

JOURNAL OF WILDLIFE REHABILITATION

Volume 45, Number 1, 2025

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:

Dalmatian pelican
(Pelecanus crispus). A patient in care at Bamou Wildlife Rescue Center, Fars Province, Iran.

PHOTO ©FOOZHAN KHERADMAND.
USED WITH PERMISSION.

LEFT:

Common raccoon dog
(Nyctereutes procyonoides). IUCN red list category–least concern.

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INTERNATIONAL WILDLIFE REHABILITATION COUNCIL

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

INTERNATIONAL WILDLIFE REHABILITATION COUNCIL

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
Julissa Favela
International Wildlife Rehabilitation Council
Eugene,Oregon, USA

Production Consultant
Nancy Hawekotte
Cumulus Creative
Art offices: Omaha, Nebraska, USA

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GUEST EDITORIAL

Celebrating 50 Years of Education, Conservation, and Compassion in Wildlife Rehabilitation

Fifty years—half a century—and we have so much to celebrate! Since its founding in 1975, the International Wildlife Rehabilitation Council (IWRC) has remained dedicated to its mission to advance the field of wildlife rehabilitation.

What better way to honor this milestone than by sharing a story that illustrates IWRC's impact?

My journey into wildlife rehabilitation began unexpectedly while working at the Adventure Aquarium (formerly the New Jersey State Aquarium) in New Jersey. In June 2000, I volunteered to assist in the response to the Treasure oil spill in Cape Town, South Africa. There, I met an IWRC board member—one of many dedicated wildlife professionals from around the world who travelled to South Africa to assist —who encouraged me to get involved with the organization and the broader field of wildlife rehabilitation. Inspired and eager to learn more, I joined IWRC upon returning home and discovered its foundational Basic Wildlife Rehabilitation course (then called the Basic 1AB). Soon after, I traveled to Rhode Island to complete the course, then flew to Montreal to attend IWRC's annual symposium—knowing little about the robust community I was about to become part of.

That decision changed everything. Shortly after, I secured my first job as a wildlife rehabilitator at the Monterey Bay Aquarium. Twenty-five years later, I'm still in the profession, specifically focusing on oiled wildlife response, and in 2022, I came full circle by joining IWRC's Board of Directors.

My story is just one example of IWRC's lasting influence. Today, with approximately 1,700 members across 47 countries, IWRC continues to shape the field at both individual and professional levels. Over the past 50 years, it has played a leading role in promoting and professionalizing wildlife rehabilitation—developing standards, providing education, and publishing 153 issues of The Journal of Wildlife Rehabilitation, which debuted in 1977. Since 2010 alone, IWRC has offered around 370 individual courses to 8700 students across five countries, expanding knowledge and strengthening the global wildlife rehabilitation community.

As we look to the future, our commitment to educational excellence, science-based research, and evidence-driven practices remains strong. However, sustaining and growing this impact comes with challenges. In an increasingly complex world, ensuring the long-term viability of IWRC is critical to the future of our profession.

Here's to 50 years of progress—and to the decades of education, conservation, and compassion still to come.

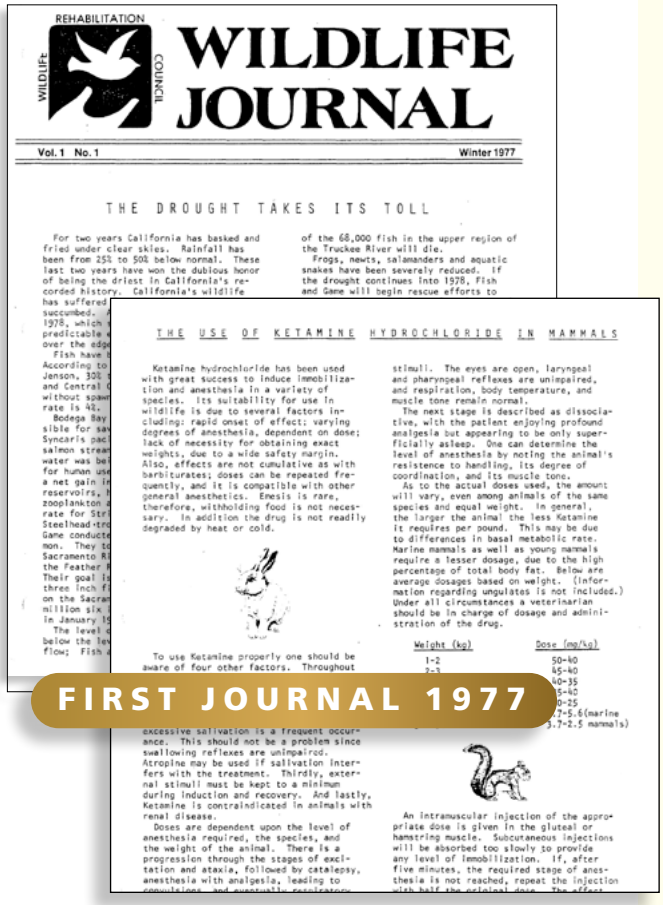
Happy golden anniversary, IWRC!

Danene Birtell
IWRC Secretary
California, USA

and counting

Everyone has a story and each story is rich in its own right. Through these past 50 years we have seen what was once considered a backyard hobby transform into a viable and important field of wildlife rehabilitation. We marvel at how far this field has come and look in excitement to what it will be in the future.

The Journal of Wildlife is no different. From its humble beginnings. Yes, I believe it was typed, as in, on a typewriter. Some of you may remember those. Since 2010, the journal has been available online as a flip magazine or pdf. Technology and science have propelled the journal forward but it would be a mistake to not mention all of the people who have made the journal, wildlife rehabilitation and all that we know today. We would not be here without all of the pioneers of the past and all of those who have now joined this dynamic field.



REHABILITATION COUNCIL WILDLIFE

WILDLIFE JOURNAL

Vol. 1 No. 1 Winter 1977

THE DROUGHT TAKES ITS TOLL

For two years California has basked and fried under clear skies. Rainfall has been from 25% to 50% below normal. These last two years have won the dubious honor of being the driest in California's recorded history. California's wildlife has suffered ... succumbed. ... 1978, which ... predictable ... over the edge ... Fish have ... According to ... Jenson, 30% ... and Central ... without spawn ... rate is 42. ... Bodega Bay ... sible for sav... Syncaris pac... salmon strea... water was be... for human use ... a net gain in ... reservoirs, ... zooplankton ... rate for Str... Steelhead trou... Game conducts ... mon. They to... Sacramento R... the Feather R... Their goal is ... three inch f... on the Sacram... million six ... In January 19... The level ... below the lev... flow; Fish ...

of the 68,000 fish in the upper region of the Truckee River will die.

Frogs, newts, salamanders and aquatic snakes have been severely reduced. If the drought continues into 1978, Fish and Game will begin rescue efforts to

THE USE OF KETAMINE HYDROCHLORIDE IN MAMMALS

Ketamine hydrochloride has been used with great success to induce immobilization and anesthesia in a variety of species. Its suitability for use in wildlife is due to several factors including: rapid onset of effect; varying degrees of anesthesia, dependent on dose; lack of necessity for obtaining exact weights, due to a wide safety margin. Also, effects are not cumulative as with barbiturates; doses can be repeated frequently, and it is compatible with other general anesthetics. Emesis is rare, therefore, withholding food is not necessary. In addition the drug is not readily degraded by heat or cold.

To use Ketamine properly one should be aware of four other factors. Throughout excessive salivation is a frequent occurance. This should not be a problem since swallowing reflexes are unimpaired. Atropine may be used if salivation interfers with the treatment. Thirdly, external stimuli must be kept to a minimum during induction and recovery. And lastly, Ketamine is contraindicated in animals with renal disease.

Doses are dependent upon the level of anesthesia required, the species, and the weight of the animal. There is a progression through the stages of excitation and ataxia, followed by catalepsy, anesthesia with analgesia, leading to convulsions and eventually respiratory

stimuli. The eyes are open, laryngeal and pharyngeal reflexes are unimpaired, and respiration, body temperature, and muscle tone remain normal.

The next stage is described as dissociative, with the patient enjoying profound analgesia but appearing to be only superficially asleep. One can determine the level of anesthesia by noting the animal's resistence to handling, its degree of coordination, and its muscle tone.

As to the actual doses used, the amount will vary, even among animals of the same species and equal weight. In general, the larger the animal the less Ketamine it requires per pound. This may be due to differences in basal metabolic rate. Marine mammals as well as young mammals require a lesser dosage, due to the high percentage of total body fat. Below are average dosages based on weight. (Information regarding ungulates is not included.) Under all circumstances a veterinarian should be in charge of dosage and administration of the drug.

Weight (kg)	Dose (mg/kg)
1-2	50-40
2-3	45-40
	40-35
	35-40
	30-25
	7.7-5.6(marine
	3.7-2.5 mammals)

An intramuscular injection of the appropriate dose is given in the gluteal or hamstring muscle. Subcutaneous injections will be absorbed too slowly to provide any level of immobilization. If, after five minutes, the required stage of anesthesia is not reached, repeat the injection with half the original dose. The effect

FIRST JOURNAL 1977

JOURNAL OF WILDLIFE THROUGH TIME

1. Volume 1:1 **Wildlife Journal** first issue
Editorial staff
Joyce Abrams, Ann Brice, Carol Patterson, Martha Williams

1978 Editorial staff
Joyce Abrams, Ann Brice, Kathy Hobson, Charlene Modena, Martha Williams

1977

2. **1980** Editorial staff
Gary Bogue, Anne Brice, Susan Kelly, Tina Papenhause

1981 Editorial staff
Gary Bogue, Anne Brice, Susan Kelly, Tina Papenhause, Carter Schleicher

1982 Editorial staff
Anne Brice, Susan Kelly, Tina Papenhause, Carter Schleicher

1982 Volume 5:3-Volume 6:2
Editor Gary Bogue with assistant and associate editors

1980

3. **1983** Editor
Jan White
(with assistant and associate editors)
Volume 6:3-Volume 20:3

1983

4. Volume 16:1
Title change to **Journal of Wildlife Rehabilitation**

1993

5. **1997** Editors
Mary Reynolds and Marge Gibson
Volume 20:4 to 21:1

1998 Editor
Jan Amborsini
Volume 21:3/4 to 22:1

1999 Editor
Mary Reynolds
Volume 22:2

1999 Editor
Marianne Skoczek
Volume 22:3 to 29:1

1997

6. **2008** Editor
Kieran Lindsay
Volume 29:2/3-present
First Art Director
Nancy Hawekotte

2008

7. Volume 30
First digital issue

2010

8. Issues to date: 153
Volume 45(1)

2025

FILL OUT THE SURVEY


WILDLIFE REHABILITATION COUNCIL
WILDLIFE JOUR
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THE DROUGHT TAKES
For two years California has basked and fried under clear skies. Rainfall has been from 25% to 50% below normal. These last two years have won the dubious honor of being the driest in California's recorded history. California's wildlife has suffered from the drought but not succumbed. Another year of drought for 1978, which seems to be a literally un-
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Dealing with Avian Emaciation . . . . . p. 3
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Volume 30, Number 1 2010
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Up for Discussion: Testing rehabilitated predators for release readiness
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JWR–A NEW LOOK 2022
IWRC
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1975-2025
50
YEARS

A retrospective study of causes and outcomes of wildlife rescue in Fars Province, Iran (2019–2021)

Foozhan Kheradmand[1], **Ehsan Saeidi** [1,2]



PHOTO ©FOOZHAN KHERADMAND. USED WITH PERMISSION.

