

Reproductive Chronology of the Northern Flying Squirrel on the Olympic Peninsula, Washington

Abstract

The timing and frequency of breeding by northern flying squirrels (*Glaucomys sabrinus*) on the Olympic Peninsula, Washington were inferred from seasonal changes in the occurrence of juvenile flying squirrel remains in the pellets of northern spotted owls (*Strix occidentalis caurina*). Juvenile flying squirrels were uncommon or absent in the diet of spotted owls except during late August to early November. This suggested that breeding was largely concentrated in late May and early June, and that most females produced only a single litter in years when they bred. Infrequent breeding did occur outside the primary breeding season, as evidenced by the occasional occurrence of juvenile remains in pellets during mid-summer, late fall, and winter. Quantitative information on the population dynamics of flying squirrels and other arboreal mammals is important to our understanding of forest communities in the Pacific Northwest.

Introduction

Recent attempts to design management plans for spotted owls and late-successional forest ecosystems in the Pacific Northwest have been plagued by a considerable lack of knowledge regarding many species of animals and plants (Thomas *et al.* 1990, Forest Ecosystem Management Assessment Team 1993). This is particularly true of arboreal mammals like the flying squirrel and red tree vole (*Arborimus longicaudus*). Although these arboreal mammals are important prey for a variety of forest birds and mammals (Forsman *et al.* 1984, Barrows 1980) and play an important role in the spread of hyphogeous fungi within forest communities (Maser *et al.* 1978, Fogel and Trappe 1978), there is little information on their population dynamics or life history traits. As a result, their role in forest systems is only vaguely understood. Any attempt to understand processes and functions within forest communities must include a better understanding of the life histories and population dynamics of these little known mammals.

Because studies of arboreal mammals are labor-intensive and expensive, they are invariably limited to relatively small areas and there is always some

question regarding their applicability to larger geographic areas. In this paper we describe a study in which we used the seasonal occurrence of juvenile flying squirrel remains in pellets of spotted owls to estimate the timing and frequency of breeding by flying squirrels within a relatively large geographic region. The data were collected during a study of the habitat use and diet of spotted owls on the Olympic Peninsula in northwestern Washington. By examining flying squirrel remains in the pellets of owls, we were able to sample from the flying squirrel population throughout the year and to examine large numbers of squirrels from many different locations on the peninsula.

Study Area and Methods

The Olympic Peninsula is characterized by mountainous terrain covered by dense coniferous forests of western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*), Sitka spruce (*Picea sitchensis*), and Douglas-fir (*Pseudotsuga menziesii*). Forests where we found spotted owls were typically dominated by multilayered canopies in which the dominant overstory trees exceeded 100 cm diameter at breast height (dbh). Some owls were also found in stands of younger, smaller trees (20-50 cm dbh) interspersed with scattered patches of large old trees. Our study area included the entire peninsula.

Pellets were collected from spotted owls between 1 March 1987 and 31 August 1989. During fall and winter (September-February), we collected pellets from 20 radio-marked adult owls by locating the owls in their roost trees and then

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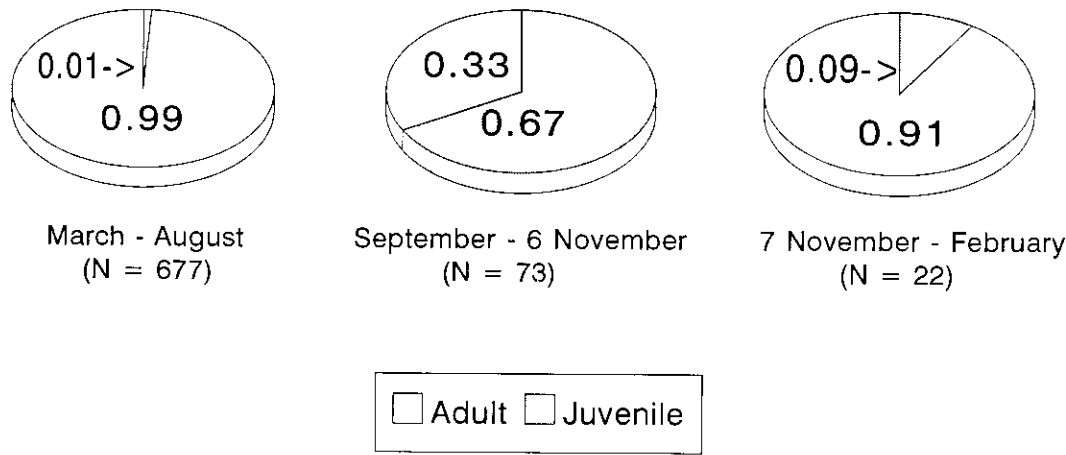


Figure 1. Relative proportions of juvenile and adult flying squirrels in the diet of spotted owls during different periods of the year on the Olympic Peninsula, Washington. Data summarized from March 1987-August 1989. Sample sizes indicate number of flying squirrels identified in pellets.

