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IDENTIFICATION AND MOLT STRATEGIES OF EASTERN AND WESTERN WARBLING-VIREOS

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ABSTRACT: The reclassification of the Eastern (*Vireo gilvus*) and Western (*V. swainsoni*) Warbling-Vireos as separate species has stimulated interest in their identification. We examined photographs of 85 Easterns and 89 Westerns in the Cornell Lab of Ornithology's Macaulay Library, finding the ratio of the distance between the tips of primaries 6 and 5 to that between the tips of p5 and p4, the "p6:5 ratio," to be the most useful difference. A p6:5 ratio >0.90 eliminates 95% of Westerns and includes 68% of Easterns, whereas a ratio <0.73 eliminates 95% of Easterns and includes 52% of Westerns. Our results support previous reports that the Eastern molts primarily on its summer grounds, before southbound migration, but are counter to reports that all Westerns migrate before molt: 36% of adults and 39% of first-fall birds had molted or commenced molt within the breeding range. Thus retention of worn plumage in adults and juvenile greater coverts in first-year birds suggests a Western, whereas replacement of these feathers does not distinguish the species. Prealternate molt is more extensive in the Eastern than the Western, aiding identification in spring. Applying our findings to records of vagrants, we identified 12 Westerns from east of the Mississippi River and in South America and six Easterns from Alaska, Arizona, California, and the Azores that appear to represent vagrants. Distinguishing many, but not all, Eastern and Western Warbling-Vireos is possible with high-quality images in which the spacing of primaries, facial markings, molt state, and/or side coloration can be assessed.

The warbling-vireos were generally considered a single species until 2025, when the American Ornithological Society's North American Classification Committee elevated the Eastern Warbling-Vireo (*Vireo gilvus*) and the Western Warbling-Vireo (*V. swainsoni*) to full species status on the basis of a suite of concordant differences, including genetics, morphology, song, molt strategy, and response to brood parasitism (Chesser et al. 2025, Clements et al. 2025). Prior to the split, several authors had proposed or evaluated various physical dissimilarities between the two taxa, including differences in back and crown color, underpart color, and bill morphology (Ridgway 1904, Oberholser 1974, Phillips 1991, Buckley and Mitra 2003, Lovell 2010, Browning 2019, Carpenter et al. 2022, Pyle 2022a). Shortly after the split,

we reassessed identification by plumage and morphology (Mlodinow et al. 2025a, b), adding primary spacing, supercilium size, and auricular color to the suite of characters that might be helpful. Unsurprisingly, many of these evaluations arrived at somewhat divergent conclusions.

Additionally, the two warbling-vireos' molts reportedly differ, with the Eastern undergoing a partial preformative and complete prebasic molt on the breeding grounds from July to September, and the Western undergoing these molts primarily at migration stopover sites in the monsoonal region of the southwestern United States and northwestern Mexico from August to October (Volker and Rohwer 1998). Therefore, during fall migration, adult Eastern and Western Warbling-Vireos should be distinguishable by whether their plumage is worn or fresh, respectively. And first-year birds should be distinguishable by whether they had replaced or retained, respectively, juvenile greater coverts. However, the timing, extent, and location of preformative and prebasic molts in birds are highly variable, as Pyle et al. (2009, 2018) found among the warbling-vireos of both species. Both species also undergo a first and a definitive prealternate molt of some to most body feathers (Volker and Rohwer 1998), with that of the Eastern reportedly more extensive, on average, than that of the Western (Pyle 2022a).

Hoping to improve our ability to distinguish the two warbling-vireo species and to clarify differences in their molt, we reviewed photographs from the Cornell Lab of Ornithology's Macaulay Library. As part of our analysis, we also evaluate prospective vagrants that we found in the Macaulay catalog and elsewhere. We do not cover differences between these species in vocalizations, which have been addressed in other publications (e.g., Sibley and Monroe 1990, Lovell 2010, Spencer 2012, Floyd 2014, Carpenter 2022, Guo 2026).

METHODS

Examination of images in the Macaulay Library has been successfully employed for studying birds' molts, plumages, and wing morphology (Pyle 2022b, 2026a, b, Clark et al. 2024, Lee and Birch 2025). We used these images to assess 11 characters (including wing morphology, eight plumage characters, and differences in preformative and prealternate molt) that have been previously suggested for the discrimination of the two warbling-vireos. We ordered the photographs according to "best quality" and selected at least 20 images for both the Eastern and Western in each of four categories: adults in fall (September–December), first-cycle birds in fall, adults in spring (March–June), and first-cycle birds in spring, resulting in a total sample size of 174 individual warbling-vireos. See Table 1 for the sizes of the samples of each age and seasonal category. Pyle, following Pyle (2022a), aged the birds and scored their molt. We ensured that none of the images in our sample represented the same individual bird (i.e., same date and location) but, when necessary, used multiple images of the same bird to assess its age and score each plumage and molt characteristic. In three cases among our initial sample, we concluded that the species as indicated in the Macaulay Library may not have been correct. We excluded these from our analysis but give our reasoning under the Discussion to address a potential circularity bias in our method. We are, therefore, confident of the identification of all birds in our sample, all but two

Table 1 Mean Values of P6:5[a], Plumage Scores, and Number of Replaced Tertials for the Eastern and Western Warbling-Vireos by Age Class and Season

	Eastern		Western	
	First year	Adult	First year	Adult
Fall	*n* = 20	*n* = 20	*n* = 21–23	*n* = 20–22
P6:5	0.95 (0.66–1.24)[b]	0.94 (0.75–1.13)	0.72 (0.44–1.01)	0.68 (0.47–0.88)
Supercilium length	1.19 (0.50–1.88)	1.07 (0.11–2.02)	1.60 (0.70–2.50)	1.63 (0.34–2.92)
Supercilium breadth	0.83 (0.68–0.98)	0.71 (0.18–1.23)	0.95 (0.39–1.51)	1.01 (0.44–1.58)
Lateral crown stripe	2.68 (0.28–5.37)	2.65 (0.10–5.19)	2.71 (–0.19–5.62)	2.79 (0.16–5.42)
Loral stripe	4.05 (1.61–6.50)	4.30 (1.95–6.65)	2.83 (–0.35–6.00)	2.55 (–0.93–6.02)
Back color	2.63 (0.97–4.79)	2.65 (0.47–4.83)	3.26 (0.99–4.88)	2.55 (0.18–4.91)
Side color	2.37 (–0.32–5.05)	2.25 (0.55–3.95)	3.00 (1.40–4.60)	2.36 (1.32–4.46)
Crown color	2.53 (0.60–4.45)	2.05 (0.78–3.32)	3.35 (1.80–4.90)	2.68 (0.43–4.93)
Auricular color	3.28 (0.38–6.17)	3.12 (0.68–3.80)	4.00 (1.81–6.19)	3.95 (2.06–5.84)
Tertials replaced	0.32 (–0.13–1.96)	—	0.00 (0.00–0.00)	—
Spring	*n* = 20–23	*n* = 20–22	*n* = 21–24	*n* = 20
P6:5	0.99 (0.66–1.32)	1.00 (0.71–1.29)	0.74 (0.50–0.99)	0.76 (0.55–0.96)
Supercilium length	1.36 (0.58–2.14)	1.33 (0.46–2.21)	1.75 (0.98–2.52)	1.75 (1.02–2.47)
Supercilium breadth	0.82 (0.46–1.19)	0.92 (0.55–1.28)	1.03 (0.71–1.35)	1.15 (0.65–1.64)
Lateral crown stripe	2.80 (0.59–5.60)	3.27 (0.72–4.55)	3.10 (0.79–5.40)	3.00 (0.69–5.31)
Loral stripe	3.57 (1.00–6.15)	4.10 (1.68–6.52)	3.17 (0.50–5.45)	2.79 (0.52–5.06)
Back color	2.57 (0.77–4.36)	3.09 (0.55–5.63)	2.29 (0.21–4.38)	2.30 (0.57–4.03)
Side color	2.52 (0.73–4.32)	3.00 (1.74–4.26)	2.00 (0.40–3.56)	2.10 (0.66–3.54)
Crown color	2.91 (1.02–4.81)	3.18 (0.72–5.65)	2.79 (1.02–4.56)	3.10 (0.72–5.85)
Auricular color	2.38 (0.03–4.79)	2.67 (0.85–4.48)	3.71 (1.39–6.03)	3.58 (2.04–7.16)
Tertials replaced	2.09 (–0.32–4.49)	2.00 (–0.23–4.14)	1.92 (–0.44–4.27)	1.15 (–0.48–2.78)

[a]See text for definition.

[b]95% confidence limits.

of which were photographed within the expected range of each species; the two vagrants are discussed further below.

The Eastern Warbling-Vireo is monotypic whereas the Western Warbling-Vireo is polytypic. From the broad geographic range of images in our sample, our analysis undoubtedly included both *V. s. swainsoni* and *V. s. brewsteri*, but we did not attempt to separate these (cf. Pyle 2025, who lumped these two subspecies on the basis phenotypic characters assessed in photographs of live birds). The locations associated with our sample excluded the much larger-billed *V. s. victoriae* of Baja California Sur, Mexico, and *V. s. sympatricus* of Puebla, Mexico, the latter a taxon of unclear taxonomic affiliation (Mlodinow et al. 2025b).