DALMATIAN PELICAN (*Pelecanus Crispus*)

[1] Department of Veterinary Medicine, University of Sassari, Italy
[2] Collaborator veterinarian of Department of Environment, Shiraz, Iran

ABSTRACT

With increasing anthropogenic impacts on wildlife species, wildlife rehabilitation is becoming more prominent. Although the primary aim of wildlife rehabilitation is to release rehabilitated animals back into the wild, the data recorded by these centers is important for evaluating various aspects of wildlife management. In this study, we examined 173 wildlife cases that were rescued by the Bamou Wildlife Rescue Center from April 2019 to February 2021. We categorized the accepted cases according to the causes of distress, their taxonomic classifications, and the outcomes. These included 131 birds (75.72%), 36 mammals (20.80%), and 6 reptiles (3.46%). The primary reasons for presentation were trauma (41.61%), followed by illegal wildlife trade (18.49%), orphaning (16.18%), infectious diseases (12.71%), unknown causes (8.67%), and poisoning (2.31%). The highest outcome was related to the non-releasable category, accounting for 30.63%. The overall release rate for admitted cases was 25.43%, while 43.92% either expired or were euthanized. Although this study mentioned the release rate for different species, no post-release monitoring method was practiced, which is essential for evaluating the measure of success.

KEYWORDS

Bamou National Park, successful release, trauma, wildlife rehabilitation.

CORRESPONDING AUTHOR

Foozhan Kheradmand
Department of Veterinary Medicine, University of Sassari, Italy
Phone: +987136238421
Cellular phone: +989390495243
E: foozhan_kheradmand@yahoo.com

Introduction

Wildlife rehabilitation is the practice of caring for sick, injured, orphaned, and displaced wild animals with the primary goal of returning them to their natural habitat.[1,2] Treating injured wildlife often focuses on common and wide-spread species, and human–wildlife interactions are typically the main cause of admission.[3]

Wildlife rescue/rehabilitation centers (WRCs) are increasing in number around the world in various sizes and degrees of advancement. Some are large and equipped with high-quality facilities and professional staff, while others are smaller and operated by volunteers with fewer resources. The scale and standards of these centers are influenced by

a range of factors. They may be managed by public organizations or NGOs and collaborate closely with local authorities.[4]

The effectiveness of wildlife rehabilitation can be controversial.[3] On one hand, wildlife rescue/rehabilitation centers can play crucial roles in various ways, including efforts to counterbalance the adverse effects humans have on species populations and the well-being of individual animals. Additionally, they often have an educational aspect, utilizing their cases and experiences to inform the public about wildlife importance, identifying injured animals, and proper behavior around wildlife.[1,2] Moreover, data from wildlife rehabilitation centers can be utilized for wildlife management objectives, like monitoring wildlife diseases, ecosystem assessment, and other conservation efforts.[4] On the other hand, the dominant attitude among conservationists is that rehabilitation activities have little effect on wildlife populations. This perspective emphasizes the necessity of post-release monitoring of rehabilitated individuals to evaluate various criteria such as survival rates, level of human imprinting, and their potential contribution to generating new populations.[5] Such monitoring is crucial for determining the success or failure of the rehabilitation process.[6,7]

Iran occupies a unique position where three major zoogeographic zones intersect. Its complex geography and varied climate create numerous transitional areas between different ecosystems, resulting in diverse habitats ranging from lush temperate forests to harsh desert environments. This diversity contributes to the rich variety of fauna and flora found within Iran. A total of 192 terrestrial mammal,[8] 241 reptiles,[9] and 550 bird species[10] have been documented within Iran. Despite the rich biodiversity, the lack of principled, well-equipped rehabilitation centers across the country poses significant challenges. Instead, only a few small centers with minimal facilities, such as the Bamu Wildlife Rescue Center, are present, neither providing the minimum requirements for indoor/outdoor enclosures for rescued individuals nor ensuring proper rehabilitation procedures. As a consequence of this defective process, even for individuals that are eventually released, no post-release monitoring measurements are practiced, and the success or failure rates of treatment and rehabilitation efforts remains uncertain. In this study, an attempt has been made to evaluate all cases of wild animals admitted to the Bamou Wildlife Rescue Center from 2019 to 2021 to gain insight into wildlife rehabilitation attempts, identify obstacles, suggest necessary modifications, and provide a perspective on its future.

Materials and Methods

Study design

A retrospective study of wildlife rehabilitation in Fars Province, Iran, was conducted based on individual cases admitted to the Bamou Wildlife Rescue Center during the period from April 2019 to February 2021 (Fig. 1). Fars Province, located in the southern region of Iran, ranks as the country's fourth largest province. Alongside its unique zoogeographic location, the province boasts a wide array of geographic features combined with diverse climatic environments. These factors contribute significantly to the province's remarkable biodiversity.

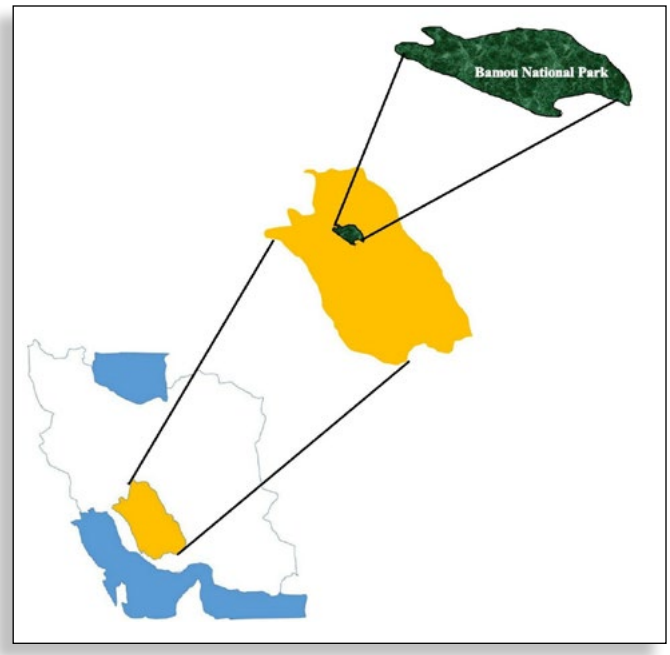


FIGURE 1. Location of Bamou National Park within Fars Province and its position in Iran.

Data source and preparation

The Bamou Wildlife Rescue Center serves as the primary facility for treating injured animals from across Fars Province. Detailed records are kept for each individual animal from the moment of admission until the completion of its treatment, with each case being assigned a dedicated medical file. Alongside noting the species and primary date, the records also included the approximate age, sex (if identified), and the location where the animal was discovered. Initial status, treatment measures, and final outcome/decision were recorded for each animal. All handwritten medical files were transcribed manually into Excel format. The conservation status of species was checked by the IUCN Red List of Threatened Species. All recorded data were reviewed for precision and stability. Errors such as misspellings of scientific names of species were corrected. Species names were standardized according to currently recognized taxonomic listings.

Animal sorting

Recorded species were classified into 3 primary and 28 secondary taxonomic groups based on different classes and families. These groups are as follows: birds (Falconidae, Tytonidae, Phasianidae, Columbidae, Accipitridae, Corvidae, Apodidae, Phalacrocoracidae, Pelecanidae, Strigidae, Upupidae, Caprimulgidae, Phoenicopteridae, Ardeidae, Meropidae, Pycnonotidae); mammals (Canidae, Erinaceidae, Ursidae, Bovidae, Felidae,

Sciuridae, Herpestidae, Hyaenidae, Suidae); and reptiles (Colubridae, Viperidae, Testudinidae).

Primary causes and outcomes sorting

The primary causes of admission were classified into 6 categories: Infectious disease, Orphaned, Poisoning, Trauma, Illegal wildlife trade, and Unknown. Cases involving bacterial, viral, or parasitic afflictions were grouped under Infectious disease; orphaned individuals, regardless of the reason or unnecessary human intervention, were categorized as Orphaned; Poisoning included individuals exposed to various types of toxicants; Trauma encompassed animals injured due to illegal shooting, trapping, vehicle collisions, or attacks by feral domesticated animals or other animals. All illegally captured or kept wild individuals were classified under Illegal wildlife trade, while cases lacking clear history were categorized as Unknown. Some cases might have been admitted due to multiple primary causes; these cases were considered with the main primary cause.

The outcomes of the Bamou Wildlife Rescue Center during this period were categorized as follows: 1) expired during the treatment process/prior to receiving treatment; 2) euthanized; 3) released; 4) permanently unable to be released and relocated to a zoo or wildlife sanctuary.

Results

Between April 2019 and February 2021, the wildlife rescue center admitted 173 individuals from 52 species (Table 1). Of these cases, 131 were birds (75.72%), with mammals comprising 36 individuals (20.80%) and reptiles totaling 6 individuals (3.46%). A majority of birds belonged to the family Accipitridae (28.24%); subsequently, 14.50% belonged to Falconidae, followed by 12.21% Strigidae, 9.92% Pycnonotidae, 8.39% Columbidae, 7.63% Phasianidae,

TABLE 1. ADMITTED INDIVIDUALS PER CLASS/FAMILY/SPECIES.

