The Hunting Behavior of Eastern Screech-owls (*Otus asio*)

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Abstract.—We studied the nocturnal hunting behavior of eight radio-tagged Eastern Screech-owls (*Otus asio*; five females and three males) during the period from November 1994 through March 1995. Screech-owls selected low perches when hunting ($\bar{x}$ = 1.66 m), presumably to obtain a clear view of the ground and an unobstructed flight path to prey. Low perches may also improve the ability of screech-owls to hear and locate prey. Screech-owls used perches at different heights when hunting different types of prey and also tended to perch higher when moonlight was available, perhaps because increased light levels permit owls to rely more on vision. Only 8 of 35 attacks were successful, and this low success rate suggests that owls were more often attempting to capture small mammals rather than invertebrates. Male and female screech-owls exhibited similar hunting behavior, with no differences observed in the types of prey hunted or in giving up times. Weather conditions and season (early winter vs. late winter) had little effect on the hunting behavior of screech-owls.

While the hunting behavior of diurnal predators has been studied by several investigators (e.g., Fitzpatrick 1981, Greig-Smith 1983, Rice 1983, Sonerud 1992), few studies of the hunting behavior of nocturnal predators have been conducted (Bye *et al.* 1992). The hunting behavior of owls, in particular, is little known, with most information anecdotal or speculative (Bent 1938, Voous 1989). Consequently, little is known about how factors such as weather, moon phase (i.e., light levels), snow cover, sex, and temporal distribution of prey might influence the hunting habits of owls.

Eastern Screech-owls (*Otus asio*) are small, nocturnal predators found throughout eastern North America (Johnsgard 1988). Researchers have examined several aspects of their behavior and ecology, including food habits (Craighead and Craighead 1956, Ritchison and Cavanagh 1992), home range sizes and habitat use (Belthoff *et al.* 1993, Sparks *et al.* 1994), nest site selection (Belthoff and Ritchison 1990), and the postfledging behavior of adults and young (Belthoff 1987). Very little is known, however, about their hunting behavior.

Gehlbach (1994) gathered information concerning the hunting behavior of Eastern Screech-owls in central Texas, however, observations were made only in suburban yards and in the immediate vicinity of nests. Thus, little is known about how screech-owls hunt in more natural habitats and at locations some distance from nest sites.

Eastern Screech-owls apparently hunt in a sit-and-wait fashion, using short flights to capture prey (Marshall 1967, Gehlbach 1994). It has also been suggested that Eastern Screech-owls may rely primarily on sight when searching for prey because they have symmetrical ear openings (Marshall 1967, Norberg 1987). Bye *et al.* (1992) suggested that Boreal Owls (*Aegolius funereus*) used low perches while hunting because they rely primarily on their sense of hearing. Thus, at least in Boreal Owls, sensory capabilities may play an important role in determining how prey are located and captured. This may also be the case for Eastern Screech-owls.

The objective of this study was to describe the hunting behavior of Eastern Screech-owls during the non-breeding period. We specifically sought to examine: (1) possible differences between the hunting behavior of males and females, (2) seasonal and temporal variation in

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screech-owl hunting behavior, and (3) the possible effects of weather and moon phase on hunting behavior.

STUDY AREA

The hunting behavior of Screech-owls was studied from November 1994 through March 1995 at the Central Kentucky Wildlife Management Area, located 17 km southeast of Richmond, Madison County, Kentucky. The study area was composed of a patchwork of small deciduous woodlots, old fields, agricultural fields, and mowed fields connected by woodrows. Dominant woodland canopy tree species included shagbark hickory (*Carya ovata*), bitternut hickory (*C. cordiformis*), post oak (*Quercus stellata*), chinquapin oak (*Q. prinoides*), boxelder (*Acer negundo*), and red oak (*Q. borealis*). The mid-story layer was composed primarily of red maple (*Acer rubra*), flowering dogwood (*Cornus florida*), pawpaw (*Asiminia triloba*), spice bush (*Lindera benzoin*), silky dogwood (*C. amomum*), and hackberry (*Celtis occidentalis*). Common edge and old field tree species included black locust (*Robinia pseudo-acacia*), white ash (*Fraxinus americana*), smooth sumac (*Rhus glabra*), and sweetgum (*Liquidambar styraciflua*); while American sycamore (*Plantanus occidentalis*) and black willow (*Salix nigra*) were frequently found in wet and riparian areas. The eastern red cedar (*Juniperous virginiana*) was widely distributed throughout the study area. Two vines, summer grape (*Vitus aestivalis*) and heart-leaf ampelopsis (*Ampelopsis cordata*), were common in woodlots.

Terrestrial crayfish (*Cambarus* spp.) are common throughout much of the study area, particularly in low, poorly drained areas and along streams (Ritchison and Cavanagh 1992, pers. observ.). These crayfish typically produce small mounds of soil around the entrances to their burrows, and these mounds clearly indicate the presence of active crayfish. Other prey species that are potentially available to screech-owls in our study area include various small mammals, birds, and invertebrates (Ritchison and Cavanagh 1992).

