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ABOUT THE JOURNAL

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

On the cover:
Orphaned Asian elephant (***Elephas maximus maximus***) calves in rehabilitation, at feeding time.
PHOTO: ELEPHANT TRANSIT HOME, SRI LANKA.

Left:
European hedgehog (*Erinaceus europaeus*).

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

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A Profession Built on Science

A discussion with a retired rehabilitator, my mother in fact, reminded me of the amazing work done in the field of wildlife rehabilitation over the last forty-odd years. Practices in wildlife rehabilitation have changed significantly, as have those in related fields of veterinary medicine, conservation biology, and wildlife management. At our core are the values and beliefs that make us a community; and those have remained constant. We retain our values and build our knowledge.

In the previous editorial, I stated, "Science is a process, not an indivisible fact. Each inquiry refines our understanding of best practices and sets a brick in the foundation of wildlife rehabilitation." Such is our progress. Everything we do is built on what we did last week. We learn, and our learning leads to revision and growth. We practice science and we gain knowledge, each and every day.

IWRC's work is to train people in the practice of wildlife rehabilitation. We inform practitioners and allies about changes and advancements. Some days we receive inquiries from long time rehabilitators frustrated with a government requirement for continuing education when, "I've been doing this for 20 years!"

How do we explain the need for continuing education without disregarding years of hard fought experience? While pondering this question, I realized that not only are we in a young, growing, and evolving field, it is a science-based discipline, as I argued in the Spring editorial. Our practices impact a diverse group of species, and they are iterative by nature so, yes, the practice is always changing. There is always more to learn.

While new knowledge might invalidate old protocols, it never invalidates the work that went into those efforts, for current practitioners stand upon the shoulders of pioneers, of visionaries. A wildlife rehabilitator should never feel ashamed or chastised by continuing education requirements. Lifelong learning is required of us, not because we are doing things wrong, but because what is right changes, and we want to provide our charges with the best, most current care.

If my mother were still a practicing rehabilitator, there is much she'd find new. She could trace the path of 'new' standards of practice backwards, through the work she did in the 00's, the 90's, the 80's, and the work others were doing before the start of her own practice. Continuing education is a requirement, but what we learn today does not reduce the value of what has come before.

—Kai Williams
Executive Director

Cause of Mass Eagle Poisoning Uncovered

MARYLAND, USA (June 20, 2018)—It is now known that thirteen bald eagles found dead in 2016 in Federalsburg, Maryland were likely poisoned by carbofuran. The USFWS Forensic Lab found traces of the poison in the six birds tested. Carbofuran is an illegal pesticide in the United States. The culprits have never been apprehended.

New Program to Report Arkansas Wildlife Health Issues

LITTLE ROCK, Arkansas, USA (June 20, 2018)—Jenn Ballard, the Arkansas Game and Fish Commission's veterinarian, has introduced a new program to report sick or dead animals and fish that she hopes will help the agency stay on top of health problems affecting wildlife. Any sick or dead animal, other than a deer, encountered in the state of Arkansas can be reported via email, agfc.health@agfc.ar.gov. Those reports will be reviewed by the AGFC's fish and wildlife health professionals and, if possible, investigated in person.

Dr. Ballard said adding an email submission system to the AGFC's new Fish and Wildlife Health Program has been "on my mind" since she started with the agency 18 months ago.

"It's kind of filling a gap," Dr. Ballard said. "If people find injured wildlife, they can still go to a licensed rehabilitator. For deer road kills, our CWD line (1-800-482-9262) is still available and is where to go for that.

"But for sick animals or dead animals that we need to investigate because of the mortality, this email system allows people to report things, attach photos, details, and a location. That's the main thing. We may not be able to respond to every submission personally, but by having it centralized, we will be able to look for patterns and determine if they are more regional or statewide issues."

When submissions are made, an automated response is generated that reminds people to never pick up or handle sick, injured or dead wildlife unless asked to by AGFC personnel and aware of how to do so safely. Also, if rabies is suspected, the submitter is asked to contact the state Department of Health, the state agency that handles rabies cases.

Hawaiian monk seal (*Monachus schauinslandi*) sleeping in the surf on the shores of Kauai. PHOTO ©MINETTE LAYNE. CC BY-NC-ND 2.0 LICENSE.

With an injured animal that may only require rehabilitation, people can access a list of licensed rehabilitators on the agency's website at www.agfc.com/en/resources/wildlife-conservation/wildlife-rehabilitation. It is unlawful for anyone to rehab wildlife in Arkansas without a state or federal rehabilitation permit. Also, deer, elk and bears may not be rehabbed due to disease transmission and safety risks.

Dr. Ballard is being assisted in the program by A.J. Riggs, recently promoted to the role of AGFC health biologist, based in Russellville; and by Kelly Winningham, a fish pathologist at the Andrew Hulsey Fish Hatchery in Hot Springs, who will handle fish issues.

"We will read all the emails submitted and keep an eye out for issues that could have population-level impacts in the state," Dr. Ballard said. "The key for the public is being safe around those situations and passing along the information."

Dr. Ballard said that in the past, many calls about sick or dead wildlife have gone to AGFC regional offices or to the main headquarters through telephone calls, the agency's Facebook page, the Ask AGFC email and other means. "We don't have a way to centralize or track that information." Dr. Ballard said. "We appreciate the public helping us keep an eye out for these issues and to be safe with these animals and not necessarily pick them up."

Toxoplasmosis in Hawaiian Monk Seal Population

HONOLULU, USA (June 18, 2018)—The recent deaths of three critically endangered Hawaiian monk seals on O'ahu due to toxoplasmosis is very sad and could have been entirely preventable, according to a joint statement from the heads of the Hawai'i Departments of Health (DOH) & Land and Natural Resources (DLNR).

Health Director Dr. Bruce Anderson explained that the parasite NOAA veterinarians found that caused the deaths of the seals is far more impactful than just killing seals.

"The only thing certain about toxoplasmosis is that there are far more cases in humans and more deaths in seals, dolphins, native birds and other animals today than are recognized and reported," said Anderson. "Since cats are the only animal

that transmit the disease, it only makes sense that reducing the number of feral cats will reduce the risk of infection and serious illness or death," Anderson added.

DLNR Chair Suzanne Case is again encouraging people not to feed cats and other animals near water. "In addition to preying on native wildlife, cats pose a significant health risk to people, marine wildlife and birds," Case explained. Toxoplasmosis can also infect Hawai'i's native birds, including the nēnē and the newly released Hawaiian crow, the 'Alalā.

"Feeding cats near water obviously increases the risk of transmission but, given the nature of the watersheds in Hawai'i, cats almost anywhere are probably contributing to the problem," Case said. "The cysts can live for months in soil and can wash into streams and runoff and be carried into the ocean from almost anywhere. Feeding cats at state parks, boat harbors and other coastal areas increases the risk of transmission because the cysts don't need to travel very far to get into the ocean." Case added, "Frankly, feeding cats anywhere where their feces can ultimately wash into the ocean is a problem."

One of the seals, RK60, killed by toxoplasmosis gave birth to a pup on Moku Iki off shore from Lanikai in the spring of 2017. This seal and her pup moved to Moku Nui and were featured in a safe wildlife viewing video produced by DLNR and shown over the past year to thousands of people who rent from Kailua kayak rental firms

In Hawai'i, the National Oceanographic and Atmospheric Administration has recorded at least eleven Hawaiian monk seal deaths that are attributable to toxoplasmosis infection since the first confirmed deaths in 2001. Spinner dolphins are the only other marine species that have been documented as dying from toxoplasmosis in Hawai'i, but there are many other marine mammal species around the world that have also been affected and infections have been linked to the marine food web. This, according to Case and Anderson, should be enough to prompt people to stop feeding feral cats near any bodies of water.

"With only an estimated 1,400 Hawaiian monk seals still in existence, we simply cannot afford to lose even one of these critically endangered mammals to a disease that is preventable. We hope people will provide as much love to our few very special seals as they do to the hundreds of thousands of feral cats around our islands," Case said.

Australian Org Launches New Feral Cat Initiative

NEW SOUTH WALES, Australia (May, 2018)—Feral cats kill more than 1 million birds, 1 million reptiles, and 1 million mammals in Australia every day (Woinarski et al. 2017, 2018).

Australian Wildlife Conservancy (AWC) believes action is urgently needed to protect and restore populations of our most vulnerable wildlife and identify a solution to the feral cat crisis. Their strategy:

- **Establish a national network of feral cat-free areas**

  AWC manages more cat-free land than any other organization on mainland Australia. Within 12 months there will be six feral cat-free areas of greater than 5,000 hectares on mainland Australia—five of these will be managed by AWC. These feral-free areas provide a secure refuge for wild populations of some of Australia's most endangered mammals.

- **Develop and implement best practice feral cat control ("beyond the fence")**

  AWC implements direct feral cat control (e.g., trapping, shooting and indigenous tracking) and indirect control (management of ground cover and dingoes), as well as undertaking ground-breaking scientific research on feral cat ecology in order to improve the effectiveness of control strategies.

- **Invest in gene drive technology**

  AWC has signed an agreement with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to explore whether gene drive technology can be utilised to effectively remove feral cats from the landscape – for example, by causing feral cats to become sterile or to have only male kittens. Initial priorities include: (a) completing a genome for feral cats and, in particular, having sex chromosomes mapped and sequenced; and (b) undertaking the extensive research required to better understand the population ecology and mating behaviour of feral cats (critical information to ensure the spread of any genetic control). This is a long term project but it is potentially our best hope in finding an effective continent-wide solution.

Ohio Manatee Rehabilitation

COLUMBUS, Ohio, US (April 24, 2018)—The Columbus Zoo and Aquarium welcomed two rehabilitating manatee orphans in April. The two new additions, one male and one female, became the 28th and 29th manatees to be rehabilitated at the Columbus Zoo since the Zoo's involvement in the Manatee Rescue and Rehabilitation Partnership (MRP) began in 2001.

The 143-pound male calf was found as an orphan February 6, 2018. The female calf was rescued on February 8, 2018 with her mother off the coast of Florida. The female calf showed signs of cold stress, while her mother was negatively buoyant. Unfortunately, the calf's mother succumbed to her serious injuries just two days after her rescue, leaving the female calf an orphan. After beginning rehabilitation at SeaWorld Orlando, both manatees have stabilized and will continue to recover in Columbus before their eventual releases to Florida waters.

As part of the MRP, the Columbus Zoo and Aquarium is a second-stage rehabilitation facility that provides a temporary home for manatees until they are ready for release back to the wild.

The only other facility that assists with rehabilitating manatees outside of the state of Florida is the Cincinnati Zoo and Botanical Garden. Along with the Columbus Zoo arrivals, the Cincinnati Zoo welcomed an approximately 1-year-old orphaned female calf named Daphne early this morning.

Both facilities participate in the MRP

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Songbird collision injuries during migration season

Jane Hudecki and Esther Finegan

White-breasted nuthatch (*Sitta leucopsis*), victim of a window collision.

ABSTRACT: Millions of migratory birds are killed or injured every year in North America by colliding with lit structures or windows in cities. Unfortunately, limited research describing typical songbird collision injuries is presently available to wildlife rehabilitators. A clear understanding of migratory songbird collision injuries is needed to assist rehabilitators in helping window collision victims recover quickly and effectively. The current study reviewed information on the injuries of patients admitted to Toronto Wildlife Centre following window or building collisions from the spring and fall of 2013–2016. Records from 563 individuals of ten species of songbird were examined. Injuries did not differ significantly between species ($P>0.05$) and were consistent year to year. Corneal ulcers were shown to occur at significantly higher rates ($P<0.0001$) compared to any other injury, and were seen across species and across years. Corneal ulcers in impact collision victims have not previously been reported for migratory songbird species. Wildlife rehabilitators should therefore include a thorough eye exam with songbird patient care during the migration season to ensure correct treatments and to facilitate quick recovery times.

KEY WORDS: abrasion, bird–window collision, corneal ulcer, eye, impact trauma, migratory songbird, rehabilitation, window, window strikes, wound

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Introduction

Every spring and autumn, diurnal songbirds will often become partially nocturnal to migrate by relying on starlight, moonlight, polarized light patterns, and the sun's position at sunset.[1,2,3] Unfortunately for songbirds relying predominantly on light cues to navigate, light emanating from the buildings of cities at night can attract and entrap individuals flying overhead along their migration routes.[4,5] Once trapped in a city, songbirds find themselves in a maze of reflective obstacles and can become susceptible to colliding with windows.[5,6] This has been shown to occur not only in songbirds but in other migratory bird species that rely partially on visual cues to navigate.[4]

Bird–window collisions that occur during the migration season are most often fatal.[7,8] Songbird individuals that manage to survive collisions often sustain painful and debilitating head injuries, which ultimately become fatal if left untreated.[7,8] If songbirds somehow avoid building collisions, they may continue to fly around the light sources of taller buildings until exhausted.[9] City light pollution in the spring and the fall when migration occurs is therefore a serious welfare concern for nocturnal migratory birds. In addition, recent estimates for annual bird–window collisions are between 365 and 988 million in the United States[10] and 16–42 million in Canada.[11] The abundance of city lights in the spring and fall is therefore not only a welfare concern for individual birds, but a major conservation issue for songbird populations.

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Although there have been many studies covering songbird collision fatalities, limited research exists on the types of injuries sustained by migratory songbird individuals that survive window strikes. A study by Daniel Klem (1990) and a study by Veltri and Klem (2005) found that most specimens killed from collisions exhibited varying degrees of intracranial hemorrhaging and cerebral blood pooling.[7,8] These two studies focused mainly on killed specimens and not on collision survivors, demonstrating the need for more research to develop a greater understanding of the injuries sustained by songbirds that survive window strikes. This would provide more information to assist rehabilitators in helping window collision victims recover, both in the field and in wildlife centers.

The main objective of the current study is to analyze information on injuries sustained by migratory songbirds after colliding with structures in Toronto, and to determine whether there is species relevance to various types of trauma sustained by window-strike victims.