NO	CLASS	FAMILY	ENGLISH NAME	SCIENTIFIC NAME	IUCN STATUS	CASES
1	Aves	Accipitridae	Common Buzzard	*Buteo buteo*	LC	14
2	Aves	Accipitridae	Eastern Imperial Eagle	*Aquila heliaca*	VU	1
3	Aves	Accipitridae	Egyptian Vulture	*Neophron percnopterus*	EN	1
4	Aves	Accipitridae	Eurasian Sparrowhawk	*Accipiter nisus*	LC	2
5	Aves	Accipitridae	European Honey Buzzard	*Pernis apivorus*	LC	1
6	Aves	Accipitridae	Golden Eagle	*Aquila chrysaetos*	LC	2
7	Aves	Accipitridae	Hen Harrier	*Circus cyaneus*	LC	1
8	Aves	Accipitridae	Levant Sparrowhawk	*Accipiter brevipes*	LC	1
9	Aves	Accipitridae	Long legged Buzzard	*Buteo rufinus*	LC	6
10	Aves	Accipitridae	Steppe Eagle	*Aquila nipalensis*	EN	8
11	Aves	Apodidae	Common swift	*Apus apus*	LC	5
12	Aves	Ardeidae	Little Bittern	*Ixobrychus minutus*	LC	2
13	Aves	Ardeidae	Night Heron	*Nycticorax nycticorax*	LC	1
14	Aves	Caprimulgidae	European Nightjar	*Caprimulgus europaeus*	LC	1
15	Aves	Columbidae	Collared Dove	*Streptopelia decaocto*	LC	2
16	Aves	Columbidae	European Turtle Dove	*Streptopelia turtur*	VU	1
17	Aves	Columbidae	Rock Dove	*Columba livia*	LC	8
18	Aves	Corvidae	Common Magpie	*Pica pica*	LC	1
19	Aves	Falconidae	Barbary Falcon	*Falco pelegrinoides*	LC	2
20	Aves	Falconidae	Common Kestrel	*Falco tinnunculus*	LC	16
21	Aves	Falconidae	Peregrine Falcon	*Falco peregrinus*	LC	1
22	Aves	Meropidae	European Bee-eater	*Merops apiaster*	LC	3
23	Aves	Pelecanidae	Dalmatian Pelican	*Pelecanus crispus*	NT	3
24	Aves	Phalacrocoracidae	Cormorant	*Phalacrocorax carbo*	LC	2
25	Aves	Phasianidae	Chukar	*Alectoris chukar*	LC	10
26	Aves	Phoenicopteridae	Greater Flamingo	*Phoenicopterus roseus*	LC	2
27	Aves	Pycnonotidae	White Eared Bulbul	*Pycnonotus leucotis*	LC	13

TABLE 1. ADMITTED INDIVIDUALS PER CLASS/FAMILY/SPECIES CONTINUED...

NO	CLASS	FAMILY	ENGLISH NAME	SCIENTIFIC NAME	IUCN STATUS	CASES
28	Aves	Strigidae	Eurasian Eagle-Owl	*Bubo bubo*	LC	5
29	Aves	Strigidae	European Scops Owl	*Otus scops*	LC	1
30	Aves	Strigidae	Little Owl	*Athene noctua*	LC	3
31	Aves	Strigidae	Long-eared Owl	*Asio otus*	LC	6
32	Aves	Strigidae	Omani Owl	*Strix butleri*	LC	1
33	Aves	Tytonidae	Barn Owl	*Tyto alba*	LC	2
34	Aves	Upupidae	Eurasian Hoopoe	*Upupa epops*	LC	3
35	Mammals	Bovidae	Indian Gazelle (Chinkara)	*Gazella bennettii*	LC	1
36	Mammals	Bovidae	Wild Goat	*Capra aegagrus*	NT	2
37	Mammals	Bovidae	Wild Sheep	*Ovis gmelini*	NT	4
38	Mammals	Canidae	Golden Jackal	*Canis aureus*	LC	3
39	Mammals	Canidae	Gray Wolf	*Canis lupus*	LC	5
40	Mammals	Canidae	Red Fox	*Vulpes vulpes*	LC	5
41	Mammals	Erinaceidae	Brandt's Hedgehog	*Paraechinus hypomelas*	LC	2
42	Mammals	Felidae	Jungle Cat	*Felis chaus*	LC	3
43	Mammals	Herpestidae	Small Indian Mongoose	*Urva auropunctata*	LC	1
44	Mammals	Hyaenidae	Striped Hyaena	*Hyaena hyaena*	NT	4
45	Mammals	Sciuridae	Persian Squirrel	*Sciurus anomalus*	LC	2
46	Mammals	Suidae	Wild Boar	*Sus scrofa*	LC	1
47	Mammals	Ursidae	Brown Bear	*Ursus arctos*	LC	3
48	Reptiles	Colubridae	Braid Snake	*Platyceps rhodorachis*	NE	1
49	Reptiles	Colubridae	Spotted Whip Snake	*Hemorrhois ravergieri*	LC	1
50	Reptiles	Testudinidae	Spur-thighed Tortoise	*Testudo graeca*	VU	1
51	Reptiles	Viperidae	Blunt-Nosed Viper	*Macrovipera lebetina*	LC	2
52	Reptiles	Viperidae	Saw-Scaled Viper	*Echis carinatus*	LC	1
						173

3.81% Apodidae, 2.29% Ardeidae/ Meropidae/ Pelecanidae/ Upupidae, 1.52% Phalacrocoracidae/ Phoenicopteridae/ Tytonidae, and 0.76% Caprimulgidae/ Corvidae.

In the case of mammals, Canidae were the most frequent family, accounting for 36.11%, followed by Bovidae at 19.44%, Hyaenidae at 11.11%, and Felidae and Ursidae at 8.33% each. Erinaceidae and Sciuridae comprised 5.55%, while Herpestidae and Suidae represented 2.77%. As for reptiles, which constituted the least represented class, Viperidae made up half of the cases, with Colubridae and Testudinidae appearing next, respectively.

At the species level, the common kestrel (16/173) and common buzzard (14/173) were the most frequently admitted cases to the rescue center, comprising 84.21% and 37.83% respectively of the Falconidae and Accipitridae families. Within the Columbidae family, the rock dove was the predominant species admitted to the rescue center, accounting for 72.72% of cases.

Among the six categories of primary causes of admission, trauma accounted for the largest number of admitted individuals (41.61%), followed by illegal wildlife trade (18.49%), orphaned (16.18%), infectious disease (12.71%), unknown (8.67%), and poisoning (2.31%) (Table 2) (Fig. 2).

Within the bird species, the highest percentage of cases (45.80%) involved trauma (59.45% of family Accipitridae and 47.36% of family Falconidae were admitted with trauma), followed by illegal trade (20.61%) (over 75% of the Phasianidae and Pycnonotidae families were associated with illegal trade) and orphaned individuals (16.03%) (43.75% of the Strigidae family admitted to the rescue center were orphaned). The Strigidae family accounted for 25% of the total orphaned category and 33.33% of all orphaned birds. As for mammals, the majority of cases were due to infectious diseases (36.11%), with a significant portion (84.61%) affecting carnivores. Trauma accounted for 22.22% of cases, Orphaned mammals comprised 19.44% of admissions.

The non-releasable category contained the highest number of individuals at 30.63%, succeeded by those released at 25.43%, euthanized individuals at 23.69%, and finally those that expired at 20.23% (Table 3) (Fig. 3). Illegal wildlife trade accounted for the majority of primary causes resulting in release, comprising 47.72%. Trauma came next at 31.81%, with unknown factors after that at 11.36%. In reptiles, 4 individuals out of 6 were released (66.66%) while the release

TABLE 2. PRIMARY CAUSES OF ADMISSION PER FAMILY.

FAMILY	PRIMARY CAUSES						
	INFECTIOUS DISEASE	ORPHANED	POISONING	TRAUMA	ILLEGAL WILDLIFE TRADE	UNKNOWN	TOTAL
Accipitridae	6	3	1	22	1	4	37
Apodidae				3		2	5
Ardeidae				3			3
Bovidae	2	3		2			7
Canidae	7	1	1	2	2		13
Caprimulgidae				1			1
Colubridae				1	1		2
Columbidae	3	2		4		2	11
Corvidae		1					1
Erinaceidae				1		1	2
Falconidae		4		9	4	2	19
Felidae	2			1			3
Herpestidae	1						1
Hyaenidae	1		2	1			4
Meropidae				3			3
Pelecanidae				3			3
Phalacrocoracidae				2			2
Phasianidae				2	8		10
Phoenicopteridae				1		1	2
Pycnonotidae		3			10		13
Sciuridae					2		2
Strigidae		7		4	3	2	16
Suidae		1					1
Testudinidae				1			1
Tytonidae		1		1			2
Upupidae				2	1		3
Ursidae		2		1			3
Viperidae			2			1	3
Totals	22	28	4	72	32	15	173

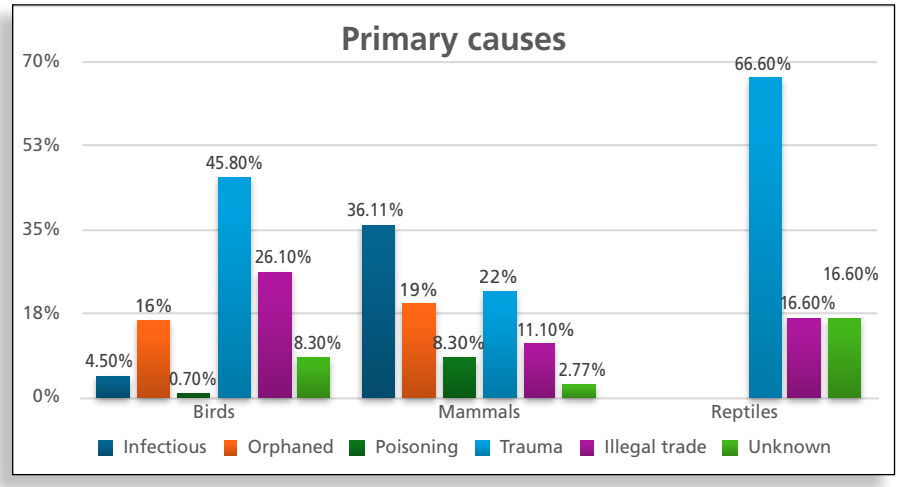


FIGURE 2. Percentages of primary causes of admission for each class.

rate in mammals and birds were 11.11% and 27.48% respectively. Pycnonotidae (10/13), Phasianidae (6/10), and Accipitridae (8/37) had higher release rates as compared to the other families of birds. In the case of mammals, a minority of individuals belonging to Canidae (2/13), Hyaenidae (1/4), and Sciuridae (1/2) were released.

