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I am submitting herewith a thesis written by Linda J. Duley entitled "Life History Aspects of the Screech Owl (*Otus asio*) in Tennessee." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

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LIFE HISTORY ASPECTS OF THE SCREECH OWL (*Otus asio*) IN TENNESSEE

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Linda J. Duley

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ABSTRACT

The objectives of this study were to: (1) delineate the nesting cycle of the screech owl (Otus asio) in Tennessee, (2) investigate food habits of the screech owl in Tennessee and (3) determine the adaptability of the screech owl to artificial nesting structures in a variety of habitat types.

Based on 25 active screech owl nests examined in east Tennessee in 1978, average clutch size was 4.1. An incubation period of 25-26 days was determined from daily monitoring of two of these nests. Peak egg laying, hatching and fledging periods were 29 March-11 April (80%), 26 April-9 May (76%) and 24 May-6 June (82%), respectively, from 25 nests examined in 1978.

Sexual size dimorphism between male and female screech owls was slight. Of 74 screech owls collected dead on roads (DOR) in Tennessee, the culmen, tarsus, and tail lengths of female owls were not significantly larger than those of male owls. However, wing lengths of female owls were significantly larger than wing lengths of male owls.

Food habits information was obtained from identification of food items cached in nest boxes and from analysis of stomach contents of DOR birds. Food caches revealed a preponderance of birds consumed in all seasons; stomach contents indicated the importance of mammals in late fall

and winter and insects in spring and summer.

From 117 DOR screech owls collected from November 1976 to June 1978 in Tennessee, 89 (76.1%) were red, 25 (21.3%) were gray and 3 (2.6%) were intermediate in coloration. Ratio of red to gray phase birds was 3.6:1.

Use of 150 nest boxes examined in 1977-1978 (50 each in rural, urban-suburban and woodland areas) by roosting screech owls was significantly higher ($p < .05$) in urban-suburban and rural areas than in woodland areas. Boxes in urban-suburban areas supported the largest number of nesting screech owls. In the woodland area, 40 nest boxes were never used by vertebrate animals; this was compared to four and five next boxes that were unused in rural and urban-suburban areas, respectively.

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CHAPTER I

INTRODUCTION

The screech owl is confined to North America and has a continuous breeding range which extends from ". . . southeastern Alaska, southern Manitoba and Ontario, and northern New England south to southern Baja California, Oaxaca, and the Florida Keys (Owen, 1963a:8)." The screech owl is considered to be nonmigratory although owls occupying extreme northern regions may wander south in the winter (Owen, 1963a; Mengel, 1965). Currently the American Ornithologists' Union (A.O.U., 1957) recognizes 22 subspecies of *Otus asio*, chiefly based upon variations in the lengths of the wing, bill, tail and tarsus and in the color pattern of the plumage. Three subspecies (*Otus a. asio*, *O. a. naevius*, *O. a. floridanus*) occur east of the Rocky Mountains (Figure 1). Although there has been some controversy regarding this subspecific classification (Ridgway, 1914; Bangs, 1930; Marshall, 1967), this paper will consider *Otus a. asio* as the subspecies present in Tennessee in concurrence with the current A.O.U. listing (A.O.U., 1957). The screech owl occurs in two distinct color phases in the eastern part of its range; west of 104.6° longitude only gray birds are found (Owen, 1963b).

Several aspects of the screech owl's life history have been poorly documented. The published literature is

Otus asio naevius

Otus asio asio

Otus asio floridanus

Copy

Figure 1. Distribution of the three eastern races of the screech owl.

concerned mostly with food habits (Cahn and Kemp, 1930; Errington, 1932b; Baumgartner and Baumgartner, 1944), color phase (Schorger, 1954; Hrubant, 1955; Owen, 1963b) and taxonomy (Ridgway, 1914; Owen, 1963a; Marshall, 1967). Breeding biology and population dynamics have received little attention. VanCamp and Henny (1975) provided a major documentation of the bird's life history in northern Ohio; however, a careful search of available literature revealed a paucity of information concerning screech owl life history in the southern United States. Few studies have been conducted on the owl in Tennessee and these primarily deal with color phase (Stupka, 1953; Laskey, 1963). Although scattered nesting records exist in the Tennessee literature (Ijams and Hofferbert, 1934; Lyle and Tyler, 1934; Langridge, 1957), complete information on hatching rates, nest success, fledging rates, clutch size and nesting chronology is not available. Food habits and habitat preference of the bird in Tennessee are also poorly documented.

The present study examines the adaptability of the screech owl to artificial nesting structures in a variety of habitat types (rural, urban-suburban and unmodified woodland) in Tennessee. Also investigated were: (1) several aspects of the owl's reproductive biology, (2) its food habits and (3) its plumage color phases.

CHAPTER II

METHODS AND MATERIALS

I. THE HOLSTON RIVER STUDY

A total of 88 nest boxes was placed along the Holston River in Hawkins County, Tennessee in 1971-1972 by the Tennessee Valley Authority (TVA) as part of a resident waterfowl project (Muncy and Burbank, 1975). Additional boxes were placed on the Holston River by TVA from 1972-1977, until by 1978, 210 nest boxes were available for cavity nesting animals along a 38.6 km section of the river. As part of a continuing effort to index year-to-year changes in abundance of wood ducks (*Aix sponsa*), these boxes are monitored by TVA during late spring and summer.

Types of Boxes

Of the 88 boxes originally placed on the Holston River, 24 were horizontal metal, 36 were metal rocket and 28 were wooden (Figure 2) design. By 1978, 40 horizontal metal, 76 metal rocket and 94 wooden nest boxes were located on the Holston River by TVA.

The horizontal metal boxes were designed principally as starling proof structures. The shallowness of the box body, the large side opening and the well-lighted interior seemed to be avoided by starlings. Unfortunately, these

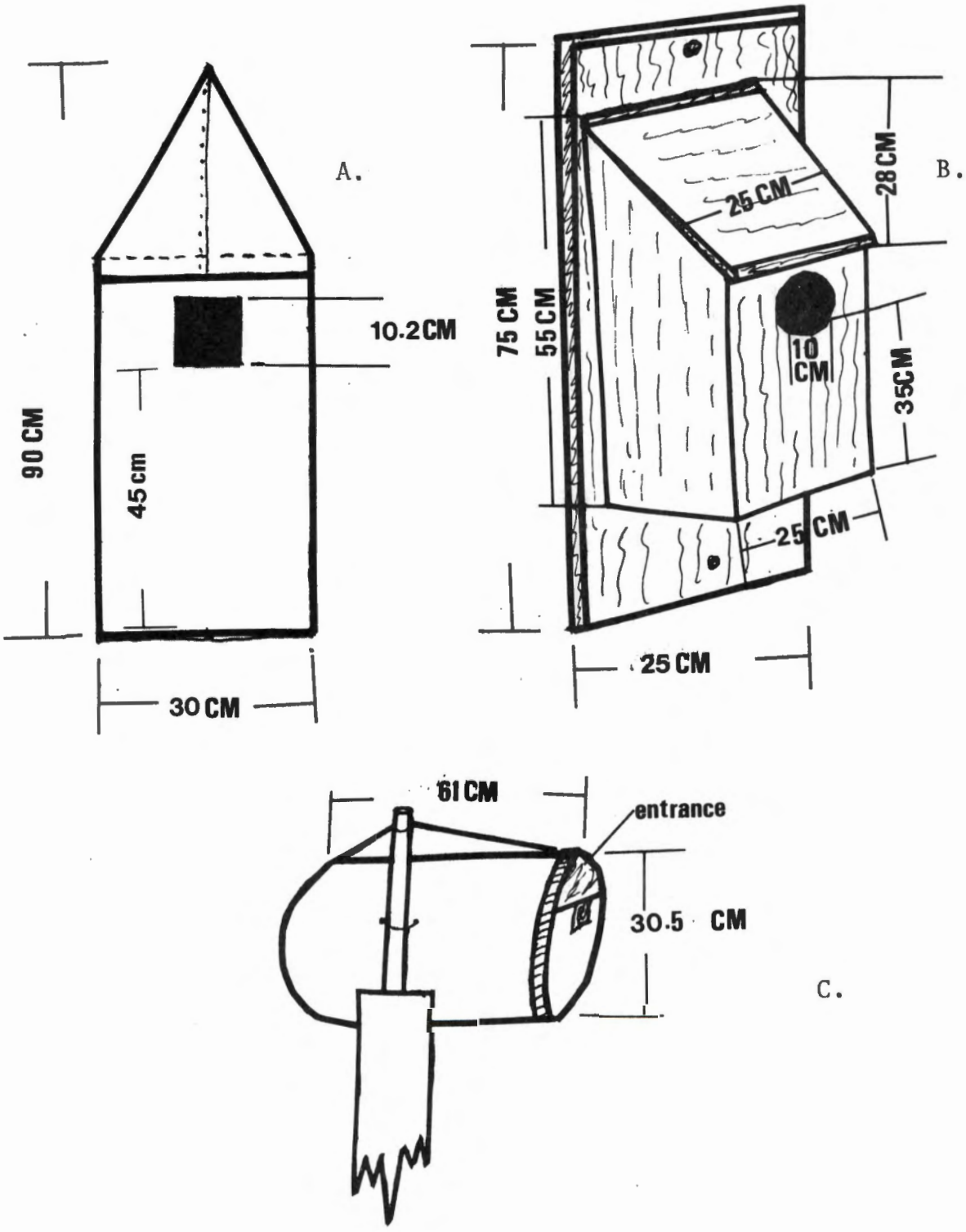


Figure 2. Metal rocket (A), wooden (B) and metal horizontal (C) nest boxes used on the Holston River, Hawkins County, Tennessee.

same features seemed to discourage use by wood ducks, screech owls and other cavity nesting birds (Muncy and Burbank, 1975). The horizontal metal boxes contained a sliding metal side door for maintenance.

The metal rocket boxes were deep-bodied with a square entrance hole of 10 cm. No special maintenance door was present and entrance was only possible from the front cavity hole. The box interior was the darkest of the three different box designs.

Wooden boxes were constructed of untreated white pine. Entrance holes measured 10 cm in diameter. A removable lid simplified box maintenance.

Placement of Boxes

The bottom of each nest box was covered with 8-10 cm of wood chips and placed at an average height of 4.5-6.5 m. Boxes were placed in both open and heavily wooded areas, usually facing the river. Box spacing varied from approximately .05 to .25 river miles.

Maintenance of Boxes

Nest box maintenance checks are conducted by TVA once a year, usually during late winter or early spring. Nest boxes were refurbished with new wood chips and repaired or replaced as necessary. Animal use was recorded at this time.

Examination of Boxes

The March 1978 maintenance check indicated which boxes would most likely be used by nesting owls. Boxes that contained roosting owls or paired owls were checked again in early April for active nests. Because of the time involved, only boxes with some indication of screech owl use were investigated for the presence of nesting owls. Most active nests were visited at least six times, although some nests that were discovered late in the nesting season were visited less often.

During the majority of these visits, a 5.2 m aluminum canoe equipped with a 3 h.p. Johnson outboard motor was used for river navigation. A light-weight Swedish climbing ladder was used to reach the nest boxes.

Data Collected

During the maintenance checks, screech owls found in the nest boxes were banded, color phase was recorded and wing length was measured. The following information was recorded for each screech owl nest: (a) clutch size, (b) hatching dates, (c) fledging dates and (d) any other pertinent breeding biology information. Female owls were not handled or banded until after all of the eggs had hatched in order to decrease chances of desertion.

The right wing length of juvenile birds was measured at various stages in their development. The wing

length of known-aged birds was compared with the wing lengths of juvenile owls of unknown ages to derive an estimate of their ages. The young owls were banded as soon as their color phase could be ascertained. Food cache items found in nest boxes were collected and identified.

II. INFLUENCE OF HABITAT TYPE ON NEST BOX UTILIZATION

Fifty nest boxes were placed in each of three general habitat types (rural, urban-suburban and woodland areas) to assess differences in screech owl habitat utilization and their tolerance to disturbance.

Criteria for Nest Box Placement

Rural. The main criterion for the rural habitat type was that the land be mainly in agricultural use (grazing livestock or raising crops). Although small tracts (less than 4 ha) of scattered wooded areas and structures such as houses and barns were considered as part of a typical rural area, large forested areas (greater than 4 ha) were not included in this habitat type.

A rural area in west Knox County was chosen for study. Nest box locations were plotted on an aerial photograph which placed one box per 1.4 ha. All boxes in

rural habitat were placed by the end of October 1977.

Urban-suburban. The main criterion for the urban-suburban area selection was that subdivisions be in a nonrural area containing house lots of 1.2 ha or less. An additional criterion was that each lot contain at least five trees of dbh (diameter at breast height) of 60 cm or more. Three different subdivisions in Knoxville, Knox County, Tennessee were chosen for study--one in north, one in south and one in west Knoxville. A Knox County map was obtained and points were plotted that placed one nest box per 2.5 ha. Each site was examined and inspected for suitability. The homeowner was shown the box and informed of the study. Permission was requested to allow placing the next box in one of his trees. The nest box was frequently placed in a tree of the homeowner's choosing. All of these nest boxes were erected by the end of September 1977.

Woodland. A large tract (not less than 4 ha) or tracts of land in mixed hardwoods and pines of sufficient size to allow adequate nest box spacing was the main criterion for the woodland habitat type. The study area chosen was essentially undisturbed by man and did not contain any man-inhabited structures. Points were plotted on a topographical map which placed one nest box per 2.0 h. Three different woodland sites were chosen for study.

Thirty-six nest boxes were placed in the Norris watershed area in Norris, Anderson County, Tennessee. This was an area of approximately 2000 ha of mixed hardwoods and pines, primarily used for collecting and storing run-off water for the town of Norris. Both logging roads and gravel roads were interspersed throughout the area.

Four nest boxes were placed in a wooded area owned by The University of Tennessee in Knoxville, Knox County, Tennessee, known as the Cherokee Woodlot. This area is approximately 52 ha; it is used by University of Tennessee classes for teaching and field trip purposes. No roads traverse this area and nest boxes are inaccessible except by foot.

The remaining 10 nest boxes were placed in an 80 ha tract of land in Powell, Knox County, Tennessee. This area was once a Boy Scout camp and is now unused except for occasional camping or wood cutting activity. Roads are interspersed throughout the area but most are accessible only by four-wheel-drive vehicles. All woodland boxes were placed by the first week of December 1977.

