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Humerus fracture surgery and rehabilitation in a release-bound wild langur.

Human dimensions: How human residents repond to bear management after illegal feeding creates problem behavior.

"One Health" perspective on the spread of disease in Maryland deer.

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 an annual symposium, IWRC works to disseminate information and improve the quality of the care provided to wildlife.



On the cover:

Langurs (*Presbytis entellus*) on the wall of Jaigarh Fort, Jaipur, Rajasthan, India.

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Left:

Indian rhinoceros. (*Rhinoceros unicornis*).

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Sharing All Experiences

Wildlife rehabilitators have many opportunities to share their experiences these days. From a commiserating call to a Facebook post, we are more closely connected and able to share data than ever. And share we do. But what should we be sharing? Our latest successful release and the puzzling case that just came in, certainly; the bizarre and surprising, naturally. But I posit we should also share the deaths and disappointments.

Recently, I was moved by a Facebook post from the Wildlife Rehabilitation Center of Minnesota (WRCMN) describing a rehab case that ended in euthanasia. The piece introduced an emotional topic in a public forum with an accuracy and sensitivity that resonated with both rehabilitators (we all know the blessing an appropriate euthanasia can be) and the general public. Nearly all of the 112 responses expressed gratitude, sorrow, and compassion.

It's important for the public to understand that all rehabilitation efforts do not end in a successful release or a happily ever after captive life. Of course, reports of success rates and stories of releases are important. They personalize the value of wildlife rehabilitation and encourage the donations that support this important work. But it's also important to manage expectation, to help non-rehabilitators understand there is no magic cure for every wildlife patient, and that the human actions have consequences, including fatalities.

And it's important to share these bittersweet endings with fellow rehabilitators. In a world where people share only happy endings, the death and euthanasia we experience every day despite our best efforts turn into shame. We need to share negative outcomes for our own psychological well-being, as well as that of our community of practice.

As a professed data junkie, I understand that deaths and euthanasia are just as important to the story of rehab as releases are. We need these data to determine release rates and other relatively simple metrics. We also need data to assess whether a new protocol for neonate opossums truly improves their ability to thrive, or if a clever technique to set a raptor's wing results in improved post-injury flight recovery. And we need to provide others with access to our findings.

Start by drafting some communication guidelines for public audiences, colleagues, and staff/volunteers. Include considerations such as: Who is best suited to communicate to each audience? What types of photos are appropriate? How much data should be released? How best to verify Internet-provided advice? Please, take advantage of all the distribution channels now available in our remarkable world, such as a peer-reviewed paper submitted to this journal, a post on social media, or even an old-fashioned, face-to-face conversation at the next conference. Each type of communication has its own benefits.

So share widely and wisely. What I found so striking about the WRCMN post was its appropriateness to the audience. How might you incorporate this kind of generosity—I would go so far as to call it courage—into your rehab practice?

Kai Williams
Executive Director

Trawler Provides Assistance for Diving Ducks

MANITOWOC, Wisconsin, USA (February 28, 2014)—Wisconsin's diving ducks received help from residents who learned that winter ice was keeping ducks from gathering food.

Animal rehabilitation clinics have been caring for a larger-than-usual number of malnourished ducks this winter. Some ducks don't migrate and must dive into water in search of food.

When conservationist Tom Kocourek heard frozen waterways were preventing the birds from finding food, he decided to do something about it, HTR Media reported (http://htrne.ws/1bRJ0oF) Friday. The Two Rivers man called a marine contracting firm, Susie-Q Fish Co., which used a trawler to break up ice in Manitowoc and Two Rivers harbors.

"We figured we had to do something," said Mike LeClair, president."

Days after ducks had been spotted wandering through streets in search of anything to eat, they were back in the water, diving for food again.

Seal Releases Begin for 100 December Orphans

NORFOLK, United Kingdom (February 27, 2014)—The first batch of the tidal orphan seal pups were released 26 February back into the wild following weeks of rehabilitation by the RSPCA.

Eight pups were released to the sea at Winterton on Sea, Norfolk – to the delight of staff and volunteers at the RSPCA East Winch Wildlife Centre.

The centre has been caring for a staggering 100 pups since December following one of the biggest rescue projects the charity has ever seen.

The pups, some just a few weeks old, had washed up on the shore after violent storms and were too young to survive without their mothers. Scores were rescued by RSPCA officers and taken to their specialist hospital in Norfolk.

This was the start of an epic rehabilitation program which involved intensive care, hand feeding as often as every four hours, and round-the-clock supervision for the youngsters. The short intervals between feeds proved challenging for the staff, accompanied by continuous food prep and cleanup for so many pups.

RSPCA centre manager Alison Charles said, "This has been an extremely hard time for all the staff and volunteers – just coping with the sheer number of seals. This is the biggest rescue program we have ever had to deal with in the 25 year history of the centre.

"We had to completely juggle the whole centre to make room for so many extra seals... We had seals in every suitable room, in all the 17 cubicles in isolation, the box room, the orphan bird room, and the hedgehog room. Fortunately, all the rooms have under floor heating and tiled floors and drains so this helped with the cleaning, as seal pups can be messy.

"There was nothing better than today watching the seals going back into the water and knowing it was a result of the staff and volunteers' hard work and dedication."

This is the first batch of seals to be released of the scores still at the centre—30 still in isolation units and 48 in various pools. There are also six pups at the RSPCA Stapeley Grange Wildlife Centre and Welsh Mountain Zoo.

Orphaned Rhino Transferred to National Park for Final Stages of Rehab

GUWAHATI, Assam, India (February 20, 2014)—A young male rhino now at the Manas National Park in Assam will be released in the wild following a period of acclimatization, an official said Thursday.

The rhino, named Maju, was brought from the Centre for Wildlife Rehabilitation and Conservation (CWRC) near the Kaziranga National Park, about 400 km from Manas, a Unesco World Heritage site.

"The rhino was less than a month old when it was found alone in September 2009 at Baghmari area in Kaziranga," said Rathin Barman, deputy director of the International Fund for Animal Welfare-Wildlife Trust of India (IFAW-WTI). He said the reason for its separation from its mother was not clear.

The rhino is about four years old and would join two other rhinos at the pre-release site at Manas.

The CWRC is a wildlife rehabilitation facility jointly run by the state forest department and IFAW-WTI. It has successfully rehabilitated many rhinos since 2006.

Northwest Wildlife Rehabilitation Center Closes its Doors

BELLINGHAM, Washington, USA (February 12, 2014)—Effective February 14, 2014, the Northwest Wildlife Rehabilitation Center (NWRC) ceased operations. The Whatcom Humane Society (WHS) assumed operation the next day at a rehabilitation center located off Mount Baker Highway in Whatcom County.

"The difficult decision to dissolve our non-profit agency was made due to an increase in the number of animals the center was receiving and the continued financial strain to provide care to those animals" says Brian Genge, board president for NWRC. "We are saddened by our circumstances but relieved and happy that the Whatcom Humane Society is available and able to provide this important service to the community. On behalf of everyone at NWRC, I want to thank the community, our supporters, and volunteers for their great support over the years that allowed us to grow and meet the needs of wildlife in our area. We hope everyone will continue to offer their support to WHS and the service they will now be providing."

Last year, over 1,100 wild animals were received by NWRC. The Whatcom Humane Society will provide rehabilitation services to injured and orphaned wildlife with the goal of release back into

their native wild habitat.

WHS has been caring for animals in Whatcom County since 1902 and currently operates a newly constructed domestic animal shelter on Division Street in Bellingham. Last year, WHS provided care for approximately 3,800 homeless, unwanted, and abused animals. The WHS Wildlife Rehabilitation Services Department will house and care for native wild animals at a state-permitted property located at Nugents Corner near Everson, owned by the Whatcom County Parks Department.

WildCare Oklahoma Set to Break Ground for New Rescue and Education Center

NOBLE, Oklahoma, USA (February 19, 2014)—WildCare Oklahoma, a non-profit organization dedicated to wildlife rehabilitation, has launched a capital campaign to raise funds to build a much needed and overdue new 5,200 square foot center, according to Rondi Large, co-founder and operational director.

In the early 1980s, the organization grew out of Large's single-handed effort to rehabilitate a few wild animals at a time. Today, WildCare is a fully staffed facility that has taken in and cared for over 55,000 animals.

"We still have $100,000 to raise of the $375,000 project, but we feel we have enough to start the process." "And," Large added, "we still have the naming rights available—if someone or a company wants to donate more than $100,000, then the facility can be named after them."

Currently, WildCare Oklahoma is made up of 7.5 acres located east of Noble. It includes 13,700 square feet of outside mammal enclosures, 26,000 square feet of outside bird enclosures, and 2,600 square feet of dedicated inside space, which evolved out of Large's home.

"With the new Wildlife Rescue and Education Center, we can not only house more animals, but we'll have an amazing education room where we can teach people about what we do and why we do it. We'll also be able to give you a look at what happens behind the scenes with remote cameras in different rooms. You'll be watching young owls trying to balance while they flap their wings for the first time. The volunteers and staff are always commenting about a breathtaking moment they observed while quietly working. With the Center, we will be able to share these moments with you."

Cynthia Armstrong, Oklahoma State Director for the Humane Society of the United States, said, "WildCare is truly a shining star in the field of wildlife rehabilitation, and their dedicated work is most deserving of the support of those who recognize the beauty and wonder of creatures who share our world."

Florida Panther Released Back Into the Wild

TAMPA BAY, Florida, USA (March 5, 2014)—Florida Fish and Wildlife Conservation Commission (FWC) officials released a rehabilitated Florida panther back into the wild in early March. A homeowner spotted the panther kitten dragging its rear leg in the Collier County area in May 2013; the nine-month-old female cat likely had likely been struck by a car.

Collier County deputies found the panther hiding in thick brush. FWC biologists transported her to the Animal Specialty Hospital of Florida where she underwent surgery for her injuries.

Veterinarians discovered the panther had a compound fracture in her rear right leg, rib fractures, and bruising around the lungs. A steel plate was used to mend the leg bone together. After undergoing successful surgery, the cat was taken to the White Oak Conservation Center in Yulee, where she received additional care and rehabilitation.

Kid-Friendly "Wildlife Rescue" Exhibit at the Great Lakes Science Center

CLEVELAND, Ohio, USA (February 14, 2014)—"Wildlife Rescue" is the latest traveling exhibit to visit the Great Lakes Science Center (GLSC) in Cleveland, Ohio. Full of information on diverse species from around the globe and the efforts to protect them, the exhibit is intended for animal lovers young and old, but especially the former.

"Wildlife Rescue" is a creation of Science North in Sudbury, Ontario, Canada, a co-producer several years ago with GLSC on the OMNIMAX film, "Mysteries of the Great Lakes." Visitors "meet" the people who dedicate their lives to saving animals, visit an orangutan orphanage and an elephant sanctuary, fly an ultralight to follow young whooping cranes, and apply veterinary medicine techniques to diagnose animals.

One station allows youngsters to strap on a soft turtle shell and then attempt to crawl through a mock turtle crossing like those built below roads. "It's fun, but it's also something you don't think about," explained Dante Centuori, Director of Creative Productions for GLSC. "In a lot of areas where there's heavy turtle migration, they build these culverts."

GLSC has also worked with some other northeast Ohio organizations, including the Lake Erie Nature & Science Center in Cleveland, the Greater Cleveland Aquarium, and Lake Metroparks Penitentiary Glen Reservation. "They bring animals from their collections, and some of them are very involved in wildlife rehabilitation, so they're sharing that message about what's happening locally," Centuori says.

"Wildlife Rescue" also looks at environmental disasters, such as oil spills. If there is a silver lining to so many spills over the years, Centuori says, it's that rehabilitators have been able to improve their practices over time. Ultimately, this exhibition may speak to the breadth of knowledge possessed by the folks who work in this field."

"There's so much you need to know to treat a person, and we're just one species," Centuori marveled. "Then you go into the vet and they have to know how to treat, say, your five common house pets. But [rehabilitators], they come in, and it's like, who knows? It's a muskrat. It's an otter. The next day it's a turtle. It's remarkable how much knowledge you have to have to handle this stuff." ■

Invasive management of humerus fracture in wild langur (*Presbytis entellus*) with a view to rehabilitation back to the wild

A. K. Majie, P. Mondal, S. K. Ghosh, and D. N. Banerjee

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ABSTRACT: The occurrence of humerus fractures in non-human primates is uncommon. A male, wild, common langur (*Presbytis entellus*) was brought to the Zoological Garden, Alipore, India. The langur presented with a compound, oblique, mid-shaft fracture of the humerus with severe damage of muscles in the dorsal aspect of the humerus and peripheral nerve damage. The fracture was managed using an intramedullary pin, single circlage wiring, and external immobilization. The peripheral nerve injury was treated conservatively. After completion of treatment, the animal was released in the zoo with a view to rehabilitation back into the wild in the future.

