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DIET COMPOSITON OF FISHERS (*PEKANIA PENNANTI*) REINTRODUCED ON THE OLYMPIC PENINSULA, WASHINGTON

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ABSTRACT—Knowledge of diet composition can inform management strategies and efforts to recover endangered carnivore populations in vacant portions of their historic ranges. One such species, the Fisher (*Pekania pennanti*), was extirpated in Washington State prior to any formal documentation of its food habits in the coastal coniferous forests of western Washington. Fisher recovery efforts in Washington, based on translocating Fishers from extant populations, have been ongoing since 2008, beginning with the release of 90 Fishers on Washington's Olympic Peninsula from 2008 to 2010. We collected fecal samples or digestive tracts from 13 Fishers opportunistically on the Olympic Peninsula from 2009 through 2013. Subsequently, we identified the species composition of each sample's contents to determine the primary foods consumed by the reintroduced Fishers. Fisher diets were diverse and dominated by mammalian prey. Contents of feces and digestive tracts of Fishers were composed primarily of Snowshoe Hare (*Lepus americanus*) remains, followed by lesser proportions of Mountain Beavers (*Aplodontia rufa*), Northern Flying Squirrels (*Glaucomys sabrinus*), Douglas Squirrels (*Tamiasciurus douglasii*), Southern Red-backed Voles (*Myodes gapperi*), shrews (*Sorex* spp.), and unidentified ungulate species. The diet of Fishers comprised species that occur across a wide range of land uses and management prescriptions, including previously logged forests and mature forests that have been set aside for retention of old-growth forest characteristics. Additional study of prey abundance and Fisher foraging behaviors related to structural habitat characteristics across a gradient of land uses would provide useful insights for enhancing the effectiveness of conservation efforts to benefit Fishers in Pacific Northwest coastal forests.

Key words: diet, Fisher, foods, Olympic National Park, *Pekania pennanti*, prey, Washington

Fishers (*Pekania pennanti*) originally ranged over boreal and temperate forests throughout most of northern North America. Fishers were extirpated from over half of their historical range during the mid to late 1900's, including all of Washington State, as a result of overharvest, predator control, and habitat loss and fragmentation (Powell and Zielinski 1994; Lewis and

Zielinski 1996; Lewis and others 2012). But with increased conservation effort, coupled with a growing understanding of the Fisher's ecological niche, habitat needs, and vulnerabilities to threats, populations have recovered in significant portions of their historical range, including much of the upper Midwest and eastern North America (Lewis and others 2012). The Fisher remains rare in many portions of its former West Coast range, including the US Pacific Northwest, and is listed as a State Endangered species in Washington State.

Improved understanding of Fisher food habits will help define conservation strategies for reestablishing populations in the coastal Pacific Northwest. Fishers depend widely on structures found in mature forests, notably large live and standing dead trees, dense forest canopies, and downed logs for reproduction, resting, and security (Lofroth and others 2010; Raley and others 2012). Consequently, in planning Fisher recovery actions in Washington, the most promising reintroduction areas were identified based largely on the location, extent, and connectivity among patches of mid-to-late-seral coniferous forest habitats (Lewis and Hayes 2004). Although previous research documents the critical importance of mature forest structures for denning, security, and perhaps thermal advantages (Lofroth and others 2010; Raley and others 2012), dietary needs of Fishers are poorly understood by comparison (Raley and others 2012).

Throughout their range, Fishers are dietary generalists consuming a variety of small and mid-sized mammals and birds in addition to other foods such as arthropods, reptiles, and plants (Powell and Zielinski 1994; Lofroth and others 2010). Most of the available information on Fisher diets comes from investigations conducted in eastern North America (Raine 1987; Arthur and others 1989; Giuliano and others 1989; Powell and others 1997; Van Why and Giuliano 2001; McNeil and others 2017). A limited number of studies conducted from northwestern California to western Canada reveal that Fishers commonly prey on a variety of mammals, including a high frequency of Snowshoe Hares (*Lepus americanus*), squirrels (Sciuridae), American Beavers (*Castor canadensis*), woodrats (*Neotoma* spp.), and smaller mammals, depending on species' availabilities within the individual study areas (Weir and others 2005; Golightly and others 2006; Parsons and others 2020; Raley and Aubry 2020). In southwestern Oregon, male Fishers consumed larger prey species such as Striped Skunks (*Mephitis mephitis*) and Porcupines (*Erethizon dorsatum*) than did females, and reproductive females consumed larger prey (e.g., Snowshoe Hares) than non-reproductive females during the kit-rearing season (Raley and Aubry 2020). In central British Columbia, males specialized in preying upon Snowshoe Hares whereas by comparison, female Fishers consumed smaller mammal species (Weir and others 2005).

