

Orn. Union, Baltimore, MD.
nter, Jr., (ed.)
Worcester, MA.
Paynter, Jr. (ed.),
Press, Worcester, MA.
ss, Cambridge, MA.
Mus. Nov. 1496.
ds. Bull. Brit. Orn. Club

erica, etc., part I.

tc., part II.

ss [of *Vireo huttoni* Cassin].
Middle America, etc., part II.

onomy of the birds

scribed from 1976 to 1980.

, Nuevo León, Mexico.
ited by John P. Hubbard
left by Dr. Phillips.
of commission

A FURTHER EXAMINATION OF WING AND TAIL FORMULAE IN *EMPIDONAX* AND *CONTOPUS* FLYCATCHERS

PETER PYLE¹

ABSTRACT.—Useful new information on identifying and sexing specimens of *Empidonax* and *Contopus* flycatchers, two of the most critically examined genera of North American birds, is presented in a format most useful for in-hand determinations.

As first emphasized by Allan Phillips (1944a, 1944b) differences in wing formulae, as well as the length of the wing minus the length of the tail (WG-TL), have proven important means to identify *Empidonax* and *Contopus* flycatchers in the hand (Johnson 1963; Stein 1963; Phillips et al. 1964, 1966; Phillips and Lanyon 1970; DeSante et al. 1985). Since these original examinations were published, some refinements to the differences have been suggested (Unitt 1987, Hussell 1990, Seutin 1991); however, little further work on this topic has been performed. Phillips et al. (1966) also noted that the distance from the tip of the tail to the tip of the uppertail coverts could be used to separate many young male Eastern (*Contopus virens*) from Western (*C. sordidulus*) wood-pewees; but no analyses have been performed on other age/sex groups, nor any information on wing formulae in wood-pewees been published.

The use of wing formulae to identify flycatchers is complicated by intraspecific variation according to age, sex, feather wear and geography, factors that have been recognized but not thoroughly documented in most original works. Published ranges of wing formula and wing-tail measurements, furthermore, may contain anomalous or mis-classified individuals, or may not have been based on adequate samples; thus, intraspecific ranges useful in separating 95% of populations are usually not known. In addition, formulae based on different primary tips and various methods of representation have been published for different species groups, making genus-wide comparisons difficult (e.g., see Table 1 in Pyle et al. 1987). Wing-tail figures in Pyle et al. (1987) were based on a quick appraisal of 10-15 specimens of each taxon (unpubl. data). A standardized reassessment of wing and tail formulae in *Empidonax* and *Contopus* flycatchers, is therefore needed.

In revising and attempting to clarify the information on flycatcher identification in Pyle et al. (1987), I have measured certain wing and tail formulae on 517 specimens of twelve taxa found north of Mexico. Specimens were selected in consideration of age, sex, season and geographic location of collection. Here I present some new information on identifying and sexing *Empidonax* and *Contopus* flycatchers in the hand, using standardized methods of measurement analysis and representation.

METHODS

In addition to the two wood-pewees, ten taxa of *Empidonax* flycatchers were considered: Yellow-bellied (*E. flaviventris*), Acadian (*E. virens*), Alder (*E. alnorum*), Willow (*E. traillii*), Least (*E. minimus*), Hammond's (*E. hammondii*), Dusky (*E. oberholseri*), Gray (*E. wrightii*), "Pacific-slope" (*E. [d.] difficilis*) and "Cordilleran" (*E. [d.] occidentalis hellmayri*) flycatchers; a taxonomic opinion on the latter two forms, the "Western" Flycatchers (see Phillips 1994, Johnson 1994), is beyond the scope of this paper. All specimens were housed at the California Academy of Sciences (CAS), Museum

of Vertebrate Zoology (MVZ), and Western Foundation of Vertebrate Zoology (WFVZ). For the pewees, only birds collected on or near the allopatric breeding grounds were measured. For Alder and Willow flycatchers only specimens identified by song-type or collected during the breeding season within allopatric ranges (see Stein 1963, Zink and Fall 1981) were included.

Forty specimens of each taxon were included in core analyses, ten each of the four age/sex classes young female, adult female, young male, and adult male; "young" birds being those in first basic or first alternate plumage but with juvenal flight feathers, and "adults" those with definitive flight feathers. Because the "Traill's" Flycatchers are difficult to separate (Browning 1993 and references therein), 37 additional specimens (12 Alders and 25 Willows) were measured to increase sample sizes. Age was based on flight feather wear and shape in consideration of each taxon's molt strategy (Pyle et al. 1987), and sex, presumably based on internal examination, was that recorded on specimen labels. An attempt was made to select specimens representing all times of year and throughout the entire geographic distribution of each taxon, although smaller samples of some of the less-represented taxon/age/sex groups (e.g., young wood-pewees and Acadian and known Alder flycatchers) precluded much choice of selection. Beyond these two considerations, specimens were chosen at random. Two seasons were defined for analyses: fall (end of the prebasic molt through December) and spring (January through beginning of the prebasic molt).

