

ARBOREAL NESTS OF *PHENACOMYS LONGICAUDUS* IN OREGON

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ABSTRACT.—Searching felled trees proved effective for finding nests of *Phenacomys longicaudus*; 117 nests were found in 50 trees. Nests were located throughout the live crowns, but were concentrated in the lower two-thirds of the canopy. Abundance of nests increased with tree size; old-growth forests provide optimum habitat.

Red tree voles, *Phenacomys longicaudus*, are specialized, primitive arvicolines restricted to the humid, temperate forests of western Oregon and northwestern California (Bailey, 1936; Hall, 1981; Johnson, 1973; Johnson and Maser, 1982). Red tree voles are closely associated with old-growth forests (Carey, 1989; Corn and Bury, 1986, 1991) and prey for the spotted owl, *Strix occidentalis* (Forsman et al., 1984), but the degree of the association between red tree voles and old-growth forests is not well documented. Also, methods are lacking to determine the patterns of abundance of red tree voles. The arboreal habits and specialized diet of conifer needles make red tree voles difficult to study by use of standard sampling techniques (Carey et al., 1991a; Hamilton, 1962). However, limited captures in pitfall traps with and without drift fences in the Oregon Cascades and Coast Ranges and in northern California indicate some terrestrial activity (Carey, 1989; Corn and Bury, 1986, 1991; Raphael, 1988).

METHODS

We explored pitfall trapping in grids and around nest trees, livetrapping, searching for nests in standing trees, and searching for nests in felled trees for estimating relative abundance of red tree voles. We conducted or assisted in a series of studies in the Oregon Coast Ranges between Corvallis and Roseburg, Oregon, during 1984-1988. Corn and Bury (1991) used 45-trap pitfall arrays without drift fences for 50 days in 1984 and 30 days in 1985. In 1986, we spent 1-2 h searching for red tree vole nests in the 13 stands in Douglas Co. where Corn and Bury (1991) had captured voles. We also operated pairs of Sherman live traps set on platforms attached to 25 trees for 3 weeks, and clusters of 10 Sherman live traps set at the bases of seven trees with nests for 10 days. Eight pitfall traps with drift fences encircling each of the seven nest trees were examined for captures of red tree voles during a 10-day period. Also, we repeatedly searched 1.1-km transects in 47 stands for arboreal rodent and cavity-using bird nests in conjunction with bird surveys, snag surveys, and observations of foraging birds and Douglas' squirrels (*Tamiasciurus douglasii*) during 1985 and 1986 (Carey et al., 1991b). Searches for arboreal rodent nests within 10 m of 1,900 trap stations in 17 stands were recorded during trapping of northern flying squirrels (*Glaucomys sabrinus*) from 1985 to 1988.

In 1987, we explored an alternative sampling technique: searching felled trees. The Bureau of Land Management assesses the value of timber in old-growth stands by felling trees and examining them for defects. Trees are selected with a probability in proportion to their predicted volume. We examined 82 felled trees in four sites in a 35.2-ha area 80 km NW Roseburg, near Yoncalla, Douglas Co., Oregon. Nests of red tree voles were identified by the presence of discarded resin ducts from needles of Douglas-fir (*Pseudotsuga menziesii*).

For each sample tree, we recorded species, diameter at breast height, total height, height at first foliage, condition of top (broken or intact), diameter of top (if broken), presence and degree of rot, number of nests, and total search time. For each nest or fragment found, we recorded the height at which the material was found, bole diameter at that height, horizontal location (on a branch, next to the bole, in a cavity, unknown), and canopy location. Also, we recorded components of the nest material to their proportion of overall volume.

Near 50 intensively searched trees, we estimated total cover on an octave scale (interval midpoints were 0, 2, 4, 8, 16, 32, and 64%) of ground, shrub, and midstory layers of vegetation within a 5.6-m radius around the base of each sample tree. Trees (> 10 cm in diameter at breast height) were counted and overstory cover was

TABLE 1.—Abundance of nests of *Phenacomys longicaudus* as determined by intensive searches of felled trees in four samples and sample stand characteristics in southwestern Oregon in 1986.