METHODS AND MATERIALS

Beginning in November 1994, Eastern Screech-owls were captured by checking nest boxes distributed throughout the study area. Nest boxes were checked during daylight hours when screech-owls are typically docile and more easily handled. After capture, radio-transmitters (Wildlife Materials, Inc., Carbondale, IL) were attached backpack style (Smith and Gilbert 1981). Transmitters weighed approximately 6 g (3 to 4 percent of total body mass). The owls appeared to adjust quickly to the transmitters, and did not appear to behave abnormally (pers. observ.). Owls were allowed at least 1 week to become accustomed to the transmitter before observations began. To facilitate observations, a 5 to 6 cm piece of reflective tape was attached to the transmitter antennas.

Observations typically began shortly after sunset and continued for 3 to 5 hours. During owl observations, the general location of a radio-tagged owl was determined using a receiver (TR-2; Telonics, Inc., Mesa, AZ) and a hand-held, two-element antenna. Then, a Petzel headlamp or portable wheat lamp was used to scan the area from which the signal originated. Normally the light would strike the reflective tape on the transmitter's antenna and permit us to precisely locate the owl. While observing an owl, a light with a red cellophane filter was used to minimize disturbance as owls are known to have limited vision at the red end of the light spectrum (greater than 600 nm; Martin *et al.* 1975).

Eastern Screech-owls are relatively tame and typically do not fly until an observer comes within 3 or 4 m (pers. observ.). Our observations of screech-owls were usually made at a distance of 10 to 12 m using 10 x 25 binoculars. At this distance, our presence appeared to have little effect on the owls. The owls sometimes allowed us to watch them for more than an hour before moving, and owls often flew in our direction or directly over us when changing perches.

To examine possible differences in hunting behavior over time, November and December were categorized as early winter, and January, February, and March as late winter. For each hunting observation, we recorded the time the owl landed on a perch and the time until the owl either initiated an attack or left for another perch (i.e., giving up time). If an owl was not observed landing on a perch, we sometimes estimated their time of arrival at the perch by monitoring the transmitter's signal. Transmitters had activity switches so pulse rates typically changed when an owl stopped moving.

After the owl moved to another location, perches and attack sites (the point on the ground where the owl hit or attempted to hit the prey) were marked with flagging and plotted on an aerial photograph of the study area. We returned to these marked perch sites during daylight hours to measure perch heights, identify and measure the tree, shrub, or vine in which the perch was located, measure attack distances (the distance from the perch to the prey item attacked), and measure distances between consecutive perches.

We also noted whether or not attacks were successful and, if so, attempted to identify the prey species. We noted and flagged the search area (where the focal owl appeared to be looking for prey). For perches where no attack was made or where the attack was unsuccessful, we noted the type of prey (e.g., crayfish, small mammal, or bird) that the owl was probably hunting. We made this judgement based either on where the owl appeared to be searching or, less frequently, on prey species that we actually observed the owl to be watching. For example, an owl searching the ground in a low, poorly drained area with numerous crayfish burrows was assumed to be hunting crayfish, while an owl searching the ground in a drier area with no crayfish burrows was assumed to be hunting small mammals. Owls peering intently into eastern red cedars or dense shrubs were thought to be hunting birds.

During each observation period, we recorded the air temperature and, for subsequent analysis, categorized temperature as either above freezing or below freezing. We also noted the presence or absence of precipitation and, on that basis, categorized conditions as: snowing, raining, or no precipitation. We also noted the presence or absence of snow cover and whether or not the moon was visible.

Analysis

Because the number of observations on each owl varied, and to avoid bias from pooling such data (Leger and Didrichsons 1994), overall mean values were calculated using the means for each bird. We used different subsets of the data for other analyses. Owls were included in a particular analysis only if represented in all categories. For example, an owl would be included in an analysis of possible differences in perch height with season only if observed hunting during both seasons (early winter and late winter).

Multiple comparisons were made using non-parametric analysis of variance (analysis of variance on ranked data which is equivalent to the Kruskal-Wallis test; SAS Institute 1989). Paired comparisons (e.g., males versus females) were made using Wilcoxon rank sum tests (which are equivalent to Mann-Whitney U tests; SAS Institute 1989). All analyses were performed using the Statistical Analysis System (SAS Institute 1989). All values are presented as mean $\pm$ standard deviation.

RESULTS

Capture and Observation of Owls

Eight adult Eastern Screech-owls (five females and three males) were tracked during the period between November 10, 1994 and March 11, 1995. These owls were observed for a total of 168.5 hours during 91 evenings. Hereafter, these owls will be referred to by the last three digits of their U.S. Fish and Wildlife Service aluminum bands (table 1). Based on observations during previous breeding seasons and during the breeding season that followed our study, it was determined that two of these owls (male 099 and female 285) represented a mated pair. The mated status of the other owls was unknown. One owl (female 285) died during the study, and the cause of death could not be determined.

