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Diets of Fishers (*Pekania pennanti*) and Evidence of Intraspecific Consumption in Pennsylvania

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ABSTRACT.—The fisher (*Pekania pennanti*) is a forest-dwelling mesocarnivore native to northern North America. The species had been extirpated from many southern parts of its historic range, but several states have implemented fisher re-introduction programs over the past 40 y. While many studies have previously examined fisher diet, most occurred in northern and western portions of the species' range where mixed and coniferous forests are the dominate cover types. We examined fisher diet, in a re-introduced population in the central Appalachian Mountains where deciduous forests were the dominate cover type. We collected 91 fisher carcasses from 2002–2014 and examined their stomach contents. We detected mammalian and avian prey in 82.6% and 10.9% of stomachs, respectively. Fishers we sampled consumed a variety of plant materials ($n = 11$) and prey items ($n = 30$ spp.). Diet composition of males and females overlapped considerably ($O = 0.87$). Our most noteworthy and novel finding was the presence of fisher remains in 11 (12%) stomachs. We suggest here that rapid population growth of Pennsylvania fishers may have resulted in aggressive behaviors underlying our observations of interspecific consumption. Future research that examines the cause for intraspecific consumption in this central Appalachian fisher population would be a worthy endeavor.

INTRODUCTION

Re-introduction of extirpated wildlife populations is often a goal of wildlife agencies and land managers (Groom, 2006; Seddon *et al.*, 2007). At a minimum understanding the diet of a re-introduced species is helpful for understanding resource needs, potential impacts of predation on resident species, and guiding adaptive management (Robbins, 1983; Breitenmoser and Haller, 1993; Stahler *et al.*, 2006; Mee *et al.*, 2007; Carlson *et al.*, 2014). The fisher (*Pekania pennanti*) is a secretive mesocarnivore that has been the target of several re-introduction attempts over the past several decades (Lewis *et al.*, 2012). The fisher's historic range once spanned throughout the majority of North America's northern forests (Powell, 1981). Habitat loss, unregulated trapping, and systematic elimination of predators resulted in a significant range contraction for fishers across the U.S. (Lewis *et al.*, 2012). By the early 1900s, fishers were extirpated from southern New England and the central and southern Appalachians (Kelly, 1977; Powell, 1981).

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Throughout the 20th century, forest and wildlife management techniques improved and reforestation on many lands occurred via natural succession (Lorimer and White, 2003). Ultimately, the combined effect of habitat availability and increased societal acceptance shifted the landscape from a hostile, unaccepting place for fishers to a vacant landscape, far below carrying capacity (Kelly, 1977; Kellert, 1985; Klyza, 2001; Hardisky, 2001). These events spurred several fisher re-introduction efforts in the central and southern Appalachian Mountains (Lewis *et al.*, 2012).

Few studies have focused on understanding the basic ecology of fishers in recently repopulated portions of the central and southern Appalachian Mountains (Dzialak *et al.*, 2005; Gess *et al.*, 2013). This knowledge gap may limit the ability of biologists and land managers to identify and manage high quality habitats for re-introduced fisher populations in Appalachia. Although previous studies have examined fisher diets, most have taken place in the northern portion of the species range in areas dominated by mixed and coniferous forests (Raine, 1987; Arthur *et al.*, 1989; Golightly *et al.*, 2006). It seems reasonable that, due to differences in potential prey communities, diets of fishers may differ substantially in the deciduous forests of the central Appalachians compared to more northerly portions of the species range. To help inform this aspect of fisher ecology, we examined the stomach contents of fishers from a well-established and expanding re-introduced population in Pennsylvania.

METHODS

STUDY AREA

From 1994–1998, 190 fishers were translocated from northern New York and New Hampshire and released across northern Pennsylvania (Hardisky, 2001). These founding individuals and natural immigrants from neighboring states resulted in exponential fisher population growth and colonization of nearly all of Pennsylvania's forests (Lovallo, 2008). Forests are the dominant land cover type across Pennsylvania and comprise approximately 58% (670,000 km²) of the state (McWilliams *et al.*, 2007). The majority of Pennsylvania's forests are deciduous with mixed-oak and northern hardwood communities comprising about 86% of the state's forests (McWilliams *et al.*, 2007). Fishers in this study were collected from across much of Pennsylvania's forested regions (Fig. 1).

