

ROOSTING BEHAVIOR OF POSTFLEDGING EASTERN SCREECH-OWLS

JAMES R. BELTHOFF¹ AND GARY RITCHISON

Department of Biological Sciences, Eastern Kentucky University,
Richmond, Kentucky 40475 USA

ABSTRACT.—We examined roosting behavior of adult and juvenile Eastern Screech-Owls (*Otus asio*) during the postfledging period using radiotelemetry. We located 1,107 screech-owl roost sites in 39 species of trees, shrubs, and vines. Nearly half (47.8%) were in eastern red cedar (*Juniperus virginiana*), shagbark hickory (*Carya ovata*), black locust (*Robinia pseudo-acacia*), and black walnut (*Juglans nigra*). Owls used open limb roosts (46.4%), tangle roosts (36.2%), and conifer roosts (17.4%). Tree cavities were used rarely ($n = 3$). Open limb roosts were most common early in the postfledging period, whereas use of tangles for roosting increased later in the season. The mean roost site was 10.2 ± 0.2 m high in a tree 14.2 ± 0.2 m tall with a DBH (diameter at breast height) of 23.8 ± 0.4 cm. Based on a random sample of 800 potential roost trees, screech-owls used significantly shorter trees than those available. However, we found no significant difference in mean DBH between used and available trees. On average, screech-owls roosted 252 ± 5.3 m from their nests and moved 64 ± 3.5 m between daily roost sites. Juvenile and adult owls differed little in selection of roost sites, although juveniles used a greater variety of trees. Paired adults did not differ in roost-site use. The mean distance between roost sites of young owls and their parents (both male and female) increased significantly after the fifth week postfledging. After this period, juvenile owls roosted unaccompanied by adults much more often, which suggests young gain some independence from adults. We noted significant differences among families for all roost-site variables, with most variation explained by differences in areas occupied by families. Entire families roosted together in the same tree $31 \pm 7.5\%$ of the time (range: 16.7–51.5%). Coefficients of association at roost sites between adults and their young were similar for both members of a pair. We suggest that adult Eastern Screech-Owls do not divide their broods. Received 26 June 1989, accepted 8 February 1990.

EASTERN Screech-Owls (*Otus asio*) are small, nocturnal birds found throughout much of the eastern United States. Many aspects of screech-owl biology have been examined (e.g. Hrubant 1955; Owen 1963a, b; Marshall 1967; Ross 1969; VanCamp and Henny 1975; van der Weyden 1975; Turner and Dimmick 1981; Smith and Gilbert 1984; Cavanagh and Ritchison 1987; Hegdal and Colvin 1988; Ritchison et al. 1988; Belthoff and Ritchison 1989, MS), but little is known about the roosting behavior of Eastern Screech-Owls. Although previous work suggests that screech-owls usually roost in tree cavities, most observations were made during the autumn, winter, and early spring (Merson et al. 1983, Smith et al. 1987). Few data are available on the roosting of screech-owls during summer. Even less is known about the roosting behavior of

juvenile screech-owls and their parents during the time between fledging of the young and their subsequent dispersal.

Our objective was to examine the roosting behavior of radio-tagged adult and juvenile Eastern Screech-Owls during the postfledging period in central Kentucky. We sought to determine if screech-owls selected roost trees non-randomly from available trees, if roosts of adults and their young differed, if roosting behavior varied either among families or over time, and if parents divided their broods into subgroups.

STUDY AREA AND METHODS

We examined the postfledging behavior of Eastern Screech-Owls between mid-May and late July in 1985 and 1986 at the 680-ha Central Kentucky Wildlife Management Area, located 17 km southeast of Richmond, Madison County, Kentucky. This area comprises small deciduous woodlots and thickets interspersed with cultivated fields and old fields.

We captured adult Eastern Screech-Owls directly

¹ Present address: Department of Biological Sciences, Clemson University, Clemson, South Carolina 29634 USA.

from nest boxes and natural tree cavities, or with mist nets while using their young or playback of bounce songs (Ritchison et al. 1988) as lures. Juvenile owls were captured from nest cavities just before fledging (i.e. leaving the nest cavity permanently). In the case of one family, we captured young from tree limbs just after they fledged. We fitted captured adult and juvenile screech-owls with radio transmitters (Wildlife Materials Inc., Carbondale, Illinois) backpack style with woven nylon cord (Smith and Gilbert 1981). The transmitter and harness weighed <8 g.

After young owls fledged, we located diurnal roost sites of adults and juveniles at least four times per week in 1985 and daily in 1986 until young dispersed from natal territories (55 ± 1.3 days after fledging; Belthoff and Ritchison 1989). We located owls between noon and 1800 with portable receivers (Wildlife Materials TRX-24 or Telonics TR-2) and hand-held 2-element yagi antennas (Telonics Inc., Mesa, Arizona). Owls occasionally (<5% of observations) flew from roosts as we approached, particularly near the beginning of the postfledging period. No more than one family member ever flew from the roost, and we were usually close enough to determine the original roost location. The roost sites selected by owls after flushing were not included in the analyses. Although we did not record information about flushing behavior, adults were more likely to fly than young. Owls initiated fewer flight-intention movements and flew from roosts less frequently as the study progressed, perhaps because the owls habituated to our presence.

We categorized each roost as either cavity, open limb, conifer, tangle (Merson et al. 1983), or ground. If an owl roosted among vines in either a deciduous or coniferous tree, we classified the roost as a tangle. For each roost site, we recorded tree species, roost height, tree height, percent height (roost height/tree height), diameter at breast height (DBH), distance from nest, and distance from previous roost (only those distances recorded on consecutive days were included in the analyses). We also noted which owls in a family unit roosted together (in the same tree). We calculated coefficients of association from the formula: $2ab/(a + b)$, where a is the total number of times owl A was observed, b is the total number of times owl B was observed, and ab is the total number of times owls A and B were observed together (Cole 1949). When family members roosted separately, we measured distances between individuals (using aerial photographs of the study area to estimate distances >500 m). We estimated tree and roost heights with a clinometer. Finally, we used point-quarter sampling (Greig-Smith 1964) to determine the relative abundance of trees available for roosting. We randomly positioned transects through five woodlots used by owls, and sampled 40 stations (i.e. 160 trees) along each transect. We estimated heights and DBHs of available roost trees using these same trees.

In 1985 we radio-tagged and monitored the roosting behavior of all individuals in three families (2 adults and 3 young in each; referred to as Off-property, Muddy Creek, and Trap Range families). All individuals (4 adults and 5 young) in two families (Stream and Hilltop families) were radio-tagged in 1986. Three days before the young fledged, a Great Horned Owl (*Bubo virginianus*) killed the adult female in the Hilltop family. We captured and radio-tagged the adult male and three young from another family (Goose Pen) in 1986. We were unable to radio-tag the Goose Pen adult female, who was observed only occasionally. We also monitored a seventh family, the 1986 Trap Range family. We were able to radio-tag only 3 of 4 young in this brood, considered these data supplemental, and excluded them from analyses. All references to the Trap Range family refer to 1985 unless otherwise noted.

