JOURNAL OF

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IN THIS ISSUE

Bot fly infestation of rodents and lagomorphs ... A case of syndactylism in a buzzard ... Survival, fates, and success of transplanted beavers in Wyoming ... The value of uniformly collected information on rehabilitation cases ... MacDiet revised ... Antimicrobial resistance ... Selected abstracts ...

## 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: Larvae of *Cuterebra* bot flies infest many species of rodents (such as this eastern gray squirrel) and lagomorphs throughout North America. These parasites can be removed from their host without general anesthesia or surgery by pulling them out with forceps. [see page 7; photo: F. Slansky and L. R. Kenyon]

BELOW: Beaver dams create habitats that are rich mosaics of diversity that are beneficial hydrologicaly, biologically, and socially. [see page 17; photo: USFWS/Luther C. Goldman]




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# JOURNAL OF WILDLIFE REHABILITATION

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EDITORIAL

# The Value of Uniformly Collected Information on Rehabilitation Cases

On "September 23, 1999, NASA's Mars Climate Orbiter was lost, due to a lack of unit conversion from metric to English. Contact was then lost in December with Climate Orbiter's sister ship, Mars Polar Lander, as it neared the planet."[1] The computer didn't know that the data were incompatible, and it wasn't instructed to convert it. You can bet that the engineers knew that they should all be talking in the same language, and you can bet that NASA won't do such a "stupid" thing again. Why use such a harsh word? Well sometimes, like in the case of the missing space craft, you have to stop hiding behind your mistakes and change.

I recently reviewed a stack of scientific papers on global warming and had to convert tons of $CO_2$ to teragrams of $CO_2$ (1 million tons /1 Tg) in order to compare the results. What a pain. While writing a ten-page review article on genetically modified plants, I had to convert half of the data from acres to hectares (2.47 acres/hectare) in order to compare hazards. And while preparing a talk on the oil spills of the first Gulf War, I had to equate barrels of oil (one barrel of oil = 44 gallons) spilled by Sadam Heusin with gallons of oil spilled in the Gulf of Mexico. Without the comparison between Gulf War spill and the Gulf of Mexico spill I couldn't predict the down time for the ecosystem.

I sometimes think that people pick and choose their units of measurement in order to make their data more impressive. For example, the use of standard error of the mean SEM as opposed to standard deviation SD. Both are legitimate statistical expressions used to express levels of confidence for data. But when the data is all over the place as it frequently is using human experimental subjects, SEM is the unit of choice. This is because SD may illustrate that there is very little difference between experimental groups. The standard error of the mean tells you how much the data deviates from the deviation. It is almost double talk but is often the only way to tease significance out of the experiment.

So? What's the point? Do we believe we can gain anything by publishing wildlife rehabilitation data if we don't standardize our terms? We all need to be on the same page so that we can understand each other. Who is going to tell the difference between a release rate of 50% for treatment "A" and a release rate of 50% for treatment "B" when nobody tells us that treatment "A" data are for animals that survived the first four days in rehab, and treatment "B" included all the animals from the moment they were received? By the time you sort out the nonconformities you might just as well write the article yourself. What a pain.

Good science writing requires as much critical thinking as good scientific reading. We must do our best to collect information on more than one animal or one treatment or one season. You can't even get an average from one. When we collect weights and measures, we need to be doing it all at the same time in the patients treatment plan. What do we mean when we say, "It seemed to work better"? What does "It gained weight" mean? Does the statement "It ate well" tell us enough? We will all benefit from even the smallest amount of real data and the animals we see next year will benefit an enormous amount if we all make real measurements using the same units and then share them with the whole community.

**—Joe Watson**
*Volunteer, Lindsay Wildlife Museum, Walnut Creek, California*

**References:**

[1]Jon Lucksinger. Anniversaries. *StarDate* Jan/Feb 2004, p.15.

# On Wildlife Law and Native American Feather Use, Aspergillosis

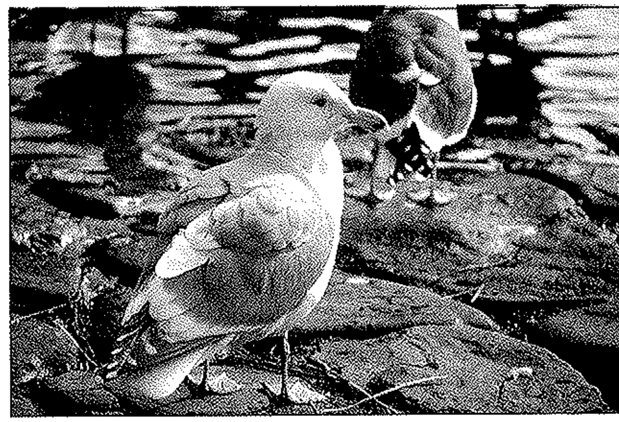
To the Editor,

"Native American Use of Bird Species for Ceremonial Purposes: Can Wildlife Rehabilitators Legally Address the Need?" by Janelle Harden (Journal of Wildlife Rehabilitation, 26.2) clearly points out how wildlife law is typically a series of boxes that go on and on, attempting to explain which activities are allowed and which are prohibited. Being involved with law enforcement, permits, biological specimens, scientific collecting, and so forth, one often finds oneself so confined within these boxes that one cannot perform in a logical day-to-day, pragmatic fashion.

For example, the paper refers at one point to disposition of carcasses held by rehabilitators. Instead of trying specifically to describe the disposition of carcasses, why does the law instead not build in some latitude that takes into consideration local needs and unique situations?

In the 1970s, we a special situation in New Mexico and other Southwestern states concerning commerce between Native American craftsmen and non-Indian customers. A lot of plain-old hard work went on to change the practice of using protected bird feathers on such items as kachina dolls, peyote fans, headdresses, etc. This work included meeting with Native American craftsmen, writing letters to the tribes, explaining which feathers were protected, and prosecuting those who didn't seem to get the message.

In conjunction with this effort was our recognition of the legitimate need by Native Americans for feathers for religious purposes. So we did a little "horse trading." We receipted thousands of feathers to the tribes with the understanding that they could not be used in association with commercial trade and that they could only be used for religious purposes. This was done as an action of good faith on our part.



GLAUCOUS-WINGED GULL ~ USFWS/LEE KARNEY

The 70s were the 70s, and today is today. But ask me today how I would deal with the question, and I would probably give you a 70s answer. I would receipt feathers to the tribes just as I did in then, either from the state or the Fish and Wildlife Service, directly to the religious heads of the tribes with minimal formality. I would tell the rehabilitators that all feathers in their possession are the property of the state, and I would gather the feathers periodically for dispersal to the tribes. Any feathers that were held (for some obscure reason) outside my control would be destroyed in accordance with law.

Wildlife law usually does a poor job when it comes to dealing with legitimate exceptions. The administrator has two good options: (1) write simpler laws, and (2) deal with exceptions at a more fundamental legal level (i.e., these agencies have the power to "manage"; they have the power to "receipt" wildlife to people for legitimate purposes).

The administrator also has a poor third option, and that is to construct more little boxes that try to explain what can and cannot be done when it comes to the issuing of wildlife parts and who can have them and for what purposes. My guess is that this option will be the one that is pursued.

BALD EAGLE ~ USFWS/MIKE LOCKART

—**Jim Vaught**
*Assistant Director (Retired)
New Mexico Department of Game and Fish*

To the Editor,

The Fact Sheet, *Rehabilitation Notebook: Aspergillosis* (*Journal of Wildlife Rehabilitation*, 26.2) was an interesting summary, but left out an important fact. It is common knowledge that debilitated birds and animals, especially those on antibiotic and corticosteroid therapy are easily infected by opportunists such as *Aspergillus fumigatus*. Sick, unambu-latory animals in confined spaces are at high risk of succumbing to a fatal infection.

—**Karen Scheuermann, MPH**
*Volunteer, Shasta Wildlife Rescue & Rehabilitation, Inc., Shasta County, California; Public Health Microbiologist*

**To Our Readers,**

***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.)***

# A Case of Syndactylism or Webfoot in a Buzzard (*Buteo buteo*)

**by Dorota Rozanska, Aleksandra Sobczynska-Rak, Andrzej Cwiek, and Ireneusz Balicki**

**ABSTRACT:** Syndactylism or *syndactyly* is the partial or complete fusion or nondivision of one or more functional digits. There is no documented evidence of syndactyly in birds of prey. This article describes a case of syndactylism noted in an emaciated juvenile male buzzard (*Buteo buteo*) brought to the Department and Clinic of Animal Surgery at the Agricultural University in Lublin (Poland). Upon examination, abnormalities in both pelvic limbs were observed: the inter-digital webs of toes 3 and 4 were fused, as were the dorsal sheaths of the talons. The authors discuss the surgical separation of the fused toes and talons and the bird's recovery. The article also considers the possibilities of hereditary and teratogenic influences in the development of syndactyly in birds of prey, and examines whether the condition is life threatening consequent to the inability to hunt and ingest food in a normal manner.

**KEY WORDS:** syndactylism, syndactyly, webfoot, buzzard, birds of prey, *Buteo buteo*

**DOROTA ROZANSKA** completed her studies with the Faculty of Veterinary Medicine at the Agricultural University in Lublin (Poland) in 2000. Since then, she has worked in the univeristy's Department and Clinic of Animal Surgery, where she specializes in anesthesiology of small animals, surgery, and rehabilitation of birds, and conducts research on avian anesthesia and on new methods of osteosynthesis in avian orthopedics.

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*J. Wildlife Rehab.* 26(3): 4–7


## Introduction

The partial or complete fusion or nondivision of one or more functional digits is described as syndactylism or webfoot (Leipold 1969; Hollander 1969). The condition is seldom noted in birds. Reports in the literature describe it only in poultry (Deleanu 1964; Hollander 1969; Landauer 1954) and pigeons (Hollander 1969). Webfoot has been observed in Holstein cattle (Leipold 1969), Holstein-Friesian cattle (Leipold 1972), a neonatal lamb (Dennis 1970), a pig (Leipold 1972), a dog (Richardson 1994), a mouse (Chaudhry 2001), a deer (Rollor 1993), and a rhesus monkey (Primack 1972). In humans, syndactyly is often only one of a complex of symptoms in a syndrome (e.g., Poland's syndrome [Kramer 1998, Slezak 2000], Silver-Russel syndrome [Keppen 1983], or Apert's syndrome [Ashmead 1995, Meyer 1981]. Cenani-Lenz syndactyly also occurs in humans [Elcioglu 1997, Seven 2000]).

The toes of buzzards and other birds of prey are normally devoid of webbing. Partial webbing or even syndactylism is normal in some Coraciiformes such as kingfishers, in which toes 3 and 4 are closely joined. Waterfowl typically have complete webbing (Hollander 1969). In most birds, toe 1 is turned back and opposed to the other toes, which are front-facing. The claws, or talons, are medially decurved and mucronate. Designed for capturing and puncturing prey, the normal function of talons and toes of predatory birds is critical to efficient hunting.

This study presents a case of syndactylism in a buzzard, and describes the surgical treatment of a condition that is life threatening to a bird of prey. The possible causes of webfoot in buzzards are also discussed.

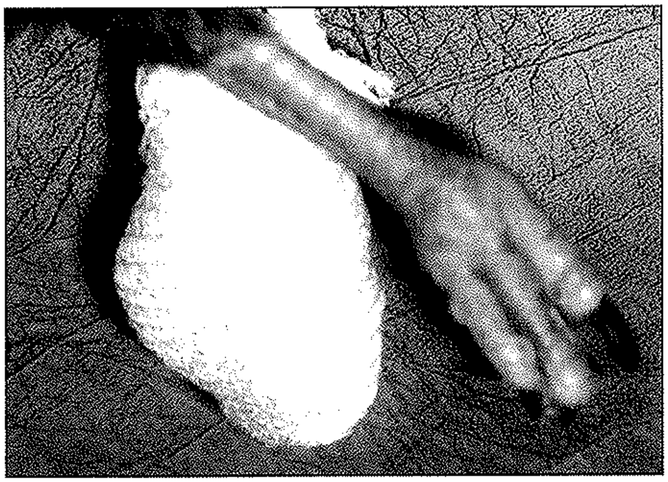
## Case Report

A juvenile male buzzard (*Buteo buteo*) was brought to the clinic of the Department of Animal Surgery of the Agricultural University in Lublin (Poland). The buzzard had been living in the wild and was found on the ground. The bird was highly stressed, weak, and emaciated. Aside from these symptoms, the presentation was unremarkable. However, it was noted that claws and toes 3 and 4 of both pelvic limbs were connected. This connection involved the skin of the interdigital web and the dorsal laminae of the talons. The toes were found to have the correct number of segments, and articulation was also normal. The patient did not show any other phenotypic abnormalities. The buzzard was kept confined in the clinic to facilitate weight gain. Its appetite increased, and after one week, it was decided that the bird was in acceptable condition for surgery.

The bird was presurgically fasted. It was anesthetized using xylazine (2 mg/kg) and ketamine (5 mg/kg) administered intravenously. The surgical field was cleaned and prepared aseptically. The dorsal laminae of the fused claws and the interdigital webs were separated by cutting. A blood vessel in the middle of the webs between the toes was ligated and cut. The skin was sutured with a single interrupted suture. After the operation, the wounds were cleaned and covered with dressings. The dressings were changed daily until the sutures were removed. Within a few hours of surgery, the bird's posture was normal and the toes were positioned typically for its species. Ten days after the operation, the skin sutures were removed. The bird's ability to catch and to kill prey with the repaired talons was observed to be satisfactory, and all aspects of prey capture and dispatch appeared normal. After a further 2 weeks of observation and convalescence, the fully recovered buzzard regained its freedom.

## Discussion

The bird discussed in this study was malnourished upon admission, probably because it could not properly catch and pierce prey due to the fusion of toes 3 and 4 of



PHOTOS: DOROTA ROZANSKA

Figure 1. Syndactylism of toes 3 and 4 in a buzzard (*Buteo buteo*).

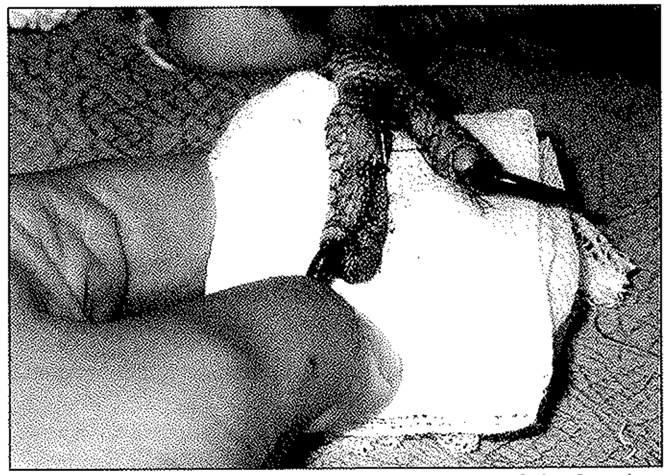


Figure 2. The surgical wound after separation of the fused toes.

Figure 3. Protective dressing on repaired toes.

both pelvic limbs. *Buteo buteo* capture and eat a wide variety of live prey in the wild, including rabbits, rodents, reptiles, insects, and birds (Sauer 1984, Sokolowski 1992). Although they opportunistically eat carrion and do not rely entirely on the ability to seize live prey, it is doubtful that a buzzard could subsist solely on carrion in the wild.

In Poland, *Buteo buteo* hatch through the months of May and June and fledge within about 40 days, typically in late June. Parent birds continue to feed the juveniles for a few weeks after fledging. In August, when wandering begins, the family disperses. Young birds fly away from the family territory, or wander south. Adult birds usually stay in central Europe, and often spend the winter in their territory (Sauer 1984).

The period following family dispersal can be difficult even for anatomically normal juvenile birds, and starvation due to scarce prey, suboptimal hunting skills, competition, and other factors is not uncommon. If this bird was at all disadvantaged by its abnormalities, its survival in the already-precarious first year would be all the less certain. It is possible that the young bird in this study developed normally while being fed by its parents, but that it could not reliably capture food when parental care ended. Because of its eventual poor condition, it avoided certain death when it was rescued by the finder in late August.

No cases of syndactyly in a buzzard or other bird of prey have been reported in the literature. It might be assumed that the incidence of webfoot in buzzards compared to, for example, cattle is very low (Gruneberg 1968, Leipold 1969). Obviously, domestic animals are highly inbred, and hereditary abnormalities do occur at higher frequencies in such animals than in outbreeding wild populations. On the other hand, it is possible that syndactyly occurs in buzzards at a higher frequency than is observed, since presumably the great majority of such birds would neither survive nor be discovered by humans.

Hereditary syndactyly has been observed in humans and cattle (Leipold 1969, Huston 1961), and congenital syndactyly of unknown etiology has been reported in a pig, deer, dog, mouse, and sheep (Dennis 1970). It is impossible to know whether the condition is hereditary in buzzards, as the described case is the only one known. Hollander and Brumbaugh researched the possibility of inheritance of syndactylism in fowl (Hollander 1969). They proved that webfoot appears in about 60% of offspring from two parents affected with syndactyly. They also showed that syndactyly observed in poultry always, as it does in this case, involves toes 3 and 4.

It has been reported that syndactyly of toes 3 and 4 may be the result of teratogenic effects of environmental factors on avian embryos. Landauer found that injection of 3 mg of pilocarpine into the yolk sac of 4-day embryos causes syndactyly in about 16% of treated embryos (Landauer 1954). Deleanu and Menkes reported that injection of 6 gamma of Janus green into the amnion of Rhode Island red chickens at 6.5 days causes syndactyly in 100% of embryos. It is not known why, in birds, toes 3 and 4 are principally predisposed to fuse in both teratogenic and hereditary conditions. Hollander and Brumbaugh suggest that there may exist some homologous relation with wing development, where digits 3 and 4 normally remain attached (Hollander 1969).

If this form of syndactyly in buzzards is inherited, it would almost certainly have to be the result of a recessive mutation. If it were a dominant mutation, it is likely that birds with webfoot would die before they reached sexual maturity and were able to reproduce, so those birds would not be able to transfer the trait to their offspring. The other possibility is that this condition in a bird of prey has teratogenic origins. Reported increases in environmental pollution are consistent with this hypothesis. As early as 1971 it was known that mercuric salts have an embryopathic effect on fetuses of golden hamsters, causing a small number of miscellaneous abnormalities including syndactylism (Gale 1971). In the vincinity of Lublin, Poland, the level of contamination with heavy metals is higher in wild animals than in farm animals. The possible cause may be perennial usage of mercuric mortars and intensive mineral fertilization of arable lands (Kolacz 1996). Even though no other cases of webfoot in buzzards or other birds of prey have been reported, it is possible that such abnormalities are the result of progressive contamination of the environment and embryopathic influence of this pollution on avian embryos.

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# *Cuterebra* Bot Fly Infestation of Rodents and Lagomorphs

by Frank Slansky and Lou Rea Kenyon

**ABSTRACT:** Some 50 species of rodents and 10 species of lagomorphs serve as the typical hosts for the parasitic larvae (bots) of more than 30 species of *Cuterebra* bot or warble flies throughout North America. Other mammals—including humans—occasionally are infested. Exposure occurs upon contact with *Cuterebra* eggs on twigs, foliage and other substrates. An animal's body heat causes the eggs to hatch rapidly; larvae transfer to the host and develop in large, fluid-draining lumps (warbles) in their host's skin.

This article provides information about *Cuterebra* behavior and ecology relevant to their infestation of wildlife, the clinical signs of infestation, effects on the hosts, and treatment methods. The important contributions wildlife rehabilitators are making to understanding these parasite/host associations and to improving diagnosis of afflicted wildlife are also described.