Nest Box Type

Unlike the Holston River nest boxes, these structures were designed specifically for screech owls (Figure 3). For example, a 7.6 cm hole as opposed to a 10 cm hole

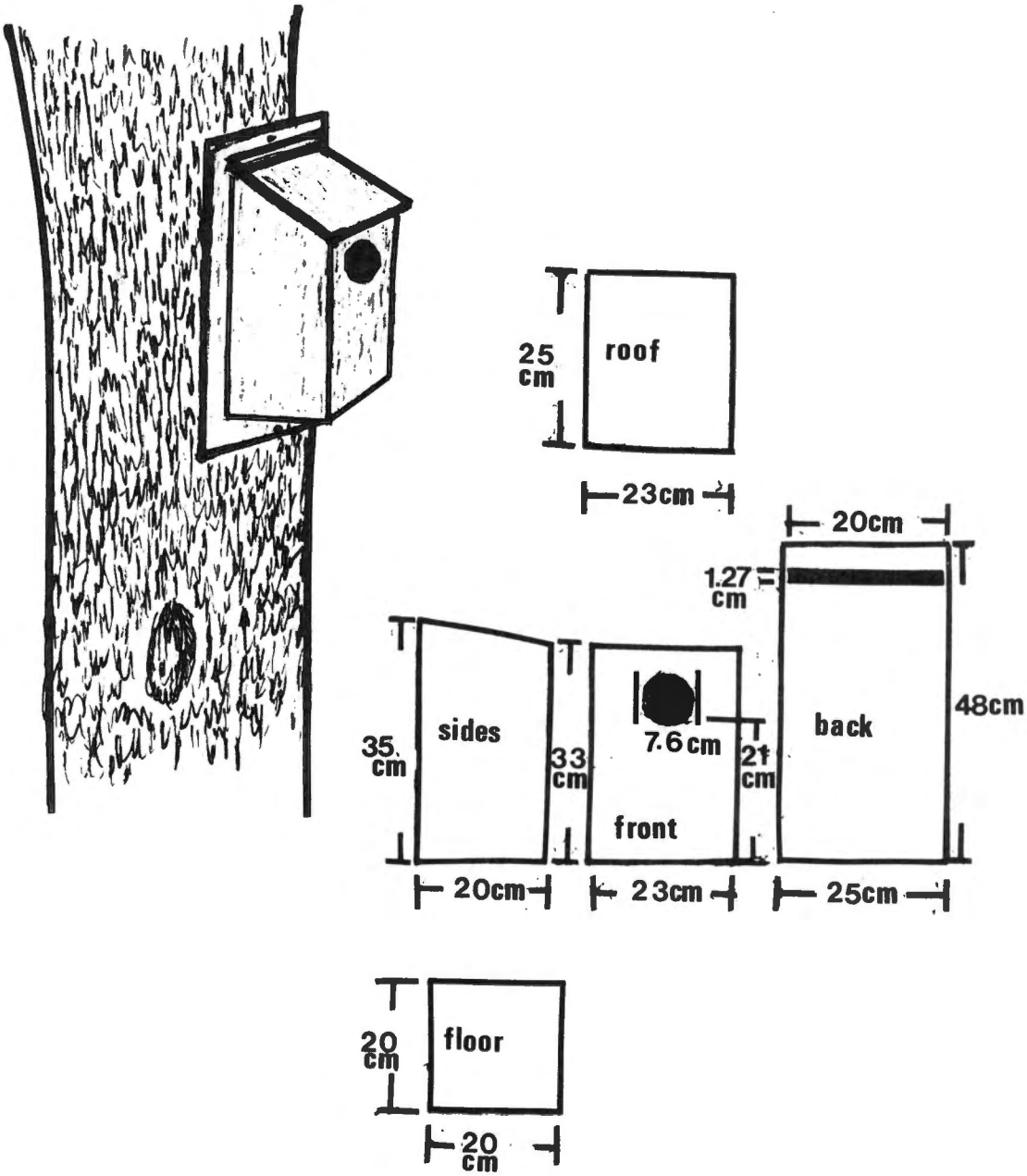


Figure 3. Screech owl nest box.

was used. The smaller floor area (400 cm^2) was adequate room for a brood of young owls and parents. Boxes were constructed of white pine. A removable lid facilitated nest box maintenance. Nest boxes were filled with wood chips to an approximate depth of 7.6 cm and placed at heights of 4.6-6.1 m, usually in a hardwood tree.

Examination of Boxes

Boxes in all three habitat types were checked at least once in both January and February 1978 for roosting owls. In March 1978, all 150 nest boxes were checked at least twice to discover any active screech owl nests. Boxes that contained nesting owls were checked at least once a week during the entire nesting cycle (mid-March to early June). Boxes which did not contain nesting owls in March were checked twice from April to June 1978 for late nesting owls or other occupants. Data collected were the same as collected on the Holston River study.

III. NECROPSY OF SCREECH OWLS KILLED ON TENNESSEE ROADS

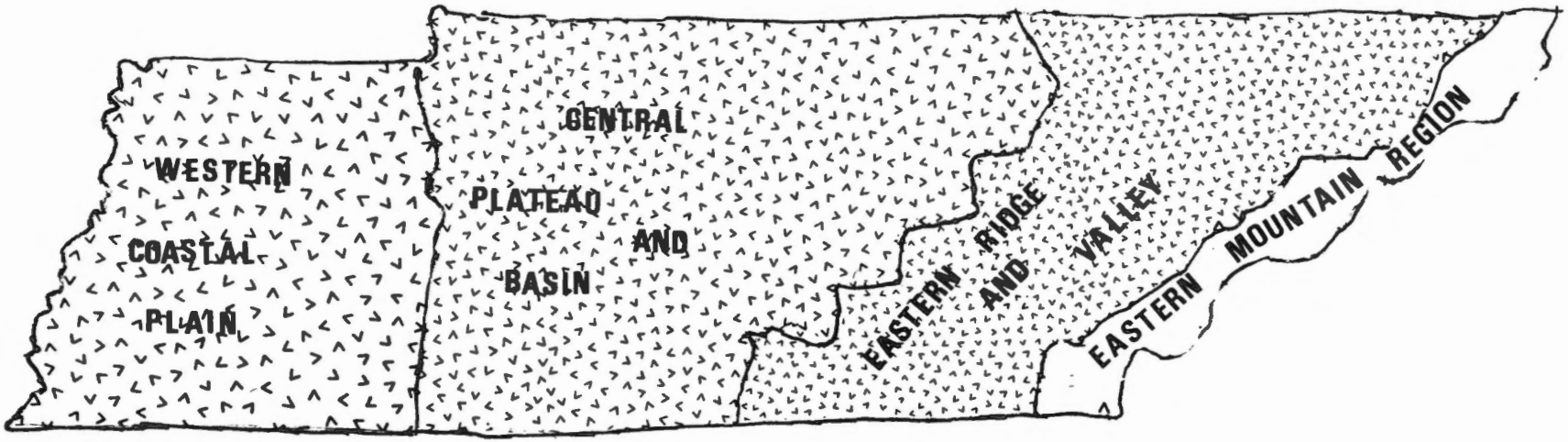
Acquisition of Owls

The eastern screech owl is frequently found dead on highways. These DOR specimens are a valuable source of life history information. An attempt was made to collect as many DOR birds as possible from all parts of

Tennessee. Several amateur and professional ornithologists were informed of this study and requested to collect DOR owls. Notices were posted on several University bulletin boards. Articles appeared in the Knoxville News-Sentinel (in J. B. Owen's column, "Nature Scrapbook"). Requests for DOR screech owls were placed in the Migrant, the journal of the Tennessee Ornithological Society (TOS). Announcements were also made at the Fall and Spring meetings of the TOS concerning this study.

A total of 117 screech owls was collected from 31 different counties in Tennessee from November 1976 to June 1978 (Figure 4). Although many of the birds were collected in Knox County, three major regions of the state were represented among the DOR birds. No birds were collected from the Eastern Mountain Region.

Peak periods when DOR birds were collected were in February and October (Figure 5). The large number of birds killed on Tennessee roads during these two months possibly resulted from increasing activity in the screech owl population. During February, food is low in abundance and reproductive activity is reaching a peak. Thus movement in the screech owl population would reach a peak in February. Few DOR birds were found from March to August, probably because of the close adherence of birds to the nest site and because of the abundance and availability of food.



WCP	CP and B	ER and V	Continued
Dyer(1)	Coffee(2)	Anderson(13)	Knox(31)
Hardeman(1)	Cumberland(3)	Blount(5)	Loudon(1)
	Dickson(2)	Campbell(2)	Monroe(3)
	Giles(1)	Carter(5)	Roane(9)
	Lawrence(1)	Claiborne(2)	Sevier(3)
	Lincoln(1)	Grainger(1)	Sullivan(11)
	Moore(1)	Greene(2)	Union(4)
	Putnam(2)	Hamilton(1)	Washington(4)
	Stewart(1)	Jefferson(1)	
	Warren(1)		
	Wilson(1)		

2 owls collected

17 owls collected

98 owls collected

Figure 4. Counties within major physiogeographic regions of Tennessee where DOR screech owls were collected from November 1976 to June 1978. Map enlarged from Migrant 48(2):44.

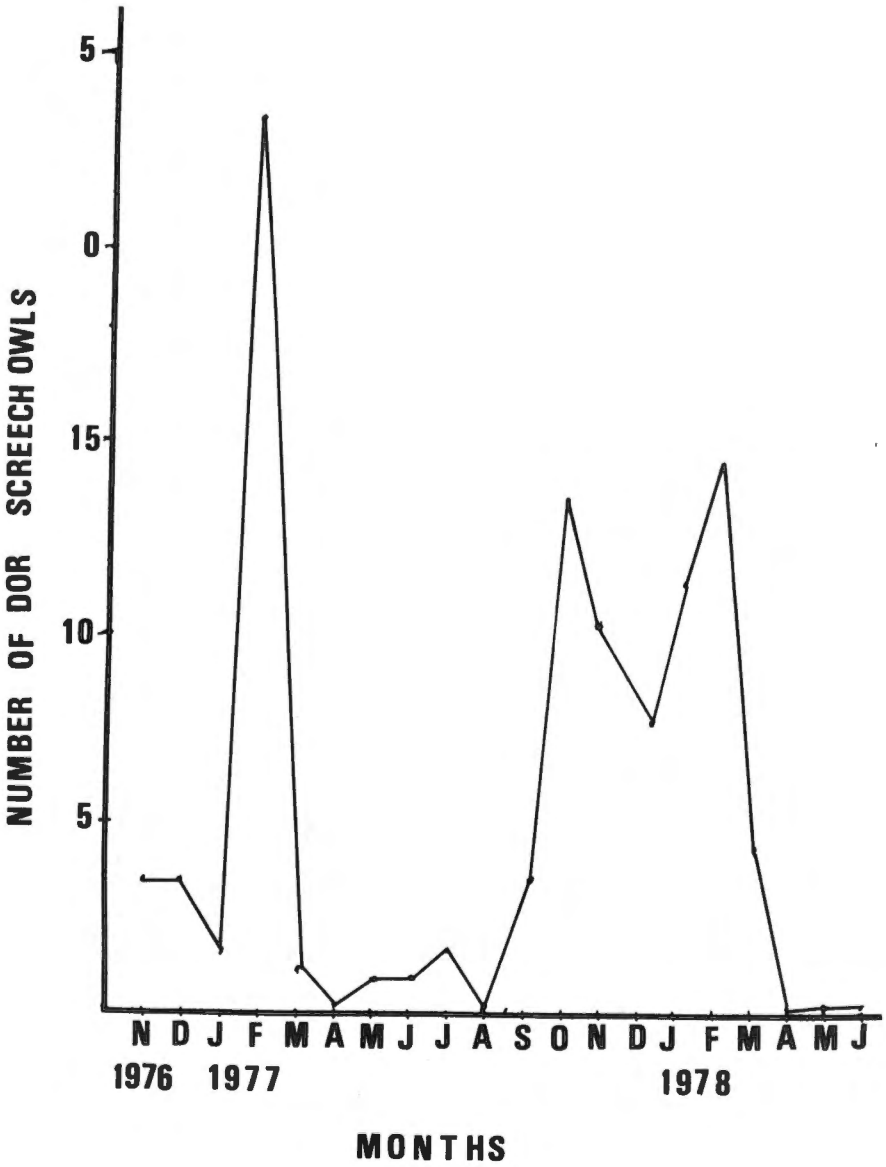


Figure 5. Number of screech owls collected on Tennessee roads from November 1976 to June 1978.

Data Collected

The following information was recorded for each DOR bird: locality, sex, color phase and body measurements (wing, culmen, tarsus and tail lengths). In addition, the stomach contents and gonads were removed and placed in 75% isopropyl alcohol. Wing length was measured from the end of the wrist joint to the tip of the longest depressed primary feather. A wing length as opposed to a wing chord measurement was taken, since the natural curvature of the wing (which a wing chord measures) is frequently destroyed or distorted in DOR birds. Exposed culmen, tarsus and tail lengths were measured as outlined in Pettingill (1970).

Both male and female gonads were removed from alcohol and measured with dial vernier calipers to the nearest 0.1 mm. Length of the testes or diameter of the largest ovarian follicle were measured for each owl that could be sexed. Stomach contents were systematically separated and then identified to the lowest possible taxon. Food items were placed in vials of 75% isopropyl alcohol. After identification, specimens were blotted dry and a volumetric measurement was taken by water displacement to the nearest 0.1 ml.

IV. ANALYSIS OF DATA

Student's T-test (Steel and Torrie, 1960) was used to compare male and female body measurements (wing, tarsus, culmen and tail lengths). Values were tested at the .05 level of significance.

Chi-square (Sokal and Rohlf, 1969) was used to compare: (1) color phase and sex of screech owls, (2) numbers of nest boxes used by roosting screech owls and other vertebrate animals in rural, urban-suburban and woodland areas, (3) use of nest boxes oriented in eight different compass directions by roosting screech owls. Values were tested at the .05 level of significance.

Percent volume (the volume of the food item divided by the total stomach volume times 100) and percent occurrence (the number of times a food item occurred divided by the total possible times it could occur times 100) were calculated for each food item. The product of these two values (percent volume and percent occurrence) yielded an importance value (IV).

CHAPTER III

RESULTS AND DISCUSSION

I. BREEDING BIOLOGY

Gonadal Development

The gonads of 63 DOR screech owls (33 males and 30 females) were examined to determine: (1) peaks in reproductive activity in the population and (2) the physiological state of screech owls during different times of the year. Length of testes and diameter of the largest ovarian follicle were measured to determine extent of each bird's sexual maturation (Appendix, Tables 23 and 24).

Female. Gonadal size in female screech owls increased from October to March and reached a peak in March (Figure 6). The sharpest increase occurred between the months of February and March. This increase was preceded by an intense period of calling and mating which occurs in January or early February. The greatest peak in gonadal size coincided with the major egg laying period which occurs in March (VanCamp and Henny, 1975).

Measurement of the ovarian follicle indicated that the degree of sexual maturation varied widely among screech owls examined from November to March (Table 1).

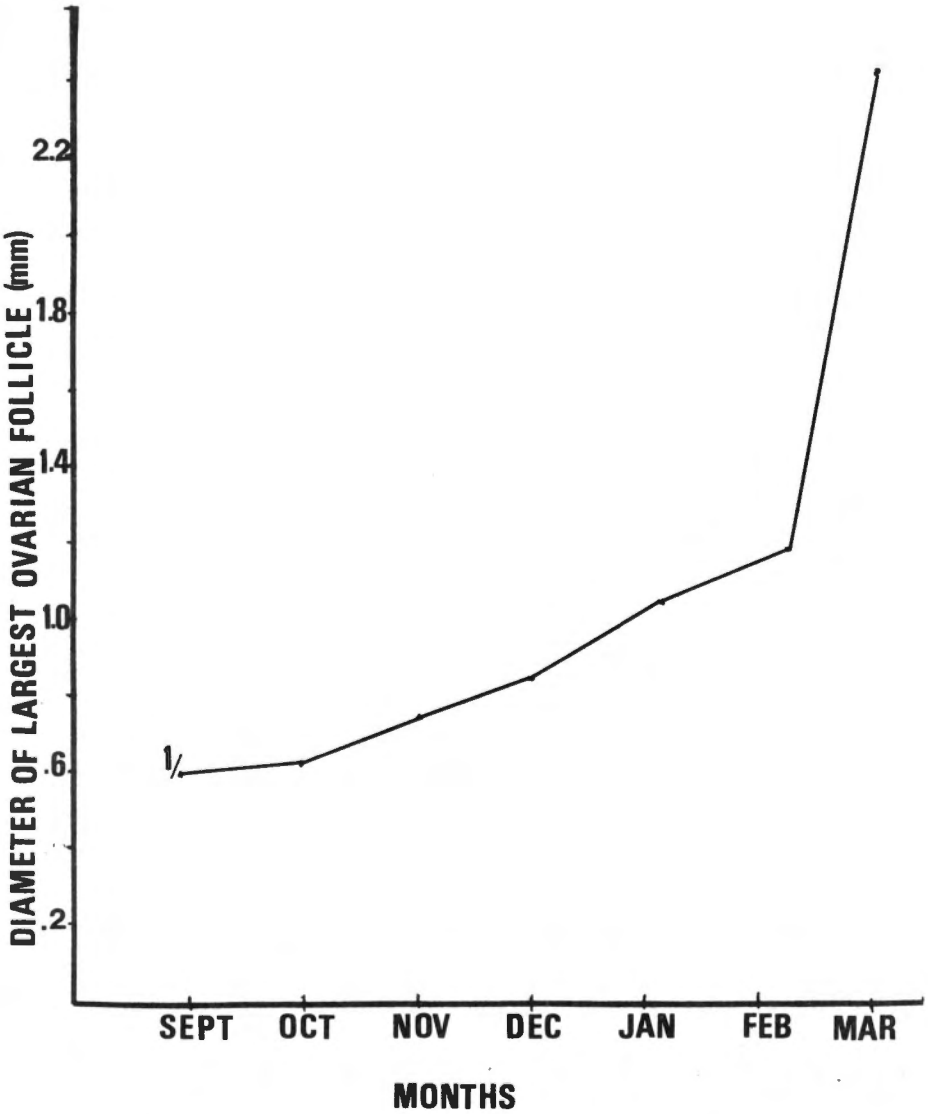


Figure 6. Average diameter of largest ovarian follicle in mm for 30 screech owls collected on Tennessee roads from September-March, 1977 and 1978. 1/ = This point is represented by only one gonadal measurement.