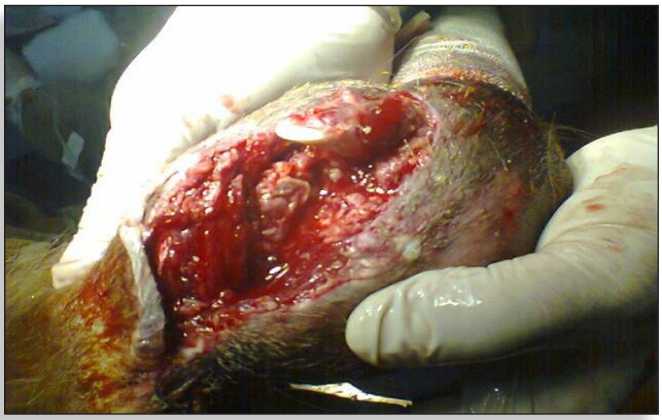
KEY WORDS: Alipore Zoo, humerus fracture, intramedullary pinning, rehabilitation, *Presbytis entellus*, wild langur.

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Introduction

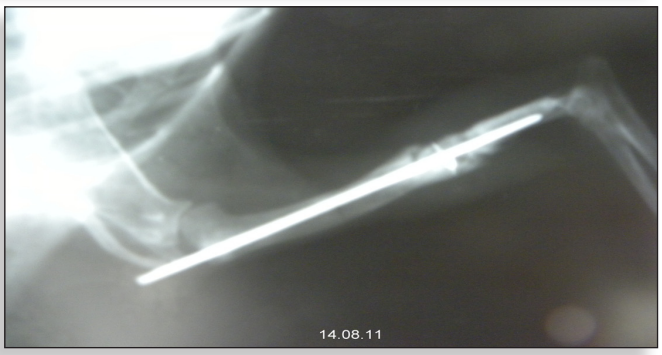
Incidence of long bone fracture in wild, adult, non-human primates is rare (1). A few reports on invasive management of a femur fracture in a non-human primate are cited in the literature (2), but similar information on a humerus fracture is rare. Humeral fractures are the least-common long bone fracture in small animals (3). The low incidence of these fractures, combined with the unique anatomy of the humerus, makes repair of humeral fractures challenging (4). In addition to automobile collisions with animals, direct violence on roaming animals is one of the major etiologies of fractures (5). This article discusses the successful invasive management of a humeral fracture of a wild common langur (*Presbytis entellus*).

J. Wildlife Rehab. 34(1): 7–10. © 2014 International Wildlife Rehabilitation Council.









Top to bottom:

Figure 1. Presenting condition of affected area of the right hand of langur

Figure 2. Drowsy animal after internal and external immobilization of the humeral fracture

Figure 3. Post-operative X-ray after pinning of humeral fracture

Figure 4. X-ray with evidence of healing at 90 days post-operative

History and Clinical Symptoms

A male, wild, common langur weighing about 20 kg was brought from the Kharagpur Forest Division, West Bengal, India, to Zoological Garden, Alipore, Kolkata, India, with a history of being chopped by a bayonet on its right hand three days prior. A compound oblique midshaft fracture of the humerus, with serosanguineous discharge from the wound, was evident clinically. The langur also presented with severe damage of muscles in the dorsal aspect of the humerus, especially the triceps brachii muscle, and numbness of all fingers to external stimuli (Fig. 1).

Management

At first after receiving the animal, it was chemically restrained with Xyxil 100 (xylazine HCl 100 mg/ml, 1 mg/kg body weight; Troy Laboratory Pty. Ltd., Glendennin, Australia) and ketamine (ketamine HCl 100 mg/ml, 2.5 mg/kg; Parnell Australia Pty. Ltd., Alexandria, Australia) for primary management. Initial care included wound dressing, temporary immobilization of fracture site with hard cardboard (rigid, but light in weight), and intravenous (i.v.) administration of 500 ml normal saline (Nirma Ltd., Gujrat, India). Also administered were Intacef (ceftriaxone 500 mg, 20 mg/kg i.v.; Intas Pharmaceuticals, Ahmedabad, India), Melonex™ (meloxicam 5 mg/ml, 0.2 mg/kg intramuscular [i.m.]; Intas Pharmaceuticals), and Rantac (ranitidine 25 mg/ml, 0.5 mg/kg i.m.; J. B. Chemicals and Pharmaceuticals, Mumbai, India). After 3 days, intramedullary (IM) pinning with a Steinmann pin (4.5 mm) and single circlage wiring was done with reapplication of external immobilization after anesthetizing the animal by a mixture of xylazine (1 mg/kg i.m.) and ketamine (5 mg/kg i.m.). The pin was driven up from the shaft of the fracture site, keeping the shoulder flexed, and was directed towards the lateral side of greater tuberosity. Then a single circlage wiring (20 G) was given in the fracture site. Post-operatively, Intacef (20 mg/kg i.v.) was continued for 7 days, and Melonex (0.2 mg/kg i.m.) and Rantac (0.5 mg/kg i.m.) were given for 3 days. At the end of the process, Riverzine™ (yohimbine Hcl 10 mg/ml, 0.125 mg/kg; Bomac Pty. Ltd., Leighton Place, Hornsby, Australia) was administered. The animal was kept within a small wooden cage for better post-operative management. On every third day, the dressing was redone until the skin suture was removed on day 12 post-operative (p.o.). Another reapplication of external immobilization was done on day 12 p.o. Oral calcium-phosphorus preparation was offered with feed for 1 mo. From day 14 p.o., parenteral B1, B6, and B12 (1 ml Trineurosol-H) were administered 3×/wk for 5 wk. On day 21 p.o., after removal of external immobilization, the animal was unable to lift and grasp with his hand due to massive nerve injury. So, in conjunction with the parenteral vitamin-B complex, application of physical therapy was begun, after removal of external immobilization, by applying hot and cold water on the affected site for 2 wk. The animal was able to lift his hand partially after completion of the parenteral B1, B6, and B12 course and the physical therapy. A post-operative X-ray was taken on days 40 and 90 p.o. Satisfactory fracture healing was visible in the

day 90 radiograph, so the pin was then removed. After that, the animal was shifted to a larger enclosure from a small cage for the purpose of potential rehabilitation and return to the wild in the future. The animal's physical activity in the enclosure was closely monitored, and the animal is now able to move the affected hand in a near-normal manner (Figs. 2–5).

Discussion

In this case, the xylazine and ketamine combination of anesthesia was adequate to perform surgical procedures, as this combination results in enhanced analgesia, muscle relaxation, fast anesthetic emergence, and quick, uneventful recovery compared with ketamine alone in a non-human primate. Moreover, investigators have found a wide safety margin with this combination; however, xylazine markedly reduced the thermoregulatory abilities of animals. The negative cardiopulmonary effect of an α_2 agonist is also minor in a non-human primate. The effects of α_2 agonists are reversed in primates by the α_2-adrenoceptor antagonists such as atipamezole, yohimbine, and so forth (6). In a diaphyseal fracture of a small animal, an IM pin is inserted in either normograde or retrograde fashion (7); in this case, it was driven up from the shaft of the humerus (retrograde) as per the technique described by Denny and Butterworth (8). Along with IM pinning, single circlage wiring and external, light-weight, rigid immobilization were used to reduced post-operative complications of IM pinning that could be caused by mechanical factors (9). Post-operative care is often problematic in primates due to their aggression, but the present animal was docile in nature. Post-operatively, the animal was kept in a small wooden cage to limit its motion. The severe muscle damage in the triceps brachii (which is innervated with the radial nerve and caused acute-onset forelimb paralysis) is the most common form of forelimb paralysis in the dog and cat. Injury to a single radial nerve in the form of neurapraxia, axonotmesis, or neurotmesis most often accompanies oblique or comminuted fractures of the humerus and is located at the junction of the middle and distal thirds of that bone. In this case, peripheral nerve injury was treated conservatively. Post-operative physical therapy is also very important for motion of the elbow (10).



Figure 5. X-ray after removal of the intramedullary pin

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Local attitudes towards bear management after illegal feeding and problem bear activity

Sara Dubois and David Fraser



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ABSTRACT: The "pot bears" received international media attention in 2010 after police discovered the intentional feeding of over 20 black bears during the investigation of an alleged marijuana-growing operation in Christina Lake, British Columbia, Canada. A two-phase random-digit dialing survey of the community was conducted in 2011 to understand local perspectives on bear policy and management, before and after a summer of problem bear activity and government interventions. Of the 159 households surveyed in February 2011, most had neutral or positive attitudes towards bears in general, and supported the initial decision to feed the food-conditioned bears until the autumn hibernation. In contrast to wildlife experts, however, most participants supported relocating the problem bears, or allowing them to remain in the area, ahead of killing; in part, this arose from notions of fairness despite the acknowledged problems of relocation. Most locals were aware of the years of feeding but did not report it, evidently failing to see it as a serious form of harm, even after many bears had been killed. This underscores the importance of preventive action on wildlife feeding and the need to narrow the gap between public and expert opinion on the likely effects of relocation versus killing.

KEYWORDS: attitudes, black bear, British Columbia, Christina Lake, food-conditioned, human-wildlife conflict, intentional feeding, telephone survey

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Introduction

Many lessons have been learned over decades of bear conflict management in North America (1–3), with the response of government agencies to human-bear interactions evolving over time (4). Although expert-driven policy has generally directed bear management in British Columbia (5), the public has increasingly come to expect participatory decision-making in both resource and wildlife management, facilitated by the growth of social science research in the fields (6–8). A potential benefit of increasing public participation is that an understanding of public attitudes may lead to better communication of management goals and greater support for the actions taken (9,10).

In August 2010, the story of more than 20 Canadian "pot bears" appeared in the international media after a police raid of a property near Christina Lake, a seasonal tourist town in the interior of British Columbia (BC) near the United States border, with fewer than 1,000 permanent residents. The investigation discovered an alleged marijuana-growing operation and numerous docile black bears, seemingly curious about the presence of the police (11). Photographs and reports of police standing beside the bears quickly

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dominated local news and spread to international news agencies (12–14). Media stories spoke of a "Bear Lady" living in the woods (15), and an online video showed "The Bear Dude" (16) who described feeding dog food to the bears for years and denied reports that the bears were being used to "guard" the marijuana production.

Upon hearing that generations of bears had been fed on the property for over two decades, members of the public (mostly non-local) began creating online petitions and Facebook pages to "Save the Christina Lake Bears." Public concern that the bears would be killed by the authorities was legitimate as there are limited non-lethal options for dealing with highly habituated bears who are food-conditioned (definitions as per [2]). Further, the current provincial problem-bear policy supports killing such bears rather than relocating them (17). Finally, black bears do not hold any special conservation status in BC; the estimated population of 120,000–160,000 province-wide is considered healthy, and several thousand are hunted annually (18). In fact, BC has one of the highest black bear populations in North America; the government receives about 10,000 bear complaints annually (4), and several hundred problem black bears are killed annually as a result of human-bear conflict (19). Therefore, killing these particular food-conditioned bears was a likely option for wildlife officials.

Contrary to current policy and laws against feeding dangerous wildlife, the government agency responsible for bear management in BC decided to allow the food-conditioned bears to continue to be fed by the resident until they started hibernation, given the time of year (late summer), the complexity of the issue (high number of bears, criminal court case pending), and significant media attention (20). The authorities required, however, that more natural foods be introduced to the diet (such as fruits and vegetables) and that all feeding cease after hibernation. Although this was an unusual case for wildlife managers in BC, human encroachment into wildlife habitat and a wide availability of attractants has meant that some black bear populations are becoming increasingly reliant on anthropogenic food sources (21), creating more potential for human-bear conflict. Most problem black bear incidents result from the unintentional feeding of bears that access fruit trees, garbage, and other attractants (3,21,22), rather than intentional feeding as in this case.

There were many media reports on opinions of the broader public about saving the food-conditioned bears, but little was known about the views of Christina Lake locals. Therefore, a random-digit-dialing telephone survey of the community was initiated to understand participant opinions and perceptions of local bears. As attitudes can change over time and with experience, the survey was repeated after the initial management intervention (lethal removal of problem bears). As management decisions directly affect local residents, who may or may not share the views of the greater public or experts or both, the telephone study was able to take an active approach by surveying local attitudes on the highly publicized problem bear issue as it was still unfolding.

The first survey aimed to understand attitudes and beliefs about bears in general; tolerance levels specifically towards the food-conditioned bears before they awoke from hibernation (i.e., before any possible interaction between the community and the bears); and levels of public support for wildlife management options and penalties for intentional feeding. The second survey with the same individuals was designed to see whether attitudes towards the food-conditioned bears, management options, and penalties changed after a spring, summer, and fall during which there would be a high potential for bear activity and human-bear conflict.

Methods

Survey Design

Given the quantity of data desired, the limited time for pre- and post-intervention questioning, and uncertainty of ensuring a sufficient number of responses to less personal surveys (mail or Internet), a telephone survey was selected as the research tool. Further, mail surveys can be costly and time consuming (23), and an Internet survey was not chosen due to difficulty in targeting only Christina Lake residents and the unknown extent of Internet usage in this remote area; however, a telephone directory of households was publicly available for random sampling. Cost effective and easy to administer (24), telephone surveys face considerable challenges in an era of growing technology (24–27). Despite these concerns, this method was a valid option for this study as the remote mountainous location has limited mobile telephone service and most homes continue to have a land line.