FISHER SAMPLING

Fisher carcasses were found within 32 Pennsylvania counties, all within 230 km of -77.8031, 40.8752. We collected carcasses of road-killed, incidental trapper-killed, and legally harvested fishers from 2002 to 2014. We extracted the entire stomach from each carcass and placed it in a separate jar containing 10% formalin solution for 24 h. We then dissected each stomach and rinsed the contents of each over a wire sieve. The contents of each stomach were then teased apart and allowed to dry under a ventilation hood for ≥ 24 h. Once dried, we sorted stomach contents into groups based on macroscopic classification of like parts: hard parts (bones, teeth, and claws), vegetative material, fur, feathers, and other materials (*e.g.*, egg shells). If multiple tufts of hair appeared to be potentially from the same prey species, but the relationship was uncertain, we treated each tuft separately to help ensure we maximized prey detection probability. We first attempted to identify stomach remains macroscopically by comparing them to specimens from Indiana University of Pennsylvania's (IUP) museum collections.

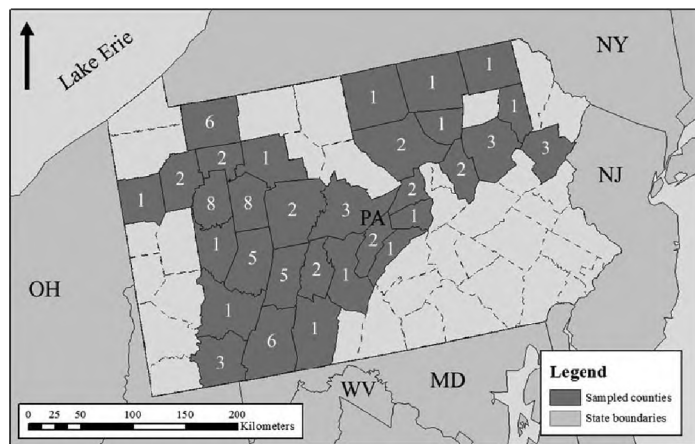


FIG. 1.—Pennsylvania counties from which fisher (*Pekania pennanti*; $n = 91$) carcasses were collected from 2002–2014. Numbers within each county boundary represent the number of carcasses from each county from which we had reliable spatial data ($n = 79$)

To further aid in the identification of stomach contents, we created hair scale slides for any hair samples that we could not identify macroscopically to species (Day *et al.*, 1966). We used three identification keys and our reference slides to identify the mammalian hair found within fisher stomachs to the lowest possible taxa level (Mayer, 1952; Feretic *et al.*, 2008). Although some prey could be individually counted within fisher stomachs as they were consumed whole (*e.g.*, small rodents, etc.), larger prey could not be individually counted. Further, organ/muscle tissue consumed without associated hair is not discerned by this method. Therefore, we quantified dietary diversity (using percent occurrence) as a measure of presence-absence of each species within fisher stomachs (*e.g.*, see Giuliano *et al.*, 1989; Zielinski *et al.*, 1999; Weir *et al.*, 2005). The percent occurrence method is also limited in that multiple individuals of the same species found within a common stomach are considered as a single confirmation of occurrence. Ultimately, these methods provide a quantitative index for the relative importance of a wide range of potential food resources and are comparable to those used by previous fisher diet studies. Note that percent occurrence values may exceed 100% as individual stomachs may contain multiple food items.

We calculated the Shannon–Wiener Diversity Index (H') for all stomach contents of male, female, and all fishers combined (Shannon, 1948). We calculated H' as $-\sum p_i \ln(p_i)$ where p_i is the proportion of the i^{th} species found within each stomach. Additionally, to quantify potential differences in prey size consumed by male and female fishers, we categorized prey into three size classes based on an average mass reported for a species: (1) small prey were <1 kg; (2) medium prey were 1–6 kg; and (3) large prey were >6 kg. We used a Multivariate Analysis of Variance (MANOVA) in program R to examine potential effects of sex on prey size class consumption frequencies (R Core Team, 2015). Finally, we estimated the amount of dietary overlap between males and females using a Pianka's Index (Pianka, 1973) where 0 represents no dietary overlap and 1 represents complete overlap. Overlap was estimated as $(\sum p_{ij} p_{ik}) / \sqrt{\sum p_{ij}^2 \sum p_{ik}^2}$ where p_{ij} and p_{ik} represent the proportions of the i^{th} species consumed by the j^{th} and k^{th} sex class.

RESULTS

We examined the stomach contents of 91 fishers (46 males: 42 females: three unknown) collected from 30 counties in Pennsylvania (Fig. 1). All fishers examined in our study were entire (*e.g.*, no missing limbs or digits) upon their collection. Carcass collection was biased toward fall/winter months so we did not consider seasonal effects on diet. Of the fisher stomachs, 75 were from road-killed, 15 were harvested by trappers, and cause of death was not documented for one carcass. Six (6.7%; all from males) stomachs had no contents. Hair, feathers, teeth, and claws were the most useful “hard parts” for aiding in the identification of animal prey as bones were typically highly fragmented.

