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IN THIS ISSUE: CLINICAL SIGNS OF A NEWLY RECOGNIZED PROTOZOAL DISEASE IN THE HOUSE FINCH...COMPARED GROWTH RATES AND NUTRITIONAL STATUS OF URBAN VS RURAL AMERICAN CROW NESTLINGS...POST-RELEASE GPS TRACKING OF HAND-REARED IRISH HARES

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:
Irish Hare *(Lepus timidus),*
Dromara Hills, N. Ireland.
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Left:
Male house finch *(Carpodacus mexicanus).*
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JOURNAL OF WILDLIFE REHABILITATION

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Outreach

Are you an ethical wildlife rehabilitator? I expect most, if not all, readers will answer with a resounding, possibly indignant, "*Yes!*" But what does it mean to care for captive wild animals in an ethical manner?

In the early days of rehabilitation, our priority was often just to keep the patients alive. We knew so little then about the nutritional requirements of wild species, or about minimum housing standards, or which drugs could be used safely on which species. Looking back, it's hard to believe anything lived to be released back into the wild.

There will always be more to learn, but wildlife rehabilitation has come a long way. We've moved from a veterinary medicine emphasis to a more holistic approach that considers diet along with natural history and behavior. Perhaps the time has come to think about wildlife rehabilitation even more broadly.

My first conscious brush with the ethical treatment of wild animals came when I was 12 years old. My younger brother, Steve, had carried a hapless wild box turtle home. This was nothing unusual. I'd done the same thing many times, as had most of my cohorts, back when a kid had to come up with an excuse to stay inside and watch TV on a sunny summer day. Steve wasn't cruel; he was curious. He dragged a large galvanized tub out of the tool shed, added an Imperial® margarine dish filled with water, tossed in some handfuls of vegetation, and set the reptile down gently in his new habitat.

He then promptly ran off in search of other adventures.

As I went about my 12-year-old business in the backyard, I periodically peered inside the tub. The turtle walked in a resolute circle along the metal wall, searching for an undiscovered escape hatch. The next morning, I went to check on the prisoner. He was tucked securely in his shell, but once the day warmed up sufficiently, the circular march began again and continued through the day.

By evening, I was consumed with worry over the poor creature. So under cover of darkness, I slipped outside and tipped the tub on its side, as if a large dog had wandered by and upset the apple cart. The turtle sped off, and I went back inside to a much better night's sleep than I'd had the night before. As a pre-teen, it's clear I was more concerned with doing right by a turtle than I was about the ethics of lying to my brother.

The ethics of living—and of caring for nonhuman animals—have grown more complex as I've aged. Maybe it's my perspective that's changed. When I directed a rehabilitation center in Houston, I faced all kinds of ethical dilemmas, and I was often too busy to give much thought to treatment protocols once they were established. I'm astonished to realize that was only 15 years ago, when rehabbers still fed neonate songbirds high-calorie, low-nutrient "turkey mash."

Thanks to the persistent drive to improve care standards within the rehabilitation community, our patients have a better chance than ever to survive not only what brought them to us, but the care itself.

In the spirit of a desire to see that progress continue, I'm proud to introduce a new column, *Wild Rights* (see page 30). Columnist Deb Teachout, DVM, will guide us in exploring ethics and animal welfare in the rehabilitation practice. Deb is an IWRC Board member, an associate editor for JWR, and a long-time animal advocate. I know she's going to give everyone plenty to chew on while they're warming bottles and filling gaping mouths in the wee hours.

Kieran J. Lindsey, Editor
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Group Plans to Sue for Species Protection

BIRMINGHAM, Ala., USA (April 23, 2011)—A coalition of environmental groups has notified the U.S. Fish and Wildlife Service (USFWS) of its intention to sue the agency, claiming failure to act on a petition asking that more than 400 species in Southeastern streams and rivers be listed as threatened or endangered species.

Alabama Rivers Alliance, the Center for Biological Diversity, and others petitioned the department a year ago. They cited the declining numbers of animals such as the Florida sandhill crane, hellbender and black warrior waterdog salamanders, Alabama map turtle, and burrowing bog crayfish.

Jeff Fleming, spokesman for the USFWS Southeast Regional Office, said the agency has been strained by diminished budgets and the Gulf oil spill but still processes petitions for species protection.

Virus Killing Florida Ducks

ST. PETERSBURG, Fla., USA (April 21, 2011)—Florida Fish and Wildlife Conservation Commission officials say a virus may be killing ducks near downtown St. Petersburg. A necropsy performed on one of the 25 dead ducks recently found along the shores of Crescent Lake revealed viral enteritis, also known as duck plague. Officials say the disease, which affects geese, ducks, and swans, is highly contagious and causes internal bleeding and severe diarrhea.

Louise Shimmel Receives NRWA's Lifetime Achievement Award

EUGENE, Ore., USA (April 6, 2011)—Twenty-one years ago, Louise Shimmel founded the Cascades Raptor Center, operating from her two-bedroom duplex. Now, the center's home is a 3.5-acre nature facility with three paid employees and over 100 volunteers who typically care for an average of 200 birds a year. The center has cared for approximately 3,000 birds over its two-decade history.

Along the way, Shimmel has become well-known as a reliable and knowledgeable resource among wildlife rehabilitators, falconers, and veterinarians around the world. She has served as an IWRC instructor, on the editorial staff of the *Journal of Wildlife Rehabilitation*, and on the organization's board of directors.

In February of this year, Shimmel received the National Wildlife Rehabilitators Association Lifetime Achievement Award, presented at the organization's annual meeting in Albany, New York. Congratulations, Louise!

Potent Rat Poisons Killing Wildlife

SACRAMENTO, Calif., USA (April 21, 2011)—A new generation of highly toxic, long-lasting poisons intended for rodents is also killing the animals that feed on them. Sold variously as D-Con, Havoc, Talon, Tomcat Ultra, and Just One Bite, the poisons are used in warehouses, at apartment complexes, on golf courses, and even on nature sanctuaries, killing not only rats and mice but non-target species such as bobcats, coyotes, kit foxes, owls, and

IN MEMORIAM

FRANCINE JONES, CWR (1962-2011)

Francine Jones, age 49, died unexpectedly on May 24th, 2011 in Michigan, USA.

Francine volunteered with River Raisin Raptor Center in Michigan for a number of years before getting her own state and federal permits. Dody Wyman, also of River Raisin, described Francine as one of the most unique people she has known, "full of generosity, quirkiness, and friendliness...When it came time for her raptor patients, she was all serious business."

Francine and her father, Paul, did many rescues and releases together in the Ann Arbor, Michigan area.

BOB LINDSAY (1951-2011)

Bob Lindsay, of Wichita Falls, KS, USA died April 25, 2011, at 59 years of age.

Bob was a Director and Volunteer Coordinator for Wildlife Rescue and Rehabilitation (1993-2005) and Executive Director for Wild Bird Rescue (2005-2011).

Bob served 24 years in the USAF until retirement. He is survived by his wife, Phyllis; daughter Heather Lindsay of San Antonio, TX; and extended family. The family requests remembrances be made in Bob's honor to Wild Bird Rescue, Inc., Wichita Falls, Kansas. Condolences may be sent to the family at www.owensandbrumley.com.

NONDA SURRATT (1954-2011)

Nonda Surratt passed away March 25, 2011 in Hebron, OH, USA. She was 56.

Nonda's love for animals was a cornerstone of her life. A long-time wildlife rehabilitator, she spoke at the National Wildlife Rehabilitation Association throughout the U.S. and Canada. She was a Director of the Michigan Wildlife Rehabilitators Association and an avid outdoor photographer.

Nonda is survived by husband Donald Surratt, mother Marguerite Miller, stepfather Russell Miller, and extended family. The family requests memorial gifts be given to Dawes Arboretum, Newark, OH, where a fund has been established for a bench in her memory.

ANDREA RENE WICKHAM (1957-2011)

Andrea Wickham, Cuero, Tx, USA, died April 9, 2011 after a brief bout with cancer. She was 53.

Andi worked for 20 years at the University of Texas Marine Science Institute, joining numerous research trips to Antarctica, and caring for injured wildife from dolphins to shore birds to sea turtles at the Animal Rehabilitation Keep (ARK) in Port Aransas. She is survived by parents RO and Barbara Thomas Wickham and brother Drake (Cuero), sister Kris Fowler and husband Jim, brother Matt Wickham and wife Gay, nieces and nephews, and many pets. The family suggests the ARK in Port Aransas or Hospice of South Texas for remembrance gifts.

hawks. Companies have been developing more lethal compounds because rats and mice have developed resistance to older poisons such as warfarin (which is also used as a prescription blood thinner).

Research by Stella McMillin, an environmental scientist with the pesticide investigations unit of the California Department of Fish and Game, as well as by others, shows that exposure to rat [poison] is widespread, especially in and near urban areas. Around Bakersfield, 79% of endangered San Joaquin kit foxes tested have turned up positive for rodenticide. Near Los Angeles, 90% percent of bobcats sampled had rat poison in their blood. Research by Seth Riley, a wildlife ecologist with the National Park Service, has linked rat poison exposure to a rare, often-fatal form of mange in southern California bobcats.

The problem isn't limited to California. When owls in western Canada were tested, 70% had rat poison in their livers. In New York, 265 raptors tested positive for poison and, in Great Britain, half of all barn owls tested were contaminated.

Maggie Sergio, director of advocacy at WildCare, a [San Francisco] Bay Area wildlife rehabilitation center that has responded to many poisoning cases, says rodenticides are the new DDT, killing nature's own rodent control.

Researchers say the federal government has been slow to respond to the problem, which has been building for more than a decade. This June, after years of study, regulations take effect nationwide banning the most toxic, long-lasting rat poisons from hardware stores, big box home improvement centers, and other consumer outlets. But many feel the move does not go far enough, since the poisons can be purchased from other sources.

Sales of small packets and blocks will be banned, but larger bait blocks will continue to be available at farm stores. Licensed commercial pesticide applicators will still be able to use these poisons. Another possible source of exposure for wildlife is marijuana farms. McMillin told the *Sacramento Bee* that when the growers are busted, law enforcement officers usually find a lot of pesticides. "And obviously they are not being careful to use them legally."

Alaska to Ban Firing Stun Guns at Wild Animals

ANCHORAGE, Alaska, USA (April 13, 2011)—The state of Alaska is moving to outlaw firing stun guns at wild animals. While it isn't clear whether anyone has been engaged in an activity referred to as "catch-and-release hunting," a regulation approved by the state Board of Game aims to stop the problem before it starts. Larry Lewis, a wildlife manager with the Alaska Department of Fish and Game, said, "This was a proactive measure. With new, emerging technology, there's always potential for misuse." The regulation, which applies to Tasers and other electronic devices, will go into effect July 1.

Naked Penguin Chicks Puzzle Researchers

CAPE TOWN, So. Africa (April 8, 2011)—Researchers from the Wildlife Conservation Society (WCS) and the University of Washington are baffled by a mysterious disorder that has caused penguin chicks on both sides of the South Atlantic to lose their feathers.

The condition, known as feather-loss disorder, was first seen in a wildlife rehabilitation center in Cape Town, South Africa in 2006, where around 59% of the chicks lost their feathers. The following year, researchers observed the same disorder in the chicks of wild Magellanic penguins at four sites along Argentina's coastline.

In both cases, penguin chicks with feather-loss disorder grew more slowly than feathered chicks, possibly because they needed to expend more energy to regulate their body temperature in the absence of an insulating coat of feathers.

"The recent emergence of feather-loss disorder in wild bird populations suggests that the disorder is something new," said Mariana Varese of WCS's Latin America and Caribbean Program, [and] says the emergence of this disorder suggests that it's something new to wild bird populations. Penguins are already facing a number of survival challenges, including oil pollution and climate changes, causing researchers to be even more concerned about understanding the disorder and finding a way to stop feather loss.

Studies Link Hunting to Lead in Scavenging Birds

DAVIS, Calif. USA (April 16, 2011)—Two studies by University of California, Davis suggest that carrion-eating birds, including eagles and vultures, often consume lead ammunition. These species feed on remains left behind after hunters clean their kill or when a wounded animal escapes capture only to die later on.

When eaten, shot pellets and bullet fragments can result in lead poisoning, which causes birds to die of anemia, seizures, and starvation. In 1991, lead ammunition was banned in the United States for hunting waterfowl, in large part to protect bald eagles. Lead ammunition was banned in the range of the endangered California condor in 2008.

Now, U.C. Davis has found direct evidence that the blood lead levels of free-flying turkey vultures rose in areas where deer and wild pig hunts took place. A second study found that the lead-ammunition ban in California condor range reduced lead exposure in golden eagles and turkey vultures.

Indian Tiger Population Rises 14%

NEW DELHI, India (March 28, 2011)—According to a new census by the National Tiger Conservation Authority (NTCA), in cooperation with the World Wildlife Fund (WWF), India's wild tiger population has increased 14% over the past three years. There are now an estimated 1,706 wild tigers in India.

Census results in the largest count ever attempted were released at the opening of the International Tiger Conservation Conference. During a previous meeting, officials established the Global Tiger Recovery Program, designed to boost a species that has seen its numbers in the wild shrink by 94% in the past century. ■

Clinical Signs and Histopathologic Findings Associated with a Newly Recognized Protozoal Disease (*Trichomonas gallinae*) in Free-Ranging House Finches (*Carpodacus mexicanus*)

Nancy L. Anderson, D.V.M., Ph.D., Christine K. Johnson, D.V.M., Ph.D., Sandy Fender, Susan Heckly, B.A., Marcia Metzler, B.A., Pam Nave, and Jean Yim, B.S.

Male House Finch *(Carpodacus mexicanus).*

ABSTRACT: This paper describes the clinical signs and histopathologic findings associated with an emergent disease associated with *Trichomonas gallinae* infections in free-ranging house finches *(Carpodacus mexicanus)* in California. Wet mounts were necessary to detect *T. gallinae* infections in house finches because classical clinical presentation, such as caseous stomatitis or ingluvitis, occurred in <25% of cases. Early detection was instrumental in preventing trichomonosis outbreaks in a high-density nursery ($P < 0.0001$). Detection before onset of clinical signs was critical. Despite treatment, ~95% of house finches died within 24 hr of displaying signs of illness. In contrast, 58% of *T. gallinae*-positive house finches housed in a nursery survived if they received treatment before onset of clinical signs. Recurrent protozoal shedding in survivors was not evident.

KEY WORDS: *Carpodacus mexicanus*, house finch, trichomonad, *Trichomonas gallinae,* wildlife rehabilitation.

