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MIGRANT STOPOVER AND POSTFLEDGING DISPERSAL AT A MONTANE FOREST SITE IN VERMONT

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ABSTRACT.—To investigate the use of high elevation fir forests by fall passage migrants, we conducted standardized mist-netting and banding at a 1150–1175 m elevation site on Mt. Mansfield in north-central Vermont during the autumns of 1995–1997. Overall, we captured 3024 individuals of 62 species in 10,048 cumulative net hours (30.1 birds/100 net hr). We divided species into 3 classes: (1) those breeding regularly on Mt. Mansfield above 916 m elevation (16 species), (2) those breeding only sporadically or at very low densities above 916 m (6 species), and (3) those occurring only as transients (40 species). Breeding species accounted for 68% of new captures, followed by transients (22%), and sporadic/low density breeders (10%). Of the ten most abundant species captured, only two, Black-throated Blue Warbler *(Dendroica caerulescens)* and Ovenbird *(Seiurus aurocapillus)*, were transients, accounting for 50% and 9%, respectively, of all transient captures. Hatching-year birds accounted for 94% of known-age transients and 81% of known-age individuals among locally breeding species. Recapture rates of transients were extremely low (0.3%), while recapture rates among species known to breed locally (including presumed transient individuals) were higher (2.2%). Nearly 75% of all birds captured were very lean at first capture, and only 26% of recaptured individuals increased their fat scores between first and final captures. Weight changes of recaptured birds varied: 48% lost weight, 44% gained weight, and 8% maintained the same weight between first and final captures. Our data suggest that conditions on the Mt. Mansfield ridgeline are not conducive to prolonged migratory stopovers and that most migrants may be unable to meet their energetic requirements for continued migration. However, we believe that montane forest habitats may be preferentially selected by those migrants that use them for breeding. We further believe that montane fir forests may be an important postfledging dispersal habitat for Black-throated Blue Warblers and other low or mid-elevation breeding species, and that conservation planning for montane forest sites should carefully consider the needs of migrants outside the breeding season. *Received 18 March 1999, accepted 25 Oct. 1999.*

Of the numerous demands that migrant birds face during their annual migrations, selection of enroute stopover habitat is paramount. Choice of stopover habitat may play a pivotal role in determining a migrant's survival and is dependent both on intrinsic suitability of the habitat and on extrinsic factors such as weather, time constraints, energetic condition, and availability of the habitat (Hutto 1985, Moore and Simons 1992). Stopover migrants must resolve potentially conflicting needs to meet their energy demands, avoid predation, adjust to unfamiliar habitats, compete with other migrants and residents, and deal with unfavorable weather conditions (Moore et al. 1995). Loss or degradation of stopover habitat may have significant adverse effects on migrant populations (Moore et al. 1995, Yong et al. 1998).

Despite recent heightened interest in stopover ecology and its conservation implications (see Moore and Simons 1992, Moore et al. 1995, Hutto 1999), few researchers have focused on high elevation forested habitats of North America (but see Hall 1981, Hall and Bell 1981). In the northeastern United States, montane forests occupy a prominent, although geographically limited, space in the regional landscape. Their maximum extent is only 0.39% of all land area (uncorrected for topography) above 915 m elevation in northern New England and New York, and they occur as habitat ''islands'' of varying size and distance from one another (see Atwood et al. 1996). These forests support a distinctive assemblage of breeding bird species, including most of the world's population of Bicknell's Thrush (*Catharus bicknelli*; Rosenberg and Wells 1995; Rimmer and McFarland, unpubl. data). High elevation forests in the Northeast are potentially threatened by an array of factors including atmospheric pollution, global warming, ski resort development, telecommunications facilities, and wind power development (Weiss and Millers 1988, Atwood et al. 1996, Rimmer 1996). Although the significance of these habitats for breeding birds has become increasingly well-recognized, virtually nothing is known about the importance of

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montane forests as stopover habitats. Similarly, the use of montane forests during the postfledging period, when availability and quality of suitable habitats are especially critical (Anders et al. 1998), has been poorly studied.

During the course of field research on Bicknell's Thrush in September of 1994, we observed marked influxes of passage migrants on three widely separated Northeast peaks (Mt. Mansfield in north-central Vermont, Equinox Mountain in southwest Vermont, and Slide Mountain in the Catskills of New York). These concentrations included many species that breed only in lower elevation habitats, leading us to consider that montane forests might provide important fall stopover habitats. In this paper we present the results of a three-year study on Mt. Mansfield to examine the extent and patterns of migrant stopover use at a single montane forest site.

STUDY AREA AND METHODS

We conducted standardized mist-netting and banding at a 1150–1175 m elevation site on the ridgeline of Mt. Mansfield (44° 32′ N, 72° 49′ W) in north-central Vermont during the autumns of 1995–1997. Mt. Mansfield, Vermont's highest (1339 m elevation) and second largest (769 ha area above 915 m elevation) mountain, is characterized by a north–south ridgeline that extends about 4 km southward from the summit. Forming part of the spine of Vermont's Green Mountains, Mt. Mansfield is isolated from similar montane forest patches to the northeast (5.1 km) and south (9.9 km). The ridgeline forest is dominated by balsam fir *(Abies balsamea)*, with lesser amounts of red spruce *(Picea rubra)*, heart-leafed paper birch *(Betula papyrifera* var. *cordifolia)* and mountain ash *(Sorbus americana)*. This vegetation is stunted by chronic exposure to high winds and heavy winter ice loads, and is extremely dense. Canopy heights average 1–4 m (mean 2.2 m) and stem densities average 8274/ha (McFarland and Rimmer, unpubl. data). Weather can be severe at any time of year, and snow and ice storms are frequent after mid-September. Mean minimum temperatures on the Mt. Mansfield ridgeline during the months of August through October in 1995–1997 were 3.3° C colder than those at a northern hardwoods forest site in nearby Underhill at 400 m elevation (10.1° C vs 12.8° C in August, 5.5° C vs 8.0° C in September, 0° C vs 4.6° C in October, respectively; Vermont Forest Ecosystem Monitoring, unpubl. data). Total precipitation during the same period was 74 cm higher on Mt. Mansfield than at Underhill (185 cm vs 111 cm, respectively). The ridgeline is moderately impacted by human activities, with narrow gravel roads, hiking trails, a 0.25 ha parking lot, several telecommunications towers, small buildings, and occasionally heavy foot and vehicle traffic during the summer and fall.

