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The Importance of Vegetation, Insects, and Neonate Ungulates in Black Bear Diet in Northeastern Oregon

Abstract

Fecal samples were examined to estimate black bear (*Ursus americanus*) diet in northeastern Oregon during 1998 and 1999 to determine the important food items. Mean estimated relative volume of food items in 621 scats was 35% grasses, 24% insects, 16% fruit, 11% soil and wood, 10% animal remains, and 4% leaves and stems. During June, remains of mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) occurred in 44% of the scats in 1998 and in 25% in 1999, at a time when other protein-rich food sources were unavailable. Between May and October, > 40% of all scats collected in each month contained insects, and 98% of those scats collected in July contained insects. A significantly higher volume of insects occurred in scats in 1999 compared to 1998, probably because berries were scarce in 1999. Of the 434 scats containing insects, 40% contained carpenter ants (*Camponotus* spp.), 45% other small ants (*Lasius* sp, *Tapinoma* sp., *Aphaenogaster* sp.), 36% forest ants (*Formica* spp.), and 23% yellowjackets (*Vespula* spp., *Dolichovespula* sp.). Because these ant species are all log-dwelling, management for coarse woody debris is an important consideration in maintaining this important food resource for black bears in northeastern Oregon.

Introduction

Black bears (*Ursus americanus)* are the largest terrestrial omnivore in Oregon, consuming a variety of vegetation, insects, and animal matter (Tisch 1959, Poelker and Hartwell 1973, Irwin and Hammond 1985, Raine and Kansas 1990, Holcroft and Herrero 1991). Knowledge of their food habits is a prerequisite to understanding how black bears interact with their habitat. Although studies on black bear food habits elsewhere further our knowledge of the species, they are of limited value on a local basis in a given population because of their omnivorous habits and opportunistic foraging behavior (Poelker and Hartwell 1973).

Black bears feed at both the lower and upper strata of the food chain, so forest management practices can directly or indirectly influence availability of their food sources. Because black bears rely on log-dwelling ants in some areas (Beeman and Pelton 1977, Costello 1992, Beecham and Rohlman 1994), management of coarse woody debris is important. High fuel loadings in the aftermath of insect outbreaks can result in a high risk of wildfire and might prompt land management agencies to view coarse woody debris as a hazard rather than an important biological component.

The role of bear predation on deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) population dynamics is unknown. Predation, primarily by black bears, was the most important source of mortality of calf elk in north central Idaho (Schlegel 1976). In the Jackson elk herd in Wyoming, 10 of 15 depredated calves were killed by black bears (Smith 1994). In Yellowstone Park, Singer et al. (1997) reported losses of neonatal elk primarily from predation by grizzly (*Ursus arctos*) and black bears. Black bears preyed on neonatal white-tailed deer (*Odocoileus virginianus*) in Michigan (Ozoga and Clute 1988) and in New York (Mathews and Porter 1988). Although predation of neonates by black bears has been documented in Idaho and Wyoming, few studies have attempted to determine the extent to which individual black bears utilize neonates. The objectives of this study were to compare the seasonal and annual composition of bear diets based on scat analysis and to quantify the frequency with which neonates and log-dwelling insects occurred in the scats.

Study Area

The study area encompassed about 200 km^2 in the Starkey Wildlife Management Unit in northeastern Oregon located 10-25 km south of La Grande. Portions of the following drainages were included in the study area: Grand Ronde River, Beaver Creek, Wolf Creek, and Ladd Creek. Topography consisted of moderately steep mountains dissected by drainages. Permanent water in the form of springs and streams was abundant. Elevation ranged from 1320 to 1980 m. Stands in the following forest types (Johnson and Hall 1990) occurred in the study area: grand fir (*Abies grandis*), Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), subalpine fir (*Abies lasiocarpa*), and ponderosa pine (*Pinus ponderosa*). Successional stages (Oliver 1992) ranged from stand initiation to old multistoried stands. Harvest activity ranged from regeneration cuts to unlogged stands.

Methods

We used telemetry to monitor the activity of 12 radio-collared black bears from May 1998 until October 1999. Bears were radio-collared using techniques described by Akenson et al. (In press). The radio-collared bears consisted of four subadult females, six adult females, and two adult males. Two of these bears, an adult male and a female, were harvested by hunters in the fall of 1998, so only 10 of the same bears were monitored in 1999. Each bear was typically located once a week by ground-tracking from the first week in May until they entered dens in October. We attempted to actually find collared bears and observe their behavior during weekly monitoring. If a bear was feeding on a carcass, we flushed the bear after 15 minutes of observation and determined the prey item. The ungulate carcasses were not intact and could not be necropsied to determine cause of death (Knight and Judd 1983, Murphy et al. 1998). A neonate was defined as any calf or fawn fed upon between 15 May and 15 July. This definition applies only to carcasses, because age of animal tissue in a scat could not determined. When a bear was located, the area within a 200-m radius was searched for scats after the bear moved. Each scat was collected separately in a plastic bag and labeled with date, bear number, and whether the scat was fresh (1-3 days old) or old (1-4 weeks old). Modifications of Costello's (1992) methods were used. Scats that appeared to be older than a month based on deterioration were not collected. No more than eight scats were collected from one site on a given day to prevent overemphasis of an individual bear, although eight scats were not always found. We assumed that the bear present at each location was the source of the scats found there.