In the first survey (conducted in February 2011, 8 multi-part questions) and second survey (conducted in December 2011, 8 multi-part questions), participants were asked to describe their general bear sighting experiences as either "positive" (uneventful, comfortable), "negative" (uncomfortable, stressful), or "neutral." A five-point scale (1 = not supportive at all to 5 = very supportive) was used to measure support for varying management strategies for the food-conditioned bears. Both closed and open questions were asked and bears were referred to in the survey calls as either "general bears" or the "fed bears." Answers to closed questions were designed to be analyzed in a pre-coded format (e.g., male = 0, female = 1) (28). Calls were not recorded, but qualitative responses and post-survey comments were noted verbatim and some are presented as quotes.

The first question in the initial survey asked about length of residency in Christina Lake to determine the respondent's eligibility for the survey (29), and gender of respondent was noted. The next question asked if there was a registered hunter in the household. Questioning then progressed from questions about frequency of bear sightings and safety concerns in general to questions on attitudes towards past and future management strategies specifically for the food-conditioned bears (listed in Table 2). Finally, an open-ended question on what respondents felt would be an appropriate penalty for feeding these bears was asked.

The second survey was administered to the same person who participated in the first survey within the sampled household. It

focused on observed bear activity within the past year, including any problem bear activity and attitudes towards this. Given that all participants knew the location of the bear feeding, they were asked how far in kilometers they lived from this property. Participants were also asked to score recent management strategies for the food-conditioned bears and advise what strategies they would recommend to other communities facing similar circumstances. Also, respondents were asked if they agreed or disagreed with the proposed legal charges for feeding the bears (as full penalty details were not known at this time). As part of survey development, the questions were reviewed with a government biologist familiar with the bear issue and a polling company manager with expertise in public opinion surveys.

Sampling and Recruitment

As individuals within one household likely would have discussed this well-known local event, household rather than individual was selected as the research unit. A household was categorized as a "hunting household" if it included at least one registered hunter, whether or not that individual was still active. The 2006 Christina Lake census reported 475 households in the area, averaging 2 individuals per household (30), and only adult (over 18 years of age) permanent inhabitants were surveyed. To achieve a sample size with 5–10% margin of error and 95% confidence level, the random-digit-dialing survey would require a sample between 81 and 213 households (29).

In order to randomize potential participants, residential telephone numbers listed in the 2010 print and 2011 online telephone directories for Christina Lake were entered into a spreadsheet and assigned a random number, which was then sorted from lowest to highest. Interviewers were given a sequential page of new numbers for each call session or a list of numbers from previous uncompleted call attempts or both. To advise participants about the first survey and to help legitimize participation, newspaper advertisements were published in the Christina Lake News (print) and The Boundary Sentinel (online) to inform the community that they might be contacted to participate in the research survey by telephone.

Data Collection and Analysis

Telephone numbers were called in the randomized order until the call was completed or five attempts were made (24,31). Calling sessions totaled 100 hours for the first survey (calls to all area non-business phone numbers) and 60 hours for the second (only calls to past participants), and included a variety of weekday, weekday evening, and weekend sessions. Interviewers logged all call attempts. For completed calls, interviewers read the survey script verbatim, ensured eligibility (adult, Christina Lake resident), briefed respondents on their anonymity and confidentiality, and received verbal consent before recording answers. Although respondents were anonymous during the survey, they were given the option of providing a first name or nickname to be reached for the second survey.

Quantitative results produced descriptives and frequencies compiled in SPSS, which was also used to calculate inferential statistics (32). T-tests were used to assess differences by gender and hunting activity in attitudes towards management options as evaluated by the five-point scale. A paired t-test was used to determine any change in participants' attitudes towards penalties for feeding. Chi-squared tests were used to assess residents' attitudes towards bears and support for management actions based on the distance they lived from the property of concern. Qualitative analysis of text responses and comments involved inductive content analysis (33). Reporting of comments was categorized as "few" (<5% of participants), "some" (<50%), "many" (50–75%), and "most" (>75%) participants. Quotes (reported in italics) were chosen as representative statements of important themes or unique noteworthy insights.

Results

Recruitment

In the first survey, 1,478 call attempts were made to 610 telephone numbers listed in the directories. Ineligible numbers included business numbers (33), non-working numbers (143), numbers with no eligible respondent (3), and hearing impairment or language barrier (2). Unknown number status (150) included all "no answer" and answering machines. Of the remaining 279 eligible and known working numbers, 159 households completed the survey (for +/-6.13 margin of error), and 120 declined. The response rate of 43% for the first survey was calculated according to the method of CASRO (31). To help determine non-response bias, respondent gender was noted and showed a similar ratio for refused surveys (45% male, 55% female) as for completed surveys (39% male, 61% female) (p>0.05, Fisher's Exact test). The gender ratio of refused surveys did not differ significantly from that of the 2006 census data of the area (50% male, 50% female) (30) (p>0.05, Fisher's Exact test).

In the second survey, a maximum of five attempts were also made to the same 159 households. Of these, there were 150 eligible and known working numbers with 123 households completing the second survey, three declining, and 24 unreachable, for a CASRO response rate of 82% of original respondents.

Participants

Because results could reflect household attitudes on the issue and not just individual opinions, few individual demographic variables were collected. In the first survey, 61% of respondents were female, 75% of households were non-hunting, and 86% had lived in the area for more than 10 years. Demographic data were almost identical in the second survey, as 123 of the 159 original participants were re-surveyed. All respondents had heard of the bear feeding incident from media or other locals, and many said they knew it was going on long before the recent media attention. Several respondents recounted anecdotes about the well-known residents buying excessive amounts of dog food and about bears following these individuals into town.

Awareness of Bears and Attitudes towards Bears in General

When asked in the first survey how frequently respondents observed general bear activity in 2010, signs of bears (scat, markings, tracks, damage) were seen more than once by 82% of respondents, and actual bears on properties were observed more than once by 69%. Most respondents reported seeing bears in the general Christina Lake area in the past year. Usually, respondents related bear sightings to the presence of garbage, compost, or fruit trees on their properties. Many respondents indicated that local residents were more accepting of the bears' presence than they were of "summer visitors." Some respondents said they had seen fewer bears in 2010 than in previous years, while others suggested they had seen more. Respondents noted that the local landfill, where "dump bears" had often been seen and tolerated, was converted to a transfer station in 2010, likely leaving these bears without their usual source of food before winter.

When asked in the second survey about general bear activity over the past year, 50% of respondents stated they observed more bear activity in the general Christina Lake area in 2011 over 2010, but 32% saw about the same and only 18% saw less. Sightings of bears on respondents' properties in 2011 were also reported as higher than in 2010 by 45% of respondents, while 39% saw about the same, and only 16% saw fewer. Further, signs of bears (scat, markings, tracks, damage) on respondents' properties were also reported to be seen more frequently in 2011 over the previous year by 44% of respondents, while 45% experienced about the same amount of signs, and 11% observed fewer.

When asked to describe their bear sighting experience as positive, negative, or neutral, most respondents in the first survey had a mixed, neutral-to-positive attitude with a "live and let live" approach towards bears and said it was normal for living near natural bear habitat (Table 1). Some respondents indicated they were more cautious as bears approached settled areas, while others had dogs and fences they felt gave them some protection. Although many respondents had generally positive views of local bears, some expressed negative attitudes towards the bears if they would come onto their properties. A few suggested they did not walk in areas known for high bear activity as they felt in general that bears were not afraid of people. Significant concerns over safety were expressed by a few that experienced bear destruction on their properties (e.g., destroying sheds, appliances) or attempts to enter a home.

Although attitudes towards both seeing bears and signs of bears on their property were negative, signs of bears were qualified as an "annoyance" related to having to clean up feces, being messy, or damage to trees and fences rather than fear of the bears' presence. Many respondents shared concerns captured by this participant:

> *"Seeing a bear on your property is both positive and negative. Positive because they are wonderful animals and negative because of the damage they cause. They can be annoying because of the damage but they are nice to have around."*

In the second survey, fewer of the same respondents felt positive about seeing bear signs and bears, both on their property and in the area (Table 1). Most notably, more respondents felt negative towards seeing bears in Christina Lake and more felt neutral towards seeing bears on their property in 2011 than in 2010 ($p<0.05$ Fisher's Exact test). Many respondents knew of serious damage caused to property that was not related to garbage, compost, or fruit trees, including destruction of sheds, trailers, cabins, and cars. Several unusual reports of very persistent bears seeking food, and bears opening doors and entering vehicles, were cited as examples of learned behavior by the food-conditioned bears. Compared to respondents who lived at least 10 km from the property, those who lived within 5 km of the property were more likely to have generally negative attitudes towards (1) bears in the Christina Lake area, (2) bears on their property, and (3) signs of bears on their property, as determined by a chi-squared test ($p<0.01$) in each case.

Bear Activities in 2011

During the summer and fall of 2011, the BC Conservation Officer (CO) Service received 260 bear complaints in the Christina Lake area, in contrast to an average of 33 complaints received annually and the previous maximum number of 56 complaints from the area in 2004 (34). Complaints in 2011 included extensive property damage, bears entering residences, and multiple vehicle break-ins. The CO Service destroyed 24 bears in 2011 in the area (not including bears killed by private landowners), as compared to the previous maximum of 4 bears killed by the CO Service in 2004 (34). Of these, 18 were large males, which is unusual as normally 2–3 year olds and orphaned cubs or yearlings are killed as problem bears. In 2011, "Bear Aware," a government-sponsored education program focused on managing food attractants, was offered in the community for the first time in several years (35), in an attempt to reduce conflicts in light of the feeding event.

In the second survey, over 90% of respondents were aware of bears being killed in 2011, mostly for nuisance activities and for being too close and not afraid of people. Very few participants knew how many bears had actually been killed. Most respondents based their information on local "talk around town" rather than personal experience or media reports. Media outlets were monitored for related stories throughout the summer, but only one report of bear deaths in late September emerged; hence, media did not appear to influence attitudes between surveys.

One-quarter of respondents believed the bears that were killed were the food-conditioned bears. Just over half were unsure, however, and suggested that some were likely *"garbage-conditioned"* and "*dump bears*." Several respondents pointed out that since the resident was caught feeding bears again in the summer of 2011, some bears must have been back at the property of concern. Fourteen respondents did not believe the 24 bears killed were the food-conditioned bears, including a respondent who felt very neutral towards bears in general, and suggested that "*stomach contents should have been checked*" to confirm if in fact they were

TABLE 1. PERCENTAGE OF RESPONDENTS STATING THAT THEY FELT POSITIVE, NEUTRAL, OR NEGATIVE TOWARDS GENERAL BEAR SIGHTINGS ACROSS TWO SURVEYS (FEBRUARY AND DECEMBER 2011)[a]

ATTITUDES	BEARS IN GENERAL CHRISTINA LAKE AREA		BEARS ON OWN PROPERTY		SIGNS OF BEARS ON OWN PROPERTY	
SURVEY	FIRST	SECOND	FIRST	SECOND	FIRST	SECOND
POSITIVE	40%*	16%*	27%*	15%*	17%	13%
NEUTRAL	43%	40%	33%*	43%*	42%	47%
NEGATIVE	17%*	44%*	40%	42%	41%	40%

[a] Based on the 123 respondents who completed both surveys.
*Significant difference between first and second surveys ($p<0.05$) by Fisher's Exact test.

TABLE 2. PERCENTAGE OF RESPONDENTS IN THE FIRST SURVEY EXPRESSING DIFFERENT LEVELS OF SUPPORT FOR POST-HIBERNATION MANAGEMENT OPTIONS FOR THE FOOD-CONDITIONED BEARS[a]

LEVEL OF SUPPORT	NO FEEDING NATURAL FOOD ONLY	KEEP FEEDING	TRAP & RELOCATE	TRAP & CAPTIVITY	HUMANELY KILL
NOT SUPPORTIVE	21%	89%	26%	75%	70%
NEUTRAL	11%	6%	6%	6%	7%
VERY SUPPORTIVE	65%	5%	67%	18%	23%

[a]Results do not add to 100% in some cases because 0–3% responded with "don't know" or "no opinion."

the fed bears that were supposed to be targeted.

Attitudes towards Pre-hibernation Management of Bears

When asked in the first survey, before the nuisance bear activity, how supportive they were of four management options (continue feeding until hibernation, trap and relocate, trap and place in captivity, humanely kill), 62% households were somewhat or very supportive of the government decision in fall 2010 to feed until hibernation. These respondents believed it was the "best," "fairest," and "most viable" option given the time of year. Further, it "*would have been cruel not to feed last fall*" and it "*saved neighbors grief*." Several households that opposed the decision said that the feeding had gone on for a long time and that government was fully aware and did not act appropriately in the past. They suggested it was "*too late for these bears*" and that "*[they] are unhealthy and now the whole ecosystem is thrown off*," as it was a "*death sentence first day they were fed*." In contrast, a few individuals said the government should have left the people feeding the bears alone, as it had been happening without incident for years.