Table 1. Diameter of the largest ovarian follicle in mm for 30 screech owls collected on Tennessee roads from September-March, 1977 and 1978.

September	October	November	December	January	February	March
.65	.65	.75	.95	1.90	1.55	1.25
	.70	.90	.55	.80	1.45	2.40
	.55	.45	1.00	1.20	.80	3.95
	.70		.90	.55	.85	
	.65			1.65	1.15	
				.55	1.15	
					1.25	
					2.00	
Mean:						
.65	.65	.70	.85	1.11	1.28	2.53

In October, follicular size varied little among five screech owls examined (from .55 mm to .70 mm). However, diameter of ovarian follicles ranged from .45 to .90 mm in November and from .55 to 1.0 mm in December. By January, follicular development was even more pronounced and varied from .55 to 1.90 mm. During the month of February enlarged gonads were found in all eight owls examined. However, the degree of follicular development differed greatly among individual screech owls (from .80 to 2.00 mm) in February. All three owls examined in March contained follicles of 1.25 mm or greater. One owl collected in March contained the largest ovarian follicle, 3.95 mm. No eggs were found in the oviducts of any of the birds examined. There were no female owls

collected from April to August (Appendix B, Table 27).

Males. Testes length increased from October to March (Figure 7). A sharp increase in testes size occurred between December and February. During this time, male screech owls are involved in an intense calling period and in territory and mate selection (Kelso, 1944). Only three male owls were collected from April to August, one each in May, July and August. Length of the left testis collected in May was 8.0 mm and was the largest testis examined. Lengths of left testes collected in July and August were 2.9 and 2.5 mm, respectively. The small size of these two gonads indicates that the birds were not reproductively active at this time.

Degree of sexual maturation varied among male owls collected in the same month (Table 2). Greatest differences in testes sizes were seen among owls collected in February. From 10 screech owls examined in February, testes length varied from 2.5 to 7.0 mm. This seems to indicate the presence of nonreproductive males in the population.

Nesting Chronology

Twenty-five screech owl nests found in nest boxes in 1978 were monitored to determine the chronology of the nesting cycle (Figure 8). Paired owls were first found occupying the same nest box on 8 March 1978. No evidence of pairing prior to this time was recorded.

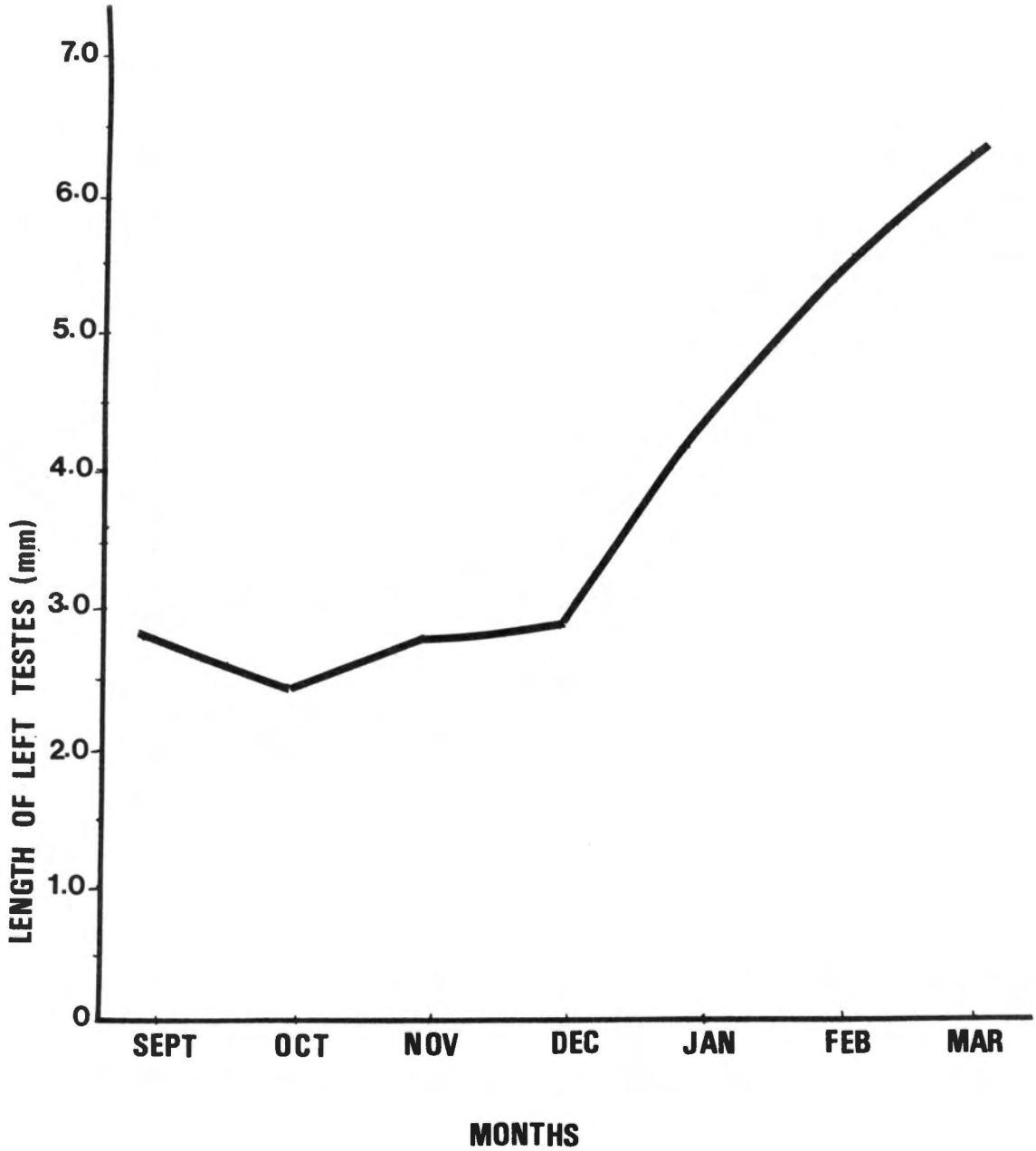


Figure 7. Average length of left testes in mm for 33 screech owls collected on Tennessee roads from September-March, 1977 and 1978.

Table 2. Length in mm of left testes of 33 screech owls collected on Tennessee roads from September-March, 1977 and 1978.

September	October	November	December	January	February	March
2.5	2.9	2.7	3.2	3.5	5.4	7.1
3.0	1.6	2.0	2.6	4.2	4.4	5.8
	2.5	3.0	3.2	4.5	6.8	
	3.4	3.8		5.6	4.8	
	2.1	2.9			7.0	
	2.5	2.3			6.0	
					5.0	
					5.2	
					4.5	
					2.5	
Mean:						
2.75	2.50	2.78	3.00	4.45	5.16	6.45

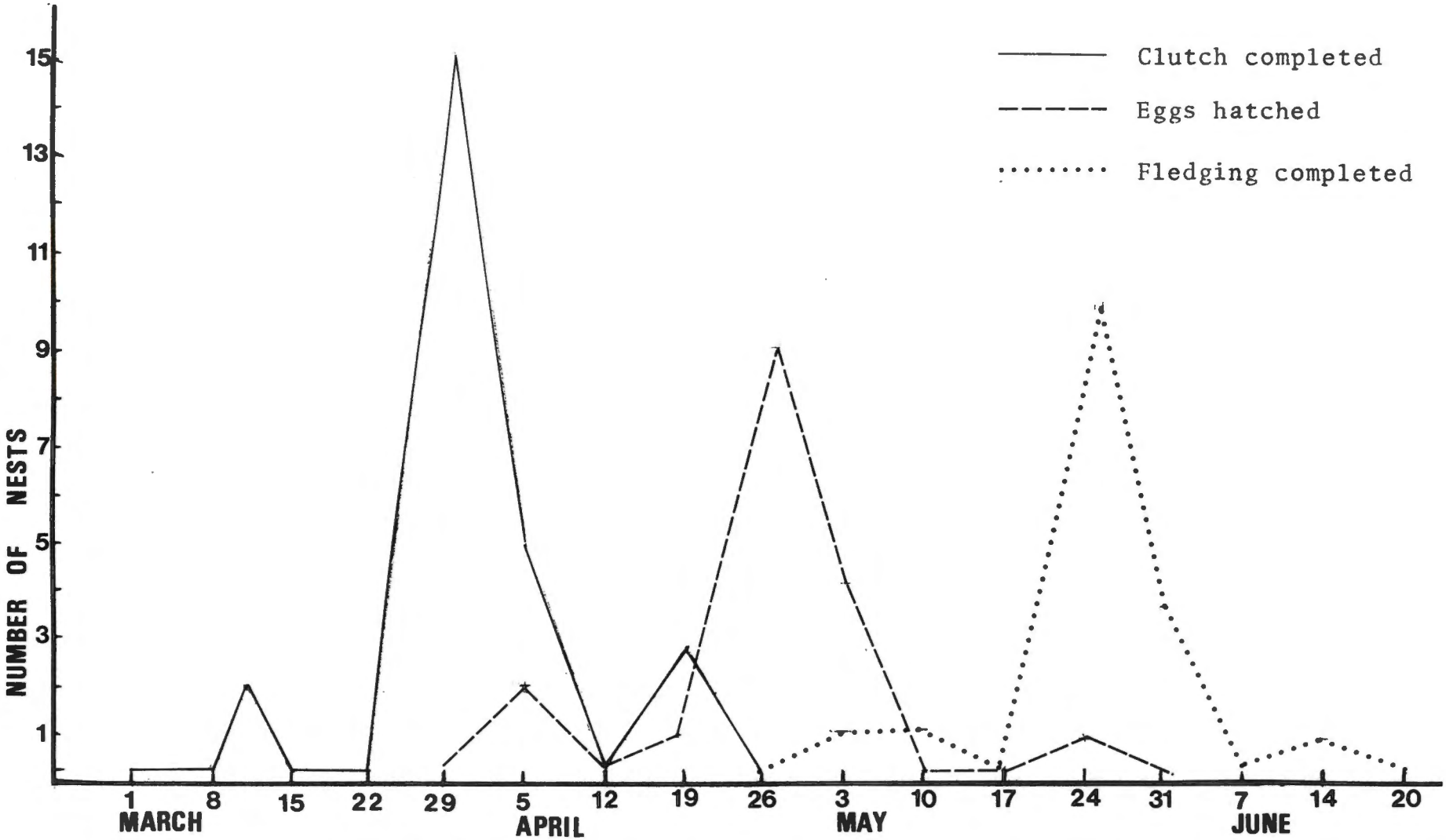


Figure 8. Chronology of the screech owl nesting cycle from 25 nests examined in east Tennessee in 1978.

Hough (1960) reported that sometime during mid or late January the screech owl begins its spring mating call in New York; pairing and mating follow. Craighead and Craighead (1956) reported that the first selection of nesting territories by paired screech owls was at the end of February in Superior Township, Michigan. Carpenter (1883), studying a pair of captive owls, discovered that by the first of February their attentions towards each other had changed. The male would bring food to the female and the pair would sit as close together as possible, frequently preening each others feathers. Kelso (1944:5) reported that "All this, however, is the usual attention the male owl shows the mate during the two to three weeks between pairing and laying the eggs, and it continues even after the young have hatched."

Eggs were first observed in a nest on 9 March 1978. Many of the other clutches examined in east Tennessee in 1978 were often completed prior to the first observation of eggs in the nest. Assuming an eight to nine day egg laying period as determined by Sherman (1911) in Iowa, most clutches in east Tennessee were probably initiated during the third and fourth weeks of March 1978. Two screech owls had complete clutches by 14 March 1978, although the majority of the clutches (87%) were completed from 29 March to 11 April 1978 (Table 3).

Two nests were carefully monitored to determine the

Table 3. Nesting chronology of 25 screech owl nests examined in east Tennessee during 1978.

Egg Laying Completed		Hatching Completed		Fledging Completed	
Date	Nests No.(%)	Date	Nests No.(%)	Date	Nests No.(%)
1-7 March	0(0)	5-11 April	2(12)	3-9 May	1(6)
8-14 March	2(8)	12-18 April	0(0)	10-16 May	1(6)
15-21 March	0(0)	19-25 April	1(6)	17-23 May	0(0)
22-28 March	0(0)	26 April-2 May	9(53)	24-30 May	10(59)
29 March-4 April	15(60)	3-9 May	4(23)	31 May-6 June	4(23)
5-11 April	5(20)	10-16 May	0(0)	7-13 June	0(0)
12-18 April	0(0)	17-23 May	0(0)	14-20 June	1(6)
19-25 April	3(12)	24-30 May	1(6)		
Total	25(100)		17(100)		17(100)

length of the screech owl incubation period. In one nest, the first egg was laid by 29 March 1978. Two eggs were present on 31 March 1978 and a third on 2 April 1978. One egg hatched on 25 April 1978 and a second hatched on 26 April 1978. The third egg of the clutch did not hatch. The unhatched egg was smaller than the other two eggs (35.5 x 29.5 mm for the unhatched egg as compared to 37.0 x 30.0 mm for the other two eggs). The incubation period for this nest was 25 days if calculated from the day that the last egg was laid to the day that the last egg hatched. In another nest, a clutch of five eggs was completed on 30-31 March 1978. The last egg hatched on 24 April 1978, indicating an incubation period of 25-26 days.

In a northern Ohio study, VanCamp and Henny (1975) found paired owls in nest boxes as early as 1 and 3 February but most egg laying did not begin until 15 March. Carpenter (1883) discovered a complete clutch on 15 April; incubation lasted 22 days. Sherman (1911) reported that a clutch of four eggs was completed on 4 April and had hatched by 29 April. She concluded that the incubation period was 26 days.

Thirteen clutches (76%) had all eggs hatched between 26 April and 9 May 1978. The majority of young (82%) were fledged between 24 May and 6 June 1978. One exceptionally early nest had all young birds fledged by

11 May 1978. Three late nests were found on 18 May 1978 in which females were incubating eggs. Although two of these late nests were abandoned, one nest successfully fledged three young between 14 June and 20 June 1978.

Craighead and Craighead (1956) reported that in Michigan the earliest egg laying in 1942 and the latest egg hatching in 1948 was 18 April and 2 May, respectively (no average egg laying or hatching dates were listed). They reported that most young were fledged by 1 June, spending an average of 30 days in the nest. VanCamp and Henny (1975) assumed a 26-day incubation period and concluded that most young in northern Ohio fledged during the last week of May or the first week of June.

Nesting records from Tennessee are inconclusive and fail to follow the nesting cycle from start to finish. Therefore, to delineate the screech owl nesting cycle in Tennessee more accurately, records from (a) the Migrant, (b) TVA wood duck nest box checks, and (c) several unpublished sources were compiled (Table 4). From these data, the earliest and latest dates that eggs were found in the nest were 24 March and 5 May, respectively (Figure 8). However, from 25 nests examined in east Tennessee, the earliest and latest dates that eggs were found in the nest were 9 March 1978 and 18 May 1978, respectively. Thus, information from all of these sources indicates that the majority of the egg laying and incubation by

Table 4. Nesting records for the screech owl in Tennessee.

