The Condor 95:1016–1023

DIET AND FORAGING BEHAVIOR OF VAUX'S SWIFTS IN NORTHEASTERN OREGON[1]

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Abstract. The diet of Vaux's Swifts (*Chaetura vauxi*) during the breeding season consisted primarily of insects in the orders Homoptera (hoppers, aphids, whiteflies), Diptera (flies), Ephemeroptera (mayflies), and Hymenoptera (ants, parasitic wasps). Diet was determined from 223 food boluses collected from adults feeding nestlings and represented 24,133 individual insects and spiders. Diet did not differ among five study areas or by time of day. A pair of swifts feeds an average of 5,344 arthropods to their nestlings each day, and an average of 154,976 arthropods during the nestling growth period.

Radio-tagged swifts foraged up to 5.4 km from the nest. Of actual sightings of radio-tagged birds, 64% were foraging over land, 27% were foraging over water, and 9% were traveling in a straight line.

Key words: Chaetura vauxi; *diet; arthropods; northeastern Oregon; swift; Vaux's Swift.*

INTRODUCTION

The Vaux's Swift (*Chaetura vauxi*) is a neotropical migrant whose numbers have declined significantly in Oregon since the 1980s (Sharp 1992). This species is more common in old-growth forests than in younger stands (Manuwal and Huff 1987, Bull and Hohmann 1992), and the amount of old-growth forest has decreased since the 1970s. Certainly their habit of nesting and roosting in large-diameter, hollow trees would explain this association with old growth (Bull 1991, Bull and Cooper 1991).

There is little published quantitative information on the diet of Vaux's Swifts. Huey (1960) examined the stomach content of one bird and found that it fed on Lepidoptera, Hymenoptera, and Diptera. Davis (1937) determined that leafhoppers appeared to be the primary food that swifts fed their young. A collection of Psocoptera obtained from swift boluses was published by Turner (1984). Stomachs of Vaux's Swifts collected in Nicaragua contained small Hymenoptera in June (Howell 1957).

Our objectives were to (1) determine diet of Vaux's Swifts during nesting in northeastern Oregon, (2) compare diet among five study areas, (3) compare diet at different times of the day, (4) relate diet to habitat within study areas, and (5) determine movements of nesting swifts in relation to habitat.

[1] Received 22 April 1993. Accepted 13 July 1993.

METHODS

STUDY AREAS

Five study areas, herein referred to as Syrup, Frog, Ukiah, Balm, and Little, were in the Blue Mountains of northeastern Oregon. Syrup and Frog were 35 km west-southwest and 41 km southwest of La Grande, Union County, respectively. Ukiah was 17 km west of Ukiah, Oregon, in Umatilla County. Balm and Little were 38 km southeast and 11 km east of Union, Oregon, in Baker and Union counties, respectively. All the study areas were predominantly coniferous forest with 2–17% of the area in grassland. Common tree species included grand fir (*Abies grandis*), Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), and western larch (*Larix occidentalis*). All areas had streams and ponds with permanent water that comprised 2–3% of each area. The study areas were selected on the basis of swift abundance.

DIET

We searched for nest trees used by Vaux's Swifts in June and July in 1991 and 1992 in all five study areas. Nests were located by watching for 1 hr trees that swifts had previously used for nesting (Bull and Cooper 1991) and that we presumed might be suitable for nesting because they appeared to be hollow. Swifts flying in or out of a tree indicated that the tree was being used as a nest site.

Once a nest tree was located, we checked it weekly for 1 hr to determine when the swifts started feeding young. When young were present, we collected diet samples by catching the adult in a net just before it entered the nest cavity. When the adult returned to the nest with a food bolus for the young, we simply collected the food bolus to get a food sample.

We used two methods to trap adults. We suspended a mist net (2 × 5 m and 6-cm mesh) between two trees so it hung in front of the nest entrance. We also used a mist net on a frame (55 × 55 cm) suspended from two shelf brackets mounted above the nest entrance. The frame was raised and lowered with strings. A tarp (5 × 6 m) was placed under the net to catch the food bolus when the bird was caught because they commonly expelled the bolus when they flew into the net.

