2002 Report to the Vermont Monitoring Cooperative

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

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It is well established that elevated levels of Hg deposition and methylmercury (MeHg) availability in the northeastern U.S. have negatively impacted some wildlife populations. However, little is known about Hg availability to or toxicity in terrestrial wildlife (Thompson 1996), including 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 songbirds, obligate insectivores like Bicknell's Thrush 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.

Bicknell's Thrush is a rare, range-restricted habitat specialist of montane forests in the Northeast (Rimmer et al. 2001). The species has been intensively studied by VINS since 1992 and is in many respects an ideal avian bioindicator of montane forest health. Knowledge of mercury burdens in this species could be instrumental to development of both species-specific and ecosystem-based conservation plans. Preliminary data collected in 2000 by VINS on Mt. Mansfield have documented blood and feather Hg levels and MeHg:total Hg ratios in this and three other species (Blackpoll Warbler *[Dendroica striata]*, Myrtle Warbler *[Dendroica coronota coronata])*, and White-throated Sparrow *[Zonotrichia albicollis]*). This report presents new data on a series of samples collected from Mt. Mansfield in 2001, updating VINS' previous dataset.

Methods

We collected blood samples from a total of 55 individuals of the four species in 2001 (n = 26 Bicknell's Thrush, 10 Blackpoll Warbler, 10 Myrtle Warbler, and 9 White-throated Sparrow). We collected feather samples from 24 Bicknell's Thrushes. 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 by element-specific cold-vapor atomic absorption (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 1). Bicknell's Thrush showed relatively high variability in total blood Hg levels, as did Myrtle Warbler (Table 1). Overall mean feather levels were highest in Myrtle Warblers, but one individual (4.32 ppm) strongly skewed this mean. Small sample sizes preclude meaningful interspecific comparisons of either blood or feather Hg levels.

An important result from this study is further 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 0.90-1.1 (Table 1), 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 (Evers et al. 2001).

Sample size constraints limited our ability to test for demographic 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. Males had a mean blood level of 0.117 ppm $\pm$ 0.125 SD (n = 32), while females had a mean level of 0.069 $\pm$ 0.025 SD (n = 9). Mean feather Hg in males was 0.671 $\pm$ 0.225 SD (n = 31) and in females 0.735 $\pm$ 0.282 SD (n = 8). Among age classes, mean blood Hg levels differed significantly between second-year (SY; yearlings [0.091 $\pm$ 0.028; n = 13]) and after second-year (ASY; individuals $\geq$ 3 years old [0.113 $\pm$ 0.13; n = 30]) individuals (Kruskal-Wallis test statistic = 11.06, df = 2, P = 0.004; Fig. 1). The cause of this discrepancy is not clear, but could be related to dietary differences between the two age classes. Five individuals sampled in both 2000 and 2001 showed no consistent between-year differences in mean blood Hg levels, as four birds had higher levels in 2000 than in 2001, while one showed the opposite pattern (Fig. 2). There was no significant difference at the population level in mean blood Hg between 2000 and 2001.

Feather Hg data show a more compelling trend by age class, as SY Bicknell's Thrushes had significantly lower mean levels (0.485 $\pm$ 0.12 SD; n = 11) than ASY birds (0.783 $\pm$ 0.245 SD; n = 29; Mann-Whitney U test = 38, df = 1, P = 0.0002; Fig. 3). Because the ASY age class encompasses all birds older than 3 years, we analyzed a subset of precisely known-aged adults. Feather Hg levels again showed a significant trend, with older individuals carrying higher Hg burdens (Spearman rank coefficient = 0.50; Fig. 4). 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 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.

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 (D. Evers, unpubl. Data; Fig. 5). 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. 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.

