DEMOGRAPHIC CHARACTERISTICS OF DICKCISSELS IN WINTER

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Abstract. Populations of breeding Dickcissels (*Spiza americana*) have declined in North America by 40 percent since 1966. One proposed explanation for this decline is female-biased mortality during the nonbreeding season, resulting in a male-dominated breeding population that produces too few offspring to replace annual losses. We tested this hypothesis by examining Dickcissel sex ratios on the species' central wintering grounds in Venezuela. The overall mean sex ratio of 1.53 males per female differed significantly from 1:1. Although the Dickcissel population was male dominated, sex ratios were not sufficiently skewed to support the hypothesis of female-biased mortality in the non-breeding season. The sex ratio of juveniles, which was also skewed in favor of males, appeared to be determined prior to the juveniles' arrival in Venezuela and not by differential survival during winter. These data, combined with other observations, including the absence of female starvation in Venezuela, appear to indicate that Dickcissels have not undergone major demographic changes since the late 1960s.

LAS CARACTERÍSTICAS DEMOGRÁFICAS DEL ARROCERO AMERICANO EN EL INVIERNO

Sinopsis. Las poblaciones del Arrocero Americano (*Spiza americana*) en reproducción han dismi-nuido en América del Norte en un 40 por ciento desde 1966. Una explicación sugerida para esta disminución es la mortalidad sesgada en las hembras durante la estación no reproductiva, lo que ha resultado en una población reproductiva dominada por machos que produce insuficientes progenies para reemplazar las pérdidas anuales. Comprobamos esta hipótesis examinando las proporciones de sexos en el Arrocero Americano en los terrenos invernales centrales de la especie en Venezuela. La proporción promedio total de sexos de 1,53 machos por cada hembra se diferenció significativamente de 1:1. Aunque la población del Arrocero Americano fue dominada por los machos, las proporciones de sexos no fueron lo suficientemente desiguales para probar la hipótesis de mortalidad sesgada en las hembras durante la estación no reproductiva. La proporción de sexos de los jóvenes, también sesgada a favor de los machos, parecía existir antes de la llegada de los jóvenes a Venezuela y no debido a una sobrevivencia diferencial durante el invierno. Estos datos, en combinación con otras observaciones, entre ellas la ausencia de inanición de las hembras en Venezuela, parecen indicar que los Arroceros Americanos no han experimentado mayores cambios demográficos desde fines de los años 60.

Key Words: Dickcissel; mortality; population demographics; sex ratio; *Spiza americana.*

Populations of breeding Dickcissels (*Spiza americana*) in North America have declined 40% since 1966 (Sauer et al. 1996). One proposed explanation for this decline is female-biased mortality during the nonbreeding season, result-ing in a male-dominated breeding population that produces too few offspring to replace an-nual losses (Fretwell 1977, 1986). The proposed mechanism for this female-biased mortality fo-cuses on the Dickcissel's granivorous winter diet and how the species' diet and survival have been affected by changes in agricultural practices on the winter range.

Because male Dickcissels are larger than fe-males, Fretwell (1986) hypothesized that males are better suited to feed on large-seeded culti-vated grains such as rice (*Oryza sativa*) and sor-ghum (*Sorghum vulgare*). Increased production of rice and sorghum throughout the Dickcissel's winter range therefore may have created more food for males but not for females. To support these ideas, Fretwell (1986) presented evidence for sex-specific foraging strategies and a sex ra-tio severely skewed in favor of males.

Previous estimates of the population-level sex ratio of the Dickcissel were derived from mist-net samples of wintering birds in Trinidad (ffrench 1967) and from breeding-colony cen-suses in North America (Fretwell and Calver 1970). These two estimates were obtained using different techniques and therefore are not com-pletely comparable. Both estimates may be bi-ased. The population in Trinidad may not rep-resent the entire winter population because it is on the fringe of the winter range (Fretwell 1986). And estimating sex ratios during the breeding season is complicated by several fac-tors, including detectability differences between the sexes (females are more cryptic than males) and differing degrees of polygyny throughout the range (Zimmerman 1966).