Based on previous work, the following distance measurements (to the nearest mm) were recorded: tip of the longest primary to tip of primary 6 (LP-P6; primaries numbered proximally), tip of P6 to tip of P10 (P6-P10), tip of P9 to tip of P5 (P9-P5), tip of longest primary to tip of longest secondary (LP-LS), and WG-TL. Additionally, the tip of the tail to the tip of the uppertail coverts (TL-UTC) was measured to the nearest mm on all wood-pewees and bill (anterior of nares to tip, to the nearest 0.1 mm) was measured on each Alder and Willow flycatcher. Wing formula measurements were performed on the closed wing with a clear plastic ruler (see Figure 10 in Pyle et al. 1987) and the wing measurement was that of the chord. All wing measurements were performed on the right wing; specimens with broken or extremely worn primary tips were excluded.

Ranges are represented here as 95% confidence intervals, estimated by mean + 2 S.D. This form of representation is advocated over true range to lessen the influence of anomalous individuals or mis-classified (e.g., mis-sexed; see Parkes 1989) specimens, and to help ensure that full statistical ranges are represented. It is also strongly advocated over such vague terms as "P9 usually > P5", as it allows one to know when a bird falls into a zone of overlap. Assuming normal distributions of measurements and adequate samples, use of these ranges (considering birds in overlap zones indeterminable) enables separation of populations with over 97.5% accuracy. Analysis of variance (ANOVA) was used to test for significant differences between populations.

RESULTS AND DISCUSSION

Results of this study (Table 1) generally confirm those of previous works indicating the usefulness of certain wing and tail formulae in separating similar species of *Empidonax* flycatchers. In addition, several previously unemphasized differences were found that may be of additional use in identification, e.g., differences in LP-P6, P9-P5, LP-LS and WG-TL in the Yellow-bellied-Acadian-Western flycatcher group and differences in P6-P10 and WG-TL in the Least-Hammond's-Dusky-Gray flycatcher group. As clearly presented in Table 1, these measurements plus additional information on plumage features and bill size and color (Phillips et al. 1964, 1966; DeSante et al. 1985; Pyle et al. 1987) should enable easy separation of these taxa in the hand. It should be noted, how-

95% CONFIDENCE
BY AGE AND
IN *CONTUPUS* AND *EMPI*
OF EQUAL

SPECIES	LP-P
Western Wood-Pewee	10.3-
Eastern Wood-Pewee	9.6-
Yellow-bellied Flycatcher	2.2-
Acadian Flycatcher	5.2-
Alder Flycatcher	3.8-
Willow Flycatcher ^c	1.8-
Least Flycatcher	0.8-
Hammond's Flycatcher	1.8-
Dusky Flycatcher	0.0-
Gray Flycatcher	0.9-
Pacific-slope Flycatcher	0.2-
Cordilleran Flycatcher	1.2-

^a Significant intraspecific differences

^b All P6-P10 values in wood-pewees and *Empidonax* flycatchers.

^c Measurements of Willow Flycatcher (see text), both of equal distributions

^d Significant intraspecific differences (the more significant (P<0.0001) of the

ever, that slight differences in birds (Winker 1993); e.g., WG on specimens (pers. observation based on data taken from live

Many significant measurements were found within wings than females (Phillips et al. and LP-LS whereas females are the more significant of these differences in Table 2. Most notable was that values < 17 mm indicated birds were accurately sexed and inaccurately sexed according to sexed specimen. By combining higher percentages of birds on the formula LP-LS / (P6-P10 males and 2.76-8.14 in males labels. This or similar formula might be useful for even more flycatchers (see Table 2 and Phillips

Vertebrate Zoology (WFVZ).
 metric breeding grounds were
 identified by song-type or
 (see Stein 1963, Zink and

more analyses, ten each of the
 ale, and adult male; "young"
 with juvenal flight feathers,
 the "Traill's" Flycatchers are
 37 additional specimens (12
 sizes. Age was based on flight
 strategy (Pyle et al. 1987),
 but recorded on specimen la-
 all times of year and through-
 smaller samples of some of
 wood-pewees and Acadian and
 on. Beyond these two consid-
 were defined for analyses: fall
 January through beginning of

measurements (to the nearest
 primary 6 (LP-P6; primaries
 of P9 to tip of P5 (P9-P5), tip
 WG-TL. Additionally, the tip
 measured to the nearest mm on
 (at 0.1 mm) was measured on
 measurements were performed on the
 (Pyle et al. 1987) and the wing
 measurements were performed on the right
 specimens were excluded.