We specifically selected images in which the morphology of the primaries could be accurately assessed, and we excluded from our sample birds undergoing active molt of primaries. Our preliminary examination of wing morphology indicated that "on the folded wing of a Western Warbling Vireo, the distance between the tip of p6 and that of p5 is usually shorter than the gap

between the tip of p5 and that of p4, so that p6 – p5 < p5 – p4, whereas in the Eastern Warbling Vireo these distances are equal, so that p6 – p5 = p5 – p4 (Mlodinow et al. 2025a, b; primaries numbered innermost to outermost, from p1 to p10). To test this hypothesis, we examined the ratio of p6 – p5:p5 – p4 (the "p6:5 ratio") by following the methods of Lee and Birch (2025), who used similar ratios to identify *Empidonax* flycatchers. We imported the images of warbling-vireos into a photo-processing program, enlarged them, and then measured the distances between each set of primaries with a ruler on the monitor screen. The benefit of using ratios over actual distances is that ratios eliminate the factor of enlargement as a variable as well as reducing bias due to the angle of the wing relative to the photographer (Lee and Birch 2025). When the p6:5 ratio could be calculated from measurements of multiple images of the same bird, we either selected the image in which the wing was most perpendicular to line of sight or took a mean of several measurements, which varied by no more than 10% of each other.

In the warbling-vireos, the longest primary is often p7, with p8 and p9 progressively shorter among the outer primaries, and p6, p5, and p4 shorter to varying degrees among the inner primaries (Figures 1–4). In some birds,

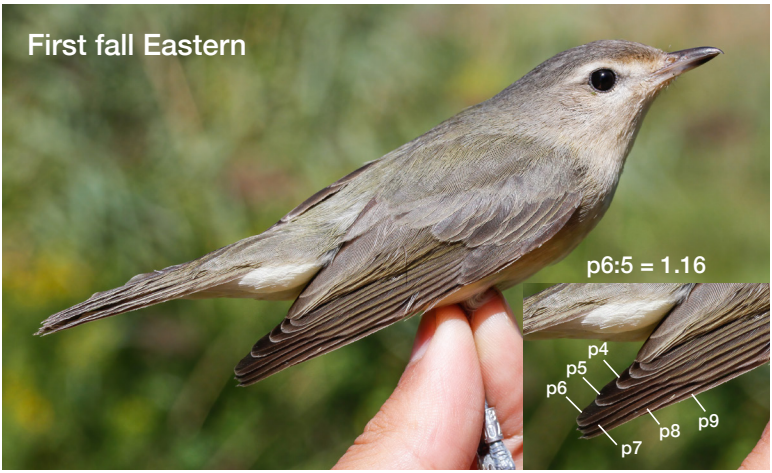


FIGURE 1. First-fall Eastern Warbling-Vireo captured for banding in Ontario, 6 September 2013, in which the ratio of the spacings between the tips of primaries 6, 5, and 4 (p6 – p5/p5 – p4, or "p6:5 ratio") is 1.16, which is diagnostic of the Eastern within our sample. Note that in this case p7 and p6 are about the same length. The bird's supercilium, with a length of 1.2 eye diameters and breadth of 0.8 eye diameters, also support its identification as the Eastern. The medium rating for darkness of the auriculars (score 3) is neutral, and the pale lores (score 1) are more typical of the Western. All marks rarely align, but the spacing of the primaries is generally the most reliable criterion. The greater coverts have been replaced, a pattern shown in our sample of photographs of southbound migrants by 100% of the Eastern Warbling-Vireos but only 39% of the Westerns. The greater coverts contrast slightly with the primary coverts, implying the bird was in its first fall. Photo used by license agreement from the Macaulay Library (ML373224281).

Photo by James Kennerly

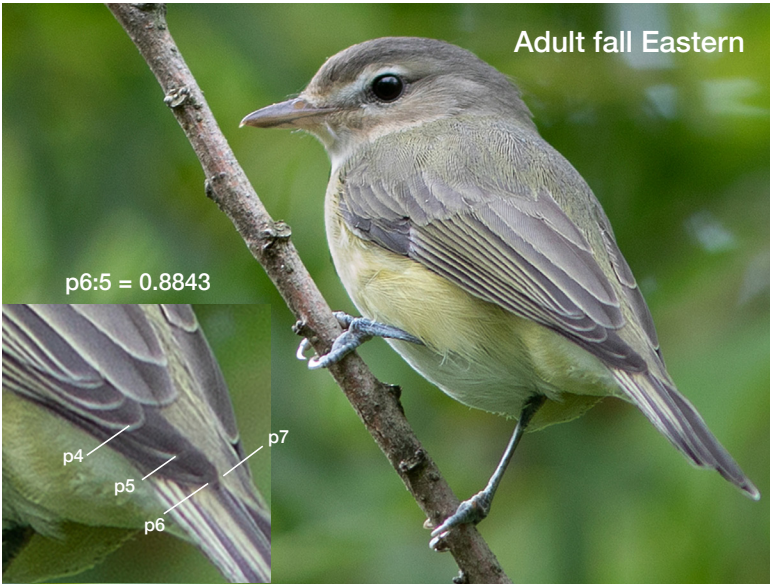


FIGURE 2. Fall adult Eastern Warbling-Vireo, photographed in Quebec on 6 September 2019. The p6:5 ratio of 0.883 is in the zone of overlap between the Eastern and Western. In this case, the tip of p7 extends a short distance beyond that of p6. The ratios of supercilium length and breadth, both 0.3, strongly support the identification as the Eastern as well, while the moderately pale loral stripe (score 2) and moderately dark auriculars (score 4) are neutral. The dusky primary coverts and broad and truncate (squared) outer primaries indicate an adult in fresh plumage. Photo used by license agreement from the Macaulay Library (ML176004381).

Photo by Suzanne Labbé

the tip of p7 falls short of the tip of p6, whereas in others the tip of p7 extends sufficiently beyond that of p6 that it creates a gap that could be confused with that between p6 and p5 (Figure 5). In such cases, however, the ratio of p7 – p6 to p6 – p5 (p7:6) is always less than 0.5, which is below the lowest end of the confidence interval for the p6:5 ratio in our sample (0.505; Table 1) and should preclude confusion due to potential misidentification of the primaries (see Lee and Birch 2025 for further discussion of this issue).

Using the same sample of images, we scored eight plumage variables, the selection of which was based on proposed differences between these two taxa in the published literature noted above. We assessed the length and breadth of the supercilium by measuring these dimensions and the vertical and horizontal diameters of the eye (excluding the orbital ring), with a tape measure on the monitor screen after importing Macaulay images into a photo-processing program and enlarging them. We define "supercilium length" as the ratio of measured supercilium length to horizontal eye diameter and "supercilium breadth" as the ratio of measured supercilium breadth to vertical eye diameter. The use of these ratios offers the same benefits as for wing morphology. When

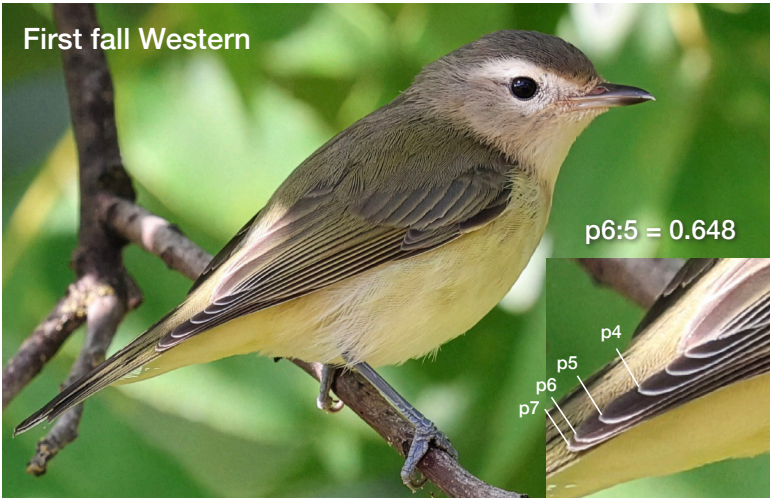


FIGURE 3. First-fall Western Warbling-Vireo photographed in California, 11 September 2024. The p6:5 ratio of 0.648 is diagnostic of the Western within our sample of photographs. The ratios of supercilium length of 1.5 and breadth of 1.3 strongly support the bird's identification as the Western, as does the pale loral stripe (score 1). The moderately pale auriculars (score 2) are neutral. The narrow and pointed primary coverts and primaries indicate a first-fall bird. The greater coverts have been replaced for migration, as seen in 39% of the immature Western Warbling-Vireos in our sample of photographs. Photo used by license agreement from the Macaulay Library (ML623623066).
Photo by Tom Uslan

the supercilium could be measured in multiple images of the same bird, we selected the image in which the head was positioned closest to true lateral.

We scored the remaining six plumage features, distinctness of the lateral crown stripe and loral stripe (absent or incomplete to distinct), extent and hue of green in the back (gray with little or no green to bright green), extent of yellow in the sides (white with little or no yellow to bright yellow), crown color (pale to dark), and auricular patch (pale or absent to dark and distinct), on a scale from one to five. See Figure 6 for examples. We calculated means and ranges (based on 95% confidence intervals) for the p6:5 ratio, supercilium length and width, and the six plumage scores (Table 1).