We operated 10–20 mist nets (12 m × 2.6 m, 36-mm mesh) over a study area of about 8 ha from 2 August–13 October in 1995, 1 August–10 October in 1996, and 5 August–10 October in 1997. Netting was terminated in mid-October of each year because of deteriorating weather and closure of the mountain toll road. Because of extremely dense habitat and the ridgeline's protected status as a University of Vermont Natural Area, net sites were restricted to existing hiking trails and natural openings. Thus, we were unable to space nets in a regular pattern over the study area. Nets were opened for 6 hr/d for 5 d/wk beginning at dawn, except in conditions of rain, ice, snow, or high winds. Sampling effort (hours of operation/12 m mist-net) was recorded daily. Although numbers of nets varied among years, net sites remained constant. All captured birds were banded with a U.S. Fish and Wildlife Service aluminum leg band, aged and sexed, and the following data were recorded: (1) body weight to the nearest 0.1 g, (2) subcutaneous fat class, (3) unflattened wing length, (4) degree of skull pneumatization (Pyle 1997), (5) extent of flight feather or body molt, (6) time of banding, and (7) capture site. We used the fat classification system described by Cherry (1982): 0 = no visible subcutaneous fat; 0.5 = traces of visible subcutaneous fat; 1 = solid sheet of fat lining the furculum, but concave; 2 = fat filling the furculum, but not mounded; 3 = fat filling furculum, and bulging out but not meeting layer of fat from abdomen; and 4 = furcular and abdominal fat mounded and meeting. For birds recaptured within a single morning, only body weight and fat class were recorded on subsequent captures. Weights were not corrected for time of day because we found no significant correlation between initial capture weights and time of day for any of the ten most commonly captured species (see methods in Winker et al. 1992; range of r^2 values = 0.0003–0.0439).

Because our netting sampled many locally breeding species and was initiated during late stages of nesting and postfledging parental care in each year, we assigned all species in our total sample of captures into one of 3 classes. These included: (1) species regularly breeding on Mt. Mansfield above 915 m elevation (breeders), (2) species breeding sporadically or at low densities above 915 m elevation (sporadic breeders), and (3) species known to occur only as transients above 915 elevation (transients). While many individuals in the two breeding classes, especially those captured in September and October, were most likely transients from other breeding areas, we were unable to unambiguously distinguish these individuals from local breeders. This classification, while arbitrary, enabled us to examine stopover differences between known transient species and those species adapted to montane spruce-fir forests for breeding.

We compared stopover patterns of Black-throated Blue Warblers (*Dendroica caerulescens*), our most commonly captured transient species on Mt. Mansfield, with those from another high elevation migration banding site, Allegheny Front Migration Observatory

TABLE 1. Mist-netting effort and capture rates on Mt. Mansfield, Vermont.

Year	# Net hrs	# Days	# New captures	Birds/100 net hrs.	# Species
1995	3115	45	939	30.2	52
1996	4157	46	1442	34.7	46
1997	2776	37	643	23.2	44
Total	10,048	128	3024	30.1	62

(Allegheny Front), at about 1200 m elevation in northern West Virginia (39° 02′ N, 79° 18′ W). The physical characteristics and banding operations at this site, approximately 820 km southwest of Mt. Mansfield, are described by Hall and Bell (1981). We compared only those capture data collected in August–October 1995–1997 at each site. We also conducted a more limited comparison of our Black-throated Blue Warbler data with those for the same period at two other long-term, inland banding stations at low elevations, the Vermont Institute of Natural Science (VINS) in Woodstock, Vermont (43° 36′ N, 72° 32′ W, 106 km south of Mt. Mansfield) and the Powdermill Nature Reserve (Powdermill) in Rector, Pennsylvania (40° 10′ N, 79° 16′ W, approximately 725 km southwest of Mt. Mansfield and about 130 km north of Allegheny Front). The Vermont Institute of Natural Science is characterized by second-growth shrub-scrub habitat embedded in a landscape matrix of northern hardwoods forest (Rimmer, Faccio, and McFarland, unpubl. data), while the Powdermill site is composed of old fields and second-growth deciduous forest in various seral stages, with several small ponds and wetlands (Leberman 1976).

RESULTS

Both sampling effort and capture rates varied considerably among the three years of netting on Mt. Mansfield (Table 1). Differences in sampling effort among years resulted from the operation of fewer nets in 1995 (10 in August, 15 in September and October) than in 1996 and 1997 (15–20 in each year), and unusually inclement weather in 1997 that often caused us to close the nets. Relatively low capture rates in 1997 may have resulted in part from frequent and prolonged inclement weather conditions, especially during the peak migration period in September.

Of the 62 species we captured on Mt. Mansfield, 22 (35.5%) locally breeding species accounted for 78% of all captures and 40 transient species accounted for 22% of the total individuals captured. Of these 40 transient species, 33 (82.5%) were Nearctic-Neotropical migrants (see Rappole et al. 1983). Of species in the two breeding classes, only 8 (36.4%) are considered Nearctic-Neotropical migrants. Numbers of transients peaked in late August to mid-September, while captures of individuals in the two breeding categories peaked later, in mid-September to early October (Appendix).

The ten most abundant species captured accounted for a large proportion (82.8%) of the total number of individuals captured (Appendix). Five of these [Yellow-rumped Warbler (*Dendroica coronota*), Blackpoll Warbler (*Dendroica striata*), Dark-eyed Junco (*Junco hyemalis*), White-throated Sparrow (*Zonotrichia albicollis*), and Bicknell's Thrush] are among the most common breeding species on the Mt. Mansfield ridgeline (Rimmer and McFarland, unpubl. data). Captures of Yellow-rumped and Blackpoll warblers, in particular, greatly exceeded their overall relative breeding abundance, suggesting that many transients augmented local populations of these two species in fall. Ruby-crowned and Golden-crowned kinglets *(Regulus calendula* and *R. satrapa)* are uncommon breeders on the ridgeline, and nearly all individuals we captured were undoubtedly transients. Of the ten most abundant species, only two [Black-throated Blue Warbler and Ovenbird (*Seiurus aurocapillus*)] were true transients, accounting for a disproportionate number (50.2% and 9.2%, respectively) of all transient captures. Of the 19 transient species represented by 5 or more new captures (Appendix), 14 (73.7%) are characteristic breeders of mature northern hardwoods and mixed forests that generally occur below elevations of 760 m on Mt. Mansfield and throughout northern New England (DeGraaf et al. 1992).

Age ratios.—Hatching-year (HY) birds accounted for 94% of known-age transient captures, 82% of individuals of regularly-breeding species, and 75% of sporadic breeders (Appendix). Age ratios varied markedly among species. Among the 20 species with at least 20 new captures, 5 had HY ratios of 97–100%; of these, only Golden-crowned Kinglet breeds above 915 m elevation on Mt. Mansfield. Eight of the 20 most abundant species had HY ratios less than 75%; all breed at the site. With the exception of Bicknell's Thrush, we suspect that the majority of individuals of these species were transients.