Many households supported the option of relocating the bears, stating that the authorities should "*give it a try*" because "*it was not the bears' fault.*" Those opposed said relocation would not work and the bears would return or become someone else's problem. Both captivity and humane killing (by government officials) were strongly opposed by three-quarters of households. A common view was that "*there has got to be a better option than killing*."

Women were more likely to support relocation than men were ($p = 0.015$) and were less supportive of killing ($p = 0.012$). Hunting households were significantly less supportive of relocation in fall 2010 than non-hunting households were ($p = 0.000$) and slightly less opposed to humane killing in fall 2010 than non-hunting households were ($p = 0.026$), although many hunting households opposed humane killing as they felt there were better solutions.

Attitudes towards Post-hibernation Management of Bears

When asked in the first survey what the food-conditioned bears would do on emerging from hibernation, most respondents believed the bears would return to where feeding previously occurred because it had been happening for so long. Almost all respondents thought that once the bears realized no food was being provided, they would seek other human-sourced food. Some expressed concern for neighboring properties and believed the bears would come closer to town. Although many were hopeful, few believed that bears would go back to the wild and forage naturally. Weather and food availability in spring and summer were suggested as significant factors in determining natural foraging opportunities.

When asked their views about five possible management options for the food-conditioned bears once they emerged from hibernation, few respondents used the categories of "somewhat supportive" and "somewhat unsupportive," so these results were combined respectively with "very supportive" and "not supportive" in Table 2. Almost two-thirds of the households said they supported prohibiting feeding and allowing the bears to live in the same area and forage naturally. Continued feeding of the bears on the property was strongly opposed. Relocation was supported by

many households but a quarter of respondents were opposed to this option. Three-quarters of respondents did not support captivity, although a few felt it was preferable to killing. Humanely killing the bears in spring 2011 was not supported by more than two-thirds of respondents. A *t*-test for independent samples found that women were more supportive of relocation than men were (p = 0.007), but there were no gender differences for the other options. Compared to hunting households, non-hunting households were more opposed to humane killing (p = 0.002) and more supportive of relocation (p = 0.010).


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Attitudes towards Bear Management after the Summer

When contacted in the second survey after the bear activity in summer and fall of 2011, two-thirds of respondents supported the government decision to kill the problem bears, but most acknowledged that killing was not the end they had wanted. Numerous respondents said the government should "keep a closer eye on the people doing it," since it was well known to be happening for many years. A third of respondents were not supportive of the decision to kill the bears, but these views were split between those who opposed killing and preferred "diversionary feeding" or believed the government "should have relocated [the bears] immediately last year," and those who believed the residents "should have been punished and bears killed right away." Those respondents who lived more than 10 km from the property of concern were less supportive of government actions than those who lived closer (chi-square p<0.05).

When asked what management actions they would recommend if another community faced similar challenges with intentional bear feeding, participants ranked relocation as most preferable. Many recognized, however, that relocation was unlikely to be successful and that bears would return or cause problems elsewhere. Allowing food-conditioned bears to continue to live in the area was ranked second, but the "live and let live" approach was recognized as having limits of tolerance. Killing, although disliked by many as an option, was seen as a last resort to be used when public safety becomes a concern. Diversionary feeding (intentional feeding away from original source) was generally not seen as acceptable.

Respondents' Views on Penalties for Feeding Local Bears

When asked in an open-ended question in the first survey what an appropriate penalty would be for feeding the bears, 78% of households felt the bear-feeding residents should be held responsible somehow for their actions, although they differed on what would be appropriate. Close to half of these respondents thought a significant penalty was needed (high fine, jail time, or both, or seizing residents' land), sharing this respondent's concern: "*Yes, huge fine and jail time. I love animals, but I love kids, too.*" But some believed fines were not realistic because the residents "lived off the land." Others felt the residents should not be put in jail as the feeding was not a malicious act and because jail might not be a deterrent to future feeding. The remainder of the pro-penalty respondents said the residents should perform community service or pay compensation directly for future management interventions or both, or as one respondent explained, "*It depends on what happens to the bears.*"

However, 17% of respondents opposed any type of penalty (a few suggested a warning only), as many said they knew the residents and their good intentions. Although the feeding was seen as a misguided and reckless act, it was viewed as a non-violent crime and "jail isn't for feeding bears." Some respondents felt the feeding had gone on for so long without issue; education of feeders was needed; and that although an outsider may agree with a penalty, locals may not, as one respondent expressed "as an insider, knowing the people, no penalty." Eight respondents did not want to comment on penalties as they knew the residents personally.

In the second survey, when asked about the appropriateness of the current legal charges against the feeders, attitudes toward penalty options did not change significantly (paired sample *t*-test p = 0.081), but some respondents felt there should now be some consequence, especially in light of the repeated feeding in 2011 and the high number of bears that had to be killed.

Discussion

Survey Error Considerations

All surveys inherently have some degree of error. Sampling error was addressed here with a high sample size (43% response rate is high for a random-digit-dialing telephone survey). Some coverage error was possible, as not all homes have fixed-line telephones, although mobile telephone usage is limited in this remote geographic area. Language or hearing barriers experienced in this survey were few; the number of households that did not respond to the calls due to these constraints is unknown. Non-response error can occur when results are correlated with a type of person who is underrepresented in the sample. Gender of non-respondents and respondents was recorded and did not differ significantly. Other differences between respondents and non-respondents could not be tested. Under different circumstances, an intercept survey (initial in-person contact) would be a complementary method to gain information on non-respondents. This research used labor-

intensive telephone surveys; however, face-to-face community meetings or virtual town hall meetings by telephone may be another strategy to solicit local and timely opinions.

Local Attitudes towards Management Options

Although this community was very experienced with bears and tolerant of their presence in general, attitudes towards bears became more negative between survey phases after increased sightings and higher problem-bear activity. These results agree with findings of other studies where increased experience of conflict can lead to more negative attitudes towards wildlife (36–38). Although many respondents believed the government decision to feed the food-conditioned bears in fall 2010 was the best decision at the time, the majority opposed continued feeding in spring 2011 and wanted better government monitoring of the property in the future. Consistent with studies of other species associated with human-wildlife conflict, participants who lived closest to the property with the food-conditioned bears held the most negative attitudes and were most supportive of lethal government actions after summer (39).

Relocation was the preferred outcome for most participants, although some were unsure whether it would be effective, as the bears might return, become another community's problem, or not survive in a new environment. Captivity and diversionary feeding were not supported for this situation or future incidents of intentional bear feeding. Before the busy summer, most respondents felt that the food-conditioned bears should be killed only as a last resort if they became a threat to people. Those bears that appeared unusually determined to obtain anthropogenic foods and not leave human areas were killed by COs. Other bears that were reported as a nuisance in the local area were also trapped and killed, presumed to be the food-conditioned bears. Overall though, the community wanted another option to lethal, reactive management, especially given a lack of pro-active prevention.

Relocation was also favored by the public in other situations of human-bear conflict as shown by surveys of residents of Vancouver Island (40) and Colorado (9). In the present survey, verbal comments showed that many understood the potential pitfalls of relocation, which is often dictated by social pressure over biological merit (4). One respondent declared that "*generations of bears*" were "*forced into a life of crime*," when describing the actions of the bears when they broke into homes, cabins, and cars, in search of food. However, given the community's strong desire to give these bears a "second chance," an option of relocating some of the bears (juveniles only), who had less food-conditioning experience and the best possibility of success (41), could have been explored by government to increase overall support for management. Public support for relocation versus killing indicates a large gap between the public and experts' opinion on management methods for mitigating this conflict. As relocation often ends badly for at least some animals, future public education on management strategies should better communicate the humaneness and limitations of practices in order to achieve better alignment of public and expert views (42).

The notion of fairness and justice were ongoing themes throughout the study, as the bears appeared to some participants as being "forced" into their problematic behavior and thus killing them would not be fair. This demonstrates the complex motivations behind public views of wildlife management, which is generally expert-driven. There is likely no easy way to resolve this expert-public gap without a significant investment in education and attempts to create shared levels of understanding of both the public's and expert management's thinking on difficult conservation issues. This study can, however, offer a common solution: the importance of preventive action on wildlife feeding. Once wild animals have become food-conditioned, there are simply no attractive management options. Killing, even if done humanely, is seen by the public as unfair; relocation, although more palatable to the public, is seen by experts as not viable or not humane.

A number of other potentially significant issues raised were known only by the local community. First, many respondents believed that a fear of bears was exaggerated by seasonal tourists who were less tolerant of bears and made hasty nuisance reports. Tracking resident type in nuisance bear calls could have determined whether there was a disproportionate reporting frequency reflecting a lack of experience and tolerance with bears. Further, the closure of the garbage dump was never discussed in media or in government reports, but numerous respondents wondered if any of the bears killed in 2011 were those displaced from the landfill. Marking the food-conditioned bears in fall 2010 or checking stomach contents (for the presence of dog food) of the killed bears might have provided answers to these concerns from locals.

The value of public participation in wildlife management decision-making has been well documented (7,10,43), but local attitudes may be distinct from broader public attitudes. This study suggests that local experience, including knowledge of past feeding activities and other factors such as the landfill closure, could have provided insight for management actions. If locals knew of past feeding and were on board with management strategies, they may have reported that it had restarted; officials could have then acted quicker to stop the activity before so many bears were involved, and perhaps fewer would have been killed. Separately tagging the "pot bears" and any known problem bears from the landfill would have confirmed which were targeted by the lethal actions, resolving these unanswered questions from locals and increasing support for management intervention. Future studies of contentious management dilemmas may also benefit from distinguishing local from broader societal attitudes; in this case, the Canadian public reacting online and in the media had no idea about the complexity of the feeding event or community impact.

Perceptions of Wildlife Feeding and Consequences

Local residents, although clearly aware of the feeding, allowed it to continue for many years without reporting it to the authorities. Moreover, several respondents indicated, and government officials confirmed, that a number of food-conditioned bears from the same property were killed approximately 10 years earlier under



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the same circumstances. Further, despite the killing of at least 24 bears, attitudes towards penalties shifted little as the need for consequences was emphasized between the two surveys. It is notable that many participants did not regard the illegal feeding of bears as a serious offence that merited significant penalties; they believed the individuals feeding the bears were misguided but well-motivated and generous, rather than as engaging in behavior that harms animals. Hence, participants did not favor serious punishment of the offenders and eventually the justice system concurred (44). In fact, the feeding became a focus for enforcement only when the perpetrators were investigated for an entirely different offense.

This case highlights a significant problem with the public view of wildlife feeding. As seen here, feeding inevitably leads to poor outcomes for the animals—death, relocation, or captivity—but the general "laissez-faire" attitude towards feeding all wildlife demonstrates that the public does not seem to see it on par with other forms of animal harm (48). Thus, there is a major need for education so that people understand that illegal feeding of such wildlife is a serious form of harm to animals. The only approach is for both the authorities and the public to not tolerate such wildlife feeding and exercise the same vigilance that would be directed to other forms of animal harm (e.g., neglect, abuse). Moreover, although much research has focused on measuring the success of managing problem bear behavior (3,49), more research is needed on measuring the success of deterrents for human behavior, such as public education (50) and attitudinal changes (51), as well as the effectiveness of enforcement and penalties (52).

Conclusion

In contrast to wildlife experts, most participants supported relocating the food-conditioned bears or allowing them to remain in the area ahead of killing, despite the acknowledged problems of relocation. The general finding that people prefer non-lethal methods to lethal alternatives in contrast to experts is not surprising and adds to growing literature that highlights the disconnect between the public and experts on wildlife management issues. The strongly polarized management options of relocation and killing signal a need to address the current limitations of mitigating conflict with bears, and explore the use of more deterrents (for both people and bears) to expand the overall management toolbox. Intentional wildlife feeding should be one management issue where the public and experts agree on the importance of preventive and unified action. Yet, in this case most locals were aware of the years of feeding but did not report it, evidently failing to see it as a serious form of harm, even after many bears had been killed. Contrary to the "save the bears" websites and social media campaigns which mostly reflected idealism, local attitudes were diverse, more contextualized, and pragmatic, as residents seemed more aware of the consequences. In fact, locals were not merely pragmatic, seeking the best outcomes for themselves; they also included notions of fairness and justice for the bears, noting that it was not the bears' fault. Given that managers want to retain community support and ensure reporting of illegal feeding, lethal solutions should be a last resort and proactive alternatives (i.e., evaluative education and strict enforcement of feeding penalties) should be standard tools for human-wildlife conflicts.

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Conflicts of Interest

The authors declare no conflict of interest.

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Habitat, wildlife, and one health: *Arcanobacterium pyogenes* in Maryland and Upper Eastern Shore white-tailed deer populations

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ABSTRACT: The intracranial abscessation suppurative meningitis (IASM) disease complex in deer has been linked to *Arcanobacterium pyogenes*, an under-diagnosed and often misdiagnosed organism considered commensal in domestic livestock but associated with serious disease in numerous species, including humans. Our study used standard bacterial culture techniques to assess *A. pyogenes* prevalence among deer sampled across six physiogeographic regions in Maryland and the Upper Eastern Shore under Traditional Deer Management (TDM) and Quality Deer Management (QDM), a management protocol that alters population demographics in favor of older male deer.