We think a more appropriate estimate of the Dickcissel's sex ratio can be obtained on the species' central wintering grounds in the Vene-

zuelan llanos. The agricultural regions of the Venezuelan llanos harbor most of the world's Dickcissels during the nonbreeding season (Basili 1997). Dickcissels congregate and form large communal roosts that sometimes comprise millions of birds. From 1990 through 1993, and briefly in 1995, we obtained demographic information on Dickcissel populations in Venezuela from November through April. Most of these data were obtained with the same methods employed by ffrench (1967) in Trinidad, allowing us to make spatial and temporal comparisons between these sites and time periods.

We tested Fretwell's (1986) hypothesis that female-biased mortality during the nonbreeding season results in a male-dominated breeding population that ultimately produces too few offspring to replace annual losses. We examined whether several predictions consistent with this hypothesis, such as the presence of underweight females in winter and changes in sex ratios, were supported. We also examined whether winter flocks of Dickcissels in Venezuela were substructured based on sex, age, or breeding location, as is the case in some other migratory passerines (e.g., White-crowned Sparrow [*Zonotrichia leucophrys*; King et al. 1965] and Dark-eyed Junco [*Junco hyemalis*; Ketterson and Nolan 1976]).

METHODS

STUDY AREA

Field research was conducted in 1990–1993 and 1995 in the center of the Dickcissel's winter range on the central llanos of Venezuela (Friedmann and Smith 1955, Basili 1997). The llanos that surround the Orinoco River constitute the largest neotropical savanna north of the equator (Sarmiento 1984). Historically, Dickcissels were distributed widely throughout these llanos, but since the early 1950s a changing agricultural landscape has altered the species' winter distribution. Presently the Dickcissel's center of abundance in winter occurs in farmland in the Venezuelan states of Portuguesa (southeast of the city of Acarigua) and Guárico (south of the city of Calabozo), where approximately 6 million individuals can be found (Basili and Temple 1999). By day Dickcissels forage in large flocks (10,000+ individuals), and at night they come together to roost in even larger aggregations (Basili and Temple 1995). Roost sizes vary from several thousand to several million individuals. From 1990 through 1993 we identified 19 different nocturnal roosts. We collected most of our demographic data at 17 of these roosts. We also sampled the structure of populations at feeding sites and at daytime roosts.

DATA COLLECTION

We obtained demographic data for Dickcissels in Venezuela primarily from mist-net samples. The roosting behavior of Dickcissels greatly facilitates their capture in mist nets. Large numbers of birds were caught at nocturnal roosts by placing 12-m mist nets to intercept birds moving within the roost. Sugarcane (*Saccharum officinarum*) fields, where most Dickcissels roosted, were usually criss-crossed with service roads that provided ideal lanes for net placement. Nets were open in the evenings from the time birds first started arriving until dusk, a period of about 90 min. Morning operations lasted about 45 min, as birds departed from roosts more quickly than they arrived. After capture, birds were placed in holding cages and processed quickly (Bub 1991). We used only mist-net samples in our analysis because early comparisons of mist-net samples and direct observations in 1990–1991 demonstrated that direct observations produced consistently higher estimates of males (68%) than did mist-net surveys (58%; G = 18.35, df = 1, P < 0.001). The brightly colored males are probably easier to detect at long distances, thus biasing samples.

We recorded the sex, age, mass, and wing chord of each captured bird prior to banding it with a U.S. Fish and Wildlife Service aluminum band (size #1B) and releasing it. Dickcissels are sexually dimorphic and can be reliably sexed and aged by wing length and plumage (Pyle et al. 1987). Because they undergo a partial pre-basic molt on the wintering grounds, however, they cannot be reliably aged after February (ffrench 1967); therefore, we only present age data obtained before March of any year. Dickcissels were weighed to the nearest 0.5 g with a Pesola spring balance that was checked periodically for accuracy throughout the study. Wing chord was measured "unflattened," as described by Pyle et al. 1987.

DATA ANALYSIS

We used contingency tables and G-tests (Sokal and Rohlf 1995) to test for independence between observed sex ratios and those expected based on hypotheses of an even sex ratio (1:1) and a sex ratio heavily skewed in favor of males (5:1; Fretwell 1986). Heterogeneity in yearly sex-ratio data was tested using the additive properties of individual G-tests (G_{het} of Sokal and Rohlf 1995). We also used G-tests to test for independence between sex ratios obtained with different sampling methods and for independence of sex ratios and age ratios among years, roosts, and regions.