Data analysis.—We used analysis of variance (ANOVA) to test for effects of age, family, and time (weeks) on the roosting behavior of Eastern Screech-Owls. If significant effects existed, then we estimated means (least squares means) for ages, families, and time and conducted pairwise t -tests to make comparisons of these means. To examine possible effects of increasing age on the roosting behavior of juvenile screech-owls and their parents, we pooled observations into weekly categories. Most young Eastern Screech-Owls dispersed during the eighth and ninth weeks after fledging, which resulted in some empty cells in the ANOVA for week 9. We combined data from these 2 weeks for analyses. To avoid possible temporal pseudoreplication (Hurlbert 1984), we considered the effect of time as a repeated measure in the ANOVA (Krebs 1989: 274). For these analyses we considered roost sites of individuals as independent observations. Thus, if all five members of a family roosted in the same tree on the same day, or if one owl roosted in the same site on five different days, we considered these as five independent roosts. We assumed that sites used more than once were favorable. In this manner, characteristics of roosts used more than once, or by more than one family member, were weighted proportional to their use.

We used Mann-Whitney U -tests (Zar 1974) to examine differences in the number of roost-tree species used by owls of different age classes, to examine differences between sexes of adults in coefficients of association with offspring, and to examine differences in trees used for roosting and available roost trees. We conducted Chi-square goodness-of-fit tests to examine differences among frequencies of observed and expected roost species. If a cell in any contingency table had an expected value <1, species were pooled to raise the value and reduce the degrees of freedom. All tests were two-tailed (nondirectional), and significance levels were set at 0.05. Values are means and standard errors ($\bar{x} \pm SE$).

RESULTS

ROOST-SITE CHARACTERISTICS

Overall.—We located 1,107 roost sites of adults ($n = 10$) and juveniles ($n = 17$) during postfledging in 1985 and 1986. Screech-owls used 39 species of trees, shrubs, and vines, plus unidentified snags for roosting (Table 1). Nearly half (47.8%) of all roosts were located in four species of trees. Species in owl territories but not used include pawpaw (*Asimina triloba*), sugar maple (*Acer saccharum*), tulip poplar (*Liriodendron tulipifera*), and white mulberry (*Morus alba*).

The mean roost site was 10.2 ± 0.2 m high (range: 0–27.1 m, $n = 1,068$) in a tree 14.2 ± 0.2 m tall (range: 0.9–36.0 m, $n = 1,103$) with a DBH of 23.8 ± 0.4 cm (range: 2.5–89.4 cm, $n = 1,094$). The mean height of a sample of 800 trees was 15.2 ± 0.3 m, significantly taller than trees used by roosting owls (Mann-Whitney U -test, $P < 0.0001$). The mean DBH of available trees was 24.9 ± 0.5 cm, but this did not differ significantly from DBH of trees used by roosting owls (Mann-Whitney U -test, $P > 0.140$). Owls roosted an average of 252.5 ± 5.3 m (range: 1.8–691.3 m, $n = 1,107$) from their nest sites. Although roost sites used by owls on successive days were 63.7 ± 3.5 m (range: 0–740.7 m, $n = 861$) apart, individuals used the same roost on consecutive days 10.7% of the time. Juvenile owls roosted 53.4 ± 4.5 m (range: 0–717.8 m, $n = 734$) from the adult male, and 36.0 ± 3.8 m (range: 0–512.1 m, $n = 522$) from the adult female.

Eastern Screech-Owls used open limb roosts most frequently (46.4%), then tangle roosts (36.2%) and conifer roosts (17.4%). Only one individual (1986 Trap Range adult female) roosted in tree cavities ($n = 3$) during the post-fledging period, all during the first week after the young fledged. Once, a young owl roosted on the ground beneath a fallen branch.

The mean open limb roost was 12.7 ± 0.3 m ($n = 491$) high in a tree with a mean height of 17.6 ± 0.4 m ($n = 510$) and a mean DBH of 26.2 ± 0.6 cm ($n = 504$). Open limb roosts were significantly higher and in trees significantly taller than either tangle or conifer roosts (ANOVA; $P < 0.05$). Owls roosted on open limbs in 34 species of trees and shrubs. Shagbark hickory (*Carya ovata*, 25.4%), black walnut (*Juglans nigra*, 7.8%), and sweet gum (*Liquidambar styraciflua*, 7.8%) were used most frequently. The mean tan-

gle roost was 8.8 ± 0.3 m ($n = 393$) high in a tree with a mean height of 11.9 ± 0.3 m ($n = 399$) and a mean DBH of 22.1 ± 0.7 cm ($n = 396$). Tangle roosts were located in trees significantly smaller than available trees, both in height (Mann-Whitney U -test, $P < 0.0001$) and DBH (Mann-Whitney U -test, $P < 0.0002$). Owls roosted in tangles in 31 species of trees and shrubs, with black locust (*Robinia pseudoacacia*, 17.6%), eastern red cedar (*Juniperus virginiana*, 9.3%), and box elder (*Acer negundo*, 6.8%) used most frequently. The mean conifer roost was 6.9 ± 0.2 m ($n = 184$) high in trees with a mean height of 9.9 ± 0.3 m ($n = 192$) and mean DBH of 20.7 ± 0.9 cm ($n = 192$). Conifer roosts were also in trees significantly smaller both in height and DBH (Mann-Whitney U -test, $P < 0.0001$ for each) than available trees. Eastern red cedar was the only species of conifer used.

Variation among families.—All six families roosted in tree species at frequencies different from expected based on availability (Table 1). Three families (Muddy Creek, Off-property, and Goose Pen) roosted in eastern red cedar significantly more than expected. Other tree species used more often than expected by individual families included shagbark hickory (used by Trap Range), southern red oak (*Quercus falcata*) and black gum (*Nyssa sylvatica*) (used by Off-property), black locust and black walnut (used by Stream), and apple (*Malus* sp.) (used by Hilltop). Tree species used less often than expected based on availability included sassafras (*Sassafras albidum*), red maple (*Acer rubrum*), and southern red oak (all used by Trap Range); green ash (*Fraxinus pennsylvanica*) (used by Off-property and Goose Pen), shagbark hickory, black gum, and sweet gum (all used by Muddy Creek), chinquapin oak (*Quercus prinoides*) and Shumard oak (*Q. shumardii*) (used by Stream), and white ash (*Fraxinus americana*) (used by Hilltop). Three families (Off-property, Stream, and Goose Pen) used snags less often than expected.

All six owl families roosted in trees that differed significantly in size (height and DBH) from available trees. Four families roosted in trees smaller than those available, while the remaining two families roosted in larger than expected trees (Fig. 1a, b). We noted many significant differences in mean roost height, tree height, DBH, percent height, distance from nest, and distance between successive roosts among fam-

TABLE 1. Percentage tree and shrub species selected by six families of Eastern Screech-Owls ($n = 1,107$) during the postfledging period in central Kentucky. We determined percentages of available tree species (Avail. %) using point-quarter sampling of 160 randomly selected trees along transects through each owl territory. The Muddy Creek and Stream families used the same woodlot, and only one census of 160 trees was conducted for both. Sample sizes are in parentheses beneath each age class.

