THE FOOD HABITS OF FISHERS (*PEKANIA PENNANTI*) IN THE CASCADE RANGE OF SOUTHERN OREGON

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ABSTRACT—The Fisher (*Pekania pennanti*) is a mesocarnivore of conservation concern in the Pacific coastal region of North America with a diverse but poorly understood diet. From 1995 to 2001, we collected 297 scats from 11 radio-collared females and 83 scats from 8 radio-collared males, and used frequency of occurrence (percentage of scats containing a particular food item) to investigate their diets. Mammals were the most frequently occurring food item in the diets of both female and male Fishers (84.8 and 77.1 % of scats, respectively); however, the prevalence of small (≤166 g) mammalian prey was relatively low (<13% of female and <9% of male scats). Medium (191–579 g) and large (643–1710 g) mammalian prey were 6.6 and 2 times more prevalent, respectively, in the diet of females compared to males, and very large prey (≥2085 g) were almost 26 times more prevalent in the diet of males. Female Fishers are about 50% smaller than males and may be less effective than males at capturing very large prey. However, in the diet of females raising kits, leporids (large prey) and ground squirrels (medium prey) were 3 and almost 2 times more prevalent, respectively, than they were among females with no kits. Focusing on such prey would provide more metabolic energy per capture than mice, voles, and other small mammals, and require fewer hunting forays away from kits. Thus, our findings show that sexual dimorphism and female reproductive condition influence the diet of Fishers in the Cascade Range of southern Oregon. Studies that use molecular techniques to identify food items in scats that were collected with a rigorous sampling design that enables researchers to link Fisher diets with correlates of fitness are needed to determine the extent to which food habits influence Fisher population dynamics in this region.

Key words: Cascade Range, diet, Fisher, food habits, Oregon, *Pekania pennanti*, prey, scat analysis

Understanding the food habits of forest carnivores provides insights about their ecological linkages to prey populations and foraging habitat, and how changes in the availability and abundance of these resources may influence their population dynamics. For species at risk, knowledge of their food habits is critical for developing effective conservation and management strategies. The Fisher (*Pekania pennanti*) is a mesocarnivore of conservation concern in the Pacific coastal region of North America (British Columbia, Washington, Oregon, and California) that occupies low- to mid-elevation mixed conifer or conifer-hardwood forests with complex vertical structure (including large live trees and snags) and relatively dense canopies (Lofroth and others 2010; Raley and others 2012; Aubry and others 2013). The Fisher's geographic distribution has contracted substantially since European settlement, primarily as a result of overtrapping, predator control, and habitat loss through timber harvesting and other anthropogenic changes to low- and mid-elevation forests (Zielinski and others 1995; Aubry and Lewis 2003; Lofroth and others 2010; Lewis and others 2012). The Fisher is designated as a species of "special concern" in British Columbia (BC Conservation Data Centre 2015), "endangered" in Washington (WDFW 2013), "sensitive-critical" in the Coast Range, Klamath Mountains, and western Cascade Range in Oregon (ODFW 2019), and "threatened" in the southern Sierra Nevada in California (CDFW 2019). On federal lands managed by the US Forest Service and Bureau of Land Management in Washington and Oregon, the Fisher is designated as a "special status" species (ISSSSP 2019a, b); in California, it

is considered a "sensitive" species (USFS 2013; BLM 2014).

Most information on Fisher food habits is based on studies conducted in eastern North America (Powell 1979, 1981; Raine 1987; Arthur and others 1989; Giuliano and others 1989; Kuehn 1989; Martin 1994; Powell and others 1997; Van Why and Giuliano 2001; McNeil and others 2017) in forested ecoregions with vegetation communities and available prey that differ substantially from those in western North America (see Wiken and others 2011). Although some aspects of Fisher ecology have been well studied in the Pacific coastal region (for example, resting habitat; Raley and others 2012; Aubry and others 2013), few studies have been conducted on their diet. In British Columbia, Weir and others (2005) investigated the winter diet of Fishers by analyzing the stomach contents of 256 Fishers that had been harvested by fur trappers. In northwestern California, Grenfell and Fasenfest (1979) examined the stomach contents of 8 Fisher carcasses, and Golightly and others (2006) reported food items in 388 Fisher scats collected from 4 study areas. In the southern Sierra Nevada of California, Zielinski and others (1999) analyzed 201 scats to investigate the diet of Fishers and subsequently compared prey species and diet diversity of Fishers with a sympatric population of the Pacific Marten (*Martes caurina*; Zielinski and Duncan 2004). Analyses of scats or stomachs to investigate the diets of Fishers have not been conducted in Washington (but see Parsons and others 2020) or Oregon.