We used t-tests to compare same-sex mass between sampling periods, ages, and regions. We also used t-tests to compare wing chords between ages and regions. Differences in mass among roosts and years were tested with a one-way analysis of variance (ANOVA; Wilkinson 1992).

RESULTS

Mist-net data from Venezuela revealed a pattern in monthly variations in Dickcissel sex ratios that was similar to what ffrench (1967) observed in Trinidad; males were more abundant in December and less abundant in April because males arrived and departed from the wintering range before females (Fig. 1). To minimize the effect of this seasonal variation on estimates of sex ratios, we excluded December and April data from all of our analyses. Yearly sex ratios were determined from remaining data. In addition, we performed within-year comparisons
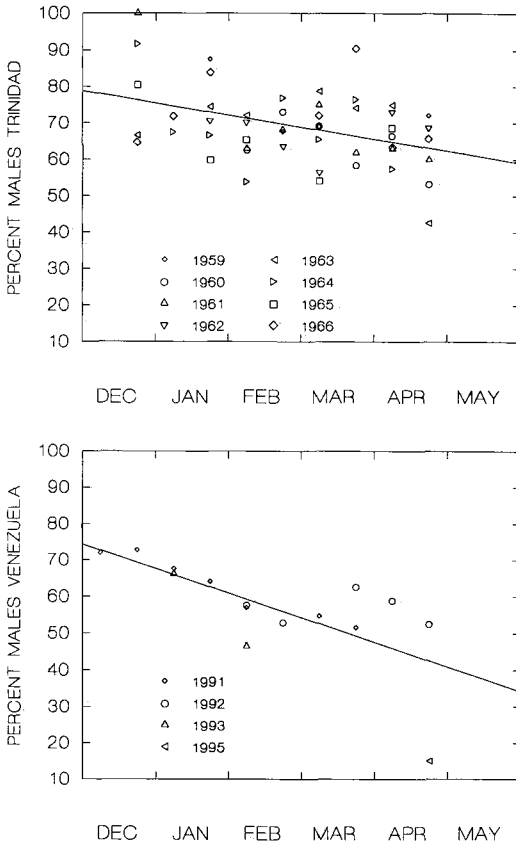
FIGURE 1. Seasonal change in the sex ratios of Dickcissels in Trinidad (N = 2,882; ffrench 1967) and Venezuela (N = 6,326).

only with data from the same 2-wk period, or when appropriate, from the same month.

How Skewed Are Dickcissel Sex Ratios?

The sex ratios of Dickcissels in Venezuela favored males (61%) and were significantly different from 1:1 (one-way G-tests, P < 0.001). Yearly estimates of males ranged from 58 to 65%. There was a mean sex ratio of 1.53 males per female. Although the Dickcissel population was male dominated, sex ratios were not sufficiently skewed to support Fretwell's (1977, 1986) hypothesis of five males per female (G = 1,654, df = 1, P < 0.001). In fact, we rejected the hypothesis of two males for every female (G = 98, df = 1, P < 0.001).

ffrench (1967) also observed a male-biased population of Dickcissels in Trinidad, where from 1959 to 1966 populations averaged 70% males. If Trinidad estimates were representative of the entire Dickcissel population, which is doubtful, and selection continued to operate

against females (Fretwell 1986), we would have expected the proportion of males in the population to have increased over the next three decades. Instead, there were significantly lower proportions of males in Venezuela in the early 1990s than in Trinidad in the 1960s (G = 58.84, df = 1, P < 0.001).

Dickcissel sex ratios in Venezuela were not, however, constant between years. In 1990–1991 and 1991–1992 we found 59 and 60% males, respectively; the 1992–1993 sample contained 65% males, accounting for the significant heterogeneity in the data (G_{het} = 14.63, df = 2, P < 0.001). Likewise, in Trinidad the data were heterogeneous (G_{het} = 42.24, df = 7, P < 0.001), indicating that sex ratios differed among years.

Is the Juvenile Population Dominated by Males?

The juvenile sex ratio in Venezuela did not favor males in 1990–1991 (43%; G = 2.116, df = 1, P > 0.1), but the sex ratios were different in 1991–1992 (66% male, P < 0.001) and 1992–1993 (60% male, P < 0.001). Consequently, juvenile male ratios differed among years (G = 21.06, df = 2, P < 0.001).