Knowledge of Fisher diets remains particularly scant in the coastal coniferous forest regions of the US Pacific Northwest. Fishers were extirpated from coastal areas in western Washington and Oregon before their food habits and natural history could be formally studied and recorded, and the species has only recently been reintroduced in the region (Parsons and others 2019; Happe and others 2020). Accounts of early trappers (reported by Scheffer 1995), however, reported that Mountain Beavers (*Aplodontia rufa*), squirrels (family Sciuridae), rabbits (presumed to be Snowshoe Hares [*Lepus americanus*]), grouse (family Phasianidae), huckleberries (*Vaccinium* spp.) and Salal berries (*Gaultheria shallon*) were possible food items on Washington's Olympic Peninsula. A recent study of reintroduced Fishers in the central Cascade Range of Washington reported major taxonomic groupings of prey consumed by Fishers based on isotopic signatures found in hair samples collected from 20 Fishers, but individual species composing the diets were not distinguishable (Parsons and others 2020).

From 2008 to 2010, the National Park Service and Washington Department of Fish and Wildlife translocated 90 Fishers from central British Columbia and released them in Olympic National Park, which preserves the greatest contiguous extent of low-elevation mature coniferous forests remaining in western Washington. Subsequently, 170 Fishers were also translocated from both British Columbia and Alberta to the Cascade Range in Washington in 2015–2020 (Parsons and others 2019). Telemetry monitoring of Fisher movements and follow-up camera surveys revealed that Fishers released in both the Olympic Peninsula and Cascade Range occupied habitats across a variety of land uses and forest ages, particularly near the boundary between lands managed for timber production and those managed for retention of mature forest characteristics (Lewis and others 2016; Parsons and others 2019; Happe and others 2020). Studies from the Cascade Range also reported that Fisher occupancy patterns were associated with intermediate densities of Snowshoe Hares and proximity to recently disturbed sites (Parsons and others 2019). On the Olympic Peninsula, we hypothesized that alignment of Fisher distribution near disturbed sites might also reflect availability of potential prey species, although diet composition of Fishers and prey availability had not been reported. Additional and more refined estimates of Fisher food habits in the coastal Pacific Northwest would help to define foraging habitat requirements and increase the understanding of Fisher spatial use patterns in the region.

As part of the effort to restore Fishers to Washington, we collected fecal samples and carcasses of Fishers following their reintroduction on the Olympic Peninsula to expand understanding of Fisher diet composition in this understudied portion of the species' range. Here, we provide information that complements a recent study of Fisher diets in Washington's Cascade Range (Parsons and others 2020), by providing a more complete taxonomic listing of individual prey species consumed by Fishers in western Washington. Although the samples collected on the Olympic Peninsula were from a limited sample of predominantly female Fishers during the breeding season, they represent the first definitive information on the species composition of Fisher diets in the coastal coniferous forests of western Washington, Oregon, or British Columbia.

METHODS

The Olympic Peninsula is in the northwest corner of the contiguous United States in Washington State (Fig. 1). Elevations range from sea level to 2427 m atop Mt Olympus near the center of the Peninsula and approximately 50 km from the Pacific Ocean. Less than 200,000 people reside on the Peninsula (https://www.census.gov/quickfacts/fact/table/WA/PST045218; accessed 17 March 2020), with residential and commercial development concentrated primarily along the northern and eastern edges of the Peninsula and the Chehalis Valley to the south (Fig. 1). Seventy-two percent of the 9324-km^2 peninsula is publicly owned and managed primarily in Olympic National Park and the Olympic National Forest (Fig. 1). Old-growth forest habitats are protected in their entirety in Olympic National Park, whereas approximately 14% of the Olympic National Forest is protected as designated wilderness and an additional 65% is managed as a late-successional reserve under the Northwest Forest Plan (Moeur and others 2005). Most of the remaining public lands are managed by the State of Washington (1502 km^2, Washington Department of Natural Resources) for multiple uses, principal among which is timber production. Most of the remaining private and tribal lands are managed for timber production.

The Olympic Peninsula has a maritime climate, characterized by relatively dry, warm summers and wet, cool winters. There is a pronounced precipitation gradient across the Peninsula. From 200 to 600 cm of precipitation falls annually on the western and southern Peninsula where moist Pacific storms intercept the Olympic Mountains and deliver the greatest rainfall. In the Peninsula's northeastern corner, in the mountain's rain shadow, <40 cm of precipitation falls (Gavin and Brubaker 2015). Most precipitation occurs from October through March, falling primarily as rain at elevations <300 m, and as snow at elevations >800 m. In higher elevations, snowfields often persist into early July.