Fishers are sexually dimorphic, whereby males are typically 1.5 to 2.3 times heavier than females (Powell 1993; Lofroth and others 2010). They have been described as dietary generalists that forage opportunistically on a variety of food items (Zielinski and others 1999; Lofroth and others 2010). However, Snowshoe Hares (*Lepus americanus*) occurred more frequently in the winter diet of Fishers in British Columbia than any other prey species, suggesting that Fishers targeted this relatively large prey, and that predation on smaller animals was opportunistic (Weir and others 2005). Further, the smaller size of females appeared to influence Fisher foraging strategies, whereby females consumed relatively small prey (mice, voles, shrews, squirrels) more frequently than males (Weir and others 2005). In contrast, Fishers in California did not appear to target any one mammal over another. In California, Fishers consumed a broad array of food items that included a greater prevalence of reptiles and insects than in other regions in North America (Zielinski and others 1999; Golightly and others 2006). Although there were some minor seasonal differences in the occurrence of rodent and ungulate remains in the scats of females compared to males, the diet of Fishers did not appear to vary by sex in the southern Sierra Nevada (Zielinski and others 1999). Fishers are an effective predator of North American Porcupines (*Erethizon dorsatum*; Powell 1993), and this species was relatively common in their diets in British Columbia (Weir and others 2005) and other regions of North America (see Martin 1994). However, North American Porcupines have not been found in the diets of Fishers in California despite their occurrence in most of the areas where Fishers were studied (Grenfell and Fasenfest 1979; Golightly and others 2006). Thus, we lack a clear understanding of Fisher food habits in the Pacific coastal region, as no consistent patterns have emerged from previous investigations of their diet.

In this study, we analyzed scat contents to describe the food habits of Fishers in the Cascade Range of southern Oregon and identify patterns in their diet that may be biologically meaningful. Because Fishers are sexually dimorphic, females and males may target different prey species to meet their respective energetic needs. Published information on the food habits of female Fishers who are actively raising young is lacking; however, Powell and Leonard (1983) determined that the energetic requirements of females increase substantially when they are nursing and rearing kits. Thus, the diet of females that are actively raising kits (reproductive females) may differ from the diet of females that are not (non-reproductive females). Our objectives in this study were to: (1) compare the diet of female Fishers to that of male Fishers; (2) compare the diet of reproductive females to that of non-reproductive females; (3) determine if the diet of reproductive females varied with kit development; and (4) compare our findings with those from other Fisher food habits studies conducted in the Pacific coastal region.

Methods

Our study area was located primarily in the upper Rogue River drainage on the west slope of

the Cascade Range in northeast Jackson and southeast Douglas Counties, Oregon. However, some of our study animals made long-distance movements and used areas on the east side of the Cascade crest in Klamath County. Topography in our study area is mountainous with elevations ranging from 400 to 2892 m. Average annual temperatures across the elevational gradient in our study area vary from 8.2 to 11.2°C, and average annual precipitation ranges from 106.5 to 167.6 cm. During winter and early spring (December–March) precipitation generally falls as snow, with accumulations on the ground ranging from 4 cm at lower elevations to 73 cm at upper elevations. Our study area occurred primarily in the mixed-conifer vegetation zone (Franklin and Dyrness 1988) and contained varying amounts of Douglas-fir (*Pseudotsuga menziesii*), Grand Fir (*Abies grandis*), White Fir (*A. concolor*), Western Hemlock (*Tsuga heterophylla*), Incense Cedar (*Calocedrus decurrens*), Ponderosa Pine (*Pinus ponderosa*), Sugar Pine (*P. lambertiana*), Western White Pine (*P. monticola*), and Golden Chinquapin (*Chrysolepis chrysophylla*). California Red Fir (*A. magnifica*), Mountain Hemlock (*T. mertensiana*), Engelmann Spruce (*Picea engelmannii*), Lodgepole Pine (*P. contorta*), and Subalpine Fir (*A. lasiocarpa*) became more common at higher elevations. Most of our study area was located on federal lands, including the Rogue River-Siskiyou National Forest and the Medford District of the Bureau of Land Management and, to a lesser extent, Crater Lake National Park. The remainder was privately owned and managed primarily for timber production; other uses included agriculture and rural residential development.

From 1995 to 2001, we collected the scats of Fishers monitored during a radio-telemetry study designed to investigate their habitat relations in the Cascade Range of southern Oregon (Aubry and others 2013, 2018). We tracked study animals year-round and collected scats opportunistically at reproductive-den (hereafter, den), rest, and active sites (scats deposited at a kill site or along a travel route in the snow by the study animal being tracked). We also collected scats that were deposited by captured Fishers in live-traps or during immobilization and radio-collaring. We placed scats in labeled paper bags and air-dried them before storing the bags at room temperature in a dry location.

Our study was conducted prior to the development of standardized genetic methods to identify species, sex, or individual from scats (see McKelvey and others 2006; Ulizio and others 2006; Franklin and others 2019). To improve data quality, we used the same field crews throughout the duration of our study. Field crews were trained in ground-based very-high-frequency (VHF) telemetry methods for pinpointing the location of inactive and active study animals (Aubry and Raley 2006; see Thompson and others 2012), and in the identification of forest carnivore scats and tracks. Only scats identified as being from Fishers (based on size and morphology) were collected. However, we did not assign a Fisher scat to the study animal being tracked unless the age of the scat was consistent with our knowledge of how long that individual had been using the site. For example, because we monitored each study animal 2–3 times per week throughout the year, we typically knew whether an individual used a particular rest site for a short period of time ($\leq$1 d) or for several days or weeks. Consequently, we excluded scats from our analyses that were older than the time frame during which a study animal used a site or if, for any other reason, we could not reliably assign a scat to a specific study animal.

