The Pocket Computer: A New Tool For Identifying Eastern *Empidonax* Flycatchers in the Hand

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Abstract.

We measured six morphological characters on 85 study skins of four eastern *Empidonax* species. Analysis of this calibration data set yielded linear discriminant functions which we used to construct an identification procedure. We implemented this procedure in BASIC and programmed an inexpensive pocket computer for use in the field. We tested the procedure on 78 additional *Empidonax* study skins. Our procedure correctly identified 96 percent of the specimens.

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The genus *Empidonax* is a group of morphologically similar flycatchers characterized by small size, brownish-green plumage, pale wingbars and eye-rings. This group presents a notoriously difficult identification problem when vocal and behavioral clues are lacking. Phillips et al. (1966) developed a dichotomous key to the eastern *Empidonaces* that has been widely used. However, there are serious drawbacks to using a dichotomous key with any group in which the ranges of measured characteristics exhibit large overlap. Furthermore, the Phillips key includes choices based on color, a subjective characteristic that varies with the available light and the perception of the observer.

Wood (1969) compiled notes from Robbins (1959) into a trichotomous key which omitted from consideration measurements in the overlap zone. Phillps and Lanyon (1970) acknowledged the inadequacy of dichotomous and trichotomous keys for *Empidonaces* and suggested a better approach would be the simultaneous consideration of several characters in the identification of these flycatchers.

MacBriar (1968) adapted the Phillips key into a comparative chart which led the user to simultaneous consideration of multiple characteristics. Pyle et al. (1987) extended the concept of consideration of multiple characteristics by presenting identification criteria in tabular form.

Each of these methods has a drawback in that the statistical distributions of the measurements are neglected. For example, Pyle et al. (1987) gives the tail length range in *E. flaviventris* as 46-55 mm. All values within this range are given equal weight, while statistically possible values outside this range are given no consideration.

Sophisticated statistical analyses for classifying individuals into groups by considering a suite of characters have been available since Fisher (1936). Until recently, however, application of these methods has been restricted to mainframe computers. We present here a statistical approach to in-hand identification of eastern *Empidonaces* which can be implemented on an inexpensive pocket computer.

Materials and Methods

We measured study skins of Yellow-bellied Flycatcher (*E. flaviventris*), Acadian Flycatcher (*E. virescens*), Least Flycatcher (*E. minimus*), Alder Flycatcher (*E. alnorum*), and Willow Flycatcher (*E. traillii*). Alder and Willow Flycatchers were grouped as Traill's Flycatcher in our analysis. Our justification for lumping Alder and Willow is their close morphological similarity. In addition, the Bird Banding Laboratory will not accept differentiation of these species outside their breeding range (Klimkiewicz 1988). We used a calibration data set of 85 individuals consisting of 22 Acadian, 13 Traill's, 10 Yellow-bellied, and 40 Least Flycatchers.

We measured wing chord, primary extension, bill length (culmen), bill width, tail length, and 6th primary emargination. All measurement procedures are as described in Pyle et al. (1987), except that primary extension is as described in Whitney and Kaufman (1985). Bill length, bill width, and primary extension were measured to the nearest 0.01 mm using digital calipers. Wing chord and tail length were measured with a metric rule to the nearest millimeter. Emargination of the sixth primary was scored as 1 if feather was emarginated and 2 if the feather was not emarginated. Even though we used digital calipers in our work, we found that measurements to 0.01 mm were not necessary and that inexpensive plastic calipers were suitable.

Analysis of Calibration Data

Measurements were coded into a fixed-length ASCII data file on an IBM-AT running Microsoft™ DOS v.3.1. Calibration data were analyzed using the DISCRIM procedure from the SAS/STAT™ package for personal computers (SAS Institute, Inc., 1985). Multivariate normality was assumed. Simple statistics (Table 1), linear discriminant functions, generalized squared distances between groups, and posterior probabilities of membership in each group were calculated.

Results

The generalized squared distances (Table 2), based on the six characters measured, revealed that the Least and Yellow-bellied Flycatchers are morphologically very similar. Acadian and Traill's also display close similarity. Least and Acadian Flycatchers exhibited the greatest generalized squared distance (least similarity). A small distance indicates a high degree of overlap in the characters whereas a large distance means little overlap.

Analysis of the calibration data yielded the following four discriminant equations:

Least=
$(4.452a)-(0.990b)+(31.656c)+(38.102d)+(6.698e)+(35.839f)-543.43$

Acadian=
$(4.170a)+(1.938b)+(7.179c)+(52.325d)+(6.819e)+(57.542f)-818.671$

Yellow-Bellied=
$(4.715a)+(0.635b)+(36.748c)+(44.708d)+(5.489e)+(40.044f)-593.403$

Traill's=
$(4.899a)-(0.440b)+(42.405c)+(45.929d)+(7.032e)+(51.597f)-750.081$

a = wing chord
b = primary extension
c = bill length
d = bill width
e = tail length
f = 6th primary emargination

(1 if cut out, 2 if not)

Using these equations, it is possible to classify unknown eastern *Empidonaces*.

Using the Method

Classification of an unknown specimen is accomplished in a few steps: 1) take the six measurements; 2) calculate the value of each of the four discriminant equations, noting which equation yields the largest value; and 3) assign the individual to the species which yielded the largest value. Posterior probabilities of an individual belonging to a group are calculated following the method of Truett, Cornfield, and Kannell (1967). A simple BASIC program written for the Tandy™ PC-4 pocket computer automates these steps and is listed in the appendix.

