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IN THIS ISSUE:

Post-release studies as a tool in measuring the success of black bear rehabilitation in Virginia Case study: Anesthesia and veterinary care of the Temminck's ground pangolin Reviewing the literature in search of solutions to conflict between humans and Panthera

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:

Adult male African lion (Panthera leo), a species classified as vulnerable with worldwide populations fewer than 30,000 individuals.

PHOTO: B WINSTON HENDRICKSON. CC BY-NC-ND 4.0.

Left:

Juvenile whooper swans (Cygnus cygnus) in Obihiro River, Hokkaido, Japan. PHOTO ©NANCY O, FLICKR. CC BY-NC-ND 2.0.



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

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On the Map

WRC ran a fundraising campaign this winter with For the Love of All Things (FLOAT). The graphics included a map to symbolize that the IWRC connects wildlife rehabilitators around the world. Funny thing, the map as originally provided to us was missing a fairly large country: New Zealand. We were able to add the missing country to the final map and in the meantime had a lot of fun using New Zealand birds to point out the error. But this highlights challenges inherent in our desire to be inclusively international.

IWRC supports wildlife and wildlife caregivers. To do good work within this broad arena, some parameters must be defined, especially for a tiny organization. We've chosen to draw our boundaries around education, resources, and vertebrates. Within these guidelines, IWRC functions from a lens of international wildlife conservation and welfare.

Language, distance, and local knowledge are challenges that IWRC accepts in being a global organization. Fortunately, no organization needs to go it alone. Many of these "challenges" become smaller when approached collaboratively. If you'll bear with my pun, IWRC collaborates all over the map, figuratively and literally. We work with national rehabilitation organizations such as NWRA and Irish Wildlife Rehabilitation Council, organizations and individual members, conservation NGOs, government agencies, and, via social media, citizens all over the world. It is only through these partnerships that we can succeed in improving wildlife welfare and conservation.

IWRC is currently seeking funds to translate *Wildlife Rehabilitation: A Comprehensive Approach* into Spanish. This is not the only language we want to make the book available in, but it's a beginning. It will extend the reach of the combined knowledge of more than 20 authors to



ILLUSTRATION © PAT LATAS.

many more wildlife rehabilitators. Not only that, it'll open up new and valuable communication with experts IWRC hasn't yet met.

The IWRC Board of Directors is global. The 2019 board find their homes on three continents. Actually, for most of the last six years we've had board members on three continents (and not always the same three!) A full one-fourth of our current board is outside of North America, including our president.

New Zealand, as it turns out, goes missing from maps fairly often, often enough for the country to have an official campaign, *#getNZonthemap*. We hope our humor with the kākāpō, the kiwi, the kererū, and other NZ natives amused our followers and provided inspiration to all those working to ensure they *are* on the map.

We'll never be perfect, but that will always keep us striving to do better.

—Kai Williams Executive Director

IN THE NEWS

Fungal Disease Causing Mass Amphibian Extinction

WASHINGTON, DC (March 28, 2019)-An international study led by The Australian National University (ANU) has found that a fungal disease has caused dramatic population declines in at least 501 amphibian species, including 90 extinctions, over the past 50 years. The study, published in Science, involved collaborations with 41 different amphibian and wildlife disease experts from around the world. Smithsonian scientists contributed data from Panama-one of the worst-hit areas of the world by the disease—for the study.

Of the 90 confirmed extinctions of frogs across the globe, eight of those species were from Panama. Another 52 species of frogs in Panama have experienced more than a 90 percent decline.

"This study confirms that we are not dealing with a unique problem in Panama," said Brian Gratwicke, amphibian biologist, international coordinator of the Panama Amphibian Rescue and Conservation Project, and one of the coauthors of the study who provided data. "If we, or anyone, does find a solution or cure for chytrid, it will likely have global implications."

Collaborators like Smithsonian scientists allowed the lead researchers from ANU to get a first-hand insight into the conditions on-the-ground in countries around the world.

Chytridiomycosis, which eats away at the skin of amphibians, has completely wiped out some species, while causing more sporadic deaths among other species. Amphibians, which commonly live part of their life in water and the other part on land, mainly consist of frogs, toads and salamanders.

The deadly disease is present in more than 60 countries-the worst affected parts of the world are Australia, Central America and South America. The researchers found that chytridiomycosis is responsible for the greatest loss of biodiversity due to a disease.

IN MEMORIUM

Theresa Maria Smelser (January 10, 1950–February 26, 2019)

WRC member, and state and federal licensed bird rehabilitator Teresa Marie Smelser, of Montrose Michigan, died Tuesday, February 26, 2019 at Medilodge of Montrose. She

was 69 years of age.

Teresa was widely known for her selfless, generous nature, genuine smile and warm heart. She never hesitated to extend a helping hand, repair fractured songbirds, or to take the most misunderstood or underappreciated species of orphaned birds under her wing. From mourning doves to crows, neonates to injured adults, she had a determined and gentle skillset and was always encouraging and positive in spirit, never revealing a glimmer of stress despite working from dawn till dusk, and many times in the middle of the



night, to ensure her patients' best care.

Teresa mentored many now-licensed wildlife rehabilitators in the state of Michigan and networked with countless AZA-accredited zoos for non-releasable songbird placements. I will always have fond memories of her one-handed, fast wing wrap skills on the smallest of species!

Her empathy for all animals and warm candor will be remembered and carried on in the work of those who had the benefit of working alongside her. Teresa set a stellar example of how to be both an animal advocate, and patient teacher.

Surviving are her husband, Ronnie; children Chesla (Amber) Smelser, Bob (Jessica) Smelser; grandchildren Cody Smelser and Jacob Smelser; siblings Clare "Cricket" (Art) Aldrich, Irene King, and Ola (Roy) Lovely; brother-in-law Leonard Kusky; and several nieces and nephews. She was preceded in death by her parents; siblings Betty Kusky and Bill Severn; and brother-in-law, Dan King.

The disease is caused by chytrid fungus, which likely originated in Asia where local amphibians appear to have resistance to the disease.

The unprecedented number of declines places chytrid fungus among the most damaging of invasive species worldwide, threatening similar numbers of species as rats and cats.

Lead researcher Ben Scheele, of the Fenner School of Environment and Society at ANU, said highly virulent wildlife diseases, including chytridiomycosis, were contributing to the Earth's sixth mass extinction.

"The disease we studied has caused mass amphibian extinctions worldwide. We've lost some really amazing species," said Scheele.

More than 40 frog species in Australia had declined due to this disease during the past 30 years, including seven species that had become extinct.

"Globalisation and wildlife trade are the main causes of this global pandemic and are enabling disease spread to continue," said Scheele. "Humans are moving plants and animals around the world at an increasingly rapid rate, introducing pathogens into new areas."



The iconic Panamanian golden frog (*Atelopus zeteki*), one of the critically endangered species at risk from viral chytridiomycosis in Panama.

Scheele said improved biosecurity and wildlife trade regulation were urgently needed to prevent any more extinctions around the world.

"We've got to do everything possible to stop future pandemics, by having better control over wildlife trade around the world."

Scheele said the team's work identified that many impacted species were still at high risk of extinction over the next 10–20 years from chytridiomycosis due to ongoing declines.

"Knowing what species are at risk can help target future research to develop conservation actions to prevent extinctions." Conservation programs in Australia have prevented the extinction of frog species and developed new reintroduction techniques to save some amphibian species. "It's really hard to remove chytrid fungus from an ecosystem – if it is in an ecosystem, it's pretty much there to stay unfortunately" said Scheele "This is partly because some species aren't killed by the disease. On the one hand, it's lucky that some species are resistant to chytrid fungus; but on the other hand, it means that these species carry the fungus and act as a reservoir for it so there's a constant source of the fungus in the environment.

New Marine Wildlife Rehabilitation Center for Oregon Coast

NEWPORT, OREGON, USA (March 27, 2019)-The Oregon Coast Aquarium plays an active role in conservation and wildlife rehabilitation efforts. Currently, the Aquarium utilizes aging warehouse facilities to diagnose and treat marine life, and contracts with veterinarians. Facility limitations make it difficult to quarantine injured or ill animals to safeguard the Aquarium's current marine population against disease, and minimize the impact of human contact. Moving a wild animal imposes further stress, and anesthetizing them puts it at undue health risk. To accommodate increased marine life rescue, improve conditions for rehabilitation, and create an opportunity for learning, the Aquarium plans to build a state-of-the-art Marine Wildlife Rehabilitation Center for animal husbandry and veterinary staff to provide critical care to injured or stranded marine animals as well as their own collection. The facility will include indoor and outdoor enclosures, clinical facilities for veterinary diagnostics, observation and treatment. It will also serve as a teaching facility, enabling age-appropriate visitors a clinical view of this vital work in species survival.

Archaeological Evidence of Otter Tool Use

JENNA, GERMANY (March 14, 2019)—An international team of researchers has analyzed the use by sea otters of large, shoreline rocks as "anvils" to break open shells, as well as the resulting shell middens. The researchers used ecological and archaeological approaches to identify patterns that are characteristic of sea otter use of such locations. By looking at evidence of past anvil stone use, scientists could better understand sea otter habitat use.

Sea otters are an especially captivating marine mammal, well known for their use of rocks to break open shells. Sea otters are estimated to have once numbered between 150,000–300,000 individuals and their range stretched from Baja California, Mexico, around the northern Pacific Rim

WILDLIFE REHABILITATION

Evaluating the success of an orphaned American black bear (Ursus americanus) rehabilitation program in Virginia

Brianna J. Hashem



Introduction

Professional wildlife rehabilitation facilities emerged in the late 1960s in response to public concern for injured and orphaned wildlife.¹ The goal of wildlife rehabilitation of birds, small mammals, and reptiles has been widely accepted by the general public.¹ Success in wildlife rehabilitation has commonly been measured by release rates.^{3,4,5,6,7} However, post-release studies can provide data on survival, dispersal, breeding success, and human conflicts,^{3,4,6,8,9,10,11,12} thus giving insights as to whether wildlife rehabilitation achieves the broader intentions for the effort. Therefore, collection and detailed evaluation of post-release data can provide a more comprehensive assessment of the success of a wildlife rehabilitation program than simple release rates.

Wildlife rehabilitation standards include avoiding habituation to humans² because habituated wildlife accept the close presence of humans¹³ and could result in human conflicts. Concern for human conflicts resulting from habituation has negatively affected public acceptance of rehabilitation programs for large carnivores.¹⁴ Habituation in American black bears (*Ursus americanus*; hereafter "black bears") may increase the likelihood of human conflicts and bear-inflicted human injuries.¹⁵ Examples of human conflicts include property damage, attempts to enter a building, association with food attractants,

ABSTRACT: While success in wildlife rehabilitation is most often measured by release rates, post-release studies can provide a more comprehensive analysis of the success of a wildlife rehabilitation program. In 2014, The Wildlife Center of Virginia began fitting all rehabilitated orphaned American black bears (Ursus americanus) with ear tags prior to release to allow for collection of post-release data. Analysis of the available data revealed that of 52 releases from The Wildlife Center of Virginia's orphaned black bear rehabilitation program from 2014-2018, 44 (84.6%) were considered successful because they did not result in a known natural death or human conflict within a year of release. The high success rate of releases indicates that orphaned black bear rehabilitation is a viable management option for black bear managers in Virginia. Large carnivore rehabilitation programs provide opportunities for educational, outreach, and research outcomes crucial for gaining public acceptance and support for such programs and contributing to the conservation success of wild populations.

KEYWORDS: American black bear, habituation, human conflict rates, orphan, postrelease studies, success, Virginia, wildlife rehabilitation

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American black bear (*Ursus americanus*) released from The Wildlife Center of Virginia's orphaned black bear rehabilitation program. Photo courtesy of Steve Dibbern.

presence in a campground or fox pen, presence in a populated or confined area with no escape route, and attacks on humans. Public safety concerns, either real or perceived, may necessitate the need for the humane dispatch of individual black bears.¹⁶

Orphaned black bear rehabilitation is acknowledged as having limited impact on populations. However, it is important to black bear managers in the northeastern U.S. primarily for sociological issues including public outreach, positive opinion and trust of agency operations, and derived educational benefits.¹⁷

Orphaned black bears have been raised in wildlife rehabilitation facilities and released back into occupied habitat as cubs or yearlings for more than 30 years.¹⁴ Elements associated with successful releases include minimizing the number of caretakers and frequency of contact, particularly after weaning, and allowing cubs the opportunity to socialize with other cubs. Other elements of successful releases include selecting remote release locations with good quality black bear habitat and timing releases to coincide with the availability and abundance of natural foods. Releasing black bears with sufficient fat reserves and at the time of natural family break-up also contributes to successful releases.¹⁸ Higher weight at release could provide a buffer of energy during the acclimation period, and might compensate for the lack of previous experience in the wild.¹⁹ A study of 424 black bears raised in captivity and released into the wild as yearlings found that increased release weight decreased the probability of a human conflict.14 Releases of black bears have been considered successful if individuals were not involved in a human conflict within either 30 days²⁰ or a year²¹ of release and were not found dead

from unknown causes.^{20,21} Other measures of the success of rehabilitated orphaned black bear releases have included individuals showing similar life-history traits as their wild counterparts, including dispersal distances and reproductive rates.