Scats were frozen until they could be processed. Processing began with a measurement of volume determined by displacement by submerging each scat in a known volume of a 10% solution of chlorine and water for 30 minutes to reduce odors and kill parasites. Each scat was gently broken apart and flushed through a series of three or four sieves, with decreasing mesh sizes ranging from 5 to 0.7 mm, to retrieve identifiable dietary items. The percent volume of animal remains (hair, bone and cartilage, meat and sinew), insects, grasses, fruit, leaves and stems, and coarse fiber (soil, rocks, and wood chips) was estimated ocularly for each scat using techniques modified from Tisch (1961) and Costello (1992). Frequency of occurrence, as well as volume of food remains, were recorded because volumetric analysis tends to overestimate the amount of vegetation consumed and underestimate the amount of animal remains eaten (Raine and Kansas 1990, Holcroft and Herrero 1991). Remains in sieves were put in a shallow pan with water where insects were skimmed off the water surface where they tended to float, and seeds and bones were taken off the bottom because they usually sank. Only remains that passed through the animal were collected. Intact beetles, other arthropods, and earthworms were presumed to have been attracted to the scat after it was deposited and were not counted. A maximum of 1 hr was spent collecting a representative sample of identifiable food remains from each scat. Remains were dried at 40° C overnight and were placed in plastic bags for later taxonomic identification under a stereoscopic microscope.

Vegetation

Grasses and sedges were classified as "grasses." Seeds were collected and identified from a reference collection obtained from field samples and from Northplan Mountain Seed (PO Box 9107, Moscow, ID 83843-1607). Personnel at Northplan Mountain Seed and the Idaho State Seed Lab (Kellogg Lane, Boise, ID) identified several unknown seeds. Leaves and stems from shrubs that were associated with consumed fruit were easily distinguished from grasses.

Insects

We separated insect material into major taxa, which were mainly ants and yellowjackets. We used

Wheeler and Wheeler (1986) to identify ants and Akre et al. (1980) to identify yellowjackets; the term "yellowjackets" refers to members of the genera *Vespula* and *Dolichovespula* as recommended by Akre et al. (1980). Because many of the specimens were fragmented, body size, color, shape of head, and eye size were used as identifying criteria. Damage to the specimens prevented identification beyond genus. A reference collection (located at Forestry and Range Sciences Laboratory, La Grande, OR) was used to compare and verify identification of ants and yellowjackets.

The insect fauna in scats were separated into four categories because their remains were easily identified. One category comprised yellowjackets, which were represented by at least three species (*V. vulgaris*, *V. pennsylvanica*, and *D. maculata*). The dominant ant faunas were separated into three categories. The remains of large ants were separated into *Formica* (forest ants) and *Camponotus* (carpenter ants). A third composite category of small brown to honey-colored ants, which we called "Other ants," represented at least the genera *Lasius*, *Tapinoma*, *Aphaenogaster*, and *Leptothorax*.

The composition of ant taxa in scats was assessed both years, but methods differed each year. In 1998, the ants in a scat were categorized by taxon (*Camponotus*, *Formica*, and Other) and counted. If fewer than 150 ants were in a scat, all were categorized and counted. For scats with >150 ants, a representative subsample of >100 ants was extracted, and the ants were categorized and counted. This yielded a numerical basis for assigning dominance of each ant taxon in scats from 1998. In 1999, the assignment of dominance among ant taxa in a scat was based on a subjective estimate of their proportional representation in each scat. For example, some scats contained all three categories of ants, but one of the categories dominated in terms of apparent number of individuals. Head capsules, thoracic parts, legs, and abdominal terga constituted the major portion of ant remains in scats. However, head capsules were most often used to assign taxonomic category and estimate relative numbers of individual ants that were eaten because heads appeared to be the most durable part of each ant.

To determine the approximate biomass of the ants in each taxonomic category, we made field collections of live ants of *Camponotus modoc*, *Formica neorufibarbis*, and *Lasius alienus* in the summer of 1998. We chose these species to represent each category because they were the dominant species found in logs in northeastern Oregon by Torgersen and Bull (1995), and both studies occurred in similar habitats in the Starkey Wildlife Management Unit. Based on this earlier study, we anticipated that our "Other ants" category would contain a mix of genera of small brown ants, dominated by *Lasius*, but also containing *Tapinoma*, *Leptothorax*, and *Aphaenogaster*. The ants were preserved in 70% ethyl alcohol in the field, counted, and oven-dried at 40°C overnight. Samples of 113 *C. modoc*, 489 *F. neorufibarbis*, and 968 *L. alienus* were weighed to the nearest 0.01 mg. To assess dominance of each ant group collected in 1998, we calculated the biomass of each ant group by multiplying the number of ants by its appropriate individual weight.

Animal Remains

Hair was identified to taxon using a compound microscope, a taxonomic key (Moore et al. 1974), and a reference collection. Deer and elk hair could not be reliably distinguished from each other so were classified as deer or elk. Scats that contained only several strands of bear hair were not recorded as representing predation. Presumably, such small amounts of bear hair were the result of grooming (Beecham and Rohlman 1994). Only scats where the majority of the volume comprised bear hair were counted as evidence of predation on bears.

