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Feather imping and rehabilitation of a red-tailed tropicbird

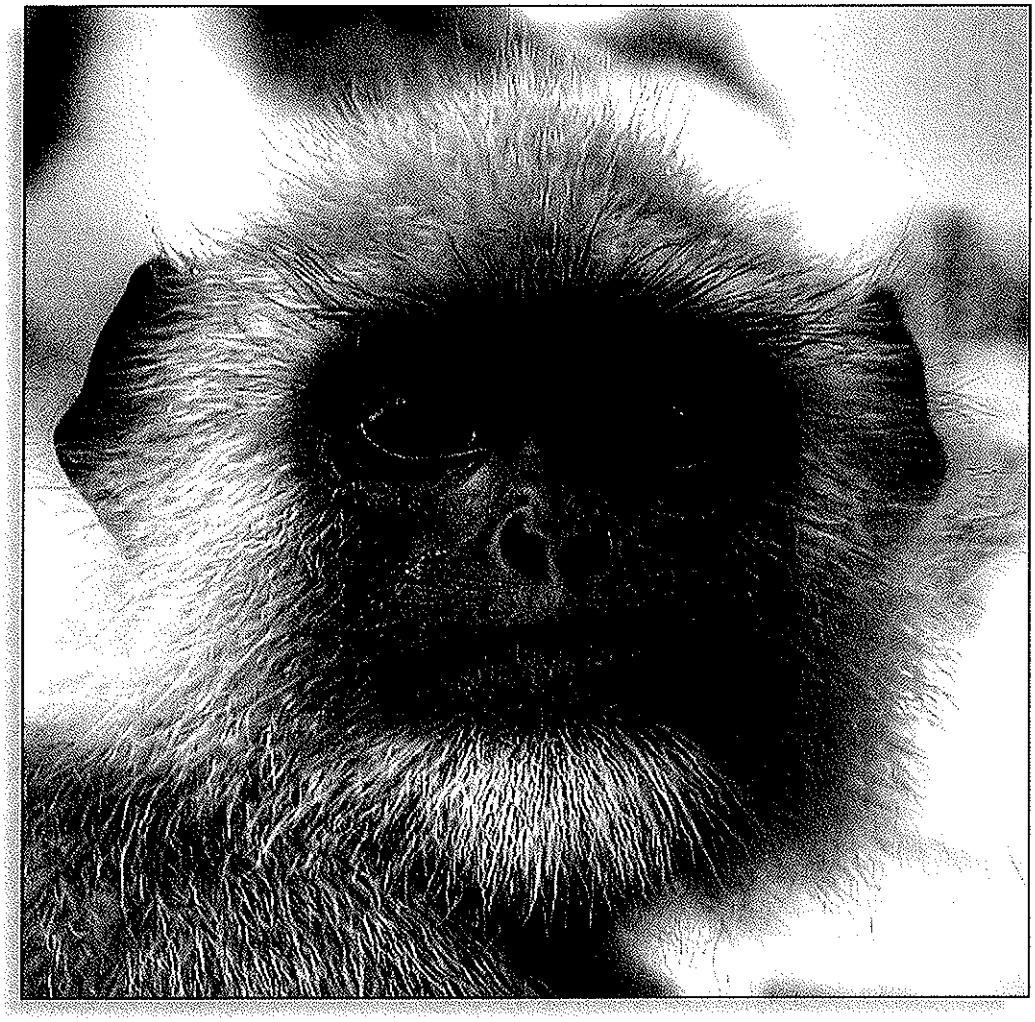
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ABOUT THE JOURNAL

THE JOURNAL OF WILDLIFE REHABILITATION is designed to provide useful information to wildlife rehabilitators and others involved in the care and treatment of native wild species, with the ultimate purpose of returning them to the wild. The journal is published by the International Wildlife Rehabilitation Council (IWRC), which invites your comments on this issue. Through this publication, rehabilitation courses offered in numerous locations, and an annual conference, IWRC works to disseminate information and improve the quality of care provided to wildlife.



Portrait of a Hunuman langur (*Semnopithecus entellus*). Photo ©Jhinuk Chowdhury, PhD. Used with permission.

ON THE COVER:
A nesting red-tailed tropicbird (*Phaethon rubricauda*).
Photo ©Scott Buckel. Used with permission.

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First Come, First Serve

The recent U.S. presidential election and subsequent flurry of political appointments has had me thinking about the role of "firsts"... about the challenge an individual faces when she or he is seen by others as representing all members of some previously excluded group, simply by virtue of being the first in that cohort to hold a particular position. Just like the new (and therefore exotic) kid at school, every utterance is discussed, every action scrutinized by the old gang of insiders.

I have my own experiences as a first; there's been less media scrutiny, to be sure, but the frustrations—and fortuity—are similar. As a wildlife biologist employed on the faculty of a college of natural resources, and whose resume includes tenures as an active rehabilitator, director of a rehabilitation center and, currently, editor of a rehabilitation journal, I'm often the first member of the rehabilitation "demographic" my colleagues have ever met face-to-face. During casual conversations in the halls or at professional conferences, I may find myself attempting to clear up misconceptions or explaining how rehabilitation can contribute to our understanding of wild species. These conversations are generally friendly in tone and are motivated, by and large, by a sincere curiosity. Sometimes, of course, questions take a familiar direction: do I know someone who could bring an eagle to their child's classroom?

The greater challenge is when I am *not* the first rehabilitator this colleague has ever met. It's sad but true; humans seem to latch on to the negative even when it represents a small percentage of the whole, and I've been subjected to my share (and then some) of rehabilitator horror stories. How, my Inquisitor will ask, can I possibly justify rehabilitation and my continued involvement?

I've got plenty of answers, believe me. Even so, I could legitimately respond that it's not my job to be the rehabilitation poster child or to answer as Rehabilitator for the real or perceived transgressions of others in this discipline. I could ask my Inquisitor how s/he would like to be ambushed into speaking for all wildlife biologists everywhere, the worst as well as the best. I could just walk away...

Instead, I try to recognize that I have a unique and priceless opportunity: to educate; to challenge stereotypes; to be a role model. And then I do my best to open or change their minds.

Is it fair that I am called upon in this way? Well, as my mother asked me many times (yours too, I'll bet), "Who told you the world was fair?" Rehabilitators are the new kid at the wildlife profession school and we shouldn't be surprised if we're subjected to both curiosity and scrutiny. Each and every one of us is a representative of Rehabilitation, whether we like it or not. Yet we can only benefit, individually and as a discipline, by modeling to others what we know to be good and true and valuable about this work we've taken on. Every day, whether the evening news cameras are rolling or not.

Kieran Lindsey, PhD
Editor
Journal of Wildlife Rehabilitation

On Rights and Obligations

To the Editor:

As a philosopher, John Hadidian [Editorial, *JWR* 29(1)] is a very good anthropologist. The animal rights thing is not philosophically interesting, except as a way of getting at a discussion of rights and obligations, which is more a matter of law than moral philosophy taken as a whole, and a very small part of post-Modern moral philosophy. You can't separate rights and obligations; if I have a right, then there is a corresponding set of obligations—on another to honor my right, and on me to assert it. There is a balancing act, an attempt at equity.

The pigeons I bring in for care (among the most traduced of urban wildlife, I note in passing) impose no obligation, they demand nothing of me—even when they appear to be deliberately presenting themselves to me as needful. What they do evoke is my pity and my love, and sometimes a great deal of emotion I would normally consider foreign to my nature—which is quite enough. These are expressions of what it is to be human; they are part of caring for the world in which we find ourselves—a very loaded set of concepts. It is out of duty to ourselves to be the best kind of human beings we can be, to be the most caring and careful we can be, that we do what we do. This is both theoretically true and readily substantiated in experience.

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The Editor encourages readers to respond to any articles featured in the *Journal of Wildlife Rehabilitation*. Please direct general questions and comments to *journal@iwrc-online.org*. To respond to a specific article or column, please contact the author directly. Letters may be edited for clarity and length.

SELECTED ABSTRACTS

Post-release survival of hand-reared pipistrelle bats (*Pipistrellus* spp.)

A. Kelly, S. Goodwin, A. Grogan, and F. Mathews

Animal Welfare 17(4): 375-382

Very little is known about the post-release survival of hand-reared pipistrelle bats (*Pipistrellus* spp). The authors radio-tracked 12 hand-reared pipistrelle bats released under three different protocols: 1) limited pre-release flight training and over-wintering (n = 5); 2) prolonged pre-release flight training, but with limited space (n = 2); and 3) prolonged pre-release flight training in large flight cage (n = 5). Of the five bats reared under the first protocol, four were recovered, grounded, within 48 hr; the signal from the fifth bat was lost on day two due to either tag failure or from the bat flying out of the study area. Both bats in the second group flew strongly on the night of release, but on the second and third nights, only one emerged and briefly flew. The signals from both bats remained stationary on subsequent nights. In contrast, bats from the third group were tracked for between 5–10 nights, indicating that they were able to survive independently following release. These preliminary results suggest post-release survival depends on extensive pre-release conditioning in a large flight cage, rather than on the limited flight opportunities traditionally provided within domestic houses by bat caregivers. Other factors that may affect post-release survival are discussed, and further work is encouraged to determine whether rehabilitated bats integrate with the local population.

The effects of captive experience on reintroduction survival in carnivores: A review and analysis

Kristen R. Jule, Lisa A. Leaver, and Stephen E.G. Lea

Biological Conservation 141(2): 355-363

This review focuses on the success and survivorship of captive-born versus wild-caught carnivores used in reintroductions. Previous reviews have suggested reintroduction projects using captive-born animals are less likely to be successful than projects translocating wild-caught animals. The authors examined this hypothesis statistically and investigate how captivity may affect the survival of reintroduced carnivores. Published results from previous reviews support that reintroduction projects using wild-caught animals are significantly more likely to succeed than projects using captive-born animals. They further compiled their own review of 45 case studies in carnivore reintroduction projects (in 17 species across 5 families) to specifically investigate survival rates rather than just overall project "success." The authors also found: 1) wild-caught carnivores are significantly more likely to survive than captive-born carnivores in reintroductions; 2) humans were the direct cause of death in over 50% of all fatalities; and 3) reintroduced captive-born carnivores were particularly susceptible to starvation, unsuccessful predator–competitor avoidance, and to disease.

How Does Imping Affect Wing Performance?

Eli S. Bridge

Introduction

Although birds' feathers are fairly resilient to damage, they are quite often broken, split, or severed when birds encounter environmental hazards. Such damage to the flight feathers can severely impair a bird's ability to fly, which in most circumstances means imminent death for that individual. Imping refers to the replacement of worn or damaged feathers wherein a new feather is grafted onto the base of the existing feather by means of a splint glued into the shaft. This technique has been used for centuries by falconers (Michell 1900, Hoefler 1986) and has been adopted by veterinarians and avian caregivers as a useful means of rehabilitating birds with damaged feathers (Lahr 2000, Lierz 2000, Vaassen 2000).

Imping has aided the rehabilitation of several types of birds including vultures (Cathartidae; Vaassen 2000), raptors (Acciptridae; Lierz 2000), and albatross (Diomedidae; Howell 1994). However, little is known regarding the actual effects of imping on wing aerodynamics and how those effects compare to alternative approaches to dealing with injured birds. Clearly, if a bird's flight feathers are heavily damaged or broken off, then imping is the best solution. However, it is less clear what course to take when feathers are abraded or only partially damaged or missing, and considerations such as the availability and quality of replacement feathers may further complicate treatment decisions.

This paper describes an experimental evaluation of imping and wing aerodynamics in which a model of the left half of a pigeon torso, equipped with a freeze-dried wing, was mounted in a wind tunnel in such a manner that the effects of feather removal, feather replacement, and heavy feather wear could be quantified. Comparison of simple aerodynamic parameters such as lift and drag are presented to allow for a rudimentary evaluation of the relative costs of imped feathers, wing gaps of various sizes and in different locations, and feather wear, with the intent of guiding rehabilitators in the use of imping procedures.

Methods

Model construction

The pigeon model consisted of a wood and aluminum torso to which I attached freeze-dried pigeon wings (Fig. 1). Using photographs from the literature as a reference (e.g., Butler et al. 1977), I hand-carved the torso to match the profile and proportions of a pigeon flying in a wind tunnel. At the location of the shoulder joint, I installed a steel ball joint that could be locked into a particular position by tightening a set screw.

I used nine pigeon wings in this study, all of which I obtained from birds that were used in instructional dissections or euthanized as part of other research projects. Only wings with no visible signs of wear were used. I removed the wings at the shoulder joint and pinned them in a gliding position with an angle of approximately 140° at the wrist joint. However, because of anatomical variation in the wings, it was impossible to have strict standardization of

IN YOUR PRACTICE: For those who work with avian species, this paper provides insight on the ways in which feather wear, missing feathers, and imping effect the flow of air over the wing and, as a result, the effect of these conditions on flight performance.

ABSTRACT: Imping is a means of repairing damaged remiges in which relatively new feathers are grafted in place of worn or broken feathers. Although imping has often been used successfully by avian rehabilitators, to date there has been no scientific valuation of how imping may affect flight performance. This study uses a wind tunnel model to evaluate the relative effects of imping, wing gaps (i.e., missing feathers), and feather wear on lift, drag, and lift coefficients in pigeon (*Columba livia*) wings. The results indicate that imping is benign with regard to gliding performance, and that the effects of small wing gaps are also relatively minor. Feather wear, however, had a strong negative effect on wing performance, indicating that releasing rehabilitated birds with abraded feathers should be avoided.

KEY WORDS: imping, feathers, feather wear, damaged feathers, treatment decision, flight, lift, drag, wind tunnel

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all aspects of wing posture. After pinning, I placed the wings in a freeze drier, where they remained until weight loss (i.e., water loss) ceased. I then inserted a piece of stiff wire into the medullary cavity of the humerus and glued it in place with superglue. The wing was then attached to the torso by inserting the free end of the wire into a hole machined into the ball joint, and a small set screw in the ball was used to hold the wire in place. The final product was a wood-and-aluminum body with an adjustable, freeze-dried wing attached (Fig. 1).

The wind tunnel

For this study I used an open-ended (blow-through) wind tunnel owned by the University of Minnesota Department of Aerospace and Engineering. The tunnel was powered by a variable-speed motor with a centrifugal blower and was equipped with a large diffuser that minimized turbulence before air passed into a rectangular test area with a 60 × 60 cm (2 × 2 ft) cross-section. I used the same speed setting during all measurements in this study, and airspeed measurements varied from 10.84 m/sec (35.56 ft/sec) and 11.14 m/sec (36.55 ft/sec), with an average of 11.09 m/sec (36.38 ft/sec).

The tunnel was equipped with an NK Mini-6 Sensor (NK Biotechnical Engineering Company, Minneapolis, Minnesota, USA) that employed an array of six stress sensors to provide three-dimensional measurements of the composite forces and moments acting on the model. The sensor was installed into a sidewall sting that attached to, and supported, the model from the model's right side. The model was mounted by means of a square cavity that was machined to fit the sting, and a set screw was used to lock the model in place.

Because the model consisted of only the left half of a bird, substantial components of lift and drag were detected, as axial and normal torque, respectively. In a real bird (or a two-winged model) there would be equivalent and opposite moments on both wings, such that axial torque would result in lift and normal torque would be a component of drag. To calculate lift and drag components comparable to a full bird model, I used a removable extension rod to alter the distance between the model and the sensor by a known amount (6 cm; 2.36 in). Because torque can be represented as a force acting at a distance (d) from a rotational axis, the torque generated without the extension (To) equals F • d, where F is the force on the wing that gives rise to torque. Similarly, after controlling for the torque caused by the wind resistance of the extension itself, the torque generated by the wing mounted on the extension (Te) equals F • (d + 6 cm). If we assume that F remains unchanged with or without the extension, then we can calculate this force from the above equations as F = (Te – To)/6 cm (Fig. 2). Hence, I was able to convert lift and drag moments into simple forces that would apply to a two-winged model.

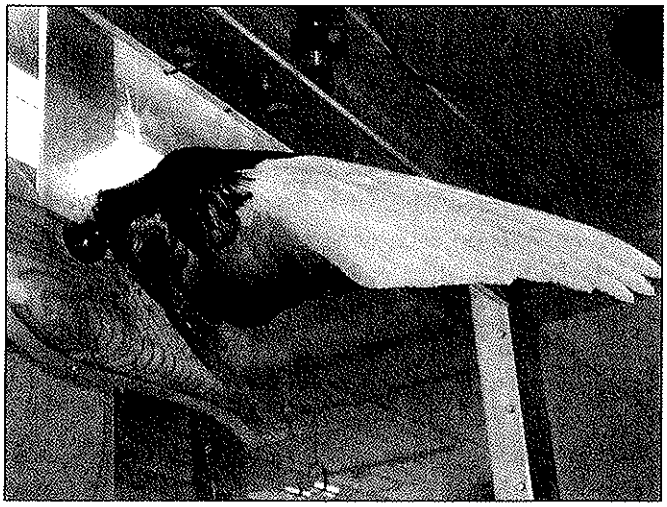


FIGURE 1. Photograph of the bird model inside the wind tunnel test section.

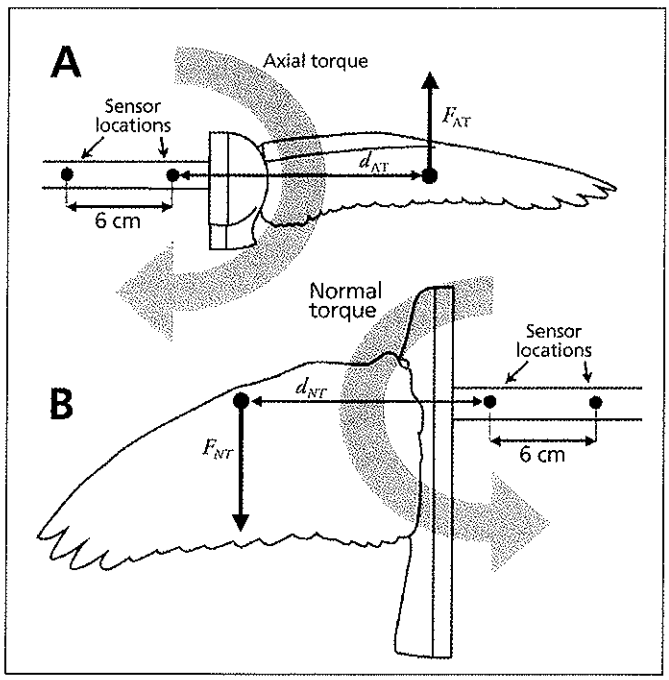


FIGURE 2. **Frontal (A) and overhead (B) views of the pigeon model used to measure wing performance.** The gray arrows illustrate axial (drag) and normal (lift) torque and point in the positive direction (in this case upward lift is regarded as a negative number). Force vectors F_{AT} and F_{NT} give rise to negative axial torque and positive normal torque, respectively. These forces act on the wing at distances of d_{AT} and d_{NT} from the initial sensor location where torque is measured. By adding an extension to the end of the sting supporting the model, the sensor location is effectively moved 6 cm (2.4 in) farther from the model, such that the distances between the centers of forces F_{AT} and F_{NT} are d_{AT} + 6 cm and d_{NT} + 6 cm, respectively.

Measurement procedure

Because of the camber and irregular shape of the wings used in this study, as well as the morphological variation among them, there was no objective way to establish a consistent angle of attack to be used throughout the study. Therefore, I performed a series of preliminary measurements on each wing to find a wing position in which the lift-to-drag ratio was maximized. This angle of attack was found by trial and error and involved numerous small adjustments of the wing angle on the torso (the torso was maintained in the same position for all measurements).

After finalizing the wing position, each measurement began by taring the sensor with no airflow in the wind tunnel to eliminate the effects of the model's weight. I then initiated airflow in the wind tunnel and waited until the airspeed had leveled off at approximately 11 m/sec (36 ft/sec) before taking a measurement of the forces and moments caused by airflow over the wing model. All measurements were averages of 30 sensor readings taken over a period of approximately 1.5 min.

I used a video camera mounted directly above the working area of the wind tunnel to record digital images of the wings during the measurement process. These images were later analyzed using Carnoy v2.0 software (Schols et al. 2002) to determine the changes in wing surface area caused by experimental manipulations of the feathers.

Molt gap and feather wear treatments

Gaps were created in the wings by trimming the primaries just below the coverts such that the entire exposed portion of the feather was removed. Feathers were restored to the wing using a piece of bamboo glued inside the shaft of the feather. After feathers were imped, I took a set of measurements with the repaired wing to establish a new set of baseline measurements for comparison with subsequent measurements on wings with gaps. Gap treatments included the removal of two, three, and four feathers among the inner, middle, and outer primaries. Imping treatments entailed the replacement of each group of feathers that were removed to generate gaps. The order of the treatments with respect to wing region was randomized, but the gap size treatments within each region always progressed from small to large (Fig. 3). To control for the effects of previous treatments on a wing, treatment measurements were compared to previous measurements in which the relevant gaps or imped sections were absent, but imped feathers from previous treatments were present. For example, in the series of treatments illustrated in Figure 3, measures from treatments 6, 7, 8, and 9 would be compared with those of treatment 5.