Methods

Data collection

Historical data was obtained from Toronto Wildlife Centre (TWC), a wildlife rehabilitation center in Toronto, Ontario, Canada. Injuries of patients admitted for rehabilitation following window collisions were analyzed from the spring and fall of 2013–2016. Records from 563 individuals of ten species of migratory songbird were examined (Table 1). The species examined were the ten species most frequently collected and transferred to Toronto Wildlife Centre by Fatal Light Awareness Program (FLAP) volunteers from 2013–2016.

Songbirds were collected by volunteers and staff from FLAP Canada during the migration season (late March to early June in the spring, and mid-August to mid-November in the fall).[4] Daily monitoring and collection began before dawn and continued throughout the morning and afternoon, depending on volunteer availability. Areas searched included select regions in Toronto and the surrounding vicinity, with greater emphasis placed on specific buildings historically known to experience higher volumes of bird collisions. Staff and volunteers patrolled around most building sides looking for migratory birds that had collided with structures. Surfaces such as above-ground patios, terraces, or open-topped atria were not accessible for collection. Live birds were captured by hand or with a hand-held net. Arnica (*Arnica montana*) was administered in mist form to mucous membranes or exposed skin once birds were captured to act as a temporary analgesic. Birds were placed in individual un-waxed paper bags and transported to TWC for assessment. Any birds that were deemed releasable were subsequently taken to natural areas, and any dead birds were catalogued and donated to the Royal Ontario Museum. Due to the many variables that occurred when conducting collision monitoring (volunteer availability, weather conditions), collection methods employed by FLAP volunteers could not always be standardized or consistent.

TABLE 1. Nocturnal migratory songbird records examined from 2013–2016. The four-letter codes are standardized from the American Ornithological Union (AOU) Bird Species List.[15]

Species	Code	2013	2014	2015	2016	Total
Brown creeper (*Certhia americana*)	BRCR	23	8	11	19	61
Dark-eyed junco (*Junco hyemalis*)	DEJU	9	2	8	13	32
Golden-crowned kinglet (*Regulus satrapa*)	GCKI	45	15	22	20	102
Ruby-crowned kinglet (*Regulus calendula*)	RCKI	10	2	11	8	31
Ovenbird (*Seiurus aurocapilla*)	OVEN	36	6	5	12	59
White-throated sparrow (*Zonotrichia albicollis*)	WTSP	84	13	11	19	127
Hermit thrush (*Catharus guttatus*)	HETH	21	7	14	22	64
Nashville warbler (*Leiothlypis ruficapilla*)	NAWA	8	9	10	10	37
Magnolia warbler (*Setophaga magnolia*)	MAWA	10	3	4	6	23
Common yellowthroat (*Geothlypis trichas*)	COYE	16	3	6	2	27

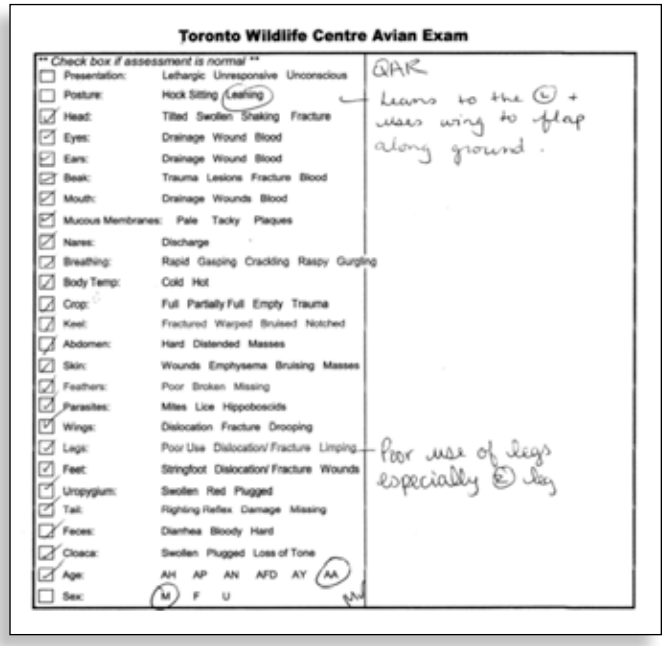

FIGURE 1. Toronto Wildlife Centre avian exam checklist example.

Thorough exams were performed once birds were transported to TWC for assessment. A typical assessment began with an overall appraisal of a bird's composure and posture, followed by the administration of 1–2 drops Nutri-Cal (a caloric supplement) before weighing and performing the rest of the exam. The

exam protocol followed a thorough avian assessment checklist (Fig. 1). Specific injuries were classified into twelve categories, defined in Table 2.

Statistical Analysis

Descriptive analyses[12] of the information from the 563 assessments were performed using Microsoft Excel for Mac (Version 15.28). Interpretive statistical analyses were performed using IBM SPSS Statistics (Version 24). A generalized linear model was used to check for significant differences in injuries between species and across years, and a Pearson's chi-square test was used to check for associations between injuries across years. Results were considered significant at $P<0.05$ for both tests.

TABLE 2. Injury categories for songbirds admitted to Toronto Wildlife Centre from 2013–2016.

Injury	Example
Eye Trauma	Corneal ulcer, periorbital swelling, blood in eye, ruptured eye
Soft Tissue Trauma	Bruising, swelling, lacerations, punctures, abrasions
Head Trauma	Swollen head, torticollis, head tracking, blood from nares
Weak	Weak, weak flight, weak flap, lethargic
Fracture	Shoulder girdle (clavicle, coracoid, scapula), maxilla, mandible, wing (radius/ulna, humerus, carpal), keel, leg (tibiotarsus, tarsometatarsus)
Internal Trauma	Subcutaneous emphysema, spinal trauma, respiratory distress
Stunned	No abnormalities found (NAF)
Immobile	Dead before exam (DBE), dead on arrival (DOA), agonal, moribund, unresponsive
Feather / Skin Damage	Feathers missing or damaged, skin or feathers covered in foreign material
Wing Injury	Poor extension, wing droop
No Fly / No Capture Avoidance	Reluctant to fly or easy to catch if test flown
Other	Other

TABLE 3. Number of injury occurrences in ten species examined from 2013–2016. The total number of individual injuries exceeds 563 to account for birds sustaining multiple injuries.

Injury	Number of individuals with injury out of 563 birds
Eye Trauma	414
Head Trauma	75
Fracture	69
Soft Tissue Trauma	62
Internal Trauma	42
Weak	37
Stunned	35
Immobile	17
Other	13
Feather / Skin Damage	13
Wing Injury	11
No Fly / No Capture Avoidance	10

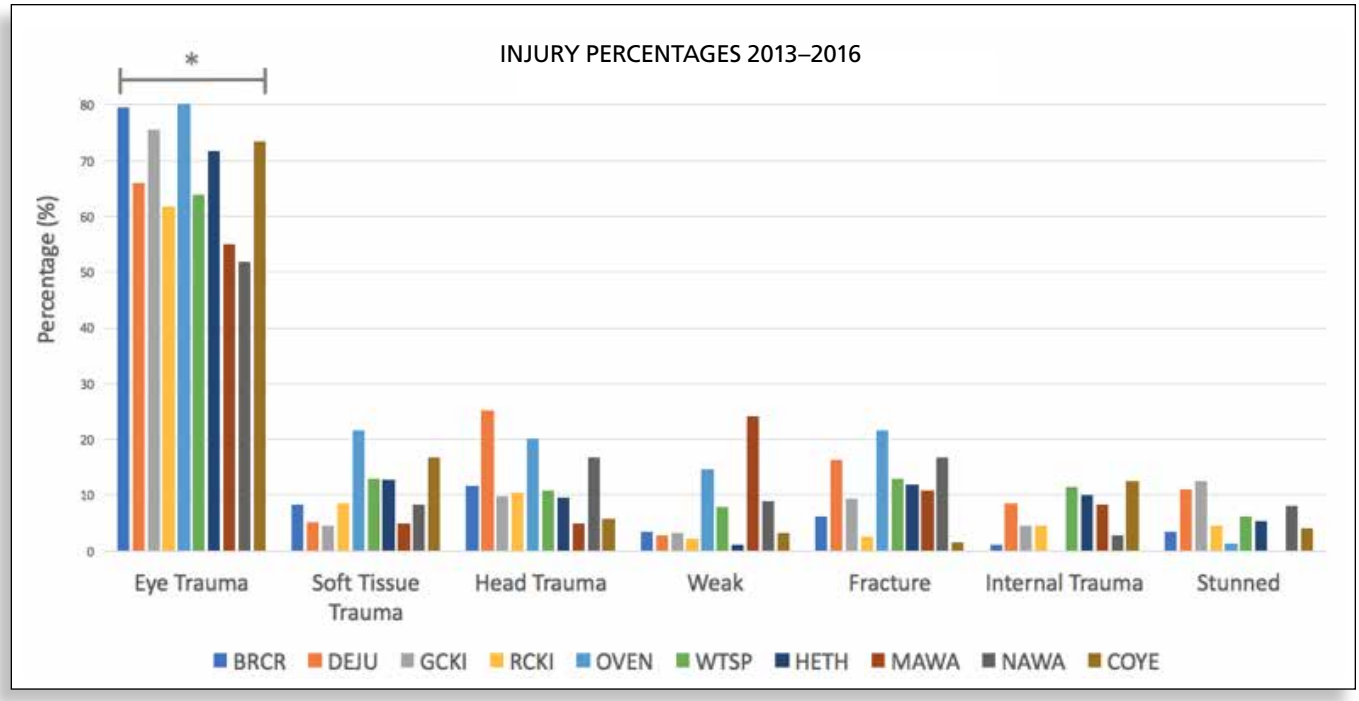

FIGURE 2. Injury percentages from 2013–2016. This figure represents injuries most frequently seen in the ten species of migratory songbird examined. Other injuries listed in Table 2 were also seen across species in small percentages. *Indicates significance from other injuries.

Results

The types of injuries the ten species of songbird sustained did not differ significantly ($P>0.05$), and this was consistent between years (2013–2016). Eye and head trauma, fractures, and soft tissue trauma were the injuries most frequently seen among individuals (Table 3). Eye trauma presented mainly in the form of corneal ulcers, and was shown to occur at significantly higher rates ($P<0.0001$) compared to any other injury. This pattern was also consistent across species and across years (Fig. 2).

Discussion

There was no significant difference in the types of injuries the ten species of songbird sustained. This suggests, for example, that a 2 g golden-crowned kinglet has the same chance of being admitted with a fracture as a 30 g hermit thrush. This was supported in a 1990 study by Daniel Klem, who found that the consequences of window strikes differed greatly between each individual bird but not necessarily by species of bird; consequences are likely to be associated with differences in the speed and direction at which songbird individuals collide with a windowpane or structure.[8]

Several injuries found in initial assessments were not necessarily caused by striking a window. When birds collide with a structure and fall to the ground they become susceptible to predation by cats, raccoons, and ring-billed gulls in the case of downtown Toronto.[4] Injuries such as deep puncture wounds would therefore possibly be caused by avian or mammalian predators. There were also cases of the presence of foreign materials on birds' feathers (i.e., vegetable oil, tar-like substances), which are also not likely to be directly caused by colliding with a structure, but may be associated with the birds' attempts to fly away, perhaps with some residual form of trauma.

Head injuries were seen in many cases of the songbird individuals admitted to TWC, which is supported by previous studies that reported varying degrees of head trauma in songbird collision victims.[7,8] Mandible and maxilla tip fractures were also seen in many cases of birds admitted to TWC; this is supported by Klem's 1990 study which found that individual birds sustaining fatal injuries often suffered from broken bills.

Results from the current study found that eye trauma occurred at significantly higher rates compared to any other injury, which has not yet been reported in the literature about songbird species. Corneal ulcers were the most prevalent type of eye trauma seen in bird cases admitted to TWC. Corneal ulcers are defined as abrasions or lesions on the corneal epithelium or underlying stroma.[13] There have been studies on corneal ulcers in raptors after impact collisions (striking buildings, windows and cars),[13,14] but not yet in nocturnal migratory songbird collision victims. The results of the current study suggest that eye ulcers are the most common type of injury resulting from collision trauma in migratory songbirds. Wildlife rehabilitators should therefore include a thorough eye exam with migratory songbird patients that have struck a window or building, since corneal ulcers are painful[13] and, if left untreated, can become infected or lead to necrosis.[13] Future research could investigate why corneal ulcers are so prevalent among collision victims. Numerous replications of similar observational studies could also provide more statistical power to the findings of this research.

The owners or operators of buildings in large cities should be advised to limit the amount of lights on at night during the spring and fall to reduce migratory songbird casualties.[4] If a bird is found on the ground by a building, it should be placed in a dark, quiet, breathable space (un-waxed paper bag)[4] and transported to the nearest wildlife rehabilitation center for treatment.

Conclusions

Migratory songbirds that are attracted to the light emanating from windows are at serious risk of collision, which often results in fatal injuries.[4] Approximately 1 billion bird individuals are killed hitting manmade structures every year in the United States alone,[10] making city light pollution in the spring and fall when migration occurs a serious welfare and conservation issue for songbird populations. Owners and operators of tall buildings in dense urban areas should therefore limit the number of unnecessary lights on at night during the migration season, to help songbird individuals navigate past city hazards. Results from this study suggest that different species of songbird have an equal chance of sustaining various injuries when striking a building or window, and that eye trauma in the form of corneal ulcers is the most prevalent type of collision injury seen among the ten species of migrants studied. Wildlife rehabilitators should therefore include a thorough eye exam when assessing songbird patients to ensure proper treatment for a quick recovery.

About the Authors

Jane Hudecki is a master's student in the Department of Animal Biosciences at the University of Guelph, and had worked as a senior wildlife rehabilitator at Toronto Wildlife Centre for three years prior to enrolling in her graduate program. Jane has a keen interest in songbird welfare and conservation, and hopes to continue researching songbird collision injuries in the future.

