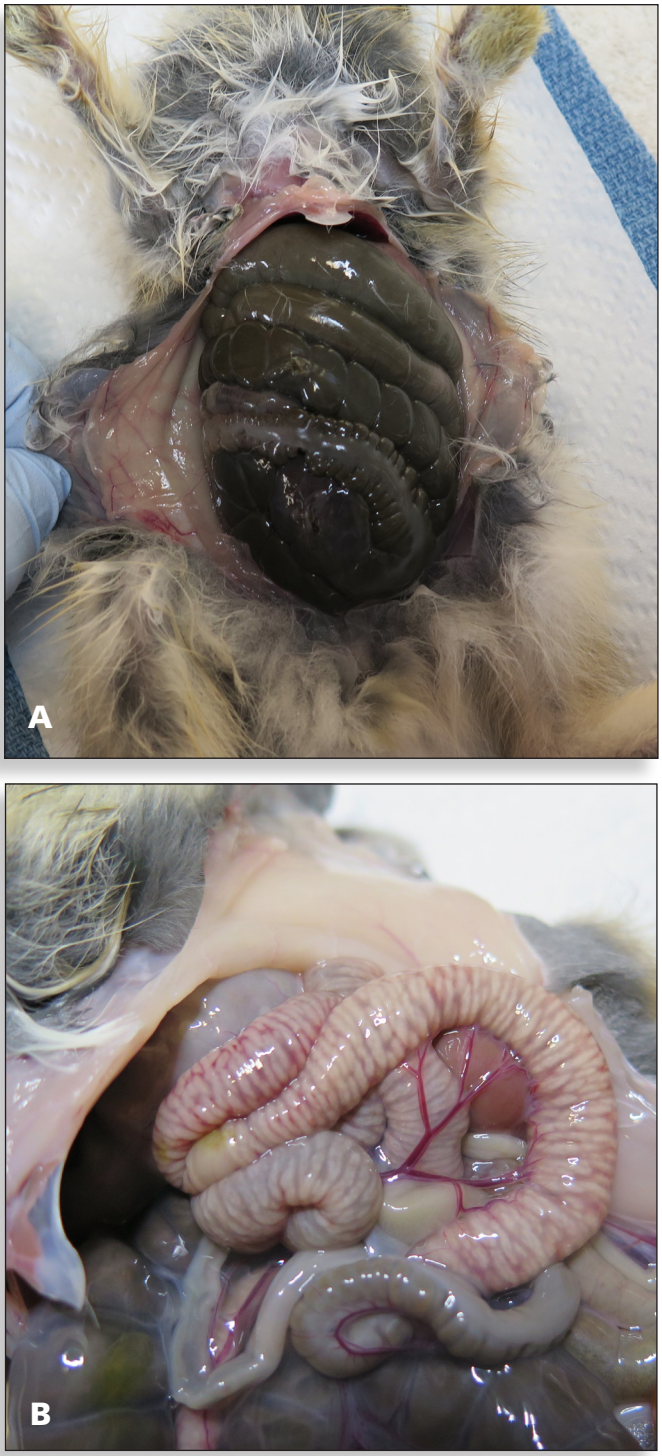


FIGURE 1. Characteristic necropsy signs of coccidiosis in immature cottontail rabbits: a) impacted cecum; b) jejunal lesions.

Results

Table 1 summarizes outcomes associated with these protocols. The table includes both raw numbers and mortality ratios, defined as the number of deaths (from a specific cause or overall) divided by the total number of individuals studied in a given year. The mortality ratios associated with GI diseases using Protocol I are 29% and 26% in 2017 and 2018, respectively. These are statistically similar ($p = 0.43$, two-tailed z-test). The decrease in



FIGURE 2. Blood-tinged, edematous cecum from a cottontail rabbit with clostridial enterotoxemia.



FIGURE 3. Soft and misshapen feces from a cottontail rabbit with coccidiosis.



FIGURE 4. Oocysts in the feces from a cottontail rabbit with coccidiosis (400x magnification).



FIGURE 5. Cottontail rabbit ill with coccidiosis. Note piloerection, and hunched posture with front and hind legs close together.

the number of patients in the study after 2017 reflects capacity limitations at our facility. We were not able to directly compare results prior to 2017 (i.e., with no use of toltrazuril), as other aspects of rehabilitation protocols, GI disease protocols, and release protocols were evolving during this period and would have confounded any comparisons. However, it is generally concluded that mortality ratios from GI disease in young cottontails undergoing rehabilitation (either untreated or with less effective protocols) are extremely high, often more than 50%.[4,5]

The more aggressive treatment of Protocol II in 2019 resulted in a mortality ratio from GI disease of 13%; essentially, the mortality ratio from GI disease was cut in half. Significantly, the overall mortality ratio in this population is proportionately reduced (from a 2017/2018 combined value of 48% down to 36%), indicating that the populations under study and outcomes of treatment for non-GI morbidity are similar: the increased use of toltrazuril was not accompanied by any serious adverse pathology. Finally, our most aggressive treatment/prophylaxis protocol (III) in 2020 resulted in a mortality ratio from GI disease of 7%, a 75% decrease in mortality ratio (from GID) compared to the two years using Protocol I ($p < 0.0001$, one-tailed z-test). The overall mortality ratio in these populations is also down between 2019 and 2020, but the ratio from "other causes" remains roughly the same ($p = 0.21$, two-tailed z-test, not significantly different), indicating that outcomes for diseases other than GI disease were not substantially affected by our protocol changes.

Discussion

The success of Protocol III in reducing the GI disease mortality ratio seemed to be due to better treatment of undiagnosed cases of coccidiosis. Importantly, it was accompanied by a reduction in mortality from clostridial enterotoxemia. This was established through necropsies, Gram stains, and PCRs. Prior to implement

TABLE 1. Mortality ratios for immature cottontail rabbits (*Sylvilagus* spp.) using three anticoccidial protocols.

YEAR	PATIENTS TREATED WITH TOLTRAZURIL	NO. PATIENTS	NO. DEAD	MORTALITY RATIO	NO. DEATHS DUE TO GID*	MORTALITY RATIO GID	NO. DEATHS DUE TO OTHER	MORTALITY RATIO: OTHER
2017	(I) Clinical coccidiosis cases only	360	168	47 %	104	29 %	64	18 %
2018	(I) Clinical coccidiosis cases only	228	115	50 %	59	26 %	56	25 %
2019	(II) All with GID* clinical signs	222	81	36 %	29	13 %	52	23 %
2020	(III) All, prophylactically	201	52	26 %	15	7 %	37	18 %

*Gastrointestinal disease

ing Protocol III, clostridial infections due to *Clostridium spiroforme* and *Clostridioides difficile* were a common cause of death in our patients; with Protocol III, such findings were rare. We suspect that prior to Protocol III, clostridial pathogens may have proliferated in the presence of untreated coccidial infections.[2,6] The release ratio (R_{24} = 74 %) for this cohort in 2020 seems to be a clear signal of an improved protocol.

While many drugs, primarily coccidio*stats*, are used for prevention and treatment of coccidiosis in domestic/European rabbits (*Oryctolagus cuniculus*),[7,8] toltrazuril is coccidio*cidal*,[9] and we have found it to be highly effective in treating even advanced coccidiosis.[2] For prophylaxis, we considered options using coccidiostats, including medicated feed or water. However, an important component of wildlife rehabilitation involves acclimating patients to the natural foods they will encounter upon release,[10] so limiting their diet to pelleted feed (required to achieve therapeutic doses of medication) could compromise their post-release survival. Also, daily water intake has not been established for these species, some of which are adapted to arid environments (e.g. desert cottontails, *Sylvilagus audubonii*); this may limit the possibility of dosage through drinking water. An advantage to using the coccidiocide toltrazuril (or its metabolite ponazuril (Marquis, Merial Inc., Duluth, GA) as described by Harrenstien[11]) for prophylaxis is that it may be effective with a less frequent dosing schedule. This would avoid stressful daily handling and administration of drugs, often unpalatable to cottontail rabbits, for extended periods, as might be needed for coccidiostatic drugs. For this study, we adopted the dosing schedule from Harrenstien[11] (e.g. two days on, five days off).

As mentioned above, the dose of toltrazuril we used for both treatment and prophylaxis was 25 mg/kg. Carpenter[12] lists a dose of 25 mg/kg given orally once a day for two days, repeated after five days, as one option. Other, lower doses are also included in this formulary, and are commonly seen in other references.[13] However, we have found the higher dose to be more effective in quickly reducing clinical signs in critically ill patients. We have been using 25 mg/kg for over 5 yrs with no adverse effects observed. It is possible that a lower dose would be adequate for mild infections or prophylaxis.

While deaths from GI disease were reduced considerably using the above prophylaxis protocol (III), there remain some issues of concern. First, we saw some cases in which clinical signs of coccidiosis appeared between treatments (during the five-day "off" period), and we had to resort to our active disease protocol of daily treatment for up to five days. We then resumed the prophylaxis schedule, continued until release, in case of infection with a different species of coccidia or if immunity had not been completely established. We have not determined whether the two-day "on" period was insufficient to clear any previously established infection, or if the five-day "off" period may have been too long and allowed these rabbits to become infected and symptomatic. Another concern with our protocol is the potential for development of anticoccidial resistance to toltrazuril; this has been documented in a number of livestock species,[14] and it may be only a matter of time before resistance appears in populations of cottontail rabbits if our protocol is widely adopted. A different approach, probably involving a rotating schedule of coccidiostats, as is common in the domestic rabbit farming industry,[15] should be investigated for prophylaxis in cottontail rabbits in order to preserve the efficacy of toltrazuril for treating acute disease.[16]

At our facility, we regularly receive juvenile rabbits with severe coccidiosis, acquired in the wild, with body weights of up to 350 g (rarely over 400 g). This suggests that they remain susceptible to this disease until that weight/age. However, we release our patients at weights of 220–250 g,[17] suggesting that if they had not been infected and acquired immunity prior to release (either before intake or while in our care), they may still be susceptible to coccidiosis post-release. Therefore, the development of a vaccine

for this disease would be valuable. While some progress towards such a vaccine has been made in the domestic rabbit farming industry,[18] it is not commercially available (although a vaccine exists for the poultry industry[15]).

Since GI diseases and associated morbidities and mortalities in young cottontail rabbits present a frequent challenge for wildlife rehabilitators, implementing a protocol for the treatment and prophylaxis of coccidiosis may be a highly effective and straightforward means of increasing success in rehabilitating these species. While our practices have produced good results, further research is needed to establish optimal protocols, including establishing minimum effective doses for treating critical cases, preventing coccidiosis in general, ensuring that immunity has been established prior to release, and effectively suppressing opportunistic and co-infections.

Disclaimer

The authors received no financial support from any manufacturer or organization mentioned or cited in this paper for the research, authorship, and/or publication of this article, and assert that no conflicts of interest are present. The authors affirm that all animals enrolled in this study received the highest standards of rehabilitation care, conforming to ethical guidelines of the Colorado Wild Rabbit Foundation, the International Wildlife Rehabilitation Council, and the National Wildlife Rehabilitation Association; all interactions with these animals were in accordance with the relevant local, state, national, and international laws, rules, treaties, and regulations for such interactions.

Literature Cited

1. Paul GC, Friend DG. Comparison of outcomes using two milk replacer formulas based on commercially available products in two species of infant cottontail rabbits. *J Wildl Rehabil.* 2017;37(1):13–9.
2. Paul GC, Friend DG. Clostridial Enterotoxemia and Coccidiosis in Weanling Cottontail Rabbits (*Sylvilagus audubonii, Sylvilagus floridanus, Sylvilagus nuttallii*) from Colorado, USA. *J Wildl Dis*. 2019;55(1):189–95. https://doi.org/10.7589/2018-02-026.
3. Lenz JL. Letter to Editor. *Wildlife Journal: Journal of the Wildlife Rehabilitation Council.* 1983;6(3):15.
4. Oberly M. An Assessment of Infant Eastern Cottontail Rehabilitation Success. [Undergraduate Honors Thesis]. Columbus (OH): School of Environment and Natural Resources, Ohio State University; 2015.
5. Santos ARBMF. Eastern cottontail rabbit (*Sylvilagus floridanus*) admission causes, corresponding outcomes and period in treatment at the Wildlife Rehabilitation Center of Minnesota: A retrospective study from 2011 to 2017 [Master's Thesis]. [Lisbon (Portugal)]: University of Lisbon, Faculty of Veterinary Medicine; 2018.
6. Barthold SW, Griffey SM, Percy DH. Rabbit. In: Barthold SW, Griffey SM, Percy DH, editors. Pathology of Laboratory Rodents and Rabbits, 4th ed. Ames (IA): Wiley-Blackwell; 2016. p. 273–5.
7. Varga M. Digestive Disorders. In: Textbook of Rabbit Medicine. 2nd ed. Edinburgh (UK): Elsevier; 2014. p. 338–42.
8. Carpenter JW. Antiparasitic Agents Used in Rabbits. In: Carpenter JW, Marion CJ, editors. Exotic Animal Formulary. 5th ed. St. Louis (MO): Elsevier; 2018. p. 500–2.
9. Stock ML, Elazab ST, Hsu WH. Review of triazine antiprotozoal drugs used in veterinary medicine. *J Vet Pharmacol Therap.* 2018;41(2):184–94. https://doi.org/10.1111/jvp.12450.
10. Perlman J. Nutrition. In: Wildlife Rehabilitation: A Comprehensive Approach. Poisson K, Goodman M, editors. Eugene (OR): The IWRC; 2016. p. 146–80.
11. Harrenstien L, Finnegan M, Case A, Woodford N, Mansfield K, Garner M, Becker P. Disease Issues Affecting Species Recovery of Pygmy Rabbits. In: Proceedings of the Association of Avian Veterinarians; 2011. p. 433–8.
12. Carpenter JW. IBID. Toltrazuril. p. 502.
13. Miller EA, Goodman M, Cox S. Toltrazuril. In: NWRA



PHOTO © J N STUART. CC 2.0 LICENSE.

Desert cottontail *(S. audubonii),* Albuquerque, New Mexico.