Throughout our study, mass of juveniles of each sex was similar to that of adults of the same sex, except in 1990–1991 when juvenile males weighed less than adult males (Table 1). In addition, the proportion of adults that were males in 1991–1992 (53%) was significantly smaller than in 1990–1991 (66%) or in 1992–1993 (67%; G = 44.18, df = 2, P < 0.001), possibly because of poor survival in the 1990–1991 male cohort.

We also examined whether the juvenile sex ratio in Venezuela changed as the season progressed by comparing sex ratios in 2-wk blocks. For all 3 yr, juvenile sex ratios remained constant (1990–1991: G = 3.232, df = 3, P = 0.357; 1991–1992: G = 0.804, df = 1, P = 0.370; 1992–1993: G = 0.719, df = 1, P = 0.396). Thus, the skewed sex ratio of young Dickcissels was likely determined prior to their arrival in Venezuela and not by differential survival during the winter.

How Have Age Ratios Changed?

In the early 1990s adults comprised 74% (range 71–76%) of the Dickcissel population in Venezuela. Differences among years were significant (G = 9.89, df = 2, P < 0.01). In Trinidad the proportion of adults was even more variable. From 1959 to 1966, adults comprised 73% (range 62–87%) of the population. The age structure in Trinidad also differed among years (G = 51.50, df = 7, P < 0.001; ffrench 1967). When data were combined into two time periods

TABLE 1. MEAN MASS OF JUVENILE AND ADULT DICKCISSELS WINTERING IN VENEZUELA

Year	Sex	Age	N	Mass (g) ± SD	P[a]
1990–1991	male	adult	381	28.50 ± 1.84	
		juvenile	75	27.64 ± 1.77	< 0.001
	female	adult	194	23.49 ± 1.50	
		juvenile	94	23.44 ± 1.48	0.785
1991–1992	male	adult	403	27.18 ± 1.79	
		juvenile	136	27.11 ± 1.59	0.686
	female	adult	363	22.55 ± 1.61	
		juvenile	75	22.41 ± 1.36	0.459
1992–1993	male	adult	24	28.16 ± 1.57	
		juvenile	31	28.04 ± 1.30	0.759
	female	adult	41	23.44 ± 1.47	
		juvenile	17	23.59 ± 1.50	0.731

Note: All measurements were obtained in Portuguesa between December and February.
[a] Within-sex t-test comparing adults and juveniles.

(e.g., the 1960s and 1990s), however, there was no significant difference in age structure between periods (G = 0.961, df = 1, P = 0.327).

ARE FEMALES STARVING IN VENEZUELA?

Evidence of starving females could be revealed in several ways. Their winter mass could be significantly lower than their breeding-season mass. Their mass could also decline during the winter while in Venezuela. In addition, females might have trouble depositing fat in preparation for the northward migration. If selection pressure is strongly sex specific, we would not expect similar trends in body mass of males. Therefore, we used male mass as a control.

To examine whether females were underweight in Venezuela, we compared mass recorded in the winter with that reported from the breeding season (Dunning 1993). Two-tailed t-tests revealed no significant differences in the seasonal mass of females ($t_{[2],1168}$ = 0.860, P > 0.2) or males ($t_{[2],1615}$ = 0.653, P > 0.05).

Because we lacked replicated data for all months during each year, and because the one month (February) sampled repeatedly in 1990–1991, 1991–1992, and 1992–1993 revealed no significant differences in the mean mass of females (ANOVA: $F_{[2,591]}$ = 1.535, P = 0.216) or males ($F_{[2,766]}$ = 2.206, P = 0.111) among years, we combined data across years to analyze change in mass over the winter in Venezuela. Trends in male and female mass were similar. Both sexes were heavier early in the season, followed by a period of lower but stable mass until late March. After March, Dickcissels become hyperphagic and rapidly gained mass in preparation for their northward migration. Females and males both increased their mass by 28% during the month of April.