Dr. Esther Finegan is a professor and graduate faculty member in the Department of Animal Biosciences at the University of Guelph. Esther has dedicated countless years of research and teaching in relation animal behavior within zoos in Canada and the United States, and shares a similar interest in migratory songbird welfare and conservation.

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Rehabilitation of orphaned Asian elephant *(Elephas maximus maximus)* calves in Sri Lanka

B. Vijitha Perera,[1] Ayona Silva-Flecher,[2] Suhada Jayawardena,[1] Neshma Kumudini,[1] and Tharaka Prasad[1]

Group of rehabilitated and released elephants, one with own calf born in the wild at the Udawalawe National Park, Sri Lanka.

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ABSTRACT: Approximately 6,000 (13%) of the global Asian elephants live in Sri Lanka and human elephant conflict (HEC) is intense. Due to HEC, around 150 elephants die and 14 elephants are orphaned per year. The Elephant Transit Home (ETH) in Sri Lanka was established in 1995 to rehabilitate orphaned elephants with the aim to release them back to the wild. The ETH management ensures minimum human contact and that calves are free to roam in a diverse habitat composed of water reservoirs, forests, and grasslands. During the last 22 years, the ETH has received 308 orphaned calves, and 178 (58%) of them were less than six months old. There were 130 (42%) and seven (4%) mortalities before and during rehabilitation, respectively. The ETH has released 103 elephant calves back to the wild and they are closely monitored using VHF and GPS collars. So far, eight deaths of released elephants and 16 births from released females have been recorded. Surviving and breeding in the wild and integrating with wild elephants are the major indicators of success of this rehabilitation program.

KEY WORDS: Asian elephants, Elephant Transit Home, orphan elephant calves, rehabilitation, releasing back to wild, Sri Lanka

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Introduction

The Asian elephant has been listed as endangered in the International Union for Conservation of Nature and Natural Resources (IUCN) Red List[1] and is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).[2] The current population of the unique subspecies *Elephas maximus maximus* in Sri Lanka is around 6,000, and this represents more than 13% of the global Asian elephant population.[3,4] Sri Lanka is an island in the Indian Ocean with 65,610 square km of land area and the highest density (per land mass) of elephants in the world. With a population of 21 million people, it also has a high density of human habitation. The current growth rate of the Sri Lankan population is 0.7% and the demand for land for cultivation and urban development is continuously increasing.[5] Future development is expected to reduce the area of forested land available to wild elephants and lead to increased human-elephant conflict (HEC).

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The elephant has historically been considered a keynote species of Sri Lanka and up to the present day there is a close association between elephants and the people. The cultural background and religious beliefs of Sri Lankans have fostered respect and compassion for wild and captive elephants. At one time, elephants ranged throughout the island of Sri Lanka, but the onset of colonization in 1505 began a period of decline in their numbers and geographical distribution. It was during British rule, from 1815 to 1948, that elephant populations were completely lost from most parts of the country, caused by the practice of intensive hunting and the development of large scale plantations. However, before the end of colonial rule the first steps were taken to protect the elephants and other wildlife in Sri Lanka. The Fauna and Flora Ordinance was declared in 1937 and is still enforced with relevant amendments.

Today, habitat loss and fragmentation is the major threat to elephant existence in Sri Lanka. The elephant population has to tolerate increased human exploitation of land and water resources. Elephants often have to live in relatively close proximity with human habitations and are at risk from numerous associated hazards. As a consequence, over 150 elephants die due to anthropogenic causes in Sri Lanka every year. Many are wounded by gunshots, their trunks and legs are damaged by snares, their mouths are damaged by locally made explosive "jaw bombs," they are poisoned, they may fall into wells, and suffer electrocution.[6,7] It is thought that most wild elephants have to live under chronic stress due to human disturbances.[8]

One of the outcomes associated with HEC in Sri Lanka is the occurrence of orphaned elephant calves. The parents of these orphaned elephants may have been killed or driven away and lost contact with their young. Traditionally, orphaned calves were often looked after by private individuals or temple authorities. However, many of those orphans did not survive to adulthood, and those that did survive were often maintained as captive elephants in poor conditions. The Department of Wildlife Conservation (DWC), the authorized government institute for implementation of the Fauna and Flora Protection Ordinance, established the Pinnawela Elephant Orphanage[9] for the care of these elephants in 1975. Since then, the number of elephants rescued and cared for by the orphanage has increased gradually. The number of elephants housed at the orphanage increased further following the beginning of the breeding program in 1984. The facility at Pinnawela is highly successful as it has rescued and maintained significant numbers of young elephants. It has also become a major tourist attraction that draws international attention to the condition of elephants in Sri Lanka. However, the elephant orphanage is designed to maintain a population of captive elephants and it does not have a program for rehabilitation and returning orphans back into the wild.

Because of concerns about the decline of the elephant population in Sri Lanka as well as the welfare of orphan elephant calves, in September of 1995, the DWC decided to establish a new facility with the aim of rehabilitating elephant calves and releasing them back into the wild. This facility is the Elephant Transit Home (ETH).[10] The establishment of the ETH attracted criticism from some environmentalists and some members of the general public. Their major concern was the feasibility of re-introducing hand-reared elephant calves back into the wild. They questioned whether traumatized elephant calves that had been cared for by humans for an extended period of time would be able to survive and thrive when returned to a wild environment, and if they would be able to re-integrate with existing elephant herds.[11] At that time there were no rehabilitation facilities for Asian elephants anywhere in the world. There was some experience with successful rehabilitation of African elephants in Kenya,[12] but this initiative was not well documented at that time.

Following the establishment of the ETH, the first batch of rehabilitated elephant calves were released into the wild in 1998. The ETH is now 21 years old and since that first milestone, a total of 103 calves have been released. The experience of the ETH shows that released calves can indeed survive and successfully integrate with wild elephants. This paper describes the ETH facility, the management practices, and the data obtained from on-going studies at the ETH.

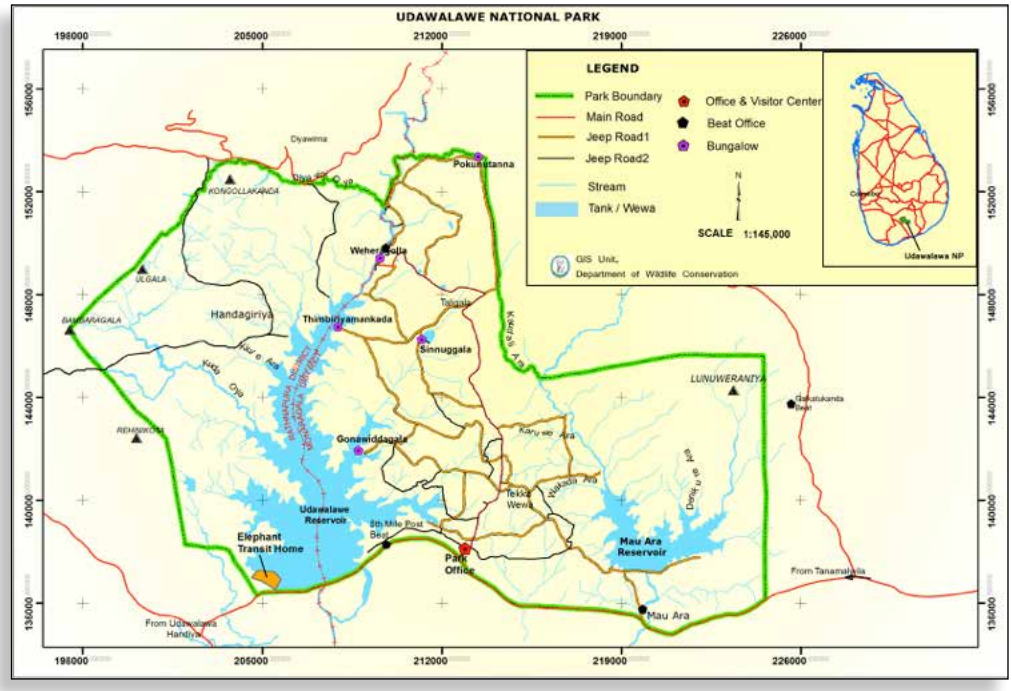

FIGURE 1. Location of Udawalawe National Park and Elephant Transit Home (DWC, Sri Lanka).

Location of the ETH

The ETH is situated at the western border of the Udawalawe National Park (UNP). The park lies on the boundary of Sabaragamuwa and Uva Provinces in Sri Lanka. The park is approximately 308 km^2 in area. It is situated between latitudes 6°25′–6°34′N and longitudes 80°46′–81°00′E, at an average altitude of 118 m.[13] The park is rich with wildlife and the elephant is the flagship species. The elephant population of the park is estimated to be between 804 and 1,160 individuals.[14] The habitats of UNP include open savannah-like grasslands, dense scrub, riverine forest, secondary forest, a permanent river, seasonal streams, and water holes, as well as large human-made reservoirs.[15] The Udawalawe reservoir (maximum area of 3,400 ha) is the largest man-made reservoir at UNP (IUCN/CEO 2006) and the ETH is situated adjacent to the reservoir at the western border of UNP (Fig. 1).

The rescued and rehabilitating calves at the ETH roam in an area of approximately 150 ha. The two annual monsoons, generally occurring from October–December and March–April, cause fluctuations in the water level of the Udawalawe reservoir. When water levels go down, the grasslands emerge in the reservoir bed, and following rain the grasslands become covered by water. The rehabilitating elephant calves are restricted in the forest by electric fences separating them from humans. There is no barrier between the wild elephants of the park and rehabilitating elephant calves.

Methods and Results

Occurrence and identification of orphaned elephant calves

The ETH receives calves from all over the country, who become orphaned under a variety of different circumstances. If their mother suddenly dies, for example as a result of gunshot injuries, electrocution, or railway accident, other members of the herd or small group may leave the carcass and the calf tends to remain with the dead mother. If the mother dies from a chronic problem, such as parasitic infection, infected gunshot wounds, or from injuries incurred in a vehicular accident, the calf and mother may become separated from the herd. In this situation, the calf remains with the mother, and when she dies is unable to rejoin the herd. In addition, elephant calves may just become lost and separated from their mother and the herd. Villagers and wildlife officers may rescue weak calves roaming alone with no apparent human disturbance. In these circumstances it is strongly believed that the orphaned calves are the result of abandonment by their mothers.

Most orphan elephant calves rescued by the ETH are found outside formal wildlife protection areas and are first seen by villagers. Orphan wild calves have an extreme fear of humans, and avoid them or run away when the calves notice their presence. However, weakened, depressed, or collapsed elephant calves are often helpless when found by local people. At that moment, villagers get a chance to observe them and are able to recognize that a calf is alone and helpless. These elephant calves receive compassion and help from villagers who usually take the animal to their village. Sometimes villagers find orphan calves trapped in wells, canals, and toilet pits. While treating the animal to the best of their abilities, they inform the government authorities, usually the police station, the government agent within the village, or, in some instances, the Department of Wildlife Conservation. From the moment the DWC officers receive the information, they take the animals into their custody and transport them directly to the ETH. When necessary, the DWC field officers provide emergency first aid for injured or sick calves. In some occasions, elephant calves spend time in regional wildlife health centers and receive some health care before reaching the ETH.

FIGURE 2. Newly received orphaned elephant calf with injuries.

The elephants received at the ETH are not always orphans. In some rescue operations, elephant calves are collected from wild herds by force in order to save their lives. This happens when elephant calves have incurred critical wounds, for example due to gunshots, vehicular accidents, snares, land mines, or jaw-bomb explosions. Taking calves from a herd is the only option when they have critical health problems and need repeated treatment. After passing a few weeks under human care, it is not possible to re-introduce these calves back into their herds. Therefore, they have to undergo a period of rehabilitation. In Sri Lanka, it is illegal to capture and domesticate wild elephants. If the authorities detect such illegal activity, those responsible are prosecuted and the elephant calves confiscated and handed over to the ETH for care and rehabilitation.

Calves that have been orphaned, forcefully separated from their herds, or confiscated are transported by jeeps or lorries to the ETH. Depending on the distance, this journey may take from several hours to several days. While being transported, calves may suffer badly from any injuries they have and from fear associated with a new and strange environment and human handling (Fig. 2). At the time of arrival at the ETH, the health and psychological status of many elephant calves is very poor.

Management of elephant calves at the ETH

Between September 1995 and September 2016, a total of 308 elephant calves were received at the ETH from all over the elephant range of the country, with an average of 14 calves per year (Fig. 3).

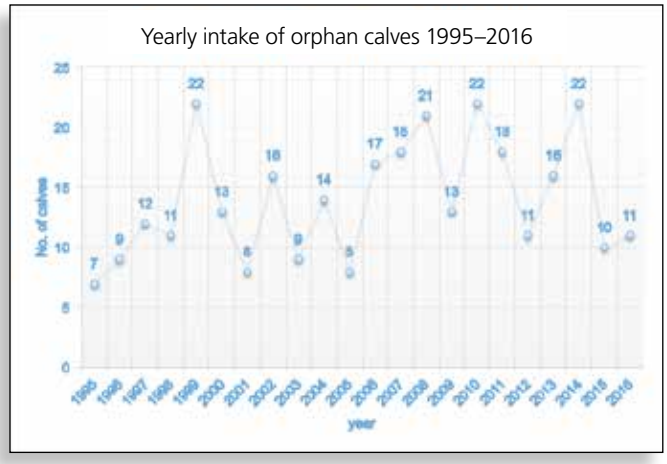

FIGURE 3. Yearly intake of orphan calves between 1995–2016.