A management plan for orphaned black bears has been in place in Virginia for more than 30 years. The Black Bear Research Center at Virginia Tech (VTBBRC) began housing research black bears in 1986 and fostered orphaned black bears from Virginia with captive females that currently had cubs. The family groups were released together in the spring until the VTBBRC closed in 2009. The Virginia Department of Game and Inland Fisheries (VDGIF) was left with limited options for orphaned black bears, and euthanized the majority of orphaned black bears found until 2011.17 The Wildlife Center of Virginia (WCV) began rehabilitating orphaned black bears for release in 2011 and is the only facility in Virginia permitted to rehabilitate black bears. From 2011 to 2014, WCV did not limit the number of caretakers interacting with cubs and released the majority (66.7%) of their black bears in the fall or winter. In 2015, WCV changed their orphaned black bear rehabilitation protocols, limiting the number of caretakers to a maximum of four individuals per season and releasing all orphaned black bears in the spring following admission.

In 2014, WCV began fitting all rehabilitated orphaned black bears with ear tags from VDGIF prior to release. This allows black bear managers to ascertain if individual bears they encountered (e.g., research, roadway fatality scenes, hunter check stations, human conflict situations) had been rehabilitated and released by WCV. Between 2014 and 2018, WCV fitted 52 orphaned black bears with ear tags. Each ear tag contains a unique number and instructions to contact VDGIF if encountered. Ear tags require an encounter to obtain data, and therefore provide opportunistic data on survival, movement, and human conflict. The breeding success of ear-tagged individuals can only be evaluated for females who are encountered with cubs or lactating.¹⁴

There have not been any post-release studies of rehabilitated orphaned black bears released in Virginia. While 25 ear tags have been encountered, the data had not been analyzed to formally evaluate the success of WCV's orphaned black bear rehabilitation program. A retrospective analysis of the available data was performed to answer the following research questions: (1) Is the average weight of yearlings released from WCV's orphaned black bear rehabilitation program greater than the average weight of wild yearlings in Virginia? (2) Is there a difference between hunter harvest rates of rehabilitated orphaned and wild black bears in Virginia? (3) Is there a difference between the human conflict rate of rehabilitated orphaned and wild black bears in Virginia? (4) How does the human conflict rate of rehabilitated orphaned black bears released in Virginia compare to rates observed in other states? and (5) Does a relationship exist between either circumstances of rescue or release date and human conflict situations? In answering these questions, the research objective was to evaluate the success of WCV's orphaned black bear rehabilitation program and to identify areas for improvement.

Methods

Orphaned black bears were defined as cubs (i.e., admitted on or before December 31 of their birth year). Patient records for all orphaned black bears admitted to WCV between 2013 and 2017 were compiled using Wildlife Incident Log/Database and Online Network (WILD-ONe[®]). Relevant data including patient ID, other identifier, ear tag information, gender, life stage, date admitted, circumstances of rescue, rescue jurisdiction, rescue address, weight, weigh date, disposition date, disposition comments, disposition jurisdiction, disposition address, latitude, and longitude were exported to an Excel spreadsheet. VDGIF provided post-release encounter data, including date, type of encounter, and additional comments. The encounter data points were classified as caught in trap, electrocuted, hit by vehicle, hunter harvest, or human conflict, and summary statistics were calculated for the encounter classifications. To evaluate the population scale success of WCV's orphaned black bear rehabilitation program, "success" was defined as a release that did not result in a known natural death or human conflict within a year of release.

Comparing encounter data from rehabilitated black bears to data collected from wild black bears can help explore the efficacy and potential vulnerabilities of rehabilitation efforts. Human conflict, hunter harvest, and vehicle collision data for wild black bears in Virginia were provided by VDGIF, as was the 2018 statewide population estimate (18,000 black bears). Vehicle collision data for wild black bears in Virginia was incomplete and only compiled until 2014 (VDGIF unpublished data), so direct comparison to

that risk for rehabilitated orphaned black bears was not possible. The average summer weight of wild yearling males ($\overline{x} = 40.6$ kg, n = 105) and wild yearling females ($\overline{x} = 30.8$ kg, n = 18) was obtained from research trapping records.^{22,23} A one sample t-test ($\alpha = 0.05$) was used for each sex to determine if the average weight of yearlings released from WCV's orphaned black bear rehabilitation program was greater than the average weight of wild yearlings in Virginia.

To compare hunter harvest rates of rehabilitated orphaned and wild black bears in Virginia, the number of rehabilitated orphaned black bears released from WCV harvested during the 2018–2019 hunting season (n = 3) was divided by the number of rehabilitated orphaned black bears released from WCV and still presumed alive at the start of the 2018–2019 hunting season (n = 32). The three rehabilitated orphaned black bears released from WCV harvested during the 2018–2019 hunting season included one yearling, one two-yearold, and one three-year-old black bear. The harvest rate of wild black bears in Virginia was calculated by dividing the total number of black bears across all age classes harvested in Virginia during the 2018–2019 hunting season (n = 2,715) by the 2018 statewide population estimate (n = 18,000) (VDGIF unpublished data). An exact binomial test was then performed, using the harvest rate of wild black bears in Virginia as the true proportion.

To determine if there is a difference between the human conflict rate of rehabilitated orphaned and wild black bears in Virginia, the number of rehabilitated orphaned black bears released from WCV involved in human conflict situations (n = 8) was divided by the total number of rehabilitated orphaned black bears released from WCV (n = 52). Human conflict data for wild black bears in Virginia requiring a site visit by VDGIF during 2014–2017 was tallied (n = 93) and divided by the 2018 statewide population estimate (n = 18,000) to calculate a human conflict rate (VDGIF unpublished data). An exact binomial test was performed, using the human conflict rate of wild black bears in Virginia as the true proportion. To compare the human conflict rate of rehabilitated orphaned black bears released from WCV to the average human conflict rate across eight other published cases, a descriptive table was created (Table 1).^{14,19,20,21,24,25,26,27}

To test for correlation between circumstances of rescue or release date and human conflict, the three categories were coded using binary code. Circumstances of rescue were coded "1" for "Confiscation", "Inappropriate human possession / Unauthorized

TABLE 1. Human conflict rate of rehabilitated orphaned black bears released in Virginia compared to rates observed in other states

STATE(S) OR PROVINCE(S) SOURCE	YEAR(S)	ABBEARS RELEASED	ABBEAR– HUMAN CONFLICTS	% OF RELEASED ABBEARS INVOLVED IN HUMAN CONFLICTS
AB (CANADA) Smeeton & Walters 2005	2001	2	0	0
CA, ID, MI, NV, OR, UT, WA, WY (USA) Idaho Black Bear Rehab 2014	1989-2014	206	4	1.9
ID, MT, NJ, NM, UT, WA (USA) AND ON (CANADA) Beecham et al. 2015	1991-2012	424	26	6.1
ID, PA (USA) Alt & Beecham 1984	1973-1983	39	4	10.3
NH (USA)	2011	7	0	0
Smith et al. 2016	2012	3	3	100.0
NC, TN (USA) Clark et al. 2002	1998	11	0	0
TN (USA) Stiver et al. 1997	1982-1995	23	5	21.7
UT (USA) <i>UT DOWR 2005</i>	2005	14	0	0
VA (USA)	2014	21	7	33.3
	2015-2018	31	1	3.2

or untrained rehabilitation," and "Inappropriate human possession / Pet," and "0" for all other circumstances of rescue. Release date was coded "1" when the release year was the same as the admission year (i.e., released as cub) and "0" when the release year was the year after the admission year (i.e., released as yearling). Encounter type was coded "1" for human conflict and "0" for no encounter or all other encounter types. A correlation analysis was performed to determine the Pearson correlation coefficient for both circumstances of rescue and human conflict and release date and human conflict.

Discussion

The releases of 44 (84.6%) rehabilitated orphaned black bears from WCV's orphaned black bear rehabilitation program can be considered successful because they did not result in a known natural death or human conflict within one year of release. Rehabilitated orphaned black bears released from WCV as cubs had a higher incidence of human conflict, and thus, lower success rate, than those released as yearlings. This finding is in alignment with previously cited recommendations to release rehabilitated orphaned black bears as yearlings to allow for the buildup of fat reserves and to coincide with the period of natural family break-up.^{18,19} The significantly greater average weight of yearlings released from WCV's orphaned black bear rehabilitation program compared to the average weight of wild yearlings in Virginia could have contributed to the high number of successful releases for rehabilitated orphaned black bears released as yearlings.

Rehabilitated orphaned black bears are released with the intention of becoming functioning members of a harvestable population. However, rehabilitated orphaned black bears should not be overly susceptible to harvest compared to their wild counterparts.¹⁹ The lack of a significant difference between the harvest rate of rehabilitated orphaned black bears released from WCV and the harvest rate of wild black bears in Virginia shows that rehabilitated orphaned black bears released from WCV were not more susceptible to harvest than their wild counterparts.

The significantly higher human conflict rate of rehabilitated orphaned black bears compared to wild black bears in Virginia could be attributed, in part, to underreporting of wild black bears compared to more conspicuous ear-tagged rehabilitated black bears.²⁸ All rehabilitated orphaned black bears released from WCV and involved in human conflicts were humanely dispatched due to public safety concerns.¹⁶ However, a single wild black bear could require multiple site visits. Human conflict data for wild black bears in Virginia requiring a site visit by VDGIF represents an annual index, not the number of human conflicts per wild black bear.

Studies of rehabilitated orphaned black bears released in other states with the highest human conflict rates (21.7% and 100%, respectively) allowed for extensive public viewing during the rehabilitation period²⁷ or had a shortage of natural foods available at the time of release.¹⁹ The Wildlife Center of Virginia's human conflict rate (33.3%) for orphaned black bears released in 2014 could be

attributed, in part, to releasing black bears with insufficient fat reserves and before the time of natural family break-up. In addition, WCV did not minimize the number of caretakers prior to 2015, which could have increased the likelihood for habituation, and thus, human conflict. The only orphaned black bear released from WCV between 2015–2018 known to be involved in a human conflict was found wearing a dog collar and leash before admission to WCV and exhibited habituated behaviors on admission. The Virginia Department of Game and Inland Fisheries made the decision to release this patient; he raided a campground three weeks post-release and was humanely dispatched.

The lack of evidence of a correlation between circumstances of rescue and human conflict was surprising given that these circumstances of rescue involved increasing the number of caretakers and limiting opportunities to socialize with other cubs. Minimizing the number of caretakers and frequency of contact, particularly after weaning, and allowing cubs the opportunity to socialize with other cubs have been cited as elements associated with successful releases.¹⁸ The weak to moderate positive correlation between release date and human conflict, with rehabilitated orphaned black bears released as cubs having a higher probability of human conflict involvement than rehabilitated orphaned black bears released as yearlings, provides further support for releasing rehabilitated orphaned black bears as yearlings.^{18,19}

Although WCV's orphaned black bear rehabilitation program had a high success rate for releases of yearlings, measuring success by releases alone ignores other possible elements of success such as educational and research outcomes.^{3,17} The Virginia Department of Game and Inland Fisheries recognizes that orphaned black bear rehabilitation is important for public outreach and positive opinion and trust of agency operations.¹⁷ The high success rate for releases of yearlings from WCV indicates that orphaned black bear rehabilitation is a viable management option for black bear managers in Virginia.

To improve upon the success of WCV's orphaned black bear rehabilitation program, it is recommended to continue to release rehabilitated orphaned black bears as yearlings at the time of natural family breakup and to continue to limit the number of caretakers. Because extensive public viewing during the rehabilitation period has been associated with high levels of human conflict post-release,²⁷ it is also recommended to restrict viewing to the caretakers only. To achieve this, orphans not requiring medical attention should only be evaluated by caretakers, and additional visual barriers should be installed around orphan enclosures.