Intervals, estimated by mean + 2
 range to lessen the influence of
 (see Parkes 1989) specimens,
 It is also strongly advocated
 to know when a bird falls into
 measurements and adequate samples,
 (determinable) enables separa-
 variance (ANOVA) was used to

Use of previous works indicat-
 separating similar species of
 emphasized differences were
 differences in LP-P6, P9-P5,
 flycatcher group and differ-
 ky-Gray flycatcher group. As
 additional information on plumage
 (deSante et al. 1985; Pyle et al.
 found. It should be noted, how-

TABLE 1
 95% CONFIDENCE INTERVALS (MM) AND INTRASPECIFIC DIFFERENCES
 BY AGE AND SEX FOR WING AND TAIL FORMULAE
 IN *CONTUPUS* AND *EMPIDONAX* FLYCATCHERS; N=40 FOR EACH MEASUREMENT
 OF EQUAL AGE AND SEX DISTRIBUTION (SEE TEXT).

SPECIES	LP-P6	P6-P10	P9-P5	LP-LS	WG-TL
Western Wood-Pewee	10.3-14.8	2.7-7.8 ^b	14.5-20.5 ^a	22.3-29.7 ^a	19.0-28.3
Eastern Wood-Pewee	9.6-15.5	1.7-8.2 ^b	14.5-19.5	17.3-26.4	16.2-26.2
Yellow-bellied Flycatcher	2.2-6.7	1.9-6.3	5.8-11.5 ^a	10.3-17.5 ^a	12.2-18.7
Acadian Flycatcher	5.2-9.3 ^a	-2.9-1.7 ^a	8.6-14.4 ^a	13.3-23.5 ^a	11.6-21.3
Alder Flycatcher	3.8-7.4 ^a	-1.2-3.5 ^a	6.9-11.1 ^a	10.2-17.1 ^a	12.4-20.3 ^a
Willow Flycatcher ^c	1.8-5.2 ^{a,a}	1.4-6.4	4.7-9.7 ^{a,a}	10.3-17.4 ^a	6.2-17.4 ^a
Least Flycatcher	0.8-3.7	2.7-7.0 ^a	3.4-7.8 ^a	9.0-15.7 ^a	6.5-13.0
Hammond's Flycatcher	1.8-5.5 ^a	2.8-8.0 ^a	5.6-11.6 ^a	13.3-20.6 ^a	10.7-18.9
Dusky Flycatcher	0.0-3.0	6.0-10.8	2.2-5.5	9.2-15.2	3.2-11.8
Gray Flycatcher	0.9-4.6	4.1-8.1 ^a	3.5-8.8 ^a	9.0-16.9	8.2-16.4
Pacific-slope Flycatcher	0.2-4.4 ^{a,a}	4.7-9.2	2.8-8.4 ^a	8.6-16.1 ^a	6.3-13.3
Cordilleran Flycatcher	1.2-3.8 ^a	6.4-9.8	5.0-9.8 ^a	10.8-17.1 ^a	7.2-14.9

^a Significant intraspecific differences by age were found. Most of these reflected differences in season. See text.

^b All P6-P10 values in wood-pewees should be negative as P6 < P10 vs. P6 > P10 in most *Empidonax* flycatchers.

^c Measurements of Willow Flycatchers are based on 20 each of western and eastern birds (see text), both of equal distributions of age and sex.

^a Significant intraspecific differences by sex were found. See Table 2 for confidence intervals of the more significant (P<0.0001) of these.

ever, that slight differences may occur between measurements of specimens and of live birds (Winker 1993); e.g., WG-TL appears to average slightly smaller on live birds than on specimens (pers. observation). Similar analyses to those of this study are encouraged, based on data taken from live birds at banding stations.

Many significant sex-specific differences in wing formulae and wing-tail measurements were found within taxa (Table 1), indicating that males have more pointed wings than females (Phillips et al. 1966). In all taxa, males averaged larger LP-P6, P9-P5 and LP-LS whereas females averaged larger P6-P10. Intrasexual confidence intervals for the more significant of these differences (where P<0.001 according to ANOVA) are listed in Table 2. Most notable was the difference in LP-LS in Acadian Flycatcher; assuming that values < 17 mm indicated females and values > 19 mm indicated males, 57.5% of birds were accurately sexed and only one male (MVZ107140 with LP-LS = 15 mm) was inaccurately sexed according to specimen labels. I suspect that the latter bird was a mis-sexed specimen. By combining measurements into a formula (see Phillips et al. 1966) higher percentages of birds can be accurately sexed. In Acadian Flycatcher, for example, the formula LP-LS / (P6-P10 + 5), resulting in confidence intervals of 1.06-4.50 in females and 2.76-8.14 in males, correctly sexed 82.5% of birds according to specimen labels. This or similar formulae based on larger samples of correctly sexed specimens might be useful for even more accurate sex determinations in Acadian and other *Empidonax* flycatchers (see Table 2 and Phillips et al. 1966).