**KEY WORDS:** bot flies, *Cuterebra*, *Dermatobia*, myiasis, parasite, warble

**FRANK SLANSKY** has a Ph.D. in entomology. Since 1980 he has been a professor at the University of Florida in Gainesville, where he teaches and performs research in insect ecology.

**LOU REA KENYON**, a retired school nurse practitioner with a B.S. and graduate education in nursing, has more than 20 years of experience as a mammal rehabilitator and educator. Her research has led to the successful use of cecotropes as a probiotic to avoid weaning-onset diarrhea in infant cottontails (see http://www.squirrelworld.com/RabRehab.html). She is the author of *Basic and Advanced Squirrel Rehabilitation* (2001).

*J. Wildlife Rehab.* 26(3): 7–16


## Introduction

Wildlife rehabilitators often cope with various diseases and parasites affecting the animals they nurture and medically treat (Miller 2001, Samuel et al. 2001, Williams and Barker 2001). Arthropods comprise a key group of parasites that frequently infest wildlife, and include ticks, mites, fleas, lice, and flies (Wall and Shearer 1997). Infestation of living animals by the larvae of flies (a phenomenon termed "myiasis"; Wall and Shearer 1997; Catts and Mullen 2002, 317–48) can be especially insidious, as many rehabilitators are well aware. For example, the larvae (maggots) of blow flies can penetrate deep within an animal's orifices and wounds, making them difficult to extract, often with fatal consequences. This article focuses on another group of parasitic flies, namely those in the genus *Cuterebra*, variously called bot flies (after the larvae, or "bots"), warble flies (based on the lump or "warble" created by a larva living under its host's skin), and "wolves" (the relevance of this term is obscure).

The more than 30 species of this genus in North America parasitize some 60 species of mammals, including tree squirrels, rabbits, raccoons, and other commonly rehabilitated animals (Sabrosky 1986). Thus, the goal of this article is to provide wildlife rehabilitators with information relevant to these parasites' infestation of the animals receiving their care. Much of the published literature on the biology of *Cuterebra* is summarized, especially in regard to the clinical signs and diagnosis of infestation, and how host animals become parasitized. The effects of *Cuterebra* larvae on their hosts and treatment methods are also described. Finally, this article discusses the contributions wildlife rehabilitators are making to research on bot flies, and the significance of this work, in terms of answering basic ecological questions, its practical applications, and monitoring the impact of environmental changes.

## Clinical Signs and Diagnosis

*General description of infestation* The larvae (Figure 1) of *Cuterebra* flies live as subcutaneous parasites, creating fluid-draining warbles on their mammalian hosts (Figure 2; Slansky and Kenyon 2001a). A warble begins as a small wound created by a larva cutting through an animal's skin from the underside (Figure 3), and it becomes a localized circular or oblong swelling that increases in size (up to about 38 mm [1.5 in] long by 25 mm [1 in] wide) as the larva within it grows and the host's tissues react to the parasite's presence (Cogley 1991). There is usually only one larva per warble, and the posterior tip of the younger (cream-colored) or older (dark brown) larva often protrudes from the hole it has made in the warble (the warble pore; Figure 4). Other than the presence of the warbles (often with the fur on and around them sloughed and scratched off), infested animals may look and behave normally if the number of larvae per host is low, but at higher levels of infestation, animals may become lethargic, especially if secondary bacterial infection is present. (See "Effects on Host Animals" below for further discussion of this topic.)

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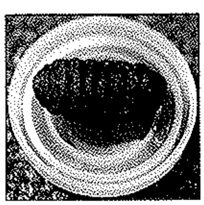


Figure 1. Nearly mature squirrel bot fly larva ("head" end to left; approximate length = 2.5 cm [1 in]).

Figure 2. Eastern gray squirrel with 2-week-old warble.

Figure 3. Newly forming warble on an eastern gray squirrel.

Figure 4. Posterior tip (arrow) of a squirrel bot fly larva protruding from the warble pore.

*Location of warbles and intensity of infestation* The location of warbles on an animal's body depends on the species of *Cuterebra* and host. For example, warbles of *Cuterebra buccata* are located primarily in the lower abdominal region of eastern cottontails (*Sylvilagus floridanus*), with some on the rib cage and shoulders, while those of *Cuterebra abdominalis* occur mostly on the throat and neck of the same host species (Sabrosky 1986). On black-tailed jackrabbits (*Lepus californicus*), the warbles of *C. jellisoni* usually are found on the face and in front of the ears (sometimes on their rump; Baird 1971). When *C. emasculator* infests eastern gray squirrels (*Sciurus carolinensis*), warbles commonly occur around the animal's neck on its shoulders, back, and chest, but they may also be found on its sides, abdomen, head, and more posteriorly on its back (Slansky and Kenyon 2000). In contrast, when this species infests eastern chipmunks (*Tamias striatus*), its warbles occur primarily in the lower abdomen, with some on the flanks and back (Bennett 1955). The number of warbles on an infested animal commonly ranges from one to three, although maximum numbers in the range of five to 10 (and occasionally more) have been reported for various host species (Figure 5; Richens 1965; Bennett 1972a; Hensley 1976; Baird 1979, 1997; Durden 1995; Crenshaw and Henke 1997; Gummer et al. 1997).

*Other lump-causing afflictions* Other arthropod parasites can cause various types of skin lesions on wildlife and these could, on gross examination, be confused with bot fly infestation (Forrester 1992, Wall and Shearer 1997). Space limitations preclude more than a brief overview here. For example, the bites of lice can cause small (up to about 6 mm [0.25 in] diameter) reddish spots that might be misdiagnosed as early stage warbles. However, infestation by the larvae of another group of flies is the arthropod-caused affliction most likely to be misdiagnosed as bot fly myiasis. The larvae of flies in the genus *Wohlfahrtia* produce warble-like lesions (usually on young animals; Eschle and Defoliart 1965; Baumgartner 1988, 3–46; Schorr and Davies 2002), but these flies are in the flesh fly family Sarcophagidae and thus are not closely related to *Cuterebra*, which are in the robust bot fly family Cuterebridae. Similar to *Cuterebra*, the posterior end of a *Wohlfahrtia* larva can protrude through the opening in the host's skin, but unlike *Cuterebra*, there often is more than one larva per lesion.

Some bacterial and viral infections can also produce skin lesions (Forrester 1992, Williams and Barker 2001). For example, *Staphylococcus* bacteria can cause abscesses, especially due to swelling and necrosis of lymph nodes. However, the non-arthropod afflictions probably most likely to be initially misdiagnosed as bot fly infestation are the various diseases caused by pox viruses, including Shope's or rabbit fibroma (fibromatosis) in cottontails and squirrel fibroma in tree squirrels (Robinson and Kerr 2001, 179–201). Pox lesions can vary from slightly raised, flattened reddish wart-like areas to substantially elevated pinkish to gray nodules that can be similar in size and shape to warbles (Figure 6; Miller 1992, 185–92; Slansky and Kenyon 2001b). These nodules can sometimes ulcerate and resemble a warble with its warble pore. However, two key characteristics generally facilitate the diagnosis of bot fly infestation: (1) the existence of the warble pore (vs. afflictions producing closed lumps), and (2) the presence of a larva within the warble, often with its posterior tip protruding slightly from the warble pore (vs. diseases producing open lumps). One must be aware, however, that after a bot fly larva fully develops and leaves its host, the warble pore takes some days to seal shut, so in this case open warbles lacking larvae (but possibly containing pus) will be present (Figure 7), and there also may be closed warbles in which the warble pore has healed before the swelling has fully subsided.

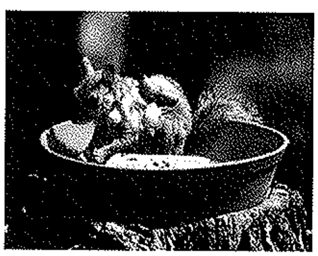
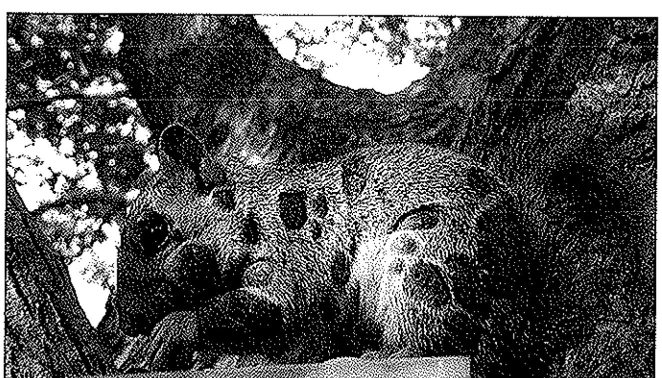


**Figure 5 (left). An eastern gray squirrel heavily infested with bot fly larvae.**

**Figure 6 (below). A Texas squirrel with fibromatosis (squirrel pox). Photo: Patricia Prewitt**



### Animal Hosts and Geographic Distribution

Approximately 50 species of rodents (including chipmunks, pocket gophers, mice, rats, tree squirrels, voles, and certain other species) and some 10 species of lagomorphs (jackrabbits, cottontails, and other rabbits) serve as the usual hosts of these parasites in North America (Sabrosky 1986). *Cuterebra* species that parasitize rodents do not normally infest rabbits and vice versa, and each species is rather specialized in its use of hosts, parasitizing only one or a few mammal species. For example, *C. emasculator* normally infests only eastern chipmunks and tree squirrels (Bennett 1955, Slansky and Kenyon 2000); *C. polita* parasitizes northern pocket gophers (*Thomomys talpoide*)

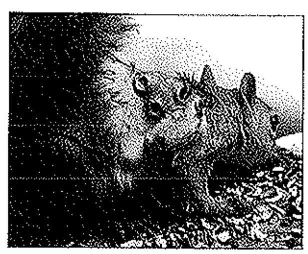


**Figure 7 (left). An eastern gray squirrel with empty warbles, from which the mature larvae have exited.**

**Figure 8 (below). Nest-bound infant eastern gray squirrel (eyes not yet opened) with a bot fly warble on its side.**

(Capelle 1970) and kangaroo rats (*Dipodomys ordii*) (Gummer et al. 1997); and eastern wood rats (*Neotoma floridana*) are the sole reported natural hosts of *C. americana* (Sabrosky 1986).

In most cases, any one host species is parasitized by only one *Cuterebra* species; one exception is the eastern cottontail, which can be infested by at least four bot fly species (Sabrosky 1986). Depending on the host species, the prevalence of parasitism may or may not differ between the sexes and between adults and juveniles (e.g., Richens 1965; Bennett 1972a; Baird 1979, 1997; Crenshaw and Henke 1997; Galindo-Leal 1997), but infestation of nest-bound infants (Figure 8) appears to be a rare occurrence (Slansky and Kenyon 2002). Some mammals that are not rodents or lagomorphs, such as raccoons, skunks, foxes, deer, cats, dogs, zoo animals kept in open-air enclosures, and even humans occasionally serve as "accidental" or "atypical" hosts, but which species of *Cuterebra* are involved in these cases has seldom been determined (Sabrosky 1986, Baird et al. 1989, Fitzgerald et al. 1996, Glass et al. 1998, Suedmeyer et al. 2000, Safdar et al. 2003). The *Wohlfahrtia* flies mentioned previously have been most commonly reported infesting captive or domesticated animals, including foxes, mink, ferrets, rabbits, cats, and dogs, as well as humans (especially babies left outdoors unprotected by insect-proof netting; Eschle and Defoliart 1965; Baumgartner 1988, 3–46). The few wild species that have thus far been found serving as hosts for these flies include mostly mammals (mice, voles, wood rats, and cottontails), but there are also a few records of birds (ducks and robins) being parasitized (Boonstra 1977, Baumgartner 1988, 3–46; Schorr and Davies 2002). The larvae of a different flesh fly (*Cistudinomyia*) causes warble-like lesions in box turtles (Gould and Georgi 1991). Finally, the warbles occurring on cattle are produced by *Hypoderma* larvae in yet another family of flies (Hypodermatidae; Wall and Shearer 1997, Colwell 2001, 46–71).

As a group, *Cuterebra* bot flies occur throughout North America from Canada to Florida and Texas. (Some species extend into Mexico and a few others are found even farther south in Central America; e.g., Manrique-Saide et al. 2000, Adler et al. 2003), but any one species has a more limited geographic distribution (Sabrosky 1986). For example, *C. emasculator* is found in most states from Minnesota and Iowa eastward and from southern Canada to Florida, whereas *C. approximata*, which infests deer mice (*Peromyscus maniculatus*), ranges from British Columbia and Washington eastward to South Dakota and southward into California and Colorado. One species (*C. cuniculi*) that infests eastern cottontails is known only from southern Georgia and Florida while another species (*C. abdominalis*) parasitizes the same host species throughout much of the midwestern and eastern U.S. (Sabrosky 1986). The *Wohlfahrtia* flies that produce lesions similar to *Cuterebra* are broadly distributed throughout the U.S. (including Alaska) and Canada.

## Infestation and Transmission

Animals become infested while moving about in their habitat and contacting *Cuterebra* eggs, which the female flies lay on foliage, twigs, exposed roots, and other habitat substrates (Figure 9), often in the vicinity of their hosts' nests (Beamer 1950, Catts 1982). As far as is known, *Cuterebra* do not lay eggs directly on their hosts, unlike other (non-*Cuterebra*) bot flies (such as those infesting horses or cattle), blow flies, and *Wohlfahrtia* flesh flies (the latter actually "lay" larvae rather than eggs; Wall and Shearer 1997, Catts and Mullen 2002). Their "off-host" egg-laying behavior apparently makes it very unlikely that a host will contact some of the eggs; consequently, the females of these species exhibit very high fecundity for insects, well exceeding 1000 eggs per female (Catts 1967, 1982; Baird 1974). Adult *Cuterebra* are large, broad-bodied flies (ranging from about 16–25 mm [0.625–1 in] long; Sabrosky 1986), but they are secretive and seldom seen in nature. For mating purposes, males of certain western species aggregate at distinctive sites such as hill tops and cliff faces, and chase after females that fly through the area (Catts 1994). There is little information on whether eastern and midwestern species behave similarly. The species differ in color from mostly all black to black and white or light yellow (Figure 10). Those that are black and yellow somewhat resemble bumblebees, but unlike the latter, these flies do not live in colonies or sting, nor do they visit flowers for nectar and pollen; in fact, adult *Cuterebra* cannot eat or bite, as they have nonfunctional mouthparts (Catts 1982).

When an animal brushes against the eggs, they hatch rapidly and the tiny (smaller than 1.6 mm [0.0625 in] long) infective-stage larvae may transfer to it and enter one of its orifices or a wound and begin their approximately week-long journey through the host's body, eventually settling under its skin (Gingrich 1981, Catts 1982). They then use their two, pointed mouth hooks (Figure 11) to make a hole in the host's hide to create the warble pore through which they respire and excrete fluid (in contrast, *Wohlfahrtia* flesh fly larvae cut through their

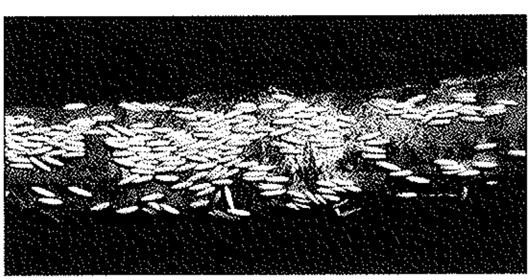


**Figure 9. *Cuterebra* bot fly eggs laid on a branch (an egg is approximately 1.5 mm long [1/16 in]). Photo: P. M. Choate, Department of Entomology & Nematology, University of Florida**

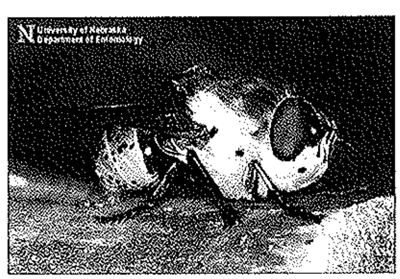


**Figure 10. Adult *Cuterebra* bot fly. Photo: J. Kalisch, Department of Entomology, University of Nebraska–Lincoln**

**Figure 11. Photomicrograph of *Cuterebra* larval mouth hooks (original magnification: 15X). Photo: F. Slansky, Department of Entomology & Nematology, University of Florida**

host's skin from the outside). A *Cuterebra* larva typically remains in the warble during its entire development, which takes from about 3–10 weeks, depending on the species of bot fly and host (Catts 1967; Baird 1971, 1972, 1997); in contrast, *Wohlfahrtia* larvae develop in fewer than 10 days; Eschle and Defoliart 1965). Thus, an infested animal typically does not transmit larvae to another animal. However, an adult female mammal returning from foraging may inadvertently bring infective-stage larvae crawling on it into its nest, resulting in infestation of its nest-bound infants (Slansky and Kenyon 2002).

After completing its development, a larva leaves the warble through the warble pore, drops to the ground, and burrows into the soil. It then forms a pupa within a hardened puparium, from which an adult fly eventually emerges (Figure 12; Bennett 1972b, Catts 1982). Depending on the *Cuterebra* species and environmental conditions, it can take from about 1–10 months (and in some cases almost 2 years) before the adult emerges. If an animal with *Cuterebra* dies, older larvae may exit the carcass and pupate, but if they are not sufficiently developed they are unable to form a pupa and will die, as they are incapable of infesting another animal to obtain nourishment for completing their development (unpublished observations of the authors).

## Seasonality

As with other features of *Cuterebra*/host associations described above, the seasonality of infestation depends on the species of fly, but the geographic location can also be an influential factor. Generally, animals are infested during the warmer part of the year, most commonly over a 3–4 month period occurring between June and October (Catts 1967; Baird 1974, 1975; Jacobson et al. 1981; Slansky and Kenyon 2000). In some cases, however, animals are infested outside this range or over a longer time period. For example, deer mice in Montana can be infested as early as April (Smith 1977), whereas parasitized cotton mice (*Peromyscus gossypinus*) in Georgia and cactus mice (*Peromyscus eremicus*) in Arizona were captured from November to January (Durden 1971, Nichols 1994).

Many *Cuterebra* species, such as *C. emasculator* infesting tree squirrels and chipmunks, go through only one infestation cycle per year; that is, adult flies→eggs→larvae (host infestation)→pupae. This occurs because when the larvae complete their development and leave their hosts to pupate in summer or autumn, they go into extended hibernation for some 8–10 months and do not emerge as new adults until the subsequent summer (Bennett 1972a, 1972b; Baird 1975). In contrast, some species appear to have more than one infestation cycle per year, as adults may emerge from pupae after only a month or so to begin another cycle. For example, cotton mice in Georgia are infested by *C. fontinella* larvae from May through July and again from November through January (Durden 1971), and eastern cottontails may be subjected to as many as four infestation cycles per year by *Cuterebra buccata* in the southeastern states (Jacobson et al. 1978).

