Dietary Patterns of Pennsylvania Coyotes During Winter

Keith W. Steinmann, Melanie J. Cegelski, Pablo R. Delis

[1]Richard L. Stewart Jr.
Faculty Mentor

Department of Biology
Shippensburg University, Shippensburg, PA 17000

ABSTRACT

The eastward expansion and increase of coyote (*Canis latrans* Say) populations has generated widespread interest in their natural history in Pennsylvania. Our study analyzed coyote diet during winter, when resources are most limited. We examined and identified artifacts from the contents of 98 coyote stomachs collected throughout most of Pennsylvania over three winters, 2002-03, 2005-06, and 2006-07. White-tailed deer (*Odocoileus virginianus*) was the most prominent food item for coyotes, occurring in 62.2% of the stomachs. Small and medium-sized mammals, particularly shrews (*Sorex sp.*) and cottontail rabbits (*Sylvilagus sp*.), and birds are important winter supplemental food items, occurring in 9.2% of the stomachs. Only two farm animals, chicken and hog, occurred in 2% of the stomachs. Two predatory mammals, red fox (*Vulpes vulpes*), 3.1%, and house cat, 2%, were identified as food items, indicating the possibility of intraguild predation. Predation on mesopredators and farm animals occurs, but these do not appear to be significant food sources during the winter. Coyotes practice a considerable amount of plant foraging, as plant material was found in 25.5% of stomachs, and little coprophagy, as 3.1% of stomachs contained fecal matter. Although deer appear to be the most important coyote food item, at least during winter, it is unclear if this pattern is entirely the result of predation or scavenging. We recommend the emphasis on the study of stomach contents rather than scat analysis to determine dietary habits. Additional studies should be conducted to better understand the natural history and ecological impact of the coyote in Pennsylvania.

Keywords: Canis latrans, coyote, diet, winter

Coyotes are predators in all ecosystems across the state of Pennsylvania. Although there have been intentional coyote introductions in the southeastern United States (Parker 1995) and likely accidental introductions in Pennsylvania (McGinnis 1979), DNA evidence supports their range expansion and hybridization with wolves into the northeast through a northern route (Kays et al. 2010). Many people have shown interest in Pennsylvania coyotes both because the population is relatively new, arriving in the late 1930s (McGinnis 1979), and because their abundance is likely to continue to increase (Gompper 2002a; Gompper 2002b) as it has done in other areas (Parker 1995). This predicted increase in coyote populations has concerned wildlife managers, the public and farmers, because of the potential predatory effect on livestock and game animals (Bergeron and Demers 1981; Cepek 2004; Green and Flinders 1981; Meinzer *et al*. 1975). Available data suggest that coyote diet is only occasionally supplemented by livestock (Parker 1995; Sacks and Neale 2002). Pennsylvania hunters, who gained permission from the Pennsylvania Game Commission in fall 2007 to bait coyotes while hunting, may also be interested in learning what coyotes regularly use as food items to increase their success.

As generalist mesopredators, coyotes consume a variety of food including mammals, birds, insects and vegetation. Coyote food selection also varies among populations and is heavily dependent on prey availablitiy (Cunningham *et a*l.