Recapture rates.—Overall, we recaptured very few birds on the Mt. Mansfield ridgeline one day or more after initial capture (Appendix). Recapture rates of transients were extremely low (0.3%), while recapture rates among species known to breed locally (including presumed transient individuals) were higher (2.7%). Bicknell's Thrush, which appears to remain on or close to its breeding and possibly natal territories until southward departure in late September (Rimmer and McFarland, unpubl. data), had the highest recapture rate (15.1%). Second was the Black-capped Chickadee (*Poecile atricapillus* 12.2%), which may be one of very few species to regularly occur in winter above 915 m elevation on Mt. Mansfield (Rimmer and McFarland, pers. obs.). There were no significant differences in the recapture rates of after hatching-year (AHY) individuals (2.6%) and HY birds (1.7%; $\chi^2 = 2.29$, df = 1, $P > 0.05$).

Fat loads and weight changes.—Nearly three quarters (72.7%) of all birds captured on Mt. Mansfield were lean (fat class 0 or 0.5) at first capture. Individuals of transient species carried lower initial fat stores than those of species in the two breeding classes combined (85.8% and 69.4% of scores, respectively, in fat classes 0 or 0.5; $\chi^2 = 69.8$, df = 1, $P < 0.001$). Few birds carried visibly large fat loads (fat class 2 or 3) upon initial capture or subsequent recapture. Significantly fewer (1.1%) individuals among strictly transient species had initial fat scores of 2 or 3 than birds in the two breeding classes combined (8.9%; $\chi^2 = 38.6$, df = 1, $P < 0.001$). Overall, HY birds were leaner than AHY individuals (78.7% and 57.4%, respectively, of initial fat scores in classes 0 or 0.5; $\chi^2 = 94.9$, df = 1, $P < 0.01$). This difference was more pronounced among transient species (87.5% HYs and 64.3% AHYs with initial fat scores of 0 or 0.5) than among birds in the two breeding classes (75.7% HY and 56.7% AHY with initial fat scores of 0 or 0.5; $\chi^2 = 34.1$, df = 1, $P < 0.001$).

A comparison of fat scores among the two most common breeding species, Myrtle and Blackpoll warbler, and the two most commonly captured transient species, Black-throated Blue Warbler and Ovenbird, further highlights the differences between these two classes of migrants on Mt. Mansfield. Among Blackpoll Warblers, 24.5% of all birds captured (20.3% of HYs, 35.3% of AHYs) had initial fat scores of at least 1; 2.9% of birds had fat classes of 2 or 3. Among Myrtle Warblers, 16.7% of all captures (13.3% of HYs, 45.0% of AHYs) were of birds with fat classes of at least 1; 1.9% of individuals had fat scores of 2, none were captured with a fat class of 3. Among Black-throated Blue Warblers, only 7.6% of all birds captured (7.5% of HYs, 10.0% of AHYs) had fat scores of at least 1 and none was captured with scores of 2 or 3. Among Ovenbirds, only 6.7% of all captures (6.8% of HYs, 0% of AHYs) were of birds with fat classes of at least 1; 1 individual had a fat score of 2.

Our sample of recaptured individuals was too small to statistically analyze fat or weight changes of individuals within or among species. However, of the 52 recaptured birds that provided weight change data (uncorrected for body size, time of day, or length of stay), 25 (48.1%) lost weight, 23 (44.2%) gained weight, and 4 (7.7%) maintained the same weight between first and final captures. Of the 53 recaptures for which we recorded both initial and final fat scores, 30 (56.6%) maintained the same class, 14 (26.4%) increased by at least one class, and 9 (17.0%) decreased by at least one class. Few dramatic changes in weights or fat classes were recorded. Twenty-eight (58.3%) of the individuals that experienced weight changes gained or lost less than 5% of their original weight, while 15 (56.3%) birds experienced changes from 5–10%. Only 3 (6.3%) birds gained or lost more than 15% of their original weight. Among transient species, the only individual that provided weight and fat change data was a Lincoln's Sparrow *(Melospiza lincolnii)* that gained 2.5 grams (16.1% of original weight) and increased its fat class from 1 to 3 between 6 and 21 September 1995.

Black-throated Blue Warbler.—A striking feature of our results was the predominance of Black-throated Blue Warblers in our sample, accounting for more than half of all transients captured. We captured nearly five times as many Black-throated Blue Warblers as Ovenbirds, the second most abundant transient species (Appendix). Comparison of Mansfield and Allegheny Front data show similarly high capture rates (birds/100 net hr), while Black-throated Blue Warbler capture rates at the two

TABLE 2. Summary of Black-throated Blue Warbler (BTBW) fall capture data (1995–1997) at Mt. Mansfield, Allegheny Front Migration Observatory (AFMO), Vermont Institute of Natural Science (VINS), and Powdermill Nature Reserve (PNR).

Banding site	# New BTBW captures	BTBW /100 net hrs	% BTBW in total banded sample	% Recap-tured	% HY[b]
Mansfield	338	3.4	11.2	0	97.0
AFMO	1479	7.4	16.4	0.2[a]	78.8
VINS	19	0.1	0.5	5.3	73.7
PNR	140	0.3	0.6	2.9	92.1

[a] AFMO recapture data from 1997 only.
[b] Hatching-year birds.

low elevation sites, VINS and Powdermill, were much lower (Table 2). Of the total banded sample at each site in 1995–1997, Black-throated Blue Warblers accounted for a significantly higher proportion of all new captures at Mt. Mansfield and at Allegheny Front than at VINS and Powdermill (Table 2; $\chi^2 = 3584$, df $= 3$, $P < 0.001$).

Recapture rates showed a reversed pattern of variation among the 4 sites (Table 2). Although recapture data were not systematically collected at Allegheny Front, the numbers of Black-throated Blue Warblers recaptured at that site are negligible (Hall, unpubl. data). In 1997, the only season for which such data were available, only 1 of 603 (0.2%) banded Black-throated Blue Warblers at Allegheny Front was recaptured. No individual of this species was ever recaptured on Mt. Mansfield. At the two lowland sites, recapture rates were markedly higher than at the two montane forest sites (Table 2). Although recapture samples were insufficient to enable statistical comparisons of stopover lengths, fat gains, or weight changes among sites, the one individual recaptured at VINS, a HY female, remained on site a minimum of 4 d and gained 2.9 g. Three Powdermill birds, all HY, had mean minimum stopover lengths of 2.3 d (range = 1–4 d) and mean weight gains of 0.2 g (range = −0.2–0.5 g).