Following these gap and imping treatments, I abraded all feathers on each wing using an industrial sandblaster loaded with glass-bead grit (0.05 to 0.1 mm in diameter) that was propelled by compressed air through a hand-held nozzle. Because this machine was not designed for experimental studies, it was difficult to standardize wear treatments. I first passed the nozzle slowly over each feather three times and subsequently blasted areas that remained relatively unworn. Unfortunately, I could not devise a

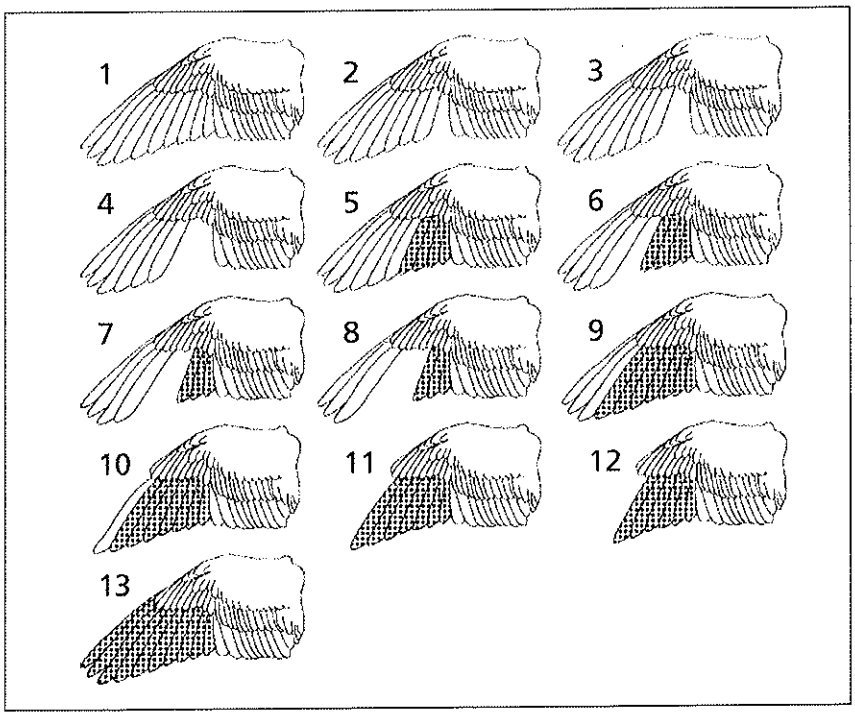


FIGURE 3. **An example of molt gap treatments applied to a wing.** The numbers associated with each drawing indicate the order in which the treatments and controls were conducted, and stippling is used to show feathers that have been imped onto the wing. In this example, the first treatment was the creation of gaps among the inner primaries, but the order of treatments with respect to the gap locations varied among the nine wings used. Wing performance measurements were taken in association with each treatment stage shown here, with an additional treatment following number 13, wherein feathers had been abraded with a sandblaster.

means of objectively evaluating the extent of feather wear. Visual comparison of artificially worn feathers with wing feathers from museum specimens indicated that the degree of wear generated by the sandblaster was considerably greater than what normally occurs in free-living birds, but was not beyond the range of variation (Fig. 4).



FIGURE 4. Feather abrasion caused by sand blasting.

Analyses

Because multiple treatments were performed on each wing, each measurement associated with a wing manipulation is only meaningful in the context of its specific control measure. For this reason, and to eliminate variation associated with differences among the wings, results are presented as average-effect sizes in terms of increases or decreases relative to a control measurement. Statistical tests presented for these effects are simple *t*-tests to determine whether or not the mean effect size differs from zero.

The evaluation of wing performance can be a complex enterprise. However, this study evaluated only three basic parameters: lift, drag, and lift coefficient (C_L). Lift is an upward force that acts in opposition to gravity, and drag is a force acting in the same direction as airflow that is caused by the wind resistance. The C_L is a dimensionless parameter that scales lift force by both airflow and wing area; C_L is defined as follows:

$$C_L = 2L / (\rho \bullet Y^2 \bullet A)$$

where L is lift, ρ is air pressure, Y is airspeed, and A is wing area.

For all practical purposes, airspeed and air pressure are kept constant in this study, so C_L pertains primarily to lift and wing area.

Results

Corroboration with expected values

Lift forces produced by unmanipulated wings averaged 4.4 Newtons (N), or approximately 450 g (1 lb). For a two-winged model, this force would be doubled to just under 900 g (2 lb), a force that is more than adequate to provide lift for a 400–500 g (0.9–1.1 lb) bird. The average C_L for the wing model with unmanipulated plumage was 1.9, which is high compared to C_L values for birds in gliding flight (Pennycuick 1968, Pennycuick 1983). However, my measure of 1.9 is below the maximum C_L for pigeons, which is probably between 2.5 and 3 (Pennycuick 1967, Pennycuick 1968), and a high value should be expected because the wing was positioned to generate optimum lift.

Effects of imping, gaps, and wear

Imping appeared to have negligible effects on lift and drag. The mean effect size on lift associated with imping all the primaries was a decrease of 0.09 ± 0.1 N or 2.0%, which was not significantly different from zero (t = 0.94, P = 0.38). Effects of imping fewer feathers were smaller and also nonsignificant (t = 0.90, P = 0.40; Fig. 5). Conversely, lift was reduced in association with gaps of all sizes and in all locations (t_8 = 4.45, P = 0.002), with reductions ranging from 0.76 ± 0.08 N (17.3%) to 0.24 ± 0.05 N (5.5%). Gaps among the middle primaries had slightly stronger effects on lift than did gaps among the inner and outer primaries, and the magnitude of the reduction in lift increased with gap size in all three feather regions (Fig. 5). The largest reduction in lift, however, was associated with feather wear. Feather wear reduced lift by 1.47 ± 0.19 N, or 33.3%.

Lift coefficients remained essentially unchanged for all imping treatments (t = 1.20, P = 0.26), but were reduced by some of the gap treatments and by abrasion. Gaps of all three sizes among the middle primaries were associated with reductions in C_L (t = 2.73, P = 0.026; Fig 5). Among the inner primaries, only gaps with three or four missing feathers caused significant changes in C_L (t = 3.45, P = 0.009), and there were no significant effects of gaps among the outer primaries on C_L (t = 1.50, P = 0.17). The effects of gaps on C_L ranged from decreases of 7.30% to 18.38% relative to controls, which were relatively small compared to the decrease of 71.25% in C_L associated with feather wear (t = 7.84, P < 0.001; Fig 5).

Finally, drag, which averaged 0.87 ± 0.06 N in the unmanipulated wings, was not affected appreciably by any of the imping and gap treatments (t = 1.33, P = 0.22). Wear, however, decreased drag by 0.23 ± 0.06 N or 26.78% (Fig. 5).

Discussion

There were no demonstrable effects of imping on lift and drag, which indicates that imping is a relatively benign procedure with regard to its effect on wing performance.

The relatively minor effects of small wing gaps suggests that imping one or two feathers may not be worth doing, especially since most birds are able to cope with a few missing feathers during molt. Furthermore, if only one or two feathers are broken or badly damaged, the remaining shaft may be plucked as a means of initiating growth of a new feather. However, plucking feathers is not recommended for raptors and other large birds whose feather follicles are deeply seated in the dermis and may be permanently damaged by plucking.

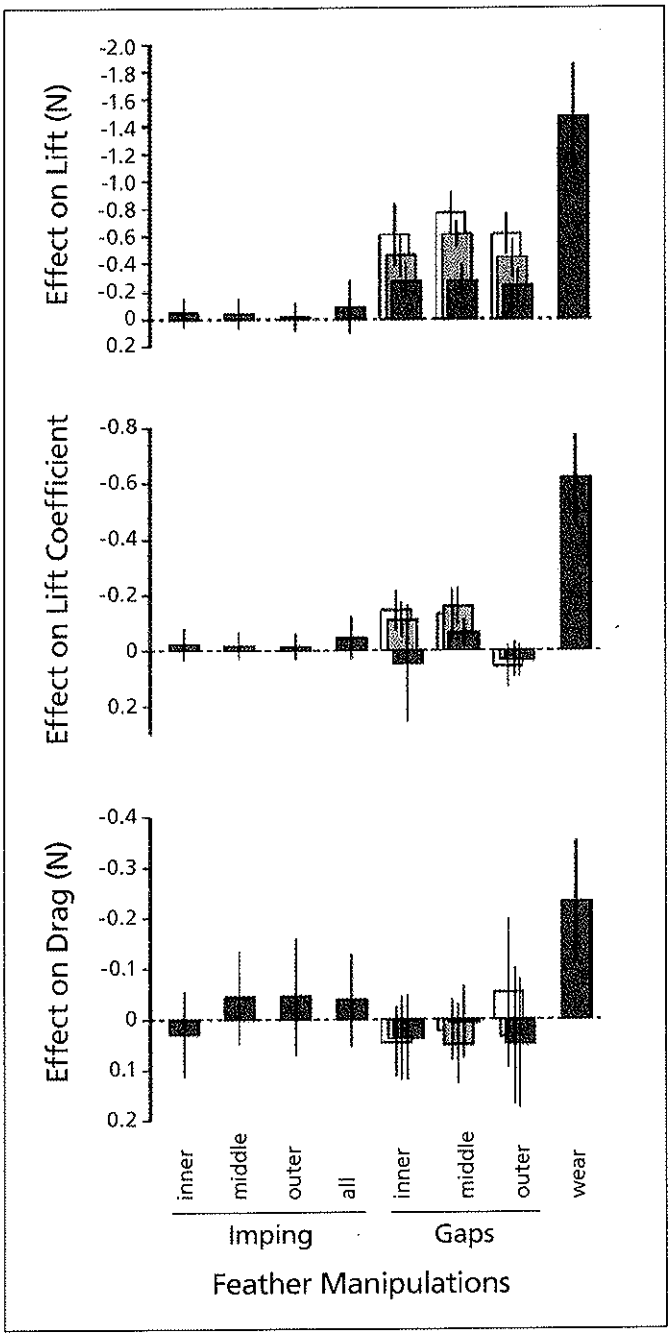


FIGURE 5. **Effects of imping, wing gaps, and feather abrasion on lift, lift coefficients, and drag.** Bar heights correspond to effect sizes and are shown on a reversed y-axis such that bars extending upward indicate negative effects. Grouped bars represent different gap sizes within each of the three wing regions; dark gray, light gray, and white bars correspond to gap sizes of two, three, and four feathers, respectively. Error bars represent 95% confidence intervals. Mean values for lift, lift coefficient, and drag were 4.45 N, 1.9, and 0.87 N, respectively.

The differences in wing performance associated with the locations of missing feathers may also be of interest when considering imping and its alternatives. Gaps among the middle primaries caused the greatest reduction in lift, and those feathers may be the most important for sustained flight. The outer primaries do not appear to contribute to lift as much as the more proximal feathers, but it is well known that the outer primaries are vital for propulsion and maneuverability (Freethy 1982). Hence, birds may be better able to endure gaps among the inner primaries, which deduct the least from the overall wing area, than in the more-distal parts of the wing.

Finally, considerations of a patient's natural history such as its reliance on flight for foraging and escape, the degree to which a bird must bear loads (i.e., prey), and the amount of time before a bird naturally replaces its feathers, will probably also be important in determining how to treat minor cases of feather damage.

In contrast with missing feathers, worn feathers had surprisingly strong negative effects. The substantial reductions in lift and drag suggest that worn feathers essentially lose their ability to act as airfoils. Hence, rehabilitated birds with severe feather wear should not be released prior to some form of feather replacement (molt or imping). Furthermore, it is not advisable to use worn feathers to replace broken feathers in imping procedures. My results suggest that even with as many as four damaged primary feathers, a bird may be better off with a gap in the wing than with severely worn plumage.

Unfortunately, there is no good way of determining how much wear is too much to preclude a reasonable chance of survival in the wild, as quantification of feather wear appears to be limited to subjective or relativistic classifications (e.g., Rogers 1990). Some familiarity with the amount of wear that usually accumulates in a particular species would probably allow for a reasonable treatment decision where imping is concerned. Clearly, when the barbules in a bird's feathers fail to integrate to form a continuous surface, either imping or continued captivity will be necessary. Whenever possible, rehabilitators should exercise birds with imped feathers prior to release so the birds can get used to the implants and to make sure that flight performance following imping approaches expectations for the species' endurance and flight mechanics.

This study is the first to experimentally examine the effects of imping, and as such, it is somewhat limited in

its scope. More specifically, this study examines only gliding flight in a single species. Evaluations of different wing shapes, flight modes (e.g., flapping flight), and flight velocities need to be performed to gain a full understanding of the effects of imping. Also, each imped feather was the same feather that was removed. In most rehab situations, practitioners must use feathers from a different individual, and sometimes, from a different species. This study did not attempt to evaluate the effects of mismatched feathers, but only the effects of the slight feather misalignment error inherent in imping.

Although this study, along with numerous examples of successful rehabilitation involving imping, indicates that imping has negligible effects on flight performance, the procedure may require the use of a general anesthetic (Hoefler 1986, Lierz 2000) and can be a stressful procedure for a bird to endure. In most cases, alternatives to imping should be considered, such as an induced molt or no treatment at all (Hoefler 1986). However, when these alternatives are inappropriate, as is often the case with raptors, imping provides a fast and reliable means of repairing damaged wings.

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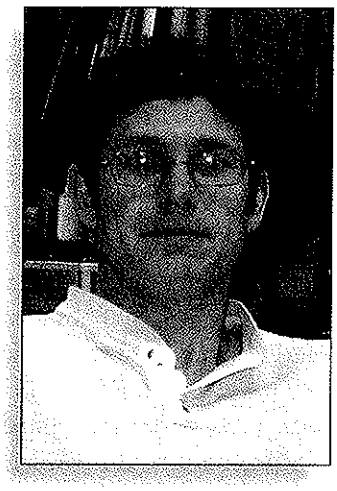
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About the Author



Eli Bridge's interest in birds emerged when he was an undergraduate at Westminster College where, after taking comparative vertebrate anatomy class, birds suddenly became these fascinating and elegant flying machines. Expanding on this theme, his Ph.D. research at the University of Minnesota focused on how feather molt affected flying and diving in seabirds and how molt strategies fit into the varied life histories demonstrated by seabirds. After graduating, he worked as a post-doc at the University of Memphis where he studied endocrinology and breeding behavior in Florida scrub-jays. He now has a second post-doc at the University of Oklahoma where he works with belted kingfishers on the Hudson River in New York, as well as several local bird species.

Late-Stage Granulomatous Interstitial Pneumonia Secondary to Near-drowning in an Osprey *(Pandion haliaetus)*

Nancy L. Anderson, DVM, ABVP

Introduction

Ospreys (*Pandion haliaetus*), also known as fish hawks, are the only diurnal birds of prey that feed exclusively on fish. They hunt by plunging feet-first into water; however, they are not known to be good swimmers and cannot dive below the surface. Females (1,700–2,100 g) weigh more than males (1,200–1,600 g). In North America, females often have dark breast bands referred to as "necklaces." Ospreys are found along the coasts of shallow bodies of water in North America, the Caribbean, Australasia, Europe, and northern Africa. Ospreys are known to be relatively social, for raptors, but tenaciously defend their nesting sites from predators and other ospreys. Phylogenetically, ospreys have been placed in their own family. They are most closely related to Accipiters. Similar to these close relatives, they are high-strung and fare poorly in captivity, often refusing to eat (Poole 1989).

Drowning is rarely documented in wild birds and is usually associated with unusual environmental circumstances such as flash flooding or strong winds combined with high waves (Springer et al. 1989, Miller et al. 1986, Craig and Powers 1972). Recent surveys of free-ranging raptor morbidity and mortality do not list drowning as a category for presentation (Ellis et al. 2007, Harris et al. 2007, Saito et al. 2007, Komnenou et al. 2005, Wendell et al. 2002, 91807 , Deem et al. 1998, Morishita et al. 1997, Fix and Barrow 1990, Clausen and Gudmundsson 1981, Keran 1981). The only incidence of a raptor drowning reported in the literature was associated with a man-made water trough that acted as a trap (Craig and Powers 1972).

To date, all diagnoses of drowning occurring in free ranging birds (primarily water fowl) were made postmortem (Springer et al. 1989, Miller et al. 1986, Craig and Powers 1972). At necropsy, typical birds were well-fleshed, with no signs of underlying disease aside from incidental helminth infestations (Springer et al. 1989, Miller et al. 1986). The tracheae and bronchi were filled with clear-to-red fluid that sometimes contained small amounts of particulate matter such as sand or algae (Springer et al. 1989). The lungs were dark and fluid-filled with multiple areas of hyperemia, hemorrhage, or both (Springer et al. 1989, Miller et al. 1986). Interestingly, although 50% of inhaled air in birds enters directly into the caudal air sac system, all air sacs appeared normal (Orosz 1999, Tully and Harrison 1994).

Differential diagnoses for free-ranging birds found after drowning include poisoning (lead, organophosphate, carbamate, strychnine, fumarin, anticoagulant rodenticides, etc.), acute trauma (gunshot, hit by car, electrocution), and infections resulting in acute death (avian cholera, botulism, herpesvirus) (Morishita et al. 1996). This paper describes the treatment of a free-ranging raptor that survived an initial drowning event and developed late-stage aspiration pneumonia.

Clinical report

An osprey was presented to the hospital on 1 May 2000 after being rescued

IN YOUR PRACTICE: Rehabilitators are often called upon to respond to both natural and man-made disasters which result in the near-drowning of a wide variety of wild species. Therefore, the treatment and outcome described in this paper have broad application in any rehabilitation practice.

ABSTRACT: This report describes case management of a granulomatous pneumonia occurring in an osprey (*Pandion haliaetus*) after a near-drowning incident. The bird initially responded to aggressive antimicrobial therapy, but was euthanized after 26 days due to severe pulmonary hemorrhage. Necropsy revealed the source of the hemorrhage to be a multifocal granulomatous and heterophilic interstitial pneumonia affecting 30% of the lungs. The bird was cachectic on presentation and required aggressive nutritional support. A major achievement of this case was to stimulate an osprey to eat on its own in captivity by using live fish.

KEY WORDS: drowning, nutritional support, osprey, *Pandion haliaetus*, pneumonia

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from the surface of a freshwater marsh the previous day. A witness reported that the bird was attacked and forced into the water by a second osprey. Prior to physical examination, the bird stood normally in its carrier, with no wing droop. The osprey was classified as a young adult female based on a brown "necklace" of feathers at the base of the neck and on wear and color of the talons, beak, and nonfeathered skin. The bird initiated open-mouthed breathing within a few minutes of capture, so the initial physical examination and treatment were brief. The bird was estimated to be 10% dehydrated, weighed 1,300 g, and had a prominent keel, indicating that the bird was in poor body condition (Poole 1989). Feather lice were present, which was not unexpected, but the unusual abundance of lice, in addition to the low weight, indicated that the bird was physiologically stressed. The heart and respiratory rates (per minute) were 260 and 80, respectively. The heart ausculted within normal limits (WNL), but the lungs had marked, wet inspiratory wheezes and clicks. The right ear and surrounding tissues were bruised and swollen; this was considered to be compatible with trauma. Bilateral superficial (eyelids, cornea, and rest of globe) and fundic (retina) ophthalmic and left auricular (ear) examinations were WNL. Material that appeared to be dried blood or vomitus was adhered to feathers overlying an empty crop. Abdominal palpation and vent appearance were WNL. A 3-mm diameter puncture wound and bruising compatible with a talon puncture were observed on the right lateral tibiotarsus. No obvious limb fractures were palpated.

A tentative diagnosis of near-drowning was made based on history and clinical signs (Orlowski and Szpilman 2001). Because the near-drowning event had taken place 24 hours previously, and because the bird was able to maintain oxygenation at rest, emergency treatment and diagnostic testing were focused on differentiation between pulmonary edema and infectious pneumonia. Blood was drawn from the right jugular vein for hematology, plasma chemistry, and blood lead followed by intravenous (IV) administration of 6 ml warmed lactated Ringer's solution (LRS). Only 40 ml of LRS was administered subcutaneously (s.q.) before the bird showed increased signs of respiratory distress, so the bird was placed in a cage to recover. Two hours later, an additional 40 ml of LRS was administered s.q. Four hours after presentation, the bird was anesthetized for 10 min with 4% isoflurane anesthesia via mask for a more complete physical examination, radiographs (right lateral and ventral-dorsal views of the whole body), and a tracheal swab for aerobic culture. There were no additional physical examination findings, and the bird recovered from anesthesia uneventfully. A second aerobic culture was obtained from a fresh fecal sample. Further fecal samples were collected for parasite detection (float and centrifugation).

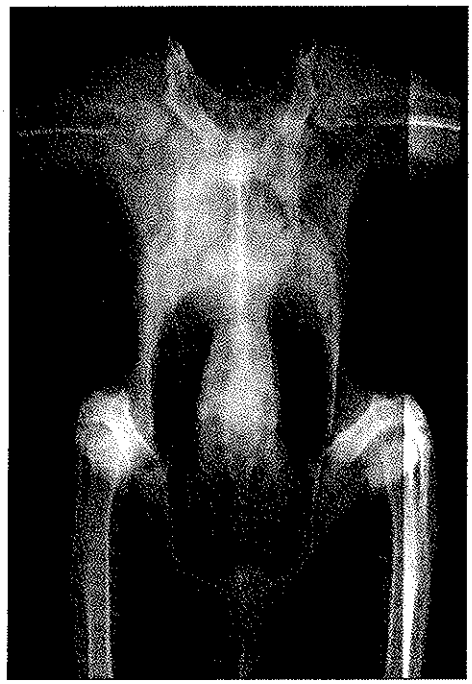


FIGURE 1. Ventro–dorsal radiographs of a female osprey showing a right transverse distal coracoid fracture with caudomedial displacement of the coracoid bone, lack of a visible right clavicular air sac, and subcutaneous emphysema along the caudal aspect of the left femur and body wall.

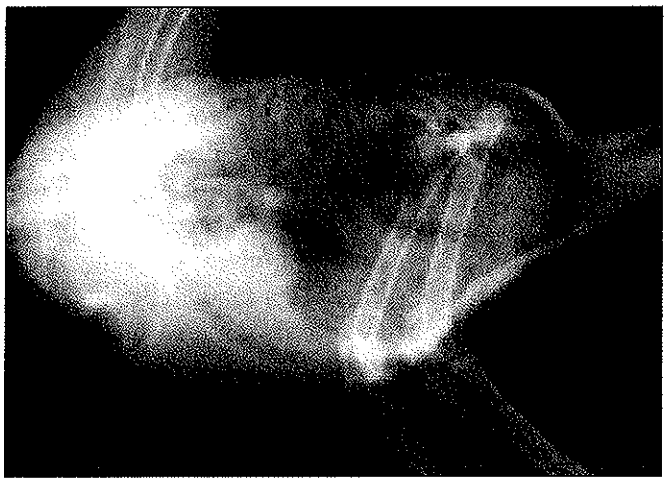


FIGURE 2. Right lateral radiographs of a female osprey showing a right transverse distal coracoid fracture with caudomedial displacement of the coracoid bone, an irregularity on the ventral border of the keel in its mid-portion, and increased soft tissue opacity of the cranial lung fields.

