SCWDS BRIEFS

A Quarterly Newsletter from the

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Raccoon Roundworm in Florida and North Carolina

The raccoon intestinal roundworm *Baylisascaris procyonis* is an important zoonotic disease agent that can cause severe disease in people and various wild and domestic animals. In addition to raccoons, domestic dogs and some exotic pets (e.g., kinkajou) can serve as definitive hosts and shed eggs into the environment. Disease in raccoons is exceptionally rare; however, as larvae migrate through various tissues of non-raccoon hosts, including humans, they cause visceral larval migrans. Clinical disease caused by the migration of the larvae depends on the host species, number of ingested eggs, and the tissues through which larvae migrate. If migrating larvae enter the eye or the central nervous tissue, blindness or fatal neurological disease may occur. To date, infection has been documented in over 90 species of birds and mammals, and high morbidity and mortality is reported in many of these species (e.g., rodents, rabbits, and birds).

Historically, *B. procyonis* was most commonly found in raccoons in the upper Midwest, Northeast, and isolated parts of the western United States; however, range expansions have been documented in the last 10 years. Although many of the recent reports may be due to sampling in areas that had not been surveyed previously, considerable surveillance had been conducted in the Southeast, and the worm appeared to be restricted to small areas in the Appalachian region. However, in recent years it has been documented in additional isolated regions of Georgia and Florida (SCWDS BRIEFS Vol. 26 No. 3).

In an effort to better identify the distribution of this zoonotic parasite in the Southeast, we have been conducting enhanced surveillance. In Florida, we first detected the worm in 2010 in raccoons from Leon and Wakulla counties in the panhandle and in a single raccoon and kinkajou from Broward County in the southern part of the state. In late 2010, SCWDS, the Florida Fish and Wildlife Conservation Commission (FWC), and USDA-APHIS-Wildlife Services (WS) began a joint study to investigate the prevalence and distribution of *B. procyonis* in Florida. All raccoons submitted are necropsied, and intestinal tracts are examined for *B. procyonis.* As of December 2012, we have examined 579 samples from 35 counties, and to date, 20 (3%) raccoons from 6 counties are positive. These data, combined with data from previous studies, indicate *B. procyonis* is present in Bay, Broward, Escambia, Hernando, Hillsborough, Leon, Pasco, Pinellas, and Wakulla counties. Based on these data, *B. procyonis* is established and widespread in Florida, although overall prevalence rates appear considerably lower than those reported in other regions of the United States. On the other hand, some local prevalence rates may actually be higher (e.g., 1 of 3 raccoons in Leon County and 1 of 5 raccoons in Escambia County), but larger sample sizes are needed to better determine regional differences in prevalence rates across Florida.

Beginning in 2010, a pilot study was started in North Carolina to document the presence of *B. procyonis*. Working collaboratively with WS personnel, SCWDS examined 74 raccoons from western counties of the state: 9 (12%) were infected and several had high parasite burdens (up to 122 adult worms). In addition, 34 raccoons collected from Guilford County in central North Carolina by collaborators at North Carolina State University were examined and found to be negative. These data confirm that *B. procyonis* is present in North Carolina; however, infections in the western part of North Carolina were expected based on results from neighboring states and the location of most sampled counties (in the Appalachian Mountains). Future surveillance in

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other regions of the state is needed to better identify the distribution of the parasite.

Surveillance for pathogens is critical to determine the public health risks and to develop effective preventative or management strategies. This is especially true for zoonoses associated with wild animals, such as raccoons, that have adapted well to urbanization and can be found in high densities in cities and suburbs, thus increasing the risk of human exposure. A review of the literature shows that in the Southeast, *B. procyonis* is widespread throughout the Appalachian Mountains, while outside the mountains, the parasite had only been reported in isolated raccoon populations in Georgia and Florida. However, it is important to note that the number of counties that have been examined is limited, especially in areas near known positive counties, and some of the positive counties are in or near major metropolitan areas. For example, when you look at all data available for counties from Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia (for which at least 10 raccoons have been examined), only 80 counties have been examined. Of these, 36 are positive (20 are from Appalachian counties of Kentucky, North Carolina, Tennessee, Virginia, and West Virginia). Finally, of the 44 negative counties, 24 were last surveyed 20-50 years ago, so these results may no longer be valid. For a detailed county-level map, please refer to our publication in *Parasitology Research* (2013, volume 112(2): 693-698) or contact Dr. Yabsley (myabsley@uga.edu) for a reprint. (Prepared by Michael Yabsley with assistance from Mark Cunningham and Dan Wolf, FWC)

Fatal EHDV-2 in an Alpaca

In late September of 2012, a female alpaca from Adams County, Pennsylvania, was found dead one day after displaying lethargy, anorexia, and oral ulcerations. Epizootic hemorrhagic disease virus (EHDV) serotype 2 was isolated from spleen and lung samples from this animal that were submitted to SCWDS for orbiviral isolation.

