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WINTER ECOLOGY, BEHAVIOR, AND CONSERVATION NEEDS OF DICKCISSELS IN VENEZUELA

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Abstract. Dickcissels (*Spiza americana*) were studied in 1990–1993, and briefly in 1995, during the nonbreeding season in agricultural regions of the Venezuelan llanos. These llanos comprise the Dickcissel's core wintering area, and birds occurred there for more than seven months, September through April. Dickcissels were gregarious, feeding and roosting together in large flocks. We found that sugarcane (*Saccharum* sp.) fields were the preferred roosting habitat, and we estimated that individual roost sizes could reach three million birds. Dickcissels were mainly granivores in winter, and while in the llanos they fed on wild grass seeds and agricultural crops, especially sorghum (*Sorghum vulgare*) and rice (*Oryza sativa*).

Since the 1950s, increases in cereal agriculture in Venezuela have provided Dickcissels with a superabundant food supply, yet the Breeding Bird Survey has indicated a 40 percent population reduction in North America since monitoring efforts were initiated in 1966. We think this decline has likely resulted from high overwinter mortality induced by lethal control operations. In many areas of Venezuela, farmers consider Dickcissels to be agricultural pests. Although most farmers use nonlethal controls to mitigate damage, some intentionally kill Dickcissels with agricultural chemicals. The Dickcissel's highly gregarious nature and small geographic range make the entire population vulnerable to catastrophic mortality. We propose that further efforts to prevent declines, and possibly to restore Dickcissel populations to historical levels, be aimed at reducing lethal control on the species' central wintering grounds in Venezuela.

ECOLOGÍA, COMPORTAMIENTO Y NECESIDADES DE CONSERVACIÓN DEL ARROCERO AMERICANO DURANTE EL INVIERNO EN VENEZUELA

Sinopsis. Estudiamos los Arroceros Americanos (*Spiza americana*) entre 1990–1993, y brevemente en 1995, durante la estación no-reproductiva en regiones agrícolas de los llanos de Venezuela. Estos llanos contienen el corazón del área invernal del Arrocero Americano, y las aves estuvieron allí por más de siete meses, de septiembre hasta abril. Los Arroceros Americanos eran gregarios, alimentándose y descansando juntos en grandes bandadas. Encontramos que los posaderos preferidos eran los campos de caña de azúcar (*Saccharum* sp.), y estimamos en tres millones de aves las agrupaciones de aves. Los Arroceros Americanos eran principalmente granívoros durante el invierno, y mientras estaban en los llanos se alimentaban con semillas de hierbas silvestres y cosechas agrícolas, especialmente sorgo (*Sorghum vulgare*) y arroz (*Oryza sativa*).

Desde los años 50, el aumento de la agricultura de cereales en Venezuela ha suministrado provisiones alimenticias excesivamente abundantes, pero el Breeding Bird Survey ha indicado una disminución de población de un 40 por ciento en América del Norte desde que se iniciaron los esfuerzos de medición en 1966. Creemos que es probable que esta disminución sea el resultado de la alta mortalidad durante el invierno provocada por operaciones letales de control. En muchas áreas de Venezuela, los agricultores consideran a los Arroceros Americanos como pestes agrícolas. Aunque la mayoría de los agricultores usa controles no letales para mitigar los daños, algunos matan a los Arroceros Americanos intencionalmente con sustancias químicas agrícolas. El carácter gregario del Arrocero Americano y su pequeña extensión geográfica hacen que la población entera sea vulnerable a la disminución del Arrocero Americano y a una mortalidad catastrófica. Proponemos que los futuros esfuerzos para impedir declinaciones y posiblemente para restaurar sus poblaciones a niveles históricos, sean dirigidos a la reducción del control letal en los principales campos invernales de la especie en Venezuela.

Key Words: Dickcissel; feeding behavior; lethal poisoning; mortality; population decline; roosting behavior; *Spiza americana*; winter distribution.