Introduction

Trichomonas gallinae is a well-documented protozoal parasite of free-ranging Columbiformes, raptors, and domestic poultry (McDougald 1991, Conti 1993, Samour 2000, Krone *et al.* 2005, Dolan 2006, Bunbury *et al.* 2007). Infections are classically associated with caseous lesions of the mouth, esophagus, and crop. Regurgitation, crop stasis, depression, and anorexia are also common clinical findings. Trichomonosis has only infrequently been documented in other orders of birds. Almost all of these reports occurred in colonies of sick, captive birds where exposure to Columbiformes was possible or documented (Baker 1986, Henderson *et al.* 1988, McKeon *et al.* 1997, St. Leger and Shivaprasad 1998, Silvanose *et al.* 1998). Species reported to be infected include canary (*Serinus serinus*), gouldian finch (*Chloebia gouldiae*), zebra finch (*Taeniopygia guttata*), budgerigar (*Melopsittacus undulatus*), Houbara bustard (*Chlamydotis undulata*), and Kori bustard (*Ardeotis kori*) (Baker 1986, Henderson *et al.* 1988, McKeon *et al.* 1997, St. Leger and Shivaprasad 1998, Silvanose *et al.* 1998). Clinical signs varied by species, but with the exception of caseous sinusitis in a collection of canaries, zebra finches, and gouldian finches, clinical signs were similar to those described for Columbiformes (Baker

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1986, Henderson *et al.* 1988, St. Leger and Shivaprasad 1998).

Only within the last 15 yr have trichomonad organisms been associated with disease in free-ranging passerines. These reports are rare and incompletely describe the clinicopathologic features of trichomonad infections in these orders. A postmortem examination of a free-ranging juvenile mockingbird (*Mimus polyglottos*) from Tennessee, United States described fatal pyogranulomatous diverticulitis, enteritis, and necrotizing meningoencephalitis. The lesions were associated with an organism appearing similar to *Tetratrichomonas gallinarum* on electronmicroscopy (Patton and Patton 1996). Trichomonas-like organisms were also detected on wet mounts obtained from North American songbirds diagnosed with caseous sinusitis. The birds were group-housed in aviaries at a wildlife rehabilitation center located in Delaware, United States (Welte 2000). Host species affected included mockingbird, wood thrush (*Hylocichla mustelina*), robin (*Turdus migratorius*), catbird (*Dumetella carolinensis*), brown thrasher (*Toxostoma rufum*), and blue jay (*Cyanocitta cristata*). Clinical signs included periocular swelling, chemosis, oculonasal discharge, and respiratory compromise. Treatment with metronidazole was unsuccessful. Subsequently, birds were treated with ronidazole, topical amikacin, and surgical debridement of the infraorbital sinuses. Clinical signs resolved in 75% of birds and these individuals were released 10–12 days post-treatment (Welte 2000). Finally, *Trichomonas*-like organisms were found in free-ranging greenfinches (*Carduelis chloris*) and chaffinches (*Fringilla coelebs*) experiencing mortality in Great Britain. Associated clinical signs were classical for trichomonosis and consisted of caseous ingluvitis and esophagitis (Holmes and Duff 2005, Pennycott *et al.* 2005).

In contrast to the few reports found in the literature, the wildlife rehabilitation hospital at Lindsay Wildlife Museum, located in Walnut Creek, California (United States) routinely admits sick house finches (*Carpodacus mexicanus*) with *Trichomonas*-like organisms on wet mounts. Polymerase chain reaction (PCR) testing and DNA sequencing of the flagellated protozoa cultured from house finches admitted to the wildlife hospital identified the protozoa as a strain of *T. gallinae* that was genetically identical to *T. gallinae* cultured from free-ranging Columbiformes (mourning dove [*Zenaida macroura*], band-tailed pigeon [*Columba fasciata*]), raptors (barn owl [*Tyto alba*], red-shouldered hawk [*Buteo lineatus*]), and corvids (scrub jay [*Aphelocoma californica*], crow [*Corvus brachyrhynchos*]) from the same geographic area (Anderson *et al.* 2009). The organism was also identical to *T. gallinae* (strain g7), cultured from domestic poultry, for the 5.8s ribosomal RNA (rRNA) gene (gb AY349182.1) (Anderson *et al.* 2009). Prevalence of infection and case fatality ratio among admitted house finches were 1.7% and 95.5%, respectively (Anderson *et al.* 2009).

Historically, trichomonosis outbreaks at Lindsay Wildlife Museum usually occurred in immature house finches while being raised in the baby bird nursery. A positive diagnosis was made when saline wet mounts obtained from the oral cavity were positive for flagellated protozoa. Infected birds and exposed cage mates were routinely treated with carnidazole (20–30 mg/kg p.o. q24 for 3–5 days). However, this protocol did not control trichomonosis outbreaks in the nursery. Each year, dozens of finches required multiple courses of treatment and deaths due to trichomonosis occurred throughout the summer season.

The objectives of this study were to document the clinicopathologic features and response to treatment of house finches infected with *T. gallinae* and to determine whether screening house finches at admission with saline wet mounts could prevent *T. gallinae* outbreaks in the baby bird nursery.

Materials and Methods

Case classification

From 2001 to 2005, house finches were screened on admission (i.e., before treatment or hospitalization) for mobile, flagellated protozoa with fresh, warmed (37.8°C or 100°F) saline wet mounts obtained with a clean, pre-moistened, cotton-tipped applicator from a combination of the oral cavity and crop. If birds had ocular abnormalities, the conjunctiva was also swabbed. Wet mounts were viewed immediately by light microscopy (×3,400 magnification). When motile flagellated protozoa were observed, birds were classified "*T. gallinae*+." If no organisms were observed, birds were classified "*T. gallinae*–." This wet mount technique was 99.9% specific and 97% sensitive in detecting *T. gallinae* infections in house finches admitted to the wildlife hospital when compared with InPouch TFTM cultures (BioMed Diagnostics, White City, Oregon, USA) (Anderson *et al.* 2009). During hospitalization, any house finches that developed disease, and all cage mates, were screened with wet mounts.

Clinical signs at accession and during treatment were recorded in the medical record for all birds. All birds received standard treatments for concurrent conditions (fluids, heat, wound care, nutritional support, non-nitroimidazole antibiotics, etc.). On the basis of wet mount results, birds were placed into one of three groups (see below). Once groups were established, individuals did not move between groups. All enclosures were cleaned with soap and water, disinfected with a tamed bleach solution, and allowed to dry thoroughly in the sun before reuse. To minimize cross-contamination, each enclosure was assigned its own equipment. Equipment was cleaned with soap and water, disinfected with Benz-all (Xttrium Laboratories, Inc., Chicago, Illinois, USA), rinsed, and thoroughly dried before reuse. Food containers were washed in a dishwasher before reuse.

Group 1 birds consisted of *T. gallinae*– birds and their clutch mates. If any group 1 bird later tested *T. gallinae*+, the bird and its cage mates were moved to group 3. A subset of group 1 birds that died or were euthanized for conditions other than trichomonad infection were submitted for histopathology to provide a comparison to *T. gallinae*+ birds. Group 2 birds consisted of birds that were *T. gallinae*+ at admission and their exposed clutch mates. Enclosures of group 2 birds were clearly marked with quarantine signs. Birds were treated with carnidazole (20–30 mg/kg p.o. q24 for 5 days). Group 2 birds were retested with wet mounts 7–10 days after admission and then every 2 wk until death or release.

Group 2 birds were considered to become *T. gallinae*– if all wet mounts from all individuals within an enclosure remained negative for a minimum of 1 mo. This time period was chosen because it generously exceeded the 7-day relapse period reported for rock doves after drug withdrawal (Franssen and Lumeij 1992, Munoz *et al.* 1998). Tissues from a subset of group 2 birds that died were submitted for histopathology. Group 3 consisted of birds that were *T. gallinae*– at admission or after treatment or that tested *T. gallinae*+ at a later date. Once diagnosed as *T. gallinae*+, group 3 birds were treated similarly to group 2 birds.

Histopathology

Twenty-two *T. gallinae*+ and 46 *T. gallinae*– house finches (as determined by wet mounts) were submitted to IDEXX Veterinary Services, Inc. (West Sacramento, California, USA) for routine histopathology. Within a few minutes to a few hours after death, carcasses were transected and shipped to IDEXX Veterinary Services in 10% buffered formalin. Tissue blocks were obtained from the formalin-fixed carcasses and imbedded in paraffin. For each sample, tissue sections were cut to 5 mm, stained with hematoxylin and eosin (H&E), and evaluated under light microscopy by a staff pathologist.

Female House Finch *(Carpodacus mexicanus).*

Aging birds

House finches were classified as adults if they displayed complete adult plumage. Birds were classified as immature if their flight and contour feathers were completely formed but residual down feathers were present on the head. Finches were classified as fledglings if their contour feathers were completely formed and flight feathers were <25% encased in keratin sheaths. Birds that did not have completely formed contour feathers or had >25% of their flight feathers covered by keratin sheaths were considered to be pre-fledglings or younger.

Data analysis

Medical records from juvenile house finches housed in the baby bird nursery during the year 2000 were reviewed for age, *T. gallinae*+ diagnosis, clinical signs at time of *T. gallinae*+ diagnosis or treatment with carnidazole, receipt of carnidazole, exposure to *T. gallinae*+ birds, and outcome. Medical records of all *T. gallinae*+ birds from 2001 to 2005 were reviewed for age (adult, immature, fledgling, or younger), admission date, date of *T. gallinae*+ diagnosis, clinical signs at presentation, clinical signs at time of *T. gallinae*+ diagnosis, outcome, and date of death or release. Data analysis was performed with Microsoft® Office Excel 2003 SP2 (Redmond, Washington, USA: mean, standard deviation, binomial test for comparison between populations). Groups were considered statistically different at $P < 0.05$.

Results

Study period 2001–2005

During the 5-yr study period, wet mounts were performed at admission on 1,985 house finches. Of these, 317 were adults (16.0%), 103 were immature (5.2%), and 1,565 were fledgling or younger (78.8%). Fifty-one unique clusters of *T. gallinae* infection represented 66 individual *T. gallinae*+ finches. Clusters consisted of individuals, siblings (four clutches, affecting 14 individuals), or cage mates. Only one cluster of infection was not detected at admission and consisted of one enclosure of six birds derived from two clutches consisting of two and four individuals, respectively (group 3 birds). Twenty-three of 66 *T. gallinae*+ birds were adults (34.8%). Adult *T. gallinae*+ house finches were admitted to the wildlife hospital throughout the year except for February and March (Fig. 1). Coincident with the breeding season, immature *T. gallinae*+ house finches presented May to September with a peak in June and July (Fig. 2).

Clinical features

Nonspecific or atypical clinical presentation, including an initial history or physical examination finding compatible with trauma,

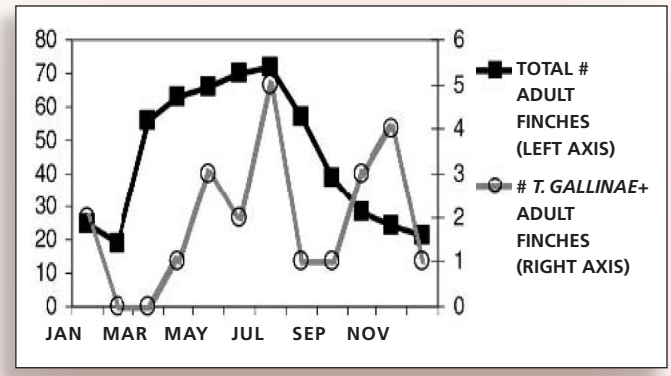

Figure 1. Comparison of admission dates for *Trichomonas gallinae*–positive (*T. gallinae*+) adult house finches to all adult house finches.

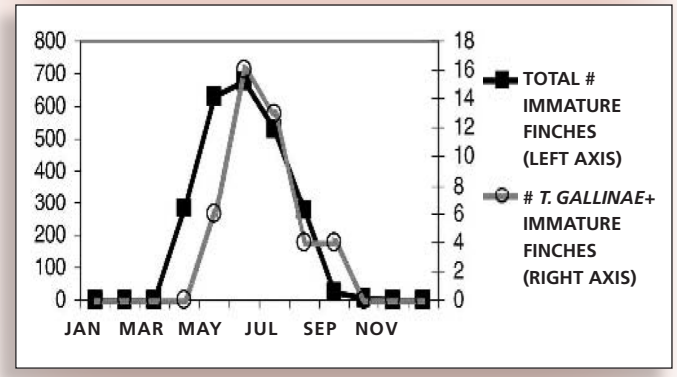

Figure 2. Comparison of admission dates for *Trichomonas gallinae*–positive (*T. gallinae*+) immature house finches to all immature house finches.

were common among *T. gallinae*+ house finches (Table 1). Only 18.2% of *T. gallinae*+ house finches presented with classical signs of trichomonosis, as described for other species (caseous stomatitis or pharyngitis; Table 1). If present, these lesions appeared as typical caseous plaques and could be found anywhere in the oral cavity or pharynx. Oral or nasal discharge or both was most common (30.3%) and was often observed as matted head feathers or sticky material on the beak. The material was most often clear or serosanguinous.

Most *T. gallinae*+ finches showed worsening of clinical signs and death within <72 hr (usually <24 hr) of admission. Only three out of 66 *T. gallinae*+ house finches survived to release. Two were adult males and one was a fledgling. Wet mounts from surviving birds were *T. gallinae*– in ≤7 days from initiation of treatment. All three survivors remained consistently *T. gallinae*– and disease free for >30 days. Except for finches that were agonal on admission, the clinical signs of survivors on admission were similar to those of birds that died. Treatment regimens for survivors were the same for birds that [eventually] died (fluids, heat, wound care, nutritional support, antibiotics, and carnidazole).

Group 3 birds consisted of one cluster of six pre-fledgling finches that developed disease 2 wk after admission. Shortly after admission, this enclosure of birds was moved to a separate building where exposure to other birds or contaminated equipment was not possible. Clinical signs included acute death, caseous stomatitis, and weight loss. None of these birds survived long enough to initiate treatment.

Histopathologic features

Fifty percent (11 of 22) of the *T. gallinae*+ house finches submitted for histopathology were positive for flagellated protozoal organisms in at least one tissue. Accompanying inflammation was described as lymphoplasmacytic, heterophilic, granulomatous, or necrotizing. The most common sites for inflammation associated with presence of *T. gallinae* organisms were esophagus, oral cavity, eyelids, and crop ($P < 0.001$). In contrast, of 46 tissue sets submitted for histopathology from *T. gallinae*– house finches, no birds had lesions in the mouth or crop and only one bird had lesions in the esophagus (2.2%). The esophageal lesion consisted of a pustular esophagitis associated with cocci bacteria. In addition, 34.8% of *T. gallinae*– house finches had lesions of the gastrointestinal tract distal to the proventriculus. These lesions were associated with bacteria or coccidia. Lesions in the oral cavity, esophagus, crop, eyelids, or lungs, or observation of flagellated, protozoal organisms occurred more frequently in *T. gallinae*+ house finches, whereas no significant lesions and lesions of the intestines were more common in *T. gallinae*– house finches (binomial test, $P < 0.001$).