TABLE 2
95% CONFIDENCE INTERVALS (MM) FOR EACH SEX,
WHERE DIFFERENCES AT P<0.001 WERE FOUND (SEE TABLE 1).

SPECIES	MEASURE	FEMALES	MALES
Yellow-bellied Flycatcher	LP-LS	10.5-15.3	11.4-18.4
Acadian Flycatcher	P9-P5	8.4-12.9	9.9-14.8
Acadian Flycatcher	LP-LS	13.2-18.8	16.9-24.1
Willow Flycatcher	LP-LS	10.3-15.3	12.6-17.5
Least Flycatcher	LP-LS	8.4-14.6	10.5-15.9
Hammond's Flycatcher	LP-LS	12.8-19.2	14.7-21.0
Pacific-slope Flycatcher	LP-P6	0.0-3.6	1.0-4.7
Cordilleran Flycatcher	LP-P6	1.3-2.8	1.8-4.0
Cordilleran Flycatcher	LP-LS	10.0-16.5	12.9-17.8

There were not as many significant differences in wing formulae by age (Table 1) and no differences were significant at P<0.001. In all significant cases adult birds averaged longer measurements than young birds. All but one of these age-related differences were also significant by season; in each case fall birds had larger measurements than spring birds. Wearing of flight feathers appears to reduce certain measurements, especially those involving the wing tip: LP-P6, P9-P5, and WG-TL. Differences in feather wear likely contributed to these age-specific differences, especially in species (e.g., Willow, Least, Dusky, Gray and Western flycatchers) where adults molt on the winter grounds and young retain juvenal flight feathers through their second summer (Pyle *et al.* 1987). Multiple ANOVA in those cases indicated that the effects of season usually swamped those of age, supporting this conclusion.

Except in Willow Flycatcher (see below), only three significant differences due to geographic variation were found, geographic division being based on both north-south and east-west midpoints in the distributions of all taxa. LP-LS averaged longer in northern than in southern populations of Hammond's and Dusky flycatchers. The only significant difference at P < 0.001 was WG-TL in Dusky Flycatcher, birds collected along the Pacific Slope and in the Sierra Nevada region having a 95% confidence interval of 3.2-9.6 mm, and birds collected in the Rocky Mountain region having an interval of 4.5-12.8 mm.

EASTERN vs. WESTERN WOOD-PEWEE

The two North American wood-pewees have been notoriously difficult to separate in the hand (Phillips *et al.* 1966), to the point at which their species recognition has been questioned based on specimen evidence alone (Ridgway 1907, Grinnell 1928, van Rossem 1940, Rand 1948, Jewett *et al.* 1953). Phillips *et al.* (1966) proposed that the distance from the tail tip to the tip of the longest uppertail covert (TL-UTC) could separate most immature males but fewer immature females; this difference in adults was not examined. In the present analysis it was found that TL-UTC is quite useful in identifying all birds, with a 95% confidence interval of 24.9-33.9 mm for Western and 31.4-40.1 mm for Eastern Wood-Pewee. A cutoff of 32.5 correctly identified 37 of 40 Western Wood-Pewees (true range 26-34 mm) and 38 of 40 Eastern Wood-Pewees (true range 32-41 mm): 93.8% of all pewees measured, regardless of age, sex, geographic location, or sea-

son. Caution is advised, however, in using the longest coverts (due to spurious TL-UTC values indica

A new result of this study is longer in Western than in Eastern thus provided the best means of an interval of -1.2 to 7.0 mm in W of 6.5 mm correctly identified male Western Wood-Pewee will Pewee with a value of six both noted that this formula is based for live birds is higher, perhaps 9-

WILL

Hussell (1990) current cult species, based on modification of "buffer zones," within which zone is equivalent to that of the measure the distance from p10 and Hussell's separation method which could be useful in separa

Among Willow Flycatcher western populations (collected *extimus*, and *campestris* in part *campestris* in part and *trillii*), i 1987). P6-P10 was greater in w greater in eastern Willows (Tab closely approached those of Al the best separation formula using Bill), or "Formula R" in Table 3 3 allowed separation to specie Flycatchers and 100% of weste

95% CONFIDENCE INTERVALS
AND WILLOW (EASTERN [MINIMUM
OF RANGE

MEASURE	
LP-P6	
P6-P10	
P9-P5	
WG-TL	1
Bill	
Formula R*	

* Formula R = (LP-P6 + P9-P5 + WG-TL) / 3
of the nares.