[1]Correspondance to rlstew@ship.edu

2006; Fedriani and Kohn 2001; Kitchen *et al.* 1999; Neale and Sacks 2001a; Neale and Sacks 2001b; Weintraub 1986). Coyotes exhibit several feeding strategies including hunting for prey items (Green and Flinders 1981), coprophagy (Livingston *et al*. 2005), scavenging for food items and grazing on vegetation (Cepek 2004). Studies shed light on the factors that affect the nature of these feeding strategies. Geographically separated coyote populations often use different food items. In Oregon, for example, Toweill and Anthony (1988) reported the dominant food items were fruit, rodents, and ungulates. By contrast, in areas of Texas, lagomorphs were the dominant food item (Windberg and Mitchell 1990). Coyote diet varies on the availability of prey items, and is most likely a result of the opportunistic nature of coyotes (Andelt *et al.* 1987; Bartel and Knowlton 2005; Cunningham *et al.* 2006; Meinzer *et al.* 1975; Sacks and Neale 2002). Winter conditions, primarily associated with snow and ice abundance, also appear to affect food availability or food selection in northern habitats. Food availability or selection normally favors larger mammals during more severe winters. In Idaho, Green and Flinders (1981) reported coyotes switching from feeding primarily on rodents to larger prey like rabbits as winter progressed. Additionally, human activity, such as an increase in the density of forest edges, also seems to affect food selection. This habitat alteration increases the exposure of lagomorphs, therefore increasing their consumption by coyotes (Dumond *et al.* 2001).

Little published information is available concerning coyote diet in the northeast. Predation of white-tailed deer fawns has been reported in northeastern U.S. coyotes (Ballard *et al.* 1999). In at least three other northeastern studies, coyote diet switched from primarily lagomorphs to a higher percentage of deer during winter, and that switch was thought to be caused by increased vulnerability of deer during winter (Dibello *et al.* 1990; Patterson *et al.* 1998; Patterson and Messier 2003). Additionally, carrion, snowshoe hare (*Lepus americanus*), small mammals and miscellaneous food sources were reported in the stomach contents in coyotes from Maine (Richens and Hugie 1974). Scat analysis of Ohio coyotes indicated that meadow vole (*Microtus pennsylvanicus*) was the predominant food item in 28% of the scats, Eastern cottontail (*Sylvilagus floridanus*) and white-tailed deer (*Odocoileus virginianus*) occurred in 20% of the scats, and raccoon (*Procyon lotor*) occurred in 18% of the scats (Cepek 2004). In Pennsylvania, however, there is a general lack of reliable information. Unpublished data from the Pennsylvania Game Commission indicates that scat analysis of 300 coyotes includes at least 13 genera of mammals, birds, insects, and plant material. To our knowledge, Bixel (1995) and Hayden (2010) provide the only other information describing coyote diets in Pennsylvania. Bixel (1995) examined 184 coyote scats and was able to identify 10 mammal genera and a variety of passerines and insects, with plants as annual seasonal dominant. However, the winter sample included only seven scats, and given the relatively small sample size during winter, the breadth of coyote diets may not be accurately represented.

In this study, we examined winter feeding habits of coyotes from all areas of the state. To accomplish our diet analysis, we analyzed the stomach contents of recently killed coyotes rather than the more typically published methods using scat. Although a larger sample size is more easily attained through scat analysis, stomach content analysis allows for a more accurate identification of food items because specimen samples are less altered by the digestive process (Meinzer *et al.* 1975). Analyzing stomach contents also has the advantage of limiting the specific food items to a particular known individual, unlike scat analysis. Additionally, it is possible that removal of scats by coprophagous animals could bias a study (Livingston *et al.* 2005).

METHODS

Sample Collection

We obtained samples from the Mosquito Creek Sportsmen's Association in Frenchville, PA, and from trappers, hunters, and collectors statewide over three seasons. During the February 17-19, 2006 Mosquito Creek Sportsmen's Association's annual coyote hunt, 24 stomachs were collected; 32 stomachs were collected during the February 16-18, 2007 hunt. Harvested coyotes were brought to a check station where they were weighed and examined. When the hunters permitted, stomachs were removed from the coyotes and were frozen for later analysis. During the 2006 and 2007 hunts, almost 70% of the coyotes were taken using dogs, tracking, or performing drives with a poster, resulting in little opportunity for coyotes to eat bait.

Forty-two stomachs were also collected from coyotes killed through hunting or trapping during the winter season spanning December 2002 to March 2003. All samples from this season came from counties in the northwest area of the state. The stomachs collected from these coyotes were opened and the contents preserved with 95% ethanol in individually labeled jars. Fact sheets on each stomach included the information detailing when, where, by what means, and by whom the coyote was harvested.

