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MORPHOMETRIC IDENTIFICATION OF TRAILL'S FLYCATCHERS: AN ASSESSMENT OF STEIN'S FORMULA

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Abstract.—Stein (1963) proposed an equation for the morphometric identification of the sibling species Willow Flycatcher (*Empidonax traillii*) and Alder Flycatcher (*E. alnorum*), collectively referred to as Traill's flycatchers. The equation, based on bill length and wing formula, was reported to be very efficient, but the test was biased because the same specimens were used to derive the equation and to evaluate its power. Applied to specimens from eastern Canada, Stein's formula correctly identified about 80% of the sympatric and allopatric Alder Flycatchers and less than 70% of the sympatric Willow Flycatchers. The formula is thus judged not to be very reliable where it is most needed (in areas of sympatry). Caution is recommended in attempts to identify Traill's Flycatchers on morphometric grounds before the question is reinvestigated using large series of specimens identified by song.

IDENTIFICACIÓN MORFOMÉTRICA DEL PAPAMOSCAS DE TRAILL, UNA EVALUACIÓN DE LA ECUACIÓN DE STEIN

Sinopsis.—Stein (1963) propuso una ecuación para la identificación morfométrica de dos especies hermanas, *Empidonax traillii* y *E. alnorum*, colectivamente conocidas como papamoscas de Traill. La ecuación, basada en el largo del pico y una fórmula para el largo del ala ("I"), fue informada como muy eficaz en su uso. Sin embargo, la prueba de la ecuación estuvo viciada, ya que los mismos especímenes que se emplearon para derivarla fueron luego utilizados para evaluar su aplicabilidad. La ecuación de Stein, al ser aplicada a individuos de Canada identificó correctamente cerca del 80% de individuos simpátricos y alopátricos de *E. alnorum*, y menos de 70% de individuos simpátricos de *E. traillii*. La ecuación no parece ser muy confiable en áreas de simpatría. Mientras ésta no se ponga a prueba con una muestra considerable de individuos, identificados por su canto, se recomienda precaución en la utilización de la misma.

Biosystematic work by Stein (1958, 1963) led to the recognition that the Traill's Flycatcher was a complex of two distinct species, the Willow Flycatcher (*Empidonax traillii*) and the Alder Flycatcher (*E. alnorum*). The two taxa differ in vocalizations (Kroodsma 1984; LeGrand 1979; Stein 1958, 1963), breeding ecology (Stein 1958, 1963), habitat preferences (Stein 1963, Zink and Fall 1981, but see Barlow and McGillivray 1983), and are genetically distinct (Seutin and Simon 1988, Zink and Johnson 1984). Stein (1963) found several morphometric differences between the species in New England, and proposed a formula based on bill length and wing formula (I) for specimen identification. Stein (1963:44) reported that the formula correctly identified 90.6% of the specimens to which he had access, regardless of their sex or geographic origin (his samples comprised mainly specimens from New England and British Columbia).

An identification equation is optimal for the data set from which it is derived; therefore, the actual power of such an equation should always be assessed with an independent data set. Stein (1963) used the same

TABLE 1. Samples of Willow and Alder flycatchers used in the analysis.

Location[a]	Status	*n* males	*n* females
Willow Flycatcher			
Brighton	Sympatric	11	2
Montreal	Sympatric	7	2
Alder Flycatcher			
Brighton	Sympatric	13	0
Montreal	Sympatric	11	0
Mont-Tremblant	Allopatric	12	3
St-Jean-Vianney	Allopatric	11	4
Various[b]	Allopatric	37	13

[a] Coordinates of locations are given in Seutin (1987).

[b] Specimens from various locations in Quebec (some females were taken in Ontario) more than 300 km north of the zone of sympatry; no location was represented by more than six individuals so the group could not be subdivided by precise locality.

specimens to derive his equation and to evaluate its efficiency, and almost 30 yr later, the equation still has not been appropriately evaluated. Recent reference to Stein's equation (De Smet and Conrad 1988, Hussell 1990, Pyle et al. 1987) prompted me to test it using series of song-identified specimens of both species from an area of sympatry in eastern Canada, and eastern Canadian specimens of allopatric Alder Flycatchers that were either identified by song or collected several hundred km north of the zone of contact. The results cast doubts on the usefulness of Stein's formula.