We also recorded the extent of molt on the basis of the replacement of greater coverts and tertials. In vireos, the greater coverts are replaced synchronously, resulting in either no coverts replaced or all coverts replaced during the preformative molt (Pyle 2022a). For birds in their first fall and first spring, we recorded whether the greater coverts were juvenile or formative. For adults in fall, we recorded whether the plumage was fresh or worn, indicating that prebasic molt had taken place before fall migration, or would take place after, respectively. We also scored the number of tertials (one to three, numbered proximally from s7 to s9) that had been replaced in molt, for both age groups in both seasons. The sequence of tertial replacement s8–s9–s7, found in the majority of birds (Pyle 2022a), prevails in the warbling-vireos as well.

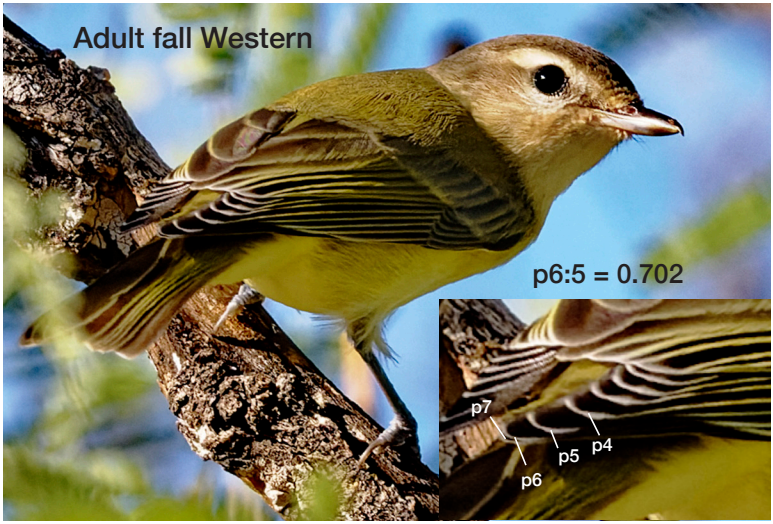


FIGURE 4. Fall adult Western Warbling-Vireo, photographed in Pima County, Arizona, on 13 September 2022. The p6:5 ratio of 0.702 is diagnostic of Western within our sample of photographs; p7 extends a short distance beyond p6. The pale loral stripe (score 1) supports the identification, the dark auriculars (score 5) are somewhat supportive, and the supercilium ratios (length 1.3, breadth 0.8) are neutral. The dusky primary coverts with olive edging and the broad, blackish, and truncate outer primaries indicate an adult in fresh plumage. Photo by an anonymous photographer used by license agreement from the Macaulay Library (ML484054071).

We evaluated records of possible vagrants of both species for which photographs were available to us from the Macaulay Library or elsewhere. These included all reports in eBird.org of birds identified as either the Western or "Eastern/Western" Warbling-Vireo recorded east of the Mississippi River, and all reports in eBird of birds identified as either the Eastern or "Eastern/Western" Warbling-Vireo recorded west of the Cascade Mountains or in the states of Nevada, California, and Arizona. We also considered records of possible vagrants from outside of continental North and Middle America, including South America, the western Palearctic, and the islands of western Alaska. Additionally, we reviewed all images of all birds photographed in the United States from December through February. We did not otherwise actively search for misidentified warbling-vireos in the Macaulay Library, e.g., during migration periods.

RESULTS

Among the characters examined (except molt), we found few substantial differences between first-cycle birds and adults of either warbling-vireo species, so we generally pooled our findings for the two age groups. We did detect seasonal differences within a species, however, and present our findings for some characters separately for fall and spring. The means of the two

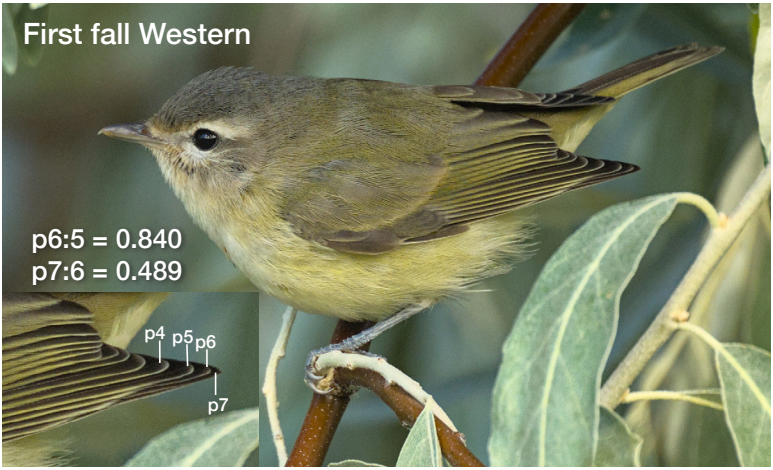


FIGURE 5. First-fall Western Warbling-Vireo photographed in Washington State, 13 September 2024. The p6:5 ratio of 0.804 is within the zone of overlap between the Eastern and Western but favors the Western. In occasional birds, such as this one, the tip of p7 extends sufficiently beyond that of p6 that it creates a gap large enough to potentially be confused with that between the tips of p6 and p5. In such cases, however, the ratio of p7 – p6/p6– p5 is always less than 0.5 (0.49 here—the highest value for this ratio in our data set), which is below the low end of the confidence interval for the p6:5 ratio in our sample (0.51; Table 1). This criterion should preclude confusion due to potential misidentifcation of the primaries. The juvenile greater coverts with pale tips have been retained, creating an indistinct wing bar and contrasting with replaced lesser coverts and scapulars, a pattern that is nearly diagnostic of migrant first-fall Westerns within our data set. Other characters supporting the identification include ratios of supercilium length (1.5) and breadth (1.0), pale lores (score 1), and dark auriculars (score 5). Photo used by license agreement from the Macaulay Library (ML 623680517).

Photo by Bartholomew Birdee

species' ratios for p6:5 and supercilium length and breadth differ distinctly but we failed to find useful differences in back color, lateral crown stripe, or fall crown color (Table 1).

Spacing of Primaries

On a warbling-vireo's folded wing, the longest primary can be either p6 or p7; if p7, the tip extends only a short distance beyond p6 (see Methods). In the Eastern, the distance between the tip of p6 and that of p5 (p6 – p5) is commonly greater than or equal to the distance between the tip of p5 and that of p4 (p5 – p4), so that p6:5 is commonly ≥1.0, whereas in the Western Warbling-Vireo p6:5 is nearly always <1.0 (Table 1, Figures 1–5). Differences in p6:5 values differed little by season (Table 1). For both seasons combined, for the Eastern (n = 85) the mean is 0.95 ± 0.12 (standard deviation; 95% confidence limit 0.71–1.18), whereas for the Western (n = 89), the mean is 0.73 ± 0.11 (95% confidence limit 0.50–0.96). On the basis of these confidence limits, 48% of the Easterns and 48% of the Westerns in our sample could be

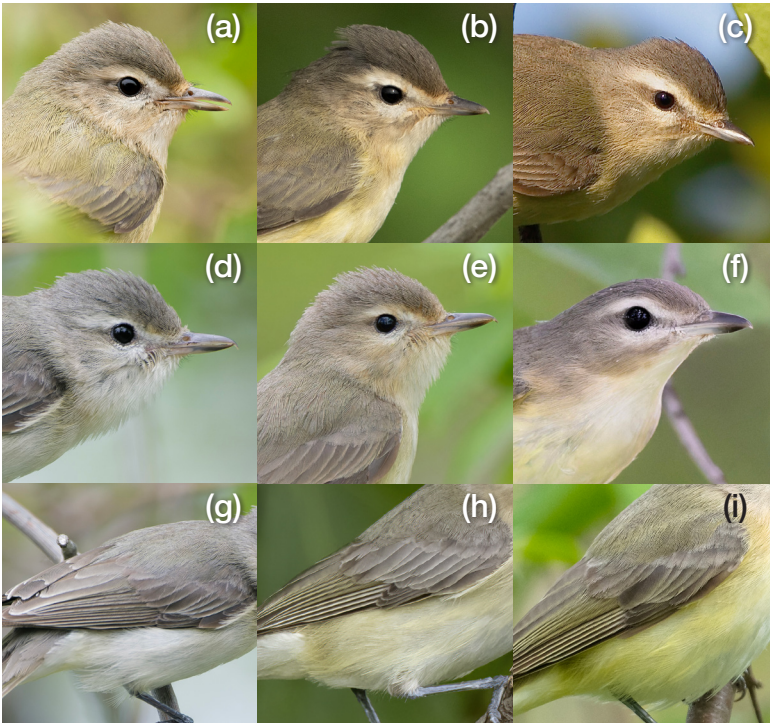


FIGURE 6. Examples of variation in the plumage of the warbling-vireos, scored on a scale from 1 to 5. Top row (all are Western Warbling-Vireos,), loral stripe (a) pale (score 1), (b) medium (score 3), (c) dark (score 5). Middle row (all are Eastern Warbling-Vireos), auriculars (d) pale (score 1), (e) medium (score 3), (f) dark (score 5). Bottom row (all are Eastern Warbling-Vireos), sides (g) with little or no yellow (score 1), (h) medium yellow (score 3), and (i) bright yellow (score 5). Photos used by license agreement from the Macaulay Library; (a) Marky Mutchler, ML493687391; (b) Darren Clark, ML607003811; (c) DigiBirdTrek CA, ML160944351; (d and g) Roy Chatburn, ML583166041; (e) Ankur Dave, ML634173927; (f) Marky Mutchler, ML641316717; (h) Iris Kilpatrick, ML617956826; (i) Don Danko, ML231812731.

identified by this metric alone. A p6:5 ratio >0.90 eliminates 95% of Westerns and includes 68% of Easterns, whereas a ratio <0.73 eliminates 95% of Easterns and includes 52% of Westerns.