Analysis

Analyses were based on scats from 12 bears in 1998 and 10 in 1999. Diet remains were classified as grasses, fruit, leaves and stems, insects, animal remains, and soil and wood. Estimated percent volumes were tested for normality and arcsine transformations were used to normalize the data (Snedecor and Cochran 1980). One-way analysis of variance was used to compare estimated percent volume of diet among months and between years. Tukey's B tests were used to identify which months were driving the significant differences identified by the analyses of variance. Frequency of diet items were compared using Pearson Chi-square analyses among months and between years. The occurrence of the four categories of insects were compared between years using Pearson Chi-square analyses. The mean biomass per scat for each category of ants was compared among months in 1998 using a one-way analysis of variance and Tukey's B tests.

Estimated percent volume of diet was compared among reproductive classes of female bears (subadults, females with cubs, females without cubs) using a one-way analysis of variance and Tukey's B tests. Only fresh scats were used in this analysis because they had a high probability of being correctly assigned to an individual bear. Differences in use of animal remains in the first half of the season and in the second half of the season were compared among the reproductive classes of bears using one-way analysis of variance and Tukey's B tests.

Results

Total diet by frequency of occurrence in 621 bear scats collected between April and October in 1998 and 1999 was 75% grasses, 73% soil and wood, 70% insects, 56% leaves and stems, 35% fruit, and 25% animal remains (primarily deer and elk) (Table 1). Mean estimated percent volume composing all scats was 35% grasses, 24% insects, 16% fruit, 11% soil and wood, 10% animal remains, and 4% leaves and stems (Table 2).

Vegetation

Vegetation made up the largest component of black bear diet and included grasses, fruit, and leaves and stems. Frequency of grasses in scats differed among months ($X^2 = 116.27$, 5df, $P < 0.01$), among years ($X^2 = 9.01$, 1df, $P < 0.01$), and among reproductive classes ($X^2 = 13.54$, 2df, $P < 0.01$). The estimated percent volume of grasses in scats differed among months ($F = 163.09$, $P < 0.01$) and among reproductive classes ($F = 4.18$, $P = 0.02$), but not between years ($F = 0.03$, $P = 0.87$).

TABLE 1. Diet of 12 radio-collared black bears presented as frequency (%) by month determined from 621 black bear scats in northeastern Oregon, 1998-1999.

Food Item	May 1998	May 1999	June 1998	June 1999	July 1998	July 1999	August 1998	August 1999	September 1998	September 1999	October 1998	October 1999	Mean 1998	Mean 1999
Grasses	100	98	85	94	85	73	58	40	82	33	67	60	80	70
Fruit	4	0	8	14	28	29	88	66	62	69	3	65	34	36
Leaves/stems	19	21	36	33	72	76	88	76	85	71	87	51	59	53
Insects	52	40	61	44	98	94	75	94	50	92	80	97	67	73
Animal remains	13	9	44	25	22	18	25	5	30	27	30	49	28	21
Soil/wood	28	51	36	65	95	98	79	95	98	98	100	100	65	82
Scat (*n*)	69	57	66	69	40	55	67	38	40	52	30	37	312	308

TABLE 2. Diet of 12 radio-collared black bears presented as mean percentages of estimated volume (± SE) by month determined from 612 scats in northeastern Oregon, 1998-1999.

Food Item	May 1998	May 1999	June 1998	June 1999	July 1998	July 1999	August 1998	August 1999	September 1998	September 1999	October 1998	October 1999	Mean 1998	Mean 1999
Grasses	81 (4.1)	88 (2.7)	53 (4.8)	66 (4.7)	8 (2.0)	17 (3.4)	6 (2.2)	3 (1.5)	11 (3.8)	2 (0.8)	31 (6.7)	4 (2.0)	36 (2.4)	35 (2.4)
Fruit	0.3 (0.2)	0 (0.0)	0.7 (0.6)	4 (1.8)	8 (2.7)	2 (0.8)	57 (4.2)	24 (4.6)	46 (6.6)	29 (5.2)	0.2 (0.2)	18 (4.2)	20 (1.9)	11 (1.4)
Leaves/stems	3 (1.4)	0.5 (0.2)	8 (2.4)	3 (1.2)	4 (0.9)	3 (0.9)	6 (0.8)	4 (0.7)	3 (0.7)	4 (1.8)	4 (2.2)	8 (2.9)	5 (0.7)	3 (0.6)
Insects	5 (2.1)	7 (1.7)	10 (2.3)	10 (2.2)	57 (3.9)	54 (3.4)	20 (3.0)	54 (4.2)	14 (4.4)	37 (4.6)	30 (6.0)	24 (4.4)	20 (1.6)	29 (1.8)
Animal remains	4 (2.1)	3 (1.3)	21 (4.5)	13 (3.4)	5 (2.0)	5 (1.6)	3 (1.2)	0.5 (0.4)	17 (5.2)	10 (2.8)	10 (4.5)	31 (6.1)	10 (1.4)	10 (1.5)
Soil/wood	6 (2.6)	2 (0.6)	7 (2.0)	4 (1.4)	18 (2.7)	19 (2.8)	8 (1.4)	15 (2.1)	9 (1.6)	18 (2.6)	26 (6.4)	14 (2.0)	11 (1.1)	11 (0.9)
Scat (*n*)	69	57	66	69	40	55	67	38	40	52	30	37	312	308

Tukey's B analyses indicated that the volume of grasses was significantly higher in May and June than during other months. During both years the majority of the scats from May consisted of grasses (Tables 1 and 2). In 1998, grasses increased in frequency in September and October after a fall greenup, although this increase in grasses was not observed in 1999 when drought conditions prevented any fall greenup. Tukey's B analyses indicated that the estimated volume of grass was higher for females without cubs (51%) than for females with cubs (38%) or subadults (34%).

