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REPRODUCTION OF SOUTHERN FLYING SQUIRRELS (*GLAUCOMYS VOLANS*) IN WEAKLEY COUNTY, TENNESSEE

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ABSTRACT--During 1983 through 1989, I observed 15 litters of southern flying squirrels (*Glaucomys volans*) in nest boxes erected for eastern bluebirds (*Sialia sialis*) on three farms in Weakley County, Tennessee. The squirrels had two reproductive periods per year; nine spring nests contained young in January through March, and six fall nests contained young in August through October. The average litter size was 2.9 with a range of two to five. For the spring nests, the average litter size was 2.3 (range of two to three), and, for the fall nests, the average litter size was 3.7 (range of two to five).

Southern flying squirrels (*Glaucomys volans*) occur throughout Tennessee where suitable habitat exists (Dolan and Carter, 1977). While accounts of the reproductive biology of the southern flying squirrel are available for some adjacent or nearby states (e.g., Louisiana--Goertz et al., 1975; Arkansas--Heidt, 1977; Virginia--Sonenshine et al., 1979), little information is available from Tennessee. Linzey and Linzey (1971) reported the collection on 4 August 1937 of a female southern flying squirrel with four large embryos. The only systematic studies that I could find that deal with the biology of the southern flying squirrel in Tennessee are four theses describing population size, movements of individuals, habitat preference, behavior, and reproductive biology in a woodlot in Putnam County (Todd, 1976; Duggan, 1978; Litzenberger, 1979; Robertson, 1981). In these studies, which covered four breeding seasons, seven litters were found. In this report, I present data on 15 litters of southern flying squirrels in Weakley County, Tennessee.

MATERIALS AND METHODS

In January 1983, I erected 10 eastern bluebird (*Sialia sialis*) nest boxes on the Moore farm, 6.5 km northeast of Martin, Weakley Co., Tennessee. In March 1984, I erected 10 nest boxes on the Byars farm, about 1.5 km southwest of the Moore farm, and, in February 1985, I erected 10 nest boxes on the Carmichael farm, between the Moore and Byars farms. Each nest box had a floor size of 1.27 by 10.2 cm with a 3.8-cm diameter entrance hole located 13.3 cm above the floor. The volume of each nest box was approximately 2,850 cm^3. Boxes were placed about 2 m above the ground on metal conduit posts. Each farm was used exclusively for beef cattle production; pasture and wooded areas were interspersed. Boxes were positioned at least 100 m apart along fencerows or at the intersection of pastures and wooded areas which were primarily oak (*Quercus* spp.) and hickory (*Carya* spp.) with introduced loblolly pine (*Pinus taeda*) in some areas. The Moore farm contained 33 ha with approximately 30 ha in pasture. The farm carried a small number of cattle and, consequently, was lightly grazed; the wooded areas (a mixture of loblolly pine and hardwoods) had in most areas a dense undergrowth of shrubs and vines. The Byars farm also contained 33 ha, with approximately 25 ha of pasture; all of the farm was heavily grazed. The wooded areas were exclusively hardwood and had virtually no undergrowth as a result of the cattle. The Carmichael farm contained 133 ha with approximately 60 ha of pasture; this farm was not only larger than the others but also consisted of a higher percentage of wooded areas. I did not conduct vegetation analyses, but, based on my subjective estimate, the woodlands on the Carmichael farm contained a greater percentage of pines than woodlands on the other farms. Moderate to light grazing pressure from cattle allowed the development of a definite, but not dense, understory in most of the wooded areas. All three farms were adjacent to wooded areas.

I inspected the nest boxes at least once per week during March through August and at irregular intervals during September through February from 1983 through 1989. When flying squirrels were present in a box, I systematically recorded the number of young and adults, but not the size of the young. Identification of flying squirrels as predators on bird nests was based on the criteria given by Pinkowski (1975). In 1988, the nest boxes that had been consistently used by flying squirrels were moved into more open areas to facilitate utilization by bluebirds and to reduce interference from flying squirrels.