Wildlife Formulary. 4th ed. Miller EA, Goodman M, Cox S, editors. St. Cloud (MN): The National Wildlife Rehabilitators Association; 2017. p. 192.
14. Odden A, Enemark HL, Ruiz A, Robertson LJ, Ersdal C, Nes SK, Tømmerberg V, Stuen S. Controlled efficacy trial confirming toltrazuril resistance in a field isolate of ovine *Eimeria* spp. *Parasit Vectors*. 2018;11(1):394. https://doi.org/10.1186/s13071-018-2976-4.
15. Noack S, Chapman HD, Selzer PM. Anticoccidial drugs of the livestock industry. *Parasitol Res.* 2019;118(7):2009–26. https://doi.org/10.1007/s00436-019-06343-5.
16. Saunders RA, Davies RR. Coccidiosis. In: Notes on Rabbit Internal Medicine. Ames (IA): Blackwell Publishing; 2005. p. 183.
17. Paul GC, Friend DG. Body Weight as an Indicator of Vulnerability to Domestic Cat Predation for Juveniles of Three Species of Cottontail Rabbits (*Sylvilagus* spp.) in Colorado, USA: Implications for Release Criteria. *J Wildl Dis*. 2020; 56(4):965–7. https://doi.org/10.7589/JWD-D-20-00036.
18. Song H, Dong R, Qiu B, Jing J, Zhu S, Liu C, Jiang Y, Wu L, Wang S, Miao J, Shao Y. Potential Vaccine Targets against Rabbit Coccidiosis by Immunoproteomic Analysis. *Korean J Parasitol*. 2017;55(1):15–20. https://doi.org/10.3347/kjp.2017.55.1.15.

About the Authors

Gabriele C. Paul has been involved in wildlife rehabilitation since 2007, and has focused on lagomorph rehabilitation since 2013. She is the co-founder and Director of the Colorado Wild Rabbit Foundation. Gabriele has a master's degree in biology from the University of Colorado and is a Certified Wildlife Rehabilitator (CWR). She is licensed by the state of Colorado for the rehabilitation of small mammals.

Daniel G. Friend has been involved in lagomorph rehabilitation since 2010, and was a founding Director of the Colorado Wild Rabbit Foundation in 2013, in which he maintains an active role. He recently retired as a research physicist (Cornell University, AB and University of Colorado, PhD) and continues active leadership roles in several domestic and international physics-focused organizations.

Survival of infant eastern cottontails (*Sylvilagus floridanus*) rehabilitated using a rabbit-specific and non-specific milk replacer: a retrospective study

Pauline Kosmal[1,2]



PHOTO PROVIDED BY AUTHOR.

AUTHOR AFFILIATIONS
[1] Department of Animal Sciences, University of Guelph, Guelph, Ontario, Canada
[2] Shades of Hope Wildlife Refuge, Ontario, Canada (prior position as seasonal supervi-

ABSTRACT: This paper reports the release rate of infant eastern cottontails *(Sylvilagus floridanus)* raised at a southern Ontario rehabilitation center. Rabbits were either fed Esbilac puppy milk replacer (Formula 1) or Wombaroo rabbit milk replacer (Formula 2) using the same delivery method until weaned. Results show that there was a significant difference in release rate between groups. Rabbits fed Formula 2 rabbit milk replacer were 1.89 times more likely to survive when compared to those fed Formula 1. Energy content was likely a contributing factor to these results. Energy content on an as-fed basis of Formula 2 was 1.56 times higher per feeding when compared to Formula 1.

KEYWORDS: eastern cottontail, Esbilac, milk replacer, survival, Wombaroo, wildlife rehabilitation.

Introduction

Born hairless and with their eyes closed, eastern cottontails are classified as an altricial species and are dependent on their mother for milk several weeks after birth. The average weight of a newborn eastern cottontail is between 28 and 40 g.[1] Weaning typically begins around 15 days of age or 115 g.[2,3,4] Due to the limited number of feedings and the need for rapid growth, rabbit milk is considerably rich and high in energy.[5,6]

Common milk replacers used for feeding young eastern cottontails in rehabilitation include kitten milk replacer (KMR) and Esbilac puppy milk replacer; however, these alone are likely insufficient nutritionally.[7] In order to meet the caloric requirements, it has been determined that Multi Milk or heavy cream should be added.[8] Other milk replacers include goat milk or goat milk replacer and added UltraBoost.[4]

Rabbit milk is specialized in the sense that it is high in energy when compared to other mammalian species and contains a unique saturated short chain fatty acid profile[6,9] The short chain fatty acids capric acid (C10:0) and caprylic acid (C8:0) form a 'milk oil' in the stomach of rabbits which acts as an antimicrobial factor to reduce the risk of gastrointestinal infection.[9] Formula 2 has high fat and protein content as well as the antimicrobial-forming fatty acids found in mother rabbit milk. Previous studies have

CORRESPONDING AUTHOR
Pauline Kosmal
Department of Animal Biosciences
University of Guelph
50 Stone Road E
Guelph, Ontario N1G 2M7
Canada
P: 647.219.5840
E: pkosmal@uoguelph.ca

J. Wildlife Rehab. 41(3): 13–17. © 2021 International Wildlife Rehabilitation Council.

TABLE 1. Energy content of milk replacers used for captive-reared eastern cottontails where energy content on an as-fed basis is represented by ME and body weight is represented as BW.

	FORMULA 1	FORMULA 2
Instructions	1-part Esbilac powder[16] + 2 parts water	For 500 mL, mix: 180g Wombaroo powder + 330mL water[18]
ME	900 kcal/kg[17]	2,063 kcal/kg[18]
Amount Fed	10% BW[8]	6.78% BW18

*Energy content for Formula 2 was converted to kcal/kg on an as fed basis.

TABLE 2. Feeding and housing guidelines used for infant eastern cottontails from 2015–2019.

WEIGHT (G)	SIZE OF TUBE USED (FR)	FEEDING FREQUENCY	HOUSING
60–80	5.0 White	BID	Box
80–100	6.0 Grey	BID	Indoor enclosure
100–115	7.0 Green	BID	Indoor enclosure
115–120	7.0 Green	SID	Indoor enclosure
120+	N/A	Not Fed	Released at 125+

assessed survival and morbidity of hand-raised eastern cottontails fed different formulas[4,10] but did not assess the effects of feeding a rabbit-specific milk replacer. Therefore, the purpose of this study is to determine if there is a difference in survival between unweaned eastern cottontails fed puppy milk replacer and those fed rabbit milk replacer.

Materials and Methods

Study Design

The study was conducted between the years 2015–2016 and 2018–2019 at Shades of Hope Wildlife Refuge located in Pefferlaw, Ontario, Canada. Data from 2017 is excluded from this study because it was incomplete. All unweaned eastern cottontails admitted in the described time frame were included in this study. However, in agreement with a similar study by Paul and Friend,[10] subjects that died or were euthanized within 3 days of admission were removed from the data, resulting in a total of 508 individuals.

Upon admission, the date, initial weight, and injuries or illnesses were recorded (Tables 3 and 4). Any injured or ill rabbit entering care received medication immediately following admission, according to guidelines set by the NWRA Wildlife Formulary.[11] Age of eastern cottontails was determined both by weight and developmental indicators. Unweaned rabbits were considered infants. Due to the number of intakes and resources available, eastern cottontails with eyes closed were transferred to another facility when possible, or humanely euthanized.

Treatment of Gastrointestinal Illness

Gastrointestinal illness is a large concern for rehabilitated eastern cottontails. Common gastrointestinal illnesses observed in infants include clostridial enterotoxemia and coccidosis.[12] The clinical symptoms associated with these illnesses include anorexia, diarrhea, collapse, GI stasis, cecal impaction, and sudden death.[13] If symptoms of coccidosis appeared and were identified by fecal floatation, Baycox® (toltrazuril) at a concentration of 50 mL/mg, obtained from Bayer, was given at 5 mg/kg for treatment.[8]

Enclosure description

Enclosures were consistent with IWRC minimum standards (Table 2).[14] Less active infant eastern cottontails (<80 g) were housed with littermates in boxes (10 gallons or greater) until they became more mobile. Boxes were punctured with holes, lined with fleece, and contained nests made of grass and hay. Active infants (>80 g) were housed in indoor enclosures with their littermates when possible. The indoor enclosures consisted of four pens, 47 × 29.5 × 47 inches each, and were located in a separate room to minimize noise. Enclosures had three closed-off walls with wire grate doors to allow natural lighting to enter; however, in order to prevent injury, a visual barrier was built at the base of each door. Each enclosure also included at least one place to hide with the entranceways facing away from the door. Healthy singletons were housed with conspecifics at a similar developmental stage. The number of rabbits housed in a single pen was determined by the total number of rabbits in care.

Feeding

Rabbits admitted between 2015 and 2016 were tube fed Formula 1 and rabbits admitted between 2018 and 2019 were tube fed Formula 2 (Tables 1 and 2). All eastern cottontails were provided with hay and fresh greenery. Hay was provided as an additional source of fiber to reduce the presence of diarrhea as supported by previous research on the relationship of high fiber:starch diets and digestive health in rabbits.[15] Weaned rabbits were provided with oats and occasional native fruits and vegetables. Rabbits were released between 125 and 140 g if healthy, gaining weight, and over 21 days of age.

Results

The following model was used to analyze the dataset in SAS University Edition Version 6.1.0:

$$\textbf{survival} = \mu + \textbf{formula} + \textbf{circumstance of rescue} + \textbf{injuries} + \textbf{year} + \textbf{error}$$

There was a significant formula effect at a 95% confidence interval (P-value 0.024). Release rate was significantly improved with the use of Formula 2 (Table 5).

Formula 1 contained 900 kcal/kg ME[17] on an as-fed basis,

TABLE 3. Reason for admission of infant eastern cottontails kept >72 hours in care.

REASON FOR ADMISSION	2015		2016		2018		2019	
	n	%	n	%	n	%	n	%
Orphan	24	40%	44	40%	85	56%	87	47%
Animal attack	3	5%	28	25%	34	22%	26	14%
Collision	1	2%	1	<1%	5	32%	1	<1%
Entrapment	0	0%	2	2%	0	0%	1	<1%
Inappropriate human possession	6	10%	22	20%	17	11%	7	4%
Nest destruction	25	42%	11	10%	10	7%	63	34%
Undetermined	1	2%	2	2%	2	1%	0	0%

TABLE 4. Category of injury or illness for infant eastern cottontails kept >72 hours in care.

CATEGORY OF INJURY OR ILLNESS	2015		2016		2018		2019	
	n	%	n	%	n	%	n	%
Clinically healthy	5	87%	89	81%	130	85%	135	73%
Infection or inflammatory response	1	2%	0	0%	1	<1%	2	1%
Nutritional	6	10%	14	13%	7	5%	36	19%
Physical injury	0	0%	0	0%	7	5%	6	3%
Spinal trauma	1	2%	3	3%	4	3%	0	0%
Undetermined	0	0%	4	4%	4	3%	6	3%

TABLE 5. Final Disposition of eastern cottontails kept >72 hours in care

YEAR	FORMULA GIVEN	NUMBER ADMITTED	DIED	EUTHANIZED	RELEASED	RELEASE RATE
2015	Formula 1	60	43	4	13	21.7%
2016	Formula 1	110	71	13	26	23.6%
2018	Formula 2	153	86	20	47	30.7%
2019	Formula 2	185	75	43	67	36.2%



FIGURE 1A. Active infant eastern cottontails with ears and fur up.



FIGURE 1B. Less active infant eastern cottontails with ears down and slick fur.

whereas Formula 2 contained 2,063 kcal/kg on an as fed basis. ME for Formula 2 was calculated by converting 24 MJ/kg to 5,732 kcal/kg, then multiplying by 0.36 to account for the 180:330 powder:water ratio, resulting in 2,063 kcal/kg. This energy content is similar to the energy content count in maternal rabbit milk; 8.4MJ/kg (or 2006 kcal/kg).[6]

Formula 1 was offered at 10% bodyweight, whereas Formula 2 rabbit milk replacer was offered at 6.78% bodyweight. Typically, young rabbits are fed 10% of their bodyweight each feeding;[8] however Formula 2 was offered at 6.78% bodyweight at each feeding based on the similarity to maternal milk and the known milk consumption of maternal rabbit milk in rabbits.[6] This means at each feeding rabbits fed Formula 2 received 1.56 times more ME than those fed Formula 1.

Using an odds ratio estimation procedure in SAS, it was determined that rabbits were 1.89 times more likely to survive when fed Formula 2 replacer when compared to Formula 1. The circumstance of rescue, presence of injuries, and year were included as random effects in the model. A COVTEST using SAS determined the covariance parameters (random effects) were not significant sources of variation. The lower survival rate using Formula 1 could be explained by the significant difference in energy content.

Discussion

This retrospective study presents a comparison of release rates in eastern cottontails raised in a Southern Ontario rehabilitation center, fed two different milk replacers. Using previously-collected

data presents with limitations as it pertains to the methods and data collection. Data from previous years was provided to the author for the purpose of this study and, therefore, additional experimental error may have been present. However, to reduce this error, circumstance of rescue, the year, and injury or illness were included as random effects in the model, and those that reached final disposition within three days of admission were excluded from the study. Other parameters that affect final disposition include age, body condition, weight class, presentation number (singleton or in a group), hydration status, and prior human intervention.[19,20]

It is also important to note the difference in energy content between the two milk replacers. Although Formula 1 was fed at a higher percent BW, Formula 2 provided approximately 1.56 times more energy (kcal/kg) at each feeding. Therefore, it is likely that the difference in survival is attributed to the low energy content of Formula 1. Further studies are required to determine if the specific short-chain fatty acid profile could result in fewer mortalities in eastern cottontails given formulas with equal energy content.

Tube feeding allows a controlled amount of formula to be delivered. However, it is understood that it is a controversial practice among rehabilitation centers. Since tube feeding was used, a larger number of individuals could enter care, which offered a larger sample size for the study.