Mt. Mansfield differed from the 3 other sites in having a significantly higher ratio of HY/AHY Black-throated Blue Warblers (Table 2; difference between Mansfield and Powdermill: $\chi^2 = 5.52$, df $= 1$, $P = 0.02$). Ratios of HY/AHY birds at Allegheny Front and VINS did not differ significantly from one another ($\chi^2 = 0.29$, df $= 1$, $P > 0.05$; Table 2). The preponderance of HY birds at Mt. Mansfield was not reflected at the southern high elevation site (Allegheny Front), although HY sex ratios were nearly 1:1 at both sites (167 males, 154 females at Mt. Mansfield; 582 males, 592 females at Allegheny Front). At both Mt. Mansfield and Allegheny Front, HY birds preceded AHY individuals, but there was a less discernable peak of movement overall at the northern site than at Allegheny Front (Fig. 1). At Mt. Mansfield, Black-throated Blue Warblers were captured at a more or less steady rate from early August through September, with some birds occurring into October; however, 55.6% of all captures were in August. At Allegheny Front, numbers of this species were relatively low through August (7.5% of total captures), then rapidly increased to a peak in mid-September and decreased into October, with few birds appearing after 10 October (Fig. 1). At both sites, HY birds occurred throughout the species' overall range of capture dates, but a much more pronounced HY peak was evident at Allegheny Front than at Mt. Mansfield. At VINS, 106 km south of Mansfield, only 1 Black-throated Blue Warbler was captured before 5 September and only 3 after 1 October; the remaining 15 birds (78.9%) were captured between 6–24 September. At Powdermill, only 10 individuals (7.1%) of this species were captured in August, 109 (77.8%) in September, and 21 (15%) in October.

DISCUSSION

Few migration stopover data from other montane forest sites in North America or elsewhere are available for comparison to our results on Mt. Mansfield. These suggest that the Mt. Mansfield ridgeline does not generally support large numbers of stopover migrants in fall. The 3-yr mean of 30.1 new captures/100 net hr is lower than that of other regional fall migration banding operations at inland sites during the same period, including southern sites like Allegheny Front (40.0 birds/100 net hr; Hall, pers. comm.) and Powdermill (44.8 birds/100 net hrs; Mulvihill and Leberman, pers. comm.), and well below that of more northern sites like Braddock Bay Bird Observatory (71.3 birds/100 net hr; Brooks 1996,

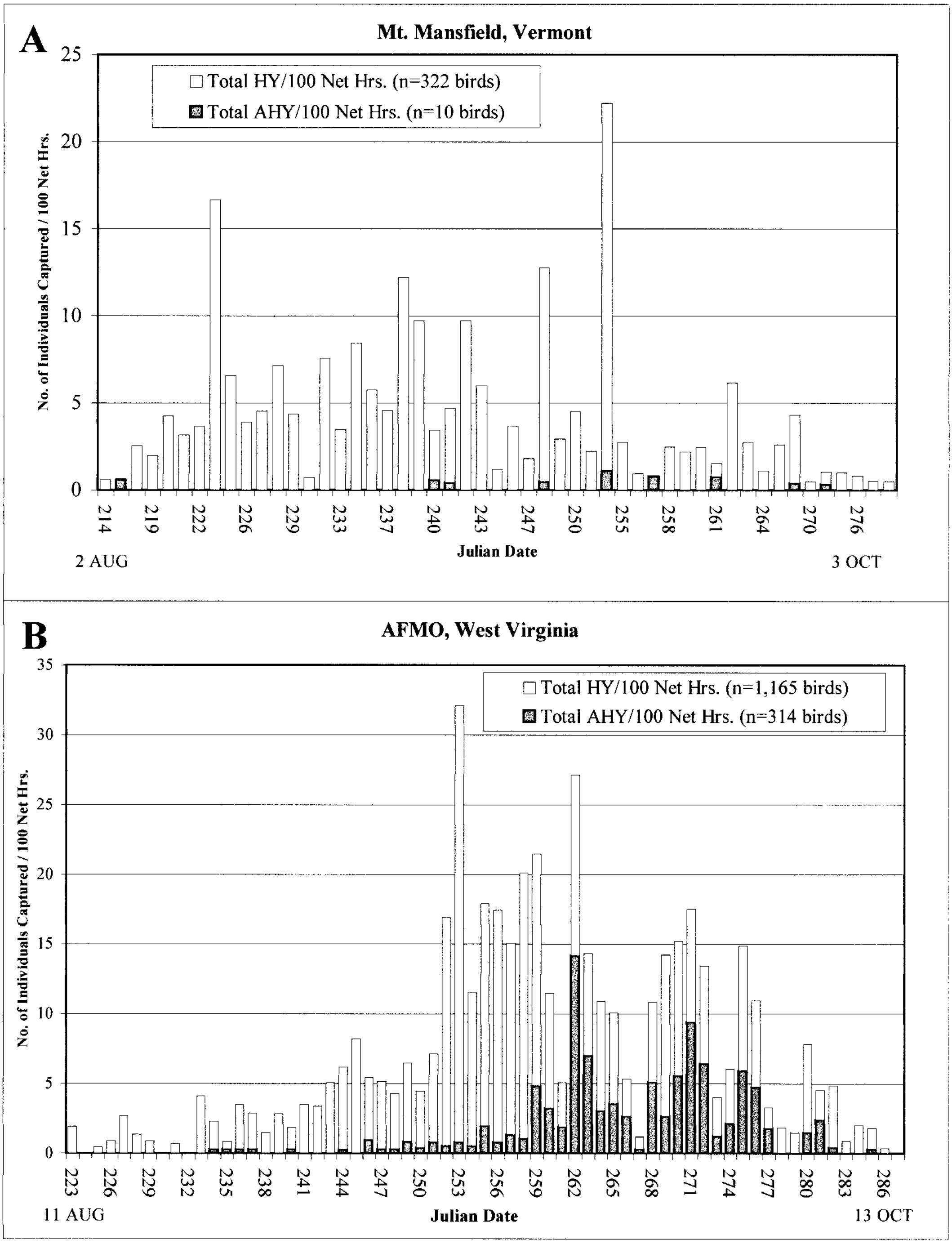

FIG. 1. Distribution by date of Black-throated Blue Warbler new captures at (A) Mt. Mansfield and (B) Allegheny Front Migration Observatory (AFMO), 1995–1997. Totals represented as birds/100 net hours.