	Sample sites			
	1	2	3	4
Area (ha)	15.8	6.9	4.9	7.7
Trees searched	13	13	12	12
Trees with nests (%)	46	62	67	75
Mean nests/tree	1.8	4.1	3.6	2.2
Mean tree diameter of breast height (cm)	72	108	105	98
Mean tree height (m)	47	49	49	55
Stand composition				
Douglas-fir (%) ^a	75	53	61	42
Grand fir, <i>Abies grandis</i> (%) ^a	4	18	11	15
Tree density (stems/ha) ^a	164	118	125	106

^a Estimates from Roseburg District, Bureau of Land Management sampling estimators.

estimated within a 10.6-m radius. For 32 cursorily searched trees, the immediate environment was described only when nests were found. Species composition of trees and the density of merchantable trees (>25.4 cm in diameter at breast height) were obtained from the Bureau of Land Management sampling crew.

RESULTS

Although Corn and Bury (1991) caught 17 red tree voles in pitfall traps (0.01/100 trap nights), we did not catch any voles in pitfall traps set in trees, or in pitfalls with drift fences set in the vicinity of trees with vole nests. Live traps set in trees and in clusters also did not result in any captures. In searches from the ground, we found nests of red tree voles in only four stands. From searches in the stands in which we captured red tree voles, we did not locate any nests, despite the use of binoculars and hillside vantage points.

We found 117 nests and nest fragments in 50 felled trees. Thirty-five trees contained one or two nests; only two trees had more than five nests (nine and 11 nests). Nests were composed of resin ducts (51% mean volume), lichen (19%), feces (13%), needles (9%), and fine twigs ≤ 3 mm in diameter (9%). Nests were found in all parts of the tree canopy, except below the live foliage. Numbers of nests decreased with height above the first foliage; of 117 nests located, 10 were on the first live branch, 49 were in the lower one-third, 34 in the middle one-third, and 22 in the upper one-third of the canopy. Only two nests were among the topmost branches. Horizontal locations of nests were undetermined in most cases, but of 27 nests located precisely, 15 were attached to branches and 12 were adjacent to the boles of the trees. Two of four cavities searched contained nests of red tree voles. One nest was found inside a broken top, and the other was located inside a large branch.

Two-way analyses of variance (trees with and without nests and four sample areas) showed that trees with nests ($n = 31$) were significantly larger in diameter (100 as opposed to 78 cm) and total height (52 as opposed to 44 m) than those trees that did not contain nests ($P < 0.05$); diameter and height did not differ significantly among the samples ($P > 0.05$). The two trees with nine and 11 nests were exceptionally large, with diameters at breast height of 134 and 142 cm, respectively. Mean height at first foliage (17 m) and immediate environmental measures did not differ significantly between trees with and without nests. Both the proportion of trees with nests and the number of nests per tree were smallest in site 1, which had a higher percentage of Douglas-fir, more trees, smaller trees, and fewer nests (per sample tree) than sites 2-4 (Table 1).

Search time varied with the size of the sample tree, the degree of foliage development, the amount of rot present, and the condition of the tree and its surrounding environment. An intensive search of a tree

required 1-3 h; short searches, 15-30 min. A greater proportion of trees with nests (0.62 as opposed to 0.45) and more nests per tree (2.9 as opposed to 0.5) were found with intensive searches than with short searches.

DISCUSSION

Searching felled trees in conjunction with sampling, thinning, or other silvicultural felling of trees appears to be a reasonable alternative to climbing trees in old growth for locating vole nests. Because felling trees is destructive, we recommend that searches for nests be conducted with such silvicultural operations. Ground searches are feasible in young stands where vegetation is open, tree limbs are small, and nests are close to the ground, but they become difficult in older stands because large limbs block observations and tree heights preclude discovery of all red tree vole nests, especially the smaller nests attributed to males (Howell, 1926). Lichen and moss may effectively camouflage nests from view and nests in cavities may not be detected from the ground. Although Meiselman and Doyle (in press) found 79 nests with the use of binoculars, they suggested possible underestimation of nests in the upper canopy of old-growth stands.