The EHD type-2 virus most often is associated with hemorrhagic disease in white-tailed deer (WTD) (*Odocoileus virginianus*). Although alpacas and other camelids historically were thought to be resistant to EHDV, bluetongue virus (BTV) infections in camelids have been reported on two occasions: In 2007, a fatal BTV (serotype 1) infection was described in an alpaca in Europe, and in 2010, BTV-related mortality was reported in an alpaca in California.

Genetic analysis of the EHDV-2 VP2 gene I, which encodes an outer glycoprotein involved in cell attachment, indicated that the alpaca EHDV-2 was 99.6% similar to an isolate from a WTD that died in Cumberland County, Pennsylvania, in the 2012 hemorrhagic disease outbreak. This suggests that both viruses originated from a common source and that these viruses can be shared between numerous hosts, including camelids, during outbreaks. To our knowledge, this is the first report of EHDV mortality in a camelid in North America, and it broadens the list of domesticated animal species that were affected by EHDV-2 in 2012. (Prepared by Jamie Phillips)

Salmonellosis and Songbirds

In the winter of 2009, SCWDS diagnosed salmonellosis as the primary cause of death in the largest number of wild birds submitted to SCWDS in a single season since 1974. The first cases were diagnosed in northern cardinals submitted in early January, but within a few weeks we had received dozens of cases, with case submissions peaking in February. By the end of the winter, we had diagnosed salmonellosis in 162 birds, representing 89% of our avian submissions; our previous average was 2-6 cases per year. Although salmonellosis was confirmed in 17 species at SCWDS, 3 species in the finch family (Fringilidae) made up 90% of the cases: Pine siskins, American goldfinches, and house finches. Simultaneously, other labs reported high bird mortality due to salmonellosis across the country: The USGS-National Wildlife Health Center (NWHC) received 57 cases from 16 states.

Salmonella enterica subspecies *enterica* serovar Typhimurium (*S.* Typhimurium) is the causative agent of avian salmonellosis in wild birds and is responsible for the majority of avian salmonellosis outbreaks, causing high mortality rates in affected songbirds and aquatic birds. Among songbirds, avian salmonellosis is a widespread, annual problem in the winter months in the United States, Canada, and the United Kingdom. The repeated and frequent isolation of specific types suggests that these *S.* Typhimurium strains have become adapted to some passerine species and may be endemic in those populations. However, the

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specific conditions under which epornitics occur are not completely understood.

The salmonellosis cases received at SCWDS displayed typical lesions: Nearly all birds had round to irregular, firm, yellowish, necrotic masses in the esophagus and, less commonly, in the crop. In many cases, the spleen was enlarged and mottled, and necrotic masses were present in other tissues, such as liver, testes, and skeletal muscle. Most birds were in poor body condition, indicating a chronic disease process.

This epornitic coincided with a human outbreak of *S.* Typhimurium infection linked to contaminated peanut products, and there was concern that peanut products in wild-bird food were a possible source of the avian infections. This concern led to recalls of products by several birdseed manufacturers and to a temporary cessation of bird feeding activities by some enthusiasts. To address these concerns, SCWDS partnered with collaborators at the University of Georgia to investigate the geographic, spatial, and genetic relationships of the avian salmonellosis cases submitted to wildlife diagnostic laboratories in the United States during this outbreak. We utilized pulsed field gel electrophoresis (PFGE) to compare the genetic relatedness of isolates from 57 SCWDS cases, 24 isolates from NWHC, and 6 isolates provided by the Pennsylvania Game Commission, as well as isolates from past SCWDS cases. PFGE also was used to investigate any potential genetic relationship between isolates from the epornitic and non-food-borne human salmonellosis cases.