A. pyogenes was detected on deer in three of the six regions studied, and was common in only one region, the Upper Eastern Shore. In the Upper Eastern Shore, 45% and 66% of antler and nasal swabs from deer were positive for *A. pyogenes*, respectively.

Our study indicates *A. pyogenes* may be carried widely among white-tailed deer regardless of sex or age class, but we found no evidence the pathogen is acquired *in utero*. The distribution of *A. pyogenes* across regions and concentration in a region with low livestock levels suggests the potential for localized endemicity of the organism and the possibility that deer may serve as a maintenance reservoir for an emerging one health concern.

KEY WORDS: *Arcanobacterium pyogenes*, white-tailed deer, one health, intracranial abscessation, emerging diseases

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Introduction

The "one health" concept is enjoying resurgence as physicians, scientists, and veterinarians develop greater appreciation for the health implications of the complex interactions between the environment, humans, and domestic and wild animals (1-3). Wildlife species serve important roles in one health processes as key players in disease interactions involving feral and domestic livestock, and through direct impacts on human health. The majority of emerging infectious diseases in humans are zoonotic (4), and most of these are believed to originate from wildlife populations or to be amplified though interactions between wildlife and domestic and feral livestock (5,6). Understanding the spatiotemporal distributions of disease in wildlife is key to identifying the dynamics and predicting the establishment of emerging infectious diseases (7).

White-tailed deer (*Odocoileus virginianus*) represent one of the most abundant and widely distributed large ruminant mammal species in North America (8-10). In the United States, white-tailed deer populations have expanded vastly since the early 20th century through management focused on species recovery (11,12). Human-deer and deer-livestock interactions have increased and evolved with the expansion of the interface boundary among the species, though more quantitative data on this phenomenon are needed (13,14). Approaches to management of burgeoning deer populations have implications beyond resource stewardship, including the potential for increased deer-human conflict (15) and for deer populations to serve as reservoirs for infectious diseases (5). Similarly, environmental impacts on pathogen viability in different physiogeographic environments can alter the overall impact of potential emerging one health concerns.

The intracranial abscessation suppurative meningitis disease complex (IASM) is generally considered a minor cause of population-wide mortality among white-tailed deer in the United States (16,17) However, infection prevalence differs regionally, and the disease complex can contribute substantially to deer mortality in some areas. IASM has been associated with high losses on the Upper Eastern Shore of Maryland, where it was pinpointed as the cause of nearly 35% of annual mortality among mature males (18). Skulls of animals affected by IASM are characterized by erosion and pitting of bones, and the frequent occurrence of fluid-filled nodules beneath the antler pedicle, lesions that are not readily appreciated in living deer (Fig. 1). Clinically, antlers may be disfigured and the antler pedicle is typically surrounded by inflamed tissue and extravasated viscous fluid (Fig. 1). Clinical signs of IASM in white-tailed deer mimic other key zoonoses and include incoordination, lack of fear, blindness, weakness, emaciation, and circling (16,19).



FIGURE 1. Pitting of bone and fluid-filled nodule inside skull plate of infected white-tailed deer and male white-tailed deer with signs of IASM at Chesapeake Farms, Maryland, USA.

The precise etiology of IASM in white-tailed deer is not definitively established, and though other bacteria can be cultured from lesions meeting the criteria of the syndrome, studies to date have shown that abscesses are most frequently associated with the gram-positive, non-motile, non-spore-forming, short, rod-shaped bacterium *Arcanobacterium pyogenes* (formerly *Corynebacterium* and *Actinomyces* 1982) (16,17). *A. pyogenes* is generally considered a commensal organism and an opportunistic pathogen of domestic livestock, particularly cattle (*Bos primigenius*) and swine (*Sus scrofa*). It is a common inhabitant of the mucous membranes of both cattle and swine and can be routinely isolated from the digestive tract, udders, urogenital region, and upper respiratory tracts of healthy animals (20-25). The organism has also been isolated from clinical infections in a wide range of domesticated and wild ungulates, including domestic sheep (*Ovis aries*), blackbuck (*Antilope cervicapra*), and fallow deer (*Dama dama*) (24-31). *A. pyogenes* has been associated with various disease conditions ranging from abortion to osteomyelitis (21,32). It is possible that *A. pyogenes* plays a similar role in white-tailed deer populations, which could serve as a reservoir for the pathogen in the absence of abundant livestock.

A. pyogenes expresses several known and suspected virulence factors, which may explain its ability to colonize many different host tissues and cause a diverse range of diseases (29). *A. pyogenes* is not considered part of the normal human flora (29), and it is an under-recognized and frequently misdiagnosed human pathogen with the potential to serve as a primary pathogen, though it is more commonly isolated as part of a mixed infection (33,34). Under-reporting of *A. pyogenes* infections likely occurs because the organism's biochemical profile is very similar to that of *A. haemolyticum* (34,35). Many, but not all, human cases of *A. pyogenes*-related disease reported in the literature have been associated with underlying health problems including diabetes and cancer (36), but the organism can express a wide range of virulence factors, and the pathogenesis of infection by *A. pyogenes* is not well characterized (29). The broad array of human disease conditions reported due to *A. pyogenes* includes abdominal abscessation, otitis media, cystitis, mastoiditis, septicemia, sigmoiditis, appendicitis, cholecystitis, peritonitis, endocarditis, meningitis, arthritis, empyema, and pneumonia (34,35,37-41). Some authors suggest the predominant risk factors associated with human disease include close contact with animals, but that contact is not always recognized in the history or signalment of the specific cases (34). We believe this contributes to the lack of published reports of human cases associated with deer contact, and we are unaware of any aspect of the understood pathogenesis and transmission routes from domestic animals that would preclude infection from exposure to deer. In addition, hunting brings humans and deer into close contact providing a possible route of *A. pyogenes* transmission between IASM-infected animals as well as animals serving as a reservoir for the pathogen.

The *A. pyogenes*-associated IASM syndrome in white-tailed deer presents unique opportunities to examine factors that may play a role in the dynamics of what may be an under-recognized emerging one health problem. Adult male white-tailed deer appear to be particularly susceptible to IASM (16,18), which could be an important mortality factor in deer populations operated under management strategies that foster a balanced sex ratio and an older age structure among male deer such as quality deer management (QDM) (42). If strategies such as QDM contribute to IASM, management decisions may have broader impacts on the health of the deer population than previously recognized. Management decisions for deer may impact the health of feral and domestic livestock as well as the health of humans who come in close contact with deer, for example during hunting season. Infections in male deer are more frequently recognized, but female deer and fawns (>6 months old) can acquire IASM and pulmonary, mammary, and disseminated systemic infections associated with *A. pyogenes* (17,43,44). These health outcomes suggest deer management strategies might not be the only determinant of the prevalence of the disease complex. Other factors such as environmental characteristics and livestock prevalence may play a role in the impact of the bacterium. Though *Arcanobacterium* infections and cervid IASM occur across much of North America (17), there is evidence that *A. pyogenes* may not thrive under certain environmental conditions, particularly in arid climates (17,18).

In the context of data indicating high prevalence of IASM in some deer populations as well as our hypothesis that *A. pyogenes*

might play a similar role in deer populations as it does in other ungulate populations, we initiated a study on the prevalence of *A. pyogenes* across Maryland. We used recognized long-standing and well-accepted bacterial culture and biochemistry identification techniques to assess the prevalence of *A. pyogenes* across deer populations in different physiogeographic regions and under different deer management strategies to evaluate the impacts of these factors on a potential emerging one health concern.

Ethics Statement

All procedures followed guidelines set by the North Carolina State University Institutional Animal Care and Use Committee (09-065-O), and all animal handling methods used followed guidelines approved by the American Society of Mammalogists (45). The Maryland Department of Natural Resources provided permission for all studies conducted for this project, including live capture of white-tailed deer fawns and sampling from hunter-killed adult white-tailed deer in the Upper Eastern Shore, Lower Eastern Shore, Western Shore, Piedmont, Ridge and Valley, and Appalachian provinces of Maryland.

Methods

Three related studies were conducted. In all studies, we determined sex of white-tailed deer by manual palpation and visual examination and assigned to age classes (i.e., 0.5, 1.5, and 2.5+) using tooth replacement and wear (46). Animals were weighed when possible and examined physically for external visible signs of disease or injury. We used successful culture of viable bacteria, a highly discriminatory approach for detection of the presence of *A. pyogenes* as our diagnostic standard. Following the methods of Karns et al. (18), we collected head and nasal swabs from each animal using Remel Bacti-Swab transport swabs (Thermo Fisher Scientific, Waltham, Massachusetts, USA). For head samples, we swabbed around antler pedicles for males, and residue was collected from the top of the head where pedicles would be, if present for females, or the whole dorsal frontal area of the head for neonates. We collected nasal samples by swabbing the nasopharyngeal membranes by inserting the sterile swab deep into the nasal cavity of one nostril taking care not to contact the external nares, and rotating the swab gently before removing it. All samples were kept on ice, immediately refrigerated upon leaving the field, and transported to the Salisbury Animal Health Diagnostic Lab (Maryland Department of Agriculture, Salisbury, Maryland, USA) or to the Frederick Animal Health Diagnostic Lab (Maryland Department of Agriculture, Frederick, Maryland, USA) for aerobic bacterial culture on blood agar plates. To harmonize procedures between the two laboratories, the microbiologists processing the cultures were in direct communication and used identical culture and organism identification protocols. A Gram stain and catalase test were conducted for all colonies that were growing. Aerobic bacteria were identified to genus and species based on morphology, staining characteristics, and biochemical characteristics based on standard American Society for Microbiology techniques (47,48).

Statewide study

Based on prior studies by our group and anecdotal evidence that IASM across Maryland differs regionally and is more prevalent on the Eastern Shore, we hypothesized that habitat characteristics would impact the presence of *A. pyogenes* on deer. To test this, we sought to establish the prevalence of *A. pyogenes* relative to habitat characteristics by sampling from six regions across Maryland. These regions approximately follow physiogeographic provinces specified by the Maryland Geological Survey (MGS), but sampled animals could only be identified to county of origin. Therefore, when county boundaries overlapped provinces, the entire county was assigned to the region that included the majority of the county land mass. Similarly, we divided the MGS-designated Blue Ridge province into the adjacent Ridge and Valley province and Piedmont Plateau province because of sampling difficulties. The westernmost Appalachian province was characterized by gently folded bedrock of shale, siltstone, and sandstone. The second westernmost Ridge and Valley province was characterized by poor soils and deeply folded sedimentary, shale, or sandstone bedrock. The central Piedmont Plateau province largely comprised eroded rocks of volcanic origin. The Coastal Plain regions of the east, the Western Shore, and the Upper Eastern and Lower Eastern shores were characterized by fertile soils and abundant ground water (49). Data for this study were collected from October 18, 2010, to December 12, 2010. In each of the six regions, head and nasal swabs were collected from a total of 234 hunter-killed male deer (Appalachian N = 50; Ridge and Valley N = 21; Piedmont N = 50; Western Shore N = 33; Lower Eastern Shore N = 32; Upper Eastern Shore N = 48). The antlered:antlerless ratio (fawn males are included in antlerless numbers) in the statewide harvest was 1:2.2 and 1:1.96 in 2009 and 2010, respectively.

White-tailed deer management study

To study the hypothesis that deer management practices may impact the prevalence of *A. pyogenes* on the Upper Eastern Shore region of Maryland, we collected head and nasal swabs from (N = 113) hunter-killed male and female deer data from two properties with similar habitat characteristics, only one of which has documented history of IASM (18). The QDM property was 1,300 ha on Maryland's Eastern Shore comprising 50% forest with non-alluvial swamps, 20% cropland, 13% fallow fields, with the remaining 17% comprising impoundments and other managed wildlife habitat (18,50). The QDM property has been managed since 1994 under QDM, which fosters a balanced sex ratio and an older age structure among male deer (51). On the QDM property, white-tailed deer had been hunted annually with the harvest of males limited to individuals with antler spreads wider than ear tips (i.e., 2.5. years old). Harvest male: female sex ratio was 1:3.4 and 1:2.5 for 2009 and 2010, respectively. Previous research identified IASM as a cause of 35% of mortality among adult males in the QDM population, and *A. pyogenes* had been cultured from live-captured adult males at this site (18). Flora of females and younger-age-class animals had not previously been evaluated.

