IDENTIFICATION OF WILLOW AND ALDER FLYCATCHERS BY PRIMARY-TIP SPACING: THE P6:7 RATIO

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ABSTRACT: Discrimination of silent Alder (*Empidonax alnorum*) and Willow Flycatchers (*E. trailli*) has long been considered exceedingly difficult from photographs or under field conditions. Through extensive specimen and field research, we explored the applicability of primary-tip spacings on a folded wing to field identification. We found that the distance from the tip of primary 5 to primary 6 divided by the distance from the tip of primary 6 to primary 7, which we term the "P6:7 ratio," is a nearly diagnostic field mark. In our sample of 217 Alder Flycatcher specimens, 95% have P6:7 < 1.02, whereas in our sample of 371 Willow Flycatcher specimens 95% have P6:7 > 1.05. Because the dividing line between the two species is close to a P6:7 ratio of 1, this field mark is discernible from photos and, with experience, in the field.

Distinguishing the Alder (*Empidonax alnorum*) and Willow (*E. traillii*) Flycatchers from visual field marks alone has often been thought to be impossible. So similar in appearance, they were confused as one species, the Traill's Flycatcher, from the time of the original description of *E. traillii* until Stein's (1963) thorough study in the zone of range overlap showed that the two species have distinctly different songs and calls. With the realization that individuals with different vocalizations had slightly different habitat preferences, nest structures, and morphology (Stein 1963), the checklist committee of the American Ornithologists' Union recognized two separate species (Eisenmann et al. 1973). Knowledge of vocal differences between these two species, combined with the recent proliferation of our ability to record vocalizations, has since made identification easier.

Identification of silent individuals, however, remains challenging. Because the structural and plumage field marks distinguishing the *Empidonax* flycatchers are subtle and often overlap, no single field mark is diagnostic when it comes to *Empidonax* identification. Instead, the holistic approach is recommended (Whitney and Kaufman 1985, 1986, Kaufman 1990, Rowland 2009, Lee and Birch 2023), in which a combination of multiple field marks and structural features is applied. This holistic approach significantly improves the rate of success of identifying *Empidonax* flycatchers in the field, but visual differences between the Alder and Willow Flycatchers are so subtle that much uncertainty remains. There is thus a need for an objective and quantitative method by which silent Alder and Willow Flycatchers can be distinguished.

In this study, we explore whether the relative distances between the tips of the primaries of the Alder and Willow Flycatchers differ. We present the results of extensive specimen research, focusing specifically on relative proportions rather than absolute dimensions. We introduce a novel method of using relative primary-tip spacing that can greatly aid the identification of silent Alder and Willow Flycatchers in the field or from photographs.

CURRENT KNOWLEDGE OF IDENTIFICATION CRITERIA

Plumage and Structural Field Marks

As summarized by Lee and Birch (2023), the Alder Flycatcher tends to have a rounder head, a smaller and stubbier bill, a thin but crisp eye-ring, more contrasting wingbars, and a whiter chest (Figure 1). The Willow tends to have a more peaked crown, a longer and thinner bill, a less contrasting eye-ring, duller wingbars, and slightly grayer chest (Figure 1). The Alder is also a rounder and thicker-bodied bird, resembling a Least Flycatcher at times, while the Willow is slenderer and more likely to be confused with wood-pewees than with the Least Flycatcher. In Texas, where both species occur side by side (during migration), we have had the opportunity to test this holistic approach after subsequent validation with vocalizations. From our own experience, we have applied this holistic approach with reasonably good success, but an immense amount of field experience is still needed for identifications to be made by the holistic approach. A good deal of humility is required, and over-confidence can be problematic. With our current state of knowledge, only with vocalizations can one arrive at an identification with near 100% certainty, especially in the case of potentially extralimital birds.

Morphometrics

Considerable work has already been done on the genus *Empidonax* in terms of structural measurements of wing morphology and dimensions of bills, tarsi, and rectrices (Stein 1963, Phillips et al. 1966, Unitt 1987, Benson and Benson 1988, Browning 1993, Pyle, 1997a, b, 2022, Rowland 2009, Paxton et al. 2011). Pyle's seminal compilation of morphological metrics into a single handbook significantly advanced the identification of birds in the hand. For *Empidonax*, however, absolute values of any given metric unfortunately overlap too much, so no single metric can be used for confident identification, especially in the case of the Alder and Willow Flycatchers (Pyle 2022). Identification of Alder and Willow Flycatchers has so far relied on scatter diagrams relating bill length (nares to tip) versus a wing-formula index, specifically, the difference in the distances between the tips of two primaries, F1 = (longest P – P6) – (P5 – P10), where P stands for primary. While there is considerable overlap between the species in bill length and F1, Stein (1963) showed that the two species cluster differently when these variables are plotted, defining an empirical line of separation, which has become known as Stein's formula and subsequently adopted or modified (Hussell 1991, Seutin 1991, Pyle 1997b, 2022). Pyle (1997b, 2022) suggested that 85% of specimens could be distinguished by these formulae. In a study where the two species are sympatric in eastern Canada, however, Seutin (1991) showed that Stein's formula correctly identified about 80% of Alder Flycatchers but fewer than 70% of Willow Flycatchers.

Because P9 and P10 are hidden on a folded wing, absolute measurements cannot be made in a natural setting. Application of Stein's formula is thus restricted to birds in hand (specimens or banded birds), but great care must be taken to measure the primaries accurately because the absolute differences in primary-tip spacings are <1 mm.

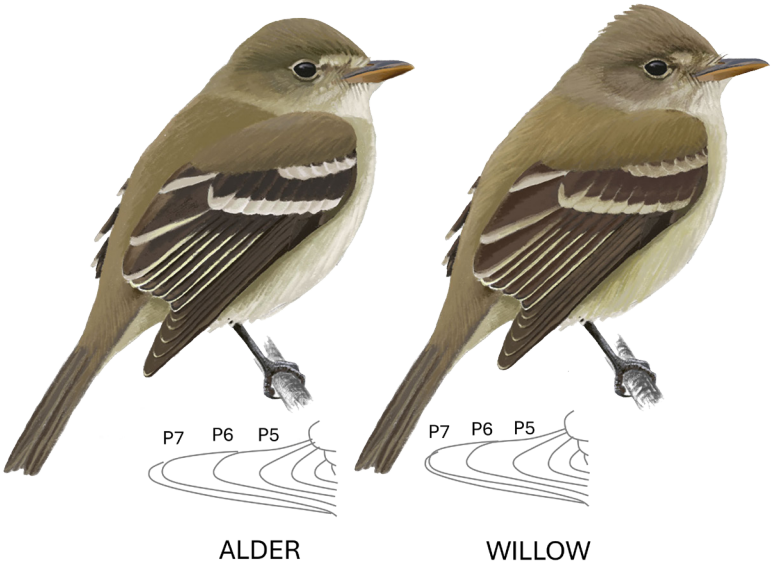

FIGURE 1. Summary of overall plumage and structural differences between the Alder (left) and eastern Willow (right) Flycatchers, showing [P7–P6] greater than [P6–P5] in the Alder Flycatcher and [P7–P6] less than [P6–P5] in the Willow Flycatcher.