Ninety-three passerine isolates were examined by PFGE, and 99% of the isolates clustered tightly in one clonal group (group A). *Salmonella* Typhimurium PFGE type A3 was responsible for most cases in pine siskins and American goldfinches (94%) in 2009, and was associated with cases in birds in the finch family as far back as 1998. *Salmonella* Typhimurium PFGE type A3 was common in members of the Fringillidae from the eastern USA, whereas type A4 typified cases from the central and western part of the country. Subtype A6 was isolated from songbirds outside the finch family, but it was distinct from waterfowl and poultry isolates.

In the United Kingdom, evidence is mounting for avian salmonellosis as a contributor to the decline of some songbird species (particularly in combination with other infectious diseases). It is unclear whether the same is occurring in the United States, although several large epornitics have occurred, totaling more than tens of thousands of birds each. Investigations that describe the spatial, temporal, and molecular relationships of *Salmonella* outbreaks are critical for piecing together how these outbreaks may affect songbird populations.

None of the songbird *Salmonella* PFGE patterns matched the *S.* Typhimurium pattern associated with the 2009 human outbreak linked to contaminated peanut products. However, several passerine PFGE patterns were indistinguishable from *S.* Typhimurium patterns in the PulseNet USA database. PulseNet is a national network of public health and food regulatory agency laboratories coordinated by the U.S. Centers for Disease Control and Prevention (CDC) in which participants perform standardized molecular subtyping ("fingerprinting") of disease-causing bacteria for rapid comparison. The songbird PFGE patterns A3 and A6 we obtained matched a total of 77,941 *S.* Typhimurium PFGE entries from human cases in the PulseNet database.

February was the peak of the 2009 epornitic of strain A3 in the songbird populations and most human illnesses due to PFGE type A3 were reported for the Atlantic states (76%) from December 2008 to November 2009. There was spatial (Orange County, Vermont) and temporal (February 2009, Knox County, Tennessee) overlap in the identification of PFGE type A3 for songbird and human *S.* Typhimurium isolates in this study. However, the peak of human cases associated with this and other passerine *S.* Typhimurium strains was in late spring and early summer, a period in which the epornitics generally had subsided. Thus, these sporadic cases in humans could reflect transmission resulting from contact with birds actively shedding *Salmonella* or, more likely, via contact with a common, contaminated environmental source, such as a bird feeding station.

Our understanding of salmonellosis in wild birds will increase through coordinated nationwide surveillance and standardization of testing methods. Ultimately, studies that simultaneously investigate avian, human, and environmental sources of *Salmonella* and describe potential mechanisms of transmission of this pathogen among all three sectors by utilizing empirical data

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and predictive modeling will lead to a more complete picture of the epidemiology of *Salmonella*. (Prepared by Sonia Hernandez)

Hedgehogs and Human Salmonellosis

During the past year, 20 human infections with *Salmonella* Typhimurium associated with pet hedgehog exposure have been reported from eight states: Alabama, Illinois, Indiana, Michigan, Minnesota, Ohio, Oregon, and Washington. The sources of infection were identified using microbiological techniques and patient interviews. To date, four persons have been hospitalized, and one has died.

It is estimated that there are 40,000 pet hedgehogs in the United States. There are 17 species of hedgehogs native to Africa, Asia, and Europe, but they have been introduced and are free-ranging in New Zealand. Pet hedgehogs became popular in the 1980s and African pygmy hedgehogs, which are hybrids of the four-toed and Algerian hedgehog species, are the most common pets. As interest in exotic and nontraditional pet ownership continues to rise, exposure to zoonotic agents like *S.* Typhimurium can be expected to increase.

The current salmonellosis outbreak is the largest associated with pet hedgehogs, but it was preceded by smaller outbreaks of human salmonellosis in three countries over the past two decades: two cases in the United States in 1994, nine cases in Canada from 1995-1997, and six cases in Australian in 2002.

Salmonella is carried in the gastrointestinal tract and shed in feces of many animals, including some pet hedgehogs. While they can develop illness, many hedgehogs do not typically show signs of disease. The pet hedgehog and its environment are both sources of potential exposure to humans. Children, immuno-compromised individuals, and the elderly are at the greatest risk of becoming infected.