The results of this study suggest that survival of infant eastern cottontails can be improved with the use of a high energy milk replacer. However, further protocol refinement is required to increase the release rate. Due to the role in the diet, rabbits should not be prevented from eating their cecotropes (aka caecal pellets). Cecotropes are the product of the cecum, a part of the digestive systems in order Lagomorpha. Cecotropes are passed through the intestines and subsequently reingested to improve nutrient uptake. Young rabbits begin to consume their mother's cecotropes at two wks of age along with milk, to aid in gut development and digestion.[21] When they can eat solid food, they will begin to ingest their own. Unfortunately, rehabilitation centers rarely have access to cecotropes from healthy rabbits. With limited access to microbes and nutrients found in cecotropes, young rabbits may develop symptoms of bloat and diarrhea which may eventually result in death.[10,15,20]

Conclusion

Eastern cottontails have a high mortality rate, so ensuring the correct milk replacer is chosen is important for their survival.[10] Individual rehabilitation centers can have varying success with eastern cottontails, so it is important to follow a well-researched and predictable protocol.[3] This study suggests that captive-reared eastern cottontail survival can be improved with the use of a milk replacer with suitable nutritional and caloric composition. Further research could assess which aspects of milk replacers have the greatest effect in order to further improve the survival of hand-raised eastern cottontails.

Acknowledgements

I would like to thank my advisor, Dr. Esther Finegan, for her support and encouragement during the writing of this article. I would also like to thank and acknowledge the following staff members at Shades of Hope Wildlife Refuge for their contributions to this study: Gail Lenters (Founder and Board President), Kate Purvis (Wildlife Care Technician), Cathy Stockman (Director of Operations), and Sarah Townson (Wildlife Care Technician). These individuals took part in the proper handling and care of admitted infant eastern cottontails and provided the data presented in this article.

Copyright

The output for this study was generated using SAS® studio software, University Edition 2.8.1 9.4 of the SAS system for UNIX. Copyright © 2012–2018 SAS Institute, Inc.

Literature Cited

1. Swihart RK. Body size, breeding season length, and life history tactics of lagomorphs. *OIKOS,* 1984;43(3):282–90.
2. Tseng FS. Natural history and medical management of lagomorphs. In: Sonia MH, Baron HW, Miller EA, Aguilar RF, Yabsley MJ, editors. Medical Management of Wildlife Species: A guide for practitioners. 1st ed. Hoboken (NJ): John Wiley & Sons, Inc; 2020. p. 186.
3. Hentz P. Cottontail juveniles—Mother knows best. NWRA Symposium. Murfreesboro (TN); 2014. Unpublished.
4. Oberly M. An assessment of infant eastern cottontail rehabilitation success [thesis]. Columbus (OH): Ohio State University; 2015.
5. Coates ME, Gregory ME, Thompson SY. The composition of rabbit's milk. *Br J Nutr.* 1964;18(1):583–6.
6. Maertens L, Lebas F, Szendrö Z. Rabbit milk: A review of quantity and non-dietary affecting factors. *World Rabbit Sci.* 2006;14(4):205–30.
7. Taylor KH. Orphan rabbits. In: Gage LA, editor. Hand rearing wild and domestic mammals. 1st ed. Ames (IA): Blackwell Publishing; 2002. p 5–12.
8. Carpenter JW. Recommendations for the Captive Management of Cottontail Rabbits. In: Carpenter JW, Marion CJ, editors. Exotic Animal Formulary. 4th ed. St. Louis (MO): Elsevier; 2013. p. 527, 672.
9. Cañas-Rodriguez A, Smith HW. The identification of the antimicrobial factors of the stomach contents of sucking rabbits. *Biochem J.* 1996;100(1):79–82.
10. Paul G, Friend DG. Comparison of outcomes using two milk replacer formulas based on commercially available products in two species of infant cottontail rabbits. *J Wildl Rehabil.* 2017;37(3):13–9.
11. Miller EA, Goodman M, Cox S. NWRA Wildlife Formulary. 4th ed. St Cloud (MN): NWRA; 2017.
12. Paul GC, Friend DG. Clostridial Enterotoxemia and Coccidiosis in Weanling Cottontail Rabbits (*Sylvilagus audubonii,*

Sylvilagus floridanus, Sylvilagus nuttallii) from Colorado, USA. *J Wildl Dis.* 2019;55(1):189–95.
13. Varga M. Digestive disorders. In: Textbook of rabbit medicine. 2nd ed. Edinburgh (UK): Elsevier; 2014. p. 338–42.
14. Mammal housing requirements. In: Miller EA, editor. Minimum Standards for Wildlife Rehabilitation. 4th ed. St. Cloud (MN): NWRA & IWRC; 2012. p. 55–61.
15. Gidenne T, Jehl N, Lapanouse A, Segura M. Inter-relationship of microbial activity, digestion and gut health in the rabbit: effect of substituting fibre by starch in diets having a high proportion of rapidly fermentable polysaccharides. *Br J Nutr.* 2004;92(1):95–104.
16. Bewing M, Mitchell MA. Wildlife. In: Manual of exotic pet practice, Mitchell MA, Tully TN Jr, editors. St Louis (MO): Elsevier; 2009. p. 521.
17. Esbilac puppy milk replacer product page. Pet-Ag; c2020 [Accessed 2020 Aug 5]. https://www.petag.com/products/esbilac-puppy-milk-replacer-powder
18. Wombaroo rabbit milk replacer product page. Pet-Ag; c2020 [Accessed 2020 Aug 5]. www.wombaroo.com.au/product/rabbit-milk-replacer/
19. Principati SL, Keller KA, Allender MC, Reich S, Whittington J. Prognostic indicators for survival of orphaned neonatal and juvenile eastern cottontail rabbits (*Sylvilagus floridanus*): 1,256 cases (2012–17). *J Wildl Dis.* 2020;56(3):523–9.
20. Santos RA. Eastern cottontail rabbit (*Sylvilagus floridanus*) admission causes and corresponding outcomes at the wildlife rehabilitation center of Minnesota: a retrospective study from 2011 to 2017 [thesis]. [Lisbon (Portugal)]: University of Lisbon; 2018.
21. Akande KE. The requirements of protein and amino acids in rabbit nutrition and production. *IJCS.* 2015;4(4):13–6.

About the Author

Pauline Kosmal first became involved with wildlife rehabilitation and Shades of Hope during her internship the summer of 2019. She returned to Shades of Hope the summer of 2020 as a seasonal supervisor. Pauline holds a Bachelor of Science in Honours Animal Biology and a Master of Science from the University of Guelph. She has a special interest in caring for eastern cottontails and has begun a PhD on post-release behaviour and survival of eastern cottontails raised in rehabilitation.

A case study of complicated Horner's syndrome in a fledgling wild naturalized lilac-crowned parrot

Patricia J. Latas DVM[1*], Brooke Durham[1], Sarah Mansfield[1], and Rebecca L. Miller[1]

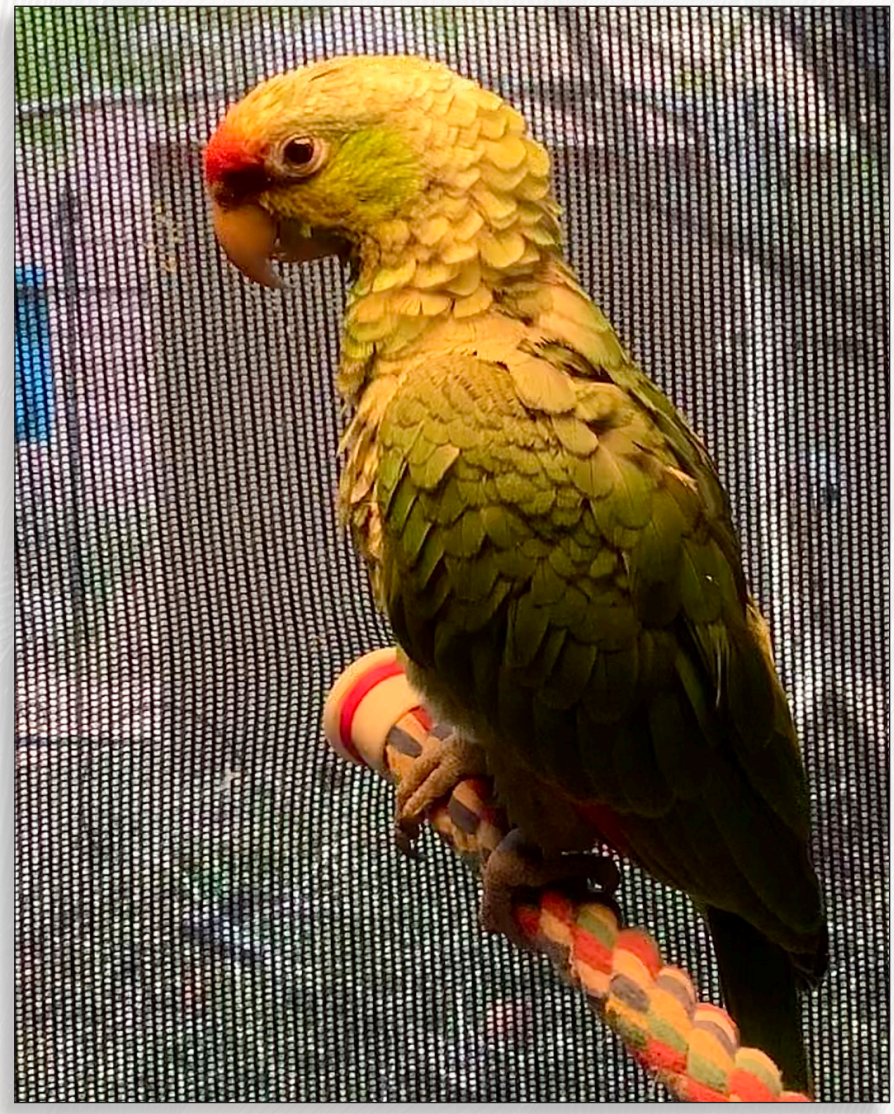
AUTHOR AFFILITATIONS:
[1]SoCal Parrot, Jamul, CA
*Corresponding author

ABSTRACT: A wild fledgling lilac-crowned parrot was presented to a wildlife rehabilitation facility and was diagnosed with Horner's syndrome and other neurological deficits. Clinical signs included unilateral ptosis responsive to phenylephrine ophthalmic drops, contralateral erection of the feathers of the head and neck, tongue mobility deficits, dysphagia, and postural and behavioral abnormalities. Horner's syndrome is rarely reported in avian species, with few reports in psittacines, and with only one report summarizing Horner's syndrome in wild psittacine species. Head and neck injuries resulting from collision or falls are common in birds presented to wildlife rehabilitation, and ptosis is commonly observed in many species but underrecognized as Horner's syndrome. This case was further complicated by an array of other traumatic injury and neurological signs, demonstrating the neurologic nature of head and neck injury in psittacines. Of note was the immediate amelioration of the non-Horner's signs and overall improvement following a single treatment with midazolam for anxiety, suggesting its usefulness in brain injuries. This case also demonstrates the need for detailed and accurate observations with thorough neurological and motor evaluation over time.

KEYWORDS: *Amazona finschi,* Horner's syndrome, lilac-crowned parrot, midazolam, phenylephrine, ptosis, tongue, urban psittacines, wild parrot, wildlife rehabilitation head injury.

CORRESPONDING AUTHOR
Patricia J. Latas DVM
7223 E. Camino Valle Verde
Tucson AZ 85715 USA
E: dr.latas@socalparrot.org

J. Wildlife Rehab. 41(3): 18–22. © 2021 International Wildlife Rehabilitation Council.



Juvenile lilac-crowned parrot (*Amazona finschi*) with Horner's syndrome and other neurological abnormalities. PHOTO PROVIDED BY AUTHOR.

Introduction

An approximately 4-week-old fledgling wild lilac-crowned parrot (*Amazona finschi*) was presented for deviation of the tongue, difficulties with prehension, dysphagia of food and water, droopy left upper eyelid, and general depressed demeanor. The bird had been rescued from an urban backyard in southern California after repeated attempts by the parents failed to elicit a flight-and-follow. The owners of the property had witnessed the fall and were fearful of predation and potential injuries the fledgling may have suffered, and brought the bird to SoCal Parrot, a wildlife rehabilitation facility for urban, naturalized psittacines.

Methods

On initial examination by the wildlife carers/caregivers* the bird was agitated, vocal, and extremely fearful—abnormal behavior for the age of the chick—but no injuries were discovered at that time. Plans were made to house and observe the bird overnight then attempt reuniting with the parents the following day. However, several hours later the bird was unable to perch, had diminished mentation, was severely depressed, and was not reactive to tactile handling. Carers initiated critical care with warm water at 10% body weight *per os*, placed in a pediatric ICU, and arranged emergency veterinary examination. In the interim, carers noted that the tongue deviated to the right, and did not apparently move to the left, with no signs of muscle atrophy; the head and face seemed asymmetrical; and the left eye appeared "squinty." Difficulty or inability to swallow formula offered by syringe prompted tube feeding.

The initial examination recorded no abnormal findings except a slightly thin body score. On presentation to the veterinary hospital, the bird did not exhibit any neurological deficits. A follow-up examination for the complaint of continued dysphagia and lagging behavioral development indicated decreased mobility of the tongue, especially in the lateral directions, and hyoid trauma or nerve abnormality were postulated. The bird was sent with meloxicam 0.28 ml q12h (Metacam 1.5 mg/ml oral suspension Boehringer Ingelheim, St. Joseph, MO, USA) and instructions for cage rest, tube feeding if syringe feeding was unsuccessful, and close monitoring in ICU.

The bird initially responded positively to nutritional and pain management and was eventually housed with an age cohort for continued handfeeding and introduction to various food items. Carers noted at the time that the bird was alternatively "irritable," "crabby," "short-tempered," or depressed and reserved; or mentally and behaviorally lagging behind similarly- and younger-aged birds. The abnormal behavior persisted, and the tongue deviation, prehension and oral processing of food, and potential dysphagia worsened over the following 3 wks.

On pre-anesthetic examination for microchip implantation, the bird showed marked ptosis of the left eye, deviation of the tongue to the right, extrusion of food material to the left, and marked asymmetry of the head where the right side appeared smooth or flattened and the left side feathers looser. The cranium on the right followed an asymmetrical and lesser degree of arc compared to the left side; no fractures or other abnormalities were palpable, and mandible and maxillary range of motion were normal; radiography was not available. Pupillary size and response were equal, and the remainder of neurological examination was normal. The bird was in excellent body condition, and anesthesia with isoflurane and oxygen via mask, implantation of nanochip and recovery were unremarkable.