Food Source Identification and Measurements

The undigested contents of each stomach were placed in a dissecting tray where potential food material including bones, feet, teeth, hide, hair, feathers etc. was separated. Stomach contents were not weighed because of the different hunting methods used to obtain coyotes and the differential treatment of coyote carcasses and entrails after harvest. Additionally, because we were unable to determine if an item in the stomach was hunted or scavenged, we referred to all items as food items. These items were washed using wire mesh, a funnel, and a steady stream of water to remove undesirable stomach fluids. Many stomachs had pieces of flesh contain-

ing meat, skin, and hair in them. When hair was present, the medullar and scale patterns were microscopically compared with reference specimens. When no hair was present, bone fragments were compared with bones from known reference specimens, and while more difficult, some identification was possible solely from the fragments. When bird parts were recovered, in addition to bone examination, further identification of feathers was done by comparison to reference specimens. Most reference samples were obtained from the Vertebrate Museum of Zoology at Shippensburg University. To ensure continued accuracy, cleaned items were also visually/microscopically compared against samples that had been identified from other stomach contents examined during this study.

RESULTS

We examined the stomach contents from 98 coyotes. The coyote stomachs were obtained from hunters and trappers from the following 30 counties with the number of stomachs examined from each county in parentheses: Bedford (1), Blair (1), Bradford (6), Cambria (1), Carbon (1), Centre (1), Clarion (3), Clearfield (5), Clinton (5), Crawford (19), Dauphin (1), Elk (2), Erie (7), Forest (2), Franklin (1), Greene (3), Indiana (1), Jefferson (1), McKean (3), Mercer (20), Monroe (1), Montour (1), Potter (1), Snyder (1), Sullivan (2), Susquehanna (2), Tioga (1), Washington (2), Warren (2), and Westmoreland (2). Eighty stomachs had distinct food items, evidence of a recent and sizable meal. No identifiable food items were collected from 18 stomachs and thus, were classified as empty. We identified 15 different food items including mammals, birds, scat, and vegetation (Table 1). The most prominent food item from each sampling period was white-tailed deer. The highest frequency of deer occurred during the 2006 winter season with deer observed in 70.8% of stomachs. Overall, the second most common individual food item was vegetation. Small and medium-sized mammals also were well represented as food items during winter. Among these mammals, the most frequently encountered were shrews (*Sorex* sp. and *Blarina brevicauda*), especially in the 2006 season, and cottontails (*Sylvilagus* sp.) in the 2002 to 2003 season. Additional mammals that we detected included: vole (*Microtus* sp.), mole (*Condylura cristata* or *Parascalops breweri*), mouse (*Peromyscus* sp.), groundhog (*Marmota monax*) and two predatory mammals, the red fox and the house cat (*Felis catus*). We identified only two potential farm animals, hog (*Sus scrofa domestica*) and domestic chicken (*Gallus gallus domesticus)*, in the coyote stomachs examined. We also discovered the presence of wild birds in the contents of several stomachs. Wild turkey (*Meleagris gallopavo*) was the most frequently observed bird, except during the 2002 to 2003 winter season. During the 2002-03 season, the highest bird frequency was observed for both non-Galliformes and chickens. In addition to these food items, some samples showed coprophagy; specifically we identified formed scats in three male coyote stomachs.

Table 1. Identified artifact sources (n = number of stomachs that contained artifacts identified from a distinct source) and frequency percentages for each item found in Pennsylvania coyote stomachs. An individual stomach may have identifiable artifacts from more than one source or may not contain any identifiable artifacts.