Illustration by Andrew Birch

METHODS

We examined specimens from the Museum of Vertebrate Zoology at the University of California, Berkeley, the Museum of Natural Science at Louisiana State University, Baton Rouge, the American Museum of Natural History, New York, and the Field Museum, Chicago. All four subspecies of the Willow Flycatcher were represented in our study (*brewsteri*, *adastus*, *traillii*, and *extimus*). We have, however, considerable concern over whether specimens were correctly identified, especially for those collected before the Traill's complex was split. We report data only for those specimens we could independently and confidently identify. Our first criterion was that the identifications conform with the species' known geographic and temporal patterns of breeding, migration, and wintering. For example, we assumed any Traill's Flycatcher collected in the conterminous United States west of the Rocky Mountains to be a Willow Flycatcher because the Alder Flycatcher is only a rare vagrant to the west of them. A Traill's Flycatcher collected from the boreal forests of Canada and Alaska during the breeding season can be unequivocally assumed to be an Alder Flycatcher. We excluded specimens collected in areas where the species' breeding ranges overlap unless the collector had identified the species by voice. We considered winter birds (October to April) collected in western Mexico to be Willow Flycatchers. Specimens collected during migration (and hence away from breeding grounds) in eastern North America were problematic because both Alder and Willow Flycatchers pass through

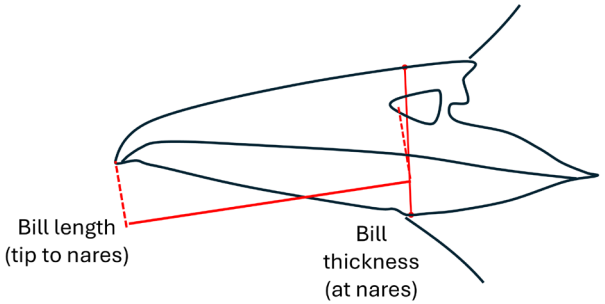

FIGURE 2. Bill morphometrics reported in text. Bill length here refers to the distance from the front of the nares to the tip of the bill. Bill thickness and width are measured at the nares.

the same region roughly simultaneously. For these specimens (<10% of the sample set), we used the holistic approach outlined above for identification, considering only those that were clearly identifiable. Applying all these criteria, we measured 217 Alder and 371 Willow Flycatcher specimens.

Sex was noted if such information was provided by the collector, but we did not analyze the influence of sex on wing morphometrics. Age (adult versus hatch-year) was evaluated based on plumage and molt (Carnes et al. 2021, Pyle and Carnes 2022) or by extent of skull pneumatization reported by the collector. Fresh-plumaged birds with buffy wingbars in fall were identified as juveniles. Variably worn spring specimens with a clear contrast between two generations of primaries were denoted as second-year birds. Specimens with missing or growing flight feathers (which were often fall adults) were excluded from analysis.

Bill dimensions and flight-feather metrics were measured. For bill dimensions, we measured the distance from the front of the nares to the tip of the maxilla, the bill thickness at the nares, and bill width at the nares (Figure 2). For flight feathers, we measured the spacings between the tips of the primaries directly, that is, the distance between the tips of *adjacent* primaries on a folded wing (Figure 3), rather than measuring the total length of each primary and then taking the difference. This approach minimizes measurement and propagation errors. On the basis of our experience, the reproducibility of determining the start of the feather base is not sufficient for calculating primary-tip spacing distances at the level of precision needed. We did not measure primary projection because this index may be compromised during preparation of the skin. If primaries were slightly spread, we aligned them to ensure that their tips were colinear. All measurements were done with a digital caliper rather than a ruler to ensure the highest precision (±0.05 mm).

By convention, the primaries are numbered from the inside outward, e.g., P10 corresponds to the outermost primary (Figure 3). Our convention for reporting primary-tip spacings is as the distance from an outer primary to an inner one. For example, [P10–P9] corresponds to the distance between the tips of P10 and P9, and [P8–P5] corresponds to that between the tips of P8 and P5. If the outer primary is shorter than the inner primary, then the

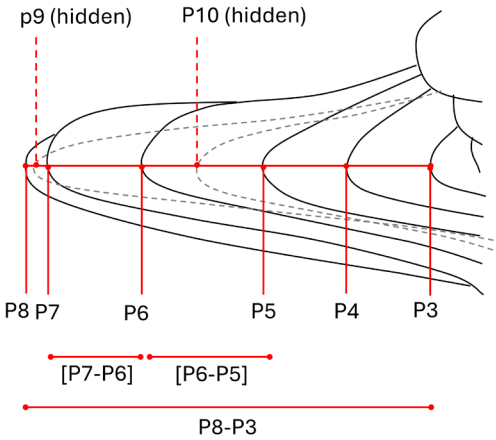

FIGURE 3. Numbering of the 10 primaries of the Alder and Willow Flycatchers, from the innermost primary (P1) to the outermost (P10). P10 and P9 are always hidden on a folded wing and denoted here with dashed lines. P8 projects only slightly and is often the same length as P7 and sometimes not visible. Spacings between the tips of the primaries are denoted as the difference between primary-tip lengths, e.g., [P7–P6], which represents the spacing between P7 and P6.

value is negative. In *Empidonax* flycatchers, P9 and P10 are always shorter and stacked beneath P8 and never visible on a folded wing, thus [P10–P9] and [P10–P8] are always negative (Figure 3). In the Alder and Willow Flycatchers, the longest and outermost exposed primary is usually P8, although the amount of P8 exposed can sometimes be limited, especially in the Willow. Tip spacings from P7 or P8 inward are always positive (e.g., [P8–P6], [P7–P6], [P6–P5], etc.). We did not measure distances to P1 or P2 as on a folded wing these primaries are usually hidden beneath the secondaries (see Figures 3 and 4). A summary of how these measurements are applied to specimens is shown in Figure 5.

Directly measured distances between adjacent tips, e.g., [P7–P6], can be added to calculate spacings between non-adjacent tips, e.g., [P7–P5]. We recalculated tip spacings relative to P3 by consecutively summing spacings between adjacent tips, beginning with [P4–P3] (Table 1), that is,

$$[P_i{-}P_3] = \Sigma_4^i\,[P_i{-}P_{i-1}] \quad (1)$$

For example, [P7–P3] = [P4–P3] + [P5–P4] + [P6–P5] + [P7–P6] from Equation 1. Once done, calculating any other spacing of non-adjacent primaries is straightforward. For example, [P7–P5] = [P7–P3] – [P5–P3]. All distances are reported in mm. To obtain nondimensional indices, we calculated the ratios of two primary-tip spacings, i.e., [P6–P5]/[P7–P6]. When this ratio is >1, [P6–P5] is greater than [P7–P6].

We report mean and median values of measurements and variability in a morphometric index with the 5 and 95 percentiles. For example, the 5% value of a morphometric indicates that only 5% of measurements fall below this

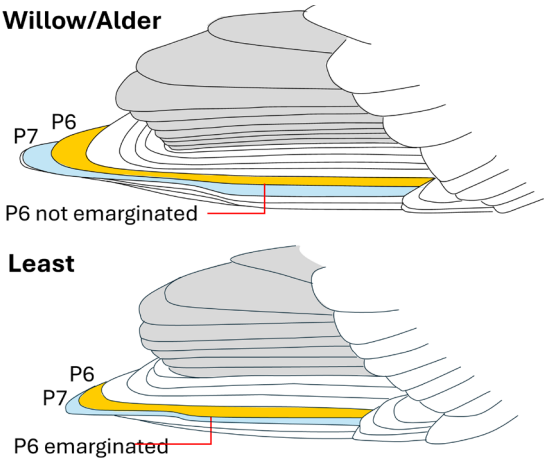

FIGURE 4. Differences in emargination of outer primaries of *Empidonax*. In both wing diagrams, blue represents P7 and orange P6. In the Willow, Alder, and Acadian Flycatchers, P6 is not emarginated. In the Least and other species of *Empidonax*, P6 is emarginated. Note that in the Least [P7–P6] is distinctly short and P7 can be mistaken for P8, so great care must be taken in identifying the primaries accurately before the spacings between the primaries' tips are measured.