Results

Of the 52 orphaned black bears fitted with ear tags and released from WCV between 2014 and 2018, eight (15.4%) were involved in a human conflict, 11 (21.2%) were harvested by hunters, five (9.6%) were killed by a vehicle, and one (1.9%) was caught in a trap set for a sow radio-collaring project and was later found dead due to electrocution (Table 2, Fig. 1). Human conflict encounters included two black bears residing in campgrounds, three black bears causing property damage, and three black bears attempting to enter buildings. The fates of the remaining 27 (51.9%) ear tagged orphaned black bears are unknown.

The average weight of 28 male yearlings released from WCV (\overline{x} = 52.0 kg, SD = 13.1) during January to June of the year following admission was significantly greater (t = 4.60, p < 0.01) than the average weight of male yearlings trapped during the

summer in Virginia ($\overline{x} = 40.6$ kg, n = 105).²² The average weight of 19 female yearlings released from WCV ($\overline{x} = 36.1$ kg, SD = 8.6) during January to June of the year following admission was significantly greater (t = 2.72, p < 0.01) than the average weight of female yearlings trapped during the summer in Virginia ($\overline{x} =$ 30.8 kg, n = 18).²³ The average weight of five cubs released from WCV in August of the year of admission was 18.0 kg (SD = 5.8). Of these five cubs, three (60%) were involved in a human conflict within 48 days post-release.

There was no significant difference (p = 0.47) between the harvest rate of rehabilitated orphaned black bears released from WCV and the harvest rate of wild black bears in Virginia (VDGIF unpublished data). The human conflict rate of orphaned black bears released from WCV was significantly greater (p < 0.01) than the human conflict rate of wild black bears in Virginia (VDGIF unpublished data). The published human conflict rate ranged from 0% to 100% (Table 1).^{14,19,20,21,24,25,26,27} The human conflict rate of rehabilitated orphaned black bears released in Virginia in 2014 was 33.3%. The human conflict rate of rehabilitated orphaned black bears released in Virginia between 2015–2018 was 3.2%.

There was no correlation (r = -0.01) between circumstances of rescue and human conflict. There was a weak to moderate positive correlation (r = 0.40) between release date and human conflict, with rehabilitated orphaned black bears released as cubs having a higher probability of human conflict involvement than rehabilitated orphaned black bears released as yearlings.

Conclusions

Post-release studies can provide a more comprehensive analysis of the success of a wildlife rehabilitation program than release rates. Rehabilitation practices can affect the success rate of releases. Analysis of post-release data of rehabilitated orphaned black bears released from WCV revealed a high success rate for releases of yearlings, indicating that orphaned black bear rehabilitation is a viable management option for black bear managers in Virginia. Educational, outreach, and research outcomes derived from large carnivore rehabilitation programs are crucial for gaining public acceptance and support for such programs and contributing to the conservation success of wild populations.

TABLE 2. Annual numbers of American black bears (Ursus americanus) released from The Wildlife Center of Virginia's orphaned black bear rehabilitation program and their fates.

YEAR ADMITTED	TOTAL RELEASED	ELECTROCUTED	HIT BY VEHICLE	HUNTER HARVEST	HUMAN CONFLICT	UNKNOWN
2013	16	-	1	4	4	7
2014	5	-	-	-	3	2
2015	7	-	-	5	-	2
2016	15	-	2	1	1	11
2017	9	1	2	1	-	5
TOTAL	52	1	5	11	8	27



FIGURE 1. Fates of American black bears (*Ursus americanus*) released from The Wildlife Center of Virginia's orphaned black bear rehabilitation program.

About the Author

Brianna Hashem earned her B.S. in Environmental Resource Management from Pennsylvania State University in 2010 and her Master of Natural Resources from Oregon State University in 2018. Brianna has more than seven years of professional wildlife rehabilitation experience and is now the black bear rehabilitator and the head of the wildlife rehabilitation department for The Wildlife Center of Virginia.

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Case study: Anesthesia and veterinary care of rescued Temminck's ground pangolins *(Smutsia temminckii)*

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Introduction

emminck's ground pangolin (Smutsia temminckii) is one of four pangolin species native to Africa, and is the only pangolin found in Zimbabwe and South Africa.1 The species' principal diet consists of ants and termites, which pangolins dig out by using their powerful clawed limbs.² With the exception of snout, ventrum and foot pads, the species is covered with dermal scales.³ Temminck's ground pangolin has been assessed by the IUCN Red List of Threatened Species as Vulnerable, defined as being at high risk of extinction in the wild in the medium-term future.⁴ Illegal trade in pangolin or its body parts (especially its scales) for traditional medicinal use in both Africa and Asia represents a main threat to the species' survival.¹ The demand for pangolin products has increased while the Asian pangolin population has decreased.^{2,5} As a result, pangolins are smuggled from Africa to feed this demand. Since 2010, the number of Temminck's ground pangolins seized from illegal trade has increased drastically.^{1,2} Consequently, wildlife rescue and rehabilitation facilities receive an increasing number of pangolins confiscated from illegal trade activities by law enforcing authorities.^{1,4} Those animals are generally in poor health due to acute stress, malnutrition, and injuries related to hunting methods, and often require veterinary treatment.⁵ Data on anesthesia and veterinary care of the pangolin are scarce.³ As the number of pangolins confiscated from trade rises, there is a need to further develop our understanding of the anesthesia and veterinary care of this species.

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ABSTRACT: Like other pangolin species, the Temminck's ground pangolin suffers from illegal trade in body parts. Pangolins are increasingly seized from illegal trade; consequently, the number of confiscated individuals received by rescue and rehabilitation centers has been rising. Confiscated pangolins are generally in poor condition and often require medical treatment. However, data on veterinary care and anesthesia of pangolins are scarce. In this study we used isoflurane to anesthetize nine Temminck's ground pangolins. We describe the procedure used for anesthesia and provide information about the treatment of common health conditions using commercially available antibiotics and nonsteroidal anti-inflammatory drugs. The information provided in this study will assist with the development of our understanding of anesthesia and veterinary care of pangolins.

KEY WORDS: pangolin, *Smutsia tem*minckii, inhalation anesthetics, isoflurane, veterinary care

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Methods

Anesthesia

When threatened, pangolins curl into a tight ball to protect their soft abdomen. Especially in wild animals which are not used to handling, forceful uncoiling of a pangolin is likely to result in injury and stress. Therefore, chemical restraint is advised to allow for physical examination, basic veterinary care and specimen collection.³ Between August 2015 and February 2016, we anesthetized nine confiscated ground pangolins for physical examination, microchipping, blood sampling, DNA harvesting, and general measurements at our rehabilitation center. One of these pangolins, an adult female (5.1 kg), required veterinary surgery on a head abscess. All pangolins fasted for a minimum of 12–14 hours prior to being anesthetized. For pangolins, their scales account for about 30% of their total body weight (EC unpublished data). When calculating drug dosages based on body weight, it is therefore important to base these calculations on body weight excluding the scales.

We anesthetized eight adult pangolin females with an average age of 3.5 ± 0.42 years (mean \pm SE) (range 2–5 years, median 3.5 years) and an average body weight (including scales) of 8.63 ± 0.99 kg (mean \pm SE) (range 5.10-11.85 kg, median 9.25 kg), and one adult 4 yrs. old male with a body weight of 12.4 kg (including scales). Of the nine pangolins, three of the more fractious individuals were premedicated with medetomidine hydrochloride 1 mg/ml (Domitor[®], Pfizer Animal Health, Australia) which was injected subcutaneously in the lower lumbar region under a scale, at a dose rate of 0.125 mg/kg body weight excluding scales. An induction time of 8-10 minutes provided sufficient sedation for two of the three pangolins to unroll the head so that an anesthesia facemask could be placed over the face.

In the case of two nonpremedicated pangolins (fractious behavior prevented premedication) and one premedicated pangolin (adult female with head injury), applying an anesthesia facemask was not feasible. In these cases, anesthesia was induced by placing the animals into a dark plastic bag, into which 5% isoflurane vaporized in medical oxygen at a flow rate of ca. 1 L/ min was directed until, after approximately 10 minutes, a light plane of anesthesia was achieved. At this time the animals could be partially uncoiled so an anesthesia facemask could be placed over their faces. For all nine pangolins, once an anesthesia facemask was in place, isoflurane was delivered at 5% with an oxygen flow rate of 1 L/min via an open circuit. As soon as anesthesia was induced, a light plane of anesthesia was maintained at 2-3% isoflurane vaporized in 0.75 L/min medical oxygen. Depth of anesthesia was judged by respiratory rate and the degree of uncoiling of the body. Depending on the required procedures, the pangolins were anesthetized for approximately 38.3 ± 10 minutes (mean \pm SE), with a minimum of 20 minutes and, in the case of a female requiring surgery to treat an abscess to the head, a maximum of 55 minutes. For this longer procedure we substituted the cumbersome facemask with a mask fashioned from the barrel of a 20 ml syringe (Fig. 1). This provided a perfect fit for the pangolin's slender muzzle, and respiration (visible on a mini lack circuit with a 500





FIGURE 1. Pangolin with facemask fashioned from the barrel of a 20 ml syringe to allow for surgery on a head abscess.

ml rebreathing bag) was good, with no evidence of compromise or obstruction.

Once procedures on the nine pangolins were completed, delivery of isoflurane ceased, and the animals received medical oxygen (0.75 L/min) for about four minutes. As soon as isoflurane delivery ceased, the medetomidine of one of the three pangolins which received premedication was reversed with 0.4 ml (2.0 mg) atipamezole hydrochloride (5 mg/ml) (Antisedan®, Janssen Animal Health, UK). For the other two premedicated pangolins we either did not have atipamezole hydrochloride available or the individual was already responsive and therefore reversal not required. In eight of the nine cases, recovery was uneventful and took approximately 20 minutes; a longer duration of anesthesia did not affect recovery time. In the case where atipamezole hydrochloride was not available, the 11.95 kg female which was premedicated with 1.5 mg medetomidine had an uneventful but relatively long recovery time of about 60 minutes. In our experience, an anesthetized pangolin's breathing rate is around 16 breaths per minute and heart rate 70-80 beats per minute. Body temperature can decrease to 33°C, therefore, as standard practice, all pangolins were placed on a heating pad during anesthesia and recovery.

TABLE 1. Name, dosage and route of administration of antibiotics used to treat dermal wounds, skin abscesses, and bacterial infections in rescued Temminck's ground pangolins.

DRUG NAME (ACTIVE INGREDIENT + TRADE NAME)	NUMBER OF INDIVIDUALS TREATED	DOSE (MG/KG)	ROUTE OF ADMINISTRATION	FREQUENCY AND LENGTH OF COURSE	CONDITIONS TREATED
Enrofloxacin 5% (Baytril [®] , Bayer Ltd, Germany)	2	5 mg/kg	Subcutaneous	Once per day for 5 days	Dermal wounds and skin abscesses
Cefovecin 80 mg/ml (Convenia®, Pfizer Ltd, South Africa)	5	8 mg/kg	Subcutaneous	Single dose	Post-partum (where infection suspected), diarrhea, skin abscesses. Also used where non-specific clinical signs (e.g. foul odor) suggested bacterial infection.

TABLE 2. Name, dosage and route of administration of nonsteroidal anti-inflammatory drugs used to treat dermal wounds, skin abscesses, thermal burns, and soft tissue trauma in rescued Temminck's ground pangolins.