Table 1.—*Tracking period and number of nights tracked for each Eastern Screech-owl.*

Owl	Sex	Tracking period	Number of nights tracked
931	Female	11/10/94 - 2/24/95	19
016	Female	1/4/95 - 3/5/95	8
285	Female	11/14/94 - 11/24/94	4
959	Female	1/8/95 - 2/22/95	9
041	Female	11/18/94 - 2/25/95	13
099	Male	11/10/94 - 3/11/95	11
307	Male	11/11/94 - 3/8/95	14
215	Male	11/12/94 - 3/2/95	13

Hunting Behavior - Overall

Eastern Screech-owls (N = 8) used a total of 338 hunting perches, and these perches were an average of 1.66 $\pm$ 0.22 m high. The mean

height of the vegetation (e.g., tree, shrub, or vine) in which these perches were located was 5.04 ± 1.81 m, and the mean d.b.h. was 11.07 ± 6.13 cm. Most hunting perches (63.2 percent) were on an open branch (25 cm or more away from the trunk), rather than near the trunk (less than 25 cm from the trunk) (23.0 percent) or on the stub or top of a plant (13.8 percent).

Owls (N = 6) initiated 35 attacks from hunting perches, with 27 being unsuccessful (no prey captured) and eight successful. The successful attacks resulted in the capture of one bird, one crayfish, one small mammal, and five moths. The mean attack distance was 3.41 ± 0.79 m. Owls (N = 8) remained on perches for an average of 393.7 ± 204.2 sec before either attacking or giving up. Screech-owls (N = 8) leaving perches without making an attack (i.e., giving up time) remained on perches for an average of 278.9 ± 99.3 sec, while owls (N = 5) that attacked prey were on perches for an average of 226.1 ± 108.9 sec prior to initiating the attack. Mean giving up time for these latter five owls was 323.9 ± 90.4 sec. When owls (N = 6) changed perches (either after an attack or after giving up), the mean distance between consecutively used perches was 9.28 ± 4.12 m.

Screech-owls appeared to hunt six different types of prey: birds, insects, crayfish, small mammals, leeches, and fish. Owls appeared to hunt primarily crayfish (49.7 percent of all observations), small mammals (29.7 percent), and birds (5.4 percent) (fig. 1). Four owls (041, 215, 931, and 959) were observed hunting all three of these primary prey items, and perch height varied significantly with type of prey being hunted ($F_{2,9}$ = 17.69, P = 0.0008). Mean perch height when hunting birds was 2.86 ± 1.11 m. By contrast, mean perch height was 1.90 ± 0.45 m when owls were hunting small mammals and 1.27 ± 0.10 m when hunting crayfish. We found no significant differences in the perch position (open branch, near trunk, or at the top of the plant) used by owls hunting the three primary prey items (χ^2 = 6.7, df = 4, P = 0.155). Giving up times for these four owls varied significantly with type of prey hunted ($F_{2,6}$ = 6.35, P = 0.033): a mean of 308.7 ± 539.7 sec for crayfish, 486.8 ± 522.7 sec for small mammals, and 721.9 ± 1175.9 sec for birds.

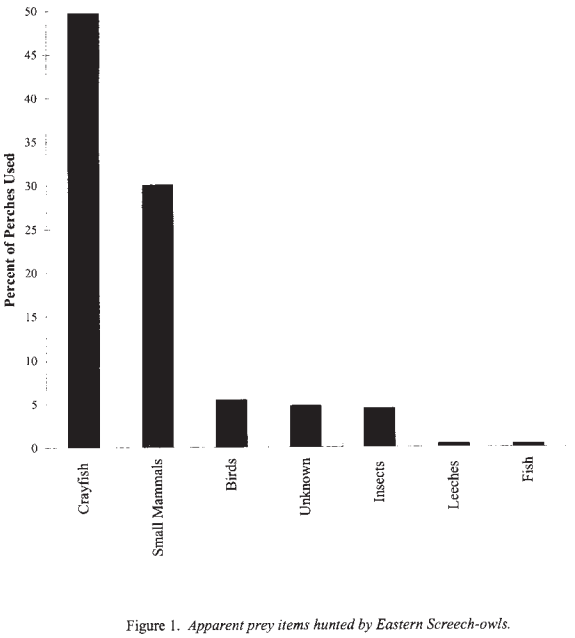

Figure 1. *Apparent prey items hunted by Eastern Screech-owls.*

Figure 1.—*Apparent prey items hunted by Eastern Screech-owls.*

Hunting Behavior - Males versus Females

Hunting perches used by male and female screech-owls did not differ significantly in height (z = 0, P = 0.99), with a mean perch height of 1.65 ± 0.18 m for females (N = 5) and 1.66 ± 0.35 m for males (N = 3). Similarly, there were no differences in either the mean height (z = 0.89, P = 0.37; $\bar{x}$ = 5.69 ± 1.98 m for females and 3.97 ± 0.93 m for males) or mean d.b.h. (z = 1.49, P = 0.14; $\bar{x}$ = 13.56 ± 6.60 cm for females and 6.92 ± 1.70 cm for males) of the vegetation in which these perches were located. Males and females did, however, exhibit a significant difference in choice of perch positions (χ^2 = 7.6, df = 2, P = 0.023), with females more likely to perch near the trunk and males more likely to perch on the stub or top of a plant (fig. 2).