RESULTS

During the seven years (1983 through 1989) of this study, I observed 15 litters of flying squirrels. I did not find any litters in the first three years (1983 to 1985) of the study; the distribution of the observed litters by year and farm is shown in Table 1. The flying squirrels had two distinct reproductive periods: January through March (= spring nests) and August through October (= fall nests). Nine spring litters had a mean size of 2.3 young and contained either two or three young. Six fall litters had a mean size of 3.7 and contained two to five yound (Fig. 1). Using the criteria reported by Linzey and Linzey (1979), I was able to determine the approximate parturition time for each litter (Fig. 1). I found two nests, one in the spring and one in the fall, with only dead young; each of these nests contained two young. I included these two litters in subsequent calculations and totals; it is possible that additional young (which I never observed) in each litter could have been moved by an adult to another nest site. The mean size of all 15 litters was 2.9 with a range of two to five young (Fig. 1). Litters containing four or five young were seen only in the fall. In addition to nests with young, I detected flying squirrel use of nest boxes by the presence of adults, the presence of nesting material, and the destruction of active nests of birds. These observations are summarized in Table 2. A summary of all activities of flying squirrels on each farm is given in Table 3.

TABLE 1. Distribution of southern flying squirrel litters by year[1] and farm in Weakley County, Tennessee.

Year	Byars	Carmichael	Moore	Total
1986	0	2	4	6
1987	0	3	0	3
1988	1	2	1	4
1989	0	1	1	2
Combined	1	8	6	15

[1]No litters were found in 1983 through 1985.

DISCUSSION

My data on the breeding biology of southern flying squirrels are similar to those reported from middle Tennessee and from nearby states. I found two distinct breeding periods per year, January through March and August through October; parturition dates for the seven litters reported from middle Tennessee (Todd, 1976; Duggan, 1978; Litzenberger, 1979) were likewise divided into two groups (two litters in March and five litters in August through October). A similar pattern has been reported from nearby states. For example, Goertz et al. (1975) reported that in northern Louisiana, about 3.5°S lat. of my study site, southern flying squirrels produced litters as early as January and as late as November with peaks in February and March and in September. In West Virginia, about 1.5°N lat. of my study site, Uhlig (1956) also found distinct spring and fall breeding seasons in the one year (1953) for which he had complete data.

I found the average size of spring litters (2.3) to be smaller than fall litters (3.7). This same pattern was found in middle Tennessee where two spring litters averaged 2.5 young, and five fall litters averaged 4.0 young (Todd, 1976; Duggan, 1978; Litzenberger, 1979). I calculated from the data of Goertz et al. (1975) that spring litters in Louisiana averaged 2.0 young and fall litters averaged 2.5 young. Linzey and Linzey (1979) reported that southern flying squirrels in southern Alabama also had larger litters in the fall than in the spring breeding season. In West Virginia, Uhlig (1956) reported an average litter size of 2.4 in the spring and 3.5 in the fall. I did not find in the literature an hypothesis explaining the difference in litter size between the spring and fall breeding seasons. Intuitively, one might expect females to be in better physical condition in late summer to early fall than in early spring because of milder temperatures and, presumably, easier access to more abundant food. However, part of the variation in litter size between spring and fall may be due to the age of the females involved.

It has been known for many years that southern flying squirrels produce litters in late winter to early spring and late summer to fall in many parts of the species' range (Wells-Gosling, 1985). However, whether or not individual females produced two litters in one year remained unclear until recently. Lee and Zucker (1990) clearly showed that captive females held under natural photoperiods frequently produced two litters per year. Wells-Gosling (1985) noted that young females produced small litters but that litter size increased in older females. If many of the females producing litters in the spring period are breeding for the first itme, the average litter size might be smaller than in the fall breeding period when few, if any, of the females are producing their first litters. However, this simplistic explanation may not be realistic. Lee and Zucker (1990) summarized the available information dealing with the effect of birth date on the age of puberty in flying squirrels; currently, the relationships between food supply, date of birth, age of puberty, and age at which first litters are actually produced remain unclear.

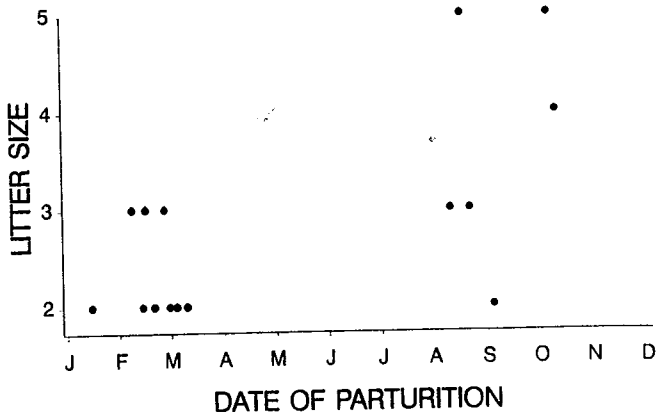

FIG. 1. Date of parturition and litter size for 15 litters of southern flying squirrels in Weakley County, Tennessee.