In 1991, when we were developing this technique, we attempted to collect one diet sample from each of five nests daily for one week. In 1992, we attempted to collect three diet samples, representing different times of the day, from each of 15 nests each week. Time periods were morning (07:00–12:00), afternoon (12:01–17:00), and evening (17:01–21:00). Samples collected from one nest usually were collected on different days to reduce stress to the birds. Samples were not always obtained when scheduled because the birds learned to avoid the net or did not return to the nest tree when we were present. We attempted to catch a bird at a particular nest for up to 2 hr and then abandoned our efforts so young could be fed. Diet samples were collected in July, August, and September.

The arthropods in the food boluses were initially separated by order and then identified to family. Except for the Diptera (flies) and Hymenoptera (ants, wasps, and sawflies), some families represented by one or two specimens were classified as "others" in their particular order. The Araneida (spiders) were listed as such and not separated further. To determine the size-range of the arthropods comprising the diet, the body length of representatives of each order were measured under a microscope equipped with an ocular micrometer.

We also determined the number of arthropods fed to the young in a day by determining the average number of arthropods in each bolus and multiplying by the average number of visits to the nest in a day. We assumed that each visit was to deliver food to the young. We then multiplied by the duration of the nesting period to determine number of arthropods fed during this period. Average number of visits/hr to the nest was determined by recording activity for 9 hr at each of three nests with nestlings (Bull and Collins, in press).

We compared swift diet among five study areas and at different times of the day (morning, afternoon, and evening) in each study area and for all areas combined by using a two-way analysis of variance. Significance was defined as $P \leq 0.05$.

TELEMETRY

We gathered information on movements of nesting swifts by following swifts in two study areas. We radio-tagged four adult swifts associated with three nests in the Ukiah area and five swifts associated with three nests in the Frog area. A 0.7-g transmitter was glued to the back of each swift, and the swifts were located daily during 10 days between 29 July and 9 August.

We determined how much time swifts spent foraging above the nest stand versus foraging at a distance. Swift presence in the nest stand was monitored by standing at the nest trees at Frog and Ukiah for 6 hr on three different days and recording if the radio-tagged birds were close-by or distant. A bird with a "booming" transmitter signal, where we could not detect a direction, was classified as within the nest stand (within 0.2 km). On at least 12 occasions, the shiny antenna on a bird was actually seen, and the signal was booming. A bird with no signal or a weaker signal, where we could discern a direction, was classified as distant. These distances and categories determined from the volume of the transmitter signal are supported by other telemetry studies we have conducted in the same areas (Bull and Holthausen 1993).

Locations ≥0.4 km from the nest were extremely difficult to discern, so we attempted one location per bird per day. If we obtained two locations for one bird, they were at least 1 hr apart. To get locations throughout the day, we worked during 08:00–14:00 on half the days and during 14:00–20:00 on the other half.

We used actual sightings of the birds and very near approximations based on the volume of the signal. We found birds by getting at least two

TABLE 1. Number and percentage of arthropods in Vaux's Swift boluses collected in northeastern Oregon by year.

Arthropods	1991 *n*	1991 %	1992 *n*	1992 %
Homoptera	2,955	61	7,399	38
Diptera	891	19	5,732	30
Ephemeroptera	514	11	3,728	19
Hymenoptera	216	4	1,505	8
Lepidoptera	80	2	115	<1
Coleoptera	65	1	393	2
Araneida	51	1	256	1
Hemiptera	12	<1	72	<1
Psocoptera	1	<1	36	<1
Unknown	17	<1	95	<1

compass bearings from a transmitter, going to the general area as quickly as possible, and taking more bearings to find the bird. There were two people on all-terrain vehicles covering a 5-km radius around each nest. We did not use triangulation because of rough terrain and lack of personnel to get three simultaneous readings per bird.

When a bird was located, we recorded if it was actually seen or was judged to be within 200 m based on a strong signal. If a swift was actually seen, we recorded whether it was foraging over land (circling in flight), foraging over water (circling over water), or traveling (flying in straight line). We also recorded if the bird was foraging above a forest or grassland, the type of forest (ponderosa pine or mixed conifer), and the type of successional stage (old growth or other). A grassland was defined as an opening >2 ha. We also recorded the location on an aerial photograph and determined the distance from the nest.

We calculated the amount of forest, grassland, and permanent standing and running water within 3.5 km (3,848-ha area) of each nest (90% of all swift locations were within this radius) and defined this as available habitat. This information was obtained from aerial photographs, field work, and consultations with Forest Service personnel who had conducted stream surveys. Our sample size of actual observations was too small to statistically compare used habitat with the habitat available within each study area.