The radiographs showed a right transverse distal coracoid fracture with caudomedial displacement and an irregularity on the ventral border of the keel (Fig. 1, 2). The right clavicular air sac was not visible. This was attributed to hemorrhage from the coracoid fracture.

There was increased soft-tissue opacity of the cranial lung fields. Because the near-drowning incident took place in fresh water >24 hr previously, and because there was no enhanced honeycomb pattern on the lateral view, the opacities were interpreted to be due to pneumonia and not to pulmonary edema. Subcutaneous emphysema was present along the left body wall and was attributed to administration of s.q. fluids, but could also have been due to penetrating trauma or air leakage from the coracoid fracture. No metal density objects were present. The blood lead was 2.0 ug/dl (>20 ug/dl suggestive for lead toxicity) (Ritchie et al. 1994). Significant hematology findings were heterophilia (high heterophil count), lymphopenia (low lymphocyte count), and a mild anemia (Table 1). The anemia was most likely secondary to blood loss from the trauma. The heterophilia and lymphopenia were most likely due to a stress response or to early infectious pneumonia. Because the near-drowning had occurred in fresh water >24 hr previously, we did not expect severe electrolyte abnormalities from the immersion event, so we attributed the hypokalemia (low potassium), as well as the concurrent hypoalbuminemia (low albumin; one of the major blood proteins), to chronic malnutrition (Table 2). The high uric acid was most likely secondary to dehydration combined with a catabolic state, but renal disease could not be ruled out. Fecal tests were negative for ova or larvae, suggesting that verminous pneumonia was unlikely.

The history, physical examination, and initial diagnostic test results were used to limit the working list of differential diagnoses. The poor body condition and marked external parasitism was evidence that this individual was not faring well in the wild. Although preexisting disease conditions had to be considered, given its young age it is most likely that this bird was a marginally successful hunter. Hunger probably forced this bird to enter the attacking osprey's territory, perhaps in an attempt to steal food from nestlings, resulting in the obsee prevsserved drowning. The attack and subsequent near-drowning were the most likely causes for the traumatic lesions and pulmonary disease.

The following treatment plan was established after initial diagnostic results were available. Fluid needs for the first 24 hr were met with 120 ml LRS s.q. The hypokalemia was treated with an oral potassium supplement (0.45 mEq potassium/kg p.o. q 12 hr). Pending the culture results, enrofloxacin at 15 mg/kg q 12 hr, sodium ampicillin (150 mg/kg i.m., one dose), amoxicillin/clavulanic acid (100 mg/kg p.o. q 12 hr), and itraconazole (10 mg/kg p.o. q 24 hr) were administered as antimicrobials. For the first 24 hr, butorphanol (2 mg/kg i.m. q 4 hr) was administered for pain relief and to reduce anxiety. To treat for lice, the bird was dusted with 5% carbaryl powder. A wing and body wrap were not placed for the coracoid fracture because the level of stress to the osprey was considered to be too high relative to the benefits of better fracture stabilization.

The next morning (May 2), the physical examination was unchanged, except that the dehydration was resolved and there was a large amount of urine and dark green diarrhea in the cage. Fluid therapy volumes were reduced to maintenance levels (30–35 ml s.q. q 12 hr) and a tail wrap was placed. Due to the poor body condition, it was important to establish a positive energy balance as soon as possible. Although the dried debris on the feathers was most likely vomitus that occurred secondary to near-drowning, the presence of diarrhea on this morning supported the possibility that the gastrointestinal tract might not be able to tolerate whole foods, so an easily digestible liquid diet consisting of a mixture of 50% avian hand-feeding formula: 50% chicken baby food (1.2 kcal/ml as fed basis) was used for initial feedings. Using the formula for basal metabolic rate in nonpasserine birds, and a factor of 1.5–2.0 to account for increased metabolic demands due to illness, we estimated that the bird required 45 ml of the diet 3–4 times per day (Pokras et al. 1993). We initially gavaged 25 ml and watched for signs of regurgitation. None occurred, so the volume was increased to 35 ml 12 hr later, and fresh whole smelt were left in the cage.

On May 3, the bird weighed 1,498 g and the feces appeared WNL. Inspiratory rales and clicks were confined to the trachea. Vitamin C (25 mg/kg), vitamin E (5 mg/kg), selenium (0.1 mg/kg), and vitamin B complex (based on 1 mg/kg thiamine) were administered as intramuscular (i.m.) injections to provide nutritional and anti-oxidant support. The bird did not eat overnight, and the crop was not distended after administering 35 ml of food, so the tube-feeding volume and frequency was increased to 45 ml q 8 hr. Smelt were left in the cage in a water dish.

On May 4, the tracheal culture resulted in no growth. The fecal culture grew many lactase-negative *E. coli* that were interpreted to be normal intestinal flora by the diagnostic laboratory, so no susceptibility testing was performed. The bird appeared stronger, well hydrated, and started to vocalize, but rales were still ausculted in the trachea. Subcutaneous fluids were discontinued and blood was drawn for repeat hematology and plasma chemistry (Tables 1, 2). Repeat radiographs were obtained under isoflurane anesthesia. The bird was maintaining (1,504 g) but not gaining weight. Consensus among the caretakers was that handling the bird q 8 hr was stressful and inhibiting the bird from eating on its own. The caretakers also agreed that the additional restraint and time needed to hand-feed fish, versus to administer a gavage, made

TABLE 1. HEMATOLOGY VALUES FOR A FEMALE OSPREY (*PANDION HALIETUS*) POST NEAR-DROWNING INCIDENT

Date	5/1/00	5/4/00	5/8/00	5/15/00	5/24/00	5/26/00	Normals[1] (SD)[2]
Plasma protein (g/dL)	3.3	2.6	3.0	3.9	3.9	<2.5	4.0 (1)
PCV (%)	37	30	34	41	40	14	44 (4)
Hemoglobin (g/dL)	11.3	9.2	10.4	12.8	11.8	3.6	–
Total WBC count X10^9/L)	31.1	36.2	20.8	15.8	16.7	17.8	12.8 (4.8)
Heterophils (% / X10^9/L)	97/30.2	95/34.3	87/18.0	65/10.3	96/16.0	98/17.4	75 (13)
Lymphocytes (% / X10^9/L)	1/0.3	4/1.4	7/1.4	23/3.6	3/0.5	2/0.4	18 (10)
Monocytes (% / X10^9/L)	2/0.6	–	–	4/0.6	–	–	3 (3)
Eosinophils (% / X10^9/L)	–	–	2/0.4	4/0.6	–	–	4 (3)
Basophils (% / X10^9/L)	–	1/0.3	4/0.8	4/0.6	1/0.2	–	Rare
Thrombocyte count (per OIF[3])	1–3	5–7	5–8	3–7	3–7	2–6	–

[1] Published reference ranges for osprey are not available. Normal values given are for bald eagles *(Haliaeetus leucocephalus)* (Altman, 1997). [2] ( ) = Standard deviation. [3] OIF = Oil immersion field

TABLE 2. PLASMA CHEMISTRY VALUES FOR A FEMALE OSPREY (*PANDION HALIETUS*) POST NEAR-DROWNING INCIDENT

Date	5/1/00	5/4/00	5/24/00	5/26/00	Normals[1] (SD)[2]
CO_2 (mEq/L)	19.4	21.6	22.9	13.3	21–26 mmol/L[a]
Calcium (mg/dL)	8.1	8.7	9.4	7.6	8.0–10.0[b]
Phosphorus (mg/dL)	2.5	2.8	3.6	6.0	1.9–4.0[b]
Glucose (mg/dL)	253	331	272	355	250–400[b]
Sodium (mEq/L)	145	150	150	152	156 (4)[c]
Potassium (mEq/L)	1.2	2.4	1.8	3.6	3.0 (0)[c]
Chloride (mEq/L)	109	119	115	120	120 (3)[c]
Total protein (g/dL)	1.9	1.7	3.0	1.2	3–5[b]
BUN (mg/dL)	5	4	6	12	3.10 (2.47)[c]
Albumin (g/dL)	0.8	0.7	1.1	0.6	1.0–1.7[b]
Cholesterol (mg/dL)	133	107	237	71	100–200[b]
ALP (iu/L)	147	147	192	58	20–100[b]
CK (iu/L)	3,737	4,663	3,259	20,291	383 (300)[c]
AST (iu/L)	90	225	20	3,094	100–200[b]
Bile acids (µmol/L)	13	8	21	56	<100[d]
Uric acid (mg/dL)	8.4	6.8	11.0	8.2	4–15[b]

[1] Published reference ranges for osprey are not available. Normal values given are for [a]budgies (Hochleithner 1994), [b]birds of prey (Halliwell 1980), [c]bald eagles (*Haliaeetus leucocephalus*) (Altman 1997), or [d]birds in general (Lumeij 1994).
[2] ( ) = Standard deviation.

TABLE 3. PROBLEM LIST AND DIFFERENTIAL DIAGNOSES FOR CLINICAL SIGNS AND DIAGNOSTIC TESTS FROM POST–NEAR-DROWNING OSPREY

- Radiographic increased hilar opacities
  - Hemorrhage into lungs
  - Granulomas
    - Bacterial
    - Fungal
    - Parasitic
    - Foreign body
    - Fat emboli
  - Neoplasia
- Bleeding from lungs
  - Granuloma eroding into large blood vessel
  - Bacterial (E. coli)
  - Fungal
  - Foreign body reaction
  - Fat emboli
- Coagulopathy
  - Disseminated intravascular coagulopathy (DIC)
  - Liver failure
  - Anticoagulant rodenticide
  - Vitamin K deficiency associated with prolonged use of antibiotics
- Parasite migration
  - Nematodiasis (adults or larvae)
  - *Sarcocystis* spp.
  - Sporogony of Leukocytozoon or other hemoparasite
- Pulmonary hypertension
  - Renal failure, heart failure
- Neoplasia
- Inhaled toxin/irritant
- Electrocution
- Allergic/idiosyncratic reaction
  - Drugs
- Hematuria
  - DIC or other coagulopathy
  - Damage to nephron
    - Hypoxia
    - Infectious
    - Neoplasia
    - Drug
    - Pigments from hemolysis or myoglobin

tube-feeding preferable. The volume of the gavage feeding was increased to 50 ml, but the frequency decreased to q 12 hr. The bird was still not accepting dead fish; this was not unexpected. That afternoon, a privately owned pond stocked with pan fish was located, and a team of volunteers was formed to go fishing every 3–4 days. An aquarium was set up to temporarily house live fish. That afternoon, the bird did not respond to live fish flopping in the cage, so one fish was left in a water bowl in the cage.

Hematology results showed that the packed cell volume (PCV) had dropped from 37 to 30% (approximately 20% of the total value); this was attributed to rehydration. The heterophil count had increased, one basophil was now present, and the lymphopenia persisted, indicating that in spite of the bird's clinical improvement, infectious pneumonia was likely present. The hypokalemia was resolved, so the potassium supplement was stopped. The albumin and total protein remained unchanged after rehydration, indicating that the cachectic state was starting to resolve. The high uric acid was resolving with rehydration, so had likely been due to decreased blood flow to the kidneys while dehydrated. Repeat radiographs showed a mild decrease in lung field and air sac opacities.

Due to the increase in the heterophil count, failure of greater improvement in lung sounds, and the lack of useful culture results from the tracheal wash, rigid endoscopy was performed to allow visualization of the air sacs and caudal lungs. On May 5, the bird was anesthetized with isoflurane. A standard, left-flank surgical preparation and approach was made to the coelomic cavity, and a 2.7-mm rigid arthroscope was inserted into the left caudal thoracic air sac. The bird was confirmed to be female. The coelomic contents, including visible portions of the lungs, were WNL except for a mild, increased opacity and vascularity of all the air sacs and several 3–4 mm irregular yellow plaques. Three biopsies of these plaques were taken for bacterial and fungal cultures. The material was friable, and none was successfully harvested for cytology. The bird recovered uneventfully from surgery. On removal, the endotracheal tube was coated with blood-tinged mucous that was submitted for aerobic culture. Due to the minimal changes seen on endoscopy, the current course of antimicrobials was continued and nebulization therapy was not instituted. Later in the afternoon, caretakers experimented with fish presentation and found that a fish splashing in shallow water stimulated the osprey to grab and eat the fish. The bird ate five small blue gill fish over the course of the afternoon. Gavage feeding was discontinued.

Over the next week, the bird continued to eat live fish on her own, the respiratory signs resolved, and she slowly gained weight (1,543 g on May 8). Hematology values from May 8 showed a modest increase in the PCV and a 30%

reduction in the heterophilia (Table 1). The number and percent of basophils increased; this was one indication that a respiratory or allergic disease was still progressing. The aerobic air sac cultures grew a hemolytic *E. coli* that was susceptible to all antibiotics tested. Since the *E. coli* was hemolytic, and is a common isolate in cases of pneumonia in human near-drowning victims, it was considered to be a significant pathogen (Van Berkel et al. 1996). The bacteria's presence in the face of antimicrobial therapy was not unusual, in that weeks of therapy are often required to fully treat infectious pneumonia. The air sac fungal and anaerobic cultures and the aerobic culture from the endotracheal tube were negative for growth. Based on the improvements in hematology values and culture results, the medications were reduced to amoxicillin/clavulanic acid and itraconazole at previous dosages. The bird was offered, and ate, stunned fish. The bird was dusted again for lice with 5% carbaryl powder.

On May 13 (12 days after presentation), while the bird was restrained, the caretaker noticed a small amount of red-tinged discharge on the floor under the bird. The handler checked the bird's mouth, vent, and eyes for signs of discharge and found nothing. Cytology performed on the material revealed acellular debris. The same discharge was observed on May 14. This time, cytology showed many red blood cells (RBC) and an occasional white blood cell (WBC). This sample was interpreted to be fresh blood in mucous. A Gram stain performed on a smear made from the same material revealed rare Gram-positive diplococci that were considered to be normal flora. The bird appeared WNL on physical examination and was gaining weight (1,624 g). Repeat hematology showed an increasing PCV and decreasing heterophilia that was interpreted as continued improvement (Table 1). On May 14, the osprey ate dead fish. No bloody discharge was noted on May 15 or 16.

To reduce stress from further handling, and because the bird was reliably eating dead fish, medications were administered inside a dead fish. Once the medicated fish was eaten, other live fish were offered. When the bird refused to eat fish heads, delivery of the antibiotic was changed from a pill placed in the fish's mouth to injecting the fish with 160 mg cefazolin q 12 hr. On May 16, the tail guard was removed and the bird was moved to an outdoor flight cage. The bird adapted well to the move. On May 21, the osprey was observed flying from perch to perch. On May 24, the bird was caught for a physical examination, weight, and blood work. The physical exam was WNL (body weight [BW] = 1,623 g), except that during restraint 1–2 drops of blood fell from the bird's mouth.

On May 25 (BW = 1,568 g), the osprey was brought into the hospital from the flight cage because it had dried blood on its beak and nares. It had not eaten overnight. The hematology values from May 24 were similar to previous values. On physical examination by another veterinarian, the mucous membranes were pale and the bird appeared dehydrated. A very small amount of fresh blood was observed in the proximal trachea. Increased lung sounds were ausculted; they were mostly referred from the trachea. An otoscope was used to examine the choanae and nares, and dried blood was found in these locations. A red rubber feeding tube was placed into the crop. No blood was aspirated, but there was a small amount of blood on the tube itself when withdrawn. A fecal occult blood test was positive. It was not possible to localize the source of the bleeding to the respiratory versus gastrointestinal tract. Emergency treatment consisted of vitamin K1 (2 mg/kg i.m.), iron dextran (10 mg/kg i.m.) and 30 ml LRS s.q. The bird was placed in a cage to recover from handling.

In the afternoon, the bird was anesthetized as described previously. A flexible endoscope was used to visualize the lumen of the upper gastrointestinal tract. A small amount of blood was found in the crop. One nematode was found in the ventriculus. The endotracheal tube was coated with blood-tinged mucous when removed. Cytology of this mucous showed many RBCs and a few WBCs. A rigid 1.3-mm cystoscope was advanced through the endotracheal tube to visualize the trachea. A small amount of blood-flecked mucous was observed along the trachea. Ventro–dorsal and lateral whole body radiographs showed increased opacity of the kidneys, patchiness in the perihilar area, and loss of definition of the trachea just cranial to the thoracic inlet, when compared to radiographs obtained on May 4. A diagnosis was made of perihilar pulmonary hemorrhage, most likely secondary to a granuloma eroding into a major pulmonary vessel (See Table 3 for complete differential diagnoses list). The blood in the gastrointestinal tract was due to the bird swallowing blood coughed from the lungs. The increased opacity of the kidneys was attributed to dehydration, although deposition of uric acid was also possible. During recovery from anesthesia, 70 ml warmed LRS was administered s.q. The recovery from anesthesia was prolonged, and the bird remained weak after recovery. In the evening, the bird was gavaged with 35 ml of the avian hand-feeding formula:chicken baby food mixture.

The next morning (May 26), no fresh blood was observed in the mouth or trachea, but the bird was extremely weak. A small amount of regurgitated gavage formula tinged with blood was found in the cage. Urates in the cage were also tinged with blood, indicating that the bird might be suffering from disseminated intravascu-

lar coagulation, other coagulopathy, or renal endothelial tissue damage. Blood was drawn from the right jugular vein (1.5 ml) for immediate hematology and chemistry (Tables 1, 2). The PCV was 14% and the total protein was 1.2 g/dl, indicating severe, acute blood loss. The WBC count was unchanged. The thrombocyte count remained WNL, reducing the likelihood of a coagulopathy. The phosphorus and potassium levels had increased, indicating possible hemolysis of the sample. The creatine kinase (CK) and aspartate aminotransferase (AST) levels were markedly increased, concurrent with normal bile acid values, indicating severe tissue damage or hemolysis of the blood sample rather than liver disease.

A final diagnosis was made of a bacterial or foreign-body granuloma, eroding into a large vessel near the hilus, causing blood-loss anemia and hypoproteinemia. Although blood transfusion (one donor osprey had been located) or artificial hemoglobin therapy would have temporarily alleviated the clinical signs of blood loss, the site of the blood loss (perihilar) was not accessible surgically, so the bleeding was likely to continue longer than blood replacement therapy could be maintained. Hypertension was not ruled out, but the perihilar patchy density—rather than a diffuse loss of the honeycomb pattern of the lungs—made this differential unlikely. In addition, hypertension was not a treatable disease for a free-ranging bird. The other differentials (neoplasia, inhaled toxin, parasite migration, etc.) were extremely unlikely given the history, physical examination findings, and diagnostic test results. The presence of blood in the urates was an indication that the body was suffering from the degenerative effects of hypoxia. The prognosis for this condition was grave and the bird was euthanized with IV euthanasia solution. The bird was submitted for complete necropsy.

On necropsy, the bird was found to be in excellent body condition with adequate fat stores. Red, gelatinous material was found surrounding the right coracoid fracture. The proventriculus contained a single nematode. The air sac walls were clear and shiny. The lungs exuded abundant clear fluid from the cut surfaces and were dark red and consolidated in well-demarcated areas around the hilus, representing 30% of the total lung volume. Histopathology of the lungs revealed multifocal acute and chronic granulomatous and heterophilic interstitial pneumonia. Ingesta was apparent without reaction within some airways, suggesting agonal aspiration. The only other abnormalities were mild lymphocytic interstitial proventriculitis and acute multifocal, moderate centrolobular hepatic necrosis, most likely secondary to hypoxia. The necropsy results were compatible with late-stage granulomatous interstitial pneumonia, with resulting hemorrhage leading to generalized tissue hypoxia.

Discussion

Due to a lack of information regarding treatment of near-drowning in birds (Phalen 2000, Altman et al. 1997, Ritchie et al. 1994), the human literature was consulted to evaluate if the diagnostic and treatment plans for this case were appropriate. In humans, drowning is defined as death resulting from suffocation within 24 hr of submergence in a fluid (Orlowski and Szpilman 2001). The term 'near-drowning' is used for people who survive suffocation by submersion for >24 hours (Orlowski and Szpilman 2001). Submersion results in hypoxia, hypercarbia, and respiratory acidosis that terminate in cardiopulmonary arrest if submersion lasts longer than 4–10 min (Orlowski and Szpilman 2001, Clarke and Niggeman 1975). Contrary to early theories about drowning, few significant serum electrolyte abnormalities have been documented in drowning victims, regardless of the osmolality and quantity of fluid aspirated (Orlowski and Szpilman 2001, Clarke and Niggeman 1975). Serum electrolyte changes in near-drowning victims are solely attributable to hypoxia and metabolic acidosis rather than to exchange of solutes from inspired fresh- or salt-water (Orlowski and Szpilman 2001, Clarke and Niggeman 1975). Therefore, aggressive treatment of electrolyte imbalances is rarely needed once oxygenation is maintained.

In humans, submersion victims are usually classified into one of four groups, based on clinical presentation (Orlowski and Szpilman 2001, Van Berkel et al. 1996):

Class I

No clinical signs, normal chest auscultation, normal chest radiographs

Class II

Coughing, rales on auscultation, abnormal chest radiographs or blood gases, but no need for mechanical ventilation

Class III

Similar to Class II, but in need of mechanical ventilation

Class IV

Cardiac arrest

The most immediate goals in treatment of a drowning victim are removal from submersion, clearance of the airway, and institution of positive-pressure ventilation until the victim can breathe on their own (Orlowski and Szpilman 2001, Van Berkel et al. 1996). After ventilation is established, the patient should be checked for a heartbeat and, if necessary, external chest compressions instituted

(Orlowski and Szpilman 2001, Van Berkel et al. 1996). Postural drainage of fluid does not improve survival and takes time away from providing cardiopulmonary support (Orlowski and Szpilman 2001).