The mean litter size (2.9) and the range in litter size (two to five) that I found are intermediate to values reported from nearby states and are in agreement with the trend of larger litter sizes at higher latitudes. Goertz et al. (1975) found a mean litter size of 2.1 (range of one to four) in Louisiana, and Uhlig (1956) reported a mean litter size of 3.1 (range one to six) in West Virginia. Spencer and Steinhoff (1968) proposed that larger litter sizes occur at higher latitudes because shorter seasons at high latitudes limit the number of times a female can reproduce, and, therefore, phenotypes producing large litters are favored.

Numerous authors (e.g., Ellis, 1987; Nixon, 1979) have noted that southern flying squirrels readily use vacant nest boxes. However, this generalization is apparently not true in all habitats. Goertz et al. (1975) noted that use of nest boxes was lowest in mature hardwoods and highest in cutover pine-hardwood areas. This may partially explain the different rates of nest-box utilization I observed. The Byars farm had the smallest amount of pines and the lowest utilization of nest boxes, while the Carmichael farm, which had the largest amount of pines, had the highest utilization of nest boxes (Table 3). Even though the Carmichael farm was larger than either of the other farms, I had fewer box-years there (Table 1); consequently, I do not think the size of the farm was a factor influencing box use. It is possible that the three farms had different population densities of flying squirrels and my observations simply reflect these differences. I have no estimates of the density of flying squirrels on any of the three farms in my study area. However, all three farms had large populations of gray squirrels (*Sciurus carolinensis*); I suspect all three farms had similar densities of flying squirrels. Harlow and Guynn (1983) concluded that snag density decreases with an increased pine component in the forest. The higher rate of nest-box utilization by flying squirrels on the farm with the greatest amount of pine may be due to a shortage of suitable cavities in the trees. This may also explain why in my 20 years of monitoring nest boxes in Obion County, Tennessee, in an area where there were no pines, I rarely encountered flying squirrels in the boxes even though I knew from the reports of raccoon hunters and loggers that flying squirrels were common in the area.

Flying squirrels eat a variety of animals and animal products including birds, both nestlings and adults, and eggs (Wells-Gosling, 1985). The characteristic signs of mammalian predation (Pinkowski,

TABLE 2. Evidence of use of nest boxes by southern flying squirrels (nests with young not included).

Year[1]	Nests with adults only	Empty nests	Adults in empty box	Bird nests destroyed[2]
1985	0	0	1	0
1986	1	5	1	3
1987	0	3	0	4
1988	2	3	2	1
1989	0	0	0	0
Combined	3	11	4	8

[1]No activities were observed in 1983 through 1985.

[2]Eastern bluebird (*Sialia sialis*) and Carolina chickadee (*Parus carolinensis*).

1975) enabled me to determine that at least eight active bird nests were destroyed by flying squirrels (Table 2); in some cases, flying squirrels remodeled the bird nest and used the cavity as a nest site. I suspected that flying squirrels destroyed several other bird nests in the nest boxes. Because my primary objective was the study of bird nesting activities, I moved the nest boxes most frequently used by flying squirrels. This resulted in a decline in nest box use by flying squirrels in 1989 (Tables 1 and 2).

Because the reports of Todd (1976), Duggan (1978), and Litzenberger (1979) from middle Tennessee have not been published, it is perhaps appropriate to combine their data with my results to present a summary of research on the breeding biology of southern flying squirrels in Tennessee. A total of 11 spring litters (nine from the present study and two from middle Tennessee) averaged 2.4 young (range of two to three); 11 fall litters (six from the present study and five from middle Tennessee) averaged 3.8 young (range of two to six). The overall mean size of the 22 litters (15 from the present study and seven from middle Tennessee) is 3.1 (range of two to six).

The paucity of published data on the reproductive biology of southern flying squirrels in Tennessee surprised me. This species, even though not seen by most persons, is apparently common across much of the state and will readily use nest boxes, at least in some habitats. Intensive study of southern flying squirrels, especially their reproductive biology, is needed from all parts of Tennessee.

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TABLE 3. Summary of use of nest boxes on three farms in Weakley County, Tennessee, by southern flying squirrels.

Farm	Box years[1]	Number of litters	Other activities[2]	Total activities[3]	Activities/box year
Byars	60	1	4	5	0.08
Carmichael	50	8	17	25	0.50
Moore	70	6	5	11	0.16
Combined	180	15	26	41	0.23

[1]One nest box present for a year equals 1 box year.

[2]Summarized from Table 2.

[3]Number of litters plus other activities.