A variety of forest associations reflect the joint expression of landform, elevation, temperature, and precipitation gradients across the Peninsula (Henderson and others 1989). Hardwood forests of primarily Red Alder (*Alnus rubra*) and Bigleaf Maple (*Acer macrophyllum*) dominate early-seral floodplains and colluvial deposits along the major river systems (Van Pelt and others 2006). Sitka Spruce (*Picea sitchensis*) and Western Redcedar (*Thuja plicata*) forests prevail at low elevations on the western coast and on glacial and alluvial terraces of the west-flowing rivers (Franklin and Dyrness 1988). Western Hemlock (*Tsuga heterophylla*) and Douglas-fir (*Pseudotsuga menziessi*) dominate low-to-mid-elevation forests (approximately <1000 m). These forests transition to forests with a greater prevalence of Pacific Silver Fir (*Abies amabilis*) at mid elevations (approximately 900 to 1200 m), and Mountain Hemlock (*Tsuga mertensiana*) and

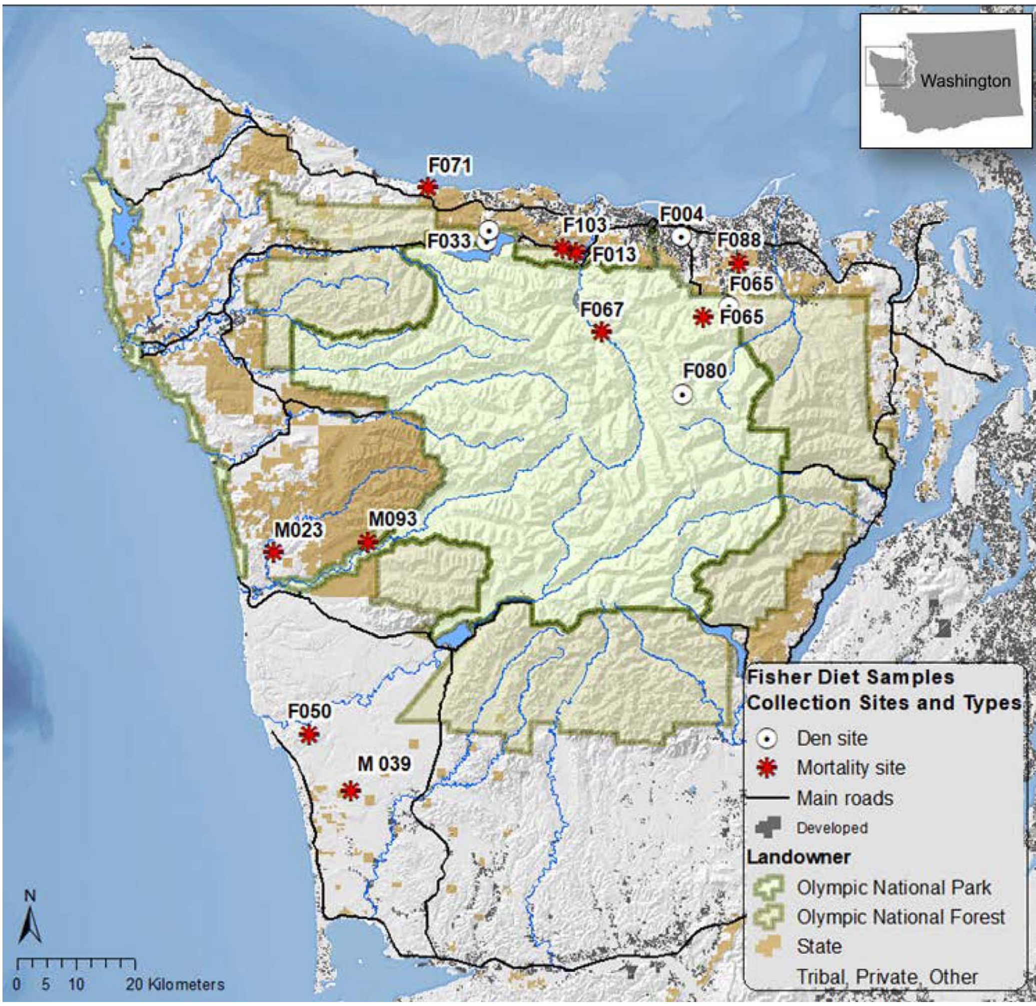

FIGURE 1. Locations of Fisher den and mortality sites where feces and carcasses of Fishers were collected, respectively, and land ownership and development patterns on the Olympic Peninsula, 2009 to 2013.

