INTERNATIONAL WILDLIFE REHABILITATION COUNCIL

Vol. 27, Nos. 3–4 2004

JOURNAL OF WILDLIFE REHABILITATION



IN THIS ISSUE

Insects and related anthropods: A nutritional primer for rehabilitators ... Thoracic and pelvic limb fracture and luxation management in raptors ... The value of wildlife rehabilitation data to the scientific community ... Healing maggot-infested wounds ... Forester's Log: Burn restoration ... abstracts, news, and more

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 quarterly 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.

ON THE COVER:
Common grackle (*Quiscalus quiscula*) nestling about to eat a cricket at Avian Haven (Freedom, Maine). [photo: Amy Campbell]

BELOW: A great horned owl (*Bubo virginianus*) with open fracture of the left radius and ulna. The ulna was surgically reduced with an IM pin, and the bird was released in January 2005. [photo: Tim Greenfield; courtesy of Cascades Raptor Center, Eugene, Oregon]



IWRC
International Wildlife Rehabilitation Council

IWRC PUBLICATIONS COMMITTEE

Elizabeth Penn Elliston, Chair
Wildlife Rescue Inc., of New Mexico
Albuquerque, New Mexico

Susan Heckly
Lindsay Wildlife Museum
Walnut Creek, California

Astrid MacLeod
Manitoba Conservation
Anola, Manitoba, Canada

Kieran Lindsey
Natural Assets Consulting
Cedar Crest, New Mexico

Janine Perlman
Wildlife Nutrition Consultants
Alexander, Arkansas

Louise Shimmel
Cascades Raptor Center
Eugene, Oregon

FOR INFORMATION

International Wildlife
Rehabilitation Council (IWRC)
P.O. Box 8187
San Jose, CA 95155
USA

408/271-2685
Fax: 408/271-9285
office@iwrc-online.org
www.iwrc-online.org

JOURNAL OF
WILDLIFE REHABILITATION

CONTENTS FALL/WINTER 2004 VOL. 27, NO. 3-4

Editor
Marianne Skoczek
Animal Related Communications Consultants
916/488-3991

Associate Editors
Elizabeth Penn Elliston
Susan Heckly
Louise Shimmel

Contributing Editors
Kathy Dolan
Jennifer Hill
Mary Steuver

Veterinary Consultants
Lora R. Ballweber, DVM
Edward J. Gentz, DVM
Martin Haulena, DVM
Patrice Klein, DVM
Kathleen Linn, DVM
Victoria Lukasik, DVM
Tracey Neff, DVM
Helene Van Doninck, DVM
Jonathan Sleeman, DVM

Printing
Modern Litho-Print Co.
Jefferson City, Missouri

WILDLIFE MEDICINE AND REHABILITATION

5
Thoracic and Pelvic Limb Fracture and Luxation Management in Raptors: A Five-Year Retrospective Study
by Marcy J. Souza, Erica L. Fields, and Laurel A. Degernes

14
Insects and Related Arthropods: A Nutritional Primer for Rehabilitators
by Mark Finke and Diane Winn

28
Formula for Nestling Songbirds (FoNS)©: Updates for 2006
by Mark Finke and Diane Winn

DEPARTMENTS

Editorial by Zoe Dalton 2
Letters 3
Bugs & Drugs by Kathy Dolan 30
Rehabilitation Notebook by Louise Shimmel and Kathy Snell, DVM 33
The (Other) Value of Rehabilitators by Jennifer Hill 36
Selected Abstracts 38
Forester's Log by Mary Steuver 42
Book Reviews 43
News Briefs 48
Ditto 51
Tail Ends by Penny Elliston 52

IWRC

BOARD OF DIRECTORS

President
Joe MacLeod
Anola, Manitoba, Canada

Vice President
Elizabeth Penn Elliston
Wildlife Rescue, Inc. of New Mexico
Albuquerque, New Mexico, U.S.A.

Treasurer
Dody Wyman
River Raisin Raptor Center
Manchester, Michigan, U.S.A

Secretary
Lee Thiesen-Watt
Dallas, Texas, U.S.A.

Lloyd Brown
Wildlife Rescue of Dade County
Marine Mammal Conservancy
Miami, Florida, U.S.A.

Debby Farley
Spring Brook Nature Center
Itasca, Illinois, U.S.A.

Susan Heckly
Lindsay Wildlife Museum
Danville, California, U.S.A.

Nathalie Karvonen
Toronto Wildlife Centre
Toronto, Ontario, Canada

Rob Lee
U.S. Fish and Wildlife Service (retired)
Lubbock, Texas, U.S.A.

Carlos Mclean
Fundacion Ecolombia
Medellin, Colombia

Helene Van Doninck
Cobequid Wildlife Rehabilitation Centre
Truro, Nova Scotia, Canada

Director
Jennifer Gursu
San Jose, California, U.S.A.

JOURNAL OF
WILDLIFE
REHABILITATION

Published quarterly by the International Wildlife Rehabilitation Council, IWRC, P.O. Box 8187, San Jose, CA 95155, USA, ©2004 (ISSN: 1071-2232). All rights reserved. Permission to make duplicate copies can be obtained by contacting IWRC directly or through the Institute for Scientific Information at 3501 Market Street, Philadelphia, PA 19104, USA. Articles from this publication are abstracted and cited in Focus On: Veterinary Science and Medicine, SCISEARCH, and RESEARCH ALERT.

EDITORIAL

Connecting to the Future



Wildlife rehabilitation is a field of connections. Suturing together two sides of a wound, reuniting supposed orphans with their parents, reintroducing to its wild home a successfully rehabilitated patient—ensuring these connections forms the foundation of a rehabber's life.

Equally important to the direct assistance we provide wild animals in need, though, is the forming of connections between our daily work and the broader scope of the reality currently facing wildlife. Helping individual wild animals recover their health is, no one in this field could deny, a mammoth task, and one that can quite literally become the sole focus of one's life.

But if our motivation for helping wildlife is rooted in our desire to ensure the best chance at a healthy life for these magnificent creatures, we as a group must take our thinking beyond the million immediate necessities of those individuals in our care and into the long-term.

And what is wildlife's future based on if not the health of the natural environment?

Recognizing that rehabilitation of an individual animal is but the first step in giving wildlife a chance at a healthy future means recognizing also that our commitment to these animals must translate into a commitment to the environments on which their long-term well-being depends.

Logically, practitioners in our field must, by default, be as ardent conservationists as they are rehabilitators. If we neglect this aspect of our efforts on behalf of wildlife, we risk rendering our work of negligible importance. Wildlife recovered from injury or illness, or successfully raised from babyhood to the status of releasable adult, must have available to them intact ecological settings in which to carry on the next phase of their lives. And who better to voice this need than those who work daily on behalf of these animals?

Who in this field doesn't worry about the many hazards present in the environments into which we must release our wild patients? Vehicles, domestic cats, toxins...the list is endless. But there is no question that the two most influential hazards facing wildlife today are the disappearance and degradation of the habitats on which their survival is based.

Our responsibility to the conservation of wild spaces therefore stems from the very feature that distinguishes wildlife rehabilitation from other fields: namely, the ultimate goal of *release back into the wild.*

So what does this responsibility demand? Does it mean that you must work 24 hours a day rather than the 20 you currently spend looking after the wild patients in your care? Does it mean that another life crusade must be begun, that a steep learning curve must be conquered yet again?

This responsibility demands as much as each of us is able to give. But at a minimum, the answer lies in an evolution in our field's philosophy, an inclusion of a new priority in our list of ultimate goals, and in communicating this change to those with whom we come in contact.

Becoming an advocate for the natural wild spaces upon which wildlife depends does not have to mean attending protests or lobbying government (but, of course, take these steps and many more if they feel right to you). Rather, the area in which rehabilitators can be most effective is in our educational initiatives and in our efforts at networking with the wider community.

Every day rehabilitators speak with finders, deal with regulatory agencies, cooperate with other animal-related organizations, and act in our communities as representatives of wild animals. In our actions, we share with those around us what we believe to be priorities for the future of wildlife.

A commitment to conservation must begin by prioritizing the rehabilitation of not only sick, injured, and orphaned individual wild animals, but also the rehabilitation of the future of wildlife on a broader scale.

And this commitment must be based on voicing our new priorities, on sharing them in every possible way with those around us. Sewing together the patchwork quilt of wildlife's still very uncertain future will require each of us to contribute our piece; together, we can ensure that what emerges from this shared project is a healthy and vibrant environment ready and waiting for the release of those wild animals whose return to these places wild animals we all work so hard to ensure.

—Zoe Dalton
Development Coordinator
Toronto Wildlife Centre
Toronto, Ontario, Canada

LETTERS

The Native American Feather Issue; Mac Diet

At the IWRC's Annual Conference in October 2004, Janelle Harden and Gary Siftar gave partnered presentations about two related issues: (1) correcting federal regulations to allow Native Americans to obtain feathers and avian carcasses from permitted rehabilitators, and (2) finding a regulatory mechanism to allow Native Americans to construct permitted eagle aviaries on tribal lands. In both cases, rehabilitators would take the lead position in providing eagles and all other bird species to the tribes. For this reason, a questionnaire was provided during the sessions to ascertain the opinions of IWRC rehabilitators attending those seminars. Two questionnaires included additional comments, reproduced below.

Dear Janelle,

I attended the third of the sessions that you and Gary Siftar presented at the IWRC conference. I brought the questionnaire back so that we could discuss the topic and provide answers that express the opinion of Wolf Hollow, rather than an individual person.

Enclosed is the complete form, as well as a few comments that came up during our discussion.

(a) We have sent a young eagle to the Native American Aviary at Zuni Pueblo and are supportive of this concept for other tribes. We would only be comfortable sending birds to a facility if we knew that USFWS [U.S. Fish and Wildlife Service] was making sure that these birds would be kept in excellent conditions, as they will most likely be there for the rest of their lives.

(b) We wondered who would ensure that individual birds were suitable for continued captivity. When selecting birds to keep for an education program, we have to choose those that are less stressed by having people around, adapt well to being in a confined space, etc. Some birds are just not suitable for a life in captivity, and it would be unfair to keep them just because they are "unreleasable eagles."

(c) We felt it was important for there to be records of all birds and feathers sent in by rehabilitators and also records of their distribution to tribes, to ensure that they were used for ceremonial, not commercial, purposes.

(d) We suggested that feathers and bodies should be turned over to a wildlife agency rather than directly to tribes, to make sure that they are distributed fairly and that we would not be involved deciding "who should get what."

(e) We hoped that a simple system could be set up to send bodies, so that it would not be complex or expensive for rehab facilities.

(f) A question arose as to whether birds that had been chemically euthanized could be part of this program. We want to ensure that no parts of a euthanized bird could end up putting other animals at risk.

—Shona Aitken
Education Coordinator
Wolf Hollow Wildlife Rehabilitation Center
Friday Harbor, Washington

Dear Janelle,

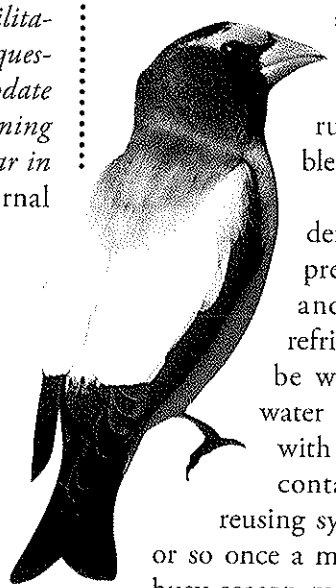
Thank you for your efforts in regard to feathers going directly to the Tribes. We work closely with the Confederated Tribes of the Umatilla Indian Reservation. We have two nonreleasable golden eagles that came from the reservation and have been unable to return their molted feathers to the tribe. It is good to know there is a precedent for building an aviary on the reservation. We will pursue that avenue!

—Lynn Tompkins
Blue Mountain Wildlife
Pendleton, Oregon

Janelle Harden expresses her gratitude for the thoughtful—and thought-provoking—comments provided by these two rehabilitation centers. The results of the questionnaires, along with an update on USFWS activities concerning regulatory changes, will appear in a forthcoming issue of the Journal of Wildlife Rehabilitation.

Dear Janine and Astrid,

I recently heard about a convenient way to make up Mac Diet in advance of needing a large supply. I was wondering how you feel this would stand up with regard to the shelf life and perishability of mixed ingredients. The technique involves measuring the kitten chow and freeze-dried insects and running them through the food processor a batch at a time. Then add other dry ingredients, egg white powder, Ca, and ascorbic acid and seal in a plastic container. When a batch is needed, just pull a container from the shelf and add 1/3 to 1/2 cup of warm water. It softens up in about 10 minutes. The remaining more perishable or unstable ingredients are added: vitamins, gelatin, yogurt, and canned kitten food. For syringe feeding, run it through the blender.



Another wonderful time saver is pre-filling syringes and storing in the refrigerator. They can be warmed in a hot water bath, as needed, with no fear of cross-contamination from reusing syringes. An hour or so once a month during the busy season making Mac Diet pre-mix is a wonderful time saver in the end.

—Songbird Suzie

Dear Suzie

This method is efficient, and should give good results. Because ascorbic acid (vitamin C) degrades very quickly, we suggest that it be added later, along with the other vitamins, gelatin, yogurt, and canned kitten food. The pre-mix should be stored in the freezer, with all possible air removed from the (air-tight) container first; it should be stored for no more than a month. It is extremely important to ensure sufficient water is added to the diet, so that the dry ingredients are reconstituted. Some rehabilitators who chose to use powdered egg whites reported dehydration when the powder was not reconstituted before use, and we must avoid dehydration at all costs.

Thanks to Elaine Yuhas, who developed this method, and to Susan Birch, who brought it our attention.

—Janine Perlman and Astrid MacLeod

The Editors encourage readers to respond to the articles, columns, and other items featured in the *Journal of Wildlife Rehabilitation*. Please direct general questions and comments to the Editor at runmuki@earthlink.net (USPS address on the journal's inside back cover). To respond to a specific article or column, please contact the author directly. (NOTE: Letters may be edited for clarity and length.)

Thoracic and Pelvic Limb Fracture and Luxation Management in Raptors: A Five-Year Retrospective Study

by Marcy J. Souza, Erica L. Fields, and Laurel A. Degernes

ABSTRACT: Fractures and luxations of the thoracic and pelvic limbs are frequently encountered in wild raptor populations, and are most commonly due to trauma such as collisions with vehicles, powerlines, and other objects. Correction of these injuries can involve surgery, physical therapy, and significant amounts of time and other resources. This study examined the factors associated with rehabilitation outcomes in 301 birds with fractures and luxations of the thoracic and pelvic limbs treated at the Carolina Raptor Center over 5 years. Factors examined included (1) age of the bird, (2) species/size of the bird, (3) joint involvement, (4) closed versus open fractures, (5) method of repair, and (6) whether physical therapy was performed. The study sought to determine which variables are more likely to lead to the successful repair and release of a raptor. Factors associated with a successful release in birds with thoracic limb injuries included closed fractures, nonsurgical intervention, and physical therapy performed on the affected limb. No specific factors were identified to be associated with successful release of birds with pelvic limb injuries.

KEY WORDS: Wildlife, rehabilitation, raptors, fracture repair, avian, physical therapy

MARCY J. SOUZA, DVM, is a resident in Avian & Exotic Medicine and Surgery at the University of Tennessee.

ERICA L. FIELDS, DVM, is an associate in a small animal practice outside Atlanta, Georgia.

LAUREL A. DEGERNES, DVM, DAVBP (Avian) is an associate professor of companion and wild avian medicine at North Carolina State University College of Veterinary Medicine.

J. Wildlife Rehab. 27(3–4): 5–13
© 2004 International Wildlife Rehabilitation Council

Introduction

Fractures and luxations make up a large percentage of the raptor cases admitted by wildlife rehabilitation centers. Most fractures occur in the wings or legs, and injuries are often due to trauma such as collisions with automobiles and powerlines (Cooper 2002; Heidenreich 1997). Fractures are typically classified as open or closed and simple, comminuted, or greenstick (Benyon et al. 1996). These different characteristics of a fracture may play a role in prognosis. One study found that wing pathology, including bones, soft tissue, and feathers, accounted for 60–70% of the raptor caseload (n=1180) over a 3-year period (Cooper 2002). Pathology (fractures) to bones made up 65.6% of the wing pathology population. The large numbers of birds with fractures presented to wildlife centers can play an important role in the management of resources such as money, time, space, and medical care. When resources are limited, decisions must be made to utilize these resources for those animals with the greatest likelihood for successful release to the wild.

Previous studies have examined variables associated with successful release of raptors that presented with fractures. Many studies have examined success as it relates to different surgical repair techniques (Degernes et al. 1993a, Howard and Redig 1994, Redig 2000). Repair can include nonsurgical techniques, such as bandaging and cage rest, and surgical techniques such as intra-medullary pins, cerclage wires, and external fixation (Degernes et al. 1993a). Redig (2000) found that raptor fractures repaired with an external fixator-intramedullary pin tie-in technique had an increased success rate. Studies across species have indicated that rigid fixation that opposes rotational, bending, and compressive forces is important in the proper and rapid healing of fractures (Bennett and Kuzma 1992, Piermattei and Flo 1997, Redig 2000).

Soft tissue injury can also play an important role in the successful repair and release of a raptor. Both closed and open fractures can involve soft tissue damage, but the damage associated with an open fracture is typically more severe (Benyon et al. 1996). Degernes et al. (1993b) reported that soft tissue injury contributed to inadequate return to function in some raptors. Another study reported that raptors that had closed fractures were more likely to return to full function (Redig 2000). Additionally, Redig noted that contraction of the propatagium led to failure in three of 27 cases, although no cause for the contraction was known. Physical therapy was performed as part of the rehabilitation of these birds, but was not started until 7–10 days after removal of the external fixators (Redig 2000). Physical therapy has been shown to be important in many species to decrease both soft tissue and joint restriction that can result from injury (Martin et al. 1993b). Additionally, starting physical therapy and weight bearing earlier, rather than later, improves return to function. While most wildlife rehabilitators agree that physical therapy is beneficial for a successful outcome, there is little published information that substantiates this perceived benefit. This study will deter-

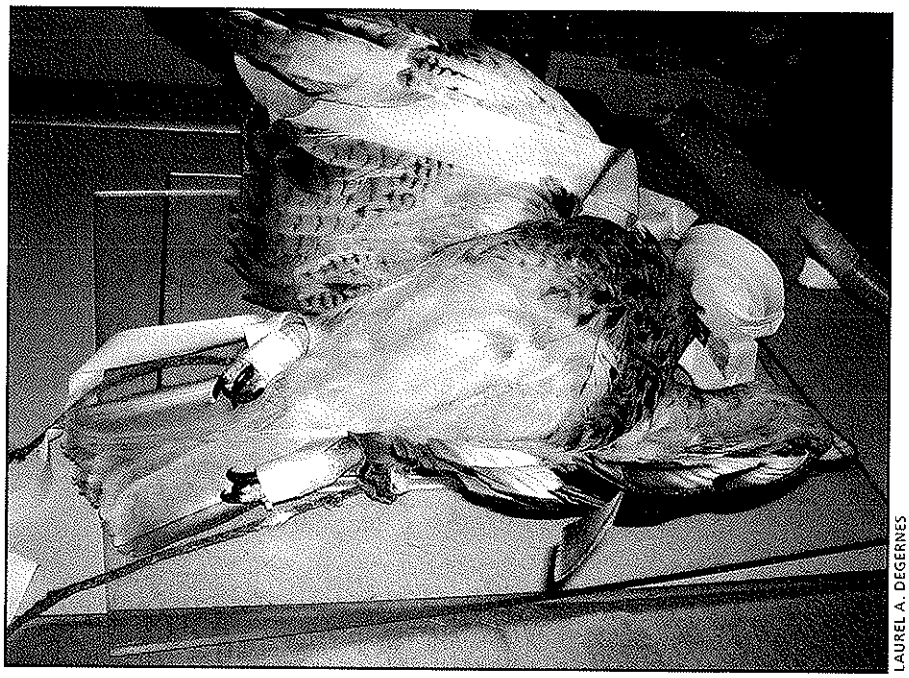

LAUREL A. DEGERNES

FIGURE 1. Adult red-tailed hawk (*Buteo jamaicensis*) under isoflurane anesthesia, set up for a ventral-dorsal radiograph to evaluate a right humerus fracture.

mine which factors—such as age and size of the bird, joint involvement, whether a fracture is open or closed, type of repair performed, and whether physical therapy was performed—play a role in the successful release of a wild raptor that presents with a thoracic or pelvic limb fracture or luxation.

Materials and Methods

The Carolina Raptor Center in Charlotte, North Carolina, accepts approximately 700 birds per year. Currently there is no veterinarian on staff, so birds are referred to local veterinarians when surgical intervention is required. All nonsurgical patient management is performed by staff rehabilitators, or experienced volunteers under supervision of staff members. Cases for this study were chosen from birds that presented with thoracic or pelvic limb fractures and/or luxations from 1998–2003. Birds that died or were euthanized within the first 24 hours or birds that had old, calloused fractures were excluded from the study population. Radiographs were not available for all cases; therefore, only information from written medical records was used. Once included in the study, characteristics of each case were classified according to: (1) age (juveniles were birds presented in their hatch year and adults were birds presented after hatch year), (2) size of the bird (specifically if the species is typically greater than or less than 1 kg), (3) injuries that had either a luxation, a fracture that was recorded as proximal or distal on the bone (next to a joint), or a fracture in which joint involvement was specifically recorded were classified as having joint involvement, (4) fractures were assumed to be closed unless specifically noted as open or soft tissue injury description indicated an open fracture, (5) repair methods were classified as either nonsurgical (bandaging only), surgical with internal fixation—such as intramedullary pins and cerclage wires—or surgical with external fixation, and (6) physical therapy was defined as passive range of motion on the affected limb. Additionally, birds that were euthanized, died or placed as education birds were classified as nonreleasable. Species that were included in the >1 kg category included great horned owls (*Bubo virginianus*), osprey (*Pandion haliaetus*), red-tailed hawks (*Buteo jamaicensis*), turkey vultures (*Cathartes aura*), black vultures (*Coragyps atratus*), and bald eagles (*Haliaeetus leucocephalus*). All other species were included in the <1 kg category (Table 1). A total of 301 birds from 18 species were included in the study (Table 1). Of these birds, 249 had thoracic limb injuries and 62 had pelvic limb injuries (10 birds had both thoracic and pelvic limb injuries). Cases were divided into three groups for statistical analysis, (1) all birds, (2) birds with thoracic limb injuries, and (3) birds with pelvic limb injuries. Analysis was done using the Chi Square Test or Fischer's Exact Test (when sample sizes were <5) with level of significance set at P value <0.05 (Graph Pad 2004).