Birds from different nocturnal roosts fed on different types of food because of regional differences in food availability (Basili and Temple 1999). Thus, we were interested in determining if mass varied among regions. The mass of females roosting in Portuguesa (23.00 ± 1.50 g), where rice and sorghum were cultivated, was not significantly different from the mass of females roosting in Guárico (23.25 ± 1.54 g), a predominately rice-growing region ($t_{[400]}$ = −1.46, P < 0.142). Males, however, were significantly heavier in Guárico (28.39 ± 1.74 g) than in Portuguesa (27.47 ± 1.71 g; $t_{[535]}$ = −5.34, P < 0.001).

ARE WINTER ROOSTS SUBSTRUCTURED BY SEX?

To determine whether males and females segregated themselves on the wintering grounds, which could influence sex-ratio estimates, we compared sex ratios at 17 of 19 nocturnal roosts located throughout the study area. Excluding the last half of April, when males had already started migrating north, males constituted a minority at only two roosts (48 and 46%). We never discovered a roost at which females heavily outnumbered males.

Because Dickcissels were concentrated in two agricultural regions of the Venezuelan llanos (Portuguesa and Guárico), and because food availability differed between these two regions, there could be demographic differences between birds occupying these areas. A comparison of roosts in Portuguesa and Guárico, however, revealed that sex ratios between regions did not differ (G = 0.188, df = 1, P = 0.664).

To evaluate whether sex ratios differed in foraging groups and in nocturnal roosts, we compared sex ratios of a nocturnal roost with sex ratios of one of its satellite daytime roosts. In late January 1991, the daytime roost had 68% males, which did not differ from the 61% males
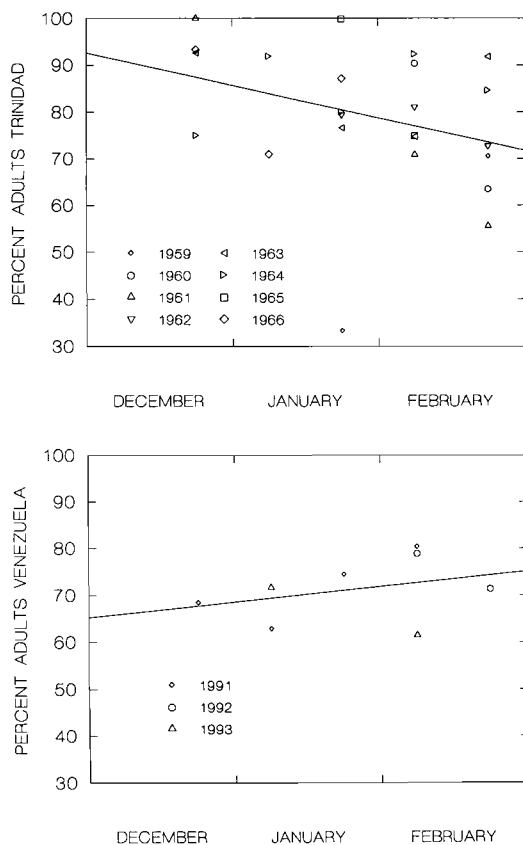
FIGURE 2. Seasonal change in the age ratios of Dickcissels in Trinidad (N = 1,309; ffrench 1967) and Venezuela (N = 3,519).

at the nocturnal roost (G = 2.59, df = 2, P = 0.11).

ARE WINTER ROOSTS SUBSTRUCTURED BY AGE?

We never found a roost in which the majority of birds were juveniles. It appears, at least in Venezuela, that young Dickcissels arriving on the central wintering grounds for the first time do not segregate themselves from the rest of the

population. We did find, however, that age structure varied by region and time. In February 1992 we found different proportions of juveniles in Portuguesa (19%) and Guárico (33%; G = 15.419, df = 1, P < 0.001). In addition, when plotting percent adults over time, it appears that in Trinidad adults arrived earlier than juveniles. This pattern was not observed in Venezuela, however (Fig. 2).

ARE WINTER ROOSTS SUBSTRUCTURED BY BREEDING LOCATION IN NORTH AMERICA?

Fretwell and Shane (1975) proposed that local populations of breeding Dickcissels may overwinter together in discrete subpopulations identifiable by variations in wing length; they presented evidence that birds breeding in Texas winter together in Guárico. Our comparisons of adult and juvenile wing lengths revealed significant age differences in both sexes (Table 2). When we compared adult wing lengths between regions, however, we found no regional differences (Table 2).