Overall, fruit comprised 16% of the diet by volume. Of the 216 scats containing fruit in both years, 32% contained bearberry (*Arctostaphylos uva-ursi*), 27% hawthorn (*Crataegus* spp.), 22% big huckleberry (*Vaccinium membranaceum*), 11% swamp gooseberry (*Ribes lacustre*), 8% apple (*Malus* spp.), 7% raspberry (*Rubus ibaeus*), and ≤ 4% of plum (*Prunus* spp.), grouse huckleberry (*V. scoparium*), mountain snowberry (*Symphoricarpos oreophilus*), strawberry (*Fragaria* spp.), dogwood (*Cornus canadensis*), bitter nightshade (*Solanum dulcamara*), Nootka rose (*Rosa nutkana*), creeping Oregon-grape (*Berberis repens*), bearberry honeysuckle (*Lonicera involucrata*), buffaloberry (*Shepherdia canadensis*), and a domestic cherry (*Prunus pumila*). Frequency of fruit in scats differed among months (X^2 = 228.81, 5 df, P < 0.01), but not between years (X^2 = 0.43, 1df, P = 0.51), nor among reproductive classes (X^2 = 1.22, 2df, P = 0.54). There were significant differences in estimated percent volume of fruit among months (F = 67.45, P < 0.01), between years (F = 12.94, P < 0.01), and among reproductive classes (F = 3.24, P = 0.04). Tukey's B tests showed the amount of fruit consumed in August and September was significantly higher than during other months. In 1998, approximately half the diet by volume consisted of fruit in August and September, in contrast to 1999, when only about a quarter of the diet consisted of fruit (Tables 1 and 2). However, fruit continued to be consumed in October 1999, unlike 1998. This difference in years may have been reflected in the species of fruit consumed each year. In 1998, 52% was hawthorn, 24% was big huckleberry, and 16% was bearberry. In 1999, 48% was bearberry, 20% was big huckleberry, and 15% was swamp gooseberry. Swamp gooseberries ripen later than huckleberries, and hawthorns did not produce berries in 1999. Females without cubs used a significantly greater volume of fruit (25%) than did females with cubs (16%) or subadults (15%). Scats with fruits usually contained other vegetation in the form of leaves and stems probably eaten while obtaining the fruit.

Remains of soft forms of vegetation, such as mushrooms, were difficult to detect in the scats because of their high digestibility. Evidence of bears feeding on the tubers of Indian pipe (*Monotropa uniflora*) in grand fir forest types was observed in the field in 1998 on 12 and 27 June, 8 September, and 20 October. On three occasions in September remains of a rare white chanterelle (*Cantharellus subalbidus*) were found either eaten or in bear beds where they had apparently been carried. Based on these field observations and the difficulty detecting mushrooms in scats, use of mushrooms and soft tubers by bears may be more common than suggested by this study.

Insects

Insects were second only to plant matter as food for black bears in this study. The ants (Formicidae) and yellowjackets (Vespidae) were the most common insects found in the scats. Minuscule, unrecorded amounts of other insects were also found in the scats. These were represented by mandibles, elytra, or portions of legs, which we speculate came mainly from larval and adult Coleoptera.

Among scats collected each year, the frequency of insect remains was 68% in 1998 and 73% in 1999 (Table 1). The frequency of ants was statistically different between years (X^2 = 4.29, 1df, P = 0.04), among months (X^2 = 105.50, 5df, P < 0.01), and among reproductive classes (X^2 = 15.55, 2df, P < 0.01). Insects constituted the second largest proportion of the diet on an estimated volumetric basis (Table 2). Overall, estimated volumes of 30% and 31% were composed of insects in 1998 and 1999, respectively (Table 2). Significant differences in the estimated volume of insects occurred among months (F = 49.47, P < 0.01), between years (F = 13.11, P < 0.01), and among reproductive classes (F = 3.20, P = 0.04). Tukey's B analyses indicated July scats had significantly more insects than all other months, whereas scats collected in August, September, and October had significantly more insects that those in May and June. The estimated volume of insects in scats was higher in 1999 than in 1998 (Tables 1 and 2, Figure 1). Females without cubs used a significantly