RESULTS

DIET

We collected 49 diet samples in 1991 and 174 samples in 1992. These samples represented a total of 4,802 arthropods in 1991 and 19,331 arthropods in 1992. It seems that the Vaux's Swift gathers many arthropods that are airborne during the nesting period. The spiders were probably "ballooning" on silk threads when they were caught.

The dominant arthropod taxa were similar in 1991 and 1992 (Table 1). The Homoptera (hoppers, aphids, and whiteflies), primarily three species of Cicadellidae (leafhoppers), are the most abundant, and are followed by Diptera, Ephemeroptera (mayflies), and Hymenoptera. The minor components of the diet were not comparable in 1991 and 1992, but each of these groups represented ≤2%. The percentage of the Homoptera in the diet dropped in 1992 but probably reflects the larger number of boluses examined and the greater variety of habitats represented.

The order Diptera had the most diverse assemblage of families in the diet, with the Empididae (dance flies), Muscidae (muscid flies), and Tachinidae (tachinid flies) dominant (Table 2).

The Hymenoptera were dominated by the Formicidae (ants) which represented 51% and 74% of the total in 1991 and 1992, respectively (Table 2). The parasitic Hymenoptera belonging to the families Braconidae (braconids), Ichneumonidae (ichneumons), Pteromalidae (pteromalids), and Dryinidae (dryinid wasps) were also commonly collected by the swifts. Only one stinging wasp (Vespidae) was collected during the study. Other swifts are not deterred from feeding on stinging Hymenoptera (Morse and Laigo 1969; Collins, unpubl.).

Lepidoptera (moths and butterflies) were primarily Tortricidae (leaf rollers) and smaller microlepidoptera. Western spruce budworm (*Choristoneura occidentalis*) adults accounted for most of the Tortricidae. No Lepidoptera larvae were found in the food boluses which might have indicated use of a foliage-gleaning technique reported by George (1971) for Chimney Swifts (*Chaetura pelagica*).

Although Coleoptera (beetles) were represented by several families, the Scolytidae (bark beetles) accounted for 83% of the individuals in the boluses. Species of the bark beetle genera *Ips, Scolytus,* and *Dendroctonus* were the major genera captured by swifts. Small Elateridae (click beetles) and Staphylinidae (rove beetles) were also collected.

It was interesting to note that the Hemiptera (true bugs) were not routinely found in the swift's boluses. They represented <1% of the total arthropods collected during both years (Table 1).

TABLE 2. Number of prey items (individuals/family) found in 223 food boluses of Vaux's Swifts in northeastern Oregon.

Family	1991	1992
Homoptera		
Cicadellidae	2,740	6,709
Aphidae	155	426
Psyllidae	1	160
Cercopidae	21	79
Fulgoridae	14	18
Others	24	7
Coleoptera		
Scolytidae	56	326
Curculionidae	3	4
Elateridae	—	3
Staphylinidae	—	4
Buprestidae	1	—
Others	5	56
Hymenoptera		
Formicidae	111	1,110
Braconidae	75	198
Ichneumonidae	8	84
Pteromalidae	11	68
Eulophidae	2	7
Dryinidae	1	7
Encyrtidae	—	5
Eupelmidae	—	5
Aphididae	4	4
Torymidae	—	4
Eurytomidae	—	3
Diprionidae	1	2
Chrysididae	—	1
Cynipidae	—	1
Eucharitidae	—	1
Halictidae	—	1
Figitidae	—	1
Megaspilidae	1	1
Pamphiliidae	—	1
Vespidae	—	1
Proctotrupidae	1	—
Stephanidae	1	—
Diptera		
Chloropidae	28	208
Sepsidae	33	130
Mycetophilidae	27	121
Stratiomyiidae	24	120
Syrphidae	70	118
Simuliidae	5	103
Phoridae	25	95
Sphaeroceridae	19	75
Therevidae	21	71
Lauxaniidae	3	70
Tephritidae	5	70
Ceratopogonidae	3	63
Pipunculidae	5	62
Agromyzidae	5	53
Sarcophagidae	19	53
Drosophilidae	3	47
Dolichopidae	26	45
Bombyliidae	7	42
Piophilidae	2	27
Tipulidae	7	25
Empididae	235	1,101
Muscidae	108	609
Tachinidae	70	595
Ephydridae	25	409
Bibionidae	2	388
Sciaridae	26	325
Anthomyiidae	34	286
Chironomidae	4	255
Chamaemyiidae	3	24
Heleomyzidae	1	24
Milichiidae	5	23
Lonchaeidae	8	17
Platypezidae	1	15
Scenopinidae	2	14
Cecidomyiidae	1	11
Chaoboridae	—	10
Otitidae	—	6
Dryomyzidae	—	5
Lonchopteridae	8	5
Pallopteridae	1	2
Psychodidae	—	2
Rhagionidae	4	2
Acroceridae	2	1
Asilidae	1	1
Calliphoridae	6	1
Culicidae	—	1
Opomyzidae	1	1
Tabanidae	3	1
Scatophagidae	2	—
Xylophagidae	1	—