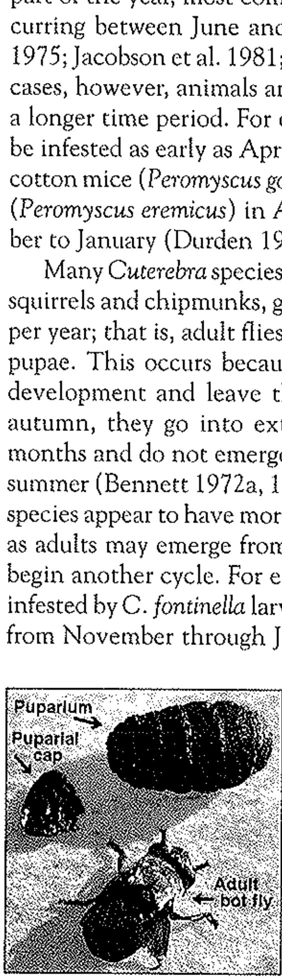


**Figure 12. Empty puparium with its cap split off, and the adult *Cuterebra* bot fly that emerged.**

## Effects on Host Animals

There are more than 60 published reports addressing the effects of *Cuterebra* infestation on their hosts (Slansky, unpublished literature review). Most of these studies focused on small rodents (especially *Peromyscus*), and thus it is likely that many of the reported impacts per *Cuterebra* larva will be less in larger hosts, where the size of a larva, and thus its energetic and nutritional demands, will be smaller relative to the host's size and resource budget. The importance of "parasite demand" on a host is demonstrated by the increase in deleterious effects often seen as the number of larvae per host increases. Many of these studies were laboratory-based, which allowed precise measurements of body weight, blood composition, food intake, etc., for both parasitized and unparasitized individuals, as well as experimental manipulation of the number of larvae per host. Nonetheless, the relevance of these results to the survival and reproduction of infested animals in the wild often remains uncertain. For example, parasitism-induced stresses that may affect an animal under less-than-ideal field conditions may exert little or no impact in a laboratory situation with abundant food, moderated temperatures, and absence of natural enemies.

Overall, the results of these studies were quite varied; in some, few or no negative effects were found at an infestation level of one or two larvae/ host (e.g., Munger and Karasov 1994), whereas in other cases greater mortality and/or reduced reproduction were demonstrated or surmised (see below). It is clear that *Cuterebra* larvae can cause anemia in their hosts, with the reductions in number of erythrocytes (red blood cells) and hemoglobin concentration most likely resulting from physiological stress on the animal rather than from direct consumption of blood by the bots (Sealander 1961, Bennett 1973, Boonstra et al. 1980). That is, unlike immature and adult ticks, and adult fleas, mosquitoes, horse flies, deer flies, etc. (Wall and Shearer 1997), *Cuterebra* larvae are not blood feeders but instead ingest tissue lymph fluid, and possibly leucocytes (white blood cells) and "cellular debris" (Hunter and Webster 1974, Munger and Karasov 1994). Once the larvae leave a host, its blood composition soon returns to that occurring before infestation. Infested hosts exhibit immune responses, including an increase in the number of leucocytes (Bennett 1973, Weisbroth et al. 1973, Baird 1979, Pruett and Barrett 1983), but at high levels of infestation in eastern gray squirrels (i.e., greater than five or six larvae per adult host), the authors have observed that the host's immune system apparently becomes overwhelmed, and bacterial infection can occur, which may result in necrosis of the animal's hide and underlying tissues, and fatal septicemia (see also Bennett 1955, 1973). The wounds caused by *Cuterebra* larvae can also facilitate secondary infestation by the maggots of other species of parasitic flies (Boonstra 1977). There is evidence that some animals may develop limited immunity to repeated infestation by bot flies, but this effect is probably not strong enough to totally prevent reinfestation (Catts 1967, Capelle 1970, Weisbroth et al. 1973, Gingrich and Barrett 1976).

*Cuterebra*-parasitized animals may drink more water and consume more food in an attempt to compensate for the nutritional drain created by the larvae (Hunter and Webster 1974;

unpublished observations by the authors). Their movement patterns may also be altered. Some studies found reduced activity (probably because the parasites weakened the host) and/or physical interference with movement, especially for a small animal such as a mouse or vole (because of the relatively large size of a warble; Bennett 1973, Smith 1978a). Difficulty with running, fitting into its burrow, finding food, etc., as well as "distractions" such as increased eating, drinking, and scratching, can likely all lead to an increased susceptibility to predation, whereas reduced activity may decrease this risk. The results of a few studies support these hypotheses (e.g., Hensley 1976, Smith 1978b, Boonstra et al. 1980), but the data are limited, as it is very difficult to investigate predation of wild animals in a field setting. That is, many individuals (both parasitized and unparasitized) must be monitored over a considerable period of time. In addition, when an individual "disappears" from a study site, one must determine whether this was due to mortality (and if so, the cause), dispersal out of the area, or reduced on-site activity, which poses formidable methodological challenges.

For many years it was thought that the *Cuterebra* species that infests tree squirrels and chipmunks emasculates the male hosts by eating their testes, as reflected in its scientific name, *C. emasculator*. However, more thorough investigation demonstrated that emasculation does not occur (Timm and Lee 1981). Apparently this misconception resulted because of a lack of knowledge that a male squirrel's testicles only become prominent during the breeding season, and that the larvae are fluid feeders. The larvae of some *Cuterebra* species characteristically produce warbles in their host's inguinal (groin) area, which may interfere physically with its ability to mate, but the reproductive organs typically are not permanently damaged (Sealander 1961, Wecker 1962, Hensley 1976).

Bot fly infestation (especially at higher levels) may interfere with a female host's ability to nurture her fetuses and nurse her offspring. For example, the authors have observed, for heavily infested eastern gray squirrels, one case of premature birth and another in which the mother's milk production declined to the point that her nursing infants starved to death (see also the discussion in Munger and Karasov 1994). In another case, it was noted that one baby squirrel died of septicemia after attempting to nurse on a *Cuterebra* warble located on its mother's chest. Infestation of nest-bound infants, although apparently rare, will likely reduce their growth by sapping their resources and can also result in fatal infection (Slansky and Kenyon 2002).

Effects of *Cuterebra* on "atypical" host animals are probably generally similar to those discussed above for the usual hosts, although more trauma may occur, especially when the mature larvae exit some atypical hosts (Catts 1982). However, infestation of cats and kittens (and to a lesser extent dogs) often presents a more serious situation, because in some cases the larvae behave abnormally and move into the animal's brain or central nerve cord rather than settling under its skin (Fitzgerald et al. 1996, Glass et al. 1998). The subsequent neurophysiological problems can kill the animal or necessitate its euthanization.

## Treatment of Infested Animals

Treatment of infested animals brought in for rehabilitation involves extracting the larvae and flushing the empty warbles

**Figure 13. Removing a bot fly larva from the shoulder of an eastern gray squirrel by using forceps to pull the larva out through the unexcised warble pore.**

with an antiseptic. Treating the animal with topical and oral antibiotics facilitates healing of the wounds, as warbles often become infected once the larvae are removed (Baird 1979, unpublished observations of the authors). Preliminary analyses of *C. emasculator* warbles on eastern gray squirrels indicate the presence of a variety of aerobic microorganisms, including *Staphylococcus*, *Streptococcus*, *Corynebacterium*, and *Klebsiella*, among others, with the combination of microbes differing among squirrels (unpublished data of the authors).

The basic, relatively simple procedure for removing a larva is to use forceps to grab its posterior end as it protrudes from the warble pore and carefully pull the insect out (Figure 13). Attempting to squeeze a larva out of its warble is not recommended, as this could rupture it, making it difficult to clean out the warble and likely prolong healing. Whether an anaphylactic reaction would occur if a larva were ruptured within a warble apparently has not been studied. Anaphylactic reactions are often mediated by an antibody/antigen response (Bochner and Lichtenstein 1991), and antibody production in an immunological response to infestation by *Cuterebra* larvae (probably from antigens in the insect's feeding secretions) does occur (Weisbroth et al. 1973, Baird 1979, Pruett and Barrett 1983). Thus, anaphylactic reactions may occur in response to a ruptured larva. However, in the typical wild rodent and lagomorph hosts, the larvae become encapsulated by an avascular, connective tissue layer within the warble (Smith 1977, Cogley 1991). This could hinder contact between fluids from a ruptured larva and the host's vascular system, and thus perhaps reduce the risk of anaphylaxis. In contrast, for young larvae, young hosts, and atypical hosts such as cats, dogs, and domestic rabbits, the warble capsule may be less well developed. This could allow greater movement of larval fluids into the host's blood stream and thus possibly increase the risk of anaphylaxis.

Based on the experience of the authors described here, larval extraction very rarely requires any invasive technique. Infested animals typically do not require general anesthesia during larval removal, thereby avoiding its risks and side effects. Appropriate chemically induced immobilization may, however, be advisable for safety in handling and minimizing stress in infested wild animals of medium or large size. Because the warble pore provides adequate access to the larva within the warble, making an incision to enlarge this opening is inappropriate, as it unnecessarily causes the complications of stressful pain, increased risk of systemic infection, and delayed healing. Also, the warble pore should not be sutured after larval removal but rather needs to remain open to allow for application of antibiotic ointment and for drainage during the healing process. Caution should be exercised when flushing the wound to avoid penetrating into the animal's body cavity, especially with young animals and atypical hosts.

Small (young) larvae can be difficult to grab because they can withdraw deep within the warble when disturbed. In addition, the authors' observations of eastern gray squirrels indicate that attempted removal of small larvae can cause them to move under the skin from their warble to another site and cut another warble pore, causing the animal considerable pain. In contrast, older larvae become "walled off" within the warble capsule, thereby preventing movement to a new site, and they are too large to pull fully within the warble. Thus, they are easier to grab, but they are somewhat more difficult to extract because of their larger size. Injecting sterile saline solution, antiseptic, or antibiotic through the warble pore may help drive the larva at least partially out of its warble. Temporarily occluding the warble pore in some manner can cause the larva to protrude as it attempts to get access to the air for breathing. For example, in some cases where people were infested by bot fly larvae (see "Public Health Considerations" below), uncooked bacon fat was placed over the warble pore and the larvae eventually migrated partially from the patient into the fat, and were then removed with forceps (Brewer et al. 1993). However, this process probably occurs too slowly (a few hours) for this method to be used effectively with a wild animal. Manual removal of the bots is currently the only treatment for *Cuterebra*-infested animals. A commonly used antiparasitic drug (Ivermectin) has been shown to kill *Cuterebra* larvae (Campbell and Benz 1984), but it is likely that if the dead larvae were not physically removed from the warbles, inflammation and infection would result, requiring the animal to be subjected to additional treatment measures.

### Public Health Considerations

*Cuterebra* appear to have a relatively minor impact on public health, especially when compared with other arthropods, such as deer ticks that carry the bacteria causing Lyme disease and mosquitoes that vector West Nile virus, eastern equine encephalitis, and a variety of other human and animal diseases. Human infestation by *Cuterebra* seems to be a rare occurrence, with only some 50 cases being reported in the United States and Canada between 1941 and 1986 (Baird et al. 1989) and a few dozen others since then (e.g., Glasgow and Maggiano 1995, Shorter et al 1997, Engelbrecht et al. 1998, Keth 1999, Safdar et al. 2003) . However, because some people infested with *Cuterebra* may not seek medical attention and doctors are not required to report this affliction, its actual prevalence in the North American human population remains uncertain. Most of the reported cases occurred in eastern North America from August through October, with about half of the patients being children aged 16 years or younger (Baird et al. 1989).

Similar to wildlife hosts, people presumably become infested by contacting infective-stage larvae in the environment, such as when walking through weedy vegetation. Possibly, close contact with a pet that had recently roamed outdoors and had infective-stage larvae crawling on it could result in a person becoming infested, although this has not been proven. Unlike the situation with wildlife, however, it appears that the tiny larvae can bore directly through a person's skin and establish their warble at the site of entry or a short distance from it (the latter is indicated by a reddish "movement track" under the skin; Penner 1958, Engelbrecht et al. 1998). Direct skin entry may be the cause of the "stinging" sensation reported in some of the cases some days prior to a wound being observed. Wildlife rehabilitators are not at risk of becoming infested by the larvae from warbles on the animals they handle, because once these insects settle under an animal's skin and cut the warble pore, they are no longer able to naturally infest another host. Which *Cuterebra* species infest humans has not been determined, but species that parasitize rabbits have been implicated in some cases.

Infestation of humans by *Cuterebra* typically is a localized problem, causing inflammation and tenderness in the immediate vicinity around the warble. *Cuterebra* larvae have been found in most parts of the human body, including the scalp, face, eyelids, neck, arms, chest, back, and legs (Baird et al. 1989). Apparently because it is such a rare occurrence, doctors often initially misdiagnose the wound caused by a *Cuterebra* larva as a local bacterial infection and prescribe treatment with antibiotics. These patients usually returned to the doctor a week or so later, often complaining of feelings of movement under their skin and/or reporting observations of something moving in the wound. Once the cause of the problem is correctly diagnosed, the larvae are relatively easily removed under local anesthesia and antibiotics are used to treat bacterial infection while the wound heals. Occasionally, a small larva has been found in a person's eye (a phenomenon termed "ophthalmomyiasis"), in some cases having made tracks in the retina, with various effects on the patient's vision (Custis et al. 1983, Glasgow and Maggiano 1995). A few cases of upper respiratory tract infestation have also been reported.

Another example of myiasis of humans involves larvae of the "human bot fly," *Dermatobia hominis*, which is also a member of the Cuterebridae. It does not occur in the U.S. or Canada, but rather inhabits parts of Mexico and Central and South America, where it can be a considerable pest of cattle in addition to infesting a variety of other domestic and wild animals as well as humans (Koone and Banegas 1959, Hunter 1990). This species has relevance to people living in North America and elsewhere who travel to areas in which these flies are present and thus risk becoming infested. There are many published records of people returning home after a trip to one of these areas and noticing some days later an open swelling on their body, from which a *Dermatobia* larva is eventually removed (e.g., Lane et al. 1987). As with *Cuterebra*, *Dermatobia* infestation typically causes a minor, localized wound that heals rapidly once the larva is removed. *Dermatobia* employ a unique and much different method than that used by *Cuterebra* to infest their hosts. The female flies capture mosquitoes and various blood-feeding flies and glue some of their eggs to these insects before releasing them. When one of these "carrier" insects feeds on a potential host, the warmth from the animal causes the *Dermatobia* eggs to hatch and the emerging larvae then infest the host.

### Significance of Bot Fly Research and the Role of Wildlife Rehabilitators

Despite the wealth of knowledge gained about the biology of *Cuterebra* over the last 100 years or so of study, much about the associations between these parasites and their hosts remains unknown. Continued research on this "system" has relevance for both basic science and its practical applications. For example, there is interest among ecologists in assessing the extent to which some populations of a species can escape from their parasites, predators, and/or pathogens, such as by colonizing particular geographical areas or local habitats lacking certain of these natural enemies

(Esch and Fernandez 1993; Poulin et al. 2000). If such patterns are found, attempts are then made to determine the causative factors. Because the large, often hairless, fluid-draining warbles characteristic of *Cuterebra* infestation are rather conspicuous, especially on frequently observed and rehabilitated animals such as tree squirrels, this is an ideal "model system" for investigating the potential escape of animals from their parasites. Thus, the many wildlife rehabilitators who provide care for tree squirrels, as well as others who observe these animals raiding backyard bird feeders and elsewhere, can be an important source of valuable information to research scientists studying host/parasite interactions (Slansky and Kenyon 2002/2003, 2003).

As an example of this type of research, information provided by wildlife rehabilitators and other wildlife-oriented people has resulted in a more precise determination of the range of the tree squirrel bot fly in South Carolina and Florida (Slansky and Hilton 2003, unpublished data of the authors). Prior to these studies, this species was documented from only one or two counties in each of these states, but now its known range has been expanded to statewide in South Carolina and to more than 40 of Florida's 67 counties. Interestingly, although bot fly-infested squirrels are commonly encountered throughout the northern and central portions of Florida, this parasite appears to be absent from or very rare in the southern portion of this state, such that the squirrels living there apparently occupy a "bot fly–free" zone. The cause(s) of this distribution pattern and the consequences for the southern squirrels remain to be studied. Other unstudied questions along these lines include whether the parasites of eastern tree squirrels have "tagged along" as their hosts have become established in various western states (and if so, have they expanded their host ranges to include the western squirrel species), and whether western species of parasites have begun colonizing these newly available species of hosts. Such long-distance movement of organisms (whether natural or human-caused) can provide unique opportunities for studying evolutionary processes as organisms adapt to new circumstances.

In addition to the basic research described above, there are a variety of practical reasons for more precisely determining the geographic distribution of the various *Cuterebra* species, as well as deriving a better understanding of other aspects of their biology. This information can lead to improved diagnosis of afflicted animals. For example, if it were known that the bot flies infesting a certain mammal species do not occur in a particular area, then an animal of that species in that area with lumps on its body would more readily be determined to be afflicted with some other ailment (e.g., a pox virus). In areas where *Cuterebra* and some other lump-causing affliction co-occur but differ in their seasonality, a more accurate diagnosis of a "lumpy" animal could result if it were known that only one of these afflictions typically was present during that time of year. Distributional data on parasites and other natural enemies could also be useful in making reintroduction and other management decisions for at-risk species. For example, in Florida it might be more effective, at least initially, to attempt to re-establish populations of the Sherman's fox squirrel (*Sciurus niger shermani*; listed as a "species of special concern"; FFWCC 1997) and the threatened Big Cyprus fox squirrel (*S. niger avicennia*) in areas of suitable habitat devoid of their bot fly parasites, to help limit the stresses faced by these animals as they attempt to colonize a new area.

## Conclusions and Future Challenges

*Cuterebra* bot flies are a natural part of the ecology of some 60 species of mammalian wildlife throughout North America, along with many other parasites that are not so readily apparent, including ectoparasitic (externally living) fleas, lice, ticks, and mites, and endoparasitic (internally living) species such as tapeworms and roundworms (Samuel et al. 2001). As a group, a wild animal's parasites comprise but one component of the many natural factors with which it must cope, including unfavorable weather, predators, and food that may be in short supply and/or of suboptimal quality (Caughley 1994). All of these factors can contribute to the regulation of animal populations in the wild, and each species has a long evolutionary history of adapting to endure them. Because the survival of a parasite is dependent on a living host, in many cases parasites have evolved such that they exert limited deleterious effects (Esch and Fernandez 1993, Poulin et al. 2000). This is not to say that parasites have no negative impacts; for example, as seen with *Cuterebra*, the survival and/or reproduction of infested hosts can be reduced compared with uninfested individuals. However, severe deleterious effects tend to be limited to only a small portion of the host population, especially those few individuals with a high intensity of infestation. Indeed, host species may in turn have evolved increased resistance to and/or tolerance of their parasites.

Injured, ill, and orphaned wildlife are routinely subject to intervention by wildlife rehabilitators and veterinarians. Because some of the typical hosts (tree squirrels, rabbits, chipmunks, etc.) parasitized by *Cuterebra*, as well as atypical ones (e.g., raccoons and white-tailed deer) often receive rehabilitation, it would be beneficial if wildlife caretakers were knowledgeable about the biology of these parasites and their diagnosis and treatment. Toward this end, this article synthesizes and summarizes the relevant information on these insects. If an injured or ill animal that is infested with bot fly larvae is brought in for rehabilitation, and if the animal is going to be kept in captivity for at least several days (to allow for a course of antibiotics), the authors suggest that it would be appropriate to extract the larvae. For a person experienced with this relatively straight-forward procedure (as previously described), it entails little risk and very limited stress to the animal. Extracting these larvae would remove one source of physiological drain on the animal, such that it could better cope with its other problems. Similarly, bots in otherwise healthy orphaned infant and juvenile wildlife in the care of a rehabilitator should be removed because the larvae could significantly hamper the growth of these animals or prove fatal.

In contrast to the approach of wildlife rehabilitators described above, wildlife biologists and others who work with free-roaming wildlife generally do not attempt to interfere with these animals' parasites or other aspects of their natural ecology, but instead "allow nature to take its course." Furthermore, it is likely that the trauma imposed by capturing and treating a wild animal which has a generally non–life threatening infestation of natural parasites places more stress on the animal than does the infestation itself. For these reasons, capturing free-roaming wildlife to extract bot fly larvae is not routinely done. One obvious exception to this "nonintervention" philosophy involves "at risk" species, where a 'helping hand' may be offered to try to alleviate some of the numerous stresses (both natural and human-associated) faced by these animals (Caughley 1994).