We await results of 97 additional Bicknell's Thrush blood and feather samples collected in 2002 and 2003 on Mt. Mansfield and Stratton Mountain. These are currently at Texas A&M University Trace Element Research Laboratory. The data will enable an in-depth comparison between two geographically disparate breeding sites in the northern and southern Green Mountains, respectively, and they will significantly augment the data presented in this report. Overall samples sizes of known age and sex individuals will be increased, and several individuals on both mountains will yield 2-4 years of sample data, enabling between-year comparisons and further insights on age effects of Hg accumulation in feathers. Additionally, 10 birds yielded blood samples 3-6 weeks apart in the same season, which will allow an examination of seasonal changes in blood Hg levels. This new set of data will be pooled with our existing data and summarized in a paper, "Mercury levels in Bicknell's Thrush and other insectivorous passerine birds in montane forests of the northeastern U.S.", to be submitted in March of 2004 for a special volume of Ecotoxicology that will focus on Hg issues in wildlife.

Future plans include seeking funding to analyze additional samples of known age and known sex Bicknell's Thrushes from Mt. Mansfield and Stratton Mountain, to correlate known breeding histories with Hg levels, and to sample arthropod prey and foliage for examination of pathways for Hg uptake in thrushes. The data presented here represent the largest data set known to us of Hg data in terrestrial insectivorous birds and are thus of significant value as a baseline for future comparative studies.

Literature Cited

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Table 1. Hg and MeHg levels in four species of montane forest breeding birds (adults only) sampled in 2000-2001 on Mt. Mansfield, VT. Data given as mean ± standard deviation in ppm.

Species	**Total Blood Hg (*n*)**	**Blood MeHg:Hg ratio (*n*)**	**Total Feather Hg (*n*)**
BITH[ab]	0.108 ± 0.11 (43)	0.983 ± 0.254 (39)	0.701 ± 0.255 (40)
BLPW[a]	0.057 ± 0.016 (12)	0.895 ± 0.21 (12)	0.397 ± 0.237 (5)
MYWA[a]	0.12 ± 0.121 (15)	0.959 ± 0.189 (15)	1.507 ± 0.167 (6)
WTSP[a]	0.059 ± 0.026 (14)	1.091 ± 0.372 (14)	0.502 (1)

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

[b] Includes 3 birds sampled on adjacent Spruce Peak in 2001 (see text)

Figure 1. Mean blood Hg levels (ppm) in Bicknell's Thrushes sampled on Mt. Mansfield, 2000 and 2001.