Source of Information	Location of Nest	Eggs in Nest		Young in Nest	
		Number	Date	Number	Date
Ijams, H. P. and L. A. Hofferbert. 1934.	Athens, McMinn Co.	4	11 April 1934	-	-
		2	14 April 1934	-	-
		4	24 April 1934	-	-
		5	25 April 1934	-	-
		3	2 May 1934	-	-
		3	4 May 1934	-	-
Lyle, R. B. and B. P. Tyler. 1934.	Northeast, Tennessee	4	28 March 1934	2	18 April 1934
		3	25 April 1934	-	-
Todd, H. C. 1944.	Murfreesboro, Rutherford Co.	5	31 March 1944	-	-
		4	1 April 1944	-	-
		4	25 April 1944	-	-
		4	28 April 1944	-	-
Anonymous. 1947.	Knoxville, Knox Co.	-	-	5	4 May 1947
Langridge, H. P. 1957	Elizabethton, Carter Co.	2	7 April 1957	2	29 April 1957
Williams, M. D. 1974.	Lawrence Co.	3	13 April 1974	-	-
Williams, M. D. (Unpubl.)	Ijams Nature Park, Knoxville, Knox Co.	4	18-29 April 1971	4	9 May 1971
	Lawrence Co.	3	13 April 1974	3	6 May 1974
	Cherokee Woodlot Knoxville, Knox Co.	3	-	3	9 May 1975
	Crystal Lake, Knox Co.	-	-	3	30 May 1975

Table 4 (Continued)

Source of Information	Location of Nest	Eggs in Nest		Young in Nest	
		Number	Date	Number	Date
TVA wood duck nest box checks (Unpubl.)	Holston River, Hawkins Co.	-	-	4	16 May 1974
		-	-	4	16 May 1974
		-	-	*	16 May 1974
		-	-	2	1 May 1974
		-	-	4	8 May 1975
		-	-	3	9 May 1975
		-	-	5	30 May 1975
		-	-	5	30 May 1975
		-	-	5	30 May 1975
		4	24 March 1976	4	13 April 1976
		3	24 March 1976	1	13 April 1976
		-	-	3	11 May 1976
		3	7 April 1977	3	27 April 1977
		*	8 April 1977	3	11 May 1977
		4	13 April 1977	3	11 May 1977
		-	-	4	18 May 1977
		-	-	2	18 May 1977
		-	-	4	18 May 1977
		-	-	2	18 May 1977
		-	-	3	18 May 1977
		-	-	2	18 May 1977
		-	-	4	18 May 1977
		-	-	2	18 May 1977
		-	-	2	5 June 1977

*Eggs not counted.

screech owls in Tennessee takes place between 9 March and 18 May. Tennessee records indicated that juvenile birds were found in the nest from 13 April to 5 June. However, from 17 nests observed in east Tennessee in 1978, juveniles were found in the nest from 13 April to 20 June. This would indicate that most birds were hatched by 13 April and were fledged by 20 June in Tennessee.

Clutch Size

Average clutch size for 25 nests examined in 1978 in east Tennessee was 4.1 (Table 5). The majority (52%) of clutches contained four eggs although clutch size ranged from three to six.

Bent (1938) reported that the screech owl lays from three to seven white eggs. He observed that most

Table 5. Clutch size of 25 nests examined in east Tennessee in 1978.

Number of Eggs	Number of Clutches	Percent
2	0	0
3	5	20
4	13	52
5	6	24
6	1	4
7	0	0
	Mean 4.1	

clutches numbered four or five, with the average in favor of five. He noted that clutches of eight or nine eggs have been reported but that these reports were probably inaccurate. VanCamp and Henny (1975) determined that the average clutch size for screech owls in northern Ohio was 4.4. Craighead and Craighead (1956) observed nesting screech owls in Superior Township, Michigan in 1942 and in 1948 and determined that the average clutch size was four eggs in both years. VanCamp and Henny (1975) examined egg sets from 12 museums in the eastern United States and discovered a clinal pattern in which clutch size increased from east to west and from south to north. They found that the average clutch size from Georgia-Tennessee-Florida was 3.10 eggs.

Egg Hatchability

An average of 3.6 eggs (88.6%) was hatched from 17 clutches examined in east Tennessee (Table 6). In each

Table 6. Hatchability of eggs for 17 screech owl nests examined in 1978 in east Tennessee.

Clutch Size (n)	Eggs Hatched Total (Mean)	Percent Hatched
3(2)	5(2.5)	83
4(11)	39(3.5)	89
5(4)	18(4.5)	90

of four clutches, one egg failed to hatch. A single clutch of four eggs failed to hatch any young although the female incubated until mid-May. Only two of the four eggs were fertile; however, cause of hatching failure for the other two eggs was not ascertained.

In general, researchers (Craighead and Craighead, 1956; VanCamp and Henny, 1975) have failed to provide information on hatching success. The time involved to check nests during the egg laying period and the fear of causing the incubating female to abandon her eggs are primary reasons for the lack of this information.

Fledging Success

Of 25 nests examined in east Tennessee in 1978, 2.5 young were fledged per nesting attempt (Table 7).

Table 7. Success of screech owl nests in east Tennessee in 1978.

Number Active Nests	Number Nests Successful[a]	Percent of Nests Successful	Number Young Fledged	Young Fledged Per Successful Nest	Young Fledged Per Nesting Attempt
25	17	68.0	62	3.6	2.5

[a]Fledged at least one young.

This estimate includes those nests destroyed, abandoned and those in which eggs did not hatch. Seventeen (68%) of these nests were successful (fledged at least one young); a total of 3.6 young were fledged per successful nesting attempt.

VanCamp and Henny (1975) estimated that the number of young fledged during a 30 year study in northern Ohio was 2.5 to 2.6 young per nesting attempt. However, when only successful nests were included, they estimated that 3.8 young were fledged per successful nest. They concluded that this estimate was inflated because of undetected losses before the first visit to the nest. Craighead and Craighead (1956) estimated that 2.6 and 3.0 young were produced per pair of adult screech owls in Michigan and Wyoming, respectively.

It was estimated that 60.2% of the eggs laid produced fledged young in east Tennessee (Table 8).

Table 8. Fledging percent of 25 east Tennessee screech owl nests in 1978.

No. Active Nest	No. Young Fledged	Maximum[a] Possible No. Young Fledged	Percent Fledged
25	62	103	60.2

[a]Calculated using an average clutch size of 4.1.

This estimate was based on an average clutch size of 4.1; unsuccessful nests were included. Craighead and Craighead (1956) estimated that 65% and 67% of the eggs laid successfully fledged in 1942 and 1948 in Michigan.

Of the 25 nests which I studied in 1978, mortality in the nest after hatching was not observed. Thus, 100% of the young that hatched, fledged. Similarly, Craighead and Craighead (1956) reported no juvenile mortality in the nest in Michigan and Wyoming. VanCamp and Henny (1975) also acknowledged that mortality from the period of hatching to fledging appeared to be low.

Causes of Nest Loss

Eight nests were unsuccessful in 1978 (Table 9).

Table 9. Causes for unsuccessful screech owl nests from 25 nests in east Tennessee in 1978.

Cause of Loss	Number of Nests
Deserted or destroyed (reason unknown)[a]	4
Starling competition	3
Eggs failed to hatch	1
Total	8

[a]Starling competition was probable cause in two of these nests.

Four nests were deserted or destroyed for unknown reasons. One nest failed to hatch any young even though the female incubated the eggs from the end of March until mid-May. The dispossession of one of these nests by starlings (Sturnus vulgaris) was observed by Mrs. Frank Emert (personal communication). She observed three starlings enter the nest box and force the incubating female owl to depart.

I made several observations of two other nests that were destroyed by starlings. In one nest, a starling was found perched on top of a nest box containing an incubating female owl in mid-April. The following day two eggs were found missing from the clutch and were located at the base of the nest tree. Some egg shells were found in the nest box, but the female owl continued to incubate the remaining four eggs. When I examined the nest box several days later, the female owl was gone and broken eggs were found at the base of the nest tree. Starlings began nest building immediately thereafter. A similar sequence of events was observed in another screech owl nest destroyed by starlings.

I did not observe the starlings throwing the eggs out of the nest boxes, but I strongly suspect they did. Mrs. Frank Emert (personal communication) observed a starling evacuate an incubating common flicker (Colaptes auratus) and then pick up the flicker eggs in its bill

and drop them out of the nest box. Screech owl eggs are larger than common flicker eggs, averaging 35.5 x 30.0 mm as compared to 26.9 x 26.0 mm (Harrison, 1975), but still appear small enough to be handled by starlings. Two of the four nests that were destroyed for unknown reasons were believed victims of starling competition. A starling nest was found on top of the abandoned owl eggs in both boxes. It is not known if the female owl abandoned and the starlings began using the nest box or if the starlings chased her out.

VanCamp and Henny (1975) provided the only published account for nest loss in the screech owl. Of 66 unsuccessful nests, 41 were deserted or destroyed for unknown reasons while raccoons (*Procyon lotor*) destroyed 15 nests. Eggs failed to hatch in seven of the nests. Young dead in the nest (in two nests) and destruction by children (in one nest) accounted for the other three unsuccessful nests.

II. SEXUAL SIZE DIMORPHISM

Of 74 screech owls examined in Tennessee, females were slightly larger than males (Appendix, Tables 25 and 26). Although the culmen, tarsus and tails of female screech owls were generally larger than those of male screech owls, these differences were not significant (Table 10). A significant difference in wing lengths of

Table 10. Mean ($\bar{X}$), standard deviation (SD) and range (R) of wing, culmen, tarsus and tail (in mm) for 74 screech owls collected on Tennessee roads from November 1976 to June 1978.

	Wing[a]		Culmen[b]		Tarsus[b]		Tail[b]	
	Female	Male	Female	Male	Female	Male	Female	Male
$\bar{X}$	167.28	160.13	21.82	21.44	42.17	40.84	86.83	84.08
SD	4.88	4.20	1.36	1.05	3.19	4.33	3.84	4.16
R	160-180	152-168	20-25	19-23	32-46	32-54	79-96	72-92

[a]Significant differences between the means by t-test ($p < 0.05$).

[b]No significant difference between the means by t-test ($p < 0.05$)

female and male owls occurred. Wing lengths of female owls varied from 160 to 180 mm; wing lengths of male owls ranged from 152 to 168 mm. Thus, an owl with a wing length of 170 mm or greater was a female and an owl with a wing length less than 160 mm was a male. However, an owl with a wing length between 160-168 mm could be either a male or female owl (Figure 9). Therefore, since 59% of the screech owls could not be sexed by wing length alone, this technique cannot be recommended.

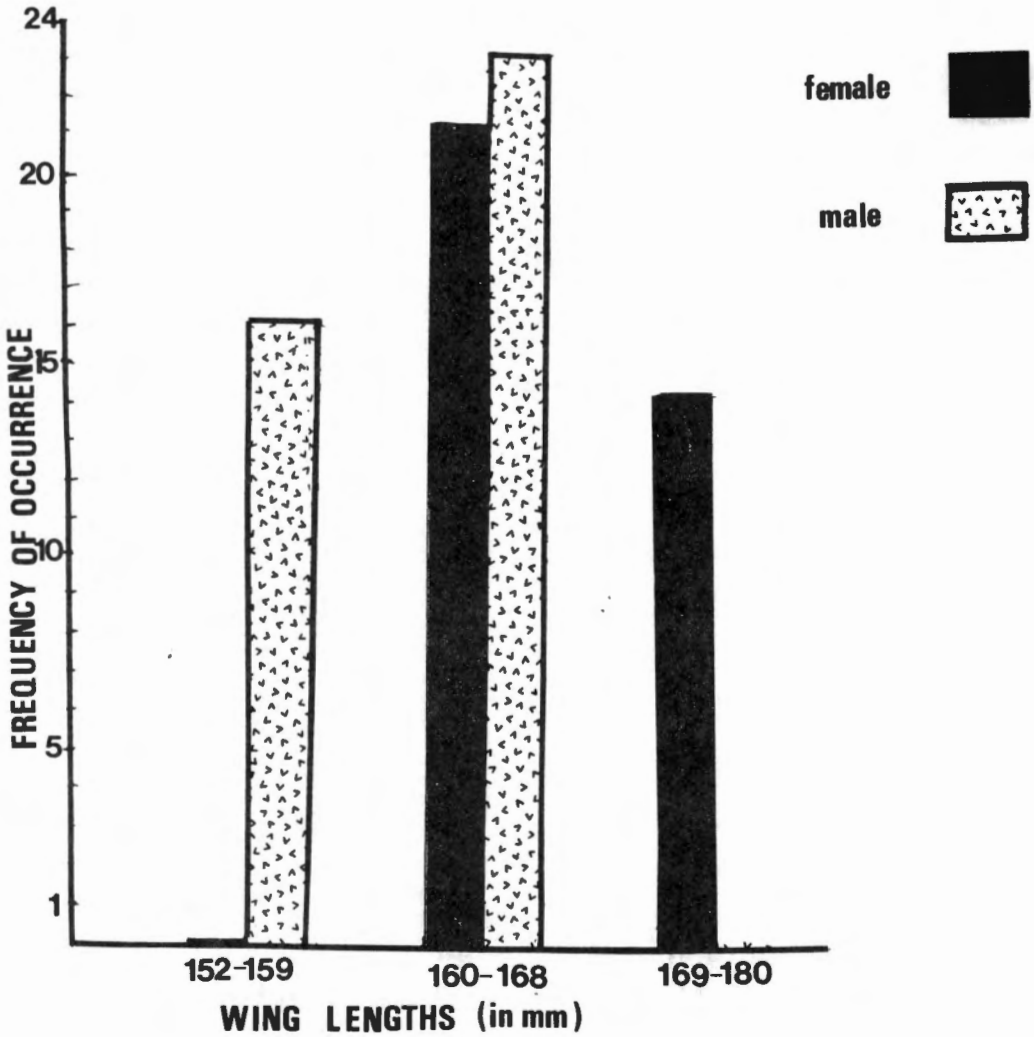


Figure 9. Wing lengths of 74 male and female screech owls collected on Tennessee roads.

III. FOOD HABITS

Food habits of the screech owl in Tennessee were investigated by examining (1) food items cached in nesting structures by screech owls, (2) stomach contents of DOR screech owls, and (3) records in the Migrant and other literature sources pertaining to Tennessee.

A total of 139 food items was cached in 42 nest boxes by screech owls during 1977-1978 (Tables 11 and 12). Sixty-seven percent (67%) of the total food items found were birds. Ninety-three birds of 20 species were identified. Blue jays, mockingbirds and cardinals, all permanent residents, were the most common birds encountered in the caches. Mammals (12%), fish (9%), invertebrates (9%) and amphibians (3%) comprised the remaining 33% of the total food items identified.

Of 90 screech owl stomachs collected from November 1976 to June 1978, 14 (16%) were empty. A total of 407 food items were identified from the remaining 76 stomachs (Table 13). Insects, mostly lepidopterans (32%), orthopterans (27%) and coleopterans (16.5%) comprised the majority of the food items identified. Spiders (9.1%) and mammals (4.7%) also contributed a significant amount to the total. Birds, fish, amphibians, crayfish, millipedes and centipedes made up the remaining 6.6%.

Few researchers have discussed the food habits of the screech owl in Tennessee. Ijams (1931:3) reported

Table 11. Species stored as food by screech owls during the spring (March-May) in east Tennessee.