Evidence of mammalian and avian prey was found in 75 (83.3%) and 11 (12.2%) stomachs, respectively. Eleven (12.2%) stomachs contained fruit/seeds, four (4.4%) contained eggshells, and 11 (12.2%) contained foliage (Table 1). The most commonly detected orders were Rodentia (48.9% of stomachs), Carnivora (23.3%), and Artiodactyla (13.3%). Mesocarnivore remains (Carnivora and Didelphimorphia) were found in 29 (32.2%) stomachs. Small mammals (Rodentia: Cricetidae, Soricomorpha, Eastern chipmunk, and American red squirrel) were detected in 29 (32.2%) stomachs (Table 1). The most common individual species detected were the white-tailed deer (13.3%), fisher (12.2%), and eastern/Appalachian cottontail (*Sylvilagus* spp.; 12.2%).

Because fisher remains have not been reported previously in the literature, we carefully scrutinized the fisher remains we detected in order to exclude self-groomed hair. We detected fisher hair in 12 stomachs. Of these we determined the presence of fisher hair in one stomach may have been the result of self-grooming as it contained no fisher flesh, bones, or claws. The remaining 11 (four male and seven female) stomachs had fisher remains that were clearly the result of cannibalistic behavior. Of the 11 fisher stomachs containing conspecific remains, six were from road-killed animals and five from trapper-killed. Consumed fisher remains included copious amounts of hair, pieces of epidermis, and/or other hard parts that were from fishers (Fig. 2). In fact, eight of 11 (72.72%) stomachs containing fisher remains had at least a single fisher claw and many stomachs contained multiple claws. Most of these claws were still attached to the distal phalanx and many also included the digital toe pad as well as additional phalanx bones (Fig. 2). Ten of the 11 stomachs that contained fisher remains were from carcasses collected between Nov.–Feb., which ruled out predation of natal fishers as a reason for consumption. The five stomachs from trapper-kills that contained fisher parts were from individuals that had all of their feet intact and therefore ruled out self-mutilation as an explanation for consumption.

We identified 26 mutually exclusive dietary categories each for male and female fishers with a total number of prey categories of 32 for both sexes combined. Male ($n = 46$) and female ($n = 42$) fishers contained similar proportions of all three animal prey size classes (MANOVA, Wilke's $\lambda = 0.99$, 3, 87 d.f., $P = 0.98$; fig. 3). Combined diversity of prey was high ($H' = 2.92$) with female diversity calculated higher ($H' = 2.38$) than for males ($H' = 1.88$). Our values for dietary overlap ($O = 0.90$) suggests there is a high degree of dietary overlap between male and female fishers.

DISCUSSION

Our study provides perspective into fisher diet in a portion of the species range for which information is limited (Dzialak *et al.*, 2005). Our results suggest fishers are capitalizing on the diversity of prey species and vegetation found in deciduous forests of the central Appalachian Mountains. Much of our findings are in agreement with those from a number

TABLE 1.—The frequency of dietary components for fishers (*Pekania pennanti*) collected in Pennsylvania, 2002–2014. Fisher stomach contents were identified to the species level by a combination of microscopic hair inspection and macroscopic examination of bones, teeth, claws and other hard parts. We classified each prey into size classes based on mass with <1 kg as “small” (S), 1–6 kg as “medium” (M), and >6 kg considered “large” (L)