	Year			
Identified Artifact Source	2002-2003 (n=42)	2006 (n=24)	2007 (n=32)	Total (n=98)
Deer *(Odocoileus virginianus)*	57.1	70.8	62.5	62.2
Vegetation	16.7	37.5	28.1	25.5
Empty (nothing identified)	16.7	20.8	18.8	18.4
Cottontail Rabbit *(Sylvilagus* sp.)	26.2	4.2	6.3	14.3
Shrew (*Sorex* sp. and *Blarina* sp.)	4.8	20.8	6.3	9.2
Wild Turkey (*Meleagris gallopavo*)	2.4	4.2	12.5	6.2
Vole (*Microtus* sp.)	4.8	4.2	-	3.1
Red Fox (*Vulpes vulpes*)	4.8	-	3.1	3.1
Formed scat (Canid)	2.4	8.4	-	3.1
Cricetid Mouse (*Peromyscus* sp.)	4.8	-	-	2
Hog (*Sus scrofa domestica*)	-	8.4	-	2
Chicken (*Gallus gallus domesticus*)	4.8	-	-	2
Other Bird (Passeriformes sp.)	4.8	-	-	2
Ground Hog (*Marmota monax*)	-	4.2	-	1
Mole *(Condylura* or *Parascalops*)	-	-	3.1	1
House Cat (*Felis catus*)	-	-	3.1	1

DISCUSSION

Studies using scats have shown that coyotes rely on a relatively diverse diet. However, during winter there is a shift toward deer as the primary food item (Bixel 1995; Dibello *et al.* 1990; Patterson *et al.* 1998). For instance, Bixel (1995) working at Letterkenny Army Depot, Pennsylvania, found deer traces in 32.4%, 1.1%, 14.0%, of scats during spring, summer, and fall respectively. During winter, however, he found deer in 71.4% of coyote scats. Our winter study found deer traces in 62.2% of examined stomachs which further supports the notion that Pennsylvania coyotes switch from a heterogeneous, non-deer dominated diet during the food prolific

spring, summer, fall seasons to a primarily deer dominated diet during the winter season. Several factors could explain this diet shift. Obviously, during the winter season many of the previously abundant food items are absent because of inclement weather conditions (i.e. vegetation, insects, amphibians, reptiles, and winter dormant mammals). Another possible explanation is that severe winter conditions, including deep snow and frozen lakes, can lead to increased vulnerability in deer by affecting their mobility (Dibello *et al.* 1990; Patterson *et al.* 1998; Patterson and Messier 2003). This increased vulnerability would allow coyotes to prey on deer more easily in the winter season than in other seasons, as suggested by Brocke (1992) with coyotes of the Adirondack region in New York. However, deer consumption by coyotes may not be solely the result of predation, as coyotes will scavenge on carcasses of deer (Patterson and Messier 2003). Deer carcasses that are the result of highway mortality, hunter harvests, or death by natural causes are conspicuous during the harsh winter conditions throughout the state.

Annual diets of coyotes will differ due to the effect of climatic conditions on the availability of food (Meinzer *et a*l. 1975). Therefore, a difference in the annual abundance or vulnerability of these food items in Pennsylvania possibly causes differences in food selection during an individual season. Additionally, each of these food items is important in supplementing the winter diet of coyotes when larger prey (i.e. deer) is not available or is more difficult to obtain. It is likely that many of the birds and small mammals detected were predated because dirt and rocks were present which may have inadvertently been consumed during prey acquisition. Small mammals seem to be an important aspect to coyote diet and could facilitate dietary needs in winter when deer or deer carcasses become scarce.

