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**Abstract**

Wing and tail data from fifteen years of breeding bird studies in Hopewell, NJ, indicate that age class separation enhances possible sex determination by wing and tail in the Veery *(Catharus fucescens)* and Wood Thrush *(Hylocichla mustelina).* In breeding birds of these species, second-year (SY) birds, having retained juvenal wing and tail feathers, measured smaller than known third-year (TY) birds and after-hatching-year (AHY) birds of unknown exact age that had gone through at least the first complete molt. Furthermore, after-second-year (ASY) or older return encounters in the breeding season showed increase in wing and tail measurements over initial AHY measurements (older than SY). Males measured significantly longer than females in all age classes. By separating the data of the subadults from the adults, the wing and tail length differences between adult males and females widened, giving sex determination by measurement more potential. A tentative scheme for separating the sexes is suggested based on the measurements that extend beyond the overlap of two standard deviations.

**INTRODUCTION**

The smaller size of young birds in first basic plumage compared to older birds that have undergone the first complete molt is widespread among passerines and well known to bird banders (cf. Stewart 1963). Extensive data were compiled (Robbins 1964) from the cooperative Atlantic coastal netting project Operation Recovery (Baird et al. 1958) and from tower kills (Goodpasture 1963, Taylor 1972). This size difference is used in the Bird Banding Manual (1977) for sexing the Red-eyed Vireo *(Vireo olivaceus).* Less publicized are changes in adult wing lengths in molts subsequent to the first complete molt (Francis and Wood 1989, Suthers and Suthers 1990).

Longer wing and tail lengths in male compared to female passerines are also the general rule and these data are compiled in Pyle et al. (1987). The usefulness of this size dimorphism in sexing birds varies according to families or species. Size dimorphism is well defined in icterids (Meanley 1967). It is small in the mimids, eastern flycatchers, vireos and thrushes (Blake 1962) though useful in the Swainson's Thrush *(Catharus ustulatus)* (Stewart 1971). It is variable within the genera of the warblers (Eaton 1957a, Robbins 1964). Geographical size variation in certain species complicates sex determination outside the breeding season as seen in the Common Grackle *(Quiscalus quiscula)*, Eastern Meadowlark *(Sturnella magna)*, American Robin *(Turdus migratorius)* (Sheppard and Klimkiewicz 1976 and Bird Banding Manual II 1977), and Hermit Thrush *(Catharus guttatus)* (Aldrich 1968).

One of the goals of a long-term study of breeding passerines started in 1978 in old successional fields in central New Jersey was to elucidate the problem of sexing monomorphically plumaged birds by wing and tail measurements. Species of breeding birds in abundance were the Gray Catbird *(Dumetella carolinensis)*, Song Sparrow *(Melospiza melodia)*, Field Sparrow *(Spizella pusilla)*, Wood Thrush, and Veery. The catbird results have been published (Suthers and Suthers 1990).

The purpose of this paper is to explore the possibility, in samples of known ages and sexes of Veeries and Wood Thrushes, that age class separation enhances separation of the sexes by measurement. This has particularly important application in the Eastern Bird Banding Association's cooperative project, "Operation Wing Chord," which tests the hypothesis that the sex of monomorphically plumaged songbirds is correlated with wing chord (Graedel 1992).

## METHODS

Methods used in Wood (1969) and in the Bird Banding Manual, Vol. II (1977) were used here to age and sex birds. All breeding birds were sexed by brood patch or cloacal protuberance. Breeding individuals with ossified skulls and no retained juvenal plumage were aged AHY. Veeries were aged SY by retained greater wing coverts or tertials or incomplete skull ossification. Wood Thrush were aged SY by incomplete skull ossification. Fledglings banded on natal grounds and returning to breed also provided known SY birds. Wing chords were measured to the nearest mm on closed wing using a ruler with shoulder stop. Tails were measured by slipping a ruler between the central pair of rectrices. Birds were banded with U.S. Fish and Wildlife Service bands.

Sample means, sample standard deviations (SD), minimum and maximum measurements were calculated and plotted (Figure 1) for a quick evaluation (cf. Suthers 1984, Schneider 1984). The mean of a given sample and two SD's above and below the mean include 95.4% of the individuals of that sample. Where measurements of one sample lay beyond two SD of the other sample, possible real differences between the means were indicated, so the sample means were tested by the *t* test (cf. Schneider 1984, Suthers 1984), analysis of variance (ANOVA) and the multiple comparison tests Scheffe' F-test and Fisher Protected Least Significant Difference (Feldman and Gagnon 1991). Changes in wing and tail measurements in returning birds over initial adult measurements were tested by the *t* test for matched pairs, two-tailed. Significance levels for all the tests were set at $P < 0.05$.