Results

Of the birds evaluated in this study, 45.8% (n=138/301) were successfully rehabilitated and released to the wild. When the entire group was analyzed, three variables

TABLE 1. SPECIES AFFECTED WITH FRACTURES OR LUXATIONS AND RELEASE RATES

Species	Total Number of Birds	Number and (%) of Released Birds
American kestrel (*Falco sparverius*)	12	6 (50%)
Bald eagle (*Haliaeetus leucocephalus*)	2	1 (50%)
Barred owl (*Strix varia*)	60	30 (50%)
Black vulture (*Coragyps atratus*)	1	1 (100%)
Broad-winged hawk (*Buteo platypterus*)	7	4 (57%)
Common barn owl (*Tyto alba*)	10	5 (50%)
Coopers hawk (*Accipiter cooperii*)	17	10 (59%)
Eastern screech owl (*Otus asio*)	34	12 (35%)
Great horned owl (*Bubo virginianus*)	26	10 (38%)
Merlin (*Falco columbarius*)	1	0 (0%)
Northern harrier (*Circus cyanrus*)	1	1 (100%)
Osprey (*Pandion haliaetus*)	6	2 (33%)
Peregrine falcon (*Falco peregrinus*)	1	0 (0%)
Red-shouldered hawk (*Buteo lineatus*)	28	10 (36%)
Red-tailed hawk (*Buteo jamaicensis*)	74	39 (53%)
Sharp-shinned hawk (*Accipiter striatus*)	15	5 (33%)
Short-eared owl (*Asio flammeus*)	1	0 (0%)
Turkey vulture (*Cathartes aura*)	5	2 (40%)
Total	**301**	**138 (46%)**

TABLE 2. DISTRIBUTION OF THORACIC LIMB FRACTURES

Bone(s) Affected	Number of Birds Affected	Number and (%) of Released Birds
Clavicle and/or coracoid	16	12 (75%)
Humerus	66	16 (24%)
Radius	7	5 (72%)
Ulna	65	47 (73%)
Radius and ulna	38	12 (32%)
Metacarpals	34	16 (47%)
Other fractures	9	4 (44%)
Other fractures and luxations	4	0 (0%)
Total	**239**	**112 (47%)**

were significantly associated with an increased release rate: nonsurgical repair, closed fractures, and physical therapy. Nonsurgical repair was significantly associated with release (n=105/205 [51%]; p=0.006). The presence of a closed fracture (instead of an open fracture) significantly improved the rate of release (n=116/218 [53%]; p<0.001). Passive range of motion exercises of the affected limb significantly improved the rate of release (99/192 [52%]; p=0.008). There was no difference in release rates associated with age of the bird, size

TABLE 3. DISTRIBUTION OF THORACIC LIMB LUXATIONS

Joint Affected	Number of Birds Affected	Number and (%) of Birds Released
Shoulder	3	2 (66%)
Elbow	7	3 (43%)
Total	**10**	**5 (50%)**

TABLE 4. DISTRIBUTION OF PELVIC LIMB FRACTURES

Fractured Bone(s)	Total Number	Number and (%) of Birds Released
Femur	16	7 (44%)
Tibiotarsus	21	9 (43%)
Tarsometatarsus	16	4 (25%)
Phalanx	7	6 (86%)
Other	2	0 (0%)
Total	**62**	**26 (42%)**

of the bird, or joint involvement. Additionally, of birds that were treated surgically, there was no difference in release rates between birds that were treated with only intramedullary pins and/or cerclage wires and birds that had external fixators.

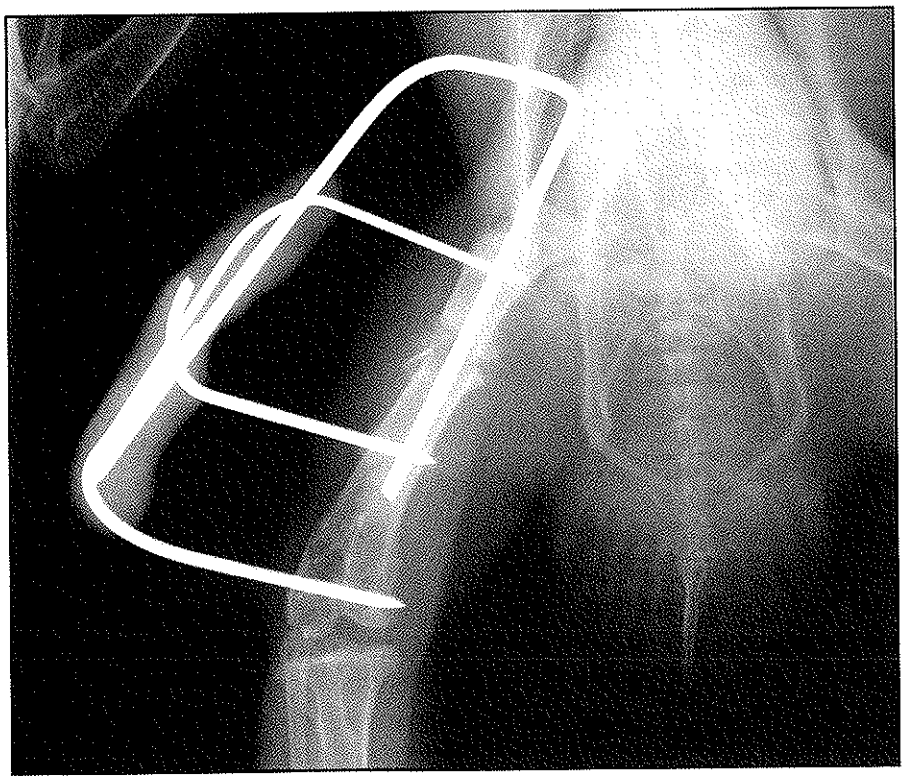
There were 249 birds with thoracic limb injuries, and 47% (n=117) were released to the wild. Fractures were distributed among the coracoid, clavicle, humerus, radius, ulna, and metacarpals (Table 2). Luxations involved the shoulder or elbow (Table 3). Three variables were significantly associated with increased release rate: closed fractures, nonsurgical treatment, and physical therapy. The presence of closed fractures significantly increased the release rate (96/173 [55%]; p=0.001). Birds with thoracic limb injuries that were treated nonsurgically were more likely to be released (n=94/175 [54%]; p=0.005). There was no difference in the release rates between the two classifications of surgical repair. Physical therapy of the affected limb (passive range of motion) significantly improved release rates (n=93/173 [54%]; p=0.009). No difference was observed in the release rates of these birds associated with age, size of the bird, or joint involvement.

Pelvic limb fractures were present in 62 birds and 26 of these birds were released (42%; Table 4). There were no birds with pelvic limb luxations included in the study. None of the variables analyzed were associated with an increased release rate.

Discussion

Raptor rehabilitation can be a rewarding activity, but costly in terms of time, space, and medical or surgical treatment. For this reason, a detailed study of factors relating to rehabilitation success, defined here as releasability, is valuable to assist veterinarians and rehabilitators in determining the most efficient allocation of these resources. The data analyzed in this study indicate that there are several factors that significantly improve release rates in raptors with thoracic limb injuries, including closed fractures, nonsurgical treatment, and physical therapy. For raptors presented with pelvic limb injuries, there were no significant variables associated with successful rehabilitation. The lack of statistical significance in birds with pelvic limb injuries may be due to a relatively small sample size or to increased variability of results.

Avian bones differ from mammalian bones in several important ways. They have thin cortices and large medullary canals; some bones, including the humerus and femur, may be pneumatized (Bennett 1997). Avian bones are susceptible to comminuted fractures, and minimal soft tissue coverage over the distal extremities makes avian patients susceptible to open fractures (Bennett 1997). Fracture healing depends on several factors, including anatomic alignment, motion at the fracture site (bending, rotation, and compression), presence of infection, and disruption of soft tissue structures and blood supply (Bennett 1997, Bennett and Kuzma 1992,



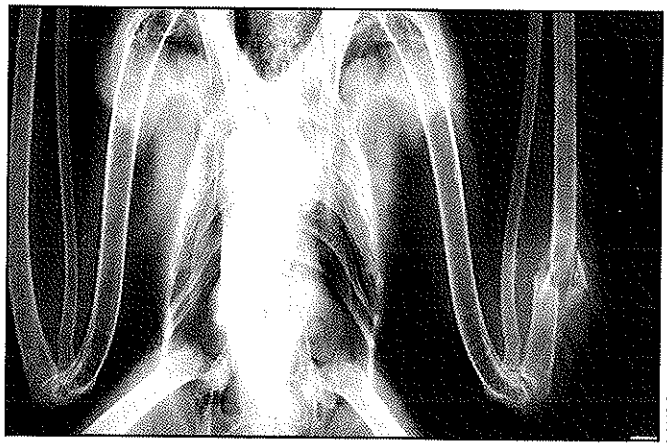
LAUREL A. DEGERNES

FIGURE 2. Radiograph of a barred owl (*Strix varia*) with a slightly comminuted, closed, midshaft fracture of the right femur. An IM pin with an external skeletal fixator tie-in technique was used to stabilize this fracture. This approach provides excellent rotational and longitudinal stability for femur fractures that are extremely difficult to adequately immobilize with bandaging alone.

Hulse and Johnson 1997). These characteristics of avian bones and soft tissue may play a role in determining the best methods for fracture repair in a raptor. Clinical approaches to treatment of fractures vary widely, encompassing both surgical and nonsurgical repair techniques.

Age was hypothesized to be a prognostic factor in rehabilitation outcome, but the data did not support this hypothesis. Because fractures in young mammalian patients typically heal much faster than fractures in adults, it seems logical that young raptors would show similar healing traits (Hulse and Johnson 1997). The structure of bone tissue is similar across animal species, and therefore, generalizations of the mechanisms of bone growth and repair from mammalian to avian species are possible (Tully 2002). Little information is available regarding differential rates of avian bone healing with respect to age. Because birds in their hatch year or younger were classified as "juvenile," birds with a wide range of physical and bone development were included in the same category. Many of the birds included in the juvenile category were fully flighted and may have essentially the same bone structure as an adult. The presumed similarity in bone structure and development in post-fledgling juvenile and adult birds could explain the lack of statistical differences in outcome between the two age groups. Future studies may examine avian bone development to determine when maturation occurs. Furthermore, it may be important to distinguish pre-fledgling from post-fledgling juvenile birds, as their rate of bone healing may differ.

Size of species (<1 kg or ≥1 kg) was not statistically correlated to rehabilitation outcome in this study. It was hypothesized that larger birds should be more releasable since their larger bones should make them better candidates for surgical repair. Some studies have questioned the feasibility of using standard orthopedic hardware in avian patients, due to excessive weight of the hardware (Bennett and Kuzma 1992). In addition, bone plating has traditionally been avoided due to problems with screw-holding strength of thin avian cortices (Bennett and Kuzma 1992). Larger birds, therefore, may be better suited to surgical repair techniques using commonly available orthopedic hardware. In this study, however, birds receiving nonsurgical treatment were more likely to be released, and size of the bird did not affect the success of medical treatment. A study that has more consistent surgical techniques may be able to better examine patient size as it relates to suitability for surgical repair. It would also be important to have just one or two veterinarians performing the surgeries to minimize variability in outcome based upon surgical skills. Future studies could also examine temperament of a bird as it relates to releasability because fractious birds are more likely to re-injure themselves during the rehabilitation process.



LAUREL A. DEGERNES

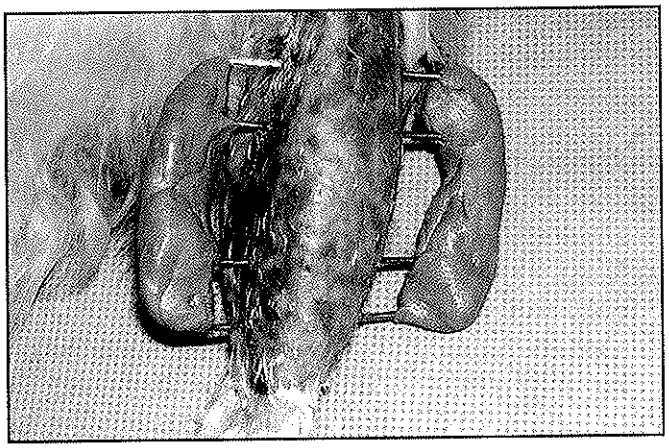
FIGURE 3. Radiograph of a comminuted, closed fracture of the left proximal ulna in a great horned owl (*Bubo virginianus*). The intact radius can provide an "internal splint" to help maintain the length and alignment of the fractured ulna. Although the bone is comminuted, the distance from the elbow joint and intact radius makes this type of fracture amenable to bandaging with a figure-of-eight bandage, with a good prognosis for release to the wild.

Elbow luxations have been reported to occur in 12% of raptor patients, and similar to fractures, luxations are frequently a result of trauma during flight, such as collisions with motor vehicles or powerlines (Martin et al. 1993a). Shoulder, carpus, stifle, and coxofemoral luxations may also occur in avian patients. Often, injuries that involve joints are less likely to return to full function because of reduced range of motion in the affected joint (Martin et al. 1993b). In this study, joint involvement was not shown to be significantly related to release rates. Although a lack of significance was not expected, two factors may have contributed to this result. Only 14 luxations (4.7%) were reported in our study group. Additionally, because joint involvement was classified according to fracture location, as described in the patient record, the information may not have been completely accurate if the descriptions were vague or incomplete. Ideally, patient records would include a detailed description of fracture locations, and patient radiographs would have been evaluated to corroborate the written descriptions in the medical record, however radiographs were not available for this study.

Birds with closed thoracic limb fractures were significantly more likely to be released than were birds with open fractures. Although soft tissue damage does occur with closed fractures, tissue damage is usually less severe than that associated with open fractures (Benyon et al. 1996). Additionally, open fractures may easily become contaminated, leading to osteomyelitis and possibly sepsis. Osteomyelitis is a significant threat to fracture healing since infected bone ends may become necrotic and sclerotic (Bennett and Kuzma 2002). Wound cleansing and debridement, and broad-spectrum antibiotic therapy should be performed for any patient with an open fracture (Bennett and Kuzma 2002). In addition to standard wound management, some studies have begun to examine the use of avian skin grafts and swine small intestinal sub-mucosa to improve soft tissue healing (Stroud et al. 2003).

That nonsurgical treatment appears to yield more releasable birds than surgical treatment was unexpected. These findings may result from several possibilities. First, because this was a retrospective study, we were unable to control the distribution of birds to different treatment groups. Less severely injured birds may be more likely to receive nonsurgical treatment, whereas severely injured birds, with more complex fractures and extensive soft tissue damage, may be more likely to receive surgical therapy. Unfortunately, due to incomplete fracture descriptions in case records, we were unable to determine whether most fractures were simple or comminuted. Secondly, birds that are treated surgically may endure more systemic insults due to long anesthesia times, surgical tissue trauma, or poor reactions to surgical implant techniques or materials. In this way, surgical treatment itself could actually be detrimental to the birds' releasability (Degernes et al. 1993a, Grimm 1993). Additionally, because multiple surgeons performed the surgical repairs, and because information about each surgical procedure is limited, it was not possible to thoroughly evaluate surgical techniques and their relationship to rehabilitation outcomes.

Our results did not demonstrate that surgical repair, and specifically external fixation, improved release rates. Possible explanations could include the small number of birds that received surgical repair and the inconsistency of technique between different veterinarians. Several studies of surgical fracture repair methods have demonstrated that certain surgical techniques achieve stronger and more functional repairs (Degernes et al. 1993a, Redig 2000). There is currently no perfect fixation method, but any method must include consideration of rotational, compressive and bending forces. Intramedullary (IM) pinning is a repair technique that is frequently used by veterinarians treating raptors. IM pins are excellent at



LAUREL A. DEGERNES

FIGURE 4. Bilateral external skeletal fixation device for a midshaft tibiotarsal fracture in a red-tailed hawk (*Buteo jamaicensis*). Epoxy putty was used to stabilize the pins. This type of surgical repair provides excellent stability for tibiotarsal and tarsometatarsal fractures in birds. Patients will usually start weight bearing on the surgically repaired leg within 24 hours.

resisting bending forces in all planes, but IM pins alone do not resist compressive or rotational forces around the long axis of a fracture (Hulse and Johnson, 1997; Redig 2002). External skeletal fixation, another frequently used technique, is good at reducing rotation, but unilateral (Type Ia) external fixators can be subject to bending forces perpendicular to the long axis of the bone (Hulse and Johnson 1997). The external skeletal fixator-IM pin tie-in technique described by Redig has the advantage of resisting bending, compressive and rotational forces, while providing a fixator that can be completely removed after clinical union (Redig 2002). In addition, it does not rely on external coaptation (bandaging) or joint immobilization to achieve fixation, thereby avoiding reduced range of motion and periarticular fibrosis (Redig 2002). When repairing long bone fractures in raptors, IM pins are often insufficient for repair and additional methods, such as external skeletal fixators, must also be used to improve the chance for rapid and complete return to function.

Physical therapy, defined at Carolina Raptor Center as passive range of motion exercise, was positively associated with releasability. This result may reflect population bias due to the retrospective nature of this study. Birds that are more severely injured, or whose conditions are less stable during rehabilitation, may be less likely to receive physical therapy due to concerns about stress tolerance. Birds that appear to rehabilitators to be more releasable (their recovery is progressing more rapidly or their injuries appear to be less severe) may be given more attention by the personnel performing physical therapy. In this way, the population of birds receiving physical therapy could be biased toward less severely injured birds. Despite the possibility of bias, physical therapy has been used with success in humans and domestic animals, and there is evidence that certain modalities can be beneficial in avian species as well (Martin et al. 1993b, Wimsatt et al. 2000).

Although physical therapy has been shown to be beneficial in many mammalian species, there is little information available regarding physical therapy in raptors. Orosz (2002) recommends passive range of motion exercises beginning 1–2 days postsurgery for humeral fractures repaired with ESF-IM tie-in devices and at 10 days postsurgery for other fracture types. Marsolais et al. (2002) showed that passive range of motion activities, massage, and controlled exercise increased peak vertical force and vertical impulse in dogs with cranial cruciate ligament injuries. Similar activities could be beneficial in raptors with bone or joint injuries.

The physical rehabilitation modalities that seem most applicable to wild raptor rehabilitation include passive range of motion, massage, electrical stimulation, and ultrasound. Passive range of motion exercise is employed by rehabilitators at Carolina Raptor Center during bandage changes for wing injuries, and this technique can accelerate a return to normal limb use (Wimsatt et al. 2000). Refracture is a possible complication of this treatment, so care must be taken when performing this therapy (Wimsatt et al. 2000).

Massage is used in domestic animal rehabilitation to enhance circulation, reduce fibrous tissue adhesions, and to increase flexibility (Hourdebaigt and Seymour 1999). Because of this increase in flexibility, massage could be used prior to passive range of motion exercises in raptors. Studies in humans have shown that massage may also be useful in the treatment of acute postoperative pain (Piotrowski et al., 2003). This modality is contraindicated in animals that are (1) febrile, (2) suffering from shock, (3) have an open or healing wound (the animal may be massaged in areas other than the wound), or (4) have acute trauma or an acute sprain (Hourdebaigt and Seymour 1999). Massage therapy could have applications in raptors that are being prepared for exercise in flight cages.

Constant direct electrical current was used in a rough-legged hawk (*Buteo lagopus*) for treatment of a nonunion fracture (Bennett and Kuzma 1992). Although there has been little research in avian species, electrical stimulation has been shown to promote a faster return to function and to increase osteogenesis in other species (Collins et al. 1981, Johnson et al. 1997, Lagey et al. 1986). This modality would require adaptation for use in raptors because most electrodes are sized for humans.

Ultrasound therapy has been widely used in human physical therapy and is gaining more popularity for use in domestic animals (Wimsatt et al. 2000). This modality is associated with increased vascularity and tissue temperature, faster wound healing, accelerated fracture healing, ultrasound-induced cell streaming, and enhanced muscle contractility (Rawool et al. 2003, Wimsatt et al. 2000). Ultrasound therapy is also associated with increased extensibility of collagenous tissue, including tendons, scars, and contracted joint tissues (Wimsatt et al. 2000). Wimsatt et al. (2000) found that extension of the carpus was significantly increased following three treatments of ultrasound therapy after long-term bandaging in 12 pigeons. Ultrasound therapy could complement passive range of motion therapy, possibly accelerating return to normal function (Wimsatt et al. 2000). Although ultrasound therapy is not currently widely available, it could prove economically feasible in large rehabilitation centers because it could accelerate return to normal function, thereby reducing time in rehabilitation.

Conclusion

In summary, it is important to identify factors that may be associated with successful rehabilitation in order to maximize the use of limited resources. Compromised birds with complex fractures may not be good surgical candidates and therefore may not be good rehabilitation candidates. In this 5-year retrospective study of raptors with thoracic and pelvic limb fractures and luxations, birds with thoracic limb injures were significantly more likely to be released if they had closed fractures, were nonsurgically managed, and/or had physical therapy performed. These findings may influence the way raptors with fractures or luxations are treated in the future, as more information about surgical treatment, nonsurgical treatment, and physical therapy modalities becomes available.

Acknowledgements

Special thanks to the staff and volunteers at the Carolina Raptor Center in Charlotte, North Carolina.

Note

This research was performed as an epidemiology study at North Carolina State University.

Literature Cited

Bennett, R. A. 1997. Orthopedic surgery. In *Avian medicine and surgery.*, Edited by R. B. Altman, S. L. Clubb, G. M. Dorrenstein, and K. Quesenberry. Philadelphia: W. B. Saunders.

Bennett, R. A., and A. B. Kuzma. 1992. Fracture management in birds. *J. Zoo. Wildl. Med.* 23: 5–38.

Benyon, P. H., N. A. Forbes, and N. H. Harcourt-Brown (eds.). 1996. *Manual of raptors, pigeons and waterfowl.* Ames: Iowa State University Press.

Collins, P. C., D. C. Paterson, B. Vernon-Roberts, and D. Pfeiffer. 1981. Bone formation and impedence of electrical current flow. *Clin. Orthop.* 155: 196–210.

Cooper, J. E. 2002. *Birds of prey: Health and disease.* 2nd ed. Ames: Blackwell Science Ltd.

Degernes, L. A., P. J. Lind, and P. T. Redig. 1993a. Raptor orthopedics using methyl methacrylate and polypropylene rods. In *Raptor biomedicine.* Edited by P. T. Redig, J. E. Cooper, J. D. Remple, and D. B. Hunter. Minneapolis: University of Minnesota.

Degernes, L. A., and P. T. Redig. 1993b. Soft-tissue wound management in avian patients. In *Raptor biomedicine.* Edited by P. T. Redig, J. E. Cooper, J. D. Remple, and D. B. Hunter. Minneapolis: University of Minnesota.

Graph Pad Quick Calcs. 2004. http://graphpad.com/quickcalcs/contingency1.cfm.

Grimm, F. 1993. Fracture healing in predatory birds, with special consideration given to a modified external fixator. In *Raptor biomedicine.* Edited by P. T. Redig, J. E. Cooper, J. D. Remple, and D. B. Hunter. Minneapolis: University of Minnesota.

Heidenreich, M. 1997. *Birds of prey: Medicine and management.* Malden, Mass.: Blackwell Science Ltd.

Hourdebaigt, J. P., and S. L. Seymour. 1999. *Canine massage: A practical guide.* New York: Howell Book House.

Howard, D. J., and P. T. Redig. 1994. Orthopedics of the wing. *Seminars in Avian and Exotic Pet Med.* 3: 51–62.

Hulse, D. A., and A. L. Johnson. 1997. Fundamentals of orthopedic surgery and fracture management. In *Small animal surgery.* Edited by T. W. Fossum. St. Louis: Mosby, Inc.

Johnson, J. M., A. L. Johnson, G. J. Pijanowski, S. K. Kneller, D. J. Schaeffer, J. A. Eu, C. W. Smith, and K. S. Swan. 1997. Rehabilitation of dogs with surgically treated cranial cruciate ligament-deficient stifles

by use of electrical stimulation of muscles. *Am. J. Vet. Res.* 58: 1473–78.

Lagey, C. L., J. M. Roelofs, L. W. Janssen, M. Breedijk, R. H. Lentferink, W. J. Visser, L. M. Akkermans, P. Wittebol, and W. Renooij. 1986. Electrical stimulation of bone growth with direct current. *Clin. Orthop.* 204: 303–12.

Marsolais, G. S., G. Dvorak, and M. G. Conzemius. 2002. Effects of postoperative rehabilitation on limb function after cranial cruciate ligament repair in dogs. *J. Am. Vet. Med. Assoc.* 220: 1325–30.

Martin, H. D., K. A. Bruecker, D. D. Herrisk, and J. Scherpelz. 1993a. Elbow luxations in raptors: A review of eight cases. In *Raptor biomedicine.* Edited by P. T. Redig, J. E. Cooper, J. D. Remple, and D. B. Hunter. Minneapolis: University of Minnesota Press.