Supercilium

On average, the Eastern has a shorter and narrower supercilium than does the Western, irrespective of age class and season, but in both species the supercilium is longer and broader in spring than in fall (Table 2).

Supercilium ratios of the two warbling-vireos overlap more than do the primary-spacing ratios. Nonetheless, the following criteria should be useful

Table 2 Mean Supercilium Length[a] and Breadth[b] in the Eastern and Western Warbling-Vireos by Species and Season

	Eastern		Western	
	Supercilium length	Supercilium breadth	Supercilium length	Supercilium breadth
Fall	1.1 ± 0.4[c] (0.3–2.0)[d]	0.8 ± 0.2 (0.4–1.2)	1.6 ± 0.6 (0.5–2.7)	1.0 ± 0.3 (0.4–1.5)
Spring	1.4 ± 0.4 (0.5–2.2)	0.9 ± 0.2 (0.5–1.2)	1.8 ± 0.4 (1.0–2.5)	1.1 ± 0.2 (0.7–1.5)

[a]Measured supercilium length/horizontal eye diameter.
[b]Measured supercilium breadth/vertical eye diameter.
[c]Standard deviation.
[d]95% confidence limits.

for identifying the Eastern in spring and the Western in fall. In spring, a supercilium length of ≤1.0 (i.e., less than the horizontal diameter of that bird's eye) rules out the Western in our sample (32% of Eastern; 0% of Western). In fall, ratios strongly favoring the Western include a supercilium breadth ≥1.1 (34% of Western; 5% of Eastern) and a supercilium length ≥1.9 (33% of Western; 5% of Eastern). Also in fall, the combination of a supercilium length ≥1.7 and a breadth ≥1.1 eliminates the Eastern in our sample (21% of Western; 0% of Eastern).

Loral Stripe

On average, the Western has the loral stripe weaker than in the Eastern, though these differences are more pronounced in fall. A weak loral stripe strongly suggests the Western in fall but is not as indicative in spring (Table 3).

Auricular Color

The auriculars average paler in the Eastern than in the Western, especially in spring. We scored only 2% of Westerns but 17% of Easterns as having very pale auriculars (score of 1) in both spring and fall. We found very dark auriculars (score of 5) on 0% of Easterns versus 21% of Westerns in spring, and on 11% of Easterns versus 36% of Westerns in fall.

Crown Color

The crown color of the two species is very similar in spring, but in fall, the Eastern has a paler crown on average (Table 3). In fall, we assigned a score of 4 or 5 (indicating a dark crown) to only 8% of Easterns versus 44% of Westerns, while we assigned a score of 1 or 2 (indicating a light crown) to 59% of Easterns and 23% of Westerns.

Table 3 Percent Frequency of Scores of Strength of the Loral Stripe in the Eastern and Western Warbling-Vireos by Species and Season

	Fall		Spring	
	Eastern	Western	Eastern	Western
Weak (score 1)	3	43	7	19
Intermediate (score 2–4)	34	35	44	60
Strong (score 5)	63	22	49	21

Side Color

In fall, the color of the warbling-vireos' sides is similar, but in spring, the Eastern averages brighter or yellower. In spring, we rated 27% of Easterns as having bright sides (score of 4 or 5 on a scale of 1–5) compared to only 2% of Westerns. Dull sides (score of 1 or 2) are less useful, represented by 75% of Westerns and 42% of Easterns.

Potentially Helpful Combinations

Several of the above characters can be combined to aid identification. In the fall, we found the combination of pale to intermediate lores (score of 1–3 on 1–5 scale) and a supercilium breadth of ≥1.1 in 0% of Easterns and 30% of Westerns, whereas we found a supercilium length of ≤1.0 combined with relatively pale auriculars (score of 1–3 on 1–5 scale) in 0% of Westerns and 16% of Easterns. In spring, the combination of pale auriculars (1–2 on a scale of 1–5) and a supercilium breadth of <1.0 appeared in only 2% of Westerns versus 25% of Easterns.

Molt

The photographs we reviewed of warbling-vireos in fall were all taken just before or during migration in Canada or the United States. Among the adult Easterns in fall, 17 of 20 (photographed from 1 September to 5 October) were in freshly molted plumage, whereas three (photographed 2–4 September) were in worn plumage and had not yet undergone most or any of their prebasic molt (Figure 7). Two of these birds, in Michigan and Ohio, may still have been on or near their breeding grounds (and so still had the opportunity to molt prior to migration), whereas one in Texas was south of the breeding range and presumably was a molt migrant (Figure 7). Among adult Westerns, 8 of 22 (36%) birds, recorded from 16 September to 20 November in Alaska (2), Washington (1), California (3), New Mexico (1), and Arizona (1, Figure 7), were in fresh plumage and had molted somewhere within the breeding range, whereas the remaining 13 (59%; recorded from 2 to 30 September) were in worn plumage and were undergoing molt migration (Figure 7).

Among first-fall birds, none of 20 Easterns had retained juvenile greater coverts, whereas 14 of 23 Westerns (61%) had done so (Figure 8). Among first-spring birds, only four of 24 Westerns (17%) and none of 23 first-spring Easterns had retained the juvenile greater coverts (Figure 9). The seasonal difference within the Western (61% to 17%) results from many birds replacing the juvenile greater coverts during preformative molt on the molting or wintering grounds.

With respect to the tertials, fall adults had either replaced or retained all three feathers (s7–s9), coinciding with whether or not the bird has undergone its prebasic molt (see above). Among first-fall birds, none of 23 Westerns and three of 20 Easterns (15%) had replaced juvenile tertials with formative tertials. Of these three Easterns, one each had molted one (s8), two (s8–s9), or three (s7–s9) tertials (Table 1, Figure 7), for a mean of 0.3 tertials replaced per individual. Among adults in spring, 17 of 20 Easterns (85%) had replaced one to three tertials during the definitive prealternate molt, with a mean of 1.96 tertials replaced, and 16 of 20 Westerns (80%) had replaced a mean of

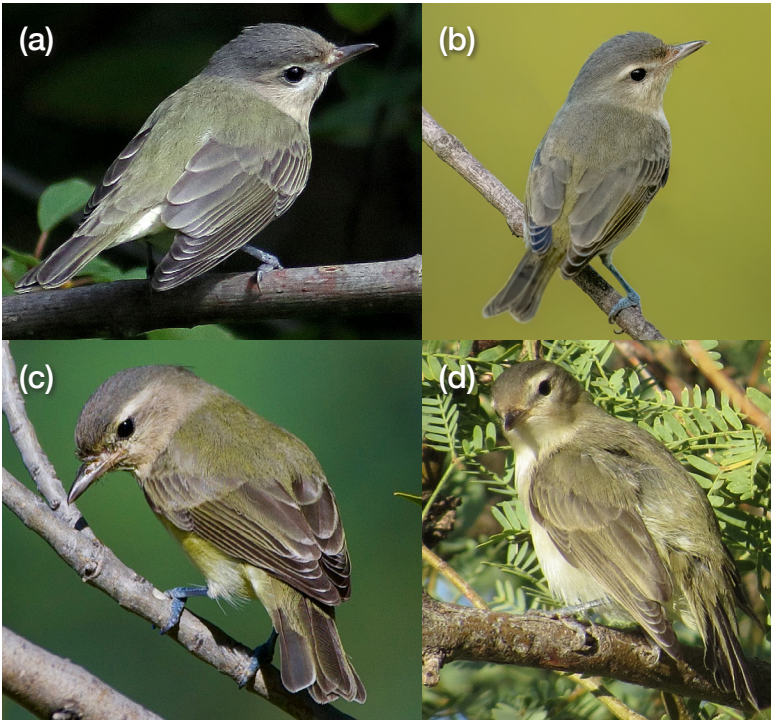


FIGURE 7. Adult warbling-vireos showing fresh and worn plumage during fall migration. (a) Eastern Warbling-Vireo in fresh plumage, Ontario, 11 September 2023; (b) Eastern Warbling-Vireo in worn plumage, Texas, 2 September 2023; (c) Western Warbling-Vireo in fresh plumage, Arizona, 16 September 2022; (d) Western Warbling-Vireo in worn plumage, Arizona, 30 September 2019. All but one Eastern in our sample had undergone a complete prebasic molt prior to fall migration, the exception being the bird from Texas (b), that was south of the breeding grounds in worn plumage. Note that the worn Eastern (b) had replaced all three tertials (s7–s9) and the worn Western (d) had replaced only two tertials (s8 and s9) during the previous prealternate molt. Photos used by license agreement from the Macaulay Library; (a) John Cameron, ML 608729100; (b) Bob Hurst, ML 608467919; (c) Tim DeJonghe, ML484725571; (d) Vincent Maglio, ML 179731601.