FIGURE 5. Comparison of primary-tip spacings of Alder and Willow Flycatchers. Willow has [P6–P5] > [P7–P6]. Alder has [P6–P5] < [P7–P6]. Specimens from the Field Museum of Natural History, Chicago.

value (or, equivalently, 95% of measurements fall above this value). The 95% value indicates that 95% of measurements fall below this value (or, equivalently, only 5% of values fall above this value). The range of values between the 5% and 95% percentiles reflects 90% of measurements.

To test the applicability of measurements of primary-tip spacing in the field, we also examined high-quality photographs of 50 Willow and 50 Alder Flycatchers available through the Cornell Laboratory of Ornithology's Macaulay Library of photos. Identifications were based on vocalizations or geographic range according to the same criteria discussed above. For taking measurements from photos we used the "ruler" tool in Adobe Photoshop.

RESULTS

The Alder and Willow Flycatchers differ subtly in overall wing structure (Figure 5). Table 1 presents direct measurements of the spacings between the tips of adjacent primaries as well as indices calculated from these measurements.

In both species, P8 is the longest primary, but there is a slight tendency for P8 to project out more in the Alder, as measured by its value for [P8–P7] averaging slightly longer than in the Willow. Consistent with previous work (Pyle 2022), our measurements showed that the Alder has slightly longer wings than the Willow, as exemplified by the Alder's longer [P8–P3] (Figures 6 and 7; Pyle 2022). Subtle differences were also seen in the length of P10 relative to P5 ([P10–P5]). In the Alder, P10 tended to be longer than P5 (i.e., [P10–P5] ≥ 0; Figure 7). In the Willow, P10 was equal to or slightly shorter than P5 ([P10–P5] ≤ 0). We found [P7–P6] to be generally longer in the Alder than in the Willow (Figure 8). However, we found considerable overlap between the two species in these direct measures, so these differences can be described only as tendencies and should not be used as diagnostic except at the extremes.

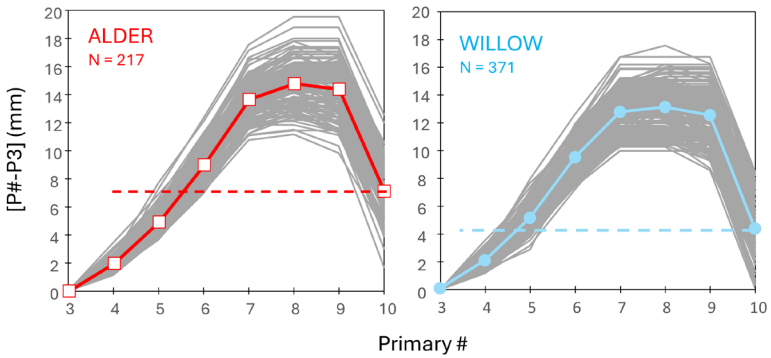

FIGURE 6. Lengths of the primaries of the Alder and Willow Flycatchers relative to P3, e.g., [P_i–P3]. Each gray line represents one specimen. Solid colored line in each panel represents the mean. Alder Flycatchers have slightly more pointed wings than do Willow Flycatchers, as evidenced by the Alder's longer P8 and P9. On average, P10 is longer than P5 in the Alder (red dashed horizontal line) but equal to or shorter than P5 in Willow (blue dashed horizontal line).

Table 1 Summary of Morphometric Data from Specimens of the Alder and Willow Flycatchers

	Alder (n = 217)				Willow (n = 371)			
Metric	Mean	Median	5%[a]	95%[b]	Mean	Median	5%[a]	95%[b]
Measured values								
Bill length (BL)[c]	8.79	8.82	7.85	9.54	9.61	9.61	8.71	10.60
Bill thickness (BTh)[d]	4.15	4.14	3.58	4.67	4.20	4.19	3.75	4.67
Bill width (BW)[d]	6.67	6.65	6.05	7.33	6.83	6.84	6.18	7.40
[P10–P9]	–7.31	–7.29	–8.62	–5.95	–8.12	–8.03	–9.66	–6.49
[P9–P8]	–0.39	0.00	–1.58	0.00	–0.59	0.00	–1.91	0.00
[P8–P7]	1.01	1.07	0.00	1.96	0.37	0.00	0.00	1.34
[P7–P6]	4.60	4.52	3.67	5.79	3.23	3.21	2.29	4.17
[P6–P5]	3.95	3.94	3.05	4.74	4.33	4.24	3.41	5.39
[P5–P4]	2.80	2.76	2.04	3.74	2.99	2.87	2.20	4.01
[P4–P3]	1.91	1.93	1.18	2.64	1.97	1.96	1.18	2.87
Calculated values								
[P10–P3]	6.56	6.57	3.26	9.87	4.16	4.19	1.15	7.55
[P9–P3]	13.9	14.0	10.7	16.7	12.3	12.2	9.6	15.2
[P8–P3]	14.3	14.3	11.3	16.9	12.9	12.9	10.4	15.4
[P7–P3]	13.2	13.2	10.7	15.6	12.5	12.4	10.3	14.8
[P6–P3]	8.65	8.60	6.65	10.4	9.27	9.23	7.63	11.29
[P5–P3]	4.69	4.67	3.33	6.12	4.95	4.87	3.72	6.43
[P4–P3]	1.89	1.92	1.14	2.64	1.96	1.96	1.14	2.87
[P8–P4]	12.4	12.4	9.68	14.6	10.9	11.0	8.70	13.2
[P7–P4]	11.4	11.4	9.18	13.5	10.5	10.5	8.60	12.6
[P6–P4]	6.75	6.77	5.37	8.14	7.31	7.23	5.99	8.86
[P10–P5]	1.87	2.00	–0.54	4.36	–0.80	–0.91	–3.49	2.08
[P6–P5]	3.96	3.94	3.04	4.74	4.32	4.24	3.41	5.35
Ratios								
P6:7 = [P6–P5]/[P7–P6]	0.87	0.88	0.64	1.02	0.87	0.88	0.64	1.02
[P6–P4]/[P8–P4]	0.55	0.55	0.48	0.61	0.55	0.55	0.48	0.61
[P6–P4]/[P7–P4]	0.59	0.60	0.53	0.65	0.59	0.60	0.53	0.65
BL/BTh	2.13	2.13	1.87	2.46	2.13	2.13	1.87	2.46
[P7–P6]/BL	0.52	0.52	0.41	0.66	0.52	0.52	0.41	0.66

[a]Value beneath which only 5% of specimens fall and which 95% of specimens exceed.

[b]Value above which only 5% of specimens fall and which 95% of specimens do not reach.

[c]Measured from anterior edge of nares to tip of bill.

[d]Measured at the nares.