Species	Family								
	Off-property			Muddy Creek			Trap Range		
	Ad. (67)	Juv. (104)	Avail. %	Ad. (73)	Juv. (110)	Avail. %	Ad. (65)	Juv. (95)	Avail. %
<i>Juniperus virginiana</i>	17.9	25.0	7.5	56.1	48.2	6.9	3.1	4.2	0.6
<i>Carya ovata</i>	0.0	1.0	0.0	0.0	0.0	10.0	53.8	61.1	31.3
<i>Robinia pseudoacacia</i>	20.9	13.5	23.1	1.4	0.0	0.0	0.0	0.0	0.0
<i>Juglans nigra</i>	3.0	3.8	1.9	1.4	0.0	3.8	0.0	9.4	0.6
<i>Liquidambar styraciflua</i>	1.5	1.0	0.0	2.7	1.8	10.0	15.4	9.4	10.0
<i>Cercis canadensis</i>	0.0	0.0	0.6	0.0	1.0	5.6	0.0	0.0	0.0
<i>Acer negundo</i>	5.9	3.8	0.0	1.4	2.7	3.1	0.0	0.0	0.0
<i>Ulmus americana</i>	4.5	3.8	11.9	9.6	7.3	2.5	0.0	0.0	2.5
<i>Quercus falcata</i>	16.4	21.2	0.0	0.0	0.0	0.0	1.5	3.2	12.5
<i>Fraxinus americana</i>	1.5	0.0	1.3	5.5	9.1	6.9	0.0	0.0	1.3
<i>Morus rubra</i>	9.0	5.8	0.6	5.5	3.6	0.6	0.0	0.0	1.3
<i>Celtis occidentalis</i>	4.5	3.8	6.3	2.7	1.8	2.5	0.0	0.0	0.0
<i>Ostrya virginiana</i>	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	0.6
<i>Malus</i> sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Quercus shumardii</i>	0.0	0.0	0.0	0.0	0.0	4.4	12.3	6.3	1.3
<i>Cornus florida</i>	0.0	3.8	0.0	0.0	2.7	1.3	0.0	0.0	0.0
<i>Gleditsia triacanthos</i>	0.0	1.0	2.5	4.1	0.0	1.3	0.0	0.0	0.0
<i>Sassafras albidum</i>	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	7.5
<i>Nyssa sylvatica</i>	5.9	5.8	0.0	0.0	0.0	5.6	0.0	0.0	0.0
<i>Diospyros virginiana</i>	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Quercus alba</i>	0.0	0.0	0.0	0.0	0.0	1.3	1.5	0.0	1.9
<i>Q. imbricaria</i>	4.5	1.0	0.6	2.7	2.7	1.9	1.5	0.0	3.1
<i>Platanus occidentalis</i>	0.0	1.9	8.8	0.0	0.0	1.3	0.0	1.1	1.3
Others*	3.0	3.8	35.0	6.9	19.1	23.7	10.8	5.3	29.8
χ^2 -value, df	142.0, 18			158.6, 23			87.4, 11		
P-value	0.0001			0.0001			0.0001		

* Other species used for roosting (Overall [%] used, Overall [%] sampled): *Carya tomentosa* (0.8, 0.4); *Quercus stellata* (0.6, 1.3); *Carya laciniata* (0.6, 0.9); *Rhamnus caroliniana* (0.5, 0.0); *Quercus prinoides* (0.5, 1.3); *Acer rubrum* (0.5, 2.0); *Ailanthus altissima* (0.5, 0.0); *Quercus velutina* (0.5, 0.5); *Ulmus rubra* (0.5, 0.5); *Carya cordiformis* (0.4, 1.4); *Fraxinus pennsylvanica* (0.4, 6.9); *Prunus serotina* (0.3, 0.1); *Tilia americana* (0.1, 0.0); *Vitis* spp. (0.1, 0.0); *Lonicera* spp. (0.1, 0.0); *Carya glabra* (0.1, 0.1); unidentified snag (2.5, 7.6); utility pole/vines (0.3, 0.0); ground (0.1, 0.0).

ilies (Table 2). Families also differed significantly in the mean distance between roost sites of adults and their young (Table 2) and in the roost types they used ($\chi^2 = 249.6$, $df = 10$, $P < 0.001$; Fig. 2).

Adult males vs. females, and adults vs. juveniles.—Overall, we observed no significant differences in the type or characteristics of roost sites used by adult male and female screech owls (Table 3); and there was no family effect. Adult and juvenile owls did not differ significantly in their use of roost types (Table 3), although we noted a significant family effect ($P < 0.01$). Significant differences existed between adults and juveniles in two families only. Ju-

veniles in the Stream family used open limb roosts more, and tangle roosts less, than their parents (Chi-square test, $P < 0.05$), whereas Goose Pen juveniles used conifer roosts less often, and tangle roosts more often than their parents ($P < 0.001$).

We noted no differences between adult and juvenile owls in roost height, roost-tree height, DBH, percent height, or the distance of roost sites from nest trees (Table 3). The mean distance between daily roost sites was significantly greater for adults than juveniles for all six families pooled ($P < 0.05$), but we also noted a significant family effect ($P < 0.0001$). Within individual families, distances between daily

TABLE 1. Extended.

Family										
Stream			Goose Pen			Hilltop			Overall	
Ad. (108)	Juv. (107)	Avail. %	Ad. (66)	Juv. (155)	Avail. %	Ad. (54)	Juv. (101)	Avail. %	Total	Avail. %
13.0	9.3	6.9	48.5	22.6	4.4	0.0	1.0	0.0	20.8	3.9
21.3	18.7	10.0	1.5	2.6	1.3	0.0	0.0	5.6	12.9	9.6
12.0	0.0	0.0	9.1	23.2	23.8	5.6	5.9	3.1	8.4	10.0
14.8	13.1	3.8	0.0	0.0	3.8	13.0	9.9	8.1	5.7	3.6
6.5	8.4	10.0	0.0	0.0	0.6	7.4	5.9	18.8	4.6	7.9
0.9	1.9	5.6	7.6	23.9	16.9	0.0	3.0	0.6	4.4	4.8
6.5	5.6	3.1	0.0	0.0	0.0	14.8	13.9	4.4	4.3	1.5
0.9	0.0	2.5	3.0	3.9	6.9	9.3	6.9	11.9	3.9	7.1
0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	3.4	2.5
3.7	5.6	6.9	1.5	1.9	0.6	0.0	0.0	9.4	2.6	3.9
0.0	0.0	0.6	4.6	2.6	0.6	0.0	0.0	0.0	2.4	0.9
0.0	1.9	2.5	0.0	1.3	3.8	0.0	9.9	4.4	2.3	3.4
7.4	11.2	3.8	0.0	0.0	0.0	0.0	0.0	3.8	1.8	1.6
0.0	0.0	0.0	0.0	0.0	0.0	18.5	8.9	0.0	1.7	0.0
0.0	0.0	4.4	0.0	0.0	0.0	0.0	4.0	2.5	1.6	1.6
0.0	5.6	1.3	1.5	1.3	0.6	0.0	1.0	0.0	1.5	0.4
0.9	0.0	1.3	0.0	1.9	3.1	7.4	3.0	2.5	1.4	1.9
0.9	2.8	3.8	4.6	5.2	2.5	0.0	0.0	1.3	1.4	3.0
0.9	1.9	5.6	0.0	0.0	0.6	0.0	0.0	0.0	1.2	1.4
0.0	0.0	0.0	7.6	3.9	6.3	0.0	0.0	0.0	1.1	1.3
5.6	3.7	1.3	0.0	0.0	0.0	1.8	0.0	5.0	1.1	1.6
0.0	0.0	1.9	0.0	0.0	0.0	0.0	1.0	0.6	1.0	1.3
0.0	1.9	1.3	3.0	0.0	3.1	3.7	2.0	2.5	1.0	3.4
4.5	8.4	23.1	7.5	5.7	21.2	16.4	23.0	13.7	9.4	23.0
	93.1, 23			85.1, 15			81.8, 19			
	0.0001			0.0001			0.0001			

roost sites were significantly different for adults and juveniles ($P < 0.01$) in the Hilltop family only ($\bar{x} = 177.5 \pm 37.5, n = 51$ and $\bar{x} = 56.3 \pm 10.4, n = 98$ for adults and juveniles, respectively).