We found no difference between male and female screech-owls (z = 0.6, P = 0.55) in giving up time: a mean of 238.8 ± 122.7 sec for males (N = 3) and 303.0 ± 88.4 sec for females (N = 5).

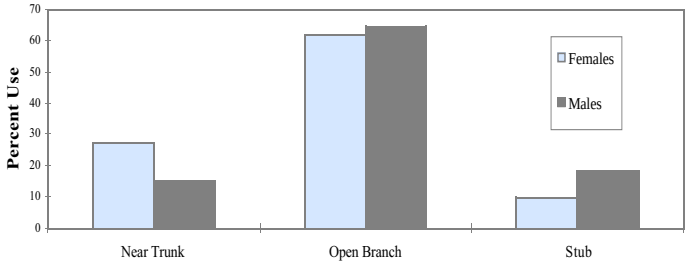

Figure 2.—*Choice of perch positions by male and female Eastern Screech-owls.*

We also found no difference (z = 0.29, P = 0.77) between males and females in mean attack time, with a mean of 273.3 ± 122.4 sec for females (N = 3) and 155.4 ± 28.4 sec for males (N = 2).

Male and female screech-owls also did not differ (z = 0, P = 0.99) in mean attack distance. The mean attack distance for females (N = 4) was 3.64 ± 0.91 m, while for males (N = 2) the mean distance was 2.96 ± 0.01 m. Similarly, the mean distance between consecutive perches did not differ (z = 0.23, P = 0.82) between the sexes, with females (N = 4) moving a mean distance of 8.3 ± 4.8 m and males (N = 2) a mean distance of 11.3 ± 2.0 m.

Both males and females appeared to hunt primarily for crayfish, followed by small mammals and birds. There was no difference (χ^2 = 1.8, df = 2, P = 0.4) between the sexes in the frequency with which they appeared to be hunting for the three primary prey items.

Hunting Behavior - Effect of Outcome

The height of hunting perches from which attacks were initiated ($\bar{x}$ = 1.54 ± 0.36 m; N = 6 owls) did not differ significantly (z = 0.8, P = 0.42) from that of perches from which owls did not initiate attacks ($\bar{x}$ = 1.59 ± 0.16 m; N = 6 owls). The mean height of perches from which successful attacks were initiated was 1.58 ± 0.59 m (N = 4 owls), while that for perches from which unsuccessful attacks were initiated was 1.40 ± 0.71 m (N = 4 owls). This difference was not significant (z = 0.43, P = 0.67). The mean attack distance was 3.10 ± 1.34 m (N = 4 owls) for successful attacks and 4.03 ± 2.31 m (N = 4 owls) for unsuccessful attacks, and this difference was not significant (z = 0.14, P = 0.89).

Screech-owls (N = 6) that eventually initiated an attack remained on perches for an average of 614.6 ± 956.5 sec, while those that did not initiate an attack remained on perches an average of 299.9 ± 100.0 sec. This difference in perch time was not significant (z = 0.56, P = 0.58). One owl (Female 285) had a longer perch time prior to attack than the other owls because she once spent 84 minutes on a perch before making an attack. It is likely that this female, while roosting, happened to locate and then attack a prey item. If female 285 is removed from the analysis, the mean time until attack decreases to 226.1 ± 108.9 sec (N = 5 owls) and the mean time until giving up increases slightly to 323.9 ± 90.4 s (N = 5 owls). Nonetheless, this difference in perch time is still not significant (z = 1.2, P = 0.21).