Discussion

This study represents the first investigation into the causes and outcomes of wildlife rescues in Iran, providing insights into the challenges of wildlife rehabilitation efforts in the country. No study had previously been conducted on rehabilitation activities in Iran, despite the fact that aspects of rehabilitation such as success rates, various procedures, and the direct and indirect impacts of rehabilitation activities on different taxa have been evaluated in different parts of the world.[1,11–15]

In this study, the majority of admitted cases involved birds, while reptiles had the fewest admissions. Similar findings have been reported by various studies on wildlife rehabilitation centers across three different continents, excluding amphibians, which were not considered in our study.[1,13,16–18] Birds are the most common group of terrestrial vertebrates. Because of their exceptional adaptability to various environments and their capacity to fly in open spaces, it is not surprising that the most injured cases belonged to the class Aves.

Regarding mammals, the cases admitted to rescue centers vary depending on the geographic region and the species occurring in each habitat. In two studies carried

TABLE 3. OUTCOMES OF ADMITTED INDIVIDUALS PER FAMILY.

FAMILY	OUTCOMES				
	EXPIRED	EUTHANIZED	RELEASED	NON-RELEASABLE	TOTAL
Accipitridae	6	8	8	15	37
Apodidae	2	2	1		5
Ardeidae	1			2	3
Bovidae	2	1		4	7
Canidae	2	6	2	3	13
Caprimulgidae		1			1
Colubridae		1	1		2
Columbidae	2	5	2	2	11
Corvidae				1	1
Erinaceidae	1	1			2
Falconidae	3	4	3	9	19
Felidae	1	1		1	3
Herpestidae		1			1
Hyaenidae		1	1	2	4
Meropidae	2	1			3
Pelecanidae	1		2		3
Phalacrocoracidae	1	1			2
Phasianidae	2		6	2	10
Phoenicopteridae	1	1			2
Pycnonotidae			10	3	13
Sciuridae	1		1		2
Strigidae	4	4	3	5	16
Suidae	1				1
Testudinidae			1		1
Tytonidae		1		1	2
Upupidae	1	1	1		3
Ursidae				3	3
Viperidae	1		2		3
	35	41	44	53	173

out at different rescue centers, one in the Czech Republic and the other in the southwest of England, the most commonly admitted mammals belonged to Chiroptera and hedgehogs, respectively.[17,19] In another study in Costa Rica, Didelphimorphia was the most commonly admitted order of mammals to the rescue center.[18] In addition, Adhikari et al.[20] indicate that Cervidae (27%) covered the largest proportion of the studied cases in a wildlife rescue center in Nepal. Also, in Turkey, roe deer and red fox were the most commonly admitted species.[20,21]

More than one-third of admitted individuals suffered from different types of traumatic occurrences. Trauma is the most common primary cause of admission in different parts of the world. In one study conducted based on submission forms from wildlife rehabilitation centers in New York state, trauma was the most common overall cause of submission.[1] In another study in the Northern Region of Portugal, the number of deaths due to trauma was three times higher than non-traumatic cases.[16] Moreover, Thomson et al. (2013) showed that 25% of all admitted raptors suffered from motor vehicle accidents or flew into buildings.[22] Similar results were found by another study in Canada, which showed that anthropogenic activities leading to trauma, particularly collisions with vehicles and windows, as well as predation by domestic animals, result in the deaths of billions of birds and mammals annually in North America.[23] Furthermore, 83% of all trauma cases were bird species, and around half of them (28 out of 60) were victims of illegal hunting. It has been indicated that around 3.2 million birds from at least 413 species are illegally killed or captured annually in the Middle East, with an estimated mean of 801,000 birds in Iran.[24]

Also, illegal wildlife trade and orphaned cases together accounted for another one-third of the total primary causes of admission. Parchizadeh and Belant demonstrated that during 1980–2021, 433 large carnivores in Iran died due to human-caused mortality, with 21% classified as victims of illegal trade. Carnivores are also illegally traded for purposes such as medicine, clothing, and household ornaments.[25]

The proportion of released vs. non-releasable rescued individuals can vary greatly depending on the primary cause of admission, the species, the principles each rescue center adheres to, equipment and facilities, the policies of the specific region or state, and so forth. In an Australian survey, over 50% of rehabilitators stated that wild individuals which showed different types of stereotyped behaviors were still released, and more than 64% did not conduct any pre-release medical testing.[5] In this study, the lack of standard rehabilitation facilities or comprehensive pre-release medical techniques, and the potential for latent viral infections in certain infectious cases, resulted in a higher number of non-releasable mammal individuals compared to other studies.

In a study conducted in New South Wales, Australia, the release rate of admitted wild individuals was found to be 37.1%. In contrast, a study in Spain reported a release rate of 63%. Across three studies from various countries, including New York State (USA), Italy, and Greece, the overall release rate for admitted cases ranged from 50% to 56%, while 45–46% of admitted cases either died or were euthanized in New York State, Australia, and Italy.[1,26,27] Despite euthanasia being considered an option by every wildlife rehabilitation center, the criteria to determine candidates

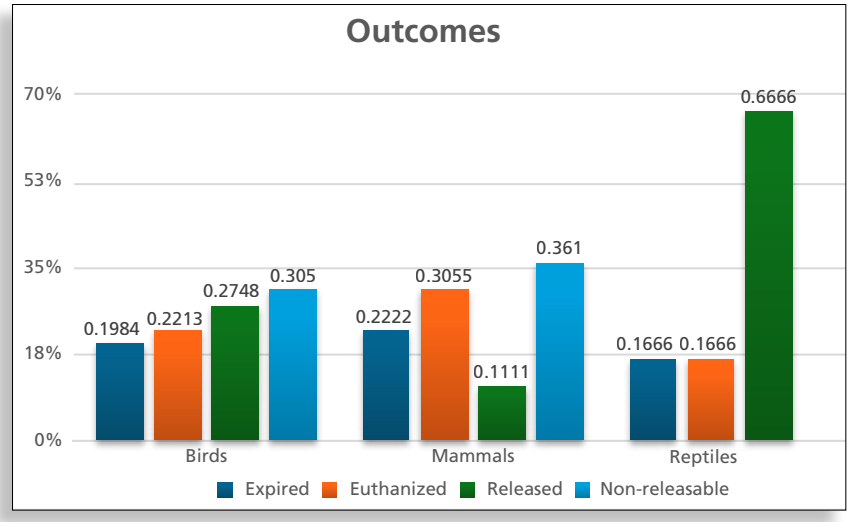


FIGURE 3. Percentages of outcomes for each class.

for euthanasia can vary. In this study, in addition to suffering from unmanageable pain despite treatment, or lacking quality of life even after recovery in lifelong care facilities, candidates for euthanasia were identified based on similar, obviously untreatable conditions and clear-cut cases, following established guidelines.[28] The rate of euthanasia is significantly correlated with the primary causes of admission and is higher among injured individuals.[17]

Unfortunately, since no post-release monitoring method was practiced in this study, achieving any measure of successful release rate was not possible. Many wildlife rehabilitation centers consider releasing an animal to be an indicator of success,[6,7] although these efforts should only be considered successful if they lead to the establishment of a self-sustaining population. This involves ensuring the survival and breeding of released individuals, as well as the persistence of the new population over time.[6,29] Therefore, wildlife rehabilitators must consider rehabilitation unsuccessful unless they can verify that released animals survive for a specified period. Consequently, post-release monitoring should not be considered optional, but rather an important step of the treatment, rehabilitation, and release of wildlife casualties.[30] However, unfortunately, due to funding deficiencies and other potential reasons such as the concern that negative outcomes may challenge the goals of rehabilitation activities,[6] post-release monitoring studies are rarely conducted, even in developed countries.[14]

In conclusion, despite Iran's rich biodiversity, there is no rescue or wildlife rehabilitation center equipped with adequate space and enclosures, facilities, and essential supplies, and wildlife rehabilitation activities lack both governmental and non-governmental support. In some cases, this shortage leads to injured wild species being taken to companion animal clinics, entering a vicious cycle of treatment and rehabilitation that ultimately fails to comply with the principles of rehabilitation and, consequently, results in unsuccessful releases. In addition, these conditions create a situation where there is a risk of encouraging illegal wildlife possession and trafficking. Efforts to establish wildlife rehabilitation centers and equip them could lead to an increase in the percentage of released cases and provide an opportunity for numerous studies, including monitoring after release.

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High intensity blood parasite infections are associated with negative health effects in rehabilitated birds

Bren Lundborg



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BARRED OWL (*Strix varia*)

AUTHOR AFFILIATIONS
Center for Wild Bird Rehabilitation and Animal Care at the Vermont Institute of Natural Science (VINS) Vermont, USA.

ABSTRACT
Infections with *Haemoproteus, Leucocytozoon*, and *Plasmodium* (malaria) are common in both free-ranging and rehabilitated birds. Although rates of infection are similar, infection intensities in many rehabilitated birds are higher than in most free-ranging birds. *Haemoproteus* infections are associated with lower intake body condition in barred owls (*Strix varia*), and longer time to self feed in broad-winged hawks (*Buteo platypterus*). Barred owls and broad-winged hawks coinfected with *Haemoproteus* and *Leucocytozoon* had significantly lower intake body condition scores than individuals infected with one or no parasites. Rates of *Plasmodium* infections appear to have increased over time in Vermont passerines, and are common in some species such as corvids and American robins (*Turdus migratorius*). *Plasmodium* infection has regularly caused disease in rehabilitated passerines at VINS. Rehabilitators should be aware of the potential of high intensity infections and co-infections causing negative health effects, and should consider screening high risk species for *Plasmodium* infection.

KEYWORDS
Blood parasites, disease, *Haemoproteus*, hemoparasites, infection, *Leucocytozoon*, malaria, parasites, *Plasmodium*.