Historical assessment

In the year 2000, before onset of routine screening for *T. gallinae* infections, 31 of 228 (13.6%) house finches housed in the nursery were diagnosed as *T. gallinae*+. As a result, a total of 125 house finches (54.8%) received carnidazole 20–30 mg/kg p.o. q24 for 3–5 days (infected and exposed birds). Twenty of the 31 *T. gallinae*+ birds (64.5%) were released. However, of these 20 survivors, 18 (90%) received carnidazole before showing clinical signs. One finch (5%) showed only mild clinical signs (fluffed feathers) before commencement of carnidazole. The final survivor (5%) required intensive care and multiple surgeries to remove caseous abscesses.

Comparison of study results to historical data

Performing wet mounts on admission of all house finches significantly reduced trichomonas outbreaks in the baby bird nursery ($P < 0.0001$, binomial probability: six group 3 house finches out of a possible population of 1,565 compared with an expected incidence of 13.6% in 2000). The expected survival of house finches treated with carnidazole but already displaying clinical signs was significantly lower than survival of house finches receiving treatment with carnidazole before onset of clinical signs ($P <$ 0.0001, binomial probability: one survivor out of 43 *T. gallinae*+ ≤fledge house finches with clinical signs during study compared with expected survival of 58% [18 of 31] of finches treated with carnidazole before onset of clinical signs in 2000).

Discussion

Clinical signs that increased suspicion of trichomonosis in house finches were oral or nasal discharge, most often presenting as sticky material adhered to the beak or head feathers (~30%), caseous

stomatitis or pharyngitis (~20%), and conjunctivitis or caseous sinusitis (10%). However, most often, *T. gallinae*+ finches had a nonspecific clinical presentation such as a history of trauma, weakness, weight loss, or dehydration. Clinical presentation alone was not a sensitive method for diagnosis of trichomonosis in house finches. Wet mounts were highly sensitive and specific for differentiating *T. gallinae* infections from other common causes of similar clinical signs (trauma, pox, bacterial or fungal infections, exposure to irritants or viscous materials). Only half of the *T. gallinae*+ house finches testing positive on wet mounts were positive for flagellated protozoal organisms on histopathology.

This finding was not unexpected because histopathology is reported to be a poor method to diagnose *Trichomonas* (McDougald 1991). The most common sites for inflammation associated with *T. gallinae* organisms were consistent with *T. gallinae* infections in other orders of birds (McDougald 1991, Samour 2000).

Trichomonosis was a severe, acute disease in house finches with death occurring in ~95% of house finches in <72 hr from admission or recognition of clinical signs. The highly fatal clinical course of trichomonosis in house finches reported here suggests that naturally infected birds are not likely to survive in the wild. An incubation period of >2 wk can be inferred from the enclosure of group 3 finches that developed disease 2 wk after admission because these birds were never in contact with infected birds or equipment used on infected birds during rehabilitation. Because *T. gallinae*+ finches presented with similar age and temporal patterns as *T. gallinae*– individuals, trichomonosis does not appear to have a strong age or seasonal trend in house finches. Survivors appeared to clear the parasite in >7 days of receiving carnidazole.

Unlike rock doves, in which relapses occurred 7 days after drugs were withdrawn, no treated house finches became *T. gallinae*+ once treatment was completed (Franssen and Lumeij 1992, Munoz *et al.* 1998). Therefore, house finches that are able to survive infection are not likely to shed the parasites persistently. The most likely source for *T. gallinae* infections in free-ranging house finches is water and food sources that are shared with Columbiformes (i.e., backyard birdbaths and feeders) (Anderson *et al.* 2009) Therefore, house finches treated and recovered from *T. gallinae* infections that remain *T. gallinae*– on wet mounts for longer than 1 mo are not likely to be a risk to other hospitalized or free-ranging populations of birds.

Early detection of trichomonosis using wet mounts was instrumental in preventing trichomonosis outbreaks in a high-density baby bird nursery at Lindsay Wildlife Museum. Preventing outbreaks increased finch survival and decreased resources expended on managing *Trichomonas*. For example, in 2000, before the onset of routine screening, 54.8% of finches in the nursery required some intervention that was related to *Trichomonas* infections (i.e., diagnostic testing, administration of medications, additional husbandry protocols because of quarantine measures, etc.). If the same percentage of birds were affected during the study period, the wildlife hospital would have had to treat and maintain quarantine space for 858 fledge or younger house finches instead of 43.

TABLE 1. Clinical presentation for *Trichomonas gallinae*–positive house finches (*n* = 66).

OBSERVED	% POSITIVE
SKIN LESIONS COMPATIBLE WITH AVIAN POX	9.1
NO LESIONS	42.4
TRAUMA (BRUISING/LACERATIONS/ETC.)	19.7
WEAK OR AGONAL	15.2
THIN	10.6
DEHYDRATED	4.5
DYSPNEA	30.3
ORAL OR NASAL DISCHARGE	18.2
CASEOUS ORAL LESION	7.6
CASEOUS EYE OR SINUS LESION	7.6
NEUROLOGICAL SIGNS	7.6
MITES	3.0

Thus, use of the screening protocol reduced labor time expended on house finches by >500 hr (>75%). This estimate does not consider the savings realized by the wildlife rehabilitation hospital because of reduced costs for medications and disinfectants. In the resource-restricted environment of a wildlife rehabilitation hospital, reallocation of this substantial amount of labor is likely to improve significantly the level of care offered to other animals undergoing rehabilitation.

Because of the difference between the populations, caution was used when comparing response to treatment between study birds and nursery birds. All study birds were sick at the time of diagnosis and survival was low (4.5%). Similarly, only 6.5% (2 of 31) of wet mount-positive nursery birds that displayed clinical signs before receiving carnidazole survived. In contrast, in a nursery setting where supplemental heat, nutrition, and supportive care were provided, 58.1% of *T. gallinae*+ house finches survived if they received carnidazole before onset of clinical signs. In this controlled situation, it appears that when *Trichomonas* infections are detected by wet mounts before onset of clinical signs, treatment with carnidazole is worthwhile and can significantly reduce mortality.

Reliance on presence of classical clinical signs of trichomonosis (caseous stomatitis or ingluvitis) failed to detect >75% of infections. Therefore, diagnostic testing (wet mounts) is necessary to diagnose *T. gallinae* infections in house finches. Before institution of routine wet mount screening of all house finches on admission for this study, multiple enclosures of house finches became *T. gallinae*+ and [finches] died while housed in the bird nursery. In contrast, during the 5 yr of the study, only one enclosure screened *T. gallinae*+ after admission (99.9% specific). This was a clinically significant reduction. Because the mortality rate is high and the parasite easily transmitted among cage mates, early detection by wet mount at admission and quarantine of infected individuals is the most effective and inexpensive means to minimize death loss in group-housed house finches. Early detection of trichomonosis

could be critical for successful treatment because, once house finches showed clinical signs, ~95% died within 24 hr, even with treatment. However, if house finches survived, it appeared that *T. gallinae* infections were reliably cleared after 5 days of carnidazole with no signs of repeated shedding at least 30 days post-treatment.

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Growth and Nutritional State of American Crow Nestlings Vary Between Urban and Rural Habitats

Rebecca S. Heiss, Anne B. Clark, and Kevin J. McGowan

Introduction

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Rapid worldwide urbanization is altering the environment for many wildlife populations (Shochat *et al*. 2006). These populations may experience changes in available foods, breeding sites, predation risk, dispersal patterns, and territory sizes (Marzluff 1997, Sol *et al*. 1998, McGowan 2001, Sorace 2002, Vigallon and Marzluff 2005, Withey and Marzluff 2005). Some bird species have adapted to human expansion and seem to be thriving in urban areas while others seem less able to cope with the ever-increasing human presence (see Marzluff [1997] for review).

Historically, American crows (*Corvus brachyrhynchos*) have lived near human settlements (Verbeek and Caffrey 2002, Marzluff and Angell 2005), but only since the 1950s have they become a common urban and suburban bird, perhaps as a response to hunting prohibitions and the abundant food in cities (McGowan 2001). These benefits have not necessarily translated into reproductive advantages. Richner *et al*. (1989) argued that European cities may be ecological traps for urban carrion crows (*Corvus corone*), whose offspring are smaller and less competitive for future breeding positions in comparison to their rural neighbors. Similarly, American crows nesting in suburban areas of New York State produced fewer and smaller nestlings than birds nesting in nearby rural areas (McGowan 2001). Both McGowan (2001) and Richner (1989) suggested that these patterns might be the result of the different foods available in urban areas.

Suburban and urban environments are rich in anthropogenic food sources, particularly human refuse. This continuous and readily available supply of food attracts scavengers like the American crow. Easily accessible food is particularly important when birds are raising young and the demand for food is especially high. Anthropogenic foods that are adequate for adults may, however, be nutritionally inadequate for their nestlings. When normal, protein-rich nestling foods such as insects are limited or unavailable, adult birds will compromise by feeding lower-quality foods to ensure short-term survival of their

ABSTRACT: In urbanized areas, many adult birds find sufficient foods to survive, but the anthropogenic foods that are abundant there may be detrimental to nestling growth. In fact, American crow *(Corvus brachyrhynchos)* nestlings are smaller in suburban than in rural areas, possibly because of nutrient limitation. Here, we seek to identify possible causes of size differences by comparing both size and blood chemistry measures in rural and suburban crow nestlings. We quantified land use in known crow territories and distinguished three distinct environments: suburban-residential, suburban-managed (e.g., golf courses), and rural. We measured nestlings near fledging age in each environment and bled them for determination of unbound plasma calcium, total protein, and corticosterone. We supplemented a subset of broods in suburban-residential and rural areas with a food high in protein and calcium. Rural nestlings were significantly larger than suburban-residential crows and had higher total serum protein. Nestlings in suburban-managed areas were intermediate in size and serum protein but had the lowest plasma calcium levels. Nestling corticosterone levels did not differ significantly among habitats indicating that, although suburban nestlings may be food-limited, they were not starving. Supplemented nestlings in suburban-residential areas were significantly larger in some growth measures than their unsupplemented counterparts. Unexpectedly, supplemented rural nestlings were significantly smaller than unsupplemented rural ones, suggesting that parents use easily accessible food even when it is nutritionally suboptimal. Our results indicate that nestlings in suburban areas are nutrient restricted rather than calorie restricted.

KEY WORDS: American crow nestling, bird blood chemistry, corticosterone, *Corvus brachyrhynchos*, crow nestling nutrition, land-use environment, nestling size, nutrition, nutritional supplementation, plasma calcium, protein, urban vs. rural bird food sources

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young (Wright *et al*. 1998). Feeding primarily anthropogenic foods may provide insufficient levels of key nutrients to support normal growth of suburban-reared nestlings (Pierotti and Annett 2001).

Critical growth-limiting nutrients for altricial nestlings include protein and calcium (Ricklefs 1983). Sufficient dietary calcium is extremely important for a chick whose skeleton is still mineralizing (St. Louis and Breebaart 1991, Starck and Ricklefs 1998). Calcium deficiencies have been implicated in bird population declines (Hames *et al*. 2002), and documented hyperparathyroidism among young urban American crows suggests that they may frequently be calcium deficient (Tangredi and Krook 1999).

Dietary deficiencies may have other negative consequences. Elevated corticosterone, the primary avian glucocorticosteroid (Siegel 1980, Schoech *et al*. 1997), has been documented in several species of malnourished chicks (Nuñez de la Mora *et al*. 1996, Kitaysky, Piatt *et al*. 1999, Kitaysky, Wingfield *et al*. 1999, Kitaysky 2001, Walker *et al*. 2005). While short-term elevation of corticosterone may be adaptive, continued stress and chronically elevated levels of corticosterone can produce markedly deleterious effects including muscle deterioration (Harvey *et al*. 1984, Gray *et al*. 1990), immune-system suppression (Siegel 1980, Sapolsky 1987), compromised growth (Siegel 1980, Sapolsky 1987), and reproductive difficulties (Wingfield and Silverin 1986).

In this study, we expanded on McGowan's (2001) study of American crows by comparing both size and physiological state of nestlings from the same population across a gradient of rural, park-like, and suburban-residential environments. We tested the hypothesis that suburban-reared nestlings would have lower serum calcium and serum protein levels than did nestlings in rural environments. We also tested corticosterone levels as a measure of malnutrition. Finally, we looked for experimental support for the nutritional explanation by food-supplementing suburban and rural nestlings, predicting that supplemented suburban nestlings would benefit more than rural nestlings.

Methods

Study population and site

The study population was located in Ithaca, New York and nearby surrounding rural areas of Tompkins County, New York, United States (for detailed description see McGowan [2001]). Ithaca is a small city of only ~30,000 people (U.S. Census Bureau, 2006 data; available at http://quickfacts.census.gov/qfdi). It does not meet the definition of an urban area according to Marzluff *et al*. 2001: >50% built, building density >10 buildings/ha, residential human density >10 persons/ha), and is best described as a suburban city. The study area contained wooded hillsides, agricultural fields, heavily residential sections, large areas of maintained lawns on the campus of Cornell University, blocks of stores and small businesses, and local golf courses.

American crows in this population are cooperative breeders that live in extended family groups (McGowan 1995, 2001) and maintain year-round territories. Several members of the extended family may help the breeding pair build the nest and raise nestlings on one territory (Verbeek and Caffrey 2002). During each breeding season (March–June in upstate New York), crows raise at most one brood. Families do most of their foraging to feed nestlings on their breeding territory.

Environmental classification of territories

We developed an objective environmental classification of territories based on land-use differences. We identified territories based on sighting locations of individual birds known to be associated with a particular nest. We used sightings from January through August 2005, during weekly censuses, as points in outlining the family territory on aerial maps. We estimated territories by minimum convex polygons (Jennrich and Turner 1969, Schoener 1981).