Once the patient is breathing, the next step is to treat and prevent further development of pulmonary edema. In general, 0% of Class I and 72% of Class II–IV patients develop pulmonary edema. Pulmonary edema is 2–3 times more likely to occur in patients with impaired neurological status (Van Berkel et al. 1996).

In saltwater, pulmonary edema develops because saltwater is hyperosmolar and draws water from the bloodstream into the alveolar space. After saltwater drowning, the total amount of water collected from the lungs is greater than the volume aspirated because the osmotic effect lasts for several hours. Fluid exudation results in systemic hypovolemia. In freshwater drowning, the presence of hypo-osmolar fluid in the alveoli washes out surfactant. This leads to alveolar collapse and secondary pulmonary edema. In freshwater drowning, aspirated fluid is usually absorbed by the lungs within three minutes, resulting in a transient, clinically insignificant hypervolemia. Pulmonary edema will continue to be evident until the body replaces surfactant (Clarke and Niggemann 1975).

A diagnosis of pulmonary edema in humans is based on crackles or rales on lung auscultation that occur with alveolar and interstitial patterns on lung radiographs (Orlowski and Szpilman 2001, Van Berkel et al. 1996). Cyanosis may or may not be present (Clarke and Niggemann 1975). In birds, pulmonary edema is diagnosed by clinical signs of respiratory distress (tail bob, open-mouthed breathing), wet wheezes on chest auscultation, and an initial increase in the honeycomb pattern of the lungs on lateral radiographs (Phalen 2000). With severe pulmonary edema, the honeycomb pattern is lost as the air capillaries fill with fluid. Due to the relatively rigid structure of the avian lung, crackles do not occur in birds (Phalen 2000). Differential diagnoses for pulmonary edema in wild birds are infectious pneumonia (bacterial, *Chlamydophila*, fungal, viral), pulmonary hemorrhage secondary to trauma or anticoagulant rodenticide poisoning, pulmonary parasitism (*Sarcocystis, Syngamus* trachea, etc.), electrocution, inhalant irritant or toxin (polytetrafluoroethylene, chlorine gas, etc.), severe anemia or hypo-proteinemia, and heart disease.

In humans, treatment of acute pulmonary edema secondary to drowning is best accomplished by providing adequate ventilatory assistance with supplemental oxygen (i.e., maintaining SaO2 > 60–90 mm Hg) (Orlowski and Szpilman 2001). Tracheal intubation and suctioning airways to maintain patent airways, and positive end-expiratory pressure to reinflate collapsed areas of lung and ventilation–perfusion mismatches, may be required (Orlowski and Szpilman 2001, Van Berkel et al. 1996). Measurement of dissolved blood gases is used to determine if adequate oxygenation is being maintained and to evaluate response to therapy. Standard fluid therapy techniques are used to mitigate abnormalities in blood volume, osmolality, and acid–base status. In drowning patients, use of diuretics is not recommended, as they may potentiate hypovolemia and exudation of plasma-rich exudates into the lungs (Clarke and Niggeman 1975).

Late-stage pulmonary edema occurs within a few hours, to days, after submersion, when the body develops an inflammatory response to foreign material such as mud, sand, or algae aspirated into the lungs (Van Berkel et al. 1996). The presence of vomitus in the lungs is a common finding because 25–60% of drowning victims vomit during submersion or recovery (Orlowski and Szpilman 2001, Van Berkel et al. 1996). The low pH of vomitus causes acute and chronic tissue damage in the lungs, resulting in further pulmonary edema. Late-onset pulmonary edema also occurs secondary to delayed acute respiratory distress syndrome or as neurogenic pulmonary edema secondary to hypoxic brain damage (Orlowski and Szpilman 2001). Rarely, acute fulminant pulmonary edema develops in initially clinically normal patients up to 12 hr postsubmersion, so hospitalization for all drowning victims is recommended for at least 24 hr (Orlowski and Szpilman 2001, Clarke and Niggemann 1975). Aspiration of foreign materials can also result in tissue necrosis, hemorrhage, and bronchoconstriction (Bartlett 1998). Diagnosis and treatment for late-stage pulmonary edema are similar to acute pulmonary edema, with the addition of administration of bronchodilators, if bronchoconstriction is present. The initial acute inflammatory response can organize over time, resulting in granulomas (Nelson and Couto 1998). The resulting tissue hypoxia in large granulomas predisposes patients to develop infectious pneumonia.

Aside from complications attributable to foreign-body reaction and chemical damage, listed previously, aspiration of microorganisms can lead to infectious pneumonia. Infectious pneumonia secondary to near-drowning becomes a concern in the days to weeks postimmersion. In birds, the condition is most similar to the aspiration pneumonia that occurs secondary to poor hand-feeding technique (Altman et al. 1997). Differential diagnoses for clinical signs associated with infectious pneumonia secondary to near-drowning in raptors are primary bacterial pneumonia (Gram-negative enterics, anaerobes, *Pasteurella* spp., mycobacteria, mycoplasmosis), primary fungal pneumonia (*Aspergillus*), respiratory nematodiasis, protozoal pneumonia, viral pneumonia (paramyxovirus, systemic

poxvirus), *Chlamydophila*, inhalant irritant, heart disease, neoplasia, pulmonary fat emboli, and immune-mediated asthma-like disease (Dennis et al. 2000).

Infectious pneumonia occurred in 14.7% of Class II–IV human near-drowning victims. In patients suffering from pneumonia, but not requiring mechanical ventilation, late mortality due to infectious pneumonia was 26%. Patients requiring mechanical ventilation were 17 times more likely to develop pneumonia than those not requiring ventilation. The increased risk was attributed to more severe lung damage resulting from aspiration of sufficient quantities of water or gastric contents to require mechanical assistance. Body temperature, neurological status, and use of corticosteroids or prophylactic antibiotics had no effect on the risk for developing pneumonia (Van Berkel et al. 1996).

Diagnosis of aspiration pneumonia in humans is based on rales on lung auscultation, a pulmonary infiltrate that persists >24 hours on radiographs, and at least three of the following four criteria: acute fever, leukocytosis on hematology, leukocytosis on sputum cytology, or positive Gram stain or culture of pathogenic organisms from sputum (Van Berkel et al. 1996). In birds, an initial diagnosis of aspiration pneumonia is based on history of an aspiration event, respiratory distress (tail bob, open-mouthed breathing, cyanosis, etc.), and moist respiratory sounds on auscultation (Phalen 2000, Altman et al. 1997).

Further diagnostic testing is needed to confirm aspiration pneumonia. In cases of near-drowning in humans, radiographic densities from pulmonary edema usually clear in 24–48 hr, making persistent densities due to pneumonia (Van Berkel et al. 1996). Radiographic signs of aspiration pneumonia (diffuse, increased interstitial pattern with alveolar flooding) are most common in dependent lung lobes (Bartlett 1998, Wunderlich et al. 1985). Chronic infections may result in nodular interstitial patterns, and large nodules may form around inhaled material (Nelson and Couto 1998). Anaerobic lung infections may show signs of cavitation (Bartlett 1998). In birds, pneumonia is visualized as increased opacity of the honeycomb pattern and increased patchiness of the lung fields (Phalen 2000). Granulomas appear as soft-tissue density nodules (Phalen 2000). Advanced air sacculitis is visualized as thickening of the caudal thoracic or abdominal air sac walls, or both (Phalen 2000).

Hematology of birds suffering from infectious pneumonia shows leukocytosis, primarily heterophilia with monocytosis (Phalen 2000). Total white blood cell counts in excess of 30,000 cells/ml are usually associated with overwhelming bacterial, *Aspergillus, Chlamydophila*, or avian mycobacterial infections. In immune suppressed birds, *Aspergillus* is a common secondary invader of the respiratory system. Diurnal birds of prey are notably susceptible to this pathogen (Redig et al. 1980). In people, bacterial cultures from the lower airways are usually obtained by fiber-optic bronchoscopy with bronchoalveolar lavage or a protected brush (Bartlett 1998). The airways of most birds are too small to allow passage of a bronchoscope, so tracheal wash through an endotracheal tube or rigid arthroscope, or air sac wash procedures, are used to obtain samples for cytology and for aerobic, anaerobic, and fungal cultures (Phalen 2000). Rigid arthroscopes can also be used to visualize the caudal air sacs and lung fields (Phalen 2000). Cultures of sputum from human patients diagnosed with infectious pneumonia uniformly grow pathogenic microorganisms (Bartlett 1998, Van Berkel et al. 1996). The most common aerobic bacterial isolates are *E. coli*, *Aeromonas* spp., and *Pseudomonas* spp. (Van Berkel et al. 1996), and common anaerobic isolates are *Peptostreptococcus* spp., *Fusarium nucleatum*, and *Prevotella melaninogenica* (Bartlett 1998, Van Berkel et al. 1996). *Aeromonas* spp. were cultured postmortem from heart blood in 6 of 67 drowned swans (Miller et. al 1986).

Treatment of aspiration pneumonia is based on maintaining airway function, as described previously, and antibiotics based on culture and sensitivity. While awaiting culture results, combination antibiotic therapy is recommended (Bartlett 1998). Clindamycin is the drug of choice for anaerobes, followed by amoxicillin/clavulanate or penicillin combined with metronidazole (Bartlett 1998). Fluoroquinolones or aminoglycocides are excellent choices for aerobic bacteria (Bartlett 1998). Antibiotic therapy is required until clinical and radiological signs have resolved and until lower airway cultures are negative for pathogen growth. In most cases, this usually requires several weeks. In cases where large granulomas are refractory to long-term antimicrobial therapy, and are anatomically accessible, surgical removal is recommended (Hernandez-Divers 2002). In birds, the air sacs have a poor vascular supply that inhibits the effectiveness of antimicrobials (Phalen 2000). Nebulization therapy with particle size less than 0.5 microns can be used to deliver antimicrobials such as amikacin and clotrimazole to the lungs and to some parts of the air sacs (Tully and Harrison 1994). In raptors, itraconazole is often administered as a preventive medication against *Aspergillus*. Examination of the feces and tracheal cytology for parasites should be performed in birds with a history compatible with exposure to parasites (Lavoie et al. 1999, Young et al. 1998). Treatment for parasites reduces tissue damage caused by the parasites or by migrating larvae. The prognosis for birds

diagnosed with aspiration pneumonia is guarded (Altman et al. 1997, Tully and Harrison 1994).

Coracoid fractures in free-ranging birds most often occur after hitting a solid object while in flight (Orosz 2002). Birds with coracoid fractures usually present with a wing droop and an inability to lift the wing over the back (Orosz 2002). Differential diagnoses for a fractured coracoid are fracture of the clavicle, scapula, or head of the humerus, radial nerve damage, brachial plexus avulsion, soft-tissue damage to the muscles of flight, electrocution, neoplasia, or bone cysts (Orosz 2002). In well-muscled birds, fractures of the coracoid may be difficult to palpate (Orosz 2002). Using rubbing alcohol to wet and part the feathers over the cranial edge of the shoulder can allow visualization of soft-tissue bruising in the area that is suggestive of a coracoid fracture. Definitive diagnosis is often made only with radiographs. Treatment of nondisplaced coracoid fractures consists of analgesia and restriction of movement of the affected wing (Orosz 2002). Restriction of wing movement can be accomplished by a combination of figure-eight wing wrap and body wrap or cage rest (Orosz 2002). Surgical intervention is not warranted (Orosz 2002). The clinician must weigh the advantages of better immobilization of the fracture with the wing and body wrap versus the bird's tolerance for the wrap and the risk of iatrogenic morbidity associated with the wrap (i.e., fracture disease, loss of joint mobility, pytagial stricture). If a wing wrap and body wrap are used, the wraps should be removed, physical therapy performed, and the wraps replaced every 3–4 day for approximately 3 wk (Orosz 2002). An additional 3–5 wk of cage rest may be needed until radiographs show solid callus formation and the birds are ready for flight training (Orosz 2002). Markedly displaced coracoid fractures can be treated conservatively, as described above, or with bone plates or intramedullary pins. The clinician must carefully weigh the morbidity associated with gaining surgical access to the coracoid by cutting through the pectoral musculature, versus the benefits of aligning the fracture. Eighty-five percent of raptors regain flight ability, regardless of whether surgery or conservative management is chosen (Redig 2000). If an intramedullary pinning is performed, the pin is usually left in place until there are radiographic signs of callus formation (usually 3–4 wk) (Orosz 2002).

This case emphasizes the difficulties inherent in treating granulomatous pneumonia in birds. In hindsight, tracheal bleeding was first noticed five days after the enrofloxacin was discontinued. Although cultures indicated that enrofloxacin was no longer needed, it is quite possible that the air sac and tracheal samples did not reflect the bacterial flora within the perihilar area. Enrofloxacin or other antimicrobial treatment was not re-initiated because clinical signs and hematology results indicated that the pneumonia was improving. Because no cultures were obtained at necropsy, it is not possible to assess whether continuing the enrofloxacin would have prevented the development of pulmonary hemorrhage. However, considering the extensive nature of the granulomatous inflammation in the lungs, resulting in questionable perfusion and therefore tissue levels of antimicrobials, it is unlikely that the re-institution of enrofloxacin would have changed the outcome of this case. In addition, amoxicillin/clavulanic acid was changed to delivery of cefazolin injected into a fish. Against most anaerobes, cefazolin is not as effective as amoxicillin/clavulanic acid, and it is not known how long it is stable or if it is bioavailable when mixed in food. Although no anaerobic cultures grew bacteria, it is possible that the worsening of the bleeding could also have coincided with the change in these antibiotics. However, histopathology was not suggestive of an anaerobic infection, so this scenario seems less likely.

Since this case occurred, the author has treated a second osprey for bacterial pneumonia (not related to drowning). This bird also initially responded well to antimicrobial and supportive therapy and then similarly succumbed weeks later to hilar granulomas. This result was unusual because, over the years, the author has successfully treated several hawks, eagles, and waterfowl for severe, acute lung traumas and bacterial pneumonias with no recognized occurrence of chronic granulomatous disease. It is also interesting to note that while there are extremely few published case reports for ospreys, the only reported occurrence of pulmonary fat embolism in any bird occurred in a free-ranging osprey (Dennis et al. 2000). Given these observations, this author suggests that it may be reasonable to assign a more-guarded prognosis to osprey suffering from respiratory-disease trauma than may be warranted in other avian species with similar clinical conditions.

The choice in using conservative therapy for treatment of the coracoid fracture appeared to be appropriate, in this case, because the bird was observed flying from perch to perch in its flight cage, and on gross necropsy, the fracture appeared to be healing. A major achievement in the management of this case was to stimulate the osprey to eat on its own while still under treatment. As mentioned in the introduction, ospreys are notorious for not eating in captivity. The successful management of a systemically ill osprey, that was 25% underweight at presentation, required exceptional animal handling and organizational skills from the animal care team. Constant fine-tuning

of the treatment plan was necessary to administer all the medications required without stressing the bird to the point of refusing food.

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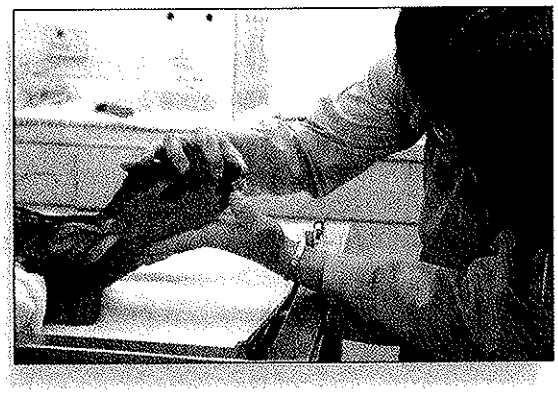
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About the Author

Nancy Anderson, DVM, ABVP (Avian), PhD, graduated from Ohio State University (OSU) College of Veterinary Medicine in 1988. She worked as a private practitioner (small animals, horses, food animals, exotics) and provided services for area wildlife rehabilitators until 1991, when she joined the OSU faculty. She taught general practice and exotic animal medicine and surgery and was the faculty advisor for the Raptor Rehabilitation Program. In 1997, she started a PhD in ecophysiology and radio-tracked brown tree snakes through the rain forest on Guam. In 2000, while finishing her dissertation, she joined the staff at Lindsay Wildlife Museum (Walnut Creek, CA). She is the staff veterinarian for approximately 6,000 wildlife patients per year and 130 educational-animal ambassadors.



Feather Imping and Rehabilitation of a Red-tailed Tropicbird (*Phaethon rubricauda*)

Brenda J. Zaun, Scott Sims, DVM, Kathy Batha, Marilou Knight, Colett Welch, Cathy Granholm, and Keith Swindle

Species and natural history

Red-tailed tropicbirds nest colonially in the Hawaiian Islands and are the rarest of the three tropicbird species in North America (Schreiber and Schreiber 1993). They range widely across the Pacific and Indian Oceans, nesting on islands. Red-tailed tropicbirds are sexually monomorphic, have white plumage and a black crescent around the front of the eye, and a black line continuing just behind the eye. The middle two rectrices extend well beyond the other tail feathers, often as long or longer than the length of the birds' body.

On Kauai, the red-tailed tropicbirds' nesting season spans from March through November, with most eggs hatching in May, June, and July after an approximately 43-day incubation period. The chicks fledge approximately 90 days after hatching (range 73–123 days; Schreiber and Schreiber 1993). Both adults share in the parental duties of incubation and chick provisioning. Colonies that nest on the main Hawaiian Islands, where predation by rats, cats, dogs, and mongoose is high, are slow to recover. Kilauea Point National Wildlife Refuge hosts the largest population of breeding red-tailed tropicbirds in the main Hawaiian Islands with a current estimate of 300 to 325 breeding pairs. The refuge's population of breeding red-tailed tropicbirds has increased nearly 400% in the last eight years due to protection by fencing and predator control.

Red-tailed tropicbirds feed offshore, usually not visible from land (Gould et al. 1974). This species is the most pelagic of the tropicbirds, usually foraging solitarily by plunge-diving in pursuit of fish and squid. Le Corre (1999) found that their mean diving depth was 4.6 ± 2.7 m (range 1–13 m). Flying fish and ommastrephid squid are their most common prey items, per sampling from 270 birds (Harrison et al. 1983).

Annual molt of adults is not fully described, and even less information is available on feather molt in juvenile birds. Red-tailed tropicbirds appear to lack pre-alternate molts, with adults having only a single prebasic molt per cycle (LeValley and Pyle 2007). Additionally, tropicbirds exhibit Staffelmauser (a strategy in which one wave of molt in the primaries and secondaries begins before the preceding wave has been completed; Pyle 2006). On a cruise from La Paz to Tahiti in March and April 2006, LeValley assessed red-tailed tropicbird plumage characteristics and molt cycles at sea (LeValley and Pyle 2007).

Because red-tailed tropicbirds can breed year round, the ages of the individuals encountered were estimated; however, immature status could be ascertained based on the bill color, length of the two central tail feathers, and amount of black barring on the body plumage and along the shaft at the tips of primaries (P) 9, 8, and 7. He encountered one bird with slight barring on the nape, an orange bill, and pure white primaries with P10 still growing and estimated that it was approaching two years of age.

IN YOUR PRACTICE: The authors' experience working with this bird, particularly the use of imping, may have broader implications for the rehabilitation of other pelagic seabird species.

ABSTRACT: Birds with broken feathers are often unable to fly or demonstrate compromised flight. Feather imping is a procedure in which broken feathers can be quickly repaired using feathers from the same or another species with similarly-sized feathers. A red-tailed tropicbird chick (*Phaethon rubricauda*) at Kilauea Point National Wildlife Refuge, Kauai, Hawaii, sustained broken outer primaries and was unable to fly. This paper describes the first successful feather-imping procedure performed on this species, for which we replaced portions of five primary feathers. Feather imping is a quick method of feather repair that allows release almost immediately. It serves as an excellent alternative to holding the bird in captivity until natural feather replacement, a situation that may jeopardize its chances of survival, particularly if the species does poorly in captive situations.

KEY WORDS: feather imping, red-tailed tropicbird, white-tailed tropicbird, Hawaii, *Phaethon rubricauda*, *Phaethon lepturus*

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How the bird was obtained

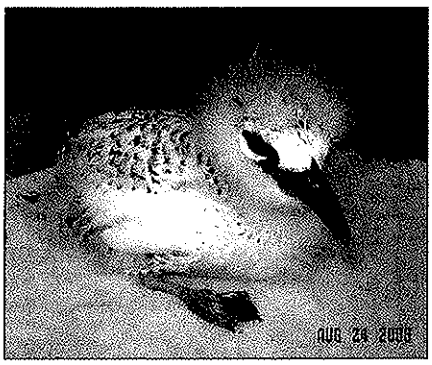
To minimize disturbance, routine refuge monitoring of tropicbird chicks includes noting their presence or absence without approaching the chick until it is of sufficient age for banding with a U.S. Fish and Wildlife Services (FWS) metal band. On 23 August 2006, when a 10-week-old chick (±2 days) was captured for banding, it was discovered that the chick was severely underdeveloped and underweight. The chick appeared weak and lethargic and was still mostly downy. In a normal chick, all down is lost by 57 to 76 days of age (Schreiber and Schreiber 1993); however, this individual had the developmental appearance of a 5-week-old chick. We assumed that the chick had not been receiving adequate amounts of food for several weeks, possibly due to death or abandonment by one parent, and it was taken to the refuge headquarters for rehabilitation. Although studies have shown that breeding pairs of red-tailed tropicbirds are capable of adjusting food delivery to chick demand (Schreiber 1996), one parent alone may be unable to raise a chick to fledging.