The miscellaneous arthropods, 27 and 95 in 1991 and 1992, respectively, were composed of small numbers of Trichoptera (caddisflies), Plecoptera (stoneflies), and broken unknowns that would require more time for proper identification than could be justified considering their small component of the diet.

The diets among study areas were not statistically different ($F = 0.47$, df $= 4, 24$, $P = 0.13$). However, the higher percentage of Homoptera at Ukiah and of Diptera at Little indicated either an apparent difference in prey selection by the swifts or more likely, a local abundance of their prey (Fig. 1).

The ephemerids (mayflies) were not always present in swift boluses; however, they comprised more than 75% of each of 18 boluses. This high percentage probably correlates with timing

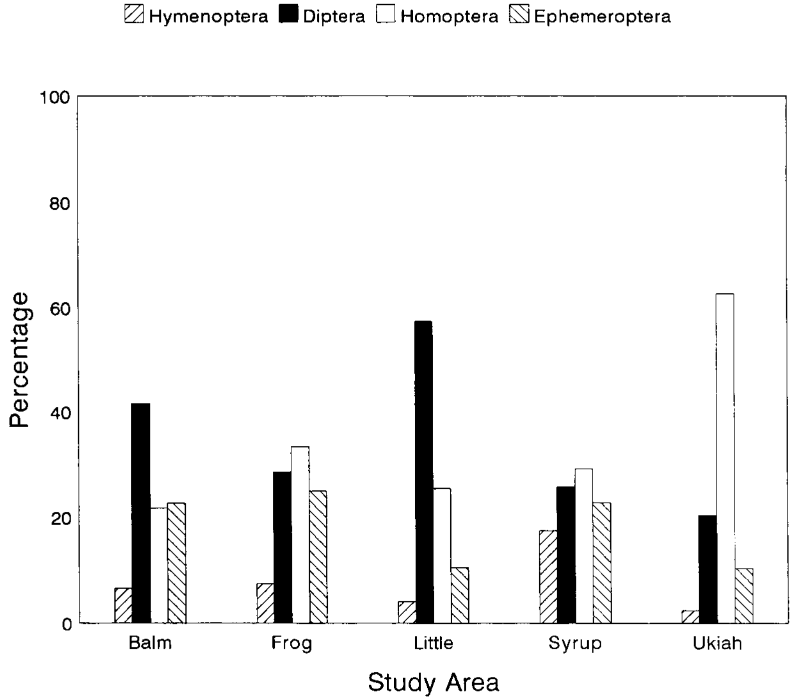

FIGURE 1. Composition (%) of major arthropod taxa in the diet of Vaux's Swifts in five study areas in northeastern Oregon, 1992.

of adult emergence of this aquatic taxon. In a similar way, individual boluses also showed peaks of occurrence of ants during swarming of reproductives; one such bolus contained 99% winged adult ants.

The average number of arthropods per bolus ranged from 96.6 at Frog to 146.4 at Ukiah (Table 3). The greater average at Ukiah probably resulted from the frequency and small size of the leafhoppers and aphids in their diet. The number of arthropods per bolus was reduced as the frequency of larger arthropods increased. The body length of the arthropods included in the diet is shown in Table 4. This range and mean size of prey items is similar to that reported for the Short-tailed Swift (*Chaetura brachyura*) (Collins 1968) and Vaux's Swifts in Venezuela (Collins, unpubl.).

TABLE 3. Mean number of arthropods per bolus of the Vaux's Swift collected in northeastern Oregon, 1992. Seven of the 174 boluses contained only partial samples so are not included here.