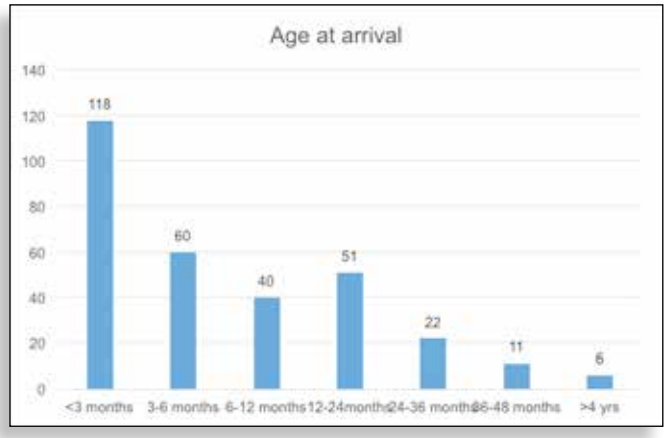

FIGURE 4. Age of elephant calves at arrival.

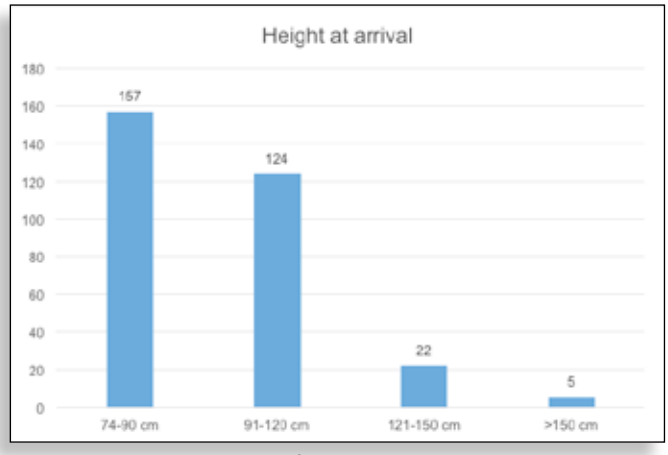

FIGURE 5. Shoulder height of elephant calves at arrival.

The number of male and female calves received at the ETH is 182 and 126, respectively. On arrival, calves ranged in age from a few hours old to several years. One hundred and eighteen (38%) of new arrivals were less than three months of age. Overall, 70% (216) were less than one year and 30% (92) were over one year, including six animals that were over four years of age (Fig. 4). The size (shoulder height) of elephants arriving at the ETH ranged from 74 cm to 158 cm and 51% of animals were less than 90 cm (Fig. 5). The first task of the ETH when elephant calves arrive is to assess their health status and determine whether they are suffering from physiological and psychological problems. The ETH has a specialized hospital for the care of newly arrived animals with indoor and outdoor elephant pens to hold and acclimatize them. While it may be an advantage to hold newly arrived elephants in quarantine, the ETH does not have an adequate quarantine facility. However, during the initial period, elephant calves are maintained in separate pens.

The veterinary team conducts a general clinical examination as soon as a new elephant calf arrives at the ETH. This includes measurement of temperature, auscultation, and hydration status; inspection of body condition for visible wounds, fractures, and the presence of ectoparasites such as ticks, fleas, and lice; and a blood and fecal examination. The calf is offered food, water, and milk, and behavior is noted. Body measurements such as height and weight are recorded and the age of the calf is estimated based on height, size, and the stage of tooth development. Based on the general clinical, blood, and fecal examination data, an appropriate treatment plan is determined. If the EGB (eggs per gram) of nematodes is very high, calves are dewormed using fenbendazole, albendazole, levamisole, and ivermectin. If there are *Fasciola jacksoni* and *Anocephala manubriata* eggs in the feces, they are treated with praziquantel and triclabendazole. Ectoparasites are treated with the insecticide flumethrin. If the calves develop diarrhea, antibiotic and hydration therapy is offered and the calves are monitored on an hourly basis.

Other than veterinary intervention, the provision of suitable feed is the major challenge faced by newly arrived calves. In addition, it takes a significant time to train calves to accept bottle-feeding. The ETH uses human infant milk formula to replace the elephant mother's milk. Most of the deaths of young and newly received calves at the ETH are associated with gastrointestinal problems, including infections, indigestion, intolerance, and chronic diarrhea. The composition of elephant milk differs significantly from human milk[16,17] and formulas are designed for consumption by human infants, which may be a factor in the digestive problems experienced by young elephant calves. To try and overcome these problems different kinds of infant formulas have been used at the ETH, and when milk allergy has been suspected, the formula milk is replaced temporarily with electrolyte rehydration solutions, soya base milk, rice broth, or fruit juice.

Rehabilitating elephant calves in the ETH live as a single herd composed of very young animals and juveniles up to about six years old. When the health of newly arrived elephant calves has been stabilized, they are introduced into the existing herd. The response of the herd varies depending on the size and gender of the new arrival and the character of the herd members, as individuals of the herd have diverse personalities. If the introduced calf is small, older males do not show any interest, irrespective of the gender of the calf. If the new arrival is an older and larger male calf, the males in the herd express more interest and may interact with the newcomer by pushing behavior to compare their size and strength. Sometimes they may charge the newcomer, but after two to three

days, they usually settle down and tolerate the new member of the herd. If the newcomer is female, there is little immediate interaction with the group. When a small calf is introduced, all the female herd members usually express their interest. They follow the new arrival and even show typical guarding behaviors. They also engage in a series of vocal communications with the new arrival. Small calves introduced into the herd usually find older females that express instinctive maternal behavior, and the introduced calf may interact and follow one of the older females thereafter. This kind of alloparenting behavior seems to bring a great deal of comfort to the newcomer.

The calves at ETH are fed milk seven times a day at three-hour intervals during the day and at four-hour intervals at night (Fig. 6). In between milk feeds, the calves are free to forage and find their own food in a nearby forest (Fig. 7). When there is shortage of naturally occurring food, elephant calves are also provided with externally sourced pastures. Elephant calves spend approximately 70% of the day foraging. They have human interaction when they are fed milk and when they need veterinary intervention. At other times, they have the freedom to behave according to their wishes. They decide if and when they want to engage in foraging, drinking, bathing, playing, and sleeping.

FIGURE 6. Orphan calves are fed milk at 3-hour intervals.

FIGURE 7. Elephant calves browsing in the habitat surrounding the ETH with a water reservoir, grasslands, and nearby forest.

Currently, there are 45 elephants undergoing rehabilitation in the ETH. The staff of the ETH is composed of 55 members headed by a veterinary surgeon. There are 35 elephant caretakers among the staff whose major roles are feeding and monitoring the calves, collecting provisions from pastures when needed, cleaning and maintenance, assisting health management activities, and post-release monitoring. The other staff members carry out office duties and manage visitor activities. Staff members also attend rescue operations and other wildlife health management activities in the field. In 2017, an additional veterinary surgeon was recruited to the ETH. The ETH offers training and research opportunities to undergraduate and post-graduate veterinary and biology students, and conducts training programs for veterinarians and wildlife managers. The ETH also organizes and conducts awareness programs for school children and the general public.

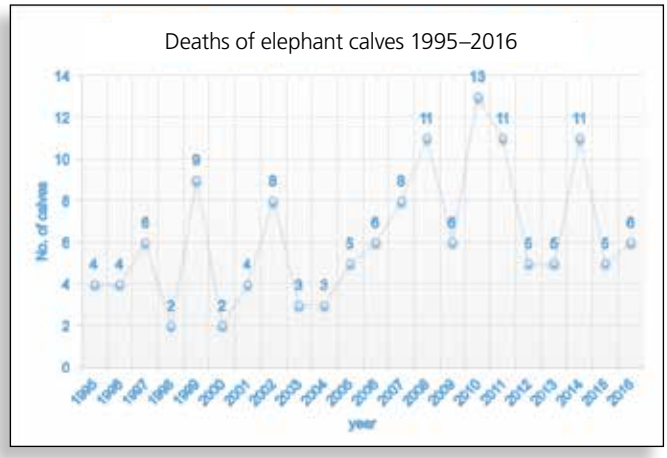

FIGURE 8. Annual deaths of elephant calves between 1995–2016.

Elephant Mortality at the ETH

In the wild, elephant calves that are orphaned at less than one year of age have no chance of survival and will die of starvation, dehydration, and stress within a few days of losing contact with their mother. Calves at this age are also susceptible to attacks from predators, such as leopards, crocodiles, jackals, and dogs. Orphaned elephants between one and three years of age are capable of surviving in the wild from a few weeks to several months. However, they usually die because of chronic poor nutrition and associated health complications, such as gastrointestinal disease and problems caused by parasites. These survival times are reduced if orphaned calves lose contact with their herd. By the age of three

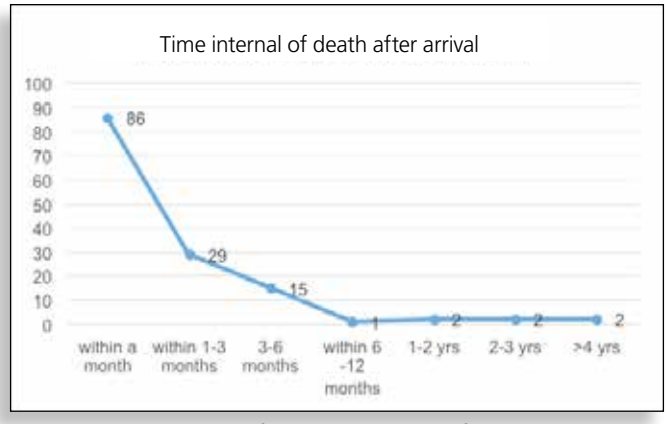

FIGURE 9. Relationship of deaths and times of arrival.

years, orphaned elephant calves generally have a high chance of survival and above the age of about four years, orphaned elephants can usually feed and protect themselves. Again, there is a significant advantage if young calves are members of a herd.

The fate of the majority of orphan elephant calves who do not receive human care is death. When people rescue orphaned calves, they are generally in very poor health and at serious risk of early death. The restoration of health of these traumatized calves is the major challenge of the ETH.

The health status of calves received at the ETH varies from critically ill to healthy. From a total of 308 elephants received at the ETH, 130 (43%) died within six months of their arrival. This includes 14 (11%) calves that died within 24 hours of arrival and 86 (66%) that died within a month of arrival (Fig. 8). The majority of these deaths happened while they were receiving treatments and before the introduction to the rehabilitating elephant group.

Release of rehabilitated calves back into the wild

The decision whether to return an individual elephant to the wild is based on assessment of its ability to survive in the natural environment, which is based on two major factors. The first is age and body size. If the calf is estimated to be over five years of age with a normal height and size range and has no physical defects or obvious health issues, such as chronic wounds, it will be considered for release. The second factor is feeding and social behavior. The calf should be able to forage between milk feeds and display normal social and play behaviors. The calves are followed and observed throughout the day by trained keepers at the ETH and abnormal behaviors are noted. Key survival skills are assessed by observing the foraging and social behavior of an elephant. Elephant calves judged to be capable of successful rehabilitation are released as small groups. When forming these groups, attention is paid to friendliness and cooperative behavior among the individuals to be released. Each member of the group is fitted with a radio collar for post-release monitoring. If there are insufficient radio collars for all the released animals, canvas neck belts are fitted as an alternative. The collars and belts are placed on the elephants about two months before release and are retained for about two years.

The decision to release elephant calves to the wild is taken after a general clinical examination and when the calf is confirmed as healthy. Fecal samples are examined for parasites, and if there are parasitic eggs in the feces, the calves are dewormed. As the calves are reared at the western border of the Udawalawe National Park, integration with wild elephants is normal. The calves are not screened for any diseases before release as they are considered semi-wild with minimum human contact and the likelihood of calves developing any human or livestock related diseases is considered minimal.

FIGURE 10. The releasing of elephants to the wild.

When releasing rehabilitated calves, the ETH practices what is called "hard-releasing methodology." Until the day of release, elephant calves undergo routine management at the ETH. At dawn on the day of release, while they are milk feeding, the animals are sedated with drugs (xylazine hydrochloride) and loaded onto an elephant-transporting lorry. A single lorry carries four to five animals and if there are more than five animals, two lorries are employed. The elephants are transported to a pre-determined release site in a national wildlife park (Fig. 10).

At the time of release, the elephants are still in a state of mild sedation. Long-term monitoring of animals after release has shown that they gradually acclimate to their new environment and become integrated with wild elephants and existing herds. When elephants are released with VHF collars, they can be monitored for three to five years. If a collar is seen to interfere with the growth of the elephant calf in the wild, the elephant will be sedated and the collar removed. The GPS collars are guaranteed for a two-year time period and sometimes work beyond that. The battery of the collar can run out and the collar may malfunction after two years. However, the ETH staff can identify all the released elephants and can locate the individual animals. Therefore, the monitoring process goes on for a longer period in an informal manner. For example, during regular inspection of the Udawalawe National Park, the veterinary team

and ETH staff identified females who had calves and often note one particular female who has formed a herd with her own calves and other females with calves.

The first group of elephants was released from the ETH in 1998, and thereafter, 16 groups have been released. The total number of animals released is 103, consisting of 53 males and 50 females. The released elephants were monitored by direct observation and with radio telemetry devices. In the early days, elephants were fitted with VHF collars, and currently both VHF and GPS collars are used for monitoring (Fig. 11).

In terms of growth and survival, long-term monitoring shows that released elephants generally do as well as their wild counterparts in the park environment. After release, some elephant groups follow wild herds led by a matriarch with younger males and females from a few days to few months. Subsequently, some of the released elephants become permanent members of the wild herds. Some temporarily follow existing wild herds, and later separate to form new herds made up of released elephants. Some released groups form associations with previously released elephants. It has been observed that released males show a distinctive pattern of behavior. They join a wild herd or stay with herds made up of released elephants for a short period and at an appropriate age leave the herd to associate with wild male groups/bachelor groups following adult bulls. Released males therefore express the typical behavior of wild males.

FIGURE 11. Rehabilitated and released elephant (with VHF collar) with a wild herd at Udawalawe National Park, Sri Lanka.

The response of wild elephants encountering released elephants varies; some individuals are very curious and engage quickly with released young calves while others do not respond at all. When released elephants enter a wild herd, the existing herd members of a similar age become very cautious. They check the strength of newcomers and on some occasions have chased the newcomers from the herd. It is of interest that adult cows pay little or no attention to these interactions and fights among juveniles.