Rehabilitation

The rescued chick was fed approximately 120 g of previously frozen whole squid and smelt daily for the first two wk, then its diet was increased to 180 g per day. After the first two days in captivity, the chick adapted to its caretakers and readily took food offered from the hand. Supplemental vitamins (Mazuri® bird vitamin, B-complex, fish oil, and calcium) were given approximately once per week, and 15 ml of an electrolyte solution (unflavored Pedialyte®) was given each day to prevent dehydration. The chick was housed in a medium-sized Petmate® portable kennel (approximate dimensions 27" × 18" × 19") adjacent to the refuge headquarters where it was protected from direct sunlight, rain, and disturbance. The plastic bottom of the kennel was lined with absorbent material that was changed when soiled (every other day initially, then every day). To assess growth and development, we periodically photographed the bird and recorded mass and morphological measurements.

After approximately six wk in captivity, the chick, now fully feathered and normal in appearance and development, voluntarily decreased its food intake. This behavior is indicative of prefledging (Fleet 1974). We also observed other behavioral changes at this time. The chick vocalized substantially less frequently during feeding and consistently looked up into the sky, perhaps observing other seabirds in flight. It also spent more time at the front of the kennel, where it could view the surroundings through the wire door. We had observed these same prefledging behaviors a few weeks earlier in a white-tailed tropicbird chick (*Phaethon lepturus*) that we rehabilitated and held in captivity for one mo prior to fledging.

We attempted to allow the chick to fledge on 10 October 2006, but it was unable to fly. We placed the bird in a round, 2.5-m diameter, covered and fenced enclosure where it had ample space to flap its wings and strengthen the pectoral muscles. Although fault bars were present on the outer primaries, the tips were still attached. Four days later, the birds' appetite was still waning and its mass decreasing, so we again attempted a release. Wing chord measurements were obtained just prior to this, and it was noted that approximately 5 cm of P9 and P10 on the right wing were missing and there was a fault bar on P8. The P9 and P10 feathers on the left wing were also stressed at this point, but the feather tip was still attached, although pliable, and probably did not afford any functional lift. The primary feathers bear most of the stress in take-off and maneuvering and help provide the lift needed for flight. It was believed that these missing and broken feathers inhibited the bird's flight. It was also noted that most of the rectrices were broken, and the unbroken feathers had fault bars at the same point as the feathers with breakage. Feather growth requires an array of nutrients for normal feather development. Fault bars are a result of isochronic defects in the barbules created by disruptions in the assimilation of nutrients during development (Prum and Williamson 2001). Young birds


Red-tailed tropicbird chick



Colett Welch feeding chick

that undergo periods of sickness or starvation can develop fault bars at the same level on all of the feathers that were developing during that time.

Options

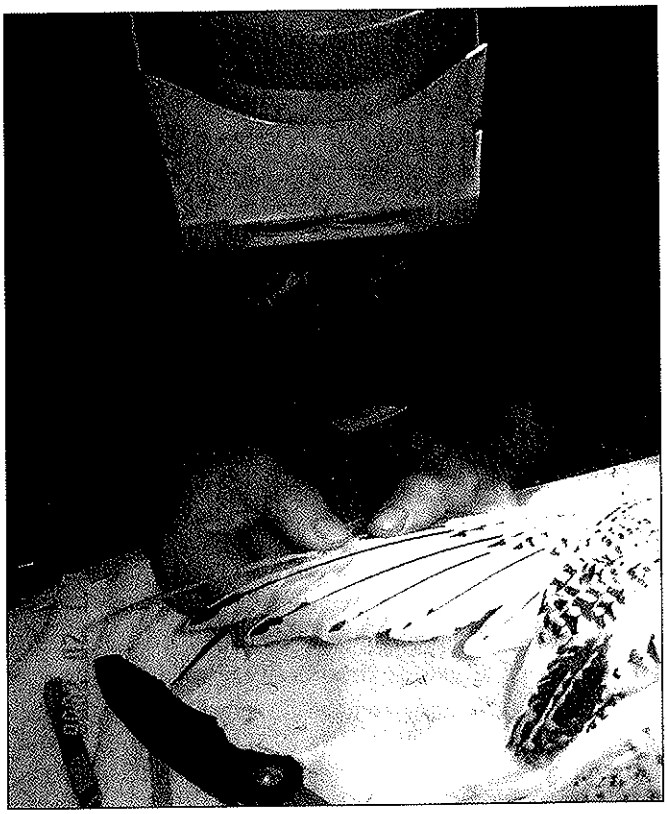
Three options were considered: 1) care for the bird through molt and primary replacement, a process that may take over one year (LeValley and Pyle 2007); 2) pull the broken feathers to facilitate new feather growth; or 3) "imp" the feathers. We decided that feather imping, the more immediate "fix," was desirable and would improve the chances of survival for this individual. Tropicbirds, particularly adults, are generally stressed in captivity and are often difficult to sustain in a situation requiring long-term care (Zaun, unpubl data).

The feather-imping procedure

On 20 October 2006, author S.S. performed feather imping on P8, P9, and P10 on the right wing and P9 and P10 on the left wing. Red-tailed tropicbird primaries were unavailable, so white-tailed tropicbird *(P. lepturus)* primaries were used from two frozen carcasses. First, the patient was placed under general anesthesia to minimize stress caused by restraint and handling. The broken primaries were prepared by cutting the proximal end of the rachis approximately 10 cm from the point of breakage. The rachis diameter was greater here, allowing for a stronger bridge between the donor and original feathers. The donor feathers were cut to ensure a proper length. An oak sliver, whittled to the appropriate diameter, was then inserted into the donor feather rachis. When the proper fit was achieved, it was removed, and a small amount of quick-bonding glue (Superglue™) was placed on the wood and it was then carefully reinserted into the rachis. The wood served as a bridge between the shafts of the old and the replacement primaries. The same procedure was



Broken primaries



Imping feathers

accomplished for the other end of the wooden sliver, and the rachises were butted together for a snug, even fit.

The release

The morning after the imping procedure, the bird was placed on a grassy slope above refuge cliffs that abut the ocean. The bird was very alert, turning and tilting its head to gaze around at the surroundings. After approximately 10 min, with only a few interim wing flaps, the bird suddenly took flight. It rapidly gained altitude as it headed northeast, then turned to a more northerly direction over the ocean. We watched with binoculars as it gained elevation to approximately 75 m and leveled out, and it soon disappeared out of sight. Prior to release, the bird was banded on the left tarsus with a standard metal FWS band.

Comments and conclusions

Fault bars weaken feathers and may lead to breakage and inhibit flight. The P9 and P10 feather breakage did not occur until after the bird was removed from the medium-sized plastic kennel and placed in the larger fenced enclosure 11 days prior to its successful release. However, if the bird flapped its wings in the kennel and consistently hit the outer primaries against the hard plastic, it could have contributed to their extreme weakened state and eventual breakage at the fault bar. To minimize

the potential of feather breakage during rehabilitation, we recommend housing a near-fledged tropicbird chick or adult in a large pen where the bird has ample space to freely flap its wings.

Seabirds that become captive due to illness or injury often do not self-feed and can be aggressive and difficult to handle. Additionally, caring for the animal may require an extensive amount of staff time and resources. Feather imping is an excellent alternative to holding a bird in long-term captivity while awaiting molt and feather growth, particularly for species that typically do not fare well in captivity. We are optimistic that this red-tailed tropicbird will survive and return to the refuge; the imping procedure went impeccably well and resulted in strong outer primaries and sustained flight.

One other successful seabird feather imping was documented when a Laysan albatross was found wandering the streets of San Francisco with its wings clipped. After the extensive imping of all primaries and secondaries, and two months of rehabilitation at the International Bird Rescue Research Center in Berkeley, California, it was released on Midway Atoll National Wildlife Refuge. The bird's fate was unknown until nine years later when it was discovered incubating an egg on Isla Guadelupe, Mexico (Howell 1994).

Red-tailed tropicbird



Acknowledgments

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Product List

Pedialyte®— Abbott Laboratories, 100 Abbott Park Road, Abbott Park, Illinois 60064-3500, USA

Petmate®— Petmate, P.O. Box 1246, Arlington, Texas 76004-1246, USA

Mazuri®— Purina Mills, LLC, 555 Maryville University Drive, Suite 500, St. Louis, Missouri 63141, USA

Superglue™— Superglue Corporation, 9420 Santa Anita Avenue, Rancho Cucamonga, California 91730, USA

About the Authors

Brenda Zaun, U.S. Fish and Wildlife Service biologist at the Kauai National Wildlife Refuge Complex, is responsible for the biological program for three refuges on Kauai, Hawaii. Bird rehabilitation is often an added necessity in her scope of work and she relies on the help of dedicated volunteers to assist with these tasks.

Scott Sims, DVM, is an extraordinary veterinarian who donates time and expertise for the care of sick and injured wildlife. His skills and abilities have been an asset for the refuge and the many birds he has treated over the years.

Kathy Batha is a ranger for the Kauai National Wildlife Refuge Complex and leads the volunteer program, coordinates environmental education, and assists with rehabilitation activities. Kathy's biology background with the U.S. Fish and Wildlife Service has been an asset in rehabilitation efforts and outreach activities.

Marilou Knight is a volunteer at Kilauea Point National Wildlife Refuge and has assisted in the rehabilitation of numerous seabirds and waterfowl. She describes this work as inspirational and enjoys sharing her knowledge and experience with the thousands of annual visitors to the refuge.

Colett Welch has volunteered at Kilauea Point National Wildlife Refuge for 2.5 years, interpreting the wildlife and history of the refuge and historic Lighthouse for its visitors. Recruited by Brenda Zaun for field work and special projects, she says, "...helping the tropicbird get to fledging weight, observing imping, and watching it fly is one of the most exhilarating things I've experienced."

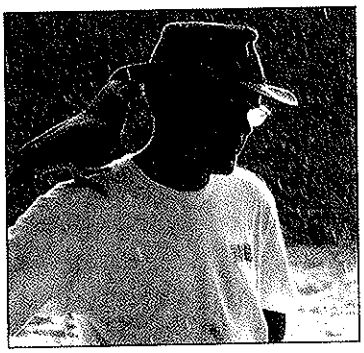
Cathy Granholm has been a Kilauea Point National Wildlife Refuge volunteer for the past six years, donating over 1,600 hours of her time. Cathy enriches the refuge visitors experience with her knowledge, and assists with rehabilitation of a variety of bird species.

Keith Swindle (not pictured) works for the U.S. Fish and Wildlife Service, Office of Law Enforcement to enforce the nation's wildlife protection laws including the Endangered Species Act, the Migratory Bird Treaty Act, and the Lacey Act. Keith has worked with Brenda Zaun and others on Kauai, and elsewhere in the Pacific, to aid injured seabirds and to support their welfare by education, outreach, and law enforcement.



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Marilou Knight, Brenda Zaun, Colett Welch, Cathy Granholm



Scott Sims



Kathy Batha

Feeding, Growth, and Plumage Changes of Mallard (*Anas platyrhynchos platyrhynchos*, Linnaeus) Ducklings in Captivity

G. Mustafa Shah, Ulfat Jan, Fayaz A. Ahanger, Bilal A. Bhat, and Javid A. Wani

Introduction

A century ago, mallards (*Anas platyrhynchos*, Linnaeus) bred in large numbers in Kashmir, India. Destruction of wetland habitat in general, and at mallard nesting sites in particular, combined with illegal egg collection and indiscriminate poaching, caused mallards to discontinue breeding in Kashmir, although they do overwinter there. Breeding pairs have recently been observed again, albeit in small numbers. It is a good sign, but there is a need for research on various breeding parameters in order to facilitate an increase in the breeding population.

Newly hatched mallard ducklings are precocial; they hatch with open eyes and are covered with downy feathers. The female and her ducklings leave the nest 2–4 days later and do not return. The ducklings spend most of their time at well-concealed sites, particularly tall and dense macrophytic vegetation, where they are difficult for researchers to relocate. This makes the study of their growth in the wild very difficult. Therefore, an attempt was made to observe growth and plumage changes in captive mallard ducklings.

Methods

Study Site

Eight newly hatched mallard ducklings were collected from a nest at Hokersar wetland, Kashmir, India on 10 June 2005 with permission of the Department of Wildlife Protection, Jammu and Kashmir Government. The ducklings were raised in an 8 × 4 × 1.5-ft rectangular pond, half filled with water. To avoid predation, a wire net on wooden supports was used to cover the pond. A wooden raft was placed on the pond for ducklings to rest upon. Two of the ducklings died during the first seven days of study. The cause of the death could not be determined.



Ducklings captured for captive-rearing study

Feeding

Food was provided to ducklings in the form of aquatic invertebrates, earthworms, aquatic plants, and paddy (*Oryza sativa*). The young ducklings pecked at dark spots and small objects during the first few days. They also followed and tried to catch flying insects such as mosquitoes and flies. On average, the ducklings fed almost exclusively on the animal matter (*Chironomus* larvae, small mollusks [*Lymnea columella*, *Planorbis* spp., *Sphaerium* spp.]), small crustaceans (*Gammarus* spp.), and other aquatic invertebrates) through the 25th day. On day seven, pieces of earthworms were provided to the ducklings. Around day 25,

IN YOUR PRACTICE: This study offers an opportunity to compare previously published growth rates for captive-reared ducklings fed specially-designed, protein-rich diets with ducklings raised on a diet created from foods used by mallards in the wild.

ABSTRACT: Very little study has been carried out on growth and plumage changes of mallard ducklings, with age, because of their precocial nature and the secretive behavior of females while rearing young. Therefore, an attempt was made during the present study to appraise growth and plumage changes of mallard ducklings in captivity. Growth in captivity was slightly less than in nature. Growth rate in females was slightly less than males. Onset of flight was also delayed in captivity.

KEY WORDS: Mallards, ducklings, growth rates, plumage changes.

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TABLE 1. GROWTH OF DUCKLINGS IN CAPTIVITY.

	FEMALE GROUP (N = 4)			MALE GROUP (N = 2)		
AGE (DAYS)	MEAN WEIGHT (G)	MEAN TARSUS LENGTH (MM)	MEAN BILL LENGTH (MM)	MEAN WEIGHT (G)	MEAN TARSUS LENGTH (MM)	MEAN BILL LENGTH (MM)
1	33.07	20.70	11.62	33.43	20.75	11.75
10	43.43	23.12	15.47	56.26	25.05	16.55
20	66.90	27.22	19.85	84.80	29.40	20.15
30	97.93	30.55	24.42	151.85	33.85	26.10
40	174.61	32.15	30.42	228.50	37.80	34.00
50	227.88	35.40	34.45	332.50	40.10	36.85
65	398.57	38.50	37.10	612.50	42.00	39.20
80	567.50	40.20	38.10	740.00	44.80	40.15
110	717.50	43.40	40.20	887.50	46.00	40.90

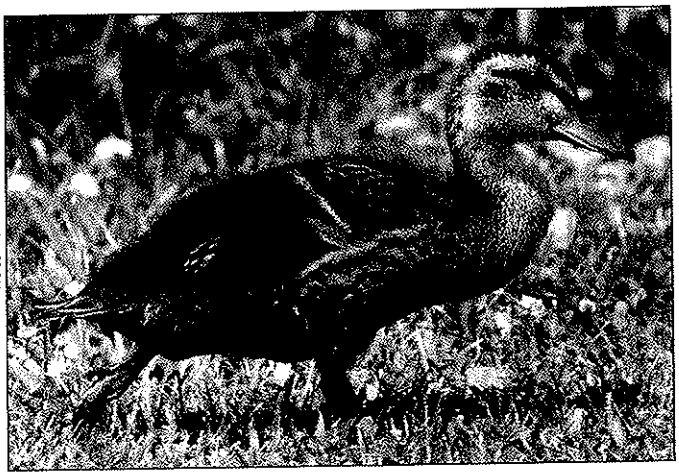


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Duckling at Day 60



PHOTO © JUST CHAOS USED WITH PERMISSION

Monomorphic plumage in juveniles

ducklings started feeding on small amounts of duckweed (Lemna minor). The amount of plant material consumed increased gradually with age, and after one mo ducklings were fed small amounts of paddy along with the duckweed. From day 40 onward, paddy formed the bulk of the food ingested by ducklings.

Data Collection

The weight of the remaining six ducklings (named A, B, C, D, E, and F) was recorded daily; the other parameters studied for growth (tarsus length and bill length) were measured at various intervals. These ducklings were also studied for plumage changes that occurred with age. The ducklings were raised for 205 days, after which they were released back into the wetland.

Results

Growth

At the onset of sexual dimorphism, ducklings B and E were identified as males and A, C, D, and F as females. Males had a slightly higher growth rate than did females. The mean values of weight, tarsus length, and bill length of male and female groups at various intervals are shown in Table 1 and Figs. 1, 2, and 3.

The growth changes appeared to be uniform and steady. Day-to-day changes were rather inconspicuous and, as such, visible changes were described at 10, 15, and 30-day intervals, although weight was measured and recorded daily (the other parameters were measured only at intervals as shown in Table 1). After 110 days, the changes in these daily measurements leveled off and developmental changes were limited to plumage.

Plumage Changes

The plumage change in mallard ducklings is a gradual process, i.e., a duckling passes from one plumage stage to the other gradually over a period of several days. Therefore,

in this section, the plumage change has been described with the average age (not with the exact age).

Newly hatched mallard ducklings are richly colored. The back and crown of the head are clove-brown, darkest on the crown, with a dark stripe on each side of the eye. The ducklings are yellowish below (breast and abdomen), as are the cheeks. There are four yellowish spots, two of which are on the scapulars and two on the rump. Wings are dark dorsally and yellowish ventrally. The upper beak is blackish, the lower beak light orange. Legs are grayish black.

As the young birds increased in size, the colors of the back and crown became duller and lighter, and the yellows faded, replaced by more buffy shades. Juvenile plumage began to emerge on scapulars, flanks, and tail, on average, at day 25; and began on rump and breast, on average, at day 33. Juvenile plumage appeared on the head and neck at day 60. The wing feathers started developing, on average, at day 60 and were well developed by 85 days. On average, at day 80 the young birds made flying attempts.

In the juvenile plumage, mallards are sexually monomorphic; the young birds resembled the adult female but were darker and browner, especially on chest and back. At about the age of 3 months (90 days), sexual dimorphism began. The males became grayish while the females retained their mottled brown plumage. By 120 days, males and females were easily differentiated. On day 136, on average, the head of the males started turning green; the tail hooks had not yet appeared. However, by 180 days, the characteristic adult plumage had been achieved.

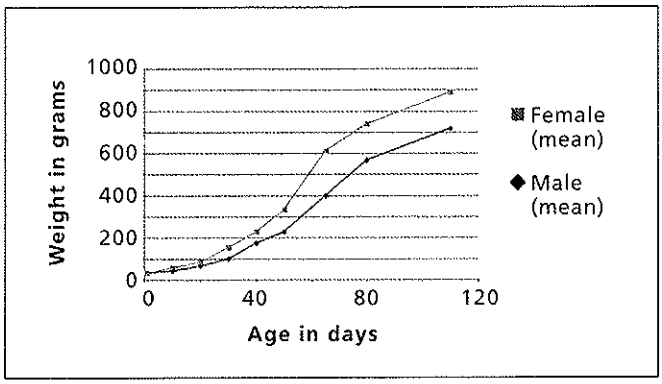


FIGURE 1. WEIGHT INCREASE IN MALLARD DUCKLINGS, WITH AGE.

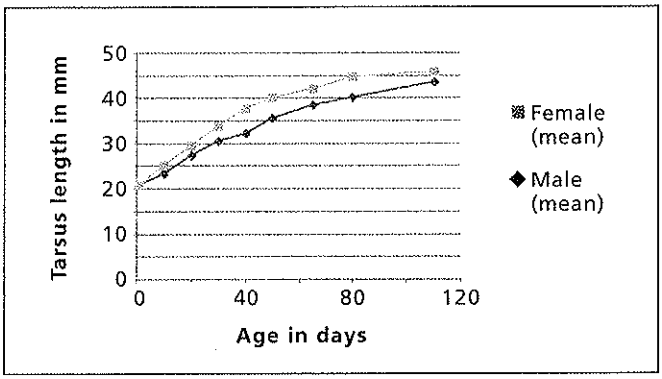


FIGURE 2. INCREASE IN TARSUS LENGTH IN MALLARD DUCKLINGS, WITH AGE.

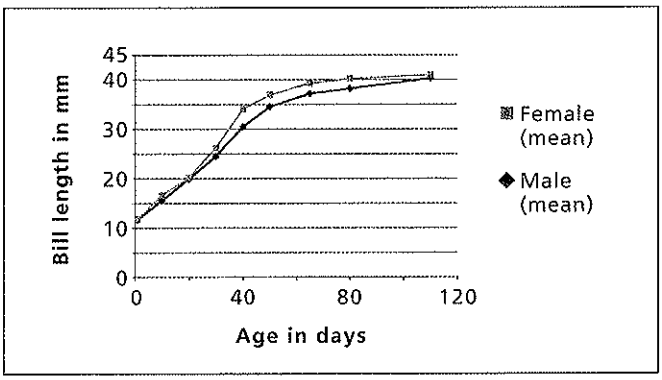


FIGURE 3. INCREASE IN BILL LENGTH IN MALLARD DUCKLINGS, WITH AGE.

Discussion

The studies on the growth and behavior of mallard ducklings are very limited. This paucity of data is largely due to logistical difficulties associated with the mallard's precocial young and the secretive behavior of females while rearing young.