We quantified land cover in territories using aerial photographs ("tiles") downloaded from the New York State Geographic Information Systems (GIS) Clearinghouse website (available at http://www.nysgis.state.ny.us/i). These color, infrared images were collected by the state in 2002 (0.3-m image resolution) and we checked for land-use changes that may have occurred between 2002 and 2005. Using the Image Analysis extension in ArcView GIS 3.2 (ESRI 1999), we classified land into the following categories: "grass" (specifically lawns or other maintained patches of grass), "pavement" (including houses, buildings, or other impermeable surfaces), "trees," "agricultural fields," "woods" (patches of trees at least four trees deep and four trees across), "shrubs" (area dominated by bushes and secondary growth), and "shadows." We could not reliably separate water from shadows and, thus, water was either included in the shadows category (<13% total) or left as unclassified land (<5% of total areas). We removed both "shadows" and "unclassified land" from consideration. We then calculated the percentage of all other land types for each territory. On the basis of these percentages, we then classified territories into three discrete environments (suburban-residential, suburban-managed, and rural) using a discriminant function analysis. The suburban-residential territories contained commercial areas and suburban backyards but no agricultural fields or golf course areas. The suburban-managed category was a suburban habitat containing large expanses of regularly maintained grass such as found on a golf course or in a cemetery. The rural territories included a majority of undeveloped land, agricultural fields, or both. We hypothesized that the suburban-managed areas would be potentially better foraging environments than traditional suburban-residential territories but not as high-quality as rural territories.

Nestling age and sex determination

Because exact hatch dates were not known for many nests, we determined nestling ages from morphometric data obtained at the time of banding. We uniquely marked all nestlings with bands and patagial tags at 24–30 days old when only the feathers are still growing rapidly. We estimated ages based on the two significant regression lines for tail length and 7th primary length *versus* age for known-aged birds banded in this population over the previous 15 years (n = 213; tail: r_2 = 0.52, intercept = 22.77, slope = 0.06; 7th

primary: r_2 = 0.52, intercept = 19.98, slope = 0.057). The two ages predicted by tail- and primary-based regressions usually differed by less than a day and were averaged. We determined the sex of banded birds molecularly (Fridolfsson and Ellegren 1999) based on blood samples collected at banding.

Measuring and blood sampling

Crows in this population nest in trees at heights that range from 4.75 m to 34.2 m (McGowan 2001). To band and sample nestlings, we climbed to their nests when the nestlings were 23–31 days old. We climbed throughout the day from morning to dusk. We used a stopwatch to track the time between when the climber reached the nest (used as the starting point of stress initiation) to the time it took to lower the nestlings to the ground and obtain a first blood sample from each individual. We bled nestlings as quickly as possible from the brachial (wing) vein using a tuberculin nonheparinized syringe with a 27.5-gauge needle (Becton Dickinson, Franklin Lakes, New Jersey, USA). We based stress-induced corticosterone levels on a second blood draw from the other wing vein, timed to be exactly 20 min after the first blood draw. Because no data exist on the timing of peak corticosterone levels in American crows, and because the timing of a corticosterone peak after a stressor varies between species and with age, we chose 20 min as a reasonable sampling point. Love *et al*. (2003) found corticosterone levels peaking in American kestrel (*Falco sparverius*) nestlings at approximately 10 min. This level of corticosterone essentially plateaued for up to 45 min. While 20 min may not be an accurate measure of "peak" corticosterone levels, we also were constrained by our efforts to minimize the amount of time we had the nestlings away from their parents. By taking blood at 20 min, we were confident that we were capturing the corticosterone response at least within the plateau of peak corticosterone levels without allowing excessive time for recovery.

We handled birds extensively during banding and measuring procedures. Because handling is a known cause of stress in wild birds (Wingfield *et al*. 1982, Harvey *et al*. 1984), it was essential that each nestling experience similar handling between blood samples (Schoech *et al*. 1997). We handled those nestlings that were not being banded between their first and second blood draws in a manner comparable to their siblings that were being banded. We took standard morphometric measures and body mass for all nestlings. These measures included: tarsus length, bill (nares to tip), total exposed culmen, bill depth and width at the nares, head length (+ bill), wing chord, 7th primary, and tail length. We also measured from the tip of the 7th primary to the beginning of the feather sheath (exposed primary). To categorize overall bill size, we calculated "bill volume" as the product of bill length (nares to tip), bill width, and bill depth. All banding and crow handling was done according to approved IACUC (Institutional Animal Care and Use Committee) protocols (Binghamton 527-03; Cornell 88-210-04) and under federal and state banding permits to K. J. McGowan.

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Food supplementation

We supplemented five rural nests and five suburban-residential nests with a nutritious nestling food daily for 2 wk to test for the effects of added, high-quality nutrients on nestling development. We did not supplement any of the 31 remaining successful nests. We chose nests for supplementation based on their accessibility and the associated birds' willingness to come to food. Of the supplemented nests, only three rural nests and four suburban-residential nests survived until banding age, the rest being depredated before that time. Because of the obvious stunting and unusual coloration of a singleton nestling in one of the supplemented suburban-residential nests, it was dropped from all analyses. We observed similar stunting at one rural and one managed nest, neither of which was supplemented and both of which were removed from all reported analyses.

We began supplementation when nestlings were estimated to be 10 days old based on observations from the ground and, when known, initial date of incubation. All original estimated ages of the supplemented nestlings turned out to be within 3 days of the ages calculated at banding.

We adapted the supplementation formula from Winn's (2002) formula for nestling songbirds (FoNS), originally designed as an "insect-replacement formula" for nestling passerine birds in rehabilitation centers. The formula approximates the macronutrients present in insects with additional calcium for healthy nestling

bone growth and development. This high-quality diet significantly improved the release rate of birds in at least one rehabilitation facility (Winn 2002). We baked the ingredients from the FoNS at 165°C and then cut the mixture into 2.5-cm cubes. We placed ~250 ml of the cubes (~1,255 kJ) daily in a specific site within each family's territory.

During the first days of supplementation, we watched until the crows took food at least one time. On all territories, crows took the food within the first 3 days of supplementation. Crows took the food directly to the nest at least once at every site but, more commonly, they flew off with it, possibly to eat it themselves or to cache it for future use (Verbeek and Caffrey 2002). We did not supplement birds at any specific time of day, but we gave food to all families receiving supplementation within the same hour on any given day. We also visited unsupplemented nests on a regular basis during this time. The short period of time that it took for birds to remove all the supplemented food from its original site (<15 minutes) is unlikely to have caused any significant disruption of normal feeding patterns.

Feeding rates

We watched nests to determine feeding rates, and time spent away from the nest between feedings, in suburban-residential and rural environments. We estimated the gross food delivery to nestlings in suburban and rural environments by determining the rate of feeding visits (nest visits with subsequent transfer of food to nestlings or brooding females). We watched 10 suburban-residential and eight rural nests for 1 hr each on 3 days at intervals of 6–7 days during the last 2 wk before the scheduled banding of nestlings at age 28 days. We chose this time period because actual feedings were only visible once the nestlings were large enough to beg above the top of the nest, at 10–12 days old. Nests that failed during this period before banding (three rural; one suburban-residential) had fewer nest watches and were not used in calculations of feeding rate. For well-concealed nests where we could not directly observe feedings, we approximated feeding rate by the number of times adult crows flew into and, soon after, out of the nest tree. We could not always tell if crows flying into the nest trees were carrying food because adult crows usually carry food in their antelingual pouch (Verbeek and Caffrey 2002). We calculated feeding-trip time for individual birds from the moment a known bird left the nest after feeding until the same bird returned to the nest and fed again. For all broods surviving to banding, we calculated feeding-visit rates (number of visits per nestling per hour) based on the number of nestlings alive in the nest at the time of banding. Because feeding rates vary with the age of the nestlings (Caffrey 1999), we regressed them on age and used the residuals to compare rates between environments.

Analysis of blood biochemistry

We transferred blood samples into labeled serum separator tubes and kept them cool on ice until they could be transported to a nearby laboratory at Cornell University (usually within 4–5 hours). We separated serum by centrifugation within 36 hr of collection. We had all serum samples tested for West Nile virus. After they were found negative, we then stored them at –20°C until we transferred them on ice to a laboratory at Binghamton University, where we again stored them at –20°C until we assayed them for corticosterone, calcium, and protein. Total protein and serum calcium were not expected to vary within the 20-min time frame and, thus, we used serum from either or both blood draws in these analyses.

We assayed serum for total protein counts using the Bradford (1976) method. We diluted samples and ran them in microtiter plates in duplicate. We used total protein standard bovine serum albumin and measured absorbance with a spectrophotometer at 595 nm. Four 96-well plates were required to run all samples and each had $r^2 > 0.98$.

We determined unbound plasma calcium levels using a QuantiChrom calcium assay kit (DICA-500; BioAssay Systems, Hayward, California, USA). We assayed samples in duplicate following the 96-well plate protocol specified with the kit. We needed four 96-well plates to run all the samples. We used only curves with $r^2 > 0.97$.

We assessed plasma corticosterone with a radio-immunoassay using rabbit antiserum (antibody B3-163; Endocrine Sciences, Tarzana, California, USA) (Deak *et al*. 2005). We diluted samples (40 µl serum: 460 µl PBS [phosphate-buffered saline]) as derived from testing levels of plasma corticosterone in a captive Budgerigar (*Melopsittacus undulatus*) population as well as from a previous set of samples of nestling American crow blood in an unpublished pilot study. We ran all samples in duplicate. We required two spins to run all samples. Both the intra- and inter-assay coefficients of variation were <8%. The assay sensitivity was 0.5 µg/dl. Procedures followed Deak *et al.* (2005).

Statistical analyses

We performed all statistical analyses using SPSS 11.5 for Windows (SPSS 2002) or DataDesk 6.0.2 (Data Description 2003). Many morphological measures in nestlings were sexually dimorphic. Furthermore, there were small differences in age at banding both within and between broods. To control for sex and age, we first separated all morphometric measures by sex and then regressed them on age. We then combined the residuals from the sex-specific regressions and used them for all additional analyses. Although we used residuals for statistical evaluation, we report actual measures.

The central question was whether both size and health of nestlings varied with their rearing environment. Nestling growth and health has been related to survival and measures of reproductive fitness (Boag 1987, Richner *et al*. 1989, Richner 1992). We used a nested analysis of variance (ANOVA; brood within environment) to test for differences in morphometric measurements (residuals of measure *vs.* age) among environments while controlling for the effects of nest. Only a subset of nestlings from many broods were represented in the tests of blood parameters—as a result of insufficient blood drawn or not meeting specific criteria assigned

for baseline corticosterone measures. Thus, we ran an ANOVA for blood parameters of individuals among the environmental groups (suburban-residential, suburban-managed, and rural).

We used *post hoc* tests to identify significant differences between pairs of environments and independent *t*-tests to test for differences in feeding rates between rural and suburban-residential nests.

Results

Nestling growth across environments

We banded nestlings in a total of 37 nests in 2005; 11 rural, 13 suburban-managed, and 13 suburban-residential environments. We used 114 nestlings in the analysis, 38 chicks from each environment. Brood size did not differ among rural, suburban-managed, or suburban-residential environments (3.74 ± 0.98, 3.45 ± 1.03, and 3.68 ± 1.23 chicks/brood [mean ± SD], respectively).

Rural nestlings were significantly larger than suburban-residential nestlings in all measures except for total exposed culmen, which showed the same trend, and those related to feather growth. Suburban-managed nestlings were significantly smaller than rural nestlings in head and bill as measured nares to tip.

Feeding rate

Feeding visit rates did not differ significantly between suburban-residential and rural birds (1.53 ± 0.59 visits/hr and 1.33 ± 0.59 visits/hr [mean ± SD, as are all data following]; $t = 2.63$, df = 10, $P = 0.80$). Seconds spent away from the nest between feeding trips also did not differ for suburban-residential and rural birds (248.44 ± 199.36 sec and 157.72 ± 109.07 sec, respectively; $t = -5.49$, df = 10, $P = 0.60$).

Corticosterone

Corticosterone levels for adult birds are usually considered baseline when obtained in under 3 min from an initial stressor (Schoech *et al.* 1999, Romero and Romero 2002). Removing all nestlings from the nest, lowering them to the ground, and bleeding them rarely took less than 3 min, and the sample size of nestlings bled in less than 3 min was small. We compared corticosterone levels for chicks bled in less than 3 min with the corticosterone levels for chicks bled within 3–6 min and found no significant difference (<3 min: $n = 11$ chicks, 3.37 ± 3.91 ng/ml *vs.* 3–6 min: $n = 30$ chicks, 3.32 ± 4.25 ng/ml; $t = 0.06$, df = 27, $P = 0.95$). Over this time period, a regression between time from disturbance to corticosterone measurement and corticosterone level showed no relationship ($r^2 < 0.01$, $P = 0.98$). Thus, we considered all corticosterone samples collected in under 6 min as baseline levels for this study.

Both baseline and stress-induced corticosterone levels were positively significantly related to age ($r^2 = 0.26$, $P = 0.01$ and $r^2 = 0.35$, $P < 0.01$, respectively) when all nestlings banded were included in the analysis (ages 22–33 days). Increases in corticosterone production are, however, associated with near-fledging ages (Heath 1997), and young crows fledge at approximately 35 days (K. J. McGowan, pers. observ.). For those birds less than 30 days old, an age at which crow nestlings are not normally fledged, neither baseline nor stress-induced levels of corticosterone were significantly related to age ($n = 21$; $r^2 = 0.03$, $P = 0.43$; $r^2 = 0.08$, $P = 0.19$, respectively). We restricted subsequent corticosterone analyses to include only birds less than 30 days old. Neither baseline nor stress-induced corticosterone levels differed between the sexes (baseline, $t = -0.46$, df = 21, $P = 0.65$; males, 1.56 ± 1.69 ng/ml, females, 2.94 ± 3.03 ng/ml; stress-induced, $t = 1.48$, df = 21, $P = 0.15$, males 12.61 ± 2.61 ng/ml, females = 11.44 ± 5.97 ng/ml). Corticosterone increased significantly from baseline to stress-induced levels (paired *t*-test: $t = -8.72$, df = 22, $P < 0.01$; baseline 2.52 ± 2.61 ng/ml, stress-induced 11.75 ± 4.80 ng/ml).

Environment did not significantly affect baseline corticosterone levels ($F_{2,23} = 9.12$, $P = 0.080$), stress-induced levels ($F_{2,23} = 0.34$, $P = 0.72$), or the magnitude of change from baseline to stress-induced corticosterone levels ($F_{2,34} = 1.43$, $P = 0.26$) in nestlings. However, suburban-residential nestlings tended to have the highest baseline levels of corticosterone (rural 1.35 ± 2.16 ng/ml, suburban-managed 1.14 ± 1.65 ng/ml, suburban-residential 3.68 ± 2.79 ng/ml).

