2000 Report to the Vermont Monitoring Cooperative

An Investigation of Mercury Levels in Bicknell's Thrush and other Montane Forest Birds

Submitted by:

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It is well established that elevated levels of mercury (Hg) deposition and methylmercury (MeHg) availability in the northeastern U.S. have negatively impacted some wildlife populations. However, studies to date have focused on aquatic-based organisms and ecosystems (e.g., Welch 1994, Stafford and Haines 1996, Wiener and Spry 1996, NESCAUM 1998, Evers et al. 2001), where accumulated MeHg biomagnifies through the food chain, from phytoplankton and zooplankton to invertebrates, fish, and piscivorous vertebrates. Particular emphasis has been on higher trophic piscivorous wildlife, which are most at risk from Hg's ability to bioaccumulate and biomagnify (Scheuhammer 1991, Thompson 1996, USEPA 1997). Piscivorous birds have commonly been used as bioindicators of MeHg availability (e.g., Thompson 1996, Wolfe and Norman 1998, Evers et al. 2001).

Little is known about Hg availability to or toxicity in terrestrial wildlife (Thompson 1996). Further, exceedingly few data exist on Hg burdens in terrestrial, migratory passerine birds, which are potentially exposed to varying environmental levels during their breeding, migration, and wintering periods. Birds are an important taxon for sampling because they are well established bioindicators of MeHg availability (e.g., USEPA 1997, Nichols et al. 1999), they are relatively easily sampled, and feathers reflect up to 95% of the total body burden of Hg (Burger 1983). Among migratory passerines, obligate insectivores are the most likely to be at risk from Hg toxicity, although there appear to be no established impact thresholds to assess risk, either at the individual or population level.

While pathways for Hg uptake and bioaccumulation in terrestrial ecosystems are not well understood, recent research has shown that Hg loading is significantly (2-5x) higher in montane areas of the Northeast than in surrounding low elevation areas (Lawson 1999). Orographically enhanced precipitation and interception of acidic, pollutant-laden cloud water contribute to increased Hg deposition in high elevation ecosystems. However, the possible toxic effects of such deposition on montane biota are largely unknown. Baseline data on total Hg levels and ratios of MeHg:Hg in wildlife are needed to address this issue.

During the summer of 2000, we sampled Hg levels in breeding birds at selected montane forest sites in the northeastern U.S., concentrating on Mt. Mansfield, Vermont. Our research focused on Bicknell's Thrush *(Catharus bicknelli)*, the subject of intensive demographic studies by the Vermont Institute of Natural Science (VINS) since 1992 (Rimmer et al. 2001). We also collected samples from Blackpoll Warbler *(Dendroica striata)*, Myrtle Warbler *(Dendroica coronota coronota)*, and White-throated Sparrow *(Zonotrichia albicollis)*. Bicknell's Thrush and Blackpoll Warbler are near-obligate breeding residents of montane forests in the Northeast, while Myrtle Warbler and White-throated Sparrow breed at high densities in these forests, but are also common in a variety of low elevation forested habitats throughout the Northeast. All four species are primarily insectivorous during the breeding season, with Bicknell's Thrush and White-throated Sparrow foraging mainly on or close to the ground, Blackpoll Warblers mainly gleaning foliage, and Myrtle Warblers capturing

insect prey both by foliage gleaning and fly-catching. Bicknell's Thrush and Blackpoll Warbler are long-distance migrants to the Caribbean Greater Antilles and northern South America, respectively, Myrtle Warbler and White-throated Sparrow are short- to medium-distance migrants, wintering primarily in the southeastern U.S. These four species thus represent a diverse array of habitat specialization, foraging guilds, and migration strategies.