Juvenile owls used significantly more tree species for roosting than adults (Mann-Whitney U -test, $P < 0.02$). Adults used 14 ± 0.9 species for roosting (range: 11–17, $n = 6$ families), and juvenile owls used 16 ± 1.9 species (range: 8–22). We noted few differences in the roost species used by adult and juvenile owls within families, although occasional large differences (greater than approximately 10% difference in use) appeared (Table 1).

Accompanied vs. unaccompanied young.—Unaccompanied young roosted in significantly different sites than young roosting with one or

both adults (Table 4). There were, however, significant interactions ($P < 0.001$) with family for roost height, tree height, DBH, and percent height. In two families (Muddy Creek and Stream), unaccompanied young roosted in significantly smaller trees (height and DBH) than accompanied young. Young in these two families also roosted lower when not accompanied by adults (both in actual height and percent height). Hilltop family young roosted proportionately lower (percent height) when unaccompanied by adults. Neither the distance between daily roost sites nor the distance of roost sites from nests was influenced by the presence or absence of adults ($P > 0.860$ for each). Finally, unaccompanied and accompanied young did not differ in use of roost types ($\chi^2 = 3.71, df = 2, P > 0.16, n = 5$ families).

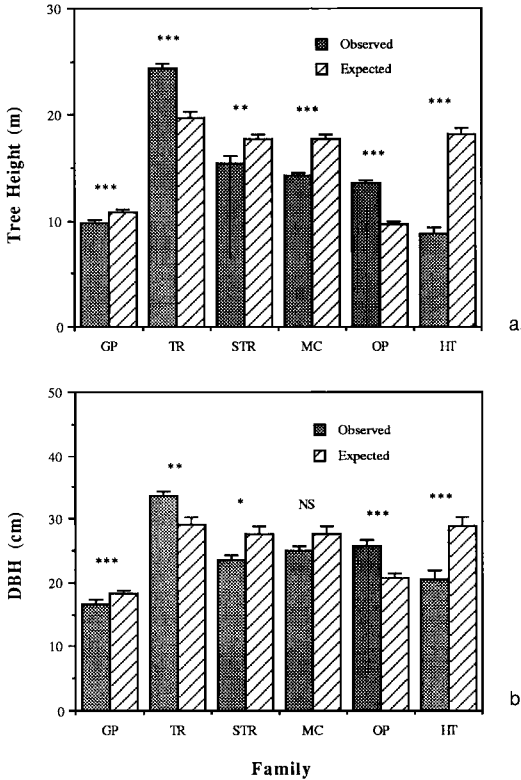


Fig. 1. A comparison of (a) observed vs. expected tree heights and (b) observed vs. expected DBHs. We generated expected values based on point-quarter sampling of 160 potential roost trees in each owl territory and compared them with observed sites using a Mann-Whitney *U*-test (* = *P* < 0.05; ** = *P* < 0.01; *** = *P* < 0.001; NS = *P* > 0.05). Families: GP = Goose Pen; TR = Trap Range; STR = Stream; MC = Muddy Creek; OP = Off-property; HT = Hilltop.

ASSOCIATION OF FAMILY MEMBERS

Entire families (*n* = 4) roosted together 31 ± 7.5% of the time (range: 16.7–51.5%). Although all members of a family never roosted together on the first day after fledging, they did so frequently from the 2nd through the 44th day. Between the 44th day and juvenile dispersal, entire families no longer roosted together. Young screech-owls roosted with adults (one or both) 63 ± 7.7% of the time (range: 54–86%). Adult females (coefficient of association = 57 ± 8.1; range: 42–81) roosted with young more often than adult males (43 ± 7.1; range: 24–59), but the difference was not significant (Mann-Whitney *U*-test, *P* > 0.20). Within families (*n* = 4),

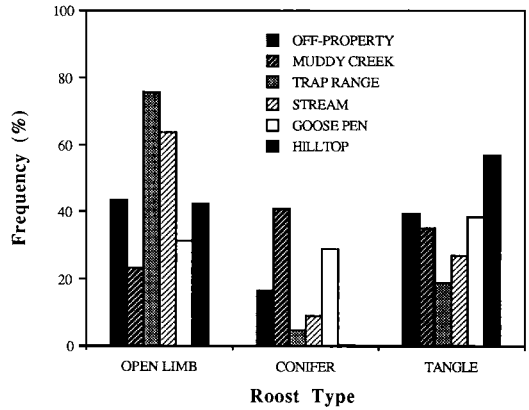


Fig. 2. Frequency (%) of open limb, tangle, and conifer roosts used by six families of Eastern Screech-Owls (adults and juveniles pooled) during the post-fledging period in central Kentucky. Sample sizes: Off-property (173), Muddy Creek (183), Trap Range (161), Stream (214), Goose Pen (220), and Hilltop (155).

adult males and females did not exhibit preferences for roosting with particular young (Fig. 3).

TEMPORAL VARIATION

Characteristics of roost sites.—Eastern Screech-Owls exhibited significant variation in the types of roost sites used as the postfledging period progressed ($\chi^2 = 244.8$, *df* = 14, *P* < 0.001; Fig. 4). During the first 2 weeks postfledging, owls used open limb roosts most commonly, and used few tangle roosts. Together, these weeks accounted for 50.9% of overall Chi-square variation. During week 4 after fledging, owls used each roost type equally. From week 5 after fledging until dispersal of young, owls used tangle roost sites more often than either open limb or conifer roost sites.

Most roost-site characteristics varied significantly during the period from fledging until dispersal. Because a significant family effect (ANOVA) existed, we could not pool family data. Mean roost height varied over time in all six families, but we observed no consistent tendencies (Fig. 5a). We observed similar results for tree height, DBH, and percent height. In contrast, the mean distance of roost sites from the nest was significantly lower during week 1 after fledging in all six families (Fig. 5b). The

TABLE 2. Characteristics (LS $\bar{x} \pm$ SE) of roost sites used by six families of Eastern Screech-Owls (adults and juveniles pooled). Means with the same letter are not significantly different ($\alpha = 0.05$). Sample sizes are in parentheses.