Both intensive and short searches proved effective in finding nests of red tree voles. Short searches led to the discovery of the same numbers of nests per unit effort as intensive searches. More trees can be examined using short searches without sacrificing reliability in estimation of the relative abundance of red tree vole nests.

All the trees we searched were Douglas-fir. However, in areas where other species are available as potential nest trees, Douglas-fir is selected (Howell, 1926; Meiselman and Doyle, in press; Vrieze, 1980; Zentner, 1977). This may be related to the general availability of Douglas-fir within the range of the red tree vole (Taylor, 1915), but also may be attributed to Douglas-fir needles comprising a great portion of the diet of the vole (Hamilton, 1962; Meiselman and Doyle, in press).

Red tree voles build nests where there is a suitable foundation and readily accessible food supply (Benson and Borell, 1931; Maser et al., 1981). Nests may be placed at any height in trees of any size (Howell, 1926), but we found the majority of nests within the lower one-third of the live canopy, as did Meiselman and Doyle (in press), Vrieze (1980), and Zentner (1977). Of those nests that we could locate precisely, about one-half were attached to branches. Zentner (1977) found nests distributed throughout large firs, with one-half located on single boughs and one-half situated against the bole. In contrast, Meiselman and Doyle (in press) found most nests adjacent to the trunk, perhaps because nests on limbs were less visible. Taylor (1915) and Jewett (1920) reported similar findings. Conversely, Howell (1926) found only two of 15 nests situated against the bole. In young stands, a whorl of branches adjacent to the trunk may provide the needed support for the large nests of females and their young. Food and cover are abundant in the lower canopy where the crown interweaves with adjacent trees, effectively increasing foraging capacity and escape routes (Vrieze, 1980). Single, large limbs of mature and old-growth trees provide adequate support and escape routes from predators, as well as access to mates; nests may be located well out on the limb to be near or among green foliage (Maser et al., 1981).

Although Meiselman and Doyle (in press) reported more rot (fire and damage scars, fungal conks, and dead tops) in nest trees than expected, we observed only minimal decay. Nest trees were classified predominantly as overstory, vigorous, and with intact tops. Of four cavities found, two contained red tree vole nests. Cavities provide protection from predators and extreme weather conditions for many cavity-using species, and may serve red tree voles similarly.

Red tree voles occur in all seral stages of Douglas-fir forest (Carey, 1989; Maser et al., 1981), but the species occurs with the greatest frequency and reaches greatest densities in old growth (Carey, 1989; Corn and Bury, 1986, 1991; Meiselman and Doyle, in press; Zentner, 1977). Zentner (1977) found more nests in old growth than in young Douglas-fir. Corn and Bury (1986) trapped most voles (12/18) in wet and mesic old growth sites (one-third the sites sampled). Also, Meiselman and Doyle (in press) reported that nearly one-half the red tree vole nests found (39/79) were located in old growth (one-third the stands surveyed) and nest trees were significantly larger in diameter and in total height than expected on the basis of availability. We found this to be true of our samples, and we found that the mean number of nests per sample tree increased with mean diameter at breast height of the trees in the sample (Table 1).

It seems that live old-growth trees provide optimum habitat for the red tree vole because primary

production is high and leaves are concentrated in old growth, resulting in maximum food availability. Also, the moist old-growth canopy functions as a climatic buffer and its high water-holding capacity maintains fresh foliage and provides free water to be licked from needles (Franklin et al., 1981). The voles select large trees, which can accommodate more than one vole, promote colony formation, and increase access to mates. Carey (1989) suggested that the availability of suitable forested habitat may be a major factor limiting the abundance of red tree voles. Although red tree voles have disappeared in many localities because of extensive logging and land development (Benson and Borell, 1931; Howell, 1926; Zentner, 1977), a cause-and-effect relationship has not been documented. It remains to be seen whether a landscape dominated by young growth can support viable and self-maintaining populations of this species.

ACKNOWLEDGMENTS

We thank R. B. Bury, P. S. Corn, S. P. Horton, L. L. Jones, and J. Mires for their assistance. M. L. Johnson and P. S. Corn reviewed a draft of the manuscript.

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Submitted 4 September 1990. Accepted 6 January 1991.