Of the 103 elephants released from the ETH between1998 to 2016, there have been eight deaths recorded: five males and three females. One male calf died from gunshot wounds, one succumbed to a jaw bomb, one died from a fall, and one died after being trapped in a mud hole. The cause of death of one male and one female juvenile could not be ascertained, and two females died due to poor nutrition associated with heavy parasitic infestation. In addition to the released elephants, the ETH has also transferred 23 (16 male, 7 female) elephant calves to other captive elephant facilities in Sri Lanka.

Public interest and management of the ETH

Wildlife rehabilitation is often seen as playing a vital role in conservation and increasing public awareness of animal welfare issues.[18] At the ETH, visitors are allowed to observe elephant calves when they are being hand-fed with milk four times a day. There is a special, raised platform for visitors about 40 m from the feeding place. The calves are milk-fed at three-hour intervals from 6:00 in the morning to 6:00 in the evening, and then again at 10:00 pm and 2:00 am. Visitors are allowed to observe at 9:00 am, 12:00 noon, 3:00 pm, and 6:00 pm. Visitors are not allowed to interact with elephant calves and cannot come closer than the observation platform. The calves quickly become oblivious to the platform and are not disturbed by the presence of visitors. At any one time, about 40 elephants may be milk-fed, which takes around 20 minutes. After feeding, the elephant calves return to the park. The ETH also has an information center where visitors can find displays and information about the ETH, on elephants in general, and about conservation issues.

The ETH is managed by the Department of Wildlife Conservation of Sri Lanka. The animals, property, and facilities belong to the government and the staff are employed by the government. The average running cost of the ETH is approximately 60 million Sri Lankan rupees per year (about USD $400,000) and currently, more than 35 million rupees (about USD $230,000) is generated from the entrance fee charged to visitors, donations, and a sponsorship "foster parent" scheme (see below). In 2016, there were 52,594 international and 161,111 local visitors to the ETH. The number of visitors to the ETH continues to increase year by year.

To encourage public interest and engagement with elephant welfare and conservation issues, the ETH runs a "foster parent" scheme. Under this program, the public can adopt a particular elephant calf at the ETH. Although they cannot personally interact with an elephant calf, individuals or groups can contribute a portion of the expenses associated with maintaining a calf at the ETH. They have the option to select and choose a name for the

calf, receive a monthly update of information about their baby elephant, and are invited to be special guests at the event of his or her release. At the moment, 27 elephant calves out of a population of 43 have been adopted by local and overseas members of the public.

Discussion

The elephant is an example of a species that is highly social, long-lived, and characterized by extended parental care and investment.[19] The maternal bond of elephants is very strong and care from the mother is essential for the survival of elephant calves. Calves depend on their mothers and other family members for social support, physical survival, and learning for the first years of life.[20,21] Under these circumstances, loss of their mother inevitably brings death to the young orphaned calf in the wild.

Wildlife rehabilitation is defined as "the treatment of injured, ill, and orphaned wild animals, displaced indigenous animals, and the subsequent release of healthy animals to appropriate habitats in the wild."[22,23] Hand-raising a wildlife orphan is one of the most challenging and specialized aspects of wildlife rehabilitation.[24] Experience with other wild animals suggests that to achieve successful rehabilitation, a strict set of criteria should be used for the selection of animals to enter the rehabilitation process. These criteria are based on the age of the animal, its physical and psychological health, and the behavioral characteristics of the animal. However, as the ETH is the only facility in Sri Lanka responsible for the care and rehabilitation of orphaned elephant calves, it is not possible to select animals for rehabilitation based on age and health criteria. Although there is no legal restriction on animal euthanasia in Sri Lanka,[25] it is rare to find veterinary professionals willing to practice euthanasia. Under these circumstances, animals with little or no chance of survival are transported to the ETH. The ages of calves taken into care at the ETH range from a few hours up to four years, and the calves are diverse in health status, ranging from critically ill to healthy. From the start of the ETH, 130 elephants died before they were able to begin the process of rehabilitation; this represents 43% of the total number of elephants received. Many of these deaths were inevitable, particularly in the case of deaths during transportation and due to fatal wounds from gunshots, jaw bombs, and railway or vehicular accidents. When the ETH receives critically ill elephant calves that are suffering from exhaustion, malnutrition, mental distress, and other diseases, their chance of survival is also low and most deaths (95%) occur within six months of arrival. The death rate of calves that are able to enter the rehabilitation program (178) is low (4%) and this compares favorably with the mortality rate of captive elephant calves in zoos in Europe and USA, and those in facilities of the Tamil Nadu Forest Department and the Myanmar timber enterprises.[21,26,27,28] After any necessary veterinary treatments, a healthy calf or a recovered animal that joins the rehabilitation program has a very good chance (96%) of going back to the wild.

The feeding regime of elephants in the care of the ETH must take into account their wide age range, from one day up to six years of age. Some have been in the wild for a few years and have lived with and learned from older elephants; however, very young calves have little or no experience of normal feeding behavior. In terms of management and training for rehabilitation, this age diversity has advantages and disadvantages. Male elephants in the social organization of the herd disperse on reaching adulthood, but females and calves are usually found in small groups.[29,30,31,32]

Young elephants are reared in a matriarchal society embedded in complex layers of extended family.[33] The ETH gives priority to the youngest and smallest elephants, which are milk-fed by hand every three hours. Elephant calves over two years of age are able to graze on available plant material and need milk less frequently than younger animals; it should therefore be possible to give their milk quota once or twice a day. In a wild environment, elephants over four years of age usually do not suckle their mother[34] and do not depend on mother's milk, but to encourage all the elephants undergoing rehabilitation to mingle and socialize with each other, they are all milk-fed. The elephant calves at the ETH get milk until they are released. The calves live as a single herd and come for milk feeding every three hours as a group. It would require human intervention to prevent any older calves receiving milk, an intervention which would also affect the "group bonding" of the elephant calves with each other. Therefore, the older calves up to and above four years are also fed with milk until they are released. This practice has a disadvantage for the older elephant calves because they are exposed to unnecessary and more frequent human interaction. However, maintaining and encouraging interactions between calves of different ages has significant advantages for the smaller elephants. Before coming to the ETH, very young calves may have been in contact with their mothers and other adults for only a short time, from a few hours to a few weeks. This limited exposure to adults does not give them sufficient time to learn the skills necessary to survive and grow in a wild environment. Promoting all the elephants at the ETH to live as a social group allows animals to share or respond to information, thereby assisting group members in developing skills. In addition, living in a social group helps animals find resources and helps them become aware of nearby threats, such as jackals, dogs, other potentially harmful wildlife, and humans.[15,35,36] In addition to these practical benefits, the association with older calves brings psychological comfort to the little ones.

The health status of animals arriving at the ETH varies greatly and cannot be controlled. This creates the potential problem of disease introduction into the animals already at the ETH and represents a challenge to the management practices of the ETH. As the work force and physical resources of the ETH are limited, there is not the capacity for proper quarantine procedures. Fortunately, in the experience of the ETH so far, there has been no noticeable impact of new arrivals on the health status of existing animals, or vice versa. However, this practice is not ideal and raises the possibility of the spread of parasitic and infectious diseases, such as tuberculosis and endotheliotropic herpes virus, that would seriously harm the health of the ETH elephants.

The age and health status of elephants at the ETH are important factors in determining their welfare and chances of successful rehabilitation. Another important consideration is the personality of elephants that arrive at the ETH. The social world of elephants is very complex and individuals express diverse personalities. For example, they may be violent, timid, fearful, or friendly with other elephants, readily show alloparenting behavior, or may be aggressive, fearful, or indifferent to humans. The occurrence of these diverse personality types and corresponding behavior can also be observed among free-ranging elephants. The incorporation of newcomers into the social structure of the existing elephant herds at the ETH requires close monitoring and, when necessary, management intervention to ensure that all members of the herd tolerate and cooperate with each other.

When the ETH was established there was an opinion among some experts that elephants brought up in close association with humans would lose their fear of people and if sent back into the wild, they would likely become "problem animals."[37] The first group of elephants was released from the ETH in 1998 and a total of 103 have so far been returned to the wild. Long-term monitoring of released elephants has shown that there have been no incidents of significant harm to anyone inside or outside the protected areas. A few complaints have been received from villagers about crop raiding by released elephants, but most of these incidents happened in places where electric fences that separate elephants from cultivated land had collapsed. It is probable that rehabilitated calves had simply followed the common behavior of their wild counterparts in raiding crops when given the opportunity. This situation does not, however, diminish the perceived threat that some people may feel from released elephant calves and highlights the need for continuing public education programs about rehabilitation efforts, particularly in areas where elephants are released.

Although there have been no major incidents of harm against humans from released elephants, the elephants themselves have experienced serious harm from human activities. Out of the 103 elephants released, two have died from gunshot injuries and one from the effects of a jaw bomb explosion. Three more elephants have been the victims of gunshot wounds, but survived after treatment.

Genetic Considerations

In wildlife rehabilitation programs, genetic considerations are frequently cited as a major concern regarding the decision to release rehabilitated elephants back into the wild. The primary concern involves the potential loss of genetic integrity in the recipient elephant population as a result of hybridization.[38] The Sri Lankan population of Asian elephants holds a unique and very important position in the conservation of this species.[39] Among the Asian elephants, the Sri Lankan elephant population is considered a distinctive subspecies with the highest genetic diversity.[1,31,32,40] In the past, when morphological features were the basis for classification, some populations confined in specific areas were considered to be subspecies: for example, the elephant population living in the Mahaweli river basin, *Elephas maximus vilaliya*.[41,42] Recent genetic studies have confirmed this hypothesis and demonstrated that significant genetic differences occur between the populations in the Indian mainland and Sri Lanka, and between northern, mid-latitude, and southern regions within Sri Lanka.[40] It may benefit the survival of the Asian elephant as a species to maintain these genetically unique sub-populations in the country. Some mixing of these sub-populations has already occurred, due to management strategies resulting in the translocation of displaced and conflict-affected elephants. It should also be noted that Sri Lanka is a relatively small island and elephant ranging habitat is shrinking day by day. There is no capacity or resources available to maintain the separation of genetically distinct elephant sub-populations. However, only a minority of free-ranging elephants exist in large undisturbed protected areas in Asia.[43] Intensively managed populations of elephants in small reserves closely resemble populations of elephants in zoo populations, some of which are kept in extensive enclosures.[44] Such small populations in small areas may raise concerns about inbreeding, as it can greatly reduce average individual fitness, and loss of genetic variability from random genetic drift can diminish future adaptability to a changing environment.[45] Therefore, when we consider the current and future status of the whole elephant population of Sri Lanka, the release of rehabilitated orphaned baby elephants, wherever they originated, may be considered as an enrichment of the genetic pool rather than genetic pollution.

Selection of elephants for release and choice of locations for release

Released elephants have ranged from four to seven years of age. When selecting elephants for release, major consideration is given to their abilities and skills for survival in the wild. In between the milk feedings every three hours, the elephants roam in the Udawalawe National Park, foraging and interacting as a group with each other and displaying a variety of activities. Two keepers always follow the group in the forest to observe the behaviors of the calves, evaluate the activity budgets, and assess the bond between the animals to be released. These extensive behavioral observations are used to assess the suitability of releasing any individual elephant, and when selecting several elephants for release as a group, priority is given to those elephants that have been observed to display friendly and cooperative behavior with each other. Through this process suitable animals are selected, as this will ensure that the group will stay together at least for a short time period after being released to the wild.

Expert opinion on rehabilitation procedures recommends that rehabilitated animals should be released whenever possible within the animal's normal home range, or no more than 10 miles from the point of capture. This practice minimizes the unnatural spread of parasites, diseases, and genetic material among wild populations, and maximizes the animal's chance of survival.[22] In addition, expert guidelines stress that released animal should be healthy and capable of surviving in the wild, as assessed by observation of their behavior.[46,47,48] As noted above,

the ETH follows this expert guidance whenever possible, but in some cases this is impractical. For example, sometimes the ETH receives orphaned calves from parts of the country where HEC is intensive and therefore it is unsafe to release them back into the same locality. At other times, it is necessary to take into account that elephants are social animals, and to optimize their welfare and chances of survival in the wild they need to be released as small groups and not as individuals. The members of the group may consist of elephants that were found at different locations.

The identification of potential sites for release of elephants from the ETH is an integral part of the rehabilitation process and many factors are considered for this selection. The major factors taken into account are safety of the released animals and minimizing the threat to human beings. Ideal places for release should have sufficient food resources, water, and vegetation cover. There should be wild counterparts in the locality for released elephants to join with, or to follow and learn from to enhance their survival skills. The release sites should be free of poaching and other negative human interactions, such as excessive tourist disturbances. In addition, they should not be overpopulated with elephants and other wildlife where additional numbers would create excessive competition for resources. Consideration should be given to the future health of the released elephants and to the indigenous elephant population by not releasing elephants that may harbor harmful pathogens. Release should not occur at localities where the wild population of elephants is known to contain diseased animals. Finally, a very important criterion of successful rehabilitation is that released animals should eventually integrate with and breed with their wild counterparts.

Conventional guidance suggests that rehabilitated elephants and other wild animals should be released at, or as close as possible to, their original encounter site.[48] This technique is recommended for animals that have been in captivity for only a short time. The practice at the ETH over the last 18 years has been to use a "hard" or direct release of rehabilitated elephants. In this methodology elephant calves are taken to a predetermined destination and released at once.