Testing the Method

In order to blind test the procedure on an unknown set of *Empidonax* flycatchers, we measured 36 study skins from the Dallas Museum of National History (DMNH) and 42 study skins from the Warren M. Pulich collection housed at the University of Dallas, for a total of 78 skins. Most of these specimens had been previously examined and identified by A. R. Phillips, an accepted expert.

Under the assumption that prior classification of all skins was correct, the pocket computer program correctly identified 32 skins from the DMNH collection and 39 from the Pulich collection or 71 out of 78 specimens (91 percent).

Four skins in the DMNH collection very likely had been misclassified. Specimen #6698 tagged as *E. minimus* was identified using our procedure as *E. alnorum* /*E. traillii* with 99.92% probability. Specimens #3767 and #3795 were tagged as *E. minimus* and were identified using our procedure as *E. alnorum* /*E. traillii* with 99.99% probability. Specimen #5034 tagged as *E. flaviventris* was identified using our procedure as *E. minimus* with 99.94% probability. These four skins had not been examined by Phillips. In addition, we classified these questionable skins using methods described in Pyle et al. (1987). The Pyle method also suggested that these four skins were misidentified.

Assuming four skins from the DMNH were misclassified, and therefore should be excluded from the blind test, our method correctly identified 71 of 74 specimens, or 96 percent.

Discussion

The method described here applies modern computer technology to an important ornithological field identification problem. Our method is robust owing to the clear separation of individuals along multivariate axes. Figure 1 shows all study skins plotted on the first two canonical axes and no overlap is present.

The PC-4 hand-held computer is small, lightweight, and inexpensive. The PC-4 can compute the values of the discriminant equations in less than a second. Using the PC-4 and our method, the bander can correctly identify the eastern *Empidonax* Flycatchers in the hand with speed and accuracy.

Even though we used expensive digital calipers to make some of the measurements, we found that our method is very robust. Rather large errors in one or more measurements can be tolerated without affecting the identification. For example, errors as large as 1 cm in the wing chord measurement will not change the classification of the average Traill's Flycatcher if the other five measurements are accurate. Likewise, a five percent error in all six measurements can be tolerated. However, bill length, bill width, and primary extension should be measured within 0.1 mm.

This method has not been extensively tested with live birds. However, it is known that study skins undergo shrinkages smaller than the tolerances in measurements allowed by our method. We stress that banders should use our method in conjunction with older methods until it is proven on live birds in the field.

Summary

In a blind test, our method was able to correctly identify 96% of a group of unidentified eastern *Empidonax* flycatchers based on only six morphological characters. Our method and an inexpensive hand-held computer will allow a bander to correctly and quickly identify most of the *Empidonaces* encountered in the eastern United States.

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Table 1. Mean (and standard deviation) for six measurements used to discriminate four Empidonax species.

	Traill's	Yel-Bel	Least	Acadian
Wing chord	69.94(2.54)	64.25(2.90)	61.64(2.83)	71.17(2.28)
Primary ex.	13.76(1.85)	14.99(1.54)	11.59(1.90)	18.60(1.74)
Bill length	9.04(0.52)	7.95(0.19)	7.32(0.43)	9.42(0.48)
Bill width	5.74(0.29)	5.40(0.30)	4.86(0.33)	6.22(0.33)
Tail length	61.02(1.02)	53.32(2.39)	55.27(2.54)	61.34(2.12)
P6 emargin.*	1.69(0.48)	1.20(0.42)	1.03(0.16)	2.00(0.00)

*P6 emargination was coded as 1 if evidence of emargination was present and 2 if no evidence of emargination was present. For example, Least Flycatcher had the highest frequency of P6 emargination as indicated by a value of 1.03 and Acadian Flycatcher had the lowest frequency with a value of 2.0. A value of 2.0 means all were without P6 emargination.

Table 2. Generalized squared distances between groups (a measure of morphological similarity).

	Traill's	Yel-Bel	Least	Acadian
Traill's	0			
Yel-Bel	26.53	0		
Least	42.72	16.06	0	
Acadian	17.34	47.48	92.04	0

COMPUTER PROGRAM -- EMPIDONAX IDENTIFICATION
(Only for TANDY PC-4)

```
5 INPUT "WC = ",A
10 INPUT "PE = ",B
15 INPUT "BL = ",C
20 INPUT "BW = ",D
25 INPUT "TL = ",E
30 INPUT "P6 = ",F
35 G=A*4.452-B*.99+C*31.656+D*38.102+E*6.698+F*35.836-543.43
40 H=A*4.17+B*1.938+C*47.279+D*52.325+E*6.82+F*47.742-
        818.671
45 I=A*4.715+B*.635+C*36.748+D*44.708+E*5.489+F*40.044-
        593.403
50 J=A*4.899-B*.44+C*42.405+D*45.929+E*7.032+F*51.597-
        750.081
55 L=G
60 IF H>L THEN L=H
65 IF I>L THEN L=I
70 IF J>L THEN L=J
75 IF G=L THEN PRINT "LEAST"
80 IF H=L THEN PRINT "ACADIAN"
85 IF I=L THEN PRINT "YEL BELLD"
90 IF J=L THEN PRINT "TRAILL"
95 P=(1/( EXP(G-L)+ EXP(H-L)+ EXP(I-L)+ EXP(J-l))*100
100 PRINT "PRB = "
110 $= STR$(P)
125 PRINT MID$(1,5)
130 GOTO 5
```