Family	Species	n
Birds		
Picidae		
	Common Flicker (*Colaptes auratus*)	1
Tyrannidae		
	Eastern Kingbird (*Tyrannus tyrannus*)	1
Corvidae		
	Blue Jay (*Cyanocitta cristata*)	8
Troglodytidae		
	Carolina Wren (*Thryothorus ludovicianus*)	1
Mimidae		
	Mockingbird (*Mimus polyglottos*)	4
	Brown Thrasher (*Toxostoma rufum*)	2
Turdidae		
	American Robin (*Turdus migratorius*)	1
	Wood Thrust (*Hylocichla mustelina*)	2
Bombycillidae		
	Cedar Waxwing (*Bombycilla cedrorum*)	2
Sturnidae		
	Starling (*Sturnus vulgaris*)	1
Vireonidae		
	White-eyed Vireo (*Vireo griseus*)	1
	Red-eyed Vireo (*Vireo olivaceus*)	3
	Unidentified Vireo	1
Parulidae		
	Tennessee Warbler (*Vermivora peregrina*)	1
	Yellow-rumped Warbler (*Dendroica coronata*)	
	Unidentified Warbler	1
Fringillidae		
	Cardinal (*Cardinalis cardinalis*)	10
	American Goldfinch (*Carduelis tristis*)	4
	Chipping Sparrow (*Spizella passerina*)	1
	Field Sparrow (*Spizella pusilla*)	2
	Song Sparrow (*Melospiza melodia*)	5
Unidentified family		
	Small bird	3
	Subtotal (percent occurrence)	58 (63.7%)
Mammals		
Soricidae		
	Short-tailed Shrew (*Blarina brevicauda*)	1
Vespertilionidae		
	Red Bat (*Lasiurus borealis*)	1

Table 11 (Continued)

Family	Species	n	
Cricetidae			
	Eastern Harvest Mouse (*Rheithrodontomys humulis*)	2	
	Deer Mouse (*Peromyscus* sp.)	1	
	Hispid Cotton Rat (*Sigmodon hispidus*)	1	
	Meadow Vole (*Microtus* sp.)	4	
	Muskrat (*Ondatra zibethica*)	1	
Muridae			
	House Mouse (*Mus musculus*)	4	
	Subtotal (percent occurrence)	15	(16.5%)
Amphibians			
Ranidae			
	Pickerel Frog (*Rana palustris*)	1	
	Bullfrog (*Rana catesbeiana*)	2	
	Subtotal (percent occurrence)	3	(3.3%)
Fish			
Centrarchidae			
	Bluegill (*Lepomis macrochirus*)	3	
	Redbreast Sunfish (*L. auritus*)	1	
Cyprinidae			
	Whitetail Shiner (*Notropis galacturus*)	2	
	Subtotal (percent occurrence)	6	(6.6%)
Invertebrates			
	Crayfish (*Orconectes* sp.)	3	
	Red Worm	3	
	Beetles (Carabaeidae and Scarabaeidae)	2	
	Dragonfly	1	
	Subtotal (percent occurrence)	9	(9.9%)
Grand Total		91	(100.0%)

Table 12. Species stored as food by screech owls during the winter (December-February) in east Tennessee.

Family	Species	n	
Birds			
Picidae			
	Common Flicker	2	
	Red-bellied Woodpecker (*Melanerpes carolinus*)	3	
Columbidae			
	Mourning Dove (*Zenaida macroura*)	1	
Corvidae			
	Blue Jay	11	
Troglodytidae			
	Carolina Wren	1	
Mimidae			
	Mockingbird	9	
	Brown Thrasher	4	
Bombycillidae			
	Cedar Waxwing	3	
Fringillidae			
	Cardinal	1	
	Subtotal (percent occurrence)	35	(72.9%)
Mammals			
Soricidae			
	Short-tailed Shrew	1	
Cricetidae			
	Hispid Cotton Rat	1	
	Subtotal (percent occurrence)	2	(4.2%)
Amphibians			
Ranidae			
	Bullfrog	1	
	Subtotal (percent occurrence)	1	(2.1%)
Fish			
Cyprinidae			
	Goldfish (*Carassius auratus*)	1	
Clupeidae			
	Gizzard Shad (*Dorosoma cepedianum*)	6	
	Subtotal (percent occurrence)	7	(14.6%)
Invertebrates			
Astacidae			
	Crayfish (*Orconectes* sp.)	3	(6.2%)
Grand Total		48	(100.0%)

Table 13. Food items found in the stomachs of 76 screech owls collected on Tennessee roads from November 1976 to June 1978.

Family	Species	Number of Food Items
Mammals		
Cricetidae		
	Peromyscus sp. (Deer Mouse)	3
	Microtus pinetorum (Pine Vole)	1
	Unidentified genus	3
Muridae		
	Rattus norvegicus (Norway Rat)	1
Soricidae		
	Blarina brevicauda (Short-tailed Shrew)	2
Sciuridae		
	Glaucomys volans (Flying Squirrel)	1
Unidentified family		8
	Subtotal (percent occurrence)	19 (4.7%)
Birds		
Unidentified family		5
	Subtotal (percent occurrence)	5 (1.2%)
Fish		
Unidentified family		3
	Subtotal (percent occurrence)	3 (.74%)
Amphibians		
Plethodontidae		
	Eurycea bislineata (Two-lined Salamander)	1
	Subtotal (percent occurrence)	1 (.25%)
Crayfish		
Astacidae		
	Cambarus sp.	1
	Orconectes sp.	2
	Unidentified genus	4
	Subtotal (percent occurrence)	7 (1.7%)
Spiders		
Araneidae		
	Araneus sp. (Orb Weavers)	2
Atypidae		
	Atypus sp. (Purse-web Spiders)	7
Lycosidae		
	Lycosa helluo (Wolf Spiders)	1

Table 13 (Continued)

Family	Species	Number of Food Items
Pisauridae		
	Dolomedes sp. (Fishing Spiders)	3
Thomisidae	(*Xysticus* sp.) Crab Spiders)	7
Salticidae		
	Phidippus sp. (Jumping Spiders)	1
Unidentified family		16
	Subtotal (percent occurrence)	37 (9.1%)
Millipedes		
Unidentified family		1
	Subtotal (percent occurrence)	1 (.25%)
Centipedes		
Scutigeridae	(House Centipede)	2
Unidentified family		4
	Subtotal (percent occurrence)	6 (1.5%)
Insects		
Beetles (Coleoptera)		
Carabidae	(Ground Beetles)	30
Curculionidae	(Weevils)	3
Scarabaeidae	(Scarab Beetles)	13
Tenebrionidae	(Darkling Beetles)	3
Unidentified family	(adult)	16
Unidentified family	(larvae)	2
	Subtotal (percent occurrence)	67 (16.5%)
Bugs (Hemiptera)		
Pentatomidae	(Stink Bugs)	1
	Subtotal (percent occurrence)	1 (2.5%)
Hoppers (Homoptera)		
Membracidae	(Treehopper)	1
	Subtotal (percent occurrence)	1 (2.5%)
Wasps (Hymenoptera)		
Unidentified family		4
	Subtotal (percent occurrence)	4 (.98%)
Moths and Caterpillars (Lepidoptera)		
Noctuidae	(Noctuid Moths)	25
Unidentified family	(adult)	25
Unidentified family	(larvae)	80
	Subtotal (percent occurrence)	130 (32%)

Table 13 (Continued)

Family	Species	Number of Food Items
Dragonflies (Odonata)		
Aeschnidae (Darners)		1
	Subtotal (percent occurrence)	1 (.25%)
Grasshoppers and Crickets (Orthoptera)		
Acrididae (Short-horned Grasshoppers)		3
Gryllidae (Crickets)		38
Gryllacrididae (Camel Crickets)		10
Phasmatidae (Walking Sticks)		3
Tettigoniidae (Long-horned Grasshoppers)		
	Phaeropterinae (Round-headed Katydids)	1
	Copiphorinae (Cone-headed Grasshoppers)	17
	Unidentified subfamily	26
Unidentified family		12
	Subtotal (percent occurrence)	110 (27%)
Unidentified Insect		10
	Subtotal (percent occurrence)	10 (2.5%)
Unidentified Arthropod		4
	Subtotal (percent occurrence)	4 (.98%)
Grand Total		407 (99.9%)

that the screech owl in Tennessee ". . . eats lots of mice and beetles, but is not averse to songbirds." Laskey (1933:21) examined a nest box previously occupied by a screech owl that contained crayfish parts and feathers ". . . of at least two bluebirds, two cardinals and one robin." Trent (1938) reported on a fishing screech owl on Norris Lake, Anderson County, Tennessee.

Researchers in other areas of the United States (mostly northern United States) have also reported on the diversity of food items consumed by the eastern screech owl. Fisher (1893:173) examined 255 screech owl stomachs and found that ". . . 1 contained poultry; 38, other birds; 91, mice; 11, other mammals; 2, lizards; 4, batrachians; 1, fish; 100, insects; 5, spiders; 9, crawfish; 7, miscellaneous; 2, scorpions; 2, earthworms; and 43 were empty." Bent (1938:253) reported that ". . . in addition to mammals, birds, and insects, the screech owl has been known to eat snakes, lizards, frogs, toads, various fishes, crayfishes, snails, salamanders, spiders, millipeds [sic], and earthworms." McDowell and Luttringer (1948) reported that the diet of the screech owl consisted of 22.8% mice, 18% other mammals, 18% songbirds, with the remaining 41.3% composed of reptiles, amphibians, fish, insects, and other invertebrates. Korshgen and Stuart (1972) examined 419 pellets in western Missouri and reported that mice and rats together made up 87% of

all foods eaten; songbirds were 8.4% in occurrence and comprised 4.1% of the total volume. More recently, VanCamp and Henny (1975) reported a diet consisting of mammals, birds, fish, frogs and crayfish from food caches examined in northern Ohio.

Spring and Summer

A total of 91 food items was found cached by screech owls in 27 boxes during the 1977 and 1978 nesting seasons (7 March-7 June) in east Tennessee (Table 11, page 41). Most of the food was stored in the nests during the first two weeks after the young owls had hatched (late April and early May) as was also reported by VanCamp and Henny (1975). Fifty-eight birds of 19 species were identified, comprising 63.7% of the total food items found during the nesting season. Permanent residents of Tennessee, cardinals, blue jays and song sparrows were the most commonly occurring birds. Mammals, mostly meadow mice and house mice, comprised 16.6% of the total food items found. A red bat found on 23 April 1978 was of special interest. There is no other record of the screech owl feeding on this species, though Cahn and Kemp (1930) found two other species of bats in the diet of the screech owl in Illinois. Amphibians (3.3%), fish (6.6%) and various invertebrates (9.7%) made up the remaining 19.8% of food items cached.

The contents of six stomachs from screech owls collected on Tennessee roads in March, April and May were examined (Table 14). Insects (mostly beetles, moths, caterpillars and crickets) occurred in 83.3% of the stomachs examined. The remaining 17.7% was comprised of crayfish, spiders and centipedes. No vertebrate remains were found. Four stomachs collected in the summer months (June, July and August) all contained insects (beetles, grasshoppers, crickets, moths and wasps). Birds were present in only one stomach. No other vertebrate food items were found in the summer stomachs (Table 15).

The two preceding methods of food habits study (stomach analysis and food cache identification) indicated different diets for the screech owl during the nesting season. While stomach analysis indicated that screech owls ate an abundance of invertebrates (100%) during the spring and summer, food cache identification indicated that the majority of the diet consisted of birds (63.7%). Mammals, fish and amphibians were not present in the stomachs examined although they were present in food caches. VanCamp and Henny (1975) reported that invertebrates are rarely cached and are usually consumed immediately in their entirety. Thus, invertebrates would always appear to contribute little to a diet based on food caches. Allen (1924:7) explained that the large

Table 14. Spring (March-May) stomach contents for six screech owls collected on Tennessee roads from 1976 to 1978.[a]

Food Items	Percent Occurrence	Percent Volume	Importance Value
All Crayfish (Astacidae)	33.3	8.3	2.8
All Spiders (unidentified family)	16.7	3.3	.6
All Centipedes (unidentified family)	16.7	1.7	.3
All Insects	83.3	85.0	70.8
All Coleoptera	50.0	13.3	6.7
Carabidae	50.0	8.3	4.2
Scarabaeidae	16.7	1.7	.3
Tenebrionidae	16.7	3.3	.6
All Lepidoptera	50.0	66.7	33.4
Unidentified family (larvae)	33.3	55.0	18.3
Unidentified family (adult)	16.7	11.7	1.9
All Orthoptera	16.7	5.0	.8
(Gryllidae)	16.7	5.0	.8
Unidentifiable	16.7	1.7	.3

[a]Total stomach content volume = 6.0 ml.

Table 15. Summer (June-August) stomach contents for four screech owls collected on Tennessee roads from 1976 to 1978.[a]

Food Items	Percent Occurrence	Percent Volume	Importance Value
All Birds (Unidentified family)	25.0	11.8	2.9
All Insects	100.0	86.3	86.3
All Coleoptera (unidentified family)	75.0	35.3	26.5
All Hymenoptera (unidentified family)	25.0	2.0	.5
All Lepidoptera (Noctuidae)	25.0	19.6	4.9
All Orthoptera	50.0	25.5	12.8
Tettigoniidae	50.0	21.6	10.8
Gryllidae (Oecanthinae)	25.0	3.9	1.0
Unidentified insect order	25.0	3.9	1.0
Plant Material (pine needle)	25.0	2.0	.5

[a]Total stomach content volume = 5.1 ml.

number of birds identified in screech owl nests was ". . . due to the fact that it was impossible for them [screech owls in general] to eat a bird without dropping some of the feathers, especially as they [nestlings] fought over it before it was eaten." The absence of vertebrates in the stomachs of screech owls examined can possibly be attributed to a small sample size.

Several northern studies have supplied most of the information on the food habits of the screech owl during the nesting season. Allen (1924) identified 77 birds of 18 species brought to young screech owls during the nesting season in New York. He reported that remains of birds were found on 35 days, insects on 28 days, crayfish on 24 days, amphibians on 15 days, mammals on 12 days, fish on 6 days, and spiders, snails and reptiles on 1 day each. Errington (1932b) examined screech owl pellets in the spring and summer months in Wisconsin. He found 137 prey items in the following proportions: Norway rat, 1; meadow mouse, 49; deer mouse, 37; shrew (*Blarina*, 6; *Sorex*, 1), 7; small bird (predominately English sparrow), 36; fish, 4; crayfish, 3. VanCamp and Henny (1975) identified 477 items in food caches of the screech owl during the nesting season (26 March-7 June) in northern Ohio. Fifty-three species of birds were recorded, amounting to 64.8% of the food items found during the nesting season. VanCamp and Henny concluded

that the screech owl takes advantage of the spring migration of birds to feed its young. Craighead and Craighead (1956) also emphasized the importance of birds in the diet of the screech owl during the nesting season.

Fall and Winter

A total of 48 food items was cached in 15 nest boxes by screech owls during the winters of 1977 and 1978 (Table 12, page 43). Thirty-five birds of nine species were identified, amounting to 72.9% of the total food items cached during the fall and winter. Two permanent residents, the blue jay and mockingbird, accounted for over half of the avian food items cached. The remaining 27.4% was composed of fish (14.6%), crayfish (6.2%), mammals (4.2%) and amphibians (2.1%).

The contents of 25 stomachs from screech owls collected in the fall (September-November) in Tennessee were examined (Tables 16 and 17). Insects (92%), spiders (32%) and mammals (24%) were highest in percent occurrence. When both percent occurrence and percent volume were considered (Importance Value), insects (IV=31.2) and mammals (IV=11.6) were most important. All other food items identified had an importance value of less than 1.0.

A total of 41 stomachs examined during the winter months (December-February) contained insects (46.3%

Table 16. Fall (September-November) stomach contents for 25 screech owls collected on Tennessee roads from 1976 to 1978.[a]

Food Items	Percent Occurrence	Percent Volume	Importance Value
All Mammals	24.0	48.3	11.6
Cricetidae (*Peromyscus* sp.)	8.0	27.0	2.2
Muridae (*Rattus norvegicus*)	4.0	17.6	.7
Soricidae (*Blarina brevicauda*)	4.0	.4	0.0
Unidentified family	8.0	3.4	.3
All Birds (unidentified family)	8.0	2.5	.2
All Crayfish (Astacidae)	4.0	2.2	.1
All Spiders	32.0	2.9	.9
Araneidae (*Araneus* sp.)	8.0	.4	0.0
Atypidae (*Atypus* sp.)	12.0	2.2	.3
Unidentified family	12.0	.4	
All Millipedes (unidentified family)	4.0	.1	0.0
All Centipedes (unidentified family)	4.0	.5	0.0
All Insects	92.0	33.9	31.2
Coleoptera (unidentified family)	12.0	.9	.1
Hemiptera (Pentatomidae)	4.0	.2	0.0
Hymenoptera (unidentified family)	8.0	.4	0.0
All Lepidoptera	24.0	3.2	.8
Noctuidae	8.0	1.1	.1
Unidentified family (larvae)	8.0	1.6	0.0
Unidentified family (adult)	8.0	.5	0.0
All Orthoptera	60.0	29.0	17.0
Gryllacrididae	8.0	.1	0.0
Gryllidae	16.0	6.4	10.2
Phasmatidae	8.0	2.4	.2
Tettigoniidae	24.0	15.4	3.7
Unidentified family	20.0	4.2	.8
Unidentified insect order	8.0	.2	0.0
Unidentified Arthropod	4.0	.1	0.0
Unidentified	8.0	9.5	.7

[a]Total stomach content volume = 85.3 ml.