Three wks following the microchipping implantation, the bird did not maintain a stable body weight required for removal to outdoor enclosures. A decision to euthanize was under consideration. Due to worsening feeding behavior, the bird was submitted for off-site care. On presentation to private veterinary care, the right eye was normal (Fig. 1a); ptosis of the left eye was marked (Fig. 1b). Two drops (approximately 0.01 ml) of 10% phenylephrine hydrochloride ophthalmic solution (Akorn, Lake Forest, IL, USA) were instilled in the left eye, with resolution of the ptosis in less than 3 min and the effect lasting 96 hr. Abnormal resting posture was noted, where the head was held in a "chin-tuck" position with the neck extended (Fig. 1b).

The bird was at the stage of development where use of the feet for feeding was just beginning to be explored. Hands-on physical therapy involving placement of food items in the feet and guidance to the mouth. The "foot-to-eye" coordination resulted in improved tongue function, prehension, and processing the food in the oral cavity. Feeding activity normalized. Hyperactivity, including flustered re-attempts and aggression directed at perches or food with obvious frustration, was noted on many occasions when the bird was unable to feed or climb using the beak and tongue in combination as desired. Unexpected tactile contact with objects elicited extreme fear and aggression. A witnessed uncontrolled hyperesthetic panic episode ensued following minor entanglement with a shred of paper on a toe, including aimless, terrified, and frantic escape activity with alarm vocalizations and hyper-reactive fearful response to all sensory stimuli; 0.2 ml midazolam (midzolam for injection, 2 mg/ml, West-Ward, Eatontown, NJ, USA) was administered immediately IM and the bird was allowed to recover without disturbance. Following that episode and the single treatment, general hyperactivity, fear, and aggression disappeared and did not reappear later; and the tongue deviation diminished to the point where observations of normal tongue protrusion from

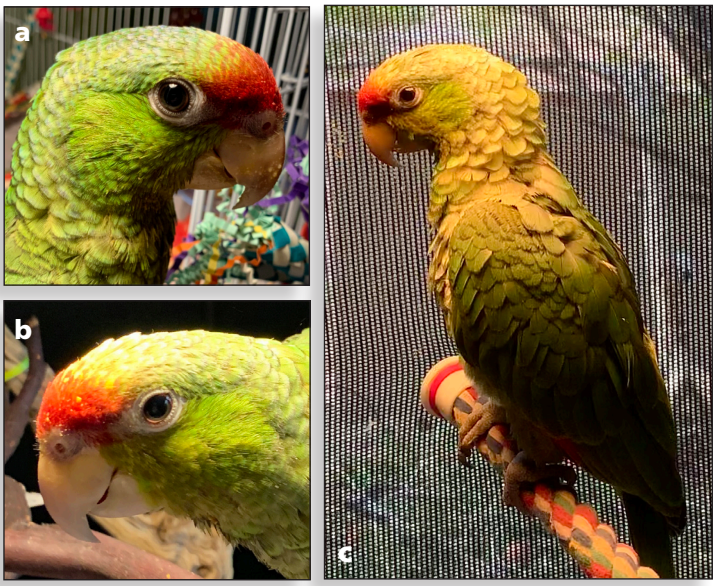


FIGURE 1. A juvenile lilac-crowned parrot with Horner's syndrome and other neurological abnormalities. The first photograph shows the head from the right lateral (a) aspect, with normal eyelids. The same bird, photographed in left-lateral aspect (b), shows the marked ptosis of the left eyelids. The bird in relaxed, non-stressful perching posture is shown in photograph (c) demonstrating the "tucked-chin" and extended neck.

the left side were observed during self-beak cleaning of the left tomia. The marked ptosis of the left eye remained. Midazolam may have removed the severe anxiety associated with abnormal perception of the environment, and the anxiolytic effect diminished the impact of hyperesthesia-related negative feedback.

At fourth wk in private veterinary care, the bird was moved to a larger enclosure for climbing and short-flight training. Behavior was commensurate with similar age cohorts; however, the bird was observed during periods of rest and calm maintaining an unusual extended-neck, rostral-down posture; and during climbing, consistently missing a perch with the beak but tapping it with a sliding-motion action of the left side. Prehension of food items continued to be abnormal, where the bird used a scooping motion with the upper beak to introduce food to the oral cavity, although normal biting of certain fruits and vegetables, perches and toys was also observed. Although encouraged, using the feet to handle and hold food, as is normal in this parrot species, was only rarely observed, although toys were frequently held in the feet. At that point, ptosis and occasional contralateral piloerection of rostral head feathers were intermittent and appeared worse with the level of tiredness toward the end of the day; treatment with phenylephrine ophthalmic solution, used to manage third-order neuron abnormalities caused by damage to the sympathetic nervous system, resolved both for more than a week at a time.

On continued improvement, the bird was returned to the flock in the flight-training enclosure. Flight ability was slow but eventually was fully coordinated, and the bird had consistent and stable body weight and good flight muscle mass. Approximately 2 mo after introduction to the flight enclosure, the bird was found deceased, and subsequently admitted for full necropsy. Gross necropsy findings included emaciated condition with prominent keel with ulceration of the skin, swollen kidneys, and intracranial hemorrhage. Histiopathological diagnosis included focal, necroulcerative dermatitis and panniculitis; diffuse pulmonary congestion; lymphohistiocytic portal hepatitis; and lymphohistiocytic interstitial nephritis. The brain was autolyzed and not submitted for histopathological analysis. The sudden demise was attributed to bacterial sepsis secondary to the injury to the skin over the keel, which in turn was a suspected fall or collision injury.

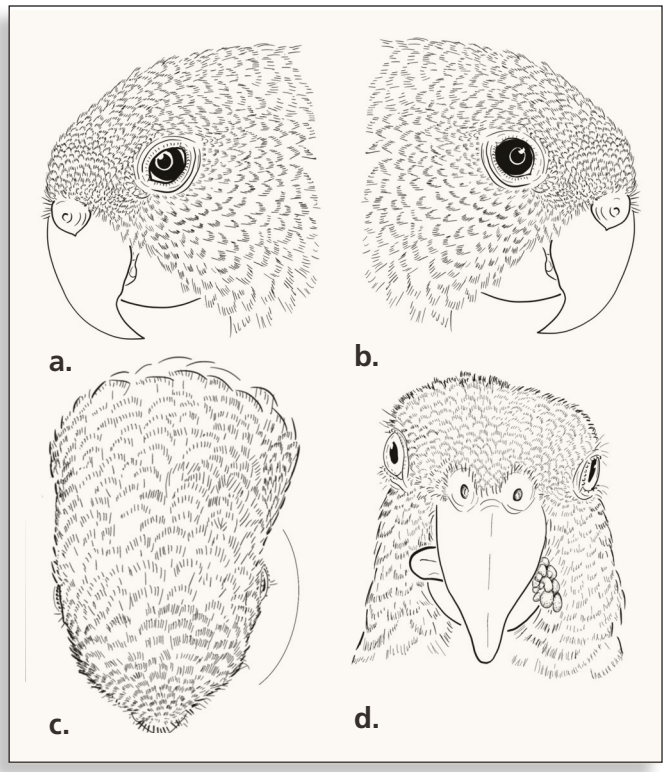
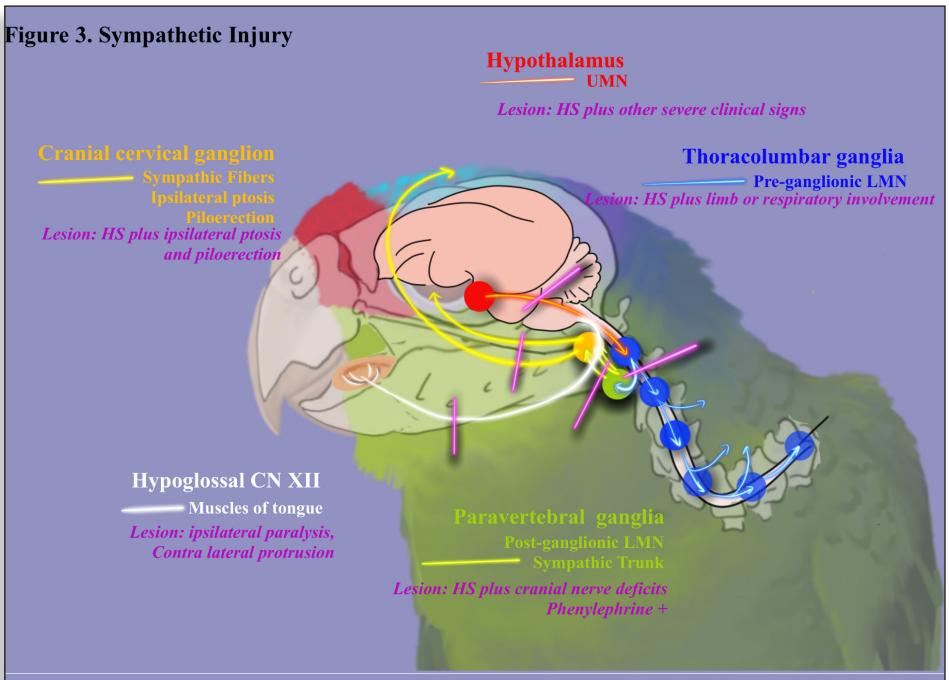


FIGURE 2. Horner's syndrome in a juvenile lilac-crowned parrot, with other complications, is illustrated in the lateral aspects showing ptosis of the left upper eyelid (a), compared to the normal right eyelids (b). The dorsal aspect of the head (c) shows asymmetrical and decreased arc of the right skull and face with normal eyelids, and the normal curvature of the left side with ptosis of the left upper eyelid. The lines indicate the curvature of the arcs. The frontal view (d) illustrates the protrusion of the tongue to the right while feeding and swallowing and escape of food from the left side as evidence of poor prehension and oral processing, and dysphagia. All illustrations were directly drawn from photographs by the author.

Discussion

Horner's syndrome is well-described in mammals, and less so in avian species, where it may be rare, under-reported, or under-recognized .[1-5] In Fig. 3 we show a diagrammatic representation of the neural pathways involved with sympathetic innervation of the eyelids and feather follicles, and the pathway of the hypoglossal nerve. The anatomy of the avian oculosympathetic nervous system originates at the hypothalamus and includes three levels of neurons: one upper motor neuron and two levels of lower motor neurons. [8,9] The upper motor neuron originates in the hypothalamus, whereas the preganglionic and postganglionic lower motor neurons originate in the thoracolumbar spinal cord and the cranial cervical ganglion, and innervate the eye, vasculature, and feather follicles. In birds, Horner's syndrome differs from the typical mammalian presentation (ptosis, miosis, enophthalmos, third-eyelid protrusion, and various vasodilation activity) by usually presenting with ptosis and ipsilateral piloerection of the feather position of the head and neck, and rare and very mild miosis.[1,2] Ptosis results from loss of sympathetic innervation to smooth muscle of the eyelids with prolonged erection of the ipsilateral head and neck feathers likewise.[1,2] Amelioration of ptosis after topical application of diluted phenylephrine was reported in a number of avian species.[1-7] The rapid and prolonged response to 10% phenylephrine would suggest a postganglionic lesion; but the amount of drug administered may have been large enough to cause response even with a preganglionic lesion.

The interesting twists to the neurological presentation for this bird include mild contra-lateral piloerection of the head feathers (or conversely the ipsilateral "smoothing" of feathers); where ipsilateral piloerection is pathognomonic for avian Horner's syndrome.[1,2] In addition, the tongue deviation to the right suggests injury to the right cranial nerve XII. The hypoglossal nerve innervates the ipsilateral muscles of the tongue, and its activation causes the



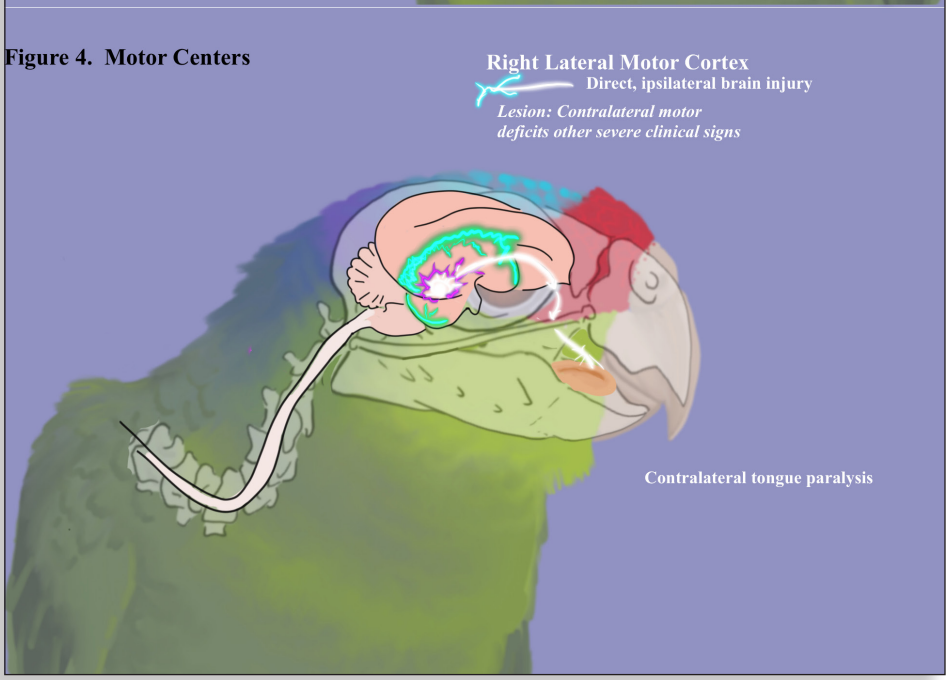


FIGURE 3. Diagram of the neural pathways involved with sympathetic innervation of the eyelids and feather follicles, and the pathway of the hypoglossal nerve in a juvenile lilac-crowned parrot. The sympathetic nervous system and lesions associated with it are extremely complex. This diagram only represents simple lesions, in an effort to clarify the many possibilities and neurological deficits that might manifest clinically.