Hunting Behavior - Probability of Prey Detection and Pattern of Giving Up

For a screech-owl on a perch searching for a prey item, the probability of detecting prey may increase, decrease, or remain the same as time passes. As described by Bye *et al.* (1992:270): "The cumulative distribution of detection times may be used to determine which of these possibilities is the case. This distribution decays exponentially if the probability of detecting prey remains constant. If the probability of prey detection increases or decreases, this will appear as a concave or convex deviation, respectively, from the exponential model." For all screech-owls that initiated attacks, we plotted the proportion of owls still remaining on their perches versus perch time (total time spent on the perch). These proportions were log-transformed to facilitate the assessment of fit to an exponential model (Bye *et al.* 1992). The decay in the distribution of attack times (detection times) was, in fact, close to exponential (fig. 3). The straight line representing the

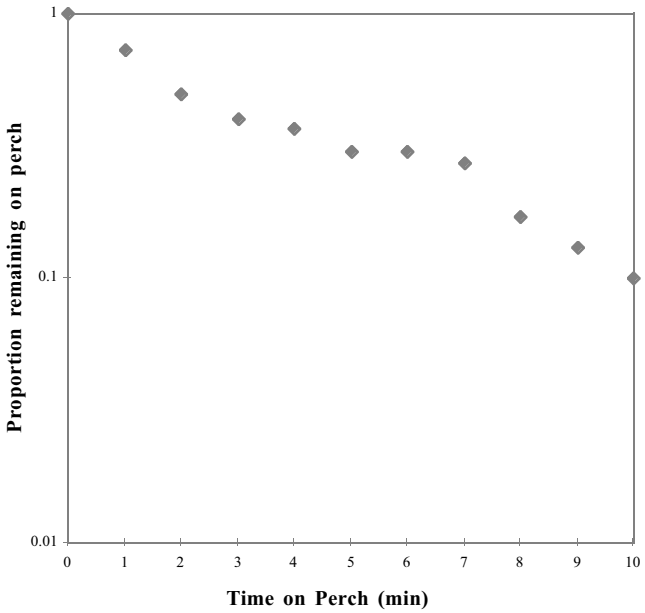

Figure 3.—*Proportion of Eastern Screech-owls remaining on perch in relation to time on perch for perches from which an attack was made (N = 35). The straight line pattern indicates that how soon an owl is likely to attack is not predicted by perch time.*

best-fitting exponential model for attack times up to 10 min was log y = -0.09x - 0.056. In other words, prey were attacked by screech-owls at a constant rate.

The decay in the distribution of giving-up times was also close to exponential (fig. 4). The straight line representing the best-fitting exponential model for giving-up times up to 10 min was log y = -0.09x - 0.036. Thus, screech-owls also gave-up at a constant rate.

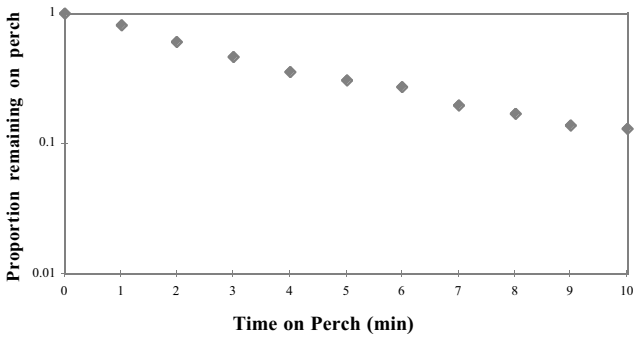

Figure 4.—*Proportion of Eastern Screech-owls remaining on perch in relation to time on perch for perches that were given up (N = 303). The straight line pattern indicates that how soon an owl is likely to give up is not predicted by perch time.*

Hunting Behavior - Effect of Season

Examination of the hunting behavior of owls (N = 5) observed during both early and late winter revealed no significant seasonal variation in perch height, height or d.b.h. of the vegetation in which perches were located, perch time (before either giving up or attacking), attack distance, or distance between consecutive perches (table 2).

Table 2.—*Seasonal variation in the hunting behavior of Eastern Screech-owls. (Numbers represent mean ± standard deviation.)*

	Early winter (Nov.-Dec.)	Late winter (Jan.-March)
Perch height (m)	1.65 ± 0.16	2.14 ± 0.90
Perch tree/shrub height (m)	3.93 ± 1.21	5.88 ± 3.62
Perch d.b.h. (cm)	7.84 ± 2.68	11.16 ± 10.34
Perch time (sec)	319.3 ± 155.0	368.8 ± 305.5
Attack dist. (m)	3.42 ± 0.72	3.47 ± 2.07
Interperch distance (m)	8.98 ± 4.73	9.95 ± 2.08

We also examined possible seasonal variation in the types of prey that the four most frequently observed owls appeared to be hunting. Although three of these owls exhibited significant seasonal variation (χ^2 tests, P < 0.035), and variation for the fourth owl approached significance (χ^2 = 5.45, df = 2, P = 0.065), no clear trends were apparent. For example, two owls (307 and 041) appeared to be hunting for small mammals more than expected during early winter, while, in contrast, the other two owls (931 and 215) hunted for small mammals more than expected during late winter. Also illustrating the absence of any trends, one owl (931) hunted for crayfish more than expected in early winter, while two owls (307 and 041) did the same in late winter.

