2001 Ann. Rept. – Strong

Long-term monitoring of high elevation understory and leaf litter arthropod communities

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Abstract:

This report summarizes preliminary results on the effects of prey abundance on Bicknell's Thrush (*Catharus bicknelli*) productivity and mating strategy on Mount Mansfield and Stratton Mountain. Bicknell's Thrush productivity is strongly indirectly affected by balsam fir (*Abies balsamea*) cone crops, leading to increased red squirrel (*Tamiasciurus hudsonicus*) and chimpmunk (*Tamias striatus*) populations and increased nest predations rates. The 2001 breeding season was characterized by high predation rates, with only 3 nests (all on Stratton Mountain) successfully fledging young. Consequently, the effects of prey biomass on Bicknell's Thrush productivity and mating strategy were probably overshadowed by the effects of nest predators.

Available biomass of arthropods for breeding Bicknell's Thrushes was sampled on Mt. Mansfield and Stratton Mountains using sweep nets (foliage fauna) and visual counts (ground fauna). Foliage prey biomass showed significant spatial and temporal variation with the ski area plots on Stowe and Stratton and the high elevation plot on Mt. Mansfield showing irregular peaks of prey biomass at different times during the growing season. In general, the temporal and spatial patterns were more variable than in 2000, perhaps owing to high nest predation rates and decreased effects of fledgling birds on insect populations. In 2000, we found a significant inverse relationship between prey biomass on a female's home range and the number of male feeders. Although the pattern was not statistically significant in 2001, the trend was similar. These results show that variation in home range quality (in terms of resource availability) may have a significant effect on the number of males with which a female will copulate in an attempt to increase provisioning rates for her young. We found no effect of prey biomass on the number of young fledged per nest, probably as a result of the overwhelming effect of high nest predation rates. Analysis of long-term pitfall trapping on both Mount Mansfield and Stratton Mountain is ongoing.

Introduction

The Bicknell's Thrush is a spruce-fir specialist is restricted in its distribution to the northeastern U.S. and southeastern Canada. The species' wintering distribution is restricted almost entirely to the Dominican Republic, where forest clearing continues to be a major ecological problem. Because of the species' limited range and anthropogenic habitat modifications on both the breeding and wintering grounds, biologists are concerned about the continued viability of the species' population.

As with many Neotropical-Nearctic migrants, there are large gaps in our understanding of Bicknell's Thrush biology. Further, the species exhibits a polygynandrous mating system that is extremely rare in birds. One hypothesis for the evolution of this mating system is that monogamy may be inadequate for provisioning young due to the short breeding season and harsh climatic conditions associated with high elevation forests. This research was designed to investigate how temporal and spatial variation in insect (i.e., prey) biomass has affected the timing of the breeding season, nesting productivity, number of males feeding at a particular nest, and chick provisioning rates.

Methods:

To estimate temporal variation in the biomass of prey availability for Bicknell's Thrush, we established five transects: one each in the Mount Mansfield (Stowe) and Stratton Mountain ski areas, and three in contiguous forest (two on Mt. Mansfield and 1 on Stratton Mountain). In the contiguous forests, we established 225 m transects and sampled at 10 locations separated by 25 m. At each sampling location, 25 sweeps of understory (0.1 - 2 m) foliage were sampled with a canvas sweep net. On the ski areas, the transects were more haphazard and sampled edge vegetation in areas that had supported nesting Bicknell's Thrush in previous years; sweep net samples were conducted as in contiguous forest.

After 25 sweeps, all arthropods were counted and recorded by order and size (nearest mm). To estimate biomass, we developed length-weight regression equations for the major taxa encountered in the sweep samples: ants, Coleoptera, Diptera and Hymenoptera combined, Homoptera and Hemiptera combined, holometabolous larvae (primarily Lepidoptera and Hymenoptera) and spiders. For groups that we did not have adequate sample sizes to develop individual regression equations, we pooled all taxa and developed a composite regression equation. Sample sizes varied from 19 for ants to 51 for holometabolous larvae; correlation coefficients varied from 0.75 to 0.98 and all relationships were highly significant ($P < 0.0001$).