Several domestic animals were identified as food items during this study. Chicken was detected in two coyote stomachs and hog was also detected in the stomachs of two different individuals. The two stomachs containing hog, coming from north-central PA (Elk and Clinton counties), are outside documented ranges of breeding populations of feral hogs (PGC 2008). Therefore, these food items were either scavenged from butchered animals, scavenged from discarded carcasses, or the result of depredation on domestic hogs. Domestic depredation may be significant in localized areas. Bergeron and Demers (1981) analyzed 22 coyote stomachs in winter in Quebec and found that cow, hog, and chicken occurred in nine, six, and four stomachs respectively. Our results suggested that coyotes did not rely heavily on farm animal scavenging or depredation as a feeding strategy during winter in Pennsylvania. However, Houben (2004) reported that the rate of livestock losses due to coyote attacks has been increasing. Green *et al.* (1994) noted coyote depredation on livestock is less severe in winter than in other seasons, primarily because livestock are under more controlled care during winter. Our findings, at least for the winter, indicate that scavenging or depredation on farm animals by coyotes in Pennsylvania is low. This is contrary to concerns reported by Witmer and Hayden (1992) who surveyed 331 sheep producers from Pennsylvania and reported that 22% of surveyed producers reported predator losses, primarily from coyotes and dogs, in 1991.

Two predatory mammals, house cat and red fox, were identified as winter food items of coyotes. Fedriani *et al.* (2000) reported that intraguild predation became so intense that high population densities of coyotes led to local exclusion of gray foxes. However, based on the geographic range of our sample and the low frequency of red fox and house cat found as food items in our winter study, we cannot support the notion that there is a significant interaction between coyotes and other mesopredators in Pennsylvania. Even if coyote predation on mesopredators occurred in our study, it does not seem to have a significant negative influence on mesopredator abundance. However, we acknowledge that in other seasons there is the potential for increased coyote predation which could result in a change in the top down regulatory effects of trophic interactions, as suggest by Parker (1995).

Vegetation was identified frequently, 25.5%, in the coyote stomachs analyzed. These results are very similar to the findings of Bixel (1995), where he observed 28.6% in 7 coyote scats during winter. While coyotes seem to continue foraging on plant material during winter, vegetation provides nutrition, but is not contributing significantly to their overall diet. The majority of the vegetative material that we identified was composed of primarily indigestible cellulose, either woody (twigs) or dead plant material (leaves).

Coyotes also practice coprophagy during winter, as formed scat was identified in three stomachs. The specific reasons for this are unclear. It is possible that coyotes practice coprophagy to supplement their diet with nutrients such as nitrogen (Chilocette and Hume 1985). It is also possible that males are attempting to remove scent markers of other individuals from their territories, as all of the scats found in our study were from the stomachs of male coyotes. This practice has been observed to be beneficial in other mammals for acquiring mates (Rich and Hurst 1998).

Prior studies by Bixel (1995) in Pennsylvania and Cepek (2004) in Ohio have relied on scat analysis to understand the diet of coyotes. While scat analysis is helpful in providing insight into the food habits of this generalist predator and does not require the animal to be sacrificed, we believe that stomach content analysis is more reliable and productive in illuminating the predaceous aspect of the coyote seasonal diet. Cavallini and Volpi (1995) examined the guts (stomach and intestines) from 320 red foxes and 211 scats collected from the same area and during the same time frame. They concluded that mammals, particularly small mammals, were more abundant in guts and invertebrates and grass were more abundant in scats. Analyzing coyote stomach contents provides a more detailed scope of the items ingested by the pred-

ator, because the contents are fresher and less deteriorated (Gales and Cheal 1992). They can also be linked to a chronologically concise time frame.

The northeastern coyote population appears to be expanding and increasing. To date, there is very little detailed knowledge on this secretive predator in Pennsylvania. Because of the lack of essential studies, we do not fully understand the potential effects of the eastern coyote on game, non-game wildlife, and farm animals. Our study suggests patterns in diet, but is restricted to the winter season. With the exception of very limited data from scat studies, little is known on the dietary habits of the coyote in the spring, summer, and fall seasons. We specifically recommend that stomach content analysis be expanded to include other seasons than winter to more accurately assess predation.

ACKNOWLEDGEMENTS

We would like to thank the people at the Mosquito Creek Sportsmen's Association for providing support and allowing us to participate in their annual coyote hunts and to collect samples. We would also like to thank Karen Martin and Steve Rogers for collecting stomach samples and contributing them to our study. Many thanks are also due to the hunters who allowed us to collect stomach samples from their coyotes as well as Dick, Susan and Renee Stewart for providing accommodations and support.