1.15 tertials (Table 1, Figure 9). Eight adult Easterns (40%) but only one adult Western (5% of our sample) had replaced all three tertials (Figures 7 and 9).

Assessing the replacement of tertials during the first prealternate molt is complicated, as during a suspended preformative molt they may be replaced at stopover locations or on the winter grounds, and so appear fresher than those replaced on the breeding grounds. Thus whether a tertial is formative or first alternate may be unclear (Pyle 2022c). Among first-spring birds, 20 of 23 Easterns (87%) had replaced a mean of 2.1 tertials and 20 of 24 Westerns (83%) had replaced a mean of 1.9 tertials during either the preformative and/

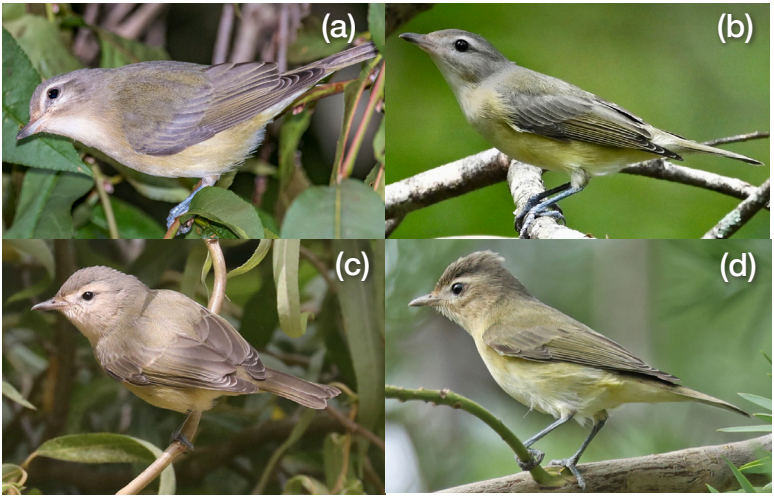


FIGURE 8. First-fall warbling-vireos showing variation in replacement of the greater coverts and tertials during the preformative molt. (a) Eastern Warbling-Vireo that has replaced its juvenile greater coverts but retained juvenile tertials, New York, 9 September 2018; (b) Eastern Warbling-Vireo that has replaced its juvenile greater coverts and one of its tertials (s8), Alabama, 7 September 2021; (c) Western Warbling-Vireo with retained juvenile greater coverts and tertials, California, 17 September 2022; (d) Western Warbling-Vireo that has replaced its juvenile greater coverts but retained its juvenile tertials, California, 13 September 2022. As expected, all four of these birds have retained juvenile primaries and rectrices that are narrow, tapered at the tips, and more worn than in adults that had replaced these feathers. Photos used by license agreement from the Macaulay Library; (a) Alan Schroeder, ML114492951; (b) Joe Wujcik, ML367558161; (c) "Pair of Wing-Nuts," ML485488091; (d) George Nothhelfer, ML483892481.

or the first prealternate molt (Table 1, Figure 8). Thirteen of the 23 first-spring Easterns (57%) and 11 of the 24 Westerns (46%) had replaced all three tertials. In eight Easterns and 10 Westerns, the middle tertial (s8) was more worn than the inner (s9) and/or outer (s7) tertial, indicating that molt was suspended after s8 was replaced, whereas in five Easterns and one Western, s8 was much fresher than both s7 and s9, indicating that it had been replaced twice and so, by definition, was a first alternate feather, provided that the tertials were replaced in the order s8–s9–s7 during the preformative molt (Figure 8, Pyle 2022c).

DISCUSSION

Encouragingly, our analysis of photographs suggests several characteristics or combinations of characteristics that distinguish a subset of the two warbling-vireo species. We then used our findings to assess the validity of records of vagrants of each species.

Molt

Volker and Rohwer (1998) reported that all adult Eastern Warbling-Vireos molt on their breeding grounds, before fall migration, whereas all adult West-

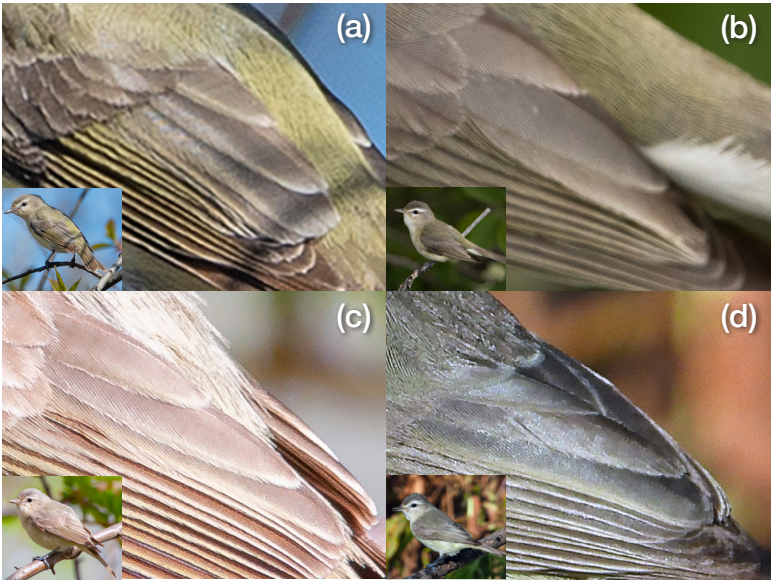


FIGURE 9. Spring warbling-vireos showing variation in replacement of the tertials during the first and definitive prealternate molts. (a) Adult Eastern Warbling-Vireo with three replaced alternate tertials, Michigan, 5 May 2019; (b) adult Western Warbling-Vireo with one replaced alternate tertial (s8) and two retained basic tertials, Idaho, 2 June 2022; (c) first-spring Eastern Warbling-Vireo in which s7 and s9 are formative (replaced the previous fall) and s8 is alternate (replaced once in fall and again in spring), Massachusetts, 8 May 2022; (d) first-spring Western Warbling-Vireo that had replaced all three tertials during the preformative molt (but none during the first prealternate molt), with s8 more worn than s7 and s9, reflecting the sequence of replacement and possibly a suspension of molt, California, 18 May 2021. In each case these patterns support the identification; see text and Pyle (2022c) for discussion of molt terminology in migratory birds in which the tertials are replaced in these patterns during the preformative and prealternate molts. Photos used by license agreement from the Macaulay Library; (a) Jocelyn Anderson, ML156639701; (b) Darren Clark, ML459525131; (c) Pavel Hanc, ML 445877871); (d) James Maley, ML345203711.

ern Warbling-Vireos molt south of the breeding range, at stopover locations or on the winter grounds. Our results indicate that this is largely true of the Eastern (with only one exception among a sample of 20), whereas in the Western, 36% of the adults in our sample of 22 had undergone a complete prebasic molt prior to departure from the breeding range. Similarly, during the preformative molt, all 20 first-fall Easterns had replaced wing coverts prior to fall migration whereas in the Western 39% of 24 individuals had replaced them and 61% had retained them for migration. This supports the conclusion of Pyle et al. (2009, 2018) that the timing and location of the prebasic molt in the warbling-vireos, as well as other species that undergo molt migration, is variable. The decision of an adult to molt before or after migration may correspond to whether it bred successfully as well as the availability of food

resources on its summer grounds (Pyle et al. 2009, 2018). These factors can vary from year to year for both species, but especially for the Western, for which food resources in the breeding range typically diminish during late summer. Examples demonstrating that the Eastern occasionally undergoes molt migration include one in our sample that was in worn condition in central Texas (ML622985289) and one undergoing molt photographed in Alabama (Mlodinow et al. 2025a). Conceivably, molt migration might be less adaptive in those portions of the Western's range that are relatively wet in summer (e.g., western Washington) and more adaptive in those parts of the Eastern's range that are relatively dry in summer (e.g., eastern Colorado). In any case, with rare exceptions, retention of worn plumage in fall adults and retention of juvenile greater coverts in first-fall birds indicates a Western, whereas replacement of these feathers cannot be used to distinguish the species, as Voelker and Rohwer (1998) inferred. Voelker and Rowher (1998) based their analysis largely on birds undergoing active molt (of which adults are difficult to locate on migration), whereas our analysis also incorporates plumage wear, which may account for the difference in our conclusions.

Both species undergo a prealternate molt (Voelker and Rohwer 1998, Pyle 2022a) that includes at least some body feathers. Our results regarding changes in the coloration of the sides (see above), typically the last feathers to be replaced in a molt, suggest that this molt may include most or all body feathers in the Eastern but not in the Western. In the Eastern, the loral stripe averages less distinct in spring than in fall, the opposite in the Western. This discrepancy may imply prealternate molt of these feathers in the Eastern, whereas in the Western it may be due instead to wearing of pale fringes from unmolted loral feathers in some birds. Likewise, the auriculars becomes paler in spring in the Eastern, likely a result of prealternate molt, whereas they remain similar year round in the Western, perhaps signifying lack of feather replacement. These suppositions, along with more tertials being replaced during the definitive prealternate molt in the Eastern than in the Western, imply a more extensive prealternate molt in the Eastern than in the Western, as Pyle (2022a) suggested. As many Westerns molt later in the summer or fall than do the Easterns, and on molting grounds following southbound migration, by spring, the Eastern's plumage is more worn and a more extensive prealternate molt may be more adaptive.