Subalpine Fir (*Abies lasiocarpa*) at higher elevations (>1200 m; Henderson and others 1989).The unique coniferous rainforest community, found primarily along the Pacific coast and up the west-side river drainages is renowned for its large trees, prolific understory, and epiphyte development in the tree canopies (Franklin and Dyrness 1988)

We identified the contents of Fisher fecal samples and digestive tracts collected on the Olympic Peninsula from 2009 to 2013. We collected feces by radio-tracking female Fishers to reproductive dens where they gave birth and reared their young during late spring and early summer. Upon locating these reproductive dens, which were primarily cavities in large trees but occasionally in ground burrows, we searched the area around the den tree or burrow, collected all feces detected, stored them in individual plastic bags, and froze them until they could be analyzed. To minimize disturbance, we searched den sites for fecal samples after determining that the female was away from the den (based on radio-telemetry tracking). We also collected digestive tracts of radio-collared Fishers that died during the study as determined through radio telemetry tracking or reported by the public. We submitted carcasses to Colorado State University for necropsy, while also requesting the return of digestive tracts for subsequent diet analysis.

In 2010, we conducted a preliminary analysis of Fisher diets by examining feces collected from female F033's den site in 2009 following methods outlined by Golightly and others (2006). Individual feces were placed in nylon stockings, soaked overnight in a dilute bleach solution, and washed and rinsed in a clothes-washing machine. Washed contents were dried and sorted into major categories (bone, teeth, claws, feathers, plant material, and so forth). Mammalian remains were identified using the reference collection of mammal specimens maintained for examining Northern Spotted Owl diets at the US Forest Service Pacific Northwest Research Station Forestry Sciences Laboratory in Corvallis, Oregon. The laboratory was not equipped to determine mammalian species by fur characteristics, so all fur was identified as mammal with no finer distinction made. Although we sorted remains from birds, reptiles, insects, and vegetation, we made no attempt to distinguish these groups at any finer taxonomic level except for the occasional bird remains that were complete enough to identify from feathers. The relative abundances of all identifiable taxa were reported as the percentage of total fecal mass.

In 2017, we analyzed a larger sample of feces collected from reproductive dens of 3 females from 2010–2011. Feces were frozen at –80°C for 2 wk to kill potential parasites (Hildreth and others 2004), placed in fine-mesh nylon bags, soaked in a tub of water for 4 h, rinsed until the water ran clear, and air-dried on flat trays. Contents were then sorted into piles (hair, bones, feathers, plant material, and so forth). As with the prior pilot sample, we identified mammalian remains to the species or genus level, but we did not attempt to identify species of birds, reptiles, amphibians, or arthropods. Hair and other remains of mammals (mainly teeth and claws) were identified separately and used to cross-check findings to ensure the correct prey species was identified. Fecal contents were compared to a reference collection of mammals in the Prugh lab at the University of Washington, which included skins, skulls, and microscope slides of individual hair samples of all mammals that occur on the Olympic Peninsula. Species not already in the reference collection were obtained on loan from the Burke Museum of Natural History and Culture in Seattle, Washington. A reference guide that included keys to medulla and cuticle patterns of mammalian hairs was also used to identify mammalian remains (Moore and others 1974). Hair medulla patterns were identified by mounting hairs on a microscope slide and observing them directly. Cuticle scale patterns were examined by pressing hairs into clear nail polish painted on a microscope slide and removing the hair after the nail polish had dried, leaving an impression of the cuticle pattern (De Marinis and Agnelli 1993). Slides were examined under a microscope, where the medulla and cuticular scale patterns were identified using the reference collection and guidebook (Moore and others 1974). Once the contents were identified, the volume of each diet item was visually estimated and expressed as a percentage of the total volume. The bottom of the dissection trays had equidistant vertical lines, which created a grid to assist with volume estimation. We estimated volumes of each species' remains, rather than mass as we did previously for the pilot sample, because it was nearly impossible to sort hairs of different species as needed to determine masses, whereas it was possible to estimate relative volumes without sorting hairs. All estimation of volumes was conducted by one of the authors (SAP) to minimize interobserver variability in estimation.

Foods consumed by Fishers were also determined by examining the contents of digestive tracts retrieved from carcasses. Contents were either from stomachs, from undifferentiated portions of the digestive tract (primarily intestines), or feces recovered from the large intestine. After defrosting the frozen samples, contents were extracted, placed into fine mesh bags, rinsed under running water, and air-dried on flat trays. Once the contents were dry, hair and bone samples were identified, and volumes estimated using the same procedures as in the 2017 analyses.

We estimated diet composition using two metrics: the relative volume or mass of diet components in the samples, and percent frequency of occurrence of diet components present among all the fecal samples or digestive tracts examined. We computed the average volume or mass of diet components found in samples collected from individual Fishers, and then computed means among the individuals. We computed frequency of occurrence based on the combined sample of all the feces or digestive

TABLE 1. Carcasses and fecal samples collected from 13 Fishers for the determination of diet composition on the Olympic Peninsula WA, 2009–2013.