DRUG NAME (ACTIVE INGREDIENT + TRADE NAME)	NUMBER OF INDIVIDUALS TREATED	DOSE (MG/KG)	ROUTE OF ADMINISTRATION	FREQUENCY AND LENGTH OF COURSE	CONDITIONS TREATED
Ketoprofen 2% (diluted from Ketosol 100 [®] , Interchemie, Holland)	2	2 mg/kg	Intramuscular	Once per day as required, for up to 3 days	Skin abscesses, thermal burns
Meloxicam solution for injection 5 mg/ml (Metacam [®] , Boehringer Ingelheim Ltd, UK)	3	Loading: 0.2 mg/kg, subsequent: 0.1 mg/kg	Subcutaneous	Loading dose once, then once per day at lower dose as required	Dermal wounds, skin abscesses, soft tissue trauma, thermal burns
Meloxicam oral suspension 0.5 mg/ml (Petcam®, CiplaVet, South Africa)	1	0.1 mg/kg	Oral	Once per day as required	Thermal burns

Veterinary care

We have treated a range of health conditions in rescued ground pangolins using commercially available antibiotics (Table 1) and nonsteroidal anti-inflammatory drugs (Table 2) at generally accepted small animal dose rates. Information on the name, dose rate, route and frequency of administration, length of course and the number of individual animals which have received the drug is presented in Tables 1 and 2. As there were no other injectable nonsteroidal anti-inflammatory drugs available in Zimbabwe and 100 mg/ml Keprofen (Ketosol 100°, Interchemie, Holland) is too painful and reactive for use in small animals, we diluted 10% ketoprofen to a 2% ketoprofen solution using sterilized water (Kyron Laboratories, South Africa). Drugs which were administered subcutaneously were injected in unscaled areas in the ventral abdomen or caudal hind limbs, or, in cases where the pangolin was tightly curled, anywhere between scales. Although some of these cases ultimately resulted in mortality due to the extremely poor conditions the animals were received in, all of the listed drugs appear to have been well tolerated, with no side effects being attributed to them.

Discussion

Data on anesthesia and clinical medicine of pangolins are limited.³ Historically, ketamine has been used as an injectable anesthetic to chemically restrain pangolins.^{3,6} Compared to injectable agents, inhalation anesthetics allow for better control of anesthetic depth and duration, and a fast recovery with minimal side effects.^{7,8} Although inhalation anesthetics are usually used in controlled settings such as zoos and aquariums,⁷ the use of field portable vaporizers has made application in the field possible.^{8,9} Isoflurane is one of the safest and most commonly used inhalation anesthetics,^{7,8} which has been successfully used to anesthetize a wide range of species.^{8,9} In the past we sedated our rescued Temminck's ground pangolins by injectable drugs only, using medetomidine hydrochloride at a dosage rate of 1 mg per 8 kg body weight (including scales). Although induction time was relatively short

(5–8 minutes), recovery time was significantly longer compared to inhalation anesthetics, and it would take a minimum of 2–3 hours before the pangolins would wake up and walk again. In this study, we used isoflurane to anesthetize nine adult Temminck's ground pangolins. The short induction time, absence of adverse side effects, and quick recovery time make us conclude isoflurane is a safe and appropriate inhalation anesthetics for this species.

In some cases, premedication with medetomidine, or induction of anesthesia with isoflurane delivered in a bag, was necessary to enable placement of the face mask. Premedication with medetomidine at 0.125 mg/kg body weight sufficiently enhanced muscle relaxation and did not seem to cause adverse side effects or enhance the potential side effects of isoflurane, such as a decrease in blood pressure.7 Premedication with medetomidine required more handling and a longer induction time than placing the pangolin in a bag to induce isoflurane anesthesia. Besides, for particularly fractious individuals, premedication with medetomidine was not sufficient to relax the animal to such an extent that a facemask could be placed. In this case, placement in a bag was necessary to induce isoflurane anesthesia. Therefore, for fractious individuals, we would recommend inducing isoflurane anesthesia in a bag or box; compared to premedication with medetomidine, this minimizes handling and induction time.

The commercially available antibiotics Enrofloxacin and Cefovecin, and nonsteroidal anti-inflammatory drugs Meloxicam and Ketoprofen, were well tolerated with no side effects, and are therefore suitable drugs for the treatment of dermal wounds, skin abscesses, thermal burns, and diarrhea in Temminck's ground pangolins.

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Ellen Connelly has a BSc in zoology from the University of South Africa; she is director of conservation of the Tikki Hywood Foundation, a wildlife rescue and rehabilitation organization specialized in the rehabilitation of pangolins.

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Dr. Mark Donaldson is an experienced veterinarian who operates his own veterinary surgery in Harare, Zimbabwe, treating both domestic animals and wildlife.

Dr. Esther van der Meer is a wildlife biologist with extensive experience in the capture, care, rehabilitation, and reintroduction of wild species.

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Characterizing conflict between humans and big cats *Panthera* spp: A systematic review of research trends and management opportunities

Kathleen Krafte Holland,¹ Lincoln R. Larson,² and Robert B. Powell¹



Malayan tiger (Panthera tigris jacksoni) going for a swim.

Introduction

Big cats (*Panthera* spp.), a taxonomic group that includes tigers, lions, jaguars, leopards, and snow leopards, are apex carnivore species that drive the structure and function of biological communities in diverse ecosystems around the world.¹ These majestic creatures have also been a source of apprehension, intrigue, and inspiration throughout human history.² Consequently, big cat conservation has emerged as an important global priority, yet one that remains a daunting challenge. According to the IUCN Red List, tigers (*Panthera tigris*) are classified as "endangered" with a population of 3,200, lions (*Panthera leo*) are classified as "vulnerable" with worldwide populations < 30,000, jaguars (*Panthera onca*) are classified as "near threatened" with worldwide populations of about 18,000, and leopards (*Panthera pardus*) are classified as "near threatened" with worldwide populations unknown.³

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ABSTRACT: Conservation of big cats (Panthera spp.), a taxonomic group including tigers, lions, jaguars, leopards and snow leopards, is a daunting challenge. As expanding human populations across Panthera range exacerbate competition for land and prey, conflicts between humans and big cats are inevitable. Through a systematic review of peer-reviewed literature from 1991–2014 indexed in Web of Science and Google Scholar, our study explored the current state of knowledge regarding human-Panthera conflict and potential solutions, examining spatial and temporal distribution of research, methods used to study conflict, evaluation of interventions, and management recommendations. Our synthesis revealed data gaps and research needs. Additionally, only 21% of articles included in the review evaluated interventions, and few yielded conclusive results. Success ratios suggest that compensation schemes and livestock management strategies were more effective than direct interventions (lethal removal or translocation) or community interventions (e.g. education, ecotourism, local management). More studies should evaluate efficacy of strategies, many of which are recommended without empirical support. Results highlight trends and opportunities to inform future research and management efforts, ultimately enhancing the potential for coexistence. [Abstract edited—Ed.]

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As keystone species in their ecosystems, these predators are essential to maintaining biodiversity and ecosystem balance.⁴ Because big cats require large territories and plentiful prey populations to survive, conservation efforts aimed at preserving these species have the potential to produce significant biodiversity gains across multiple taxa.⁵ However, expanding human populations and development have exacerbated competition for land and prey between people and big cats in Panthera range countries, inevitably producing conflict.^{6,7,8} Human-wildlife conflict is defined as conflict that occurs when the "needs and behavior of wildlife impact negatively on the goals of humans, or when the goals of humans negatively impact the needs of wildlife."9 Habitat loss due to land encroachment by humans,^{10,11} competition for limited resources such as prey or water,^{12,13} and reintroductions of *Panthera* species¹⁴ are all documented sources of conflict between humans and big cats. In many cases, such conflicts result in loss of livestock^{15,16,17} or injury and death to humans^{8,18} and wild animals.¹⁹ Conflict also arises when conservation and human development goals do not align,^{20,21} generating disagreements between humans about wildlife and conservation priorities.²² Such conflict may include disputes over protected area boundaries, compensation plans, legal responses to incidents, or injury and death to Panthera species.23

For decades, researchers have employed different disciplinary paradigms and frameworks in an attempt to understand sources of human–wildlife conflict and to identify potential mitigation strategies.^{24,25,26} In many cases, conflict reduction interventions are designed to physically separate big cats and humans, incorporating

strategies such as improved livestock husbandry strategies,^{17,25,27} relocation of problem animals^{28,29} or people,³⁰ and killing of problem animals.^{31,32,33} In other cases, interventions have focused more directly on the social, economic, and political factors that fuel conservation-related conflict,^{23,24,34} ranging from financial compensation schemes for predator induced losses^{35,36} to approaches centered on education³⁷ and sustainable community development.^{38,39} However, despite diligent efforts by researchers, governments, NGOs, and local communities to address conflict and increase tolerance and acceptance capacity for large predators around the world,^{40,41} management interventions have achieved limited success.^{6,25,26,42}

Enhanced sharing of information across disciplines and geographies could help to resolve this complex problem. For example, although many studies have examined different aspects of the contentious relationship between humans and big cats, few have attempted to describe lessons learned from multiple social and ecological perspectives across space and time.³⁴ Through a review of peer-reviewed literature, our study explores the current state of knowledge regarding human-Panthera conflict and potential mitigation strategies to inform future management decisions and research agendas. Our review focused on the five big cats (genus Panthera) whose level of conflict with humans has been rated as high (jaguar, snow leopard) or severe (tiger, lion, leopard).7 We sought to answer two primary questions: (1) What are the key trends and patterns in human-Panthera conflict research? and (2) Which human-Panthera conflict mitigation strategies have proven to be most effective?



FIGURE 1. Adapted PRISMA Flow Diagram summarizing total articles found and total articles included in final analysis of human–Panthera conflict papers, by species (adapted from Moher et al., 2009). Search engine codes: WoS = Web of Science, GS = Google Scholar. Search terms: each of the five *Panthera* species names (or common names) and at least one of the following words or phrases: attack, attitude, coexistence, human–wildlife conflict, or livestock. Duplicates included records that appeared multiple times in one search or overlapped between searches. Records were deemed tangential if they focused exclusively on ecological indicators or did not directly assess or evaluate conflict with humans. See S1 File for more details about the literature review search methods and S2 File for a PRISMA reporting checklist.

Methods

Selection of articles

To answer these questions, we searched peer-reviewed articles addressing human-Panthera conflict in two comprehensive databases of scientific publications (Web of Science and Google Scholar) in February 2015. To be included in the review, a journal article's title or key words had to contain at least one of the five Panthera species names (or common names) and at least one of the following words or phrases: attack, attitude, coexistence, human-wildlife conflict, or livestock (see S1 File). These key words were strategically selected after reviewing a subset of articles on the topic. All results from Web of Science were included in the review, as well as the first 100 results from Google Scholar. Due to the number of articles returned using Google Scholar searches, a complete screening was not possible. Therefore, relevancy of results for all search combinations were examined and it was determined that inclusion criteria were no longer being met past the first 100 results. Following protocols used in similar review articles,^{25,26} we included only English language journals. Non-peer reviewed ("grey") literature was excluded because (a) there was no consistent means to assess the scientific rigor of these publications and (b) there was no systematic method for retrieving this literature. Overall, these searchers returned 5,632 articles.

After removing duplicates from Google Scholar searches and articles that overlapped across multiple searches (additional hits for article across multiple searches), the potential sample was reduced to 783 (Fig 1, see S2 File for PRISMA reporting checklist). Two members of the research team then reviewed the abstracts of selected papers to confirm an appropriate focus on either conflict related to one or more Panthera species or broader human-Panthera interactions. We excluded articles that (a) did not focus explicitly on at least one Panthera species, or (b) did not examine interactions between humans and the focal species. For example, studies with an exclusive ecological focus such as species ranges or prey selection and studies that did not assess or evaluate conflict with humans were removed from the analysis (Fig 1). In total, 186 publications dating from 1991 (earliest article found) to December 2014 (the final search date) were included in the review (Fig 1). To access a full database of articles reviewed, see https:// repository.lib.ncsu.edu/handle/1840.20/35459.

Variable identification and coding

To characterize human–*Panthera* conflict and identify potential mitigation strategies, a random sample of 25 of these 186 articles was selected and screened for variables of interest including location of study, year, publication journal, data collection method, purpose of study, evaluated interventions and recommendations (a proxy for intervention efficacy). A list of specific codes was compiled for topical categories until saturation was reached. Twenty interventions and recommendations that aimed to mitigate human–*Panthera* conflict were identified.

Using content analysis, two researchers then coded a subsample of 25 articles independently without knowledge of each other's assigned codes following recommendations by Creswell⁴³ to increase the validity and reliability of results. We then compared coding and reviewed areas of discrepancy until final consensus was reached. All three authors were involved in the coding and discussion of results. Finally, the primary author used the updated coding categories and operational definitions to complete the analysis of the full list of articles. If an article studied more than one *Panthera* species (most commonly involving leopards due to range overlap), the data from that article were included in results for both (or all, if more than two) species. In addition, some relevant studies of human–*Panthera* conflict that were not speciesspecific (i.e. literature reviews) were also included in the review. We coded each of the articles for the following general categories (see S3 File for more details about coding interventions):

■ *Background Variables:* What was the context in which the study occurred (e.g., continent, country, species)?

■ *Purpose of Study:* How did the author(s) define the purpose of their study? The purpose of the article and type of conflict being studied were coded based on the purpose stated by the author(s) (e.g., assess extent of conflict, quantify impact on animals/ people, document interventions with or without evaluation).