Introduction

The three common avian hemoparasites *Haemoproteus*, *Leucocytozoon*, and *Plasmodium* have been well studied in free ranging birds, but relatively little work has focused on them in a wildlife rehabilitation setting. All three genera of parasites are known to cause adverse health effects in both wild and captive birds.[1,2] Stress-related immunosuppression from captivity and treatment, comorbidities, and infections with other parasites increase the risk of these organisms causing disease while their hosts are being rehabilitated.[3] Olsen and Gaunt (1985) reported higher mortality and longer stays in rehabilitation in raptors infected with blood parasites.[4] These factors suggest that the

CORRESPONDING AUTHOR
Bren Lundborg
Center for Wild Bird Rehabilitation and Ambassador Care at the Vermont Institute of Natural Science
355 Natures Way
Quechee, VT 05059
E: blundborg@vinsweb.org

effects of blood parasite infections may be underrecognized and perhaps undertreated in rehabilitated birds.

The symptoms of blood parasite infections have been well described elsewhere, but generally may include lethargy to depression, dyspnea, anorexia, weight loss, regurgitation, and neurologic signs, as well as anemia and hemoglobinuria.[1] The progress of infections may range from subacute to apparent sudden death, and survivors typically become chronic carriers. In the rehabilitation setting, many of these symptoms may be masked by other injuries or infections, making it difficult to ascertain what condition is responsible for them. Hemoparasite infections are also associated with a wide range of gross lesions, most often affecting the liver and spleen, but also commonly affecting the muscles, lungs, brain, and kidneys.[1] Given the wide range of adverse health effects, and that increased infection rates of *Plasmodium* have been documented in rehabilitated raptors,[5] as well as the increased prevalence of vector borne diseases related to climate change, blood parasites may very well become a more common source of disease in rehabilitated birds.[6]

The purpose of the study was to learn more about blood parasite infections in rehabilitated birds presented to the Center for Wild Bird Rehabilitation and Ambassador Care (CWBRAC), the rehabilitation clinic at the Vermont Institute of Natural Science (VINS), located in Quechee, Vermont. Its goals included looking at differences in infections between species, age groups, seasons, and ecoregions of Vermont and New Hampshire, and to compare infection data to studies on wild birds. Additionally, it evaluated certain health parameters in two species with high levels of parasites, and briefly reviewed CWBRAC cases with disease due to blood parasites. It was predicted that due to the health-related effects of blood parasites, as well as increased risk of infection due to concurrent injuries and illnesses, the prevalence and infection intensity would be higher in rehabilitated birds than in wild birds. It was also predicted that at least some measures of patient health and progress would be negatively affected by higher intensity infections.

Methods

Samples were collected from as many patients presented to CWBRAC as possible from January 1st, 2020 through December 31st, 2020. Birds were brought in from throughout Vermont, and a more limited geographical area of New Hampshire, generally from towns close to the Vermont–New Hampshire border. Avian species identification and aging was done by experienced rehabilitation staff familiar with native species. Ages were classed by nestling (N), fledgling (F), hatch year (HY), or after hatch year (AHY). In cases where it was not possible to accurately determine sex or age, both were listed as unknown (U). Location where birds were found was collected from the finders at the time of intake.

Smears were created during routine blood draws, or small blood samples were collected from patients in cases where a blood draw was not planned, but would not compromise the bird's health (e.g., samples were not collected from patients who were too unstable for the procedure). Blood was collected with a 25ga or 27ga needle, from the basilic ulnar, medial metatarsal, or jugular veins. It was collected in a plain microhematocrit tube, a smear was immediately created using the two slide method, and slides were left to air dry. They were then stained with Dip-Quick Stain (Jorgensen Labs), and stored until assessment.

To minimize changes in parasite count related to care at a rehabilitation facility, smears were collected within 48–72 hours of arrival, so that effects of stress on the immune system would have limited effects on parasitemia. Patients who had been started on medications that may reduce parasitemia (e.g., antimalarial drugs, sulfonamides, tetracyclines, clindamycin) were not included if the medications were started prior to a smear being collected. In some instances, samples were collected during euthanasia once the bird had been anesthetized, and rarely samples were collected from the jugular vein shortly after death.

Smears were initially assessed at low magnification, and smears of insufficient preparation or staining quality were discarded. Parasitemia (i.e., infection



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BROAD-WINGED HAWK (*Buteo platypterus*)

intensity) was assessed using the Miller disc method, and the number of each parasite per 2,000 red blood cells was used to calculate the percentage of infected cells. Parasites were identified down to genus by using the key produced by Valkiunas and Iezhova.[7] Rates of infection, co-infection, and infection with each genus of parasite were calculated as the percentage of positive birds for species and order, as well as for each age group, month, and ecoregion. Mean infection intensity was calculated from infected birds only. Birds from known locations were assigned to an ecoregion based on an EPA ecoregion map of New England.[8]

Infection intensities were compared between rehabilitated birds in this study and studies of free-ranging birds that reported average parasite infection intensities. Searches were performed for studies on species of free-ranging birds that appeared in this study, and infection intensities were converted into percentage of infected red blood cells for comparison if they were reported differently (e.g., infected cells per 2,000 red blood cells). Infection intensities were compared using the Wilcoxon Signed-Rank Test.

Due to their high infection prevalence and intensities, barred owls (*Strix varia*) and broad-winged hawks (*Buteo platypterus*) were selected for further analysis of health-related parameters. Additional cases (11 barred owls and 6 broad-winged hawks) were added from 2022 and 2023, when parasite counts were available using the same methodology. Intake body condition score (BCS, scored 1–5), packed cell volume (PCV), weight loss or gain at 5 days, and days until self-feeding in relation to *Haemoproteus* and *Leucocytozoon* infection intensity were assessed using linear regression analysis. The same parameters were also compared between birds with coinfections to birds with one or no infections using the student's t-test. Statistical analysis was done in Microsoft Excel and RStudio.

Results

Analysis included 448 samples from 15 orders, 36 families, and 79 species, although many species and orders were represented by small sample sizes. Infections were detected in 38.8% of samples, and coinfections were detected in 14.5% of samples. *Haemoproteus* sp. (26.8%) was the most commonly found infection, followed by *Leucocytozoon* sp. (20.1%) and *Plasmodium* sp. (4.9%), with rare *Trypanosoma* sp. and *Microfilaria* sp. infections detected. A summary of infections by order can be seen in Table 1, and rates of infections, coinfection, and infection intensities can be seen in Supplementary Table 1.

Hatch year and adult birds had the highest rates of infection of most parasites, with Microfilaria being most common in birds

TABLE 1. SUMMARY OF INFECTIONS AND COINFECTIONS VINS DURING THE SAMPLING PERIOD

ORDER	n	INFECTIONS n (%)	COINF. n (%)	LEUC. n (%)	HAEM. n (%)	PLAS. n (%)	TRYP. n (%)	MICR. n (%)
Accipitriformes	53	36 (67.9)	20 (37.7)	29 (54.7)	28 (52.8)	0	0	0
Anseriformes	21	10 (47.6)	3 (14.3)	4 (19.0)	9 (42.9)	0	0	0
Apodiformes	1	0	0	0	0	0	0	0
Caprimulgiformes	2	0	0	0	0	0	0	0
Cathartiformes	2	0	0	0	0	0	0	0
Charadriiformes	15	0	0	0	0	0	0	0
Columbiformes	23	1 (4.3)	0	0	0	0	0	0
Coraciiformes	2	0	0	0	0	0	0	0
Falconiiformes	9	4 (44.4)	1 (11.1)	0	4 (44.4)	0	1 (11.1)	0
Galliformes	12	5 (41.7)	0	1 (8.3)	4 (33.3)	0	0	0
Gaviiformes	3	0	0	0	0	0	0	0
Gruiformes	1	0	0	0	0	0	0	0
Passeriformes	171	54 (31.6)	12 (8.2)	23 (13.5)	19 (11.1)	22 (12.9)	2 (1.2)	2 (1.2)
Accipitriformes	53	36 (67.9)	20 (37.7)	29 (54.7)	28 (52.8)	0	0	0
Pelicaniformes	4	0	0	0	0	0	0	0
Piciformes	35	6 (17.1)	0	1 (3.2)	5 (14.3)	0	0	0
Strigiformes	94	58 (61.7)	29 (30.8)	32 (34.0)	51 (54.3)	0	0	4 (4.3)
Total	448	174 (38.8)	65 (14.5)	90 (20.1)	120 (26.8)	22 (4.9)	3 (0.67)	6 (1.34)

COINF. = Coinfections, LEUC.= Leucocytozoon, HAEM.= Haemoproteus, PLAS.= Plasmodium, TRYP.= Trypanosoma, MICR.= Microfilaria.

of unknown age (Supplementary Table 2). Overall rates of infected birds and *Leucocytozoon* and *Haemoproteus* infections were all lowest in the winter months (December through February) and began rising in March–April, with several peaks that may indicate spring relapse (April) and increased vector activity (June–September). The peak in November is suspected to be due to sampling bias, but may have an ecological component (Supplementary Figure 1). Coinfections peaked in July–August. *Plasmodium* infection rates did not show any clear patterns over time throughout the year. There were no significant differences in any of the infection categories between ecological regions (χ^2 (1, N = 8) $P_{Leucocytozoon}$ = 0.51, $P_{Haemoproteus}$ = 0.30, $P_{Plasmodium}$ = 0.48). Infection rates between ecoregions can be seen in Supplementary Table 3.

Parasitemia varied widely between species and orders. Broad-winged hawks had the highest average burden of *Leucocytozoon* infection, with the exception of several species with very small sample sizes. Barred owls had an exceptionally high average *Haemoproteus* burden (mean 3.48 +/– 8.48% erythrocytes infected), while broad-winged hawks, merlins (*Falco columbarius*), blue jays, and common ravens (*Corvus corax*) also had high averages. American robins had the highest average *Plasmodium* parasitemia. Images from select blood smears with high rates of infection can be seen in Figure 1. Nine studies reporting infection intensities of free-ranging birds were found to compare to species in this study (Supplementary Table 4). While the birds in this study tended to have a higher average infection intensity, there was no significant difference found (n = 9, Z = –1.40, p = 0.162).

Higher intensity *Haemoproteus* infections were linked with longer time to self-feed in broad-winged hawks, as well as lower BCS in barred owls. There was a non-significant trend towards lower BCS and higher *Leucocytozoon* infections in broad-winged hawks. No other associations were found between infection intensity and health parameters (Table 2).