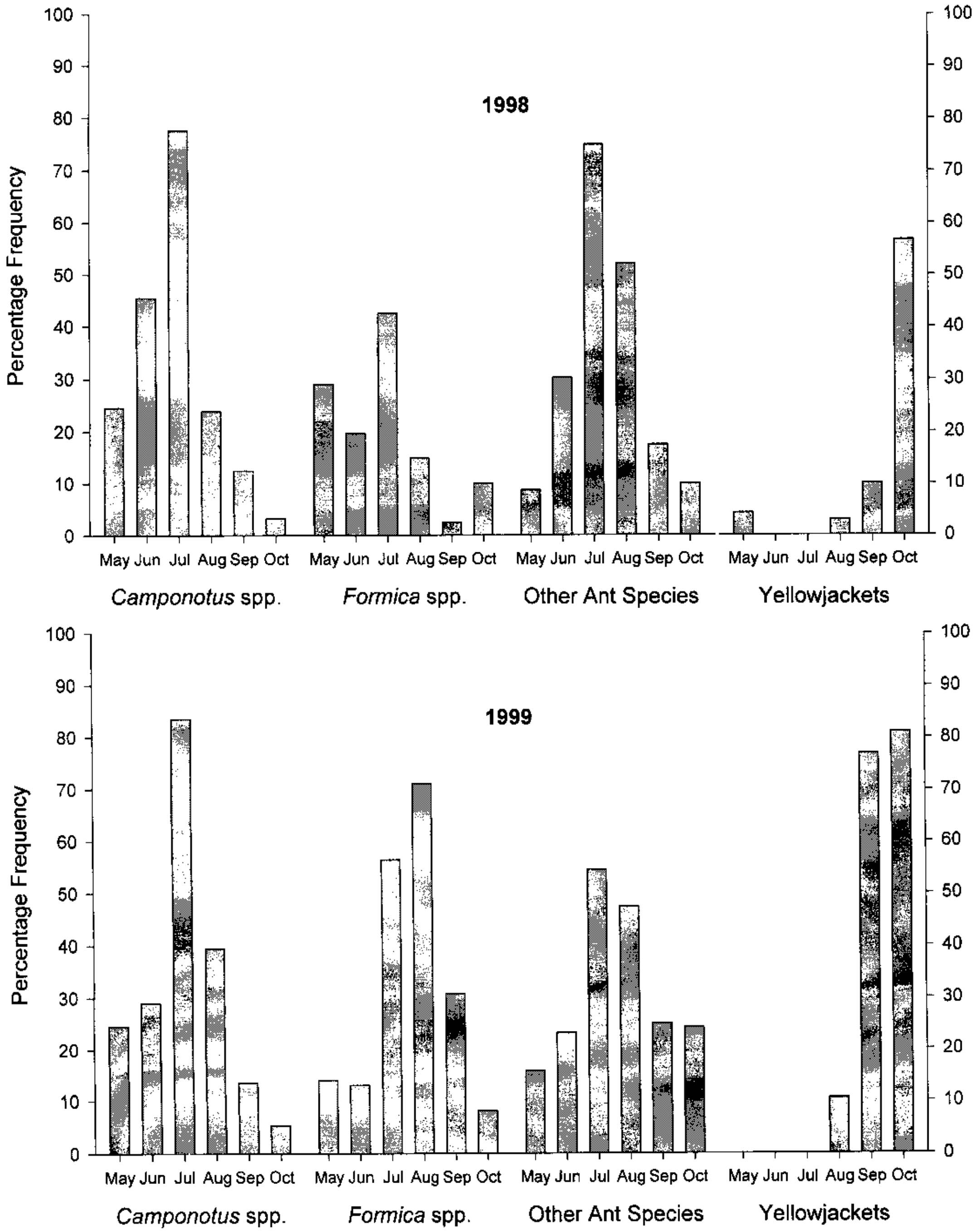

Figure 1. Monthly percent frequency of insect taxa found in 621 scats of 12 radio-collared black bears in northeastern Oregon, 1998-1999.

lower estimated volume of insects (12%) than did females with cubs (21%) or subadult females (20%). Scats containing insects often had a high percentage of soil or wood, presumably consumed while eating ants or yellowjackets.

Among categories of insects, yellowjackets were represented by statistically higher frequencies of occurrence of scats in 1999 than in 1998 ($X^2 = 28.39$, 1df, $P < 0.01$) (Figure 1). Among the ants, *Formica* was the only group that occurred in statistically different frequencies between years ($X^2 = 8.30$, 1df, $P < 0.01$), occurring in greater frequencies of scats in 1999 (Figure 1).

For the *Camponotus* category, we determined the average weight of a *C. modoc* to be 5.41 mg. *F. neorufibarbis*, which we intended as representative of *Formica* ants in the scat, had a mean weight of 1.07 mg each. Ants of the Other group, which we represented with *Lasius alienus*, weighed an average of 0.31 mg. The mean biomass in the scats of *Camponotus* ($F = 5.80$, $P < 0.01$) and Other ants ($F = 10.13$, $P < 0.01$) differed significantly by month (Figure 2). Tukey's B tests indicated that the biomass of *Camponotus* ants was significantly less in scats from May and August than in all other months in 1998. Thus there were peaks in use of *Camponotus* in June and July and in September and October. Tukey's B tests for biomass of Other ants indicated that use of these ants rose significantly with each passing 2-month period. Biomass of ants of the *Formica* category did not differ statistically by month ($F = 0.40$, $P = 0.85$).

We observed at least 34 situations where bears had preyed on yellowjacket nests within or under logs in September and October 1999. We also found one instance, as evidenced by claw-marks and broken branches, in which a bear had climbed 10 m up a 60-cm dbh western larch (*Larix occidentalis*) to obtain a nest of bald-faced hornets.