Table 17. Winter (December-February) stomach contents for 41 screech owls collected on Tennessee roads from 1976 to 1978.[a]

Food Items	Percent Occurrence	Percent Volume	Importance Value
All Mammals	36.6	60.7	22.2
Cricetidae (unidentified subfamily)	2.4	3.4	.1
Cricetinae (unidentified genus)	4.9	8.1	.4
Cricetinae (*Peromyscus* sp.)	4.9	18.2	.9
Microtinae (*Microtus pinetorum*)	2.4	7.6	.2
Soricidae (*Blarina brevicauda*)	2.4	3.4	.1
Sciuridae (*Glaucomys volans*)	2.4	6.8	.2
Unidentified family	17.1	13.3	2.3
All Birds (unidentified family)	4.9	.2	0.0
All Fish (unidentified family)	7.3	2.6	.2
All Amphibians			
Plethodontidae (*Eurycea bislineata*)	2.4	.5	0.0
All Crayfish	7.3	7.8	.6
Astacidae	2.4	4.7	.1
Unidentified family	4.9	3.1	.2
All Spiders	24.4	2.8	.7
Lycosidae (*Lycosa helluo*)	2.4	.2	0.0
Pisoridae (*Dolomedes* sp.)	4.9	.3	0.0
Salticidae (*Phidippus* sp.)	2.4	.7	0.0
Thomisidae (*Xysticus* sp.)	2.4	.1	0.0
Unidentified family	17.1	1.5	.3
All Centipedes (unidentified family)	2.4	.1	0.0
All Insects	46.3	21.7	10.3
All Coleoptera	36.6	4.2	1.5
Carabidae	19.5	3.1	.6
Curculionidae	2.4	.2	0.0
Scarabaeidae	7.3	.4	0.0
Unidentified family	9.8	.4	0.0
All Homoptera (unidentified family)	2.4	.1	0.0
All Lepidoptera	22.0	10.9	2.4
Noctuidae	2.4	2.7	.1
Unidentified family (larvae)	17.1	7.9	1.3
Unidentified family (adult)	2.4	.3	.1
All Odonata (Aeschnidae)	2.4	.1	0.0

Table 17 (Continued)

Food Items	Percent Occurrence	Percent Volume	Importance Value
All Orthoptera	12.2	6.2	.8
Acrididae	2.4	.3	0.0
Gryllidae	2.4	.1	0.0
Tettigoniidae	7.3	5.7	.4
Unidentified family	2.4	.1	0.0
Unidentified insect order	2.4	.2	0.0
Unidentified Arthropod	7.3	.3	0.0
Unidentifiable	14.6	3.3	.5

[a]Total stomach content volume = 118.06 ml.

occurrence), mammals (36.6%), spiders (24.4%), crayfish (7.3%), fish (7.3%), birds (4.9%), amphibians (2.4%) and centipedes (2.4%). Mammals (IV=22.2) and insects (IV= 10.3) were most important (Table 12, page 43).

The two methods of food habits study (stomach analysis and food identification) indicated different diets for the screech owl during the fall and winter. Mammals (36.6%) and insects (46.3%) were most common in stomachs, while birds (72.9%) and fish (14.6%) occurred most often in winter screech owl caches. An explanation for the differences in food habits from two methods was discussed in the preceding section (Spring and Summer). However, the precise explanation may not be the same. In winter the occupants of the boxes are primarily adults, whereas in the spring and summer nestlings also occupy the boxes.

Several researchers have examined the food habits of the screech owl during the fall and winter months. Wilson (1938) examined 1408 screech owl pellets in Ann Arbor, Michigan primarily collected in the fall and winter. He identified 1,549 skulls, mostly mammals. Over three-fourths of the mammals identified were meadow mice (*Microtus pennsylvanicus*) and deer mice (*Peromyscus* sp.). Wilson found that birds, crayfish, insects and fish were present in low numbers.

Craighead and Craighead (1956) examined screech

owl pellets in the winters of 1942 and 1948 in Superior Township, Michigan. Meadow mice and white-footed mice (95.3% in 1942 and 87.2% in 1948) comprised the majority of the winter diet. Late winter diet showed an increase in the percentage of small birds consumed (1.2 and 11.4%) in both years.

VanCamp and Henny (1975) examined 121 food items cached by screech owls in the fall and winter in northern Ohio. They reported that the diet of the screech owl consisted of 60.3% mammals, 26.4% birds, 5.8% fish, 5.0% frogs and 2.5% crayfish. The nonmigratory house sparrow and cardinal comprised over half of the avian food items. Meadow mice and deer mice amounted to over half of the mammals found.

Significant Transitional Features

Seasonality in the diet of the screech owl was investigated by examining the stomach contents of 76 DOR screech owls during all seasons of the year. Insects and mammals appeared to be reciprocal items in the screech owl's diet according to the seasons. Mammals were very important to the screech owl in the late fall and winter while insects were of major importance in the spring, summer and early fall (Figure 10). Birds, centipedes and millipedes varied little in occurrence with the changing seasons. Spiders occurred most often in the fall and winter months. Aquatic and semi-aquatic items

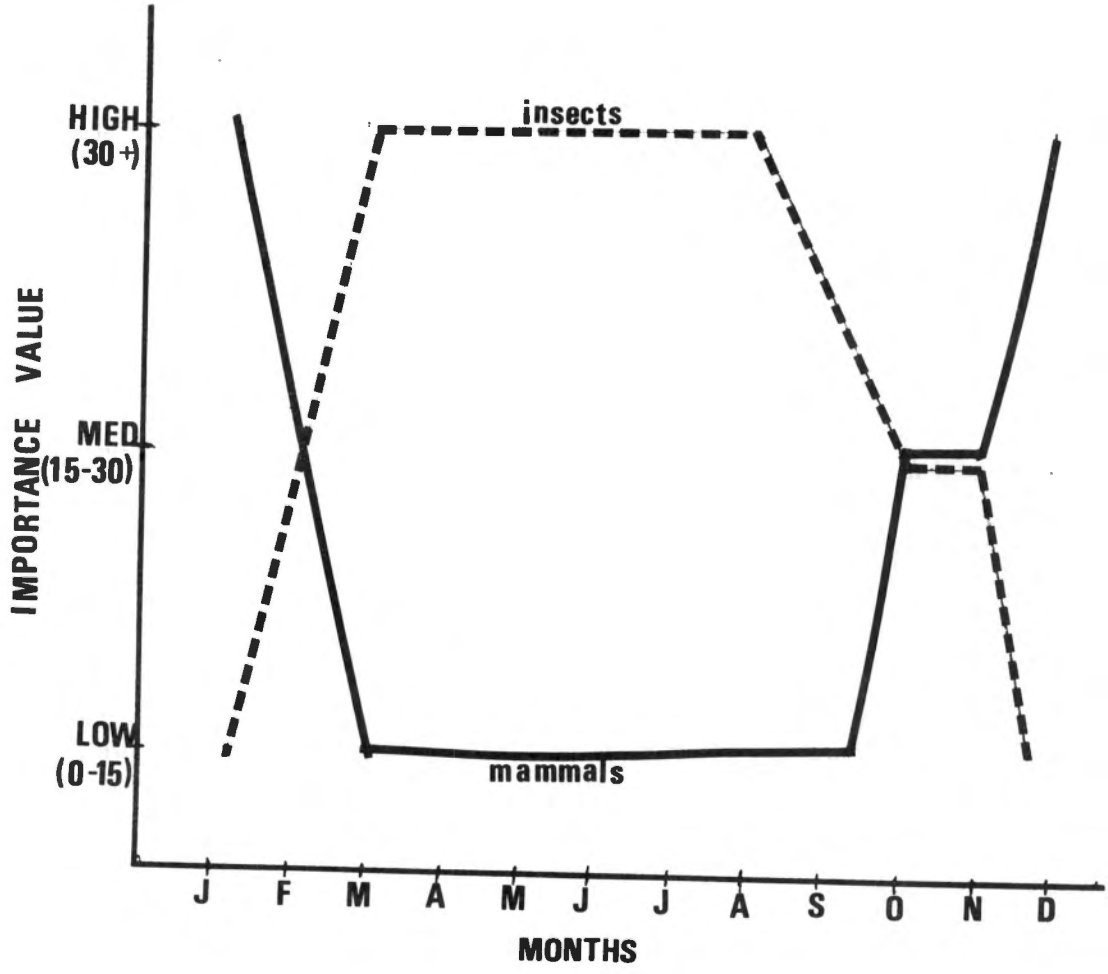


Figure 10. Importance values (percent occurrence x percent volume) of mammals and insects from 76 DOR screech owls collected November 1976 to June 1978.

(crayfish, fish, amphibians) were more commonly consumed during the winter months.

Few authors have discussed variation in food habits of the screech owl during all seasons of the year. Craighead and Craighead (1956) reported that mammals, mostly meadow mice and white-footed mice, were the most important food items consumed in all seasons of the year. VanCamp and Henny (1975) found that mammals and birds were reciprocal food items during the nesting season and the fall and winter in northern Ohio. Screech owls fed primarily on migratory bird species during the nesting season while mammals comprised the majority of their fall and winter diet.

Insects were of major importance in the diet of the screech owl in Tennessee during all seasons of the year (Tables 14-17, pages 50, 51, 54 and 55, respectively). Contents of 76 stomachs indicated that insects formed a large percentage of the spring (83.3%), summer (100%), fall (92%) and winter (46.3%) diets. A total of 324 insects of seven orders was found. Coleopterans, lepidopterans and orthopterans were the most common orders in all seasons of the year. A definite pattern in the usage of these three insect orders was seen (Figure 11). Consumption of lepidopterans, orthopterans and coleopterans peaked in March, April-August, and September, respectively.

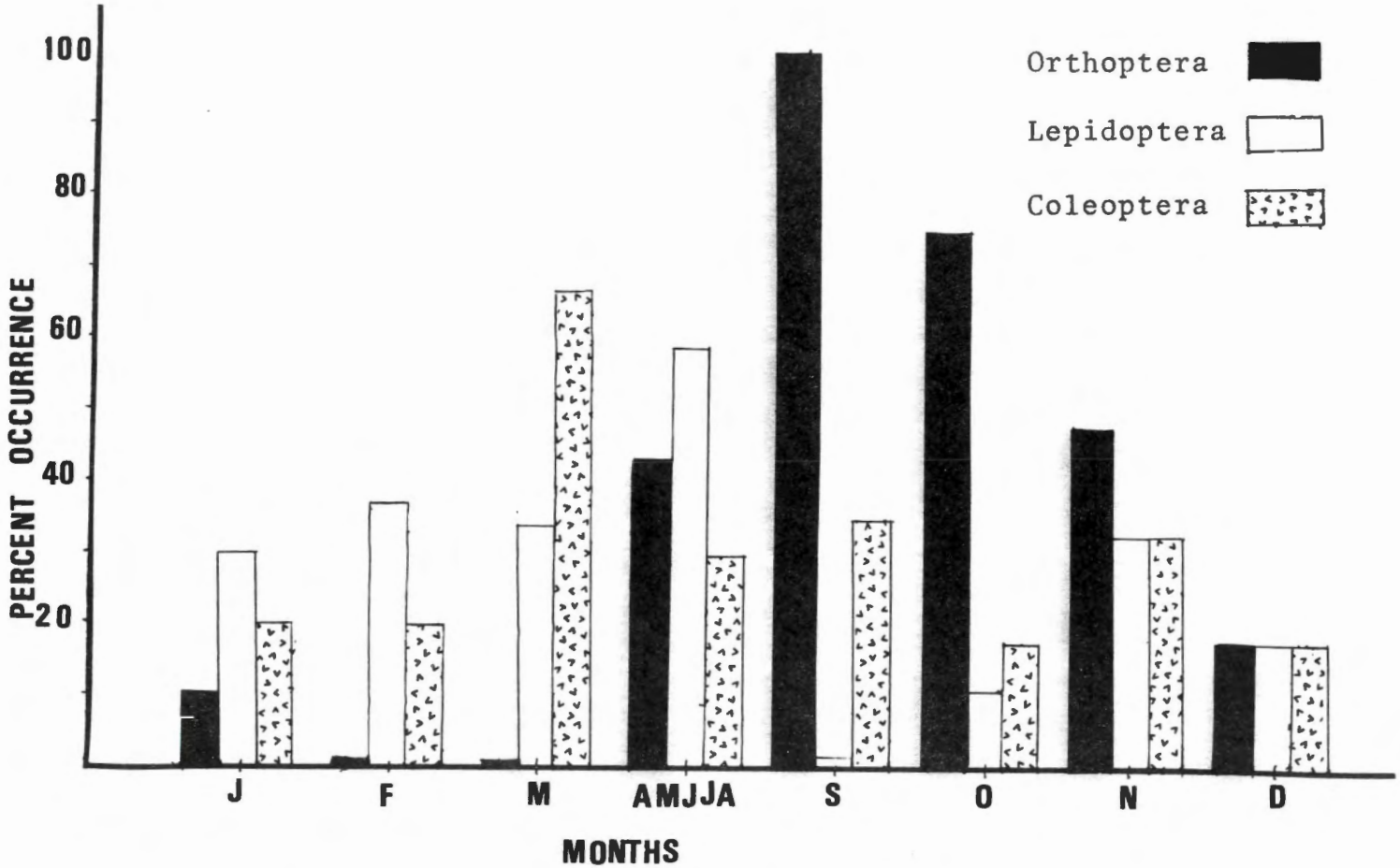


Figure 11. Percent occurrence of the three most common insect orders found in the stomachs of 76 screech owls collected on Tennessee roads from November 1976 to June 1978. 1/ = Percent occurrence represents combined total for four stomachs collected during April-August 1977.

Coleopterans (mostly adults) reached a peak in percent occurrence in the summer months. A decrease in coleopteran occurrence was seen in September with increasing numbers consumed in the following months. Coleopteran occurrence was fairly high during the winter months (up to 37% occurrence in February). Considering the fact that many coleopterans overwinter as adults, the large number consumed by screech owls during the winter months was not too surprising. Forty-five percent of the beetles identified were ground beetles (Carabidae). Carabidae is the second largest family of beetles in North America with some 2,500 species in our area (Borror et al., 1970). Carabid beetles ". . . are commonly found under stones, logs, leaves, bark, debris, or running about on the ground; when disturbed they run rapidly but seldom fly. Most species hide during the day and feed at night (Borror et al., 1976:370)." Darkling beetles (Tenebrionidae), scarab beetles (Scarabaeidae) and weevils (Curculionidae) were also found but in lesser numbers.

Lepidopterans (combined larvae and adults) reached a peak (percent occurrence) in March. This could be attributed to the transformation of larval forms into adults and increased movement due to the beginning of warm weather. All lepidopterans examined were in the family Noctuidae. Noctuidae is the largest Lepidopteran

family with some 2,700 species in the United States and Canada. These moths are nocturnal, and the majority of the moths that are attracted to lights at night belong to this group (Borror et al., 1976).

Orthopterans were present in stomachs collected at all times of the year except during the months of February and March. This is not surprising since most orthopterans pass the winter in the egg stage (Borror et al., 1976). Orthopterans reached a peak in occurrence in September and gradually decreased in occurrence from September to March. This can be explained by the fact that during the summer months most orthopterans are in a nymphal feeding stage. They are hidden in the grass and are flightless at this time. By September, the majority of orthopterans have reached the flighted adult stage and are participating in mating activity. This aerial display makes most orthopterans very conspicuous at this time of the year. Therefore, although orthopterans would not necessarily be more abundant in September, they would possibly be more available to the screech owl at this time.