Broad-winged hawks and barred owls coinfected with *Haemoproteus* and *Leucocytozoon* had lower average body condition scores than birds infected with one or no parasites. Coinfections were not linked to any other significant differences in health parameters (Table 3).

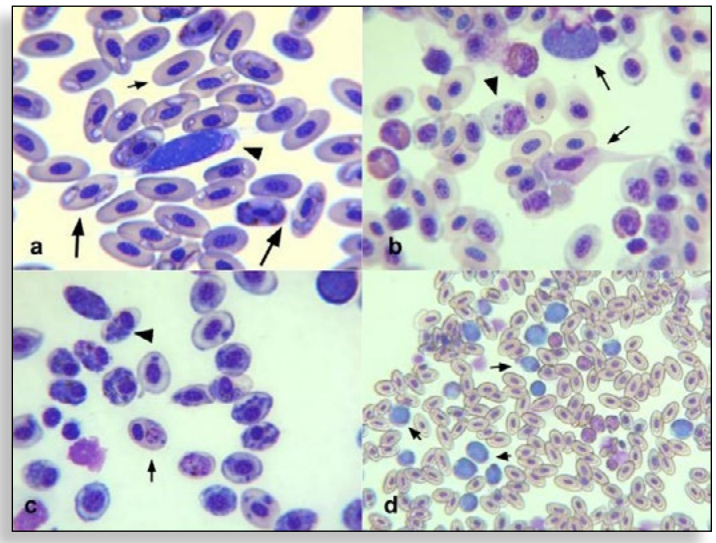


FIGURE 1. High intensity infections in birds rehabilitated at VINS. **a.** A normal red blood cell (small arrow), cells infected with *Haemoproteus* (large arrows), and a *Leucocytozoon* (arrowhead). **b.** *Leucocytozoon* with mature gametocytes (arrows) and merozoites (arrowhead) in a white blood cell. **c.** *Plasmodium* infection in a common grackle (*Quiscalus quiscula*) with mature gametocytes displacing the cell nucleus (arrow), and schizonts (arrowhead). **d.** *Leucocytozoon* infection in an American robin, with some gametocytes indicated by arrows.

TABLE 2. COMPARATIVE LINEAR REGRESSION RESULT ANALYSIS: INTENSITY OF PARASITE INFECTION TO SELECT HEALTH PARAMETERS

	Broad-winged Hawk			Barred Owl		
	p	R^2	n	p	R^2	n
Haemoproteus						
PCV	0.296	0.06	19	0.915	0.0002	64
BCS	0.711	0.008	19	0.023*	0.08	65
Self-feeding	0.006*	0.59	11	0.374	0.02	40
Weight change	0.505	0.057	10	0.207	0.036	46
Leucocytozoon						
PCV	0.76	0.005	19	0.779	0.001	64
BCS	0.07	0.18	19	0.31	0.016	65
Self-feeding	0.24	0.15	11	0.266	0.03	40
Weight change	0.733	0.015	10	0.089	0.06	46

Discussion

The findings in this study were generally consistent with other studies of avian blood parasites, such as juvenile and adult birds having the highest infection rates, and lower infection rates in winter. Sampling was limited by the types of birds brought in for care; thus, many orders and species were poorly represented. Even within well-represented orders, sampling was still biased by intakes, with 91/94 Strigiformes being barred owls. Intake bias also affected seasonal prevalence; for example, November had the highest rate of infection, but the population was predominantly groups with high rates of infection (raptors and corvids). A limitation in measuring the prevalence of parasite infections was the use of microscopy without molecular methods. This methodology makes detection of moderate to heavy infections easy to accomplish (e.g., infections that were more likely to be clinically significant), but some chronic infections with low parasitemia were almost certainly missed. Even in the absence of molecular analysis, rates of infection in many orders were similar to those found in other studies.[9–18]

Parasite burden was more difficult than prevalence to compare to free-ranging birds, as many studies report prevalence, but not intensity of infection. Furthermore, some studies only report intensity ranges, but not means, making it difficult to assess infection intensity in a population. While this study attempted to compare between free-ranging and rehabilitated birds, there were a limited number of comparison studies and highly variable

TABLE 3. HEALTH PARAMETER COMPARISONS BETWEEN BIRDS COINFECTED WITH *HAEMOPROTEUS* AND *LEUCOCYTOZOON* TO THOSE INFECTED WITH ONE OR NO PARASITES

HEALTH PARAMETER	SINGLE/NONE	COINFECTED	P, T(DF) = T STAT
Broad-winged Hawk			
PCV (%)	30 +/– 6.7	32 +/– 8.2	0.621, t(8) = –0.515
BCS	2.0 +/– 0.87	3.2 +/– 0.84	0.033, t(7) = –2.65
Self-feeding (days)	4.7 +/– 4.8	7.8 +/– 4.8	0.310, t(9) = 1.07
Weight loss (%)	4.2 +/– 4.0	1.9 +/– 5.7	0.486, t(7) = –0.736
Barred Owl			
PCV (%)	36 +/– 6.6	35 +/– 7.0	0.855, t(30) = –0.185
BCS	2.6 +/– 0.76*	3.1 +/– 0.92	0.037, t(37) = –2.17
Self-feeding (days)	5.4 +/– 4.1	3.3 +/– 2.8	0.076, t(24) = –1.85
Weight loss (%)	1.1 +/– 4.4	2.0 +/– 5.8	0.596, t(25) = 0.537

sample size between studies and individual species. Therefore, the results of this comparison may have little value given the difficulties in finding comparable data. Expanding the comparison studies to other geographical areas (e.g., South America) may allow for more comparison to free-ranging birds, but differences in infection dynamics in different regions and species may prevent a useful comparison.

Since blood parasite infections are frequently subclinical, establishing an infection intensity associated with disease may help in deciding which cases to treat, but reports with parasite counts are rare. This is also made difficult in that some pathogenic infections are associated with tissue stages of infection, and not necessarily high parasitemia.[7,19] A merlin mortality due to hemoparasite infection reported 1% and 6.6% of erythrocytes infected with *Leucocytozoon* and *Haemoproteus*, respectively.[20] Leucocytozoonosis in a juvenile snowy owl (*Bubo scandiacus*) was reported with an infection rate of 25/high powered field.[21] A study of nestling raptors found a median *Leucocytozoon* infection rate of roughly 1% associated with minor pathogenicity.[22] Garvin et al. found changes in blood parameters and histologic lesions, but no behavioral or gross pathologic changes in experimentally infected juvenile blue jays with parasite intensities up to 3%, but suggested these infections may have more detrimental effects in birds subjected to the stressors of the natural environment.[23] *Plasmodium* infections are generally considered more likely to be pathogenic, and infection levels of 13%–90% of erythrocytes have been associated with disease in CWBRAC cases and other reports.[24–26]

Multiple cases of symptomatic hemoparasite infections have been seen at CWBRAC. A fledgling American robin had mild dyspnea and lethargy associated with a *Leucocytozoon* infection, with symptoms noticed days before the infection intensity peaked at over 5%. A juvenile broad-winged hawk with a coinfection of *Leucocytozoon* (1.04%) and *Haemoproteus* (3.56%) had a histopathological diagnosis of leucocytozoonosis, with renal tubular meronts associated with pale lesions throughout the kidneys. This bird also had a severe coccidial enteritis that contributed to its death. Another juvenile broad-winged hawk was treated for a symptomatic (weight loss, lethargy, anorexia, mild regenerative anemia, biliverdinuria) coinfection of *Leucocytozoon* (8.6%) and *Haemoproteus* (3.1%), with improving condition seen as parasite counts dropped (CWBRAC unpublished data).

As expected, *Plasmodium* infections are a more regular source of disease in CWBRAC patients. At least 11 cases of symptomatic *Plasmodium* infections have been diagnosed at CWBRAC from 2019–2024, with a mortality rate of over 70%. These were diagnosed both pre- and post-mortem, so it is not clear whether *Plasmodium* was the primary cause of death in each case, but gross lesions consistent with *Plasmodium* infection (e.g., hepatosplenomegaly) were present in every bird necropsied. Many of these cases also had cytology or histopathology findings that supported a diagnosis of malaria. These cases were all passerines (mostly American robins), and most symptomatic infections appeared to be species of the *Haemamoeba* subgenus in which the mature parasites displace the host nucleus.[1] It also seems that there has been an increase in the rate of *Plasmodium* infections in Vermont passerines. A 1986 study found a 1% prevalence of *Plasmodium* infection,[12] while Martinsen et al. found a 9.3% prevalence in 2006,[14] and the current study found a prevalence of 12.9% in passerines. A significant difference in this study was the inclusion of American crows and common ravens, but with these species excluded the rate of infections was 9.4%.

It is difficult to interpret infection-related health effects in this study due to the fact that most birds had multiple comorbidities. Although *Haemoproteus* and *Leucocytozoon* infections were associated with negative health effects in barred owls and broad-winged hawks, other factors may have contributed. Reduced BCS has been associated with *Leucocytozoon* infections in barn owls (*Tyto alba*),[27] and *Haemoproteus* infections in American kestrels (*Falco sparverius*),[28] so some birds in this study may have had reduced body condition and high parasitemia prior to injury. Given these studies, as well as reduced flight performance and a myriad of other symptoms reported in falcons infected with blood parasites,[29] the birds in this study may have been at higher risk for vehicle strikes, the primary cause of intake for both species. Ultimately, it is likely that most blood parasites are not primary pathogens, but one of multiple factors contributing to disease and debilitation.

The results of this study suggest that some rehabilitated birds may be at greater risk from negative health effects due to hemoparasite infection than their free-ranging counterparts, or that infection with parasites may predispose some individuals to injury. However, given the many variables in these cases, no conclusion can be made about a definitive relationship. It strongly suggests that certain species may be more likely to have clinically relevant infections, such as *Haemoproteus* and *Leucocytozoon* in barred owls and broad-winged hawks, and *Plasmodium* in some

passerine species. Rehabilitators should consider assessing some species for blood parasite infections, particularly young birds or species at risk for *Plasmodium* infection. Further work to document effects of blood parasite infections may help to elucidate how much rehabilitated birds are affected, particularly when high parasitemia is present.