In parts of Europe, human salmonellosis has been tied to contact with wild hedgehogs. In Norway, up to 40% of hedgehogs carry *Salmonella*, and they caused outbreaks of human salmonellosis in 1996 and 2000, with 28 and 37 confirmed human cases, respectively. Wild hedgehogs frequently interface with humans by roaming in private gardens and eating from the bowls of pets, and sometimes they are intentionally fed by people. There have been reports of *Salmonella* causing disease and mortality in wild hedgehogs, but it appears most infections are subclinical.

In addition to harboring *Salmonella*, wild and pet hedgehogs can be the source of numerous other zoonotic agents including other bacteria, as well as viruses, fungi, and parasites. These zoonoses can have mild to severe consequences to human health. Hedgehogs can also transmit foot and mouth disease virus; free-ranging hedgehogs may have played a role in the local spread of foot and mouth disease during the 2001 outbreak in livestock in the United Kingdom.

There are several regulations regarding the importation and ownership of hedgehogs in the United States due to concern for zoonotic and foreign animal disease. Hedgehogs cannot be imported from New Zealand or from regions where foot and mouth disease exists, and a current health certificate and importation permit are required for entry into the United States. The sale of hedgehogs is regulated, and vendors must be licensed. Ownership of hedgehogs is illegal in Arizona, California, Georgia, Hawaii, Maine, Pennsylvania, the New York City boroughs of Brooklyn, Bronx, Manhattan, Queens, and Staten Island, and Washington, D.C. Despite these restrictions, the legal trade of live exotic animals in the United States is a massive industry, and many exotic animals are sold illegally via the Internet, avoiding the licensing and inspection requirements of pet stores.

The recent outbreak of salmonellosis is another reminder of the risks associated with exotic pets. Human salmonellosis cases have been associated with contact with pet iguanas, sugar gliders, turtles, and water frogs, but many people are unaware of the health risks regarding *Salmonella* and numerous other zoonotic pathogens carried by exotic pets. Fortunately, good hygiene practices, including frequent and thorough hand washing after handling exotic pets or contact with their environment, can help prevent salmonellosis and other zoonoses. Public health professionals, physicians, and veterinarians should work together to actively educate the public about the risks of exotic pet ownership and interaction with wild animals. (Prepared by Hannah Vanos, College of Veterinary Medicine, Michigan State University)

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Wildlife-Related Recreation is Growing

Results of the 2011 "National Survey of Fishing, Hunting, and Wildlife-Associated Recreation," published late last year, showed that active participation in fish and wildlife-related recreation in the U.S. grew by 3% since the last survey in 2006. This growth was due primarily to a 10% increase in fishing and hunting. Overall, more than 90.1 million people older than 15 years (38% of the U.S. population) participated in one or more forms of wildlife-associated recreation, with many people participating in more than one activity. More than 33 million people fished, 13.7 million hunted, and 71.8 million participated in "non-consumptive" wildlife-related activities, such as watching, feeding, and photographing wildlife.

The national survey began in 1955 and is conducted every five years at the recommendation of the state fish and wildlife agencies. It is sponsored by the U.S Fish and Wildlife Service (USFWS) and is conducted by the U.S. Census Bureau, with funding provided through Multistate Conservation Grants. The purpose of the survey is to provide accurate state-level estimates of the importance of wildlife-based recreation. The survey determines how many people participate, their demographics, and the economic impacts of fishing, hunting, and wildlife watching throughout the United States. Those who fish, hunt, bird watch, or otherwise enjoy our bountiful wildlife resources are well aware of the aesthetic values derived from participating in these activities, but the National Survey shows that the related expenditures are significant to the national economy.

In 2011, recreationists spent $145 billion (1% of the gross domestic product) on fishing, hunting, and wildlife watching activities: One of every hundred dollars of all goods and services produced in the United States in 2011 was spent on fish and wildlife-related recreation. As in previous surveys, non-consumptive wildlife-related activities were more popular than fishing or hunting, with about 71.8 million individuals participating and spending $55 billion. The 33.1 million who fished spent $41.8 billion on trips, equipment, licenses, and other items.

Hunters numbered 13.7 million in 2011 (an increase of 9%), and spent almost $34 billion. Hunter expenditures created more than 680,000 jobs, nearly $13 billion in tax revenues, and $87 billion in total economic output. The top five states for hunter numbers were, in descending order: Texas, Wisconsin, New York, Pennsylvania, and Missouri. It should be noted that federal excise taxes collected on firearms, ammunition and archery equipment are allocated to individual states through the USFWS Wildlife and Sport Fish Restoration (WSFR) program using a formula based on land mass and number of licensed hunters. More than $14 billion dollars have been provided to states for fish and wildlife restoration and management since WSFR began in 1937.