Martin, H. D., C. Ringdahl, and J. Scherpelz. 1993b. Physical therapy for specific injuries in raptors. In *Raptor biomedicine.* Edited by P. T. Redig, J. E. Cooper, J. D. Remple, and D. B. Hunter. Minneapolis: University of Minnesota Press.

Orosz, S. E. 2002. Clinical considerations of the thoracic limb. *Vet. Clinics of N. Am.: Exotic Animal Practice* 5(1): 31–48.

Piermattei, D. L., and G. L. Flo. 1997. *Handbook of small animal orthopedics and fracture repair.* 3rd ed. Philadelphia: W. B. Saunders.

Piotrowski, M. M., C. Paterson, A. Mitchinson, H. M. Kim, M. Kirsh, and D. B. Hinshaw. 2003. Massage as adjuvant therapy in the management of acute postoperative pain: A preliminary study. *J. Am. Coll. Surg.* 197: 1037–46.

Rawool, N. M., B. B. Goldberg, F. Forsberg, A. A. Winder, and E. Hume. 2003. Power doppler assessment of vascular changes during fracture treatment with low-intensity ultrasound. *J. Ultrasound Med.* 22: 145–53.

Redig, P. T. 2000. The use of an external skeletal fixator-intramedullary pin tie-in (ESF-IM fixator) for treatment of longbone fractures in raptors. In *Raptor Biomedicine III.* Edited by J. T. Lumeij, J. D. Remple, P. T. Redig, M. Lierz, and J. E. Cooper. Lake Worth, Fla.: Zoological Education Network, Inc.

Stroud, P. K., T. Amalsadvala, and S. F. Swaim. 2003. The use of skin flaps and grafts for wound management in raptors. *J. Avian Med. Surg.* 17: 78–85.

Tully, T. N. 2002. Basic avian bone growth and healing. *Vet. Clinics of N. Am.: Exotic Animal Practice* 5(1): 23–30.

Wimsatt, J., P. Dressen, C. Dennison, and A. S. Turner. 2000. Ultrasound therapy for the prevention and correction of contractures and bone mineral loss associated with wing bandaging in the domestic pigeon. *J. Zoo. Wildl. Med.* 31: 190–95.

To Contact the Authors

Marcy Souza, DVM
Avian & Exotic Resident
University of Tennessee
College of Veterinary Medicine
Knoxville, TN 37996
USA
Tel: 865/974-8387
E-mail: msouza@utk.ed

Erica Fields, DVM
Lilburn Animal Hospital
4985 Lawrenceville Highway
Lilburn, GA 30047
USA
Tel: 770/921-6766
E-mail: elfields1@yahoo.com

Laurel A. Degernes, DVM, DABVP
North Carolina State University
College of Veterinary Medicine
4700 Hillsborough Street
Raleigh, NC 27606
USA

Insects and Related Arthropods: A Nutritional Primer for Rehabilitators

by Mark Finke and Diane Winn

Introduction: Definitions and Taxonomy

Arthropods are the largest group of animals on earth, comprising insects as well as a number of other closely related species. Some of the other well-known arthropods include scorpions, spiders, ticks, and mites (Arachnida); pillsbugs, sowbugs, crayfish, crabs, and shrimp (Crustcea); millipedes (Diplopoda); and centipedes (Chilopoda). Insects are the arthropods familiar to most people; they are distinguished from other arthropods by having a body with three distinct regions (head, thorax, and abdomen); having only one pair of antennae; and, of course, having three pairs of legs. Although many animals are termed insectivores, most of them prey on other arthropods as well. As will be discussed below, some of these arthropods (e.g., isopods, millipedes) are likely an important source of select nutrients that may not be obtained in sufficient quantities from most insect species.

Generally, insects fall into two fairly distinct groups: those with simple metamorphosis and those with complete metamorphosis. In simple metamorphosis, the young (called *nymphs*) are, in most cases, similar to adults, often sharing similar food and habits. An example familiar to most rehabilitators is crickets, whose young are essentially wingless, miniature versions of the adults. By contrast, in complete metamorphosis, the young (called *larvae*) do not resemble the adults, have completely different habits, and go through an intermediate stage (*pupae*) from which they metamorphosize into an adult. Certainly, the most striking example of complete metamorphosis is seen in Lepidoptera, where the caterpillar bears absolutely no resemblance to the adult moth or butterfly. An example familiar to rehabilitators is mealworms, which are the larvae of a species of grain beetle.

More than 800,000 species of insects are found worldwide; they are grouped into 25 major orders (Triplehorn and Johnson 2005). While an in-depth review of insect taxonomy is not required, some of the major orders of insects likely used as food by rehabilitators who gather wild insects are shown below, ranked in descending order, according to the estimated number of species found in North America north of Mexico (Triplehorn and Johnson 2005).

Order	Common Names
Coleoptera	Beetles
Hymenoptera	Bees, wasps, and ants
Diptera	Flies
Lepidoptera	Moths and butterflies
Hemiptera	Bugs, planthoppers, and cicadas
Orthoptera	Grasshoppers, crickets, cockroaches, mantises, and walking sticks
Odonata	Dragonflies and damselflies
Isoptera	Termites

ABSTRACT: Insects are an important food source for numerous animals. Although insects are a good source of many nutrients, they are deficient in several others; therefore, providing adequate nutrition for insectivores in rehabilitation can be challenging. This paper presents an overview of insects' nutrient composition. The authors also analyze and discuss various strategies for supplementing cultured insects and creating insect-substitute foodstuffs. Guidelines for evaluating insectivore diets are recommended.

KEY WORDS: insects, arthropods, nutrition, calcium, vitamin A, insectivore

MARK FINKE has a Ph.D. from the University of Wisconsin with dual majors in nutritional sciences and entomology. He has been working in the area of comparative animal nutrition for more than 20 years and has published more than 20 peer-reviewed articles on the subject of nutrition in insects, birds, and mammals. He is currently president of his own consulting company and supports several rehabilitation groups by helping them develop diets for specific species and situations.

DIANE WINN, PH.D. is a Professor of Psychology at Colby College in Waterville, Maine, where her courses include Research Methods and Statistics. She has published several articles on various aspects of wild bird rehabilitation, including euthanasia, songbird nestling diets, and caging. She and Marc Payne are the cofounders of Avian Haven, a rehabilitation practice of around 900 birds per year, based in Freedom, Maine.

J. Wildlife Rehab. 27(3–4):14–27
© 2004 International Wildlife Rehabilitation Council

In addition to insects, other arthropods that might be used in a feeding program include spiders, pillbugs, sowbugs, millipedes, and earthworms. Pillbugs, sowbugs, and millipedes have a calcified exoskeleton and serve as an excellent calcium source for many species of insectivorous birds, especially during reproduction. Although earthworms are not arthropods (they are annelids), they are included here because of their use by many rehabilitators.

Nutritional Composition of Insects

Because of the large number of insect species and the diversity of environments they inhabit, insects are an extremely important food source for many animals (including, in some parts of the world, humans). Insectivorous wild animals kept in captivity (e.g., in zoo or rehabilitation settings) are often fed insects that are cultured or collected from the wild. The insect species most commonly cultured for food include house crickets (*Acheta domesticus*), waxworms (larvae of the wax moth—*Galleria mellonella*), mealworms[1] and superworms (larvae from two species of beetles—*Tenebrio molitor* and *Zophas mori*), silkworms (larvae of the silk moth—*Bombyx mori*) and fruit flies (*Drosophila melanogaster*). Earthworms (*Lumbricus terrestris*) are also commonly gathered for food. Nutritional information for these species and others is summarized in Tables 1–3 (original sources are Barker et al. 1998, Bernard and Allen 1997, Finke 2002, Finke 2005, Pennino et al. 1991). In order to facilitate comparisons between different papers, all these data have been recalculated from the original data to express the information on an as-is rather than dry-matter basis, because most insects are fed live (with the moisture they naturally contain). The life stage and any additional information on how the insect was reared or the food used are also shown

TABLE 1. MOISTURE, PROTEIN, FAT, FIBER, AND ASH CONTENT OF SELECTED INSECT SPECIES AND EARTHWORMS

Species	Comments	Moisture (%)	Crude Protein[1] (%)	Crude Fat (%)	Fiber (%)	Ash (%)	Energy (cal/g)
Lepidoptera							
Bombyx mori	Larvae fed artificial diet	82.7	9.3	1.4	1.1[a]	1.1	0.67
Galleria mellonella	Pupae and larvae	62.1	14.8	20.1	2.5[b]	0.9	2.40
Coleoptera							
Tenebrio molitor	Adults	62.6	24.2	6.3	6.8[b]	1.2	1.54
Tenebrio molitor	Larvae	62.4	19.2	12.4	2.3[b]	1.2	1.98
Tenebrio molitor	Giant larvae	59.5	19.0	18.7	2.7[b]	1.2	2.44
Zophobas morio	Larvae	57.5	19.1	17.6	2.7[b]	1.3	2.42
Orthoptera							
Acheta domesticus	Adults	70.5	19.3	5.7	3.1[b]	1.4	1.29
Acheta domesticus	Nymphs	72.0	16.9	3.3	2.2[b]	1.1	1.15
Blatella germanica	Not reported	61.3	20.9	11.0	3.6[a]	1.3	1.90
Hymenoptera							
Aphis melifera	Brood (larvae & pupae)	76.8	9.4	4.7	0.3[a]	0.8	1.12
Diptera							
Drosophila melanagaster	Adults	68.8	19.6	4.8	8.0[b]	1.5	1.22
Drosophila melanagaster	Larvae	78.8	8.5	6.2	2.1[a]	1.3	1.02
Earthworms							
Lumbricus terresstris		78.5	10.9	2.7	2.3[b]	4.8	0.71

[1] – Crude protein measured as nitrogen x 6.25

[a] – Fiber measured as acid detergent fiber

[b] – Fiber measured as crude fiber



BOB BROOKS

FIGURE 1. Syringe-feeding FoNS© to a Northern flicker (Colaptes auratus) hatchling at Avian Haven (Freedom, Maine).

in Table 1. More comprehensive reviews of the nutrient content of a wider range of insects are available (Bukkens 1997, Finke 2004).

Moisture and Other Macronutrients

Analyses of insects for moisture, protein, fat, ash, and fiber are presented in Table 1. Whole insects generally contain 55–85% moisture. After water, the nutrient in highest concentration is usually protein, which is not surprising given the protein-rich exoskeleton of insects. The protein content of whole insects shown in Table 1 ranges from a low of 8.5% for fruit fly larvae to almost 25% for adult mealworms (beetles). In addition to protein, fat is a major component of most insects, with whole insects ranging from a low of 1.4% for silkworms to a high of 20.1% for waxworms. In several instances, insects contain more fat than protein. Although limited data are available, for house crickets and other Orthoptera, female insects contain more fat than males (Finke 1984, Finke unpublished data). Most insects contain only small amounts of ash (which represents minerals) because they lack the internal calcified skeleton found in vertebrates.

Protein is composed of amino acids, and there are a number of published reports on the amino acid composition of insects. These data show that insects are a good source of protein and provide sufficient quantities of most of the essential amino acids (Finke 2002).

There are few reports on the fatty acid composition of most commercially-raised insect species (Finke 2002). Importantly, all of the insects tested contained the essential fatty acids linoleic acid (18:2) and linolenic acid (18:3). Because of their high fat content, mealworms are an especially rich source of linoleic acid.

Soft-bodied insects like silkworms usually contain less fiber than those with a hard exoskeleton like beetles. It has been suggested that insects that have a hard exoskeleton and that are high in fiber are also high in chitin, but

TABLE 2. MINERAL CONTENT OF SELECTED INSECT SPECIES AND EARTHWORMS

	Ca (%)	P (%)	Mg (%)	K (%)	Na (%)	Fe (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Mn (mg/kg)
Lepidoptera									
Bombyx mori (larvae)	0.02	0.24	0.05	0.32	0.05	16.5	30.7	3.6	4.3
Galleria mellonella (larvae & pupae)	0.03	0.28	0.04	0.26	0.03	12.5	28.0	2.9	2.0
Coleoptera									
Tenebrio molitor (adults)	0.03	0.25	0.05	0.29	0.04	25.3	34.5	6.2	2.6
Tenebrio molitor (larvae)	0.03	0.31	0.07	0.31	0.05	21.2	40.0	6.3	3.3
Tenebrio molitor (giant larvae)	0.03	0.32	0.07	0.31	0.05	20.5	39.1	6.3	3.5
Zophobas morio (larvae)	0.04	0.30	0.07	0.32	0.05	19.1	34.2	4.8	2.5
Orthoptera									
Acheta domesticus (adults)	0.05	0.27	0.03	0.38	0.14	22.5	58.4	5.7	9.7
Acheta domesticus (nymphs)	0.03	0.26	0.03	0.35	0.14	22.9	59.1	5.2	10.8
Blatella germanica	0.08	0.19	0.03	0.34	0.10	34.8	22.1	5.4	1.9
Hymenoptera									
Aphis melifera (larvae & pupae)	0.01	0.18	0.02	0.27	0.01	12.9	16.0	4.0	0.6
Diptera									
Drosophila melanagaster (adults)	0.04	0.34	0.03	0.31	0.12	28.8	49.5	4.0	8.4
Drosophila melanagaster (larvae)	0.13	0.49	0.40	0.27	0.02	49.8	37.3	3.4	23.3
Earthworms									
Lumbricus terresstris	0.23	0.19	0.04	0.10	0.05	1277.1	48.2	3.9	27.0

we now know that the hard exoskeleton of most insects is due primarily to sclerotized protein rather than chitin. So although insects that are high in fiber may mistakenly be thought of as being high in chitin, the limited data available suggest that chitin is only a minor component of most insect species (Kramer et al. 1995). Fiber is generally thought of as beneficial for most species; however, in large amounts, it may adversely affect the growth of young animals. Therefore, for rapidly growing young animals or adults with extremely high energy requirements (e.g., mammals during lactation), insects such as adult mealworms (beetles), adult crickets, and cockroaches should probably not be used as a sole source of food. For all other insectivorous animals, there is no evidence that mixtures of a variety of insect species, including those containing high amounts of fiber, are harmful.

Minerals and Vitamins

Mineral analyses of insects are shown in Table 2. As expected, insects contain little calcium and high levels of phosphorus, resulting in a calcium:phosphorus of < 1. Some arthropods, including a few species of insects, are exceptions to this rule, however. For example, millipedes and isopods contain from 7–20% calcium on a dry-weight basis (Gist and Crossley 1974, Graveland and Van Gijzen 1994, Reichle et al. 1969); stoneflies contain, on average, 1.15% calcium on a dry-weight basis (Studier and Sevick 1992). Earthworms from soil in chalky areas have significant amounts of calcium in their guts and/or adhering to their body tissue and provide sufficient calcium for nestling blackbirds (*Turdus merula*) and thrushes (*Turdus philomelos*) (Bilby and Widdowson 1971).

In the wild, insectivorous animals seek out either prey unusually rich in calcium or other sources of calcium, especially while breeding. For example, collared and pied flycatchers (*Ficedula albicollis* and *F. hypoleuca*) preferentially feed on calcium-rich isopods during reproduction (Bureš and Weidinger 2003); isopods were also found to be unusually prominent in the diet of nestling European starlings (*Sturnus vulgaris*) (Moore 1986). Other means of obtaining extra calcium include ingestion of eggshells, snail and clam shells, calcareous grit, fish bones and scales, fragments of mammal bones (gleaned

TABLE 3. SELECTED VITAMIN CONTENT OF VARIOUS INSECT SPECIES

	Vitamin A (IU/kg)	Vitamin E (IU/kg)	Thiamin (mg/kg)	Riboflavin (mg/kg)	Pyridoxine (mg/kg)
Lepidoptera					
Bombyx mori (larvae)	1580	8.9	3.3	9.4	1.6
Galleria mellonella (larvae)	57	103.6	2.3	7.3	1.3
Coleoptera					
Tenebrio molitor (adults)	<1000	<5.0	1.0	8.5	8.1
Tenebrio molitor (larvae)	301	11.1	2.4	8.1	8.1
Tenebrio molitor (giant larvae)	67	6.3	1.2	16.1	5.8
Zophobas morio (larvae)	418	10.7	0.6	7.5	3.2
Orthoptera					
Acheta domesticus (adults)	217	20.7	0.4	34.1	2.3
Acheta domesticus (nymphs)	156	16.6	0.2	9.5	1.7
Hymenoptera					
Aphis melifera (larvae)	<1000	<5.0	4.1	9.1	1.2
Diptera					
Drosophila melanagaster (adults)	ND	7.6	NA	NA	NA

ND – Not detected; NA – Not available

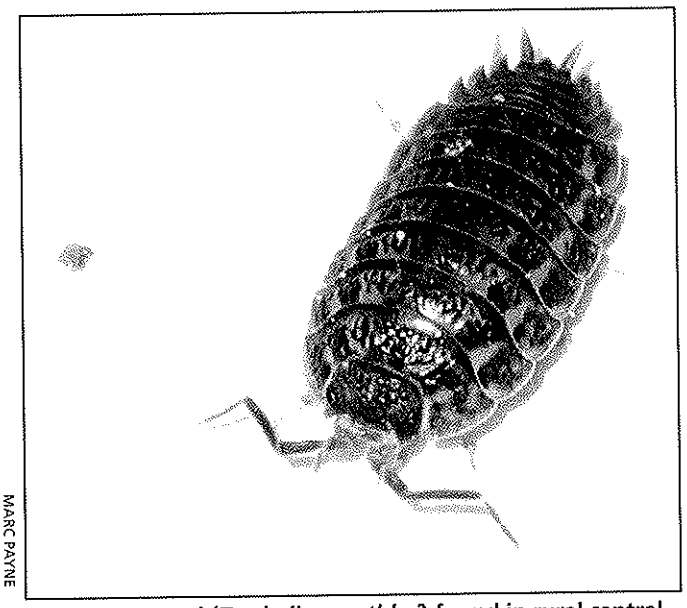
from raptor pellets), crawfish exoskeletons, limestone gravel, or mortar (see, e.g., Dhondt and Hochachka 2001, Graveland 1996, Graveland and Van Gijzen 1994, Poulin and Brigham 2001, St. Louis and Breebaart 1991, Tordoff 2001). Bats have recently been reported to drink at mineral-rich waterholes formed by seepage through limestone (Adams et al. 2003).

Most insects appear to be good sources of magnesium, sodium, and potassium as well as the trace minerals iron, zinc, copper, and manganese. Mineral composition in general probably largely reflects the food sources of the insect, both that present in the gastrointestinal tract and that incorporated into the insect's body as a result of the food it consumed. Studies of wild insects show seasonal variation as well as variations between different populations of the same species living in the same general area (Graveland and Van Gijzen 1994, Reichle et al. 1969, Studier et al. 1991).

Only limited data are available for vitamin analyses of insects; selected vitamins are shown in Table 3. B-vitamin analysis of insects is quite sparse, although most insects tested contained substantial quantities of most of the B-vitamins and choline (Finke 2002). However, a number of insects appear to contain low levels of thiamin.

The vitamin A content of insects is not well known. There are few analyses of cultured insects (and even fewer analyses of wild-caught insects), and most indicate low levels of vitamin A. An exception is silkworm larvae, which appear to contain significant quantities of preformed vitamin A (retinal). Although whole-body levels of retinoids are low in most insect species, the large compound eyes found in some species of adult insects are rich in vitamin A (Smith and Goldsmith 1990). Therefore, much like the case with calcium, wild insectivores feeding on a variety of species and developmental stages presumably consume adequate amounts of vitamin A. It is clear, however, that diets based on cultured mealworms, superworms, waxworms, and crickets are likely vitamin A deficient for most species of insectivores (Ferguson et al. 1996, Miller et al. 2001, Pennino et al. 1991). The reasons for the low vitamin A content of these species are unknown but may be related to diet carotenoid content or the fact that most of these species are fed in the larval stage, which lacks the vitamin A–rich compound eyes found on adult insects.

Although commercially raised insects appear to contain little or no β-carotene, most wild-caught insects contain a variety of natural carotenoids, which they accumulate from their food. Many vertebrates can



MARC PAYNE

FIGURE 2. Isopod (*Trachelipus rathkei*) found in rural central Maine.

convert some of these carotenoids to retinal/vitamin A, although the efficiencies vary from 0–100%, and very few species have been studied in detail. At this time, it is unknown whether insectivorous birds and mammals have the capacity to convert β-carotene to vitamin A.

Feeding Captive Insectivores

Providing adequate nutrition for insectivores in rehabilitation can be challenging. Generally, two strategies have been employed, either singly or (perhaps more commonly) in combination: feeding cultured insects along with a nutrient supplement, or feeding products primarily composed of noninsect protein sources.

Insect-Based Diets

As expected, insects should be considered a highly nutritious diet for most insectivores because they contain presumably adequate levels of proteins, amino acids, fats, and most vitamins and minerals. However, insectivores in the wild consume a variety of species of arthropods, which, when consumed in the right proportions, provides a complete and balanced diet. In contrast, insectivores fed in captivity are likely fed only two or three species of insects (typically, crickets, mealworms, and waxworms) and so, when using a diet of cultured insects, several nutrients are of special concern. Rehabilitators using insect-based diets should be primarily attentive to calcium, vitamin A, and, if adequate sunlight or full-spectrum lighting is unavailable, vitamin D.

Supplementing cultured insects with selected nutrients is expensive and time-consuming; presumably, however, it most closely matches the natural diet of an insectivore. Supplementation of insects is typically done in one of three ways (although, as discussed below, there are additional strategies as well).

The first method is dusting, where dusts (typically composed primarily of calcium carbonate) are used to coat the insect just prior to it being used as food. While effective, this method can provide variable results because the amount that adheres to the insect depends on the characteristics of the powder, the insect species involved, and the ability of the insect to groom itself and remove the added supplement (Trusk and Crissey 1987, Winn et al. 2003). To avoid the excessive amount that may cling to some types of insects (Winn et al. 2003), a given mass of insects can be dusted with a measured amount of calcium carbonate; a powdered vitamin mix can be added, if desired. Some products advertised for reptile keepers contain both calcium and vitamins (e.g., T-Rex® 2.0 Calcium/No Phosphorus Supplement).

A second method is the use of "gut-loading" diets, which increase the insects' nutrient content due to the food retained in their gastrointestinal tract (Allen and Oftedal 1989). The calcium contents of waxworms, house crickets, mealworms, and silkworms can all be increased 5–20 fold by feeding them a high-calcium diet (Strzelewicz et al. 1985, Hunt et al. 2001, Finke 2003). Other nutrients (e.g., vitamin A) can also be added using this method (Ferguson et al. 1996, Finke 2003). The calcium from gut-loaded insects and earthworms has been shown to be readily available to growing chickens, geckos, and nestling passerines (Allen 1997, Bilby and Widdowson 1971, Klasing et al. 2000). Vitamins A and D in gut-loaded crickets have been shown to be well-utilized by chameleons (Ferguson et al. 1996). Gut-loaded insects have been used successfully by zoos across the world for more than 20 years to feed their insectivorous species; this strategy is also recommended by some bat rehabilitators (e.g. Barnard in prep., Lollar 2005).

Of note is the fact that gut-loading diets are usually fed 24–72 hours prior to using the insect as food, because high-calcium diets are not suitable for growth, reproduction, or long-term (i.e., more than 7–10 days) maintenance of insects (insect viability loss attributable to high-calcium diets has been noted, e.g., by Allen and Oftedal 1989 and Klasing et al. 2000). When these diets are used to gut-load insects, a variety of factors (diet palatability, diet particle size, and the size and species of insect) can affect the results (Anderson 2000, Hunt et al. 2001, Finke 2003, Winn et al. 2003), so some care is required when choosing a gut-loading diet. Further, when seven commercially available gut-loading products


MARK FINKE

FIGURE 3. Cactus wren (*Campylorhynchus brunneicapillus*) with caterpillar for nearby nestlings.