Conclusions

While blood parasites are often reported as non-pathogenic, like any parasite they may cause disease when the host–parasite balance is altered in favor of the parasite through stressors such as injury, disease, and captivity. This imbalance may not lead to obvious disease, but might cause subtle effects (e.g., taking longer to self-feed) that cause greater handling and stress to rehabilitated birds. A slowly growing body of case reports and research suggests that the effects of blood parasite infections may have been historically under-recognized, particularly in the rehabilitation setting. This is not to suggest that blood parasite infections should be regularly treated, but that rehabilitators should be aware of their potential symptoms, particularly in species prone to high levels of infection.

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About the author

Bren Lundborg is the assistant director of the Center for Wild Bird Rehabilitation and Animal Care at the Vermont Institute of Natural Science (VINS). He has been working there for 7 years, helping to treat all species of birds that occur in Vermont. In addition to rehabilitation he has a strong interest in research related to wildlife disease and critical care. His work has included research on blood parasites, HPAI, helping to monitor wild bird mortalities in Vermont, and helping with regional loon mortality monitoring and research.

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SELECTED ABSTRACTS

Causes of death and screening for toxicants and hemopathogens of European hedgehogs (*Erinaceus europaeus*) from a wildlife rehabilitation center in northern France

Hirschinger J et al. J. Wildl Dis. 2025;61(1):100-110. https://doi.org/10.7589/JWD-D-24-00092

The European hedgehog (*Erinaceus europaeus*), common in rural and suburban environments, is perceived as declining within its native range, prompting conservation concerns. This study of hedgehogs admitted to a French rehabilitation center aimed to identify causes of death, detect potential emerging diseases, and systematically screen dead hedgehogs for toxicants and hemopathogens. Using clinical information, necropsy examination, and ancillary testing in 159 dead hedgehogs, we identified the primary cause of death of 92% of them. The leading causes of death were impaired general condition (30%); bacterial infections (26%), frequently caused by *Salmonella* Enteritidis; and trauma (20%). Additional factors contributing to death were identified in 78%, including a high proportion with significant parasite infestations. Toxicologic screening revealed that 42% of hedgehogs had been exposed to anticoagulant rodenticides, including 6.4% hedgehogs with levels compatible with acute intoxication. These hedgehogs were also exposed to trace metals, especially lead, but no pesticides residues were detected. Hemopathogen screening revealed a low diversity and prevalence of blood pathogens with 3.6, 2.9, and 2.9% individuals infected with *Anaplasma phagocytophilum*, *Mycoplasma turicensis*, and *Mycoplasma wenyonii*, respectively. The variety of diagnoses suggests that there is no unique prominent or emerging disease responsible for the mortality of these hedgehogs. This study also highlighted the high exposure of hedgehogs to various toxicants. To further investigate the extent and causes of population declines, health information issued from several centers should be combined with demographic data as well as ecologic assessments on the availability and quality of natural resources.

The illegal trade of wild birds in a social network: A call for action from Argentina

López FG et al. Ornithol Appl. 2025;duaf012. https://doi.org/10.1093/ornithapp/duaf012

The illegal trade of wild birds is a large threat to biodiversity and sellers often use social media to traffic wildlife. By monitoring and characterizing the trade of wild and domestic birds on Facebook, we show that this illegal e-commerce remains widespread throughout Argentina, despite a decrease in activity in 2023 compared to 2017, highlighting the persistence and magnitude of this issue. In 2017, we found 96,354 users in 127 buying/selling groups in 18 provinces, of which 61% were public. In 2023, we found 58,647 users in 76 groups in 14 provinces, of which 66% were public. Analyzing one group in 2017 and two groups in 2023, we found 67 bird species were offered for sale. All birds for sale in these groups had illegal origins (i.e., without authorized bands or permits), including two Endangered and one Near Threatened species. Passerines (mainly Thraupidae, Fringilidae, and Cardinalidae species) were the most offered group, but parrots, raptors, and other bird groups were also available. *Saltator aurantiirostris* (Golden-billed Saltator) was most frequently offered for sale and had the highest interest from users in the two largest analyzed groups. The Endangered *Gubernatrix cristata* (Yellow Cardinal) reached the highest price (up to 328 USD), it was also frequently offered for sale (5th position in 2017), and had high user interest (2nd in 2017). We found that Facebook was frequently used for illegal bird trade in Argentina, including species of conservation concern, which can threaten a number of species. We call for coordinated and interdisciplinary actions that engage authorities, social media companies, and local communities, which will be needed to enact top-down and bottom-up measures to continue reducing and eventually halting wildlife-related illegal activities. A translated Spanish version of this article is available in the Supplementary Material.

Gastrointestinal helminth infections and ectoparasitism in wild rodents along wildlife-human interfaces in Tanzania

Msoffe VT et al. Int J Parasitol Parasites Wildl. 2025;26(101040):101040. http://dx.doi.org/10.1016/j.ijppaw.2025.101040

Background

Gastrointestinal parasites pose a significant threat to human and domestic animal health across Africa. Despite numerous studies on ectoparasitism and endoparasitism in small mammals across different regions of the continent, the ecological role of rodents in transmission dynamics of gastrointestinal helminths remains poorly understood. This study aimed to identify gastrointestinal helminths in rodents and evaluate the influence of host-related factors, ectoparasite infestations, and environmental variables on helminth prevalence at wildlife-human interfaces in Tanzania.

Methods

Gastrointestinal helminth eggs were quantified using the modified McMaster method on samples from captured rodents. Correlations between parasitological data, host scaled mass index (SMI), and ectoparasite intensity were analyzed. Generalized linear mixed models (GLMMs) were employed to assess helminth occurrence in relation to host demographics, ectoparasite load, and environmental factors.

Results

The overall prevalence of gastrointestinal helminths was 53.59%. Seven distinct helminth egg types were identified, representing two major taxa: nematodes and cestodes. Among the nematodes, eggs of *Trichuris* spp., *Strongyloides* spp., *Syphacia* spp., Capillariidae and Spirurida were identified. Cestode eggs present were Hymenolepis-like eggs and eggs of Anoplocephalidae. Whipworms (*Trichuris* spp.) exhibited the highest prevalence (23.2%), followed by threadworms (*Strongyloides* spp.) at 22.1%.

Anoplocephalid eggs showed the lowest prevalence, at 0.56%. The occurrence of gastrointestinal helminths in rodents was significantly associated with increased SMI and ectoparasite (flea and mite) infestations, while also varying across rodent species and collection sites.

Conclusions

This study highlights the presence of potentially zoonotic helminths, including capillariids and *Hymenolepis*-like species, in rodents at wildlife-human interfaces. Furthermore, it identifies associations between gastrointestinal helminth infections and host body condition, as well as the intensity of ectoparasite infestations. These findings underscore the importance of considering host and environmental factors in understanding helminth transmission dynamics and their potential impact on public and veterinary health.

Plate rod in humerus fracture in Caracara plancus: challenges and outcomes of a case

Leitão JR et al. Arq Bras Med Vet Zootec. 2025;77(1):e13297. https://doi.org/10.1590/1678-4162-13297

The aim of this case study was to apply a robust fixation method using the plate rod technique, which combines intramedullary pins with bone plates to provide rigid stabilization. Although commonly used in mammals, this technique has not yet been documented in avian medicine. The surgery involved detailed pre-operative evaluations and meticulous surgical planning, reflecting standards used in small animal orthopedics, to ensure that the implants were well-suited to the unique anatomical needs of the bird. In the post-operative phase, the bird was closely monitored, with follow-up radiographs showing successful implant alignment and advanced bone healing without any signs of infection. The outcome was positive, with the bird regaining full wing functionality and being released back into the wild after recovery at a wildlife rehabilitation center. This case highlights the effectiveness of the plate rod technique in managing complex fractures in avian patients, emphasizing its potential as a valuable option for similar cases, particularly in large and wild birds. The successful application and outcome of this approach provide a significant contribution to veterinary orthopedics, expanding potential methodologies for fracture treatment in avian species.

Estimating the impact of sarcoptic mange epidemic on the population size of wild raccoon dogs (*Nyctereutes procyonoides*) from wildlife rescue data

Matsuyama R, Kido N, Omori R. Int J Parasitol Parasites Wildl. 2024;25(101010):101010. https://doi.org/10.1016/j.ijppaw.2024.101010

The impact of infectious diseases on host populations is often not quantified because it is difficult to observe the host population and infectious disease dynamics. To address this problem, we developed a state-space model to simultaneously estimate host population and disease dynamics using wildlife rescue data. Using this model, we aimed to quantify the impact of sarcoptic mange on a Japanese raccoon dog population by estimating the change in their relative population size. We classified the status of rescued raccoon dogs into four categories: i) rescued due to infection with mange, ii) rescued due to traffic accidents without mange, iii) rescued due to traffic accidents with mange, and iv) rescued due to causes other than traffic accidents or mange. We modeled the observation process for each category and fitted the model to the reported number of raccoon dogs rescued between 1990 and 2010 at three wildlife rescue facilities in Kanagawa Prefecture, Japan. The mortality rate induced by mange was estimated to be 1.09 (95% credible interval (CI): 0.47–1.72) per year. The estimated prevalence of sarcoptic mange ranged between 4 and 80% in the study period. When a substantial prevalence of mange was observed (1995–2002), the host population size decreased by 91.2% (95% credible intervals: 86.3–94.7). We show that the impact of infectious disease outbreak on the wildlife population can be estimated from the time-series data of wildlife rescue events due to multiple causes. Our estimates suggest that sarcoptic mange triggered a substantial decrease in the Japanese wild raccoon dog populations.

Screening wild birds for tick-borne zoonotic pathogens in Portugal

Loureiro F et al. Pathogens. 2025;14(1):75. https://doi.org/10.3390/pathogens14010075

Wild birds may be involved in the transmission of agents of infectious diseases, including zoonoses, a circumstance which raises a number of public and animal health issues. Migratory bird species play a significant role in the introduction of tick-borne pathogens to new geographic areas, contributing to the dissemination of various etiological agents. This preliminary study aimed to assess the occurrence of four potentially zoonotic pathogens (*Hepatozoon* spp., *Borrelia* spp., *Babesia* spp. and *Theileria* spp.) in the wild birds of Portugal. Blood and tissue samples were taken from 103 birds admitted at wildlife rehabilitation centers. Through the use of conventional PCR, our findings indicate no evidence of the circulation of these pathogens among the studied bird populations in the region. In the One Health context, it is relevant to understand how faraway avian populations play a role in the epidemiology of infectious diseases. Further molecular studies are needed to deepen the knowledge of avian piroplasmosis, borreliosis and hepatozoonosis.