1997, 1998) and Kestrel Haven Farm Avian Migration Observatory (120.0 birds/100 net hr; Gregoire 1997, 1998), both in central New York. Within Vermont, however, stopover volume, as measured by new captures, was higher at Mt. Mansfield in 1995–1997 than at VINS (20.8 birds/100 net hr; Rimmer, Faccio, and McFarland, unpubl. data). This suggests that Mt. Mansfield's prominent ridgeline may concentrate transients more than a lowland site like VINS, which has few physiographic features that act as a stopover focus for migrants. However, several local factors such as vegetation and weather vary between these two (and other) sites and may affect the relative capture probabilities of migrants, limiting the usefulness of between- or among-site comparisons of relative abundance (see Remson and Good 1996).

Eight of the ten most abundant species captured on Mt. Mansfield were regular or sporadic breeders (Appendix) and accounted for 70% of all captures. While some of these had undoubtedly nested or fledged locally, we believe that our samples were composed largely of transient individuals. Myrtle and Blackpoll warblers alone accounted for 24.9% and 13.7%, respectively, of our total banded sample, greatly exceeding their relative abundance as breeders on Mt. Mansfield (Rimmer and McFarland, unpubl. data). Their numbers peaked in early October and mid-September, respectively, well after each species' main period of fledgling independence on Mt. Mansfield (Rimmer and McFarland, unpubl. data), further suggesting that transients greatly augmented numbers of local breeders and HY birds. At VINS, the two species comprised only 2.8% and 0.2%, respectively, of the 1995–1997 fall totals (Rimmer, Faccio and McFarland, unpubl. data). The predominance of presumed transients of species that breed on Mt. Mansfield's ridgeline, and their relative scarcity at the low elevation VINS site only 100 km south, suggests that montane forest habitats may be preferentially selected by those migrants adapted to use them for breeding.

Conversely, Mt. Mansfield may be avoided by some transient species that do not inhabit montane forests. Although we have no direct evidence for this, certain groups of common transient genera and species at the VINS site were nearly or completely absent from our capture samples, including all flycatchers (Least Flycatcher, *Empidonax minimus;* $n = 1$), Veery *(Catharus fuscescens*; $n = 6$*)*, Wood Thrush (*Hylocichla mustelina*; $n = 1$), all mimid species (Brown Thrasher, *Toxostoma rufum*; $n = 1$), most shrub-scrub species, and all grassland species. Further indirect evidence of stopover bypass was obtained through automated recordings of nocturnal flights over Mt. Mansfield during 1997 and subsequent spectrographic analysis of nocturnal flight calls (Evans 1994, pers. comm.). Several species rarely or never documented on the ground or in mist nets were identified migrating overhead. Among those landbird species whose nocturnal flight calls were identified on 10 nights between 29 August and 26 September were Black-billed Cuckoo *(Coccyzus erythropthalmus*; $n = 2$), Veery ($n = 42$), Savannah Sparrow *(Passerculus sandwichensis*; $n = 1$*)*, and Bobolink *(Dolichonyx oryzivorus*; $n = 6$; Evans, pers. comm.). Thus we suspect that some transients regularly overfly Mt. Mansfield, possibly to avoid stopping in its unfamiliar or seemingly unsuitable habitats.

Among strictly transient species captured on the Mt. Mansfield ridgeline, most (74%) breed in mesic northern hardwoods and mixed forests that occur on Mt. Mansfield's lower slopes and at elevations below 760 m throughout northern New England. Few species restricted as breeders to Canada's and northern New England's extensive lowland boreal forest biome were represented in our samples, and these were captured in very small numbers. Among transient species with 5 or more new captures (Appendix), only Tennessee Warbler *(Vermivora peregrina)*, Bay-breasted Warbler *(Dendroica castanea)*, and Lincoln's Sparrow are true boreal habitat specialists. The disproportionate abundance of northern hardwoods breeding species on Mt. Mansfield suggests the possibility of an upslope post-breeding or postnatal dispersal rather than or in addition to migration stopover among these species. The strong elevational zonation on Mt. Mansfield is such that only about 1.5 km of distance separates the ridgeline fir-spruce forest from the lower northern hardwoods slopes.

Age-related stopover differences.—The predominance of HY individuals (94% overall) among transient species on Mt. Mansfield is contrary to the findings reported from most inland banding sites where ratios of HY : AHY birds tend be much lower than at coastal sites (see Nisbet et al. 1963; Ralph 1971, 1981; Hall 1981). High ratios of HY individuals at a site are typically explained as indicating either disorientation of young birds at the periphery of their species' migratory route (Ralph 1981), the selection by inexperienced immatures of lower quality stopover habitat caused by en-route energetic constraints (Moore and Simons 1992), or avoidance of resource competition with adults (Yong et al. 1998). Because many of the transient species (and breeding species consisting largely of presumed transient individuals) captured on Mt. Mansfield are also common coastal migrants (Murray 1966, Ralph 1981, Morris et al. 1996), it is unlikely that Mt. Mansfield constitutes either the eastern or western edge of their migration routes. It seems more likely that young birds might settle on the Mt. Mansfield ridgeline after a nocturnal flight because their energy reserves are depleted, weather conditions inhibit further flights in search of more suitable habitats, or they are inexperienced in selecting optimal stopover habitat. We believe that AHY birds of species not adapted to montane fir-spruce forests may avoid the Mt. Mansfield ridgeline as a stopover habitat because they are less energetically constrained than immatures, more familiar with resource and weather limitations of montane forests, more familiar with the availability of nearby suitable habitats, or more efficient in searching for those habitats.

Recapture rates.—We obtained extremely low recapture rates on Mt. Mansfield, especially among transient species. The overall recapture rate of 1.8% among all species (0.3% among transients) is much lower than that reported during fall from other eastern U.S. banding operations, both inland [e.g., 29.7% at VINS in 1995–1997 (Rimmer, Faccio, and McFarland, unpubl. data); 12.1% at Powdermill in 1995–1997 (Mulvihill and Leberman, pers. comm.); 6.4% at Braddock Bay Bird Observatory in 1995–1997 (Brooks 1996, 1997, 1998)] and coastal [e.g., 30.2% in southeastern Massachusetts in 1995–1997 (Lloyd-Evans, pers. comm.), 13.4% on Appledore Island off New Hampshire (Morris et al. 1996), and ca 10% in Alabama (Woodrey and Moore 1997)]. While recapture data are not strictly comparable among these sites because of differences in seasonal and daily timing of mist-netting operations, number and placement of nets, habitat structure, and other variables, we believe that they highlight the fact that very few transient birds remain on the Mt. Mansfield ridgeline for more than one day after their original capture.