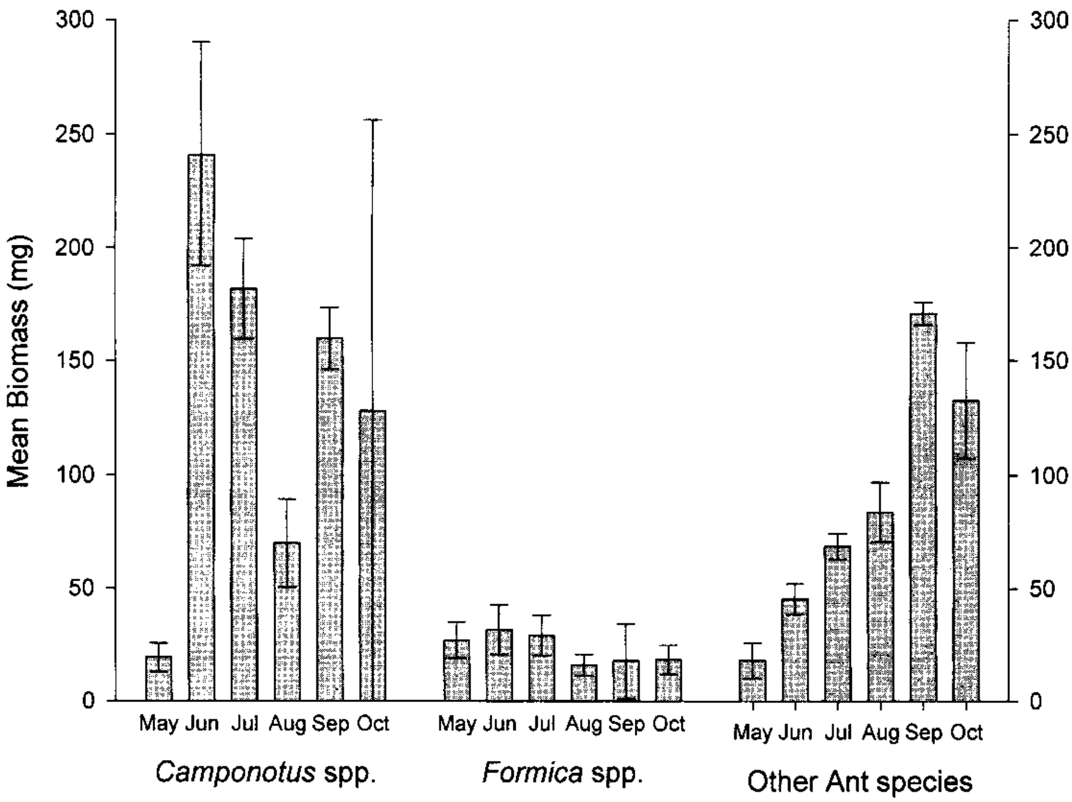

Figure 2. Monthly mean biomass (± SE) of insect taxa from 209 scats of 12 radio-collared black bears in northeastern Oregon, 1998.

Animal Remains

Frequency of animal remains was significantly different among months ($X^2 = 32.14$, 5df, $P < 0.01$), but not between years ($X^2 = 3.07$, 1 df, $P = 0.08$), nor among reproductive classes ($X^2 = 4.79$, 2df, $P = 0.9$). The estimated percent volume of animal remains differed among months ($F = 10.77$, $P < 0.01$), but not between years ($F = 0.30$, $P = 0.59$), nor among reproductive classes ($F = 2.42$, $P = 0.09$). In addition, there were no differences in estimated volume of animal remains among reproductive classes of animal remains from May through July (likely neonates) ($F = 2.14$, $P = 0.12$) nor from August through October (likely scavenging) ($F = 2.33$, $P = 0.10$). Tukey's B analyses showed significantly more animal remains in scats found in June and October than during May, July, and August. Scats from September contained more animal remains than those from May and July. Of the animal remains that could be identified, 1 scat contained a vole (*Microtus* sp.), 6 had bear hair, and 147 contained elk or deer remains. Thus, elk and/or deer comprised the vast majority of the animal remains in the bear scats.

On four occasions (29 May 98, 9 June 98, 22 June 98, 10 June 99), three different bears were observed eating mule deer fawns. One bear was a subadult female and two were adult females, each with two cubs. On four occasions (16 June 1998, 22 June 1998, 28 May 1999, 8 July 1999), three different bears were observed eating elk calves. One bear was an adult female without cubs, and two were females with yearlings. On three occasions in September and October, bears were observed feeding on adult elk. Based on these field observations, bears presumably fed on deer and elk neonates in June and scavenged adult deer and elk in September and October (which coincided with hunting seasons for both deer and elk) (Tables 1 and 2). By September, neonates were less vulnerable to bear predation because of their increased mobility.

We believe the scats with predominantly bear hair were from cubs that had been consumed. Three scats collected in May 1998 in the same location contained teeth and claws from a cub. There had been a female with three cubs in the area in March, but only two cubs were seen with her in May. In October 1998 an adult male was found eating a male cub that had evidently been killed at that location within several hours based on tissue evidence.