To estimate prey biomass on the home range of nesting Bicknell's Thrushes, we used sweep net samples and visual counts. On each home range, we randomly selected 10 points surrounding each active nest. Points were derived from pairs of random distances (< 65 m; the approximate average radius of a female Bicknell's Thrush home range) and bearings measured from the nest location. At each point we conducted 25 sweep samples, and a 5-min visual count of a $0.25 m^2$ quadrat of the ground surface. Sweep net samples were conducted as described above. For the visual counts, we recorded all arthropods observed during a 5-min period, without disturbing the leaf litter surface (Strong 2000). All arthropods were summarized by order and size and converted to biomass using length-weight regression equations.

Results:

Temporal Variation

Compared to 2000, prey biomass was much more variable. Rather than exhibiting a distinct unimodal peak, prey biomass was characterized by significant spikes, 1.5 to 3 times greater than average background levels (Fig. 1). These increases in prey biomass were most notable on the high elevation plot on Mt. Mansfield, and the ski area plots on both mountains. We found a general trend of increasing prey biomass through June, and decreasing through July, several of the plots also showed an increase in prey biomass in early September.

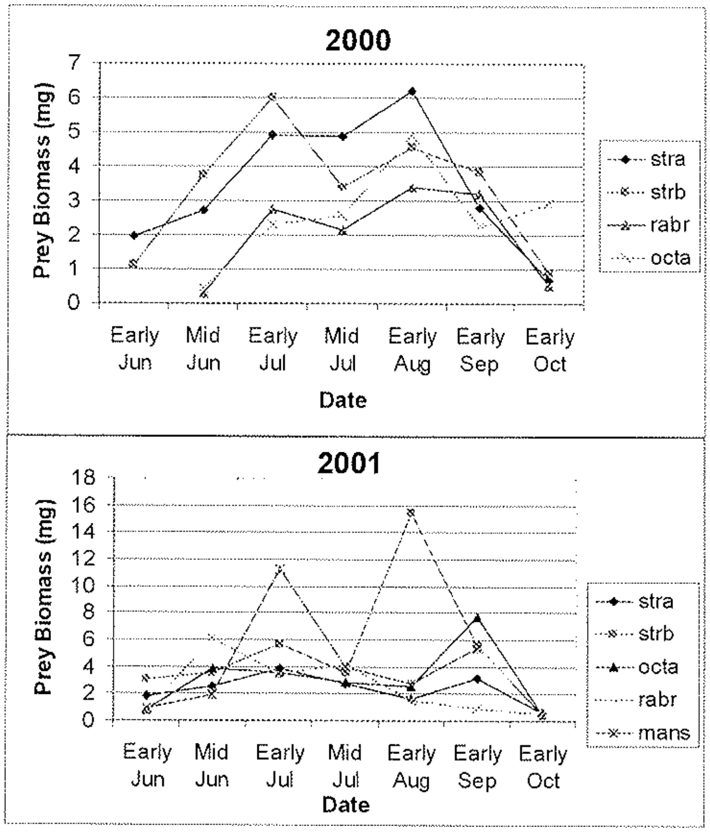

Fig. 1. Temporal variation in prey biomass on Mt. Mansfield and Stratton Mountain, 2000 and 2001. Note that the Y-axes differ in the two graphs.

Spatial Variation

In the 2000 breeding season, we found a significant positive relationship between arthropod biomass on a female's home range and the number of chicks fledged from the nest ($F_{1,14} = 6.7$, $P = 0.02$; Fig. 6). The 2001 breeding season was characterized by significant nest predation by red squirrels and chipmunks, such that only 3 nests on Stratton Mountain fledged young and no nests on Mt. Mansfield were successful. Consequently, we were unable to evaluate the relationship between prey biomass and the number of chicks fledged during this season.