We observed a lower growth rate for female ducklings than for males, as did Greenwood (1974) and Sugden et al. (1981). We also observed a growth rate of captive-reared ducklings that was slightly less than has been reported in the wild. Kear (1965) found that the body mass of wild hatchlings doubled in one week and quadrupled in two weeks. One possible reason for the lower growth rate of the captive ducklings in this study could be related to the quality of the diet they received: In this study, we relied on the diet obtained from the natural habitat of the ducklings and did not provide any artificial, protein-rich diet, which most researchers provide to the ducklings in captivity. Therefore, the quality of the diet we provided to the ducklings may not have been as adequate as an artificial, protein-rich diet. Another reason could have been the stress of captivity and handling.

Several prior studies have confirmed the relationship between growth rate and invertebrate abundance. Hunter et al. (1984) observed that, with a decline in invertebrate abundance, the growth rate of ducklings also declines; this is because, under such circumstances, the ducklings have to spend more time in moving and searching and less time in resting, which overall is energetically more demanding. Sjoberg et al. (2000) also found that mallard ducklings feeding on lakes poor in invertebrate abundance gained less

mass than those feeding on richly supplied lakes, mainly because of food limitation. This finding was supported by Hill et al. (1986), who found that mallard ducklings feeding in lakes with a high density of fish gained less weight than ducklings feeding in rivers with scarce fish; this is because fishes feed on invertebrates and, consequently, ducklings suffer a shortage of invertebrate food.

Chura (1961) and Street (1977) found that mallard ducklings of <25 days of age feed mostly on animal matter, and this was confirmed by our observations. Chura (1961) also reported that seeds made up 51% of food items for ducklings 25–30 days old and 99% of food items in ducklings >45 day old. Also in this study, the invertebrate food preference of ducklings was gradually replaced, with age, by the preference for vegetable foods. Sedinger (1992) observed that mallard ducklings require a diet containing at least 50% invertebrates during the first 2 wk to obtain sufficient dietary protein; such foods are highly digestible and pass into the intestine quickly. He also observed that, as ducklings mature and body size increases, they shift to diets containing more vegetable matter; the increased use of plant foods reduces the protein content of the diet, although this is partially counterbalanced by increased rates of food intake. These shifts in diet are consistent with increasing body size during growth; older and, therefore, larger ducklings should require higher rates of food intake but may tolerate a lower concentration of nutrients. In North Dakota, mean brood mass at 16 days was positively correlated to aquatic invertebrate numbers (Cox et al. 1998).

Our observations on the sequence of plumage development are in conformity with Southwick (1953). In captivity, the wings also developed late, as was found in studies of wild-reared ducklings. In addition, the birds were able to make flying attempts by the end of day 80, compared to a range of 52–70 days for flight and independence of wild-reared birds, as observed by Kirby et al. (1989). In our case, the onset of flight was late as compared to the observation made by Greenwood (1974), who also raised ducklings in captivity and found that birds made flying attempts by day 54. This could be related to the early development of flight feathers, in the latter case, which in turn could be related to the high-protein diet provided to the ducklings in Greenwood's study.

Conclusions

The growth rates and plumage development in our study were found to be slower than in studies carried out on the captive rearing of mallard ducklings by Greenwood (1974) and Southwick (1953). However, in their studies, the ducklings were provided with a specially designed, protein-rich food (protein rich "starter" and "grower" ration, chopped hard-boiled eggs, chick-starter mash) while we depended on the food present in natural conditions (aquatic invertebrates). Our study, when compared with the other studies involving growth of mallard ducklings in captivity (Greenwood 1974, Southwick 1953) and in nature (Kear 1965), shows that the growth rate of ducklings in captivity, fed with the natural diet, is slower than the ducklings raised in captivity with a specially designed protein food, and is also slower than those ducklings that grow in the wild, feeding on naturally available food.

We acknowledge that the data collected on growth and plumage development from just six ducklings is not sufficient to be representative of all ducklings that live in Kashmir, but we feel that by carrying out this study, we have taken a step in the right direction. We hope that our attempt will encourage other researchers to come forward and carry out extensive research on mallards.

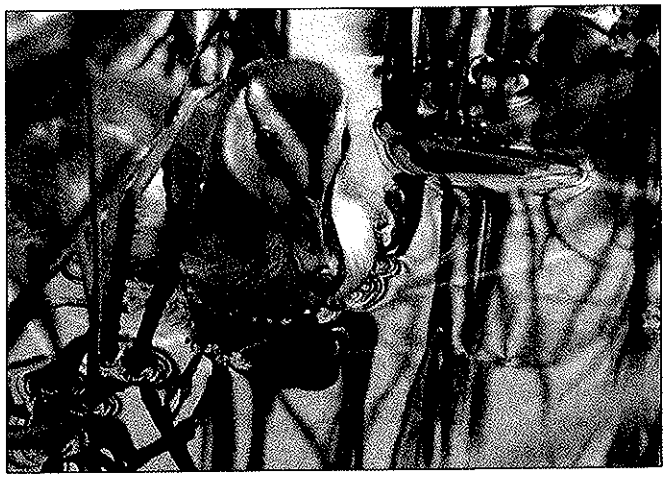


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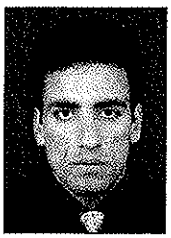
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Fracture Fixation of Femur in Hanuman Langur (*Semnopithecus entellus*) with Intramedullary Pinning

M. Raghunath, N. Singh, A. Gopinathan, T. Singh, V. Sangwan, J. Mohindroo, and A. Sharma

Introduction

Invasive management such as intramedullary (IM) pinning, locked nails, or plating with screws of long bone fractures in nonhuman primates is scarcely cited in the literature. However, several methods of fracture fixation are reported for long bone fractures in other wild mammals; for example, in a white tiger cub (*Panthera tigris*; Nath et al. 2001, Sen and Mazumdar 1990), a panther (*Panthera pardis*; Ranganath et al. 1998), and a sambar deer (*Cervus timorensis*; Thiruthalinathan and Swaminathan 1996, Singh et al. 1982). Nonhuman primates, including Hanuman langurs (*Semnopithecus entellus*), occasionally enter human habitats in search of food. They are generally wary of humans but may become aggressive when injured. Hence, they are not often amenable to medical care, and postoperative follow-up is problematic even after a good fixation of fracture with intramedullary implants. The present article records the successful repair of a femur fracture by IM pinning and cerclage wiring in a Hanuman langur.

Case Report

A 7-month-old female Hanuman langur weighing 7.3 kg was presented by a rescuer at the Veterinary Teaching Hospital, Guru Angad Dev Veterinary and Animal Science University (GADVASU) with trauma of unknown origin and non-weight-bearing lameness in the right hind limb.

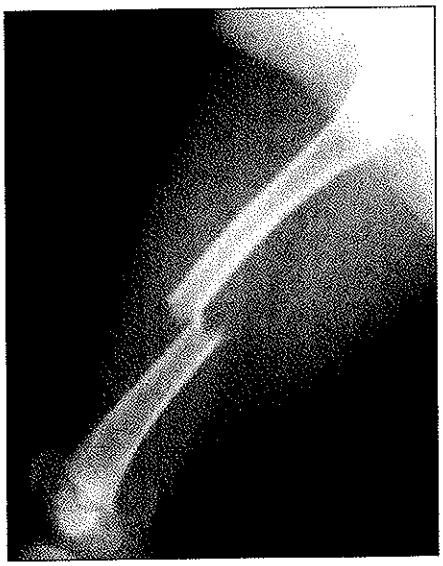


FIGURE 1. Preoperative lateral radiograph showing complete, transverse, interdigitated, overriding fracture of the femur.

On clinical examination, crepitation was felt at the mid-shaft of the femur. The animal exhibited pain on manipulation of the limb. The single lateral radiograph revealed a complete transverse mid-shaft fracture of the femur, with a longitudinal split in the proximal segment (Fig. 1). The animal was prepared for surgery. Anesthesia was induced with ketamine (20 mg/kg) i/m intubation done with a #5 uncuffed endotracheal tube. Anesthesia was maintained with 5% halothane mixed with oxygen.

Standard cranio-lateral incision was made starting from the greater trochanter to the distal part of the femur. The fascia lata was incised and vastus lateralis and biceps femoris muscles were separated to approach the femur bone. The over-riding ends of the bone were reduced and a snugly fitting 4-mm Steinmann pin was passed from the trochantric fossa, in a normograde fashion, into

IN YOUR PRACTICE: Although the focus of this paper is a primate, the specifics of treatment for a fracture have implications for a variety of mammalian species.

ABSTRACT: The incidence of femur fracture in domestic animals, especially cats (*Felis catus*) and dogs (*Canis familiaris*), is widely reported, but the literature on the incidence and surgical repair of orthopedic problems in nonhuman primates is scarce. A 7-month-old Hanuman langur (*Semnopithecus entellus*) was treated for femur fracture using intramedullary pin and cerclage wires under inhalant anesthesia. The animal recovered without any complication.

KEY WORDS: Fracture fixation, Hanuman langur, intramedullary pinning, *Semnopithecus entellus*

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the distal fragment. The distal end of the pin was firmly anchored in the cancellous part of the femur. The longitudinal split in the proximal fragment was repaired by two full cerclage wirings using a 22G stainless steel wire. The surgical wound was closed in a routine manner. An immediately postoperative radiograph revealed fracture fragments in good apposition and IM pin and cerclage wires in the desired position (Fig. 2). Recovery from anesthesia was uneventful. An injection of meloxicam, a nonsteroidal anti-inflammatory drug used to manage pain, was administered prior to complete recovery from anesthesia at 0.2 mg/kg. Postoperatively, a modified Robert Jones bandaging was used for 12 days. Injection meloxicam (0.2 mg/kg) for 3 days, and injection ceftriaxone sodium (40mg/kg) for 5 days, was administered. The caregiver was advised to restrict the movement of the animal for at least 2 wk; a telephone call confirmed that instructions were followed.

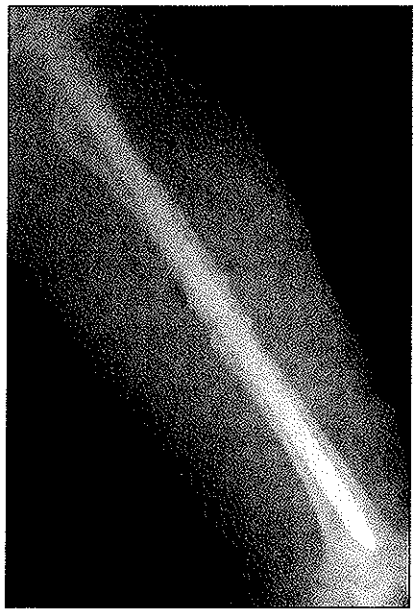


FIGURE 2. Immediate postoperative lateral radiograph showing proper apposition of fracture fragments with snugly fitting IM pin and two full cerclage wires.

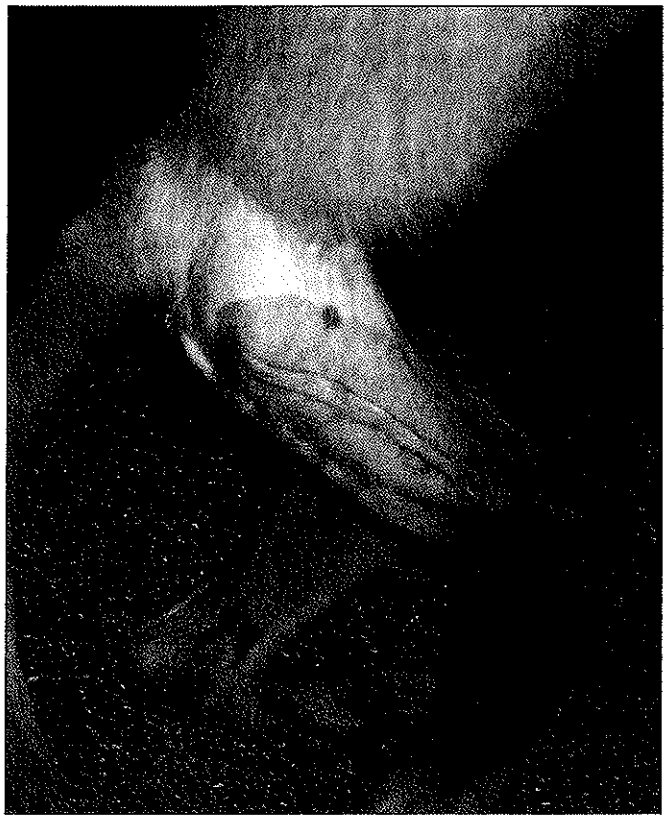


FIGURE 3. Figure showing complete weight bearing on 15th postoperative day.

The animal started to bear weight on the affected limb on the 3rd postoperative day. On the 15th postoperative day, the weight bearing was complete (Fig. 3). The animal was presented for follow-up after 2 mo, with complete limb usage and no sign of lameness. A lateral radiograph revealed a bridging callus holding the two fracture fragments (Fig. 4A). The IM pin was removed under local anesthesia after making a small incision on the trochantric fossa of the femur. A lateral radiograph after removal of the IM pin showed sufficient periosteal callus around the fracture site (Fig. 4B).

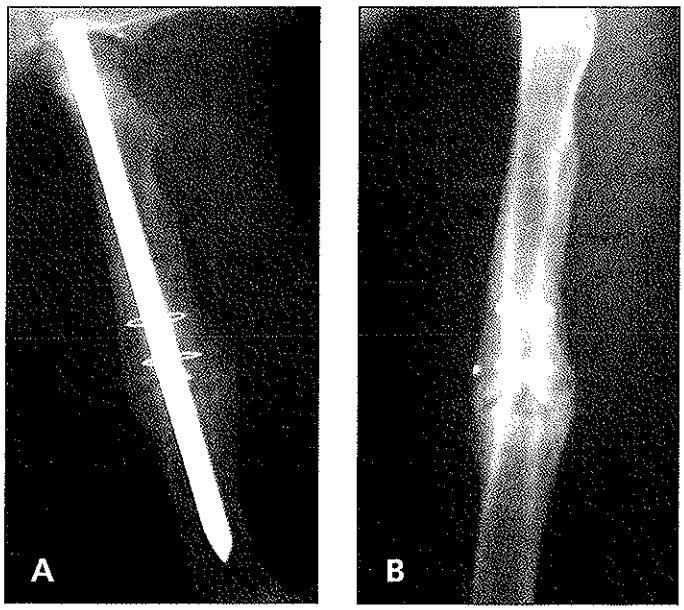


FIGURE 4. Lateral radiograph, 60 days postoperative, showing sufficient periosteal callus with cortical continuity before (A) and immediately after (B) pin removal.

Discussion

Generally, in nonhuman primates, a combination of xylazine and ketamine is used for induction of anesthesia (Nolosco et al. 2007). However, in this case only ketamine was used due to the docile nature of the animal. It has been reported that ketamine can be used as the sole anesthetic agent in nonhuman primates (Hall et al. 2001). The animal was intubated without much resistance. The standard approach described by Piermattei and Greeley (1966) was followed in this case. In wild mammals, fracture stabilization of the femur with plaster

of Paris casts is rarely indicated (Ranganath et al. 1998); hence, internal fixation with a snugly fitting Steinmann pin was done to prevent both rotation of the fragments and migration of the pin, even though the animal was very agile and started weight bearing on the 3rd postoperative day. This report records the successful management of mid-shaft femur fracture in a Hanuman langur with intramedullary pinning and cerclage wiring.

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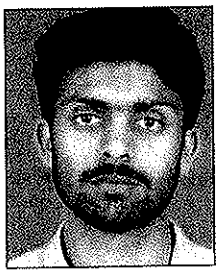
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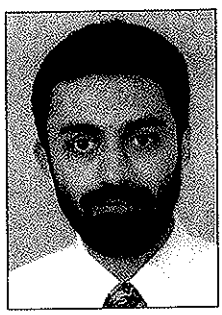
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West Nile Virus Infection in Tree Squirrels (*Rodentia: Sciuridae*) in California, 2004–2005

Kerry A. Padgett, William K. Reisen, Nicole Kahl-Purcell, Ying Fang, Barbara Cahoon-Young, Ryan Carney, Nancy Anderson, Lynda Zucca, Leslie Woods, Stan Husted, and Vicki L. Kramer

Introduction

Transmission of West Nile virus (WNV) generally involves a mosquito vector and an avian reservoir host, with the general paradigm that mammals become infected as incidental or spill-over hosts. Although most WNV infections in mammals either cause low or no morbidity or mortality, some mammals, such as horses or humans, readily develop severe illness. West Nile virus or antibodies to the virus have been detected in many other mammals such as bats, raccoons, rabbits, mice, skunks, opossums, and tree squirrels (Anderson et al. 2001; Marfin et al. 2001; Komar 2003; Root et al. 2005, 2006). Tree squirrels, in particular, may be highly susceptible to WNV neurologic disease in regions where WNV is newly established. Evidence of WNV infection in tree squirrels in the United States has been reported from at least 11 other states (Arizona, Colorado, Idaho, Illinois, Kansas, Louisiana, Michigan, New York, Ohio, Pennsylvania, and Wyoming (Marfin et al. 2001; Kiupel et al. 2003; Heinz-Taheny et al. 2004; MMWR 2004, 2005a, 2005b; Dietrich et al. 2005; Root et al. 2005, 2006).

In addition to WNV, at least six other encephalitic viruses have been detected in North American tree squirrels, such as LaCrosse virus (LACV), California virus, St. Louis encephalitis virus, western equine encephalitis virus (WEEV), eastern equine encephalitis virus, and Powassan virus (POWV) (Milby and Reeves 1990; Day et al. 1996). Although most were detected by identification of antibodies to these viruses, thereby indicating previous infection, virus has also been isolated from squirrels infected naturally with WEEV, LACV, and POWV (Timoney 1971; Ksiazek and Yuill 1977; Milby and Reeves 1990). Infection with WEEV previously related to squirrel mortality in California (Lennette et al. 1956) These results suggest that tree squirrels may be important in the transmission cycle of these viruses. Recent accounts indicated that fox squirrels and eastern gray squirrels can develop central nervous system lesions and virus has been detected in kidney, brain and heart tissue (Kiupel et al. 2003; Heinz-Taheny et al. 2004). Other rodents, such as mice and hamsters, have been experimentally infected with WNV and function as animal models for research (Kramer and Bernard 2001; Xiao et al. 2001). It is unclear whether squirrels or other rodents can function as reservoir hosts for WNV. To ascertain the importance of these tree squirrels in the transmission cycle of WNV in California, it is essential to first measure its prevalence, intensity of infection, species affected, geographic range, and whether virus is present in blood. If virus is present throughout California in high proportion of tree squirrels, with a high viremia in circulating blood, this would suggest that squirrels may play a role as competent WNV reservoirs.

Materials and Methods

Tree squirrels were reported to the California WNV hotline in conjunction with dead birds. In the summer of 2004, the number of reported sick and

ABSTRACT: West Nile virus (WNV) transmission generally involves a mosquito vector and an avian reservoir host, with mammals as incidental hosts. Although most mammalian WNV infections cause low or no morbidity or mortality, tree squirrels are susceptible to WNV-associated neurologic disease with infection prevalence comparable to that in dead birds. Positive species included fox squirrel (*Sciurus niger*), western gray squirrel (*S. griseus*), and eastern gray squirrel (*S. carolinensis*). Kidney tissue (dissected and swabbed) and oropharyngeal (oral) swab samples from tree squirrels, submitted by California vector control and rehabilitation agencies, were tested by reverse transcription-polymerase chain reaction; cycle threshold values were similar for all three samples, ranging from 21.9 to 26.5. Kidney tissue was more sensitive than oral swabs for detecting WNV in squirrels. Three of 36 live neurologic tree squirrels had viremia approximately 5 $\log_{10}$ plaque-forming units/ml or greater, similar to WNV-infected birds. Tree squirrels are useful in WNV surveillance and provide localized evidence of WNV transmission to mammals.

KEY WORDS: tree squirrel, West Nile virus, mammal transmission, disease surveillance

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dead tree squirrels increased dramatically in southern California, coincident with intense WNV activity, thereby prompting us to investigate whether tree squirrels are dying from WNV. Tree squirrels were screened following the same protocol used for birds (McCaughney et al. 2003). Squirrels were necropsied at the California Animal Health and Food Safety Laboratories (CAHFS) in a biosafety cabinet, taking precautions to guard against tularemia and plague (e.g., use of double gloves, blunt scissors, avoidance of fleas). In 2004, three samples were taken from each squirrel (kidney tissue, kidney swab, and oral swab) and placed in tissue lysis buffer (Applied Biosystems, Foster City, CA). Kidney tissue was acquired by snipping a 3-mm piece of kidney tissue using blunt scissors and placing in 1 ml of lysis buffer in a 2-ml microcentrifuge tubes; oral and kidney tissue swabs were obtained by swabbing with sterile polyester fiber tipped applicators and swirling swabs in 1ml of lysis buffer for 1 min. All three samples were submitted to the Center for Vectorborne Diseases (CVEC) at University of California, Davis and tested by reverse transcription-polymerase chain reaction (RT-PCR) following the protocol outlined by Padgett and others (Padgett et al. 2006). In 2005, only kidney tissue was submitted for testing.

From August through October 2006, sick squirrels submitted to two wildlife rehabilitation agencies (Wildlife Care Association, Sacramento, CA, and Lindsay Wildlife Museum, Walnut Creek, CA) were masked with isoflurane and bled by cardiac puncture or by ventral tail metatarsal or saphenous veins prior to being humanely killed. Whole blood (250 µl) was dispensed into 5-ml cryovials containing 1 ml viral transport medium (VTM[20]) for a 1:5 dilution of blood. After killing, squirrel carcasses from wildlife rehabilitation agencies were forwarded to CAHFS and tissues were tested as described above. Blood from sick and dying squirrels was tested for antibodies and for live virus. Whole blood in VTM from 36 squirrels was evaluated for virus by standard Vero plaque assay (Campbell et al. 1989). If there was no detectable virus in the blood sample, serum was tested for antibodies against WNV by a plaque reduction neutralization test (PRNT) (Reisen et al. 2005). Sera that neutralized 80% of the challenge dose of 100 plaque-forming unites (PFU) of the NY99 stain of WNV at a dilution ≥1:20 were considered positive.