Hypothalamus: Lesions to the upper motor neurons originating in the hypothalamus impact the sympathetic nervous system distal to the injury. Horner's syndrome and other severe clinical signs of neurological injury result.

Thoracolumbar Ganglia: The chain of ganglia associated with each vertebra of the thoracolumbar spinal column are the origins of lower motor neurons of the sympathetic nervous system. Lesions to nerves feeding into these ganglia are responsible for "pre-ganglionic" neurological signs, including Horner's syndrome, plus respiratory disruption. Nerves leaving these ganglia enter the paravertebral ganglia.

Paravertebral ganglia: These structures form the sympathetic nerve trunk and consist of post-ganglionic lower motor neurons. Lesions to these nerves result in Horner's syndrome which is responsive to phenylephrine treatment, and sometimes cranial nerve deficits due to the proximity of cranial nerve exit and the site of injury. Neurons leave the paravertebral ganglia and enter the cranial cervical ganglion.

Cranial cervical ganglion: Nerves emerging from this sympathetic ganglion control eyelid and feather erection. Lesions to these fibers result in ipsilateral ptosis of Horner's syndrome and ipsilateral piloerection.

Hypoglossal Nerve (Cranial Nerve XII): Local traumatic injury to the hypoglossal nerve, because of proximity to the many sympathetic ganglia, may result in ipsilateral paralysis of the motor nerves of the tongue, resulting in tongue protrusion on the contralateral side; as we see in our patient.

FIGURE 4. Illustration of motor cortex centers in the brain of a juvenile parrot, showing that damage to the right lateral aspect of the head may result in brain injury, including multiple motor cortices and cranial nerves. In our patient, it is possible that the craniofacial flattening we observed as the bird matured might have resulted from injury. Damage to the right motor cortex or cranial nerves would cause contralateral neurological deficits and ipsilateral tongue protrusion.

protrusion of the tongue (see Fig. 3). Unilateral tongue paralysis causes the tongue to deviate toward the injured side when protruded, and in acute injury no muscle atrophy is apparent; as is seen in ipsilateral lesions of lower motor neurons or of the hypoglossal nerve.[10] Fig. 4 shows the possible motor neuron involvement, where lesions of the upper motor neurons originating in the motor cortex could cause contralateral tongue weakness where the principal tongue protractor has crossed supranuclear innervation, and thus the tongue protrudes toward the side opposite a supranuclear lesion.[10] In our patient, it is possible that the craniofacial flattening we observed as the bird matured might have resulted from injury. Damage to the right motor cortex or cranial nerves would cause contralateral neurological deficits and ipsilateral tongue protrusion.

Physical examination and palpation of the head suggested skeletal injury to the right side of the head (flattening of the right

face), and cranio-cervical injury to the left side (left-sided ptosis); hence the confusing neurological presentation. In a moving-head/stationary-object scenario (as in a recently flighted fledgling psittacine), impact to the right head and face could result in contra-coup skull and cervical injury to the left hypoglossal and sympathetic pathways. Unusual "scooping" the upper beak to prehend could indicate musculoskeletal injury or damage to motor nerves involved with beak movement and mastication. In humans, occipital condyle fracture has been reported with hypoglossal canal and hypoglossal nerve deficits.[11] In birds, analogous anatomy is near to the motor cortex involving tongue movements.[8,9] The unusual resting posture may indicate cervical lesions, or, in combination with the climbing deficits utilizing the beak and tongue for grasping, a visual non-alignment impairment due to cranial nerve injuries as described in humans resulting from contra-coup head injury.[12]

Also of interest are the behavior modifications via physical therapy and foot use in feeding, which appeared to improve tongue coordination, abnormal tongue protrusion, oral prehension, and dysphagia of food. In humans, post-stroke and other brain injury resulting in dysphagia is treated by a combination of physical therapy, tongue resistance training, motor nerve stimulation, and dietary management. [13,14]

The fortuitous use of midazolam for successful resolution of an acute anxiety episode may suggests that the frustration, anger, and anxiety induced by impaired ability to feed and indulge in normal behaviors could benefit from an anxiolytic treatment plan, as well as possible positive therapeutic result for brain injury. The success of midazolam may also have been a result of neural inhibition through potentiation of GABA receptors and muscle relaxation, which diminished the severity of the end neurologic impacts and neuronal damage. Further investigation of its usefulness in neuronal injury in birds is warranted.

Horner's syndrome in avians may be subtle, with ptosis and head feather position being the most noticeable indications. Head injury is common in birds presented to wildlife rehabilitation; confusing neurological presentations should be pursued, and where feasible, advanced imaging and other diagnostics may assist prognostication, as is routine in human head injuries.[12] Psittacines, especially young birds, admitted to wildlife rehabilitation with head injury have a good prognosis, given enough time (up to a year in some cases) and resources to treat them.[2,15] However, in one study, 68% of wild birds (some non-psittacines) with Horner's presentation plus other neurologic complications were euthanized or died.[2] In this individual, acute death was suspected to be due to sepsis related to an ulcerative keel injury and was compromised further by emaciation. Speculation regarding the ability to prehend and feed properly, and subsequent injuries from fall or collision, further bolsters the poor prognosis for Horner's syndrome complicated by neurological dysphagia. Disability in prehension of food items and dysphagia will not lead to positive outcome, nor compatibility with successful release. Early but careful consideration of the quality of life and potential suffering of nerve- and brain-injured patients will assist decisions regarding expedient euthanasia and realistic allocation of resources.

Literature Cited

1. Gancz AY, Malka S, Sandmeyer L, Cannon M, Smith DA, Tayor M. Horner's syndrome in a red-bellied parrot (*Poicephalus rufiventris*). *J Avian Med Surg*. 2005;19(1):30–4.
2. Hill AG. A Retrospective Study of Horner Syndrome in Australian Wild Birds, 2010–2016. *J Avian Med Surg*. 2018;32(2):115–21.
3. Gancz AY, Lee S, Higginson G, Danylyk I, Smith DA, Taylor M. Horner's syndrome in an eastern screech owl (*Megascops asio*). *Vet Rec*. 2006;159(10):320–2.
4. Williams DL, Cooper JE. Horner's syndrome in an African spotted eagle owl (*Bubo africanus*). *Vet Rec*. 1994;134(3):64–6.
5. McLelland JM, McLelland DJ, Massy-Westropp N, Wigmore B, Loftus WK, Read RA. Horner syndrome with ipsilateral wing paresis in a wild, juvenile yellow-tailed black cockatoo (*Calyptorhynchus funereus*). *J Avian Med Surg*. 2020;34(2):186–91.
6. Smiley LE, Bonda M, Gaynor A, et al. Avulsion of the roots of the brachial plexus in five birds. *Companion Anim Pract*. 1988;2:38–40.
7. Smith SA. Diagnosis of brachial plexus avulsion in three free-living owls. In: Redig PT, Cooper JE, Remple JD, Hunter DB, editors. Raptor Biomedicine. Minneapolis (MN): University of Minnesota Press; 1993:99–102.
8. Baumel JJ, editor. Handbook of avian anatomy: nomina anatomica avium. 2nd ed. Cambridge (MA): Nuttall Ornith Club; 1993.
9. King AS, McLelland J. Birds, their structure and function. 2nd ed. Eastbourne (UK); Bailliere Tindall; 1984.
10. Corazza E, Lorenzut S, Valente M, Gigli G, L, Merlino G. When nothing goes right: an unexpected tongue deviation in internal carotid artery dissection. *Case Rep Neurol.* 2019;11(1):137–41.
11. Orbay T, Aykol Ş, Seçkin Z, Ergün R. Late hypoglossal nerve palsy following fracture of the occipital condyle. *Surg Neurol*. 1989; 31(5):402–4.
12. Stiller-Ostrowski JL. Fourth cranial nerve palsy in a collegiate lacrosse player: a case report. *J Athl Train*. 2010; 45(4):407–10.
13. Steele CM, Bayley MT, Peladeau-Pigeon M, Nagy A, Namasivayam AM, Stokely SL, Wolkin T. A randomized trial comparing two tongue-pressure resistance training protocols for post-stroke dysphagia. *Dysphagia*. 2016; 31(3):452–61.
14. Carnaby GD, LaGorio L, Silliman S, Crary M. Exercise-based swallowing intervention (McNeill Dysphagia Therapy) with adjunctive NMES to treat dysphagia post-stroke: A double-blind placebo-controlled trial. *J Oral Rehabil*. 2020;47(4):501–10.
15. Latas P, Buxton N, Durham B. A comparison of two psittacine rehabilitation facilities and implications for conservation planning. *J Wildl Rehab.* 2021;41(2):7–20.

Fostering orphaned pups of endangered San Joaquin kit foxes (*Vulpes macrotis mutica*): three case studies

Brian L. Cypher[1], Tory L. Westall[1]*, Erica C. Kelly[1], Nicole A. Deatherage[1], Gregory D. Warrick[2], and Linda Spiegel[3]



PHOTO © GREG SCHECTER. CC BY-NC 2.0 LICENSE.

AUTHOR AFFILIATIONS
[1]Endangered Species Recovery Program. California State University–Stanislaus, Turlock, California, USA
[2]Center for Natural Lands Management, Stallion Springs, California
[3]California Energy Commission, Sacramento, California
*corresponding author

ABSTRACT
San Joaquin kit foxes (*Vulpes macrotis mutica*) occur in central California and are endangered due to habitat loss. We describe three case studies in which orphaned pups were fostered in captivity and returned to or provisioned entirely in the wild. In February 1992, six three-week-old pups whose mother had died were recovered and fostered by caregivers until about ten wks of age. Four of these pups were placed in the den of their father and a new female (Case 1). The remaining two pups were placed with a foster kit fox family (Case 2). In April 2019, a mother of five pups was found dead and no other adults were present (Case 3). The pups were left in their natal den and provisioned and monitored. In all cases, rescuers chose courses of action based on the life stage of the pups and resources available for fostering. Among the 11 orphaned pups, at least four survived until the fall, at least two survived until the following breeding season, and at least one successfully reproduced.

KEYWORDS: California, captive rearing, fostering, orphans, San Joaquin kit fox, Vulpes macrotis mutica

CORRESPONDING AUTHOR
Tory L. Westall
Endangered Species Recovery Program
California State University–Stanislaus
P.O. Box 9622
Bakersfield, CA 93389 USA
P: 1.661.835.7810
E: twestall@esrp.org

J. Wildlife Rehab. 41(3): 23–29. © 2021 International Wildlife Rehabilitation Council.

Introduction

Wildlife rehabilitation is the process of caring for orphaned, injured, or sick wildlife with the intention of releasing them back to their natural habitat. There are frequently ethical dilemmas when making the decision to rehabilitate wildlife such as whether or not human intervention is required, whether the animal is treatable and will survive treatment, and if the animal will function normally when released back to its natural habitat.[1] At times, the situation may require euthanasia if the animal cannot be returned to its natural habitat or placed in an accredited facility.[1] This decision becomes more complicated when dealing with endangered species.

The San Joaquin kit fox (*Vulpes macrotis mutica)* is a small canid endemic to the San Joaquin Desert in Central California. San Joaquin kit foxes are Federally listed as Endangered and California listed as Threatened due to habitat loss.[2] Based on habitat modeling within the kit fox's range, there may be as few as 3,000 San Joaquin kit foxes left.[3] It is important to protect remaining individuals as much as possible, so when an orphaned, injured, or sick San Joaquin kit fox is reported, biologists do everything feasible to ensure the animals' successful rehabilitation.

Canids have a period of prolonged dependence on their parents after birth.[4] The mother of a litter is critical for pup survival until they are fully weaned at around eight wks of age.[5] If something happens to the mother after the pups are weaned, it is possible for the father or other family members to provide food for the pups and successfully raise them to dispersal age.[6] If pups do not have adult family members, they likely will perish in the absence of human intervention. Such intervention frequently involves capture and care at a facility. However, often times wildlife raised in captivity are not releasable due to habituation to people or inadequate preparation that prevents them from properly caring for themselves after release.[7] Translocations and reintroductions of wildlife species have varying post-release survival rates between 11–53%.[7]

Furthermore, permanent captivity may not be an optimal option for orphaned San Joaquin kit foxes or other endangered species. A zoo or other facility must have the proper permits to house an endangered species. Also, space may not be available for the animal(s). Thus, keeping individuals in their natural environment or returning them there as soon as possible is preferable to bringing them into long-term captivity.

We describe three case studies involving orphaned San Joaquin kit fox pups. Two cases involved raising pre-weaned pups in captivity and then returning them to the wild and the third case involved providing assistance to post-weaned pups in the wild.

General Methods

The case studies described below were opportunistic efforts that involved rapid decisions and adaptive measures as events unfolded. Thus, these were not formal studies with methods defined a priori. However, there were some methods that were common among the efforts. We trapped foxes with wire-mesh box traps (38 × 38 × 107 cm; Tomahawk Live Trap, Hazelhurst, Wisconsin) that were covered with oiled cloth tarps to guard against the elements. We opened traps at sunset, baited them with various meat-based products, and checked them at sunrise. Captured foxes were coaxed from traps into a cloth bag and manually restrained during handling.

Foxes received VHF radio collars for tracking. The collars used were made by Advanced Telemetry Systems (Isanti, MN) or AVM Instrument Company (Livermore, CA), or were handmade using small mammal transmitters (Lotek Wireless Inc, Newmarket, Canada) glued to belting material. The latter were placed on young pups and the ends of the belting were sewn together with cotton thread to provide a break-away capacity in the event the pups were not recaptured. All collars weighed <3% of fox body weight. All fox trapping, handling, and collaring was consistent with guidelines for the use of wild animals in research established by the American Society of Mammalogists[8] and conducted in accordance with conditions and protocols established in several permits from the U.S. Fish and Wildlife Service and Memoranda of Understanding from the California Department of Fish and Wildlife. Collared foxes were tracked using 2 or 3-element Yagi antennas (Telonics, Mesa, AZ or Advanced Telemetry Systems, Isanti, MN).