More considerable differences were borne out in the ratios of primary-tip spacings because ratios normalize out the effect of variation in size. This result is particularly significant because the most diagnostic primary tips are always visible on a folded wing, which lends itself to identification of birds both in the hand and well photographed. The most important derived index is the ratio [P6–P5]/[P7–P6], which we refer to as the "P6:7 ratio." This ratio is greater in the Willow Flycatcher, the median being 0.88 in the Alder and 1.33 in the Willow (Figure 8). The P6:7 ratio was <1.02 in 95% of Alder Flycatchers and >1.05 in 95% of Willow Flycatchers so is usefully diagnostic. A value of P6:7 = 1.035 effected maximum separation between the two species. Thus [P6–P5] was typically greater than [P7–P6] in the Willow, whereas

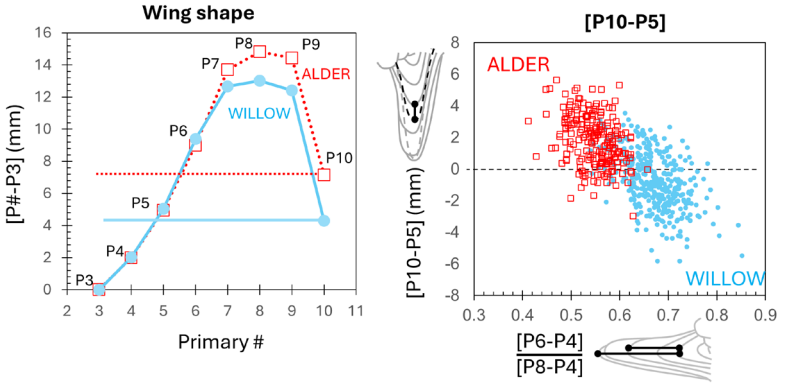

FIGURE 7. Left, average wing shapes of the Alder and Willow Flycatchers as measured from the lengths of the primaries relative to P3 (see Figure 6). Right, [P10–P5] versus [P6–P4]/[P8–P4]. The relative length of P10 in the Alder is generally greater than in the Willow. The Alder has the [P6–P4]/[P8–P4] ratio lower than in the Willow because of its longer P8 and P9.

[P6–P5] was shorter than [P7–P6] in the Alder. About 5% of specimens fell within the overlap zone and are not distinguishable from this ratio alone. We found no Alders with this ratio >1.2 and no Willows with it <1.0. Because the separation between Alder and Willow was conveniently at P6:7 of ~1, this ratio can be readily seen and quantified in the field or from good-quality photographs. Using photographs of live birds, we arrived at median values of the P6:7 ratio of 1.25 and 0.82 for Willow and Alder, respectively, which are identical to within error to values determined from specimens. Only 6%

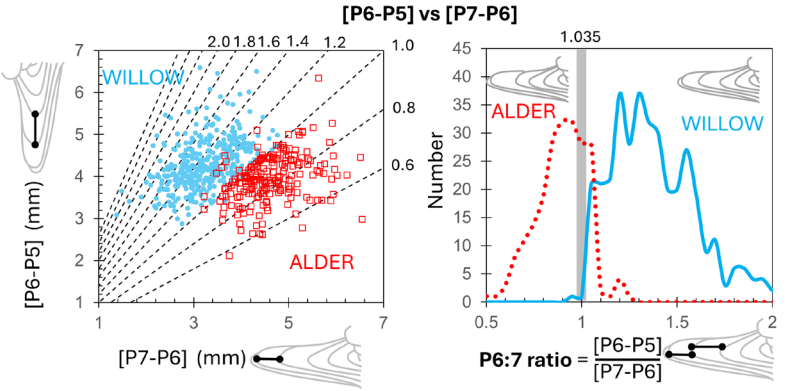

FIGURE 8. Left, [P6–P5] versus [P7–P6] in the Alder and Willow Flycatchers. The Alder has [P7–P6] slightly longer than in the Willow, but there is considerable overlap. There is complete overlap in [P6–P5]. The two species differ, however, in the P6:7 ratio ([P6–P5]/[P7–P6]) (dashed lines in left panel). Right, frequency distribution of this ratio. Vertical gray line represents P6:7 = 1.035, the line of maximum separation between the two species. This ratio is relatively easy to observe in the field.

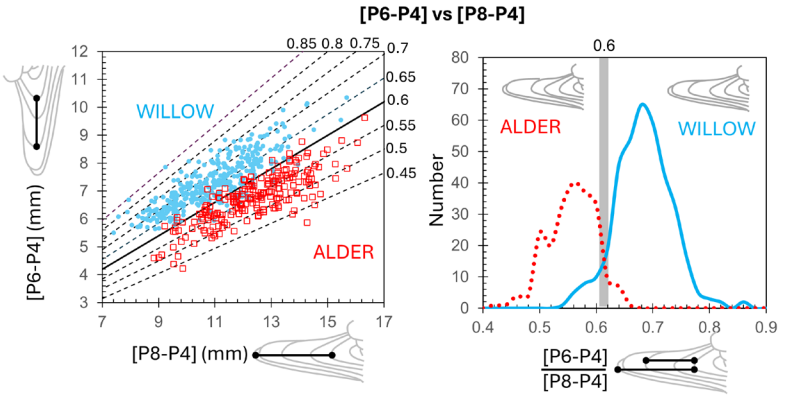

FIGURE 9. Left, measured values of [P6–P4] versus [P8–P4]. There is complete overlap in absolute spacings, but in the ratio of these two quantities the two species diverge (dashed lines represent [P6–P4]/[P8–P4]). Right, frequency distribution of [P6–P4]/[P8–P4]. This ratio must be measured from specimens or photographs as it is difficult to visualize in the field.

of the birds photographed fell out of the species' ranges as determined from specimen measurements.

We also explored whether the Alder and Willow might be differentiated with other indices of primary-tip spacing. We found no difference in [P6–P4], [P7–P4], and [P8–P4], but their ratios were significantly different (Figure 9). Ratios [P6–P4]/[P8–P4] and [P6–P4]/[P7–P4] were consistently higher in the Willow than in the Alder (Figures 9–11). Because these ratios do not involve adjacent primary tips, they are more difficult for the human eye to evaluate. However, these ratios are nearly as diagnostic as the P6:7 ratio.

For completeness, we also report the results of our measurements of bill dimensions (Table 1 and Figure 12). As reported by Pyle (2022), there is

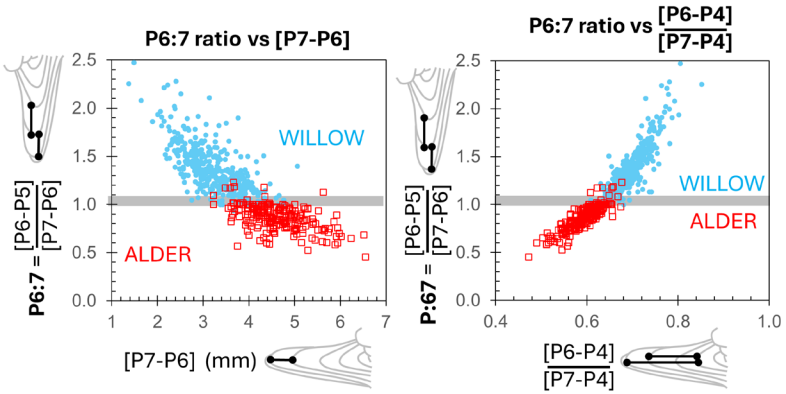

FIGURE 10. Left, the P6:7 ratio ([P6-P5]/[P7-P6]) versus [P7–P6] in the Alder and Willow Flycatchers. Right, the P6:7 ratio versus [P6–P4]/[P7–P4].