Results

Characteristics of WNV-infected mammals

Between 2004 and 2005, three tree squirrels species were found dead by the public and subsequently tested positive for WNV in California fox squirrel (*Sciurus niger*), western gray squirrel (*S. griseus*), and eastern gray squirrel (*S. carolinesis).* This is the first record of WNV infection in western gray squirrels. Fox squirrels were the most commonly reported and frequently infected squirrel species, followed by western gray and eastern gray squirrels. During summer of 2006, a high proportion of WNV-positive fox squirrels recovered by rehabilitation center were juveniles ≤10 weeks of age (16 to 18 WNV-positive squirrels). Symptoms of WNV infection in sick tree squirrels include head tilt, uncoordinated movements, chewing at feet, paralysis, tremors, circling, and lethargy. (Kiupel et al. 2003; Padgett KA, unpubl. data).

Surveillance of dead squirrels

The prevalence of WNV in dead squirrels mirrored that of dead birds each year: in 2004, 64.5% (49 of 76) of squirrels tested positive compared with 56.4% (3,232 of 5,728) of birds; in 2005, 32.2% (49 of 152) of squirrels tested positive compared with 32.9% (3,046 of 9,263) of birds. A similar pattern appeared to hold for 2006; preliminary results for 2006: 23.2% (32 off 138) of squirrels were positive for WNV thus far this year compared with 24.2% (1,398 of 5,777) of birds. Again, similar to dead birds, the highest prevalence in WNV-positive squirrels was in August of 2004 and 2005.

The first WNV-positive squirrel tested in California was collected from Los Angeles County at the end of July during the 2004 epidemic; most dead squirrels were reported from this county last year (112 of 255 reports). In 2005, as the epicenter of WNV moved north to the Sacramento area of California, the highest number of dead tree squirrels was reported from northern and central California with Sacramento and Contra Costa counties having the highest number reported (66 and 94, respectively). The number of squirrels reported increased to 493 in 2005, and the number of counties reporting dead squirrels increased from 35 in 2004 to 38 in 2005.

Comparison of sample types

Kidney tissue was the most reliable sample for detecting WNV in squirrels, followed by kidney and oral swabs. Of 36 positive tree squirrels tested by all three methods, dissected kidney tissue resulted in only four false-negative results (sensitivity = 89%) and resulted in a mean Taq-Man cycle threshold (Ct) value of 26.3. Swabs of kidney tissue detected 22 of 36 positive samples with a Ct value of 28.6. Oral swabs were the least-sensitive sample type, with only 19 of 36 true positives detected (sensitivity = 52.8%); mean Ct value was 27.6. Nevertheless, agreement in test results between paired samples of dissected kidney tissue and oral swabs was 68%. There was no significant

difference in mean Ct values among sample types (P = 0.17); estimated PFU equivalents for these samples ranged from 3.1 to 3.6 $\log_{10}$ PFU per kidney sample.

Tests of living squirrels

Of the 36 living tree squirrels with blood tested for WNV by plaque assay, 9 (25%) had a detectable viremia (mean = 3.2 log10 PFU/ml, SD = 2.2, range = 0.4–8.0). Of those squirrels that were viremic, three had titers of approximately 5 log10 PFU/ml or greater, the reputed threshold required to infect California mosquitoes (Reisen et al. 2005). All tree squirrels that were viremic and had carcasses submitted for further testing had RT-PCR-positive kidney tissue (n = 7). Of the 27 tree squirrels that tested negative by plaque assay and were tested by PRNT, 21 (75%) had antibody titers >1:80, thereby indicating exposure to WNV. Of 21 tree squirrels with antibodies to WNV, 17 were also tested by RT- PCR (kidney tissue), with 12 testing positive for WNV.

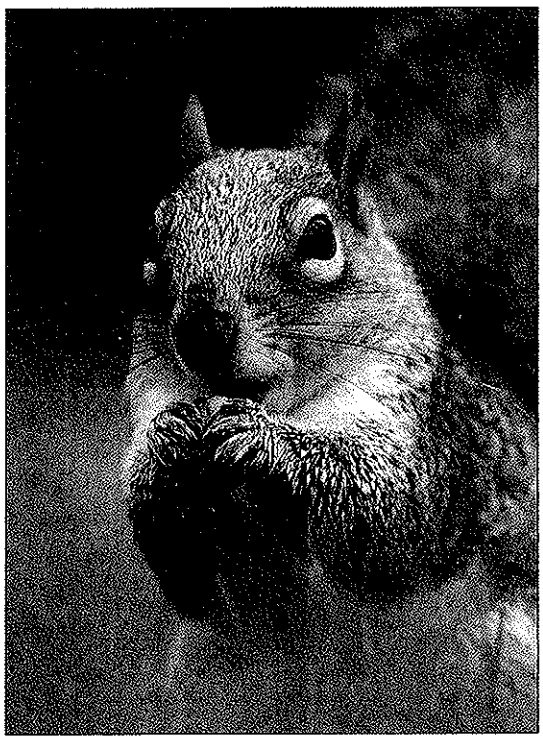


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Of four squirrels that had serial blood collections made prior to killing or death, two were viremic and two were antibody-positive only. The first animal who exhibited no neurologic signs had blood drawn four days prior to death because of neurologic signs and the death of two cage mates (siblings); this blood sample contained 8 $\log_{10}$ PFU/ml. A second sample taken three days later when squirrel was ataxic, circling and dragged its knuckles, also was viremic (5.7 $\log_{10}$ PFU/ml); this animal died the next day. The second animal was ataxic and had blood drawn two separate days prior to killing. The first sample had viremia of 1.7 $\log_{10}$ PFU/ml and was negative for neutralizing antibodies (<1:20), the second blood sample taken the day of killing was negative for viremia but neutralizing antibodies were >1:80 (animal was positive for WNV by RT-PCR of kidney tissue).

Discussion

The three squirrel species were found to be susceptible to WNV in all regions of California and were useful for WNV surveillance, with prevalence and peak of WNV infection mirroring that of dead birds. Moreover, unlike birds, tree squirrels are terrestrial peridomestic animals; thus, highly localized information on WNV transmission can be acquired by including squirrels in a WNV surveillance program. Squirrels also can be useful for WNV surveillance in areas where large corvid populations are absent or where bird numbers have decreased significantly because of WNV or other factors.

In other areas of the United States where WNV infection has been noted in squirrels, the two species involved are fox squirrels and eastern gray squirrels, both non-native species to California. Although this is the first report of WNV in western gray squirrels, other western states have noted mortality in this species (Drew M, Idaho Fish and Game, unpubl. data). Although many of the squirrels submitted during the summer of 2005 were ≤10 weeks old, it is unclear whether juvenile fox squirrels are more susceptible than adults or whether this simply reflects timing of second litter for this species (i.e., generally July in California)

Kidney tissue was a better sample to use for WNV RT-PCR testing than oral swabs because oral swabs missed up to 50% of true-positive samples. Nevertheless, oral swabs are an alternative sampling method to consider when necropsy is not possible, with the benefit being easier and safer than necropsy and sampling of internal issues (e.g., kidney, brain, spleen). Although RT-PCR detects abundance of viral RNA and not live virus, the finding that there was no difference in Ct values among positive oral tissues compared with kidney tissues suggests that a similar amount of virus is sampled by each method, provided that the squirrel secretes WNV into the oral cavity. It does appear that WNV-infected tree squirrels, regardless of sampling method, have less virus at death than WNV-infected American crows (oral swab and/or kidney tissue); crows tested at CVEC using identical methods had mean Ct values 10 units lower (or 2 orders of magnitude more PFU equivalents) than that of tree squirrels (Reisen et al. 2005).

In addition to providing a sampling method for WNV, these results indicate that at least half of all tree squirrels sampled shed WNV in their oral secretions. A recent study detected WNV RNA by plaque assay in oral, fecal,

and urine samples of experimentally infected fox squirrels (Root et al. 2006). These results suggest the potential for contact transmission of WNV among cagemates or siblings, similar to that seen by birds (Komar et al. 2003); empirical evidence from rehabilitation centers supports this premise (Padgett K, unpubl. data). Furthermore, these results indicate additional care should be made when rehabilitating squirrels, such as avoiding squirrel bites by wearing leather gloves, autoclaving cage material, and separate housing for squirrels with neurologic signs.

Some squirrels naturally infected with WNV had sufficient virus in their blood to be able to potentially infect mosquitoes (approximately 5 $\log_{10}$ PFU/ml). The viremia of one tree squirrel in this study (8 $\log_{10}$ PFU/ml) was in the range of many passerine birds that have been implicated as competent reservoirs of WNV (Komar et al. 2003). There is some concern that, if mammals such as tree squirrels and lagomorphs (i.e., rodents/hares) can serve as reservoirs, they may infect mammalophagic mosquito species (Tiawsirisup et al. 2005). For example, a secondary transmission cycle has been documented for WEEV that involved *Aedes melanimon* and lagomorphs (Hardy 1987); in this case, the jump from birds to mammals as a reservoir and day-biting mammalophagic mosquitoes as the vector markedly increases risk of transmission of WEEV to humans and horses. Of note, one of 11 California lagomorphs (black-tailed jackrabbit) tested for WNV was positive. (Padgett K, unpubl. data).

Although the role of tree squirrels in the WNV transmission cycle is uncertain, tree squirrels have been shown to be important for WNV surveillance in California. Results from our study indicate that squirrels sick or dying during the summer months with neurologic symptoms have a high likelihood of testing positive for WNV, determined either by detection of antibodies or virus in blood, kidney tissue, or oral secretions. Further studies directed at reservoir competence of tree squirrels, using *Culex* and *Aedes* mosquito species, are warranted to assess potential risk to human health.

Acknowledgments

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Up for Discussion

PRE-EXPOSURE VACCINATION FOR HANDLING RABIES-VECTOR SPECIES

Wildlife rehabilitators receive any number of rabies-vector species (RVS)—including raccoons, skunks, foxes, coyotes and bats—and of all ages, neonate to adult. They may be apparently healthy, to injured, to obviously ill—there's no way to predict what will show up at your clinic or your front door. Once someone has been exposed to the disease, through contact with blood or saliva, there is a small window of opportunity for postexposure vaccination. There is only one verified case of a human who did not receive treatment and survived. Every other case has been fatal.

It's easy to take precautions when presented with an animal that is obviously sick, but what about the possibility of exposure due to handling before the animal has exhibited symptoms of the disease? Some rehabilitation organizations have a strict protocol that requires rehabbers to receive pre-exposure (prophylactic) rabies vaccinations prior to accepting any RVS into care; such a protocol protects both the rehabilitator and the organization from potential litigation, should the unthinkable occur. Others leave the decision up to individual choice. What's your take on this important issue?

QUESTION

Should rehabilitators be required to receive pre-exposure rabies vaccinations prior to caring for rabies-vector species?

RESPONSES

AS A BAT rehabber in California, it is imperative that I and my volunteers have pre-exposure rabies vaccinations. If you're not vaccinated, you don't get to volunteer. I do not understand why this is not made standard practice for all wildlife rehabilitators. Bats aren't the only animals that get rabies. I realize rabies vaccinations are exorbitant, and not everyone can afford them, but that is no excuse for the risk taken by working unprotected with RVS—or any mammals for that matter. There should be some kind of discount or payment exemption made for pre-exposure vaccinations for people who work with mammalian wildlife. Why are they so expensive, anyway? Thanks for allowing me to vent!

Frances Zitano
Flying Mammal Rescue of California
Sacramento, California, USA

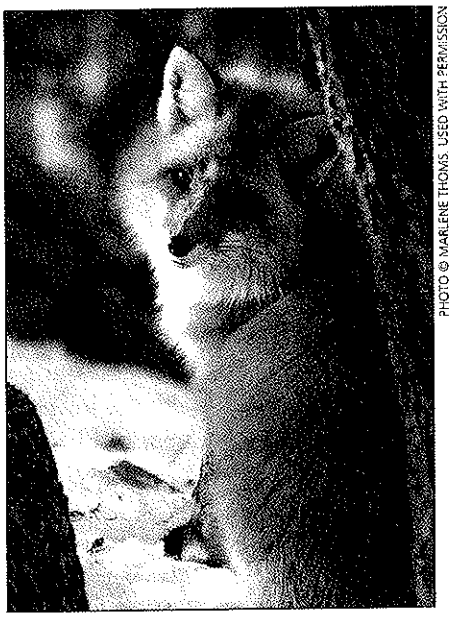


PHOTO © MARLENE THOMS. USED WITH PERMISSION

WE REQUIRE anyone working with RVS to have their pre-exposure vaccination. However, the vaccines are not currently available because of the worldwide shortage. It would be interesting to know how other rehabbers with the same policies are dealing with this. We have set our policy because of the risk, even if it is very, very small. With turnover of staff and volunteers, we might have fewer vaccinated staff next year, and therefore, a reduced capacity to care for RVS. To maintain or even increase our capacity, do we waive this requirement, even as the risk to the individual remains the same? A local vet tech college is requiring students to sign waivers in place of pre-exposure vaccinations.

Linda Laurus
Rideau Valley Wildlife Sanctuary
Ottawa, Ontario, Canada

SHOULD rehabilitators be required to receive pre-exposure rabies vaccinations prior to caring for any rabies vector species? Or should this be the choice of each individual?

I think this is a personal choice—but all of us have to be aware of the risks and consequences. Rabies is a serious issue, and we can't afford to be cavalier about it. As a licensed rehabilitator, I have a responsibility to my family, my volunteers, and to the general public to openly discuss the risks of handling wildlife without taking the proper precautions.

I accept raccoons, opossums, and bats in my rehabilitation practice. I do not require that my volunteers receive pre-exposure rabies vaccinations before working with the raccoons or opossums; however, only those who have been vaccinated and provide me with documentation are allowed to work with the bats. Most of the raccoons and opossums I see are orphaned infants, so the risk is low, but with bats the probability is higher—not because a large number of bats are rabid, but because we don't get bats that have simply strayed away from Mom or been left behind during an eviction. When bats are sick, they separate themselves from their colony to reduce the spread of the illness in the group. So any time a bat comes to me, there's a problem, and I cannot rule out the possibility of rabies without maintaining proper quarantine.

Ultimately, prudence dictates that rabies-vector species should only be handled by rehabilitators who have been vaccinated for rabies. I would include skunks, bats, bobcats, fox, and coyotes when setting that guideline. In some parts of the U.S., raccoons must also be included. However, the only situation in which vaccinations can be mandated is if rehabilitators are employed by a facility, rather than being volunteers. As employees, pre-exposure vaccinations can be a condition of employment. As volunteers, we are all responsible for our own health and safety.

Kate Rugroden
Director, Bat World Mid-Cities
Arlington, Texas, USA



PHOTO © LOREN KAHLE (WWW.LORENKAHLE.COM). USED WITH PERMISSION.

IN GEORGIA, only rehabbers who can show proof of pre-exposure vaccines—and acceptable titer levels—can legally rehab RVS. Those of us without the pre-exposure vaccines are allowed to hold RVS for up to 72 hours before transfer. I always use gloves and try to house any RVS I receive in boxes that can be transferred along with the animal, or trashed after they're transferred. I also generally use feeding implements that can be disposed of after transfer.

While it can be a pain to locate a rehabber who is RVS-licensed and not overrun with animals during the height of the "season," I also see the logic behind the Georgia DNR's "better safe than sorry" policy. Case in point: I know a rehabber who became RVS-licensed as a result of holding rabid, nonsymptomatic baby raccoons for just a couple of days prior to transfer. She was contacted by the RVS-licensed rehabber she'd transferred the raccoons to, who told her she'd been exposed and needed treatment. The coons broke with obvious symptoms just after the transfer.

Personally, it's not a risk I'd want to take. Before working long-term with any RVS, I'd prefer to minimize the risk with pre-exposure vaccines. Proper precautions aren't always enough.

Vonda Lee Morton
Laurens Wildlife Rescue, Inc.
Dublin, Georgia, USA

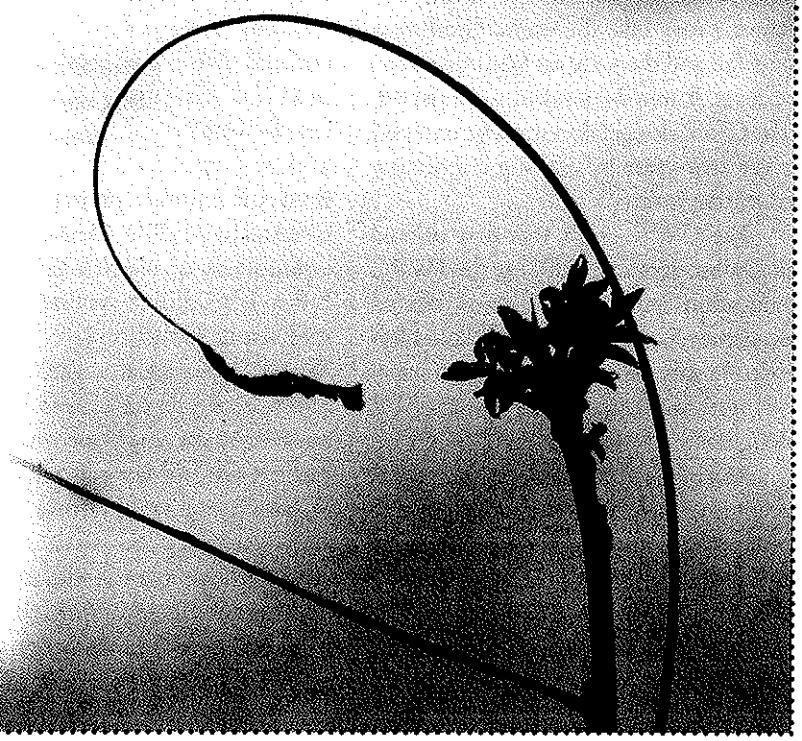
THERE ARE many parts of the U.S. where it is very unlikely that you will be exposed to rabies. If you are exposed, or suspect that you are, the vaccine can be given in a series of five injections. Because you can be treated postexposure, the choice should be up to the individual.

Janette Winkelmann
Friends of Texas Wildlife
The Woodlands, Texas, USA

Congratulations

to the following new Certified Wildlife Rehabilitators!

Delana Bean, California, USA
Deeanna Croasmun, Nevada, USA
Mikal Deese, New Mexico, USA
Kristine Harmer, Missouri, USA
Todd Jones, California, USA
Chris Smith, British Columbia, Canada
Sheila Smith, Manitoba, Canada
Rebecca Smith, California, USA
Charles Snyder, Washington, USA
Lee Theisen-Watt, Texas, USA
Gail Vermoter, Gauteng, South Africa
Rebekah Weiss, Wisconsin, USA
Sheri Williamson, California, USA
Samantha Zarazua, North Carolina, USA



INSIGHT

Certification: A Continuing Dialogue

PART TWO

by Nancy Hawekotte

Introduction

In 2006, IWRC launched the Certified Wildlife Rehabilitator™ (CWR) program. Its introduction has sparked questions and concerns from both veteran and novice rehabilitators. This is the second part of an ongoing dialogue between Kieran Lindsey, Certification Review Board Chair, and the author, a long-time mammal rehabilitator. The interview grew out of their continuing discussion, from two different perspectives, on the meaning of the CWR designation and its potential impact upon this rapidly changing field. [For Part 1 of this column, see *JWR*, Vol. 29 (1)].

The CWR designation parallels other professional certifications in intent: to ensure, by these initials after one's name, a level of knowledge, and its authentication by an independent, professional organization. The designation is earned by passing a test on a range of knowledge related to wildlife and the practice of rehabilitation. Anyone may take the exam. Grading is pass/fail and there are no required classes or texts. It may be retaken until passed. The CWR designation must be renewed every two years by earning continuing education units.

The CWR exam was first offered in Dallas, January, 2007, at the IWRC Education Symposium. It's now offered on-demand online and in proctored format. As this issue of *JWR* goes to press, 64 individuals can now display the CWR designation after their names.

More information about the CWR program, policies, and procedures can be found at *iwrc-online.org/certification/index.html*. On that page is a link to the "CWR Applicant's Handbook," a printable guide detailing the certification procedure.

The Interview

Previously, we discussed the need for certification in the wildlife rehabilitation community, the nature of professionalism, and the difference between permitting and certification. This column will continue to explore the intent of the program and the role of IWRC, and touch on how one achieves and maintains the CWR designation.

Nancy Hawekotte (NH): *We've established that certification does not equate with being permitted (in either direction). But if I am permitted, and if I'm experienced, why can't I be "grandfathered" into CWR status? Why can't my vet, executive director, or DNR officer provide references toward my certification?*

Kieran Lindsey (KL): With such great references, you should be able to pass the exam with flying colors! But seriously, on what criteria would your contacts base their judgment? Most veterinarians are trained primarily to care for small and/or large domestic animals, perhaps with a brief rotation in wildlife. Medical care is one component of wildlife rehabilitation, but so is wildlife behavior, husbandry, nutrition, wildlife law, and more. Wildlife biologists, game wardens, and others each have their own area of specialization, many of which overlap but are not the same as rehabilitation. What criteria would those individuals use to assess your rehab skills? How might those criteria differ from the references of someone else who is grandfathered into the program? How might your relationship with these individuals affect their evaluation? Beyond the issue of training and specialization, how can the Certification Review Board evaluate the credentials of your references themselves?

The CWR Exam addresses the breadth of concerns we face in wildlife rehabilitation, and the program is designed to establish a baseline all CWRs are known to have met. It's fair to everyone, including those who live outside the US, those who work under individual permits and organizational permits, those new to the field as well as seasoned veterans, those who focus on a single species, and those whose practice is more general.