Protein

Protein levels were not significantly related to age ($F_{1,110} = 1.0$, $P = 0.32$) or sex (df = 107, $t = -1.05$, $P = 0.30$). Protein levels did differ significantly among environments ($F_{2,110} = 4.39$, $P = 0.02$; Fig. 1) with ranges of 2.57–4.70 g/dl in rural areas, 2.38–5.09 g/dl in suburban-managed areas, and 2.36–4.5 g/dl in suburban-residential areas. Suburban-residential nestlings had significantly lower protein levels than did rural nestlings (3.29 ± 0.47 g/dl and 3.62 ± 0.461 g/dl, respectively; Tukey hsd, $P = 0.012$).

Calcium

Plasma calcium levels were not significantly related to age ($F_{1,108} = 0.90$, $P = 0.35$) or sex ($t = 1.18$, df = 105, $P = 0.23$). Calcium levels differed significantly among environments ($F_{2,108} = 4.18$, $P = 0.02$; Fig. 2), ranging between 5.01 mg/dl and 15.15 mg/dl in rural areas, 5.42 mg/dl and 13.01 mg/dl in suburban-managed areas, and 3.83 mg/dl and 11.89 mg/dl in suburban-residential areas. Rural nestlings had significantly higher plasma calcium levels than did suburban-managed nestlings (10.88 ± 1.96 mg/dl and 9.79 ± 1.49 mg/dl, respectively; Tukey hsd, $P = 0.02$), but levels did not differ between rural and suburban-residential nestlings (10.02 ± 1.62 mg/dl).

Food supplementation

Food-supplemented suburban-residential nestlings had significantly larger tarsi ($t = 2.62$, df = 34, $P = 0.01$) and longer bills (nares to tip: $t = 2.16$, df = 34, $P = 0.04$) than did unsupplemented suburban-residential nestlings (Fig. 3). In contrast, food-supplemented rural nestlings had significantly lower body mass ($t = -2.64$, df = 36, $P = 0.01$), shorter bills (nares to tip: $t = -2.51$, df = 36, $P = 0.02$), and smaller heads ($t = -2.40$, df = 36, $P = 0.02$), than did unsupplemented rural nestlings (Fig. 3).

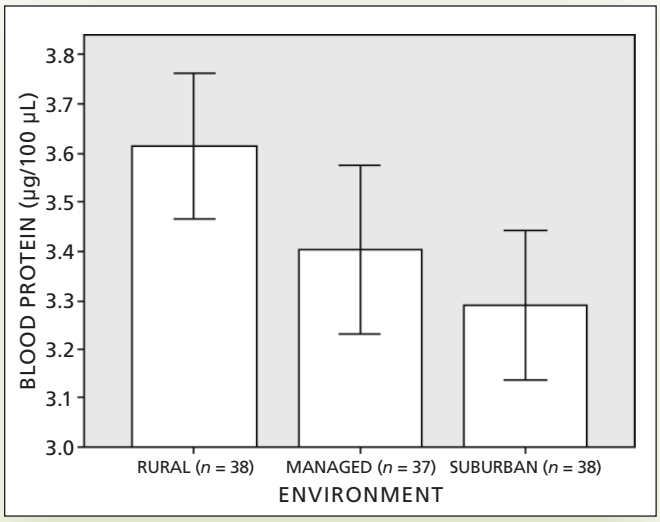

Figure 1. Comparison of total blood protein levels of American crow *(Corvus brachyrhynchos)* nestlings from three habitats in Ithaca, New York, USA; *n* = number of nestlings. We quantified land use in known crow territories and distinguished three distinct habitats: suburban-residential, suburban-managed, and rural. Data are means ± 2 SE. Total protein levels were significantly lower in suburban-residential American Crow nestlings than in rural nestlings. See **Results: Protein** for full statistics.

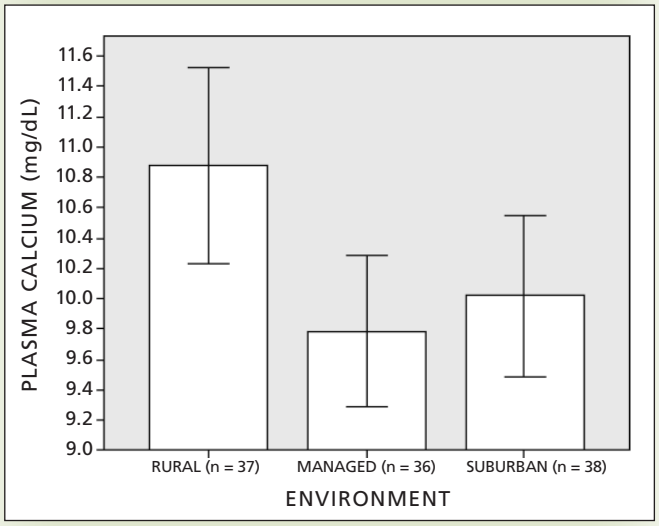

Figure 2. Comparison of total plasma calcium levels of American crow nestlings from three habitats in Ithaca, New York, USA; *n* = number of nestlings. We quantified land use in known crow territories and distinguished three distinct habitats: suburban-residential, suburban-managed, and rural. Data are means ± 2 SE. Plasma calcium levels were significantly lower in suburban-managed than in rural nestlings. See **Results: Calcium** for full statistics.

Calcium levels were also significantly lower in supplemented than in unsupplemented rural nestlings ($t = -3.24$, df = 35, $P < 0.01$), while there was no difference in calcium levels between supplemented and unsupplemented suburban-residential nestlings ($t = 0.190$, df = 36, $P = 0.85$).

No significant differences with supplementation existed for either suburban or rural nestlings in protein levels ($t = -0.17$, df = 26, $P = 0.87$; $t = 0.507$, df = 36, $P = 0.62$, respectively), baseline corticosterone ($t = -0.27$, df = 9, $P = 0.80$; $t = -1.08$, df = 5, $P = 0.33$, respectively), or stress-induced corticosterone levels ($t = -0.49$, df = 8, $P = 0.64$; $t = -1.85$, df = 6, $P = 0.11$, respectively).

Discussion

Our results suggest that American crow diet quality declined along a gradient of increasing urbanization, with negative effects on early growth of nestlings. Nestlings from suburban-residential areas were smaller and had lower serum levels of protein and calcium than did those from rural habitats, and food supplementation increased their size. Nestlings from areas of green space, the "suburban-managed" group, were generally intermediate in body size and serum protein. Our findings contribute to a growing literature on the effects of urban living on the behavior, morphology, and ecology of animals (Shochat *et al*. 2006, Grimm *et al*. 2008). Animals may respond facultatively to urban differences in predation, competition, and, in particular, to abundant anthropogenic foods. The readiness of our rural crows to use the supplied food when it was detrimental to their nestlings indicates that urban adapters may switch to lower-quality food even when better alternatives exist. Urban birds may not "make do" with bad food, but actually choose it over better existing alternatives because of ease and predictability (Sauter *et al*. 2006).

On a longer time scale, city life is a strong, new, selective force on urbanizing species (Shochat *et al*. 2006, Grimm *et al*. 2008) as demonstrated by evolved changes in behavior, morphology, and physiology in urban birds (Yeh 2004, Partecke *et al*. 2006, Partecke and Gwinner 2007). The fitness costs of changed diets could select for adaptive shifts in foraging behavior and morphology, including body size (Price and Boag 1987, Johnson and Marten 1992, Liker *et al*. 2008). These adaptations may create urban specialists competitive within the new environment and unlikely to leave it. If we are to minimize the negative effects of urban expansion on organisms and communities, we will need to evaluate both the selection pressures placed on urban species and the immediate fitness-reducing effects of city structure and our own behavior (Grimm *et al*. 2008).

Evaluating causes of growth differences among environments

We believe that the growth differences resulted from nutrient restriction, not caloric (energy) restriction. Neither adult visitation rates nor the time between visits differed between suburban-residential and rural nests. Methods to determine the actual amounts or calories of food brought, e.g., collecting food from ligatured nestlings or fecal analyses, were beyond the scope of this study, but the similarities in adult feeding rates in our results suggest that suburban adults were finding it just as easy to gather their loads of food.

Our corticosterone measures support the contention that suburban nestlings were not severely calorically limited. While nestlings in all environments were able to mount a significant corticosterone response to a stressful situation, neither baseline nor stress-induced corticosterone levels differed significantly among

environments in this study. While several experimental studies have linked elevated levels of corticosterone in nestlings with severe food-restriction (Nuñez de la Mora *et al.* 1996, Kitaysky, Piatt *et al.* 1999, Kitaysky *et al.* 2005, Walker *et al.* 2005, Pravosudov and Kitaysky 2006), none have investigated the effect of restricting specific dietary nutrients. Perhaps if diets are calorically adequate, a lack of important nutrients does not elevate corticosterone levels. This might explain why we found no difference in baseline corticosterone levels in nestlings among environments.

As argued above, the adult feeding behaviors were similar in suburban and rural environments, suggesting similar amounts of food being brought to nests. Nevertheless, when we provided relatively small, regular amounts of nutrient-rich food, suburban nestlings responded with greater growth. Thus, the difference in diets between suburban and rural nestling crows may lie in diet quality or in the quantities of key foods containing specific nutrients. Typical foods of human origin can differ dramatically from natural nestling foods, especially in protein content. Rural nestling crow diets include a high proportion of invertebrates, including beetles (Kalmbach 1939). Such foods contain 2–3 times the protein of foods such as bread and corn, readily taken by urban crows, while caloric densities are more similar (data for mealworm beetle *Tenebrio molitor*, 20.8% protein, 8.4 kJ/g [Finke and Winn 2004]; bread, 8.6% protein, 12.1 kJ/g; sweet corn, 3.3% protein, 4.6 kJ/g [product labels]). Inadequate protein could be one growth-limiting factor (Boag 1987).

Suburban crows may have adapted genetically to nutrient-poor diets to grow slower, perhaps to conserve feather growth; this remained similar across environments. This possibility seems unlikely to explain our results for two reasons: the larger size of

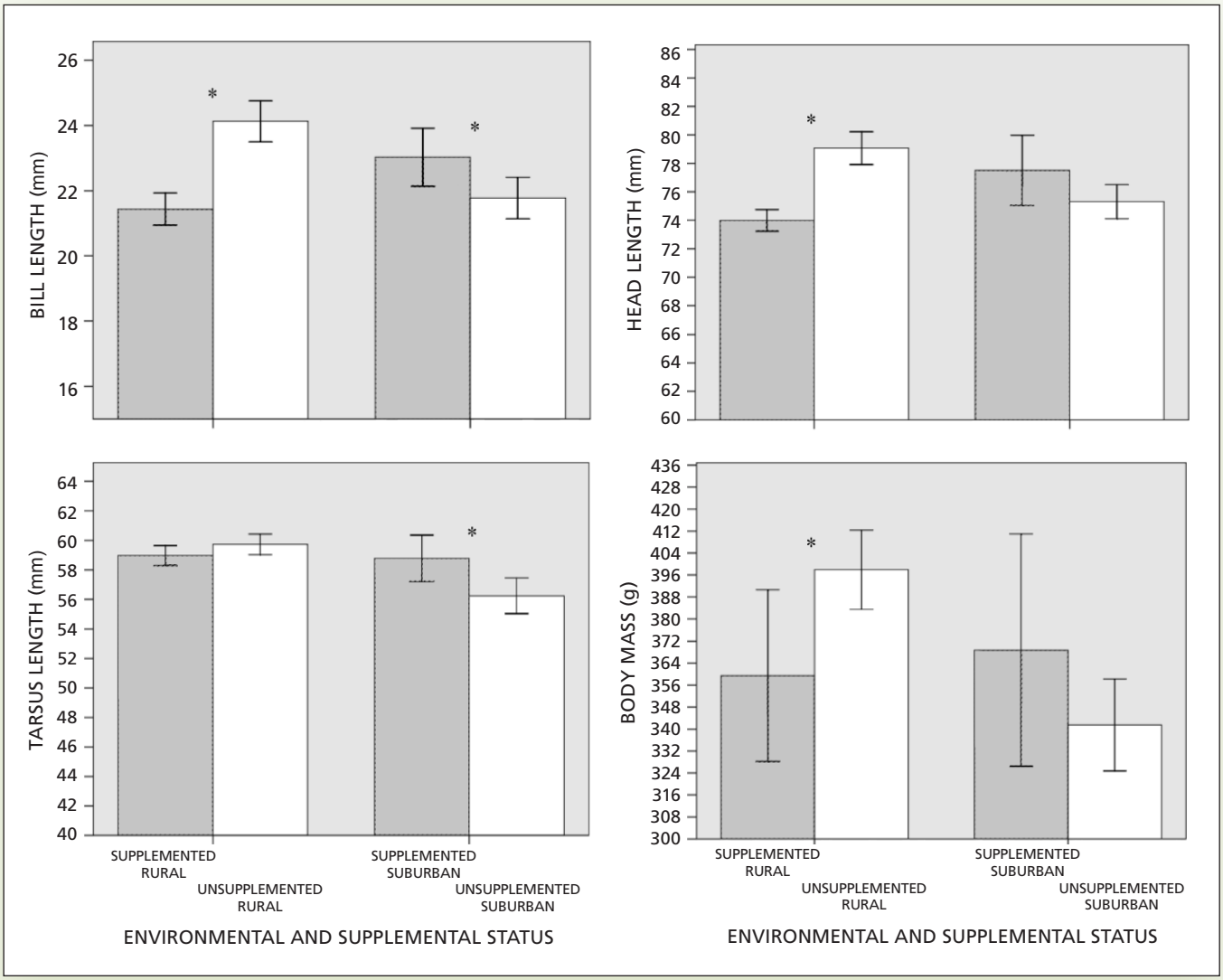

Figure 3. Comparison of morphometric measures between food-supplemented and unsupplemented American crow *(Corvus brachyrhynchos)* nestlings in two different habitats. A subset of broods in suburban-residential and rural areas were supplemented with a food high in protein and calcium. Supplemented suburban-residential American crow nestlings (n = 11 chicks) had significantly larger tarsi and bills (nares to tip) than did unsupplemented suburban-residential nestlings (n = 27 chicks). Supplemented rural nestlings (n = 9 chicks) had significantly smaller heads and bills (nares to tip) and lower body mass than did unsupplemented rural nestlings (n = 29 chicks). Data are means ± 2 SE.

The asterisks (*) above pairs of bars indicate significant differences between groups ($P < 0.05$). See **Results: Food supplementation** for full statistics.

supplemented suburban nestlings suggests a facultative release from growth restrictions; and the suburban-managed birds, whose territories abutted some suburban-residential territories, were intermediate in size between these and rural birds. Both the rapid response to nutrient supplements and the small spatial scales over which we observed growth differences support nutrient-poor foods fed to the suburban-residential nestlings as the primary explanation.