Taxa	Common name	Size	Total (%)	♂ (%)	♀ (%)
Mammalia			75 (83)	37 (80)	36 (88)
Artiodactyla					
<i>Odocoileus virginianus</i>	White-tailed deer	L	12 (13)	7 (15)	5 (12)
Soricomorpha			7 (8)	3 (7)	4 (10)
<i>Sorex cinereus</i>	Masked shrew	S	3 (3)	2 (4)	1 (2)
<i>Blarina brevicauda</i>	Short-tailed shrew	S	1 (1)	0	1 (2)
Lagomorpha					
<i>Sylvilagus</i> spp.	Cottontail spp.	M	11 (12)	6 (13)	5 (12)
Rodentia			44 (49)	24 (52)	19 (46)
Erithizontidae					
<i>Erithizon dorsatum</i>	N. American porcupine	M	10 (11)	6 (13)	3 (7)
Castoridae					
<i>Castor canadensis</i>	American beaver	L	2 (2)	1 (2)	1 (2)
Cricetidae			22 (24)	13 (28)	9 (22)
<i>Neotoma magister</i>	Allegheny woodrat	S	1 (1)	1 (2)	0
<i>Microtus</i> spp.	Vole spp.	S	11 (12)	6 (13)	5 (12)
<i>Microtus pinetorum</i>	Woodland vole	S	1 (1)	0	1 (2)
<i>Microtus pennsylvanicus</i>	Meadow vole	S	5 (6)	3 (7)	2 (5)
<i>Myodes gapperi</i>	Red-backed vole	S	3 (3)	2 (4)	1 (2)
<i>Peromyscus</i> spp.	Deer mouse spp.	S	11 (12)	6 (13)	5 (12)
Sciuridae			17 (19)	10 (22)	7 (17)
<i>Marmota monax</i>	Woodchuck	M	4 (4)	3 (7)	1 (2)
<i>Sciurus carolinensis</i>	E. gray squirrel	S	8 (9)	4 (9)	4 (10)
<i>Tamias striatus</i>	E. chipmunk	S	3 (3)	2 (4)	1 (2)
<i>Tamiasciurus hudsonicus</i>	Red squirrel	S	3 (3)	2 (4)	1 (2)
Carnivora			21 (23)	9 (20)	11 (27)
Canidae			5 (6)	2 (2)	2 (5)
<i>Canis latrans</i>	Coyote	L	2 (2)	1 (2)	1 (2)
<i>Vulpes vulpes</i>	Red fox	M	3 (3)	1 (2)	1 (2)
Mustelidae					
<i>Pekania pennanti</i>	Fisher	M	11 (12)	4 (9)	7 (17)
Procyonidae					
<i>Procyon lotor</i>	Raccoon	M	6 (7)	3 (7)	3 (7)
Mephitidae					
<i>Mephitis mephitis</i>	Striped skunk	M	1 (1)	1 (2)	0
Chiroptera					
<i>Lasionycteris noctivagans</i>	Silver-haired bat	S	1 (1)	1 (2)	0
Didelphimorphia					
<i>Didelphis virginiana</i>	Virginia opossum	M	8 (9)	4 (9)	3 (7)
Aves			11 (12)	6 (13)	4 (10)
Avian egg	—	—	3 (3)	3 (7)	0
Galliformes			1 (1)	1 (2)	0
<i>Phasianus colchicus</i>	Ring-necked pheasant	S	1 (1)	1 (2)	0

TABLE 1.—Continued

Taxa	Common name	Size	Total (%)	♂ (%)	♀ (%)
Passeriformes					
<i>Poecile atricapillus</i>	Black-capped chickadee	S	1 (1)	0	1 (2)
Piciformes					
<i>Picoides pubescens</i>	Downy woodpecker	S	1 (1)	0	1 (2)
Reptilia					
<i>Elaphe obsoleta</i>	Black rat snake	S	1 (1)	1 (2)	0
Amphibia					
<i>Lithobates</i>	True frog species	S	1 (1)	0	1 (2)
Actinopterygii	Bony fish		2 (2)	0	2 (5)
Insecta					
<i>Orthosoma brunneum</i>	Brown prionid beetle	S	1 (1)	1 (2)	
Other					
Foliage	—	—	10 (11)	4 (9)	6 (15)
Fruit/seeds	—	—	11 (12)	6 (13)	4 (10)

of previous studies which have described the fisher as a generalist carnivore that feeds on a suite of mammalian prey species supplemented with opportunistic exploitation of a variety of birds, squamate reptiles, plant materials, and fungi (De Vos, 1952; Giuliano *et al.*, 1989; Powell, 1993; Martin, 1994; Bowman *et al.*, 2006). Indeed, because prey specialization in North American Carnivora is believed to be a highly derived trait (Wesley-Hunt, 2005), it seems likely that generalist feeding behavior is the basal character for fishers and specialization on individual prey species (*i.e.*, snowshoe hare and porcupine) is an

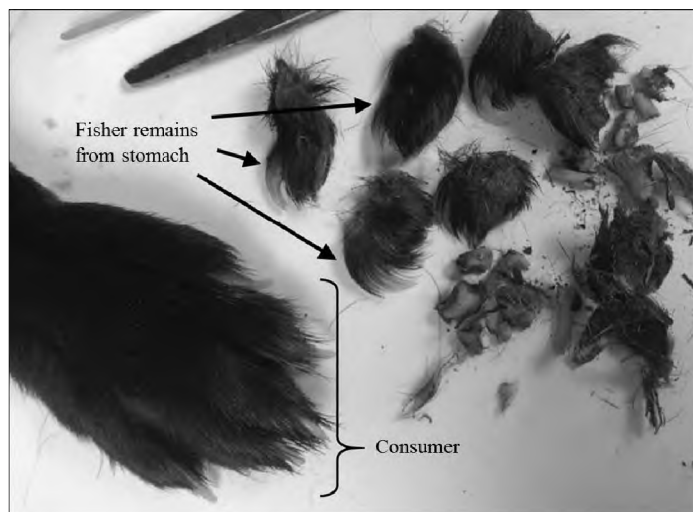


FIG. 2.—Stomach contents from a road-killed male fisher (*Pekania pennanti*) in Pennsylvania. Among the prey items detected in this stomach were the claws and toes of another fisher. The forepaw from the consumer is also shown for scale. In many cases, the conspecific claws extracted from fisher stomachs were comparable in size to those of the consumer