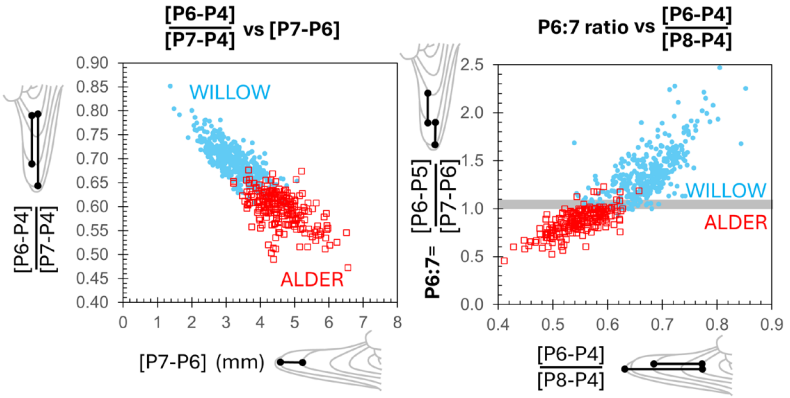

FIGURE 11. Left, [P6–P4]/[P7–P4] versus [P7–P6] in the Alder and Willow Flycatchers. Right, [P6–P5]/[P7–P6] versus [P6–P4]/[P8–P4].

considerable overlap between the two species in bill length. Only Willow Flycatchers were found to have bill lengths >10 mm, so any Traill's with a bill >10 mm is almost surely a Willow. Bill lengths <10 mm unfortunately fall in the zone of overlap. We note that many (but not all) long-billed Willows represent one of the three western subspecies (especially *extimus*), so western Willows often appear longer-billed than the Alder; in the eastern subspecies of the Willow the bill structure is more similar to the Alder (Pyle 2022). Rather than by absolute bill length, the Alder and Willow are better differentiated when bill length and primary-tip morphometrics are examined together. For example, Figure 13 shows that the Alder and Willow are differentiated by the ratio of [P7–P6] to bill length ([P7–P6]/BL). While absolute bill dimensions

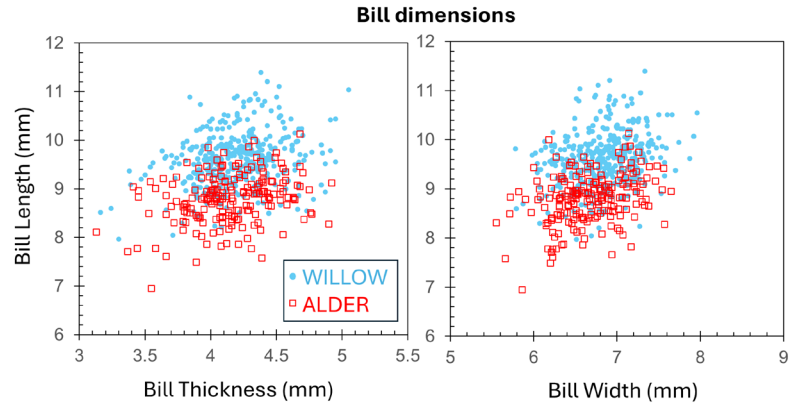

FIGURE 12. Left, bill length (nares to tip) versus bill thickness at nares in the Alder (red squres) and Willow (blue dots) Flycatchers; right, bill length versus bill width at nares panel). The Willow tends to have a bill longer than the Alder's, but only at the extremes can bill length be used for identification. The two species overlap completely in bill thickness and width.

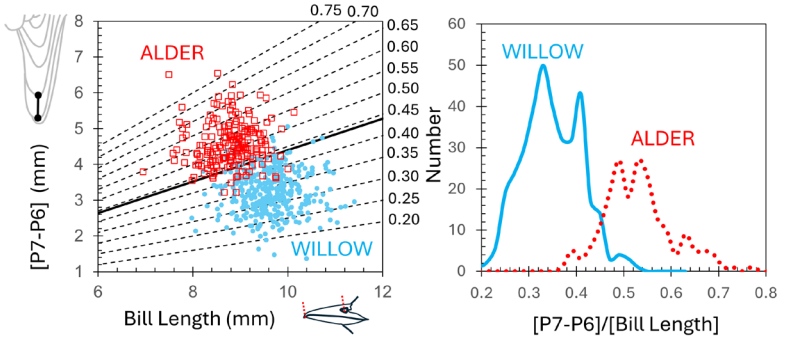

FIGURE 13. Left, [P7–P6] versus bill length (nares to tip) in the Alder and Willow Flycatchers. There is considerable overlap in absolute dimensions, but the species diverge in the ratio between these two measures (right). This ratio must be measured from specimens, birds in the hand, or photos taken in profile.

cannot be measured without the bird in hand, this ratio can be measured from photographs, provided the bill and wing are in the same focal plane so that image distortion from a telephoto lens is minimized.

DISCUSSION

We found that ratios of primary-tip spacing are more robust than absolute wing metrics for distinguishing the Alder and Willow Flycatchers. Table 1 and Figures 14 and 15 consolidate all the relevant morphometrics for ease of use. Compared to the Willow, the Alder has longer primaries and wider spacing

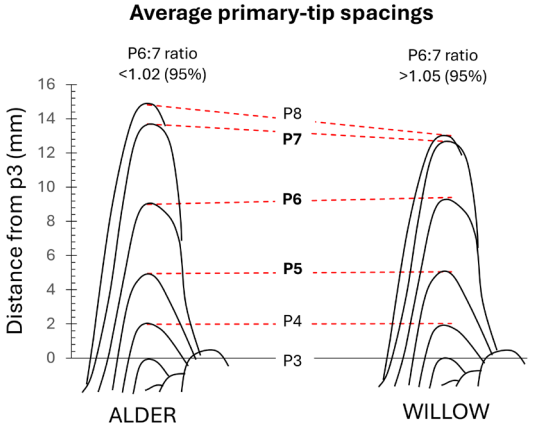

FIGURE 14. Primary-tip formulas of the Alder and Willow Flycatchers. [P6–P5]/[P7–P6] > 1.035 in 95% of Willow Flycatcher specimens and <1.035 in 95% of Alder Flycatcher specimens.

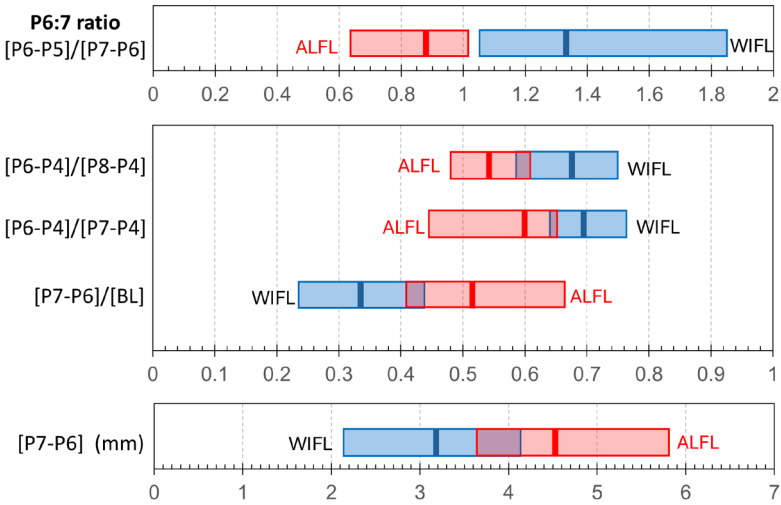

FIGURE 15. Summary of morphometric data. Red horizontal bars represent the Alder Flycatcher (ALFL), blue horizontal bars the Willow Flycatcher (WIFL). The width of each bar corresponds to 90% of sampled specimens, with the lower bound corresponding to the 5% percentile and the upper bound corresponding to the 95% percentile. Thick vertical bars represent the median value of each morphometric for each species. Fewer than 5% of the Willow and Alder Flycatchers overlap in the P6:7 ratio, [P6–P5]/[P7–P6].

between P7 and P6, which results in a smaller P6:7 ratio. Presumably these differences are related to the Alder's migrations being longer than the Willow's.