Current research on bot flies has relevance within the broader context of human impacts on the biosphere. More precise determination of the geographic and seasonal occurrence of these species will provide the baseline data necessary for tracking the effects of future environmental changes, which will likely have consequences for animal and human health. For example, as the global climate warms, if *Cuterebra* species increase in abundance and/or expand their ranges, they could exert more substantial impacts on their typical host species and pose greater risks to atypical hosts. By monitoring bot fly infestations (as well as other afflictions) in the animals they care for, wildlife rehabilitators could become an "early warning system," providing the data needed to detect such changes at their inception (Clark 2002, Slansky and Kenyon 2003). This would allow more time to identify and communicate with people in the affected areas about the situation, and perhaps provide an opportunity to develop methods to limit the impact of these changes. Clearly, there are many facets to the interactions between bot flies and their mammalian hosts, and wildlife rehabilitators are playing an important role in helping to better understand more of the details of this most interesting biological association.

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# Survival, Fates, and Success of Transplanted Beavers (*Castor canadensis*) in Wyoming

by Mark C. McKinstry and Stanley H. Anderson

**ABSTRACT:** Beaver (*Castor canadensis*), through their dam building activities, alter riparian-stream ecosystems, and many landowners recognize these benfits. From 1994–1999, we trapped and relocated 234 beaver to 14 areas throughout Wyoming to improve riparian habitat and create natural wetlands. Radio transmitters were attached to 114 beaver. Mortality and emigration (included transmitter failure) accounted for the loss of 30% and 51%, respectively, of telemetered beaver within 6 months of release. On average, 17 beaver were transplanted to each release site; at 11 locations, in an attempt to augment single beaver that had become established and increase transplant success, we transplanted beaver in 2 or more years. Success of an individual beaver's relocation was unrelated to any of the variables tested. High predation and mortality rates of released beaver may be due to habitat and extensive predator communities. Beaver were established at 13/14 of our release sites and they eventually reproduced.

**KEY WORDS:** beaver, *Castor canadensis*, transplanting, reintroduction, translocation, predation, Wyoming

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Beaver (*Castor canadensis*) alter riparian-stream ecosystems through their woodcutting and dam-building activities. Beaver dams create a lentic habitat in an otherwise lotic system. These ponds retain sediment and organic matter in the channel, create and maintain wetlands, modify nutrient cycling and decomposition dynamics, modify the structure and dynamics of the riparian zone, alter hydrologic regimes (Butler 1991), and influence the character of water and materials transported downstream (Naiman et al. 1988). The resultant habitats are rich mosaics of diversity that are beneficial hydrologically (Hanson and Cambell 1963; Rabe 1970; Johnson et al. 1992), biologically (Jenkins and Busher 1979; reviewed by Hill [1982, 256–81]; Olson and Hubert 1994; Brown et al. 1996; McKinstry and Anderson 1999; McKinstry et al., 2001), and socially (Naiman et al. 1988). It is estimated that beaver have been extirpated from over 25% of the streams in Wyoming, and in many streams where they are still present their numbers have been reduced to where they are ecologically absent (McKinstry et al. 2001). The elimination of beaver from portions of its historic range has been cited as a major influence on the structure and patterns of vegetation in these systems (Neff 1957, Barnes and Dibble 1986, Naiman et al. 1986, Nummi 1989, Kay 1994, Nolet et al. 1994).

Throughout the intermountain west, interest has been expressed in improving riparian areas for wildlife, livestock, and humans (Apple et al. 1985, 123–30; McKinstry and Anderson 1999; McKinstry et al. 2001). Beaver, through their dam building activities, can increase water storage, reduce sedimentation, and improve vegetation communities (Naiman et al. 1988), all of which are valuable to many landowners. Livestock are also attracted to beaver-influenced areas for water, shade, and vegetation that remains green after upland forage has dried out. Forage production near these wetlands is often two to three times higher than comparable upland ranges (Apple et al. 1985, 123–30; Chaney et al. 1991, 31). Many states have undertaken beaver transplant programs to improve riparian areas (Smith 1980; Hill 1987, 281–86; Butler 1991; Collins 1993; Vore 1993; McKinstry and Anderson 1997, 128–34; McKinstry 2001) and managers with the Wyoming Game and Fish Department (WGD&FD) decided to investigate the feasibility of a beaver relocation program in areas where beaver have not recolonized due to isolation from dispersing populations and poor habitat conditions.

In 1994 we initiated research to (1) document the effects of beaver on riparian areas in Wyoming (reported in McKinstry et al. [2000, 95–100; 2001]), (2) assess beaver management concerns from both private and public landmanagers (reported in McKinstry and Anderson [1999]), and (3) evaluate a beaver reintroduction project for the purpose of wetland creation and riparian improvement. Our objectives in this paper are to examine survival, mortality, emigration, and success of beaver translocated in Wyoming for the purpose of riparian restoration.

## Study Area

Beaver were trapped at 33 various locations in Wyoming (described in McKinstry and Anderson 1998) and translocated to 14 different 1st–3rd order streams (<$0.28^3$ m/sec) throughout Wyoming (Figure 1, Table 1). All drainages were walked a minimum of 3 km in both directions from the proposed release site to document any past or current beaver activity. At 13 of the release sites, old beaver sign (20–100 yrs) was present, but we found no fresh activity. At the remaining site, Breteche Creek, prior beaver activity was not found. All release sites had sufficient vegetation to support beaver. Four streams were ephemeral and dry in early August each year that we checked them (1993–1999); the remainder were perennial and carried water year-round (Table 1).

## Methods

Beaver were trapped using snares and Hancock traps (McKinstry and Anderson 1998) from areas where they were causing damage to landowners (primarily irriga-

## TABLE 1. LATITUDE AND LONGITUDE, DOMINANT VEGETATION, AND STREAM CLASSIFICATIONS (USING ROSGEN'S [1994] CLASSIFICATION) FOR BEAVER RELEASE LOCATIONS IN WYOMING.

**Letters for release sites correspond with locations in Figure 1.**

| Stream Name (nearest town) | Latitude, Longitude | Dominant Vegetation | Stream Classification |
|---|---|---|---|
| (A) Bear Gulch (Story) | 44°31′46″N, 106°53′11″W | Aspen and cottonwood | DA5 |
| (B) Breteche Crk. (Cody) | 44°24′36″N, 109°23′28″W | Aspen and cottonwood | A4 |
| (C) Bush Crk.[a] (Shell) | 44°27′41″N, 107°37′30″W | Cottonwood | A4 |
| (D) Currant Crk. (Rock Springs) | 41°12′55″N, 109°22′20″W | Willow | G5 |
| (E) Deep Crk.[a] (Sundance) | 44°47′29″N, 104°20′41″W | Gambel's oak and aspen | C5 |
| (F) Ennos Crk. (Thermopolis) | 43°54′50″N, 108°54′14″W | Willow | B4 |
| (G) Lake Crk.[a] (Saratoga) | 41°28′16″N, 106°38′20″W | Narrowleaf cottonwood (*Populus angustifolia*) and willow | B4 |
| (H) Little Red Crk. (Casper) | 42°42′55″N, 106°23′48″W | Cottonwood | F4 |
| (I) Prairie Dog Crk. (Big Horn) | 44°35′36″N, 106°54′30″W | Aspen and cottonwood | A5 |
| (J) S. Pine Crk.[a] (Sundance) | 44°44′29″N, 104°20′30″W | Scrub oak and common chokecherry (*Prunus virginiana*) | F6 |
| (K) Red Crk. (Rock Springs) | 41°04′01″N, 109°02′30″W | Engelmann spruce (*Picea engelmannii*) and cottonwood | F5 |
| (L) Spring Crk. (Centennial) | 41°12′59″N, 106°07′44″W | Willow | F5 |
| (M) Trabing Crk. (Big Horn) | 44°36′01″N, 106°58′59″W | Aspen and western hawthorn (*Crataegus succulenta*) | A4 |

[a] streams were ephemeral and dry by early August each year we checked (1993–1999)

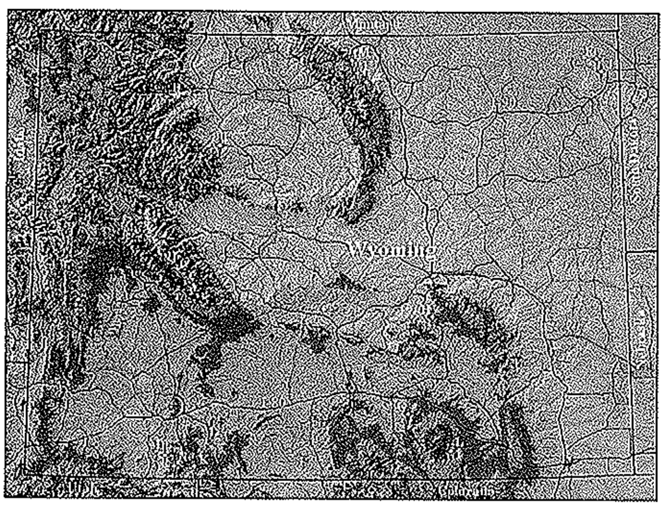


**Figure 1. Beaver relocation sites in Wyoming. Letters correspond to release site locations described in Tables 1 and 2.**

tion conflicts) (30 sites) or where they were so plentiful that selective removal would not significantly impact the habitat (3 sites). All beaver were trapped from colonies that were dam and lodge builders (creek beaver) as opposed to bank-denning non–dam builders (river beaver). We felt that these animals would be more likely to create the desired habitat.

We began trapping after ice-off in the spring (usually early to mid May) and concluded trapping by the second week in October, depending on snow and ice conditions. All traps were set between 1600 h and 1900 h each day and were checked by 1000 h the following morning to minimize the time that animals spent in traps. On average we set 17 traps/night/trapper; more than that and it was difficult to get them checked by 1000 h and find them in the thick willows where we were trapping. beaver were sexed through cloacal examinations (Larson and Taber 1980, 143–202), weighed to determine age class (kit, yearling, sub adult, and adult), and ear tagged in both ears with small monel ear tags for identification. Beaver were held up to 5 days post-capture in a 2.2 x 3.1 m cage that allowed them free access to water; this was necessary since we only caught a few (<3) animals each day and we wanted to move them as a group to the release site which was always >160 km away.

Forty-six beaver (range 11–31 kg) were implanted with Advanced Telemetry Systems (ATS, Isanti, Minnesota) model 17 internal telemetry transmitters using techniques described by Davis et al. (1984). Implanted beaver were monitored for a minimum of 24 h postsurgery prior to release (Davis et al. 1984). Beginning in 1998, 67 beaver (range 10–25 kg) were outfitted either with tail collars (8 beaver) or transmitters mounted on the tail using modified ear-tag transmitters (59 beaver) (Rothmeyer et al. 2002) in an attempt to reduce logistical problems associated with surgeries conducted in the field (e.g., cost, time, sterility concerns). All radio transmitters were equipped with 24 h mortality sensors. Animals were released after 1500 h in an attempt to decrease predation during daylight hours.

Beaver were monitored for movements and mortality for 2 days after release and approximately every 2 to 4 weeks thereafter. Mortality dates were calculated as the mid-date between the date found and the date of last-live location. At all release sites, streams were walked (minimum of 5 km) and flown (minimum of 10 km) in both directions 3 months after release to determine if beaver were established. In four instances non-transmittered beaver became established, and walking the streams allowed us to look for evidence of tree cuttings or dam construction and thus determine if non-telemetered beaver were active. Since we were interested in using beaver to improve habitat within 3 km of the release sites (usually headwater areas), we defined emigration as beaver that moved further than 3 km from the release site. Beaver moving >5 km from the release sites were not monitored unless they built dams and lodges and remained stationary.

Cause of mortality was determined through physical examination of hair and scat samples found at the kill site (Moore et al. 1974), bite marks and subcutaneous bleeding (indicating animal was alive when bitten) on beaver carcasses, track marks (O'Gara 1978, 380–93), and, beginning in 1998, DNA analysis of hair and scat samples. Dr. Elizabeth Williams, pathologist at the Wyoming State Veterinary Lab, performed lab work and necropsies. Tom Moore and Deedra Hawk, forensic supervisor and research associate, respectively, Wyoming Game and Fish Department, examined hair and scat samples.

We used a Z-test (Jandel Scientific 1994) to test proportional differences in captures of males versus females. For estimates of survival we used Kaplan-Meier product limit estimators (as reviewed by White and Garrott 1990) for both 360 and 180 day survival rates. We used the Kaplan-Meier approach since our data was staggered entry and we had considerable loss of individuals due to emigration or transmitter failure. To model success of transplants we used both logistic and multiple regression (White and Garrott 1990). For our logistic regression models we coded each beaver as either a 0 for failure (emigration or mortality) or a 1 for success (lived >6 months, constructed a dam and lodge, and had the opportunity to reproduce). For multiple regression models we used the length of success (remained within 3 km of release site) in days as our dependent variable. We used weight, sex, age class, season of release (spring [May 9–June 15] or fall [August 15–October 10]), year of release (1994–1999), and number of cohorts released concurrently with each beaver as our covariates. For age class we plotted weights and found natural distinctions in the three younger classes (kits, yearlings [1.0–1.5-year olds], and subadults [2.0–3.5-year olds]) and grouped all animals > 13.6 kg (4-year- olds) as adults. Minitab (Minitab 2000), SigmaStat (Jandel Scientific 1994), and SAS (SAS Institute 1991) were used for all analyses.

## Results

Snares and Hancock traps were used to capture 277 beaver at 33 locations throughout Wyoming, and we eventually transplanted 234 to the 14 release sites. The 43 remaining beaver either died during trapping (n=15) or transporting (n=13), or were lactating females (n=15) that we released after capture. Trapping mortality was 10% for Hancock traps and 5.3% for snares, and was not significantly different (Z=-0.07, P=0.94, df=11). Mortality from traps was due to becoming entangled in snares (n=11) and being killed by predators while restrained in snares and Hancock traps (n=4). Trapping success during our 5 years of trapping was 11.1 trap nights/beaver or 9.0% (the probability of an individual trap's capture). Average weight of animals captured was 16.2 kg (range 2.4–31 kg, SD=6.11), and there was no difference in proportion of males (0.42) or females (0.58) captured (Z=1.23, P=0.22, df=122). We transmittered 63 (55.3%) females and 51 (44.7%) males.

Of 114 beaver trapped, equipped with a transmitter, and relocated, 34 (30%) died within 180 days ($\bar{x}$=43 days, SD=37.4) of release (Table 2). Another 7 beavers (36% total mortality) died prior to the failure of their transmitters (181–503 days). Coyotes (*Canis latrans*) were responsible for at least 27% of all mortalities, followed by black bears (*Ursus americanus*) (10%), grizzly bears (*Ursus horribilis*) (10%), mountain lions (*Felis concolor*) (2%), and humans (5%). Another 22% (of all mortalities) died of unidentified predators and the remaining 24% died from undetermined causes. Within 180 days of release, 58 (51%) beavers either emigrated >10 km from the release sites and were not found again, or developed faulty transmitters, which made them impossible to relocate.

The Kaplan-Meier survival estimates for all beavers were 0.49 for 180 days and 0.433 for 360 days and did not differ between age classes (Table 3). Beavers that died lived for an average of 86 days (range 1–503 days, SD=114.8) until death, however eight died within 7 days of release. All beavers (that we found), except one, died within 0.5 km of the release site (the exception was found 0.75 km upstream of the release site).

Twenty-three (19%) beavers lived >180 days and eventually built dams and lodges in the drainages where they were released. Additionally, a minimum of 10 (actual number could not be determined since we did not retrap beavers after release) of the other 120 beavers released without transmitters were also found with dams and lodges within 3 km of the release sites. (Some of these may have been beaver with faulty transmitters, although we feel this was unlikely.) We released an average of 17 beaver at each of our sites in an attempt to get animals to establish. Beaver successfully established at 13 of the 14 release sites and, as of September 2001, the 13 sites were still occupied. At the unsuccessful site beavers had conflicts with irrigation structures (e.g., damming irrigation ditches) and they were removed.

We were unable to identify any variables in our analyses that significantly influenced the probability of success for beaver relocations. P values were >0.2 and R-squared values were <0.10 for all variables and models tested. The 2–3.5-year-old age class had greater average occupancy at a site (Figure 2), although this relationship was not significant (P=0.225, df 3). All kits and yealings (n=12) either died (n=5) or emigrated

## TABLE 2. FATES OF INTRODUCED BEAVER BY RELEASE LOCATION.

**Letters in ( ) correspond to release sites in Figure 1 and descriptions in Table 1.**

| | PREDATION | | | | | | | # RELEASED | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coyote | Black Bear | Grizzly Bear | Mountain Lion | Human | Unknown[a] | Unknown Mortality[b] | W/Transmitters F:M:unknown[c] | W/o Transmitters F:M:unknown[c] | Total F:M:unknown[c] |
| (A) Bear Gulch[d] | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0:1:0 | 1:2:0 | 1:3:0 |
| (B) Breteche Crk. | 5 | 0 | 4 | 0 | 0 | 1 | 0 | 6:6:0 | 2:3:2 | 8:9:2 |
| (C) Bush Crk. | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2:3:0 | 5:5:0 | 7:8:0 |
| (D) Currant Crk. | 3 | 0 | 0 | 0 | 0 | 0 | 2 | 5:7:0 | 3:4:0 | 8:11:0 |
| (E) Deep Crk. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1:2:0 | 4:3:0 | 5:5:0 |
| (F) Ennos Crk. | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 8:8:0 | 2:7:3 | 10:15:3 |
| (G) Lake Crk. | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 5:7:0 | 9:4:1 | 14:11:1 |
| (H) Little Red Crk. | 1 | 1 | 0 | 0 | 0 | 3 | 5 | 6:11:0 | 4:7:4 | 10:18:4 |
| (I) Prairie Dog Crk. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1:1:0 | 0:1:0 | 1:2:0 |
| (J) S. Pine Crk. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2:1:0 | 0:4:0 | 2:5:0 |
| (K) Red Crk. | 0 | 3 | 0 | 0 | 0 | 1 | 1 | 8:6:0 | 4:4:1 | 12:10:1 |
| (L) Spring Crk. | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 2:2:0 | 0:8:0 | 2:10:0 |
| (M) Trabing Crk. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2:2:0 | 2:9:0 | 4:11:0 |
| (N) Trout Crk. | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 3:6:0 | 3:9:0 | 6:15:0 |
| Total | 11 | 4 | 4 | 1 | 2 | 9 | 10 | 51:63:0 | 39:70:11 | 90:133:11 |

[a] Cause of predation was undetermined
[b] Beaver died from undetermined causes
[c] Usually kits that could not be sexed
[d] Releases at this site failed due to conflicts with irrigation structures and some beavers were retrapped

## TABLE 3. KAPLAN-MEIER 180 AND 360 DAY SURVIVAL ESTIMATES, SAMPLE SIZES, 95% CIS, AND SES FOR BEAVERS TRANSLOCATED IN WYOMING.

**Survival estimates were not computed for beaver <2 years old since 100% either died or emigrated prior to 180 days.**

| Age Class | N Total | n Surviving | n Dying | n Unknown[a] | Survival Estimate | 95% CI | SE |
|---|---|---|---|---|---|---|---|
| **180 days** | | | | | | | |
| All ages | 114 | 23 | 34 | 58 | 0.493 | 0.358–0.628 | 0.068 |
| 2.5–3.5 years old | 52 | 13 | 20 | 19 | 0.436 | 0.271–0.602 | 0.085 |
| 4+ years old | 51 | 10 | 8 | 33 | 0.658 | 0.449–0.868 | 0.107 |
| **360 days** | | | | | | | |
| All ages | 114 | 13 | 36 | 66 | 0.433 | 0.268–0.598 | 0.084 |
| 2.5–3.5 years old | 52 | 7 | 22 | 23 | 0.353 | 0.167–0.538 | 0.095 |
| 4+ years old | 51 | 6 | 8 | 37 | 0.658 | 0.449–0.868 | 0.107 |

[a] animals either emigrated >5 km or transmitters failed

(n=7) from the release site prior to 108 days and none were observed constructing dams and lodges.