Methods

We collected blood and/or feather samples from a total of 89 individuals of the four species in 2000 (Table 1). Birds were captured in mist nets both passively and by using tape playbacks. Each individual was banded, aged, sexed, measured, and weighed. The fifth secondaries on both wings were clipped just above the follicle and stored in plasticine envelopes. A small blood sample (c. 50 μl) was collected in a heparinized capillary tube, refrigerated in vaccutainers in the field, and frozen within 12-48 hours. Samples were analyzed in two batches. The first consisted of Bicknell's Thrush blood (n = 15 individuals) and feather samples (n = 14 birds) from Mt. Mansfield (n = 12), the White Mountains (n = 2), and Whiteface Mt. in the Adirondacks (n = 3). The Sawyer Laboratory at the University of Maine Orono conducted these analyses, using cold-vapor atomic absorption (CVAA) spectroscopy. Because four blood samples had weights too low to permit accurate readings using CVAA, these were reanalyzed using the more sensitive cold-vapor atomic fluorescence (CVAF) technique. This set of samples was analyzed only for total Hg.

The second set of samples included 35 blood and 23 feather samples from Bicknell's Thrush (n = 23 birds), Blackpoll Warbler (n = 6), Myrtle Warbler (n = 6), and White-throated Sparrow (n = 6). These samples were analyzed by element-specific CVAA at the Texas A&M University Trace Element Research Laboratory. All blood samples were analyzed for both total Hg and MeHg, while feathers were analyzed only for total Hg. Detection limits averaged approximately 0.009 parts per million (ppm) for total Hg and MeHg in blood and 0.04 for total Hg in feathers.

Results and Discussion

Overall blood and feather Hg levels and blood MeHg levels did not significantly differ among the four species sampled on Mt. Mansfield (Table 2). Blood and feather Hg levels and blood MeHg levels for each individual bird sampled are presented in the Appendix. Bicknell's Thrush showed relatively high variability in total blood Hg levels (Appendix) and had the highest mean level among the four species (Table 2). Overall mean feather levels were highest in Myrtle Warblers, but one individual (4.32 ppm) strongly skewed this mean (Appendix).

An important result from this study is documentation of MeHg to total Hg ratios in these four species. This ratio, which tends to be relatively invariable within a species (D. Evers pers. comm.), reflects how much of the Hg taken in by an individual is sequestered as MeHg. Understanding the MeHg:Hg ratio is a crucial first step to evaluate whether mercury toxicity may be a problem for a given species. All four species sampled in 2000 showed MeHg:Hg ratios of 0.95-1.0 (Table 2), indicating a high withdrawal of MeHg in blood from the total Hg consumed. The ratios documented here for these four montane forest species are similar to those found in piscivorous birds like the Common Loon (*Gavia immer)*, a species which is well known to suffer adverse effects from MeHg toxicity in the Northeast (e.g., Evers et al. 2001).

Sample size constraints limited our ability to test for demographic and geographic differences in any species other than Bicknell's Thrush. We detected no significant differences in blood or feather Hg levels between adult males and females. Among age classes, there was no significant difference between second-year (SY; yearlings) and after second-year (ASY; individuals $\geq$ 3 years old) individuals (Fig. 1). Juveniles had significantly lower mean blood Hg levels (0.014 $\pm$ 0.001 SD) than SYs (0.081 $\pm$ 0.038 SD) and ASYs (0.097 $\pm$ 0.057 SD) (Kruskal-Wallis test statistic = 10.46, df = 2, P = 0.005; Fig. 1). These results are not surprising, as

blood Hg levels reflect short-term dietary intake rather than accumulated body burdens, and so might be expected to be lower in individuals less than one month old.

Feather Hg data show a more compelling trend by age class, as SY Bicknell's Thrushes had significantly lower mean levels (0.445 $\pm$ 0.12 SD) than ASY birds (0.942 $\pm$ 0.315 SD; Mann-Whitney U test = 73, df = 1, P = 0.005; Fig. 1). Because the ASY age class encompasses all birds older than 3 years, we analyzed a subset of precisely known-aged adults from VINS' long-term study site on Mt. Mansfield. Feather Hg levels again showed a significant trend, with older individuals carrying higher Hg burdens (Spearman rank coefficient = 0.51; Fig. 2). Blood Hg levels in known-age birds on Mt. Mansfield also increased significantly with age (Spearman rank coefficient = 0.81; Fig. 2), but one outlier with a very high level (0.286) may have biased this dataset. Since feathers are an indicator of chronic mercury body burden, these data suggest that annual systemic inputs of mercury exceed outputs in Bicknell's Thrushes on Mt. Mansfield. This preliminary finding is noteworthy, but a larger sample of known-age birds is needed to form more robust conclusions about age effects of Hg in this species.