The complete 2011 survey results can be accessed at http://wsfrprograms.fws.gov/Subpages/NationalSurvey/reports2011.html. The 143-page report contains detailed information related to state, region, gender, and age of participants, and is organized according to the many species of fish and wildlife pursued by anglers, hunters, and wildlife watchers. For us to continue to enjoy and benefit from our precious and abundant fish and wildlife resources, it is important that we all do everything we can to maintain healthy, well-managed populations. SCWDS is proud of the role we have played for the last 56 years. (Prepared by John Fischer and Gary Doster)

Arcadia Supports SCWDS

We are excited to report that Arcadia Wildlife Preserve ("Arcadia") recently donated $200,000 to our Southeastern Wildlife Health Development Fund! The check was presented to SCWDS by Dr. Wendy B. King, President of the Arcadia Board of Directors and 1996 graduate of the University of Georgia, College of Veterinary Medicine.

Arcadia is a nonprofit organization that has supported wildlife preservation and conservation since its incorporation in 1990. Since then, it has provided donations to several organizations for projects that benefited species including right whales, ocean sunfish, swallow-tailed kites, gopher tortoises, and American kestrels. In addition to the recent contribution, Arcadia has supported SCWDS since 1997 through annual donations to our development fund that totaled more than $121,000! In particular, it has provided funding for SCWDS projects involving wildlife health issues with no implications for humans or domestic animal health. Funding can be scarce for these kinds of projects.

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SCWDS projects supported by Arcadia include:

- The endangered Key Deer health monitoring program.
- Avian vacuolar myelinopathy studies in bald eagles, ducks, coots, and other birds.
- Research into mitigation strategies for white nose syndrome of bats.
- Lymphoproliferative disease virus surveillance in wild turkeys in the United States.

The mission statement reads: "Arcadia Wildlife Preserve is a non-profit organization dedicated to long-term enhancement of free-ranging wildlife populations and the re-establishment of diminishing native species." Arcadia's dedication to native wildlife is abundantly evident in its consistent support of SCWDS and other wildlife organizations since 1990, and we are very sad to see them go: Late last year the Arcadia Board of Directors elected to dissolve the organization.

SCWDS is very grateful for this contribution from Arcadia, as well as for the gifts we have received from many other organizations and individuals. The Southeastern Wildlife Health Development Fund was started several years ago to establish a funding base to help SCWDS achieve its long-term goals. Contributions, such as those made by Arcadia and others, are vital to help SCWDS continue to serve wildlife resources and the agencies and individuals that manage them. Our ultimate goal is to use your gifts to endow permanent SCWDS faculty and graduate student positions. We know that few can afford a gift of this size, but all contributions are appreciated, and all gifts are tax deductible.

Please consider supporting SCWDS by making a donation, or by providing information about SCWDS to friends, colleagues, and organizations that support wildlife conservation projects. To learn more about the Southeastern Wildlife Health Development Fund, please visit the website at http://www.vet.uga.edu/scwds/donate.php, or contact our Director, John Fischer, at 706-542-1741.

Sarcoptic Mange in a Red Fox

Lesions of sarcoptic mange in red foxes (*Vulpes vulpes*) can be striking and disconcerting, no matter how frequently they are observed. This disease is caused by *Sarcoptes scabiei*, a parasitic mite that burrows through and lays eggs within the skin, causing inflammation and excessive keratin production. Sarcoptic mange is a common disease among red foxes and is the most frequent diagnosis in this species at SCWDS. Although red foxes are especially susceptible to sarcoptic mange, other wild mammals can be affected, as can humans and domestic animals. It is a common and important disease of coyotes. A classic case of sarcoptic mange in an adult, male red fox recently was submitted to SCWDS by the Kentucky Department of Fish and Wildlife Resources.

A resident of northern Kentucky found the fox carcass on his property and observed that it had abnormally thickened skin and hair loss over much of the body. In addition, two similarly affected foxes recently had been seen on the property. The carcass was submitted to SCWDS for examination: Skin over the dorsal and lateral chest and abdomen, legs, face, ears, and tail was markedly thickened by dry, firm crusts that were interrupted by deep fissures. Crusty areas had alopecia of variable severity, ranging from mild to complete hair loss (Figure 1).