returning within a few days to see if a pellet had been regurgitated. In most cases, we could determine the exact date that pellets from radio-marked birds were regurgitated. During spring and summer (March-August), we continued to collect known-age pellets from radio-marked owls, and also collected many other pellets from owls that were not radio-marked. Pellets from owls that were not radio-marked usually could not be assigned to an exact date of regurgitation. Pellets in the latter category were collected from roosts that were cleared of pellets every 2-6 weeks. We assigned these pellets to seasonal categories based on the date collected and the previous date that the roost had been cleared. Because owls infrequently regurgitated pellets in their roosts during the fall and winter, the number of pellets collected during that period was much smaller than during spring and summer. Old, heavily weathered pellets were not included in seasonal analyses.

Flying squirrels were assigned to age categories based on size of skeletal parts, tooth development, and degree of fusion of epiphyseal cartilages. Very small individuals with unfused epiphyses and partially erupted molars were labeled as juveniles (generally less than 4 months old). Larger individuals with moderately to fully fused epiphyses and fully erupted molars were classified as adults. In cases where skulls were missing, age determination was based on the size of leg bones and degree of fusion of the epiphyses.

Results and Discussion

Skeletal remains of 772 flying squirrels were examined (712 adults, 60 juveniles). The occurrence of juvenile squirrels in the diet followed a distinct seasonal pattern (Figure 1). From early November to late August, juveniles comprised a very small proportion of the flying squirrels taken by owls. Between 1 September and 6 November, the proportion of juvenile flying squirrels in pellets increased dramatically (Figure 1). The initial flush of juveniles in early September was comprised almost entirely of very young animals, estimated to be 40-70 days old. Older juveniles were largely absent in the sample until October and early November.

The marked increase of very small juvenile flying squirrels in the owl diet during a relatively brief period (September-October), and their relative absence in the diet during the rest of the year, indicated that breeding by flying squirrels on the Olympic Peninsula was largely concentrated in late May and early June. We arrived at this estimate by back-dating from the time when juvenile flying squirrels became common in the diet (1 September). To do this we assumed a gestation period of 37-40 days and a period of 40-50 days before juveniles began to explore outside their natal dens (Muul 1969).

The few juvenile flying squirrels captured by owls outside the September-October period indicated that breeding during late summer and early spring did occur, but was infrequent. The existence

of a single rather narrow birth pulse also suggested that, in years when they bred, most females produced only one litter.

A potential bias in using the diet of a predator to assess characteristics of a prey population is that the predator may not sample all cohorts randomly. We did not feel this was a concern in our analysis because we were interested only in the timing and frequency of breeding as indicated by seasonal changes in the occurrence of one cohort (juveniles). It would be inappropriate to draw conclusions about the age structure of the entire population from our data, as juvenile flying squirrels were probably much more susceptible to predation than adults.

Previous studies of the northern flying squirrel in Canada (Cowan 1936, Davis 1963) indicated that the peak breeding season was March and April, but pregnant females or litters have been reported from March to December (Dice and Sherman 1922, Grinnell and Storer 1924, Muul 1969, Raphael 1984, Seton 1929, Wells-Gosling and Hcaney 1984, Witt 1991). Based on examination of 916 animals that were live-trapped and 176 animals that were necropsied, A. B. Carey (pers. comm.) concluded that the breeding season of northern flying squirrels in the southern Coastal Ranges of Oregon occurred during late April to mid-July, with a peak from late May to early June. Our observations, using a very different sampling technique, and in an area nearly 450 km north of Carey's study area, lead us to very similar conclusions regarding the reproductive chronology of the northern flying squirrel. The only substantial difference was that our observations indicated infrequent instances of breeding during late summer. Observations by Raphael (1984) and Witt (1991) also suggested occasional instances of breeding by northern flying squirrels during mid-summer or fall.

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Studies by Cowan (1936) and Davis (1963) indicated a much earlier breeding season for the northern flying squirrel than in our study or in the studies by Witt (1991) and Carey (pers. comm.). Whether these differences were due to small sample size in the earlier studies or to real differences in timing of breeding is not clear. It could be that breeding is timed differently in different geographic areas, such that weaning occurs when food is most abundant. On the Olympic Peninsula, for example, young flying squirrels seem to be leaving the nest at about the same time that the fall bloom of hypogeous fungi occurs. Hypogeous fungi are a major source of food for northern flying squirrels in the Pacific Northwest (Maser *et al.* 1986, McKeever 1960), and reach peak productivity in late spring and fall (Fogel 1976).

Historically, most studies of owl diets have produced lists of prey found in pellets, but have paid little attention to the age structure of the prey animals captured. As our analysis indicates, data on the age structure of prey in owl pellets can provide interesting insights into the biology and behavior of both predator and prey. These sorts of insights are possible, however, only if pellets are collected at relatively frequent intervals so that dates of capture can be approximated.

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