The use of ratios, especially the P6:7 ratio, allows measurements to be made from photographs when absolute scale is missing. Application of the P6:7 ratio is illustrated in Figures 16 and 17 with close views of Alder and Willow wings. Additional photos of Alder (Figures 18–23) and Willow (Figures 24–28) Flycatchers illustrate both the use of the P6:7 ratio and other field marks in identification. Figure 29 shows a direct comparison of Alder and Willow Flycatchers in the hand, illustrating how these indices can be applied to banded birds. When birds are captured for banding, photos of the folded wing may be all that is necessary for identification (provided other species of *Empidonax* have been ruled out), reducing the amount of time spent taking measurements on a live bird.

In measuring specimens, one has the advantage of measuring ideally folded wings. In the field, conditions are ideal for assessing wing structure only when the bird is close, with high-quality optics. Field identification thus requires taking good-quality photographs of the wing. The wing should be photographed in one focal plane, minimizing foreshortening, which may distort ratios. It is important to remember that photographs of live birds are instantaneous snapshots, yielding more variability in ratios because feather arrangements can shift slightly when a bird moves its wings. Finally, despite the robustness of the P6:7 index, we still recommend a holistic approach

FIGURE 16. Juvenile Alder Flycatcher in fresh plumage, photographed 16 September 2023 in Galveston, Texas. P6:7 = 0.73. Note the bold wingbars and tertial edges that contrast with the wing's blackish ground color and olive mantle. Note that P7 is emarginated but not P6, helping to distinguish the Alder and Willow Flycatchers from most other species of *Empidonax*, including the Least. Identification verified by voice.

Photo by Cin-Ty Lee

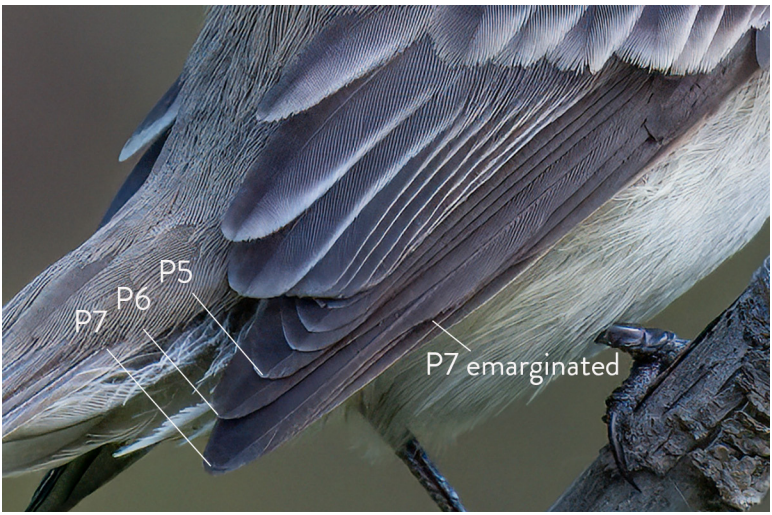

FIGURE 17. Adult Willow Flycatcher, photographed 21 June 2024 at Sibbald Lake near Kananaskis, Alberta, Canada. P6:7 = 1.23. Note the dull wingbars and tertials that show less contrast with the wing's ground color and mantle than in the Alder (Figure 16). Note that P7 is emarginated but not P6, helping to distinguish the Willow and Alder Flycatchers from most other species of *Empidonax*. Identification verified by voice and range.

Photo by Cin-Ty Lee

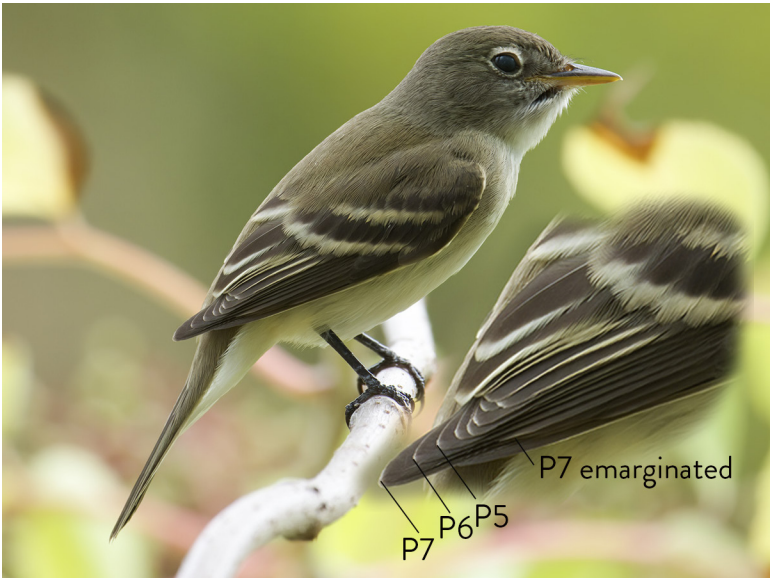

FIGURE 18. Juvenile Alder Flycatcher in fresh plumage, photographed 16 September 2023 in Galveston, Texas. P6:7 = 0.73. Note the bold wingbars and tertial edges that contrast with the wing's blackish ground color and dark olive mantle, unlike the browner wings and duller wingbars of the Willow. The crown is rounded instead of the more peaked appearance of the Willow. This bird's eye ring is more distinct than typical for an Alder. P7 is emarginated but not P6. Identification verified by voice.

Photo by Cin-Ty Lee

to identifying *Empidonax*. With these caveats in mind, we provide below a workflow for identification of the Alder and Willow Flycatchers.

Workflow for Identification

Step 1: Documentation. In the field or with birds in the hand, make every attempt to record vocalizations and take photographs from various angles. The ideal photographs are lateral profiles and dorsal views of the folded wing in the same focal plane. Ventral views are important for assessing chest coloration and underpart/upperpart contrast, which can be helpful in distinguishing the Alder and Willow from other flycatchers. If possible, one should also take photos of the spread wing and tail. Such photos, while not ideal for measuring primary-tip spacings, are useful for age determination.

Importantly, because spacings between primary tips can be measured later from photographs, the observer in the field should prioritize obtaining good-quality photos and noting other aspects such as habitat, behavior, vocalizations, and structural features that may not be captured well in photographs. For banders, *Empidonax* flycatchers are notorious for struggling in a bander's grip, making them difficult to photograph. Inexperienced banders faced with a struggling bird can often become rushed or nervous, resulting in incomplete

Figure 19. Adult Alder Flycatcher photographed 18 August 2024 in Houston, Texas. P6:7 = 0.88. Typical of the Alder are the bold wingbars (especially the lower) and tertial edges, contrasting with the olive mantle. The dark ground color of the wing accentuates the wingbars' contrast. The rounded crown is typical of the Alder. Identification verified by call.