Scat analyses were conducted by a contractor (Neil Duncan, American Museum of Natural History, New York, NY) experienced in identifying food items in the scats of both Fishers and Pacific Martens (see Zielinski and others 1999; Zielinski and Duncan 2004). The methods used to prepare and analyze scat samples collected during this study were the same as those described by Zielinski and Duncan (2004). We provided the contractor with a list of mammal, bird, and reptile species occurring in our study area and the contractor used reference collections at the American Museum of Natural History to identify food items found in the scats. All food items found were identified to the lowest taxonomic level possible. We used whole feathered chicken carcasses to bait the livetraps but, because chicken feathers are distinctive, there was no confusion between bait and prey remains in the scats. When radio-tracking Fishers, we also recorded the species of prey remains (partially consumed carcasses, clumps of fur, feathers) found at den, rest, or active sites. We only collected prey remains if we could not

identify them to species in the field. We used the same methods to collect and store prey remains as we did for scats, and submitted them to the contractor for identification.

We used frequency of occurrence (percentage of scats containing a particular food item) to investigate the diets of Fishers in our study area, which is the same metric used in most other studies of Fisher food habits in the Pacific coastal region (Zielinski and others 1999; Zielinski and Duncan 2004; Golightly and others 2006). Because frequency of occurrence is derived from presence-absence data, it is considered a qualitative metric that is less informative than other metrics, such as determining the biomass of various food items consumed by a carnivore (Klare and others 2011). However, biomass calculations require additional information that is challenging to obtain, including the volume of different food items in scats and their relative digestibility (see Klare and others 2011). Feeding trials to estimate the digestibility of various food types have not been conducted for the Fisher. Moreover, estimating the proportional volume of food items in individual Fisher scats is problematic because some remains are virtually impossible to identify (such as the underfur of mammals), making it difficult to determine whether they represent multiple food items (Zielinski and Duncan 2004). Regardless, using frequency of occurrence as our metric enables us to compare our results with those of previous studies, and will improve our understanding of Fisher food habits in a region for which such information is sparse and conservation concerns are substantial.

To elucidate potential differences in the diets of female and male Fishers, we calculated the frequency of occurrence of food items in scats collected year-round. Because male Fishers in our study area were 2.1 times larger (5.9 kg) than females (2.8 kg; Aubry and others 2018), there may be differences in the sizes of prey consumed by each sex. Consequently, we also calculated the frequency of occurrence of mammalian prey (the most important prey category reported in previous studies; see Martin 1994; Lofroth and others 2010) in Fisher scats based on their body size. To estimate body size, we used generalized values of body weight (Smith and others 2003) for each species. For mammal remains in scats that could be identified only to order, family, or genus, we used the range of body weights for potential prey species in our study area that comprised the taxonomic group identified.

To compare the diet of reproductive females with that of non-reproductive females, we calculated the frequency of occurrence of food items found in female scats collected during the kit-rearing period (March to December). In our study area, reproductive females initiated denning in mid- to late March (parturition was assumed once a female used the same tree cavity for >2 d), and kits typically did not disperse from their natal areas until after December. During each year of our study, we determined whether the females being monitored were actively raising kits or not. An individual female monitored during multiple years may have raised kits one year but not in another; thus, she may have contributed diet information to both the reproductive and non-reproductive data sets. Also, within a given year, we may not have collected scats from a reproductive female throughout the entire kit-rearing period if, for example, she died before her kits were weaned. We collected the scats of reproductive and non-reproductive females at various sites used throughout the kit-rearing period including den (reproductive females only), rest, active, and trap sites. Based on size, the Fisher scats we collected at den sites during June and July (in the immediate vicinity of cavities in trees or logs used by a reproductive female until her kits are more mobile and able to kill their own prey) appeared to be from the adult females, but it is possible that some were from kits. However, because kits at this stage of development are consuming prey captured by their mothers, their scats would reflect the food habits of reproductive females.

To further investigate the diet of reproductive female Fishers, we compared the frequency of occurrence of food items in scats among 3 distinct kit-rearing phases: (1) March to May when females are nursing kits and hunting only for themselves; (2) June to July when kits have been weaned (at about 10 wk of age; Powell 1993) and females are provisioning them with solid food; and (3) August to December when kits are able to kill their own prey (starting around 4 mo of age; Coulter 1966; Powell 1993), but prior to dispersal.

Given the qualitative nature of frequency of occurrence data, and the lack of independence among food items in a scat (see Thomas and

TABLE 1. Summary by location of 380 scats collected at reproductive-den, rest, active, and trap sites for 11 female and 8 male Fishers in the Cascade Range of southern Oregon, 1995–2001.

Fisher ID	No. of scats				
	Den site	Rest site	Active site	Trap site	Total
REPRODUCTIVE FEMALES					
1	43	30	1	2	76
3			2	1	3
9	23	13	7	1	44
11	34			2	36
18	19	3		4	26
21	59				59
NON-REPRODUCTIVE FEMALES					
1		13			13
4		1	1	4	6
8		18		2	20
10				1	1
11		1	2		3
12		2		1	3
22		7			7
MALES					
2		22	4	2	28
5		7	2	3	12
6			2	2	4
7		6	5	6	17
13		3		1	4
14		7	1	4	12
15		5			5
23				1	1

Taylor 1990) and among scats (remains from a single prey item may appear in >1 scat), it was not appropriate to conduct statistical tests on these data (see Lemons and others 2010; Morin and others 2019). Further, including scats in an analysis more than once when they contain multiple food items violates the assumption of independent samples and represents pseudoreplication (see Hurlbert 1984; Lemons and others 2010; Morin and others 2019). Consequently, we considered frequency of occurrence values that differed by at least a factor of 2 to represent strong patterns in the diets of Fishers, and interpreted our results in the form of hypotheses that warrant future investigation. Because our sampling was opportunistic, we did not have adequate samples sizes to analyze data by individual Fisher or year. Thus, for all analyses, we pooled data across individuals and years and used IBM® SPSS® Statistics Version 24 to calculate frequency of occurrence and other data summaries.