Protein and calcium levels in serum as indicators of nutritional status

Plasma protein reflects nutritional state (Jenni-Eiermann and Jenni 1998, Ots *et al*. 1998). Low values (<2.5 g/dl) are associated with chronic stress or starvation and high values (>5.0 g/dl) can result from acute infection (Lewandowski *et al*. 1986). In this study, the one individual with total protein greater than 5.0 g/dl was the sole survivor of a suburban-managed brood with a bacterial infection (Cornell Wildlife Clinic, College of Veterinary Medicine, Cornell University, Ithaca, New York, USA). Two birds, one each from suburban-residential and suburban-managed areas, had plasma protein levels <2.5 g/dl (2.36 and 2.38 g/dl), but they appeared healthy and their brood mates had higher values.

Unbound plasma-calcium levels in birds are typically not highly variable (normal range ~8–10 mg/dl; M. Pokras, pers. comm.). There is disagreement on the meaning of the existing variation. Low values may signify possible osteodystrophy, but higher serum calcium levels may be benign (Wyx *et al*. 1993). Shafey *et al*. (1990), however, found high levels associated with moderate growth reduction in chickens.

There are no published norms for plasma calcium levels in nestling American crows. The International Species Information System (ISIS, Apple Valley, Minnesota, USA; 2002) lists 7.0–9.7 mg/dl as the range of 10 American crows of unknown ages (data available online to ISIS members; http://www.isis.org/CMSHOMEi). Nestlings are actively forming bone and should have higher plasma calcium levels than do adults (Kan and Cress 1987). We have no reason to believe that any crow nestlings were suffering from excessive calcium. Our highest measured value (15.2 mg/dl) came from an otherwise large and healthy rural bird.

Sources of protein and calcium restriction in suburban environments

The suburban-residential area in this study consisted of mixed lawns and backyard woodlots. At least some of these yards were maintained with pesticides. Arthropod type and density change significantly along an urban–rural gradient (Czechowski 1982, Blair and Launer 1997, McIntyre 2000). Passerine nestlings are largely dependent on insects for food in their first few weeks of development (MacLeod and Perlman 2001); therefore, environmental differences that affect arthropod type and abundance (Gunnarsson and Hake 1999) may have a large effect on the diet quality of young nestlings.

Differences in invertebrate type and density may help to explain the pattern of plasma calcium across different environments. Birds in suburban areas, with more restricted access to high-quality or high densities of arthropods, might have compensated by feeding nestlings a diet with substantially more road kill and human-generated garbage, food sources known to be low in calcium (Pierotti and Annett 1990). Such a diet would explain the overall lower plasma calcium levels of suburban nestlings. The lowest levels of plasma calcium were, however, found in the suburban-managed birds, levels significantly lower than in rural birds. For nearly all other measures tested in this study, nestlings from managed areas were more similar to nestlings in rural areas. This result suggests some other difference in calcium availability, specific to the grass lawns of golf courses and cemeteries, beyond differences in prey variety and abundance.

Several studies suggest that soil calcium has the potential to drastically alter the quality and quantity of invertebrate prey (Graveland 1990, 1998, Eeva *et al*. 1998, Swiergosz *et al*. 1998). Golf courses and other managed areas commonly try to regulate soil pH to keep their grass in top condition. The pH level alone is linked to the abundance of a number of taxa including snails, slugs, millipedes, and crustaceans (Harvey and McArdle 1986, Okland and Okland 1986, Hames *et al*. 2002). These high–mineral-content species are particularly sensitive to pH levels and disappear at pH levels <6.0 (Harvey and McArdle 1986). The acidification of soil leaches cations, including calcium, while freeing up various toxic metals including Al, Cd, Pb, and Hg, all of which have been found in high concentrations in food items for birds (Graveland 1990, Scheuhammer 1991, Swiergosz *et al*. 1998). If nestlings are being fed earthworms, a common crow food (K. J. McGowan, pers. observ.), the nutritional quality of

the meal is highly dependent upon the soil properties. Bilby and Widdowson (1971) found the main source of calcium for song thrush (*Turdus philomelos*) and blackbird (*Turdus merula*) nestlings was the soil inside the earthworms they were fed. In summary, the prey items available in these areas may be less mineral-rich or potentially toxic as a result of hyper-uptake of metal cations. The limited availability of minerals available in soils may aggravate an already-limited supply of available sources of dietary calcium (Graveland 1998).

While specific nutrient deficiencies may not trigger a significant corticosterone response, the low levels of calcium and protein appear to be detrimental to at least some crow nestlings. Tangredi and Krook (1999) reported, and our own experiences confirm, that suburban nestlings often end up in rehabilitation centers with folding fractures (bent or buckling soft bones) and overall poor development.

Urbanization is arguably one of the most significant global changes of this century, with far-reaching effects on ecosystems and organisms at all scales (Carriero and Tripler 2005, Grimm *et al*. 2008). Ecologists are beginning to appreciate that urbanization offers new opportunities to understand broad mechanisms and patterns (Shochat *et al*. 2006, Grimm *et al*. 2008). Replacement of natural areas with urban–suburban habitats displaces some species but appears to offer others benefits such as reduced competition and predation (Shochat *et al*. 2006). At the same time, shifts to urban and suburban habitats may hold subtle costs and certainly new selective challenges (Shochat *et al*. 2006). Studies at both population and individual levels will be important in understanding the long-term effects on the urban adaptors such as the American crow.

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Post-release GPS Tracking of Hand-reared Irish Hare *Lepus timidus hibernicus* Leverets, Slemish, Co. Antrim, Northern Ireland

Neil Reid and Alan T. Harrison

ABSTRACT: Animal rescue centers release large numbers of captive-bred, rehabilitated, or translocated animals into the wild annually but little is known about their post-release survival and behavior. We developed a novel and innovative coupling of traditional radio-tags with new GPS loggers to track hand-reared Irish hare *Lepus timidus hibernicus* leverets after release into the wild. Cyanoacrylate SuperGlue® proved a poor fixative, with two out of three leverets managing to detach their tags within 24 hr. Nevertheless, a total of 2,505 GPS locations were recorded every 60 sec for one leveret over three nights (approx. 835 per night). The leveret dispersed <410 m from the original release site. It demonstrated exploratory behavior, including an ability to navigate accurately in a complex and unfamiliar environment, returning to a habitual lie-up site each day. Its survival was confirmed up to 9 days post-release at which time its radio-tag detached; however, similarly aged leverets were sighted in the area for up to 2 mo post-release (suggesting possible longer-term survival). This is the first study to publish data from any GPS-tagged lagomorph and provides 'proof-of-concept' that large quantities of behavioral data can be recovered from small mammals 1–2 kg. Further development of these techniques will be highly valuable to future studies.

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Background

Animal rescue centers release large numbers of captive-bred, rehabilitated, or translocated animals into the wild annually (L. Stocker pers. comm., cited in Moloney *et al.* 2006), including mammal species of conservation concern; for example, bats (Kelly et al. 2008) and water voles *Arvicola terrestris* (Moorhouse 2004, Mathews *et al.* 2005, 2006). However, such releases are frequently regarded as having little or no value by conservation biologists either due to the small numbers involved or their limited success (Beck *et al.* 1994, Ginsberg 1994, Mathews *et al.* 2005, Jule *et al.* 2008).

Hand-reared and rehabilitated individuals can have substantially lower survival rates following release compared to their wild counterparts (Fajardo *et al.* 2000, Robertson and Harris 1995, Werner *et al.* 1997). Post-release survival has been shown to depend on body condition both before captivity and at the time of release (Moorhouse *et al.* 2007), handling stress (Monnett *et al.,* 1990), pre-release behavioral conditioning (Suarez *et al.* 2001), and the suitability of the release site (Monnett *et al.* 1990). Consequently, conservation strategies involving hand-rearing and release have important animal welfare implications (Cayford and Percival 1992, IAAWS 1992, IWRC 2005). Nevertheless, few studies have examined post-release survival and behavior of hand-reared animals, most likely for two principal reasons: 1) until relatively recently, tagging technology was expensive and data acquisition [was] labor intensive, and 2) the large size of many tracking devices precluded tagging small animals, including many young mammals.

The maternal strategy of female hares *Lepus* spp. is to leave their leverets hidden near the natal area and return for only the briefest period each evening to suckle. Consequently, leverets are particularly vulnerable to being found, presumed abandoned, and donated to animal rescue centers for hand-rearing (Anon. 2009). However, post-release survival and behavior of hand-reared leverets is entirely unknown.

The Irish hare *Lepus timidus hibernicus* (Bell 1837) is listed as an endemic subspecies of mountain hare *L. timidus* to Ireland. It is protected under Appendix III of the

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Bern Convention (Anon. 1979), Annex V(a) of the EC Habitats Directive (92/43/EEC 1992) and is listed as an internationally important species in the Irish Red Data Book (Whilde 1993). It is subject to both a Northern Ireland and an All-Ireland Species Action Plan (Anon. 2002, 2005) and, consequently, is one of the highest priority species for conservation action in Ireland.

This paper attempts to examine the post-release survival and behavior of three hand-reared Irish hare leverets using a combination of traditional radio-tags and relatively new GPS loggers which are small, light-weight, and inexpensive. The goal was to demonstrate the 'proof-of-concept' that GPS loggers can be deployed to collect useful data from relatively small mammals (1–2 kg). Demonstration of the feasibility of GPS tagging will benefit the design of future conservation projects that wish to evaluate post-release survival and behavior of hand-reared, captive-bred, or translocated animals.

Action

Radio- and GPS-tagging

The spatial and temporal resolution of data on behavior and survival is most critical immediately after release, as this is the period during which mortality is likely to be greatest. Spatial triangulation using traditional radio-tags can have a large margin of locational error, whilst the frequency of data acquisition is dependent on the availability of labor and financial resources. GPS loggers acquire high resolution spatial data at a fixed rate, but their drawback is that they must be retrieved in order to download the data.

The present study used homemade devices which incorporated a traditional radio-tag (TW-4 backpack with thermistor mortality sensor; Biotrack Ltd., Dorest, U.K.) and an i-gotU GT-120 travel and sports GPS logger (MobileAction, Taipei, Taiwan). The latter can be purchased relatively cheaply (£30 or $35) and was designed for backpackers, hikers, and other travelers so that they may map their spatial tracks (see: http://global.mobileaction.com/product/product_i-gotU_USB.jsp).

We deconstructed each i-gotU GT-120 to remove its bulky outer casing, coupled it with a TW-4 radio-tag, and sealed both inside heat-shrink tubing to create a 40 × 20 mm, 17-g watertight unit (Fig. 1). Each i-gotU GT-120 was pre-programmed to acquire data at an interval of 60 sec, and only during the crepuscular and nocturnal periods (17:00–09:00 hr during October). Battery life dictated that only three nights of data could be recorded.

It was imperative that hand-reared animals were not hindered by the tag, but that it would remain attached for a minimum of 4 days prior to dropping-off so that data were acquired and retrieved. The latter function was facilitated by the radio-tag, which had a battery life longer than the GPS logger, enabling the location of the entire unit to be triangulated and thus retrieved. Each unit was glued to the fur of the nape of the neck on each leveret using cyanoacrylate SuperGlue®; this was expected to hold for a few days or weeks before falling off.

Release

The Dublin Society for the Prevention of Cruelty to Animals (DSCPA) recovered three Irish hare leverets close by a dead adult female. A number of suspected poisoning events had been previously recorded in the area. The leverets were approximately 3 wk old and hand-reared by the 'Hogs of the Gods' Animal Rescue Centre, Dublin. All three leverets were released at approximately 16 wk of age, ensuring that they were fully weaned and independent. The release site was situated at Slemish Mountain, County Antrim, Northern Ireland and was chosen due to the suitability of appropriate habitat, being a mix of good quality agricultural grassland providing forage, and rush *Juncus* or heather *Calluna vulgaris*-dominated rough pasture providing shelter. Moreover, the site was remote from urban and rural developments and was known to support a resident population of wild hares.

Two leverets (1 male and 1 female) were tagged and released on 15 October 2009 whilst a third (a male) was released on 22 October 2009. All handling, tagging, and release were done under Government license TSA/12/09 (Licensee No. 961).

Data manipulation

The accuracy of the i-gotU GT-120 units was tested by leaving three devices in a known location overnight with a 60-sec data acquisition regime. Mean locational error was calculated. Leveret activity was described throughout the night by plotting the interfix distance against time. However, the mean locational error measured from test devices was subtracted from each interfix movement and all negative values replaced with zero. Consequently, movements less than the mean locational error for each device were attributed to the same spatial location and it was assumed the animal did not move. The interfix distance was then divided by the time elapsed between successive points to determine mean travelling speed, expressed in kph. The mean running speed of an Irish hare travelling at maximum velocity has been measured at 43.3 ± 1.8 kph (Reid *et al.* 2007). Any sequential GPS fixes that exceeded this speed, or those that were inconsistent with the overall direction of travel, were also removed from analysis.

Analyses

The minimum convex polygon (MCP) method (Harris *et al.* 1990) was used to determine the 'home range' per night whilst the 'range' and 'core range' were determined using the 95% and 50% probabilistic kernel method, respectively (Worton 1987). All radiotelemetric analyses were conducted using the Animal Movement extension (Hooge and Eichenlaub 2000) for ArcView GIS 3.3 software. Leveret activity was described throughout the night by plotting the interfix distance against time. Activity patterns were compared between nights using Spearman's rho correlation on the mean interfix distance per hour.

Consequences

Of the three leverets released, two removed their tags within 24 hr, suggesting that cyanoacrylate SuperGlue was a poor choice

of fixative. One GPS logger failed to activate whilst the other had acquired 4 hr of data before detachment. The latter indicated that the animal moved <210 m from the release site. No evaluation of survival could be made for either animal (Table 1).

The third leveret retained its tag for 3 days (sufficient to exhaust the battery life of the GPS logger) and it was decided to remove the tag manually to retrieve the data. The animal was triangulated using the radio-signal and was approached to within 1.5 m. A net was placed over it and the tag removed using a scalpel to cut the fur to which it was attached. Unfortunately, the animal had chewed the shrink-wrap casing and had damaged the USB connector, preventing the downloading of any data. Subsequent attempts to fix the damaged tag, including contacting the manufacturer, failed. Consequently, it was retagged, released *in situ*, and 3 days later recaptured. The second logger was removed intact and the hare retagged with a radio-tag only in order to continue monitoring survival (Table 1).