Of the 103 elephants rehabilitated by the ETH, the majority (85) have been released into the Udawalawe National Park (UNP). Other locations for release have been the Maduruoya National Park (MNP; 14 elephants) and the Lunugamwehera National Park (LNP; 4 elephants). The ETH is located in the corner of the western border of the UNP and because of the proximity to this park and its environment, it takes elephants only a short time to acclimatize when released. However, despite this advantage it may be necessary in the future to reduce the number of elephants released into the UNP. Recent research has shown that the current elephant population in the park is around 1,000.[49] Furthermore, the park is suffering from heavy grazing pressure by domestic cattle. The UNP may be reaching the limit of a sustainable elephant population, and therefore the ETH is now searching for other suitable parks. The MNP has a number of advantages as a release site, situated in the northeast part of country over an area of 58,850 ha with an estimated 700 elephants. The park contains five bodies of water, where the Maduruoya reservoir is the largest and is bigger than the reservoir at Udawalawe. The average water level and the surrounding habitat is very similar in both parks, and therefore the MNP has been identified as one of the best options. Fourteen elephants have already been released there. Some of the elephants were fitted with VHF collars; however, the lack of an extensive road network in the MNP caused difficulties in monitoring them. An improved tracking system using GPS collars has been used since 2016 and it is now possible to monitor released elephants throughout the MNP. Another possible release site was the LNP which is adjacent to the UNP. However, four elephants that were released into the LNP were for some reason unhappy with their new environment and migrated to settle at the Udawalawe–Lunugamwehera corridor. Unfortunately, at this location there is a high risk of human interaction and over a period of time, one of the released elephants died from a trap and gunshot wounds, and one male, after roaming with an adult bull elephant in a mountainous area, succumbed to death by falling from a mountain. Following this bad experience, the LNP was deemed an unsuitable place for elephant release.

Improvement of the rehabilitation process

The ETH was the first facility established anywhere in the world with the purpose of rehabilitating Asian elephants. It began in a very primitive manner with limited resources. In the first few years, the ETH had a single building and no vehicle. The manager of the ETH was a veterinary surgeon supported by a small team composed of officers and youths from local villages, most of whom did not have any experience working with elephants. Currently, the ETH is one of the most well-equipped rehabilitation facilities in the world and has experienced staff and modern hospital facility available. By a process of trial and error, the ETH has had to investigate and develop methods and guidelines for elephant rehabilitation, release, and post-release monitoring. During the first 16 years of the ETH, elephant calves were tethered at night in an enclosed paddock and provided with milk and forage throughout the night. This management practice was changed in 2012 and currently, elephant calves are not tethered at night and have the freedom to roam in 10 ha of land bordered by an electric fence. At 6:00 in the morning, the gates of the confined area are opened and the animals are free to move wherever they want until 6:00 at night. In the future, the plan is to keep the elephants at night without any confinement. Another future development at the ETH is the establishment of a quarantine facility for newly arrived elephant calves. This quarantine facility is identified as one of the key priorities for the management of the ETH.

As noted above, the ETH practice uses the so-called "hard release" technique when elephants are returned to the wild. However, this method of release may not be optimal for animals that have been hand-reared, animals that have been in care for an extended period, or those being released into unfamiliar territory.[48] The hard release practice may only be ideal for animals that have

been in captivity for a short time and are being returned to the original encounter site. The ETH is now ready to implement a technique of "soft release" and this will be used for the next group of released elephants. The effects on welfare and integration of elephants into existing herds will be monitored and compared with the effects of the previous practice.

The elephants that have undergone rehabilitation at the ETH and the management experience gained can be considered as a valuable scientific resource for the future conservation of the species. The ETH is willing to provide opportunities to conduct research in many fields, such as welfare of elephants, prevalence and prevention of infectious diseases, population genetics, anatomical studies, nutritional studies, physiological studies, behavioral studies, parasitic diseases, and radio telemetry. In addition, the center has the potential to provide training for elephant keepers, university students, and veterinary professionals.

So far, the ETH has received 308 orphaned and endangered elephant calves and has released 103 elephants back into the wild. The on-going post-release monitoring program recorded the first birth from a released elephant in 2008. Thereafter, a further 15 births have been recorded up to the end of 2016. It has not been possible to record the contribution of released males to reproduction, but observations have shown that released bulls are healthy, grow to their full size, show normal patterns of behavior, and seem to be fully integrated into wild herds. Overall, the data recorded at the ETH since 1995 show that it has had a significant beneficial effect on saving the lives of orphaned elephants, greatly improving their physical and mental welfare, and provided a global example of a successful rehabilitation program. Furthermore, as a hotspot for biodiversity conservation,[50] the DWC of Sri Lanka has proven that the efforts to rehabilitate Asian elephants can be effective.

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Parasitic burdening and rehabilitation of the European hedgehog, *Erinaceus europaeus*

Kathryn E South[1] and Kelly Haynes[1]

Introduction

The European hedgehog, *Erinaceus europaeus,* was classified as being of Least Concern when last reviewed in 2008 by the International Union for the Conservation of Nature (IUCN).[1] Recent studies in the UK, however, demonstrate a substantial decline.[2–4] Specific factors driving the decline in UK populations remain unclear,[5] although habitat conversion and fragmentation, predation, road traffic accidents, and injuries sustained in gardens or caused by pets have been identified as likely causes.[4,6] A considerable number of mortalities are due to natural causes, including parasitic burdening, as *E. europaeus* is host to a diverse range of endoparasites and ectoparasites.[7] Parasitic infection may be frequent in *E. europaeus*; reports estimate that 90% of hedgehogs admitted for rehabilitation are infected.[4] *Erinaceus europaeus* is the mammal species most frequently admitted to wildlife hospitals across the UK, and is therefore a large source of information.[5] Ticks (*Ixodes* spp.) are one of the most common ectoparasites identified on *E. europaeus;* the nematodes *Crenosoma striatum* and *Capillaria* spp. are the most common endoparasites.[8] Determining patterns and occurrences of burdening and the progression of rehabilitation (specifically weight gain) stands to improve husbandry protocols and welfare of this species at rehabilitation centers.

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ABSTRACT: *Erinaceus europaeus* is experiencing population decline across the UK. The species is host to a variety of parasitic organisms. This study investigates and evaluates direct fecal smears as a diagnostic method for endoparasites. A number of *Erinaceus europaeus* (*n* = 47) were assessed on arrival at Prickles and Paws Hedgehog Rescue in Cornwall. Endoparasitic burden was determined via 10 direct fecal smears; ectoparasites were removed and counted. Minimum sample size required for representative burden estimate was determined. No significant difference was found in the mean number of eggs–larvae detected in 10 smears compared to two. No significant relationship was found between ectoparasites and endoparasites. Females had significantly greater burdens of *Crenosoma striatum* than males. This study provides new insight into gender bias in endoparasitic burdening and the relationship between endoparasitic and ectoparasitic burdening of rescued *E. europaeus.* It offers potential to influence husbandry protocols, welfare, and the success of rehabilitation, as well as increase efficiency and accuracy of endoparasite diagnosis.

KEY WORDS: *Capillaria* spp., *Crenosoma striatum,* ectoparasite, endoparasite, European hedgehog (*Erinaceus europaeus*), fecal analysis, *Ixodes* spp., parasitic burden

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Scientific literature commonly uses postmortem examination rather than fecal analysis for endoparasitic diagnosis.[9] For fecal analysis, feces is generally collected directly from the rectum of dead individuals that are either roadkill or sourced from rescue centers.[4,10] Therefore, there is a lack of research informing current diagnostic methods for live individuals. Vale Wildlife Hospital recommends direct fecal smears,[11] which is contrary to fecal flotation used in the study conducted by Gaglio et al.[4] The latter protocol is based on large mammals. Fecal flotation is an unrealistic method for hedgehog rescue centers because of the laboratory equipment required and the need for >1 g of feces.[12] Gaglio et al. reported a sensitivity of only 50 eggs or larvae per gram for fecal floatation;[4] therefore, this method is unlikely to be helpful in the detection of small burdens (under the threshold of 50 eggs–larvae) for *E. europaeus*. Thus, the use of direct fecal smears as a diagnostic method for *E. europaeus* may be more appropriate. Basic equipment and minimal resources are required,[8] and the use of direct fecal smears can easily become a simple and standardized method for detecting parasites, uncovering the level and complexity of burdening and informing treatment and husbandry. One aim of this study is to establish the minimum number of direct fecal smears required to accurately represent a burden.

Healthy *E. europaeus* are less likely than unhealthy individuals to carry *Ixodes* spp. Ectoparasite infections are strongly associated with health status.[15] Gaglio et al. reported that the *Ixodes* count was positively related to body condition (with the assumption of a high score indicating poor body condition; however, no details about the scale were presented).[4] He found no similar relationship for other parasites. Other studies have failed to address a relationship between endoparasites and ectoparasites. A recent study by Haigh et al. used dead individuals to investigate sex bias in endoparasitic loading of *E. europaeus* and found that males had a significantly greater burden of *C. striatum* but not of other endoparasites.[9] Considering the different home range sizes of males and females,[13] males may be more likely to encounter intermediate hosts (mollusks and annelids) of the parasites, thereby increasing their rate of infection. Although many studies sample more males than females, few studies have investigated this sex bias with respect to endoparasitic burdening.[14] Sex bias in ectoparasitic burdening also remains largely unreported.

The progress of rehabilitation in relation to initial parasitic burden also remains unreported in scientific literature. Because many *E. europaeus* are admitted to rescue centers across the UK,[5] an examination of the effects of parasites on living individuals and the effect of the composition of parasitic burden on the rehabilitation progress is needed to inform current practice.

The purpose of this study is to determine the minimum number of fecal smears required to accurately represent an endoparasitic burden, information that will allow rescue centers to be efficient with their resources but accurate in their treatments. Understanding the patterns and the occurrence of both endoparasites and ectoparasites of *E. europaeus* admitted to wildlife rehabilitation centers will aid in the species' rehabilitation. Specifically, this research is an investigation of the influence of initial parasitic burden on the progress of rehabilitation (measured in terms of percentage of weight gain) and the use of *Ixodes* spp. as an indicator of endoparasitic burden, as suggested by Bunnell et al.[15] It further aims to assess the effect of gender on endoparasitic and ectoparasitic burdening.

Method

Between July and December of 2014, 47 *E. europaeus* (28 males, 16 females, three unsexed) were sampled at Prickles and Paws Hedgehog Rescue Centre in Cornwall, UK. The weight, gender, number of ectoparasites present, and health of each hedgehog were recorded at the time of their arrival. Each hedgehog was monitored over the following 20 days. They were weighed daily and reassessed for endoparasitic burden at the end of this period. Those that entered hibernation during this period were excluded from further study.

Fecal analysis

Ten direct fecal smears[1] per hedgehog were analyzed. The fecal smears consisted of 0.4 ml of saline mixed with a pinhead-sized amount of the first sample produced upon arrival at the center. Microscopic analysis of the samples took place within 12 hours of collection. This prevented the development of eggs and larvae, which reportedly decrease accuracy in identification of individual species.[16] Magnification of 40x or 100x was used to identify and count the number of *Capillaria* spp. eggs and *C. striatum* larvae present in 1 mm-squared cells of a counting chamber. *Capillaria* spp. were not identified by species because of the difficulty of identification[17] and because treatment is the same for all three species (*C. erinacei*, *C. ovoreticulata,* and *C. aerophile*).[18] Levicide® (active ingredient levamisole) was administered on days 1, 2, 3, 13, 14, and 15 to treat *C. striatum,* and Ivomec® (active ingredient ivermectin) was administered on days 1, 8, and 15 to treat *Capillaria* spp. All anthelmintic (parasite) treatments were completed by day 15 with the expectation that most of the treated hedgehogs would be parasite-free. All animals were further analyzed for endoparasites 20 days after anthelmintic treatment began; as expected, there was no evidence of endoparasites post-treatment.

Data analysis

Differences between the mean number of endoparasites detected via two, three, and 10 fecal smears were analyzed via Kruskal Wallis after sampling. All other endoparasitic analyses were carried out on 10 fecal smears from a single sample of each hedgehog. To aid in the analysis of the effect of endoparasite composition on the rehabilitation rate (as measured by relative weight gain), endoparasites were grouped into "*Crenosoma striatum*-dominant" (including individuals with burdens of *C. striatum* only and individuals harboring both species but a higher burden of *C. striatum*) and "*Capillaria* spp.-dominant" (which includes individuals with burdens of *Capillaria* spp. only and individuals harboring both species but higher burden of *Capil-*

laria spp.). Spearman's rank correlation was used to determine associations between endoparasites and ectoparasites and between percentage weight gain during rehabilitation and endoparasitic burden. Sexual differences in endoparasite composition were first analyzed via Kruskal Wallis, then via Friedman's test (to look for a relationship between sex and species composition). An analysis of covariance (ANCOVA) was used to analyze the percentage weight gain of the hedgehogs with respect to the mean number of parasites and parasite species. All analyses were performed in Minitab 17.

Results

Parasites were present in 42 of the 47 individuals sampled (89%). Five endoparasites were identified: *Crenosoma striatum* (in 79% of individuals), *Capillaria* spp. (89%) and fluke, *Brachylaemus erinacei* (in one individual), and Coccidial oocysts, *Isospora* spp., and *Eimeria* spp. (in two individuals). *Ixodes* were found in 21 (44.7%) individuals.

Fecal analysis

The number of direct fecal smears required to represent a burden was investigated. No significant difference was found in the mean number of *C. striatum* or *Capillaria* spp. from estimates based on two, three, or 10 direct fecal smears (Kruskall Wallis, $n = 47$; *C. striatum* $H = 0.1$, 2 d.f., $p = 0.951$, *Capillaria* spp. $H = 0.03$, 2 d.f., $p = 0.988$). Further analysis demonstrated that the mean number of parasites detected in two fecal smears randomly selected from the 10 analyzed for each individual was not significantly different from the mean of 10 smears (*C. striatum* $p = 0.4113$, *Capillaria* spp. $p = 0.8486$, $n = 47$).