RESULTS

We collected 380 Fisher scats in the Cascade Range of southern Oregon from 1995 through 2001: 297 (78%) scats from 11 females and 83 (22%) scats from 8 males (Table 1). Most scats collected from females (69%) and males (76%) contained both food and non-food items, such as conifer needles, grass, rock, plastic, and aluminum. Three scats (2 female, 1 male) containing only non-food items were excluded from data analyses and sample size totals. Fisher hair occurred in 7% of female and 12% of male scats and, in all cases, appeared to be from grooming (single hairs rather than clumps) and did not represent a food item.

Of the 674 food items found in 380 Fisher scats (Appendix 1), 98% (661 of 674) could be identified to class, 68% (461 of 674) to order, 62% (420 of 674) to family, and 43% (288 of 674) to genus; only 20% (132 of 674) of food items could be identified to species. Thus, to investigate the breadth of their diet, we first summarized the frequency of occurrence of food items in Fisher scats by class: mammals (Mammalia), birds (Aves), reptiles (Reptilia), insects (Insecta), and plants (Plantae). Because mammal remains were more prevalent in the scats of Fishers than other food items (see Appendix 1), and 85% (307 of 362) of mammal remains could be identified

TABLE 2. Frequency of occurrence (% of scats containing a particular food item) of food items by class and mammalian order in the year-round diets of 8 male and 11 female Fishers, and in the diets of 6 reproductive (actively raising kits)[a] and 7 non-reproductive (not raising kits)[a] female Fishers during the kit-rearing period (March–December); Cascade Range of southern Oregon, 1995–2001.

	Male scats	Female scats			Fisher scats
Food item	All (Jan–Dec) $n = 83$	All (Jan–Dec) $n = 297$	Reproductive (Mar–Dec) $n = 241$	Non-reproductive (Mar–Dec) $n = 48$	All (Jan–Dec) $n = 380$
CLASS					
Mammalia	77.1	84.8	88.8	66.7	83.2
Aves	25.3	27.6	27.4	29.2	27.1
Insecta	26.5	25.6	27.8	16.7	25.8
Reptilia	4.8	7.1	7.5	6.3	6.6
Plantae[b]	13.3	14.1	14.1	16.7	13.9
MAMMALIAN ORDER					
Lagomorpha[c]	8.4	27.3	31.5	10.4	23.2
Soricomorpha	1.2	6.4	6.6	4.2	5.3
Carnivora	9.6	<1	<1	2.1	2.6
Artiodactyla	7.2	9.1	7.5	10.4	8.7
Rodentia	32.5	41.1	43.6	33.3	39.2

[a] Two females monitored for ≥1 year were reproductive some years but not others and contributed scat samples to both data sets.
[b] Seeds and mast.
[c] All but 1 food item in a female scat were leporids (Leporidae; see Appendix 1).

to order, we summarized mammal food items by order: lagomorphs (Lagomorpha), insectivores (Soricomorpha), carnivores (Carnivora), ungulates (Artiodactyla), and rodents (Rodentia).We further summarized the occurrence of mammalian prey in scats according to 4 body-size categories based on natural breaks in our data: small (4–166 g), medium (191–579 g), large (643–1710 g), and very large (≥2085 g). Ungulates were not included in the summaries of mammalian prey by body size because, based on our field observations, Fishers typically fed on the carcasses of adult ungulates and did not actively hunt and kill them. Identification of mammal remains in scats to family, genus, or species was limited and uneven among orders (see Appendix 1). Consequently, information at these taxonomic levels were used to help interpret patterns in the mammalian portion of Fisher diets that were evident at higher taxonomic levels.

TABLE 3. Frequency of occurrence (% of scats containing a particular food item) of rodents in the year-round diets of 8 male and 11 female Fishers; Cascade Range of southern Oregon, 1995–2001.

Family	Male scats $n = 83$	Female scats $n = 297$
Cricetidae	10.8	2.0
Dipodidae		<1
Erethizontidae	8.4	
Geomyidae		<1
Sciuridae	9.6	34.7
Unknown rodent	4.8	4.0

The year-round diets of female and male Fishers appeared to be similar among taxonomic classes, but we found several differences among the mammals they consumed (Table 2). Insectivores occurred 5.3 times more frequently and lagomorphs 3.3 times more frequently in female scats compared to male scats (Table 2). The lagomorph remains identified in all but 1 female scat were leporids (Leporidae; a single scat contained American Pika [*Ochotona princeps*]; Appendix 1). Scat analyses could not distinguish between the hairs of the 2 leporids (Snowshoe Hares and Brush Rabbits [*Sylvilagus bachmani*]) that occurred in our study area. However, prey remains identified at den, rest, and active sites revealed that females preyed on both Snowshoe Hares and Brush Rabbits (Appendix 2). In contrast, carnivores, all of which were skunks (Mephitidae; see Appendix 1), were 13.7 times more prevalent in male scats compared to female scats. Although rodents occurred more frequently than any other order of mammals in the diets of both sexes, females appeared to focus on different rodents than males. Female Fishers primarily consumed squirrels (Sciuridae) which were 3.6 times more prevalent than in male scats (Table 3). However, mice and voles (Cricetidae) were 5.4 times more prevalent in male scats

TABLE 4. Body size of mammalian prey identified in Fisher scats in the Cascade Range of southern Oregon, 1995–2001. For mammals identified only to order, family, or genus, we used the range of body weights for species known to occur in our study area (potential prey species). However, mammals identified as Rodentia (unknown rodents) and Sciuridae (unknown squirrels) were not included because of the large number of potential species with varying body weights, and Cervidae (ungulates) were not included because Fishers typically fed on carcasses and did not capture and kill ungulates.