■ *Data Collection Methods*: Were the data collected using social science methods (e.g., data obtained directly from people; interviews, archives, questionnaires), ecological methods (e.g., data not obtained from people; camera trap, observation, field samples, GPS/GIS, radio collars) or a combination of these methods (coded as "hybrid")?

• *Type of Impact:* What type of impact (e.g., human/animal injury or casualty, impact to human livelihood, livestock loss, ecological impact) was being studied? The type of impact was inferred by the researchers based on the results of each study.

■ *Evaluated Interventions:* What conflict mitigation interventions, if any, were evaluated by the authors? Interventions were stated by the author(s) in the methods and/ or results sections. Researchers categorized the interventions based on details provided by the author(s) (see S3 File for more details). Interventions included themes such as livestock management strategies (dogs, fences, safety gear, night guards, lighting, livestock husbandry techniques, deterring technology, water diversions), compensation schemes (proactive or reactive payments), community interventions (community conservation/ecotourism, education programs, relocation of people, land management/zoning, legal management, local management, response teams, reporting of incident) and direct intervention (hunting of animal, relocation of animal).

■ *Recommendations:* What recommended conflict mitigation strategies were ultimately identified by the authors? Recommended interventions to reduce human–*Panthera* conflict were stated by the author(s), usually in the Discussion and/or Conclusion sections, and were based on either (a) the explicit evaluation results reported in the study (if applicable), (b) the expert opinion of the authors, or (c) some combination of the two.

Because indicators of success varied across these interdisciplinary studies and effect sizes were rarely reported, a systematic quantitative comparison of intervention efficacy was not possible. We therefore assessed the efficacy of interventions by calculating subjective success ratios to determine the percentage of articles that both evaluated and recommended the same intervention strategy. We assumed that, based on the objective-centered approach frequently used to characterize program success in evaluation research⁴⁴ authors would only recommend a strategy they studied if that technique had proven to be effective based on pre-specified parameters. Success ratios for conflict mitigation interventions were therefore estimated using the following general formula:

Success Ratio = Number of articles that evaluate and recommend Number of articles that evaluate

Because the denominator in this ratio only included articles that explicitly evaluated one or more conflict mitigation interventions (n = 39), many articles in our review were omitted from this portion of the analysis.

Limitations

We encountered several challenges with regards to data collection and coding for this review. We initially intended to assess the causes of human–*Panthera* conflict identified by each study, but this proved to be challenging. For example, habitat loss and resource competition are closely linked to factors such as livelihood structures (i.e., reliance on the natural environment) and environmental policies and practices,⁴⁵ making causal attributions and coding difficult. The purpose of the articles reviewed was therefore coded based on the stated purpose by the authors in the introduction of the articles. In some cases, stated purposes implied that evaluations of intervention strategies were taking place. However, many of these studies only documented the use of an intervention, not a true assessment of its success in reducing human–wildlife conflict. These studies were therefore omitted from success ratio calculations.

It should also be noted that all articles reviewed were treated as independent studies, even though a few study sites appear to have yielded multiple related articles from the same group of researchers. Additionally, it was difficult to account and control for both social and statistical heterogeneity within our analysis, which integrated studies using various forms of data collection in very diverse research contexts. Assessing the relative quality and/or validity of so many diverse studies was also challenging. By only focusing on published research, our study might also have failed to account for null results, generating a bias toward documentation of positive intervention effects. Because some degree of subjectivity is omnipresent in social science research, we elected to standardize analysis of studies based on how they were conceptualized and conveyed by the authors, not how they were perceived and interpreted by our research team. Overall, we feel that the selection and coding criteria described above allowed for objective analysis of the literature.

Finally, three methodological limitations should be noted. First, our review only includes articles published prior to January 1, 2015. Since that time, the rapidly evolving body of literature on human–wildlife conflict has continued to progress, potentially yielding new insights not extensively reviewed here.^{25,26} Second, our search was confined to English language journals. Although English is widely regarded as the global language of science, this decision may have inadvertently excluded studies published in other non-English journals (e.g., Spanish language journals based in jaguar range countries). Third, although our key words were intentionally selected to identify articles specifically pertaining to human–*Panthera* conflict, these search terms may have inadvertently excluded tangentially related articles such as those focused on community-based natural resource management (e.g., ecotourism initiatives) or other conservation-oriented topics (e.g., trophy hunting, habitat corridor creation). Nevertheless, our search parameters generally paint a comprehensive portrait of the current state of research focused on human–*Panthera* conflict.

Results

Research trends and patterns

Our review of human–*Panthera* conflict highlighted study sites in thirty different countries (Fig 2). Distribution of studies generally mirrored species ranges, except for a gap across large portions of jaguar and leopard range. Publication dates for the articles we sampled ranged from 1991 (earliest article identified based on search criteria) to 2014, with the number of published articles increasing over this time period for all five species included in the review (Fig 3). Sixty different peer-reviewed journals were represented in the review.

The author(s) of the articles reviewed reported different reasons for studying human–*Panthera* conflict. The most common purpose (noted in 62 articles) was to simply assess the extent of conflict occurring. As human–*Panthera* conflicts vary in magnitude and severity around the world, it is not surprising that many researchers would aim to characterize the general nature of these interactions. A subset of these articles aimed to quantify the impact of conflict on either humans³³ or wild animals,¹⁹ specifically. Other stated purposes included documenting¹¹ and evaluating interventions.³⁹

Data collection methods for human-Panthera conflict studies varied. Social science research strategies that centered on human responses such as interviews with key stakeholders (63 articles) and archives (67 articles) (e.g., data obtained from news sources, local records) appeared to be the most prevalent form of data collection. Although these social science methods were used for all species, the data collected did not always pertain to socio-cultural themes. For example, interviews and questionnaires were often used to obtain information related to species movements or livestock husbandry techniques, not psychological or cultural factors that might influence conflict. Ecological methods included direct observations of conflict incidents (40 articles) and a variety of tracking and monitoring tools. Radio collars were commonly used for lions whereas camera traps and field samples (e.g. scat) were more common for tigers and leopards. Studies using a combination of ecological and social science data collection methods were rare (29 articles) and were most common for studies focused on snow leopards.

The most commonly studied type of impact was livestock loss, which was addressed by 90 articles. These data are not surprising given the important role that livestock play in the livelihoods of people worldwide, particularly in *Panthera* range countries. Twenty-seven articles examined other impacts to human livelihood such as loss of property or income. These livelihood impacts



FIGURE 2. Distribution of research on human–*Panthera* conflict over the past 25 years. All countries that were the focus of at least one study represented in orange; countries that are the focus of more than 10 publications during that period in red. Map created using Adobe Illustrator.



FIGURE 3. Number of human–*Panthera* conflict peer-reviewed publications over time, by species. Total sample size exceeds the 186 articles reviewed because some articles focused on more than one big cat species. Big cat images adapted and reprinted under a CC BY license.

were most commonly studied with regards to tigers (11 articles), snow leopards (8) and leopards (7). Loss of human life was most often studied with respect to tigers (15). More articles addressed injury or death to *Panthera* species than to humans. This was most common with regards to leopards (14 articles) followed by tigers (12) and lions (10). Only nine articles presented information related to the ecological impact of human–*Panthera* conflicts, education programs on human-*Panthera* conflict. Evaluations of interventions involving jaguars were particularly rare.

Although only a small proportion of the articles we examined explicitly evaluated interventions, many of the articles issued specific recommendations for mitigating human–*Panthera* conflict. The most commonly recommended interventions were improved livestock husbandry techniques (e.g. fencing, guard dogs) (54

and most of these focused on impacts to the prey base.

Intervention efficacy

Relatively few studies in the sample (n = 39) specifically evaluated conflict mitigation interventions. The most commonly evaluated interventions for almost all species fell into the category of livestock management strategies (34 articles), often focused on physical deterrents such as fences, dogs, and enclosed structures (Table 1). Thirteen articles evaluated compensation schemes and twelve articles evaluated direct interventions. Thirteen articles evaluated community interventions and only four studies evaluated the impact of

TABLE 1. Documented efficacy of various intervention strategies to mitigate human–Panthera co	nflict
based on journal articles reviewed from 1991–2014.	

INTERVENTION CATEGORY (sub-category)	EVALUATE (No. of articles)	EVALUATE and RECOMMEND (No. of articles)	SUCCESS RATIO
COMPENSATION PROGRAMS	14	9	0.64
LIVESTOCK MANAGEMENT STRATEGIES	34	16	0.47
Livestock husbandry techniques	14	10	0.71
Fences	6	3	0.50
Deterrents	6	2	0.33
Dogs	7	1	0.14
Water	1	0	0.00
DIRECT INTERVENTION	12	2	0.17
Hunting of Animal	5	1	0.20
Relocation of Animal	7	1	0.14
COMMUNITY INTERVENTIONS	13	2	0.15
Community Conservation / Ecotourism	4	1	0.25
Education	4	0	0.00
Local Management	0	0	0.00
Response Teams	3	1	0.33
Land Management/Zoning	1	0	0.00
Relocation of People	1	0	0.00

Discussion

Trends and patterns in human–Panthera conflict research

This review highlights the progress that has been made and the challenges that remain with respect to understanding and addressing human-Panthera conflict and the social forces (e.g., policy priorities and practices, research opportunities) that influence it.24,26 The number of publications pertaining to human-Panthera conflict has increased substantially since the 1990s (Fig 3). As human-Panthera interactions and subsequent conflict become more common and conspicuous, making coexistence with

articles), compensation schemes (44), and education (adult and/ or youth outreach) (33). Livestock husbandry was recommended most frequently for lions and leopards whereas compensation schemes and education were recommended more in reference to tiger and snow leopard conflicts. Local management (e.g. community monitoring; 31 articles), and management/zoning (e.g. creation of use/no-use areas; 22) were recommended for all five species. Legal management (e.g. new local or federal laws/ regulations; 19) was presented as a recommendation more frequently for tigers than other species. Overall, recommendations encompassed a wide range of interventions—many more than were actually studied in our sample.

Because few studies systematically evaluated specific conflict mitigation interventions, it was difficult to draw definitive conclusions regarding intervention efficacy. However, based on the evaluation studies we reviewed, compensation programs and livestock management strategies (fences, dogs, etc.) had the highest success ratios of 0.64 (nine articles evaluating and recommending) and 0.47 (16 articles evaluating and recommending), respectively (Table 1). Successful compensation programs most frequently related to conflicts with snow leopards and tigers, while livestock management tools more commonly related to conflicts with lions. Direct interventions, such as hunting or relocation of problem animals, were less successful (0.17), with only one article evaluating and recommending that approach. Community interventions, which included a wide array of approaches (e.g., ecotourism, education, local management) designed to address and improve the socio-cultural context for conservation, were infrequently evaluated. In the rare cases where such interventions were studied, the estimated success rate was only 0.15 (2 articles evaluation and recommending) (Table 1).

carnivores more difficult,^{6,46} this trend is likely to continue. Overall, more conflict-related studies have focused on tigers and leopards than other big cat species. These species occur in areas with high human population growth, which may be accelerating the rate of conflict. In addition, these species historically pose more severe threats to humans.^{37,47} The geographical distribution of studies also highlights spatial trends that reflect places experiencing human-Panthera conflict and places where researchers are motivated to do something about it (Fig 2). For example, the area with the most published research is India. Not only is India one of the world's most populous countries, but is also home to leopards and snow leopards, a small population of Asian lions, as well as the highest population of tigers in the world.⁴⁸ India also features the social capital, technical resources, and research infrastructure for supporting scientific endeavors. Given the convergence of all of these factors, one might expect India to be an epicenter of big cat conflict research. On the other hand, despite a few recent exceptions, 49,50,51 conflict in the critical jaguar corridor⁵² appears particularly under-studied. Future research is needed to fill geographical gaps in current understanding of conflict, particularly in Central America and certain parts of Africa and Southeast Asia where many big cat populations are threatened or endangered.