Fisher ID	Sex	Months in Washington	Collection date (s)	Number of subsamples	Sample type(s)	Cause of mortality
M023	Male	>12	17 Dec 2013	1	Carcass: GI tract[4]	Vehicle strike
M039	Male	>12	7 Jun 2011	2	Carcass: stomach, GI tract[4]	Vehicle strike
M093	Male	>12	24 May 2011	1	Carcass: stomach	Predation
F013	Female	>12	28 Dec 2009	2	Carcass: stomach, GI tract[4]	Vehicle strike
F050	Female	>12	23 Mar 2010	2	Carcass: stomach, GI tract[4]	Trapping injury
F067	Female	4.5	6 May 2010	3	Carcass: stomach, intestines, feces	Drowning
F071	Female	4	8 Apr 2010	1	Carcass: GI tract[4]	Vehicle strike
F065[1]	Female	>12	18 May 2011	1	Carcass: intestines	Predation
F088[1]	Female	4	8 Jun 2010	1	Carcass: GI tract[4]	Predation
F103[1]	Female	n/a[3]	21 May 2013	3	Carcass: stomach, intestines, feces	Vehicle strike
F004	Female	>12	2–24 Jun 2010	19	Den site: feces	
F080	Female	6	22 Jul–5 Aug 2010	25	Den site: feces	
F065	Female	>12	11–29 Apr 2011	48	Den site: feces	
F033[2]	Female	6	18 Jun–6 Aug 2009	20	Den site: feces	

[1] Female was denning and had dependent kits at the time of death
[2] Samples were collected from and pooled among 3 reproductive dens
[3] F103 was born on the Olympic Peninsula, WA (daughter of F004)
[4] Unspecified portion(s) of the gastrointestinal tract

tracts collected during the study. Because contents of stomachs, intestines, and feces obtained from a single carcass generally contained different constituents, we considered these independent samples in computing frequency of occurrence.

Results

We obtained diet information from 13 Fishers (Fig. 1, Table 1). We examined digestive tract contents from 10 carcasses recovered from 2009 to 2013 (3 males and 7 females) and 112 feces from den-sites of 4 females from 2009 to 2011. Both feces and digestive tracts were obtained from F065 (Fig. 1, Table 1). The 13 Fishers included 12 that were translocated from British Columbia to Washington from 2008 to 2010 and 1 offspring of a translocated Fisher that was born in Washington (female F103; Table 1; Happe and others 2014). Samples from the 12 translocated Fishers were collected from 4 to >12 mon after their release. The number of feces collected for each denning female ranged from 19 to 48. Samples from the dens of 3 females (Fishers F004, F033, F080) may have included feces from both the female and her offspring. Samples collected from F033 were collected from 3 dens used sequentially.

Remains of mammals dominated the contents of digestive tracts and feces of Fishers collected on the Olympic Peninsula (Table 2). Mammal remains were found in 93% of all digestive tract and fecal samples from Fishers on the Peninsula, averaging 80% (range 24–80%) of the volume or mass of samples collected from individual Fishers. We identified remains of 9 genera or species of mammals in the samples, as well as undifferentiated ungulate remains (Table 2). The dominant mammal species was Snowshoe Hare, found in 40% of samples and comprising an average 40% of sample contents by volume or mass (range 0–99%). Mountain Beavers were the second most prevalent prey item, found in 30% of samples, averaging 14% of fecal or digestive tract contents, and reaching a high of 78% of fecal contents recovered from 1 denning female. Other small mammals commonly detected included Northern Flying Squirrels (*Glaucomys sabrinus*), Douglas Squirrels (*Tamiasciurus douglasii*), Southern Red-backed Voles (*Myodes gapperi*), and shrews (*Sorex* spp.), with identifiable volumes or mass for these taxa ranging from approximately 3 to 8% (Table 2). Undifferentiated hairs of ungulates were found in 30% of all samples but comprised on average about 3% of sample volumes.

TABLE 2. Mean composition (percentage of volume [or mass for F033]) of food items found in digestive tracts retrieved from Fisher carcasses and in feces of live Fishers found at reproductive dens on the Olympic Peninsula, WA, 2009–2013. Values reported for individual Fishers represent the mean content (%) of subsamples (n) collected from each individual Fisher (either from carcasses or den sites). Frequency of occurrence is also reported as the percentage of the pooled samples collected from all 14 individuals that contained each food item.