Area	Nests (n)	Boluses (n)	($\bar{x}$) Arthropods	SE
Balm	4	46	108.5	11.49
Frog	3	42	96.6	45.71
Little	1	5	106.2	32.71
Syrup	3	36	111.0	10.15
Ukiah	4	38	146.4	16.41
Total	15	167	115.4	5.72

We observed an average of 3.6 visits/hr to nests during 27.7 hr of observation at nests. We observed swifts foraging as early as 06:00 and as late as 21:00. Activity depended on weather, however, so we conservatively estimated that swifts foraged for 13 hr/day. This meant that swifts made 47 daily trips to the nest and assuming that they fed young each visit, they fed 5,344 arthropods/day to nestlings, using the mean from Table 3. If this foraging rate is consistent throughout the nestling period of 27–32 days (29 used in calculation), 154,976 arthropods are fed to the nestlings at each nest.

The presence of the various arthropod taxa in a bolus varied by time of day (Fig. 2), although the difference was not statistically significant ($F = 0.47$, df = 2, 12, $P = 0.64$). The apparent difference among times probably reflects the activity patterns of their prey. At specific times, individual swifts also appeared to concentrate their feeding activity to take advantage of the readily available food sources, such as swarming ants and emerging mayflies. This behavior also has been observed for other *Chaetura* swifts (Fischer 1958, Collins 1968).

FORAGING BEHAVIOR

Swifts spent the majority of their time in or over the tree stands adjacent to the nest. We monitored three birds for 18.5 hr, three birds for 17 hr, and three birds for 5 hr, and found they spent an average of 53% of their time in proximity (<0.4 km) of the nest stand.

Outside the nest stand (≥0.4 km away), we obtained 112 telemetry locations on nine birds. The swifts were actually seen in 40% of these observations. For the remainder, we could not see the bird because our vision was obstructed by the tree canopy, but we judged the bird to be within 200 m. Birds were foraging 0.4–1 km from the nest at 60% of the locations, 1.1–2 km at 21%, 2.1–3 km at 7%, and 3.1–5.4 km at 11%.

At Frog, 52% of the visual locations over 0.4 km from the nest, were over mixed conifer forests, 30% over water, and 18% over grasslands. Half the sightings over forest at Frog were over old growth, and the remainder over younger stands. Frog contained 11 ponds, 14.5 km of stream (total 2% water), 16% of the area in grasslands, and 82% in forest within 3.5 km of the nests. Ponds and streams were preferentially selected for foraging, and forests were used less

TABLE 4. Overall body length (mm) of major groups of arthropods collected from Vaux's Swift boluses in northeastern Oregon, 1992.

Arthropods	Number measured	Mean length	SE	Range
Homoptera	100	4.08	0.21	1.47–9.65
Diptera	140	5.89	0.26	2.11–13.13
Ephemeroptera	30	6.82	0.11	5.76–7.91
Hymenoptera	85	3.80	0.16	2.30–9.11
Coleoptera	69	3.96	0.09	2.24–6.30
Other insects	26	4.87	0.52	2.64–10.99
Spiders	30	2.75	0.16	1.65–5.15
Total[a]	480	4.60	0.52	1.47–13.13

[a] Mean of means ($n = 7$).