We suggest that conditions on the Mt. Mansfield ridgeline are not conducive to prolonged migratory stopovers in that most migrants are unable to meet their energetic requirements for continued migration at the site. Although migrants approaching the ridgeline at dawn with depleted energy reserves may have few options other than to stop over, the low probability of replenishing or accumulating additional fat reserves may select for short lengths of stay (Rappole and Warner 1976, Terrill 1988, Kuenzi et al. 1991, Moore and Simons 1992). Diminishing insect food supplies and rapidly deteriorating weather during fall probably reduce the suitability of montane fir-spruce habitat for most transients, especially those that are unfamiliar with the habitat. We detected few large fat loads among the birds we examined; nearly half of the recaptured individuals of all migrant classes lost weight and most maintained or lost subcutaneous fat. We believe that most migrants leave the Mt. Mansfield ridgeline shortly after arrival because they encounter few opportunities to satisfy their energy demands.

We do not know whether the presumed rapid departures of most migrants from Mt. Mansfield were due to the initiation of nocturnal migratory flights or to downslope movements in search of more suitable habitats, or both. At Allegheny Front, where the great majority of birds captured are known transients, recapture rates are also extremely low (Hall, pers. comm.). However, Allegheny Front primarily samples migrants that are undergoing active diurnal flights and rarely stop over in the stunted, spruce-dominated ridgeline forest (Hall and Bell 1981). At Mt. Mansfield, the paucity of recaptures and the lack of any detectable diurnal flight suggest a gradual movement away from the ridgeline, possibly to lower elevations. Multiple banding sites across an elevational gradient on Mt. Mansfield's slopes, in combination with radio telemetry, would be necessary to examine this.

Black-throated Blue Warbler.—The disproportionate abundance of Black-throated Blue Warblers in our sample and the high ratio of immatures to adults, suggest that montane fir-spruce forests may be actively selected by juveniles of this species for stopover, postfledging dispersal, or both. The concentration of captures (57%) in August, before the peak of southward departure from northern New England (Holmes 1994), may indicate a pronounced upslope movement away from natal territories in lower elevation northern hardwood forests. While no published information on postfledging dispersal in this species exists, young Black-throated Blue Warblers from first or early season nests are reported to regularly disappear from their natal territories 3–4 weeks after fledging (Holmes, pers. comm.). Black-throated Blue Warblers breed at fairly high densities in northern hardwood forests of northern New England (Holmes et al. 1986, 1996), and nearly half of females are multiple-brooded (Holmes et al. 1992). Independent young from early broods may be competitively excluded from occupied territories of pairs with later nests. Regular upslope movements would take many young Black-throated Blue Warblers into montane fir-spruce forests, where intraspecific competition from territorial adults would be absent. It has been suggested that regular postfledging dispersal of Wood Thrushes to habitats different from those on their natal territories may be driven in part by avoidance of such competition (Anders et al. 1998, Vega Rivera et al. 1998). In mountainous areas of western North America, regular late summer and autumn upslope movements of non-local breeding species, mostly immature birds, are well-documented (Packard 1946, Dixon and Gilbert 1964, Pattie and Verbeek 1966) and may be mediated through competition with adults.

Other possible causes of extensive postfledging movements in Black-throated Blue Warblers might include initiation of migration, socialization, and optimal foraging (see Vega Rivera et al. 1998), but none of these seem likely. Immature Black-throated Blue Warblers do not, to our knowledge, regularly appear at sites south of their main breeding areas or at autumn migration banding sites prior to the species' peak of migratory movement (see Fig. 1; Leberman 1976, Hall 1981, Holmes 1994). Dispersal of young birds to facilitate socialization in conspecific groups (Morton 1991) is not supported by our observational or banding data; most Black-throated Blue Warblers were captured singly or in flocks of 2–3 birds, and none was known to remain on the site for more than one day after initial capture. The lack of recaptures and the low initial fat scores of most Black-throated Blue Warblers in our sample also argue that location of optimal foraging habitat does not drive the dispersal of immatures into Mt. Mansfield's montane forests. We suspect that the altitudinal dispersal of young Black-throated Blue Warblers is driven by competition with adults, and that upslope movements may offer the most rapid means to reach forested habitats free from these competitive constraints.

The apparently rapid departure of immature Black-throated Blue Warblers from a habitat that they appear to select is puzzling. Whether birds continue to disperse or begin to migrate southward along the north–south running ridgelines of the Green Mountains is unknown. A reverse downslope movement back into northern hardwood forests or other lowland habitats seems unlikely. Few HY Black-throated Blue Warblers are observed or captured on long-term study plots in unfragmented northern hardwood forests of New Hampshire during late summer (Holmes, pers. comm.). At VINS, few individuals of this species have ever been captured during the postfledging period over 15 years of banding (Rimmer, Faccio, and McFarland, unpubl. data). The relatively high proportion of Black-throated Blue Warblers captured at Allegheny Front (13.6% of nearly 50,000 wood warblers banded from 1958–1980, third in overall abundance among 33 warbler species; Hall and Bell 1981) and the relatively high proportion of adults at this site, suggest a fall migration route concentrated along the Appalachian Mountains. This is supported by comparatively low capture rates and high HY ratios of this species at the lowland Powdermill site only 130 km north of Allegheny Front (Mulvihill and Leberman, pers. comm.) and at most coastal banding stations (Murray 1966, Ralph 1981, Stewart 1986). We suspect that most individuals captured on Mt. Mansfield continue to move southward along the Green Mountains. More research, incorporating radio telemetry of postfledging birds from known natal sites, is needed to examine this phenomenon.

Conservation implications.—Although the Mt. Mansfield ridgeline and other montane forest sites in eastern North America may not provide optimal stopover habitat for most passage migrants and dispersing juveniles, we believe that the importance of these sites should not be overlooked. Degradation of high elevation habitat ''islands'' such as Mt. Mansfield could have adverse consequences not only for breeding populations of rare and potentially vulnerable species like Bicknell's Thrush (Rosenberg and Wells 1995, Atwood et al. 1996, Rimmer 1996), but for populations of migrants and postbreeding dispersers as well. Conservation measures that focus on stopover habitat requirements must take into account the diversity of habitat types, and the timing of their use, at all stages between migrants' departure from their breeding territories and arrival on their wintering grounds. We believe that further studies of stopover habitat use in montane forests are warranted and that conservation planning for montane forest sites should carefully consider the needs of migrants outside the breeding season.

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LITERATURE CITED

ANDERS, A. D., J. FAABORG, AND F. R. THOMPSON, III. 1998. Postfledging dispersal, habitat use, and home-range size of juvenile Wood Thrushes. Auk 115:349–358.