Background for Case Studies 1 and 2

In 1992, two ecological studies on San Joaquin kit foxes were in progress in the Elk Hills-Lokern area of western Kern County, California, U.S.A. One study was being conducted by EG&G Energy Measurements (EG&G)[9] and the other was being conducted by the California Energy Commission (CEC).[10] Both studies entailed monitoring radio-collared kit foxes.

On 18 February 1992, an adult female kit fox was found dead, likely killed by a coyote (*Canis latrans*), by EG&G staff. The female was lactating, and a quick necropsy revealed that she had six placental scars on her uterus. The location of the den the female was using was known, and after consulting with the U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (now the California Department of Fish and Wildlife [CDFW]), the decision was made to excavate the den to determine if pups were present. Later that day, EG&G staff began excavating the den and after approximately an hour of careful digging, they reached a chamber with four small pups.

The pups were immediately transported to Dr. Ted Murphy in Bakersfield, California, U.S.A. Dr. Murphy ran a wildlife rehabilitation facility at the California State University-Bakersfield and had experience working with kit foxes. The pups were approximately 3 wks old (eyes were open, teeth just beginning to emerge) and clearly would not have survived as they were still nursing and dependent upon their now-deceased mother.

The next day, the den was revisited, and additional digging was conducted prior to filling in the excavation. In a deeper chamber at the bottom of the den, two additional pups were found and recovered. These also were immediately transported to Dr. Murphy. The weights of the six pups (three females, three males) ranged from 240–265 g.

Dr. Murphy constructed an artificial den within his home to raise the pups. The den initially consisted of a cardboard box, and as the pups grew, additional interconnected boxes were added. Initially, the pups were fed a milk replacement formula for puppies (Esbilac, PetAg, Hampshire, Illinois, U.S.A.). After a couple of weeks, the pups transitioned to commercial puppy food, and then raw chicken pieces soon followed by dead house mice, and finally live mice. Direct contact with the pups was minimized and dirt and other natural items were added to the den to simulate conditions in a natural den. By the last week of March 1992, the pups all weighed almost 700 g and a plan was formulated for releasing them into the wild.

Prior to release, all of the pups were ear-tagged and fitted with small radio-collars. The collars were small nylon cat collars on which the metal buckle had been replaced with a button. Also, two elastic inserts were incorporated into the collars to allow expansion as the pups grew.

In five locations, the collars were cut and then stitched back together with cotton thread. This thread would deteriorate over

time thereby creating breakaway opportunities if the collars became too tight. Finally, a small VHF transmitter was attached to each collar with dental acrylic. The final weight of the collars was 10–12 g, which was approximately 1.5% of the pups' weight at the time of release. The collars were placed on the pups one week prior to their release to ensure a proper fit and to allow the pups to acclimate to the collars.

Case Study #1: Ex-situ human fostering and reintroduction with a related adult fox

Whereas EG&G staff had been monitoring the mother of the pups before she died, CEC staff had been monitoring an adult male fox that was presumed to be the father of the pups. This male had frequently been tracked to the same den as the mother prior to the birth of the pups. Since the death of the mother and the recovery of the pups, this male had been observed denning with a smaller, uncollared fox that was presumed to be a female and potentially an offspring from a previous litter that had not yet dispersed. Some female young of the year will delay dispersal and remain in their natal range, and these foxes will occasionally inherit that range if their mother dies, as may have happened in this situation.[11] These young foxes also can act as "helpers" and assist the parents in raising the current litter of pups.[12]

Thus, the decision was made to introduce four of the pups (two females, two males) into the den of their biological father and the unknown adult because she was likely a related helper. Only four of the pups were introduced to this den because (1) we were concerned about overwhelming the adult pair, and (2) success was uncertain and we did not want to risk potentially losing all six pups if the adults rejected, abandoned, or mistreated the pups. Therefore, the remaining two pups were introduced into the den of a foster kit fox family (see Case Study #2).

For two consecutive nights prior to release, a male and a female pup were placed in a cage near the den of the father at sunset and observed for approximately two h. On both nights, the father and the uncollared female emerged from the den and investigated the pups in the cage. The pups exhibited excitement at the visits, and the adults exhibited curiosity without any sign of aggression. On the morning of 24 March, the two pups were placed in the den of the adults. A tarp was placed over the opening for 30 minutes to ensure the pups did not immediately run out of the den and become lost. Later that day, pieces of chicken were left outside of the den to ensure that food was available for the pups. The den was observed that evening. The uncollared female was observed eating some of the chicken and then later was observed bringing food items to the den.

The next evening, another male and female pup were placed in a cage outside the den. The female pup released that morning emerged from the den and very excitedly interacted with her litter mates. More chicken was left at the den, and the next morning the two pups that had been caged the night before were released into the den.

During visits to the den in the days following the introduction of the pups, three of the pups were occasionally observed just inside the den entrances. The first of the male pups released was never observed, and the signal from his collar never moved. Although not confirmed, the evidence indicates that this pup likely did not survive and probably died down in the den. Supplemental food continued to be left outside of the den each day. However, by the fourth day (28 March), dead kangaroo rats and kangaroo rat parts (*Dipodomys* sp.) were observed outside of the den indicating that one or both adults were bringing prey items that the pups were consuming. Supplementation was discontinued after 10 April.

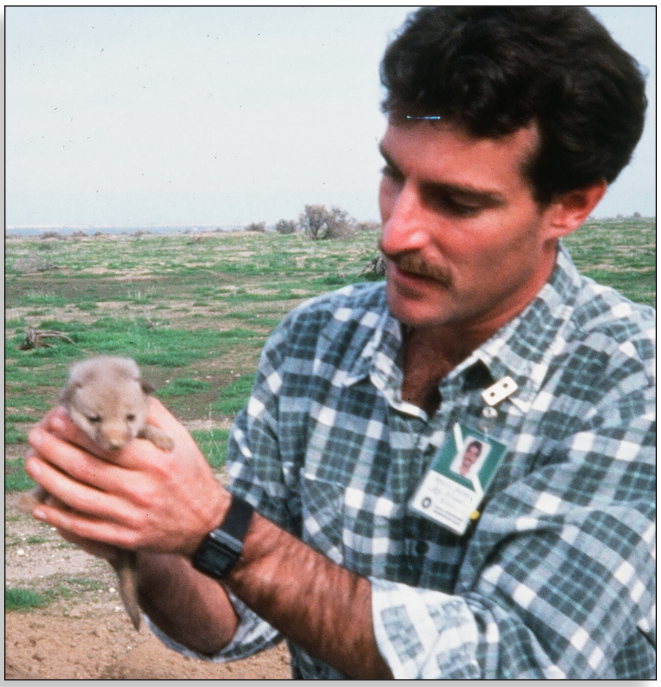


FIGURE 1. Greg Warrick of EG&G with one of the orphaned pups recovered during excavation of a natal den in the Lokern area, California, U.S.A. 18 February 1992 (photo by B. Cypher).

The second male pup was recaptured on 12 May and fitted with an adult-sized radio-collar with room for growth. This pup continued to den with the adult foxes although it occasionally denned alone, which is common for young of the year as they increasingly become more independent. This fox was found dead on 2 October and appeared to have been killed by a coyote. He was found 3.5 km from his reintroduction site and may have been in the process of dispersing when he died. Mortality rates are high among dispersing individuals because they are unfamiliar with den locations outside of their natal home range.[11]

The two female pups continued to be monitored for approximately 35 days until their transmitter batteries expired (end of May). Despite attempts, the pups were not recaptured to recollar them, and therefore their final fate was unknown.

Case Study #2: Ex-situ human fostering and release with unrelated adult foxes

CEC staff had been subsequently monitoring another adult female kit fox who was mated with an uncollared male. This pair had produced a litter of two pups (average litter size for kit foxes is

approximately four).[13] The decision was made to introduce the remaining two orphaned pups (one female, one male) into the natal den of this family group with the hope that they would successfully foster the pups.

Just before sunset on 1 April, the remaining two pups were placed in a cage outside of the den occupied by the radio-collared adult female of the foster family. The female exited the den around sunset but did not investigate the cage with the pups. Her pups were observed at a den approximately 100 m from this den. In the morning on 2 April, the two orphaned pups were placed in the den occupied by the resident pups. All pups remained in the den. That evening, biologists observed all four pups playing together, suggesting that the resident pups had accepted the orphaned pups. Supplemental food was left at this den each day until 10 April as natural prey remains found at the den indicated that the adult foxes were provisioning all of the pups.

The male pup was recaptured on 30 July and fitted with an adult radio-collar. He continued denning with his biological sister and the foster parents. He made an exploratory dispersal movement of 6 km on 7 October and returned to his original home range on 14 October. His signal could not be found after 27 October. On 29 April 1993, his signal was detected in an inaccessible area during an aerial search for missing radio-collared foxes. However, he was detected again on 9 July 1993 and tracked to a den 23 km from his release site. He had dispersed and appeared to have established a new home range. It is unknown whether he ever paired with a female and reproduced. Monitoring ended in August 1993 and no further information was available on this fox.

The female pup was recaptured on 25 May 1992 and fitted with an adult radio-collar. She was occasionally found denning alone and sometimes denning with one or both foster parents. She eventually established a home range that overlapped her natal range and was observed denning with an untagged fox presumed to be a male. On 10 March 1993, at least 5 pups were observed at the den of this female. Two of these pups were eventually captured and tagged. This female was still alive when monitoring ended in September of 1993. Later that year, one of her tagged pups was captured by EG&G staff approximately 10.5 km from his natal area and presumably had dispersed.

Case Study #3: In-situ human fostering

An urban population of San Joaquin kit foxes resides in Bakersfield, California, U.S.A. On 10 April 2019, multiple members of the public contacted both the Endangered Species Recovery Program (ESRP) and CDFW to report a dead fox near the northeastern edge of town and a nearby den with a litter of pups. ESRP staff examined the carcass and determined the fox was a lactating female that had died from a vehicle strike. The active natal den was easily located in an empty field near where the mother had died. A motion-sensing infrared camera was deployed at the den in order to determine if any other adult foxes were present. The next morning the camera showed that there were five pups, but no other adult foxes had visited the den. After two more nights of monitoring, it was clear that the pups had no adult to care for them. After consultation with CDFW and USFWS staff, the decision was made to attempt to supplementally feed the pups at the den. This decision was based on the fact that the pups appeared old enough to consume solid foods and that leaving the pups in place would provide a more natural rearing environment.

The natal den was monitored via field cameras every day from 10 April to 3 December. The cameras were checked daily with the intent to trap and capture the pups if any of them did not appear healthy. To prevent the pups from becoming habituated to humans, food was always deposited at the den before sunset when the pups were in the den. Each day, approximately 3 cups of high protein puppy kibble (Purina Pro Plan Savor Puppy shredded blend) was distributed inside the den entrances so as not to attract predators to the den area and to avoid consumption by other animals (e.g., ground squirrels, birds). The den was visited daily, and kibble was provided if the previous amount had been consumed. After a couple of weeks, thawed frozen feeder mice and rats (five per night) were hidden around the den area in the grass with the hopes of developing foraging and hunting behavior in the pups. Occasionally, raw eggs and cactus pads were provided for additional moisture. As the pups grew older, the food items were hidden farther and farther from the den to improve the pups' foraging skills.

The pups gradually expanded their movements and explorations, and they were documented using at least seven different dens during the monitoring. Within 11 days of the initiation of supplemental feeding, prey remains began appearing at the dens used by the pups. These included multiple California ground squirrel (*Otospermophilus beecheyi*) remains, a Pacific gopher snake (*Pituophis catenifer catenifer*), and some mourning dove (*Zenaida macroura*) feather piles. A pup with an unidentified prey item was detected on day 17 and a pup with a desert cottontail (*Sylvilagus audubonii*) was observed shortly after that. Soon, there were multiple detections on the cameras of the pups with natural prey including invertebrates, cottontails, ground squirrels, and birds as well as occasional anthropogenic food items (Fig. 2).

After 14 days of supplemental feeding, all five pups were no longer observed simultaneously on camera, and after 19 days only three pups were consistently seen. The three pups were trapped in late May to conduct health checks and mark them with a permanent non-toxic dye (Nyanzol-D) so that individuals could be identified on camera (Fig. 3). Sex, weight, and the unique dye mark was recorded for each pup. All three pups appeared healthy. The average weight of the one male and two females was 1.55 kg, which was comparable to other urban pups captured within two weeks of the same age (1.36 kg, n=16; ESRP unpublished data). No unmarked pups were detected on camera after the trapping and their fate is unknown. They may have died or dispersed early.

The final three pups survived for a minimum of 95 days at which point the male stopped appearing on camera after 14 July. While his final fate is unknown, it is believed that he may have dispersed at this time because males tend to disperse earlier than females.[14] The remaining two females were observed on camera



FIGURE 2. San Joaquin kit fox (*Vulpes macrotis mutica*) with a desert cottontail (*Sylvilagus audubonii*), Bakersfield, California, U.S.A. in May 2019.

until 12 August (124 days) and 2 November (206 days), respectively, after which their fate is unknown.

During monitoring, adult foxes were observed visiting the pups on three occasions. In two instances, the foxes apparently were just passing through and did not interact with the pups. The third instance was captured on video and pups were present. The adult fox had collected an egg left for the pups and the pups swarmed it. The adult was startled and backed away from the pups before leaving. The den was also visited by coyotes, domestic dogs (*Canis familiaris*), and an American badger (*Taxidea taxus*). The first coyote detections occurred in July but were infrequent. Coyote visitations increased in frequency after October.