Family	Roost height (m)	Tree height (m)	Percent height (%)	DBH (cm)	Dist. from previous roost (m)	Dist. from nest (m)	Dist. from* adult female (m)	Dist. from* adult male (m)
Off-property	9.7 \pm 0.3 B (172)	13.6 \pm 0.5 B (172)	72.2 \pm 1.2 B (172)	25.8 \pm 1.0 B (172)	68.2 \pm 10.2 BC (98)	397.3 \pm 9.1 A (173)	43.9 \pm 12.1 BC (104)	81.9 \pm 8.0 A (101)
Muddy Creek	10.5 \pm 0.3 B (183)	14.2 \pm 0.5 B (182)	73.0 \pm 1.1 B (182)	25.0 \pm 0.9 B (183)	30.4 \pm 10.2 D (99)	102.5 \pm 9.8 D (183)	13.7 \pm 11.9 C (107)	12.8 \pm 7.8 C (107)
Trap Range	20.6 \pm 0.4 A (160)	24.4 \pm 0.5 A (168)	83.3 \pm 1.2 A (160)	33.6 \pm 1.0 A (160)	21.0 \pm 10.4 D (95)	290.7 \pm 9.4 B (161)	57.9 \pm 12.7 AB (95)	24.9 \pm 8.3 BC (94)
Stream	10.4 \pm 0.3 B (194)	15.5 \pm 0.4 C (214)	71.8 \pm 1.1 B (193)	23.4 \pm 0.9 B (211)	56.3 \pm 6.9 C (213)	103.2 \pm 8.1 D (215)	44.0 \pm 11.9 BC (107)	38.6 \pm 7.8 B (107)
Goose Pen	6.3 \pm 0.3 C (208)	9.8 \pm 0.4 D (223)	72.6 \pm 1.1 B (207)	16.6 \pm 0.9 D (219)	80.1 \pm 7.0 AB (207)	405.9 \pm 8.0 A (222)	74.2 \pm 9.9 AB (154)	5.3 \pm 11.6* (48)
Hilltop	4.9 \pm 0.4 D (151)	8.8 \pm 0.5 D (155)	65.4 \pm 1.2 C (151)	20.4 \pm 1.0 C (149)	97.8 \pm 8.3 A (149)	215.3 \pm 9.6 C (154)	92.5 \pm 12.5 A (98)	—

* Data from juveniles only.

^b Female not radio-tagged and excluded from analyses.

distance between daily roost sites typically increased during weeks 6–8 (Fig. 5c), with significant increases during this period in four families.

The mean distance between roost sites of adults (both male and female) and young did not vary significantly during weeks 1–5 (Fig. 5: d, e). However, distances increased significantly during either week 6 or 7 in all families, and remained significantly higher until young dispersed from natal areas.

Association of family members.—During weeks

1–5 after fledging, adults (the male, the female, or both) roosted with young 67.5% of the time (Fig. 6). In contrast, adults roosted with young only 30.6% of the time during weeks 6–9 post-fledging. Siblings were also less likely to roost with each other during the weeks immediately before dispersal. In four families with three young, all siblings roosted together 86.5% of the time during weeks 1–5 after fledging. During weeks 6–9, all siblings roosted together only 47.5% of the time. All three siblings roosted separately only 1.5% of the time during weeks

TABLE 3. Comparisons of roost sites (LS $\bar{x} \pm$ SE) used by adult and juvenile Eastern Screech-Owls ($n = 6$ families) and by adult males and females ($n = 4$ families) during the postfledging period. Sample sizes are in parentheses (***) = $P < 0.001$; NS = $P > 0.05$.

	Adults	Juveniles		Adult male	Adult female	
Roost type						
Open limb (%)	47.0 (205)	46.0 (308)	NS	54.1 (85)	48.1 (76)	NS
Tangle (%)	34.9 (152)	37.0 (248)		33.8 (53)	33.5 (53)	
Conifer (%)	18.1 (79)	17.0 (114)		12.1 (19)	18.4 (29)	
Roost height (m)	10.6 \pm 0.3 (417)	10.0 \pm 0.3 (651)	NS	12.2 \pm 0.5 (149)	12.7 \pm 0.5 (152)	NS
Tree height (m)	14.7 \pm 0.4 (433)	13.8 \pm 0.3 (670)	NS	16.5 \pm 0.6 (157)	17.0 \pm 0.6 (156)	NS
Percent height (%)	74.0 \pm 0.8 (415)	72.4 \pm 0.6 (650)	NS	75.4 \pm 1.1 (148)	75.0 \pm 1.1 (152)	NS
DBH (cm)	24.8 \pm 0.6 (432)	23.1 \pm 0.5 (662)	NS	26.2 \pm 1.0 (157)	26.8 \pm 1.0 (156)	NS
Dist. from nest (m)	257.8 \pm 5.8 (436)	249 \pm 4.6 (672)	NS	206.3 \pm 13.2 (159)	211.8 \pm 13.3 (157)	NS
Dist. from previous roost (m)	78.5 \pm 5.8 (327)	48.7 \pm 4.5 (534)	***	53.5 \pm 6.4 (112)	50.8 \pm 6.6 (108)	NS

TABLE 4. Roost characteristics (LS $\bar{x} \pm$ SE) of accompanied (by at least one adult) and unaccompanied juveniles in five Eastern Screech-Owl families (we excluded the Goose Pen family because the adult female could not be located consistently). Sample sizes are in parentheses; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; NS $P > 0.05$.

Variable	Family			
	Off-property		Muddy Creek	
	Accomp.	Unaccomp.	Accomp.	Unaccomp.
Roost height (m)	9.6 \pm 0.5 (55)	9.7 \pm 0.6 NS (49)	11.9 \pm 0.5 (61)	8.1 \pm 0.6*** (46)
Tree height (m)	13.2 \pm 0.7 (55)	13.6 \pm 0.8 NS (49)	15.5 \pm 0.7 (61)	11.7 \pm 0.8*** (46)
DBH (cm)	26.1 \pm 1.7 (55)	27.1 \pm 1.8 NS (49)	27.6 \pm 1.6 (61)	21.2 \pm 1.9* (46)
Percent height (%)	73.3 \pm 2.0 (55)	71.3 \pm 2.1 NS (49)	76.5 \pm 1.9 (61)	69.2 \pm 2.2* (46)
Dist. from roost (m)	78.7 \pm 10.6 (41)	44.3 \pm 15.6 NS (19)	35.9 \pm 11.8 (33)	28.1 \pm 13.1 NS (27)
Dist. from nest (m)	407 \pm 14.8 (55)	402 \pm 15.7 NS (49)	107 \pm 14.1 (61)	103 \pm 16.2 NS (46)

1-5 after fledging, and 7.5% of the time during weeks 6-9. Thus, when all three siblings did not roost together, usually only one sibling roosted alone. One sibling roosted apart from the other two 11.7% of the time during weeks 1-5 postfledging, and 45% of the time during weeks 6-9. One family (Stream) had only two young, which roosted together 96.4% of the time during weeks 1-5 after fledging, and 78.9% of the time thereafter.

DISCUSSION

Eastern Screech-Owls typically selected roost sites that provided concealment. Trees frequently used for roosting were often those with dense foliage. In contrast, available trees rarely or never used for roosting appeared to provide little cover. Tangles (vines) also provided cover and were frequently used for roosting. In addition to concealing birds from potential predators, the dense cover of most roost sites probably provided favorable microclimates (e.g. shade and shelter from precipitation). Hayward and Garton (1984) found that Western Screech-Owls (*Otus kennicottii*), Boreal Owls (*Aegolius funereus*), and Northern Saw-whet Owls (*A. acadicus*) prefer roosts that provide both thermal protection and concealment.

We rarely found screech-owls in tree cavities. However, our observations ended when the

young owls dispersed (mid-July). As in other areas (VanCamp and Henny 1975, Merson et al. 1983, Smith et al. 1987), Eastern Screech-Owls in Kentucky frequently roost in tree cavities during the autumn and winter. The increased use of cavities during the autumn and winter in part reflects changes in the amount of cover (VanCamp and Henny 1975). Cavities may also provide a more favorable microclimate (McComb and Noble 1981, Smith et al. 1987) and, therefore, even those trees that provide cover throughout the year (e.g. eastern red cedar) are rarely used during late autumn and winter (pers. obs.).