	Carcasses										Feces at den sites				Mean across individuals	Frequency of occurrence
Food item	M023 ($n = 1$)	M039 ($n = 2$)	M093 ($n = 1$)	F013 ($n = 2$)	F050 ($n= 2$)	F067 ($n = 3$)	F071 ($n = 1$)	F065 ($n = 1$)	F088 ($n = 1$)	F103* ($n = 3$)	F004 ($n = 19$)	F080 ($n = 25$)	F065 ($n = 48$)	F033 ($n = 20$)	(%, $n = 14$)	(%, $n = 129$)
Mammal[1]	100.0	99.0	97.0	94.5	73.0	100.0	83.0	98.0	98.0	23.7	21.2	91.6	95.6	46.9	80.1	93.0
Snowshoe Hare	97.0	99.0	97.0	0.0	10.0	0.0	83.0	0.0	98.0	0.0	0.0	0.1	74.6	3.1	40.1	39.5
Mountain Beaver	0.0	0.0	0.0	18.0	39.5	45.2	0.0	0.0	0.0	0.0	3.4	78.4	10.5	2.7	14.1	30.2
Northern Flying Squirrel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98.0	0.0	0.0	5.1	3.8	0.0	0.0	7.6	2.3
Southern Red-backed Vole	0.0	0.0	0.0	0.0	0.0	54.7	0.0	0.0	0.0	0.0	4.3	3.9	0.0	0.0	4.5	3.1
Douglas Squirrel	0.0	0.0	0.0	46.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	3.5	2.3
Sorex spp.	0.0	0.0	0.0	0.0	20.5	0.0	0.0	0.0	0.0	23.7	0.0	0.0	0.3	0.5	3.2	3.9
Ungulate	0.0	0.0	0.0	30.0	0.0	0.2	0.0	0.0	0.0	0.0	5.7	0.4	7.3	0.0	3.1	30.2
Fisher	3.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.6	6.2
Jumping Mouse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.3	2.3
Microtus spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.1	0.1	2.3
Unidentified bone	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.3	0.7	0.0
Unidentified fur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.1	2.2	0.0
Bird[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.3	9.5	0.0	0.0	1.7	4.8	10.9
Reptile[3]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.8
Insect[4]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7	7.2	0.0	0.0	6.2	1.4	20.9
Vegetation[5]	0.0	1.0	3.0	5.5	25.0	0.0	17.0	2.0	2.0	15.3	37.2	8.4	4.4	24.2	10.3	90.7
Seeds[6]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5	0.0	0.0	0.0	0.8	4.7
Other[7]	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	13.5	0.0	0.0	0.8	1.2	10.1
Unidentified	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.2	1.4	6.2
Totals	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	

[1] Mammals: Snowshoe Hare (*Lepus americanus*); Mountain Beaver (*Aplodontia rufa*); Northern Flying Squirrel (*Glaucomys sabrinus*); Southern Red-backed Vole (*Myodes gapperi*); Douglas Squirrel (*Tamiasciurus douglasii*); Ungulate (*Cervus canadensis* and *Odocoileus hemionus*), most likely from carcasses; Fisher (*Pekania pennanti*), most likely from grooming; jumping mouse (*Zapus* spp.); vole (*Microtus* spp.).

[2] Ruffed Grouse (*Bonasa umbellus*) and unidentified species of small owl identified in feces from F033.

[3] Gartersnake (*Thamnophis* spp.) identified in feces from F033.

[4] Hymenoptera and Coleoptera identified in feces from F033

[5] Identifiable items included conifer needles and fragments of conifer cones, moss, bark, wood, and grass.

[6] F004 contained black seed hulls, likely from sunflower seeds.

[7] Other identifiable fragments included dirt/sediment, paper, plastic, rock, shells, including one identifiable bivalve mollusk in sample from M033.

The frequency and relative abundance of other taxonomic groups or items present in the Fisher digestive tracts and feces were relatively low and variable compared to mammals (Table 2). Remains of birds were found in approximately 11% of the samples, but reached a high of nearly 55% of volume in the digestive-tract remains of F103. In most cases we were not able to determine the species of bird, but remains of a small species of owl and a Ruffed Grouse (*Bonasa umbellus*) were identified in feces from F033. Insect remains were found in over 20% of the samples but made up a relatively low percentage of sample volumes. Vegetation was present in over 90% of samples but was approximately 10% by volume or mass on average. Many vegetation fragments adhered to the fecal samples and did not appear to be part of the diet, whereas vegetation formed a relatively high proportion of other samples (F004, F050, F033). Miscellaneous seeds, other content, or unidentifiable materials were also found in the digestive and fecal contents of Fishers, including fragments of ropes, paper, shells, and inorganic materials, including one distinct bivalve shell in the feces of F033.