MATERIALS AND METHODS

Samples included in the analysis are described in Table 1. Specific identification of all sympatric specimens was established by a playback experiment (Seutin 1987). Allopatric Alder Flycatcher samples included specimens collected by the author and identified by song (Mt-Tremblant and St-Jean-Vianney samples), and specimens from eastern Canada (housed at the Canadian Museum of Nature, Ottawa) which were collected more than 300 km north of the zone of sympatry (Table 1). All specimens included in the analysis were adults, taken in June or July, with moderately worn plumages typical of summer and early fall birds.

All measurements were taken by the author with dial calipers to the nearest 0.1 mm. Bill measurements were taken according to Stein (1963) from the anterior edge of the nostril to the tip. Lengths of primaries 4–10 were independently measured from the bend of the folded wing. Formula I was calculated, following Stein (1963), as:

$$I = (\text{longest P} - P6) - (P5 - P10),$$

where P stands for length of a primary and the number indicates which primary, counted from the most internal one. Hussell (1990) presents another method to calculate I that may be more practical for persons

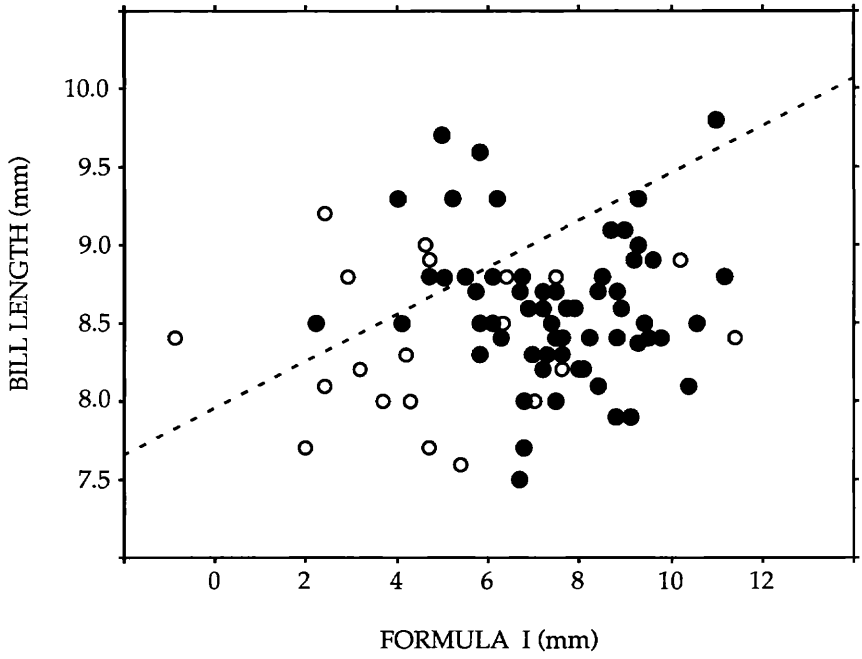

FIGURE 1. Distribution of allopatric specimens of the Alder Flycatcher in the bivariate space of bill length and wing formula I. The dotted line (bill length = 7.95 + 0.15I) represents the boundary between the Alder and Willow flycatchers as defined by Stein's (1963) equation. ● = males; ○ = females.

handling live birds. The formula as presented in Pyle et al. (1987) is incorrect.

Stein's (1963) equation for identifying the two species is:

$$X = 7.95 + 0.15I - \text{bill length}.$$

Willow Flycatchers are characterized by negative values of X, and Alder Flycatchers by positive values.

Proportions of correctly identified specimens were analyzed statistically using log likelihood ratio tests (*G*-tests) with Williams' correction as recommended by Sokal and Rohlf (1981). Equiprobable population ellipses were calculated following Sokal and Rohlf (1981).