Studying the population dynamics of nearctic-neotropical migrants is complicated because important demographic events take place over huge geographic areas (Maurer and Villard 1996). Most research on migrants, especially grassland species such as the Dickcissel (*Spiza americana*), has taken place during the breeding season (Petit et al. 1995). Although the Dickcissel has been well studied, relatively little is known about its ecology during the nonbreeding season. This dearth of information confounds conservation efforts because it is impossible to implement successful management plans when uncertainties remain concerning the species' geographic distribution, behavioral ecology, and natural history during more than half of its an-

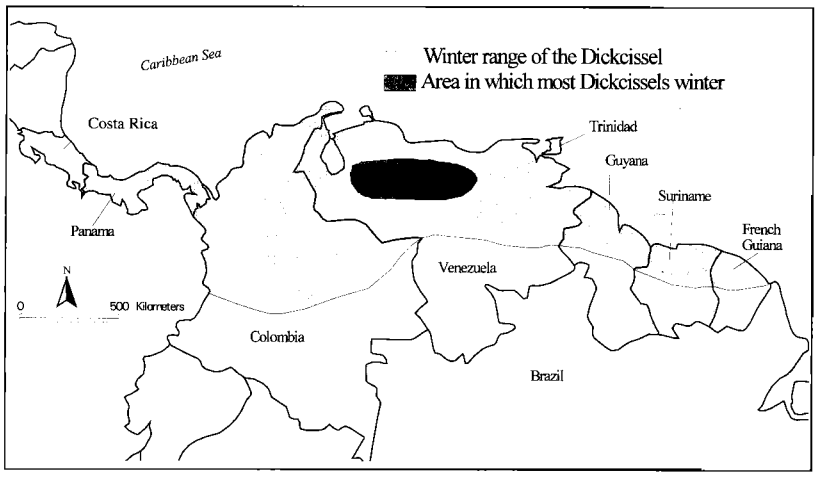

FIGURE 1. Primary winter range of the Dickcissel in South America.

nual cycle (Petit et al. 1995). Although we agree that existing knowledge of neotropical migrants should be used for immediate conservation action (Martin and Finch 1995), we remain cautious because our experience with Dickcissels, like those of Sherry and Holmes (1995) and Temple (1995), suggests that taking action without a complete understanding of the species' annual cycle may lead to inappropriate and/or inefficient conservation strategies.

We reexamined the Dickcissel's winter range and identified patterns of abundance in this range. In this paper we provide information on natural history, diet and foraging, and habitat use. We also describe conflicts between Dickcissels and Venezuelan farmers that may have catastrophic consequences for the Dickcissel population. Finally, we suggest that conservation efforts focus primarily on the Dickcissel's winter range in Venezuela.

STUDY AREA AND METHODS

Field research was conducted during the nonbreeding season in 1990–1993, and briefly in 1995, in the Venezuelan llanos (Fig. 1). We also reviewed museum specimens and literature and communicated with ornithologists, birdwatchers, and farmers in Trinidad, Venezuela, Colombia, Panama, Costa Rica, Nicaragua, Guatemala, and Mexico. The llanos that surround the Orinoco River in Venezuela and Colombia constitute the largest neotropical savanna north of the equator (Sarmiento 1984). This region is characterized by a rainy season from May through October and a dry season from November through April (Monasterio 1970). Our primary study sites were located in the grain-producing regions of the states of Portuguesa, Cojedes, and Guárico. In Portuguesa and Cojedes, study sites were located in the vicinity of the agriculturally prosperous town of Acarigua. Dominant dry-season crops there include rice (*Oryza sativa*), sorghum (*Sorghum vulgare*), and sugarcane (*Saccharum* sp.), but tobacco (*Nicotiana* sp.), cotton (*Gossypium* sp.), tomatoes (*Lycopersicon esculentum*), sesame (*Sesamum indicum*), and sunflowers (*Helicanthus* sp.) are also cultivated. Study sites in Guárico were in rice-growing areas south of the town of Calabozo. Rice is currently the only crop cultivated on a large scale in this area.