## Discussion

Limited range of transmitters and transmitter failure may have influenced the number of animals we found after release (Rothmeyer et al. 2002), subsequently increasing the number of beavers assumed to have emigrated. Advertised range of the internal transmitters was 0.5 km but we found that the range was usually limited to <200 m, and animals within dens were not located until we were within 50 m of the transmitter. Range of the tail-mount transmitters was better but never approached the 1 km advertised range. Walking up- and downstream of the release site within 20 m of the creek bed was necessary to determine movements and mortality.

Animals emigrating or not found after release may have had higher survival rates, but we believe this is improbable. More likely, these beaver were killed and cached in holes and dens, or dragged out of range of receivers. Animals moving out of the vicinity of the release area may also have experienced higher predation rates due to increased exposure time and less time spent hiding in dense vegetation or constructing dens. Beavers, sympatric with black bears on islands in Lake Superior traveled shorter distances from water than those found on islands where bears were not present, posssibly a direct attempt to avoid predation (Smith et al. 1994). Survival estimates for unexploited (i.e., untrapped) adult beaver are generally ≥0.80 (Boyce 1974; Bergerud and Miller 1977; Bishir et al. 1983, 105–13) but these animals have ponds and lodges for escape. High mortality (5/10) and loss (4/10) (never relocated) rates were reported for beaver translocated in the James Bay area of Quebec, Canada (Courcelles and Nault 1983). Translocated animals undoubtedly have a higher susceptibility to predation for many reasons, including unfamiliarity with the surrounding habitat, reduced fitness due to trapping stress, and possible exposure to more numerous and greater varieties of predators (Griffith et al. 1989, Stanley-Price 1989). Beaver have many natural predators and do not avoid predation through fighting, preferring instead to use water as an escape medium (as reviewed in Smith et al. 1994). Without ponds and dens to use for escape, beaver are vulnerable to predation. Naturally dispersing beaver have been seen in upland areas >1 km from water sources and have been observed crossing mountain passes (Smith 1980) far from water where they would be extremely vulnerable to predation. Movements across upland areas are undoubtedly successful but we question the frequency of this success in areas like Wyoming where multiple predators occur sympatrically.

Translocated beaver in North Dakota, Wisconsin, and Maine moved an average of 14.6, 7.4, and 11.2 stream km, respectively, although the longest movement was 238 km (Hibbard 1958; Knudsen and Hale 1965; Hill 1982, 256–81) and naturally dispersing Beaver in Idaho and Quebec moved an average 8.5 and 18 km (Leege 1968, Courcelles and Nault 1983). While movements greater than 3 km are common for beaver, exposure rates certainly increase during long movements through non-ponded habitat. Our animals may have been attempting to return to trapping locations, which were greater than 160 km away. Since our goal was to establish beavers in uncolonized areas, predation risk was unavoidable and high predation and emigration losses should be considered when planning releases.

Wildlife managers in Europe have made several attempts to transplant beaver (*C. fiber*) with varied success (Zurowski and Kasperczyk 1988, Hartman 1994; Nolet and Baveco 1996). Initially, mortality and emigration rates were high (14–36% and 23%, respectively) and were greatest in juvenile and yearling animals. Mortality rates declined with the establishment of dens and dams, and populations became well established over time. However, transplanting in Europe usually occurs in major river systems where flooding of the dens is the primary disruptive event and predator populations are not as large (Nolet and Baveco 1996). In Wyoming, predator communities are well developed and are thought to be increasing (McKinstry and Anderson 2003). Additionally, beaver introduced in large rivers (>2.8$^3$ m/sec) have greater aquatic escape cover than beaver released in the small (<0.28$^3$ m/sec) streams where we were working.

The value of riparian areas for wildlife has been emphasized by many authors (as reviewed by Naiman et al. 1988), but predator-prey relationships in riparian areas and how they relate to habitat quality and availability are not well understood (Smith et al. 1994). During drought periods animals may concentrate in riparian areas along with their respective predators. These predators, while normally dependent upon another prey species, may find beaver easy prey. Many wildlife species use riparian areas more frequently during fall due to increased forage and water in the riparian areas. Predators may also concentrate in these areas to take advantage of higher prey densities, greater water availability, and lowered temperatures. Our releases were primarily (71%) done during the fall (August 15–October 10) to take advantage of the beaver's natural tendency to begin construction of dams and lodges in the fall (Vore 1993). We did spring releases to establish beaver in ephemeral streams that were normally dry by mid August and to supplement one or two beaver that had become established the year before. Relocations in the spring may have lower predation risks, although we did not see this relationship in our analyses.

Several biologists suggested that we create small ponds at release sites to provide temporary refuge for released beaver. In the two instances (Bear Gulch and Spring Creek; see Table 2 for specific numbers released) where we released beaver into remnant ponds they emigrated from those areas within 10 days and constructed their own dams and lodges elsewhere in the drainage, although the remnant ponds may have provided them with initial protection from predators and helped to acclimate them to the area. Furthermore, creating small ponds is cost prohibitive and unlikely to be used in future transplants, therefore we did not consider this as a legitimate tool in our transplants.

Our goal was to establish beaver at release sites, therefore we continued to release beaver until dams and lodges were constructed. On average we released 17 beaver/site before they constructed a dam and lodge and successfully reproduced. In 11 instances a single beaver created a pond with a lodge and we transplanted additional animals in the hope that they would pair-up. We expected that many beaver would emigrate from our release sites in efforts to return home, search for mates, or look for more suitable habitat. High predation and emigration rates for introduced beaver should be expected (Griffith et al. 1989) and planned for in any beaver translocation project.

We found no significant predictors of success or survival in our analyses. The 2–3.5 year-old beavers had greater average success (Figure 2) and other researchers (Vore 1993; P. Jensen,

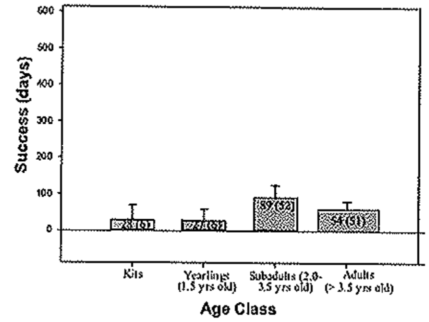


**Figure 2. Average survival, in days (n), for four age classes of relocated beavers. Error bars depict 95% CI's.**

Pennsylvania State University, pers. comm.) have suggested that this age class may be more suitable for recolonizing new areas since they are predisposed to emigrating, establishing new territories, constructing dams and lodges, and attracting mates. Our results are inconclusive, but we recommend translocating beavers >2 years old since mortality and emigration of our younger animals totaled 100% within 6 months.

Our results also call attention to programs where only one or two beaver are relocated to either unoccupied habitat, usually under the pretext of improving habitat, or to areas with existing beaver populations. These activities are common in the western U.S. and are usually carried out by district biologists or conservation officers to remove nuisance beaver without using lethal techniques. We suggest that unless managers are committed to successfully introducing beaver through planned introductions, monitoring, and follow-up releases their time and money may be better spent on other duties.

In summary, we found that beaver could be used to create natural wetlands and improve riparian habitat in 13/14 streams where we relocated them. Mortality (30%) and emigration (51%) totaled 81% within the first 6 months of release and we needed to relocate an average of 17 beaver/site to get a pair to establish and reproduce. Additional releases were also needed to augment single animals that had become established. Wildlife response to our created habitats was immediate (McKinstry et al. 2001) and landmanagers found that the habitats were valuable to both wildlife and livestock. We caution that releases should only be used in drainages where conflicts with irrigation or road crossing structures are minimal and preferably where the drainage is controlled by a few landowners to simplify evaluation and management.


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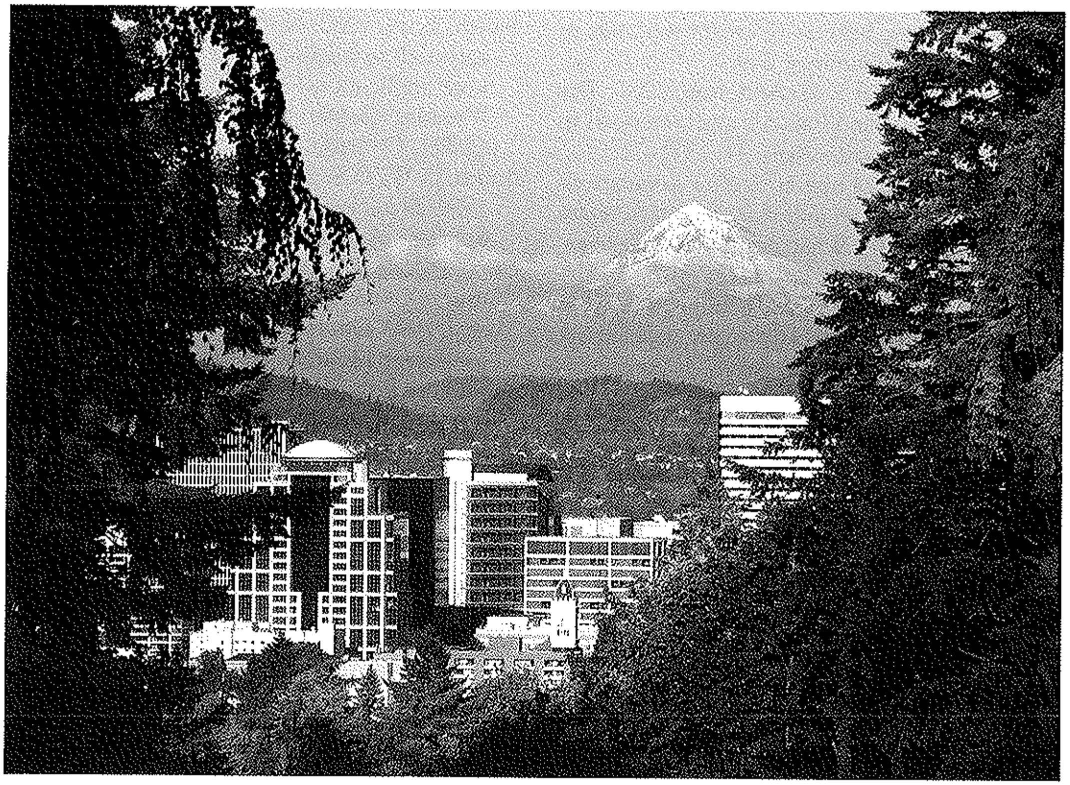

PORTLAND OREGON VISITORS ASSOCIATION

# Open Minds

## DON'T REINVENT THE WHEEL

by Beth Dillingham

Whenever a group of people embark on a project—say, working on an education program for a wildlife rescue organization—it is natural to roll up your sleeves and start developing your own training materials, curriculum, and education programs. But before you invest your precious time and energy in starting from scratch, please realize that there are gazillions of environmental curriculum/teaching materials out there already. There is no need to reinvent the wheel.

Even before the first Earth Day in 1970, people had begun to understand the growing environmental problems that affect people and wildlife. That understanding fueled efforts to work on ways to teach people to live more carefully and respectfully of wild places and wild creatures. Enormous amounts of time, money, energy, and rigorous testing of environmental education teaching materials have taken place. In this column, I'll tell you about just a few highly recommended resources. You will still need to adapt materials and develop programs and strategies that work for you, but you'll get a great head start with these resources.

Project WILD is one of the most widely used conservation and environmental education programs in grades K–12. This program emphasizes wildlife and is sponsored by Natural Resource Agencies both in the U.S. and in many countries around the world. Project WILD materials are generally free, but are only available if you attend a workshop held in your area. The workshops are fun. You'll practice the activities so you are ready to use them in your programs, and you'll leave with armloads of materials. You can contact local agencies that offer workshops near you through the programs website.

Project WILD materials contain activities that have been crafted to demonstrate the perils of migration, ("Migration Madness"), the problems of removing predators from an ecosystem ("Oh Deer"), and much, much more. The games and activities help both kids and adults understand the big ecological picture in a lively way that really makes a lasting impression. Each Project WILD activity contains all the information needed to conduct that activity, including objectives, method, background information, a list of materials needed, procedures, evaluation suggestions, recommended grade levels, subject areas, duration, group size setting, and key terms.

There are several programs that are similar to Project WILD, including Aquatic WILD and Project Wet (www.projectwet.org), which, as their names imply, covers aquatic systems. Project Learning Tree (www.plt.org) addresses forests, wildlife, community planning, waste management, and energy.

You can find Project WILD and Aquatic WILD at www.projectwild.org.

Another source of information and training opportunities is the North American Association for Environmental Education (www.naaee.org). NAAEE is a network of environmental education professionals, students, and volunteers in North America and 55 countries around the world. NAAEE follows a "cooperative, non-confrontational, scientifically balanced approach to promoting education about environmental issues." They have an annual conference and offer a range of education materials and journals, and an Internet communications site called the EE-Link (visit www.eelink.net).

GreenCom Resource Center for Strategic Participatory Communications (www.greencom.org) is intended for environmental educators. GreenCom has a collection of more than 3,000 books, journals, reports, and videos as well as other classroom materials in English, Spanish, French, Arabic, and other languages.

The National Association for Interpretation (NAI) is a professional association that emphasizes professional development and certification. *Interpretation* is the term used to describe communication activities designed to improve understanding at parks, zoos, museums, nature centers, historic sites, cruise companies, tour companies, and aquariums. Interpretation is a communication process that forges emotional and intellectual connections between the interests of the audience and the inherent meanings in the resource. NAI holds an annual national conference and offers a variety of materials for sale through its website. They also have a bimonthly publication on issues in interpretation. One of the major original thinkers in interpretation is Freeman Tilden, who wrote *Interpreting our Heritage* in 1957. Sam Hamm has published a very helpful updated book called *Environmental Interpretation*.

My favorite source of props, books, gadgets, and teaching supplies is Acorn Naturalists' catalog of "resources for the Trail and Classroom" (www. Acornnaturalists.com). Science educators interested in developing and making accessible resources for enhancing science, outdoor, and environmental education founded Acorn Naturalists more than a decade ago. Their catalog features field gear, puppets, children's environmental literature, environmental texts, hand lenses, butterfly nets, skulls, and track replicas. The products were designed to be used by teachers, naturalists, interpreters, outdoor educators, camp counselors, birders, hikers, parents, and kids.

The problem in educating about wildlife is not that there are not enough environmental education resources—but rather so many. It can be a little overwhelming to sift through them. You will need to gather materials and develop your own identity and approach in dealing with education issues concerning wildlife, but you can save so much time and energy tapping into the huge amount of resources and materials of those who have already walked down that road before you.

Enjoy your search. JWR

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# Food for Thought

## SONGBIRD NESTLING DIETS, 2004

**by Astrid MacLeod and Janine Perlman**

Baby bird season is always upon us—in one hemisphere or the other. During the last North American summer, we received some version of the following query numerous times:

> *Now that baby bird season is here, the center where I volunteer is, as always, short of money, and the staff is short of time. We've been told that we have to use a "less expensive and more convenient" formula for raising songbirds, and that MacDiet has too many expensive ingredients and is too time-consuming to make. It's obvious, though, that the birds do much better on MacDiet. Any advice?*

MacDiet can be made in large batches and frozen, as "ice cubes," for up to a month. Just omit the vitamins and yogurt; add those fresh when the food that is thawed for the day. The dried insects can be powdered using a coffee grinder, and all the ingredients can be pureed with a blender or mini-food processor. This method of mixing, along with freezing, makes it as convenient as any other formulation.

The components of this diet are not really much more expensive than "cheaper" formulas, per bird. Less MacDiet is fed because it's more bioavailable, but the main savings come in time and money, because birds are released sooner and in better health.

The central fact of feeding nestling passerines (and "honorary passerines"—e.g., woodpeckers, aerial insectivores) is that their parents feed them insects. These nestlings have evolved to *require insects*—not just the same protein, fat, and carbohydrate levels as are found in insects, but also the micronutrients that are found only in insects.

As we've said, MacDiet is not an ideal diet; only parents in the wild can supply that. It is, however, superior to other diets in common use of which we're aware. Developmental delays and health problems are both documented results of inferior diets. Rehabilitators have noted that very young or otherwise compromised birds may survive if fed MacDiet, but not if fed inferior formulas. A high-quality formula means life rather than death for such "critical" birds. For healthy, older nestlings, there are less obvious but equally important differences; dozens of rehabilitators' observations of tens of thousands of birds show that plumage and body weight at release are routinely better with MacDiet. Field studies show that these differences largely determine the odds of a juvenile's survival through its first winter.

Each component of MacDiet is included for reasons proven by both experience and research. As one example, the inclusion of dried insects, and feeding of live ones, has been shown in the hands of many rehabbers to dramatically improve the health and developmental rate of birds. The specific nutritional reasons for this are just now emerging (manuscript in preparation).

It appears, then, that MacDiet results in larger, healthier birds because it more faithfully replicates the nutrients found in insects. Feeding solely a variety of live insects (with carefully calculated and measured calcium and vitamin supplementation) is undoubtedly the best diet for nestlings whose parents feed them insects in the wild. Some rehabilitators are concerned that the variety available in feeder insects is insufficient; others cannot afford to raise nestlings in this manner. MacDiet represents a reasonable and proven alternative, but even it cannot provide everything that parents do. As the fields of nutritional biochemistry and ecology advance, we hope to approximate the natural diet better, over time.

The formulation of optimal diets for nestlings fed insects by their parents is an evolving science. We urge you to do your own studies and compare diets in a systematic manner. Split clutches and raise them side-by-side on two different diets. Evaluate the birds' health, growth, plumage, and developmental rate; take measurements and pictures; and decide for yourself. And *please* let us know what you find!

As we've repeatedly noted, the field of wildlife nutrition is rapidly evolving. Based on newly published information, we have revised the recipe for MacDiet (presented on page 27.)

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Another query we have received numerous times involves the reformulations of favorite products:

> *I checked the ingredients lists of some pet foods I like to use, and the manufacturers have changed the ingredients. Can I substitute other dry and canned pet food brands, or will I have to switch to different diets?*

It is always a good idea to check ingredients lists when you shop. Companies change formulations frequently, and while some changes are for the better, others are decidedly not. The companies that manufacture ProPlan® and Science Diet®, among others, have added soy to some of their products. We can only assume this is a cost-cutting measure, as soy is an inexpensive but inferior source of protein. Consequently, many brands that were once considered reliable and "high end" are no longer worth their premium prices. It is well worth your time and effort to evaluate and compare other brands.

Good substitutes at the time of this writing are Eukanuba®, Iams®, and Maxximum Nutrition®, Wal-Mart's store brand. Iams® canned kitten food is a good substitute for Science Diet® canned kitten food. These can be used in place of the reformulated soy-containing brands.

You may find other suitable brands locally. Kibble and canned foods for kittens should list chicken as the first ingredient. If a product also contains digests and by-products, don't assume that it is inferior. Such foods may be closer to the whole prey that is ideal for wildlife.

No matter how renowned the brand, pass up foods that contain wheat or soy. These ingredients can cause allergic reactions (that may be subtle or mistaken for illness) in many animals, and may have other serious consequences for wildlife.