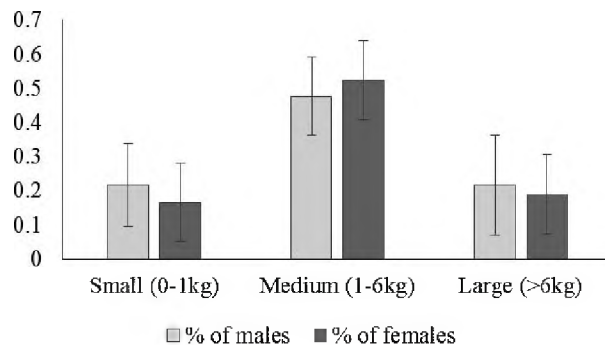


FIG. 3.—The size classes of prey contained within fisher (*Pekania pennanti*) stomachs collected as road-kill and trapper harvests in 2002–2014, Pennsylvania. Small prey (<1 kg), medium prey (1–6 kg), and large prey (>6 kg) were quantified within fisher stomachs. Male (light bars; $n = 46$) and female (dark bars; $n = 41$) fishers did not differ in the proportions of their diet comprised of any size class

example of generalist adaptability (Bowman *et al.*, 2006). This generalist diet also makes intuitive sense as the fisher is found throughout much of North America, primarily limited by increased snow depth at the northern limits of its range (Krohn, 2012).

The central Appalachian Mountains provide the ideal setting for fishers to employ generalist feeding behavior because lower trophic levels are comprised of a very diverse faunal community. In fact, Pennsylvania alone hosts 66 species of terrestrial mammals, >190 breeding birds, and an abundance of squamate reptiles, amphibians, invertebrates, and plants that fishers can incorporate into their diets (Wherry *et al.*, 1979; Hulse *et al.*, 2001; PGC, 2011; Wilson *et al.*, 2012). The diet of fishers in the central Appalachian Mountains is more diverse compared to most populations studied elsewhere (Martin, 1994). In fact, the diversity value (H') from our study is comparable to the highest value ever reported for the species (California; Zielinski *et al.*, 1999). The high diet diversity reported for fishers in the Sierra Nevada Mountains of California was attributed to the absence of “normal” fisher prey, such as porcupines (*Erethizon dorsatum*) and lagomorphs in that region (Zielinski *et al.*, 1999). Conversely, fishers in our study exhibited a high level of dietary diversity while simultaneously using porcupines and lagomorphs (cottontails) as common prey items. Because of this diverse prey base, fishers in the central Appalachians do not appear to be specialists on any individual species.

Fishers display a high degree of sexual dimorphism (most markedly in body size), and it has been suggested that their diets might also differ as a function of ideal prey size and foraging strategy (Weir *et al.*, 2005). Whereas it seems reasonable to suggest that sexual dimorphism would result in prey resource partitioning in fishers, we found no differences between males and females with respect to either prey species or prey size-class composition. Females and males we sampled also had similar values for diet diversity. Our study is not the first to fail to detect dietary differences between male and female fishers (Giuliano *et al.*, 1989; Dzialak *et al.*, 2005). The diet similarities between sexes in our study could be influenced by the availability of road-killed carcasses. If road-killed carcasses of large species (*i.e.*, ungulates, larger carnivores) are a major component of fisher diets, all size classes of prey would be accessible to all fishers, regardless of the consumer size/sex. However, even without the free availability of prey to both sexes, pronounced differences in fisher

physiology are restricted primarily to body size (rather than jaw morphology and dentition; Powell, 1993) and differences in diet are not necessarily expected.

In addition to consuming a wide diversity of herbivore and lower trophic level prey, fishers in Pennsylvania seem to readily incorporate other mesocarnivores (6 spp.) into their diets. Fisher consumption of mesocarnivores has been documented in several other studies (Giuliano *et al.*, 1989; Powell, 1993; Martin, 1994; Dzialak *et al.*, 2005; Bowman *et al.*, 2006). Mesocarnivores were found in nearly a third of the fisher stomachs we examined. This suggests mesocarnivores constitute a relatively important dietary component of Pennsylvania's fisher population.

Of the mesocarnivores we observed in fisher stomachs, by far the most novel and unexpected species was fisher. Cannibalism is not unusual among animals and it can influence population structure, life history, behaviors, and competition for mates and resources (Polis, 1981; Polis *et al.*, 1984). A recent study by Gabriel *et al.* (2015) described 58 predation events on fisher; while several predator species exploited fishers as prey (*e.g.*, coyote, mountain lion *Puma concolor*, etc.), cannibalism was not observed. In contrast to our own work, Gabriel *et al.*, (2015) worked within an imperiled population of fishers where the population size is small. Because Pennsylvania's fisher population is growing more rapidly than many northwestern subpopulations (Lovallo, 2008), different interaction dynamics would be expected among conspecifics within each region.