We located Dickcissels using road surveys. This species' gregarious nature makes it conspicuous, especially in the early morning and late afternoon when flocks move between roosting and feeding areas. Nocturnal roosts were located by following afternoon flights. We plotted locations on topographic maps available from the Cartography Department of the Venezuelan Environmental Ministry (Ministerio de Ambiente). Additional information on Dickcissel distribution in Venezuela and other parts of the winter range was obtained from the literature, personal communication with ornithologists and birdwatchers, and museum skins from the Phelps Collection in Caracas (Venezuela), Field Museum of Chicago (Illinois, USA), American Museum of Natural History (New York, USA), and Smithsonian Institution (Washington, D.C., USA).

We estimated roost size by classifying incoming flocks into size categories based on length, width, and height (e.g., Newton 1972, Lindström 1989). We observed foraging activity of males and females with a window-mounted spotting scope (Litvaitis et al. 1994). Dickcissels are sexually dimorphic, and sex was easily determined by plumage (Pyle et al. 1987). We examined crop and gizzard contents of birds killed in control operations and mist-net sampling. The contents of each sample were sorted by food item, oven-dried at 60 C, and weighed. The proportion of the dry mass represented by each food item was calculated (Litvaitis et al. 1994).

We used focal sampling to document individual feeding behavior. The time between consecutive bites (handling time) for males and females was measured

for each food item. An individual's handling time was calculated by measuring the time interval between the first and fourth bites, then dividing by three (the number of seeds handled). These data were then aggregated and averaged by sex and food item.

Fourteen individuals (12 males and 2 females) were fitted with 1.0-g radio transmitters attached with a harness (Rappole and Tipton 1991). Because the range of transmitters was approximately 1 km, these 14 birds were most easily detected at nocturnal roosts. Crop-production data were obtained from the annual agricultural statistics (Anuario Estadistico Agropecuario) published by Venezuela's Agriculture Ministry (Ministerio de Agricultura y Cria).

We made a concerted effort to communicate with farmers throughout the project. Farmers not only provided accurate information on Dickcissel movements but were also candid about their ongoing struggle to reduce damage caused by the birds. This communication was essential to our work, and we recommend that it be an integral component of future Dickcissel research and conservation efforts in the region.

RESULTS

Dickcissel Migration and Distribution in Central and South America: A Review

Dickcissels begin arriving in Venezuela in September (Fernandez-Yepez 1945, Phelps and Phelps 1963), with the largest numbers occurring from November through April. This 2-mo lag between first arrivals and peak numbers appears to be the result of some birds spending September and October in agricultural regions of Central America. Slud (1964) reported that beginning in September "clouds" of Dickcissels depredated rice fields in the lower Pacific northwest of Costa Rica. Depredations continued through November, with the species diminishing "enormously" from December through April. There are a few instances of Dickcissels staying longer in Central America. One example is a large flock of 250,000 birds observed between 19 and 21 February 1992 on the Pacific Coast of Guatemala, near the village of Montericco (C. Robbins, pers. comm.). Orians and Paulson (1969) reported a flock of 700–800 Dickcissels on 10 December 1966 near Cañas in the Guanacaste province of Costa Rica, and Zimmerman (1965a, b) observed wintering flocks in Panama in January and February 1961.

Museum specimens collected during migration indicate that Dickcissels enter and leave the Venezuelan llanos via valleys in the Andes of western Venezuela (state of Táchira) and the Coastal Corridor range of northern Venezuela (Henri Pittier National Park). Meyer de Schauensee and Phelps (1978) observed 1,000 Dickcissels per hour crossing at Rancho Grande in Henri Pittier National Park in October. More recent studies (1990–1996) of fall migration yielded one Dickcissel captured in a mist net at Rancho Grande on 28 September 1996 (M. Lentino, pers. comm.). Thus, the most heavily used migration routes remain unknown.

Relatively few Dickcissels occur outside the core wintering area in Venezuela. A small flock of about 130 birds was reported near the mouth of Rio Tocuyo, Falcón, on 26 January 1995 (S. Hilty, pers. comm.), and a group of 12 birds was observed in secondary old-field habitat during the third week of January 1995 in the Caño Colorado area east of Maturín, Monagas (C. Rodner, pers. comm.).