As animals make the transition to self-feeding, kibble may be a part of their weaning diets. Before investing in the large economy size bag of kibble, buy a few small sample bags. Eukanuba® is good food, but it may not absorb water as nicely as do other brands, and some animals seem not to like it as much. It's not only important to provide animals with foods that they should eat—it is important to provide them with foods that they *will* eat.

***

Many rehabilitators ask, "*How should I wean birds from their nestling diet?*"

As nestlings approach fledging, "adult" foods that they will be eating in nature should be gradually added to their diet. Once they've fledged, birds must be given a wide array of natural foods for proper nutrition and normal psychomotor development. Those foods should be presented in ways that maximize skill building—i.e., in forms and settings that are like those the bird would find in the wild. Depending on species, birds need the practice, challenge, and fun of finding, catching, gleaning, probing, pecking, and/or digging whole, natural food items from a complex environment that replicates what they'll encounter when they're released.

While a superior diet results in more rapid development, birds with any disadvantage such as illness, injury, or social isolation are likely to be developmentally delayed. Remember that even in the best of circumstances, self-feeding is a gradual process. In nature, the fledglings of many species of passerine stay with their parents for many weeks after leaving the nest, and are periodically fed by them. A dismaying number of young birds in rehabilitation starve either in captivity or, very probably, soon after release, either because they are allowed to "wild up" before they're actually self-sufficient, or because, out of "tough love", they are not fed even though they beg. Birds do not beg because they are "lazy" or "manipulative"; *they beg because they are hungry*. Regardless of its age, ***never stop feeding a bird that begs.*** It may be ill or developmentally delayed for any number of nonobvious reasons. Captive animals wean as soon as they are able to do so. It may not be at our convenience or on our timetable, but their neurological development compels them to become independent as soon as they're able. To rush the process is to malnourish and almost certainly doom the bird.

In the best of circumstances, only a small percent of even wild-raised nestlings survive to reproduce. Rehabilitators cannot provide for the needs of orphaned birds as well as their parents do, but we must emulate their parents as fully as possible if we are to give them any chance at all of surviving to reproductive age. We must faithfully copy nature, in how we feed them, and in the foods we provide. JWR

**MACDIET 2004**

1/2 c. (120cc), or 65g, premium quality feline growth dry kibble, soaked in just enough water to soften completely. Drain off excess water.

2 hardboiled egg whites, sieved through a fine mesh strainer

3 tbsp. (45 cc) canned premium quality feline growth food, drained of liquid

2 tbsp. (30 cc) freeze dried insects

1/2 tbsp. (8 cc) "Knox® Blox"

1800 mg elemental calcium (= 4.5 g calcium carbonate), powdered

50 mg vitamin C (ascorbic acid)

1 small pinch of powdered B-complex vitamins
(about the volume in 2 sesame seeds)

4 drops (0.3 cc) cod liver oil (supplies vitamins A and D)

1 drop (0.08 cc) of vitamin E

1 slightly rounded tbsp. (20 cc) of plain yogurt (low- or non-fat)

Be sure to feed 1 part live insects (which have, themselves, been well fed) to 2 parts MacDiet. The ratio of live insects should be about 10 mealworms: 5 waxworms: 3 crickets, if all are medium-sized. Do not attempt to "calcium-gut-load" insects; calcium is a toxin to insects, and when they ingest it, they sicken and become poor food. The MacDiet recipe supplies the amount of calcium needed for this proportion of dietary insects.

Do not change, omit, or add ingredients, because the diet will almost certainly become unbalanced.

Provide as many drops of water as the bird wants after each feeding.

**For birds days 0 to 3 post-hatch,** add digestive enzymes, and provide fecal microflora for gut colonization (this is essential!):

Use 1/4–1/2 tsp. (1.5–2.5 cc) of pancreatin (e.g., Pancrezyme®) powder per recipe (scale down pancreatin to actual amount needed for one feeding); mix thoroughly; incubate at room temperature for 15 minutes before feeding.

Twice a day, give the bird a tiny speck of fresh feces from a healthy adult conspecific. If this is added to food, discard remainders and thoroughly wash all implements.

Remove all chitinous (exoskeletal) portions of live insects before feeding.



For birds younger than 5 days old, we recommend feeding low-chitin insects with supplements. If you would like a current protocol for feeding neonates and nestlings, please contact the authors.

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*The authors welcome feedback and suggestions for future columns.*

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# Bugs & Drugs

## ANTIMICROBIAL RESISTANCE

by Kathy Dolan

Antimicrobial resistance? Super bugs? Bigger and stronger antibiotics?! Mutant strains of bacteria causing incurable diseases! What does all this mean to the rehabber? Plenty. If you are using antibiotics in your care and treatment of wildlife, please read on.

***Antimicrobial agents*** are drugs that have a negative affect on microbes and are either man-made or are produced naturally by microbes. The term ***antibiotic*** refers specifically to substances produced naturally by bacteria or fungi that, when used in small amounts, either kill or damage other microbial species. However, antibiotics have no affect on viruses. The two terms, antimicrobial agent and antibiotic, are frequently used interchangeably. Antibiotics were once hailed as miracle drugs that would cure all infectious bacterial diseases. But antibiotics do not "cure" disease, they never did. Instead, their usefulness is in helping the body fight off microbial infections. Antibiotics reduce the number of pathogenic microbes either by killing or inhibiting microbial growth. Antibiotics aid the host defense system in removing and destroying the offending microbes.

### Types of Antimicrobial Agents

Antimicrobial agents are grouped according to the structure or function they affect in the bacterial cell.

The largest group of antimicrobial agents is the inhibitors cell wall synthesis. The cell wall protects bacteria from osmotic changes in the environment. A missing or incomplete cell wall renders bacterial cells vulnerable to lysis, or bursting. Bursting is a lethal event for the bacterial cells, thus this group is termed bactericidal. Relatively few side effects are observed with these drugs because of their specificity for the bacterial peptidoglycan cell wall, which is lacking in humans and animals. Commonly used drugs in this class include the familiar penicillins and their derivatives such as amoxicillin, found in Clavamox®, the cephalosporins, and bacitracin, which is found in topical over-the-counter preparations such as triple-antibiotic ointment.

Antimicrobials that interfere with the production of bacterial proteins are another large group of drugs used to treat bacterial infections. These chemicals interact with the different proteins and subunits of the ribosome. These interactions prevent cellular protein synthesis, which reduces or eliminates essential components required for cell function and growth. If the drug and ribosome interact irreversibly, the effect is bactericidal. If the interaction is reversible, the effect is bacteriostatic. When a bacteriostatic chemical is removed from the environment, the effects of the drug are eliminated and the bacteria resume growth. More side effects are associated with the use of protein inhibitors, conditions that range from nephrotoxicitiy to transient or permanent deafness. Antimicrobials of this class include aminoglycosides such as gentamicin and tobramycin, the tetracyclines, and macrolides such as erythromycin.

Along with protein synthesis, DNA and RNA synthesis are essential functions of bacterial growth. A number of antibiotics interfere with these activities. During RNA or DNA synthesis, enzymes known as topoisomerases interact with nucleic acid strands to prevent the strands from becoming kinked and tangled. Quinolones and fluoroquinolones prevent the topoisomerases from interacting with the nucleic acid, which results in tangled knots of nucleic acid that can no longer function properly, leading to cell death. This group of antimicrobial agents is completely man-made, or synthetic. The most familiar members of this group are the quinolones, which include(s) ciprofloxacin, enrofloxacin (Baytril®) and orbifloxacin (Orbax®).

Most microbes manufacture their own folic acid, while humans and other animals obtain folic acid as a vitamin from food . Folic acid is the starting material in the synthesis of nucleotides, the building blocks of DNA and RNA. If folic acid is not made, nucleic acid synthesis comes to a halt, and growth comes to a halt. Antimicrobials that inhibit the production of folic acid synthesis include the sulfonamides/sulfa drugs and trimethoprim, which are frequently combined. Used together in preparations known as Tribissen® and Primor®, these agents have an enhanced, or synergistic effect that is greater than either drug used alone. These preparations are useful in treating Gram-positive and Gram-negative bacterial infections as well as protozoal infections caused by coccidia.

### Antimicrobial Resistance

So, what is antimicrobial resistance? A superficial examination of medical news reports released to the public would suggest that drug resistance is something new that reduces the effectiveness of drugs used to combat infectious diseases. In a way that is correct. However, resistance is not new but rather part of the dynamic world in which we live. Resistance is the microbes' response to environmental factors that are trying to eliminate them from their environmental niche. Production of antibiotics in a natural environment gives the producer an advantage over the competition for a particular niche. In response to antimicrobial attacks, microbes do what all animals do when they are threatened: they fight back, not by biting or clawing, but by evolving or acquiring strategies to destroy, block, or outwit the offending agents. Those microbes that outwit the offensive chemicals will survive to reproduce the next generation. It's evolution and chemical warfare on a microscale. Unfortunately, through misuse of antibiotics in both medicine and agriculture, and the microbes' own dynamic evolutionary processes, we have accelerated the process that selects for antibiotic-resistant bacteria.

### Types of Antimicrobial Resistance Mechanisms: Intrinsic Resistance vs. Acquired

Intrinsic resistance is determined by structural components of the bacterial cell. For example, Gram-negative bacteria like *Escherichia coli*, *Aeromonas*, *Pseudomonas*, and *Klebsiella* have an extra outer lipopolysaccharide membrane that is external to the cell wall and cytoplasmic membrane . This outer membrane is a formidable barrier to many substances including alcohols, disinfectants, and many antimicrobial agents. To cross this barrier a compound needs to be very small, highly lipid-soluble or able to pass through protein-lined channels that span the membrane. Erythromycin and other macrolides are effective in treating infections caused by Gram-positive bacteria that lack an outer membrane. In contrast, the macrolides are largely ineffective in treating Gram-negative infections because their large molecular size prevents them from crossing the outer membrane. Additionally, many cell wall synthesis inhibitors, such as Penicillin G, are excluded from Gram-negative bacteria by the outer membrane.

### Acquired Antimicrobial Resistances

The acquired or genetically encoded resistances arise either by mutation of genes within the bacterial chromosome or by acquisition of genes that code for resistance mechanisms from other antibiotic resistant bacteria. Chromosomal mutations that lead to bacterial resistance are passed on to the next generation through reproduction. But that is not the only way resistance genes can be passed. Dying bacterial cells lyse, releasing their cytoplasmic contents including the bacterial chromosome. Some bacteria have the ability to take up bits of this released chromosome and incorporate the new DNA into their own chromosomes, gaining new traits from the dying bacteria

Bacteria can also swap genetic material without reproducing. Many resistance mechanisms are carried in genes found on plasmids, known as resistance plasmids. Plasmids are double-stranded circular bits of DNA that reproduce within the bacterial cell independent of the chromosome. A little known secret of the microbial world is that many bacteria have "sex" among their own species, and across species lines, during which they transfer resistance plasmids to other bacterial cells. The recipient of such a swap obtains a set of genes that provide an increased chance of survival. Bacteriophages (bacterial viruses) can also transfer genes carrying information for resistance mechanisms. While packaging bacteriophage DNA into the bacteriophage particle, pieces of cellular chromosome or plasmid DNA can be mistakenly incorporated into the empty phage capsid. This DNA when introduced via the bacteriophage into the next bacterial cell may be incorporated into the cell's own chromosome, thus acquiring new genetic traints, possibly new resistance traits.

Bacteria such as *Staphylococcus* and *Bacillus* produce and secrete enzymes, called beta-lactamases or penicillinases that act like molecular scissors to shear the penicillin molecule rendering it nonfunctional. Penicillinases inactivate not only penicillins, but also many cephalosporins.

While penicillinases work outside of the bacterial cell, other resistance mechanisms work within the bacterial cytoplasm. Through random mutation, the target sites of antimicrobials can be altered. Resistance to fluoroquinolones occurs through one or two point mutations in the gene that codes for the targeted topoisomerase. These mutations result in a change of one or two amino acids out of 923 amino acids in the topoisomerase. This small change slightly alters the shape of the enzyme, rendering it invisible to the fluoroquinolones. Hence, fluoroquinolones are less effective against bacteria carrying this mutation. Similar mutations of the proteins found in bacterial ribosomes account for resistance to the protein synthesis inhibitors, like gentamicin and tobramycin. Other strategies within the cytoplasm include the production of enzymes that chemically modify antibiotics by adding additional chemical groups to them: aminoglycosides are inactivated by this mechanism. Excess production of the intended target is another successful means of escaping the effects of an antimicrobial agent. The antibiotic is overwhelmed by its intended target allowing the targeted synthesis to continue unimpeded. This mechanism occurs with sulfonamides and penicillins.

Tetracycline resistance is due to the presence of transporter systems or efflux systems, essentially molecular revolving doors, that span the cytoplasmic membrane and pump the antibiotic out of the cytoplasm before it has a chance to act in the cell. Efflux pumps are widespread in the microbial world and play a role in fluoroquinolone, penicillin, macrolide and aminoglycoside resistance in both Gram-negative and Gram-positive bacteria. Frequently one efflux system will pump out more than one class of antimicrobial agents leading to bacterial strains with multiple drug resistances.

### How to Avoid Development of Resistances

Discontinuing the use of antibiotics is not the answer. These are very powerful and useful drugs in the arsenals of veterinarians, doctors, and rehabbers alike, but they need to be chosen and used wisely.

The key to preventing resistances lies in limiting the exposure of microbes to antimicrobial agents. Constant exposure to antibiotics drives the selection of antibiotic-resistant microorganisms. Antibiotics should be used only when needed: dirty, open wounds, systemic infections, or prophylactically for surgeries or immune debilitated animals, etc. It is imperative to avoid the shotgun approach to antibiotic therapy. Avoid choosing the most powerful antibiotics that will knock out every bacterium in the animal. Reserve these antibiotics so they will maintain their effectiveness against the nastier, more recalcitrant bacteria. Whenever possible use information gathered from culture and sensitivity reports to choose an antibiotic that will more precisely target the pathogen. If a microscope is already in use in a clinic to do fecals and/or blood work, invest in a Gram stain kit. Kits are inexpensive and with a little practice (and guidance from a veterinarian) good results can be obtained and interpreted. Knowing the Gram reaction of the causative agent, can help in narrowing the choice of an appropriate antibiotic. Armed with the history of antibiotic usage, rehabbers can reduce the selection of antibiotic-resistant bacteria and avoid making the same mistakes that were made before.

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# Forester's Log

## SEATS TAKE NO "BACKSEAT" IN AIR TANKER BUSINESS

**by Mary Stuever**

As a twenty-year veteran firefighter I have to admit I was skeptical when I first heard about single engine airplanes being used to dump fire retardant on fires. I wondered how small planes could be as effective as the large military bombers. A visit to the Single Engine Air Tanker (SEAT) base at the Las Vegas New Mexico Municipal Airport convinced me these small planes are the answer to problems presented by the current aging large air tanker fleet.

The SEAT I toured in Las Vegas is the largest single engine plane in the world, with a wing-span 60 feet across. The Air Tractor AT-802, built in Olney, Texas, can carry 800 gallons in its hopper. Unlike the large air tankers we normally envision, the Air Tractor's versatile storage area can be loaded with water, retardant, or another fire-fighting liquid known as wet water with reduced surface tension. Typically the plane's first load is water, which can either be dropped on the fire if the reported fire is found, or dumped elsewhere without sacrificing an expensive load of slurry. When the plane isn't being used to fight fires, the hopper can also be loaded with seed, fertilizer, or any other aerial applications.

The larger bombers carry 2000 to 3000 gallons of retardant, which is loaded on the planes from permanently placed vats at designated air tanker bases. Depending on the model, these planes can drop their retardant in one pass or in several separate loads. In New Mexico the three air tanker bases are in Albuquerque, Alamogordo, and Silver City. SEATs, on the other hand, are loaded from easily transported mixing tanks mounted on a trailer. Any airstrip, or even stretch of highway, can be set up to refuel and reload the small planes in the time it takes to drive to the location. Therefore, by placing the SEAT operation closer to the fire, the SEAT has a significantly faster turnaround time between loads.

The plane is also plumbed for rapid turnaround and can be refueled and reloaded with the engine still running. The average "pit-stop" time is between three and five minutes. Louie Casaus, Las Vegas District Forester and a wildfire incident commander, described being on the ground on a recent fire utilizing the SEAT. "It would seem just a matter of minutes since the plane left, before we'd hear it coming back again. It was just amazing."

Casaus and other incident commanders have been especially impressed with the pinpoint accuracy of the retardant drops. Armed with built-in Global Positioning Survey equipment, the plane's state-of-the-art technology provides precision guidance. This ability to lay the retardant exactly in needed locations actually reduces the amount of overall retardant needed to fight the fire, providing one more cost-saving measure in the operation.

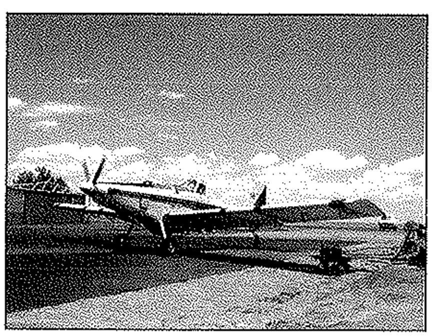
State-of-the-art technology is apparent in various safety measures built into the plane as well, including excellent pilot visibility, a rugged airframe, and features that make the plane crash-worthy. Pilot Dan Rinner of Aztec, New Mexico, recently had an incident that might have proven fatal in a different craft. After dropping a retardant load his plane hit the treetops, but he was able to fly it back to the airport and make a safe landing. Although the plane sustained damage, the pilot escaped injury. The Clovis-based company, Aero Tech, Inc. brought in a replacement plane and the SEAT operation was only temporary out of service.

"Safety is the primary focus of our operation," explains Army Ranger Harry Weeks. Now a certified "SEAT Manager", Weeks is the official agency employee responsible for the safety and use of the aircraft. Not only does the aircraft not fly without a SEAT manager on the ground to supervise the operation, but a certified crash/rescue unit must also be on-call at the airstrip. At the Las Vegas Municipal Airport, this service is contracted from the Las Vegas Fire Department. The City of Las Vegas supports the SEAT operation with the services of the city's Public Water Works as well.

In addition to hosting the SEAT operation in Las Vegas, the New Mexico State Forestry Division also sponsors a SEAT operation based out of Ruidoso in cooperation with the Village of Ruidoso. Aero Tech, Inc. has the contract for that operation as well, offering a truly New Mexican solution towards addressing the national issue of air tanker availability. JWR

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

PHOTOS: LOUIE CASAUS



**Far left: The Single Engine Air Tanker, an AT802, is largest single engine aircraft in the world and carries 800 gallons of fire retardant.**

**Left: The SEAT makes a proficiency drop at the Las Vegas Municipal Airport. Piloted by Dan Rinner, of Aztec, New Mexico, the drop is part of regular safety and maintenance checks.**

# *Cry of the Kalahari: An American Couple's Seven Years in Africa's Last Great Wilderness*

**By Mark and Delia Owens**

Boston: Houghton Mifflin Company, 1984; 341 pp.; U.S. $7.95 (paperback);
winner of the 1985 John Burroughs Medal for Best Natural History Book of the Year
ISBN: 0-395-39413-9

# *The Eye of the Elephant: An Epic Adventure in the African Wilderness*

**by Delia and Mark Owens**

Boston: Houghton Mifflin Company, 1992; 306 pp.; U.S. $15 (paperback)
ISBN: 9-780395-680902

**Books reviewed by Elsa C. Bumstead**

It's 1974. Two people have graduated from college and are on their way to Africa for the adventure of a lifetime. Having auctioned off all their possessions, Mark and Delia Owens land in Botswana, "...determined to study an African carnivore in a large, pristine wilderness" and to use the results of their research "to help devise a program for the conservation of that ecosystem."