There are many ecological (e.g., trophic cascades, competition for resources) and sociocultural dimensions (e.g., cultural values, economic resilience) that contribute to the frequency and severity of conflicts in complex social-ecological systems,^{23,53} requiring different approaches to data collection. Our review showed that a wide variety of methods have been employed to study human–*Panthera* conflict. Social science methods (interviews, questionnaires, and analysis of archives) were commonly used in the articles included in this study, but the information being gathered often focused on tangible metrics (e.g., frequency of livestock loss, types of predators involved) and rarely accounted for underlying values, attitudes, and norms that may be driving behaviors.⁴⁰ For example, Fitzherbert et al.⁵⁴ identified collective action and social factors that influenced community support for lion killing in Tanzania, and growing evidence highlights the need to move beyond purely technical fixes or simple dispute resolutions when addressing human–wildlife conflict.³⁴ More research aimed at identifying the social, cultural, historical, or political drivers of conflict, including those that focus on the process and relationships influencing approaches to conflict resolution, may prove valuable in addressing human–*Panthera* conflict.^{24,26,45}

A number of studies have also utilized ecological data collection methods to understand patterns of human-Panthera conflict. By understanding the movement, prey preferences, health, and ranges of animals, researchers may be better able to predict and ultimately prevent incidents of conflict. Ecological data collection methods used to study human-Panthera conflict include GIS/ GPS,⁵⁵ camera traps,⁵⁶ field samples,⁵⁷ and radio collars.⁵⁸ Some studies-particularly those involving leopards and tigers-are exploring the impacts and effects of human impacts on shifting prey bases and trophic cascades, which may force predators to look for alternate food sources such as people and livestock.^{1,59,60,61} For all Panthera species included in this review, however, there is a significant lack of interdisciplinary research that integrates ecological and social science methods to paint a more complete picture of conflict and its effects on both humans and animals.⁶² For example, Constant et al.⁶³ examine a multi-use land system and the management implications for leopard and human populations, highlighting the complexities of approaching conflict from a social-ecological perspective. Efforts to predict conflict using both social and ecological inputs and spatial modeling approaches would also benefit from this type of synthesis.^{64,65}

Efficacy of human–Panthera conflict mitigation strategies

Our review revealed a disconcerting finding with significant implications for big cat conservation practice: a noteworthy discrepancy between the number of conflict mitigation recommendations posited by researchers and the number of those interventions whose efficacy has actually been studied and/or systematically evaluated. Similar trends have been reported in other reviews of human-carnivore conflict.^{25,26} Ideally, recommendations for conservation strategies should be evidence-based and anchored in systematic, unbiased evaluation research. In the studies we reviewed, however, this was rarely the case. For example, livestock husbandry was recommended by 45 total articles, yet only 14 articles actually examined specific techniques that could be employed or provided sources or data to document the success of husbandry- related strategies. Similarly, conservation education was recommended in 32 total articles, but education program efficacy was only evaluated in 4 studies.

Overall, four categories of conflict mitigation strategies emerged through the review, demonstrating mixed results in terms of intervention efficacy. Given the small sample sizes and context-specific nature of intervention success,⁶⁶ our calculated success ratios (Table 1) should be cautiously interpreted. Nevertheless, they complement similar research^{25,26} and provide an informative snapshot of the state of the science with respect to human–*Panthera* conflict management.

Compensation programs

Compensation programs revealed the highest success ratios, and were most commonly studied with respect to snow leopards and tigers. Though they require financial resources that may not always be available, payment schemes that reward local people for conserving wildlife and wildlife habitat or, more commonly, compensate people for livestock loss with the hope of preventing the retaliatory killing of predators, can successfully help to secure coexistence between people and predators. In a review of financial instruments, Dickman et al.³⁵ found that payments to encourage coexistence have great potential in reducing conflicts but are susceptible to many challenges imposed by unique community contexts. Our review supports these findings. For example, a snow leopard depredation compensation plan in Pakistan whose funding is derived from tourism revenue has been successful, but only when tourism profits are sufficient.⁶⁷ Similar plans to offset predator-induced damages in India⁶⁸ and Botswana⁶⁹ described as successful are also compromised due to processing delays, corruption, and award rates that have not matched market values.

Another common challenge related to compensation plan implementation is that many are developed in relation to protected area boundaries. In reality, instances of conflict often occur outside these boundaries. Verifying conflict incidents and identifying who is responsible for compensating local people for wildlife damage outside protected areas (and across jurisdictions) is critical for the future success of this conflict mitigation strategy. The needs for enhanced communication within compensation programs to increase participation, improve response time, enhance transparency, derive fair compensation rates, and create opportunities for local management are commonly cited in the human–wildlife conflict literature,³⁵ and seem to hold true for *Panthera* cats as well. Our review suggests that compensation plans, though they might not be financially feasible in all contexts, have the potential to minimize retaliatory killings of predators while supporting local livelihoods.

Livestock management tools

Livestock management strategies were the second most successful types of intervention we studied. This category includes relocation of livestock or shifting herding patterns, fencing, dogs, water or noise deterrents, and other physical barriers. With limited funding and resources to devote to human-cat conflicts in locations around the world, refinement of livestock husbandry techniques may be among the most financially feasible and effective approaches to conflict mitigation, particularly when considering the prevalence

The use of dogs has been proven effective in limiting livestock losses to big cats with solitary lifestyles, including jaguars and leopards, as well as other cat species such as cheetah and puma in multiple contexts.^{73,74} Despite this efficacy, financial challenges such as purchasing, feeding, and training dogs remain a barrier to their use in conflict mitigation.⁷⁵ Other deterrents such as fences, water barriers, or noise deterrents have also been used in an attempt to mitigate conflict with *Panthera* cats. Hayward and Kerley⁷⁶ note that human-animal conflict reduction is a primary benefit of fencing. However, they also highlight other costs unrelated to

deterring predators.

note that human-animal conflict reduction is a primary benefit of fencing. However, they also highlight other costs unrelated to conflict such as ecological impacts or financial burdens that must be considered prior to developing fences or other enclosures. Solar lighting in villages and near livestock enclosures has also been recommended in order to keep predators away from villages and aid in rapid detection.³³

of livestock predation among all big cat species.²⁵ Evaluations of

livestock husbandry techniques were most commonly reported in

relation to conflicts with lions, which may stem from the wide-

spread traditional free-range grazing practices and the cultural

importance of livestock in many cultures across lion ranges.⁷⁰ For

example, Kuiper et al.⁷¹ showed that seasonal herding changes

impacted the rate of predation by lions in communal lands adja-

cent to Hwange National Park, Zimbabwe, with lion predation

increasing significantly in the late growing (wet) season when

herds were furthest from their home enclosures and availability

of wild prey was lowest. While seasonal patterns of livestock

grazing are not uniform across diverse Panthera range countries

due to extreme variation in climate and topography, knowledge

of temporal shifts in depredation clearly aids the development

of successful livestock husbandry techniques.72 Understanding

fluctuations in ecological variables such as seasonality, prey abun-

dance, and predator range shifts can assist herders, ranchers, or

farmers in decreasing the probability that their livestock are lost.

tant role in limiting attacks and losses to carnivores. Herding near

villages or areas of high human activity can limit incidents of

conflict^{17,71} and requires very little in terms of technical or human

capital (e.g., equipment, personnel). Herd species composition

also impacts losses due to predators. In Venezuela, cattle herders

suffered more loss to jaguar and puma than similar herds that also

included buffalo.72 While making changes to herd composition is

often costly, combinations of multiple species may be beneficial in

Spatial management of livestock herds can also play an impor-

A focus on livestock management strategies is often the most beneficial, practical, and realistic mitigation method for communities that suffer from conflicts with predators.²⁵ However, all of the livestock husbandry techniques described above require commitment to maintaining and evaluating practices over time. Additionally, focusing exclusively on livestock husbandry for conflict mitigation primarily helps to address issues linked to livestock depredation, and may not be beneficial to communities dealing with *Panthera* attacks on humans or other types of conflict.

Direct interventions

Efforts to address conflict by removing problem animals either by hunting, retaliatory killing, or relocation, appeared to achieve little success. Hunting was recommended most frequently for lions, possibly because of their unique appeal to conservationoriented trophy hunters77 or the historical role of hunting in many African cultures.⁷⁰ However, significant ecological impacts, such as changes in individual territories and impacts to prey species, are often byproducts of lethal control and can exacerbate conflict.78 Treves⁷⁹ noted that the effect of hunting on conflict reduction is unclear and that the assumption hunters will demonstrate stewardship towards carnivores if allowed to hunt them remains unproven. Additionally, because hunters are rarely selective in killing alleged problem animals, other individuals in the population may be inadvertently killed without reducing conflict. In a review of lethal and non-lethal control methods for carnivore conflict with livestock, Treves et al.³² found insufficient evidence to support the use of lethal control, ultimately recommending that lethal predator control be stopped in instances where significant evidence of functional effectiveness is not available. More research is needed to examine the factors that drive humans to kill carnivores and the impacts of these actions on conflicts and carnivore populations.⁸⁰

Direct interventions can also be carried out though translocation of problem animals. However, our review found limited instances where translocation was a success in mitigating conflict. For example, Athreya et al.²⁸ found that translocation of problem leopards in India led to an increase in conflict and attacks on humans, possibly due to increased aggression stemming from translocation stress, movement through unfamiliar human-dominated landscapes, or a decrease in fear or apprehension towards humans. Weise et al.⁶¹ evaluated the efficacy of translocations using Individual Conservation Cost, which is the cost of one successful translocation adjusted by costs of unsuccessful attempts to translocate the same species. Using these calculations, the authors determined that the cost for translocating leopards was too high for both local communities and NGOs to absorb, especially considering the low success rate of many translocation attempts. Collective evidence therefore indicates that, whether problem cats are removed through lethal or non-lethal means, direct interventions are often ineffective and frequently generate more conflict.

Community-based interventions

Our review revealed that documented success was also limited for community-based interventions designed to resolve conflict with big cats. These interventions include community-based natural resource management (CBNRM) programs, education and communication initiatives, a focus on local management and monitoring, ecotourism development, or legal management (implementation of policies or enforcement). Such initiatives can benefit communities in many ways,^{35,81,82,83} often by increasing tolerance of communities to predators,⁴¹ yet few investigations of CBNRM have focused explicitly on conflict mitigation.⁸⁴ Community or stakeholder-based efforts were not well represented in our review of human–*Panthera* conflict or reviews of broader human–wildlife conflict²⁶ either.

Some research suggests that strategies designed to influence social interactions and cultural cognitions, including social marketing techniques³³ and education,⁸⁵ can improve communication of costs and benefits that influence tolerance for predators and lead to more positive outcomes for humans and wildlife.^{34,46,49} Although education was recommended as a community intervention by several authors in our review, none of those studies systematically evaluated education as a conflict mitigation strategy—calling the presumed efficacy of the "cognitive fix" into question.

Local management, which includes community involvement in decision-making and strengthening of local leadership in response to conflict (e.g., local response teams), was also highly recommended in our review, but rarely evaluated. Local institutional arrangements are key factors in setting up successful conservation and community programs, but variability in organization and institution structures must be taken into account.^{23,81,86} In the case of big cats, incidents of conflict could have a particularly significant influence on local livelihoods and community development. In many of the countries studied, big cats represent a major tourism attraction.^{39,87} Revenue from tourism may therefore be an incentive for local communities to invest in conflict mitigation strategies that promote wildlife conservation,⁸⁸ leading to improvements in quality of life for both people and animals.⁸⁹ Interactions between tourists and wildlife have also been the focus of recent research,^{90,91} highlighting links between tourism, local communities, and local ecosystems that could positively impact both human livelihoods and big predator conservation efforts. Our systematic review found little evidence to support these claims with respect to big cats, however.

It should be noted that some successful elements of community interventions might have been inadvertently overlooked in our study due to the conflict-centered search terms. For example, specific components of social capital such as reciprocity, social networks, and stakeholder collaboration have been identified as critical to community actions to support or oppose tiger conservation outcomes in India⁹² and Malaysia.⁹³ Though not directly related to conflict mitigation, these studies complement a growing body of literature highlighting potential benefits of conservation (and conflict mitigation) strategies that integrate social, cultural, and historical inputs.^{24,26,34,45} Collectively, our results emphasize the need for future research that evaluates different types of community-level interventions and their impact on human–*Panthera* conflict and tolerance for predators.