Discussion

Food availability influences black bear growth rate, movement patterns, productivity, and survival (Beecham and Rohlman 1994). We found higher percentages in volumes of insects and animal remains in scats than reported elsewhere in the western United States (Tisch 1961, Poelker and Hartwell 1973, Beecham and Rohlman 1994), although the majority of the diet consisted of grasses. Bears may increase their consumption of vegetation when other primary foods are scarce; however, digestibility of the vegetation is low relative to digestion of fruits and nuts (Rogers 1987). Although berries provide a source of energy-rich, digestible sugars, they are not always available in our study area. Insects and animal remains may provide a critical source of protein for bears in our study area; ants contain as much as 55% protein (Beeman and Pelton 1977).

Insects

Weather differences can partially explain the greater incidence of insects in black bear scats in 1999 compared to 1998. A cold, dry spring in 1999 probably caused the shortage of fruit observed later that summer and the subsequent lack of fruit found in the scats. The wet spring of 1998 favored fruit production, but presumably was not favorable to yellowjackets. We hypothesize the bears consumed more insects in 1999 to compensate for the shortage of fruit (Figure 1). Our data suggest that ants may be consumed as a compensatory food source when other food resources are scarce. Because foraging on log-dwelling ants requires a greater expenditure of energy in finding and ripping logs open, this resource may be reserved for times when other more readily available foods are in short supply. In Idaho, Beecham and Rohlman (1994) surmised that ants played a more important role in black bear diet during drought years, and when early-season berry crops failed. In western Washington, insects comprised <10% of the diet in three separate studies presented by Poelker and Hartwell (1973), where vegetation comprised 73-98% of the diet.

The most common species of yellowjackets in this study, *V. vulgaris* and *V. pensylvanica*, are forest- and log-dwelling species (Akre et al. 1980). Although we could not positively identify all species of ants that were represented in the scats, our evidence suggests that they contain the dominant log-dwelling species *Camponouts modoc*, *Formica neorufibarbis*, and *Lasius alienus* (Torgerson and Bull 1995).

Of the 345 scats containing ants in this study, 33% contained *Camponotus*, 32% contained Other ants, and 25% contained *Formica* ants. Torgersen and Bull (1995) examined 1385 logs for ants in similar forested habitat in northeastern Oregon and found 41.1% of the logs contained the category of Other ants, 20.2% contained *Formica*, 12.5% contained *Camponotus*. Thus, assuming the same availability of ant taxa in logs in this study, bears appear to be selecting for *Camponotus* ants. Although *Formica* ants may be easier to obtain than *Camponotus* (i.e., they nest in smaller logs), they have potent formic acid defense glands (Holldobler and Wilson 1990) that may make them less attractive as prey for bears. The prominence of the Other category of ants in scats probably is a function of the ubiquitous nature of these small species of ants. They also commonly occurred in the same logs as occupied by *Camponotus* and *Formica*. Overall, they occurred over a broad range of log diameters, from 15-120 cm, and were most common in relatively rotted logs. The condition of logs in advanced stages of decay would make Other ants highly vulnerable to predation by bears. The Other ants are small; it would take about 18 of these small ants to equal the biomass of one *Camponotus* ant, and about 3.5 of them to equal the biomass of one *Formica* ant. Even though their relative biomass is small compared to *Camponotus* and *Formica*, they are readily available and in such large numbers that they presumably constitute a highly desirable food item. Their dominance in scats in terms of both biomass and frequency attests to this (Figures 1 and 2).

The greater use of insects by adult females with cubs compared to subadults and females without cubs could have a variety of explanations. Differences in nutritional requirements, movement patterns, habitat use, and behavior could influence use of food resources.

The apparent dominance of log-dwelling ants and yellowjackets in the diet of black bears in this study suggests that maintaining or enhancing black bear populations would require attention to managing coarse woody debris across landscapes. The observations that *Camponotus*, which select for large-diameter and relatively sound logs, and that other small species of ants colonize a broad array of log sizes and states of deterioration, suggest that coarse woody debris in a complex of sizes and decay states enhances ant diversity.

Animal Remains

Animal remains appeared to be an important component of the black bear diet in this study in spring and fall. The lack of intact ungulate carcasses prevented us from determining the cause of predation. Murphy et al. (1998) suggested that ungulate carrion resulting from cougar (*Felis concolor*) predation was important to bears in Glacier and Yellowstone National Parks. Although several studies evaluating mortality of elk and moose calves have identified black bears as a major factor in predation (Schlegel 1976, Smith 1994, Singer et al. 1997), studies on black bear diet in the Great Smokey Mountains (Beeman and Pelton 1977), Alaska (Hatler 1972), Idaho (Beecham and Rohlman 1994), Montana (Tisch 1959), western Washington (Poelker and Hartwell (1973), and Banff National Park (Raine and Kansas 1990) did not identify ungulate neonates as a major food source. In contrast, Holcroft and Herrero (1991) in Alberta reported considerable predation on moose calves and deer fawns and considered meat a major food of black bears.

Seven of eight neonates were found between 28 May and 22 June in this study. This timing suggests that feeding occurred when neonates were young because the peak calving period in the Starkey Wildlife Management Unit is early June (Leonard Erickson, Oregon Department of Fish and Wildlife, La Grande, OR, pers. comm.). In north central Idaho, 80% of predation losses of calf elk occurred between 30 May and 14 June (Schlegel 1976). Neonatal mortality resulting from predation in Wyoming tended to be among the early-born elk calves, and calves were 2-23 days old when killed (Smith 1994). Predation on moose calves by black bears also occurred when calves were young (Franzmann et al. 1980).