Discussion

This study provides insights into the diets of Fishers in a portion of their range where diet composition was previously unknown. Fishers on Washington's Olympic Peninsula corroborated the widespread importance of Snowshoe Hares in the diets of Fishers where distributions of hares and Fishers overlap (Powell and Zielinski 1994; Lofroth and others 2010). In the Pacific Coast region of the Fisher's range, Snowshoe Hares are an important prey item in British Columbia (Weir and others 2005) and the Oregon Cascades (Raley and Aubry 2020), although Snowshoe Hares could not always be differentiated from other species of leporids in Oregon. By contrast, Snowshoe Hares made up a smaller percentage of the diet of Fishers in Northwestern California and were altogether absent from the Fisher diets in the southern Sierra Nevada, apparently in response to regional variations in Snowshoe Hare availability (Zielinski and others 1999; Zielinski and Duncan 2004; Golightly and others 2006).

Our results confirmed the importance of Mountain Beavers as food items of Fishers in coastal forest ecosystems of Western Washington. Although previous studies of Fisher diets in the Cascade Range of Washington identified isotopic signatures of either Snowshoe Hares or Mountain Beavers (or both species) in Fisher hair samples, the two potential prey species could not be distinguished based on isotopic analyses (Parsons and others 2020). Combined, the proportional volume of Snowshoe Hares and Mountain Beavers in digestive tracts and feces of Fishers on the Olympic Peninsula (54%) and the frequencies of their occurrence combined (70%) were similar to the total percentage of undifferentiated Snowshoe Hares and Mountain Beavers in the Cascade Range (68%; Parsons and others 2020).

The lack of previous documentation of Mountain Beavers in the diets of Fishers elsewhere throughout the Fisher's Pacific Coast range likely reflects the limited overlap of Mountain Beaver distributions with extant Fisher populations. Mountain Beavers are most abundant in the mesic coastal forests of western Washington and Oregon (Verts and Carraway 1998) where Fishers were extirpated before their food habits were documented (that is, excluding the early trapper reports; Scheffer 1995). Conversely, Mountain Beavers are relatively scarce in the Klamath and southern Sierra Nevada regions where food habits of Fishers have been studied more extensively (Zielinski and others 1999; Golightly and others 2006).

Mountain Beavers also do not occur in Central British Columbia (British Columbia Ministry of Environment 2013), the source region for Fishers translocated to the Olympic Peninsula; hence they were unfamiliar prey for Fishers translocated to Washington. Fishers exploited Mountain Beavers, however, soon after their release on the Olympic Peninsula. Mountain Beaver prey remains were found at a rest site used by a translocated Fisher approximately 3 months following its release in Olympic National Park (Lewis and Happe 2009). Further, a male Fisher was found resting in a Mountain Beaver burrow system 6 months after its release (Happe, unpubl. data). Female F033 not only preyed upon Mountain Beavers (Table 1) but also used Mountain Beaver burrows as a den site during kit rearing (Lewis and others 2010).

Our findings corroborate several other general patterns of Fisher diet composition reported elsewhere in the Pacific Coast region, with a few exceptions. As elsewhere in the region, Fishers consumed a variety of squirrels, voles, shrews, and other small mammals, as well as insects and reptiles (Zielinski and others 1999; Weir and others 2005; Golightly and others 2006; Raley and Aubry 2020). Some species contributing to the diets of Fishers elsewhere in the Pacific Coast region, notably American Beavers (Weir and others 2005), Porcupines (Weir and others 2005; Raley and Aubry 2020), and Striped Skunks (Raley and Aubry 2020) were lacking among samples collected on the Olympic Peninsula. Porcupines are uncommon on the Olympic Peninsula, so lack of Porcupines in Fisher diets most likely reflects their low availability. Striped Skunks are also uncommon on the Peninsula, but the Spotted Skunk (*Spilogale putorius*) was the most frequently detected small carnivore species during camera surveys used to monitor Fisher population recovery on the Peninsula (Happe and others 2020). We caution that additional study would likely reveal other less-frequently-used prey species of Fishers on the Olympic Peninsula.

We computed 2 indices of diet composition of Fishers to help interpret potential sources of bias associated with the choice of analytical methods (Klare and others 2011). Previous research demonstrates that mass or volumetric measures of fecal contents may not reflect actual biomass of different food items consumed owing to differences in digestibility among foods, whereas indices based on the frequency of occurrence of food items may overestimate the actual contribution of small prey items in the diet. We saw evidence of both biases in our results. For example, we observed ungulate remains in 30% of samples, yet ungulate material was an average of only 3% of sample contents by volume; we surmise this is because meat associated with carrion feeding is digestible with few recognizable traces in the feces. Conversely, we observed insect remains in about 20% of samples accounting for 2% of volumes. We suspect that because insects are so small, and recognizable parts of insects are indigestible, it is likely that insects did not make up nearly the same biomass in the diets as ungulates. In considering all the potential sources of bias, our results are most useful in identifying the list of foods utilized by Fishers and relative rankings of some of the most important prey.