ATWOOD, J. L., C. C. RIMMER, K. P. MCFARLAND, S. H. TSAI, AND L. R. NAGY. 1996. Distribution of Bicknell's Thrush in New England and New York. Wilson Bull. 108:650–661.

BROOKS, E. W. 1996. Atlantic Flyway review: region II (north central) fall 1995. N. Am. Bird Bander 21:30–31.

BROOKS, E. W. 1997. Atlantic Flyway review: region II (north central) fall 1996. N. Am. Bird Bander 22:38–39.

BROOKS, E. W. 1998. Atlantic Flyway review: region II (north central) fall 1997. N. Am. Bird Bander 23:20–21.

CHERRY, J. D. 1982. Fat deposition and length of stopover of migrant White-crowned Sparrows. Auk 99:725–732.

DEGRAAF, R. M., M. YAMASAKI, W. B. LAEK, AND J. W. LANIER. 1992. New England wildlife: management of forested landscapes. USDA Forest Service, Northeastern Forest Expt. Station, Gen. Tech. Rep. NE-144:1–271.

DIXON, K. L. AND J. D. GILBERT. 1964. Altitudinal migration in the Mountain Chickadee. Condor 66: 61–64.

EVANS, W. R. 1994. Nocturnal flight call of Bicknell's Thrush. Wilson Bull. 106:55–61.

GREGOIRE, J. A. 1997. Atlantic Flyway review: region II (north central) fall 1996. N. Am. Bird Bander 22:39–40.

GREGOIRE, J. A. 1998. Atlantic Flyway review: region II (north central) fall 1997. N. Am. Bird Bander 23:21–22.

HALL, G. A. 1981. Fall migration patterns of wood warblers in the southern Appalachians. J. Field Ornithol. 52:43–49.

HALL, G. A. AND R. K. BELL. 1981. The diurnal migration of passerines along an Appalachian ridge. Am. Birds 35:135–138.

HOLMES, R. T. 1994. Black-throated Blue Warbler *(Dendroica caerulescens). In* The birds of North America, no. 87 (A. Poole and F. Gill, Eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania; The American Ornithologists' Union, Washington, D.C.

HOLMES, R. T., T. W. SHERRY, AND F. W. STVRGES. 1986. Bird community dynamics in a temperate deciduous forest: long-term trends at Hubbard Brook. Ecol. Monogr. 56:201–220.

HOLMES, R. T., T. W. SHERRY, P. P. MARRA, AND K. E. PETIT. 1992. Multiple brooding and productivity of a Neotropical migrant, the Black-throated Blue Warbler *(Dendroica caerulescens)*, in an unfragmented temperate forest. Auk 109:321–333.

HOLMES, R. T., P. P. MARRA, AND T. W. SHERRY. 1996. Habitat-specific demography of breeding Black-throated Blue Warblers *(Dendroica caerulescens)*: implications for population dynamics. J. Anim. Ecol. 65:183–195.

HUTTO, R. L. 1985. Habitat selection by nonbreeding, migratory land birds. Pp. 455–476 *in* Habitat selection by birds (M. Cody, Ed.). Academic Press, New York.

HUTTO, R. L. 1999. On the importance of en-route periods to the conservation of migratory landbirds. Stud. Avian Biol. In press.

KUENZI, A. J., F. R. MOORE, AND T. R. SIMONS. 1991. Stopover of Neotropical landbird migrants on East Ship Island following trans-Gulf migration. Condor 93:869–883.

LEBERMAN, R. C. 1976. The birds of the Ligonier Valley. Carnegie Mus. Nat. Hist. Spec. Publ. 3:1–67.

MOORE, F. R. AND T. R. SIMONS. 1992. Habitat suitability and stopover ecology of Neotropical landbird migrants. Pp. 345–355 *in* Ecology and conservation of Neotropical migrant landbirds (J. M. Hagan and D. W. Johnston, Eds.). Smithsonian Institution Press, Washington, D.C.

MOORE, F. R., S. A. GAUTHREAUX, JR., P. KERLINGER, AND T. R. SIMONS. 1995. Habitat requirements during migration: important link in conservation. Pp. 121–144 *in* Ecology and management of Neotropical migratory birds (T. E. Martin and D. M. Finch, Eds.). Oxford Univ. Press, New York.

MORRIS, S. R., D. W. HOLMES, AND M. E. RICHMOND. 1996. A ten-year study of the stopover patterns of migratory passerines during fall migration on Appledore Island, Maine. Condor 98:395–409.

MORTON, M. L. 1991. Postfledging dispersal of Green-tailed Towhees to a subalpine meadow. Condor 93:466–468.

MURRAY, B. G., JR. 1966. Migration of age and sex classes of passerines on the Atlantic Coast in autumn. Auk 83:352–360.

NISBET, I. C. T., W. H. DRURY, JR., AND J. BAIRD. 1963. Weight-loss during migration. Part I. Deposition and consumption of fat by the Blackpoll Warbler *Dendroica striata.* Bird-Banding 34:107–138.

PACKARD, F. M. 1946. Midsummer wandering of certain Rocky Mountain birds. Auk 63:152–158.

PATTIE, D. L. AND N. A. M. VERBEEK. 1966. Alpine birds of the Beartooth Mountains. Condor 68:167–176.

PYLE, P. 1997. Identification guide to North American birds. Slate Creek Press, Bolinas, California.

RALPH, C. J. 1971. An age differential of migrants in coastal California. Condor 73:243–246.

RALPH, C. J. 1981. Age ratios and their possible use in determining autumn routes of passerine migrants. Wilson Bull. 93:164–188.

RAPPOLE, J. H. AND D. W. WARNER. 1976. Relationships between behavior, physiology and weather in avian transients at a migration stopover site. Oecologia 26:193–212.

RAPPOLE, J. H., E. S. MORTON, T. E. LOVEJOY, III, AND J. L. RUOS. 1983. Nearctic avian migrants in the Neotropics. U.S. Fish Wildl. Serv., Washington, D.C.

REMSON, J. V., JR. AND D. A. GOOD. 1996. Misuse of data from mist-net captures to assess relative abundance in bird populations. Auk 113:381–398.

RIMMER, C. C. 1996. A closer look: Bicknell's Thrush. Birding 28:118–123.

ROSENBERG, K. V. AND J. V. WELLS. 1995. Importance of geographic areas to Neotropical migrant birds in the Northeast. Cornell Laboratory of Ornithology, Ithaca, New York.

STEWART, P. A. 1986. Fall migration of twelve species of wood warblers through coastal Virginia. N. Am. Bird Bander 11:83–88.

TERRILL, S. B. 1988. The relative importance of ecological factors in bird migration. Proc. Int. Ornithol. Congr. 19:2180–2190.