Screech-Owls roosted in trees that were significantly shorter than the average available. This apparent preference for shorter trees probably results in part from the frequent use of eastern red cedars and tangle roosts. Eastern red cedars sampled on the area were significantly smaller than deciduous trees. Also, some of the vines that create tangle roosts (e.g. *Lonicera japonica*) do not grow very high (Wharton and Barbour 1973), and are more common in shorter trees. Screech-owls may also use lower roost sites during summer because such sites are cooler and provide more shelter from wind than higher sites in the canopy.

We found that individuals usually did not use the same roost site on successive days. Our presence may have disturbed the owls and caused

TABLE 4. Extended.

Trap Range		Family			
		Stream		Hilltop	
Accomp.	Unaccomp.	Accomp.	Unaccomp.	Accomp.	Unaccomp.
21.6 ± 0.4 (82)	18.6 ± 1.1*	15.0 ± 0.6 (53)	4.6 ± 0.6***	5.2 ± 0.7 (31)	4.8 ± 0.5 NS (66)
25.3 ± 0.6 (82)	22.5 ± 1.5*	20.2 ± 0.7 (59)	9.1 ± 0.8***	7.6 ± 1.0 (31)	9.1 ± 0.7 NS (67)
35.0 ± 1.4 (82)	27.5 ± 3.5 NS (13)	28.7 ± 1.7 (59)	14.7 ± 1.9***	16.1 ± 2.3 (30)	19.3 ± 1.6 NS (63)
85.1 ± 1.6 (82)	77.6 ± 4.1 NS (13)	77.8 ± 2.0 (53)	59.8 ± 2.2***	71.2 ± 2.7 (31)	62.5 ± 1.8*** (66)
16.3 ± 9.3 (53)	17.1 ± 34.0 NS (4)	38.2 ± 9.0 (57)	64.0 ± 9.8 NS (48)	47.4 ± 12.2 (31)	62.5 ± 8.5 NS (64)
276 ± 12.1 (82)	311 ± 30.5 NS (13)	85 ± 14.3 (59)	111 ± 15.9 NS (48)	223 ± 19.7 (31)	180 ± 13.4 NS (67)

them to seek different roosts each day. Alternatively, using different roost sites each day may reduce the chances of predation, especially on the more vulnerable young. We often noted "whitewash" beneath roost sites, even those used for just one day. Reuse of sites, and the accumulation of droppings, could attract potential predators. It is also possible that limited reuse simply indicates that many suitable roost sites are available. Both Merson et al. (1983) and Smith et al. (1987) reported repeated use of certain roost sites by screech-owls, and similar behavior has been reported in other owl species (e.g. Dunstan 1970, Barrows 1981, Hayward and Garton 1984). However, repeated use of roost sites by Eastern Screech-Owls is more common during winter than in summer, and often involves the repeated use of certain tree cavities or nest boxes (Merson et al. 1983, Smith et al. 1987). Reduced cover from leaf fall during the autumn months plus the use of favorable microclimates during cold winter months probably limits the number of suitable roost sites available to screech-owls during winter. This could lead to the repeated use of especially favorable sites (e.g. certain cavities).

Although we noted significant variation in roosting behavior among families, this variation appeared to result from differences in the areas these families occupied. For example, one territory (Trap Range) contained tall stands of

trees with limited understory, and owls in this territory roosted significantly higher in significantly larger (taller and with greater diameters) trees than birds in other territories. Habitat differences also contributed to differences in the mean distance between the nest and roost sites. Two families (Off-property and Goose Pen) used nest cavities located in relatively small, isolated woodlots adjacent to areas characterized by wooded fence rows and scattered patches of trees separated by old fields and cropland. Because these families rarely roosted in the small woodlots that contained their nests and surrounding areas were so patchy, the average distance from nest to roost sites increased. In these habitats, suitable roost sites were also more scattered, which contributed to the greater distances between successive roosts in some families.

We found no differences in the roosting behavior of adult male and female screech-owls, and differences between adults and juveniles occurred in one or two families. Because families often roosted together, few differences among family members may be expected. Even when young owls roosted away from parents, however, we observed no consistent differences. It appears that, regardless of either sex or age (with the possible exception of newly fledged owls as described below), Eastern Screech-Owls exhibit similar roosting behavior.

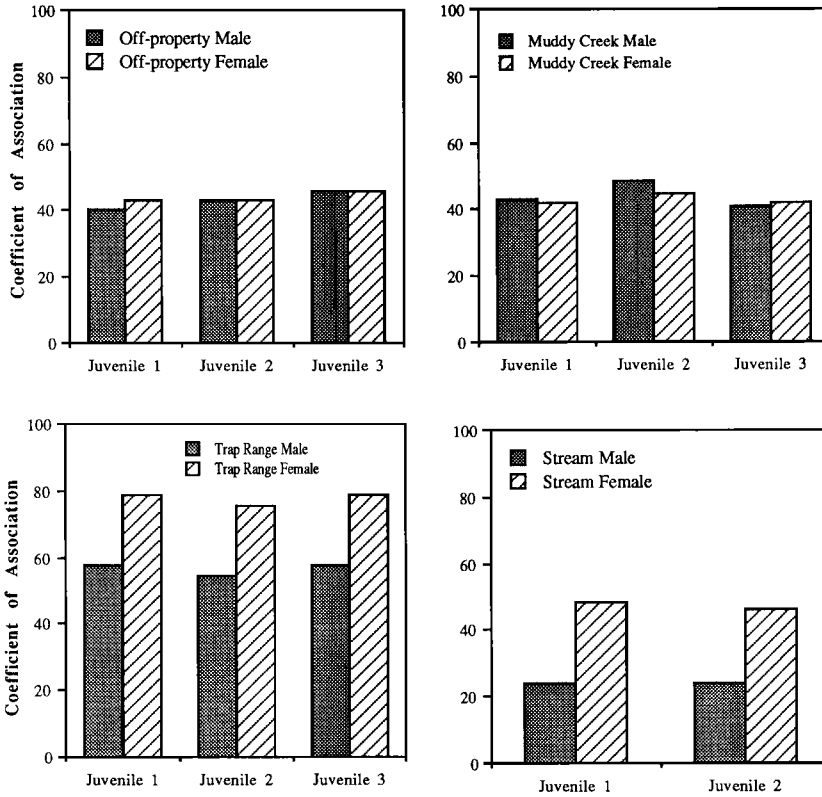


Fig. 3. Coefficients of association in roost sites between adult Eastern Screech-Owls and each of their offspring in four families.

As the postfledging period progressed, owls used tangle roost sites more and open limbs less. At least two factors contributed to this apparent shift in preferences. Most important, tangle sites probably become more common as the summer progresses and vines continue to grow, and tangles probably increase in quality (amount of cover). A second factor may be the increasing age of young owls. During the first few days after leaving nest cavities, young screech-owls may use roost sites unlike those typically used by adults (Gehlbach 1986). Sometimes they roost on open limbs that provide little or no cover (pers. obs.). Young screech-owls may use such sites because they are unable to fly and are limited in their choice of roost sites, or because some learning is involved in site selection. Open limbs may also provide adult owls coming to feed young with easier access, and the young owls may be unable to move to better sites after being fed.

