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INTERPRETING DIFFERENTIAL TIMING OF CAPTURE OF SEX CLASSES DURING SPRING MIGRATION

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Abstract.—Yunick (1988) reported a difference in the timing of spring migration between male and female Dark-eyed Juncos (*Junco hyemalis*) in eastern New York. However, data on the differential timing of passage at sites along migration routes are ambiguous with respect to whether the sexes actually differ in onset or rate of migration. This is particularly true if, as in juncos, the sexes have different wintering grounds. Ambiguity in this type of data can be minimized if observed timing of passage is compared to an expected sequence based on the known distribution of the sexes prior to migration. Using published data on the winter distribution of juncos we predicted the timing of passage in eastern New York assuming identical onset, rates, and routes of migration between the sexes and compared this prediction to the timing of passage observed by Yunick. Analyzed in this manner, Yunick's (1988) data were less ambiguous and supported inferences about the onset and rate of migration in Dark-eyed Juncos.

INTERPRETACIÓN DE LA DIFERENCIA EN EL PERIODO DE TIEMPO DE CAPTURA DE INDIVIDUOS DE DIFERENTE SEXO DE *JUNCO HYEMALIS* DURANTE LA MIGRACIÓN PRIMAVERAL

Sinopsis.—Yunick (1988) informa diferencias en el periodo de tiempo de la migración primaveral de machos y hembras de *Junco hyemalis* en el este de Nueva York. Sin embargo, los datos en relación al momento particular en que estas aves pasan por localidades específicas a lo largo de las rutas migratorias son ambiguos con respecto a si aves de diferente sexo difieren en el comienzo o velocidad de migración. Esto es particularmente cierto, como en los juncos, si los sexos difieren en los lugares en donde pasan el invierno. La ambiguedad en este tipo de datos puede ser minimizada si se compara el momento particular de pasada con una secuencia esperada, basada en la distribución particular de los sexos previo a la migración. Utilizando la literatura en referencia a la distribucion de los juncos durante el invierno, hemos podido predecir el momento particular de pasada de estas aves por la parte este de Nueva York, asumiendo un idéntico comienzo, velocidad y rutas de migración para aves de ambos sexos y comparando nuestra predicción con el momento de pasada informado por Yunick. Al analizar de esta manera los datos de Yunick (1988), estos resultan ser menos ambiguos y apoyan las inferencias sobre el comienzo y velocidad de migracion de *Junco hyemalis.*

Yunick (1988) provided evidence for differential timing of spring migration between male and female Dark-eyed Juncos (*Junco hyemalis*) at Schenectady in eastern New York. His analysis demonstrated that the percentage of males among juncos captured at this site declined signifi-

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cantly through the spring migration, suggesting that males pass earlier than females. However, it is unclear from Yunick's analysis in particular, and from studies of differential timing in general, what inferences about the timing of migration can legitimately be drawn from data such as these. We discuss how differences in the spatial distribution of the sexes may complicate the interpretation of differential timing, reevaluate Yunick's (1988) data in light of this discussion, and show the circumstances under which data such as his will support inferences about intersexual differences in the onset or rate of migration. Although our discussion is limited to differential migration of sexes, it is applicable to age classes as well.

Inferences about intersexual differences in the timing of migration are usually drawn from detection of a differential timing of passage by the sexes at sites along the migration route (e.g., Francis and Cooke 1986, Hussell 1981, Johnson 1965, Nolan and Mumford 1965, Yunick 1988). Differential timing of passage, however, may stem from three distinct causes: differential onset of migration, differential rate of travel, and/or differential geographic origin of the sexes. The ability to draw inferences about the onset or the rate of migration depends on knowledge of the spatial (geographic) distribution of the sexes within the population that gives rise to a sample of migrants. Only if the sexes have identical distributions will differential timing of passage unequivocally reflect differences in the onset or rate of migration. For example, during the fall migration the sexes are moving away from breeding grounds where they presumably had similar geographic distributions. Assuming similar migration routes for the sexes, detection of differential timing of passage at sites south of the breeding grounds should accurately reflect a difference in onset or rate of fall migration by the sexes.