Body size and taxon identified	Potential prey species	Weight[a] (g)
SMALL		
Soricomorpha	*Sorex bendirii, S. pacificus, S. palustris, S. sonomae, S. trowbridgii, S. vagrans; Neurotrichus gibbsii; Scapanus latimanus, S. townsendii*	4–142
Sorex spp.	*S. bendirii, S. pacificus, S. palustris, S. sonomae, S. trowbridgii, S. vagrans*	4–16
Neurotrichus gibbsii		9
Myodes spp.	*Myodes californicus*	18
Microtus spp.	*Microtus longicaudus, M. montanus, M. oregoni, M. richardsoni, M. townsendii*	20–85
Peromyscus spp.	*P. maniculatus, P. truei*	21–27
Zapus spp.	*Z. princeps, Z. trinotatus*	28–29
Tamias spp.	*T. amoenus, T. minimus, T. siskiyou, T. townsendii*	51–135
Scapanus spp.	*S. latimanus, S. townsendii*	55–142
Thomomys spp.	*T. bottae, T. mazama*	75–115
Ochotona princeps		158
Glaucomys sabrinus		166
MEDIUM		
Callospermophilus lateralis		191
Callospermophilus, Otospermophilus, or *Urocitellus* spp.[b]	*C. lateralis, O. beecheyi, U. beldingi*	191–579
Tamiasciurus douglasii		225
Neotoma spp.	*N. cinerea, N. fuscipes*	230–299
Otospermophilus beecheyi		579
LARGE		
Leporidae[c]	*Lepus americanus, Sylvilagus bachmani*	643–1710
Sciurus griseus		731
Ondatra zibethicus		982
VERY LARGE		
Mephitidae[d]	*Mephitis mephitis*	2085
Erethizon dorsatum		7085

[a] From Smith and others (2003).
[b] Remains in scats were identified as *Spermophilus* which, subsequent to this analysis, was split into multiple genera, of which *Callospermophilus*, *Otospermophilus*, and *Urocitellus* occurred in our study area.
[c] 1 scat contained remains identified as Lagomorpha, but the only potential species occurring in the area occupied by that radio-collared Fisher were *L. americanus* and *S. bachmani*.
[d] Although *Spilogale gracilis* occurred in portions of our study area, prey remains identified at rest and active sites indicated that Fishers were killing and consuming *M. mephitis*.

compared to female scats, and North American Porcupines (Erethizontidae) were only found in male scats (Table 3).

Body size of mammalian prey appeared to influence the diets of female and male Fishers. A diversity of small mammals (≤166 g; see Table 4) were found in Fisher scats; however, their occurrence in the scats of both females and males was relatively sparse (12.8 and 8.4%, respectively; Fig. 1). Female scats contained primarily the remains of medium and large prey (23.6 and 28.6% of scats, respectively; Fig. 1). Medium prey included ground squirrels (*Callospermophilus*, *Otospermophilus*, and *Urocitellus* spp.), Douglas' Squirrels (*Tamiasciurus douglasii*), and woodrats (*Neotoma* spp.; Table 4). Large prey included leporids, Muskrats (*Ondatra zibethicus*), and a single occurrence of Western Gray Squirrel (*Sciurus griseus*; Table 4; see Appendix 1). Male scats contained primarily the remains of large (14.5% of scats) and very large prey (18.1% of scats; Striped Skunks [*Mephitis mephitis*] and North American Porcupine); very large prey occurred almost 26 times more often in male scats than in female scats (Fig. 1). Although we could only identify skunk remains in scats to family, field observations and prey remains found at rest and active sites indicated that

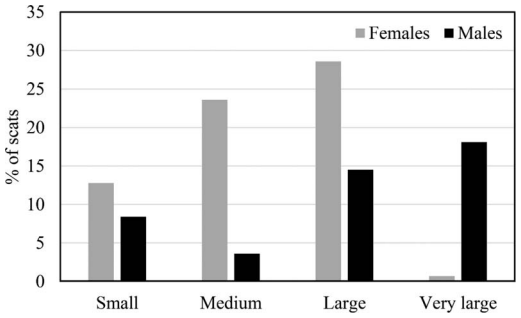

FIGURE 1. Frequency of occurrence (% of scats containing a particular food item) of small (4–166 g), medium (191–579 g), large (643–1710 g), and very large (≥2085 g) mammalian prey in the diets of female and male Fishers in the Cascade Range of southern Oregon, 1995–2001 (see Table 4).

males were consuming Striped Skunks (see Appendix 2).

Our results revealed several differences between the diets of reproductive and non-reproductive females. Lagomorphs (all leporids except for 1 American Pika) were 3 times more prevalent in the scats of reproductive females (Table 2). The occurrence of rodents in scats was only slightly greater for reproductive females compared to non-reproductive females (Table 2); however, ground squirrels (primarily California Ground Squirrels [*Otospermophilus beecheyi*]) were almost twice as prevalent in the scats of reproductive females as non-reproductive females (22 and 12.5% of scats, respectively).