Five families of orthopterans were identified. Tettigoniids (long-horned grasshoppers and katydids) were highest in percent occurrence with gryllids (crickets) following. Most katydids sing only at night; many crickets sing both day and night (Borror et al.,

1976). The nocturnal activity of these two families (Gryllidae and Tettigoniidae) would possibly account for their high occurrence in the diet of the screech owl. The other three families, Acrididae (short-horned grasshoppers), Gryllacrididae (camel crickets) and Phasmatidae (walking sticks) are primarily diurnal in habits and sing only during the day (Borror et al., 1976). These three families formed a small part (14%) of the total orthopterans identified.

Researchers (Cahn and Kemp, 1930; Craighead and Craighead, 1956) have generally underrated the importance of insects in the diet of the screech owl because of the study methods used. Most of the food habits studies on screech owls are based on food caches or pellet analysis. Both of these methods fail to detect invertebrates (especially insects) in proportion to their significance in the screech owl's diet (Errington, 1932a).

Fisher (1893) examined the contents of 254 screech owl stomachs and found primarily grasshoppers, crickets, beetles and other unidentified insects. Unfortunately, he failed to quantify his results. Errington (1932b) acknowledged that large invertebrates (crayfish, June beetles and crickets) make up a considerable portion of the screech owl's diet in southern Wisconsin during the warmer months.

VanCamp and Henny (1975) examined 479 food habit

cards filed at the Patuxent Wildlife Research Center, Laurel, Maryland. Basing their estimates solely on stomach contents, VanCamp and Henny reported that use of arthropods (primarily insects) peaked in late summer and declined during the winter months. They found that in some months up to 87% of the stomachs contained arthropods (primarily insects). However, they found no insects among 598 items identified from food caches.

Sutton (1929) reported that screech owls in West Virginia frequently caught insects in flycatcher fashion with open mouth. Some insects were also snatched from twigs and leaves with the feet. Sutton suggested that the noiseless flight, large eyes and the hair-like feathers of the nasal portion of the facial disc of the screech owl are ideal features for an insectivore. Ross (1969) reported that the screech owl catches insects on the wing and also gleans insects from vegetation. He emphasized, however, that the screech owl is partial towards the capture of ground dwelling animals.

IV. COLOR PHASE

The screech owl is polymorphic in the eastern part of its range, occurring in both red and gray color phases ". . . entirely independent of sex, age, or season (Bent, 1938:249)." Birds intermediate in coloration (brown phase) exist in the population but occur in low frequency.

Marshall (1967:3) related that through natural selection screech owl races tend to match the prevailing color and texture of the surrounding bark and foliage. Thus in the west where the surroundings are dull and monotonous, the owls are monomorphic and dull-colored; in the east where vegetation is varied with contrasting textures and colors, the owl occurs in two color phases, ". . . two plumages for the two states of vegetation."

The ratio of these two color phases varies clinally in the eastern United States in relation to climate and associated vegetation. Owen (1963:189) summarized the situation: "The relative frequency of rufous birds varies geographically in the form of a cline from north to south; about a quarter or less of the northern population is rufous, while in the south (the Gulf Coast and Florida excepted) up to three quarters of the population may be rufous. . . ." Owen (1963b) related that the Regina region of Saskatchewan is the most westerly point (104.6°W) at which red phase birds have been reported.

Color Phase Ratio

Of 117 DOR screech owls that were collected from November 1976 to June 1978 in Tennessee, 89 (76.1%) were red, 25 (21.3%) were gray and 3 (2.6%) were intermediate in coloration (Table 18). The resulting 3.6:1

Table 18. Color phase of 117 screech owls collected on Tennessee roads November 1976 to June 1978.[a]

Color Phase	Female	Male	Unknown Sex	Total[b]	Percent of Total
Red	32	27	30	89	76.1
Gray	3	10	12	25	21.3
Intermediate	0	2	1	3	2.6
Total	35	39	43	117	100.0

[a]Eight owls collected prior to November 1976 were included.

[b]No significant relationship was found between sex and color phase ($p < .05$).

ratio of red to gray phase birds is similar to the 4:1 red-gray ratio that Stupka (1953) found among 69 DOR birds in the Great Smoky Mountains National Park over a 15-year period.

Owen (1963b) reported that 79% of the screech owls in Tennessee were red phase based on specimens from museum collections and from several published records. This compares closely with the 76.1% red phase population illustrated by my data.

Screech owls which appear neither red nor gray but approach a brown coloration (intermediate) exist in the Tennessee population in low frequency. Among 117

DOR screech owls, three (2.6%) were intermediate in coloration. Two (2%) of 99 birds banded in 1977-1978 in Tennessee were intermediate in coloration. Published reports of intermediate birds in Tennessee are few. Stupka (1953) did not mention intermediate birds in his study of mortality of the screech owl in the Great Smoky Mountains National Park. Laskey (1963) found one intermediate bird among 98 birds (based on DOR specimens, banded birds and various sightings) in Nashville, Tennessee.

VanCamp and Henny (1975) reported that the breeding population in northern Ohio from 1944-1973 consisted of 2.6% intermediates. Hrubant (1955) reported that 3% of 227 screech owls in Ottawa County, Illinois were intermediate in coloration.

Sex and Color Phase

Sex was determined for 74 of the 117 screech owls collected on Tennessee roads; 35 were females (47%) and 39 were males (53%), approximately a 1:1 ratio (Appendix B, Table 27). Although other Tennessee researchers (Stupka, 1953; Laskey, 1963) examined the color phases of DOR screech owls, they failed to sex the birds. However, VanCamp and Henny (1975) examined stomach content records filed at the Patuxent Wildlife Research Center of 234 screech owls collected in the northeastern

United States. They found that 121 (51.7%) were females and that 113 (48.3%) were males. They concluded that this number did not differ significantly from a 1:1 ratio.

Of 59 red phase owls, 32 were females and 27 were males. Of 13 gray phase owls, 10 were males and 3 were females. No significant relationship was found to exist between sex and color phase ($p < .05$). VanCamp and Henny (1975) found no significant relationship between sex and color phase among 760 nesting screech owls. Other researchers (Martin, 1950; Hrubant, 1955) also concurred that there was no relationship between sex and color phase in screech owl populations.

Color Phase Inheritance

Currently two genetic hypotheses for inheritance of color phase in the screech owl are recognized (Hrubant, 1955; VanCamp and Henny, 1975): (1) one pair of genes with dominance in which the gene for red is dominant over the gene for gray and (2) a multiple allelic system in which red, intermediate and gray phenotypes are inherited with a graded order of dominance of red dominant to intermediate dominant to gray. In the "one pair of genes with dominance" hypothesis, intermediate owls are considered misclassified gradations of the red and gray phases and are not included in the sample.

VanCamp and Henny (1975) concluded that their

breeding data supported both of these hypotheses. They noted that gray by gray always resulted in gray offspring whereas red by red resulted in 25% gray offspring and 75% red offspring. This was an important finding because Hrubant (1955) noted that red by red produced only red offspring in a small sample.

From five red by red crosses of wild screech owls observed in 1978 in east Tennessee, 13 red and 1 gray offspring were produced (Table 19). Of two gray by gray matings, all progeny were gray. Although data were insufficient to test either genetic hypothesis, the fact that one red by red cross yielded one gray and three red young was significant.

Table 19. Mating types of progeny of screech owls in east Tennessee in 1978.

Mating Type Adult	No. of Successful Matings	Progeny	
		Red	Gray
1. Red x Red	5	13	1
2. Gray x Gray	2	0	8
Totals	7	13	9

V. NEST BOX UTILIZATION

In recent years increased attention has been directed towards nongame species and urban wildlife (Williamson, 1973; Geis, 1974; Crawford, 1976). Woodland and agricultural areas are constantly being converted into urban-suburban developments. Farmers are using more of their land each year for agriculture; wooded creek bottoms and woodlots are being cleared for mechanized agriculture (VanCamp and Henny, 1975). With these changing land-use patterns comes a change in species composition. Those species that are unable to adapt to these changes decrease along with shrinking habitat.

The screech owl is one such species whose primeval habitat (unmodified woodlands) is disappearing at a rapid rate. Hardin and Evans (1977) reported that cavity nesting birds, such as the screech owl, are specific in their habitat selection and sensitive to changing land-use patterns.

To investigate the effects of changing land-use patterns on the screech owl, 50 nest boxes were placed in each of three different habitat types (woodland, rural and urban-suburban). These boxes were monitored to determine patterns of utilization by screech owls.

Roosting Screech Owls

Screech owls frequently occupy nest boxes during the winter months. These winter roosts provide protection from inclement weather (Craighead and Craighead, 1956) and security for consuming and storing food (Phelan, 1977). During the winter of 1977-1978, a total of 30 and 26 nest boxes were used by roosting screech owls in rural and urban-suburban areas, respectively (Table 20). Only six boxes in woodland habitat were utilized by roosting screech owls. Use of nest boxes by roosting screech owls in woodland habitat was significantly different ($p < .05$) from use in the urban-suburban and rural habitats. This may reflect the number of natural cavities in a woodland area as compared to the other habitat types. With more available cavities, the need for

Table 20. Nest box use by screech owls in woodland (W), rural (R) and urban-suburban (U-S) areas from January-June 1978.

Nest Box Use	W	R	U-S
Number used by roosting screech owls	6	30	26
Number used by nesting screech owls	0	1	5
Number used by other animals	5	35	37
Number never used by vertebrate animals	40	4	5

artificial structures in a woodland habitat would be limited. It is also possible that the screech owl population in woodland habitat is much lower than in the other two habitat types. However, this idea conflicts with findings by Nowicki (1974) and Cink (1975). Nowicki (1974) suggested that a greater amount of available woodland habitat would provide more nesting and feeding areas and, therefore, sustain a larger population of screech owls. Cink (1975) studied screech owl populations in four areas containing different percentages of available woodland habitat. He concluded that the density of screech owls increased with increasing amount of available woodland.

Boxes in rural areas supported the largest number of roosting screech owls (30). Boxes in agricultural areas were frequently placed on a solitary tree in an open field which otherwise afforded little protection from the weather. Thus, high use of boxes in this habitat type was of special interest. Hesselschwerdt (1942) erected 56 nest boxes in an intensively farmed area in the black-soil prairie region of Illinois. During the first year he reported that 29 boxes were occupied by roosting screech owls.

An examination of 62 nest boxes revealed that there was no significant difference in direction of boxes used by roosting screech owls by chi-square (Table 21).

Table 21. Orientation of 62 nest boxes used by roosting screech owls in 1978.[a]

	Direction Facing							
	NNE	ENE	ESE	SSE	SSW	WSW	WNW	NKW
Number used	11	8	11	4	8	6	8	6

[a]Not significant by chi-square, $p < .05$.

This would suggest that factors other than direction of cavity entrance were of major importance in roost site selection. Craighead and Craighead (1956) reported that screech owls selected winter roosts that were adequately protected from snow and rain.

Nesting Screech Owls

A total of five, one and zero screech owl nests were located in urban-suburban, rural and woodland areas in 1978, respectively (Table 20). With such a small sample size (six nests), it is difficult to make conclusions concerning the significance of this management technique for screech owls. However, the adaptability of nesting screech owls to nest boxes in areas of human activity is of significance. Bent (1938:246) reported that the screech owl ". . . has been known to nest frequently, even regularly, in cavities in trees close to houses in towns and cities, thus showing more

confidence in human beings than most other owls show."

Of the six nests found, cavity entrance was oriented in five different compass directions (1, ENE; 1, SSE; 2, ESE; 1, WNW; 1, WSW). This seems to indicate that factors other than orientation of the box entrance are important in nest site selection.

Other Animals

A total of 35 and 37 nest boxes were used by animals other than screech owls in rural and urban-suburban areas, respectively, in 1978 (Table 20). Only five nest boxes in woodland habitat were occupied by other animals. Competition between screech owls and other vertebrate animals was seen in all three habitat types (Table 22). Starlings and eastern gray squirrels, *Sciurus carolinensis*, competed most frequently with the

Table 22. Nest box use by vertebrate animals in woodland (W), rural (R) and urban-suburban (U-S) areas from January 1978 to June 1978.

Species	W	R	U-S
Eastern gray squirrel (*Sciurus carolinensis*)	1	14	21
Southern flying squirrel	3	2	7
Tufted titmouse (*Parus bicolor*)	1	1	1
Great-crested flycatcher (*Myiarchus crinitus*)	0	0	2
Starling	0	21	20

screech owl for nest boxes in rural and urban-suburban areas. Of 150 nest boxes, 20 were used alternately by screech owls and eastern gray squirrels; 21 were used alternately by screech owls and starlings. Several nest boxes were used alternately by three different animals. No starlings and only one eastern gray squirrel nest was found in boxes in the woodland area. Hesselschwerdt (1942) reported that fox squirrels (Sciurus niger) competed with the screech owl in Illinois for dens. Bellrose (1964) reported that the starling was a serious competitor for nesting cavities with wood ducks and other cavity nesting birds.

Flying squirrels were present in three, two and seven nest boxes in woodland, rural and urban-suburban areas, respectively. Three nest boxes were used by tufted titmice--one in each of the three habitat types. Great-crested flycatchers nested in the urban-suburban area but were not found in the other two habitat types.

Of 50 nest boxes in woodland habitat, 40 were never used by vertebrate animals (Table 20). However, 33 boxes were used by wasps (Vespidae). In rural and urban-suburban areas, four and five boxes, respectively, were never used by vertebrate animals. Few wasps used boxes in these two habitat types.

CHAPTER IV

SUMMARY

1. A study of the screech owl in Tennessee was conducted from November 1976 to June 1978. Objectives were to obtain information on the bird's life history and to determine the adaptability of the owls to artificial nesting structures in three habitat types.

2. Gonadal size in both male and female birds increased from October to December and reached a peak in March.

3. From 25 nests examined in 1978, the majority of egg laying, hatching and fledging was completed between 29 March-11 April (80%), 26 April-9 May (76%) and 24 May-6 June (82%), respectively.

4. From 25 screech owl nests found in 1978, average clutch size was 4.1 eggs. Clutch size varied from three to six eggs; however, most clutches contained four eggs. From two nests that were monitored daily, incubation period was determined to be 25-26 days. From 17 successful clutches examined in east Tennessee, an average of 3.6 eggs (88.6%) was hatched. Causes of hatching failures were not ascertained.

5. Of 25 nests examined in east Tennessee in 1978, 2.5 young were fledged per nesting attempt. Seventeen

nests (68%) were considered successful (nests which fledged at least one young). Based on an average clutch size of 4.1, it was estimated that 60% of the young were fledged in east Tennessee. Of 17 nests observed in 1978, mortality in the nest after hatching was not observed; thus 100% of the young that hatched, fledged.

6. Causes of unsuccessful nests were determined for eight nests in 1978. Starling competition was believed to be responsible for the destruction of five nests. In one nest no eggs hatched, although the female incubated from March to mid-May.

7. Of 74 DOR screech owls collected in Tennessee, the culmen, tarsus, tail and wing lengths of female owls were generally larger than those of males examined. However, of these measurements only wing length was significantly different ($p < .05$) between the sexes. Wings of male owls ranged from 152-168 mm while wing lengths of female owls ranged from 160-180 mm. No females were found with wing lengths less than 160 mm; no males had wing lengths larger than 168 mm.

8. Food habits of the screech owl in Tennessee were determined by examining food items cached in nesting structures and stomach contents of DOR screech owls. A total of 139 food items was found cached in 42 nest boxes. Sixty-seven percent of all food items were birds. Mammals (12%), fish (9%), invertebrates (9%), and

amphibians (3%) comprised the remaining 33%. Of 90 stomachs collected from DOR birds, 14 (16%) were empty. A total of 407 food items was identified from the remaining 76 stomachs. Insects, mostly lepidopterans (32%), orthopterans (27%) and coleopterans (16.5%) comprised a majority of food items identified. Spiders, mammals, birds, fish, amphibians, crayfish, millipedes, and centipedes made up the remainder of items identified.

9. Insects and mammals appeared to be reciprocal food items in the screech owl's diet according to season. Mammals were most important in late fall and winter; insects were most important in spring and summer.

10. From 117 DOR screech owls collected from November 1976 to June 1978 in Tennessee, 89 (76.1%) were red, 25 (21.3%) were gray and 3 (2.6%) were intermediate in coloration. A ratio of 3.6:1 of red to gray birds was found. From 74 DOR owls which could be sexed, no significant relationship was found between sex and color phase ($p < .05$). Male to female ratio was 1:1.