*Cry of the Kalahari* documents their story, from the early years struggling with adapting to the ways of the Kalahari, to their evolution as topnotch scientists. From heavy rains to wildfires, from human isolation and illness to struggles with government agencies and visits to camp by inquisitive lions, hyenas, and jackals, the Owens meet the challenges and work on their studies of plants and animals in an unexplored place called Deception Valley. Located south of Maun in the northern part of the Central Kalahari Game Preserve, Deception Valley is the "remains of an ancient river that last flowed through the Kalahari about 16,000 years ago, at a time when rainfall was much more generous than it is today." The Owens find it ideal for locating their predatory subjects consistently.

From their research comes remarkable experiences that document extraordinary behaviors. A mosaic of interrelationships among lions, leopards, jackals, hyenas, and wild dogs is pieced together like a jigsaw puzzle. Thought to be solitary, spotted hyenas are seen to be much more communal in their hunting techniques. The secrets of brown hyena reproduction are uncovered when a female is observed raising her young. Unafraid and unfamiliar with humans, lions romp on occasion like kittens through the camp. Hornbills become Delia's companions in the kitchen. Laramie the lizard sleeps in an empty Di-Gel box by their bed, welcome because of his voracious appetite for flies. The camp clown, a rat by the name of Moose, entertains them with his stealing antics.

Their story, told in shared voices, is remarkable and gripping. As with many a story, the adventure had to end. Realizing they had a lot of information to process, write about, and publish, the Owens made the difficult decision in 1980 to move to California to complete their graduate studies. At the end of *Cry* are four appendices. Three provide recommendations for mitigation of wildlife and poaching issues: "Conservation of Migratory Kalahari Ungulates," "Conservation of Kalahari Lions," "Conservation of Brown Hyenas." The fourth appendix is a list of common and Latin names for the mammals, birds and snakes mentioned in the book.

After Mark and Delia complete their degrees at the University of California, they return to Africa in 1985. Their adventures continue with new challenges. Planning to return to Deception Valley to continue their lion studies, they find the area awash in controversy. Cattlemen and politicians wanted to divide the game reserve into private ranches, so their research permit is denied. *Eye of the Elephant* is the story of the Owens decision to relocate to the North Luangwa National Park in Zambia. It is there that they fight poachers to conserve habitat and game for the "benefit of the local people through wildlife tourism."

Mark and Delia engage the local tribes and villages in their preservation efforts, teaching the people that they could thrive, not by shooting elephants, but by attracting tourists to see elephants and buy native crafts. International support for a ban on the sale of elephant body parts is organized, and the worldwide market for such items withers.

Their story is poignant, and filled with life-threatening moments. Their research provides a wealth of information on understanding Africa's natural ecosystems, and how human behaviors have upset natural checks and balances. Two appendices in the second book provide background on fences and wildlife, and on elephants and the ivory ban. The story of Survivor, an elephant who survives poaching attempts, is fascinating. To quote the Owens, "The eye of the elephant is the eye of the storm." Indeed it is. Catch the reflections when you next choose a book to read.

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*Reviewer Elsa C. Bumstead is an interpretive naturalist, writer, environmental scientist, and sometime wildlife rehabilitator who is based in Albuquerque, New Mexico.*

*Conservation Classics is intended to provide our readers with suggestions for building a collection of must-have wildlife and ecology reference books.*

## Parasites and Diseases of Wild Birds in Florida

**by Donald J. Forrester and Marilyn G. Spalding.**

Gainesville: University Press of Florida, 2003; 1072 pp
U.S. $125 (hardcover)
ISBN: 32611-2079
www.upf.com/Spring2003/Forrester.htm

This is the long-awaited companion volume to Donald J. Forrester's *Parasites and Diseases of Wild Mammals in Florida*, published in 1992 and still in print at the University Press of Florida. These two references would make an invaluable addition to any rehabilitator's library.

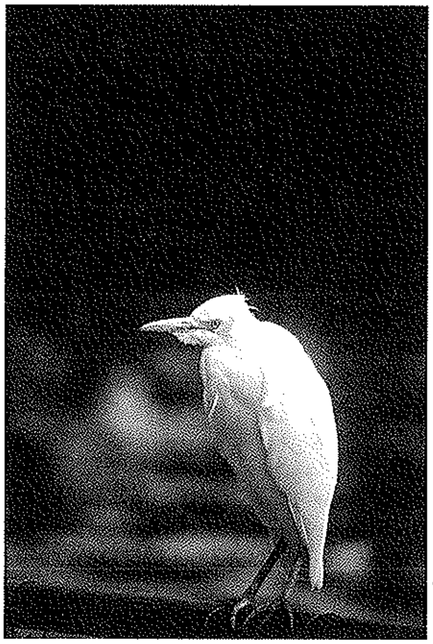
The book is organized by the host species of bird rather than by the disease agent, and each chapter is preceded by a discussion of the population and survival status of the bird or bird group. The scope of the book is much wider than might be inferred from the title. Besides the expected data on viruses, bacteria, fungi, protozoans, helminths, and arthropods for each bird, there are also discussions of the effects of inclement weather, predation, starvation, electrocution, human-related trauma, and many other conditions. There are a staggering 494 tables summarizing the data, as well as 265 figures and 59 beautiful line drawings. It is difficult, if not impossible, to think of another reference that summarizes such a wide variety of information on birds.

The lengths of the chapters vary, of course, with the amount of research that has been done on the bird groups, with comparatively little information available, for example, on "Oceanic Birds," "Vultures," and "Perching Birds" (passerines). The highlight of the book is the chapter on "Wild Turkeys," which is a small book in itself (124 pages), and summarizes Dr. Forrester's more than 30 years of research on this species. Similarly, the chapters on "Herons, Egrets, and Bitterns" and "Cranes" reflect Dr. Spalding's extensive research on these groups.

One of the most valuable aspects of this book is the Index, which is 104 pages long, and is really not an index in the pure sense, but a checklist. It is possible, for example to look up the great horned owl and see a complete list of the bacteria, protozoans, helminths, arthropods, etc. reported from that host, or to look up a disease like trichomonosis and see all the birds recorded as infected with that agent. The index alone is worth the price of the book.

In short, this book is a must-have, not just for rehabilitators, but for anyone working in the area of parasites and diseases of birds in North America and elsewhere. JWR

*Reviewed by J.M. Kinsella, HelmWest Laboratory, Missoula, Montana.*



USFWS/LEE KARNEY

## Skyward

**by Mary Alice Monroe**

Buffalo, N.Y.: Mira Books, 2003; 416 pp
U.S. $6.99 (paperback)
ISBN: 1-55166-700-2

The characters in this novel are all deeply involved in a raptor rehabilitation facility, the very loosely disguised South Carolina Center for Birds of Prey, just outside Charleston, and its birds are at the core of the book. The story itself, a love story, is disappointingly formulaic and predictable; although well written, the book was not all that gripping, without a lot of tension until the very end. But the birds are central and create some of the main threads, and since the book was written by a "USA Today Bestselling Author," it's likely to reach mainstream America. And that's a very good thing.

The most endearing and fascinating character is Elijah, a member of the Gullah-Geechee Nation—not one of the main protagonists but a critical character, who is often the bearer of many of the most powerful messages, from respect for wildlife to forgiveness for human transgressions. 'Lijah is one of those people whose communion with and understanding of wildlife is what we all aspire to. In one passage, Elijah is training Ella, an RN who is filling in for a primary bird caretaker, on how to approach the birds:

> "Birds of prey be powerful hunting birds. Remember that! They're wild. You have to be careful. And respectful. Especially when you going toward them because they're real fussy about their no-go area. You don't want to just march into they space, hanging over them or moving real quick.... Believe me, they'll let you know when they don't want you coming any closer.... And don't stare at them, either. It's tempting to look at them, but they'll mad up then.... It's simple, really. Communicating with birds ain't much different than the way you communicate with all spirits. You just have to open your heart and let the warmth inside come spilling out."

There is one description of the main male protagonist, the founder and director of the center, that strikes home.

> "Seriously, Ella, be patient with him. Visionaries are a unique brand of people. They inspire us. They challenge us to live up to possibilities. But sometimes they don't see the forest for the trees. They work with a single-minded focus, forgetting mundane things like eating, putting on socks and kicking back to relax once in a while. They feel responsible and they give everything."

Living with a wildlife rehabilitator can be a challenge—especially if you're a spouse or a child!

Although the vast majority of the descriptions of raptor care provided in the book are right on, in my opinion (the author is a volunteer at SCCBP, where they obviously practice good rehabilitation), one error hits on one of my personal sore spots: talking about putting young eagles into a hack box "in a few weeks, when they're old enough to fledge." Hack boxes work only if you put young birds in as nestlings, not waiting until they're ready to fledge—they won't stick around. Essentially hack boxes become the nest substitute and ensure the bird keeps coming back for food as it learns to hunt for itself—if the birds are put out there quite young, basically as soon as they can thermoregulate and feed themselves cut up food off a plate or "hack board." Putting them out at fledging time is more a soft release and, in my opinion, dangerous as there are no guarantees the bird will not just take off for the horizon.

Overall, Skyward is a good read—and although the copy I read was sent by a friend, I also appreciated the handwritten note on a pre-release marketing postcard that was obviously mailed to raptor centers all over: it said 'Thanks for all you do!" and was signed by the author.

Getting a book about rehabilitation into the mainstream is a great way of giving thanks for the hard work of wildlife rehabilitators everywhere.

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

## CHILDREN'S/EDUCATIONAL BOOKS

### Everybody's Somebody's Lunch

**by Cherie Mason; illustrated by Gustav Moore**

Gardiner, Maine: Tilbury House, 2002; 40 pp
U.S. $7.95 (paperback)
ISBN 0-88448-198-0

### Everybody's Somebody's Lunch Teacher's Guide: The Roles of Predator and Prey in Nature

**by Cherie Mason and Judy Kellogg Markowsky; illustrated by Rosemary Giebfried**

Gardiner Maine: Tilbury House, 2003; 70 pp
U.S. $9.95 (paperback)
ISBN 0-88448-199-9

This beautifully illustrated and wonderfully intentioned children's book opens on an emotional note. A young girl's cat, Mouser, has been missing overnight and she sets out to look for him. The text and illustrations are evocative of life surrounded by nature, as the young girl lives with her family on a farm on the coast of Maine. But she is understandingly upset when she finds just Mouser's collar, surrounded by bloody bits of fur.

As she mourns the passing of her pet and wonders what could have killed him, she starts to again notice the wildlife around her. A shrew catches and eats an earthworm. A snake tries to sneak up on the shrew, but the tables are turned and the snake becomes more calories for the shrew. A spider and a fly play out the age-old pattern. The girl's father tries to explain that everything has to eat—even us—and suggests she ask at school about "predators."

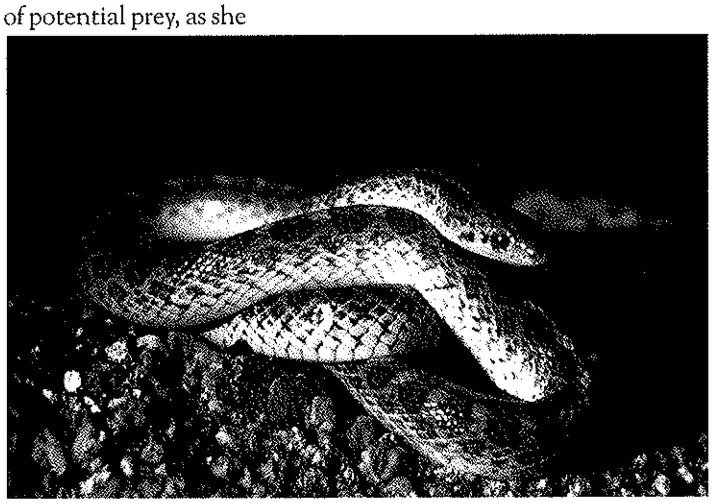
At school, the teacher acknowledges that what had happened was sad, but points out that the cat had "ventured into the wild world of predator and prey, where he didn't belong." The book presents its points clearly yet simply, without belaboring them, such as how predators and prey populations are kept in balance by each other, their interrelationship and dependency, and that there are no "bad" or "mean" animals. It also makes the point that Mouser was a predator, too—although he didn't need to kill to eat as he was a pet and supplied with food. With a Native American tale from the girl's grandmother, the point is made that "The death of the hare is the gift of life to the eagle."

In the next few days, the girl sees multiple examples of the predator relationships discussed in her class, and acknowledges how hard any hunter has to work to find food for himself or his family. She has learned that most attempts are unsuccessful. She even experiences the point of view of potential prey, as she ends up feeling lost as it gets dark, suddenly aware of and scared by night's unfamiliar noises. In the end she feels that she has grown up a lot and understands much more.

The book illustrations are very well done, clear and detailed. This is a very worthwhile book to recommend to teachers before a classroom visit or field trip and a great one for a rehabilitator's personal library.

The *Teacher's Guide*, directed primarily at grades three through six, is very complete and has wonderful pen-and-ink illustrations. It starts with a cogent introduction on the historical human attitude towards predators ("bad"—e.g., the wolf in *Little Red Riding Hood*) and wilderness (mentioned 245 times in the Old Testament of the *Bible*, and "always as a godless environment"). The *Guide* has 14 chapters, with discussion questions on predators, definitions, lesson objectives, concepts, and activities, as well as several reproducible worksheets. The chapters cover everything from food chains and how few young predators survive to adulthood to the ways different predators hunt. Also included are information and activities about bird, mammal, insect, fish, and reptile predators, making a telephone list of wildlife resources in the community, and how predators are protected. There is a chapter on humans as predators and one on death in nature. One great activity—designed to demonstrate how hard it can be to catch food—involves large tongs shaped somewhat like a heron's bill and a fake fish. Once the students master catching the fish on the floor, they then have to progress to catching it in water, then muddy water, then muddy water with simulated water plants, and eventually to tossing it in the air and catching it again...head first!

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



USFWS

# International Wildlife Rehabilitation Council

# Certification Program

International Wildlife Rehabilitation Council, at its annual meeting in November 2003, established a certification program for wildlife rehabilitators. Successful completion of the IWRC 1AB Wildlife Rehabilitation class and attendance at two IWRC or NWRA Annual Conferences entitles you to apply for **CHARTER-LEVEL CERTIFICATION.** If you would like to enroll as a certified charter-level rehabilitator, you can apply **RIGHT NOW** by sending copies of your 1AB certificate and proof of attending two national conferences (IWRC or NWRA), along with your $25 check to:

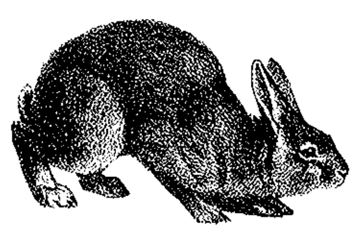
IWRC, 8080 Capwell Drive Suite 240, Oakland, CA 94621

The IWRC Certification Program benefits wildlife professionals who wish to pursue a formal certification and join a registry of others who qualify as certified Wildlife Rehabilitators in a standard, recognized way. There are several important benefits to an IWRC certification:

- Recognition by the public and professionals
- Certification may be required by a particular rehabilitation center or group
- Proof of competence in your field
- Demonstrates a commitment to excel in your field
- Certification is portable; your skill-set goes where you go, and it is backed by the IWRC Certification Standard

Information and a survey regarding this program as well as a new training plan with both instructor-led and distance-training options can be found under "New Training Plan" on our website:

http://iwrc-online.org/training/newplan.cfm



### "Double Lives" of Suburban Pumas

Researchers at the University of California–Davis recently released the most intensive scientific assessment to date of the complex relationships between pumas and people on the expanding urban fringe.

The report summarizes the first three years of the Southern California Puma Project. Using satellite radio collars, researchers tracked 20 pumas (*Puma concolor*) in and around Cuyamaca Rancho State Park (San Diego County) for 3–27 months from March 2001–December 2003, to examine the pumas' beds, dens, kill sites, and food caches.

By analyzing human use of the park's facilities (two large campgrounds, two equestrian campgrounds, two primitive camps, a school camp, and 100 miles of trails), the researchers were able to compare human and puma activity patterns.

They found that Cuyamaca pumas were generally inactive by day in oak woodlands. The pumas traveled and hunted from 1.5 hours before dusk to 1.5 hours after dawn and frequently visited communities outside the park where people kept hobby animals in open pens. They lived largely on wild deer or bighorn sheep (in another nearby state park) but also killed pets, small livestock, and hobby animals. The pumas largely avoided contact with people.

Eleven of the 20 pumas died during the study. Four were shot for threatening or killing domestic animals; four died of unknown causes, likely disease; and one each was killed by another puma, hit by a car on an interstate highway, and starved after being burned in a major firest fire.

The study also provides glimpses into individual cats' existence. One big male, M01, was the first lion the researchers collared—after it stole a dead deer from the project's pickup truck. He was the only puma that never crossed a major paved road and one of three that died for unknown reasons in June 2003. An old female, F13, had a severe 1- to 2-week-old jaw injury when collared in October 2002, and ranged more widely than most of the study pumas—possibly because she could catch only small prey. She was killed by another puma as she scavenged a dead deer.

Female F07 was a steady provider who, with her two male cubs, killed 10 of the study's radio-collared bighorn sheep, 17 uncollared bighorn sheep, and two radio-collared deer, and killed or scavenged a domestic cat. Young male M09 sired two cubs with female puma F08, had 43 percent of his home range outside of the park on private property, and was shot dead one night as he left the yard of a property owner who had chickens running loose.

The researchers made the following recommendations for the operations of Cuyamaca Rancho State Park:

- Educational programs about puma behavior and human safety in puma habitat should be continued and expanded.
- When planning locations of new trails and campgrounds, park officials should consider pumas' needs for plant cover when hunting, traveling and sleeping.
- Puma food caches should not be removed when found near human activity. Instead, the dead animal should be dragged to a safer location 100 to 300 yards away, or the area can be temporarily closed to people.

For more information about the Southern California Puma Project, visit www.vetmed.ucdavis.edu/whc/scehp/default.htm. JWR


USFWS/LARRY MOATS

### The Price of Saving a Species

Perhaps few people would argue that a vanishing population of unique native foxes should be protected at all costs from non-native predators. But what if the predators were golden eagles?

This dilemma was the subject of an article in the 28 November 2003 issue of the journal *Science*. "Solving conservation problems is often more complex than redressing its primary cause," write conservation biologists Rosie Woodroffe, Franck Courchamp, and Gary Roemer.

In this case, the species at risk is the island fox (*Urocyon littoralis*), a candidate for listing under the U.S. Endangered Species Act. The fox evolved in isolation in California's Channel Islands, which lie roughly 25 miles off the state's southern coast. Ten years ago, golden eagles (*Aquila chrysaetos*) from the mainland began breeding in the islands. Golden eagles are not considered endangered or threatened but are protected by federal laws.

Although the eagles preyed mainly on feral pigs, they also killed many island foxes. Soon the fox subspecies on San Miguel and Santa Rosa islands became extinct in the wild, with the last few animals taken into captivity. On Santa Cruz Island, 1500 foxes were reduced to just 65.

Wildlife managers opted to remove both the eagles and the feral pigs, which damage native plants. All but a few eagles have been relocated, and pig hunting began soon after. Noting that eagle predation on foxes increases as pig availability declinese, the researchers concluded that if the Santa Cruz Island foxes are to be saved, both the pigs and the remaining eagles must be removed—"by any and all means." For eagles that evade traps, that could mean shooting. JWR

## City Bears: Junk Food Junkies

According to a recent study by Wildlife Conservation Society scientists, black bears living in and around cities weigh up to one-third more—and are one-third less active—than bears living in wild areas. In lieu of hunting for their natural diet urban ursines often forage their meals behind fast-food restaurants and malls—increasing the possibility of potential human/bear conflict.