Bears are highly adapted for living on small food items that are high in nutrients, low in cellulose, and available only a portion of the year (Rogers 1987). Ants, which are high in protein, comprised a large portion of the black bear diet throughout most of the summer in this study. In this area, ants may be a more consistent source of food because fruit production varies from year to year. Consequently, managing coarse woody debris across large landscapes is an important consideration for maintaining black bear and ant populations.

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Literature Cited

Akre, R. D., A. Greene, J. F. Mac Donald, P. J. Landolt, and H. G. Davis. 1980. Yellowjackets of America North of Mexico. USDA Agriculture Handbook No. 552.

Akenson, J. J., M. G. Henjum, and T. Craddock. In Press. The use of dogs and mark-recapture techniques to estimate black bear density in northeastern Oregon. Ursus 12.

Beecham, J. J., and J. Rohlman. 1994. A Shadow in the Forest: Idaho's Black Bear. University of Idaho Press, Moscow, Idaho.

Beeman, L. E., and M. R. Pelton. 1977. Seasonal foods and feeding ecology of black bears in the Smoky Mountains. International Conference on Bear Research and Management 4:141-147.

Costello, C. M. 1992. Black bear habitat ecology in the Central Adirondacks as related to food abundance and forest management. M.S. Thesis, State University of New York, Syracuse, New York.

Franzmann, A. W., C. C. Schwartz, and R. O. Peterson. 1980. Moose calf mortality in summer on the Kenai Peninsula, Alaska. Journal of Wildlife Management 44:764-768.

Hatler, D. F. 1972. Food habits of black bears in interior Alaska. Canadian Field-Naturalist 86:17-31.

Holcroft, A. C., and S. Herrero. 1991. Black bear, *Ursus americanus*, food habits in southwestern Alberta. Canadian Field-Naturalist 105:335-345.

Holldobler, B., and E. O. Wilson. 1990. The Ants. Harvard University Press, Cambridge, Massachusetts.

Irwin, L. L., and F. M. Hammond. 1985. Managing black bear habitats for food items in Wyoming. Wildlife Society Bulletin 13:477-483.

Johnson, C. G., Jr., and F. Hall. 1990. Plant associations of the Blue Mountains. USDA Forest Service, R6-Ecological Area 3, Portland, Oregon.

Knight, R. R., and S. L. Judd. 1983. Grizzly bears that kill livestock. International Conference of Bear Research and Management 5:186-190.

Mathews, N. E., and W. F. Porter. 1988. Black bear predation of white-tailed deer neonates in the central Adirondacks. Canadian Journal of Zoology 66:1241-1242.

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Moore, T. D., L. E. Spence, and C. E. Dugnolle. 1974. Identification of the dorsal guard hairs of some mammals of Wyoming. Wyoming Game and Fish Department, Cheyenne, Wyoming.

Murphy, K. M., G. S. Felzein, M. G. Hornocker, and T. K. Ruth. 1998. Encounter competition between bears and cougars: some ecological implications. Ursus 10:55-60.

Oliver, C. D. 1992. A landscape approach–achieving and maintaining biodiversity and economic productivity. Journal of Forestry 90:2–0-25

Ozoga, J. J., and R. K. Clute. 1988. Mortality rates of marked and unmarked fawns. Journal of Wildlife Management 52:549-551.

Poelker, R. J., and H. D. Hartwell. 1973. Black bear of Washington. Biological Bulletin 14. Washington State Game Department, Olympia.

Raine, R. M., and J. L. Kansas. 1990. Black bear seasonal food habits and distribution by elevation in Banff National Park, Alberta. International Conference of Bear Research and Management 8:297-304.

Rogers, L. L. 1987. Effects of food supply and kinship on social behavior, movements, and population growth of black bears in northeastern Montana. Wildlife Monograph 97.

Schlegel, M. 1976. Factors affecting calf elk survival in north central Idaho: a progress report. Western Association of State Game and Fish Commission 56:342-355.

Singer, F. J., A. Harting, K. K. Symonds, and M. B. Coughenour. 1997. Density dependence, compensation, and environmental effects on elk calf mortality in Yellowstone National Park. Journal of Wildlife Management 61:12-25.

Smith, B. L. 1994. Population regulation of the Jackson elk herd. Ph.D. Dissertation. University of Wyoming, Laramie, Wyoming.

Snedecor, G. W., and W. G. Cochran. 1980. Statistical Methods. Seventh edition. Iowa State University, Ames, Iowa.

Tisch, E. L. 1959. Seasonal food habits of the black bear in the Whitefish Range of northwestern Montana. M.S. Thesis, Montana State University, Bozeman, Montana.

Torgersen, T. R., and E. L. Bull. 1995. Down logs as habitat for forest-dwelling ants–the primary prey of pileated woodpeckers in northeastern Oregon. Northwest Science 69:294-302.

Wheeler, G. C., and J. Wheeler. 1986. The Ants of Nevada. Allen Press, Inc., Lawrence, Kansas.