Parasitological patterns

There was no significant relationship between the number of *Ixodes* and endoparasitic burdening (*C. striatum* $r_s = 0.27$, $p = 0.243$; *Capillaria* spp. $r_s = 0.04$, $p = 0.873$) (Fig. 1). The mean number of *Ixodes* per individual differed little between sexes (females = 27.07, males = 27.67). When the two highest outlying values were removed (one from each sex), the means were still very similar (females = 12.2, males = 11.15). The sexes' respective levels of endoparasitic burdening did differ significantly, however; females displayed a greater burden of both endoparasite species detected (Fig. 2; $H = 8.55$, 1 d.f., $p = 0.005$). The difference between the sexes' endoparasite compositions was most marked for *C. striatum*. However, there was no significant relationship between sex and parasite species ($H = 1$, 1 d.f., $p = 0.3177$).

Progress of rehabilitation

The progress of rehabilitation, measured in terms of percentage weight gain over a 20-day period (day 1 representing the start of treatment), was hypothesized to be related to initial parasitic burden. There was no significant relationship between the mean number of endoparasites and percentage weight gain after 20 days (Fig. 3; $r_s = -0.068$, $p = 0.710$, $n = 32$).

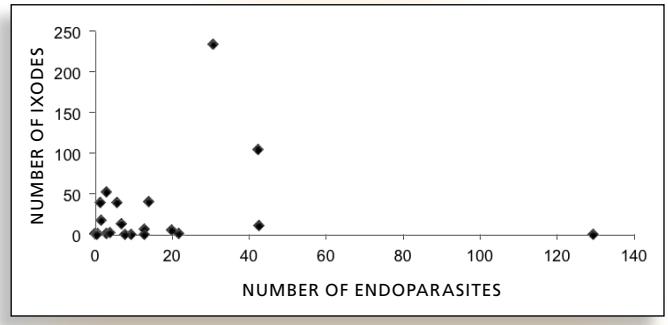

FIGURE 1. Total number of ectoparasites plotted against total number of endoparasites present on arrival at Prickles and Paws Hedgehog Rescue Centre ($r_s = 0.15$, $p = 0.526$, $n = 20$).

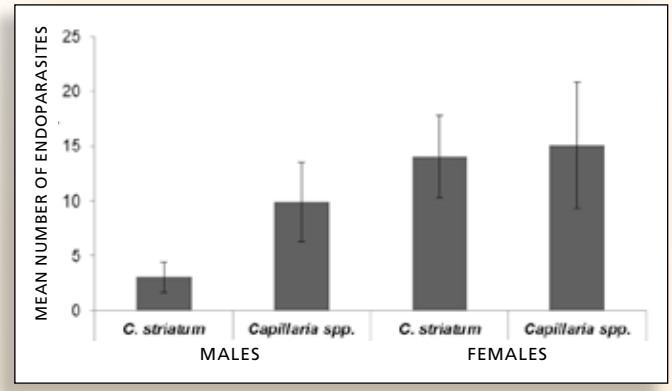

FIGURE 2. Mean (± s.e.) endoparasitic burdening of *C. striatum* and *Capillaria* spp. of males (n=16) and females (n=16) on arrival at Prickles and Paws Hedgehog Rescue Centre.

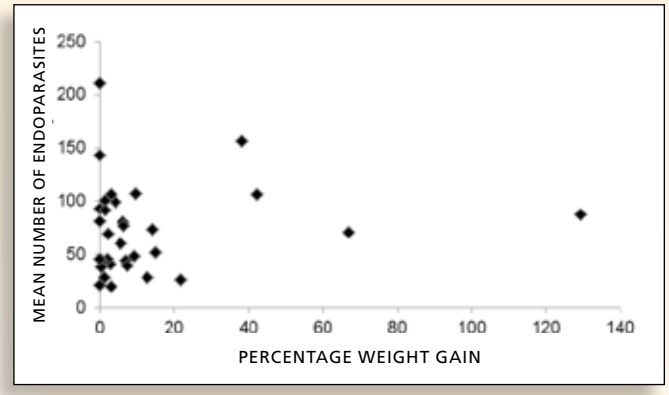

FIGURE 3. Mean total number of endoparasites, both *Crenosoma striatum* and *Capillaria* spp. (from 10 direct fecal smears) on arrival at Prickles and Paws Hedgehog Rescue Centre against percentage weight increase over a 20-day period of rehabilitation.

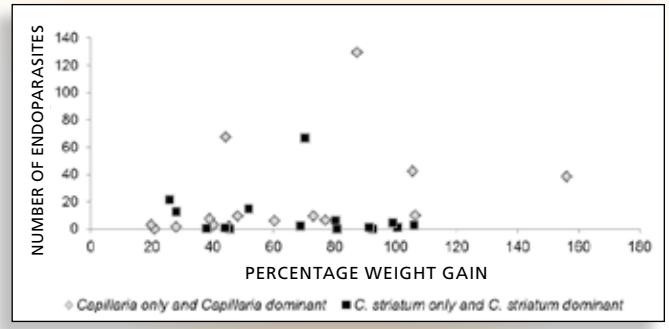

FIGURE 4. Percentage weight gain over a 20-day period of rehabilitation in relation to initial parasite burden (mean number of endoparasites from 10 direct fecal smears).

For analysis of the effects of parasite composition on subsequent weight gain, compositions were placed into two groups: *C. striatum* only combined with *C. striatum*-dominant loading species and *Capillaria* spp. only combined with *Capillaria* spp.-dominant species (Fig. 4).

The mean number of parasites, regardless of species composition in 10 direct fecal smears, was not associated with the percentage weight increase over 20 days of rehabilitation (r_s = 0.17, 28 d.f., p = 0.361). There was a significant relationship between these two factors for individuals with *Capillaria* spp. only or a higher abundance of *Capillaria* spp. in a mixed endoparasite composition (r_s = 0.69, 13 d.f., p = 0.004). However, there was no significant difference in the rehabilitation rate, as measured by relative weight gain between the groups "*C. striatum*-dominant" and "*Capillaria* spp.-dominant" [$F(df_1,df_{27}) = 0.46$, p = 0.503].

Discussion

That the majority of *E. europaeus* sampled (89%) harbored nematode endoparasites is consistent with recent findings.[4,9] Most hedgehogs admitted during the study period were male (60%). This pattern was reflected in overall admittance to the rescue center during the entire year. The number of endoparasites found in females was significantly greater than that found in males. The findings demonstrate that there is little variation in *Ixodes* ectoparasitic burdening between the sexes, but that there is a significant difference, with bias towards females, in endoparasitic burdening of *C. striatum*.

This finding contradicts the results of Haigh et al.'s (2014) research, which found a bias towards wild *E. europaeus* males in Ireland.[9] Zuk and McKean suggest that mature male mammals carry higher parasitic burdens attributed to the immunity-lowering effects of testosterone, thought to increase susceptibility to parasitic infection.[19] Of the 16 females in that data set, 13 were juveniles, which rules out an effect similar to testosterone caused by pregnancy or lactation. *Erinaceus europaeus* males have an increased range of 32 ha, compared to females' 10 ha,[13] which suggests that males would come into contact with a greater number of intermediate parasitic hosts and therefore have a higher burden than females. In further analysis of the composition and level of endoparasite burdening in male and female *E. europaeus*, males exhibited a higher mean endoparasite load in all tissues and harbored a significantly higher burden of *C. striatum* compared to females.[20] In contrast, Majeed et al. reported no difference between the sexes' respective incidences of infection.[10] Despite that study's larger sample size, the results presented here should not be discounted. The difference in results may be attributable to the site of admittance; both the center and the literature have reported a male bias in admittance.[14] The wider-ranging behavior of males may increase the likelihood that they are discovered and picked up more quickly or more frequently, while females deteriorate more before they are found by members of the public and brought to rescue centers.

Bunnell reported fecal smears (in this case, obtained from suspension) to be reliable, while being both cost- and time-effective for rescue centers.[8] The egg or larval count may not be representative of the entire sample or necessarily the burden (especially given that Gould and Partridge reported that eggs and larvae are not shed in every sample[18]), but does indicate the level of burdening. This study has demonstrated that two direct fecal smears from the sample (not obtained via suspension) demonstrate the same level of individual burdening as 10 direct fecal smears, therefore allowing for refinement of current testing protocols and more efficient utilization of resources. No significant relationship was found between the total number of endoparasites and the number of *Ixodes*. Bunnell et al. found a strong association between the health status of wild *E. europaeus* and *Ixodes hexagnous* burden; sick *E. europaeus* were more likely to carry *Ixodes hexagnous*.[15] They recorded a number of ailments, including *C. striatum* (53%), and found a significant relationship between individuals with a heavy *C. striatum* burden and those with *Ixodes* infestation.[15] However, *Ixodes* burden alone does not appear to be a reliable indicator of endoparasitic infection, with variation among catchment area of rescue, and seasonal, climatic variation, and conflicting results presented both here and in the findings of Gaglio et al.[4] Monitoring the progress of rehabilitation (through weight gain) with respect to initial endoparasitic burden (specifically, determining whether weight gain is slower for individuals with higher endoparasitic burdens or for those with burdens of specific compositions) may influence husbandry and supportive care measures. Results show no significant relationship between number of parasites harbored and percentage of weight increase; this was true even after the data had been subgrouped. Contrary to expectation, no association between weight loss and factors considered stressful (and therefore likely to affect weight gain) was found for the individuals that underwent transport to a veterinary practice and examination or anaesthetization. It is possible, however, that any reduction in weight gain or potential weight loss was short-term and therefore unobserved within the 20-day rehabilitation period measured here. The composition of parasites does not appear to affect weight gain either; however, the parasite grouping of this analysis may hide differences. Research with a larger data set may allow simultaneous analysis of both infection by a single species and of the dominant species group within a burden of multiple parasites.

Conclusion

This study provides evidence to inform diagnostic methods, specifically by reinforcing the use of direct fecal smears. The presence of *Ixodes* spp. in this study was not a reliable indicator of endoparasitic burdening. Species composition of endoparasitic burden did not affect weight gain over 20 days of rehabilitation. Further research is required into the sex bias of parasitism in *E. europaeus* (particularly in those admitted to rehabilitation centers). The available literature suggests a change in parasite prevalence in *E. europaeus* over time.[4,10] Results from previous and current studies need to be collated to establish an understanding of the current prevalence

and effects of parasitism, as climate changes are likely to have a significant impact on host–parasite population dynamics.[21]

Acknowledgements

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CONTINUED FROM PAGE 6

and, as a result, are part of the cooperative group of non-profit, private, state, and federal entities who work together to monitor the health and survival of rehabilitated and released manatees. Information about manatees currently being tracked is available at www.wildtracks.org.

"We are so thrilled not only to welcome these two new manatees, but also to have the opportunity to participate in this partnership as a second-stage rehabilitation facility for manatees," said Becky Ellsworth, curator of the Shores region at the Columbus Zoo and Aquarium. "Our team is eager to get to know these two new additions over the next few weeks and to continue to help all seven of the manatees in our care grow stronger over time for their eventual releases."

The threatened Florida manatee is at risk from both natural and man-made causes of injury and mortality, including exposure to red tide, cold stress, disease, boat strikes, crushing by flood gates or locks, and entanglement in or ingestion of fishing gear.

The Columbus Zoo and Aquarium supports field conservation projects for three of four living species of manatees through its Conservation Fund. Providing grants to researchers on three continents (North America, South America and Africa), the Zoo contributes to rescue and rehabilitation in Florida, environmental education focused on the Amazonian manatee in Colombia, and critical population surveys for the least known species: the West African manatee.

Mountain Gorilla Population Hits 1000

RUBAVU, Rwanda (May 31, 2018)—Numbers of critically endangered mountain gorillas are on the up, following conservation efforts in the transboundary Virunga Massif, one of the two remaining areas where the great ape is still found.

Survey results released today reveal that numbers have increased to 604 from an estimated 480 in 2010, including 41 social groups, along with 14 solitary males in the transboundary area. This brings the global wild population of mountain gorillas to an estimated 1,004 when combined with published figures from Bwindi Impenetrable National Park (where the rest of the sub-species is found) and makes it the only great ape in the world that is considered to be increasing in population.

The findings are the result of intensive surveying coordinated by the Greater Virunga Transboundary Collaboration and supported by the International Gorilla Conservation Programme (IGCP – a coalition programme of Fauna & Flora International and WWF) along with other partners.

The census involved twelve teams - comprising people from more than 10 institutions – which covered over 2,000 km of difficult, forested terrain systematically searching the mountain gorilla habitat for signs of the animals, recording nest sites and collecting faeces samples for genetic analysis. The teams also looked for evidence of threats to gorillas and other wildlife.

Despite this good news, the survey found that direct threats from wire or rope snares persist. During the surveys, the teams found and destroyed more than 380 snares, which were set for antelope but can also kill or harm gorillas. One of the snares discovered by the teams contained a dead mountain gorilla. There are also new threats looming large on the horizon, including climate change, infrastructure development and the ever-present spectre of disease, which has the potential to devastate the remaining populations.

Alison Mollon of Fauna & Flora International (FFI) reflects, "since FFI first began working to protect mountain gorillas in the 1970s, we have seen a remarkable transformation in the fortunes of this great ape, which at that time was on the very precipice of extinction. This turnaround is thanks to the extraordinary efforts of all those who have persisted through immense challenges – sometimes even risking their own lives – to protect these great apes. Today, mountain gorilla numbers are looking much healthier, but this is no time for complacency. We need to remain extremely vigilant, particularly in light of the ever-present and growing threat posed by the transmission of human-borne diseases that are relatively innocuous for us, but potentially fatal to other primates."

Ongoing conflict and civil unrest in the region also present an ongoing risk, impacting people and wildlife. A number of rangers have been killed in recent weeks in the Democratic Republic of Congo's Virunga National Park.

Young mountain gorilla (*Gorilla beringei beringei*) in the forests of Kisoro, Uganda.

World Migratory Bird Day: Lead Poisons Birds and People

BONN (May 9, 2018)—"Unifying our Voices for Bird Conservation" was the theme of World Migratory Bird Day 2018. Among the significant, but often underestimated threats to migratory birds across the African-Eurasian Flyways - the major bird migration corridors which links Europe, Africa and Western Asia - is lead poisoning. The UN Convention on Migratory Species (CMS) and the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA), two international environment treaties behind World Migratory Bird Day are also driving international efforts to tackle this global threat.