RESULTS

The distribution of allopatric Alder Flycatcher specimens in the plane defined by bill length and formula I is shown in Figure 1. The majority of specimens were correctly identified (i.e., fell under the line), but a fair number (15/80) were not. The percentage of correctly identified females (75.0%) is lower than the equivalent percentage for males (83.3%), but the difference is not statistically significant ($G = 0.652$, $P = 0.405$).

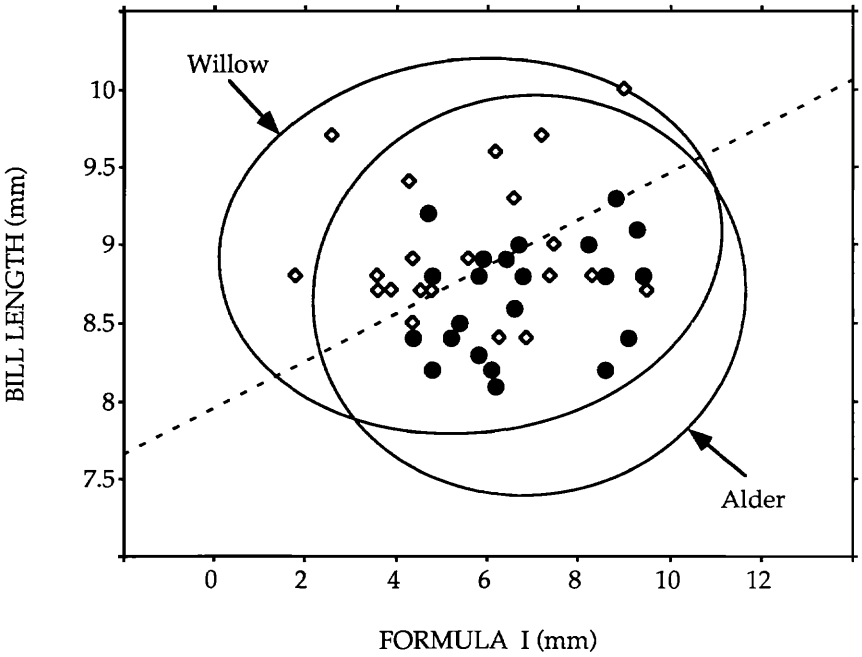

FIGURE 2. Distribution of sympatric specimens of Alder and Willow flycatchers in the bivariate space of bill length and wing formula I. The ellipses enclose the area where 95% of the population of individuals represented by the samples should probabilistically be found. The dotted line (bill length = 7.95 + 0.15I) represents the boundary between the species as defined by Stein's (1963) equation. ● = Alder Flycatchers; ◇ = Willow Flycatchers.

Figure 2 presents, in the same space, the distribution of specimens collected in the zone of sympatry. The 95% equiprobable population ellipses for the two species are plotted. These ellipses comprise 95% of the population of individuals represented by the samples, i.e., eastern Canadian sympatric Willow and Alder flycatchers. The extensive overlap of the ellipses indicates the similarity of the species in bill length and wing formula I. The proportion of sympatric Willow Flycatchers that was correctly identified using Stein's formula (15/22) was not statistically different from 50% (i.e., what would be expected by randomly allocating half the specimens to each species; $G = 2.911$, $P = 0.088$). The proportion of correctly identified sympatric Alder Flycatchers was higher (19/24) and significantly different from 50% ($G = 8.530$, $P = 0.004$). Table 2 summarizes the proportion of specimens of each type correctly identified using Stein's equation.

DISCUSSION

The identification of non-singing empidonaces usually is difficult (Phillips et al. 1966), especially for the sibling species Alder and Willow

TABLE 2. Percentages of Willow and Alder flycatchers correctly identified using the formula proposed by Stein (1963).