Conclusions

This review suggests that, despite a rapid increase in research investigating human conflicts with big cats, many unanswered questions and opportunities remain. Some questions related to human–predator conflict have been addressed in studies published after our literature review was completed in December 2014.^{25,26,34}

Despite progress, there remains an urgent need for an expanded research agenda to address factors that impact the survival of big cats and the well-being of the people who share their habitat. Improved understanding of conflicts that exist, the reasons they exist, and the efficacy of potential mitigation strategies across diverse settings will help inform future management decisions and promote adaptive responses. Particular emphasis could be placed on collecting data related to individual-level psychological variables that influence wildlife tolerance⁴⁰ and community-level cultural and political forces that affect conservation outcomes.^{34,45,66,92} A focus on these relationship and process-oriented factors could transform incident-centered conflict resolution paradigms and potentially generate long-term change.²⁴

Finally, our review echoes previous work and confirms that limited empirical evidence exists to inform recommendations for reducing human-wildlife conflict^{25,26}—and particularly human-Panthera conflict⁷—across diverse contexts. While many different big cat conflict mitigation interventions are being recommended and employed across the world, little peer-reviewed information is available to illuminate their effectiveness. The studies that exist suggest that strategies centered on compensation schemes or livestock management practices hold promise for resolving human-Panthera conflict, particularly when compared to alternatives such as direct (or lethal) and community-based interventions. Because so few studies have formally examined these strategies, however, it is difficult to draw definitive conclusions and identify best practices. Interventions must be both documented and systematically evaluated over the short and long-term to determine if they are or exacerbating or reducing conflict, ultimately impacting populations of humans and big cats. This is particularly true for community-based interventions such as education, communitybased natural resource management, and legal management (policy enforcement and capacity), which are frequently recommended but rarely evaluated. As greater conflict mitigation emphasis is placed on promoting equity and sound governance in addition to technical fixes, investigations of community-based interventions will become even more important.34

Our global assessment of research trends and opportunities reveals many insights that could be used to inform decisions, management plans, and future projects designed to address human-Panthera conflicts, complementing research on human-wildlife conflict involving a broader array of taxa.^{25,94} Local variability involving certain species and ecological, social, or political forces may necessitate different priorities and actions.9 With a pressing need for conflict resolution and technological advances that facilitate data collection across local and global scales, there is growing hope for big cat conservation. If these efforts are successful (i.e., if big cat populations grow), the potential for conflict will continue to increase.95 The need for conflict mitigation is therefore inescapable; not only do well-informed interventions have the potential to save iconic carnivore species from extinction, but they also have the potential to foster coexistence by supporting human livelihoods and greater ecosystem health.^{96,97} This review outlines a trajectory

for future research focused on human–*Panthera* conflict that may help multiple stakeholders achieve these goals.

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Veterinarians: Partners in Wildlife Rehabilitation

By Molly O'Bryan

n the two most recent issues of the Journal of Wildlife Rehabilitation, the University of Minnesota's Raptor Center introduced the Partners for Wildlife (P4W) program. P4W is a three-year initiative for wildlife rehabilitation care across all species, starting in a pilot region of seven states (Wisconsin, Minnesota, North Dakota, Montana, Idaho, Washington, and Alaska). At the heart of P4W is the desire to improve animal welfare in wildlife rehabilitation so that animals are rehabilitated more quickly and have greater chances of release back into the wild, in addition to improving and standardizing the decision-making processes for euthanasia or placement.

P4W's primary approach to achieving its objectives is to build sustainable partnerships with wildlife rehabilitators and rehabilitation organizations. Ensuring the best possible animal welfare in wildlife rehabilitation, however, also requires a strong partnership between wildlife rehabilitators and the veterinarians they work with.

Critical Colleagues

Most wildlife rehabilitators are required to have a "veterinarian of record" in order to be licensed or permitted by the relevant local, state, and/or federal agencies. The veterinarian's clinical knowledge, surgical skills, and ability to administer or prescribe drugs that otherwise wouldn't be legally available to the rehabilitator make them key partners in wildlife rehabilitation and in improving welfare. The veterinarian's role becomes especially critical when a wildlife patient is deemed non-releasable and euthanasia is the most humane option, or—less commonly—when placement



in an educational or display facility is a possibility. When dealing with placement requests for migratory birds, the USFWS relies on the veterinarian's clinical judgment for decision-making, requiring an official statement detailing why the bird is non-releasable and an assurance that the bird is suitable for placement considering its permanent injury, temperament and behavior. The veterinarian has a responsibility to determine if the animal should be kept in permanent captivity, not if it can be kept. An animal that will not adapt well to captivity or one that will live in chronic pain should not be a candidate for placement, as the result would be a lifetime of poor welfare.

As important as the veterinarian's role is, many have little or no training on the vast array of species that they may be called on to treat by a rehabilitator. Veterinarians also may be unfamiliar with their critical role in the regulatory process and unaware of where to find help if they find themselves in unfamiliar territory. Moreover, the relationship between the rehabilitator and their veterinarian sometimes exists only on paper, a symptom of the tension between the two communities that can manifest due to differences of opinion, resource constraints, or simple misconceptions.

Bridging the Gap

P4W is striving to create community between rehabilitators and veterinarians, and build the capacity of veterinarians to provide skilled care for wildlife in two important ways. First, P4W is providing one-year professional internships in clinical wildlife medicine for two veterinarians annually. These internships provide veterinarians with the rare opportunity to get high-quality training with diverse species in both a university-based wildlife clinic and in a high-volume nonprofit wildlife clinic. The internship is targeted at practicing veterinarians who hope to make a career in clinical wildlife medicine, particularly in rehabilitation settings.

Second, P4W provides year-long fellowships for three veterinarians annually who don't specialize in wildlife medicine, but do serve as veterinarians of record for wildlife rehabilitators. The goal of the fellowship is to build clinical skills and to create professional relationships with other veterinarians and wildlife rehabilitators, all with an eye towards improving the welfare of their wildlife patients.

Current veterinary fellow Dr. Sonnya Crawford of Grays Harbor Veterinary Services in Montesano, WA says that the fellowship has increased her knowledge base in both wildlife medicine and in rehabilitation: "I have seen an improvement in my case management, decision making and treatment protocols with wildlife. I've also implemented protocols that will increase animal welfare in the animals that I see at my practice." Perhaps more importantly, Dr. Crawford has come to realize how important it is for her to be a leader and an advocate: "I have a responsibility to our community and the wildlife in our area. Rather than being a passive observer and occasionally triaging injured wildlife, I am now an active participant. Since starting the fellowship, I've given lunchtime educational meetings with our clinic staff, I've shared literature and experiences with the other veterinarians on staff, and I've reached out to the other wildlife rehabilitator in our area; we've had lunch and discussed the direction and goals that we both have for wildlife rehabilitation in our community."

Ensuring that wildlife rehabilitators feel more supported, engaging more veterinary partnerships, and providing support to veterinarians to help them understand their critical role in rehabilitation should go a long way towards improving the welfare of wildlife patients. Partners for Wildlife hopes that this initiative is just the beginning of a movement that seeks to empower people to be good stewards of the wildlife with which we share our communities.

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

SELECTED ABSTRACTS

Facial complexity in sun bears: exact facial mimicry and social sensitivity

D Taylor, D Hartmann, G Dezecache, ST Wong and M Davila-Ross. *Scientific Reports.* 2019; 9(4961). doi: 10.1038/s41598-019-39932-6

Facial mimicry is a central feature of human social interactions. Although evidenced in other mammals, no study has yet shown that this phenomenon can reach the level of precision seen in humans and gorillas. We studied facial complexity of grouphoused sun bears, typically solitary, with focus on testing for exact facial mimicry. Our results provided evidence that the bears have ability to mimic expressions of their conspecifics and that they do so by matching exact facial variants they interact with. In addition, the data showed the bears produced open-mouth faces predominantly when they received the recipient's attention, suggesting a degree of social sensitivity. Our finding questions the relationship between communicative and social complexities, and suggests the possibility that capacity for complex facial communication is phylogenetically more widespread than previously thought.

Effect of high-density oral rabies vaccine baiting on rabies virus neutralizing antibody response in raccoons (*Procyon lotor*).

K Pedersen, AT Gilbert, ES Wilhelm, KM Nelson, AJ Davis, JD Kirby, KC VerCauteren, SR Johnson, and RB Chipman. *J Wildl Dis.* 2019; 55(2), 399–409. doi: 10.7589/2018-05-138

From 2014 to 2016, we examined the effect of distributing oral rabies vaccine baits at high density (150 baits/km²) in an area of Virginia, US that was naïve to oral rabies vaccination prior to study. We also compared the effect of baiting at high density in a naïve area to baiting at standard density (75 baits/km²) in an area that had been baited annually for 12 yr. Our results suggested that rabies virus seroconversion in raccoons (Procyon lotor) gradually increased each year under high-density bait treatment. However, we did not detect a difference in seroconversion between bait density treatments. Virginia opossums (Didelphis virginiana) were abundant in the study area and were a potentially important nontarget species

that competed for oral rabies vaccine baits, but the ratio of opossums to raccoons in this study did not affect virus neutralizing antibody response of the raccoon populations.

Article and associated abstract:

Receptor for bat influenza virus uncovers potential risk to humans WS Barclay. Nature News and Views. *Nature*

2019. 567, 35-36. doi: 10.1038/d41586-019-00580-5

MHC class II proteins mediate crossspecies entry of bat influenza viruses

U Karakus, T Thamamongood, K Ciminski, W Ran, SC Günther, MO Pohl, D Eletto, C Jeney, et al. *Nature.* 2019;567, 109–112.

Zoonotic influenza A viruses of avian origin can cause severe disease in individuals, or even global pandemics, and thus pose a threat to human populations. Waterfowl and shorebirds are believed to be the reservoir for all influenza A viruses, but this has recently been challenged by the identification of novel influenza A viruses in bats. The major bat influenza A virus envelope glycoprotein, haemagglutinin, does not bind the canonical influenza A virus receptor, sialic acid or any other glycan, despite its high sequence and structural homology with conventional haemagglutinins. This functionally uncharacterized plasticity of the bat influenza A virus haemagglutinin means the tropism and zoonotic potential of these viruses has not been fully determined. We show, using transcriptomic profiling of susceptible versus non-susceptible cells in combination with genome-wide CRISPR-Cas9 screening, that the major histocompatibility complex class II (MHC-II) human leukocyte antigen DR isotype (HLA-DR) is an essential entry determinant for bat influenza A viruses. Genetic ablation of the HLA-DR α-chain rendered cells resistant to infection by bat influenza A virus, whereas ectopic expression of the HLA-DR complex in non-susceptible cells conferred susceptibility. Expression of MHC-II from different bat species, pigs, mice or chickens also conferred susceptibility to infection. Notably, the infection of mice with bat influenza A virus resulted in robust virus replication in the upper respiratory tract, whereas mice deficient for MHC-II were resistant. Collectively, our data identify MHC-II as a crucial entry mediator for bat influenza A viruses in multiple species, which permits a broad vertebrate tropism.

News

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to Japan. Their numbers were dramatically reduced by the fur trade. In California, the southern sea otter population was reduced to around 50 individuals, but a massive conservation effort has resulted in increasing their numbers to around 3,000 today. However, the southern sea otter is still considered threatened.

Sea otters are unique for being the only marine mammal to use stone tools. They often use rocks to crack open shells while floating on their back, and also sometimes use stationary rocks along the shoreline as "anvils" to crack open mollusks, particularly mussels. A joint project including the Max Planck Institute for the Science of Human History, the Monterey Bay Aquarium and the University of California, Santa Cruz, among others, has resulted in a first-of-its-kind interdisciplinary study published in Scientific Reports, combining ten years of observations of sea otters with archaeological methods to analyze sea otter use of such anvil stones, also known as emergent anvils.

Researchers spent ten years between 2007–2017 observing sea otters consuming mussels at the Bennett Slough Culverts site in California. Their analysis identified that mussels were the most common prey eaten at the site and were the only prey for which the sea otters used stationary anvil stones. The sea otters used such stones for about 20% of the mussels they consumed.

Interestingly, careful analysis of the stationary anvil stones using archaeological methods showed that their use resulted in a recognizable damage pattern that was distinguishable from what would be caused by human use. For example, the sea otters preferentially struck the mussels against points and ridges on the rocks, and struck the rocks from a position in the water, rather than from the land or from on top of the rock.

In addition to the stones themselves, the researchers also carefully analyzed the mussel shells left around the stationary anvils. The researchers took a random sample of the shell fragments from these shell middens, which likely contained as many as 132,000 individual mussel shells. They found an extremely consistent damage pattern, with the two sides of the mussel shell still attached, but a diagonal fracture running through the right side of the shell.

"The shell breakage patterns provide a novel way to distinguish mussels broken by sea otter pounding on emergent anvils from those broken by humans or other animals," explains Natalie Uomini of the Max Planck Institute for the Science of Human History. "For archaeologists who excavate past human behavior, it is crucial to be able to distinguish the evidence of sea otter food consumption from that of humans."