TABLE 1. PERCENT OF WHITE-TAILED DEER CARRYING *A. PYOGENES* BY REGION AND SWAB TYPE IN MARYLAND, USA, 2010

	Head			Nasal		
Region	*n*	Mean isolates (range)	*A. pyogenes* %	*n*	Mean isolates (range)	*A. pyogenes* %
APPALACHIAN	47	2.30 (1-6)	0	48	2.35 (1-4)	0
RIDGE AND VALLEY	18	1.33 (1-3)	0	19	1.95 (1-3)	0
PIEDMONT	49	3.06 (1-9)	0	48	3.17 (1-8)	0
WESTERN SHORE	24	1.35 (1-3)	0	23	1.48 (1-6)	4
LOWER EASTERN SHORE	33	2.60 (1-5)	3	24	2.27 (1-4)	0
UPPER EASTERN SHORE	44	4.05 (2-8)	45	41	3.80 (1-7)	66

TABLE 2. BACTERIA CARRIED BY WHITE-TAILED DEER (NASAL%, HEAD%) BY REGION IN MARYLAND, USA, 2010

Genus	Appalachian	Ridge and Valley	Piedmont	Western Shore	Lower Eastern Shore	Upper Eastern Shore
ACINETOBACTER	13, 26	11, 22	19, 37	0, 0	13, 30	2, 7
AEROCOCCUS	0, 0	5, 0	0, 0	0, 0	0, 0	0, 0
AEROMONAS	0, 0	5, 0	8, 0	0, 0	0, 0	0, 0
ARCANOBACTERIUM	0, 0	0, 0	0, 0	4, 0	0, 3	66, 45
BACILLUS	25, 4	21, 0	56, 14	13, 8	13, 12	51, 61
CHRYSEOBACTERIUM	0, 0	16, 11	0, 0	0, 0	0, 0	0, 0
CHRYSEOMONAS	0, 0	0, 0	0, 0	0, 0	0, 0	24, 16
CORYNEBACTERIUM	0, 0	0, 0	0, 0	0, 0	3, 4	5, 5
ENTEROBACTER	0, 0	5, 6	0, 0	0, 0	0, 0	0, 2
ENTEROCOCCUS	13, 4	32, 0	33, 12	9, 0	46, 18	2, 7
ESCHERICHIA	10, 0	6, 0	4, 2	0, 8	0, 0	32, 27
KLEBSIELLA	2, 2	5, 0	0, 0	4, 0	0, 0	0, 0
KOCURIA	0, 0	5, 0	0, 0	0, 0	0, 0	0, 0
MANNHEIMIA	0, 0	0, 0	2, 0	0, 0	0, 0	0, 0
MICROCOCCUS	0, 0	0, 0	0, 0	0, 0	0, 0	10, 0
MORAXELLA	15, 23	5, 0	44, 47	0, 0	38, 42	0, 2
PANTOEA	17, 36	11, 17	48, 65	0, 4	17, 55	27, 30
PASTEURELLA	0, 0	0, 0	0, 0	0, 0	0, 0	7, 9
PECTOBACTERIUM	0, 0	47, 17	0, 0	0, 0	0, 0	0, 0
PROVIDENCIA	0, 0	0, 0	0, 0	0, 0	0, 0	2, 0
PSEUDOMONAS	42, 40	11, 6	50, 50	26, 29	54, 42	10, 9
SERRATIA	0, 0	0, 0	0, 0	0, 0	0, 0	5, 7
STAPHYLOCOCCUS	63, 64	11, 67	25, 35	52, 71	38, 61	66, 91
STREPTOCOCCUS	10, 0	0, 0	0, 0	17, 0	4, 3	0, 0

The traditional deer management (TDM) property, which did not employ sex-or age-based harvest restrictions resulting in a young age structure among males and a heavily female-skewed sex ratio, was 925 ha comprising 37.6% marshland, 37.3% forest, 17.6% cropland, with the remainder being grassland, moist soil, water, and developed area. The TDM property is located approximately 12.4 km from the QDM property on the same shoreline. The white-tailed deer population had been hunted annually with no age or sex restrictions. Male:female sex ratios in recent harvests on the TDM property were 1.3:1 and 2.25:1 for 2009 and 2010, respectively.

Neonate study

To examine the hypothesis of early (in utero or immediately postpartum) bacterial colonization of deer, head and nasal swabs from 11 neonates at the QDM property were collected June 5-8,

2009. The neonates were restrained manually for collection of head and nasal cultures. Survey sampling methods prevented collection of cultures from dams.

TABLE 3. PERCENT OF WHITE-TAILED DEER CARRYING *A. PYOGENES* BY SEX AND SAMPLE SITE ON THE UPPER EASTERN SHORE IN MARYLAND, USA, 2010

Site	Sex	*A. pyogenes* %	Nasal % only	Head % only	Head and nasal %
QDM PROPERTY	F	77	26	0	52
QDM PROPERTY	M	82	27	9	45
TOTAL	78				
TDM PROPERTY	F	100	19	5	76
TDM PROPERTY	M	92	40	19	35
TOTAL	95				

Data analysis

For the statewide study, we evaluated the effect of region on whether deer carried *A. pyogenes* using Pearson's chi-square test with Yates' continuity correction conducted in Program R (Version 2.9.1, http://cran.r-project.org, accessed April 25, 2009). For the white-tailed deer management study, we tested whether site, age class, and sex predisposed animals to carrying *A. pyogenes* using binary logistic regression with presence of *A. pyogenes* as the dependent variable, and site, age class, and sex as independent variables. Analyses were conducted in SYSTAT 13 (Systat Software, Chicago, Illinois, USA), and alpha was set at $P \leq 0.05$.

Results

Statewide study

Prevalences of *A. pyogenes* and other bacteria across Maryland physiogeographic regions are summarized in Tables 1 and 2. Physiogeographic region was a significant predictor of *A. pyogenes* presence for nasal samples (chi-square = 111.684, df = 1, $P<0.001$) and head samples (chi-square = 74.932, df = 1, $P<0.001$). We did not detect *A. pyogenes* on deer in three of the six physiogeographic regions studied. On the Lower Eastern Shore, we cultured *A. pyogenes* from only one (3%) nasal swab of 32 deer sampled and none of the head swabs. Similarly, on the Western Shore, only one (3%) head swab and no nasal swab cultures included *A. pyogenes* out of 33 animals sampled. The Upper Eastern Shore was the only region where *A. pyogenes* was common; 45% (22/48) and 66% (32/48) of the antler and nasal swabs tested positive, respectively.

White-tailed deer management study

We cultured bacteria from 55 animals (33 females, 22 males) at the QDM property and 58 animals (21 females, 37 males) at the TDM property. The mean number of bacterial species isolated from the QDM property was 2.6 per nasal culture (range 1-4) and 3.0 per antler culture (range 1-5). Overall, 78% of animals sampled on the QDM property carried *A. pyogenes* on at least one swab; 54% of head swabs contained *A. pyogenes*, and 79% of nasal swabs carried *A. pyogenes*. The mean number of bacterial species isolated from the TDM property swabs was 3.6 per nasal culture (range 1-7) and 4.0 per head culture (range 1-8, Table 3, Table 4). Overall, 95% of the TDM property animals were positive for *A. pyogenes* on at least one swab; 84% of nasal swab cultures contained *A. pyogenes*, and 65% of head swab cultures contained *A. pyogenes*.

TABLE 4. BACTERIA CARRIED BY WHITE-TAILED DEER (NASAL%, HEAD%) AT TWO PROPERTIES IN MARYLAND, USA, 2010

Genus	TDM property	QDM property
ESCHERICHIA	30, 23	17, 37
STAPHYLOCOCCUS	66, 81	37, 48
BACILLUS	57, 75	23, 19
PANTOEA	27, 25	40, 38
PSEUDOMONAS	7, 4	25, 27
STREPTOCOCCUS	0, 0	2, 0
PROTEUS	4, 0	0, 2
ARCANOBACTERIUM	84, 65	79, 56
CORYNEBACTERIUM	4, 9	2, 12
CHRYSEOMONAS	23, 0	15, 0
MICROCOCCUS	9, 0	0, 0
SERRATIA	4, 7	2, 4
PENICILLIUM	9, 2	0, 0
PROVIDENCIA	2, 0	0, 0
PASTEURELLA	11, 7	0, 2
MUCOR	0, 2	0, 2
FLAVIMONAS	2, 4	2, 2
ENTEROBACTER	0, 2	4, 0
EDWARDSIELLA	0, 0	2, 2
KLEBSIELLA	2, 0	0, 2
ACINTOBACTER	0, 2	0, 0
ENTEROCOCCUS	0, 5	0, 19

Prevalence of *A. pyogenes* on hunter-killed deer was similar between the QDM and TDM properties for head ($P = 0.35$) and nasal samples ($P = 0.34$, Table 5). Similarly, the prevalence of *A. pyogenes*-positive cultures was similar between the sexes for head ($P = 0.13$) and nasal samples ($P = 0.14$) and across age classes for head ($P = 0.20$) and nasal samples ($P = 0.99$, Table 5, Fig. 2).

Neonate study

Eleven neonates were sampled on the QDM Property. *A. pyogenes* was not cultured from nasal or head swabs of any of these animals.

TABLE 5. BINARY LOGISTIC REGRESSION FOR OCCURRENCE OF *A. PYOGENES* ON WHITE-TAILED DEER ON THE UPPER EASTERN SHORE OF MARYLAND, USA, 2010.

						95% confidence interval	
Sample	Parameter	Estimate	Standard error	Z	P	Lower	Upper
HEAD	SITE	–0.404	0.430	–0.939	0.348	–1.246	0.439
	AGE	0.386	0.303	1.273	0.203	–0.209	0.981
	SEX	0.632	0.420	1.505	0.132	–0.191	1.455
NASAL	SITE	0.514	0.540	0.953	0.340	–0.543	1.572
	AGE	0.003	0.366	0.009	0.993	–0.713	0.720
	SEX	0.785	0.533	1.473	0.141	–0.259	1.829

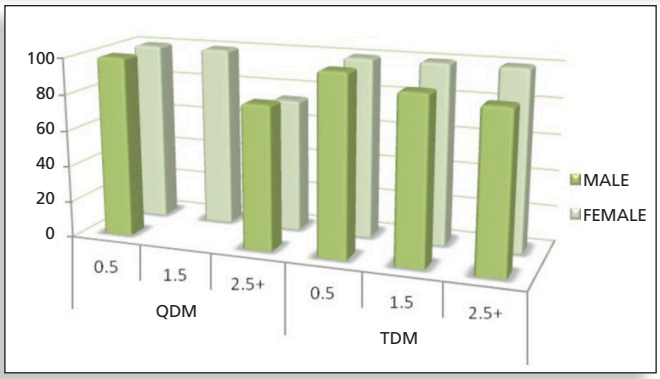


FIGURE 2. *A. pyogenes* percentage by sex, age class (0.5, 1.5, and 2.5+ years), and property on the Upper Eastern Shore, Maryland, USA.

Discussion

There is a tendency for health research to focus on highly communicable zoonotic diseases with devastating impacts on human patients (ebola, anthrax, bovine spongiform encephalopathy, and rabies), and in recent times, a particular emphasis has been placed on what are termed emerging diseases. However, less dramatic and more common zoonoses can have serious economic and environmental impacts. Endemic, chronic infections with a range of disease manifestations can impact one health in ways that may go unrecognized, despite the potential for control through relatively basic means. The concept of "emerging" is particularly complex because recognition of a disease can be affected by observer and diagnostic effort with increasing prevalence simply reflecting greater awareness by the health community. *A. pyogenes* fits the basic definition of zoonosis from Stedman's Medical Dictionary as "an infection or infestation shared in nature by humans and other animals (52)." It is carried by economically important wild and domestic animal species with high potential for close human contact and can cause disease in humans (17,30,34). The long recognition of *A. pyogenes* as a zoonosis argues against assigning it status as an emerging disease on the basis of definitions focused on recent identification of the pathogen, but because it is a zoonotic pathogen that has likely been under-reported and misdiagnosed in humans, the term is not entirely unwarranted. The geographic differences in prevalence of *A. pyogenes* detected in our study suggest the disease may be considered "emerging" in the sense of locality, regional environmental conditions, and the broadening of reservoir potential, including deer. It is challenging to separate environmental and host factors in the epidemiology of disease occurrence. Our environmental study, limited to the six regions of Maryland, showed that site was an important factor in predicting whether *A. pyogenes* was carried by deer. Our design using two different state laboratories to process samples for logistical purposes would have been strengthened with the inclusion of positive controls created with laboratory strains of the organism, but we are confident of the results. Colony growth patterns and colony censuses on plates were similar between laboratories, and each laboratory positively identified *A. pyogenes* in submitted samples. In interpreting data, chi-square *P*-values can be problematic when a data set includes observed values of less than 5, but our results support the hypothesis that region plays a role in distribution of *A. pyogenes* in deer, and the *P*-values are so small that even serving as an approximation, they are highly significant. A broader variety of habitat types or a more fine-scale approach could have shown more profound differences. Our results indicate that environment plays a role in whether *A. pyogenes* is present.

A. pyogenes is considered commensal in domestic livestock species present across the state, but this pattern is not well documented for Maryland, nor is this the pattern of infection we observed in deer. Our results indicate the bacterium is not routinely carried by deer in most of Maryland, lending support to the notion that environmental conditions play a key role in *A. pyogenes* persistence.