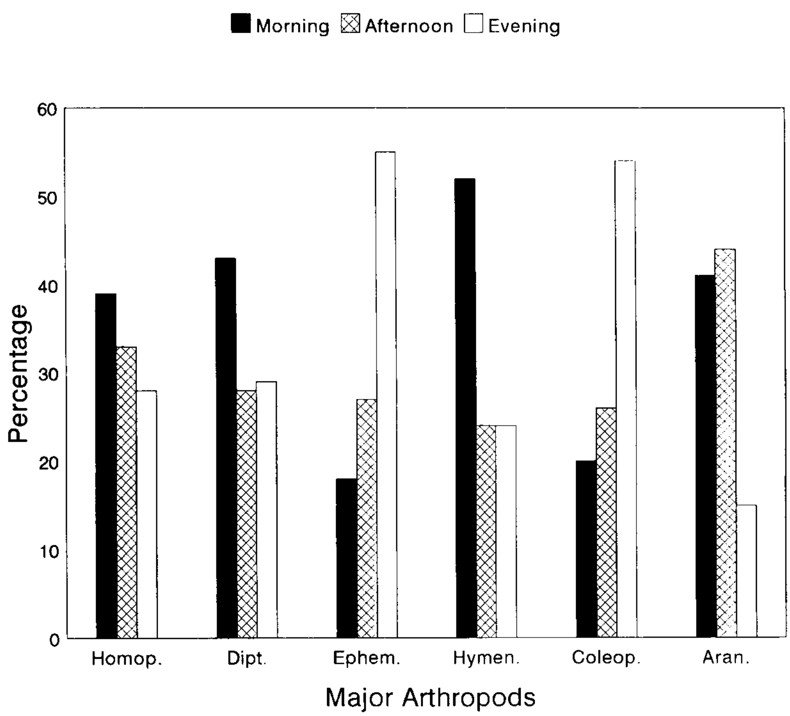

FIGURE 2. Percentage of major arthropods found in Vaux's Swift boluses at different daily times, 1992; Homop. = Homoptera, Dipt. = Diptera, Emphem. = Ephemeroptera, Hymen. = Hymenoptera, Coleop. = Coleoptera, Aran. = Araneida.

than available. Foraging over grasslands equalled their availability.

At Ukiah, 78% of the locations were over mixed conifer forests and 22% over water. Of the forest locations, 28% were in old growth and the remainder in younger stands. Ukiah contained 11 ponds, 4 km of stream (2% of area), 1% of the area in grasslands, and 97% in forest. Again foraging over water was favored.

DISCUSSION

The Vaux's Swift feeds on a high diversity and a great number of insects during the nestling period based on the content of food boluses. Radio-tagged swifts in both Frog and Ukiah foraged more over water than expected based on available area. We observed the swifts foraging over water 27% of the time, yet only 2% of the study areas had open water. Many aquatic insects (e.g., many true flies, mayflies, stoneflies, caddisflies) were likely collected near water, as well as the insects associated with the plants growing in the vicinity. The Empididae (dance flies) are often found flying in large groups near water sources or moist areas and would be easy prey for the adult swifts (Borror and DeLong 1971). During emergence periods mayflies would be a locally abundant prey item in aquatic areas (Borror and DeLong 1971).

Homoptera comprised the majority of the diet. The leafhoppers feed on a variety of plants, especially grasses and other forbs, that are common throughout all the study areas in grasslands, open pine stands, logged areas, and on a variety of plants in riparian zones (Franklin and Dyrness 1973).

The majority of foraging occurred over mixed conifer forests. Insects collected above or within these canopies likely included flies, ants, parasitic wasps, leafhoppers, bark beetles, and moths. The Muscidae (house flies, face flies, stable flies) breed in decaying vegetation and animal dung (Borror and DeLong 1971); therefore, flying adults would be common throughout all the areas because cattle were present. The Tachinidae are flies that are common parasites on herbivorous Lepidoptera and Hymenoptera larvae. The abundance of various butterflies and moths, including the western spruce budworm, can provide numerous hosts for these flies.

We found swifts foraging up to 5.4 km from the nest; however, the majority of their time was spent foraging near the nest stand. We believe it is important that nest stands have a high density of insects so the travel time and energy expenditure between foraging areas and the nest are minimized. Information is needed on insect density over and within different forest types, successional stages, and silvicultural systems to accurately assess the effects of land management activities on Vaux's Swifts.

In conclusion, the data indicate that size and composition of prey govern the composition of boluses. The Vaux's Swift feeds on rather small prey (< 13 mm) and is an extremely diverse feeder that takes advantage of the variety of arthropods that are airborne at the time the birds are nesting. In our study areas, they concentrated on the species such as leafhoppers, true flies, mayflies, flying ants, and bark beetles.

ACKNOWLEDGMENTS

We thank B. E. Carter, H. D. Cooper, R. Guse, J. E. Hohmann, C. Hunter, C. Kolmorgan, K. I. Kronner, T. Millay, S. Sheldon, P. E. Talbot, B. C. Wales, and B. R. Yonker for their assistance with field work. C. T. Collins and T. R. Torgersen reviewed an earlier draft of the manuscript. One nest was on Boise Cascade, Corp. land. We also thank J. Digiulio for identifying the Diptera and Hymenoptera to family. Funding was provided by the USDA Forest Service, Pacific Northwest Research Station.

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