Other roost-site characteristics also exhibited

significant variation during the postfledging period, but we observed few consistent trends. Screech-owls roosted significantly closer to nest sites during the first week after fledging. For

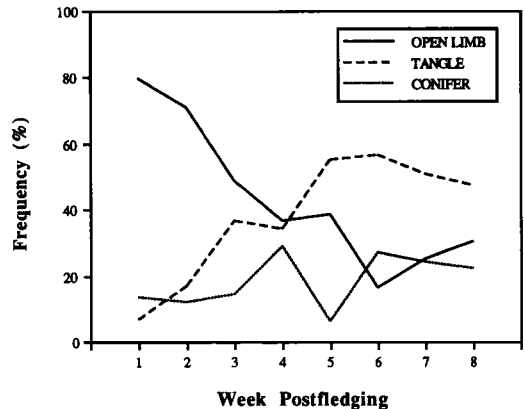


Fig. 4. Screech-owl roost type use during the postfledging period (families pooled).

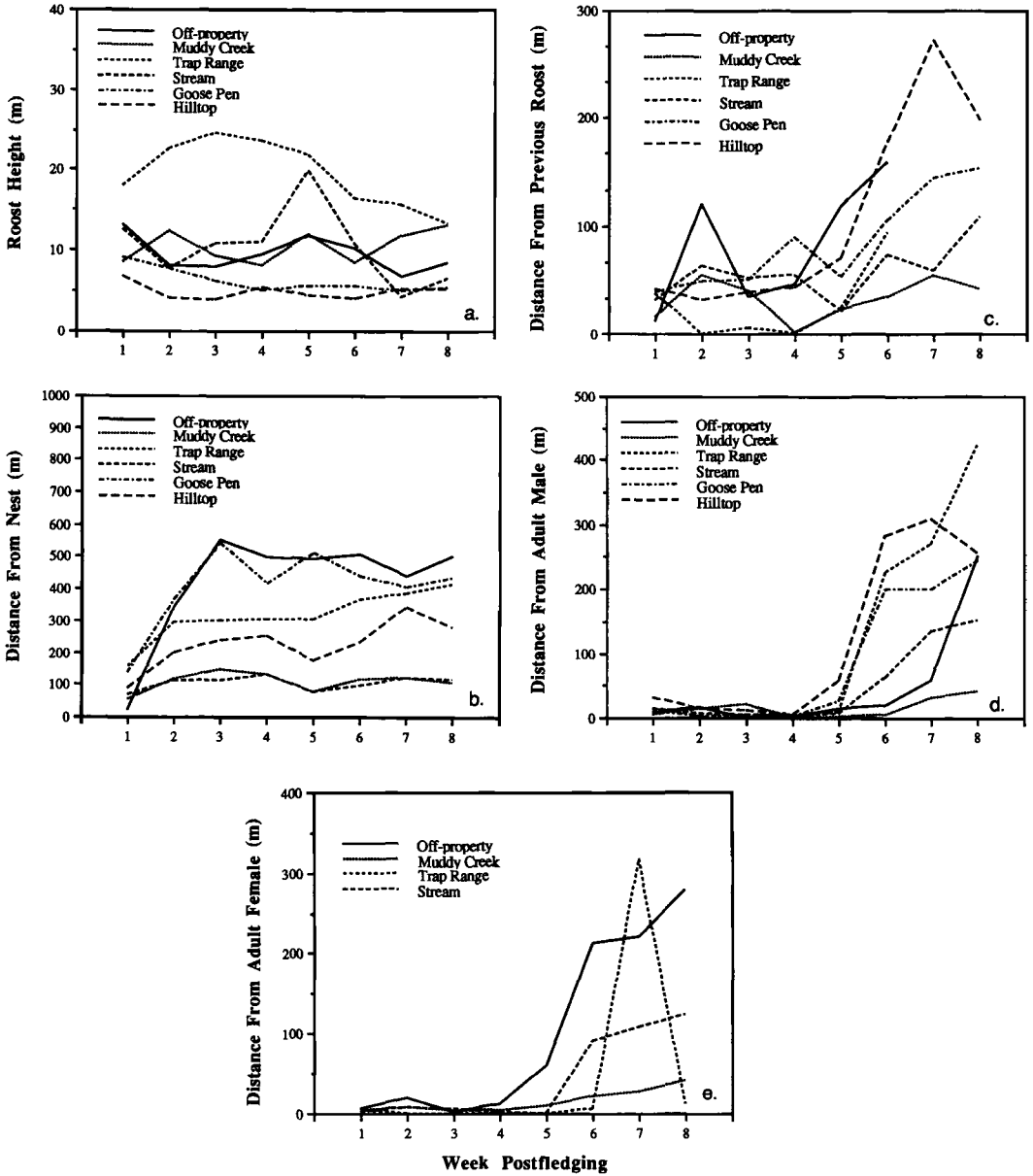


Fig. 5. Weekly family means (adults and juveniles pooled) for (a) roost height, (b) distance from nest, (c) distance from previous roost, (d) distance between young and adult male, and (e) distance between young and adult female.

several days after leaving the nest cavity, many young screech-owls are unable to fly (Gehlbach 1986). Thus, young owls, and the adults roosting with them, remained closer to nest sites during the first week after fledging.

In week 6 after leaving the nest, distances between daily roost sites increased significantly

for adults and juveniles in four families. During this same week, the distance between roost sites of adults and young increased significantly. Subsequently, adults and their young rarely roosted together. The increased distances appear to coincide with increased independence of the young. Based on biweekly home-range

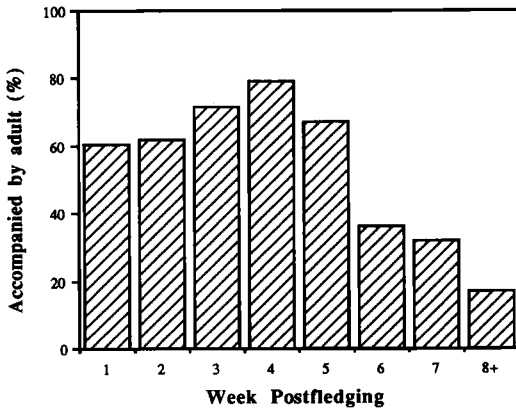


Fig. 6. Percentage of juvenile roost sites at which one or more adult owls were present (i.e. accompanied young).

overlap between adult owls and their young, juvenile owls begin to move more widely outside the ranges of their parents at this time (Belthoff 1987). Linkhart and Reynolds (1987) reported similar observations in a family of Flammulated Owls (*Otus flammeolus*). The mean distance between roosts of an adult male and its young was less than 35 m during the first 13 days after fledging, but it increased to 227 m during the next 20 days (Linkhart and Reynolds 1987). Forsman et al. (1984) also reported that adult Spotted Owls (*Strix occidentalis*) roosted with their young less frequently as the young matured.

Although we found that the frequency with which juvenile screech-owls roosted with siblings declined somewhat during the postfledging period, siblings frequently roosted together up to the time of dispersal from natal areas. Spotted Owl siblings also remain together throughout the summer (Forsman et al. 1984). Although such behavior suggests that screech-owl siblings may disperse together, we found that they do not (Belthoff and Ritchison 1989). Advantages to siblings that continue to roost together after independence are unclear, but they may relate to those associated with living in groups.