	% correct males	% correct females	% correct both sexes
Willow Flycatcher			
Sympatric	61.1	100.0	68.2
Alder Flycatcher			
Sympatric	79.2	—	79.2
Allopatric	83.3	75.0	81.2

flycatchers. Early work by Stein (1963) suggested that the species could be reliably identified using measurements of bill length and wing formula I. My results indicate that Stein's (1963) formula allows the correct identification of a smaller proportion of individuals than what Stein originally reported (90.6%). Approximately 80% of allopatric and sympatric Alder Flycatchers from Ontario and Quebec were correctly identified, but for sympatric Willow Flycatchers, the proportion of correct identifications was less than 70%. Statistically, this last proportion was not different from that obtained by randomly allocating half the specimens to each species; it could become significantly different with larger sample sizes, but my results still indicate the unreliability of Stein's equation with sample sizes typically used in modern systematic investigations. Figures 1 and 2 show that wrongly identified specimens are not necessarily found in the proximity of the line separating the species according to Stein (1963).

The existence and pattern of geographic variation in bill and primaries lengths have not been properly documented in either the Willow or Alder flycatchers. It is possible that in certain regions, Stein's (1963) equation will provide a better separation of the species than in my samples. The very extensive overlap between the population ellipses in my sympatric samples (Fig. 2), however, suggests that good separation might actually never be reached. Further, if geographic variation exists, defining a single identification function applicable over the broad distribution range of the species simply might not be possible.

In conclusion, I do not recommend using Stein's formula for the specific identification of Traill's flycatchers, even when one's focus is on population studies and not on identifying individual specimens (cf. Hussell 1990). A method for the morphometric identification of Traill's Flycatchers would be very useful to the study of their migrations and population dynamics. Unfortunately, critical samples needed to develop such a tool do not exist; the vast majority of specimens presently available in museums were not identified by song before being collected, and there are no appropriate samples from some important areas.

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LITERATURE CITED

BARLOW, J. C., AND W. B. MCGILLIVRAY. 1983. Foraging and habitat relationships of the sibling species Willow Flycatcher (*Empidonax traillii*) and Alder Flycatcher (*E. alnorum*) in southern Ontario. Can. J. Zool. 61:1510–1516.

DE SMET, K. D., AND M. P. CONRAD. 1988. First documented nesting record and status of the Willow Flycatcher in Manitoba. Blue Jay 46:149–154.

HUSSELL, D. J. T. 1990. Implication of age-dependent bill length variation in *Empidonax* for identification of immature Alder and Willow flycatchers. J. Field Ornithol. 61: 54–63.

KROODSMA, D. E. 1984. Songs of the Alder Flycatcher (*Empidonax alnorum*) and Willow Flycatcher (*Empidonax traillii*) are innate. Auk 101:13–24.

LEGRAND, H. E. 1979. Comments on the call notes of Alder and Willow Flycatchers. Chat 43:66.

PHILLIPS, A. R., M. A. HOWE, AND W. E. LANYON. 1966. Identification of the flycatchers of eastern North America, with special emphasis on the genus *Empidonax*. Bird-Banding 37:153–171.

PYLE, P., S. N. G. HOWELL, R. P. YUNICK, AND D. F. DESANTE. 1987. Identification guide to North American passerines. State Creek Press, Bolinas, California. 283 pp.

SEUTIN, G. 1987. Female song in Willow Flycatchers (*Empidonax traillii*). Auk 104:329–330.

———, AND J. P. SIMON. 1988. Genetic variation in sympatric Willow Flycatchers (*Empidonax traillii*) and Alder Flycatchers (*E. alnorum*). Auk 105:235–243.

SOKAL, R. R., AND F. J. ROHLF. 1981. Biometry, 2nd ed. W. H. Freeman, San Francisco, California. 859 pp.

STEIN, R. C. 1958. The behavioral, ecological and morphological characteristics of two populations of the Alder Flycatcher, *Empidonax traillii* (Audubon). N.Y. State Mus. Sci. Serv. Bull. No. 371.

———. 1963. Isolating mechanisms between populations of Traill's Flycatchers. Proc. Amer. Philos. Soc. 107:21–50.

ZINK, R. M., AND B. A. FALL. 1981. Breeding distribution, song and habitat of the Alder Flycatcher and Willow Flycatcher in Minnesota. Loon 53:208–214.

———, AND N. K. JOHNSON. 1984. Evolutionary genetics of flycatchers. I. Sibling species in the genera *Empidonax* and *Contopus*. Syst. Zool. 33:205–216.

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