Although previous research on fisher diet reported the occurrence of conspecific hair in scat samples, all instances were attributed to self-grooming (Zielinski *et al.*, 1999). We observed several instances of fisher hair in the stomachs we examined. While it is possible that the fisher remains we observed were the result of scavenging already dead fishers (*e.g.*, road mortalities or fisher feet used as trapping bait), neither of these explanations seem likely; for road-killed conspecific scavenging, fishers would have had to heavily selected for roadside fisher carcasses, passing-up more common species like white-tailed deer, Virginia opossum, or raccoon. Moreover, most of the stomachs with evidence of cannibalism contained fisher toes, claws, and/or foot pads. While the paws of a fisher mark the only furred portion of the carcass which would typically not be sold with the pelt, the low fisher bag limit (one individual/season) would render fisher paws as trap bait a rare occurrence indeed. We find the observation of paws in stomachs to be rather perplexing for two reasons: (1) these body parts should have less nutritional value than fleshier body parts and (2) we rarely documented the consumption of feet/paws of other, equal-sized prey species. As such we hypothesize that fisher consumption of conspecifics may have been driven by a factor independent of nutrition.

We propose that the conspecific remains we observed in fisher stomachs may have been due to intraspecific strife that resulted in the death and subsequent consumed of particular body parts. Most instances of intraspecific predation and cannibalism reported in mammals are due to infanticide (Polis *et al.*, 1984). However, this behavior does not explain the cannibalism we observed in fishers. Rather, it appears that adults were consuming other adults/subadults because the claw sizes we found in stomachs were comparable to the claw sizes of the consumers (Fig. 2). Additionally, 10 of 11 stomachs that contained fisher remains were from carcasses that were collected between Nov.–Feb., which would rule out predation of natal fishers. This timing also coincides with fisher dispersal; therefore, so perhaps the intraspecific predation we observed was the result of territorial disputes. Instances of adults killing and consuming other adults due to territorial disputes have been documented for at least eight mammalian species (Polis, 1981; Polis *et al.*, 1984).

We hypothesize fishers may exhibit a behavior whereby territorial disputes can result in an individual killing a conspecific and then consuming its feet in order to remove further chemical signaling from plantar glands (Buskirk *et al.*, 1986). The frequency of this behavior would be intensified, and therefore more likely to be observed, in high-density fisher populations. Indeed, a review of studies on intraspecific predation found 65 instances of increased predation rates due to overcrowding or high population densities (Polis, 1981), and one explanation for this observation was that at higher population densities there is an increased frequency in which conspecifics violate minimum distances for intraspecific space use (Polis, 1981). The fisher population we studied in Pennsylvania has experienced a dramatic increase over the past two decades (Lovallo, 2008). Observations of intraspecific predation might be harder to observed for populations that occur at lower densities (Polis, 1981), such as most fisher populations. This may explain why no fisher diet studies conducted previously reported evidence of cannibalism. That said, because our observations of conspecific remains in the stomachs of fishers were opportunistic rather than the outcome of experiment-based research, we are limited in our ability to explain the cause of the frequent evidence of cannibalism among fishers in our study population. Future research that provides insight regarding causal mechanisms of cannibalistic behaviors in fishers would be worthy. Specifically, future research should attempt to investigate the frequency at which intraspecific predation occurs in other fisher populations, the demographic conditions (*i.e.*, densities) that influence its frequency and the extent to which this behavior may regulate populations.

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LITERATURE CITED

- ARTHUR, S. M., W. B. KROHN, AND J. R. GILBERT. 1989. Habitat use and diet of fishers. *J. Wildl. Manage.*, **53**:680–688.
- BOWMAN, J., D. DONOVAN, AND R. C. ROSATTE. 2006. Numerical response of fishers to synchronous prey dynamics. *J. Mammal.*, **87**:480–484.
- BREITENMOSER, U. AND H. HALLER. 1993. Patterns of predation by reintroduced European lynx in the Swiss Alps. *J. Wildl. Manage.*, **57**:135–144.
- BUSKIRK, P. F. A., MADERSON, AND R. M. O'CONNOR. 1986. Plantar glands in north American Mustelidae. p. 617–622. *In*: Duvall, D. Muller, Schwarze, and R. M. Silverstein (eds.) Chemical signals in vertebrates: Vol. 4. Plenum Press, New York, New York.
- CARLSON, J. E., J. H. GILBERT, J. W. POKALLUS, P. J. MANLICK, W. E. MOSS, AND J. N. PAULI. 2014. Potential role of prey in the recovery of American Martens to Wisconsin. *J. Wildl. Manage.*, **78**:1499–1504.
- DAY, M. G. 1966. Identification of hair and feather remains in the gut and faeces of stoats and weasels. *J. Zool.*, **148**:201–217.
- DE VOS, A. 1952. Ecology and management of fisher and Marten in Ontario. Ontario Department of Lands and Forests. Technical Bulletin, Wildlife Service Number. Toronto, ON, Canada. 190 p.
- DZIALAK, M. R., T. L. SEREASS, C. L. BROWN, AND J. J. KRUPA. 2005. Fall and winter diet of the fisher (*Martes pennanti*) in West Virginia and Maryland. *P. W. VA. Acad. Sci.*, **77**:7–13.
- FERETIC, J. S., M. CICCHELLA, K. L. KREMSER, D. E. WARD, J. J. DESIMONE, AND C. A. IUDICA. 2008. Pictorial atlas and dichotomous key to the scale patterns of guard hairs for all indigenous Pennsylvanian mammalian species. Unpublished key. Department of Biology, Susquehanna University, Selinsgrove, Pennsylvania. 50 p.