The diet of reproductive females did not appear to vary among the 3 different phases of kit rearing (March–May: nursing kits; June–July: provisioning kits with solid food; and August–December: pre-dispersal). However, there were expected seasonal increases in the occurrence of insects (21, 30, and 42% of scats during phases 1–3, respectively), plant foods (3, 20, and 32% of scats), and ungulates (6, 5, and 18% of scats).

Discussion

In the Cascade Range of southern Oregon, Fishers consumed a variety of mammals, birds, insects, reptiles, and plant foods; however, mammals were the most frequently occurring food items in the scats of both females and males (84.8 and 77.1%, respectively; Table 2). This is consistent with the results of other food habits studies conducted on Fishers in California, where mammal remains occurred in >78% of Fisher scats analyzed (Zielinski and others 1999; Golightly and others 2006). Although results from scat analyses are not directly comparable to those obtained from analyses of stomach contents, the stomachs of Fishers collected during winter in British Columbia also contained primarily mammalian prey; <9% (19 of 215 of stomachs) contained non-mammalian food items (Weir and others 2005). In contrast, the frequency of occurrence of other taxa in Fisher scats collected during our study was lower than that observed elsewhere in the Pacific coastal region. Comparing our results for all scats examined (Table 2) to those obtained by Zielinski and others (1999) and Golightly and others (2006), the occurrence of reptiles in Fisher scats was 3.1 to 3.7 times greater in the California study areas than in our study area, the occurrence of insects was 2.1 to 2.2 times greater, the occurrence of plant foods was 1.5 to 2.4 times greater, and the occurrence of birds was 1 to 1.5 times greater. The importance of these taxa in the diet of Fishers is difficult to interpret, given that many are relatively small items and frequency of occurrence weighs the presence of small and large food items in scats equally, potentially overestimating the importance of smaller items (Zielinski 1986; Klare and others 2011). Regardless, non-mammalian taxa appeared to be more important in the diet of Fishers in California than in the Cascade Range of southern Oregon. Our study area was located in mixed-conifer forest, whereas California study areas were located in a broader array of vegetation types including mixed-conifer, conifer-hardwood, montane hardwood, and mixed chaparral (Zielinski and others 1999; Golightly and others 2006). Thus, the more frequent occurrence of non-mammalian taxa in the diet of Fishers in California may reflect regional differences in vegetation communities and available food resources.

The diets of female and male Fishers in the Cascade Range of southern Oregon differed and appeared to be influenced, in part, by the size of mammalian prey. Females appeared to focus primarily on medium and large prey, especially squirrels and leporids, respectively (Fig. 1). Males consumed medium prey infrequently and, although they often consumed large prey, very large prey (Striped Skunks and North American Porcupines) was the most prevalent size class in their diet. In contrast, very large prey were

virtually absent from the diet of females (Fig. 1). Although our sample of scats favored females over males 3.6 to 1, several lines of evidence show that males consumed the largest prey more frequently than females. Eight scats from 3 different males contained the remains of skunks, and we found skunk remains at 5 different rest sites associated with 4 different males. However, we only found skunk remains in 1 scat each from 2 different non-reproductive females, and no skunk remains at any of the den, rest, or active sites used by females. We identified North American Porcupine remains in 7 scats associated with a single male representing at least 3 different kills and, for another 3 males, we located the remains of a North American Porcupine that they had killed and consumed. Further, during 20 handling events associated with multiple captures of 8 males, we found the quills of North American Porcupines embedded in the skin of 5 different males. Altogether, 6 of the 8 males that we captured during our study had interactions with North American Porcupines. In contrast, we did not find North American Porcupine remains in female scats nor at any of the female den, rest, or active sites, and we found no embedded quills during 24 captures of 11 females. These differences may stem from the larger size of males and their greater energetic requirements or ability to subdue very large prey. These patterns could also reflect a kit-rearing strategy whereby females focus on medium and large prey, rather than very large prey, because they require less effort to locate, capture, and transport back to their dens, and are easier and safer for kits to consume.

Zielinski and others (1999) evaluated the annual and seasonal food habits of Fishers in the southern Sierra Nevada of California, but detected no strong differences between female and male diets. During winter in British Columbia, the stomach contents of trapped Fishers revealed that females consumed relatively small mammals (mice, voles, shrews, and squirrels) more than males, but there was no difference between the sexes in the proportions of other prey species consumed (including Snowshoe Hare, Muskrat, American Beaver [*Castor canadensis*], and North American Porcupine; Weir and others 2005). Weir and others (2005) speculated that these patterns reflected the smaller size of females compared to males, and perhaps the use of different habitats for foraging during winter by females and males. However, as suggested by our results, differences in food habits between female and male Fishers may be more evident when year-round diets are considered and body sizes (rather than taxonomic groupings) of mammalian prey are evaluated. Also, the degree of sexual dimorphism in our study animals (males were 2.1 times heavier than females; Aubry and others 2018) is at the high end of the size range reported for Fishers (1.5–2.3; Powell 1993; Weir and others 2005; Lofroth and others 2010); thus, differences in the diets of males and females may be more pronounced in our study area.