Photo by Cin-Ty Lee

Figure 20. Adult Alder Flycatcher photographed 10 August 2024 in Houston, Texas. P6:7 = 0.80. The round crown, thin eye ring, relatively white contrasting wingbars and tertial edges, wing's blackish ground color, and relatively strong contrast between whitish throat and dark face and upperparts also point to the Alder. The tail appears wider than in a Least Flycatcher. Eye-ring too thin and crisp for the Least. Identification verified by call.

Photo by Cin-Ty Lee

FIGURE 21. Adult Alder Flycatcher photographed 28 May 2023 in Tadoussac, Quebec. P6:7 = 0.98. The distinct eye-ring, rounded crown, and wide tail are also consistent with the Alder. Identification verified by song.

Photo by Cin-Ty Lee

documentation of a bird. The most consistent technique for getting a profile-view photo of an *Empidonax* is to hold it in a loose version of a bander's grip and turn it to face the camera in profile (Blaine Carnes pers. comm.).

Step 2: Rule out other flycatcher species. Before applying any of the criteria we present, all other flycatchers and pewees must be first ruled out. The most likely sources of confusion are the wood-pewees and Least Flycatcher. The Willow Flycatcher tends to be more easily confused with wood-pewees because of its slightly longer body, duskier chest, duller wingbars, indistinct eye-ring, and occasionally peaked crown. However, wood-pewees have much longer primary projections than any *Empidonax*, precluding confusion if the wings can be seen well. Wood-pewees give a "pip" call that can sound like an Alder Flycatcher to the inexperienced ear, but wood-pewees do not give the "whit" calls characteristic of the Willow Flycatcher.

The Least Flycatcher, however, can appear remarkably like the Alder. On average the Alder has a whiter chest, brighter wingbars, bolder eye-ring, and more compact body than the Willow, and these features can make the bird superficially resemble the Least Flycatcher. However, the Alder's eye-ring, while complete, is usually thin and crisp, whereas the Least tends to have a bolder but messier eye-ring whose thickness varies and edges are more diffuse. The Alder and Willow also appear to have wider tails than the Least. The Least's narrow tail often seems to narrow toward the body, but the Alder's rarely does so. The shapes of the primaries can also be useful. Primaries are

FIGURE 22. Juvenile Alder Flycatcher photographed 6 September 2023 in Sugar Land, Texas. P6:7 = 0.66. The bold wingbars and white edges to the tertials contrasting with the wing's blackish ground color are typical of the Alder and differ from the Willow's more muted wing pattern and browner tones. Note also the strong contrast between dark upperparts and whitish throat. The thin and crisp eye-ring is consistent with an Alder. Identification verified by call.

Photo Cin-Ty Lee

emarginated if the outer vane has a curved margin that broadens abruptly toward the base of the feather and unemarginated if there is no broadening of the outer vane. The edges of the broad outer vane on emarginated feathers are usually paler than the main feather itself and thus can often be seen on a folded wing. In the Least Flycatcher, P6 to P10 are emarginated, but in the Alder and Willow, only P7 to P10 are emarginated (Figure 4). The spacings between the primaries' tips are also useful. In the Least, [P7–P6] is considerably shorter than [P6–P5], which is opposite that of the Alder. However, note that the longest primary is usually P7 in the Least and P8 in the Alder. Because the Least's [P7–P6] is very short, one could mistake its P7 for P8, resulting in misidentification of a Least as an Alder. Use of the spacings and emargination of the primaries requires those feathers be identified accurately.

Step 3: Number primary tips. Correctly numbering primary tips is critical but can be challenging, especially in the field or when photographs are of poor quality. There are two reference points that may help one count primaries. In the Willow and Alder Flycatchers, P8 is the longest primary (be aware that in other species of *Empidonax* P7 may be the longest). On a folded Willow or

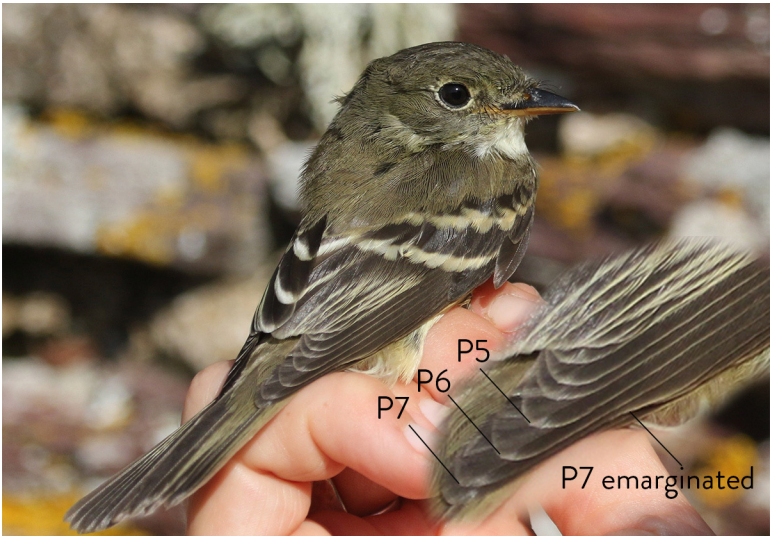

FIGURE 23. Juvenile Alder Flycatcher photographed 21 September 2023 in Skokholm, Wales. P6:7 = 0.91. This vagrant is the first Alder Flycatcher recorded for Wales and the third for Great Britain. Blackish wing ground color, bright and strongly contrasting wingbars and tertial edges, strong contrast between throat and upperparts, and thin, crisp eye-ring are consistent with the Alder. DNA extracted from a feather and a few fecal deposits confirmed the identification (Woollard 2024).

Photo by Richard Brown (https://macaulaylibrary.org/asset/609121814)

Alder wing, the tip of the wing is P8, which typically extends beyond P7 only slightly. That is, [P8–P7] is much shorter than [P7–P6]. In some cases, [P8–P7] is so short that P7 may appear to be the longest primary (more often in the Willow), but P8 is usually visible on careful inspection. The outermost visible primaries that differ conspicuously in length are thus P7 and P6 (Figure 14).

Another useful reference point is to identify the innermost emarginated primary (Pyle 1997b, 2022; Figure 4). In the Willow and Alder Flycatchers, the outermost primaries (P7 to P10) are emarginated, but the innermost primaries (P1 to P6) are not. Thus the innermost emarginated primary is P7. Some caution, however, is warranted in using this criterion because sometimes the outer web of P6 tapers slightly toward the tip, which can be mistaken for emargination.

Step 4: Determine the P6:7 ratio. The easiest and most important criterion is the relation between [P7–P6] and [P6–P5]. The maximum separation between the two species is near the point at which the two spacings are of equal length, when the P6:7 ratio ~1, that is, when the tip of P6 lies exactly halfway between the tips of P5 and P7. This criterion can often be assessed by the human eye even without a ruler. As a rule of thumb, if [P6–P5] is noticeably greater than [P7–P6], the bird is a Willow Flycatcher. If [P6–P5] is noticeably less than [P7–P6], the bird is an Alder Flycatcher. If [P6–P5] is the same as [P7–P6], additional morphometric ratios or other features must be considered.