(calcium-fortified, high-moisture cricket waters; high-moisture "gut-loading" diets; and dry "gut-loading" diets) sold in pet supply stores were evaluated for their efficacy, only one significantly increased cricket calcium content (Finke et al. 2004, Finke et al. 2005). For this reason, we suggest that anyone considering gut-loaded mealworms or crickets use a method for which there are demonstrated results.

A third method of supplementing insects is to dip them in calcium gluconate solution (Winn et al. 2003). Although this method adds an appropriate amount of calcium to the insects, veterinary calcium gluconate solutions contain boric acid as a solubilizing agent. Although labeled "calcium gluconate 23% solution," these products are more properly called calcium borogluconate. They are typically prepared from approximately 5 parts calcium gluconate to 1 part boric acid and contains roughly 2.5 g calcium to 1 g boron (Dunham pers. comm., Lyons and Spann 1985, OMRI 2000). Although using insects dipped in calcium borogluconate as a sole source of food would result in boron consumption exceeding long-term safe levels (as estimated by EPA 2004, Rossi et al. 1993, Sander et al. 1991), feeding insects dipped in calcium borogluconate as a minor component of the total diet should be safe, especially over short durations.

Kyle and Kyle (2004) use a combination of techniques for raising chimney swifts (*Chaetura pelagica*). Their method specifies that small amounts of vitamin and mineral mixes are to be added to water as a soaking solution for the mealworms, to which, subsequently, are added yeast and a mixture of yogurt and Nutri-Cal®. No analysis of the final product has been published, but we have tried to approximate one[2] (see Table 4 below).

Bat rehabilitation literature offers another variation: blending insects with other ingredients to make a syringe-fed mixture. One example is French's blend of calcium-fortified mealworms, veal and banana baby food, egg, vitamin and mineral mixes (Lollar and Schmidt-French 2002). We have also attempted an approximate analysis of this mixture (shown in Table 4).

The possibility of a behavioral regulatory mechanism for calcium has been discussed at length by Tordoff (2001), who cites several indications of calcium appetite in a variety of animals, including wild birds. Chickens fed a calcium-deficient diet show a preference for calcium supplements when they are made available (Hughes and Wood-Gush 1971). Meadow pipits (*Anthus pratensis*) and water pipits (*A. spinoletta*) bring more human-provided calcium supplements to their nestlings in areas where calcium availability is low than in calcium-abundant areas (Bureš and Weidinger 2001). Graveland and

Berends (1997) created a calcium deficiency in egg-laying captive great tits (*Parus major*); the birds' behavior demonstrated a search for calcium. Results of Cornell Laboratory of Ornithology's Birds and Calcium Project indicated that birds of a number of species increased their consumption of extraneous calcium during breeding season; even aerial foragers such as swallows would take chicken eggshell fragments from the ground (Dhondt and Hochachka 2001).

On the basis of these findings, an additional but untested strategy for calcium supplementation might be to allow self-feeding birds to regulate their own intake of calcium from extraneous sources such as crushed eggshells and mollusk shells. Alternatively, access could be provided to high-calcium arthropods like isopods and millipedes. Graveland and Van Gijzen (1994) estimated that breeding female great tits (*Parus major*) could meet their calcium needs if about 5–6% of the dry matter in their diet were woodlice or millipedes, with 3–4% sufficient for nestlings. Our theoretical calculations based on the calcium content of both isopods and insects support this conclusion. Isopods can readily be collected from the environment, and methods for rearing them have been established (Caseiro et al. 2000).

Another method used by some rehabilitators (various pers. comm.) is to give insectivorous animals a daily calcium supplement independently along with insects. The calcium requirement for most species of wild birds is not well known; however, approximate values for nestling blackbirds and thrushes can be estimated from the data of Bilby and Widdowson (1971). Their data showed that nestling blackbirds gained an average of 24.3 mg calcium/day during the first 6 days of life and 33 mg calcium/day from day 6 to fledgling (at day 13, when they weighed 71 g). Similarly, nestling thrushes gained an average of only 11.4 mg calcium/day during the first 6 days of life and 28 mg calcium from day 6 to fledgling (at day 12, when they weighed 52 g). Given that the typical human calcium supplement contains 200–600 mg calcium, the ability to accurately fractionate supplements of this size into doses as small as 10–30 mg calcium seems unlikely. Because excessive calcium intake can cause several problems, including visceral gout, kidney nephrosis, and secondary deficiencies of several other minerals (see, e.g., Klasing 1998), we do not recommend calcium supplementation in this manner for small animals such as growing passerines.

Insect-Substitute Diets

In addition to supplementing insects with specific nutrients or ingredients, another method is to use diets that attempt to approximate an insect's nutrient composition. These diets include both homemade diets and commercially prepared products. For example FoNS© (Formula for Nestling Songbirds), originally using a base of high-protein, high-fat dry kitten food augmented with sources of animal protein (egg white and chicken baby food), has been successfully used as a hand-rearing formula for a wide variety of passerine and other insectivorous nestlings (Winn 2002); however, due to changes in the commercial dry kitten food originally used as a base, we now suggest using ZuPreem® Premium Ferret Diet in place of Eukanuba® Kitten Chicken and Rice Formula for FoNS© diet (see Winn and Finke 2004 for the complete revised recipe; page 28). The commercial diets include Mazuri® Insectivore Diet ("complete and balanced for insectivores") and Insect Patee by Orlux ("a complete diet for all insect-eating birds"). In addition to the two products mentioned, other commercial products are available, but because the manufacturers do not provide enough nutritional data to make informed comparisons, they cannot be evaluated.

A combination of the two main types of strategies is to feed insects in conjunction with a formula that contains enough extra calcium to balance the lack of calcium in those insects, such as is recommended for MacDiet© (MacLeod and Perlman 2001, 2003). While one may regard the difference between this approach and that of French (Lollar and Schmidt-French 2002) or Kyle and Kyle (2004) as arbitrary, the MacDiet© is by weight mostly a home-made diet with insects added. In contrast, the Kyles' and French diets are by weight mostly mealworms with other ingredients added.

Comparative Analyses and Evaluation

Each of these strategies has its advantages and disadvantages; unfortunately, to date, no comparisons of the performance of animals fed these diets have been published. Insect-based diets require more time and higher costs, but in theory, these diets most closely resemble the diet in the wild. In contrast, non–insect-based diets are easy to prepare (or purchase) in large quantities and so lend themselves well to high-volume rehabilitation settings. Unfortunately, because the nutrient requirements of most insectivores are not known, the nutrient profiles of any of these strategies/diets can only be compared to what is known from other species or to estimates based on what the animal consumes in the wild (although, in most cases, detailed nutrient intakes of these species in the wild is not well known either). Additionally one needs to remember that the natural diet varies according to local prey availability; further, it is likely not the

TABLE 4. CALCULATED NUTRIENT CONTENT OF SELECTED DIETS USED FOR INSECTIVORES (DRY MATTER BASIS)

	Gut-loaded Mealworm[a]	Gut-loaded Crickets[b]	Kyle & Kyle[c]	French[d]	MacDiet®[e]	MacDiet® + Insects[f]	FoNS®[g]	Mazuri® Insectivore Diet[h]	Orlux Insect Patee[h]
Protein (%)	51.0	66.6	41.5	48.2	46.1	46.5	49.9	31.7	24.4
Fat (%)	30.1	22.2	33.4	30.0	25.8	29.5	22.8	13.3	18.9
Crude Fiber (%)	4.9	10.2	2.5	3.1	2.3	1.6	1.5	10.7	3.9
Ash (%)	5.3	3.6	2.4	3.0	8.2	5.8	8.8	7.2	12.2
Carbohydrate (%)	8.7	0.0	22.6	10.3	17.6	16.6	17.0	37.1	40.6
Energy (kcal/g)	5.10	4.66	5.37	5.04	4.87	5.18	4.73	3.95	4.30
Calcium (%)	0.89	1.16	0.25	0.53	2.17	1.54	2.01	1.50	1.40
Phosphorus (%)	0.75	0.96	0.68	0.89	0.77	0.75	1.00	1.09	0.72
Iron (mg/kg)	132	63	47	79	183	145	267	367	NA
Zinc (mg/kg)	120	218	111	114	135	134	165	122	NA
Vitamin A (IU/kg)	6560	3630	27,950	13,820	12,390	8700	19,970	16,670	13,890
Vitamin D (IU/kg)	657	313	1459	1676	1127	791	1487	4000	1555

NA–Not available.

[a] – Most data provided by Barnard (in prep.). Vitamin A and D levels calculated from the diet of Barnard using the equations from Finke 2003.

[b] – Based on the data of Finke 2002, 2003 for adult crickets. Cricket gut-loading diet consists of 83% Timberline Cricket Power Food and 17% T-Rex 2.0 Calcium/No Phosphorus Supplement.

[c] – Formula from Kyle & Kyle 2004. Data for mealworms from Finke 2002. Other data sources are as follows: Avi-Con—Lloyd Inc; Avimin—Lambert Kay; NutriCal—Evsco Pharmaceuticals; SuperRich Yeast—Twin Laboratories Inc.; Yogurt—USDA www.nal.usda.gov/fnic/foodcomp/Data/.

[d] – Formula from Lollar and Schmidt-French 2002. Mealworm composition was calculated based on French's gut-loading diet (Lollar and Schmidt-French 2002) using equations from Finke 2003. Data for baby foods and egg were obtained from the USDA. Data for vitamin and mineral mixes were taken from Lollar and Schmidt-French 2002.

[e] – Formula from MacLeod and Perlman 2003 (without live insects). Cat foods used were Iams® Kitten Food (dry) and Iams® Kitten Formula (canned). Data provided by the Iams Company. Freeze-dried insects assumed to be bloodworms (Finke unpublished data). Data for yogurt, egg whites, cod liver oil, and gelatin were obtained from the USDA.

[f] – Combination as specified in MacLeod and Perlman 2003: 2 parts formula to 1 part live insects (in proportions of 10 mealworms:5 waxworms:3 crickets). Insect nutrient data taken from Finke 2002. No adjustments for "chitinous" portions were made.

[g] – Original formula from Winn 2002, with modifications as described in Winn and Finke 2004. The data sources are as follows: ZuPreem Premium Ferret Diet—ZuPreem; chicken baby food—Beech Nut; dried egg whites and yogurt—USDA; Avi-Era™—Lafeber Company.

[h] – Data obtained from the company's website.

perfect diet, but one that allows the species (as a whole) to survive and reproduce. As such, it may not be ideal for every situation, but because it does allow for survival and reproduction, when available, the wild diet should be used as a starting point.

That said, we have attempted to calculate the nutrient profile of some of the various dietary options available for rehabilitators, as shown in Table 4. In each case, the published recipes were followed and the nutrient content of the finished diet was calculated based on the nutrient composition of the various ingredients in the formula (see footnotes in Table 4). In cases where an ingredient is not exactly specified (e.g., one ingredient in MacDiet© is "premium-quality dry feline growth formula"), the product used in the calculations is noted in the footnote. All nutrients are shown on a dry-matter basis to facilitate comparisons.

The first difference among the diets is in protein content, with gut-loaded insects containing protein in excess of 50%. FoNS©, MacDiet© (with or without insects), and the French and Kyles' diets contain intermediate levels of protein (41–50%); the two commercial products contain the least protein (24–32%). Insectivores consume high-protein diets in the wild; however, amino acid composition/protein quality is critical in determining protein requirements. For this reason, without detailed amino acid analysis of each of these diets, little can be said concerning the potential effects of protein content on the growth of insectivores fed these diets.

As expected, the highest fat content is seen in the three mealworm-based diets (gut-loaded mealworms, Kyles' diet, French diet); five of the six other diets were quite similar. Only the Mazuri® diet had fat levels below 14%, which may not be adequate to support the rapid growth of nestlings. Certainly the greatest difference in macronutrient content is seen for carbohydrates. The gut-loaded insects contain little if any carbohydrates, but the commercial products contain 30–40% carbohydrates because significant amounts of carbohydrates are required during the manufacturing (extrusion) process. In contrast, the home-made diets have intermediate levels of carbohydrates. Although insectivores would routinely consume diets that contained little if any available carbohydrates, the utilization of carbohydrates found in grains (especially those that have been cooked via extrusion) by insectivores is unknown. There are reports (e.g., Martínez del Rio 1990) that certain passerines lack some of the digestive enzymes required for digestion of particular carbohydrates, suggesting a limited ability of these species to utilize them.

The calcium content of most of the diets shown in Table 4 are similar, although the diets of French and the Kyles are lower than the rest. The Kyles' diet is lowest in iron, with the Mazuri® diet highest, something to be considered if working with iron-sensitive species. The levels of most other nutrients appear to be appropriate, although some of the diets appear to be unnecessarily high in vitamin A. Short-term feeding of diets high in vitamin A may be suitable for some species and perhaps benefit some nestlings or injured adults by allowing them to build up stores of vitamin A in their livers. However long-term (706 days) feeding of diets containing more than 10,000 IU vitamin A/kg diet was shown to result in increased plasma retinol levels, splenic hemosiderosis, and altered vocalization patterns in adult cockatiels (*Nymphicus hollandicus*) (Koutsos et al. 2003). This report suggests that some birds are sensitive to high levels of vitamin A (as a reference point, the National Research Council 1994 requirement for growing broiler chicks is only 1500 IU/kg diet), so long-term feeding of diets containing high levels of vitamin A is not advisable for some species of birds.

Overview, Recommendations, and Caveats

Although the above information should prove useful to rehabilitators in evaluating their feeding programs, the lack of data on the performance of animals fed the various options evaluated in Table 4 means no definite statements can be made. That said, however, a few impressions may be in order. The relatively high-fiber and low-fat content makes the Mazuri® diet the lowest in energy content. Therefore, when using this diet, it might be difficult to deliver sufficient energy to animals with high-energy requirements (e.g., rapidly growing passerines and severely injured animals). Based on calculations, the diet of Kyle and Kyle appears to be relatively low in calcium, so rehabilitators using this diet should be aware of a potential limitation for growth. Similarly, the French diet likely contains adequate calcium for maintenance of adult bats, but may be slightly low for growth. Again, because our knowledge of insectivore nutritional requirements is limited, these statements are not meant to imply that these diets should not be used—only that theoretical calculations suggest potential nutritional concerns in certain circumstances.

The complexity of some of the diets should also be mentioned. Overly complicated formulations may make it difficult for rehabilitators to follow the required steps, which may result in shortcuts and/or substitutions that dramatically change the nutrient content of the diet. Also of concern is an ambiguity about ingredients in

some diets. All components of home-made diets should be clearly defined, with specific sources (including manufacturer) if possible, so that the diet can be duplicated. For example, MacDiet© calls for a "premium-quality" kitten food, but these products vary widely with respect to many nutrients. For that reason, depending on which "premium-quality" kitten food is used, the composition of MacDiet© will vary.

For diets based on commercial cat foods, some concerns about vitamin A intake are warranted. Cats and other mammalian carnivores are tolerant of extremely high levels of vitamin A, in part because of how they store, transport, and excrete vitamin A (Schweigert et al. 1990). Many commercial cat foods contain a significant amount of liver, resulting in a finished product with an extremely high vitamin A content (many times in excess of 100,000 IU vitamin A/kg dry-weight diet). Although not a concern for cats, birds and many herbivorous and omnivorous mammals are more sensitive to high levels of dietary vitamin A (the presumed upper safe level for most species of domestic poultry ranges from 15,000 – 40,000 IU/kg diet, National Research Council 1987). Therefore, the use of the "wrong" cat food could turn an otherwise suitable diet into one that is potentially dangerous. Simply avoiding cat foods reporting liver in the ingredient statement will not solve the problem because liver may also be labeled as meat (or poultry) by-products, and some whole fish also contain high levels of vitamin A. For that reason, the composition of commercial cat diets as part of a rehabilitation diet should be carefully researched, and diets based on such products should clearly define the product to be used.

In addition to specifying all dietary components, diet developers need to constantly reevaluate and update diets that depend on commercial products because formulas may change over time. As an example, the original FoNS© diet probably contained approximately 20,000 IU vitamin A/kg, but due to a formulation change in Eukanuba® kitten food, the diet as first published would now contain in excess of 90,000 IU vitamin A/kg diet.

People using a primarily insect diet should keep in mind that considerable variation in insect nutritional composition is a result of what the insect eats. For example, the difference in calcium between the gut-loaded mealworms and the mealworm-based formulations of French (Lollar and Schmidt-French 2002) and Kyle and Kyle (2004) shown in Table 4 is mostly a result of the mealworm medium recommended by each. The calcium in both blends could be elevated by adding calcium to the mealworm diet (or to the other ingredients).

Lastly, if rehabilitators are to have any confidence when using commercial products, homemade diets, or even gut-loaded insects, then the manufacturers and/or developers of these diets need to provide detailed nutritional information concerning their products. We examined a number of commercial and homemade formulations in addition to those reported in Table 4, but a lack of nutritional information about either the commercial product or certain ingredients (e.g., oral hygiene products for pets) in home-made diets made it impossible for us to properly evaluate them. As a minimum requirement, anyone developing and recommending rehabilitation diets should provide either calculated or actual nutrient analyses of their diets. As shown by Table 4, this can be readily accomplished. Manufacturers of commercial pet foods provide this information to their customers; rehabilitators should require no less. We also encourage editors and reviewers of rehabilitation journals and books to require this information as a prerequisite for publication when diets are developed or recommended.

It would also be useful if users of commercial, published, or homemade diets could provide quantitative information about their experiences with those diets. Even the success rate (% survived) would be valuable information, especially in conjunction with success rates using other formulations. Regular weighing of animals fed particular diets would allow estimations of growth rates that could be compared to those of animals on other diets or in their natural habitats. Such data would be valuable in helping to determine which diets are best suited to a particular situation and/or species and would help dispel myths based on anecdotal comments. Ultimately, this kind of information would help achieve the basic goal of all rehabilitators—the return of as many individuals as possible to their natural environments.

Acknowledgments

We thank Drs. Flo Tseng and Mark Pokras (Wildlife Clinic, Tufts University School of Veterinary Medicine, North Grafton, Massachusetts) for consultations with regard to using allometric scaling to estimate safety levels for boron consumed by birds. We are also grateful to Professor Shari Dunham (Department of Chemistry, Colby College, Waterville, Maine) and members of her Instrumental Methods of Analysis class for analysis of a calcium gluconate product. Finally we appreciate Jonathan Wright's assistance with isopod identification, and suggestions for improving the manuscript made by two anonymous reviewers and by *Journal of Wildlife Rehabilitation* Editor Marianne Skoczek.

Footnotes

[1] Giant mealworms, which are also sold commercially, are mealworms treated with juvenile hormone—not, as some believe, the anabolic steroids typically used in cattle. Juvenile hormone is naturally present in insects and helps direct insect molting. A mealworm larva will molt/shed its skin five to seven times before changing into a pupa. High levels of juvenile hormone cause the larva to molt into another larva (hence the name "juvenile hormone"), and low levels cause the larva to molt into a pupa. So treating a large mealworm larva that would otherwise molt into a pupa causes a molt into a still larger larva. We believe giant mealworm larvae are safe to use in a rehabilitation program and that fears concerning their use are unfounded because insectivores routinely consume insects that naturally contain high levels of juvenile hormone.

[2] The directions given in Kyle and Kyle 2004 were followed. Three hundred fifty-five (355) mealworms were prepared in 15 batches ranging in size from 15–39 mealworms. Each batch was weighed to 0.1 mg first as is, then again after each of the three preparation stages, in order to assess the quantity of each added ingredient.

Literature Cited

Adams, R., S. Penderson, K. Thibault, J. Jadin, and B. Petru. 2003. Calcium as a limiting resource to insectivorous bats: Can water holes provide a supplemental mineral source? *J. Zoo. London* 260(2): 189–94.

Allen, M., and O. Oftedal. 1989. Dietary manipulation of the calcium content of feed crickets. *J. Zoo and Wildlife Med.* 20(1): 26–33.

Allen, M. 1997. From blackbirds and thrushes...to the gut loaded cricket: A new approach to zoo animal nutrition. *Br. J. Nutrit.* 78(Suppl. 2): S135–43.

Anderson, S. 2000. Increasing calcium levels in cultured insects. *Zoo Bio.* 19(1): 1–9.

Barker, D., M. Fitzpatrick, and E. Dierenfeld. 1998. Nutrient composition of selected whole invertebrates. *Zoo Bio.* 17(2): 123–34.

Barnard, S., M. Griffiths, and E. Dierenfeld. In preparation. Nutrition and feeding: Captive insectivorous bats. In *Bats in captivity.* 2nd ed. Edited by S. Barnard. Malabar, Fla.: Krieger.

Bernard, J., and M. Allen. 1997. Feeding captive insectivorous animals: Nutritional aspects of insects as food. American Zoo and Aquarium Association Nutrition Advisory Group Fact Sheet 003. Retrieved from http://nagonline.net/technical_papers.htm.

Bilby, L., and E. Widdowson. 1971. Chemical composition of growth in nestling blackbirds and thrushes. *Br. J. Nutrit.* 25(1): 127–34.

Bukkens, S. 1997. The nutritional value of edible insects. *Ecology of Food and Nutrition* 36(2–4): 287–319.

Bureš, S., and K. Weidinger. 2001. Do pipits use experimentally supplemented rich sources of calcium more often in an acidified area? *J. Avian Bio.* 32(2): 194–98.

———. 2003. Sources and timing of calcium intake during reproduction in flycatchers. *Oecologia* 137(4): 634–47.

Caseiro, I., S. Santos, J. Sousa, A. Nogueira, and A. Soares. 2000. Optimization of culture conditions of *Pocellio dilatatus* (Crustecea:Isopoda) for laboratory test development. *Ecotox. and Environ. Safety* 47(3): 281–91.

Dhondt, A., and W. Hochachka. 2001. Variations in calcium use by birds during the breeding season. *The Condor* 103(3): 592–98.

Environmental Protection Agency. 2004. Toxicological review of boron and compounds (CAS No. 7440-42-8). Retrieved from http://www.epa.gov/iris/subst/0410.htm.

Ferguson, G., J. Jones, W. Gehrmann, S. Hammack, L. Talent, R. Hudson, E. Dierenfeld, M. Fitzpatrick, F. Frye, M. Holick, T. Chen, Z. Lu, T. Gross, and J. Vogel. 1996. Indoor husbandry of the panther chameleon *Chamaeleo [Furcifer] pardalis:* Effects of dietary vitamins A and D and ultraviolet irradiation on pathology and life-history traits. *Zoo Bio.* 15(3): 279–99.

Finke, M. 1984. The use of nonlinear models to evaluate the nutritional quality of insect protein. PhD. diss. University of Wisconsin.

———. 2002. Complete nutrient composition of selected invertebrates commonly fed to insectivores. *Zoo Bio.* 21(2): 269–85.

———. 2003. Gut loading to enhance the nutrient content of insects as food for reptiles: A mathematical approach. *Zoo Bio.* 22(2): 147–62.

———. 2004. Nutrient content of insects. In *Encyclopedia of entomology.* Edited by J. Capinera. (Vol. 3, 47–60). New York: Kluwer Academic Publishers.

———. 2005. Nutrient composition of bee brood and its potential as human food. *Ecology of Food and Nutrit.* 44(4): 257–70.

Finke, M., S. Dunham, and J. Cole. 2004. Evaluation of various calcium-fortified high moisture commercial products for improving the calcium content of crickets, *Acheta domesticus. J. Herp. Med. and Surg.* 14(2): 6–9.

Finke, M., S. Dunham, and C. Kwabi. 2005. Evaluation of four dry commercial gut loading products for improving the calcium content of crickets, *Acheta domesticus*. *J. Herp. Med. and Surg.* 15(1): 7–12.