Hunting Behavior - Effect of Moonlight and Weather

Screech-owls chose significantly higher perches when moonlight was available (i.e., 1/4 moon, 1/2 moon, 3/4 moon, or full moon) than when moonlight was not available (z = 2.09, P = 0.036), with a mean perch height of 1.88 ± 0.35 m (N = 5 owls) when moonlight was available and 1.46 ± 0.08 m (N = 5 owls) when moonlight was not available.

Three owls (016, 215, and 931) were observed hunting during all weather conditions (snowing, raining, and no precipitation) and these varying conditions had no apparent effect on the type of prey that owls hunted (χ^2 = 1.68, df = 4, P = 0.79). Similarly, temperature (above versus below freezing) had no effect on the type of prey being hunted by Screech-owls (χ^2 = 4.57, df = 2, P = 0.102). Screech-owls appeared to hunt for crayfish at similar rates both when air temperatures were above and below freezing. Temperature also had no significant effect on giving up times (z = 1.46, P =0.14), with owls giving up after 366.2 ± 40.3 sec (N = 5 owls) when temperatures were above freezing and after 264.2 ± 148.4 sec (N = 5 owls) when below freezing.

Hunting Behavior - Effect of Time of Night

Overall, screech-owls exhibited significant temporal variation in type of prey hunted (χ^2 = 38.1, df = 6, P < 0.0001), with owls more likely to hunt for crayfish early in the evening (1800 - 2300 h) and small mammals later in the

evening (2300 - 0300 h). We had sufficient numbers of observations on six owls (016, 041, 215, 307, 931, and 959) to permit examination of possible temporal variation in type of prey hunted, and three of these owls (041, 215, and 959) exhibited the same significant (χ^2 tests, $P < 0.035$) tendency to hunt for crayfish earlier and small mammals later. In addition, this tendency approached significance ($\chi^2 = 9.6$, df = 6, $P = 0.14$) for another owl (931). The remaining two owls (016 and 307) appeared to hunt for crayfish and small mammals at similar levels throughout the night.

We found little evidence that giving up times varied with time of night. For five owls with sufficient number of observations for analysis (041, 215, 307, 931, and 959), only one exhibited significant temporal variation in giving up time. This female (041) had significantly shorter giving up times early in the evening ($\bar{x} = 172.1 \pm 144.8$ sec; N = 26) than later in the evening ($\bar{x} = 595.5 \pm 666.9$ sec; N = 13) ($z = 2.55$, $P = 0.011$). Three other owls (307, 931, and 959) also had shorter giving up times early in the evening, but differences in giving up times between early and late evening were not significant (Wilcoxon tests, $P > 0.09$).

DISCUSSION

Hunting Perches

The mean perch height for hunting Eastern Screech-owls in this study was 1.66 m. By contrast, screech-owls roosting on open limb perches in the same study area were found at a mean height of 10.2 m (Belthoff and Ritchison 1990). Gehlbach (1995) also reported that screech-owls used higher perches when roosting ($\bar{x} = 4$ m) than when hunting ($\bar{x} = 2.6$ m). Boreal Owls also use higher perches for roosting than for hunting (Bye *et al.* 1992). Owls may select higher perches for roosting because such sites may provide more cover than lower sites (Bye *et al.* 1992). In fact, Belthoff and Ritchison (1990) noted that screech-owls typically selected roost sites that provided concealment. The lower perch sites selected by hunting owls probably provide an unobstructed view of, and unobstructed access to, the ground (Bye *et al.* 1992), an important consideration for predators that largely depend on ground-based prey.

Screech-owls in this study used lower hunting perches than reported for other species of owls. For example, the mean height of hunting perches was found to be 3.3 m for Boreal Owls (Bye *et al.* 1992), 5.5 m for Great Gray Owls (*Strix nebulosa*; Bull and Henjum 1990), and 8.5 m for Northern Hawk Owls (*Surnia ulula*; Sonerud 1992). Norberg (1970), however, reported that the mean height of hunting perches used by Boreal Owls was 1.7 m, similar to that for screech-owls in this study. Several factors may influence the height of perches selected by hunting owls. An owl's sensory capabilities may be one such factor. For example, owls that depend heavily on acoustic cues to localize ground-dwelling prey may need to be a short distance from potential prey (Andersson 1981, Rice 1982, 1983). Thus, the use of low hunting perches by screech-owls in this study suggests that they may depend on hearing to locate prey. Anatomical evidence, however, suggests that screech-owls should be more dependent on vision. That is, screech-owls have symmetrical ears and Norberg (1987) suggested that owls with such ears may rely more on vision while those with asymmetrical ears may rely more on hearing. This may be true because asymmetrical ear openings would permit an owl to simultaneously locate prey on both the horizontal and vertical planes, but symmetrical ear openings do not preclude the use of hearing to locate prey. Owls with symmetrical ears could simply determine horizontal and vertical directions one after the other with an intervening tilting of the head (Norberg 1987). This technique would require more time but might still be effective when hunting relatively slow moving prey like terrestrial crayfish. It is likely, therefore, that screech-owls hunting from low perches may, in part, be seeking auditory cues concerning the location of prey. Other investigators have also reported observations suggesting that Eastern Screech-owls hear well and may, at times, depend on hearing to locate prey. For example, Bent (1938) and Gehlbach (1994) reported that screech-owls were able to locate prey hidden in leaf litter.