We tested for geographic differences by comparing Hg levels in ASY Bicknell's Thrushes along a west-east gradient from Whiteface Mtn. in New York, to Mt. Mansfield in Vermont, to the Bigelow Range in Maine. No significant differences in mean blood Hg levels existed among the three sites (Fig. 3). Mean feather Hg levels differed significantly across this gradient, progressively declining from Whiteface Mtn. (1.209 $\pm$ 0.385 SD) to Mt. Mansfield (0.756 $\pm$ 0.254 SD) to the Bigelow Range (0.286 $\pm$ 0.09 SD) (Mann-Whitney U test = 11, df = 1, P = 0.017). While this finding may reflect a different real-age structure among the three population samples, it suggests that regional mercury deposition patterns and/or bioavailability may differ, and it highlights the need to spatially characterize avian mercury burdens across montane forests of the northeastern U.S. Such a study would provide an initial screening to identify landscape-level issues that might warrant more intensive and localized research.

Few comparable data exist to provide context for the data presented here. The Biodiversity Research Institute (BRI) has sampled five insectivorous terrestrial species at several sites in Maine, and these show widely varying blood Hg levels (Fig. 3). In general, mean blood Hg levels in montane forest birds are lower than in the four passerine species sampled by BRI, but these latter species are all associated to varying extents with aquatic-based habitats, where rates of methylation and bioavailability are presumably higher (D. Evers pers. comm.). Sample sizes are small and variability is high, so comparisons among species must be made carefully and conditionally. We believe that the data presented here form a valuable preliminary benchmark for understanding Hg effects in terrestrial passerines, and that further extensive and intensive studies are warranted.

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Table 1. Numbers and locations of individual birds sampled for Hg blood and/or feathers in 2000.

	Number of Hg samples				
Site	**BITH[a]**	**BLPW[a]**	**MYWA[a]**	**WTSP[a]**	**Total**
Burke Mtn., VT	1				**1**
Carter Notch, NH	1				**1**
East Mtn., VT	5	1	1		**7**
Equinox Mtn., VT	1				**1**
Mt. Mansfield, VT	33	9	9	4	**55**
Mt. Snow, VT	2				**2**
Spruce Peak, VT	4	1		2	**7**
Stratton Mtn., VT	7				**7**
Mt. Washington, NH	1				**1**
Whiteface Mtn., NY	5		2		**7**
Total No. Samples	**60**	**11**	**12**	**6**	**89**

[a] BITH = Bicknell's Thrush, BLPW = Blackpoll Warbler, MYWA = Myrtle Warbler, WTSP = White-throated Sparrow

Table 2. Hg and MeHg levels in four species of montane forest breeding birds (adults only) sampled in 2000 on Mt. Mansfield, VT. Data given as mean $\pm$ standard deviation in ppm.

Species	**Total Blood Hg (*n*)**	**Blood MeHg:Hg ratio (*n*)**	**Total Feather Hg (*n*)**
BITH[ab]	0.106 $\pm$ 0.061 (19)	0.914 $\pm$ 0.168 (13)	0.756 $\pm$ 0.254 (16)
BLPW[a]	0.054 $\pm$ 0.015 (5)	0.989 $\pm$ 0.219 (5)	0.397 $\pm$ 0.237 (5)
MYWA[a]	0.079 $\pm$ 0.018 (5)	0.980 $\pm$ 0.072 (5)	1.507 $\pm$ 1.657 (6)
WTSP[a]	0.055 $\pm$ 0.018 (6)	1.040 $\pm$ 0.059 (6)	

[a] BITH = Bicknell's Thrush, BLPW = Blackpoll Warbler, MYWA = Myrtle Warbler, WTSP = White-throated Sparrow

[b] Includes 4 birds sampled in Bigelow Range, ME (3 in 1999, 1 in 2000; D. Evers, unpubl. data)