Our sample of digestive tracts and feces was limited to a relatively small number of Fishers, primarily females during the denning season. We caution that sampling constraints limit the inferences from this study. First, the data show that there appeared to be a greater diversity of prey items identified from the multiple fecal samples collected from denning females than were identified from carcass samples. The 19 to 48 feces collected from Fisher den sites reflected foods obtained over multiple weeks during the denning season, whereas carcass collections reflected only a single or up to a few recent predation bouts. As an illustration, the stomach contents obtained from F065 contained only 1 mammalian prey item (98% Northern Flying Squirrel), whereas the identifiable foods in 48 feces from this same female during the denning season covered 5 mammalian taxa, none of them Northern Flying Squirrel (Table 2). In the time period between when feces and the carcass were collected, F065 had shifted dens and presumably was foraging in a different area (Fig. 1).

Second, the sample of carcasses and feces examined was insufficient to draw conclusions on potential sex-related or seasonal differences in the Fisher diets. Other researchers have reported that male Fishers consume larger prey, such as Snowshoe Hares, more frequently than females owing to the larger size of males and their ability to handle larger prey than females (Weir and others 2005; Raley and Aubry 2020). Further, female Fishers in Oregon tended to consume larger prey during the denning season than at other times of year, presumably to support a greater nutrient requirement associated with kit rearing (Raley and Aubry 2020). We determined composition of food remains from carcasses of only 3 males. Each of the male carcasses contained only Snowshoe Hare prey remains, which is consistent with predictions based on body size differences. Additional sampling from this region, however, would be useful to verify this trend. We did not sample female diets sufficiently outside the denning season to evaluate seasonal diet variations, but based on findings from the Oregon Cascade Range (Raley and Aubry 2020), dietary results reported for females on the Olympic Peninsula may not fully represent dietary patterns during other times of the year.

Variation in the food items present in the feces and digestive tracts collected from Fishers illustrated a high degree of dietary plasticity. We collected samples from a variety of habitats on both managed forest lands and protected landscapes on the Peninsula, reflecting a very similar distribution of Fishers that we determined from unbiased aerial telemetry and camera surveys reported previously (Lewis and others 2016; Happe and others 2020). As an illustration of the diversity of diets represented in the sample, the diet of 1 female that denned in the subalpine zone in the interior of the Park was dominated by Mountain Beavers, which are common in mesic areas at that elevation (Table 2, Fig. 1, Female F080). Another female resided and denned on the National Park and National Forest boundary, moving between managed forests and park wilderness (Fig. 1, Female F065). She had a varied diet that included a range of mammals, including Snowshoe Hares and Mountain Beavers, which tend to be more abundant in recently disturbed forests than in mature forests (Hacker and Coblentz 1993; Arjo and others 2007; Lewis and others 2011; Sullivan and others 2012) and Northern Flying Squirrels, which tend to be more abundant in mature forests (Carey 1995) (Table 2). Yet another Fisher, female F004, denned adjacent to a residential area on the outskirts of Port Angeles (Fig. 1). F004's diet was not typical of other Fisher's and contained a high proportion of vegetation and seeds (Table 2). We strongly suspect that F004 was subsisting on food sources commonly found around residential areas, including cat food and seeded suet placed at bird feeders. F004 successfully occupied this area, as indicated by her rearing of 3 litters of kits in 3 consecutive years, 1 of which consisted of 4 kits (Happe and others 2015). These findings support the generality of food habits of Fishers reported throughout their range (Powell and Zielinski 1994; Lofroth and others 2010).

Considerable attention has focused on Fisher conservation in the Pacific Northwest, and this has been demonstrated by numerous recovery and planning efforts, Fisher reintroductions, and federal listing proposals (Federal Register Volume 84 Number 216: pages 60278–60305; https://www.govinfo.gov/content/pkg/FR-2019-11-07/pdf/2019-23737.pdf; accessed 6 March 2020). Suitable reintroduction sites for Fishers in Washington were identified based largely on the Fisher's requirement for mature-forest structural components such as large live and dead trees and cavities for denning and security, as well as suitable travel corridors connecting mature forest tracts (Lewis and Hayes 2004). Recent research, however, has suggested that reintroduced fishes in the Washington Cascade Range also selected for optimum densities of key prey species (Parsons and others 2020). Our results demonstrated the generality of Fisher diets in coastal Washington, which included prey that are most abundant in both young, regenerating forests, such as the Snowshoe Hare and Mountain Beaver (Hacker and Coblentz 1993; Lewis and others 2011; Sullivan and others 2012), and small mammals and sciurids that are abundant in mature coniferous forests (Carey 1995; Carey and Johnson 1995). Additional study of the foraging behaviors of Fishers related to prey abundance and structural habitat characteristics would provide useful insights for enhancing the effectiveness of conservation efforts to benefit Fishers in Pacific Northwestern coastal forests.

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