Although the constellation of pathology compatible with IASM has been observed in regions of Maryland where we did not recover *A. pyogenes*, reports have anecdotally been concentrated on the Eastern Shore, which includes the region of high prevalence in our study (Eyler, Maryland Department of Natural Resources, personal communication). In addition, the clinical and gross pathological definitions of IASM are not sufficiently developed to reliably distinguish gross lesions associated with any given bacterium, and IASM occurs in the absence of *A. pyogenes*. Therefore, it is important that studies of IASM include careful bacteriological sampling to identify which bacteria are associated with the lesions. Other bacterial genera (i.e., *Staphylococcus*, *Pseudomonas*) that have been isolated from pyogenic cerebral lesions in white-tailed deer (17) are abundant and were recovered from more than 50% of animals sampled in every region of Maryland. The simple identification of an IASM-compatible lesion on a deer should not be considered a marker for *A. pyogenes* infection.

Similarly, presence of *A. pyogenes* in a white-tailed deer is not sufficient for IASM to develop. We detected similar prevalences

of *A. pyogenes* on the QDM and TDM properties, but IASM has not been documented at the TDM Property, while IASM has become increasingly common at the QDM Property (18). It is likely that increased vigilance on the QDM property contributes to this disparity, but our results indicate that bacterial presence, sex ratio, and age structure may interact to help drive IASM prevalence on the Upper Eastern Shore. Therefore, deer management appears to play an important role in the extent to which IASM develops in populations where *A. pyogenes* is present at high levels. Conversely, the presence of IASM in a given population, as seen in our QDM population, may be an indication that *A. pyogenes* could be present, and humans and livestock who come into contact with deer may be exposed to the pathogen.

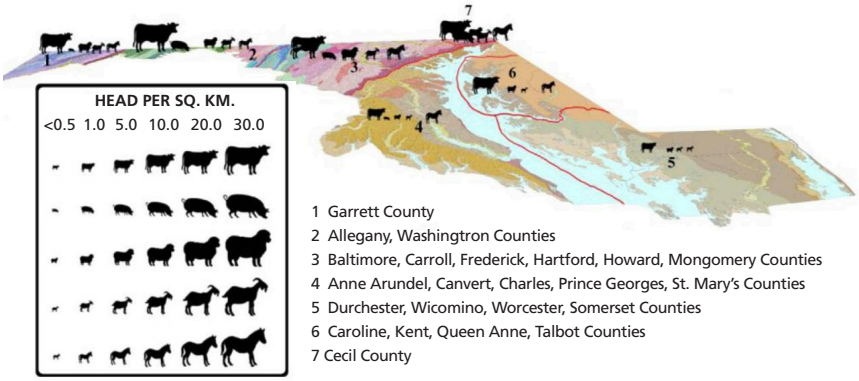


Figure 3. Livestock density by physiogeographic region in Maryland, USA

Our Upper Eastern Shore data indicate that *A. pyogenes* is endemic to that region and may even play a commensal role in some white-tailed deer populations. Although IASM is typically associated with adult male deer, the majority of deer sampled at both sites carried *A. pyogenes* in nasal passages, on heads, or both, regardless of sex or age. Management approach did not affect prevalence of *A. pyogenes*, providing further evidence that the bacterium could play a commensal role in deer populations on the Upper Eastern Shore and possibly similar habitats elsewhere. The question of maintenance of the pathogen remains open to further study.

We did not detect *A. pyogenes* in Upper Eastern Shore neonates, suggesting that neonates acquire the bacteria sometime after birth, presumably either through contact with their dams or environmental exposure sometime after the perinatal period examined in our study. Many of the neonates in our study were sampled within hours of birth, although some had been alive for several days. Even though these older fawns presumably could have been exposed to *A. pyogenes* carried by their dams through grooming interactions or in the environment, cultures of the fawns were negative. In contrast, most Upper Eastern Shore fawns sampled during the fall harvest (defined as the 0.5-year-old age class) tested positive for *A. pyogenes*, which indicates neonates eventually acquire *A. pyogenes* sometime during their first 6 months of life. A longer duration study of fawn flora identifying when fawns are colonized by *A. pyogenes* would help to clarify the role of deer social interactions, cross-species interactions, and environmental exposure in the acquisition of *A. pyogenes*.

If *A. pyogenes* is endemic to the Upper Eastern Shore of Maryland, it is worth considering the effect deer dispersal may have on distribution of the bacteria. It remains unclear how deer acquire *A. pyogenes* and to what extent carrying the bacteria predisposes them to developing IASM, but if intraspecific interactions are involved, dispersal may be an important factor. In our statewide survey, the only other regions where we detected *A. pyogenes*, the Lower Eastern Shore and the Western Shore, are adjacent to the Upper Eastern Shore. Future work could continue to monitor prevalence of *A. pyogenes* in deer and the occurrence of IASM in these areas while expanding surveillance to adjacent sites in Delaware and Pennsylvania.

The long-accepted view of *A. pyogenes* as a normal commensal organism associated with domestic production animals suggests the possibility that feral livestock or production livestock or both could serve as reservoirs in endemic areas. Further, the environmental contamination with *A. pyogenes* by livestock or livestock-deer interactions or both could be important in the maintenance of the disease in an accommodating environment. Figure 3 presents relative livestock abundance in each of the six regions based on annual Maryland livestock inventory data from 2011 (53). The agriculture profile of the Upper Eastern Shore is primarily large-scale crop farming characterized by low livestock concentrations. The region ranks fourth of the six regions we sampled in cattle and sheep density and last in swine and goat density (53). This profile suggests that the presence of farm production animals alone may not explain the high prevalence of *A. pyogenes* in the Upper Eastern Shore. It may be important to examine the density of feral livestock and the potential for white-tailed deer or other wildlife species to play key roles in the maintenance of endemic *A. pyogenes*. The low observed prevalence of IASM coinciding with a high prevalence of *A. pyogenes* at the TDM property supports the potential role of white-tailed deer under traditional management to serve as a potential maintenance reservoir of *A. pyogenes* without any outward signs indicating that they are carrying the pathogen.

The framework of one health is useful for considering the broader implications of white-tailed deer, *A. pyogenes*, and IASM. Humans are not as far removed from white-tailed deer as they may perceive themselves to be. The seasonal close contact experienced by active deer hunters is a key point of one health intersection. Hunters could be educated about the identification of IASM lesions and the importance of proper sanitation and hygiene when handling a deer carcass (24,30). Many other intersections occur, primarily because the white-tailed deer thrives in the presence of humans and is not generally considered a threatening wildlife presence. The crepuscular, edge-occupying habits of white-tailed deer, and the perception they are non-aggressive, may cause the general public to underestimate their proximity and contact with these animals as well as that of companion and domestic animals. Providing information about *A. pyogenes* and possible clinical presentations and therapeutic options to medical and

veterinary professionals in areas where high prevalence of *A. pyogenes* is detected in deer could improve disease recognition and outcome. The identification of a highly endemic area by our study offers the opportunity to better understand the actual health risk parameters, transmission routes, and environmental perturbations of disease occurrence, as well as potential of control measures in wildlife, humans, and domestic animals.

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Disclaimer

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the United States government.

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Personality Counts

By Deb Teachout, DVM

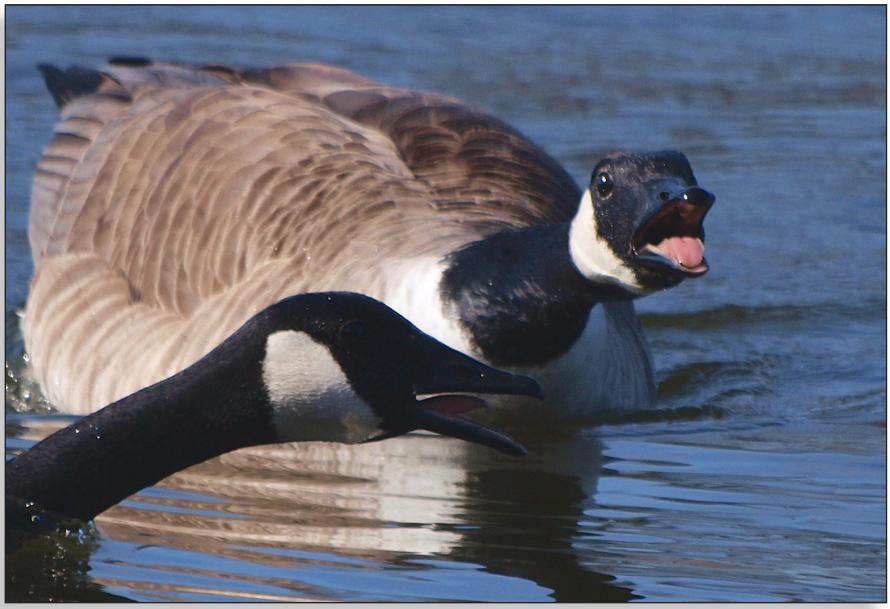


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One winter, we had four Canada geese *(Branta canadensis)* in rehab simultaneously, and I remember marveling at their individual distinctive personalities. There was the one who wanted to attack us every chance she got; there was the one who faced the back corner of the cage and wanted nothing to do with us; there was the one who wanted to follow and hang out with us; and the one who wanted to create games to play with us. When changing their cages, we tried to encourage them to exit their dirty cages on their own and walk into a clean cage. It was at this time that their behavioral differences and distinct personalities were most manifest. In hypothetically assigning personality types to the behavior we witnessed, I would have to say that one Canada goose was bold and aggressive; one was shy and frightened; one was curious and social; and one was intelligent and fun-loving. Seem anthropomorphic? Maybe, but researchers are finding a real connection between individual personality and survival in translocation of wildlife. This is actually part of a larger new movement called "Compassionate Conservation," where the welfare of each individual animal is being addressed and considered just as important as the health of animal populations. After all, the success of translocation or re-introduction of animals depends on each individual surviving, and, for an individual to survive, she requires good welfare. To assess animal welfare, we must involve animal welfare science, and this discipline regards psychological aspects of animals such as emotions, cognition, preferences, and personality as not only integral to the welfare of the animal, but also able to be studied scientifically. I hope this new merger of conservation biology and animal welfare science improve the odds of post release survival, which are currently poor. Statistics show translocation (including re-introduction) mortality rates as high as 50–95%(1). Did you know that different personalities within a population have fitness consequences? Mortality, breeding, dispersal, partner preference, disease risk, and vulnerability to parasites are correlated with individual personality difference (1). In very recent research, Liv Baker, a PhD candidate in Applied Animal Biology at the University of British Columbia, reported that translocation stressors affect individuals differently, and revealed that certain personality types do cope with translocation stressors better than others. Her dissertation is one of the first translocation projects to attempt an individual-based approach to understanding translocation success by systematically implementing animal welfare science based methodologies. One hundred fifty-two Stephens' kangaroo rats (SKR; *Dipodomys stephensi*), an endangered species of desert rodent endemic to southern California, were trapped, held in captivity, and then translocated from two separate disturbed areas (a campground overflow parking lot and a privately owned land parcel) to a protected, unoccupied habitat as part of a larger translocation project. They were soft released; some wore a transmitter, some did not. Survival was measured one month after release. To understand how individual animals respond to translocation stressors Baker used measures of stress physiology, animal behavior, and psychology. She identified three key dimensions of SKR personality that she interpreted as Assertiveness, Excitability, and Persistence. High Assertiveness SKR were more exploratory, displayed riskier behavior, and had low basal cortisol. Low Assertiveness SKR were less exploratory, less risky in behavior, and had higher basal cortisol. From the outset, the two different populations of SKR (parking lot vs. land parcel) showed distinct behavioral and physiological differences. The parking lot SKR displayed less exploratory and risky behaviors in personality tests and tended to have higher basal fecal cortisol than did SKR from the land parcel. The parking lot SKR had significantly higher survival rates at one month after release. In general, these survivors were more cautious, explored less,

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Habitat selection of a large carnivore along human-wildlife boundaries in a highly modified landscape

Chihiro Takahata, Scott Eric Nielsen, Akiko Takii, and Shigeyuki Izumiyama. 2014. *PLOS ONE*. doi: 10.1371/journal.pone.0086181. 23 January 2014.

When large carnivores occupy peripheral human lands conflict with humans becomes inevitable, and the reduction of human-carnivore interactions must be the first consideration for those concerned with conflict mitigation. Studies designed to identify areas of high human-bear interaction are crucial for prioritizing management actions. Due to a surge in conflicts, against a background of social intolerance to wildlife and the prevalent use of lethal control throughout Japan, Asiatic black bears (*Ursus thibetanus*) are now threatened by high rates of mortality. There is an urgent need to reduce the frequency of human-bear encounters if bear populations are to be conserved. To this end, we estimated the habitats that relate to human-bear interactions by sex and season using resource selection functions (RSF). Significant seasonal differences in selection for and avoidance of areas by bears were estimated by distance-effect models with interaction terms of land cover and sex. Human-bear boundaries were delineated on the basis of defined bear-habitat edges in order to identify areas that are in most need of proactive management strategies. Asiatic black bears selected habitats in close proximity to forest edges, forest roads, rivers, and red pine and riparian forests during the peak conflict season, and this was correctly predicted in our human-bear boundary maps. Our findings demonstrated that bears selected abandoned forests and agricultural lands, indicating that it should be possible to reduce animal use near human lands by restoring season-specific habitat in relatively remote areas. Habitat-based conflict mitigation may therefore provide a practical means of creating adequate separation between humans and these large carnivores.