## RESULTS AND DISCUSSION

***Samples:*** The 169 Veeries provided adequate sample sizes (N = 17 - 71) in each of the age/sex classes for a two-factor ANOVA. The 147 Wood Thrushes included an adequate sample of SY males (N = 11) but an inadequate sample of SY females (N = 2), preempting two-factor ANOVA. HY samples were included in one-factor ANOVA to provide an estimate of size differences; HY/SY wings and tails would not change except by feather wear until the complete prebasic molt in the fall of the second year. The data within the classes were homogeneous by the F-test for similarity between two variances.

***Age:*** Hatching year birds with sex unknown (and therefore combined), averaged between the separated male and female SY birds in wing and tail as expected and were not significantly different. Otherwise, age effects varied interestingly with species and sex and will be discussed in the species accounts.

***Older age:*** Returns and multiple returns of individual AHY birds of both species (N = 42 male and 33 female Veery encounters of 29 individuals, 33 male and 7 female Wood Thrush encounters of 15 individuals) were tested by the paired *t* test, two tailed, for changes in wing and tail measurements in subsequent molts beyond the first complete molt (older than SY). They increased significantly in male wings of both species (Veery wing, AHY vs. ASY, average change 1.44 mm, $t = 2.393$, *df* 8, p = .0436; Wood Thrush wing, AHY vs. ASY, average change 2.27 mm, $t = 2.63$, *df* 10, p = .0252). Female wing lengths did not increase significantly. Tail lengths did not increase significantly. Further tests by ANOVA of increases in subsequent years through A6Y (Wood Thrush) and A10Y (Veery) were not significant. That is, these birds get their full wing size by their second complete molt.

***Sex:*** Wings and tails of males were longer than females in the age classes of both species. The shaded two standard deviation areas in Figure 1 demonstrate the extent of overlapping males and females in combined and separated age classes. Birds that do not overlap two SD presumably can

be sexed by wing and tail measurement and the outlers (minimum and maximum) should cause less than 5% error (cf. Robbins 1964).

***Veery:*** Table 1 shows the sample sizes, measurements, and size ranks of the birds captured. Veeries as a whole exhibited highly significant effects of age, AHY vs. SY, by two-factor ANOVA (non-repeated measures, unbalanced model) on wing (F = 11.635, *df* 1, 1, *P* = .0008), tail length (F = 27.118, *df* 1, 1, *P* = .0001), and tail wing proportion (F = 10.26, *df* 1, 1, *P* = .0016), AHY being longer than SY. SY vs. HY measurements were not significantly different.

Males were significantly larger than females in both wing (F = 59.13, *df* 1, 1, *P* = .0001) and tail (F = 45.17, *df* 1, 1, *P* = .0001). There was significant interaction between age and sex in the female wing (F = 5.001, *df* 1, 1, *P* = .0267), in that female wings were not significantly longer in the breeding season following the first complete prebasic molt, but male wings were. Female wings showed no further increase at a subsequent breeding season but male wings did (Table 1). The shorter SY and AHY female wing should make the distinction of females from males more pronounced.

The Veery may be another example in the growing evidence that sexual dimorphism may have ecological and behavioral origin (Dilger 1956, Slatkin 1984, Shine 1989), the smaller size correlating with the partitioning of resources, resulting in an increased foraging range accessible to a pair, in a similar way that congeneric size differences affect habitat use (Martin and Pitocchelli 1991). Perhaps the male Veery sallies and flycatches more than the female, and the female forages closer to the ground in the dense cover.

**Table 1.** Veery Descriptions. Mean, mm; standard deviation (SD)

| | | | WING | | TAIL | | TAIL/WING | |
|---|---|---|---|---|---|---|---|---|
| **Count** | **Age** | **Sex** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| 71 | AHY | M | 98.5 | 2.94 | 71.3 | 3.04 | 0.72 | 0.027 |
| | | | > | | > | | = | |
| 33 | SY | M | 95.8 | 2.84 | 68.7 | 2.28 | 0.72 | 0.030 |
| | | | > | | > | | = | |
| 48 | AHY | F | 93.8 | 2.37 | 67.9 | 3.08 | 0.72 | 0.027 |
| | | | = | | > | | > | |
| 17 | SY | F | 93.2 | 2.02 | 65.1 | 3.12 | 0.70 | 0.033 |
| | | | = | | = | | = | |
| 61 | HY | U | 93.8 | 3.33 | 67.5 | 3.09 | 0.71 | 0.030 |

Reading down, Means in respective wing, tail and tail/wing columns are statistically longer (>) at the .05 level (p=0.003 to 0.0001); or statistically equivalent (=) by multiple comparison tests.