Most of the potential mammalian prey in our study area are small (primarily insectivores, mice, and voles; Table 4), widely distributed, and relatively common (Csuti and others 1997). However, the prevalence of small mammals in Fisher diets was relatively low: 1.8 times less than medium prey and 2.2 times less than large prey in the diet of females; and 1.7 times less than large prey and 2.2 times less than very large prey in the diet of males (Fig. 1). Because no other studies in the Pacific coastal region evaluated the mammalian component of Fisher diets according to body size, direct comparisons are limited; however, based on taxonomic categories, the low occurrence of insectivores (5.3% of scats) and mice and voles (3.9% of scats) in the diet of Fishers in our study area contrasts with findings elsewhere in this region. Compared to our results, the occurrence of insectivores was 0.8 to 3.9 times greater in Fisher scats in the California study areas and the occurrence of mice and voles was 5.2 to 5.7 times greater (Insectivora and Cricetidae in Table 3, Zielinski and others 1999; Insectivora and Muridae in Table 2, Golightly and others 2006). These differences may reflect regional differences in vegetation types and prey availability; however, we speculate that regional differences in the size of Fishers may also influence their food habits. Fishers have larger body sizes at more northern latitudes (Lofroth and others 2010), and our study animals were descendants of Fishers reintroduced from British Columbia and Minnesota to the Cascade Range of southern Oregon between 1977 and 1981 (Aubry and Lewis 2003). Our females were about 1.4 times larger than female Fishers in the California study areas and our males were 1.6 times larger (Truex and others 1998; Lofroth and others 2010). Thus, our study animals may have focused on larger prey

than Fishers in California to meet their greater energetic needs.

Variation in the food habits of female Fishers according to their reproductive condition (actively raising kits or not) has not been studied previously anywhere in North America. Leporids appeared to be of particular importance to reproductive females in our study area; they were 3 times more prevalent in their diet compared to non-reproductive females (Table 2). Ground squirrels (primarily California Ground Squirrels) may also be an important food resource for reproductive females in our study area, occurring almost twice as frequently in their diet compared to non-reproductive females. Powell and Leonard (1983) estimated that the energy expenditure of a reproductive female with 7-wk old kits was 2.3 times that of a non-reproductive female (2270 kJ d^{-1} vs. 970 kJ d^{-1} based on an average female weight of 2.64 kg) and would almost triple by the time kits were weaned at 10 wk (2500–2900 kJ d^{-1}). To meet those energetic needs, a reproductive female would need to consume about 1 Snowshoe Hare every other day, 1.2 to 1.4 squirrels per day, or 18.3 to 21.7 mice per day (see Powell 1981). Although these estimates may not be broadly applicable throughout the Pacific coastal region, they provide insights about the potential energetic needs of reproductive females in our study area, whose average weight (2.8 kg) was similar to that reported by Powell and Leonard (1983; 2.64 kg). In the Cascade Range of southern Oregon, leporids (Snowshoe Hares [1710 g]; Brush Rabbits [643 g]) and California Ground Squirrels (579 g) would provide female Fishers with far more metabolic energy per capture than small (and most of the medium) mammalian prey available in our study area (see Table 4). Thus, it may be beneficial for reproductive females to target leporids and ground squirrels to maximize their energy intake by reducing the number of hunting forays needed, and minimizing the amount of time spent away from their kits.

The diet of reproductive female Fishers appeared to be similar whether they were nursing kits, capturing prey for both themselves and their kits, or hunting primarily for themselves once kits were able to kill their own prey. Although we did not find any strong differences among these kit-rearing phases, it is possible that the data we collected were insufficient to detect such fine-scale patterns in the diet of reproductive females. The dates we used to distinguish the 3 phases matched the general timing of events in our study area; however, it may have taken some females longer to completely wean their kits, or there may have been longer transition times between when females were provisioning their kits with solid food and when the kits were able to regularly capture and kill their own prey. Thus, larger samples of scats collected during the peak of each phase (to avoid transition periods), as well as data on correlates of fitness (for example, female survival and survival rate of kits), will likely be required to determine whether the developmental stage of kits influences the diet of reproductive female Fishers.

Based on our findings, we hypothesize that several factors influence the food habits of Fishers in the Cascade Range of southern Oregon, including sexual dimorphism and the reproductive condition of females. We also speculate that regional differences in the diets of Fishers may reflect differences in vegetation communities and available food resources, as well as differences in the size of Fishers in northern (larger body size) and southern (smaller body size) latitudes. The survival of both females and their offspring are essential for the recovery and expansion of extant Fisher populations in the Pacific coastal region (Lofroth and others 2010; Matthews and others 2013; Sweitzer and others 2015). Thus, to provide the greatest benefits to Fishers in this region, we suggest that management and conservation efforts recognize the dietary needs of reproductive females when assessing potential prey populations and foraging habitat. However, significant information gaps remain in our understanding of Fisher food habits in this region, and additional research is needed to determine if the dietary patterns we identified occur in other Fisher populations. Given the challenges of traditional scat analysis to assess the diet of Fishers, it will be important to design future studies that test specific hypotheses, derive more quantitative diet metrics (such as biomass of food items), and employ novel analytical methods that can account for inherent biases in scat data, including the lack of independence among food items and among scats (see Morin and others 2019). Additionally, the use of new molecular methods to identify food items in scats, such as DNA metabarcoding (Taberlet and others 2012; De Barba and others 2014), will provide a more comprehensive profile of Fisher diets than

traditional mechanical-sorting methods. Regardless, studies that link the diet of Fishers with correlates of fitness will be necessary to determine how food habits may influence Fisher population dynamics in this region.