WEISS, M. J. AND I. MILLERS. 1988. Historical impacts on red spruce and balsam fir in the northeastern U.S. Pp. 271–277 *in* Proceedings of the effects of atmospheric pollution on spruce and fir in the eastern United States and the Federal Republic of Germany. Burlington, Vermont.

WINKER, K., D. W. WARNER, AND A. R. WEISBROD. 1992. Daily mass gains among woodland migrants at an inland stopover site. Auk 109:853–862.

WOODREY, M. S. AND F. R. MOORE 1997. Age-related differences in the stopover of fall landbird migrants on the coast of Alabama. Auk 114:695–707.

VEGA RIVERA, J. H., J. H. RAPPOLE, W. J. MCSHEA, AND C. A. HAAS. 1998. Wood Thrush postfledging movements and habitat use in northern Virginia. Condor 100:69–78.

APPENDIX. Summary of fall captures (1995–1997) on Mt. Mansfield, Vermont for species represented by 5 or more individuals.

Species	Migrant class[a]	Captures	% Recaptured	% HY[b]	Range of dates	Median date
Ruby-throated Hummingbird (*Archilochus colubris*)	T	5	unknown[c]	not aged[c]	9 Aug–5 Sep	26 Aug
Downy Woodpecker (*Picoides pubescens*)	T	7	0.0	66.7	3 Aug–11 Oct	19 Sep
Blue-headed Vireo (*Vireo solitarius*)	T	6	0.0	100	21 Aug–19 Sep	12 Sep
Red-eyed Vireo (*Vireo olivaceus*)	T	24	0.0	100	8 Aug–9 Oct	8–9 Sep
Blue Jay (*Cyanocitta cristata*)	S	13	0.0	76.9	9–27 Sep	19 Sep
Black-capped Chickadee (*Poecile atricapillus*)	S	49	12.2	89.1	7 Aug–7 Oct	19 Sep
Red-breasted Nuthatch (*Sitta canadensis*)	B	27	0.0	66.7	1 Aug–9 Oct	7 Sep
Brown Creeper (*Certhia americana*)	B	13	0.0	70	26 Aug–10 Oct	24 Sep
Winter Wren (*Troglodytes troglodytes*)	B	8	0.0	87.5	6 Aug–8 Sep	20 Aug
Golden-crowned Kinglet (*Regulus satrapa*)	B	133	0.0	97.5	6 Aug–12 Oct	27 Sep
Ruby-crowned Kinglet (*Regulus calendula*)	S	207	1.4	71.3	7 Aug–13 Oct	29 Sep
Veery (*Catharus fuscescens*)	T	6	0.0	100	8 Aug–1 Oct	8–9 Sep
Bicknell's Thrush (*Catharus bicknelli*)	B	53	15.1	65.4	1 Aug–2 Oct	11 Sep
Swainson's Thrush (*Catharus ustulatus*)	B	32	0.0	71.9	6 Aug–30 Sep	6 Sep
Hermit Thrush (*Catharus guttatus*)	S	28	0.0	64.3	5 Aug–13 Oct	19–20 Sep
American Robin (*Turdus migratorius*)	B	23	4.3	61.1	5 Aug–13 Oct	15 Aug
Tennessee Warbler (*Vermivora peregrina*)	T	14	0.0	57.1	1 Aug–28 Sep	13–14 Sep
Nashville Warbler (*Vermivora ruficapillus*)	B	31	0.0	90	20 Aug–29 Sep	5 Sep
Chestnut-sided Warbler (*Dendroica pennsylvanica*)	T	16	0.0	100	15 Aug–6 Sep	20–21 Aug
Magnolia Warbler (*Dendroica magnolia*)	B	54	0.0	90.7	8 Aug–29 Sep	30 Aug
Black-throated Blue Warbler (*Dendroica caerulescens*)	T	338	0.0	97.0	2 Aug–9 Oct	29 Aug
Yellow-rumped Warbler (*Dendroica coronata*)	B	754	1.3	89.2	1 Aug–13 Oct	15 Sep
Black-throated Green Warbler (*Dendroica virens*)	T	49	0.0	85.7	3 Aug–6 Oct	5 Sep
Blackburnian Warbler (*Dendroica fusca*)	T	20	0.0	100	9 Aug–19 Sep	30 Aug
Bay-breasted Warbler (*Dendroica castanea*)	T	8	0.0	87.5	7 Aug–13 Sep	7–8 Sep
Blackpoll Warbler (*Dendroica striata*)	B	414	1.7	71.9	1 Aug–9 Oct	5 Sep
Black-and-White Warbler (*Mniotilta varia*)	T	12	0.0	100	3 Aug–11 Sep	19 Aug
American Redstart (*Setophaga ruticilla*)	T	17	0.0	82.4	3 Aug–13 Sep	14 Aug

APPENDIX. CONTINUED

Species	Migrant class[a]	Captures	% Recaptured	% HY[b]	Range of dates	Median date
Ovenbird (*Seiurus aurocapillus*)	T	62	0.0	98.3	3 Aug–28 Sep	22 Aug
Canada Warbler (*Wilsonia canadensis*)	T	31	0.0	86.7	5–30 Aug	15 Aug
Scarlet Tanager (*Piranga olivacea*)	T	5	0.0	100	8 Aug–9 Sep	23 Aug
Lincoln's Sparrow (*Melospiza lincolnii*)	T	5	40.0	80	6–21 Sep	9 Sep
White-throated Sparrow (*Zonotrochia albicollis*)	B	188	3.7	73.2	1 Aug–13 Oct	20 Sep
White-crowned Sparrow (*Zonotrichia leucophrys*)	T	6	0.0	50	20 Sep–13 Oct	29 Sep
Dark-eyed Junco (*Junco hyemalis*)	B	303	3.6	80.7	1 Aug–13 Oct	19 Sep
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	T	11	0.0	100	8–30 Aug	16 Aug
Purple Finch (*Carpodacus purpureus*)	B	6	0.0	50	5 Aug–7 Oct	13 Aug
Class B	B	2044	2.1	81.8	1 Aug–13 Oct	13 Sep
Class S	S	307	2.9	75.3	5 Aug–13 Oct	27 Sep
Class T	T	673	0.3	93.6	1 Aug–13 Oct	28 Aug
Total Captures	All	3024	1.8	84	1 Aug–13 Oct	

[a] Species' status at this site: B = regular breeder above 915 m elevation, S = sporadic/low density breeder above 915 m, T = transient above 915 m elevation.
[b] HY = hatching-year.
[c] Hummingbirds were not banded or processed.