- GABRIEL, M. W., L. W. WOODS, G. M. WENGERT, N. STEPHENSON, J. M. HIGLEY, C. THOMPSON, S. M. MATTHEWS, R. A. SWEITZER, K. PURCELL, R. H. BERRETT, S. M. KELLER, P. GAFFNEY, M. JONES, R. POPPENG, J. E. FOLEY, R. N. BROWN, D. L. CLIFFORD, AND B. N. SACKS. 2015. Patterns of natural and human-caused mortality factors of a rare forest carnivore, the fisher (*Pekania pennanti*) in California. *PLoS One*, **10**(11):e0140640.
- GESS, S. W., E. H. ELLINGTON, M. DZIALAK, J. DUCHAMP, M. LOVALLO, AND J. L. LARKIN. 2013. Rest site selection by fishers (*Martes pennanti*) in the eastern deciduous forest. *Wildl. Soc. Bull.*, **37**:805–814.
- GIULIANO, W. M., J. A. LITVAITIS, AND C. L. STEVENS. 1989. Prey Selection in Relation to Sexual Dimorphism of Fishers (*Martes pennanti*) in New Hampshire. *J. Mammal.*, **70**:639–641.
- GOLIGHTLY, R. T., T. F. PENLAND, W. J. ZIELINSKY, AND M. J. HIGLEY. 2006. Fisher diet in Klamath province. Unpublished report, Department of Wildlife, Humboldt State University, Arcata, California. 56 p.
- GROOM, M. J., G. K. MEFFE, AND C. R. CARROLL. 2006. Principles of conservation biology Sunderland. 3rd ed. Sinauer Associates, Sunderland, Massachusetts. 779 p.
- HARDISKY, T. S. 2001. Pennsylvania fisher reintroduction project [Internet]. Pennsylvania Game Commission. <http://www.pgc.state.pa.us/pgc/cwp/browse.asp?a=498&bc=0&c=70024> [under “programs” select “Pennsylvania Fisher Reintroduction Program”]
- HULSE, A. C., C. J. MCCOY, AND E. J. CENSKY. 2001. Amphibians and reptiles of Pennsylvania and the northeast. Cornell University Press, Ithaca, New York. 419 p.
- KELLERT, S. R. 1985. Public perceptions of predators, particularly the wolf and coyote. *Biol. Cons.*, **31**:167–189.
- KELLY, G. M. 1977. Fisher (*Martes pennanti*) biology in the White Mountain National Forest and adjacent areas. Ph.D. dissertation. University of Massachusetts, Amherst, MA. 178 p.
- KLYZA, C. M. 2001. An eastern turn for wilderness. *Wild Earth*, **11**:10–15.
- KROHN, W. 2012. Biology and conservation of Martens, sables, and fishers: a new synthesis. p. 58–73. *In*: K. B. Aubry, W. J. Zielinski, M. G. Raphael, G. Proulx, and S. W. Buskirk (eds). Cornell University Press, Ithaca, New York.
- LEWIS, J. C., R. A. POWELL, AND W. J. ZELINSKI. 2012. Carnivore translocations and conservation: insights from population models and field data for fishers (*Martes pennanti*). *PLoS One*, **7**:e32726.
- LORIMER, C. G. AND A. S. WHITE. 2003. Scale and frequency of natural disturbances in the northeastern United States: implications for early successional forest habitat and regional age distributions. *Forest Ecol. Manag.*, **185**:41–64.
- LOVALLO, M. J. 2008. Status and management of fisher *Martes pennanti* in Pennsylvania (2008–2017) [Internet]. Pennsylvania Game Commission. <http://www.pgc.state.pa.us/pgc/cwp/view.asp?a=498&Q=173960> [select “Draft Fisher Management Plan”].
- AND T. S. HARDISKY. 2012. Pennsylvania Game Commission Bureau of Wildlife Management Project Annual Job Report [Internet]. Pennsylvania Game Commission. <http://www.pgc.state.pa.us/pgc/cwp/view.asp?a=498&Q=173960>
- MARTIN, S. K. 1994. Feeding ecology of American Marten and fishers. p. 297–315. *In*: Martens, Sables, and Fishers. S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell (eds.) Comstock Publishing Associates, Ithaca, New York. 484 p.
- MAYER, W. V. 1952. The hair of California mammals with keys to the dorsal guard hairs of California mammals. *Am. Mid. Nat.*, **48**:480–512.
- MCWILLIAMS, W. H., S. P. CASSELL, C. L. ALERICH, B. J. BUTLER, M. L. HOPPUS, S. B. HORSLEY, A. J. LISTER, T. W. LISTER, R. S. MORIN, C. H. PERRY, J. A. WESTFALL, E. H. WHARTON, AND C. W. WOODALL. 2007. Pennsylvania’s forests. United States Department of Agriculture, Northern Research Station, Resource Bulletin NRS-20.
- MEE, A., B. A. RIDEOUT, J. A. HAMBER, J. N. TODD, G. AUSTIN, M. CLARK, AND M. P. WALLACE. 2007. Junk ingestion and nestling mortality in a reintroduced population of California condors *Gymnogyps californianus*. *Bird Conserv. Int.*, **17**:119–130.
- PENNSYLVANIA GAME COMMISSION. 2011. Current list of wild mammals in Pennsylvania [Internet]. <http://www.portal.state.pa.us/portal/server.pt?open=514&objID=825100&mode=2>