The type of prey being hunted may also influence the height of hunting perches. We found that screech-owls that appeared to be hunting crayfish perched lower than when apparently hunting small mammals or birds. Screech-owls that appeared to be hunting birds used relatively high perches, perhaps because avian prey were located in dense vegetation (e.g., cedars) rather than on the ground. Although both crayfish and small mammals are

found on the ground, screech-owls perched significantly lower when apparently hunting crayfish. One reason for such behavior may be that slower moving crayfish are more difficult to detect. Similarly, Pinkowski (1977) found that Eastern Bluebirds (*Sialia sialis*) perched lower in the spring (March 15 - April 15), because "smaller, fewer, or less active" insects were more difficult to detect at greater heights. Also, crayfish and, perhaps, invertebrates (or ectotherms) in general may be less likely to detect a nearby predator (particularly during cooler weather) than would more active (and alert) small mammals.

Light levels may also influence the height of hunting perches. As already noted, Great Gray Owls and Northern Hawk Owls use relatively high hunting perches compared to screech-owls. These two species both hunt during the day when visibility is relatively high. In contrast, screech-owls are primarily nocturnal (and all our observations were made after sunset). Although screech-owls and other nocturnal owls do have eyes well-adapted for seeing under low-light conditions (Norberg 1987), they may have to perch lower to detect and accurately locate prey. Supporting this view, the hunting perches of screech-owls in this study were significantly higher when moonlight was available.

The height of hunting perches may also be influenced by perch availability. For example, screech-owls in suburban Waco, Texas, used higher hunting perches ($\bar{x}$ = 2.6 m; Gehlbach 1994) than did screech-owls in this study. One possible factor for such differences may be that the vegetation in suburban areas has been substantially altered and typically has little understory (Beissinger and Osborne 1982, Gehlbach 1994). Thus, fewer low branches may be available as perch sites for hunting screech-owls.

The hunting perches of screech-owls were primarily on open branches of small trees or shrubs and at least 25 cm from the main trunk. Such sites, in contrast to typical roost sites (Belthoff and Ritchison 1990), provided little concealment and, as a result, may increase an owl's vulnerability to predation (e.g., by Great Horned Owls, *Bubo virginianus*). As already noted, however, hunting owls must have an unobstructed view that may not be available on perches located closer to, or against, the main trunk. Perhaps in an attempt to reduce the chances of being spotted by a larger predator (as well as to reduce the chances of being spotted by potential prey), screech-owls typically remain motionless (and silent) when on hunting perches (pers. observ.).

Attack Distance and Success

The mean attack distance for screech-owls in this study was 3.41 m. Similarly, mean attack distances for Boreal Owls were reported to be 4.4 m (Norberg 1970) and 5.6 m (Bye *et al.* 1992). Bye *et al.* (1992) suggested that such relatively short attack distances indicate a restricted search area and, further, also indicate that prey are being located using acoustic cues.

Only 8 of 35 attacks (22.8 percent) by screech-owls were successful. Similarly, Ural Owls (*Strix uralensis*) hunting rodents were successful 27 percent of the time (Nishimura and Abe 1988) and Great Gray Owls also hunting rodents were successful 33 percent of the time (Bull and Henjum 1990). Eastern Screech-owls in Texas successfully captured 56 percent of vertebrate prey attacked and 83 percent of invertebrate prey attacked (Gehlbach 1994). Such results indicate that attack success rates vary with prey type, with invertebrate prey more likely to be successfully captured than vertebrate prey. The limited success of screech-owls in this study may indicate that they were attacking primarily small mammals. Whereas success rates may be higher for invertebrate prey, screech-owls may hunt small mammals because smaller invertebrates may represent less energy and, at times (e.g., during the winter months), may not be available.

Search Time

For the five screech-owls we observed both when giving up and when attacking, the mean giving up time was 323.9 sec while the mean time until attack (or detection time; Carlson 1985) was 226.1 sec. Similarly, giving up times were longer than detection times for insectivorous, or primarily insectivorous, Spotted Flycatchers (*Muscicapa striata*; Davies 1977), Eastern Bluebirds (Pinkowski 1977), and American Kestrels (*Falco sparverius*; Rudolph 1982). In contrast, detection times were found to be longer in duration than giving up times for two species of owls that prey primarily on small mammals, Boreal Owls (Bye

et al. 1992) and Northern Hawk Owls (Sonerud 1989). Several investigators have noted that small mammals are more difficult for predators to catch than are insects (e.g., Sonerud 1980 cited in Bye *et al.* 1992, Temeles 1985). As a result, Sonerud (1989) suggested that an owl must wait longer before initiating an attack. If so, observed detection times would appear longer than actual detection times because owls are waiting for an undetermined period of time before launching an attack on already detected prey. Thus, one possible explanation for the short detection times (relative to giving up times) observed in this study is that screech-owls were hunting primarily insects and other invertebrates (i.e., crayfish). Screech-owls hunting primarily small mammals might have longer mean detection times. Unfortunately, we were unable to identify a sufficient number of prey to determine if attack times (detection times) for screech-owls varied with type of prey.