The problem is more complicated with respect to spring migration, however, because it cannot be assumed that the winter distributions of the sexes are similar. During spring migration, because the sexes may be departing from significantly different wintering grounds (review by Gauthreaux 1982), identical onset and rate of migration between the sexes may still result in differential timing of passage at migration sites. Accordingly, the simple documentation of differential passage does not permit conclusions about differential rate or onset. To draw such conclusions would require a statistical comparison of observed timing of passage with an expected sequence based on the known distribution of the sexes prior to spring migration.

These points are relevant to Yunick's (1988) analysis because latitudinal segregation of the sexes in wintering Dark-eyed Juncos is well known (Ketterson and Nolan 1976, 1979, 1983, 1985). Yunick documents a significant decline in the percentage of males among juncos captured during the spring migration and concludes that there is a significant difference in the timing of passage in eastern New York with males preceding females. In the absence of additional analysis, however, it is not possible to make more general inferences about intersexual differences in the onset or rate of migration. Because male juncos tend to winter north of females, they would be expected to precede females during the spring migration even under conditions of identical onset and rate of migration. Thus, Yunick's documentation of differential passage is necessary, but not sufficient evidence to conclude that males begin migrating earlier and/or migrate faster.

Differential timing occurs only if male juncos precede females significantly more than expected based on their winter distribution. Yunick does observe that males are more common than expected early in the season (i.e., compared to the winter sex ratio of 63.3% males at his banding site), but this is not convincing evidence of differential timing for two reasons. First, sites at latitudes south of Yunick's banding station can have winter sex ratios close to 80% male (e.g., Dow 1966). If the first migrants detected by Yunick (1988) originated from such sites, he would observe an increase in the percentage of males at the beginning of migration even in the absence of differential timing. Second, even a large observed increase in males early in migration, in order to give rise to a compelling inference, requires a *statistical* test of a specific prediction about the expected temporal distribution of male and female juncos over the entire migration period.

Because the winter distribution of juncos has been studied thoroughly (Ketterson and Nolan 1976, 1979, 1983, 1985), data are available to make a prediction about the timing of spring migration in juncos. Yunick (1988) provides the data necessary for a statistical test of this prediction. For this test we first predicted the pattern of differential timing expected in male and female juncos if: 1) onset of migration is identical in the sexes, 2) the sexes migrate at equal rates, and 3) the sexes use similar migration routes. If this is true, the change in the percentage of males through the spring migration period in eastern New York should be approximately the same as the change in percentage of males with decreasing latitude on the wintering grounds south of New York. Using the distribution of sexes given by Ketterson and Nolan (1976, 1983) the percentage of males in wintering populations of juncos should range from 80% male in eastern New York to 30% male at the southern edge of the wintering grounds. We chose to use the Ketterson-Nolan data because they provide a general estimate of sex ratios over the entire winter range of juncos.

We can predict, under the assumptions outlined above, that samples of migrant juncos in eastern New York should be approximately 80% male at the onset of migration (the time interval 21–25 Mar.; Yunick 1988) and approximately 30% male at the last interval containing males (1–5 May; Yunick 1988). We then predicted a linear change in the percentage of males between these two extremes (the predicted regression was: % of males = 86.25 − 6.25 [time interval]; Fig. 1B). If there is no differential timing of migration, Yunick's (1988) results should not differ significantly from this line representing the timing of migration expected solely on the basis of geographic origin. The timing of migration observed by Yunick (1988) is qualitatively similar (males predominate early in the