During the 2000 breeding season we found a significant inverse relationship between the number of male feeders at a given nest and prey biomass on a female's home range ($F_{1,13} = 4.8$, $P < 0.05$, Fig. 2). This result excludes one nest for which we had no record of males feeding young. Although the result was not statistically significant, the trend was similar for 2001.

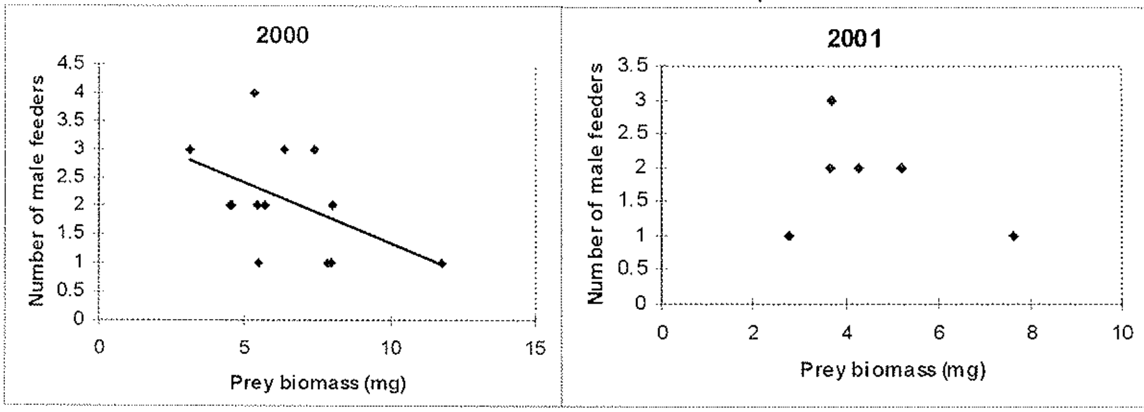

Fig. 2. Relationship between the number of male feeders at a particular nest and prey biomass on a female Bicknell's Thrush home range and number of chicks fledged. Data are from Mt. Mansfield and Stratton Mountain, 2000 and 2001.

Discussion

Intense nest predation during the 2001 breeding season complicated our analysis of the relationship between prey biomass and Bicknell's Thrush productivity. Because nest failure was primarily attributed to nest predation, food limitation played a minor role in the species' ability to successfully fledge young. We had a slightly greater sample size for investigating the effects of prey biomass on the number of male feeders. Interestingly, the significant trend from the previous year appears to at least be generally repeatable. This suggests that female decisions regarding the number of males with which to copulate may be based on home range quality (in terms of food resources), and not directly influenced by the probability of nest predation. However, the risk of predation may override food resources in terms of nest site selection. Then, once a suitable nest site is chosen, food resources may be more important in determining the number of males that are necessary to successfully fledge young.

The influence of nest predation appears to be synchronized across a suite of high elevation, open cup, Neotropical migrants. The 2001 data on temporal variation in prey biomass suggests that high nest predation rates may influence the effects of high elevation bird species on foliage arthropods. Three of the five sites showed unusually high spikes in prey biomass. These increases in prey biomass may be a result of decreased energetic demands by adult birds, as most nests were depredated early in the breeding season prior to fledging. Consequently, fewer adults feeding young may lead to increased foliar insect populations. This would be interesting to study in greater detail, as there could also be tritrophic effects leading to changes in herbivory rates on balsam fir.

In conclusion, the results from the 2001 breeding season showed some interesting contrasts to the 2000 season, particularly in the temporal variation in prey biomass over the course of the breeding season. The overriding effects of nest predation complicate our ability to understand the effects of prey biomass on the productivity and mating strategy of the Bicknell's Thrush. However, they also emphasize the importance of both top-down and bottom-up processes in the ecology of this high elevation species.