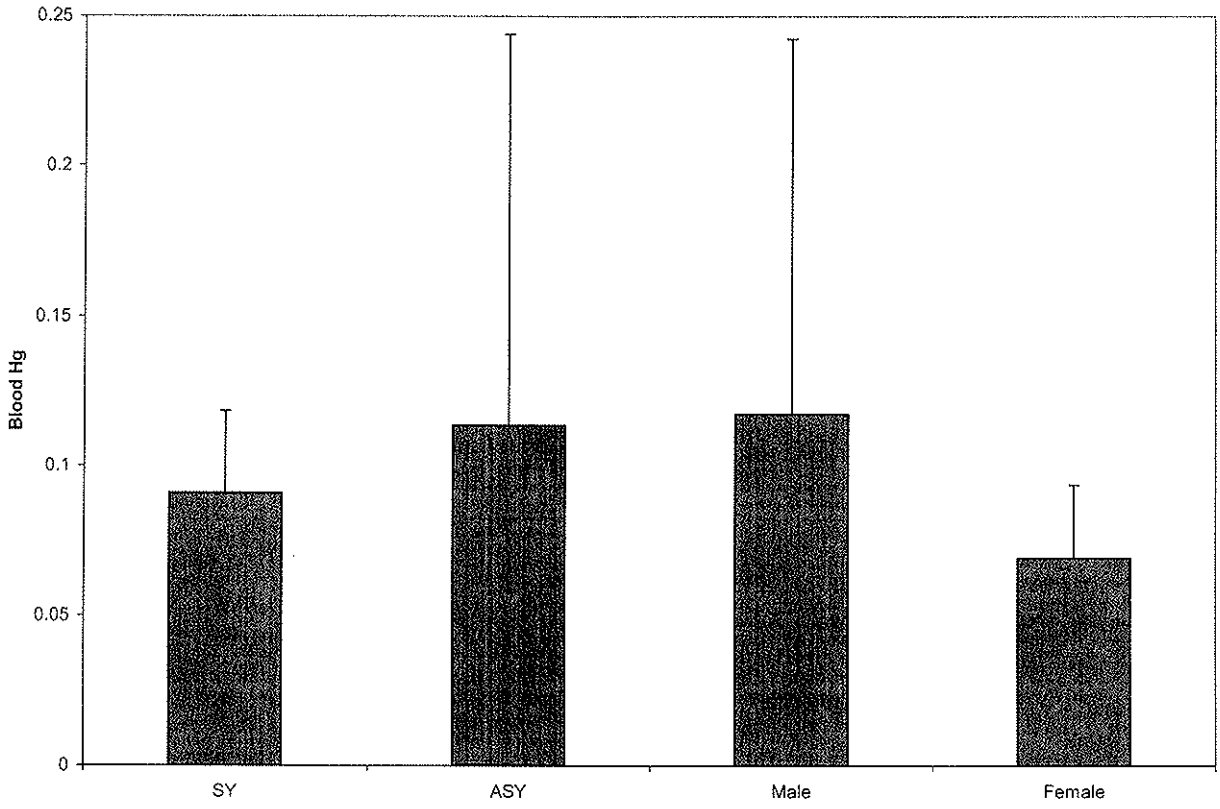

Figure 2. Mean Blood Hg levels (ppm) in 5 Bicknell's Thrushes sampled on Mt. Mansfield in June of 2000 and June of 2001.