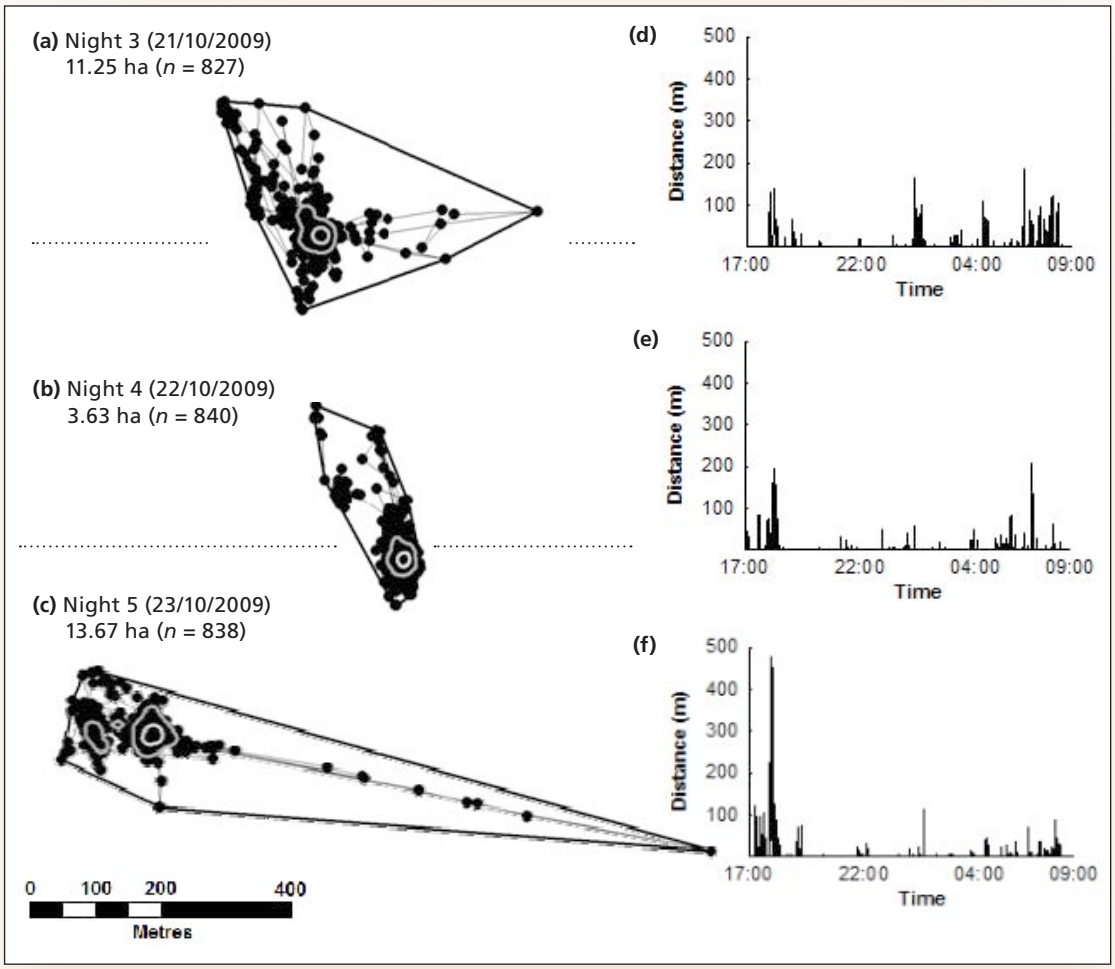

Figure 2. Minimum convex polygon home range of an Irish hare leveret during nights (**a**) 3, (**b**) 4, and (**c**) 5 post-release (external bold line). Dots represent GPS locations taken every 60 sec, thin lines represent movements, dark grey lines present the 95% kernel range, and light grey lines represent the 50% kernel core range. Graphs in (**d–f**) show movement activity throughout each night using interfix distances. The activity of the leveret was highly correlated between all three nights, being greatest just after dusk and increasing steadily towards dawn with a discrete peak during the middle of the night at 01:00 hours. We tentatively suggest that the consistency of this pattern demonstrates a regular daily routine which may vary little over short periods of time.

Survival of this leveret could only be confirmed up to 9 days post-release before the tag detached. It remained within <350 m of the release site for the first 4 days prior to recapture and GPS retagging. It subsequently dispersed <200 m from the second release site. Over the three nights during which GPS telemetry were retrieved, a total of 2,618 GPS locations were recorded. A total of 113 locations (<5%) were discarded as they either violated the maximum possible running speed of a hare or were inconsistent with previous activity. Consequently, a total of 2,505 GPS locations were retained for analysis (approx. 835 per night).

The total home range (MCP) of the leveret during each night (nights 3–5 post-initial release) was 11.25 ha, 3.63 ha, and 13.67 ha, respectively. The range of the animal (95% kernels) was significantly smaller at 0.40 ha, 0.28 ha, and 0.63 ha, respectively, whilst the core range (50% kernels) was 0.06 ha, 0.04 ha, and 0.10 ha, respectively. The ranges and core ranges overlapped between all three nights (by up to almost 100%), demonstrating a high degree of site fidelity (Fig. 2a–c). The diurnal lie-up location was at the center of each

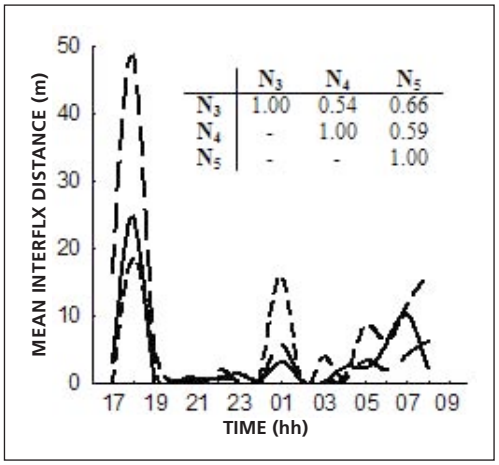

Figure 3. Leveret activity, defined as mean interfix distance (m) during each hour throughout the crepuscular and nocturnal periods for three nights (N3, N4, and N5 shown as separate lines). Insert shows the Spearman's rho correlation coefficients between each night, significant at $P < 0.05$.

TABLE 1. SUMMARY OF IRISH HARE LEVERETS THAT WERE TAGGED AND THE OUTCOME POST-RELEASE.

LEVERET ID	SEX	WEIGHT (KG)	DATE OF TAGGING & RELEASE	OUTCOME	DATE OF RETAGGING	OUTCOME	DATE OF CESSATION OF STUDY
150.104	M	2.00	22/11/2009	Tag detached within 24 hr. GPS logger failed to activate.	—	—	22/11/2009
150.155	M	1.65	15/11/2009	Tag detached within 24 hr; 4 hr of GPS telemetry acquired.	—	—	15/11/2009
150.032	F	1.65	15/11/2009	Tag remained attached for 4 days; GPS logger destroyed due to chewing.	20/11/2009	3 nights of GPS telemetry recovered.	24/10/2009

core range and did not vary over the 3 days of tracking. The total distance between the initial release site and the center of the core range during nights 3–5 was <410 m. During night 3, the leveret moved in multiple directions but never more than 400 m from the center of its core range (Fig. 2a). During night 4, the leveret moved predominately in a north-westerly direction but not more than 325 m from its core range (Fig. 2b). In contrast, during night 5, the leveret made a number of repeated long-distance exploratory movements in a roughly easterly direction up to 1,000 m from its core range (Fig. 2c).

GPS loggers had a measured accuracy of 38.8 m, and activity levels, determined by interfix distances, were adjusted accordingly. Levels of (corrected) activity varied significantly throughout each night between 0–475 m between successive fixes (Fig. 2e–f). The patterns of activity were very similar and were highly correlated between all three nights when generalized per hour (Fig. 3).

Discussion

To our knowledge, this is the first study to publish results from any GPS-tagged lagomorph and provides a proof-of-concept that satellite data can be retrieved from mammals <1.5 kg in size, elucidating behavior (in this case post-release dispersal and activity) in unprecedented detail. Moreover, the GPS loggers used here had a measurable mean error of <40 m, which is substantially better than many traditional radio-tracking triangulation techniques.

Cyanoacrylate SuperGlue proved a poor method of tag attachment, suggesting that future models of the tags used here may be better designed as collars or backpack mounts. This presents significant problems in retrieving tags. Although time-release collars are now available, they are generally too large for mammals as small as hares. Likewise, 'degradable' backpack mounts are available but these are designed to fall off over longer time periods (several months).

In the case of the individual leveret tracked successfully, it dispersed <410 m from the initial release site and may not have moved that far if it had not been for the disturbance caused by recapture and retagging. Whilst its maximum home range (MCPs) did not differ in size from that of wild Irish hares elsewhere (Wolfe and Hayden 1996, Jeffery 1996), its range (95% kernels) and core range (50% kernels) was significantly smaller (Reid 2006). The leveret used a fixed lie-up site during the 3 days for which GPS telemetry were retrieved and was capable of returning to this spot despite moving beyond its core range each night. Moreover, long-distance exploratory movements (up to 1 km) were direct and it followed the same path back to its core range with a high degree of precision. We tentatively suggest that despite being unfamiliar with the release site and surrounding area, the tagged leveret was evidently capable of accurate navigation in a complex landscape.

The activity of the leveret was highly correlated between all 3 nights, being greatest just after dusk and increasing steadily towards dawn with a discrete peak during the middle of the night at 01:00 hr. We tentatively suggest that the consistency of this pattern demonstrates a regular daily routine which may vary little over short periods of time.

Whilst the results of this study cannot be generalized, it demonstrates the extraordinary quantity of behavioral data that can be collected using readily available, economically cheap GPS loggers. Moreover, this study raises the possibility of answering questions which hitherto have been precluded due to a lack of adequate technology. Further research will allow [data collection for] not only the post-release survival and behavior of hand-reared leverets, but also other small mammals, as well as the behavior of wild animals.

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Wild Rights:
TOPICS ON ETHICS AND ANIMAL WELFARE IN WILDLIFE REHABILITATION

By Deb Teachout, DVM

The Five Freedoms

A few months ago I was attending a veterinary animal welfare forum, and I started thinking about how the ideal standards that were discussed for animal welfare in farm animals and in shelter animals would also apply to wild animals undergoing rehabilitation. As a veterinarian, I have been lucky enough to have worked with animals from all three of those groups, and I have never doubted for a minute that they all have the right to be treated with respect. But what does that mean? You might have noticed the ruckus that often breaks out when people debate animal rights *versus* animal welfare, and that's okay if you're into philosophy and need to debate that question. But, for those of us that actually work with animals and care about providing for their welfare, it really boils down to these two questions: What does the animal need and want? How do we make sure those requirements are met?

The concept of the 'Five Freedoms' can really help answer those questions. It originated in 1979 from the Farm Animal Welfare Council in the United Kingdom as a vision and definition for the ideal animal welfare standards to achieve when keeping farm animals (Farm Animal Welfare Council, 2009). It appropriately applies to both the mental and physical health of the animal, each being a necessity in terms of providing for the animal's sense of well-being. The Five Freedoms actually provide a reasonable and comprehensive framework for analyzing the welfare of animals within any particular system where animals are kept. It is so successful and well respected in this regard that, in the recently (December, 2010) released and long-awaited *Guidelines for Standards of Care in Animal Shelters* from the Association of Shelter Veterinarians, it states that the entire document was modeled along the lines of the Five Freedoms from the United Kingdom's Farm Animal Welfare Council. The Association of Shelter Veterinarians stated that the principles are relevant and appropriate measures of welfare for any animal species (Newbury *et al.* 2010). That's the beauty of these ideals; they apply to the welfare of any animal kept by humans, even wildlife. I would add that a thorough knowledge of each species' natural history is imperative to successfully utilizing the Five Freedoms in wildlife rehabilitation.

Here are the Five Freedoms (Farm Animal Welfare Council, 2009):

1. Freedom from Hunger and Thirst *by ready access to fresh water and a diet to maintain full health and vigor*
2. Freedom from Discomfort *by providing an appropriate environment including shelter and a comfortable resting area*
3. Freedom from Pain, Injury, or Disease *by prevention or rapid diagnosis and treatment*
4. Freedom to Express Normal Behavior *by providing sufficient space, proper facilities, and company of the animal's own kind*
5. Freedom from Fear and Distress *by ensuring conditions and treatment which avoid mental suffering*

Certainly the Five Freedoms should apply to welfare standards for permanently captive wildlife serving as educational ambassadors. It could be argued that the Five Freedoms are even more important for them than for the transiently captive wildlife undergoing rehabilitation.

The Five Freedoms have not widely been mentioned or employed in the field of wildlife rehabilitation in the United States yet, but a quick Google search yielded results showing application of the Five Freedoms to wildlife care in Canada, the United Kingdom, and Australia.

So, what do the animals need and want? How do we make sure those requirements are met? The Five Freedoms offer a perfect foundation for creating an ideal standard of care in our facilities that will offer the best welfare possible for captive wildlife experiencing the process of rehabilitation. And in adopting the Five Freedoms, we take our place in the strong, growing, and diverse worldwide effort to improve the quality of life for all animals, farm, companion, and wild.

Watch for application of the Five Freedoms in future columns as we traverse the field of ethics and welfare in wildlife rehabilitation. Stay tuned!

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

Up For Discussion: Do As I Say

THE ISSUE

Wildlife rehabilitators have long understood the need to educate the public about appreciating and living in harmony with wildlife. Moreover, rehabilitators have ready access to non-releasable animals who can help put a face on some abstract concepts and drive home an important message. In fact, it's often the chance to meet a wild animal "up close and personal," rather than the educational theme of the program, that draws a crowd. And that's fine, because if we've done our job well, they'll leave having been enlightened as well as entertained.

Still, nearly everyone who's stood before an audience—be they preschoolers, Millennials, Gen-Xers, Boomers, or the greatest generation—with a wild animal has had to deal with the dreaded question: "Can I keep one as a pet?"

Of course, this is not the message intended to deliver, but can you blame them? There you are, standing in front of a bunch of envious people holding a cool creature who looks pretty calm and healthy, so obviously it does pretty well in captivity… we really shouldn't be all that surprised when they wonder, "how come you can do it while telling me I can't?" If only there were some way for wildlife educators to avoid or overcome this hazard of using live animals in education programs.

THE QUESTION:

How do you avoid sending a "do as I say, not as I do" message with your captive education program animals?

THE RESPONSES:

This is an interesting subject and one where the RSPCA has strong views! First, no legislation is required for wildlife rehabilitation in the UK, so there have always been people who take wildlife to classrooms and events to 'educate' people. These animals are normally non-releasables, but could include animals due for release. We hope that good rehabilitators know not to use releasable animals in such programs, but is that always the case? Habituation to humans could lead to the death or injury of the animal, or to a member of the public, after release. Anecdotal examples of such problems are widespread.