"Black bears and people can live side by side, as long as bears don't become dependent on handouts and garbage for food," says Dr. Jon Beckmann, the study's lead author. "Lawmakers should take a proactive stance to ensure that these important wild animals remain part of the landscape."

## Thailand Cracks Down on Wildlife Trafficking

As part of a three month campaign, in December 2003 officials in Thailand intensified their investigations of illegal wildlife trafficking and recovered more than 33,000 animals, including tigers, bears, orangutans, and birds.

In one raid, a team of forestry police officers entered a house on the outskirts of Bangkok and discovered tiger carcasses quartered and on ice, 21 bear paws, severed at the joints, six starving tigers, five live bears, and four baby orangutans, one of which died because of the horrendous conditions. A raid on an open market netted more than 1,000 protected species of birds in one day. In just a couple of private zoos, police found 70 unregistered orangutans.

The animals, prized for their meat, medicinal value and putative sexual healing powers, are illegally imported from Indonesia, Malaysia and other countries, and sent to China, Korea, Japan and elsewhere. Some, including tigers, are bred or captured in Thailand, then illegally sold to wildlife traders.

Tigers are protected by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which bans their trade for commercial purposes, but allows them to be kept for breeding and research.

The illegal wildlife trade is second only to drug trafficking in profitability worldwide.

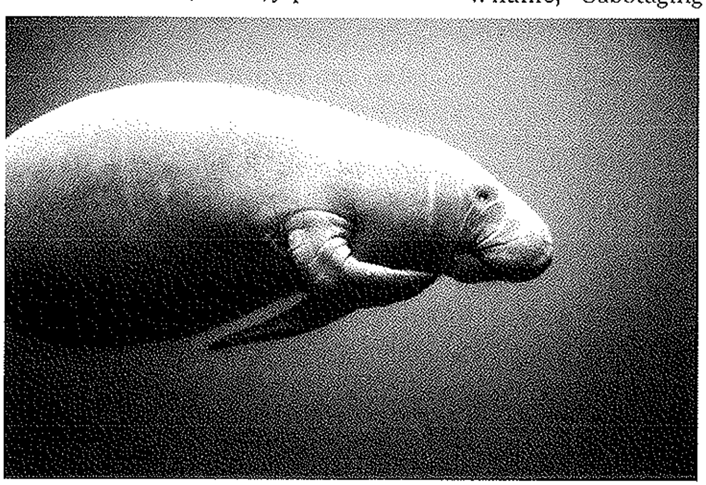
## Endangered Species Act Turns 30

28 December 2003 marked the 30th anniversary of the Endangered Species Act (ESA), one of the most important—and controversial—environmental laws in the United States.

When the law was enacted, then-Sen. Harrison Williams noted: "Each species provides a service to its environment; each species is a part of an immensely complicated ecological organization, the stability of which rests on the health of its components. ...To permit the extinction of any species which contributes to the support of this structure without knowledge of the cost or benefits of such extinction is to carelessly tamper with the health of the structure itself."

Under the Act, the federal government must identify species threatened with extinction, identify habitat they need to survive, and help protect both accordingly. Over the past three decades, the ESA has helped ensure the survival of many species, including wolves, manatees, sea otters, the American alligator, New England coastal birds, black-footed ferrets, and California condors. Helping the recovery of the American bald eagle was a signature accomplishment of the ESA.

A new report by the Defenders of Wildlife, "Sabotaging the Endangered Species Act: How the Bush Administration Uses the Judicial System to Undermine Wildlife Protections," shows that the Bush administration has, on at least 76 occasions, taken actions that nearly 30 years court rulings told them were almost certain to be found illegal. The administration was ultimately found guilty of breaking the law in 90 percent of those cases.



USFWS/JIM P. REID

During its first week in office in 2000, the Bush administration froze all pending ESA regulations, halted all listing of new species, and blocked all pending designations of critical habitat for listed species. Under President Bush, the number of species added to the ESA list has plummeted to just eight species per year. Beneficiaries of the Bush administration's actions include logging companies, road-builders, and developers.

To read the report, visit www.defenders.org/wildlife/esa/report.

## Emergency Protection Sought for Tricolored Blackbird

Over the past decade, the tricolored blackbird (*Agelaius tricolor*) population has experienced a precipitous decline. The bird forms the largest colonies of any North American passerine, and one breeding colony may consist of thousands of birds. Despite the size of some individual colonies, however, the tricolor population, which once numbered in the millions, is plummeting at an alarming rate, in large part due to the harvest of silage and plowing of weedy fields on dairy farms in Califonia's Central Valley.

Every year, thousands of pairs of blackbirds—comprising some of few remaining large colonies—unsuccessfully nest on agricultural lands because their eggs and nests are destroyed during silage harvest.

The Center for Biological diversity recently submitted a petition requesting immediate action by the U.S. Fish and Wildlife Service and California Department of Fish & Game prohibiting or at a minimum delaying harvesting and plowing activities on private lands used for breeding during the nesting season. These activities are in violation of the federal Migratory Bird Treaty Act.

Tricolors also experience widespread habitat losses to land conversions from rangeland to vineyards, orchards, and urban development, and high levels of predation in the little remaining marsh habitats.

## AVIAN

### More Eggs the Better: Egg Formation in Captive Barn Owls (*Tyto alba*)
**by J. M. Durant, S. Massemin, and Y. Handricha**
*The Auk* 121(1): 103–109

The authors studied rapid yolk deposition (RYD) in barn owls (*Tyto alba*) on the basis of the analysis of 26 eggs laid by "dye-dosed" captive female barn owls in five different broods. Pictures of yolks were examined to assess daily rates of yolk deposition. These data were used in combination with data from the dissection of ovaries of another five breeding females. Th authors found that the total duration between initiation of RYD and laying of the corresponding egg was only 13.6 days, with an interval between yolk completion and oviposition of 2.4 days. The total number of follicles that may have given eggs was found to be 25. That high number of follicles and the short RYD period explain the particularly high reproductive potential of this nocturnal raptor species.

### Night Movements of Young Reed Warblers (*Acrocephalus scirpaceus*) in Summer: Is It Postfledgeling Dispersal?
**by A. Mukhina**
*The Auk* 121(1): 203–209

Th author studied summer movements of juvenile reed warblers (*Acrocephalus scirpaceus*) marked as nestlings during four field seasons (1999–2002). To control for birds' movements, nocturnal playback of songs and daytime mist-netting were done. Captures by song playback suggest the existence of nocturnal postfledging movements in reed warblers. Birds' age during such movements was found to be 39–52 days. The author analyzes the temporal schedule and physiological condition of the birds during this period and discusses the mechanism of nocturnal postfledging dispersal and its background and relationships with other events of the annual cycle during the premigratory period.

## MAMMALS

### Selection of Den, Rendezvous, and Resting Sites by Wolves in the Bialowieza Forest, Poland
**by J. Theuerkauf, S. Rouys, and Wlodzimierz Jedrzejewski**
*Can. J. Zool./Rev. Can. Zool.* 81(1): 163–67

The authors studied wolf (*Canis lupus*) selection of 19 den, 10 rendezvous, and 31 resting sites found between 1986 and 2000 in the Bialowieza Forest (Poland). The objective was to determine whether wolves selected sites far from villages, forest edges, and roads, and whether these sites had dense ground cover for concealment. They study also tested whether wolves selected a particular forest type for their den sites. Den and rendezvous sites were located at greater distances from villages, forest edges, and intensively used roads than random points. Locations of resting sites were not affected by these artifical structures. Wolves selected dry coniferous forests for den sites but also used other forest types. The authors conclude that the suitability of an area for pup raising depended mainly on the spatial distribution of forest, human settlements, and public roads, and to a lesser extent on habitat characteristics.

### Antibodies to Canine and Feline Viruses in Spotted Hyenas (Crocuta Crocuta) in the Masai Mara National Reserve
**by T. M. Harrison, J. K. Mazet, K. E. Holekamp, E. Dubovi, A. L. Engh, K. Nelson, R. C. Van Horn, and L. Munsona**
*J. Wildlife Diseases* 40(1): 1–10

Spotted hyenas (*Crocuta crocuta*) are abundant predators in the Serengeti ecosystem and interact with other species of wild carnivores and domestic animals in ways that could encourage disease transmission. Hyenas also have a unique hierarchical social system that might affect the flow of pathogens. Antibodies to canine distemper virus (CDV), feline immunodeficiency virus (FIV), feline panleukopenia virus/canine parvovirus (FPLV/CPV), feline coronavirus/ feline infectious peritonitis virus (FECV/FIPV), feline calicivirus (FCV), and feline herpesvirus 1 (FHV1) have been detected in other Serengeti predators, indicating that these viruses are present in the ecosystem. The purpose of this study was to determine whether spotted hyenas also had been infected with these viruses and to assess risk factors for infection. Serum samples were collected between 1993 and 2001 from 119 animals in a single clan for which behavioral data on social structure were available and from 121 hyenas in several other clans. All animals resided in the Masai Mara National Reserve. Antibodies to CDV, FIV, FPLV/CPV, FECV/FIPV, FCV, and FHV1 were present in 47%, 35%, 81%, 36%, 72%, and 0.5% of study hyenas, respectively. Antibody prevalence was greater in adults for FIV and FECV/FIPV, and being a female of high social rank was a risk factor for FIV. Hyenas near human habitation appeared to be at lower risk to have CDV, FIV, and FECV/FIPV antibodies, whereas being near human habitation increased the risk for FPLV/CPV antibodies. Canine distemper virus and FECV/FIPV antibody prevalence varied considerably over time, whereas FIV, FPLV/CPV, and FCV had a stable, apparently endemic temporal pattern. These results indicate that hyenas might play a role in the ecology of these viruses in the Serengeti ecosystem. The effect of these viruses on hyena health should be further investigated. The lower prevalence of CDV antibody–positive hyenas near human habitation suggests that reservoirs for CDV other than domestic dogs are present in the Serengeti ecosystem.

### Characteristics of Current and Historical Kit Fox (*Vulpes macrotis*) Dens in the Great Basin Desert
**by W. M. Arjo, T. J. Bennett, and A. J. Kozlowski**
*Can. J. Zool./Rev. Can. Zool.* 81(1): 96–102

The authors examined the ecological and physical characteristics of den sites for 13 adult kit fox (*Vulpes macrotis*) in western Utah from December 1998 to February 2001. Current and historical den distribution among habitat types were also compared. The number of den sites used was not influenced by home-range size (P=0.11) or season (P=0.40), but was influenced by geographical area. Home-range size was smallest (P=0.007) and the number of dens used was greatest (P=0.009) in mountainous areas. Ecological and physical characteristics of single-use dens (n=30) were compared with those of multiple-use (n=53) and natal dens (n=8). Characteristics that differed between den types included number of entrances (P=0.0001), diameter of entrances (P=0.003), and height of vegetation along transects (P=0.0001). Natal den entrance azimuths were weighted towards a northwesterly aspect (P=0.0022); however, single- and multiple-use den exits appeared to be randomly distributed. Historical changes in kit fox den site selection have occurred since 1959 (P < 0.0001). We characterized more dens in invasive grasslands and fewer in greasewood (*Sarcobatus vermic-ulatus*) habitats than previously described. The conversion of native habitat to grassland and the increase in coyote population may have altered kit fox distribution to include mountainous areas not previously described.

## HERPETILES

### A New Species of *Tantilla* (Serpentes; Colubridae) of the Taeniata Group from Southern Belize

**by P. J. Stafforda**

*J. Herpetology* 38(1): 43–52

A new snake of the genus *Tantilla* is described from southern Belize. This species, a member of the taeniata group, is characterized by a dark gray-brown, almost black ground color; a narrow pale middorsal stripe confined to the vertebral scale row; a narrow pale lateral stripe on adjacent thirds of the third and fourth scale rows; a broad pale nape band that is complete medially; dark mottling on the lateral edges of the ventrals; and 153 ventrals + 64 subcaudals in the single known specimen, a female. It is most similar to *Tantilla impensa* of southern Chiapas, the central Guatemalan ranges and western Honduras but differs from this species in its darker overall color pattern, the presence of dark mottling on the lateral edges of the ventrals, and in having a lower number of ventrals.

## CONSERVATION

### Evaluating Impacts to Florida Panther Habitat: How Porous Is the Umbrella?

**by E. J. Comiskey, A. C. Eller Jr., and D. W. Perkins**

*Southeastern Naturalist* 3(1): 51–74

The endangered Florida panther (*Puma concolor coryi*) shares its shrinking habitat with agriculture, surface mining, and rapid urban growth. Although panthers have extensive home ranges and use diverse land covers, methods that dominate panther habitat evaluation for Endangered Species Act (ESA) consultations and regional land use planning consider only forested day-use elements within the landscape mosaic. Maehr and Deason (2002) present a Panther Habitat Evaluation Model (PHEM) that, in addition to excluding nonforested habitat, reduces the assessed value of forest patches based on criteria for patch size, forest type, proximity to a "core" area, and connectivity to other patches. An examination of the foundations of PHEM is therefore warranted. Building on earlier work that included an evaluation of panther habitat selection studies (Comiskey et al. 2002 ), the authors examine PHEM in light of data quality criteria and the panther's known life history requirements. They conclude that the precepts and rules of the PHEM methodology are based on unwarranted assumptions, nonstandard methods of analysis, and exclusion of relevant data, leading to an undue emphasis on day-use land cover and forest patches larger than 500 ha. Large areas of southern Florida that have abundant prey and are intensively used by panthers would score low in PHEM habitat assessments because they lack large forest patches. The authors discuss the conservation implications of applying a methodology that discounts substantial portions of occupied panther habitat as unsuitable, and describe an alternative approach to habitat definition and evaluation that is both consistent with panther habitat requirements and applicable to conservation decision-making. Conserving sufficient habitat for recovery of the panther extends an umbrella of protection to the many species that dwell within its range.


### Avian Nest Success in Midwestern Forests Fragmented by Agriculture

**by M. G. Knutson, G. J. Niemi, W. E. Newton, and M. A. Fribergd**

*The Condor* 106(1): 116–130

The authors studied how forest-bird nest success varied by landscape context from 1996 to 1998 in an agricultural region of southeastern Minnesota, southwestern Wisconsin, and northeastern Iowa, U.S.A. Nest success was 48% for all nests, 82% for cavity-nesting species, and 42% for cup-nesting species. Mayfield-adjusted nest success for five common species ranged from 23% for the American redstart (*Setophaga ruticilla*) to 43% for the Eastern wood-pewee (*Contopus virens*). Nest success was lowest for open-cup nesters, species that reject brown-headed cowbird (*Molothrus ater*) eggs, species that nest near forest edges, and Neotropical migrants. The proportion of forest core area in a 5 km radius around the plot had a weakly negative relationship with daily survival rate of nests for all species pooled and for medium or high canopy nesters, species associated with interior and edge habitats, open-cup nesters, and nests located between 75 and 199 m from an edge. The proportion of forest core area was positively related to daily survival rate only for ground and low nesters. The study's findings are in contrast to a number of studies from the eastern U.S. that report strong positive associations between forest area and nesting success. Supported models of habitat associations changed with the spatial scale of analysis and included variables not often considered in studies of forest birds, including the proportion of water, shrubs, and grasslands in the landscape. Forest area may not be a strong indicator of nest success in landscapes where all the available forests are fragmented.

# LIVING WITH GOPHERS

Pocket gophers are found in varied habitats: deserts, scrub grasslands, mountain meadows, and urban and suburban landscapes. Gophers dig two types of burrows—long, winding, shallow tunnels to obtain food, and deep tunnels for shelter with chambers for food and nesting. Fan-shaped mounds of loose dirt distinguish gopher holes from circular mole hills. Mounds signify lateral runs of the main tunnel. Unlike moles, gophers usually plug their holes. They have external fur-lined cheek pouches used for transporting food. They eat a variety of plants–leafy vegetables above ground and roots and tubers underground. Female gophers may breed up to three times a year, normally producing five or six young per litter. The young disperse from the mother's burrow when they are two months old. A gopher's maximum life expectancy is about three years. Owls, hawks, foxes, badgers, coyotes, weasels, and snakes eat gophers.

Many people consider gophers pests, however they play a major role in soil dynamics. Their constant digging results in vertical cycling of soil. This counteracts the packing effect of grazers, makes the soil more porous, reduces water run-off, and provides increased aeration for plants.

## EATING PLANTS OR TUNNELING

1: Place hardware cloth (1/4" or 1/2" mesh) 18—20" deep. Wrap commercial tree wrap around ornamental plants and trees. Reduce cover and control weeds.

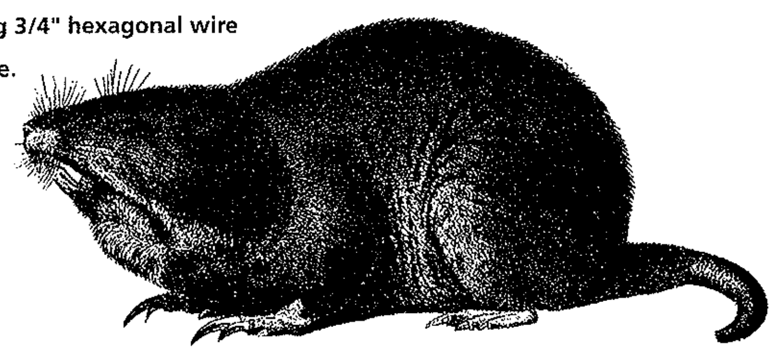
2: Place used clay cat litter in the hole.

3: Some plants are not attractive to gophers. Check at your local nursery.

## PROTECTING PLANT ROOTS

1: Plant in underground baskets of chicken wire. Line all planting holes and beds—sides and bottoms—with galvanized wire mesh or light gauge mesh when planting trees and shrubs; they need protection only while young and vulnerable. Use a heavier mesh for permanent beds where you grow annuals and vegetables. Be sure to place the mesh deep enough to accommodate growing root crops and bulbs, and leave at leave at least 3" of mesh above ground.

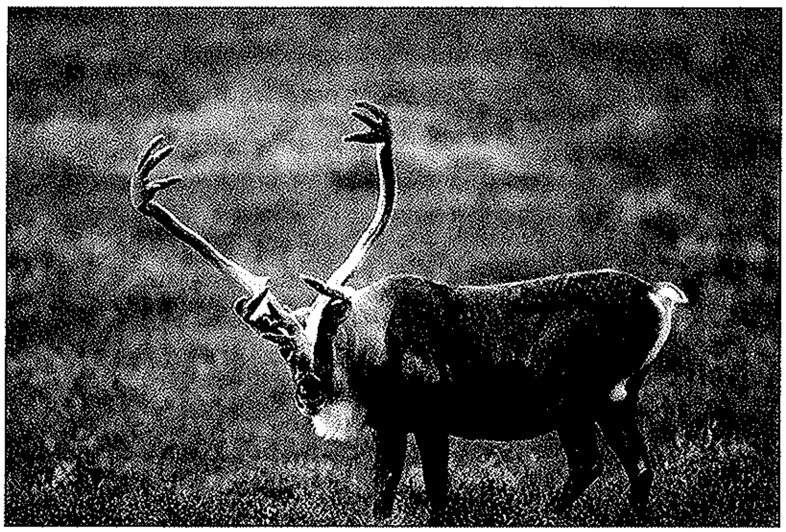
2: Make your own root protectors using 3/4" hexagonal wire netting or purchase them ready made.



Ditto content contributed by Lindsay Wildlife Museum, Walnut Creek, California (www.wildlife-museum.org)

# TAIL END

by Kieran Lindsey



"I love you T-H-I-S much!"

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