Lead poisoning is caused when lead is released into the environment. Lead is a highly toxic heavy metal that is used for both fishing weights and hunting. When fired from a shot gun, hundreds of lead pellets fall into the wider environment putting wildlife at risk.

Between 400,000 and 1.5 million waterbirds alone die in Europe annually from ingesting this lead. The number of additional birds suffering health problems because of poisoning by lead ammunition is at least as large as the number killed by lead shot every year.

Waterbirds and other birds see lead shot or lost fishing weights and pick them up either as food or mistaking them for grit. They die directly from poisoning or the ingested lead affects their immunity, behaviour and reproductive capacity. Raptors and scavengers pick up the lead shot or fragments of bullets in the prey or carrion they eat. Lead left in the environment contaminates soils, and people are exposed when they consume lead-shot game.

While habitat loss, pollution, unsustainable harvest and agricultural practices, illegal killing and trapping as well as collision and electrocution by power lines are among the greatest dangers to migratory birds, lead poisoning is one of the threats, for which there is a practical solution.

Lead-free ammunition is now available and has been demonstrated by research and in practice to be effective. Many hunters already use non-toxic ammunition. Some countries such as Denmark and the Netherlands have completely phased out all lead shot more than 20 years ago.

Changing to non-toxic alternatives could benefit nature conservation and human health. A ban on lead ammunition resulting in reduced lead emissions, secondary poisoning of vultures and other raptors and risks to human health, would bring substantive economic benefits to society in terms of healthy people and a healthy environment.

AEWA was the first international treaty to focus on addressing the problem of lead ammunition.

CMS addressed lead poisoning to prevent the risks to migratory birds and called for lead ammunition to be phased out across all habitats. While many countries in North America and Europe have made progress to ban lead in wetlands, CMS wants to take the issue to a global level and extend it to all habitats. To support this effort, CMS has formally established the Lead Task Group, a multi-stakeholder expert group bringing together the industry, the hunters and conservationists to help Member States facilitate concerted efforts to minimize poisoning of migratory birds from lead ammunition and fishing weights.

Marine Reserves are Moderately Effective Conservation Tools

NEW YORK (June 19, 2018)—A massive study of nearly 1800 tropical coral reefs around the world has found that marine reserves near heavily populated areas fail to protect many endangered species - but are a vast improvement over having no protection.

The study titled "Gravity of human impacts mediates coral reef conservation gains" appears online this week in the journal Proceedings of the National Academy of Sciences.

A team of 37 scientists collated field studies of fish on a global basis to examine the effectiveness of different reef conservation strategies and the consequences for key species. "Marine reserves near high human pressure had only a quarter the fish of reefs far from human pressures and were a hundred times less likely to have top predators such as sharks," said lead author Professor Josh Cinner of the ARC Centre of Excellence for Coral Reef Studies.

The study took advantage of a recent trend among coral reef scientists in examining the last remaining wilderness reefs to see how their ecology differed with protection offered by legally established marine reserves near human populations.

Dr. Tim McClanahan, Senior Scientist at WCS (Wildlife Conservation Society) and one of the study's authors, said: "This represents a monumental effort to study the last wild reef places and to see what people can do to replicate wilderness. The findings are sobering in that even the best reserves are not capable of simulating wilderness. Where human pressure was high, the probability of encountering a top predator was close to zero."

Human pressure appears to impact reserves even if there is no fishing within the boundaries. The study finds that the closer you get to human populations and markets, the greater the impacts. Researchers evaluated fish biomass and the presence of top predators on coral reef sites across 41 countries, states, and territories. They used a new way of measuring the human pressures that included fishing and pollution known as the 'human gravity' scale.

Human gravity calculates factors such as human population size, distance to reefs, and transport infrastructure on land, which can determine reefs' accessibility to fishermen and markets.

Professor Cinner added: "A really novel and exciting result arising from using the gravity metric is that medium to high human pressure had the greatest difference between fish biomass in marine reserves and reefs open to fishing. This means that, for most fisheries species, marine reserves have the biggest bang where human pressures are medium to high." ■

SELECTED ABSTRACTS

The influence of human disturbance on wildlife nocturnality

KM Gaynor, CE Hojnowski, NH Carter, and JS Brashares. *Science.* June 2018;360 (6394):1232-1235. https://doi.org/10.1126/science.aar7121Abstract

Rapid expansion of human activity has driven well-documented shifts in the spatial distribution of wildlife, but the cumulative effect of human disturbance on the temporal dynamics of animals has not been quantified. We examined anthropogenic effects on mammal diel activity patterns, conducting a meta-analysis of 76 studies of 62 species from six continents. Our global study revealed a strong effect of humans on daily patterns of wildlife activity. Animals increased their nocturnality by an average factor of 1.36 in response to human disturbance. This finding was consistent across continents, habitats, taxa, and human activities. As the global human footprint expands, temporal avoidance of humans may facilitate human-wildlife coexistence. However, such responses can result in marked shifts away from natural patterns of activity, with consequences for fitness, population persistence, community interactions, and evolution.

Fecal transplants could help preserve vulnerable species

S Reardon. *Nature*. 2018;558(173-174). https://doi.org/10.1038/d41586-018-05352-1

Koalas are among the world's fussiest eaters, consuming only the leaves of eucalyptus trees—and just a few varieties of eucalyptus at that. Research now suggests that the animals' discriminating diet is determined in part by the bacteria that live in their guts, which seem to restrict an individual koala's ability to digest certain species of eucalyptus.

The finding, which was presented on 8 June at the annual meeting of the American Society for Microbiology (ASM) in Atlanta, Georgia, comes amid a growing interest in how an animal's microbiome influences its ability to adapt to environmental change. Researchers studying koalas and other vulnerable species are trying to find out whether altering an animal's gut bacteria through changes in diet—or even fecal transplants—can increase its chance of survival.

Adaptation and conservation insights from the koala genome

RN Johnson, D O'Meally, Z Chen, GJ Etherington, SYW Ho, WJ Nash, CE Grueber, Y Cheng, CM Whittington, S Dennison, et al. *Nature Genetics.* 02 July 2018. https://doi.org/10.1038/s41588-018-0153-5

The koala, the only extant species of the marsupial family Phascolarctidae, is classified as 'vulnerable' due to habitat loss and widespread disease. We sequenced the koala genome, producing a complete and contiguous marsupial reference genome, including centromeres. We reveal that the koala's ability to detoxify eucalypt foliage may be due to expansions within a cytochrome P450 gene family, and its ability to smell, taste and moderate ingestion of plant secondary metabolites may be due to expansions in the vomeronasal and taste receptors. We characterized novel lactation proteins that protect young in the pouch and annotated immune genes important for response to chlamydial disease. Historical demography showed a substantial population crash coincident with the decline of Australian megafauna, while contemporary populations had biogeographic boundaries and increased inbreeding in populations affected by historic translocations. We identified genetically diverse populations that require habitat corridors and instituting of translocation programs to aid the koala's survival in the wild.

Global Reintroduction Perspectives 2018: Case studies from around the globe, 6th Ed.

IUCN/SSC Reintroduction Specialist Group, Gland, Switzerland, and Environment Agency, Abu Dhabi, UAE. PS Soorae (ed.). (2018). 6th Ed. 286pp. https://doi.org/10.2305/IUCN.CH.2018.08.en

Summary: Fifty-nine case studies are presented, covering invertebrates, fish, amphibians, reptiles, birds, mammals, and plants. Each was presented in the following order: Introduction, Goals, Success Indicators, Project Summary, Major Difficulties Faced, Major Lessons Learned, Success of Project with reasons for success or failure.

Studies were reported from the eight IUCN regions: North America & Caribbean, West Europe, South & East Asia, Oceania, West Asia, Africa, Meso & South America, East Europe, North & Central Asia.

The entire 286-page report is available online, and is open-access.

Determining raptor species and tissue sensitivity for improved West Nile virus surveillance

KL Kritzik, G Kratz, NA Panella, K Burkhalter, RJ Clark, BJ Biggerstaff, and N Komar. *Journal of Wildlife Diseases.* July 2018;54(3):528-33. https://doi.org/10.7589/2017-12-292

Raptors are a target sentinel species for West Nile virus (WNV) because many are susceptible to WNV disease, they are easily sighted because of their large size, and they often occupy territories near human settlements. Sick and dead raptors accumulate at raptor and wildlife rehabilitation clinics. However, investigations into species selection and specimen type for efficient detection of WNV are lacking. Accordingly, we evaluated dead raptors from north-central Colorado, US and southeast Wyoming, US over a 4-yr period. Nonvascular mature feathers ("quill"), vascular immature feathers ("pulp"), oropharyngeal swabs, cloacal swabs, and kidney samples were collected from raptor carcasses at the Rocky Mountain Raptor Program in Colorado from 2013 through 2016. We tested the samples using real-time reverse transcriptase-PCR. We found that 11% (53/482) of raptor carcasses tested positive for WNV infection. We consistently detected positive specimens during a 12-wk span between the second week of July and the third week of September across all years of the study. We detected WNV RNA most frequently in vascular feather pulp from Cooper's hawk (*Accipiter cooperii*). North American avian mortality surveillance for WNV using raptors can obviate necropsies by selecting Cooper's hawk and red-tailed hawk (*Buteo jamaicensis*) as sentinels and

targeting feather pulp as a substrate for viral detection.

Urban wildlife organizations and the institutional entanglements of conservation's urban turn

E Luther. *Society & Animals*. June 2018;26: 186-196. https://doi.org/10.1163/15685306-12341587

Urban wildlife organizations—which include groups focused on wildlife rehabilitation, rescue, removal, advocacy, education, and conflict resolution—have typically been viewed as out of step with the goals of wildlife conservation because of their focus on encounters with individual nonhuman animals, common species, and degraded habitats. The recent shift by large conservation NGOs toward a "humans and nature together" framework, because of its focus on urban natures, has brought the field into discursive relation with urban wildlife organizations. Drawing on a case study of four wildlife organizations in an urban center, this research explores their discourse about human-wildlife relationships in the city, and the challenges and opportunities presented by their emergent intersections.

Nest-site competition and killing by invasive parakeets cause the decline of a threatened bat population

D Hernández-Brito, M Carrete, C Ibáñez, J Juste, and JL Tella. *R. Soc. Open Sci.* May 2018;5(172477). DOI: 10.1098/rsos.172477.

The identification of effects of invasive species is challenging owing to their multifaceted impacts on native biota. Negative impacts are most often reflected in individual fitness rather than in population dynamics of native species and are less expected in low-biodiversity habitats, such as urban environments. We report the long-term effects of invasive rose-ringed parakeets on the largest known population of a threatened bat species, the greater noctule, located in an urban park. Both species share preferences for the same tree cavities for breeding. While the number of parakeet nests increased by a factor of 20 in 14 years, the number of trees occupied by noctules declined by 81%. Parakeets occupied most cavities previously used by noctules, and spatial analyses showed that noctules tried to avoid cavities close to parakeets. Parakeets were highly aggressive towards noctules, trying to occupy their cavities, often resulting in noctule death. This led to a dramatic population decline, but also an unusual aggregation of the occupied trees, probably disrupting the complex social behaviour of this bat species. These results indicate a strong impact through site displacement and killing of competitors, and highlight the need for long-term research to identify unexpected impacts that would otherwise be overlooked.

PHOTO © PAUL. CC BY-NC-ND 2.0 LICENSE.

An eastern water dragon (*Physignathus lesueurii*) at Manly Beach, New South Wales, Australia.

How many reptiles are killed by cats in Australia?

JCZ Woinarski, BP Murphy, R Palmer, SM Legge, CR Dickman, TS Doherty, G Edwards, A Nankivell, L Read, and D Stokeld. *Wildlife Research.* June 2018;45(3):247-266. https://doi.org/10.1071/WR17160

Context: Feral cats (*Felis catus*) are a threat to biodiversity globally, but their impacts upon continental reptile faunas have been poorly resolved.

Aims: To estimate the number of reptiles killed annually in Australia by cats and to list Australian reptile species known to be killed by cats.

Methods: We used data from >80 Australian studies of cat diet (collectively >10 000 samples), and estimates of the feral cat population size, to model and map the number of reptiles killed by feral cats.

Key results: Feral cats in Australia's natural environments kill 466 million reptiles/yr (95% CI; 271–1006 million). The tally varies substantially among years, depending on changes in the cat population driven by rainfall in inland Australia. The number of reptiles killed by cats is highest in arid regions. On average, feral cats kill 61 reptiles per km per year, and an individual feral cat kills 225 reptiles per year. The take of reptiles per cat is higher than reported for other continents. Reptiles occur at a higher incidence in cat diet than in the diet of Australia's other main introduced predator, the European red fox (*Vulpes vulpes*). Based on a smaller sample size, we estimate 130 million reptiles a year are killed by feral cats in highly modified landscapes, and 53 million reptiles a year by pet cats, summing to 649 million reptiles a year killed by all cats. Predation by cats is reported for 258 Australian reptile species (about one-quarter of described species), including 11 threatened species.

Conclusions: Cat predation exerts a considerable ongoing toll on Australian reptiles. However, it remains challenging to interpret the impact of this predation in terms of population viability or conservation concern for Australian reptiles, because population size is unknown for most Australian reptile species, mortality rates due to cats will vary across reptile species and because there is likely to be marked variation among reptile species in their capability to sustain any particular predation rate.

Implications: This study provides a well grounded estimate of the numbers of reptiles killed by cats, but intensive studies of individual reptile species are required to contextualise the conservation consequences of such predation. ■

TAIL END

Eddie wonders if a hat might help with his social anxiety.

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.

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Kieran Lindsey, Editor
jwr.editor@theiwrc.org

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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.

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A Coopers hawk taking an urban bath in Amherst, New York.

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