11. A total of 150 nest boxes (50 each in rural, urban-suburban, and woodland areas) was monitored for utilization. Nest box use by roosting screech owls in urban-suburban and rural areas was significantly higher than use in woodland areas ($p < .05$). Boxes in urban-suburban habitat had the largest number of nesting owls. No nests were found in woodland habitat. Other animals

that used boxes during the study were eastern gray squirrel, southern flying squirrel, tufted titmouse, great crested flycatcher and starling. The starling and gray squirrel were the most common nest box competitors in rural and urban-suburban areas. Competition for nest boxes in woodland habitat did not appear to be a problem--40 nest boxes were never used by vertebrate animals. Only four and five nest boxes in rural and urban-suburban areas, respectively, were never used.

12. Screech owls roosted in nest boxes faced in each of eight directions (NNE, ENE, ESE, SSE, SSW, WSW, WNW and NNW). No significant difference ($p < .05$) in preference of nest box direction was found.

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APPENDICES

APPENDIX A

PHYSICAL CHARACTERISTICS OF SCREECH OWLS

Table 23. Measurements of male gonads removed from 39 screech owls collected on Tennessee roads from November 1976 to June 1978.[a]

Screech Owl Number	Right Gonad (mm)	Left Gonad (mm)	Date Collected
9	5.4 x 3.1	6.8 x 3.6	15 February 1977
13	4.2 x 3.4	4.8 x 3.5	18 February 1977
14	3.1 x 2.3	4.5 x 3.4	20 February 1977
15	5.0 x 4.0	7.0 x 4.5	20 February 1977
16	4.9 x 3.9	6.0 x 4.5	22 February 1977
24	2.0 x 1.1	2.3 x 1.4	26 November 1976
27	---	2.9 x 2.5	24 November 1975
28	3.0 x 2.0	3.5 x 2.1	21 January 1977
30	---	2.5 x 1.8	Winter months 1975
31	1.7 x 1.0	3.2 x 2.0	December 1976
32	2.0 x 1.7	2.6 x 2.1	3 December 1976
40	6.7 x 5.5	8.0 x 5.6	1st week May 1977
42	5.0 x 3.7	5.0 x 3.9	21 February 1977
44	2.5 x 1.9	2.5 x 1.9	August 1976
45	2.3 x 1.5	2.5 x 1.6	26 September 1977
48	---	2.9 x 1.6	14 October 1977
49	1.6 x 1.1	1.6 x 1.1	6 October 1977
52	1.8 x 1.1	2.5 x 1.3	18 October 1977
57	3.2 x 2.2	3.4 x 1.6	28 October 1977
58	---	2.9 x 1.7	24 July 1977
59	---	2.5 x 1.9	21 February 1977
63	---	2.1 x 1.5	October 1977
64	2.0 x 1.2	2.5 x 2.0	28 October 1977
65	3.0 x 2.0	3.8 x 2.9	26 November 1977
67	2.4 x 1.8	3.0 x 2.0	19 November 1977
73	1.7 x 1.2	2.0 x 1.4	16 November 1977
80	2.4 x 1.3	3.0 x 1.8	27 September 1977
92	---	4.2 x 3.1	22 January 1978
93	---	4.5 x 3.0	29 January 1978
95	4.0 x 1.9	5.4 x 3.0	7 February 1978
96	5.9 x 4.5	7.1 x 4.9	2 March 1978
101	3.4 x 2.8	4.4 x 3.2	12 February 1978
111	5.2 x 3.2	5.6 x 4.0	17 January 1978
113	2.3 x 1.9	3.2 x 2.5	6 December 1977
117	2.9 x 1.7	3.1 x 2.2	Winter months 1977-78
121	5.0 x 3.5	5.8 x 3.7	19 March 1978
123	---	5.2 x 3.2	29 February 1976
125	1.9 x 1.6	2.7 x 1.8	21 November 1976
126	1.5 x 1.0	2.2 x 1.4	26 February 1974

[a]Four birds collected before November 1976 were included.

Table 24. Diameter of largest ovarian follicle in mm from 35 screech owls collected on Tennessee roads from December 1976 to March 1978.

Screech Owl Number	Date Collected	Length of Largest Ovum (mm)
4	9 Feb. 1977	1.55
6	10 Feb. 1977	1.45
7	12 Feb. 1977	.80
12	20 Feb. 1977	.85
17	1 Mar. 1977	2.40
18	20 Feb. 1977	1.15
26	- Oct. 1977	.70
33	21 Jan. 1977	.55
34	- Dec. 1976	.45
39	- Dec. 1977	1.00
46	1 Mar. 1977	1.25
50	13 Oct. 1977	.70
51	13 Oct. 1977	.55
72	26 Nov. 1977	.75
75	1 Dec. 1977	.95
76	8 Nov. 1977	.90
77	8 Nov. 1977	.45
78	5 Oct. 1977	.65
79	16 Sept. 1977	.65
81	15 Oct. 1977	.65
89	9 Feb. 1978	1.15
91	30 Jan. 1978	1.90
94	17 Feb. 1978	1.25
98	- Feb. 1977	2.00
103	- Jan. 1978	.80
104	11 Jan. 1978	1.20
109	- Jan. 1978	.55
110	- Jan. 1978	1.65
112	29 Dec. 1977	.90
114	Winter 1978	.30
115	Winter 1978	.50
116	Winter 1977-78	.75
118	Winter 1977-78	1.00
119	Winter 1977-78	.45
122	20 Mar. 1978	3.95

Table 25. Wing, culmen, tarsus and tail lengths in mm for 35 female screech owls collected on Tennessee roads from November 1976 to June 1978.

Screech Owl Number	Wing	Culmen	Tarsus	Tail
4	166	--	32	84
6	172	--	36	92
7	170	--	38	96
12	168	--	36	88
17	171	--	40	90
18	164	--	42	79
26	166	22	42	81
33	174	25	43	86
34	176	25	38	87
39	173	24	39	89
46	166	22	45	90
50	161	21	42	84
51	170	23	43	83
72	165	22	45	88
75	169	22	41	87
76	160	22	42	83
77	167	20	42	91
78	167	22	44	88
79	162	21	42	89
81	171	20	44	94
89	160	20	40	85
91	160	22	44	84
94	160	--	45	87
98	172	21	43	84
103	165	21	45	85
104	166	22	43	87
109	180	22	46	85
112	170	22	46	94
114	165	20	42	84
115	160	20	42	84
116	167	21	45	81
118	165	21	44	91
119	166	22	46	87
122	172	23	45	86

Table 26. Wing, culmen, tarsus and tail lengths in mm for 39 male screech owls collected on Tennessee roads from November 1976 to June 1978.[a]

Screech Owl Number	Wing	Culmen	Tarsus	Tail
9	156	--	36	83
13	157	--	35	90
14	161	--	37	82
15	159	--	33	92
16	152	--	32	90
24	166	23	54	87
27	167	20	36	82
28	160	23	36	83
30	164	23	37	87
31	155	22	35	72
32	160	22	36	80
40	160	--	41	86
42	165	21	42	81
44	168	22	38	86
45	162	22	45	86
48	164	19	42	--
49	155	22	43	83
52	163	22	43	82
57	162	22	41	80
58	168	23	38	88
59	159	20	40	80
63	165	21	41	85
64	167	22	40	81
65	156	22	46	88
67	155	20	41	--
73	158	20	40	79
80	160	20	45	85
92	160	20	44	85
93	160	21	45	84
95	158	22	43	87
96	160	21	45	82
101	157	22	42	78
111	157	22	45	92
113	153	21	44	85
117[b]	127	21	45	58
121	160	22	41	83
123	163	21	44	80
125	156	21	42	84
126	157	22	44	89

[a]Five owls collected prior to November 1976 were included.

[b]Owl seemed very emaciated.

APPENDIX B

SCREECH OWLS COLLECTED ON TENNESSEE ROADS

Table 27. Screech owls collected on Tennessee roads from November 1976 to June 1978.[a]

Screech Owl Number	Sex	Color Phase	Date Collected	Locality
1	U	Red	5 Feb. 1977	Roane Co.
2	U	Red	5 Feb. 1977	Roane Co.
3	U	Gray	5 Feb. 1977	Cumberland Co.
4	F	Red	9 Feb. 1977	Knox Co.
6	F	Red	10 Feb. 1977	Knox Co.
7	F	Red	12 Feb. 1977	Knox Co.
8	U	Red	10 Feb. 1977	Loudon Co.
9	M	Red	15 Feb. 1977	Monroe Co.
10	U	Red	22 Feb. 1977	Knox Co.
11	U	Gray	16 Dec. 1976	Knox Co.
12	F	Red	20 Feb. 1977	Lawrence Co.
13	M	Gray	18 Feb. 1977	Murray Co.
14	M	Red	20 Feb. 1977	Moore Co.
15	M	Gray	20 Feb. 1977	Warren Co.
16	M	Red	22 Feb. 1977	Hardeman Co.
17	F	Red	1 Mar. 1977	Putnam Co.
18	F	Red	20 Feb. 1977	Knox Co.
19	U	Red	3 Feb. 1977	Roane Co.
20	U	Gray	20 Feb. 1977	Giles Co.
21	U	Gray	20 Feb. 1977	Lincoln Co.
22	U	Gray	20 Feb. 1977	Coffee Co.
23	U	Gray	20 Feb. 1977	Coffee Co.
24	M	Gray	26 Nov. 1976	Knox Co.
25	U	Red	24 Nov. 1976	Knox Co.
26	F	Red	-- Oct. 1977	Knox Co.
27	M	Red	24 Nov. 1975	Sullivan Co.
28	M	Red	21 Jan. 1977	Greene Co.
30	M	Red	Winter 1975	Washington Co.
31	M	Red	-- Dec. 1976	Washington Co.
32	M	Red	3 Dec. 1976	Grainger Co.
33	F	Gray	21 Jan. 1977	Greene Co.
34	F	Gray	-- Dec. 1976	Washington Co.
35	U	Red	19 June 1975	Blount Co.
39	F	Red	-- Dec. 1977	Sevier Co.
40	M	Gray	5 May 1977	Anderson Co.
41	U	Red	28 June 1977	Knox Co.
42	M	Red	21 Feb. 1977	Knox Co.
43	U	Gray	8 July 1977	Knox Co.
44	M	Red	-- Aug. 1976	Anderson Co.
45	M	Red	26 Sept. 1977	Anderson Co.
46	F	Red	1 Mar. 1977	Knox Co.
47	U	Red	30 Sept. 1977	Wilson Co.

Table 27 (Continued)

Screech Owl Number	Sex	Color Phase	Date Collected	Locality
48	M	Red	14 Oct. 1977	Stewart Co.
49	M	I	6 Oct. 1977	Anderson Co.
50	F	Red	13 Oct. 1977	Dickson Co.
51	F	Red	13 Oct. 1977	Dickson Co.
52	M	Gray	18 Oct. 1977	Knox Co.
57	M	Gray	28 Oct. 1977	Knox Co.
58	M	Red	24 July 1977	Knox Co.
59	M	Red	21 Feb. 1977	Knox Co.
60	U	Gray	8 July 1977	Knox Co.
61	U	Red	22 Oct. 1977	Blount Co.
62	U	Red	22 Oct. 1977	Blount Co.
63	M	Gray	-- Oct. 1977	Anderson Co.
64	M	Red	28 Oct. 1977	Anderson Co.
65	M	Red	26 Nov. 1977	Putnam Co.
66	U	Gray	19 Nov. 1977	Roane Co.
67	M	Red	19 Nov. 1977	Knox Co.
68	U	Red	19 Nov. 1977	Cumberland Co.
69	U	Red	12 Nov. 1977	Blount Co.
70	U	I	22 Dec. 1977	Knox Co.
71	U	Red	29 Dec. 1977	Sevier Co.
72	F	Red	26 Nov. 1977	Roane Co.
73	M	Red	16 Nov. 1977	Knox Co.
74	U	Red	19 Nov. 1977	Cumberland Co.
75	F	Red	1 Dec. 1977	Roane Co.
76	F	Red	8 Nov. 1977	Hamilton Co.
77	F	Red	8 Nov. 1977	Union Co.
78	F	Red	5 Oct. 1977	Union Co.
79	F	Red	16 Sept. 1977	Union Co.
80	M	I	27 Sept. 1977	Knox Co.
81	F	Red	15 Oct. 1977	Claiborne Co.
82	U	Red	15 Oct. 1977	Claiborne Co.
83	U	Red	15 Feb. 1978	Monroe Co.
84	U	Red	24 Jan. 1978	Anderson Co.
85	U	Gray	7 Feb. 1978	Anderson Co.
86	U	Gray	12 Jan. 1978	Anderson Co.
87	U	Red	1 Feb. 1978	Knox Co.
88	U	Red	20 Feb. 1978	Knox Co.
89	F	Red	9 Feb. 1978	Knox Co.
90	U	Red	1 Feb. 1978	Anderson Co.
91	F	Red	30 Jan. 1978	Anderson Co.
92	M	Red	22 Jan. 1978	Jefferson Co.
93	M	Red	29 Jan. 1978	Knox Co.
94	F	Red	17 Feb. 1978	Campbell Co.
95	M	Red	7 Feb. 1978	Roane Co.

Table 27 (Continued)

Screech Owl Number	Sex	Color Phase	Date Collected	Locality
96	M	Red	2 Mar. 1978	Anderson Co.
97	U	Red	5 Feb. 1978	Blount Co.
98	F	Red	-- Feb. 1977	Knox Co.
99	U	Red	13 Feb. 1978	Dyer Co.
100	U	Red	5 Feb. 1978	Roane Co.
101	M	Red	12 Feb. 1978	Roane Co.
102	U	Red	30 Dec. 1977	Knox Co.
103	F	Gray	-- Jan. 1978	Knox Co.
104	F	Red	11 Jan. 1978	Monroe Co.
105	U	Red	4 Feb. 1978	Campbell Co.
106	U	Red	29 Jan. 1978	Knox Co.
107	U	Red	17 Feb. 1978	Knox Co.
108	U	Gray	-- April 1972	Carter Co.
109	F	Red	-- Jan. 1978	Sullivan Co.
110	F	Red	-- Jan. 1978	Sullivan Co.
111	M	Gray	17 Jan. 1978	Carter Co.
112	F	Red	29 Dec. 1977	Sevier Co.
113	M	Red	6 Dec. 1977	Sullivan Co.
114	F	Red	Winter 1978	Sullivan Co.
115	F	Red	Winter 1978	Sullivan Co.
116	F	Red	Winter 1977-78	Sullivan Co.
117	M	Red	Winter 1977-78	Sullivan Co.
118	F	Red	Winter 1977-78	Sullivan Co.
119	F	Red	Winter 1977-78	Sullivan Co.
120	U	Red	Winter 1977-78	Sullivan Co.
121	M	Gray	19 Mar. 1978	Knox Co.
122	F	Red	20 Mar. 1978	Blount Co.
123	M	Red	29 Feb. 1976	Carter Co.
124	U	Red	13 May 1974	Carter Co.
125	M	Gray	21 Nov. 1976	Carter Co.
126	M	Red	26 Feb. 1974	Washington Co.

[a]Eight owls collected on dates earlier than November 1976 were included.

[b]Owls number 5, 29, 36, 37, 38, 53, 54, 55 and 56 were prepared specimens and not included in the Appendix.

VITA

Linda J. Duley was born in Pascagoula, Mississippi, on July 20, 1953. She attended elementary schools in that city until 1963 when her family moved to Oak Ridge, Tennessee. She graduated from Oak Ridge High School in 1971 with honors and entered The University of Tennessee, Knoxville the fall of that year. She received the Bachelor of Arts degree in Zoology with honors in 1975.

The fall of 1975 she began study towards a Master's degree in Wildlife and Fisheries Science and received that degree in March 1979. Linda is a member of the Tennessee Ornithological Society, Wilson Ornithological Society, American Ornithologists' Union and the Raptor Research Foundation.

She is married to David A. Turner of Powell, Tennessee.