Discussion

The three case studies describe different approaches to assisting orphaned San Joaquin kit fox pups. The second case study is perhaps the most unusual in that pups were fostered with a family that was completely unrelated. Adoption of pups by related family members or by unrelated individuals that are part of the social group from which the pups came is fairly common among canids.[15] However, rates of adoption by unrelated adults that were

FIGURE 3. San Joaquin kit fox (*Vulpes macrotis mutica*) pups with dye markings at a den in Bakersfield, California, U.S.A. in 2019.



not part of the pups' social group is unknown, although it has been documented in red foxes[16] and has commonly been used as a conservation strategy for red wolves (*Canis rufus*).[17] Fostering with related or unrelated groups may improve survival of the orphaned pups. Survival of red fox pups fostered by humans and then simply released was quite low.[18]

In all three cases, one or more of the pups survived to June when they typically become independent of their parents and some even begin to disperse from their natal range.[11] Survival of young of the year typically is low. In the Elk Hills study, mean annual survival of pups from 1 May to the following 15 February (presumptive birth date) was only 14%.[8] Among the 11 pups in the three case studies, a minimum of four (36%) survived until the fall and a minimum of two (18%) survived until the following breeding season with successful reproduction confirmed for one.

In the first two case studies, the pups had the advantage of being able to learn from adult foxes how to find food and dens, elude predators, and other life skills. The pups fostered in-situ did not have this advantage. However, the prey remains found at the den and the camera images of the pups carrying prey indicated that they were developing natural hunting behaviors even in the absence of a parent.

Less certain is how well they learned to avoid predators. They may have learned some amount of avoidance from their mother before she died, and some of this behavior likely is innate. Coyotes and domestic dogs were likely the main predators of concern at this peri-urban location. Other natural behaviors were observed as well. Over the course of the monitoring, the kit fox pups switched dens multiple times. This commonly occurs when pups are present because flea populations will build up in the natal den. Typically, the parents will move the pups to a new den when the flea load becomes unbearable. Without the presence of an adult, the pups still used at least seven dens located in the field where they were born, which may have been an instinctive response to being overwhelmed with fleas.

Across the cases, factors that likely contributed to success included remaining and interacting with litter mates, quickly being transitioned to natural foods, innate predator avoidance, minimal contact with humans, and not prematurely dispersing.[19] In the first two cases, the pups also benefitted from interactions with adult foxes that likely provided training. Behavioral plasticity on the part of the foxes also helped immensely including eating non-natural foods (e.g., puppy chow), tolerating some handling and human presence, and an ability to accept and build relationships with unrelated individuals. Caring for orphaned young and returning them to the wild is always challenging and time-consuming, regardless of the approach. We described three approaches that had some success with orphaned kit fox pups. Others are likely possible as well.

Acknowledgements

We thank the California Department of Fish and Wildlife and United States Fish and Wildlife Service for their approval and support of our efforts. For the first two case studies, we thank Ken Spencer and Nancy Frost for helping excavate the pups, and numerous EG&G and CEC staff for helping with care and monitoring. We especially thank Ted and Peggy Murphy for rearing the pups in their home. For the third case study, we thank Abigail Gwinn, Alice Nash, Diana Grosso, and Leilani Birch for their assistance with feeding the pups and checking cameras. Lastly, we thank the members of the public that reported this litter and their dead mother. Funding for these efforts were provided by the U.S. Department of Energy, California Energy Commission, California State University–Stanislaus Endangered Species Recovery Program, and the San Joaquin Valley Chapter of The Wildlife Society.

Literature Cited

1. Mullineaux E. Veterinary treatment and rehabilitation of indigenous wildlife. *J Small Anim Pract.* 2014;55(6):293–300.
2. United States Fish and Wildlife (USFWS). 1998. Recovery plan for upland species of the San Joaquin Valley, California. United States Fish and Wildlife Service, Region 1, Portland.
3. Cypher BL, Phillips SE, Kelly PA. Quantity and distribution of suitable habitat for endangered San Joaquin kit foxes: conservation implications. *Canid Biology & Conservation*. 2013;16(7):25–31.
4. Macdonald DW, Creel S, Mills MGL. Society: canid society. In: Macdonald DW, Sillero-Zubiri C, editors. The biology and conservation of wild canids. Oxford (U.K.): Oxford University Press; 2004. p. 85–106.
5. Moehrenschlager A, Cypher BL, Ralls K, List R, Sovada MA. 2004. Swift foxes and kit foxes: comparative ecology and conservation priorities of swift and kit foxes. In: Macdonald DW, Sillero-Zubiri C, editors. The biology and conservation of wild canids. Oxford (U.K.): Oxford University Press, p. 185–98.
6. Spiegel LK, Tom J. Reproduction of San Joaquin kit fox in undeveloped and oil-developed habitats of Kern County, California. In: Spiegel LK, editor. Studies of the San Joaquin kit fox in undeveloped and oil-developed areas. Sacramento, (California, USA): California Energy Commission; 1996. p. 53–69.
7. Jule KR, Leaver LA, Lea SEG. The effects of captive experience on reintroduction survival in carnivores: a review and analysis. *Biol Conserv.* 2008;141(2):355–63.
8. Sikes RS. Animal Care and Use Committee of the American Society of Mammalogists. 2016 guidelines of the American Society of Mammalogists for the use of wild mammals in research and education. *J Mammal.* 2016; 97:663–88.
9. Cypher BL, Warrick GD, Otten MRM, O'Farrell TP, Berry WH, Harris CE, Kato TT, McCue PM, Scrivner JH, Zoellick BW. Population dynamics of San Joaquin kit foxes at the Naval Petroleum Reserves in California. *Wildl Monogr.* 2000;145:1–43.
10. Spiegel LK. Studies of the San Joaquin kit fox in undeveloped

and oil-developed areas. Sacramento (California, U.S.A.): California Energy Commission. 1996.
11. Koopman ME, Cypher BL, Scrivner JH. Dispersal patterns of San Joaquin kit foxes. *J Mammal*. 2000;81(1):213–22.
12. Westall TL, Cypher BL, Ralls K, Germano DJ. Raising pups of urban San Joaquin kit fox: relative roles of adult group members. *West N Am Nat.* 2019;79(3):364–77.
13. Cypher BL. Foxes. In: Feldhamer GA, Thompson BC, Chapman JA, editors. Wild Mammals of North America: Biology, Management, and Conservation. 2nd Ed. Baltimore (Maryland, USA): The Johns Hopkins University Press; 2003. p. 92–138.
14. Scrivner JH, O'Farrell TP, Kato TT. 1987. Dispersal of San Joaquin kit foxes, *Vulpes macrotis mutica*, on Naval Petroleum Reserve #1, Kern County, California. U.S. Department of Energy Topical Report EGG 10282-2190, National Technical Information Service, Springfield, Virginia, U.S.A.
15. Moehlman PD. Intraspecific variation in canid social systems. In: Gittleman JL, editor. Carnivore behavior, ecology, and evolution. Ithaca (New York, U.S.A.): Cornell University Press; 1989. p. 164–82.
16. Andrews RD, Storm GL, Phillips RL, Bishop RA. Survival and movements of transplanted and adopted red fox pups. *J Wildl Manage.* 1973;37(1):69–72.
17. Gese EM, Waddell WT, Terletzky PA, Lucash CF, McLellan SR, Behrns SK. Cross-fostering as a conservation tool to augment endangered carnivore populations. *J Mammal*. 2018;99:1033–41.
18. Robertson CPJ, Harris S. The condition and survival after release of captive-reared fox cubs. *Anim Welfare.* 1995;4(4):281–94.
19. Guy AJ, Curnoe D, Banks PB. A survey of current mammal rehabilitation and release practices. *Biodivers Conserv.* 2013;22: 825–37.

About the Authors

Brian Cypher is the Director and a Research Ecologist with the California State University–Stanislaus, Endangered Species Recovery Program. His primary research interest is the ecology and conservation of wild canids. Since 1990, he has been involved in research and conservation efforts for endangered San Joaquin kit foxes as well as other sensitive species in the San Joaquin Valley of California.

Tory Westall is a Research Ecologist with the California State University–Stanislaus, Endangered Species Recovery Program. She has worked with San Joaquin kit foxes since 2009 and has been involved in numerous efforts to rehabilitate sick and injured foxes in the San Joaquin Valley. She also has experience working with many other sensitive species in Central California, though the ecology of wild canids is her primary research interest.

Erica Kelly is a Research Ecologist with the California State University–Stanislaus, Endangered Species Recovery Program. Her primary research focus is the ecology and conservation of endangered San Joaquin kit foxes. For the past thirteen years, Erica has been involved in the study and conservation of threatened and endangered species in the San Joaquin Valley of California.

Nicole Deatherage has been a Research Ecologist with the California State University–Stanislaus, Endangered Species Recovery Program since 2018. Apart from completing a M.S. in Biology in 2020 with a thesis on wildlife biology, relevant experience includes an internship surveying and capturing seabirds in 2014 for USFWS in Alaska Maritime National Wildlife Refuge, a position with USGS in San Diego, CA from 2015–2018 working on projects including surveying for and trapping Golden eagles, endangered rodents, reptiles, and amphibians, a volunteer position caring for captive wolves and assisting with public tours from 2016–2018 at California Wolf Center in Julian, CA.

Greg Warrick is a Regional Preserve Manager with the Center for Natural Lands Management where he oversees the management of approximately 50,000 acres of conservation lands in central California. Greg has been involved in research and management of kit foxes and other species in central California since 1987.

Linda Spiegel is an Environmental Scientist with the California Energy Commission. Linda conducted several research projects on San Joaquin kit foxes and other rare species in the southern San Joaquin Valley of California.

Plan (HarleCAP) provides the roadmap for conserving and restoring harlequin toads as a genus and their habitat. The action plan's goals, which ASI aims to achieve by 2041 (the 200th anniversary of the description of the genus *Atelopus*), include:

- developing and implementing innovative methods to mitigate chytrid's impacts on harlequin toad populations and better understanding why some species are less susceptible to the effects of chytrid;
- protecting and restoring harlequin toads' forests and watersheds;
- creating and maintaining conservation breeding programs;
- searching for species that are lost to science and filling in other gaps in scientific knowledge about harlequin toads;
- sharing stories that will transform harlequin toads into symbols of hope for the region and the world and a flagship for conservation success, and demonstrate a commitment to the conservation of harlequin toads; and
- ensuring the *Atelopus* conservation network has the technical, logistical, and financial support to secure the long-term conservation of harlequin toads.

"The genus *Atelopus* is among the most threatened groups of amphibians in the world," said Ariadne Angulo, chair of the IUCN SSC Amphibian Specialist Group. "By rallying behind a conservation strategy with collective input from key stakeholders, the Atelopus Survival Initiative is taking an essential step towards the conservation of these diverse and highly emblematic toads and the habitats that they live in."

"Protecting and restoring harlequin toads and their habitats will also benefit the species that share the ecosystems in which they live and that provide water to tens of millions of people, and ultimately all life on Earth," Valencia said. "And we're hoping that the ASI will be a successful model that conservationists can emulate for other groups of threatened species."

The Atelopus Survival Initiative includes national and international conservation groups, zoos, captive breeding centers, academic institutions, governments and local communities. Visit the official press release for the 2021 list of partnering organizations.

African Swine Fever has Broad Impacts

BANGKOK, THAILAND *(Aug 23, 2021)*—In a joint communique issued in June, the FAO, IUCN SSC, and OIE recognize the threat of African Swine Fever (ASF) towards wildlife in the Asia Pacific region, where the disease has been active since 2018. The disease threatens not just the loss of 11 native wild pig species, but also a greater impact on the ecological community with the loss of these species.

"Any intervention needs multi-sectoral and multi-institutional cooperation involving ministries, veterinary services, wildlife services, non-government organizations, researchers, industries, and communities," the joint communique said.

As reported on the IUCN news site, "the FAO, IUCN SSC, and OIE called on increased dialogue among government ministries with related responsibilities on ASF and relevant experts to develop strong policies. They also encouraged stronger biosecurity, surveillance, monitoring and response systems across sectors inclusive of domestic and wildlife species. Lastly, they called on coordinated regional efforts to address ASF."

Central Coast (California) Condors Hard Hit by Lead

VENTANA, CALIFORNIA *(Aug 4, 2021)*—Ventana Wildlife Society reports an unusually high number of central coast California condor deaths in the first seven months of the year, with 12 deaths (approximately 15% of the local population). Of the currently known deaths, eight were related to lead; causes for the other four birds remained unknown as of August 2021. More information can be found in a report by SFGate.com.

Strengthening the Migratory Bird Treaty Act

WASHINGTON, DC *(Jul 29, 2021)*—In July, Congressman Alan Lowenthal (CA-47) joined with Congressman Brian Fitzpatrick (PA-01) to introduce the bipartisan Migratory Bird Protection Act, legislation that would permanently codify important and much-needed protections for millions of migratory birds. The legislation would provide regulatory certainty for industries and help ensure that we meet the conservation goals of the century-old Migratory Bird Treaty Act (MBTA) which forms the backbone of US migratory bird conservation efforts. The legislation is co-sponsored by 60 Members of Congress as of 9/1/2021.

"The Migratory Bird Protection Act will strengthen baseline protections for birds at a critical time," Senior Vice President of Conservation Policy for the National Audubon Society Sarah Greenberger said. "We have lost 3 billion birds in North America since 1970 and climate change threatens extinction for two-thirds of bird species. Birds are telling us they are in trouble and we are running out of time to act."

"The MBTA has been a critical tool for bird conservation for over 100 years," Congressman Lowenthal said. "Democratic and Republican presidential administrations since the 1970s have interpreted and applied the law in a similar way, which has saved countless numbers of birds. Our bill would prevent future federal executive action that may apply a flawed interpretation to the MBTA, and once and for all reaffirm and formalize all of the MBTA protections. We must prevent future reinterpretations that might let commercial interests off the hook when it comes to killing birds."

The Migratory Bird Protection Act deals with language within the MBTA that seeks to eliminate "incidental takes" by commercial activity. An incidental take is when birds are killed during an otherwise legal activity; for example, birds which are killed by flying into open oil pits.

Previous administrations have used fines and financial incentives to reduce incidental takes by commercial and business entities.

The Migratory Bird Protection Act would reaffirm decades of practice and policy of the MBTA by every previous Republican and Democratic administration; uphold our international treaty obligations regarding bird conservation; help minimize certain industrial hazards and incentivize best management practices; and allow for financial resources to recover from incidents that impacts birds, such as oil spills.