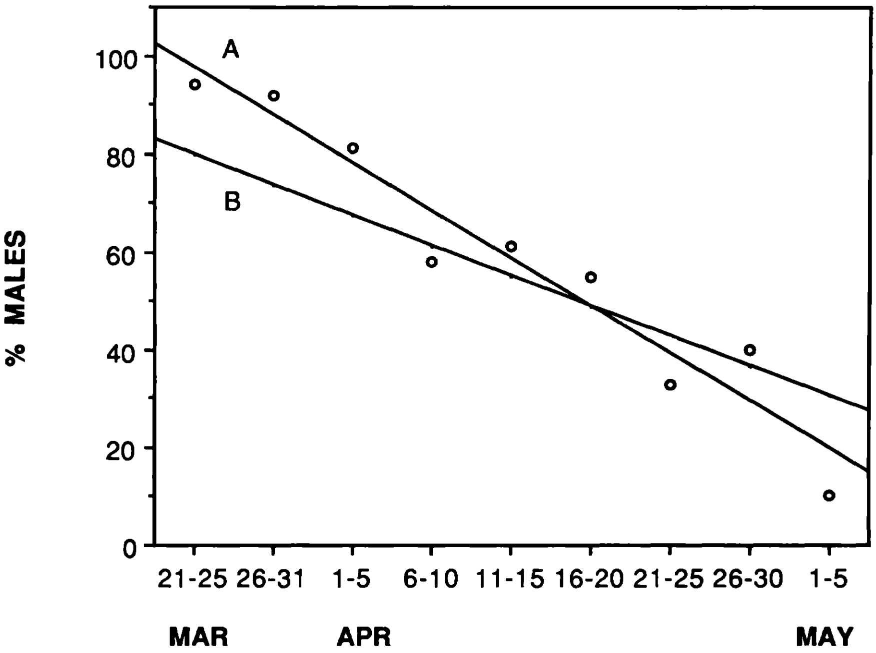

FIGURE 1. Percentage of males among Dark-eyed Juncos captured during five-day periods during spring migration in eastern New York. (A) Regression calculated from percentages observed (open circles) by Yunick (1988; his Fig. 1). (B) Percentages predicted based on similar onset, rates, and routes of migration between male and female juncos departing latitudinally-segregated wintering grounds (based on data in Ketterson and Nolan 1976, 1983).

season) to the prediction. However, using the data from Figure 1 in Yunick (1988) we recalculated the observed relationship between percentage of males and capture date (the regression was: % of males = 107.47 − 9.85 [time interval]; Fig. 1A) and tested whether this regression differs quantitatively from the prediction based on equal onset and rate of migration. The slope ($t = 3.557$, $P < 0.01$, one-tailed) and y-intercept ($t = 3.726$, $P < 0.01$, one-tailed) for Yunick's data are significantly greater than that expected under the assumptions that sexes of juncos have identical onset, rates, and routes of migration.

Yunick's data support an even stronger hypothesis about differential timing than his original analysis. Male juncos migrate through eastern New York earlier than females even after accounting for differences in distribution on the wintering grounds. We can now (if we maintain our assumption of similar migration routes) argue with some conviction that male juncos initiate migration sooner than females, migrate at faster rates than females, or both. Although intersexual differences in winter distribution may not be relevant for all migrants (e.g., wood warblers; Francis and Cooke 1986), these differences are widespread in birds (Gauthreaux 1982). For species in which winter distributions are known with some precision, data on the differential timing of passage can be analyzed in ways that will minimize ambiguity and allow inferences about other components of differential timing.

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LITERATURE CITED

DOW, D. D. 1966. Sex determination of Slate-colored Juncos by means of plumage characteristics. Ont. Bird Banding 3:1–14.

FRANCIS, C. M., AND F. COOKE. 1986. Differential timing of spring migration in wood warblers (Parulinae). Auk 103:548–556.

GAUTHREAUX, S. A., JR. 1982. The ecology and evolution of avian migration systems. Pp. 93–168, *in* D. S. Farner, J. R. King, and K. C. Parkes, eds. Avian biology, Vol. 6. Academic Press, New York.

HUSSELL, D. J. T. 1981. Migrations of the Least Flycatcher in southern Ontario. J. Field Ornithol. 52:97–111.

JOHNSON, N. K. 1965. Differential timing and routes of the spring migration in the Hammond's Flycatcher. Condor 67:423–437.

KETTERSON, E. D., AND V. NOLAN, JR. 1976. Geographic variation and its climatic correlates in the sex ratio of eastern-wintering Dark-eyed Juncos (*Junco hyemalis*). Ecology 57:679–693.

———, AND ———. 1979. Seasonal, annual, and geographic variation in sex ratio of wintering populations of Dark-eyed Juncos (*Junco hyemalis*). Auk 96:532–536.

———, AND ———. 1983. The evolution of differential bird migration. Curr. Ornithol. 1:357–402.

———, AND ———. 1985. Intraspecific variation in avian migration: evolutionary and regulatory aspects. Pp. 553–579, *in* M. A. Rankin, ed. Migration: mechanisms and adaptive significance. Univ. Texas Contrib. Marine Sci. Suppl. 27.

NOLAN, V., JR., AND R. E. MUMFORD. 1965. An analysis of Prairie Warblers killed in Florida during nocturnal migration. Condor 67:322–338.

YUNICK, R. P. 1988. Differential spring migration of Dark-eyed Juncos. J. Field Ornithol. 59:314–320.

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