Among first-spring warbling-vireos, both species had replaced a similar number of tertials, but their disparate wear patterns indicated that the feathers had been replaced at various times between fall and spring. Pyle (2022c) discussed similar patterns of replacement in first-year Summer Tanagers (*Piranga rubra*) and Indigo Buntings (*Passerina cyanea*) and distinguished the formative and first alternate feathers on the basis of a fixed replacement sequence of the middle tertial (s8) followed by the inner (s9) and outer (s7) tertials. Under this interpretation, among the photographs we studied, the Eastern Warbling-Vireo had replaced a mean of 2.1 tertials during the preformative molt, compared to a mean of only 0.3 tertials replaced during this molt prior to fall migration. Eight of 23 first-spring Easterns (35%), furthermore, showed s8 older than s7 and/or s9, indicating replacement in late fall rather than spring. These results indicate that many first-year Eastern Warbling-Vireos replace the tertials at stopover locations or upon arrival at the winter

grounds in late fall, following replacement of body feathers and wing coverts on or near the breeding grounds and thus can suspend the preformative molt for migration.

Most first-year Western Warbling-Vireos appeared to have replaced most tertials during the preformative molt on molting grounds or shortly after arrival on the winter grounds in fall, as expected (Voelker and Rohwer 1998). But 10 of 24 (42%) had suspended molt of the tertials at some time over the winter after s8 but before s7 and/or s9 had been replaced. In five of 23 first-spring Easterns (22%) but only one of 24 first-spring Westerns (4%), s8 had been replaced for a second time, further supporting the conclusion that the prealternate molt averages more extensive in the Eastern than in the Western Warbling-Vireo. Exposed to intense sun, the tertials protect the remaining remiges, a selective force that may drive replacement of these feathers twice in the bird's first year, during both the preformative and first prealternate molts (Pyle 2022a, c).

There are instances in which molt patterns can be helpful in the identification of the warbling-vireos. Adults that migrate in fall in worn plumage and first-cycle birds that retain their juvenile greater coverts during fall migration or later can be identified as the Western with a high degree of confidence. Juvenile greater coverts can be recognized by being relatively worn and often showing pale tips that result in a faint wing bar, along with molt limits or contrasts between juvenile greater coverts and replaced lesser and median coverts of the formative plumage (Pyle 2022a; compare Figures 5 and 8). Neither adults in fresh plumage, nor first-fall birds that have replaced greater coverts for fall migration, can be confidently identified by molt patterns alone, although the great majority of Easterns should show these plumage states.

In spring, the prealternate molt being more extensive in the Eastern than in the Western results in some average plumage differences that could be useful for identification. Some Eastern Warbling-Vireos of both age classes replace feathers of the sides with brighter yellow feathers, whereas in the Western Warbling-Vireo these feathers appear not to be replaced and thus are more worn and faded (less yellowish) than in fall. Lack of molt may also result in the lores being darker in spring in the Western than in the Eastern, which may show fresher and paler-fringed feathers of the alternate plumage in this region. These differences can contribute to the identification of some spring birds, as mentioned above. In adults, the replacement of three tertials during the definitive prealternate molt appears to be a useful average character for identification, having occurred in 40% of adult Easterns but in only one adult Western in our sample. Likewise, all three tertials replaced once and with the middle feather (s8) replaced for a second time may be useful for identifying some first-spring birds, having occurred in 22% of the Easterns but only 4% of the Westerns in our sample.

A Summary of Identification Criteria

Marks that are often of use for identifying any given warbling-vireo include spacing of the primaries, differences in molt status, supercilium length and breadth, brightness of yellow on the sides (spring only), and the darkness of the auriculars, lores, and crown (see Figure 10 for examples of a typical Eastern and Western). We found that back color and the presence or absence of



FIGURE 10. Only a minority of each species of warbling-vireo is "typical" in all the features that we quantified. However, these two birds, an adult Eastern Warbling-Vireo on the top (a) and a first-fall Western Warbling-Vireo on the bottom (b), are nearly exemplary. Note that the Western but not the Eastern has retained the juvenile greater coverts and that this Eastern is quite bright yellow for a spring bird, brighter than any spring Western in our sample. We scored these birds as follows: with the score for the Eastern given first: p6:5 ratio 1.045 and 0.723, supercilium length 1.2 and 1.7 eye diameters, supercilium breadth 0.7 and 1.3 eye diameters, auricular color 2 and 3 , lore intensity 3 and 1. Photos used by license agreement from the Macaulay Library; (a) Don Danko, ML231812731, Franklin Co., Ohio, 7 May 2020; (b) Marc Kramer, ML644087559, St. Paul Island, Alaska, 27 September 2023.

Table 4 Mean Score of Auricular Color[a] in the Eastern and Western Warbling-Vireos by Species and Season

	Eastern	Western
Fall	3.1 ± 1.4[b]	4.0 ± 1.0
Spring	2.5 ± 1.0	3.7 ± 1.0

[a]On a scale of 1 to 5 from light to dark.
[b]Standard deviation.

Table 5 Mean Score of Crown Color[a] in the Eastern and Western Warbling-Vireos by Species and Season

	Eastern	Western
Fall	2.3 ± 1.1[b]	3.1 ± 1.0
Spring	3.0 ± 1.0	2.9 ± 1.0

[a]On a scale of 1 to 5 from light to dark.
[b]Standard deviation.

Table 6 Mean Score of Side Color[a] in the Eastern and Western Warbling-Vireos by Species and Season

	Eastern	Western
Fall	2.4 ± 1.3[b]	2.7 ± 1.0
Spring	2.8 ± 1.1	2.1 ± 0.8

[a]On a scale of 1 to 5 from duller to brighter or yellower.
[b]Standard deviation.

a lateral crown stripe are not useful criteria. Detailed photographs are likely needed for definitive identification, especially those that provide a lateral view of the wing and head and a crisp image of the primaries.

When these marks are assessed, it is important that the effects of lighting and perspective be recognized. For instance, high-contrast lighting may cause the crown and auriculars to appear darker, an abundance of light reflected off green leaves may make the sides appear brighter yellow, and the loral stripe may seem less evident when the bird is looking away and darker when the bird is looking toward the observer. Furthermore, the bird's posture and attitude may alter some characteristics. For example, the breadth of a warbling vireo's supercilium may increase when its crown feathers are raised. The apparent p6:5 ratio may vary from photo to photo by up to 10%, so a bird should be assessed in multiple photographs, preferably with the bird at differing angles. When judging the spacing of the primaries, observers need to be aware that the longest primary may be p7, not p6, and when a bird's state of molt is evaluated, the bird should be aged first (see figures for tips on age determination in spring and fall).

The most useful characters for identification, by species and season, are as follows. Percentages represent the proportion of birds with the specified feature among the sample of photographs we examined, representing 20–24 individuals of each season and age class.

Favoring the Eastern in fall

1. p6:5 > 0.89—0% of the Western and 67% of the Eastern.
2. Pale auriculars (score of 1)—2% of the Western and 17% of the Eastern.

Favoring the Western in fall

1. p6:5 < 0.72—0% of the Eastern and 41% of the Western.
2. Supercilium breadth ≥ 1.1—5% of the Eastern and 34% of the Western.
3. Supercilium length ≥ 1.9—5% of the Eastern and 33% of the Western.
4. Supercilium length ≥ 1.7 and breadth ≥ 1.1—0% of the Eastern and 21% of the Western.
5. Weak loral stripe (score of 1)—3% of the Eastern and 43% of the Western.
6. Pale to intermediate lores (score of 1–3 on 1–5 scale) *and* a supercilium breadth ≥ 1.1—0% of the Eastern and 30% of the Western.
7. Adult migrating in worn plumage—5% of the Eastern and 64% of the Western
8. First-fall bird with retained juvenile greater coverts—0% of the Eastern and 61% of the Western.

Favoring the Eastern in spring

1. p6:5 > 0.89—2% of the Western and 76% of the Eastern.
2. Supercilium length ≤ 1.0—0% of the Western and 32% of the Eastern.
3. Pale auriculars (score of 1)—2% of the Western and 17% of the Eastern.
4. Bright side color (score of 4 or 5)—2% of the Western and 27% of the Eastern.
5. Supercilium breadth < 1.0 combined with pale auriculars (score of 1–2)—2% of the Western and 25% of the Eastern.
6. Adult with three replaced tertials—5% of the Western and 40% of the Eastern.
7. First-year bird with s8 replaced twice—4% of the Western and 22% of the Eastern.

Favoring the Western in spring

1. p6:5 < 0.71—0% of the Eastern and 39% of the Western.
2. Dark auriculars (score of 5)—0% of the Eastern and 21% of the Western.
3. First-year bird with retained juvenile greater coverts—0% of the Eastern and 17% of the Western.