A recent change now mandates a license to keep bats, and several other specific species, for educational purposes.

So what are the perceptions of those you are trying to educate? To me, an animal sitting on your arm is likely to encourage people, especially children, to want the same. It is cool, trendy, even macho, to have the latest exotic pet. Advertising campaigns such as Compare the Market/ Compare the Meerkat have increased interest in meerkats as pets—animals that are very unsuitable. This trend harms conservation, and if by our display, we suggest this activity is cool, we may do more harm than we think.

Recently on UK television, a rehabber displayed a 10-week-old otter cub. The host of the show declared he wanted one for a pet—entirely the response we do not want.

The perception of those watching you with your educational animal is the critical factor—what you think you are presenting may be different from what they perceive. Do you consider your educational animal a pet? Your audience probably does, and rightly so. According to one paper, you and your animal fulfill the public perception of a pet by displaying a bond, the animal–human 'with' (Sanders 1990).

Adam Grogan
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I have rehabilitated wildlife for over ten years, but that doesn't mean I've done it well the entire time. I began as many do—by the seat of my pants—and had to be self-starting in my education. However, this question arose early in my experience, and my answers depend on the age of the inquirer and setting in which I'm showing an animal.

I don't have educational animals, but as part of workshops, have shown baby birds, squirrels, possums, raccoons—you name it—to the public as a source of wildlife education. This question often comes with "We had one of those when I was a kid, but (proud smile here) we freed it after a couple of years!"

First, I don't resist the question. The point is not to wag a finger, but to walk the inquirer, through their own reasoning, to the best answer. If it's a young person, I ask if they understand the difference between domestic and wild and explain that certain species have been bred by humans for thousands of years to be helpers, pets, or food.

Then I ask "Why not this one? Why do you think humans didn't domesticate raccoons?" (Substitute any animal—eagles, bobcats, etc.). I want the child to invest in his or her own critical thinking skills; this is the route to their ownership of the answers,

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which is more meaningful than anything I could tell them.

Next, we talk through *exactly* what it entails to keep this animal as a pet. I address education and laws but move quickly past that. People often realize that game rangers seldom go door-to-door. I do tell them about the animal's needs: the size of cage, kind of foods, stimulation, and play. How would they manage them indoors, or outdoors? What about threatening weather? What would you do if one killed or hurt one of your domestic pets, or passed a disease to each other? Could you stand to feed them a screaming, live animal, or could you kill one for them?

I discuss hygiene in particular, reminding the person that wild animals are not potty trainable (though I know the occasional individual may be). Then we discuss the constant care and vet costs. The dollar signs are often quite discouraging, but unmanageable feces usually caps a decision.

I let them know they cannot travel for more than one or two days, or their "wild child" will revert and become re-sensitized. So no summer vacations. They must spend part of *every day* with that animal. Usually, a tamed animal is caged alone, and if they have more intelligence than a worm, they need company. *You* are their company.

Are they willing to pursue and provide research, public and personal education, housing, stimulation, licensing, nutrition, companionship—always with the bittersweet knowledge of what it must be like for the animal? And that they could invest all this time and love, only to have this creature rip your ear off one day, or watch it get sick and die with no one to help, or know that if it gets loose, it's doomed?

I let them know that animals in rehab will be released or euthanized; that educational animals are sacrificing their very nature to us for inspiration and learning, and we might choose to honor that sacrifice by taking better care of our planet.

I make a comparison. If you were an astronaut, and got hurt landing on another planet, maybe a kind-hearted alien would take you in. No more pizza or Coke—you would eat their alien food. You might heal somewhat, but you would be limited for the rest of your life; maybe unable to walk, pick things up, or feed yourself. They would put you in a box and your only company would be one of them. They don't speak your language or look like you, they would handle you all over, and sometimes take you out for other aliens to look at or touch.

You would never see people. You couldn't call a friend, you couldn't have a sweetheart, you'd never experience children.

But you would be alive, and because of that, the aliens would begin to understand humans for the first time. Maybe they'd prevent others from crashing on their planet. Maybe they'd stop blasting spaceships to pieces before landing. Maybe they would begin to see the amazing connections of the universe, how we all fit together, and take actions to improve the universe for us all.

That's as close as it comes to 'getting' what it would be like to live as an educational wild animal. It's a huge responsibility for the rehabber who undertakes it; is the person who wants this exotic "pet" ready and able to shoulder it?

If they answer "yes", then enlist them at the center or have them help you clean cages. Give them handouts and get their e-mail addresses. Book 'em, Dano.

You might have another rehabber in the making.

Kim Doner
Tulsa, OK, USA

As an elementary-age educator, I would approach the subject head-on at the beginning of my presentation. "Could you keep this animal as a pet?" Most children are smart and compassionate, and want to do what is best.

The next question might be, "Why should we *not* keep this animal as a pet?"

I would follow with, "The animals I am going to show you today have been hand raised by a trained wildlife rehabilitator and cannot be released because of [insert condition].

"Having a license to rehab means that we take an oath *not* to imprint an animal —we are raising this animal to be free and wild. But when an animal is injured and cannot be released, we must choose to euthanize it or use it to teach you how to respect this animal in nature."

Other points might be:

1. This animal is wild. Do you know the difference between domestic and wild?

2. Do you think it's a good thing to live in a cage all your life?

3. What are the reasons you have pets?

4. Do you know what this animal needs to survive?

5. This animal will never be domestic. We cannot play or interact with it like a pet.

6. Wildlife can be dangerous. You can be bitten or get a parasite from wildlife that you would not get from a pet.

7. Wild animals are not treated by most vets.

8. It is illegal to have a wild animal in your possession without a special license. Those who are caught pay very large fines.

I believe this topic should be *first* on the education agenda. Fines and disease usually elicit the appropriate response, and can be of value in preventing people from bringing animals into their homes.

I also discuss fawns, which are my specialty. However sweet they are as babies, once their hormones present themselves, they too can be dangerous.

I emphasize the special care and special food needed for all, and the expense.

To the adult population, I offer the opportunity to talk more about the work and the time and commitment to the animals. If someone is interested after that, then we talk about classes, licensing, etc.

Karen OConnor
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Mitigating Amphibian Disease: Strategies to Maintain Wild Populations and Control Chytridiomycosis

D. C. Woodhams, J. Bosch, C. J. Briggs, S. Cashins, L. R. Davis, A. Lauer, E. Muths, R. Puschendorf, B. R. Schmidt, B. Sheafor, and Jamie Voyles. *Frontiers in Zoology* 18;8(1): 8.

Rescuing amphibian diversity is an achievable conservation challenge. Disease mitigation is one essential component of population management. Here we assess existing disease mitigation strategies, some in early experimental stages, which focus on the globally emerging chytrid fungus *Batrachochytrium dendrobatidis*. We discuss the precedent for each strategy in systems ranging from agriculture to human medicine and the outlook for each strategy in terms of research needs and long-term potential. We find that the effects of exposure to *Batrachochytrium dendrobatidis* occur on a spectrum from transient commensal to lethal pathogen. Epidemiological models of chytridiomycosis suggest that mitigation strategies can control disease without eliminating the pathogen. We propose population-level treatments based on three steps: first, identify mechanisms of disease suppression; second, parameterize epizootiological models of disease and population dynamics for testing under semi-natural conditions and; third, begin a process of adaptive management in field trials with natural populations.

Does "Acoustic Anchoring" Reduce Post-translocation Dispersal of North Island Robins?

D. W. Bradley, C. E. Ninnes, S. V. Valderrama, and J. R. Waas. *Wildlife Research* 38(1): 69–76.

Animal translocations are an important conservation tool; however, post-release dispersal can hinder successful population establishment. Playback of conspecific song attracts dispersing individuals in some species, although its application following animal translocation has yet to be rigorously investigated. To determine whether conspecific song can be used as an 'acoustic anchor,' we adopted an experimental approach during the translocation of 60 North Island robins (*Petroica longipes*). At one of two release locations, we broadcasted song at natural rates from four speakers (4 hr per morning) for 9 days following release; we set the second release location as a control where identical conditions were established but no playback occurred. To assess the impact of playback, we monitored speaker and control locations, surveyed tracks around the release areas, and radio-tracked robins over 9 playback days and an additional 9 days. We demonstrated a short-term attraction effect of playback over a period of several weeks for some birds, particularly females. In contrast, we detected fewer birds over a shorter period at the silent control release site, where no females were detected. However, long-term monitoring at both sites suggested that the effect of playback on reducing post-release dispersal was transitory.

Handling Stress of Female Common Eiders During Avian Cholera Outbreaks

E. I. Buttler, H. G. Gilchrist, S. Descamps, M. R. Forbes, and C. Soos. *Journal of Wildlife Management* 75(2): 283–288

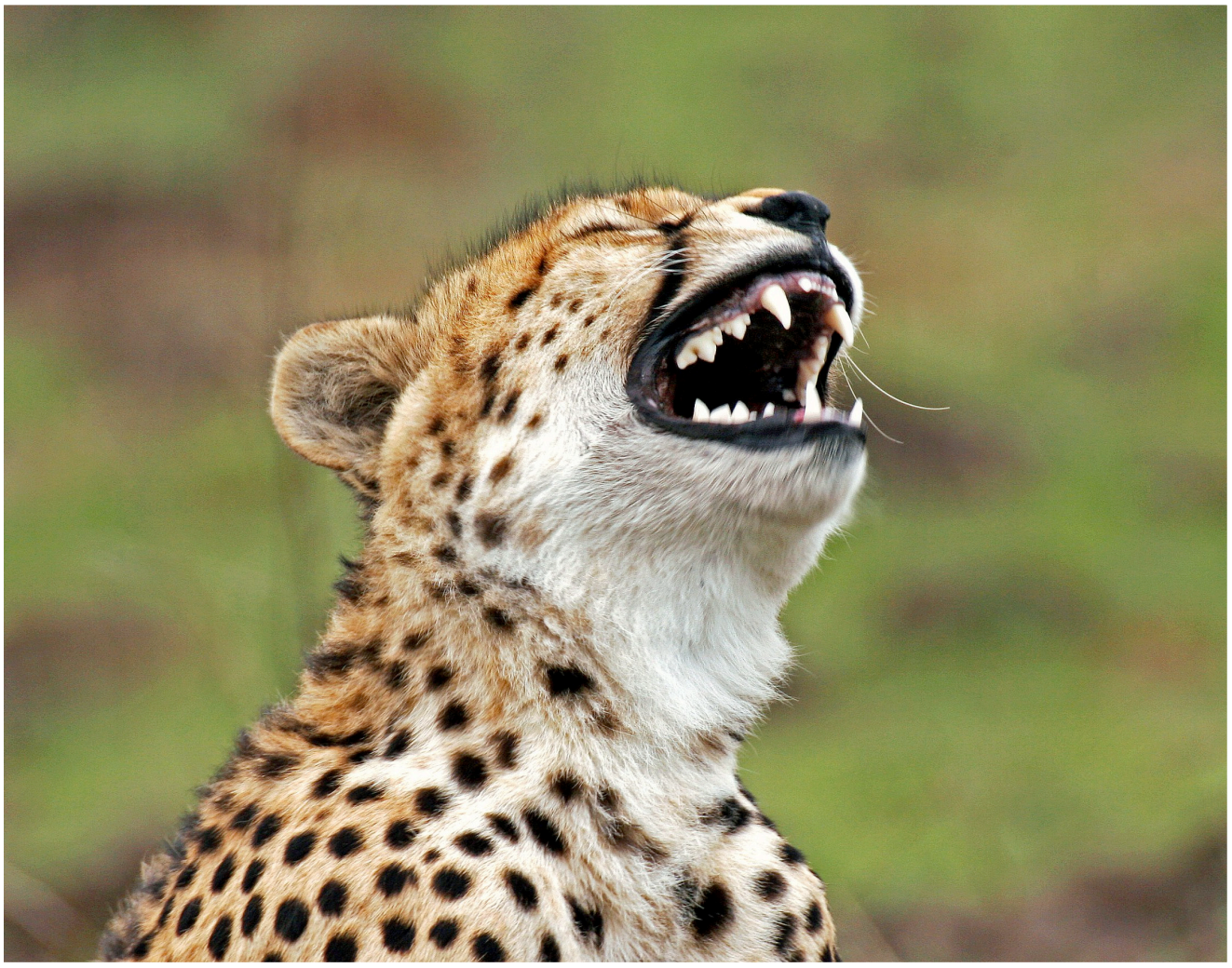
Researchers often consider the importance of minimizing holding time during research activities; however, the long-term costs of such handling stress are rarely explicitly measured. As part of an ongoing study of common eiders (*Somateria mollissima*) at a breeding colony in East Bay, Southampton Island, Nunavut, we recorded duration of restraint for females captured during avian cholera epizootics (2007 and 2008) and monitored female fates (breeding probability, onset of laying, and survival) relative to holding time. Probability of death increased with holding time in 2007 from an estimated 0.05 for females held 20 min to 0.33 for females held for 150 min. In 2008, we responded by limiting holding time to <90 min, and mortality was no longer positively correlated with holding time, although total mortality was greater due to increased severity of avian cholera. In both years, longer restraint durations delayed onset of egg-laying after capture by 0.5 days for each 10 min of additional restraint but did not prevent breeding. This delay of nest initiation did not enhance survival probability. Our results show that prolonged holding time can exacerbate mortality during epizootics and emphasizes the importance of minimizing restraint time in wild birds, especially in the presence of diseases.

Morning Release into Artificial Burrows with Retention Caps Facilitates Success of European Ground Squirrel (*Spermophilus citellus*) Translocations

C. I. Gedeon, O. Vóáczi, B. Koósz, and V. Altbäcker. *European Journal of Wildlife Research* (7 February 2011), pp. 1-5. http://dx.doi.org/10.1007/s10344-011-0504-3

Relocating ground squirrels within their natural distribution range is a popular tool in wildlife management in Central–Eastern Europe. Nevertheless, wildlife management lacks both a carefully developed and tested translocation guide and methods. We evaluated conditions of release method (time of release and retention of animals) that affect short-term settlement of translocated ground squirrels in the central region of Hungary. In a field experiment, we translocated 117 individuals from an international airport to a protected site in [the year] 2000. We found that release time should precede the animals' natural, daily activity peak. The use of retention caps, combined with artificial burrows instead of complex acclimation cages, works successfully to prevent animals from dispersing from the release site. ■

TAIL END



CHEETAH (*ACINONYX JUBATUS*) PHOTO © VEARL BROWN (PICTURE TAKER 2 ON FLICKR), CREATIVE COMMONS LICENSE.

"You want me to become a vegetarian? Riiigghhtt!"

Winning caption by Nancy Collins, Denton, Texas, USA

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