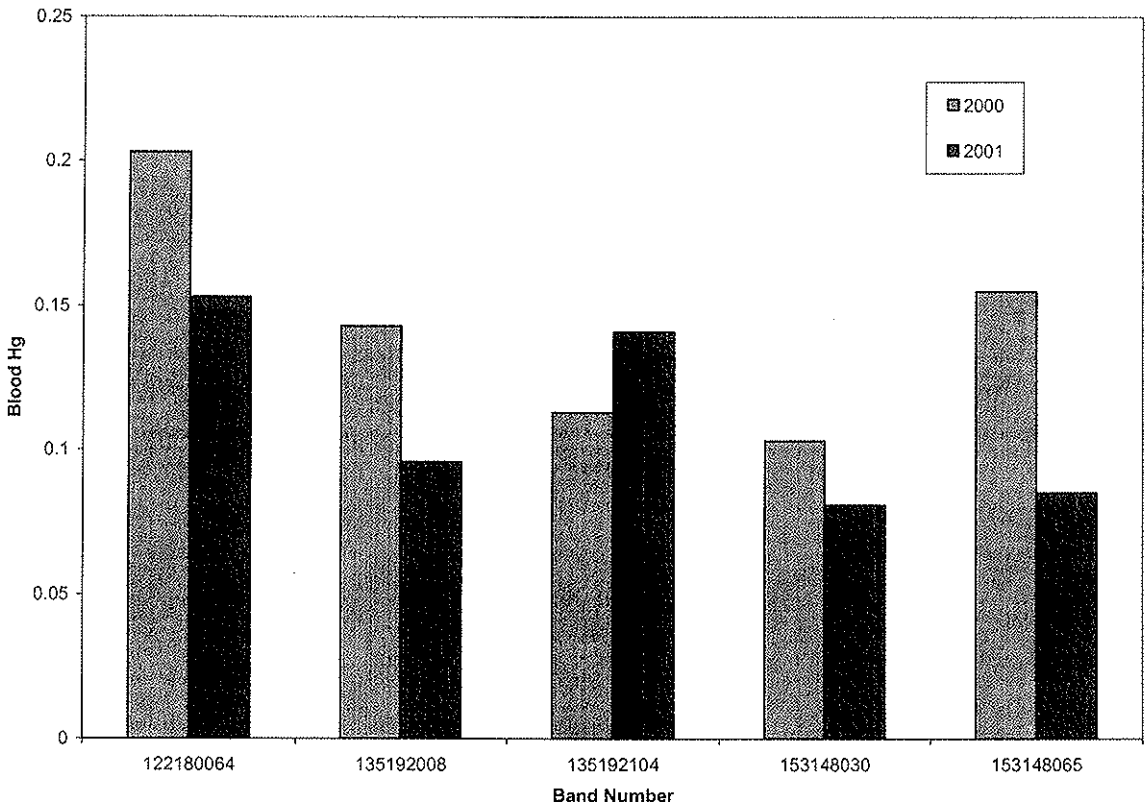

Figure 3. Mean feather Hg levels (ppm) in Bicknell's Thrushes on Mt. Mansfield, 2000 and 2001.

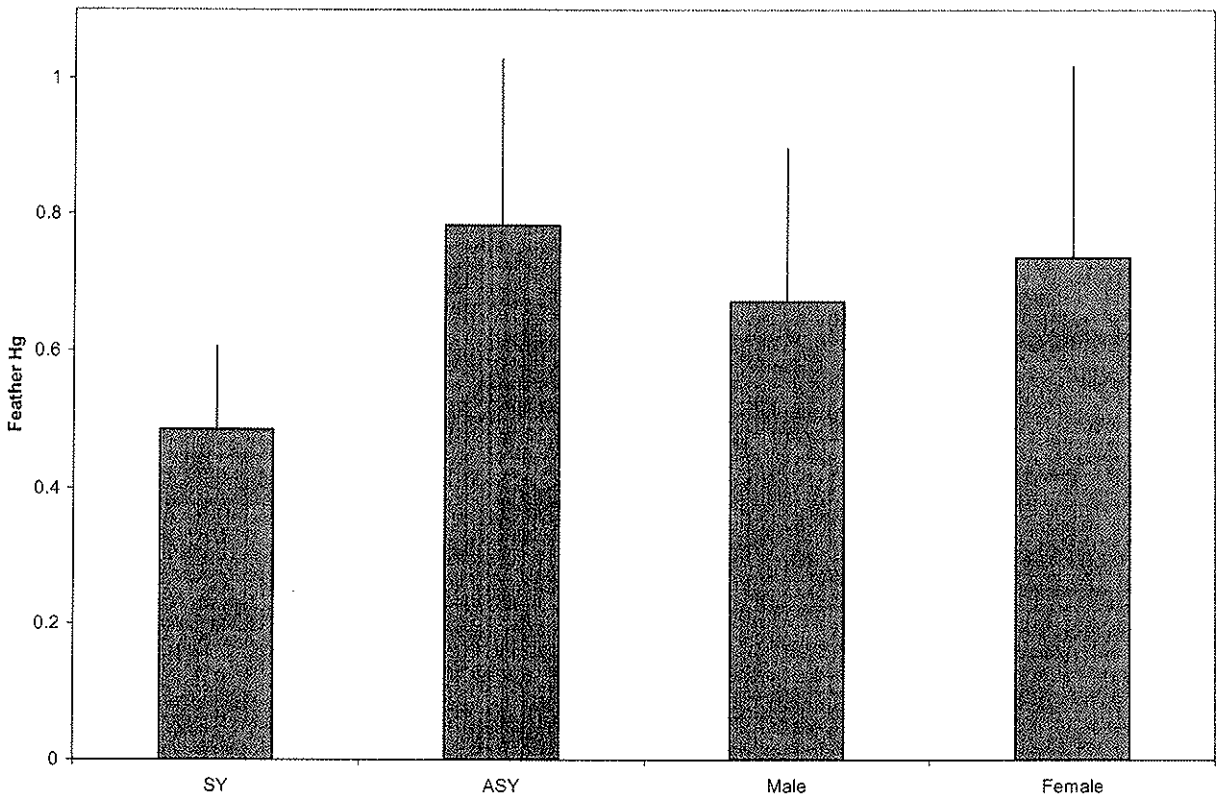

Figure 4. Mean feather Hg levels (ppm) in Bicknell's Thrushes of precisely known age class on Mt. Mansfield, 2000 and 2001.