In combination with analysis of videos they took of the otters using the anvils, researchers could see that the otters held the shells evenly in both paws, but when striking the shell against the anvil tended to have their right paw slightly on top. Though the total number of otters observed was small, these results suggest that otters may exhibit handedness, or "pawedness", as do humans and many other mammals.

The researchers hope that the study will be useful for archaeologists working with coastal populations, as a way to distinguish between human and sea otter use of rocks and consumption of marine resources. Additionally, the research could be helpful in future studies of the geographic spread of stationary anvil use throughout the former sea otter range, and how far into the past this behavior extends.

"Our study suggests that stationary anvil use can be detected in locations previously inhabited by sea otters. This information could help to document past sea otter presence and diet in locations where they are currently extirpated," explains Jessica Fujii of the Monterey Bay Aquarium.

"More broadly," she adds, "the recovery of past animal behavioral traces helps us to understand the evolution of behaviors like stone anvil use, which is rare in the animal kingdom and is extremely rare in marine animals. We hope that this study establishes a new path for the growing field of animal archaeology."

Alabama Bear Cub Survival Study

AUBURN, ALABAMA, USA (March 7, 2019)—A grant from the Alabama Department of Conservation and Natural Resources funds a five year Auburn University study on bear cub survival in the state.

"We want to understand, first, what proportion of cubs make it to adulthood, and what the cause of death is for the ones that don't. Secondly, we want to find out where the females den for giving birth and the quality of those dens. Finally, we want to see where the cubs that make it to adulthood disperse to and whether they are able to become part of the breeding population," Steury said. "These questions are a priority because anecdotal evidence from our own field research suggests that many of the cubs that are born are not surviving to adulthood. Thus, we need to determine if that's actually true and if so, why."

Chuck Sykes, director of the Wildlife and Freshwater Fisheries Division at the Alabama Department of Conservation and Natural Resources, said the state is home to one of the smallest and most fragmented black bear populations in North America.

"Given the relatively small size of the population and its isolation from other bear populations, what happens to young bears when they disperse from the mother is of particular concern," Sykes said.

"Anecdotal observation suggests that black bears in south Alabama may be lacking in appropriate denning habitat, and many young appear to be lost before they recruit into the population, which may be the cause of the stagnant growth of the population. Thus, effective management and conservation requires more information on its reproductive ecology and ultimate viability."

Steury said examining the dwellings of bears concentrated in Washington County, just north of Mobile, is key.

"Bears usually den in caves, under rock outcroppings, and in hollowed-out trees. The Mobile area doesn't really have caves or rock outcroppings, and the old, hollow cypress trees have long since been chopped down," Steury said. "Consequently, most of our Mobile bears seem to just build nests on the ground—hollowed out depressions, lined with vegetation. We're concerned that these nests don't offer good protection from predators and the elements for cubs, and hence may result in poor cub survival."

School of Forestry and Wildlife Sciences Dean Janaki Alavalapati said this continued research is vital. "Dr. Steury's research on the declining population of black bears in Alabama will yield information that is critical to preserving the species in the state," said Alavalapati. "This study will lead to efforts to protect the bears and ensure that they thrive."

In the current phase of the project, Steury and his research team are visiting Alabama bear dens, taking measurements of den characteristics and fitting cubs with expandable radio-telemetry collars. They will monitor the cubs for nine months, until the young bears are self-sufficient and have made it past the initial stage of mortality.

When the cubs are two years old—the age at which they typically disperse from their mothers—they will be caught again and equipped with GPS-enabled radiotelemetry collars to track their dispersal patterns and determine whether they recruit into the population.

The research on bear denning, reproduction and cub survival, dispersal and recruitment (population growth rate by birth or immigration) will continue through 2023.

Spring Migration Continues to Come Earlier

HELSINKI, FINLAND (February 20, 2019)— According to a new study, migratory birds in Europe and Canada have substantially advanced the timing of their spring migration due to climate change. The average migratory bird has advanced its spring migration by approximately one week in five decades, and the duration of the migration season has increased.

The greatest advances were found among short-distance migrants that winter in Europe or North America: about 1.5–2 days per decade. Long-distance migrants that winter in the tropics have



Whooper swan migration (Cygnus cygnus).

also advanced the start of their migration, but only by approximately 0.6–1.2 days per decade.

"Based on changes in median migration dates, birds have on average advanced their spring migration by a little over a week since the late 1950s," says Aleksi Lehikoinen from the Finnish Museum of Natural History, University of Helsinki.

Some species show much greater advances. For instance, whooper swans now arrive in Finland about two weeks earlier than in the 1980s.

The advances in spring migration dates are not equal across the migration season. Early migrants of a given species have advanced their migration dates more than late migrants within the species' migration season. First migrants have the highest pressure to arrive at their breeding grounds as early as possible, whereas late migrants are typically nonbreeders, which have no rush to move north. This asymmetry has led to an overall increase in the duration of migration.

Annual arrival dates of bird species were explained by local temperatures: the earlier the spring, the earlier the timing of migration and the longer the migration season. Geographical differences in climate change also explained regional differences in the advancement of spring migration.

"Birds advanced their migration dates more in Europe than in Canada, because spring temperatures have risen more quickly in Europe", says Andreas Lindén from Yrkeshögskolan Novia, Finland.

The study is based on long-term monitoring data from 21 North European and Canadian bird observatories and included almost 200 study species. The longest time series started in 1959 and the early 1960s and a large part of the data was collected by volunteer birdwatchers. The results were published in the international journal *Ecological Indicators*.

Siblings of Infamous Mountain Lion Enter Wildlife Rehabilitation

LOVELAND, COLORADO, USA (February 14, 2019)-On the afternoon of Monday, Feb. 4, a mountain lion attacked a trail runner on the West Ridge Trail, one of the more remote areas of Horsetooth Mountain Open Space. The runner killed the juvenile lion in self-defense before going to a local hospital, where he was treated and released the following day. Larimer County rangers and state wildlife officers found the deceased mountain lion on the evening of the attack. During stepped up patrols on Tuesday, Feb. 5, a Larimer County ranger encountered two additional mountain lions near the scene of the attack, prompting the temporary closure to all trails at Horsetooth Mountain Open Space due to concerns for public safety.

Since the incident, Larimer County rangers have been assisting state wildlife officers with assessing mountain lion activity at the popular open space west of Fort Collins to determine when to reopen the site. On Wednesday, Feb. 6, wildlife officers placed trail cameras in the vicinity of the attack to assess mountain lion activity.

Over the weekend, Colorado Parks and Wildlife officers captured two juvenile mountain lions at Horsetooth Mountain Open Space. Wildlife officers will be moving the mountain lions to a wildlife rehabilitation facility. Colorado Parks and Wildlife plans to release the mountain lions back into the wild at a future date.

"We have removed additional lions that we believe are siblings of the lion involved in last Monday's attack," said Mark Leslie, northeast region manager for Colorado Parks and Wildlife. "The Front Range of Colorado plays home to many of Colorado's wildlife and we have an expanding urban interface and increased recreation pressure. The interaction between wildlife and people is going to increase and we need to find a way to balance the needs of people and the needs of wildlife."

With the assessment completed, Larimer County officials decided to reopen Horsetooth Mountain Open Space to the public February 13.

"People should be aware that reopening Horsetooth Mountain Open Space to the public does not mean there are no mountain lions in the area," said Steve Gibson, district manager for Larimer County Department of Natural Resources. "While it's located close to urban areas, Horsetooth Mountain Open Space is a wild place that supports many different animals. There will always be a chance to encounter wildlife on the property, including normally elusive mountain lions."

"It's important for people to recreate with wildlife in mind. We want people to enjoy these spaces, but we live close to these animals and we have to understand that there are times when you may come across something on the trail," said Ty Petersburg, area wildlife manager for Colorado Parks and Wildlife.

"We appreciate everyone's patience while we completed the assessment of mountain lion activity," Gibson said. "The safety of our visitors will always be a top priority."

Horsetooth Mountain Open Space was conserved back in the 1980s due, in part, to its valuable wildlife habitat and to provide a place for wildlife to live on the Front Range. The allure of the area for many visitors is the chance to get a glimpse at the wildlife with which we all share this special place. Larimer County staff is planning to provide educational opportunities about recreating in mountain lion habitat for visitors to Horsetooth Mountain Open Space.

Emergency Planning for Animals in Captivity

WASHINGTON, DC (February 7, 2019)— Fires, floods and earthquakes can cause intense suffering and death to the millions of animals trapped in commercial and research facilities. Today, Representatives Dina Titus (D-NV) and Peter King (R-NY) introduced the "Providing Responsible Emergency Plans for Animals at Risk of Emerging Disasters (PRE-PARED) Act of 2019," which would require institutions where animals are housed to strategically plan for emergencies. The bill is endorsed by the Animal Welfare Institute (AWI) and other national animal welfare organizations.

This legislation, first introduced in 2014 as the "Animal Emergency Planning Act," builds on the bipartisan "Pets Evacuation and Transportation Standards (PETS) Act" of 2006, which requires state and local emergency preparedness plans to incorporate accommodations for companion animals and service animals. While this law marked a crucial step forward, it did not address commercially owned animals. The PREPARED Act would cover substantially more animals under human care.

"The lives of animals are too precious to leave to chance," Titus said. "This bipartisan bill will ensure that zoos, commercial breeders, research facilities, and the like are prepared to keep their animals safe when disaster strikes. Sadly, we've learned that if these entities do not have a plan in place when an emergency hits, it is already too late. I'm grateful for the support of Representative King and the many animal advocacy organizations that are helping advance this important legislation."

"For those who are responsible for the care and well-being of animals, it is imperative that they have an emergency plan in place when a disaster strikes," said King. "I am proud to work with Representative Titus on this legislation to ensure the safety of animals with a completely reasonable and simple plan."

Specifically, the PREPARED Act mandates that entities regulated under the federal Animal Welfare Act, such as commercial animal dealers, exhibitors, and research facilities, have contingency plans in place to safely evacuate and care for animals in an emergency or disaster situation.

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These plans also would include provisions for humane handling, treatment, and transportation. Under the proposed legislation, covered entities would be required to submit their emergency plans to the U.S. Department of Agriculture (USDA) each year, and to train all employees in emergency procedures.

"Labs, zoos, and other USDA-regulated facilities have an obligation to protect animals in captivity from devastating natural and man-made disasters," said Cathy Liss, president of AWI. "These animals are at the mercy of their handlers because they have no way to escape. The PREPARED Act would ensure that no USDA-regulated facility is ever caught unprepared in a crisis —and that no animal gets left behind."

Western Australia Introduces Licensing

PERTH, AUSTRALIA (December 31, 2018)— Wildlife carers in Western Australia will soon be licensed by the state. On 1 January 2019, the Biodiversity Conservation Act 2016 and Biodiversity Conservation Regulations 2018 replaced the Wildlife Conservation Act 1950 and the Sandalwood Act 1929 and their associated regulations. The new licensing regime specifies licences for taking, disturbing, supplying, possessing, processing, dealing, importing and exporting activities in relation to flora and fauna. Transitional arrangements ensure that any current Wildlife Conservation Act or Regulations licenses continue to be valid until they expire. The regulations will be overseen by the Department of Biodiversity, Conservation, and Attractions (DBCA). Wildlife carer license requirements are expected to go into effect in 2020.

As stated on the DBCA's website "a sick, injured or abandoned native animal must be returned to the wild at the place where it was originally taken if it is capable of fending for itself; or given to a DBCA wildlife officer, a veterinary surgeon or a person who is authorised under a licence to rehabilitate fauna (i.e. the holder of a Fauna possessing (other purposes) licence). This must be done as soon as possible and within 72 hours of finding the sick, injured or abandoned animal.

For species listed as threatened or specially protected or penguins, notification must be given to DBCA within 24 hours of taking possession of the animal."

More information can be found in the following downloads: Draft Code of Practice for Wildlife Rehabilitation in Western Australia; Fact Sheet—Wildlife Rehabilitation; Injured or Abandoned Fauna Notification Form.





Elmer desperately wanted to be the elephant in the room.

African bush elephant (Loxodonta africana). PHOTO ©TAMBAKO THE JAGUAR, FLICKR.COM. CC BY-SA 2.0.

INSTRUCTIONS FOR AUTHORS

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

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

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

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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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Puma Cub (Puma concolor). PHOTO © TAMBAKO THE JAGUAR. CC BY-ND 2.0 LICENSE.



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