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APPENDIX 1. Food items identified in the scats of male and female Fishers collected at reproductive-den (females only), rest, active, and trap sites in the Cascade Range of southern Oregon, 1995–2001.

	Male scats $n = 83$		Female scats $n = 297$	
Food item	No.	%	No.	%
Mammalia[a]				
Lagomorpha				
Leporidae	7[b]	8.4	80	26.9
Ochotonidae				
Ochotona princeps			1	<1
Soricomorpha	1	1.2	3	1.0
Soricidae				
Sorex spp.			3	1.0
Talpidae				
Neurotrichus gibbsii			8	2.7
Scapanus spp.			5	1.7
Carnivora				
Mephitidae	8	9.6	2	<1

Appendix 1. Continued.

Food item	Male scats $n = 83$		Female scats $n = 297$	
	No.	%	No.	%
Artiodactyla				
Cervidae	6	7.2	27	9.1
Rodentia	4	4.8	12	4.0
Cricetidae				
Microtus spp.	2	2.4		
Myodes spp.			1	<1
Neotoma spp.			1	<1
Ondatra zibethicus	5	6.0	4	1.3
Peromyscus spp.	2	2.4		
Dipodidae				
Zapus princeps			1	<1
Erethizontidae				
Erethizon dorsatum	7	8.4		
Geomyidae				
Thomomys spp.			2	<1
Sciuridae	3	3.6	21	7.1
Callospermophilus, *Otospermophilus*, or *Urocitellus* spp.[c]	1	1.2	8	2.7
Callospermophilus lateralis	1	1.2	9	3.0
Otospermophilus beecheyi			43	14.5
Glaucomys sabrinus	1	1.2	6	2.0
Sciurus griseus			1	<1
Tamias spp.	1	1.2	10	3.4
Tamiasciurus douglasii	1	1.2	9	3.0
Unknown mammal	20	24.1	35	11.8
Aves[d]				
Piciformes				
Picidae				
Colaptes auratus			1	<1
Passeriformes				
Corvidae				
Cyanocitta stelleri			4	1.3
Unknown bird	21	25.3	77	25.9
Reptilia[e]				
Squamata	1	1.2	2	<1
Colubridae or Viperidae	1	1.2	7	2.4
Anguidae				
Elgaria spp.	1	1.2	2	<1
Unknown reptile	1	1.2	10	3.4
Diplopoda[e]	1	1.2	2	<1
Insecta[e]				
Coleoptera	2	2.4	15	5.1
Silphidae	1	1.2	1	<1
Hymenoptera				
Formicidae			8	2.7
Camponotus spp.			18	6.1
Vespidae	13	15.7	25	8.4
Lepidoptera				
Tortricidae	5	6.0	17	5.7
Unknown insect	2	2.4	8	2.7
Plantae[e]				
Rubus ursinus	7	8.4	23	7.7
Unknown plant mast			11	3.7
Unknown seed	4	4.8	8	2.7
Eggshell (Aves or Reptilia)	4	4.8	9	3.0

[a] Taxonomy from Bradley and others (2014).
[b] 1 scat contained remains identified as Lagomorpha, but the only potential species occurring in the area occupied by that radio-collared Fisher were leporids.
[c] Subsequent to this analysis, multiple genera were split out of *Spermophilus*, of which *Callospermophilus*, *Otospermophilus*, and *Urocitellus* occurred in our study area.
[d] Taxonomy from Chesser and others (2019).
[e] Taxonomy from ITIS (2020).

APPENDIX 2. Prey remains identified at reproductive-den, rest, or active sites used by male and female Fishers in the Cascade Range of southern Oregon, 1995–2001.

Prey	No. of prey identified: Male sites	Female sites
Mammalia[a]		
Didelphimorphia		
Didelphidae		
Didelphis virginiana	1	
Lagomorpha		
Leporidae	4	10
Lepus americanus		3
Sylvilagus bachmani		5
Carnivora	1	
Felidae		
Lynx rufus	1	
Mephitidae	1	
Mephitis mephitis	4	
Artiodactyla		
Cervidae		1
Cervus elaphus	2	
Odocoileus hemionus	1	2
Rodentia		
Cricetidae		
Myodes californicus		1
Erethizontidae		
Erethizon dorsatum	3	
Sciuridae		1
Glaucomys sabrinus		5
Otospermophilus beecheyi		4
Sciurus griseus		1
Tamiasciurus douglasii		3
Unknown mammal	1	2
Aves[b]		
Anseriformes		
Anatidae		2
Galliformes		
Odontophoridae		
Oreortyx pictus	1	
Phasianidae: subfamily Tetraoninae	1	1
Bonasa umbellus		1
Dendragapus obscurus		2
Phasianidae: subfamily Meleagridinae		
Meleagris gallopavo		1
Strigiformes		
Strigidae		1
Megascops kennicottii	1	1
Piciformes		
Picidae		
Dryobates villosus		4
Colaptes auratus		2
Dryocopus pileatus		1
Passeriformes		
Corvidae		
Cyanocitta stelleri	1	5
Reptilia[c]		
Squamata		
Colubridae		
Thamnophis spp.		1
Eggshell (Aves or Reptilia)		1

[a] Taxonomy from Bradley and others (2014).
[b] Taxonomy from Chesser and others (2019).
[c] Taxonomy from ITIS (2020).