A predator attempting to optimize its hunting effort might be expected to abandon a perch as the probability of detecting prey begins to decline (Fitzpatrick 1981). However, screech-owls in this study gave up and attacked prey at a constant rate, and similar results have been reported for Boreal Owls (Bye *et al.* 1992). Fitzpatrick (1981) explained such behavior by suggesting that birds can assess the complexity of the search area around each perch independently after landing and estimate how long it will take to search it thoroughly. If a prey item appears during this time, the bird attacks and, if not, the bird gives up. If an owl's home range includes a random selection of perches with respect to the quality of search areas, the perch survivorship curve will decline exponentially (Bye *et al.* 1992).

Males versus Females

We found few differences in the hunting behavior of male and female screech-owls. Males and females did differ significantly in perch location, with males more likely to perch on the very top of plants and females more likely to perch near the trunk. This difference may be due, at least in part, to differences in body size. Female screech-owls typically weigh more than males (Gehlbach 1994, Henny and VanCamp 1979, pers. observ.) and, as a result, may have to perch on the slightly larger and stronger branches located closer to the trunk of small trees and shrubs.

The similar hunting techniques of male and female screech-owls in our study may be due to similarities in the types of prey being hunted. We found that males and females appeared to hunt primarily for crayfish and small mammals. Similarly, Hofstetter (1995) reported that male and female screech-owls on the same study area captured the same types of prey during the breeding season.

Bye *et al.* (1992) found that female Boreal Owls had longer giving up times than males, and suggested that larger females should wait longer than smaller males because the cost of flight is greater for larger females. We found no difference between male and female screech-owls in giving up time. This apparent difference in the behavior of Boreal Owls and Eastern Screech-owls may be due to differences in the degree of sexual dimorphism. Female Boreal Owls are 4 percent larger than males by wing length and 64 percent larger by body mass (Korpimaki 1986, Lundberg 1986). In contrast, female screech-owls are typically only 16-17 percent larger in body mass than males (Henny and VanCamp 1979, Gehlbach 1994). As with screech-owls in this study, Bye *et al.* (1992) found that male and female Boreal Owls did not differ significantly in the mean height of hunting perches.

Moon Phase, Weather, and Season

Screech-owls in this study perched significantly higher when moonlight was available, perhaps because more light may permit hunting owls to see greater distances and, therefore, perch higher. In addition, however, more light may permit screech-owls to rely more on vision than on hearing. Because visual hunters need not be as close to prey as acoustic hunters, screech-owls relying on vision to locate prey would be able to perch higher.

Screech-owls in this study exhibited no changes in hunting behavior with season or with changing weather conditions. Our study was conducted over a 4-month period, and conditions during that limited time may not have varied sufficiently to influence prey availability or hunting behavior. Studies conducted over longer periods have revealed that the food habits of Eastern Screech-owls do vary seasonally, with more invertebrates taken during the breeding period (March-August) than during the non-breeding period (September-February; Ritchison and Cavanagh

1992). Such changes in prey use would, as observed in this study, cause corresponding changes in hunting behavior.

An important factor in the seasonal variation in prey used by screech-owls is that invertebrates are less likely to be available during colder weather (Ritchison and Cavanagh 1992). Screech-owls in our study hunted primarily for crayfish, an invertebrate whose activity (and therefore availability to screech-owls) may be influenced by temperature. If so, fewer crayfish should have been available at lower temperatures and, as a result, screech-owls should have altered their hunting behavior (perhaps, for example, by hunting for endotherms like small mammals and birds). No such change in behavior was observed. A likely explanation for this is that the crayfish hunted by screech-owls in our study apparently remained active and available as prey even when temperatures were below freezing.

Time of Night

Four of six screech-owls observed hunting both early and late in the evening exhibited a tendency to hunt for crayfish early in the evening (1800 - 2300 h) and small mammals later in the evening (2300 - 0300 h). Because crayfish are ectotherms, declining temperatures as the evening progresses might reduce crayfish activity levels and, therefore, availability. As noted previously, the crayfish on our study area apparently remain active even when temperatures are below freezing. Another possible explanation is that the availability of crayfish and small mammals varies with nightly variation in their normal activity patterns, with crayfish more active early in the evening and small mammals later in the evening. We have no information, however, concerning the normal activity patterns of these prey species.

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