Histologic characterization of fracture repair process in wild birds in association with gross appearance of the bone lesion

Espinosa J et al. Vet Pathol. 2025;0(0). https://doi.org/10.1177/03009858251317458

This study aims to provide an in-depth examination of the histological changes that occur during the repair of untreated bone fractures in avian species, correlating these microscopic alterations with gross anatomical characteristics observed during different tissue repair phases. A total of 93 bone fractures from different wild birds were analyzed and classified based on temporality (acute, subacute, and chronic) according to the color changes of the hematoma and morphology (open or

closed; simple, comminuted, or greenstick fractures). From a microscopic standpoint, a strong correlation was observed between the temporal progression observed macroscopically and the histological changes evident in each temporal category. Microscopic variations were found to depend on the nature of the fracture. Lesional patterns directly related to the macroscopic appearance of the fracture were established. Acute fractures exhibited extensive hematomas and an intense inflammatory response; subacute fractures showed immature granulation tissue and early signs of soft callus formation; and finally, chronic fractures were characterized by prominent soft calluses and hard calluses in different stages of development. The possible factors influencing each phase of the healing process, such as the characteristics of the type of fracture, the stability of the fracture site, bacterial contamination, the chronicity of the fracture, and the potential differences in the progression of histological changes between different animal species, are discussed. This association may be of clinical utility in decision-making for the treatment and prognosis of bone fractures in birds.

Packed cell volume and plasma chemistry reference intervals for Eurasian Eagle Owls (*Bubo bubo*) in a rehabilitation setting in South Korea before release

Kim H-J, Kim K-T. J Wild Dis. 2025;61(1):159–165. https://doi.org/10.7589/JWD-D-24-00014

Rehabilitation and release of wild birds hinge upon a comprehensive understanding of both biologic and nonbiologic factors, including the medical and physical fitness of the animal. The objectives of this study were to determine reference intervals of packed cell volume and plasma chemistry values for healthy Eurasian Eagle Owls (*Bubo bubo*) and to compare blood values between age and sex classes. There were significant differences between males and females in total protein and globulin mean values, with males having higher values than females. Adult and juvenile Eagle Owls differed significantly in the mean values of calcium, alkaline phosphatase, and uric acid, with juveniles having higher values than adults. The calculated reference intervals for Eagle Owls can be used in Eurasian Eagle Owls admitted to rescue centers to assist veterinarians and wildlife managers to clinically evaluate and monitor the health of Eagle Owls and make decisions about when to release them after treatment.



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EURASIAN EAGLE OWL (*Bubo bubo*)

Exposure and survival of wild raptors during the 2022-2023 highly pathogenic influenza a virus outbreak

Rayment KM et al. Scientific reports. 2025;15(1):6574. https://doi.org/10.1038/s41598-025-90806-6

The global outbreak of clade 2.3.4.4b H5N1 highly pathogenic influenza A virus (HP H5N1) has had an unprecedented impact on wild birds including raptors, but long-term population impacts have not been addressed. To determine if raptors survive infections with HP H5N1, raptors from the upper Midwest United States were serologically tested for antibodies to influenza A virus (IAV), H5 and N1. Raptors were sampled at The Raptor Center's (University of Minnesota) wildlife rehabilitation hospital and at Hawk Ridge Bird Observatory. Samples were tested for IAV antibodies using a commercially available blocking ELISA, with positive samples tested for antibodies to H5 and N1. Antibodies to IAV were detected in 86 out of 316 individuals representing 7 species. Antibodies to H5 and N1 were detected in 60 individuals representing 6 species. Bald eagles had the highest seroprevalence with 67/97 (69.1%) seropositive for IAV and 52 of these 67 (77.6%) testing positive for antibodies to both H5 and N1. Prevalence of antibodies to IAV observed in this study was higher than reported from raptors sampled in this same region in 2012. The high prevalence of antibodies to H5 and N1 indicates a higher survival rate post-HP H5N1 infection in raptors than previously believed.

Digital platforms, privacy, and the ethics of wildlife information sharing

Rubel A, Kaehrle M, Streiffer R. Philos Technol. 2025;38(1):1–29. https://doi.org/10.1007/s13347-025-00841-4

Digital platforms allow wildlife enthusiasts to share information with larger audiences than ever before. However, by heightening awareness and human interaction, they can threaten the well-being of non-human animals (henceforth "animals"). One example of this is increased stress to Snowy Owls (*Bubo scandiacus*) from close observation by large numbers of people made possible by accurate, timely, and widely-distributed location information. In this paper, we

examine the ethics of animal privacy, wildlife observation, and information sharing on digital platforms, using Snowy Owls as a case study. We begin by reviewing Snowy Owl migration and population statistics, trends in information sharing about and observation of Snowy Owls, and resulting harms to Snowy Owls. We then argue that animals have morally weighty privacy interests that ground human obligations to protect their privacy. These obligations are strengthened by additional concerns about species protection and ecological conservation. Our arguments support an array of privacy protections, including obligations on the part of wildlife observers, researchers, and other groups. However, because the catalyst for this paper is novel information technologies, we make a focused set of recommendations applicable to digital platforms. Specifically, we argue that platforms ought to restrict public information sharing when disclosure is likely to endanger individual animals, species, or ecosystems.

Chlamydial infections in free-ranging raptors presenting to a university veterinary medical teaching hospital (1993-2022)

Hawkins MG et al. Am J Vet Res. 2025;86(3):1–10. https://doi.org/10.2460/ajvr.24.09.0277

Objective

To describe the prevalence, clinical findings, lesions, and risk factors associated with chlamydial infections in free-ranging raptors presented to a university veterinary medical teaching hospital.

Methods

Medical records retrospectively searched for raptors admitted from January 1993 through April 2022 were tested for *Chlamydia* spp infections using quantitative PCR (qPCR), immunohistochemistry, culture, and sequencing. Findings were collected and analyzed. Multivariable logistic regression analyzed the association between *Chlamydia* spp infection status and risk factors, including age class, species, sex, and season of admission.

Results

The prevalence for cases that tested positive for *Chlamydia* spp on 1 or more diagnostic tests, including mucosal qPCR samples for *Chlamydia* spp, tissue PCR for C buteonis, and mucosal qPCR genotyped as *C buteonis*, was 1.9% (74 of 3,983). All positive cases were from the genus Buteo (n = 74). Juvenile birds and winter season had higher odds of infection. All birds were in poor body condition (n = 74), often with moderate-to-severe CBC and biochemistry abnormalities consistent with multiorgan chronic inflammatory disease, emaciation, and dehydration. On postmortem examination of *Chlamydia*-positive birds (58 of 74), hepatitis (44 of 56), nephritis (24 of 39), splenitis (22 of 53), airsacculitis (21 of 43), myocarditis (21 of 39), and pneumonia (21 of 38) were common lesions, with intracellular bacteria in multiple tissues.

Conclusions

Signalment, season of admission, clinical signs, clinicopathologic findings, and *Chlamydia*-specific testing identified chlamydial infections in free-ranging raptors. Appropriate protections to prevent potential zoonotic transmission in clinical wildlife rehabilitation settings are recommended.

Clinical relevance

Many clinical parameters used to identify *C psittaci* infection in parrots can also be used to identify chlamydial infections in raptors.

Translocation of a rehabilitated juvenile platypus (*Ornithorhynchus anatinus*)

Thomas JL. Aust Mammal. 2025;47(1). https://doi.org/10.1071/am24040

The success of rehabilitated juvenile animals after release is poorly studied. This study monitored the behavior and habitat use of a juvenile male platypus (*Ornithorhynchus anatinus*) found in poor body condition on a driveway and rehabilitated, before undergoing an inter-catchment translocation. Radio telemetry tracked his movements and resting locations for 18 days during which he used more vegetation for shelter than burrows. After 8 days in the creek near the release site, he traveled through drains into a swamp, potentially displaced by resident platypuses, where the signal was lost. The results demonstrate significant challenges in post-release survival, including burrow creation. This case highlights the importance of monitoring animals after release.

SARS-CoV-2 surveillance and detection in wild, captive, and domesticated animals in Nebraska: 2021-2023

Loy DS et al. Front Vet Sci. 2024;11:1496207. https://doi.org/10.3389/fvets.2024.1496207

Widespread surveillance for SARS-CoV-2 was conducted across wildlife, captive animals in zoological collections, and domestic cats in Nebraska from 2021 to 2023. The goal of this effort was to determine the prevalence, phylogenetic and spatial distribution characteristics of circulating SARS-CoV-2 variants using various diagnostic methodologies that can utilize both antemortem and postmortem samples, which may be required for wildlife such as white-tailed deer. Statewide surveillance testing revealed high variation in SARS-CoV-2 prevalence among species, with white-tailed deer identified as the primary reservoir. In 2021, seroprevalence in white-tailed deer was 63.73% (n = 91) and 39.66% (n = 237) in 2022, while virus detection in retropharyngeal lymph nodes (RLN) was 16.35% (n = 483) in 2021 and 3.61% (n = 277) in 2022. Phylogenetic analysis was conducted on 11 positive samples from 2021. This analysis revealed the presence of four lineages of the Delta variant: AY.100, AY.119, AY.3, and AY.46.4. Conversely, other species showed no virus detection, except domestic cats, which had a low seroprevalence of 2.38% (n = 628) in 2022, indicating minimal exposure. The detection of SARS-CoV-2 in white-tailed deer and the identification of multiple Delta lineages underscores the need for ongoing surveillance and the importance of using different diagnostic methodologies. These efforts are critical for understanding virus circulation and evolution in wildlife and domestic animals, informing public health strategies, and mitigating the risks of zoonotic transmission of SARS-CoV-2 and other emerging infectious diseases. ◆

TAIL ENDS



Linda, come see this! The neighbors are going nuts!

Eurasian Red Squirrel
Sciurus vulgaris
IUCN Red List–Least Concern, Population Trend – Unknown

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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.

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Kieran Lindsey, Editor
jwr.editor@theiwrc.org

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

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OMANI OWL (*Strix butleri*) in care at Bamou Wildlife Rescue Center Fars Provence, Iran.



International Wildlife Rehabilitation Council
PO Box 3197
Eugene, OR 97403 USA
Voice/Fax: 408.876.6153
Toll free: 866.871.1869
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