Gist, C., and D. Crossley. 1974. The litter arthropod community in a southern Appalachian hardwood forest: Numbers, biomass and mineral element content. *Am. Midland Nat.* 93(1): 107–22.

Graveland, J. 1996. Avian eggshell formation in calcium-rich and calcium-poor habitats: Importance of snail shells and anthropogenic calcium sources. *Can. J. Zoo.* 74(6): 1035–44.

Graveland, J., and A. Berends. 1997. Timing of the calcium intake and effect of calcium deficiency on behaviour and egg laying in captive great tits, *Parus major*. *Physio. Zoo.* 70(1): 74–84.

Graveland, J., and T. Van Gijzen. 1994. Arthropods and seeds are not sufficient as calcium sources for shell formation and skeletal growth in passerines. *Ardea* 82(2): 299–314.

Hughes, B. and D. Wood-Gush. 1971. A specific appetite for calcium in domestic chickens. *Animal Behav.* 19(3): 490–99.

Hunt, A., A. Ward, and G. Ferguson. 2001. Effects of a high calcium diet on gut loading in varying ages of crickets (*Acheta domestica*) and mealworms (*Tenebrio molitor*). In *Proceedings of the 4th Conference on Zoo and Wildlife Nutrition*. Edited by M. Edwards, K. Lisi, M. Schlegel and R. Bray. pp. 94–99. Lake Buena Vista, Fla.

Klasing, K. 1998. *Comparative avian nutrition*. New York: CAB International.

Klasing, K., P. Thacker, M. Lopez, and C. Calvert. 2000. Increasing the calcium content of mealworms (*Tenebrio molitor*) to improve their nutritional value for bone mineralization of growing chicks. *J. Zoo and Wildlife Med.* 31(4): 512–17.

Koutsos, E., L. Tell, L. Woods, and K. Klasing. 2003. Adult cockatiels (*Nymphicus hollandicus*) at maintenance are more sensitive to diets containing excess vitamin A than to vitamin A–deficient diets. *J. Nutrit.* 133(6): 1898–1902.

Kramer, K., T. Hopkins, and J. Schaefer. 1995. Applications of solids NMR to the analysis of insect sclerotized structures. *Insect Biochem. and Molecular Bio.* 25(10): 1067–80.

Kyle, G., and P. Kyle. 2004. Rehabilitation and conservation of chimney swifts (*Chaetura pelagica*). 4th ed. Austin, Tex.: Driftwood Wildlife Association. Retrieved from http://www.chimneyswifts.org/page3.html.

Lollar, A. 2005. Bat World's Mealworm Medium. Mineral Wells, Tex.: Bat World Sanctuary. Retrieved from http://www.batworld.org/worldbatline/frequent-questions.html.

Lollar, A., and B. Schmidt-French. 2002. *Captive care and medical reference for the rehabilitation of insectivorous bats*. 2nd ed. Mineral Wells, Tex.: Bat World Sanctuary.

Lyons, D., and K. Spann. 1985. Assay of calcium borogluconate veterinary medicines for calcium gluconate, boric acid, phosphorus, and magnesium by using inductively coupled plasma emission spectrometry. *J. Assn. Official Analytical Chemists* 68(2): 160–62.

MacLeod, A., and J. Perlman. 2001. Adventures in avian nutrition: Dietary considerations for the hatchling/nestling passerine. *J. Wildlife Rehab.* 24(1): 10–15.

———. 2003. Food for thought: Songbird nestling diets, 2004. *J. Wildlife Rehab.* 26(3): 26–27.

Martínez del Rio, C. 1990. Dietary, phylogenetic, and ecological correlates of intestinal sucrase and maltase activity in birds. *Physio. Zoo.* 63(5): 987–1011.

Miller, E., S. Green, G. Otto, and D. Bouley. 2001. Suspected hypovitaminosis A in a colony of captive green anoles (*Anolis carolinensis*). *Contemp. Topics in Lab. Animal Sci.* 40(2): 18–20.

Moore, J. 1986. Dietary variation among nestling starlings. *The Condor* 8(2)8: 181–89.

National Research Council. 1987. Vitamin tolerance of animals. Washington, D.C.: National Academy Press.

National Research Council. 1994. Nutrient requirements of poultry. 9th revised ed. Washington, D.C.: National Academy Press.

Organic Materials Review Institute. 2000. Calcium borogluconate. From National Organic Standards Board Technical Advisory Panel Reviews. Retrieved from http://www.omri.org/calcium_borogluconate.pdf.

Pennino, M., E. Dierenfeld, and J. Behler. 1991 Retinol, alpha-tocopherol and proximate nutrient composition of invertebrates used as feed. *Internat. Zoo Yearbook* 30: 143–49.

Poulin, R., and R. Brigham. 2001. Effects of supplemental calcium on the growth rate of an insectivorous bird, the purple martin (*Progne subis*). *Ecosci.* 8(2): 151–56.

Reichle, D., M. Shanks, and D. Crossley. 1969. Calcium, potassium and sodium content of forest floor arthropods. *Annals Entomolog. Soc. Am.* 62(1): 57–62.

Rossi, A., R. Miles., B. Damron, and L. Flunker. 1993. Effects of dietary boron supplementation on broilers. *Poultry Sci.* 72(11): 2124–30.

Sander, J., L. Dufour, R. Wyatt, P. Bush, and R. Page. 1991. Acute toxicity of boric acid and boron tissue residues after chronic exposure in broiler chickens. *Avian Diseases* 35(4): 745–49.

Schweigert, F., O. Ryder, W. Rambeck, and H. Zucker. 1990. The majority of the vitamin A is transported as retinyl esters in the blood of most carnivores. *Compar. Biochem. and Phys. A* 95(4): 573–78.

Smith, W., and T. Goldsmith. 1990. Phyletic aspects of the distribution of 3-Hydroxyretinal in the class Insecta. *J. Molecular Evo.* 30(1): 72–84.

Strzelewicz, M., D. Ullrey, S. Schafer, and J. Bacon. 1985. Feeding insectivores: Increasing the calcium content of wax moth (*Galleria mellonella*) larvae. *J. Zoo Animal Med.* 16(1): 25–27.

Studier, E., J. Keeler, and S. Sevick. 1991. Nutrient composition of caterpillars, pupae, cocoons and adults of the eastern tent moth, *Malacosoma americanum* (Lepidoptera:Lasiocampidae). *Compar. Biochem. and Phy. A* 100(4): 1041–43.

Studier, E., and S. Sevick. 1992. Live mass, water content, nitrogen and mineral levels in some insects from south-central lower Michigan. *Compar. Biochem. and Phy.* 103A(3): 579–95.

St. Louis, V., and L. Breebhaart. 1991. Calcium supplements in the diet of nestling tree swallows near acid sensitive lakes. *The Condor* 93(2): 286–94.

Tordoff, M. 2001. Calcium: Taste, intake, and appetite. *Phys. Reviews* 81(4): 1567–97.

Triplehorn, C., and N. Johnson. 2005. *Borror and Delong's Introduction to the study of insects.* 7th ed. Belmont, Calif.: Brooks/Cole.

Trusk, A., and S. Crissey. 1987. Comparison of calcium and phosphorus levels in crickets fed a high calcium diet versus those dusted with supplement. In *Proceedings of the Sixth and Seventh Dr. Scholl's Conferences on the Nutrition of Captive Wild Animals.* Edited by T. Meehan and M. Allen. pp. 93–99. Chicago: Lincoln Park Zoological Gardens.

Winn, D. 2002. Formula for nestling songbirds: Down payment on fitness and survival. *J. Wildlife Rehab.* 25(3): 13–18.

Winn, D., S. Dunham, and S. Mikulski. 2003. Food for insects and insects as food: Viable strategies for achieving adequate calcium. *J. Wildlife Rehab.* 26(1): 4–13.

Winn, D., and M. Finke. 2004. Formula for nestling songbirds (FoNS)©: Updates for 2006. *J. Wildlife Rehab.* 27(3–4): 28.

To Contact the Authors:

Mark D. Finke, Ph.D.
Mark D. Finke Inc.
6811 E Horned Owl Trail
Scottsdale, AZ 85262
USA
Tel: 480/585-0290
Fax: 480/585-0291
E-mail: mdfinke@cox.net

Diane S. Winn, Ph.D.
Avian Haven
418 North Palermo Rd.
Freedom, ME 04941
USA
Tel: 207/382-6761
E-mail: diane@avianhaven.org

EDITOR'S NOTE: Due to production difficulties, this article, originally planned for 2005, is published in this issue of the *Journal of Wildlife Rehabilitation*, 27.3–4, dated 2004.

Formula for Nestling Songbirds (FoNS)©: Updates for 2006

by Mark Finke and Diane Winn

As noted in the accompanying article by Finke and Winn (2004), because of a change in the formulation of Eukanuba® Chicken & Rice Formula kitten food, we do not recommend continued use of this product as the base for FoNS© (Winn 2002). The commercial companion-animal food that best met our target requirements of high protein (40+%), high fat (20+%), an abundance of high quality animal protein (chicken meal, chicken and dried egg), and modest levels of vitamins A and D, was ZuPreem® Premium Ferret Diet. Ferrets and cats are both obligate carnivores with similar nutrient requirements and digestive tracts. Indeed, recent data show similar performance of cats and ferrets fed a premium quality dry cat food, and many experienced ferret owners feed their pets a premium dry cat food (Bell 1999, Fekete et al. 2005). The nutrient profile of most ferret foods is similar to some premium dry kitten foods, and so a shift from a food marketed for kittens to one marketed for ferrets is not a paradigmatic one.

This version of FoNS© received limited testing in the 2005 season. At Avian Haven (Freedom, Maine), roughly 350 nestling passerines (and other insect-eating birds) from about 30 species were raised on it, with a release rate marginally (though not significantly) higher than those in the past several seasons with the original FoNS©. We would like more information about its performance, so feedback from users in 2006 would be appreciated.

PREPARATION

135 g (1 cup)	ZuPreem® Premium Ferret Diet, presoaked in ~1.5 cups water
71 g (1 jar)	Beech-Nut Chicken & Chicken Broth® Baby Food
12 g (2 Tb)	dried egg white
5 g (0.5 tsp)	active-culture plain yogurt
3 g	calcium carbonate
1 g (0.25 tsp)	Avi-Era™ avian multiple vitamins

Blend in food processor until smooth. Add water if needed to achieve desired consistency for feeding. Soaking time is reduced if ferret kibble is pulverized in food processor prior to adding water.

Calculated Composition: As fed, 73% water, 1.27 kcal/g.

Dry weight analysis: 50% protein, 23% fat, 17% carbohydrate, 2.0% Ca, 1.0% P (see Finke and Winn 2004 for additional information).

Literature Cited

Bell, J. 1999. Ferret nutrition. *Vet. Clinics of N. Am.: Ex. Animal Practice* 2(1): 165–92.

Fekete, S., K. Fodor, A. Proháczik, and E. Andrásofszky. 2005. Comparison of feed preference and digestion of three different commercial diets for cats and ferrets. *J. Animal Physio. and Animal Nutrit.* 89(3–6): 199–202.

Finke, M., and D. Winn. 2004. Insects and related arthropods: A nutritional primer for rehabilitators. *J. Wildlife Rehab.* 27(3–4): 14–27.

Winn, D. 2002. Formula for nestling songbirds: Down payment on fitness and survival. *J. Wildlife Rehab.* 25(3): 13–18.

Product Information

ZuPreem® Premium Ferret Diet is available from a variety of sources, including Petco and Petsmart retail stores and online from www.petco.com or www.petsmart.com. The Ferret Diet as well as dried egg white, calcium carbonate, and Avi-Era™ vitamins are available from Chris's Squirrels and More (www.squirrelsandmore.com or 877/717-7748). Beechnut chicken baby food can be purchased at grocery stores.

Author Mark D. Finke, Ph.D., can be reached at mdfinke@cox.net; Diane S. Winn, Ph.D., can be reached at diane@avianhaven.org.

EDITOR'S NOTE: Due to production difficulties, this article, originally planned for 2005, is published in this issue of the *Journal of Wildlife Rehabilitation*, 27.3–4, dated 2004.

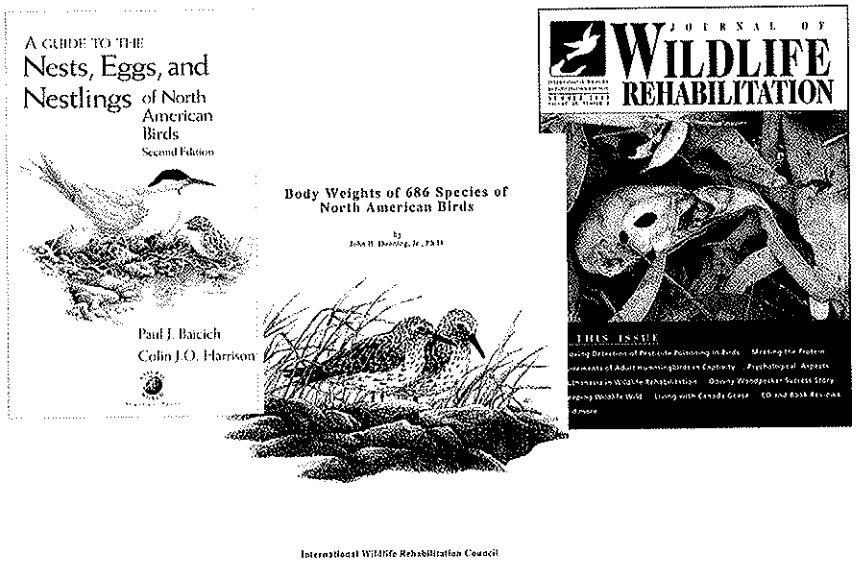
IWRC LAUNCHES

THE ONLINE STORE

WWW.IWRC-ONLINE.ORG

IWRC recently launched an online marketplace, dubbed THE ONLINE STORE. You can now purchase journals, manuals, conference proceedings, and more with the click of a few buttons.

Some of the more difficult-to-find publications are also available, including *American Wildlife Food and Plants—A Guide to Wildlife Food Habits,* which gives detailed information on the use of trees, shrubs, weeds, and herbs by birds and mammals in the United States.



To access THE ONLINE STORE simply go to www.iwrc-online.org and click on THE ONLINE STORE link.

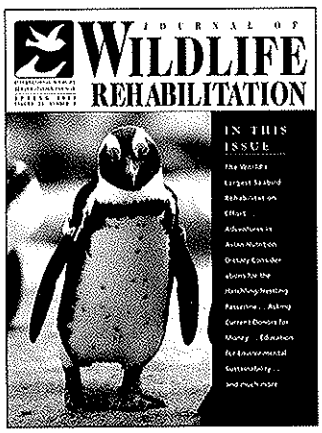
ORDERS OF MORE THAN $100 RECEIVE A FREE GIFT!

IWRC MEMBERS RECEIVE 10% OFF LITERATURE

ORDERS SHIP WITHIN 2–3 BUSINESS DAYS

GO TO WWW.IWRC-ONLINE.ORG TO ACCESS THE STORE

IWRC PUBLICATIONS ARE NOT AVAILABLE ANYWHERE ELSE



INSIGHT

Bugs & Drugs

MAGGOT-INFESTED WOUNDS

by Kathy Dolan

Maggot-infested wounds are one of the more distressing and distasteful aspects of caring for injured wildlife. There is nothing more disheartening during an initial examination than finding wiggly maggots or their eggs. Their presence changes the dynamics of care and wound treatment. The clinical term for this condition is *myiasis,* which is formally defined as "the infestation of living human and vertebrate animals by the larvae of dipterous flies, which feed on the host's dead or living tissues, liquid body-substances, or its ingested food" (1). Unlike other winged insects, dipterous flies have one pair of functional wings and are considered "true flies" in the insect world. While thousands of fly species have been identified, only a handful of flies impact rehabilitators and the animals in their care, and of these only a few are responsible for wound myiasis.[1]

In North America, the flies that are primarily responsible for wound myiasis are those commonly seen around garbage and other rotting material, namely, blowflies, houseflies, and flesh flies. Blowflies are members of the Calliphoridae family, which includes *Lucilia sericata, Calliphoria vomitoria* and members of the Phormia genus, more commonly known as the green, blue, and black bottle flies, respectively. These flies, along with the common housefly (*Musca domestica*) and the larger flesh flies (Sarcophagia species) and others, are frequently grouped under the common name of "filth flies," reflecting their preferred feeding materials. Filth flies consume and lay their eggs on rotting organic matter such as garbage, feces, and carrion. Primarily scavengers, these flies aid other decomposers in removing dead and decaying material from the environment by assisting in the breakdown and release of organic material into the soil. Filth flies are opportunists as well, feeding and depositing eggs on injured, necrotic tissue, or dirty, feces-encrusted areas of living animals as well as rotting garbage.

Flies find their food chemically by smell and taste. They can detect minute amounts of molecules of decay in the air and follow the odor back to its source. As flies land on different surfaces, they "taste" the surface with their feet to determine if the area is a suitable food resource. Unfortunately, an animal with necrotic wounds, or even areas of heavy extensive bruising, emits the same odor molecules of decay. Eggs and maggots are not found on healthy animals. Rehabilitators frequently receive abandoned or orphaned young animals without apparent injuries that are infested with filth fly eggs or maggots. There must be an underlying condition that attracted the adult flies. Perhaps flies can detect parental neglect by a lack of grooming or by an as yet unidentified chemical that is associated with either heightened stress levels of the young animals or impending death.

Like many insects, flies have a four-stage life cycle: egg to larva to pupa to reproductive adult. As gravid female flies feed on a food source, they lay eggs, which in hours

TABLE 1. OPTIMUM LIFE STAGES OF VARIOUS FLY SPECIES (IN DAYS)

Common Name	Egg	Larva	Pupa	Adult
House fly	0.5	4.5	4–5	30–40
Blue bottle fly	0.5–4	3–9	10–17	35
Green bottle fly	0.5	5–6	6	35
Flesh fly	living larvae laid	3	8–10	35

Adapted from www.clemson.edu/peedeerec/certifi/Camm_p/CH10/LIFEHIST.htm

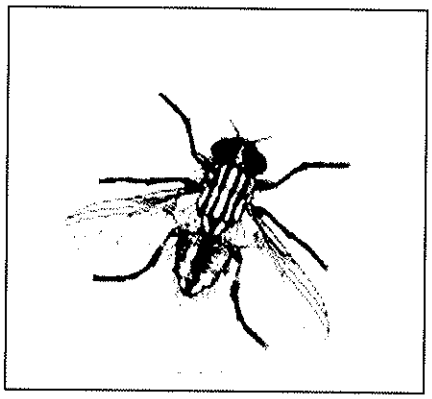
or days hatch into maggots. Maggots are the larval or caterpillar stage of the fly. Like all caterpillars, they have voracious appetites. They also move around to exploit the food around them. Flesh flies get a head start on the food source by laying larvae, not eggs. Maggots, like adult flies, feed by regurgitating digestive enzymes onto food in a process known as "vomit drop" feeding (2). The enzymes break down the necrotic tissue into a slurry that is then ingested by the insects. The voracious appetites and aggressive feeding behavior of the maggots allows them to stockpile nutrients and energy for the next stage of their development, the pupal stage. Maggots enter the pupal stage by encasing themselves in a tough impenetrable case. While in this nonmotile, nonfeeding stage, the maggots use the stored nutrients to develop into reproductive adult flies that repeat the cycle.



The period of time for each stage discussed above varies among the different fly species (Table 1). Flies, being ectotherms (cold-blooded), respond to changes in temperature. Activity, metabolism, and development slow down in cooler temperatures and speed up in warmer temperatures. This effect is seen, sometimes dramatically, when an injured, shocky animal with only a few maggots is first brought to a rehabilitator. The few maggots are removed, initial treatments are started and the animal is placed in a warm area to stabilize. When the animal is checked several hours later, many more maggots are discovered, as the eggs respond to the warmer conditions and speed up hatching.

Death from wound myiasis can result from a number of factors: shock and dehydration, intoxication, or secondary bacterial infections. Maggots consume dead tissue and also body fluids that leak into the wound, contributing to dehydration and shock of the animal. While filth fly maggots do not consume living tissue (1), in heavy infestations the secretion of digestive enzymes along with the abrasive action of their skin as they move (2) can lead to further tissue damage within the wound. More tissue damage increases the inflammatory reaction at the site resulting in more body fluids leaking into the area. The secretions and damaging mechanical actions of the maggots combined with the animal's inflammatory response gives infested wounds a "weepy" or wet appearance. The mechanical and chemical damage done by maggots and the body's response explains the tracts or tunnels seen in wound myiasis, which are sometimes more extensive than the original wound. If the injured animal is out in the wild, these tracts provide areas for adult flies to feed and deposit eggs. Actively feeding maggots also secrete toxins and waste products into the wound that are distributed throughout an animal's body. A build-up of these toxic materials in an already compromised animal can cause organ damage and death. Maggot-infested wounds do not heal, but remain open to the environment, which can lead to potentially fatal secondary bacterial infections as well as further myiasis, as more flies are attracted to the injured site.

The damaging and potentially fatal effects of maggots make it imperative to remove both eggs and maggots. Fly eggs are very difficult



WWW.CLEMSON.EDU/PEEDEEREC/CERTIFI/CAMM_P/CH10/LIFEHIST.HTM

and frustrating to remove, sometimes requiring trimming of fur or feathers. While there are many products and techniques to remove eggs and maggots from an infested animal, space limitations precludes a detailed discussion of these different methods. The method used by the rehabilitator to remove maggots will depend on a number of factors: the type of animal and it status, the number of eggs and maggots, the location and extent of the wounds and the rehabilitator's experience. Consultation with a veterinarian familiar with wildlife or with whom the rehabilitator has worked successfully is a prudent course of action. Other rehabilitators are also an excellent resource for tips in dealing with maggots.

The urge to remove as many maggots as possible is understandable; however, a stressed and debilitated animal may become overstressed and further compromised by a long, intensive maggot-picking session. In cases of heavy infestations, frequent maggot removal sessions with breaks to allow the animal to recover may be more prudent. Frequent checks allow the rehabilitator to look for maggots that may have hatched in the interim. No matter how the maggots are removed it is important to physically remove all dead maggots. Dead maggots that remain within the wound or tissue tracts will begin to decay and set up a localized area of infection, which can lead to further complications, including septicemia.

In addition to establishing wound myiasis, flies are troublesome in other ways. They are an irritating nuisance to both people and animals. Their presence can be psychologically stressful to injured, debilitated animals, which can prolong healing. Flies visit many sites a day in their search for food, providing them with ample opportunities to transfer pathogenic microbes from one place to another. Microbes are picked up on the body hairs and sticky feet of flies and are deposited in new areas as the flies feed. "Vomit drop" feeding also facilitates the spread of pathogens. Because flies can mechanically transfer pathogenic microbes, preventive measures should be in place to reduce fly populations in rehabilitation settings. These measures should include the removal and proper disposal of materials attractive to flies such as uneaten or spoiled food, animal feces, and dead animals. General hygiene and cleanliness should be very high to discourage the presence of flies. Garbage cans should have tight fitting lids and should be cleaned on a regular basis.