NH: *Will IWRC be able to control my right to practice in the future? Is IWRC trying to convince state agencies to require CWR designation for a permit?*

KL: No. There is no intent on the part of IWRC for the official adoption of certification by any state or federal agency. We want agencies to be familiar with it, but we have no legal influence over their actions. That said, it's possible state and federal agencies may look to the Certification program if they decide there is a need to set higher standards for permitting. Currently, rehabilitators would have little say in that process, but professional certification can help establish our discipline's credibility as deserving a role in such decisions. Establishing professional certification has given other disciplines a voice in defining the standards they're required to meet. Part of IWRC's mandate has always been to represent our community to the agencies that oversee us. Many agencies hang on to old, outdated

Rehabilitators have little say in regulations, but certification can give us credibility as deserving a role in such decisions.

views of rehabilitation; certification can help them understand how it has matured.

NH: *Who put IWRC in charge of certifying rehabilitators?*

KL: No one. IWRC simply recognized a growing need and saw the benefits of addressing this before it was imposed from outside.

NH: *So if you pass the exam, are you a "good" rehabilitator? What does it mean to become a CWR?*

KL: Passing a test doesn't guarantee the quality of your work any more than a medical degree on the wall ensures high quality medical care. It says you've met a basic standard as judged by an independent community of experts in the field. It's a test of knowledge, not skills. There's no lab component, so you don't have to demonstrate that you can perform gavage or give a subcutaneous injection. What is tested is whether you know when it is an appropriate situation to use either procedure. Knowledge is only one of several crucial components required to be a good rehabilitator.

NH: *After two years, IWRC requires continuing education to maintain CWR status. Why, if someone has completed the certification requirements?*

KL: In this rapidly changing field, two years is a long time. The field has come so far since its beginnings, and continues to evolve so quickly, that for one to continually provide the best care, lifelong learning is essential. It's not possible to know the best practices "in perpetuity."

Certification is not intended to be a capstone; it marks the beginning of a commitment to stay on the cutting edge. Continuing education also encourages networking with peers, expanding your knowledge base, and sharing it with others.

NH: *Who makes decisions about qualifying continuing education credits?*

KL: The IWRC Certification Review Board (CRB), comprised of five individuals: the IWRC Board-appointed chair—that's me—a wildlife biologist and faculty member at Virginia Tech with a rehabilitation background; Deb Teachout, DVM of Illinois, who has long been involved in conservation medicine and animal welfare; Penny Elliston, CWR, a founder of Wildlife Rescue, Inc. of New Mexico, past president of IWRC, and one of the first CWRs; Bonnie Bradshaw, CWR, president of 911 Wildlife (a humane wildlife exclusion service) and vice-president of WildCare Inc. in Texas; and Alex Dutkewych, CWR, of New York State, veteran of both rehabilitation and facility development. Membership on the CRB is based on the relevance of one's work in rehabilitation and extent of experience. All are committed to the long-term success of the program and its potential for advancing the field. To avoid conflicts of interest, no IWRC course instructors are on the committee.

NH: *The CE requirements may seem daunting to a rehabber who struggles to get enough funding to care for anmals. What if I can't afford to attend a conference and there are no appropriate local classes? Publishing a paper may be a foreign undertaking to many of us.*

KL: There are endless sources for continuing education, not just conferences and education symposia. Eight hours of credit can easily be accrued by attending wildlife rehabilitation-related meetings, workshops, and classes, of course; but those focused on more general wildlife issues can apply, too, like local continuing education courses and Master Naturalist classes. Look for programs at natural history museums, zoos, nature centers, university lecture series (especially with nationally recognized speakers). Or write up a case study and submit it to the *Journal of Wildlife Rehabilitation*. Speak at a conference. Reach outside your comfort level a bit.

The CRB can't know about every possible CEU opportunity, so it's important to submit a Continuing Education Application and have your event approved before it's time to renew your Certification. IWRC's website provides a list of pre-approved CEUs, if you need more ideas.

NH: *What and why does IWRC charge for certification? Where does it go?*

KL: The cost of the exam is $85, and re-testing is $20/test. Renewal is $35 per cycle. And it certainly doesn't profit the organization! There are many costs to this program: Staff is needed to prep information packets, answer queries, manage mailings and record-keeping. Subcontractors are hired to maintain and troubleshoot the web platform, update exam software, and evaluate and update the test database. IWRC must maintain testing records, CWR files, oversee biennial update schedules, send reminders, and manage and review renewals. The development of the testing database and software were the biggest subcontracting expense in the history of IWRC.

While the CWR program is not intended to generate a profit, it must be self-sustaining. Charges are based on the expenses IWRC incurs to provide and support the program. The cost to applicants is less than many similar programs, such as those for EMT, vet tech, dental assistant, and other certifications.

Watch for the next installment of "CWR: A Continuing Dialogue" in *JWR* 30(1). We'll explore the CWR examination process itself. Meanwhile, visit *iwrc-online.org/certification/index.html* for more information and a copy of the "CWR Applicant's Handbook."

Nancy Hawekotte is a communications professional and 20-year wildlife rehabilitator, having worked in a variety of roles. She lives in Omaha, Nebraska.

Aldo Leopold: His Life and Work

By Curt Meine
Madison: Univ. of Wisconsin Press ©1988, 638 pp, ISBN 0-299-114994-5

"There are two things that interest me: the relation of people to each other, and the relation of people to land."

Curt Meine is a biologist, writer, and college professor who serves on the Aldo Leopold Foundation and on the International Crane Foundation in Baraboo, Wisconsin. About ten years ago, he was the keynote speaker at a conference on management of the Rio Grande riparian forest (Bosque) in Albuquerque. His conference address was based on the thesis for his PhD, i.e., how Aldo Leopold developed his "Land Ethic." From that work, a full biography of Aldo Leopold arose, including an examination of Leopold's influence on the world of wildlife management and wilderness preservation. With words and pictures, Meine brought a legend to life. His presentation inspired me to read the book. First published in 1988, it was the first full-length biography of Leopold and was named Book of the Year by the Forest Historical Society.

One of four children, Aldo Leopold (1887–1948) was born in Burlington, Iowa into a well-to-do family with German- and Bavarian-immigrant roots. The family was well read and well educated, balancing pleasure with hard work and recreational pursuits in the outdoors.

Hunting and fishing were important activities for the Leopold men. Aldo acquired outdoor skills with his father, brothers, and grandfathers on camping trips and on family excursions to the Upper Michigan Peninsula. A gifted student at Burlington High School, Aldo acquired a respect for the written word that would sustain him for the rest of his life. The advantage of an "eastern education" was broached to the family, and he was sent to a private boarding school in New Jersey. Although his father wanted Aldo to join the family's desk company, Aldo was interested in the new field of forestry. Only one school trained foresters, and that school was Yale University. There Leopold learned the basics. His first job was for the U.S. Forest Service in New Mexico, working on forest and game management in the Gila Wilderness. It was in Santa Fe that he met the woman who would become his wife. Estella Luna was one of several children of a prominent New Mexican family. They married in 1912 and settled into life in NM for the next 15 years. While Estella followed Spanish tradition as a wife, rearing five children and tending to domesticity, Aldo traveled to various locations throughout the Southwest conducting forest inspections, studying watersheds and timber management, and camping as he went. He kept journals and took copious notes, all of which provided the material for his early writings. His passion was field work. As Chief of Operations, what challenged him were government politics, policy-making, and personnel management.

In 1924, dissatisfied with his work and repelled by the materialistic "Babbittian" spirit in Albuquerque, Leopold accepted an offer as Assistant Director of the Forest Products Laboratory near the University of Wisconsin in Madison. Although the move to Wisconsin was wrenching for Estella, it proved to be auspicious for Aldo. He bought a house, settling the family into the more-familiar Midwest in which he had grown up. He found that public interest in new conservation initiatives was as strong as the need was urgent. Major reforms in conservation policy were being led by prominent, conservation-minded citizens. He continued to do research and to write and publish, and to speak at conferences and other public forums. One job led to another, and he found himself in academia at the University of Wisconsin, overseeing the work of graduate students. He purchased a poor farm on the Wisconsin River where the family could spend time together and practice their own land restoration. A converted chicken coop, affectionately known as "The Shack," became a hangout where many a discussion would inspire essays for his classic, *Sand County Almanac*. At the time of his death, he was at the height of his powers. His initial interests in game management and forestry had evolved toward wider ecological issues, their interconnectivity, and an intuitive sense of a living earth.

Meine's biography of Leopold is a well-researched and scholarly examination of the life of a man whose work in the first half of the 1900s formed the cornerstone for the ecological movement that commenced in the second half of the century. Practical experience and thoughtful research were at the core of Leopold's life. Through his writings and speeches, Leopold promoted respect for the landscape and preservation of wilderness as an intrinsic human spiritual value. He found inspiration in the Bible and was influenced by many people, among them Teddy Roosevelt, John Muir, John Burroughs, Henry David Thoreau, Walt Whitman, Izaak Walton, Stephen Vincent Benet, and Joseph Grinnell. At the end of his life, Leopold was a skilled generalist, an accomplished synthesizer of literature, history, forestry, wildlife, and spiritual values—truly an inspiration for all those who follow in his footsteps.

Elsa Bumstead is a field biologist, environmental scientist, interpretive naturalist, writer, and sometime wildlife rehabilitator who is based in Albuquerque, New Mexico.

Forester's Log

TREE SPIRITS IN THAILAND

by Mary Stuever

Last year my daughter spent her junior year of high school in Thailand as a foreign exchange student. She and I then visited the 'Land of Many Smiles' during spring break of her senior year. She showed me the place that has become her second home and introduced me to her friends, teachers, and host family. It was an auspicious way to meet this foreign land. As a forester though, despite trying to focus on my daughter's experiences, I could not help but make a few professional observations as we traveled the countryside.

Upon arriving in Bangkok, we were whisked away to the countryside in the small town of Nakhon Nayok, where Katie lived for most of last year. We settled for the night at Katie's host family's compound, which included a 'home-stay', much like a hostel. The cabin we slept in has a large tree growing in the center of the porch, heavy with unripened fruit I had never seen or heard of. The property is full of trees, gardens and ponds, frogs and insects, and joyful night noises that quickly lulled me to sleep.

The next day, we traveled by train to Chiang Mai in the northwestern part of Thailand. After spending a claustrophobic night in an upper sleeping berth, I was delighted in the morning to discover we were traveling through mountainous countryside. To my surprise, most of the ground next to the train was blackened from recent fires. Since the canopies of the trees seemed less affected by the burns, I wondered if the fires were set intentionally or if they had started from sparks generated by metal-on-metal as trains roll down the tracks.

The next day, my forester's curiosity was piqued at the mountain-top temple of Doi Suthep, when I learned that, there in Thailand, large trees are often inhabited by tree spirits or "thep-pa-pak." Generally, these thep-pa-pak are good spirits that bring good luck when called upon. People wrap colorful strips of cloth around the tree to honor the spirit.

Later, I read in *Thai Ways* by Denis Segaller that when people wish to cut down a large tree, they leave an axe leaning against the trunk for two days. If the axe has not moved in that time, the spirit has granted permission to cut the tree. If the axe has fallen over or is in a different place, the tree should not be cut down.

On the return trip to Chiang Mai, I spent hours throughout the night standing on the steps of the train car, watching the moon-lit countryside roll by. At first I was surprised by the flames up on the mountain sides. After hours of seeing fires burning on the ridges of both sides of the long valley we were traveling through, I realized that the burning is probably intentional.

This was confirmed the next day when I asked an English-speaking woman at a Bangkok church about the burning. She told me that fire is used all of the time, and most of the burning occurs at night. I was delighted by this information, but the speaker—an American missionary who has been in the country for over a decade—seemed concerned. "You think the burning is a good thing?" she asked. I explained how our forests in the United States are suffering from the exclusion of fire that has occurred ever since European influences have dominated the land. Through ignorance of the importance of fire to forest health, our policies to keep fire off the landscape have left us with dense and overgrown forests, vulnerable to catastrophic fires. She seemed relieved and says that the burning has troubled her since she arrived. As a complete stranger to this land, I could not offer her an opinion on the burning in Thailand, but I was pleased to see flames on the hillsides.

Our first night back in Nahkon Nayok, I was driving to a night bazaar with a carload of teenagers—my daughter's friends. We passed a field burning next to homes with six- to eight-foot flame lengths. I seemed to be the only one in the vehicle to notice or comment. Burning in Thailand seems so common-place, it hardly gets noticed.

As a farang—or foreigner—I looked for answers in my guidebooks. Again, Segaller informed me that in Thai folklore, there are five goddesses and one of them is Mae Phra Plerng, the goddess of fire. Her companions include Mother Earth, Mother Water, and goddesses of wind and grain.

I still have the rest of the week here in this beautiful foreign land. My hosts are planning trips to see waterfalls and a national park and maybe a ride on an elephant! I am enthralled to be introduced to this land where trees have spirits and fire has its own goddess. Like most visiting farangs, my heart has been smitten by this intriguing country, full of friendly faces. I light my joss sticks with fervent wishes to return and learn more about this enchanting land and culture.

Mary Stuever is a consulting forester specializing in forest ecosystems of the American Southwest. She can be reached at sse@nmia.com.

BOOK REVIEW

The Hopes of Snakes & Other Tales from the Urban Landscape

By Lisa Couturier

Boston: Beacon Press paperback, 159 pages ISBN: 0-8070-8565-0

From the vantage point of New York City and Washington, D.C., Lisa Couturier ruminates on the overlooked and often maligned species that, for better or worse, inhabit the domesticated landscape. She has lived her life in some of the most urbanized places in America, but wildlife and the natural world were an integral part of her life in childhood, and they remain so today. She describes herself as someone who "has desired little except a closeness to animals, and who craved this so strongly that without them I often felt fractured and lost." Her connection to wildlife drove her to search out opportunities to connect, not by leaving the metropolitan areas where she lived, but by discovering the animals who also called these cities home—the geese who thread their way through the Upper East Side of Manhattan on their way to Central Park's reservoir; the beaver paddling up the Potomac River in search of the succulent bark of some famous cherry trees.

Because wildlife rehabilitators are often called upon to give aid and comfort to these same forgotten, unappreciated, and nearly invisible creatures, I suspect many readers will feel an instant affinity to the author. Admittedly, not many folks go out of their way to bring an injured snake in for rehabilitation, but it does happen, and rehabbers certainly see their fair share of the other species considered by the author in these thirteen thoughtful and engaging essays. The cast of characters will surely be familiar faces to *JWR* readers—crows, coyotes, hawks, herons, foxes, vultures, and, of course, snakes.

I'm sure I'm not the first to notice that, although it is changing, rehabilitation is an estrogen-dominated community, so it would come as no surprise if many readers from the rehabilitation field felt a personal connection to Couturier's essay, "For All the Girls Who Couldn't Walk into the Woods." Her father encouraged her to explore the natural world, and "There was a time I walked without fear. I suspect many girls did, in the early years of a girl's life, when we do not think of our bodies in the ways we will come to think of them later, as women," Couturier explains. "... for each of us the landscape of youth was still an animistic landscape, wherein the creatures, plants, rocks, and rivers dwelling outside had the potential to dwell—intimately, sensually, symbiotically—inside our young minds and muscles."

I was that girl, and I have to admit that as I've grown older the woods are not quite as comforting to me as they once were, at least when I'm alone. I resent the need to think about the potential consequences of taking a solitary hike, while at the same time I wonder if perhaps there's some value in knowing that the world—the larger world inhabited by both human and nonhuman animals—is not a safe place, and never was.

The Hopes of Snakes... is not filled with sweet stories of cute animals. There's humor in these pages, yes, but some of it is dark, and there's sorrow, too, and suffering. Couturier doesn't avert her eyes when faced with the less than Disneyesque aspects of life lived on the street, under the deck, in the attic, or near the dumpster, which can make some of these essays uncomfortable reading for those of us who are tender-hearted. Still, I found it ultimately enjoyable and uplifting to see the less-charismatic urban wildlife treated with respect and the lyricism of a poet.

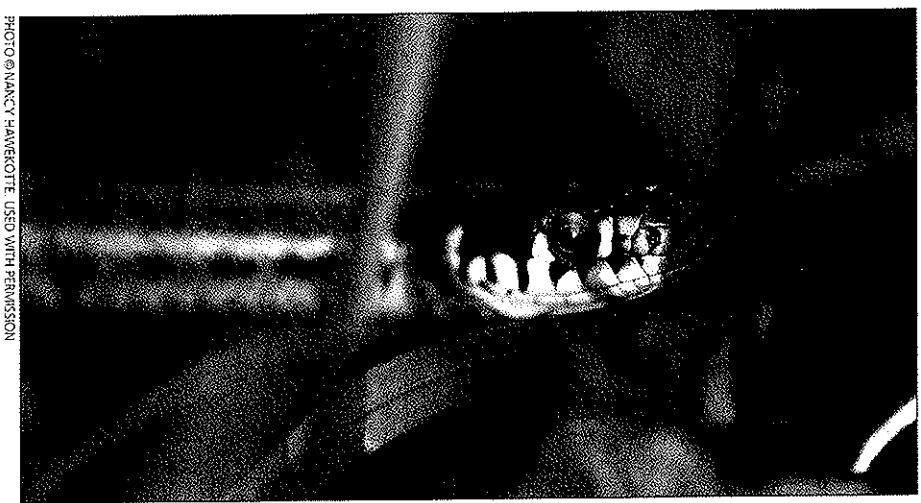


PHOTO © NANCY HAWKEKOTTE. USED WITH PERMISSION

Common garter snake (*Thamnophis sirtalis*), a typical urban resident.

Reviewer Kieran Lindsey is an urban wildlife biologist living in Blacksburg, Virginia.

Editor's Note: The *Journal of Wildlife Rehabilitation* welcomes reviews of relevant books, including veterinary reference books, essays, natural history, and novels. Reviews (600-700 words) should be submitted by email to: jwr.editor@gmail.com.

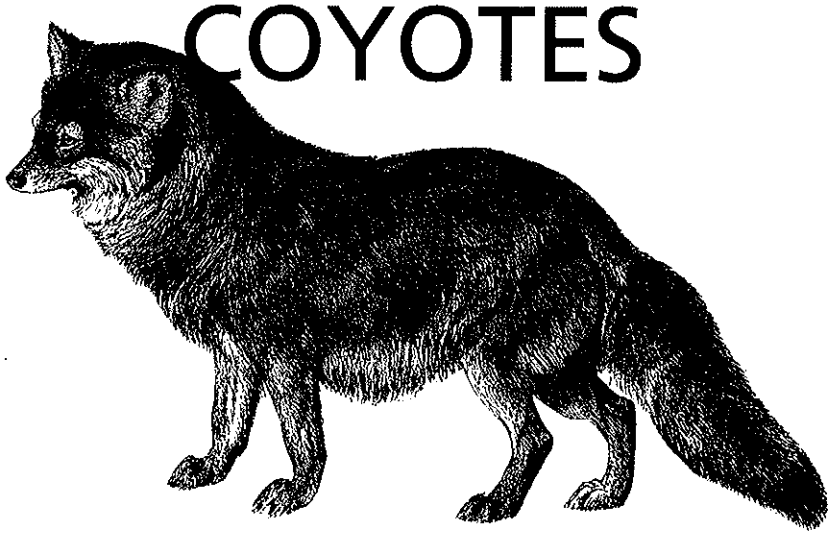
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Coyotes are extremely adaptable. They are the only large wild predator that has extended its range despite human intrusion into their habitat. They now live, mostly quietly, in rural and urban areas from California to Maine, from alpine to desert regions. Coyotes come into heat once a year in late winter or spring. About two months later they bear roughly six pups, which begin to emerge from the den about two weeks later. They are less social than wolves or domestic dogs and usually hunt alone, although they sometimes hunt in pairs for larger prey.

Coyotes are carnivores, and they are opportunistic. Their diet is 90% meat: carrion, mice, rats, ground squirrels, marmots, prairie dogs, other rodents, and the occasional bird. *Any environment that attracts small rodents will attract coyotes.*

So, since we all live in coyote country...

- **Closely supervise** small children, dogs and cats, and if you can't be with them, keep them inside, especially at dawn and dusk.
- **Eliminate cover** in landscapes and dwellings in which they can hide. Make it difficult for them to approach unseen.
- **Install outside motion detectors.**
- **Securely store** garbage, grains, pet foods, and other items that attract rodents and other wildlife. Clean up bird seed. Don't feed pets outside. *Predators follow prey.*
- **If you are confronted, stay calm, look big and tough, and back away.**
  Coyotes, historically very shy animals, are becoming accustomed to humans as we expand our territory into theirs. In some urban areas they are quite visible, and can be a threat to cats and small dogs. Proximity to humans and their pets also increases their vulnerability to diseases like distemper, so if one does approach, get away. As with most wildlife, humans mean danger to coyotes, so most will not come near.

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TAIL END

HEY BABY, IT'S YOUR LUCKY DAY...



EASTERN GRAY TREEFROG (*HYLA VERSACOLOR*). PHOTO © MILT WEST. USED WITH PERMISSION.

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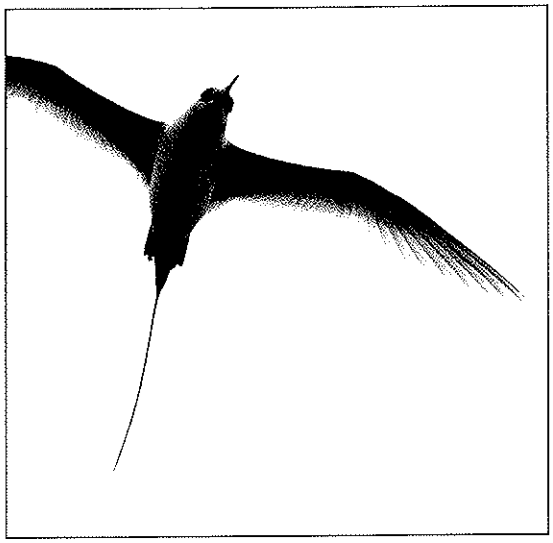
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A red-tailed tropicbird (*Phaethon rubricauda*) in flight.
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