Male and female Eastern Screech-Owls roosted with each of their young a similar proportion of time. This behavior and the tendency of siblings to roost together suggest the absence of brood division in screech-owls. Gehlbach's (1986) observation of a fledgling screech-owl being fed by both adults on the second night

after fledging supports this. In contrast, Linkhart and Reynolds (1987) found that broods of Flammulated Owls divided into two subgroups, one attended only by the adult male and the other only by the adult female. Flammulated Owl subgroups moved from nests in different directions, and subsequent contact between them was not observed during the remainder of the fledgling dependency period (Linkhart and Reynolds 1987). Despite the difficulty of observing young birds after they leave the nest, brood division has been reported in a wide variety of species (McLaughlin and Montgomerie 1985). In fact, McLaughlin and Montgomerie (1985) could find no clear examples of species in which parents did not divide their broods. Our results and those of Gehlbach (1986) suggest that screech-owl broods are not divided into subgroups, but more detailed observations are needed. For example, McLaughlin and Montgomerie (1985) observed that both parents fed young Lapland Longspurs (*Calcarius lapponicus*) on the day of fledging, and that brood division occurred on the second day after fledging. Thus, both adults may feed young screech-owls soon after fledging (i.e. Gehlbach 1986), and brood division may occur later in the postfledging period. Further, Boxall (1983) observed that each adult fed particular young in a family of American Redstarts (*Setophaga ruticilla*), even though the brood remained together. Therefore, further observations of adults feeding young later in the postfledging period are needed to determine if brood division occurs in Eastern Screech-Owls.

ACKNOWLEDGMENTS

We thank Paul Cavanagh, Keith Krantz, Earl Sparks, and Tim Towles for assistance in the field, and Dale Droge, David Tonkyn, and Steve Wagner for suggestions on the manuscript. Dwight Smith and Alan H. Brush offered many constructive comments on the submitted version. We especially thank William Bridges Jr. for assistance with statistical analyses. Financial support was provided by Sigma Xi, the Scientific Research Society, and by Eastern Kentucky University. Clemson University provided computer access for many of the statistical analyses.

LITERATURE CITED

- BARROWS, C. 1981. Roost selection by Spotted Owls: an adaptation to heat stress. *Condor* 83: 302-309.
 BELTHOFF, J. R. 1987. Post-fledging behavior of the

- Eastern Screech-Owl (*Otus asio*). M.S. thesis, Richmond, Eastern Kentucky Univ.
- , & G. RITCHISON. 1989. Natal dispersal of Eastern Screech-Owls. *Condor* 91: 254-265.
- BOXALL, P. C. 1983. Observations suggesting parental division of labor by American Redstarts. *Wilson Bull.* 95: 673-674.
- CAVANAGH, P. M., & G. RITCHISON. 1987. Variation in the bounce and whinny songs of the Eastern Screech-Owl. *Wilson Bull.* 99: 620-627.
- COLE, L. C. 1949. The measurement of interspecific association. *Ecology* 30: 411-424.
- DUNSTAN, T. C. 1970. Post-fledging activities of juvenile Great Horned Owls as determined by radio-telemetry. Ph.D. dissertation, Vermillion, Univ. South Dakota.
- FORSMAN, E. D., E. C. MESLOW, & H. M. WIGHT. 1984. Distribution and biology of the Spotted Owl in Oregon. *Wildl. Monogr.* 87: 1-64.
- GEHLBACH, F. C. 1986. Odd couples of suburbia. *Nat. Hist.* 6: 56-66.
- GREIG-SMITH, P. 1964. *Quantitative plant ecology*. London, Butterworth.
- HAYWARD, G. D., & E. O. GARTON. 1984. Roost habitat selection by three small forest owls. *Wilson Bull.* 96: 690-692.
- HEGDAL, P. L., & B. A. COLVIN. 1988. Potential hazard to Eastern Screech-Owls and other raptors of brodifacoum bait used for vole control in orchards. *Environ. Toxicology Chem.* 7: 245-260.
- HRUBANT, H. E. 1955. An analysis of the color phases of the Eastern Screech-Owl, *Otus asio*, by the gene frequency method. *Am. Nat.* 89: 223-230.
- HURLBERT, S. H. 1984. Pseudoreplication and the design of ecological field experiments. *Ecol. Monogr.* 54: 187-211.
- KREBS, C. J. 1989. *Ecological methodology*. New York, Harper and Row.
- LINKHART, B. D., & R. T. REYNOLDS. 1987. Brood division and postnesting behavior of Flammulated Owls. *Wilson Bull.* 99: 240-243.
- MARSHALL, J. T., JR. 1967. Parallel variation in North and Middle American Screech Owls. *West. Found. Vert. Zool., Monogr.* 1: 1-72.
- MCCOMB, W. C., & R. E. NOBLE. 1981. Microclimates of nest boxes and natural cavities in bottomland hardwoods. *J. Wildl. Manage.* 45: 284-289.
- MCLAUGHLIN, R. L., & R. D. MONTGOMERIE. 1985. Brood division by Lapland Longspurs. *Auk* 102: 687-695.
- MERSON, M. H., L. D. LETA, & R. E. BYERS. 1983. Observations on roosting sites of Screech-Owls. *J. Field Ornithol.* 54: 419-421.
- OWEN, D. F. 1963a. Variation in North American Screech Owls and the subspecies concept. *Syst. Zool.* 12: 8-145.
- . 1963b. Polymorphism in the Screech Owl in eastern North America. *Wilson Bull.* 75: 183-190.
- RITCHISON, G., P. M. CAVANAGH, J. R. BELTHOFF, & E. J. SPARKS. 1988. The singing behavior of Eastern Screech-Owls: seasonal timing and response to playback of conspecific song. *Condor* 90: 648-652.
- ROSS, A. 1969. Ecological aspects of the food habits of insectivorous Screech Owls. *Proc. West. Found. Vert. Zool.* 1: 301-344.
- SMITH, D. G., & R. GILBERT. 1981. Backpack radio transmitter attachment success in Screech Owls (*Otus asio*). *N. Am. Bird Bander* 6: 142-143.
- , A. DEVINE, & R. GILBERT. 1987. Screech Owl roost site selection. *Birding* 19: 6-15.
- , & R. GILBERT. 1984. Eastern Screech-Owl home range and use of suburban habitats in southern Connecticut. *J. Field Ornithol.* 55: 322-329.
- TURNER, L. J., & R. W. DIMMICK. 1981. Seasonal prey capture by the Screech Owl in Tennessee. *J. Tennessee Acad. Sci.* 56: 56-59.
- VANCAMP, L. F., & C. J. HENNY. 1975. The Screech Owl: its life history and population ecology in northern Ohio. *North Am. Fauna No. 171*. Washington, D.C., U. S. Fish and Wildl. Serv.
- VAN DER WEYDEN, W. J. 1975. Scops and screech owls: vocal evidence for a basic subdivision in the genus *Otus* (Strigidae). *Ardea* 63: 65-77.
- WHARTON, M. E., & R. W. BARBOUR. 1973. *Trees and shrubs of Kentucky*. Lexington, Univ. Kentucky Press.
- ZAR, J. H. 1974. *Biostatistical analysis*. Englewood Cliffs, New Jersey, Prentice-Hall Inc.