No discussion of wound myiasis is complete without mentioning the medical usage of maggots. During the late 19th and early 20th centuries (1880s–1930s), physicians and surgeons used fly larvae to clean and debride wounds. It was observed that the tissue under the maggot-treated areas was pink and healthy while bacterial infections were reduced. The heralding of the antibiotic era in the 1930s and '40s, along with advances in surgical techniques for wound treatment, pushed maggot therapy into a dusty corner of medical history. The newer treatments were, no doubt, more esthetically appealing to the people involved than the application of maggots. However, maggot therapy, using green bottle fly larvae, *L. sericata,* is gaining popularity in the medical community as a nonsurgical method to debride certain types of nonhealing wounds. Support for this trend is seen in the approval given in early 2004 by the FDA to market *L. sericata* larvae as a medical device (3). Unlike naturally occurring wound myiasis, all conditions for maggot therapy are tightly controlled. The eggs are "sterilized" prior to hatching. The number of maggots applied to the wound and the contact time is also carefully managed. While not suited to all cases, maggot therapy does offer a viable alternative to invasive surgeries for the debridement of wounds without the complications of surgery. JWR

References

1. Introduction to Myiasis. 2003. http://www.larve.com/maggot_manual/docs/myiasis.html.
2. http://www.merckvetmanual.com.
3. Harder, B. 2004. Creepy-crawly care. *Science News.* 166(October): 266–68.

Endnote

[1] For an excellent review of obligate myiasis caused by bots and warbles. please see: F. Slansky and L. R. Kenyon. 2004. Cuterebra bot fly infestation of rodents and lagomorphs. *J. Wildlife Rehab.* 26(3): 7–16.

Kathy Dolan, MS, is an instructor at Trident Technical College in North Charleston, South Carolina. She can be reached at kdolan2@comcast.net.

Rehabilitation Notebook

WEST NILE VIRUS: CLINICAL SIGNS AND TREATMENT PROTOCOL

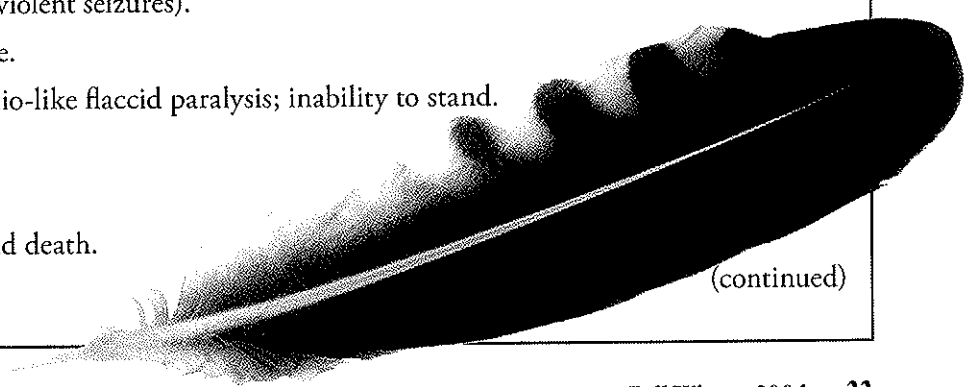
by Louise Shimmel and Kathy Snell, DVM

A Note from the Author: Oregon has been one of the last states to experience West Nile Virus (WNV), with the first cases showing up in southeastern Oregon in August 2004. At the Cascades Raptor Center our first and so far only case, a red-tailed hawk, was received in October 2004—the first noncorvid verified with the disease in the state. Although it feels rather presumptuous to be writing this, given that our facility has treated only a single bird with WNV, it also feels as though we've had the benefit of the experience of everyone east and south of here, so generously shared through personal communication, at forums such as the IWRC conference panels on WNV the last few years, and on e-mail listservs such as RaptorCare. The following was put together as an in-house protocol, based on the input and shared experiences of rehabilitators and researchers across the U.S. It is written with no claim of my being an expert, and merely offered as a starting place for others. I hope some may find it useful. Treatment will undoubtedly continue to evolve as we learn more about this disease.—*Louise Shimmel, Executive Director, Cascades Raptor Center, Eugene, Oregon*

WNV: Clinical Signs

There is no one obvious sign of WNV. Because it can cause encephalitis, any neurological signs might indicate WNV...but neurological signs might also arise from head trauma, lead poisoning, or organo-phosphate poisoning. Questioning finders carefully—and noting down what they say—is important. The following are common clinical signs:

- Depression, lethargy, slow to respond to stimuli; finder can simply approach the bird and pick it up.
- Anorexia, weight loss (in proportion to duration of starvation); inability to eat on own—though some have presented with enormously exaggerated appetite, or this can a be part of a recovery phase.
- Abnormal deepness or length of sleeping (i.e., difficult to wake, excessive sleeping).
- Pinched-off blood feathers (also a frequent sign of surviving a prior exposure).
- Elevated white blood cell count.
- Thick, ropy saliva; difficulty swallowing.
- Head tremors and other CNS disorders such as ataxia (clumsiness or poor equilibrium) or tipping forward; partial or one-sided paralysis; staggering or leaning to one side.
- Green urates (indicating liver necrosis and/or starvation).
- Mental dullness/central blindness and general lack of awareness of surroundings, up to detached retinas (perhaps caused by violent seizures).
- Conscious but unresponsive.
- Weakness in legs, up to polio-like flaccid paralysis; inability to stand.
- Exaggerated aggression.
- Very high fever.
- Severe tremors, seizures, and death.



(continued)

Intake and Treatment Protocol for Suspected West Nile Virus Cases

Examine: Normal physical exam on intake.

Stabilize: normal stabilization protocol, i.e.,

- Hydration with LRS PO (or SQ)
- B-complex IM
  no cortico-steroids, unless there is sign of traumatic injury or shock (slow palpebral response, slow capillary refill time, low body temperature). Nonsteroidal anti-inflammatory drugs (NSAIDs) may be used (see below).

Powder for ectoparasites.

If seizuring/convulsing: administer Diazepam at up to 2–3 mg/kg IM[1] as needed (Carpenter 2001, Plumb 2002); otherwise, use Meloxicam (see below).

Provide supportive care:

Heat: Put bird in an incubator or in carrier that is placed half on a heating pad. If the bird cannot stand, make a comfortable doughnut nest with towels or an upside-down stuffed toilet seat cover.

Hydrate: For second and subsequent fluids, use Emaciation Hydration Solution (EHS) (Perlman 2004) PO for at least 3 days.

Meloxicam: 0.4 mg/kg PO SID (a nonsteroidal anti-inflammatory)[2] (VIN Avian Board). ***Draw up and dose each bird with a syringe marked for that bird;*** wash out syringe and store in tray.

Vitamin B_1: Pat Redig, DVM, in his original WNV treatment notes (9/2002) suggested that Vitamin B_1 (thiamine) at 10 mg/kg/day may be helpful and is often routine with neurological conditions. The author's normal intake protocol includes B-complex, dosed at a rate of 30 mg of B_1/kg IM (Harrison 1986), for stress, debilitation, muscular weakness, and appetite stimulation. It is also recommended for neurological disorders. This is repeated weekly as needed or oral B_1 can be administered on food or in a gavage solution, or the injectable solution of B-complex can be given daily at a rate of 10 mg of B_1/kg IM.

Vitamin E: Vitamin E has also been suggested as helpful in neurological cases, dosed at a normal rate for nutrition (15 mg/kg PO once [Carpenter 2001]). Care must be taken not to overdose with fat-soluble vitamins.

Continue rehydration: Either with EHS PO BID; or, if bird is at all alert and equilibrium is intact, water can be placed in the hospital cage. If not, the beak can be gently dipped into water to see if the bird will drink on its own. Water should ***not*** be left in the cage if bird is at all ataxic (unbalanced) and could fall into it, or if towels could dip into it and soak it up, thus getting the bird cold and wet.

Feed: Food may need to be hand-fed from forceps, force-fed, or gavaged. If the bird is emaciated, re-feeding formula (RFD) recommended by Perlman and MacLeod (2004) should be tubed as needed. Once the bird is capable of eating on its own, feed as much as it will eat, as often as directed.

Continue supportive care until recovery or until euthanasia is determined necessary.

Instructions for Special Fluids and Tube-Feeding Formula

Emaciation Hydration Solution (EHS) (Perlman and MacLeod 2004)
Put 100 ml LRS in a plastic container; add the following:

B complex: add what is equivalent to 10 mg Niacin
Vitamin C (Ascorbate): 50 mg

Vitamins A & D: 1000 IU and 200 IU, respectively (cod liver oil can be used as an approximation, as it contains both)
Vitamin E: 200 IU
Probiotics: 5 cc (1 tsp) live-culture plain yogurt
L-glutamine: 1 g

Mix together, cover, label with date made; keep refrigerated. Discard after 2 days.

Refeeding Diet (RFD) for Emaciation and WNV Cases (Perlman and MacLeod 2004)
(Make half this amount if for smaller or single birds; in larger quantities for several birds or one large bird)

Beechnut turkey baby food: 2 jars
Plain low-fat yogurt: 15 cc (1 Tbsp.)
Plain reconstituted gelatin: 60 cc (4 Tbsp.) (sprinkle 1 envelope over 1 cup cold water, let stand 1 minute, then stir)
Cod liver oil: 0.2 ml (4 drops; poke hole in capsule and squeeze out 4 drops)
Vitamin E: 0.1 ml (2 drops)
Niacin via B-complex tablet: 10 mg (crush in mortar with a pestle)
Vitamin C: 50 mg
Calcium carbonate: 180 mg

Mix together, cover, label with date made; refrigerate. Discard after 2 days. Add Pancreatin only as you draw up to feed.

To feed: Open capsule of Pancreatin and sprinkle small amount into back end of separated syringe, then draw up the required quantity of RFD; warm to bird's body temperature (105°F) for 15 minutes before feeding. Refrigerate any excess and discard after 2 hours.

Note: An economical source for these vitamins is the on-line store Puritan's Pride, www.puritan.com.

Endnotes

[1] The Carpenter 2001 dosage recommended for sedation of most species of birds is 2.5–4.0mg/kg PO; *Plum's Drug Handbook,* 4th edition, gives 2–4 mg/kg IM for seizures and/or sedation in birds per VIN; Ritchie, Harison, and Harrison gives 0.5–1 mg/kg IV BID or TID, specifically 0.6 mg/kg IM, IV for seizures, or 2.5–4.0 mg/kg PO of the oral.

[2] Meloxicam in birds is as yet an off-label use, but this dose is within the known cat/dog range. 0.2–0.5 mg/kg PO SID or BID is recommended by the Veterinary Information Network (VIN) Avian Board.

Literature Cited

Carpenter, J. W., T. Y. Mashima, and D. J. Rupiper. 2001. *Exotic animal formulary,* 2nd Ed. Philadelphia: W. B. Saunders Co.

Harrison, G. J., and L. R. Harrison. 1986. *Clinical avian medicine and surgery.* Philadelphia: W. B. Saunders Co.

Perlman, J., and A. MacLeod. 2004. Stayin' alive, stayin' alive: Feeding ill and emaciated birds. *J. Wildlife Rehab.* 26(4): 8–20.

Plumb, D. C. 2002. *Veterinary drug handbook,* 4th Ed. Ames, Iowa: Blackwell Publishers.

Ritchie, B. W., G. J. Harrison, and L. R. Harrison. 1994. *Avian medicine: Principles and application.* Lake Worth, Fla.: Wingers Publishing, Inc.

INSIGHT

The (Other) Value of Rehabilitators

PART III: WHAT DO I HAVE TO LEARN?

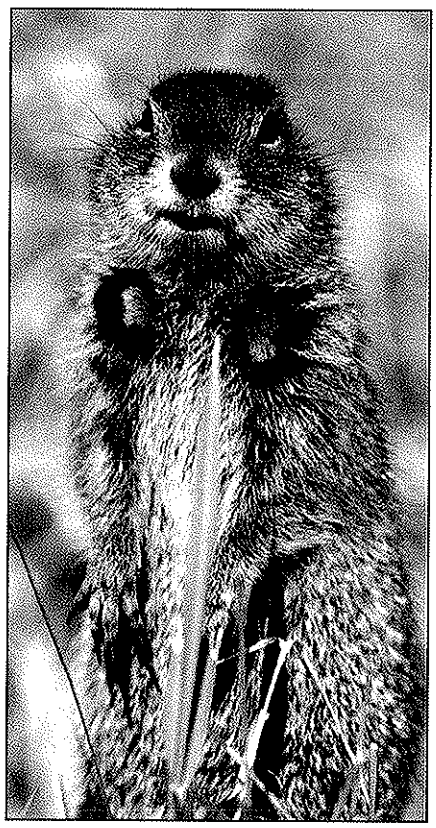
by Jennifer Hill

In the last two issues of the *Journal of Wildlife Rehabilitation,* this column has explored contributions that rehabilitators offer in addition to the release of restored wild animals (Hill 2004a, 2004b). In this installment, I will encourage us to open our minds to new possibilities. The rehabilitation ideas and methods common 20 years ago may not be the best we have to offer in the 21st century.

I am new to wildlife rehabilitation and don't presume to suggest a new feeding protocol or an alternative wound management regime. However, I've had enough interactions with "experts" in various professions to know that ego can get in the way of progress. After many years as an undergraduate and then graduate student, I discovered that many academics were less interested in "how it *really* happens" and more interested in "this is how *I've shown* it happens for the last 10 years." These individuals were determined that new advances were not going to shut out *their* important contributions, even if they were antiquated. No one wanted to look the fool and admit the earth might be round, when he or she had believed for so long that it was flat.

None of us is all-knowing. To be responsible rehabilitators we need to listen to new ideas with an open mind and admit that certain thoughts or procedures can be improved upon. It does not mean that any of us have been wrong all these years, but merely that advances in science may have shown us a better way.

In October 2003 the U.S. Fish and Wildlife Service (USFWS) announced a new permit for the rehabilitation of injured migratory birds (http://news.fws.gov/newsreleases/r9/D4278077-ADD7-4696-8BN542F38DBE3CD29.html). The new rule, Migratory Bird Permits; Regulations Governing Rehabilitation Activities & Permit Exceptions (USFWS Document 03-26823), was a monumental document, the culmination of many years of work by many dedicated individuals. It served to recognize and reconstruct the profession of rehabilitating birds. Migratory bird rehabilitation permits were no longer relegated to the catchall "special use" category. To the delight of many, good recommendations are now law, there is less ambiguity in the rules and regulations, and there is a guide to facilities standards. To the chagrin of others, the fee for permit applications is being implemented, approval must be obtained before placing nonreleasable birds, and there are new minimum facilities standards. Whether you rehabilitate birds or other animals, I'm sure you've heard discussions of the pros and cons of the new migratory bird rule and the implications to wildlife rehabilitation in general.



Was the creation of the migratory bird rehabilitation permit necessary? Yes. Are we experiencing a painful rebirth as many backyard rehabilitators have difficulty conforming to the Minimum Standards for Wildlife Rehabilitation (MSWR) (Miller 2000)? Perhaps.

Will this new document destroy our profession, or is the attention being given rehabilitation by the states threatening the practice of rehabilitation? No.

In the short term, we may have fewer permitted rehabilitators, but they will be more understanding of the many complex issues that are involved when treating sick and injured wildlife (e.g., captivity stress, imprinting, diet, contagious zoonoses, prerelease criteria, etc.). And in the long term, individuals interested in wildlife rehabilitation will join a group of professionals with goals, regulations, and standards that have the long-term interests of wildlife at their core. Change is never easy, but we must believe that adherence to the new rule will further our abilities to help sick, injured, and abandoned wildlife.

When I first began rehabilitating birds in northern Michigan, I

met a wonderful retired ornithologist/biologist who also rehabilitated birds. This gentleman had been caring for wildlife longer than I had been alive. With the issuance of the new USFWS rehabilitation rule, he decided to allow his rehabilitation permit to expire due to a lack of resources or facilities to conform to the MSWR. However, people still bring him injured birds, not knowing that his permits have expired. He can hold the birds for 24 hours under the provisions of his banding permit until he can call me or one of the few other rehabilitators in this area. Does he seem angry or disgruntled as he hands over birds to someone as "inexperienced" as me? No. He is a wise fellow and talks of the "changing of the guard" and the improvements he has seen in wildlife rehabilitation techniques. I regret his loss to the rehabilitation community, but I respect his understanding of the advances made in wildlife rehabilitation and I respect his desire for wildlife to have the highest quality of care, with or without his participation.

Like the practitioners in many professions, wildlife rehabilitators gauge their experience in years. In my last column, I mentioned several wildlife rehabilitation listservs to which I subscribe. In many of these forums, individuals posting questions or responses are encouraged to include a "signature" at the end of the post. The signature should include basic contact information, types of animals rehabilitated, permits held, number of years as a rehabilitator, and so forth. But I'd really like to know about memberships in professional organizations (IWRC, NWRA), how often that person networks, or attends local or national conferences or seminars, or has made a major change in treatment protocol based on new science, techniques, or information.

As a case in point, several months ago, the RaptorCare listserv was full of postings about an article about dexamethasone use for the treatment of head injuries (Pokras and Murray 2004). Based on a review of studies and literature, the authors concluded that dexamethasone should rarely, if ever, be used on head injuries in wildlife. The responses from the listserv were mixed. Some rehabilitators had stopped using dexamethasone years ago, mostly based on some "instinct" that said the steroid didn't help and possibly did more harm than good. Very few, if any, mentioned that they would fly in the face of the data and continue to administer dexamethasone unconditionally to head trauma patients. Others, including myself, said they would reevaluate treatment protocols immediately based on the new interpretation of human studies. I believe the measure of a good person, rehabilitator, researcher, teacher, or whatever particular hat you wear, is someone who is willing to listen to new ideas and consider the possibilities. I will respect a person's 20 years of experience rehabilitating wildlife more if I know they are continually examining and reviewing their techniques.

"It's what you learn after you know it all that counts."
— **John Wooden**

I'm sure many of us can look back at some of our first years of rehabilitating wildlife and cringe. How many birds were released into the wild that were imprinted on humans? These releases began to diminish when rehabilitators addressed the problems of human imprinting, ways to avoid it, and actions to enable conspecific imprinting. Improper imprinting of wildlife is avoidable; it is only by a lack of awareness of current techniques to avoid it that human imprinting still occurs.

I often hear stories that involve a stray and orphaned animal that was raised by the teller's family many years ago. The individual is typically very proud of their involvement in "helping" wildlife. These stories provide a great opportunity for the rehabilitator/educator to commend that person's efforts, reinforcing the attitude that wildlife is of value and that their impulse was a "good" one. It gives one the chance to explain current law and provides an opportunity to tell them that they now have a knowledgeable resource to turn to. They don't have to take all the responsibility of a displaced animal on themselves, but can contact a permitted wildlife rehabilitator in the future. It provides the opportunity to inform them about the dangers of imprinting on humans—which seriously disrupts the normal adult activities of a wild animal—and about zoonoses that can be dangerous for all. It gives us a chance to invest the public in the health of wildlife.

I encourage us all to not let ego get in the way of improving our profession or knowledge base. Wildlife rehabilitation has come so far in the past decades, and it would be a shame to not utilize the information that has been gained through the expertise and hard work of so many individuals. I know two wonderful rehabilitators here in Michigan who have both been rehabilitating wildlife for at least a dozen years. Both took the IWRC Basic Skills 1AB course (see www.iwrc-online.org) within the past few years. Even

though they were not the typical "beginners" who normally take this course, they were wise enough to know that they didn't know it all and that a refresher is always a good thing. Both reported learning much from this "basic" class. Therefore, let's all network, attend workshops, seminars, conferences, classes, and never feel that we have learned enough. JWR

Literature Cited

———. 2004. The (other) value of rehabilitators. Part I: Where, oh where, did the data go? *J. Wildlife Rehab.* 27(1): 27–28.

Hill, J. 2004. The (other) value of rehabilitators. Part II: Is there anybody out there? *J. Wildlife Rehab.* 27(2): 24–25.

Miller, E. A., ed. 2000. *IWRC/NWRA Minimum Standards for Wildlife Rehabilitation.* 3rd ed. San Jose, Calif.: International Wildlife Rehabilitation Council.

Pokras, M. A., and M. Murray. 2004. Throw away your dex!! A polemic on why rehabilitators should NOT use dexamethasone. *Wildlife Rehab. Bull.* 22(1): 4–5.

Jennifer Hill completed her Ph.D. in animal behavior at the University of New Mexico. While at UNM, she worked as a curatorial assistant at the Museum of Southwestern Biology's Division of Birds. Most recently, she was the director of NorthWings, a raptor rehabilitation and education program at SEE-North, a nonprofit environmental education center for three years. She can be reached at jenniferhill@nmo.net.

SELECTED ABSTRACTS

AVIAN

Blood Parasites of Birds from South-East Queensland

by R. D. Adlard, M. A. Peirce, and R. Lederer

EMU 104(2): 191–96.

3059 birds, presented as clinical cases to the Currumbin Wildlife Sanctuary (Gold Coast, Queensland) were examined for the presence of blood parasites at the International Reference Centre for Avian Haematozoa, Queensland Museum. The birds represent members of 40 families, 102 genera, and 133 species; of these, 350 birds (11.4%) were found to harbor one or more species of haematozoa. At least four new species of parasites have been identified. The highest occurrence of infection was found with species of Leucocytozoon (51.1% of infected birds), followed by Haemoproteus (31.4%). *Plasmodium* spp. occurred in 10.9% of birds examined, but specific identity for this genus was limited because of the low levels of parasitaemia and a lack of developmental stages required to characterize each species. The information provided by this survey and those planned for other regions of Australia will be of significance to conservation strategies that involve captive breeding and translocation of endangered species of birds.

Knemidokoptes in a Swainson's Hawk (*Buteo swainsoni*)

by D. S. Miller, G. F. Taton-Allen, and T. W. Campbell

J. Zoo and Wildlife Med. 35(3): 400–402.

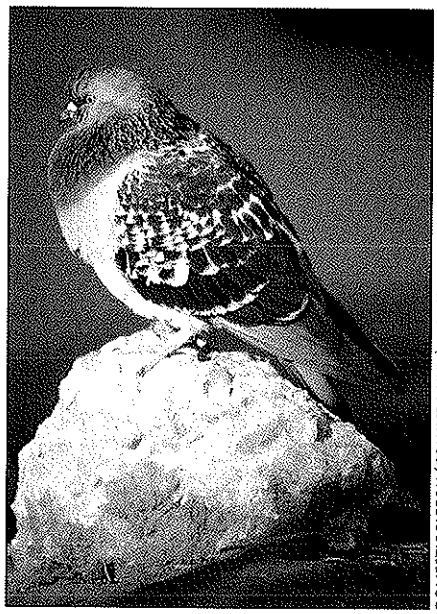
A male Swainson's hawk (*Buteo swainsoni*) at a rehabilitation facility in Colorado was presented with severe crusting of the skin on the medial thighs and caudal ventral body. Male and female Knemidokoptes mites were found on a cellophane tape preparation of the affected area. The hawk's clinical signs resolved with treatment with ivermectin administered at 200 µg/kg, IM, every 10 days for three treatments.

Clinical Evaluation of the Oral Iron Chelator Deferiprone for the Potential Treatment of Iron Overload in Bird Species

by D. P. Whiteside et al.

J. Zoo and Wildlife Med. 35(1): 40–49.

The clinical use of oral Fe chelators for the treatment of Fe-storage disease in birds requires evaluation. In this study, the efficacy of the Fe chelator deferiprone in reducing hepatic Fe stores; its effects on hematologic, biochemical, and plasma Fe parameters; and its potential toxicity during a 30-day treatment period were investigated in a controlled setting using two model species, the white leghorn chicken (*Gallus gallus* f. *domestica*) and the domestic pigeon (*Columba livia*). A second phase of



DOMESTIC PIGEON (*COLUMBA LIVIA*) PHOTO: L. KARNEY/USFWS

the study investigated deferiprone-related Fe elimination in the excreta. Deferiprone, administered orally at a dosage of 50 mg/kg twice daily to birds that had been experimentally Fe loaded, significantly reduced hepatic Fe concentrations compared with levels in Fe-loaded and non–Fe-loaded controls. There were no significant alterations in routine clinical hematologic or biochemical parameters, although decreased transferrin saturation was noted in both species. Side effects associated with deferiprone administration were decreased weight gain and significant decreases in plasma Zn concentrations. No mortalities occurred in the pigeons, but there were three deaths in the deferiprone-treated group of Fe-loaded chickens, most likely associated with acute reduction of Fe required for normal enzymatic processes. Histologic changes associated with deferiprone treatment were not noted. Deferiprone caused a dose-dependent increase of Fe in the excreta at oral dosages of 50 and 75 mg/kg once daily in both species. Deferiprone is a promising, orally active Fe chelator for the treatment of Fe overload in birds, although its potential side effects need to be considered.