DISCUSSION

EVIDENCE FOR DIFFERENTIAL MIGRATION

Many species of nearctic and palearctic migratory passerines have differential migration patterns, depending on sex and age (e.g., Heydweiller 1936, Lack 1944, Balph 1975). For some species, such as Dark-eyed Junco (*Junco hyemalis*; Ketterson and Van Nolan 1976) and White-crowned Sparrow (*Zonotrichia leucophrys*; King et al. 1965), winter populations are segregated by sex, with females wintering farther south than males.

Dickcissels appear to exhibit differential sex migration on both their north- and southbound journeys. In both Venezuela and Trinidad, males were more numerous than females in the early stages of their "winter" residence (Fig. 1). Although differential migration was discernible in these data, we lack samples of the earliest birds arriving in Venezuela. To better understand this pattern, it would be useful to sample roosts in

TABLE 2. WING LENGTHS OF DICKCISSELS WINTERING IN THE VENEZULAN LLANOS, FEBRUARY 1992

| | Mean wing length (mm) ± SD (N) | |
Group	Males	Females
Adults	81.86 ± 2.01 (504)	74.16 ± 1.98 (453)
Juveniles	79.64 ± 1.93 (200)[a]	72.75 ± 1.61 (104)[b]
Portuguesa adults	81.93 ± 1.96 (406)	74.20 ± 1.96 (363)
Guárico adults	81.58 ± 2.22 (98)[c]	73.99 ± 1.98 (90)[d]

[a] T-test for mean wing length between adult and juvenile males ($t_{[702]}$ = 13.39, P < 0.001).
[b] T-test for mean wing length between adult and juvenile females ($t_{[555]}$ = 6.77, P < 0.001).
[c] T-test for mean wing length between adult males by region ($t_{[502]}$ = 1.54, P = 0.123).
[d] T-test for mean wing length between adult females by region ($t_{[451]}$ = 0.90, P = 0.368).

Mexico and Central America during migration, and also in the fall in Venezuela, when birds first arrive on the wintering grounds.

The proportion of juveniles decreased in the Venezuela population in January and February (Fig. 2). This change could have resulted either from differential mortality of adults and juveniles or from a movement of juveniles out of central Venezuela. ffrench's (1967) data from Trinidad revealed a complementary pattern, wherein the proportion of juveniles increased in January and February. This pattern suggests that juveniles may be leaving the central Llanos during this period, with some movement to peripheral areas such as Trinidad.

POTENTIAL BIASES IN SEX- AND AGE-RATIO ESTIMATES

Sex-ratio estimates of a species can be biased by the method, time, or location of samples (Welty 1962). Biases include different capture probabilities because males and females may (1) behave differently, (2) have different migration patterns (e.g., Howell 1953), or (3) have different geographic wintering areas (e.g., Ketterson and Van Nolan 1976).

When possible, we systematically reduced biases in our sex-ratio estimate. Because male and female Dickcissels exhibit differential migration, our estimates could be affected by time of sample. We addressed this concern by excluding data that were obtained in December and April, when differential migration would be most apparent.

We think our sampling location was most appropriate for a population-level estimate of Dickcissel sex ratios. Among neotropical migratory passerines, Dickcissels present a unique opportunity for study because most of the world's population winters in a small geographic area (Basili and Temple *this volume*). Approximately 6 million Dickcissels converge in this area and form huge roosting aggregations that do not appear to be segregated by sex, age, or breeding location. Because of large sample sizes, however, we did find statistically significant differences in sex ratios between some roosts, and we therefore think the best possible population estimate results from sampling many roosts and pooling information.

The method we employed to sample roosts reduced potential biases in two ways. Mist nets were open from the time birds first arrived and were closed only after nearly all birds had returned to the roost. This reduced potential biases resulting from differential return times for sexes or ages, as has been documented in other communally roosting passerines (Jenni 1992). Nets were also stationed to intercept birds as they moved within the roost. If any substructuring among individuals occurred for preferred roost sites—central or peripheral, high or low—our samples were obtained prior to any intraspecific jockeying for positions. Therefore, we think our samples were representative of birds in a particular roost.