Sarcoptic mange can be definitively diagnosed by microscopic examination of superficial scrapings of affected skin for *S. scabiei* eggs, larvae, and nymphs. The mites also can be confirmed by routine histologic examination of formalin-fixed skin samples. We used both methods to confirm sarcoptic mange in the fox from Kentucky. As often is the case, secondary bacterial infections accompanied the mites and associated skin lesions in this fox.

Foxes become infested with *S. scabiei* by direct contact with other affected animals or indirectly via contact with contaminated areas, such as dens. Transmission of *S. scabiei* likely is facilitated by increased social interactions associated with higher red fox densities and smaller home ranges. Transmission to humans may occur directly via contact with affected animals or carcasses and may result in pruritic dermatitis that usually is self-limiting.

Animals with uncontrolled infestation and proliferation of mites in the skin may succumb to the disease. These animals often are emaciated, as in the present case. Emaciation may be due, in part, to excessive scratching, licking, and chewing skin where the mites have burrowed. This activity is a distraction and hindrance to successful

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foraging and hunting behaviors. In addition, excessive scratching and chewing of the skin can lead to self-induced trauma and secondary bacterial infections, and hair loss likely affects thermoregulation. Collectively, these factors result in undernourished animals that have difficulty recovering from generalized skin disease.

Past studies at SCWDS suggest that red foxes may not mount an appropriate immune response to prevent reinfection when compared to some other species. However, red foxes can survive milder infestations with *S. scabiei* mites. (Prepared by Nicole Nemeth)

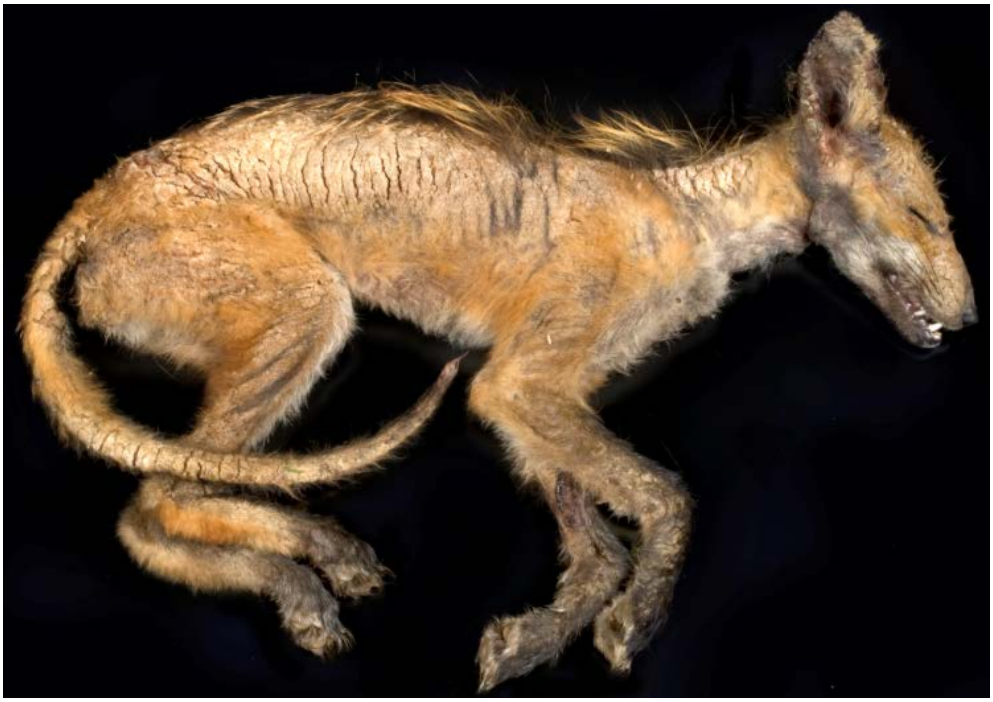

Figure 1.

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Information on SCWDS and recent back issues of the *SCWDS BRIEFS* can be accessed on the Internet at www.scwds.org. If you prefer to read the BRIEFS online, just send an email to Jeanenne Brewton (brewton@uga.edu) or Michael Yabsley (myabsley@uga.edu) and you will be informed each quarter when the latest issue is available.