OVENBIRD (*SEIURUS AUROCAPILLUS*) PHOTO: S. MASLOWSKI/USFWS

Landbird Use of Riparian and Upland Forest Stopover Habitats in an Urban Landscape

by P. G. Rodewald and S. N. Matthewsa

The Condor 107(2): 259–68.

Stopover habitat relationships of landbirds are not well known and this constitutes a shortcoming in conservation plans for migratory birds. The authors compared migrant use of mature upland and riparian forests during spring in an urbanizing landscape within central Ohio. They surveyed stopover migrants along 250-m transects, and quantified both local- and landscape-level habitat characteristics (percent urban and forest land). During spring stopover, migrant abundance was 86% and 118% higher in upland forests for Nearctic-Neotropical transient (long-distance migrants) and temperate transients (short-distance migrants), respectively. Of 27 transient species, 22 species differed in their use of riparian and upland forests, and 20 of those were most abundant in upland forest (e.g., blue-headed vireo [*Vireo solitarius*], least flycatcher [*Empidonax minimus*], Swainson's thrush [*Catharus ustulatus*], Nashville warbler [*Vermivora ruficapilla*], magnolia warbler [*Dendroica magnolia*], bay-breasted warbler [*D. castanea*], and ovenbird [*Seiurus aurocapillus*]). Species richness was 58% and 75% higher in upland forests relative to riparian forests for Neotropical transient and temperate transient groups, respectively. Percent urbanization within 1 km was unrelated to abundance of Neotropical transients and temperate transients. Abundance of Neotropical transients and temperate transients was unrelated to percent forest cover within 1 km. Mature upland and riparian forests differed in that riparian sites had lower percentage of shrub cover, higher percentage of canopy cover, and different species composition of trees. Abundance of Neotropical transients was positively associated with mean canopy height; temperate transients were positively associated with mean number of trees >38 cm DBH and mean percentage of shrub cover. The data indicate that mature upland forests were more heavily used by migrating landbirds than riparian forests within an urbanizing Midwestern landscape and may represent valuable habitats for the conservation of migratory landbirds within highly fragmented landscapes.

Survival of Young Greater Snow Geese (*Chen caerulescens atlantica*) during Fall Migration

by S. Menu, G. Gauthier, and A. Reed

The Auk 122(2): 479–96.

The many hazards that await birds along their migratory routes may negatively affect their survival, especially among newly fledged young. The authors estimated survival of young greater snow geese (*Chen caerulescens atlantica*) during fall migration from the High Arctic to temperate areas and examined factors affecting their survival over a 5-year period, using two approaches. First, each year (1993–1997) fledglings and adults were banded in mid-August, just before their departure from Bylot Island in the High Arctic (Nunavut, Canada), and again at an important staging area 3000 km to the south at the Cap Tourmente National Wildlife Area (Québec, Canada) in October; recovery data from these banding periods allowed estimation of survival during fall migration. Second, the authors visually determined brood size of neck-banded females before and after the main portion of the migratory flight, to estimate survival of young. The two approaches yielded similar survival estimates and showed the same interannual variation, suggesting that estimates were reliable. Mortality of young shortly after fledging and during fall migration was high, compared with that of adults (monthly survival 0.662 in young vs. 0.989 in adults). However, mortality of young after migration was similar to that of adults (monthly survival 0.969 in young vs. 0.972 in adults). Migration survival of young varied considerably among annual cohorts (range of 0.119–0.707 over 5 years), and most of the mortality appeared to be natural. Survival was especially low in years when temperatures at time of fledging and start of migration were near or below freezing; mean body mass of goslings near fledging was low; or mean fledging date was late. The results suggest that migration survival of young is affected by a combination of several factors (climatic conditions, body mass, and fledging date) and that survival is reduced when one of those factors intervenes.

Comparisons and Contrasts between the Foraging Behaviors of Two White-tailed Ptarmigan (*Lagopus leucurus*) Populations, Rocky Mountains, Colorado, and Sierra Nevada, California, U.S.A

by J. A. Clarke and R. E. Johnson

Arctic, Antarctic, and Alpine Research 37(2): 171–76.

The summer diets of a natural population of white-tailed ptarmigan (*Lagopus leucurus*), an herbivorous alpine grouse, in the Rocky Mountains and an introduced population in the Sierra Nevada were compared to determine if differences in alpine tundra plant communities affected nutritional intake. Foraging selections of 28 adult ptarmigan were recorded regarding number, amount, availability, nutritional, mineral and energy content of plant species eaten. The average diet of the Rocky Mountain ptarmigan was composed of nine plant species (99% g dry wt), while the average diet of the Sierra Nevada ptarmigan was composed of only two plant species, *Salix anglorum* and *Carex jonesii* (99% g dry wt). Although plant species eaten differed between the populations, the energy and lipid content of the diets were nearly identical. The diet of Sierra Nevada ptarmigan was 28% higher in protein and 13% lower in carbohydrate than the diet of Rocky Mountain ptarmigan, likely due to high consumption of Salix leaves and low consumption of flowers by the Sierra Nevada ptarmigan. Both populations exhibited sampling behavior (ingesting occasional bites from many species), which would allow ptarmigan to track changing resources in the highly variable alpine environment and may have enabled the introduced ptarmigan to identify a suitable diet.

MAMMALS

Demographics and Condition of Coyotes in Illinois

by T. A. Nelson and D. M. Lloyd

Am. Midland Nat. 153(2): 418–27.

The rapid growth of coyote (*Canis latrans*) populations in Illinois since 1980 prompted a need for current demographic data to be used in population models for management. From 1994–1997 the authors examined 977 coyotes harvested by hunters and trappers throughout the state and compiled data on age structure, sex ratios, reproductive rates, and physical condition. Statewide, 55% of harvested coyotes were juveniles, 20% were yearlings, and 25% adults. The sex ratio did not differ from unity among juveniles and yearlings, but was skewed towards males in the adult class. The number of harvested animals decreased by 45–60% between successive classes from 0.5 through 2.5 y old, then by 30–40% through 9.5 y old. Statewide, 57% of females bred; breeders averaged 4.9 placental scars. Males were larger than females, averaging 14.1 and 12.1 kg whole body mass, respectively. Kidney fat reserves were highest in juveniles and adult females and lowest in yearlings. Femur marrow fat was generally high and did not differ among age-classes. Ovulating females were heavier than non-ovulators among juveniles and yearlings. The authors found that coyotes in Illinois are in good physical condition with high winter fat reserves and reproductive rates.

However, reproductive rates are lower than in 1978–1979, when the state's population was rapidly expanding.

A Technique for Non-Invasively Detecting Stress Response in Cougars

by F. Bonier, H. Quigley, and S. N. Austad

Wildlife Soc. Bull. 32(3): 711–17.

The ability to non-invasively monitor stress hormone levels in free-ranging animals could significantly aid in conservation and management efforts. This study sought to demonstrate the effectiveness of assay of fecal corticoid metabolites in detecting a stress response in cougars (*Puma concolor*). Fecal samples were collected from 9 captive cougars before and after an artificial stressor. Steroid hormones were extracted from the samples. Adrenal corticoid metabolite concentrations of the resulting extracts were quantified using cortisol and corticosterone assays. Results indicated that fecal glucocorticoid metabolite levels increased significantly 24 hours after the stressor in 6 of the 9 individuals. Behavior correlated with the hormonal response; all cougars that displayed a flight response to the stressor also had elevated stress hormone measures. Elevated levels of stress hormones were not observed in individuals that did not attempt to flee. The authors have demonstrated with this study that measurement of fecal hormone metabolites is sufficiently sensitive to detect an adrenal response to stress in cougars and could be applied in the field to monitor stress levels in free-ranging populations.

Swift Fox Survival and Production in Southeastern Wyoming

by T. L. Olson and F. G. Lindzey

J. Mammalogy 83(1): 199–206.

The authors estimated annual survival rates of swift foxes (*Vulpes velox*) and documented number of young per pair in a transition zone between shortgrass prairie and sagebrush steppe plant communities in southeastern Wyoming during 1996–2000. Annual adult survival ranged from 40–69%, with predation by coyotes (*Canis latrans*) the primary cause of deaths. Two foxes died of canine distemper virus. Annual survival rates did not differ among years ($P > 0.12$). Nineteen of 24 (79%) swift fox pairs were observed with young older than 3 y. Mean minimum litter size was 4.6 based on these 19 litters and 6 others not associated with the study's radiocollared foxes. Adult survival was similar and litter size slightly larger than observed elsewhere in the species range, suggesting that viable swift fox populations can be supported by sagebrush steppe and shortgrass prairie transition habitat.



COYOTE (*CANIS LATRANS*) PHOTO: R. H. BARRETT/USFWS

CONSERVATION

Preliminary Remediation Goals for Terrestrial Wildlife

by R. Ryti, J. Markwiese, R. Mirenda, and L. Soholt

Human and Eco. Risk Assessment 10(2): 437–50.

Remediation of contaminated sites requires information on upper concentration limits of chemicals in environmental media that are protective of ecological receptors. These limits can be considered ecological preliminary remediation goals (EcoPRGs). The motivation for developing EcoPRGs was to provide risk managers with a simple tool for evaluating remedial actions that would be protective of the environment. Hazard quotient calculations used to support ecological screening assessments were modified to derive soil EcoPRGs for terrestrial wildlife populations. The primary modification is a population area use factor that is the fraction of a terrestrial animal population potentially affected by the contaminated site. Wildlife assessment population boundaries are based on a receptor's dispersal distance; for mammals dispersal distance is strongly related to the linear dimension (square root) of home range. Assuming that wildlife are unlikely to disperse beyond some distance from their birth or natal site, dispersal distance can be thought of as the radius of the assessment population's boundaries. This general relationship is useful as a simple way to estimate assessment population areas for terrestrial animals and helps fill data gaps for wildlife without direct measurements of dispersal. JWR

INSIGHT

Forester's Log

BAER FAIRS SHOWCASE BURN RESTORATION

by Mary Stuever

When I finally stumbled into Memorial Hall that hectic January morning, the gymnasium was a bustle of activity. Heavy black tarps protected the wooden floor from traffic of children, teachers, community members, and tribal leaders who wove lines around 30 display tables. After weeks of planning, the first White Mountain Apache Tribal BAER Fair was a whopping success.

I carried what suddenly seemed a paltry assortment of snacks to the food table, and wandered around the hall. I was amazed at how articulately my colleagues and staff were presenting the mind-boggling array of activities that have preoccupied our waking hours for the past two years.

Following the record-shattering Rodeo-Chediski Fire in June and July of 2002, the White Mountain Apache Tribe, in the spirit of Indian self-determination, chose to assume the task of stabilizing and rehabilitating 277,000 acres of charred reservation lands. Funded by the Burn Area Emergency Response (BAER) program through the Bureau of Indian Affairs (BIA), tribal leadership assumed responsibility for implementing activities described in a 352-page plan.

I was hired to spearhead this effort and am one of a handful of "white people" involved in the project. All of my staff members, which numbered 75 in the past year, are Native Americans. Looking around the fair, I proudly admired the interactions between fair visitors and BAER employees.

Many of the conversations were in Apache. Although I can pick up a word or two here and there, I cannot follow the flow of ideas. However, I heartily encourage the use of the language and am convinced that our program—which focuses on healing the land—is best described in the native tongue.

Ingenuity dominated the displays. The Log Erosion Barrier crew had a tabletop hillside of soil, demonstrating how logs are placed along the contour to slow runoff. The detail included a flagged-off archeological site and cardboard crew carrier that had many more amenities than its bare-bones, real-life counterpart.

At the Bale Bombing display, a model helicopter carried a photo of large hay bale in a cargo net. Many other photos told the story of how straw was strewn over 15,000 acres of steep, erosion-prone slopes by helicopters.

Plastic cups sliced lengthwise made a convincing model of the greenhouses for a display that celebrated the miracle transformation of seeds to seedlings. Adjacent tables and display boards described how more than a million seedlings have been planted since the fire, as well as how difficult tree survival is amid the same drought that produced severe fire conditions.

A wood-post and wire structure introduced the idea of "jetty jacks," while a table-top display demonstrated how these structures are used to protect roads and farm fields by guiding the stream channels away from cutting edges.

Other booths told more stories. A table of pottery pieces and artifacts impress the importance the tribe places on protecting cultural resources. Another display demonstrates how fire burned the unmanaged forest most severely, while stands that had been thinned, burned, or logged before the fire experienced low fire severity and still have green trees. Tribal employees shared photos of sacred springs and the exciting development of long-ago springs returning on the landscape. Visitors also learned about challenges with roads, range issues, and wildlife. Additional booths stressed health issues because the health of the people and health of the land is inseparable for Apaches.

The BAER Fair would run two days, one day in Whiteriver, and the next day in Cibecue, a community about 50 miles to the east and central to the burn area. Although the fairs themselves would be great successes, my staff and I would learn that our work informing tribal members about restoration efforts on the burn was only just beginning.

The White Mountain Apache Tribe recently received the National Fire Plan Award for Rehabilitation and Restoration. Although we are proud of this achievement, the national recognition of excellence pales if our tribal members are not fully informed on the successes and challenges that lie ahead for this area. JWR

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

The Big Year: A Tale of Man, Nature and Fowl Obsession

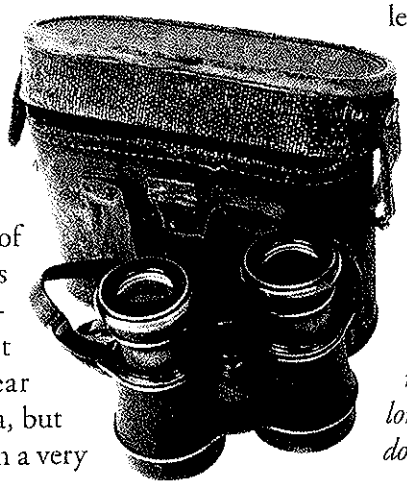
by Mark Obmascik

New York: Free Press, 2004; U.S. $17.50 (hardcover), $ 9.75 (paperback)
ISBN: 0743245466

As a subteen birder decades ago and now grandfather of an obsessed 11-year-old birder (current documented life list at about 450), this reviewer thoroughly enjoyed reading *The Big Year.* To the uninitiated, the notion of keeping lists of bird sightings may seem like thinly disguised stamp collecting, but the idea of making the construction of the longest list compiled in a calendar year into a competitive sport, would strike most—even among the initiated—as truly over the top. But then again, maybe not, as the above-mentioned 11 year old, upon completing reading the book, declared that he wanted to do a Big Year. The matter of direct costs (travel, vehicle rental, accommodation) and indirect costs (foregone earnings) detailed in the book, seemed not to register!

This is the tale of three very different but similarly obsessed birders, virtually unknown to one another, and their pursuit of the big prize. The search area is all of North America, north of the Mexican border, and the winner can be expected to make an honorable sighting of not only all of the 675 species normally residing for at least part of the year in this vast area, but then in addition a very substantial number of accidentals and vagrants. For the three participants, it appears like a continuous breathless blind dash, hither and yon, in pursuit of virtual hints posted on the birders web. The search can take the participant from suburban backyards to remote Aleutian Islands or to truly foul urban trash dumps. Many species are true opportunists and seem blithely unaware or unfussed by the ways of humankind. In contrast to the behaviour of *The Big Year* participants, the author, while tracing some of their footprints, is able to take a far more relaxed approach, providing the reader with much interesting tangential, anecdotal information. He is able to seamlessly weave into the story a nice sense of place for many of the critical sightings as well as interesting historical sketches of some of the key figures in North American birding, ranging from Audubon and Peterson to Kaufman and others. While the story line is fractured and disjointed, the author is able to carry the reader along smoothly and effortlessly.

In addition to the book presenting an interesting tale, there is a great deal of practical information about good birding sites and an excellent annotated bibliography of bird guides. A good index makes the book much more useful than it would have been, had this not been included. Overall, the book is highly recommended. JWR



Reviewer Eric Terzaghi is a molecular geneticist with a long-standing love of the outdoors and travel. Now "retired,"



he runs a deer farm in New Zealand. His extracurricular activities "continue at a level befitting the advancing years."

Lady Grayl: Owl with a Mission

by Robert W. Nero

Toronto: Natural Heritage/Natural History Inc., 1994; 176 pp.; U.S. $15.95, Can. $19.95 (paperback)
ISBN 0-920474-94-2

Dr. Nero has studied great gray owls for more than 25 years. In 1984, during field research that brought him repeatedly to one nest, he ultimately decides to take the youngest owl, at the urging of his research associates, to raise for use in education. This nestling is debilitated, apparently being attacked by older siblings due to a food shortage, and had little or no chance of survival if left in the nest. Lady Grayl is imprinted/habituated to people and embarks on a life of education and fundraising for their great gray owl research projects, helping

to protect habitat, and ultimately being instrumental in the Province of Manitoba selecting the great gray as their provincial bird. She meets Kay McKeever and Roger Tory Peterson, researchers, politicians, and thousands of school children, traveling thousands of miles. I first read the book probably 10 years ago, and then re-read it recently, after receiving a nonreleasable great gray for education.

What is particularly endearing about this book is that here is a long-time researcher (70 years old at the time of writing) who has clearly fallen completely in love with this bird. He is, of course, fascinated and intrigued by the opportunities of up-close-and-personal observation—which he never gets in the wild—and takes full advantage of it. He throws down a sleeping bag and spends occasional nights in her large mew, for example, just to see how her behavior may differ from during the day. He takes copious notes on her behavior at all times of the year, and lots of photos, both of which he shares in the book. Oddly, considering that Dr. Nero must have been educated in the days of "animals as automatons—little more than a bundle of instinctive behaviors"—he does not hesitate to use anthropomorphic terms. The owl "exploded with indignation and fury" the first time she saw herself in a mirror. Or she can give "an embarrassed look." He does not pretend that what he observes in his captive bird is transferable to wild behavior, but he takes full advantage of the learning opportunities presented, studying vocalizations, body language, molt patterns.

The body language observations and photos are particularly useful, I think, to anyone working with this species. And he even unwittingly casts a vote on a discussion once held on RaptorCare (an e-mail listserv for raptor rehabilitators) as to whether or not birds had facial expressions, saying he feels owls are the most expressive. I found it very interesting to read his interpretations of how the owl's brain works to screen out unimportant sounds, even ones that may be loud or sudden. Even more relevant to our work, Dr. Nero notices Grayl many times, having seen from inside the car or a shopping mall a raptor far overhead, apparently tracking it well past the point where it has disap-

Two poems from Lady Grayl

The Owl's Gift

In the dark rainy night
I consult with this oracle
reaching through soft feathers
to feel her warm throat
thinking as I do that
the fabric of her being
is mere thin skin stretched
over braced bones and flesh
a fragile assemblage
to so command our attention.
So then where's the spirit of
this comforting creature that
ceaselessly charms us all?
It must be in her mind
(do birds have minds?)
it's in her attitude, the way
she trusts us and accepts us;
she comes from her owl-being
to meet us in her time
gravely allowing us a
glimpse of her world
a gift of tender tolerance
we do well to honour.

Large Owl

"The bird is not as big as
it looks" say those who measure
with a finger
poked through feathers to body.

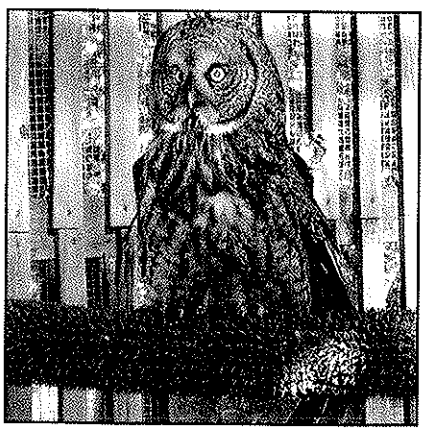
What nonsense! The owl is entire
of itself, massive in a coat of
soft plumes, and the perfect outline
of its round head is what the bird is,
no more, no less.

Each feather's tip is sensitive
to touch, a part of the bird
as leaves are part of a tree
transient as molted feathers.
Twigs, buds and hidden roots
make a tree; the maple with its
distinctive shape, the symmetry of
a spruce...who would question where
the tree begins?

All those feathers can be moved,
compressed, fluffed out
expressing changing moods or
responding to weather.

True, its light feathers
are easily ruffled by
the wind, as a girl's hair,
another part of its charm.

If the size of a bird
is judged by its spirit
then this bird is even bigger
than it looks.



LOUISE SHIMMEL

peared from actual sight—i.e., it's directly above the roof of the car or gone out of sight past the skylight of the mall. He offers the thought that perhaps this is one reason owls so often get hit by cars: that they are virtually focused on prey, "tracking" it right through, and thus ignoring, a moving object.

Dr. Nero writes charming poetry, which is also shared in the book. My favorites, which I think sum up his attitude, are both one with which he closes the book, "The Owl's Gift," and one from earlier on.

This book is an enjoyable and informative read. JWR

Louise Shimmel is director of the Cascades Raptor Center in Eugene, Oregon.

CHILDREN'S BOOK REVIEWS

Peek and Find Adventures with: Olivia Owl Oscar Otter Bobbie Bear

By Maurice Pledger
San Diego: Silver Dolphin Books, 2005; 18 pp.; U.S. $10.95 each
ISBN 1-59223-393-7

These little books are rated for ages three and older. Pop-up books don't last long with this crowd, but Richard Hawke, the paper engineer, makes the adventure of peeking under a rock or a leaf, great fun to do with your toddler. The stories could hardly be more simple. Carolyn Reeves and Jonathan Lambert have done a great job with the design.

Olivia is a little, dark-eyed owl who is looking for a friend. She looks in many types of habitat, each of which provides a friend who is adapted to it. I especially like that mushrooms and insects are not just the product of the illustrator's imagination. If one is mycophile enough to know them, russullas, chanterelles, and inky caps (maybe



even a shaggy mane) hide other denizens of the woods. Clouded yellows, sphynx moths and underwings are cryptically dispersed throughout. There are all kinds of creatures to see in the search for friends, and they are not only in hiding. On pages 12 and 13 Olivia and her friends finds many other owls... no horned owls among them, but some have yellow eyes.

Oscar Otter, one of Olivia's friends, is searching for more exotic loot in his riparian environment. He gathers a newt, a water vole, kingfisher, beaver, and turtle to help in his search until they all plunge into a pond inhabited by a shoal of goldfish. Water lilies and more beautiful birds and butterflies are scattered throughout these pages.

Even more beautiful birds and insects accompany Bobby Bear and his upland friends in their search for gold. They find it in the hollow post of a fence. The flowers and plants of Bobby's woodland include trillium and blackberry, but also English ivy, buddleia, and poppies. Do buddleia and poppies grow in the wild in North America? A bird on the last page looks suspiciously like a blue tit. Maybe it's poetic license: every work of art should have a little flaw so that the pictures don't fly right off the page... or run off the page on the little footprints that surround the margin of the cover. JWR

Reviewer Penny Elliston is director of Wildlife Rescue, Inc., of New Mexico in Albuquerque.

Pass The Energy, Please!

by Barbara Shaw McKinney
Illustrated by Chad Wallace
Dawn Publications; 2000; 32 pp; U.S. $7.95.
ISBN: 1-58469-002-X

I stumbled across this most delightful book on Amazon.com when I was looking for something entirely different. (I guess there really *is* a point to the suggested lists they maintain based on your buying preferences.) This is a book about food chains, written in rhyme reminiscent of *'Twas the Night Before Christmas.* It covers everything from plants and seeds to the scavengers and decomposers, with very realistic and engaging illustration.