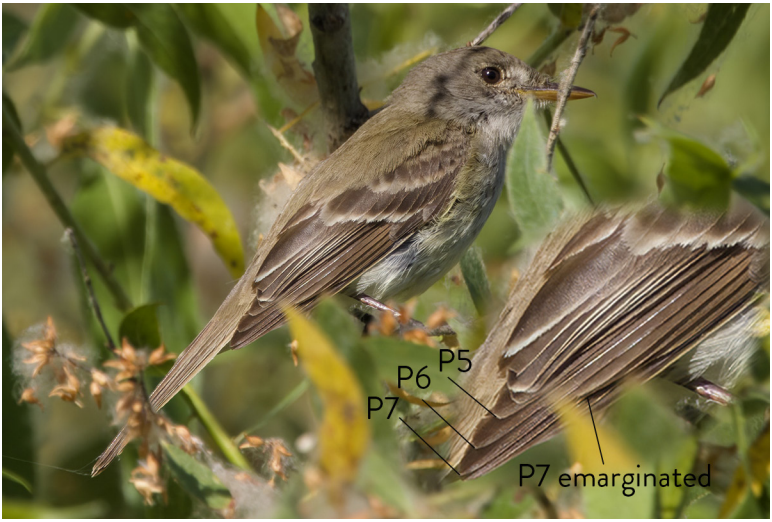

FIGURE 24. Adult Willow Flycatcher (*E. t. extimus*) photographed 8 July 2023 in San Diego County, California. P6:7 = 1.23. This bird could have been identified solely from plumage and structural features: weak plumage contrast, dull wingbars, dull tertial edges, light brown/gray upperparts, pale gray underparts, brown wings, lack of eye-ring, and long heavy bill are consistent with the Willow. Note how the wingbars, especially the upper, are almost the same color as the mantle. Emarginated P7 and unemarginated P6 visible in inset. The plumage of adult Willow Flycatchers, particularly those from the southern parts of their breeding range, tends to wear quickly after the birds arrive in their breeding range. Identification verified by song and range.

Photo by Cin-Ty Lee

Step 5: Additional ratios. Additional ratios that are useful are [P6–P4]/[P8–P4], [P6–P4]/[P7–P4], and [P7–P6]/BL, where bill length is measured from the anterior edge of the nares to the tip. These ratios are not easy for the human eye to assess quantitatively and should be based on measurements—which can be readily made from a photograph.

CONCLUSIONS AND FUTURE DIRECTIONS

In summary, we show here that relative differences of the spacings between the tips of the primaries, especially the P6:7 ratio, are useful for distinguishing the Willow and Alder Flycatchers. Provided good photographs of a folded wing can be obtained, this tool can be applied in the field. Combined with other field marks, these morphometrics allow silent Traill's Flycatchers to be identified with confidence. In the future, we hope to extend these morphometric analyses to other *Empidonax* flycatchers. Application of these morphometrics will help clarify differences in temporal and spatial patterns of *Empidonax* migration, which are currently confused in areas where multiple species pass through.

FIGURE 25. Adult Willow Flycatcher (*E. t. traillii*) photographed 10 May 2024 in Detroit, Michigan. P6:7 = 1.07. Plumage features consistent with the Willow include the dull tertial edges and weakly contrasting wingbars (especially the upper, almost concolorous with the mantle). Identification verified by voice.

Photo by Cin-Ty Lee

ACKNOWLEDGMENTS

For access to collections, we thank Steve Cardiff, Donna Dittmann, James Van Remsen, and Nicholas Mason for Louisiana State University; Libby Beckman and Rauri Bowie for the Museum of Vertebrate Zoology at the University of California, Berkeley; Ben Marks for the Chicago Field Museum; Brian Smith and Paul Sweet for the American Museum of Natural History, New York; and Allison Shultz and Young Ha Suh for the Los Angeles County Natural History Museum. Discussions with Steve Cardiff, Jon Dunn, and Daniel Baldassarre are greatly appreciated. Blaine Carnes, Santi Guallar, Daniel Ruthrauff, Philip Unitt, and Ron Weeks provided useful reviews and comments.

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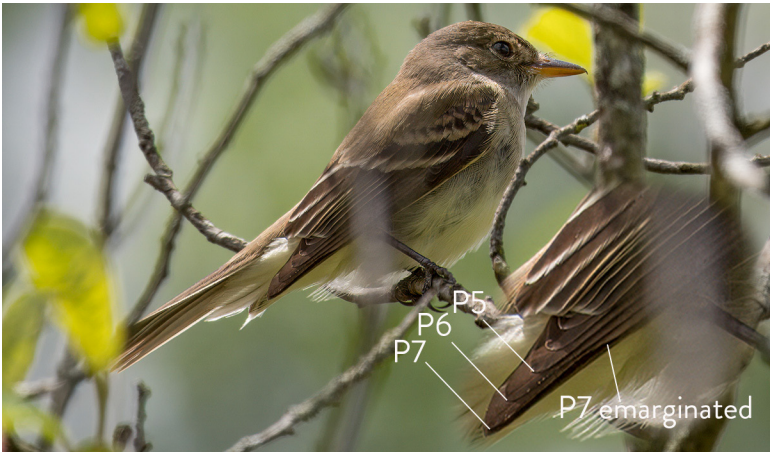

FIGURE 26. Adult Willow Flycatcher (*E. t. traillii*) photographed 10 May 2024 in Detroit, Michigan. P6:7 = 1.13. Plumage and structural features are typical for the Willow: dull tertial edges, wingbars almost concolorous with a brownish mantle; gray throat weakly contrasting with brown face and crown; indistinct eye-ring; long bill; flattish crown. The wing's ground color is brown instead of the more blackish of the Alder. P7 is emarginated but not P6, eliminating most other flycatchers. Identification verified by song.

Photo by Cin-Ty Lee

FIGURE 27. Adult Willow Flycatcher (*E. t. traillii*) photographed 8 June 2023 at Lacreek National Wildlife Refuge, South Dakota. P6:7 = 1.17. Again, typical of the Willow are dull wingbars and tertial edges, muted contrast between chest and upperparts, brown ground color of the wing, indistinct eye-ring, and long heavy bill. Identification verified by voice.

Photo by Cin-Ty Lee

FIGURE 28. Adult Willow Flycatcher (*E. t. adastus*) photographed 24 June 2024 near Golden, British Columbia, Canada. P6:7 = 1.81. Plumage and structural features typical of the Willow: dull wingbars weakly contrasting with the upperparts, dull tertial edges, the wing's brown ground color, almost nonexistent eye-ring, peaked crown, and long bill. Identification verified by song.

Photo by Cin-Ty Lee

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FIGURE 29. Juvenile Alder (left) and juvenile Willow (right) Flycatchers. P6:7 = 0.89 for the Alder and 1.22 for the Willow (measurements were done from photos). Note also the Alder's blacker wings, more contrasting wingbars, and thin crisp eye-ring as compared to the browner wings and tail, duller wingbars, and lack of eye-ring in the Willow. The Alder banded on 8 September 2024, the Willow on 2 August 2024, both at the Rice Creek Field Station in Oswego, New York.

Photos by Daniel Baldassarre

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Accepted 16 December 2024
Associate editor: Daniel R. Ruthrauff