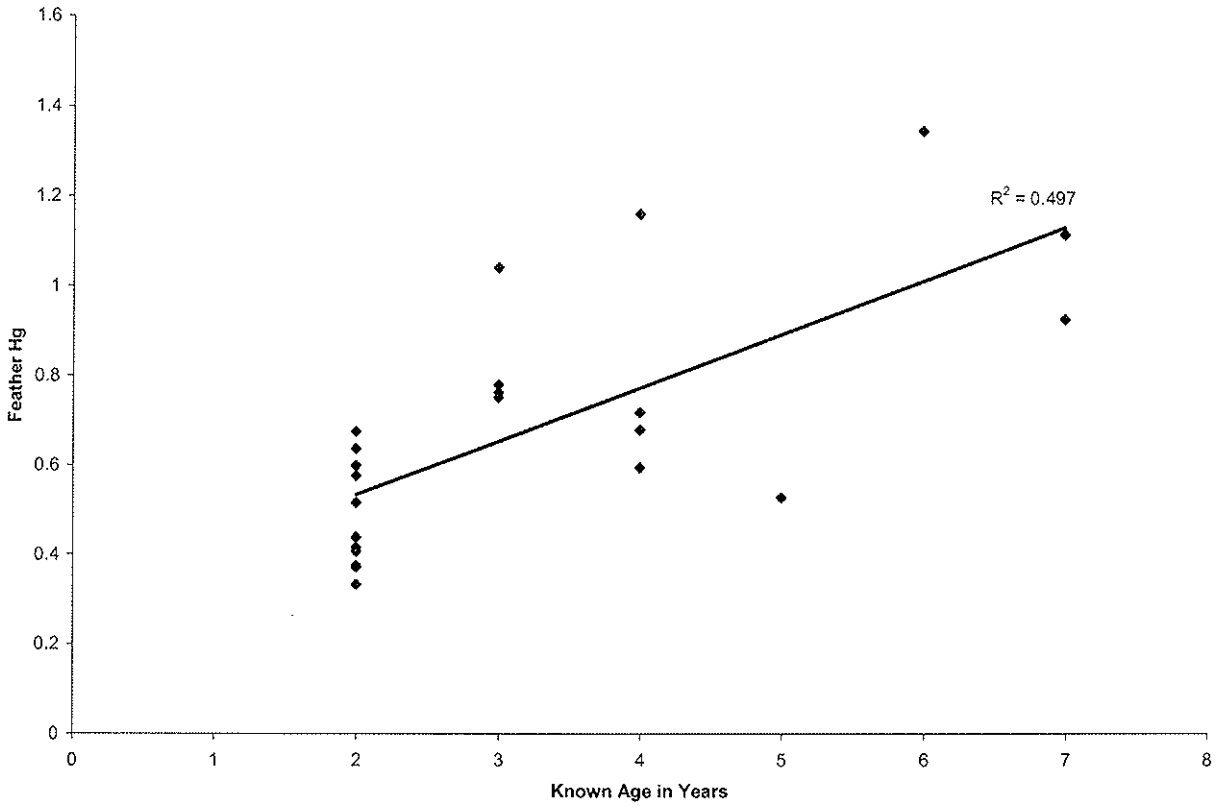

Figure 5. Blood Hg levels in selected insectivorous birds in the northeastern U.S. (mean + SD). Asterisk indicates unpublished data from D. Evers, BRI.