- PIANKA, E. R. 1973. The structure of lizard communities. *Annu. Rev. Ecol. Syst.*, **4**:53–74.
- POLIS, G. A. 1981. The evolution and dynamics of interspecific predation. *Annu. Rev. Ecol. Syst.*, **12**:225–251.
- , C. A. MYERS AND W. R. HESS. 1984. A survey of intraspecific predation within the class Mammalia. *Mammal Rev.*, **14**:187–198.
- POWELL, R. A. 1981. *Martes pennanti*. *Mamm. Species*, **156**:1–6.
- . 1993. The fisher: life history, ecology, and behaviour. 2nd ed. University of Minnesota Press, Minneapolis, Minnesota. 237 p.
- . 1994. Structure and spacing of *Martes* populations. p. 101–121. *In*: S. Buskirk, A. S. Harestad, M. G. Raphael, and R. Powell (eds). *Martens, sables, and fishers: biology and conservation*. Cornell University Press, Ithaca, New York.
- R CORE TEAM (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, <http://www.R-project.org/>
- RAINE, M. R. 1987. Winter food habits and foraging behaviour of fishers (*Martes pennanti*) and Martens (*Martes americana*) in southeastern Manitoba. *Can. J. Zool.*, **65**:745–747.
- ROBBINS, C. T. 1983. Wildlife feeding and nutrition. 2nd ed. Academic Press, New York, New York. 352 p.
- SEDDON, P. J., D. P. ARMSTRONG, AND R. F. MALONEY. 2007. Developing the science of reintroduction biology. *Conserv. Biol.*, **21**:303–312.
- SHANNON, C. E., 1948. A mathematical theory of communication. *Bell System Tech. J.*, **27**:379–423, 623–656.
- STAHLER, D. R., D. W. SMITH, AND D. S. GUERNSEY. 2006. Foraging and feeding ecology of the gray wolf (*Canis lupus*): lessons from Yellowstone National Park, Wyoming. *J. Nutrition*, **136**:1923S–1926S.
- WEIR, R. D., A. S. HARESTAD, AND R. C. WRIGHT. 2005. Winter diet of fishers in British Columbia. *Northwest Nat.*, **86**:12–19.
- WESLEY-HUNT, G. D. 2005. The morphological diversification of carnivores in North America. *Paleobiology*, **31**:35–55.
- WHERRY, E. T., J. M. FOGG, JR., AND H. A. WAHL. 1979. Atlas of the flora of Pennsylvania. The Morris Arboretum of the University of Pennsylvania, Philadelphia, Pennsylvania. 389 p.
- WILSON, A. M., R. MULVIHILL, AND D. BRAUNING. 2012. The 2nd Pennsylvania breeding bird atlas. The Penn State University Press, University Park, Pennsylvania. 612 p.
- ZIELINSKI, W. J., N. P. DUNCAN, E. C. FARMER, R. L. TRUEX, A. P. CLEVINGER, AND R. H. BARRETT. 1999. Diet of fishers (*Martes pennanti*) at the southernmost extent of their range. *J. Mammal.*, **80**:961–971.

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