In this study, we did not evaluate bill morphology or song characteristics. Additionally, although average differences in bill length and depth between the Eastern and Western Warbling-Vireos are long established (Ridgway 1904, Phillips 1991, Pyle 2022a), we chose not to pursue these characters as substantial overlap in both length and depth has been demonstrated (Lovell 2010, Carpenter et al. 2022, Mlodinow et al. 2025a, b), and this character is difficult to quantify from photographs. We did note that many Easterns showed a downward bulge along the gonys that appears to be absent in most Westerns (Figure 11), and an examination of specimens may prove this apparent difference to be of value (Phillips 1991).

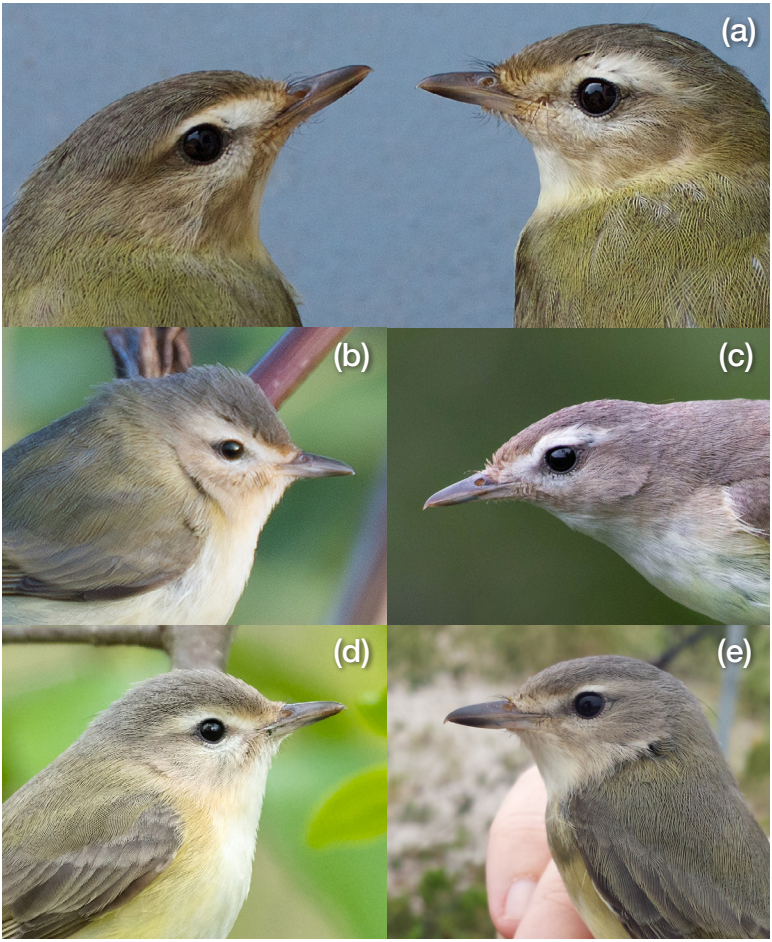


Figure 11. Bill-size variation in the Western (a–c) and Eastern (d–e) warbling-vireos. Shown are examples of each species with smaller and larger bills. The bills of Westerns that are very small and slender (e.g., b) and those of Easterns that are very stout and have a bulge to the lower mandible (e.g., e) can aid in and may be diagnostic for identification. Photos used by license agreement from the Macaulay Library; (a) Matt Brady, ML45687211, Southeast Farallon Island, California, 19 September 2010; (b) Marc Kramer, ML644087559, St. Paul Island, Alaska, 27 September 2023; (c) Tanner Martin, ML105788761, Stevens Co., Washington, 27 June 2018; (d) Don Danko, ML231812731, Franklin Co., Ohio, 7 May 2020; (e) David M. Bell, ML20122971, Halifax Co., Nova Scotia, 9 September 2015.

Possibly Misidentified Birds

For our sample, we initially selected three Eastern Warbling-Vireos so identified in the Macaulay Library and photographed well within the normal range of Eastern but later excluded them because we concluded that their identification was questionable. Here we outline our reasons to avoid potential circularity in our sample selection.

1. A first-fall bird photographed in St. Tammany Parish, Louisiana, on 27 November 2023 (https://ebird.org/checklist/S155330192) has a large supercilium (length 1.5 and breadth 1.1 eye diameters) and pale lores (score of 1), which are more consistent with the Western, while its p6:5 ratio of 0.901 is at the uppermost limit for the Western but also within the range of the Eastern. Its greater coverts were replaced, which is consistent with an Eastern but does not rule out a Western. None of the Easterns in our sample had so broad a supercilium *and* pale lores, but given its molt status and primary spacing, it may have been a Western and is thus best left unidentified. Birds such as this raise the possibility of a hybrid Western × Eastern Warbling-Vireo.

2. A first-winter bird photographed in Richmond County, Georgia, on 9 December 2019 (https://ebird.org/checklist/S62178398) was identified as an Eastern Warbling-Vireo, but we conclude that it is a Western—see discussion below under records of vagrants.

3. A first-fall warbling-vireo identified as an Eastern in Rockingham County, New Hampshire, on 29 September 2021 (https://ebird.org/checklist/S95357619) had retained juvenile greater coverts, a supercilium length of 1.5, and dark auriculars; neither the retained coverts nor this combination of supercilium length and auricular color were found in any of the other first-fall Eastern Warbling-Vireos in our sample. Its supercilium breadth (0.8) is more typical of the Eastern, however, and its p6:5 ratio of 0.817 is at the low end for the Eastern. Possibly, the bird had not yet begun its fall migration and its greater coverts could still be replaced, or the bird was a rare molt-migrant Eastern, but given these conflicting characters we prefer to leave the identification unresolved.

Vagrants

Using these criteria, we evaluated records of vagrants of which photographs were available to us from the Macaulay Library or elsewhere. The 12 vagrant Westerns and 6 vagrant Easterns that we accept are listed in Tables 7 and 8, respectively, along with the supportive and contradictory criteria. Examples of five of these suspected vagrants are shown in Figure 12.

There is one additional record of the Western Warbling-Vireo from the eastern U.S. that we did not review, based on a specimen (Tall Timbers Research Station 1047) collected as a tower-kill casualty in Tallahassee, Florida, 29 October 1956. This bird was initially identified by Allan R. Phillips (Phillips 1991), and the identification was later reviewed and supported by Henry Stevenson (Stevenson and Anderson 1994).

Most of these vagrant Western Warbling-Vireos were identified as such by the observers. The exceptions were the bird in Georgia (identified as an Eastern; see Misidentified Birds, above) and the birds in Ecuador and Kentucky, which had not been identified to the species level. The Ecuador record

Table 7 Vagrants of the Western Warbling-Vireo[a]

Location, date, and source[b]	Age and molt	p6:5 ratio	Supercilium	Lores	Auriculars
Fire Island Lighthouse, Suffolk Co., Long Island, New York, 29 Sep 1998 (Buckley and Mitra 2003)					
	first fall, **juv. coverts retained**	0.885	length 1.3, *breadth 0.8*	medium (3)	medium (3)
NE of Marlboro, Stark County, Ohio, 17–22 Nov 2008 (S277054973, S128340353)[c]					
	first fall, *juv. coverts replaced*	**0.596**	*length 1.0,* *breadth 0.8*	medium (3)	medium (3)
Bon Portage Island, Shelburne Co., Nova Scotia, 24 Oct 2013 (S15576234)[b]					
	first fall, *juv. coverts replaced*	**0.625**	*length 1.0,* *breadth 0.7*	medium (3)	medium (3)
Dade County, Florida, 15 Dec 2015–22 Jan 2016 (S103028555, S101976136, S52440159, S26500024)					
	winter adult, coverts replaced	0.833	**length 2.0**, breadth 0.9	**pale (1)**	medium- dark (4)
Jardín Botánico de Quito, Pichincha Province, Ecuador, 11 Apr 2017 (S35871298)					
	first spring, **juv. coverts and tertials retained**	0.794	**length 1.5, breadth 1.3**	medium (3)	**pale (1)**
Prinzy Swamp Nature Park, Richmond Co., Georgia, 9 Dec 2019 (S62178398)					
	first winter, **juv. coverts retained**	**0.726**	**length 1.5, breadth 1.3**	**pale (1)**	**medium- dark (4)**
Escambia Co., Florida, 11 Dec 2022 (S123825798)					
	first winter, **juv coverts retained**	**0.713**	n/a[d]	n/a	**dark (5)**
Cape May, Cape May Co., New Jersey, 18–21 Dec 2022 (S124275843, S124254725, S124306712)					
	first winter, **juv. coverts retained**	0.836	**length 1.7,** *breadth 0.7*	**pale (1)**	**medium-dark (4)**
Pea Island, Dare Co., North Carolina, 5 Dec 2023 (S155797525)					
	first winter, **juv. coverts retained**	**0.642**	**length 2.0, breadth 1.2**	n/a	n/a
New Haven, New Haven Co., Connecticut, 16 Dec 2023–6 Jan 2024 (S158308227, S158283933)					
	first winter, **juv. coverts retained**	**0.672**	length 1.2, *breadth 0.7*	**pale (1)**	**dark (5)**
Florida Atlantic University, Palm Beach Co., Florida, 27 Nov–3 Dec 2024 (S203830594, S204176937)					
	fall adult	n/a	**length. 1.6,** breadth 1.0	*dark (5)*	medium (3)
Eva Bandman Park, Jefferson Co., Kentucky, 28 Nov 2025 (S286553933)					
	fall adult, coverts replaced	0.934	**length 1.4,** breadth 1.0	**pale (1)**	**dark (4 or 5)**

[a]Boldface, characters that support the identification; italics, contradictory characters.