LITERATURE CITED

Andelt, W.F., F.F. Knowlton, K. Cardwell, and J.G. Kie. 1987. Variation in coyote diets associated with season and successional changes in vegetation. *Journal of Wildlife Management* 51:273-277.

Ballard, W.B., H.A. Whitlaw, S.J. Young, R.A. Jenkins, andG.J. Forbes. 1999. Predation and survival of white-tailed deer fawns in Northcentral New Brunswick. *The Journal of Wildlife Management* 63:574-579.

Bartel, R.A. and F.F. Knowlton. 2005. Functional feeding responses of coyotes, *Canis latrans*, to fluctuating prey abundance in the Curlew Valley, Utah, 1977–1993. *Canadian Journal of Zoology* 83:569-578.

Bergeron, J.M., and P. Demers. 1981. Le regime alimentaire du coyote (*Canis latrans*) et du chien errant (*C. familiaris*) dans le sud du Quebec. *The Canadian Field-Naturalist* 95:172-177.

Bixel, K.D. 1995. Trophic Ecology of Adult Coyotes (*Canis latrans)* in South Central Pennsylvania. M.S. Thesis. Shippensburg University, Shippensburg, PA.

Brocke, R.H. 1992. A taste for venison. *Natural History*. May:50-51.

Cavallini, P. and T. Volpi. 1995. Biases in the analysis of the diet of the red fox *Vulpes vulpes*. *Wildlife Biology* 1: 243-248.

Cepek, J.D. 2004. Diet composition of coyotes in the Cuyahoga Valley National Park, Ohio. *Ohio Journal of Science* 104:60-64.

Chilocette, M.J. and L.D. Hume. 1985. Coprophagy and selective retention of fluid digesta: Their role in the nutrition of the common ringtail possum. *Australian Journal of Zoology*. 33:1-15.

Cunningham, S.C., W. Ballard, and L. Kirkland. 2006. Gray fox and coyote abundance and diet responses after a wildfire in central Arizona. *Western North American Naturalist* 66:169-180.

Dibello, F.J., S.M. Arthur, and W.B. Krohn. 1990. Food habits of sympatric coyotes, *Canis latrans*, red foxes, *Vulpes vulpes*, and bobcats, *Lynx rufus*, in Maine. *The Canadian Field-Naturalist* 104:403-408.

Dumond, M., M.A. Villard, and E. Tremblay. 2001. Does coyote diet vary seasonally between a protected and an unprotected forest landscape? *Ecoscienc*e 8:301-310.

Fedriani, J.M., T.K. Fuller, R.M. Sauvajot, and E.C. York. 2000. Competition and intraguild predation among three sympatric carnivores. *Oecologia* 125:258-270.

Fedriani, J.M., and M.H. Kohn. 2001. Genotyping faeces links individuals to their diet. *Ecology Letters* 4:477-483.

Gales N.J. and A.J. Cheal. 1992. Estimating diet composition of the Australian sea lion (*Neophoa cinerea*) from scat analysis: an unrliable technique. *Wildlife Research* 19: 447-455.

Gompper, M.E. 2002a. Top carnivores in the suburbs? Ecological and conservation issues raised by colonization of northeastern North America by coyotes. *Bioscience* 52: 185–190.

Gompper, M.E. 2002b. The ecology of northeast coyotes: Current knowledge and priorities for future research. *Wildlife Conservation Soceity Working Paper*. 17:1-48.

Green, J.S., and J.T. Flinders. 1981. Diets of sympatric red foxes and coyotes in southeastern Idaho. *The Great Basin Naturalist* 41:251-254.

Green J.S., F.R. Henderson, and M.D. Collinge. 1994. Coyotes pages 51-76. in *Prevention and control of wildlife damage*. Editors, S.E. Hygnstrom, R.M. Timm, G.E. Larson. University of Nebraska-Lincoln.Lincoln, NB, USA.