Recreational boats and turtles: behavioral mismatches result in high rates of injury

Lori A. Lester, Harold W. Avery, Andrew S. Harrison, and Edward A. Standora. 2013. *PLOS ONE*. doi: 10.1371/journal.pone.0082370. 11 December 2013.

Recreational boats are a dominant feature of estuarine waters in the United States. Boat strike injury and mortality may have a detrimental effect on populations of diamondback terrapins (*Malaclemys terrapin*), a keystone species in estuarine ecosystems. In Barnegat Bay, New Jersey, 11% of terrapins (n = 2,644) have scars consistent with injuries from boats. Conservative estimates of injury rates from boats increased from 2006 to 2011. When exposed to playback recordings of approaching boat engines of varying sizes and speeds *in situ*, terrapins did not significantly change their behavior in response to sounds of boat engines of different sizes. The lack of behavioral response of terrapins to boat sounds helps explain high rates of injury and mortality of terrapins and may threaten the viability of terrapin populations. Boater education courses that discuss impacts of boats to wildlife, combined with closure of areas of high terrapin densities to boating, are necessary to protect terrapins and other aquatic species from injury and mortality caused by motorized boats.

Infectious canine hepatitis in free-ranging red foxes (*Vulpes vulpes*)

A. W. Philbey, & H. Thompson. 2014. *Journal of Comparative Pathology* 150(1): 84.

Introduction: Infectious canine hepatitis (ICH), caused by canine adenovirus type 1 (CAV-1), has been reported mostly in dogs, farmed foxes, and other captive carnivores. Initially called "epizootic fox encephalitis," ICH was first identified in domesticated ("tamed") silver foxes, a color variant of the red fox (*Vulpes vulpes*). ICH was diagnosed in a free-ranging grey fox (*Urocyon cinereoargenteus*) in Georgia, USA, in 2005. There is serological evidence of exposure to CAV-1 in free-ranging red foxes in North America, Germany, Australia, and the UK, as well as in free-ranging grey foxes in North America.

Materials and Methods: Sick free-ranging red foxes were presented to wildlife rehabilitation centers in the UK, where they died naturally. Tissues were submitted for virus isolation and histopathology.

Results: ICH was diagnosed in three red foxes found depressed or collapsed in the wild. Grossly, the foxes were jaundiced and had congested livers with accentuation of the lobular pattern. Histologically, there was generalized necrosis and dissociation of hepatocytes, with intranuclear inclusion bodies in hepatocytes, renal glomeruli, proximal convoluted renal tubular epithelial cells, and vascular endothelial cells. CAV-1 was isolated from all three foxes.

Conclusions: Free-ranging red foxes are considered to be a reservoir of CAV-1 in the UK and are a potential source of infection for domestic dogs.

Effects of social disruption in elephants persist decades after culling

Graeme Shannon, Rob Slotow, Sarah M. Durant, Katito N. Sayialel, Joyce Poole, Cynthia Moss, and Karen McComb. 2013. *Frontiers in Zoology* 10: 62. doi:10.1186/1742-9994-10-62.

Multi-level fission-fusion societies, characteristic of a number of large brained mammal species including some primates, cetaceans, and elephants, are among the most complex and cognitively demanding animal social systems. Many free-ranging populations of these highly social mammals already face severe human disturbance, which is set to accelerate with projected anthropogenic environmental change. Despite this, our understanding of how such disruption affects core aspects

of social functioning is still very limited.

We now use novel playback experiments to assess decision-making abilities integral to operating successfully within complex societies, and provide the first systematic evidence that fundamental social skills may be significantly impaired by anthropogenic disruption. African elephants (*Loxodonta africana*) that had experienced separation from family members and translocation during culling operations decades previously performed poorly on systematic tests of their social knowledge, failing to distinguish between callers on the basis of social familiarity. Moreover, elephants from the disrupted population showed no evidence of discriminating between callers when age-related cues simulated individuals on an increasing scale of social dominance, in sharp contrast to the undisturbed population where this core social ability was well developed.



Red Fox (*Vulpes vulpes*).
PHOTO ©PETER TRIMMING, FLICKR.COM. CREATIVE COMMONS LICENSE.

Key decision-making abilities that are fundamental to living in complex societies could be significantly altered in the long-term through exposure to severely disruptive events (e.g., culling and translocation). There is an assumption that wildlife responds to increasing pressure from human societies only in terms of demography however, our study demonstrates that the effects may be considerably more pervasive. These findings highlight the potential long-term negative consequences of acute social disruption in cognitively advanced species that live in close-knit kin-based societies, and alter our perspective on the health and functioning of populations that have been subjected to anthropogenic disturbance.

Evaluation of thermal antinociceptive effects after oral administration of tramadol hydrochloride to American kestrels (*Falco sparverius*)

David Sanchez-Migallon Guzman, Tracy L. Drazenovich, Glenn H. Olsen, Neil H. Willits, and Joanne R. Paul-Murphy. 2013. *American Journal of Veterinary Research* 74(6): 817-822. doi: 10.2460/ajvr.74.6.817

Objective: To evaluate the thermal antinociceptive and sedative effects and duration of action of tramadol hydrochloride after oral administration to American kestrels (*Falco sparverius*).

Animals: 12 healthy 3-year-old American kestrels.

Procedures: Tramadol (5, 15, and 30 mg/kg) and a control suspension were administered orally in a masked randomized crossover experimental design. Foot withdrawal response to a thermal stimulus was determined 1 hour before (baseline) and 0.5, 1.5, 3, 6, and 9 hours after treatment. Agitation-sedation scores were determined 3 to 5 minutes before each thermal stimulus test.

Results: The lowest dose of tramadol evaluated (5 mg/kg) significantly increased the thermal foot withdrawal thresholds for up to 1.5 hours after administration, compared with control treatment values, and for up to 9 hours after administration, compared with baseline values. Tramadol at doses of 15 and 30 mg/kg significantly increased thermal thresholds at 0.5 hours after administration, compared with control treatment values, and up to 3 hours after administration, compared with baseline values. No significant differences in agitation-sedation scores were detected between tramadol and control treatments.

Conclusions and Clinical Relevance: Results indicated oral administration of 5 mg of tramadol/kg significantly increased thermal nociception thresholds for kestrels for 1.5 hours, compared with a control treatment, and 9 hours, compared with baseline values; higher doses resulted in less pronounced antinociceptive effects. Additional studies with other types of stimulation, formulations, dosages, routes of administration, and testing times would be needed to fully evaluate the analgesic and adverse effects of tramadol in kestrels and other avian species.

"Magnetic cleansing" for the provision of a "quick clean" to oiled wildlife

Lawrence N. Ngeh, John D. Orbell, Stephen W. Bigger, Kasup Munaweera, and Peter Dann. 2012. *World Academy of Science, Engineering and Technology* 72: 12-27.

This research is part of a broad program aimed at advancing the science and technology involved in the rescue and rehabilitation of oiled wildlife. One aspect of this research involves the use of oil-sequestering magnetic particles for the removal of contaminants from plumage —so-called "magnetic cleansing." This treatment offers a number of advantages over conventional detergent-based methods, including portability, which offers the possibility of providing a "quick clean" to the animal upon first encounter in the field. This could be particularly advantageous when the contaminant is toxic and/or corrosive and/or where there is a delay in transporting the victim to a treatment center. The method could also be useful as part of a stabilization protocol when large numbers of affected animals are awaiting treatment. This presentation describes the design, development, and testing of a prototype field kit for providing a "quick clean" to contaminated wildlife in the field.

Welfare based primate rehabilitation as a potential conservation strategy: does it measure up?

Amanda J. Guy, Darren Curnoe, and Peter B. Banks. 2014. *Primates* 55(1): 139-147.

Many primate species are threatened with extinction and are the focus of extensive conservation efforts including re-introduction, captive breeding, and habitat conservation. Welfare-based rehabilitation (hereafter also "rehabilitation") is a management strategy commonly used for primates, particularly those species targeted by the pet and bush meat trades. Rehabilitation of rescued primates typically has the dual motivation of welfare and conservation, but has not been assessed

as a conservation strategy. As the species involved in rehabilitation are often endangered (e.g., chimpanzees *(Pan spp.)*, gorillas (*Gorilla spp.*), orangutans (*Pongo spp.*), it is important for rehabilitation projects to follow a "best practice" model in order to increase positive outcomes. In this study, we compared the approaches of 28 welfare-based primate rehabilitation projects to the "IUCN guidelines for nonhuman primate re-introductions," in addition to components of the "Best practice guidelines for the re-introduction of great apes" in order to assess where additional work might be needed for released animals to contribute to conservation outcomes. Few projects examined complied with the guidelines for re-introduction, failing to incorporate important factors such as quarantine, long term post-release monitoring, and training for predator awareness. Further development of species-specific rehabilitation guidelines may improve the outcomes of future rehabilitation projects. To support this, we recommend that detailed methods and results be published for all rehabilitation efforts, regardless of the outcome.

Does vaccination against feline parvovirus protect hospitalized raccoon kits from clinical outbreaks of parvoviral disease?

Maja-LisaBroersma. 2013. Thesis/SLU, Faculty of Veterinary Medicine and Animal Science, Veterinary Program, Dept. of Clinical Sciences, Uppsala, Sweden. Online: http://stud.epsilon.slu.se/6270/. Accessed 14 March 2014.

The northern raccoon (*Procyon lotor*) belongs to the Carnivore family and is a species endemic to North America. Every year, hundreds of orphaned raccoon cubs are admitted into the Wildlife Rehabilitation Center of Minnesota (WRCM), a non-profit organization where all injured or orphaned wild animals are admitted and receive quality health care with the goal of being released out into the wild.

The WRCM routinely vaccinates all of the admitted raccoon cubs with a killed feline panleucopenia vaccine, but despite this there are outbreaks of parvovirus infection every year where up to 50% of the admitted cubs have been euthanized or died. The objective of this study was to determine whether vaccinating the admitted raccoon kits has any significant protective effect to developing clinical parvoviral disease.

A single-blinded cohort study was designed with two parallel, independent groups. One group was given a dose of killed feline parvovirus vaccine at admission, and the other group was not given any vaccination at all. Assignment to the vaccinated or unvaccinated group was on a per-litter basis and done randomly by drawing lots out of a box. A second dose of vaccine was administered to the vaccinated group after two weeks if the litter was still in-housed. In all other respects, the groups received the same treatment, handling, and medical care. The two groups were housed in two different rooms of the same building. To accommodate room size, the two study groups were proportioned so that one-third of the study population was not vaccinated and two-thirds were vaccinated. The raccoon kits were continually assessed clinically and these observations served as the base for incidence calculations according to pre-defined criteria. The difference between the groups was calculated concerning overall disease, sickness, and death/euthanasia. Two blood samples were collected from every admitted raccoon for serological testing.

A total of 201 individual raccoon cubs were admitted into the WRCM mammal nursery in 2012 and served as the study population for this study. The non-vaccinated study group held 46 individuals, and the vaccinated study group consisted of 116 individuals. The results indicate that orphaned raccoon kits taken into the WRCM benefit from vaccination against FPV. Vaccinated individuals had a 0.54 relative risk of acquiring clinical parvoviral disease compared to unvaccinated individuals ($p = 0.07$). Serological testing for antibody titers was done for a few individuals in each study group. No significant difference was found between the vaccinated and unvaccinated individuals regarding antibody titers. ■

Personality

CONTINUED FROM PAGE 30

took longer to approach predatory stimuli, were less excitable, were more social, spent more time in available burrows, and had a more active stress response.

The SKR from the parking lot had learned to live without aerial cover, perhaps teaching them to be more vigilant. This may have served them well in their new environment. The SKR from the land parcel had dense grass and shrub cover, and they could afford to be less vigilant. Land parcel SKR liked to rest outside of their burrows. Perhaps the consistent survival rate differences between the two groups of SKR were due in part to different behaviors learned from living in their original respective habitats.

Translocation stressors differentially affect individuals. Individuals with certain personality types and certain life experience cope with translocations better than other individuals of the same species cope. Personality of the species is important to map, then, if we are to learn how to manage these different personality types for successful release and long term survival.

This will be an important and fascinating field to watch for wildlife rehabilitators, as I can see a very practical application for us if we could start to use observed personality traits as predictors of survival after release.

Makes me wonder which of my four Canada geese did the best after release. I bet it was the one who was intelligent and fun-loving. ■

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Deb Teachout is a veterinarian in Illinois, USA, treating both domestic and wildlife patients. She is a past member of the IWRC Board of Directors, an associate editor for JWR, and a long-time animal advocate.

TAIL END



"I'm King of the Road. Make my day!"

Crayfish *(Procambarus alleni)*

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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.

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

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Diamondback Terrapin (*Malaclemys terrapin*).
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