By addressing the above biases, we think our estimate is a good representation of the Dickcissel's overall sex ratio. However, although most Dickcissels winter in Venezuela, we know of a large flock of 250,000 observed in Guatemala in February 1992 (Basili and Temple 1999). It is possible that groups of Dickcissels, "short-stopped" by agriculture on their southward migration, may be segregated by sex or age. Based on our data from wintering Dickcissels in Venezuela and on data from ffrench (1967) in Trinidad, however, we do not think it likely that flocks occupying areas outside the central wintering range would be notably biased in favor of one sex or age group.

INTERPRETATION OF SEX-RATIO DATA

Because we estimated a Dickcissel sex ratio of 1.53 males per female (61% males) in 1990–1993, we rejected the hypothesis that there were five males for every female. We also rejected more conservative estimates of a 3:1 or 2:1 sex ratio. We think these data, combined with other observations, including the lack of starving females in Venezuela, indicate that the Dickcissel population has not undergone marked demographic changes since the late 1960s.

A comparison of data from Venezuela and Trinidad (ffrench 1967) revealed differences in sex ratios by region and decade. This could indicate that males are more likely to wander to the eastern edge of their winter range, which would preclude Trinidad data from being representative of the entire winter population. It could also indicate a trend in the overall sex ratio, which if true, does not support Fretwell's (1977, 1986) hypothesis because selection would have to be operating against males, not females. We cannot be sure why these data differ, and to examine this question will require simultaneous sampling in both regions. Currently, this may be difficult as Dickcissels no longer visit Trinidad regularly (Fretwell 1986; S. Temple, pers. obs.)

A male-biased sex ratio was also apparent among juveniles in Venezuela. In 2 of 3 yr, the juvenile sex ratio upon arrival in Venezuela favored males. Therefore, assuming a 1:1 sex ratio at hatch (e.g., Clutton-Brock 1986), young females either were wintering elsewhere or, more likely, experiencing greater mortality before their arrival in Venezuela.

INTERPRETATION OF AGE RATIOS

Age ratios must be interpreted carefully (Caughley 1974). The age structure of Dickcissels in Venezuela during the early 1990s did not differ from the age structure in Trinidad in the 1960s (ffrench 1967). It is likely that ffrench sampled Dickcissels when the population was in steep decline (Fretwell 1986), whereas our data were collected during a period of relative stability (Sauer et al. 1996). Nevertheless, the age ratios were the same. This suggests that factors responsible for the decline in the 1960s and 1970s were affecting mortality rates in all age classes equally.

Dickcissel age ratios varied among years in Venezuela and Trinidad. It is likely that productivity throughout the Dickcissel's expansive breeding range was variable among years, and that this variability would be apparent in age ratios on the wintering grounds.

FACTORS RESPONSIBLE FOR THE DICKCISSEL'S DECLINE

We agree with Fretwell (1977) that the decline in the Dickcissel population in North America was a result of abnormally high overwinter mortality; however, we suggest a different mechanism. Factors responsible for the decline apparently affected mortality rates of all Dickcissels equally, whether male or female, adult or juvenile.

Basili and Temple (1999) showed that Dickcissels feed on rice and sorghum. They are therefore considered agricultural pests in Venezuela and other countries in their winter range (Slud 1964). To reduce crop damage, some farmers use lethal control and intentionally kill Dickcissels with toxic chemicals. We believe that lethal control was responsible for much of the decline in Dickcissel numbers in the 1960s and 1970s. Chemicals of choice are organophosphates such as parathion and azodrin. Farmers target Dickcissels by poisoning watering holes, spraying feeding areas just prior to morning feeding bouts, and spraying nocturnal roosts with organophosphates from the air or ground. These techniques would not discriminate by sex or age; the spraying of nocturnal roosts in particular has been known to kill hundreds of thousands of birds in minutes (Basili 1997).

Although the population has stabilized in the 1990s (Sauer et al. 1996), Dickcissels are still vulnerable to human-caused catastrophic mortality. Dickcissels continue to roost in huge concentrations—sometimes numbering in the millions at a single roost—and some farmers continue to suffer economic hardship caused by Dickcissels. The conflict persists; a majority (67%) of Venezuelan farmers indicated they would consider using lethal control of Dickcissels if economic damage became severe (Basili and Temple 1998). With single roosting aggregations possibly comprising 30% of the species' entire population (Basili and Temple 1999), Dickcissels are particularly vulnerable to the catastrophic mortality that these control programs can and have caused.

ACKNOWLEDGMENTS

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