Hayden, A. 2010. Coyote. Pennsylvania Game Commission Wildlife Note number 39, LDR0603. Retrieved Feb. 22, 2011 from http://www.portal.state.pa.us/portal/server.pt?open=514&objID=596812&mode=2

Houben, J.M. 2004. Status and management of coyote depredation in the eastern United States. *Sheep and Goat Research Journal* 19:16-22.

Kays, R., A. Curtis, and J.J. Kirchman. 2010. Rapid adaptive evolution of northeastern coyotes via hybridization with wolves. *Biological Letters* 6: 89-93.

Kitchen, A.M., E.M. Gese, and E.R. Shauster. 1999. Resource partitioning between coyotes and swift foxes: Space, time, and diet. *Canadian Journal of Zoology* 77:1645-1656.

Livingston, T.R., W.B. Ballard, P.S. Gipson, P.R. Krausman,

and D.M. Sanchez. 2005. Scat removal: A source of bias in feces-related studies. *Wildlife Society Bulletin* 33:172-178.

McGinnis, H.J. 1979. Pennsylvania coyotes and their relationships to other wild *Canis* populations in the Great Lakes region and northeastern United States, M.Sc. Thesis. Pennsylvania State University, University Park, PA.

Meinzer, W.P., D.N. Ueckert, and J.T. Flinders. 1975. Food-niche of coyotes in the rolling plains of Texas. *Journal of Range Management* 28:22-27.

Neale, J.C.C. and B.N. Sacks. 2001a. Resource utilization and interspecific relations of sympatric bobcats and coyotes. *Oikos* 94:236-249.

Neale, J.C.C and B.N. Sacks. 2001b. Food habits of gray foxes in relation to sympatric coyotes and bobcats. *Canadian Journal of Zoology* 79:1794-1800.

Parker, G.R. 1995. *Eastern Coyote*. Nimus Publishing, Halifax, NS, Canada.

Patterson, B.R., L.K. Benjamin, and F. Messier. 1998. Prey switching and feeding habits of eastern coyotes in relation to snowshoe hare and white-tailed deer densities. *Canadian Journal of Zoology* 76:1885-1897.

Patterson, B.R. and F. Messier. 2003. Age and condition of deer killed by coyotes in Nova Scotia. *Canadian Journal of Zoology* 81:1894-1898.

Pennsylvania Game Commission. (PGC). 2008. 2009 Update. Retrieved Nov. 5, 2010 from http://www.portal.state.pa.us/portal/server.pt?open=space&name=Dir&psname=SearchResult&psid=18&cached=true&in_hi_userid=2&control=OpenSubFolder&subfolderID=112895&DirMode=1.

Rich, T.J. and J.L. Hurst. 1998. Scent marks as reliable signals of the competitive ability of mates. *Animal Behavior* 56:727-735.

Richens, V.B. and R.D. Hugie. 1974. Distribution, taxonomic status, and characteristics of coyotes in Maine. *Journal of Wildlife Management* 38:447-454.

Sacks, B.N., and J.C.C. Neale. 2002. Foraging strategy of a generalist predator toward a special prey: Coyote predation on sheep. *Ecological Applications* 12:299-306.

Toweill, D.E.and R.G. Anthony. 1988. Coyote foods in a coniferous forest in Oregon. *The Journal of Wildlife Management* 52; 507-512.

Weintraub, J.D. 1986. Coyote diets, five years later, at Cuyamaca Rancho State Park. *Bulletin of the Southern California Academy of Science* 85:152-157.

Windberg, L.A. and C.D. Mitchell. 1990. Winter diets of coyotes in relation to prey abundance in southern Texas. *Journal of Mammalogy* 71:439-447.

Witmer, G. and A. Hayden. 1992. Status of coyotes and coyote depredations in Pennsylvania. *Proceedings of the Eastern Wildlife Damage Control Conference* 5: 83-87.