Food manufacturing starts with
a seed,
and energy waits in a plant to be
freed.
Like an engine that powers the
rest of a train,
a plant's the first link in an
energy chain.



Each chapter adds a link to the chain, starting with plants, and sets them in different habitats. The language is occasionally advanced for the younger end of the recommended six- to 12-year-old age range but not overpowering, as it's used so well in context:

A remarkable thing about the
green plant—
it makes its own food, whereas
animals can't.
Mixing carbon dioxide, water,
and sun,
Mother Nature has photosynthesis
fun!

The text is tied in well with the drawings, with the above verse printed in the sky above a sun rising on a pastoral scene, and the following verse in the lower corner of the page, underneath the dirt!

When roots reach for water,
there's magic—osmosis!
Minerals pass through the roots
in small doses.
These liquified vitamins found in
Earth's floor
make the soil a natural health
food store.

It includes underwater scenes, herbivores, predators, higher predators eating lower ones, and decomposers. Each chapter ends with a variation on a verse. The herbivore chapter finishes with:

Energy passing from one to
another
is offered by Earth to each animal brother.
A chain unbroken along the way
links plants and creatures from
day to day.

Once predators are introduced, each chapter ends with:

Passing the energy needed to live,
is a difficult thing for a creature
to give.
But a chain unbroken along the
way
links life on the plain [or
meadow or Arctic or woodland] from day to day.

The decomposer chapter makes a wonderful point, surrounded by mushrooms:

All Nature's creatures, linked in
some way,
are returned to the ground in the
form of decay.
But their energy lives, like souls,
in the Earth,
that nurture new life and cycle
new birth.

Without hitting the reader over the head, a scene of logging (with a very sad-looking squirrel and rabbit that could either be cleaning himself or hiding his eyes!) talks about ecosystems needing balanced food chains and that we are endangering creatures by taking their habitats. The book ends by suggesting

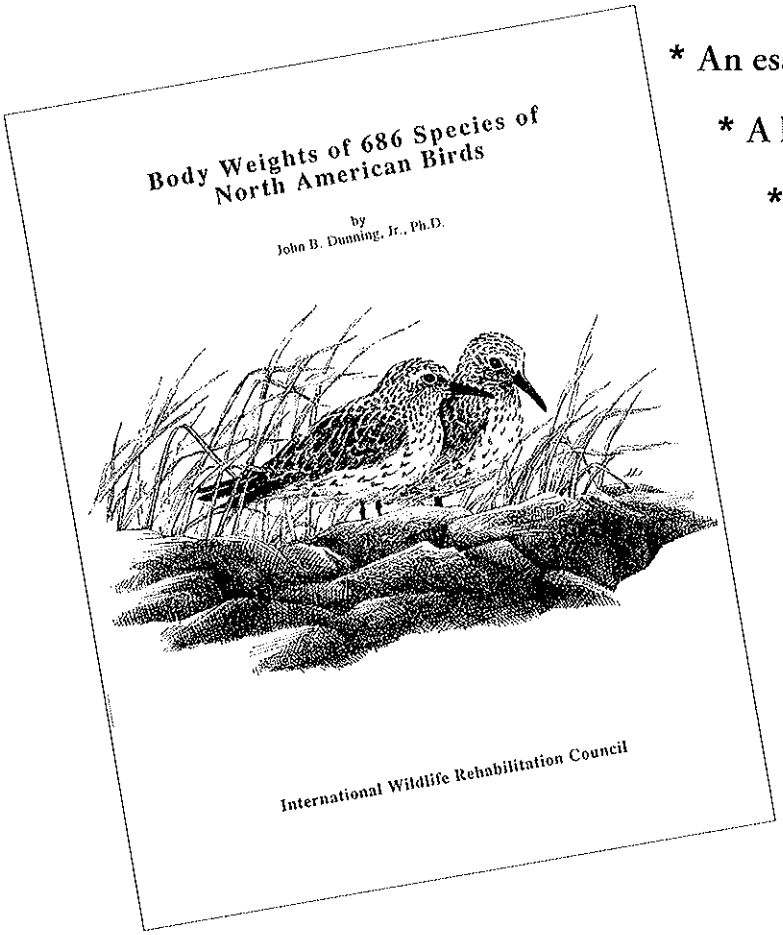
Let's learn from the creatures,
the wisest of teachers,
who pass their energy, one to
another,
respecting and trusting their
Planet Earth Mother.

This is a great book to recommend to teachers before doing a predator/prey or food chain unit, or game. It really brings to life the classic activity of a food web! The only problem is that I find myself compelled to read it out loud to everyone who will sit still long enough.... (I've ordered but haven't yet seen what the publisher calls the companion to this book—*A Teacher's Guide to Nature's Food Chain* by Carol Malnor. It sounds great, with activities using movement, art, music, writing, and math for both individuals and groups.) Dawn Publications is "dedicated to inspiring in children a deeper understanding and appreciation for all life on Earth." JWR

Reviewed by Louise Shimmel.

Editor's Note: *The* Journal of Wildlife Rehabilitation *welcomes reviews of books of interest to IWRC members, including veterinary reference books, memoirs, natural history, and novels. Please include the book's title and author, as well as publisher, date of publication, number of pages, and cost of the book. Reviews should run no longer than 650–700 words and should be E-mailed to runmuki@yahoo.com.*

Available Exclusively from IWRC



* An essential rehabilitation tool
* A handy reference manual
* Organized by species
* A great price!

Body Weights of 686 Species of North American Birds

by John B. Dunning Jr, Ph.D.

Knowing the normal weight of an animal is essential when assessing body condition. Dr. Dunning has kindly allowed IWRC to reprint this monograph, originally published by the Western Bird Banding Association. Standard and normal ranges are provided by species. An invaluable resource tool for anyone who works with birds. Just $10 (plus shipping and handling).

This title may be purchased through the Online Store at www.iwrc-online.org, or contact IWRC for an order form.

International Wildlife Rehabilitation Council
P.O. Box 8187
San Jose, CA 95155
USA
Tel: 408/271-2685 Fax: 408/271-9285

Baja California Easement Benefits Whales, Other Wildlife

In October 2005, members of the Mexican land collective Ejido Luis Echeverría agreed to limit development on their property in exchange for a $25,000 annual payment to be used as seed money for low-impact development projects. The agreement protects 120,000 acres along the shores of Laguna San Ignacio in Baja California Sur. It is the first time local residents have had a say about this sparsely settled and biologically wealthy stretch of the Baja California peninsula.

Although private easements are common in many parts of the world, they are a relatively recent phenomenon in Mexico. The agreement creates a conservation easement that covers 80% of the *ejido's* territory. Eventually, the remaining 20% of the *ejido* will be protected under a second agreement that will give members a one-time payment of $545,000.

A broad range of migratory birds and other wildlife thrives in the region; however, the grey whale (*eschrichtius robustus*) was the focus of conservation campaigns. The whales travel more than 6000 miles annually between their feeding grounds in the Arctic Ocean to three warm-water lagoons on the Baja California coast, of which Laguna San Ignacio is the smallest and least disturbed. JWR

Siberian Tigers Holding Steady

The first Siberian tiger (*Panthera tigris altaica*) census in far eastern Russia in almost a decade found that—instead of the expected decreasing population—the numbers remain constant at approximately 334–417 adults and 97–112 cubs.

The count, held in winter 2005, was led by the New York–based Wildlife Conservation Society. It involved 1000 people searching for the tigers' massive footprints across nearly 70,000 square miles over a period of several months.

Two factors may account for the steady population. The improved Russian economy has created less pressure on hunters to poach the tigers for their pelts and body parts. Also, there were more and better-trained trackers hunting the elusive big cats.

The Siberian tiger, also know as the Amur, lives primarily in the coniferous, scrub oak, and birch woodlands of eastern Russia. A few can be found in northeastern China and northern North Korea. About 490 captive Siberian tigers are managed in zoo conservation programs. JWR

In Africa, a New Monkey

In May 2005 the journal *Science* published reports of a new monkey species, the highland mangabey (*Lophocebus kipunji*), that has been discovered in the mountains of southern Tanzania.

The primate was identified by two independent research teams working more than 230 miles apart. Fewer than 1000 of the monkeys exist; it is expected that, following a formal census, the monkey will be placed on the World Conservation Union's "critically endangered" list.

The highland mangabey stands 90 cm (3 ft) tall and has a tail of the same length. Except for its furry off-white belly and tail, the monkey is covered in thick, brown fur that is well suited to its frequently below-freezing mountain habitat. Adult monkeys give a loud, low-pitched "honk-bark" that is significantly different from calls made by other primates.

The tree-dwelling highland mangabey is the first new monkey species to be discovered in Africa in 20 years. JWR

Yellowstone Grizzlies May Come Off Endangered List

Claiming that the greater Yellowstone population of grizzly bears has recovered and no longer needs



ENDANGERED SIBERIAN TIGER (*PANTHERA TIGRIS ALTAICA*) AT THE PHILADELPHIA ZOO, PENNSYLVANIA PHOTO: JOHN AND KAREN HOLLINGSWORTH/USFWS

The primarily nocturnal grizzly bear weighs 400–500 lbs; coloring ranges from blond to deep brown or black. Despite their size, grizzlies run as fast as 35 mph. Omnivores, they feed on a variety of plants and berries as well as fish, insects, and small mammals; in preparation for winter's hibernation they gain hundreds of pounds of fat. Normally solitary, grizzly congregate alongside streams and rivers during the salmon spawn. Every other year females give birth to 1–4 young, which weigh only ~ 1 lb at birth.



GRIZZLY BEAR (*URSUS ARCTOS HORRIBILIS*) IN YELLOWSTONE NATIONAL PARK PHOTO: TERRY TOLLEFSBO/USFWS

protection under the Endangered Species Act, in November 2005 the U.S. Fish and Wildlife Service proposed removing the bears from the list of threatened and endangered species.

Four other grizzly populations in the lower 48 states will remain protected under the Act.

At least 50,000 grizzly bears (*Ursus arctos horribilis*) once roamed the western U.S., but loss of habitat and high mortality from conflict with humans drove them nearly to extinction. When the species was listed in 1975, just 136 individuals were still alive. Today an estimated 580–600 grizzlies inhabit the Yellowstone ecosystem.

Since the mid-1990s, the Yellowstone population has grown at a rate of 4–7% per year. Grizzlies have occupied 48% more habitat since they were listed, and biologists have sighted bears more than 96.5 km (60 miles) from what was once believed to be the outer limits of their range.

Some conservation groups, including the National Wildlife Federation, support the USFWS proposal. However, others, including the Natural Resources Defense Council, oppose it, claiming it would allow the bears to be hunted, and would open protected habitat to large-scale development, oil and gas drilling, logging, and road building. In the process, bear-human conflict would increase.

The proposal has been published in the Federal Register (http://mountain-prairie.fws.gov/species/mammals/grizzly/2yellowstone.htm). Comments may be submitted, by 15 February 2006, to: Grizzly Bear Recovery Coordinator, USFWS, University Hall 309, University of Montana, Missoula, MT 59812, or via E-mail, to FW6_grizzly_yellowstone@fws.gov. JWR

Songbird Returns to California's Central Valley

In June 2005 a pair of the least Bell's vireo (*Vireo bellii pusillus*) and their nestlings were found in California's Central Valley after an absence of more than 60 years.

Once widespread in the region, the least Bell's vireo was listed as endangered in 1986, when only an estimated 300 remained, its riparian habitat sacrificed to development and agriculture. Today about 90% of the valley's riverside vegetation is gone.

The birds were found at the San Joaquin River National Wildlife Refuge, former ranchland purchased by the USFWS as part of its efforts to restore habitat for species listed under the Endangered Species Act.

The vireo was recognized by its distinctive song. It is the second species to rebound at the refuge: the Aleutian Canada goose (*Branta canadensis leucopareia*) recovered from the brink of extinction after it began wintering there. JWR

USFWS Releases DVD Tour

To mark the 100th anniversary of the National Wildlife Refuge System in 2005, the USFWS has released *America's Wildest Places*, the first volume in an occasional series of video tours of U.S. refuges.

The DVD features Arkansas and Matagorda Island National Wildlife Refuges in Texas (home to white whooping cranes), North Carolina's Pocosin Lakes National Wildlife Refuge (home to the endangered red wolf), and Alaska brown bears at Kenai National Wildlife Refuge. Five additional refuges are included.

The DVD costs $6, plus $2.50 shipping and handling. Each order includes the *National Wildlife Refuge System Visitor Guide*. To order visit http://training.fws.gov/refugedvd/ or call 304/876-7692. JWR

USFWS List of Species to Which MBTA Does Not Apply

The USFWS has published a list of the 125 nonnative bird species to which the Migratory Bird Treaty Act (MBTA) does not apply, as required by the Migratory Bird Treaty Reform Act (MBTRA) of 2004. The MBTRA amends the MBTA by stating that it applies only to migratory bird species that are native to the U.S. or its territories, and that a native migratory bird is one that is present as a result of natural biological or ecological processes. This list identifies species that are not protected by the MBTA, even though they belong to biological families referred to in treaties that the MBTA implements, as their presence in the U.S. and its territories is solely the result of intentional or unintentional human-assisted introductions.

This list includes all nonnative, human-assisted species that belong to any of the families referred to in the treaties and whose occurrences in the U.S. and its territories have been documented in the scientific literature. The appearance of a species on this list does not preclude its addition to the list of migratory birds protected by the MBTA (50 CFR 10.13) at a later date.

The MBTA also does not apply to many other bird species, including nonnative species that have not been introduced into the U.S. or its territories, and species that belong to the families not referred to in any of the four treaties underlying the MBTA.

To view the list, visit http://www.migratorybirds.fws.gov. JWR

U.S. Takes First Steps to Encourage Green Farming

In 2005 the U.S. government will pay $24 billion in farm subsidies, most of them for corn, cotton, and other surpluses. Under the United States Department of Agriculture's Conservation Security Program, established in 2002, 1% of this will go to farmers who have helped protect the environment in the past—and who are currently preventing fertilizer from running into streams and are conserving soil and minimizing the use of pesticides.

Farmers can earn additional payments by providing wildlife habitat and protecting streams and groundwater. JWR

EU's New Agricultural Policy

In January 2005 the European Union implemented a new, environment-centered agricultural policy that gives subsidies to farming practices that result in public benefits (e.g., cleaner water, increased wildlife habitat, a more attractive landscape) rather than to support the overproduction of wheat, milk, or beef.

The change in policy is partly due to international pressure to end EU subsidies to farmers, which critics say undermine free trade, and partly the result of a growing concern with the way large-scale agriculture destroys land and alters the landscape.

Government payments account for about 15% of all farm income in Europe. JWR



Do you have an easy answer to a frustrating rehab issue? A new way to resolve a common problem?

Share it!

Please send your "Simple Solution" to the Editor at runmuki@yahoo.com. If possible and appropriate, include high-resolution digital images, as well as a brief note about yourself.

DITTO A REPRODUCIBLE PUBLIC SERVICE ANNOUNCEMENT

What should I do if I find a baby bird?

BE AWARE OF THE FOLLOWING:

- Under the Federal Migratory Bird Treaty Act and state law, it is illegal for anyone to injure or possess an indigenous bird without a permit. Introduced species such as English sparrows, European starlings, and common rock pigeons are excluded.
- An injured animal requires immediate specialized care. Any delay reduces their chances of recovery.
- Most veterinarians do not have time, special facilities, or experience to handle injured wildlife.
- Birds learn to fly *before* they learn to find food. They rely on their parents for about two weeks (or longer) after leaving the nest.
- Cats and dogs destroy many young animals that are just beginning to try life out on their own.
- You can find a permitted rehabilitator in your area by contacting the regional U.S. Fish and Wildlife Service or your local wildlife warden.

IF A YOUNG ANIMAL IS NOT INJURED:

- Be sure the area is free of other animals that can cause harm and keep pets indoors. Leave the youngster alone.
- If a baby bird is on the ground, carefully return it to the nest or into a nearby bush
- If a bird's original nest is destroyed, place the baby in a berry basket or plastic cup (with drainage) and put it near the nest site.
- It's a good idea to watch for the parent from a discreet distance. If one does not go to the baby in an hour, take it to your wildlife rehabilitation center.

IF THE ANIMAL IS INJURED:

- Place animal on a towel, cloth, or shredded paper in a cardboard box that's just the "right size," and close it. Put box in a dark quiet place until help can be found.
- ***Do not offer food or drink.***

Wildlife rehabilitation centers are volunteer based. We appreciate your help with the transportation of injured animals to our facilities. Donations are also welcome.

Thank you for your help!

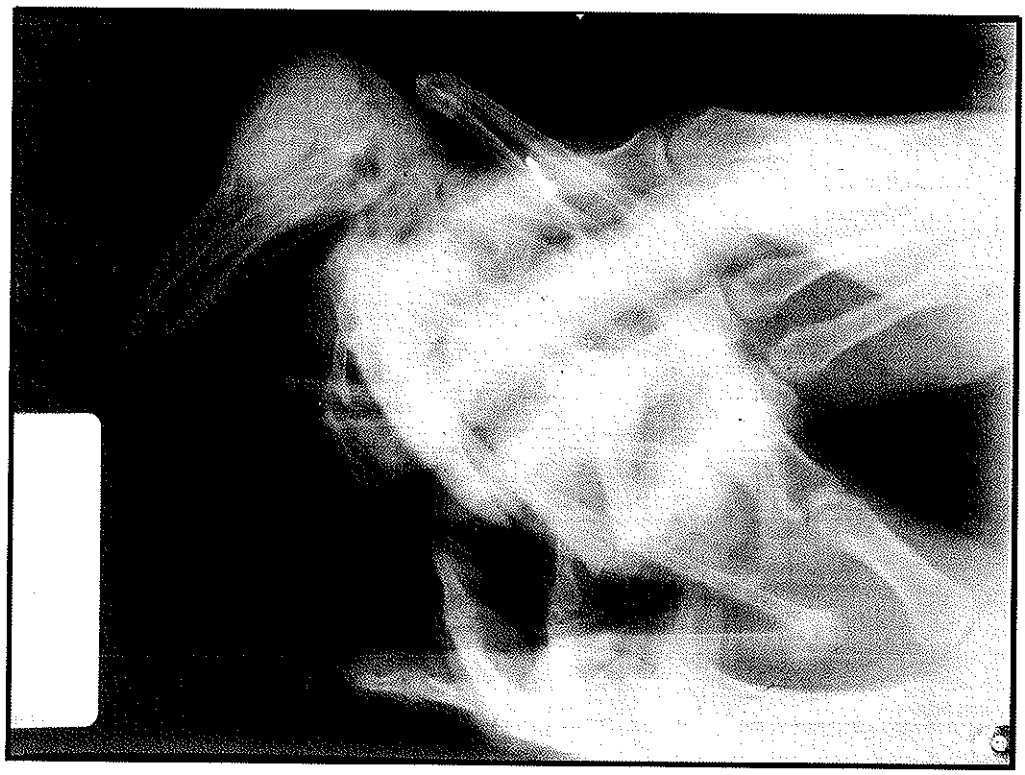
(This space for your organization's name, address, website, and phone number.)



Ditto adapted from an information sheet created by the Raptor Education Group Inc., Antigo, Wisconsin

TAIL END

by Penny Elliston



Radiographers unfamiliar with the concept!

INSTRUCTIONS FOR AUTHORS

POLICY Original manuscripts concerning any aspect of wildlife rehabilitation are welcome. Articles on topics including administration, law, education, veterinary medicine, animal husbandry, and public relations as they relate to wildlife rehabilitation are all invited. Book reviews are also welcome. Submissions are not confined to the North American continent.

Associate editors and anonymous reviewers judge each submitted manuscript on appropriate subject matter, originality, accuracy, conciseness, clarity, and contribution to existing literature. Concurrent submission to other peer-reviewed journals may preclude publication in the *Journal of Wildlife Rehabilitation* (JWR). IWRC retains copyright on all original articles published in JWR, but will grant permission to reprint articles upon request, with credit given to IWRC.

MANUSCRIPT Copy should be typewritten and double-spaced. Include the name of each author, addresses, phone numbers, e-mail addresses, a one-paragraph biography for each author, an abstract, and several keywords. Templates have been developed for the following categories of submissions: Species paper (i.e., rehabilitation notes), case study, technique, research paper, and review; authors may request a copy of one or all of these templates from the Editor or the IWRC office before developing work for submission in JWR.

SUBMISSIONS All submissions should be accompanied by a cover letter stating the intent of the author(s) to submit the manuscript exclusively for publication in JWR. Double space throughout, with one-inch margins. The author(s) should keep at least one copy of the manuscript.

ELECTRONIC SUBMISSIONS Electronic submissions (PC or Macintosh platforms) are preferred but not required. The manuscript should be attached to the submission letter and sent to ALL of the following:

Marianne Skoczek, Editor
runmuki@earthlink.net

Elizabeth Penn Elliston, Publications Committee Chair
epe@nmia.com

IWRC Office
office@iwrc-online.org

HARD COPY SUBMISSIONS In the top left corner of page 1, type the name and complete address, including e-mail, of the person who is to receive editorial correspondence. On succeeding pages, type the primary author's last name in the top left corner, and the page number in the top right corner. Use a high-quality white paper and submit four photocopies to:

Marianne Skoczek, Editor
Journal of Wildlife Rehabilitation
720 Robin Place, Davis, CA 95616
USA

STYLE Citations should be noted within the body of the manuscript with the last name of the author and the year published (with one space between—no comma) using the following format: single author (Smith 1959); two authors (Smith and Jones 1979); more than two authors (Smith et al. 1989). A complete list of literature cited should be included at the end of the manuscript in alphabetical order, beginning with the last name of the first author. (Citations with more than two authors may list all authors names in the References section.) Please use sentence- style capitalization throughout the citation (mixed case). Provide complete citation information, including date; title; issue, volume, and page numbers of journal articles; and place of publication and publisher of books. Tables and illustrations must be self-explanatory and reference to them included in the text. The first use of a common species name should be followed by scientific names in parentheses (i.e., The appearance of the American robin (*Turdus migratorius)* does not always coincide with the beginning of spring.). Use metric units of measure followed by English/U.S. units in parentheses. If trade names are used, indicate if the product is trademarked or registered and list any products cited along with generic equivalents, when available, at the end of the article. Please provide full address (including zip code) of the product manufacturers.

ABSTRACT, KEYWORDS Manuscripts require an abstract of about one typed line per typed page of text. Place keywords below the abstract.

TABLES Start each table on a separate page and continue long tables onto two or more pages. Double-space throughout and leave margins of at least one inch. Annotate abbreviations.

PHOTOGRAPHS JWR publishes high-quality black and white photographs, as available. Color slides and prints are acceptable, however, all images will appear in black and white only. Type captions on a separate page, in paragraph form, along with photographer credits. Photos should be unmounted, sharply focused, and have a good tonal range. Electronic images should be medium or high resolution (minimum 300 ppi) and should be saved as .JPG or .TIFF files. To facilitate e-mailing, files should be saved as greyscales. Files should be e-mailed to the Editor at runmuki@earthlink.net. They may be compressed with StuffIt or a similar program.

ILLUSTRATIONS Illustrations should be clear and well defined, and should be drawn in black, grey, and white only. Illustrations may be submitted on paper or electronically as .EPS or .TIFF files. Please note whether the electronic illustration was created in Illustrator® or another program. Electronic files should be e-mailed to the Editor at runmuki@earthlink.net.

INTERNATIONAL WILDLIFE
REHABILITATION COUNCIL
(IWRC)
P. O. Box 8187
San Jose, CA 95155, USA

NONPROFIT ORG.
U.S. POSTAGE
P A I D
JEFFERSON CITY, MO
PERMIT NO. 210