The shorter SY wing measurements, when combined with AHY, depress the averages (all) and make the SD of the mean more spread out. Unless birds are separated by age, the smaller SY males that measure shorter than a two-SD overlap of all males and all females could be mistaken for females. The larger females that measure longer than a two-SD overlap of all males and all females could be mistaken for males (Fig. 1).

***Veery Key:*** If separated by age classes, in AHY, a wing 91 mm or less would be female and 100 mm or more, male; in SY, wing 89 mm or less would be female and 98 mm or more, male, and the overlap error would be eliminated. In AHY, a tail 64 mm or less would be female and 75 or more, male; in SY, a tail 63 mm or less would be female, 75 mm or more, male.

***Wood Thrushes:*** Table 2 shows the sample sizes, measurements and size ranks of the birds captured. There were not enough SY females to do a two-factor ANOVA. A one-factor ANOVA of age on wing, tail and tail wing ratio, sexes combined, showed no significance between AHY and SY as the SY wing and tail overlapped the upper range of AHY. The spread possibly derives from small sample size, or the difficulty in aging Wood Thrushes in the spring. Significantly smaller wing (F = 5.464, *df* 2, 207, *P* = .0049), tail (F = 8.219, *df* 2, 207, *P* = .0004) and tail wing ratio (F = 3.223, *df* 2, 207, *P* = .0419) of HY birds comparable to AHY indicate the latter. One of the two SY females was banded as a dependent fledgling and had returned to natal grounds to breed. The other SY birds were aged by skull. Thickening of the skin may give false appearances of unossified areas in the skull, and differences in retained and fresh greater secondary coverts are subtle.

Males were significantly longer than females in wing (F = 15.512, *df* 2, 207 *P* = .0001) and tail (F = 12.543, *df* 2, 207, *P* = .0001), and similar in the tail wing ratio. Wood Thrush male wing averages were longer in the breeding season after the first complete prebasic molt as in the Veery. Female averages did not increase. Wing lengths increased in returning males for yet another year. There were not enough SY females to test wing and age interaction statistically but this interaction merits watching.

**Table 2.** Wood Thrush Descriptions. Mean, mm; standard deviation (SD)

| | | | WING | | TAIL | | TAIL/WING | |
|---|---|---|---|---|---|---|---|---|
| **Count** | **Age** | **Sex** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| 80 | AHY | M | 107.3 | 3.46 | 70.6 | 3.49 | 0.658 | 0.03 |
| | | | = | | = | | = | |
| 11 | SY | M | 105.4 | 4.08 | 70 | 2.40 | 0.664 | 0.02 |
| | | | > | | > | | = | |
| 44 | AHY | F | 104.3 | 3.49 | 68.6 | 3.74 | 0.657 | 0.03 |
| | | | = | | = | | = | |
| 2 | SY | F | 104 | - | 68 | - | 0.654 | - |
| | | | = | | = | | = | |
| 73 | HY | U | 104.6 | 3.00 | 67.7 | 4.05 | 0.647 | 0.04 |

Reading down, Means in respective wing, tail and tail/wing columns are statistically longer (>) at the .05 level (p=0.004 to 0.0001); or statistically equivalent (=) by multiple comparison tests.

***Wood Thrush Key:*** Again, in the combined age classes, the smaller SY males measuring shorter than the overlap of all males and all females could be mistaken for females (Fig. 1). Ages separated, in the AHY class, a wing 96 mm or less would be female and 113 mm or more, male; but only about 5% of the sample came that small or that large. In AHY, a tail 61 mm or less would be female, 75 mm or more, male. The SY males were too erratic and the SY females too few to propose a key.

Alatalo et al. (1983) found that while many young passerine birds have shorter wings than older birds, they have longer outer primaries than do older birds. Thrushes have a vestigial outermost primary. The length of the vestigial tenth primary compared with the primary coverts is used in separating the *Catharus* thrushes (Pyle et al. 1987). Where change in this primary length with age may complicate identifying a thrush, this primary length may facilitate aging a thrush so that it can be sexed more accurately. Since it took 14 years to accumulate the above data at a single station, testing this idea would require another cooperative project in order to accumulate adequate sample sizes. The value of a cooperative project like Operation Wing Chord is obvious!

Large sample sizes accumulated in Operation Wing Chord should make the sex determination results even firmer. WING cooperators would do well to separate the birds by age where possible so that sex determination could become more definitive.

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**Figure 1.** Comparative wing and tail measurements of age and sex classes of two monomorphic thruses, the Wood Thrush and Veery. Mean, heavy horozontal bar; ± 2 Standard Deviations, shadded box; spread, minimum and maximum values, vertical bar with caps. Measurements of one sex that go beyond the 2 SDs of the other sex many be used for separating the sexes, with tolerable error; as 95.44% of a sample falls within ± 2 SDs of the sample mean.