The Congressmen's legislation also calls on the Fish and Wildlife Service to develop a permit program to authorize incidental take in a way that would minimize regulatory burdens while incentivizing commercial entities to implement best practices that protect birds. It would also create a mitigation fee for impacts that cannot be avoided to help conserve impacted bird populations, including through the North American Wetlands Conservation Act (NAWCA) program, Neotropical Migratory Bird Conservation Act, and other conservation programs.

"Birds have inherent value and are an economic driver along with providing essential services necessary to people, from natural pest control to crop pollination. This Act provides the certainty industry needs while also ensuring birds receive the protections they deserve," Director of Conservation Advocacy for the American Bird Conservancy Jennifer Cipolletti said.

Red List Meets Green List

GLAND, SWITZERLAND *(Jul 28, 2021)*— A paper in the journal *Conservation Biology* for the first time applies the IUCN Green Status of Species, a new Global Standard to measure how close a species is to being fully ecologically functional across its range, and how much it has recovered thanks to conservation action. In the paper, preliminary IUCN Green Status assessments for 181 species are presented. They range from the pink pigeon (*Nesoenas mayeri*), which was saved from extinction by conservation measures, to the grey wolf (*Canis lupus*), a species on a promising path to recovery of ecological functionality across vast areas of its past distribution—though it is currently far from its historical baseline. More than 200 authors representing 171 institutions contributed to the paper.

"Preventing the extinction of species is the ultimate goal that conservationists have traditionally pursued. But we have come to understand that true success would be to revert the decline to the point where animals, fungi and plants fulfill their ecological functions throughout their range—resulting in species that are not just surviving, but thriving," said Jon Paul Rodríguez, Chair of the IUCN Species Survival Commission. "As the world's first standardized method for assessing species' potential for and progress toward such a recovery, the IUCN Green Status will help inform conservation plans and steer action to meet national and international goals for 2030 and beyond. It also provides a metric for quantifying and celebrating conservation success."

The IUCN Green Status of Species will be integrated into the IUCN Red List of Threatened Species,™ which will then provide a fuller picture of species' conservation status, including both their extinction risk and recovery progress.

The IUCN Green Status classifies species into nine Species Recovery Categories, indicating the extent to which species are depleted or recovered compared to their historical population levels. Each Green Status assessment measures the impact of past conservation on a species, a species' dependence on continuing support, how much a species stands to gain from conservation action within the next ten years, and the potential for it to recover over the next century.

"The IUCN Red List tells us how close a species is to extinction, but is not intended to paint a full picture of its status and functioning within its ecosystem," said the paper's lead author, Molly Grace, of the University of Oxford and co-Chair of IUCN's Green Status of Species Working Group. "With the IUCN Green Status, we now have a complementary tool that allows us to track species recovery and dramatically improve our understanding of the state of the world's wildlife. The IUCN Green Status of Species provides evidence that conservation works, giving cause for optimism and impetus for stronger action."

In the paper published today, the authors present the first-ever Green Status assessments for 181 species. They find that many species at higher risk of extinction also have high potential to recover over the next century. For example, the California condor (*Gymnogyps californianus*) Green Status assessment confirmed that rigorous conservation action prevented the species from going extinct. Although the Green Status of the species is Largely Depleted and it is Critically Endangered on the IUCN Red List, the Green Status assessment found that continued support could enable a significant rebound over the next century with a sizeable improvement from 25 percent of its fully recovered state (Largely Depleted) to 75 percent (Moderately Depleted).

This first set of Green Status assessments also reveals that, despite being at low risk of extinction according to the IUCN Red List, some species are nonetheless depleted and unable to fulfill their roles in ecosystems. The East Asian mangrove *Kandelia obovata*, which is listed as Least Concern on the IUCN Red List, was assessed as Moderately Depleted (currently at 57% of its fully recovered state). Reduced by harvesting for timber before 1950, the species, which plays an important role in coastal protection, does not presently occur in numbers high enough to fulfill that function across the majority of its range. It has started to recover, thanks to coordinated replanting efforts across range countries and the introduction of protected areas. This positive trend is projected to continue, contingent on sustained conservation efforts.

"The Green Status of Species introduces a new way of thinking about conservation impact by defining it in terms of progress toward species recovery," said Barney Long of Re:wild and co-Chair of IUCN's Green Status of Species Working Group. "As the first global framework to consider how well species function in their

ecosystems, it will help to combat 'shifting baseline syndrome', where reduced species' distribution and population size over time are accepted by newer generations as the norm."

The development of the IUCN Green Status of Species Global Standard was led by the IUCN Species Conservation Task Force, in partnership with the IUCN Red List of Threatened Species, IUCN Species Survival Commission, Re:wild, Wildlife Conservation Society, University of Oxford, Stony Brook University, Durrell Wildlife Conservation Trust and Zoological Society of London.

Unprecedented Heat Wave Increases Admissions at Northwest Wildlife Centers

EUGENE, OREGON *(July 17, 2021)*—A series of early summer historic heat waves in northwest North America has pushed increased intakes at wildlife rehabilitation centers in California, Oregon, Washington, and British Columbia over the summer. Reports are primarily of increases in raptor intakes, although colony seabird nesters were also affected. Most of the intakes were nestlings, leaping from nests to escape the heat, some suffering from hyperthermia, others with broken bones and soft tissue injuries.

Human–Wildlife Conflict Threat to Species Survival

WASHINGTON, DC *(Jul 8, 2021)*—Conflict between people and animals, from China's famed wandering elephants raiding farms for food and water to wolves preying on cattle in Idaho, is one of the main threats to the long-term survival of some of the world's most iconic species, warns a new report from World Wildlife Fund (WWF) and the UN Environment Program (UNEP).

Human–wildlife conflict—when struggles arise from people and animals coming into contact—often leads to people killing animals in self-defense, or as preemptive or retaliatory killings, which can drive species to extinction.

The report, "A Future for All: The Need for Human–Wildlife Coexistence," highlights that globally, conflict-related killing affects more than 75% of the world's wild cat species, as well as many other terrestrial and marine carnivore species such as polar bears and Mediterranean monk seals, and large herbivores such as elephants.

The report features contributions from 155 experts from 40 organizations based in 27 countries.

"For many Americans, it may seem like conflicts with animals occur only in far away places, but it also happens right here in our own backyards. From raccoons rifling through our garbage to deer eating the vegetables in our gardens, human-wildlife conflict is an issue that touches us all," said WWF Wildlife Conservation Manager Nilanga Jayasinghe. "In an increasingly crowded world where humans and wildlife are competing for space and resources, we can expect human–wildlife conflict to happen more frequently. If we want to meaningfully reduce human–wildlife conflict and steadily move toward coexistence, we need global collaboration and action that helps both people and wildlife."

According to the report, human–wildlife conflict is as much a development and humanitarian issue as it is a conservation concern, affecting the income of farmers, herders, and artisanal fishers, particularly those living in poverty. It also interferes with access to water for communities competing with wildlife for local water sources, and drives inequality as those who pay the price for living with wildlife rarely receive the benefits of coexistence.

Interactive:

How Do Animals Safely Cross a Highway? Take a Look.

New York Times, May 31, 2021
By Catrin Einhorn

Despite being so strongly linked to the United Nations' Sustainable Development Goals (SDGs), human–wildlife conflict continues to be overlooked by policymakers.

"If human–wildlife conflict is not adequately addressed by the international community, it will have a considerable negative impact on countries' ability to meet the majority of the SDGs," says Dr. Margaret Kinnaird, Global Wildlife Practice Leader at WWF International. "If the world is to have a chance of meeting the SDGs by 2030, human–wildlife conflict must be explicitly included in SDG implementation plans, as well as at the heart of the Convention on Biodiversity's new framework."

Flourishing wildlife populations help maintain healthy ecosystems that provide benefits for people all over the world, like clean air, food and livelihoods. But in developing nations rich in biodiversity, there can often be catastrophic impacts for those living closest to wildlife, such as injury and death, loss of property and livelihoods, and strained physical and mental health.

"This report is a clarion call to elevate the problem of human–wildlife conflict and give it the attention it deserves in national and international processes," said Susan Gardner, Director of UNEP's Ecosystems Division. "It is a call for the adoption of approaches that identify and address the deeper, underlying causes of conflict while developing systemic solutions with affected communities as active and equal participants in the process. As demonstrated in many of the case studies in this report, coexistence is both possible and attainable."

The report says that completely eradicating human–wildlife conflict is not possible, but that well-planned, integrated approaches to managing it can reduce conflicts and lead to a form of coexistence between people and animals. Such approaches require actions on prevention, mitigation, response, research and monitoring all backed by strong policy support and the participation of local communities.

Source: World Wildlife Fund press release. ■

SELECTED ABSTRACTS

Prevalence, treatment, and survival of burned wildlife presenting to rehabilitation facilities from 2015 to 2018.

Butkus CE, Peyton JL, Heeren AJ, Clifford DL. *J. Zoo Wildlife Med*, 2021;52(2):555–63. https://doi.org/10.1638/2020-0093

In recent decades, wildfires have increased in frequency and geographic scale across the globe. The human health implications and ecological succession after wildfires are well documented and studied, but there is a lack of empirical research about the direct effects of wildfires on wildlife. Recent wildfires have demonstrated the need to better understand animal burn injuries and innovations in veterinary burn treatment. An online survey was distributed to wildlife rehabilitation facilities internationally to collect baseline information about the number and type of burned wildlife cases admitted, treatments used, and survivorship of wildlife affected by wildfires. Approximately 80% (n = 49) of all respondents (n = 61) reported admitting cases of burned wildlife from 2015 to 2018. Respondents included facilities from six different countries and roughly 43% of facilities reported having a veterinarian on staff. Electrical burns were most commonly reported with 89% of respondents stating that they had seen electrical burns while 38% of respondents reported seeing wildfire-source thermal burns in wildlife patients. Respondents were asked about their frequency of use of different treatment methods. Bandages, colloid fluids, and opioids were used at significantly higher rates at facilities with veterinarians compared with facilities that did not report having a veterinarian; however, survival of burned wildlife patients did not significantly differ based on the factor of having a veterinarian on staff. Long-term and short-term complications were commonly reported for wildlife burn patients; 88% of facilities reported scarring, 81% reported alopecia, and 61% reported sepsis. Burned animals admitted to facilities were reported to have equal odds of dying and surviving. Burn care recommendations have changed considerably in recent decades. This study provided a unique opportunity to compare contemporary recommendations in human medicine with current methods used in wildlife rehabilitation facilities to identify potential areas of further investigation and improvement for wildlife medicine.

Approximately 80% of all respondents reported admitting cases of burned wildlife from 2015 to 2018.

Unprecedented migratory bird die-off: A citizen-based analysis on the spatiotemporal patterns of mass mortality events in the western United States.

Yang D, Yang A, Yang J, Xu R, & Qiu H. *GeoHealth*, 2021;5, e2021GH000395. https://doi.org/10.1029/2021GH000395

Extensive, severe wildfires, and wildfire-induced smoke occurred across the western and central United States since August 2020. Wildfires resulting in the loss of habitats and emission of particulate matter and volatile organic compounds pose serious threatens to wildlife and human populations, especially for avian species, the respiratory system of which are sensitive to air pollutions. At the same time, the extreme weather (e.g., snowstorms) in late summer may also impact bird migration by cutting off their food supply and promoting their migration before they were physiologically ready. In this study, we investigated the environmental drivers of massive bird die-offs by combining socioecological earth observations data sets with citizen science observations. We employed the geographically weighted regression models to quantitatively evaluate the effects of different environmental and climatic drivers, including wildfire, air quality, extreme weather, drought, and land cover types, on the spatial pattern of migratory bird mortality across the western and central US during August–September 2020. We found that these drivers affected the death of migratory birds in different ways, among which air quality and distance to wildfire were two major drivers. Additionally, there were more bird mortality events found in urban areas and close to wildfire in early August. However, fewer bird deaths were detected closer to wildfires in California in late August and September. Our findings highlight the important impact of extreme weather and natural disasters on bird biology, survival, and migration, which can provide significant insights into bird biodiversity, conservation, and ecosystem sustainability.

Early detection of wildlife morbidity and mortality through an event-based surveillance system.

Kelly TR, Pandit PS, Carion N, Dombrowski DF, Rogers KH, McMillin SC, Clifford DL, Riberi A, Ziccardi MH, Donnelly-Greenan EL, Johnson CK. *Proc. R. Soc. B,* 2021; 288(1954):20210974. https://doi.org/10.1098/rspb.2021.0974

The ability to rapidly detect and respond to wildlife morbidity and mortality events is critical for reducing threats to wildlife populations. Surveillance systems that use pre-diagnostic clinical data can contribute to the early detection of wildlife morbidities caused by a multitude of threats, including disease and anthropogenic disturbances. Here, we demonstrate proof of concept for use of a wildlife disease surveillance system, the Wildlife Morbidity and Mortality Event Alert System, that integrates pre-diagnostic clinical data in near real-time from a network of wildlife rehabilitation organizations, for early and enhanced detection of unusual wildlife morbidity and mortality events. The system classifies clinical pre-diagnostic data into relevant clinical classifications based on a natural language processing algorithm, generating alerts when more than the expected number of cases is recorded across the rehabilitation network. We demonstrated the effectiveness and efficiency of the system in alerting to events associated with both common and emerging diseases. Tapping into this readily available unconventional general surveillance data stream offers added value to existing wildlife disease surveillance programmes through a relatively efficient, low-cost strategy for the early detection of threats. ■

TAIL ENDS



I don't think you understand the nature of our relationship.

Young bearded dragon
Pogona vitticeps

PHOTO © PHILIP VEATER, UNSPLASH. CC BY-SA 2.0.

INSTRUCTIONS FOR AUTHORS

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

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

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

Kieran Lindsey, Editor
jwr.editor@theiwrc.org

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

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

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

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

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

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

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

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



Pink Pigeon (*Nesoenas mayeri*), Ile aux Aigrettes, Mauritius. Now on the IUCN Green List, the species was saved from extinction by conservation efforts. PHOTO ©SERGEY YELISEEV. CC BY-NC-SA2.0



IWRC

International Wildlife Rehabilitation Council

PO Box 3197
Eugene, OR 97403 USA
Voice/Fax: 408.876.6153
Toll free: 866.871.1869
Email: office@theiwrc.org
www.theiwrc.org

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