[b]Sources prefixed with "S" are eBird checklists accessible by appending the entire code onto "https://ebird.org/checklist/."

[c]Identified as the Western Warbling-Vireo because of the very small value of p6:5 in spite of other conflicting characters.

[d]n/a, not assessable.

represents the first of either species in South America (Mlodinow et al. 2025b; Figure 12). Lacking photographs, we did not evaluate reports of two other Western Warbling-Vireos from eastern North America—one from Ontario, 2 November 2009 (https://ebird.org/checklist/S41616262) and one from Florida, 15–16 March 2019 (https://ebird.org/checklist/S53929591, https://

Table 8 Vagrants of the Eastern Warbling-Vireo[a]

Location, date, and source[b]	Age and molt	p6:5 ratio	Supercilium	Lores	Auriculars
Peachtree Valley, Monterey Co., California, 24 Oct (S97803473, S97804606)					
	first fall, **juv. coverts replaced**	**(1.042)**	**length. 1.0, breadth 0.8**	n/a[c]	*dark (5)*
Cienega National Conservation Area, Pima Co., Arjzona, 30 Jun 2014 (S18957138, S18956900)					
	first spring, juv. covs. replaced	n/a	**length 1.2,** breadth 1.0	**medium-dark (4)**	**medium pale (2)**
Gambell, St. Lawrence I., Alaska, 12 Sep 2018 (S48776031, S48475204, S70861592, S51745916)					
	adult, **coverts replaced**	**1.029**	*length 2.0*, **breadth 0.8**	**dark (5)**	medium (3)
Lake Havasu City, Mohave Co., Arizona, 1 May 2019 (S55660082)					
	spring adult, one tertial replaced	**1.241**	**length. 1.0, breadth 0.8**	medium (3)	medium dark (4)
Corvo, Azores, Portugal, 25 Sep 2021 (Doniol-Valcroze et al. 2025)					
	first fall, **juv. coverts replaced**	n/a	**length. 1.2, breadth 0.7**	**dark (5)**	medium-dark (4)
Corvo, Azores, Portugal, 9 Oct 2024 (Doniol-Valcroze et al. 2025)					
	first fall, **juv. coverrts replaced**	n/a	**length. 0.8,** breadth 0.9	medium (3)	**pale (1)**

[a]Boldface, characters that support the identification; italics, contradictory characters.

[b]Sources prefixed with "S" are eBird checklists accessible by appending the entire code onto https://ebird.org/checklist/.

[c]n/a, not assessable.

ebird.org/checklist/S54000891. Our analysis implies that any warbling-vireo east of the Mississippi River in November or December should be identified carefully, as the Western Warbling-Vireo fits a general pattern of western passerines occurring in eastern North America during late fall migration (Farnsworth and Iliff 2012).

The bird in Monterey County, identified as an Eastern Warbling-Vireo by the observers, represents, to our knowledge, the only potentially acceptable record of that species for California. We concur with the identification as the Eastern on the basis of supercilium size (length 1.0 and breadth 0.8) and dark lores (5). The spacing of the primaries was difficult to evaluate from photographs because of the angles of the wings and obstructing vegetation, but from three images (ML389366471, ML389366491, and ML389366551) we tentatively estimated ratios of 1.06, 1.04, and 1.03, all exceeding the maximum ratio observed for the Western in our sample. The bill also looks large from above (ML389365171) and large and with a bulge to the lower mandible in images showing it in profile (e.g., ML389365161, ML389366471). The Eastern Warbling-Vireo in Pima County, Arizona, was recorded singing a song typical of the Eastern, and it matches our criteria for this species as well. A warbling-vireo in Mohave County, Arizona, 1 May 2019, was identified as a Western in eBird, but we are confident that it was an Eastern by the criteria presented in Table 8.

We propose that the bird at Gambell, Alaska, is an Eastern primarily on the basis of the spacing of its primaries: the mean value of p6:5 in five measurements from different photographs is 1.03, and all five of the ratios (0.92,

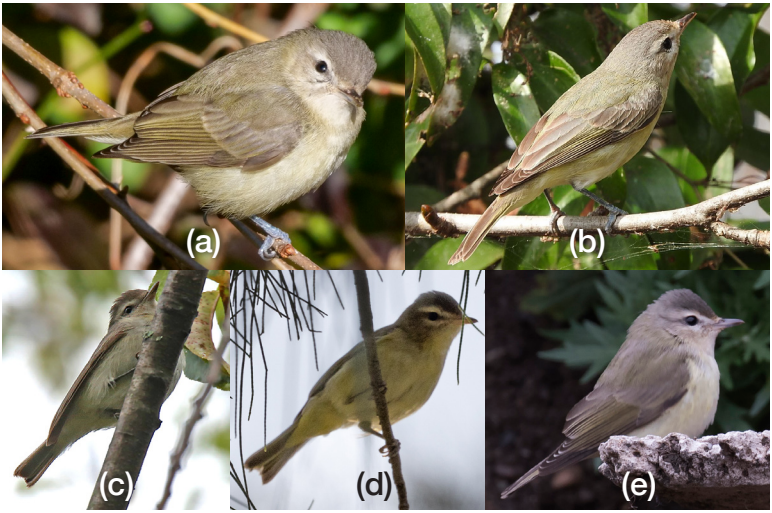


Figure 12. Examples of apparent vagrant warbling-vireos. See Tables 7 and 8 for details. Photos used by license agreement from the Macaulay Library. Western: (a) Roger Horn, ML514865991, Cape May Co., New Jersey, 20 December 2022; (b) Milton Hobbs, ML192334641, Richmond Co., Georgia, 9 December 2019; (c) Roger Ahlman, ML54158341, Jardín Botánico de Quito, Ecuador, 11 April 2017. Eastern: (d) Paul Fenwick, ML389365221, Monterey Co., California, 19 November 2021; (e) Gary Rosenberg, ML291622921, Gambell, St. Lawrence Island, Alaska, 12 September 2018.

0.98, 1.10, 1.11, and 1.04) are well above the maximum of 0.89 for the Western in our sample. We scored its lores as dark (5), which favors the Eastern, and the moderately dark (3) auriculars are unremarkable for either species. The scores for its supercilium are inconclusive, with the length of 2.0 being more typical of the Western and the breadth of 0.8 more typical of the Eastern.

Two birds on the Atlantic islands of the Azores were not identified to species by Doniol-Valcroze et al. (2025) and represent the only records of a warbling-vireo for the western Palearctic. Unsurprisingly, their characters supporting their identification as the Eastern Warbling-Vireo. The identification of the bird in 2021 is the more tenuous of the two, as the photos available to us were less than ideal. Nonetheless, the apparent supercilium length of 1.2 and breadth of 0.7 and dark lores (score of 5) would have eliminated all but 2 of the 43 fall Westerns we examined. The second bird is an Eastern by its supercilium size (length 0.8, breadth 0.9) and pale auriculars (score of 1); only 2 of 43 (5%) of the Westerns in our fall sample had a supercilium length ≤0.8, and only 1 of 42 (2%) had such pale auriculars; none showed that combination of features. Both birds had replaced all greater coverts, consistent with first-fall Easterns but not fully eliminating first-fall Westerns. Unfortunately, none of the photographs available to us of this second bird allowed for analysis of spacing of the primaries.

A bird captured for banding on Southeast Farallon Island, California, 5 September 2018 (https://ebird.org/checklist/S48321597) was identified by the

observers as an Eastern Warbling-Vireo. It was aged in the field as a first-fall bird, but we believe it is an adult. It was in fresh plumage, which fits the majority of adult Easterns but we also found such in 41% of the adult Westerns in our sample. The bill appears very large, the basis on which the identification as the Eastern largely rested. No photographs are available from which the bird's wing morphology can be analyzed. Characters that point away from an identification as the Eastern include supercilium size (length of 1.5 and width of 1.0 eye diameters) and exceptionally dark lores. The lores are darker and bolder than the postocular stripe, and the back seems quite intense olive-green, both of which are atypical of either warbling-vireo species. Possibly, this bird was a hybrid between a warbling-vireo and a Red-eyed Vireo (*Vireo olivaceus*) (McKee et al. 2016).

CONCLUSION

Distinguishing many Eastern and Western Warbling-Vireos from each other is possible but doing so without a specimen requires high-quality images that allow for the assessment of primary spacing, facial markings, molt state, and/or side coloration. Photographs should be evaluated with an eye to potentially confounding factors such as lighting, perspective, and a proportionally long p7. The application of the criteria we have outlined should improve determination of these species' ranges. Nevertheless, many warbling-vireos will remain unidentifiable by these criteria, and the possibility of hybrids (Lovell et al. 2021, Carpenter et al. 2022) should be considered, especially where the species' ranges meet along the Great Plains–Rocky Mountains interface.

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