The llanos extend into Colombia, and some Dickcissels also winter there. For example, specimens were collected in the department of Meta (Los Micos, 28 February 1957), and Hilty and Brown (1986:642) refer to Dickcissels as a "locally common winter resident but erratic in many places." Fretwell and Shane (1975) surveyed parts of the Colombian llanos near Villavicencio but found few individuals. When information about Dickcissel damage to rice and sorghum in Venezuela was presented to a rice-growing association and rice experimental station in the Colombian llanos in 1995, audiences were surprised to learn that their Venezuelan counterparts were confronted with such huge flocks (J. Botero, pers. comm.). These farmers assured us that Dickcissels are currently not a problem for agriculture in Colombia, confirming our belief that central Venezuela is the main wintering area for the species. Museum specimens collected between 1870 and 1950, however, reveal Dickcissels wintering throughout Venezuelan grasslands, including the states of Zulia (Guayabo, 27 February 1908), Barinas (Santa Barbara, 26 January 1947), Apure (San Fernando, 13 November 1948), Anzoátegui (Santa Rosa, 25 January 1939), and the federal territory of Amazonas (Caño Catamiapo, 8 February 1943).

In Trinidad, ffrench (1967) studied three roosts from 1959 to 1966. Birds generally arrived in Trinidad by December and departed by mid-April. Fretwell (1986:213) stated that Dickcissels begin to leave central Venezuela in December and January and arrive in "Trinidad to the east and Panama to the west by mid-January." Birds arriving in Trinidad undoubtedly do so via Venezuela (ffrench 1967). The origins of January birds in Panama are less certain and do not necessarily indicate a December movement west from Venezuela.

In spring, Orians and Paulson (1967) reported thousands of Dickcissels migrating north in Guanacaste, Costa Rica, between 27 and 30 March 1967, and thousands of individuals were observed flying north past the airport in Mana-

gua, Nicaragua, between 21 and 27 March 1996 (R. Purnell, pers. comm.).

Dickcissel Distribution in Venezuela

The largest Dickcissel concentrations we found in Venezuela (1–6 million) were near the agricultural cities of Acarigua and Calabozo. This confirms that the Venezuelan llanos constitute the species' main wintering area. Smaller populations are known to occur sporadically throughout Venezuela and in agricultural regions on Trinidad (< 50 km north of the Venezuelan coast).

We found few Dickcissels outside the core wintering area in Venezuela. Our surveys of southcentral Guárico, Apure, and Barinas in March 1991, March 1993, and April 1995 revealed only small flocks of Dickcissels (100–700) in rice fields near Sabaneta, Barinas. We did not observe Dickcissels in regions dominated by cattle ranching.

Dickcissels remained in Venezuela after December. A survey between 24 January and 20 February 1993 revealed a population of about 6 million birds distributed among five roosts. Similarly large numbers were present during these months in 1991 and 1993.

Dickcissels occurred in Venezuela for more than 7 mo, and their stay coincided with Venezuela's dry season. In late March and early April, birds began to depart for temperate breeding grounds. Large numbers remained in Venezuela until the third week in April, however, as evidenced by a roost near Caño Seco, Portuguesa, that had an estimated 2,950,000 birds on 15 April 1995. This was the largest roost we encountered during our study. By the end of April, when the rains usually begin (Monasterio 1970), most Dickcissels had migrated north. For example, the Caño Seco roost had nearly 3 million birds on 15 April 1995 but only 20,000 on 24 April 1995. A sample of 40 birds caught there on 25 April 1995 was heavily biased toward females (79%), indicating that males leave Venezuela before females. Our latest records included two males, one singing, at Pozo Blanco, Acarigua, on 15 May 1995.

Diet

Although insects are an important component of the Dickcissel's diet during the breeding season (Gross 1921), the species becomes granivorous on its wintering grounds (Slud 1964, ffrench 1967, Meyer de Schauensee and Phelps 1978). We observed Dickcissels feeding mainly on seeds. Direct observations of foraging individuals revealed five food items: rice, sorghum, and seeds from three wild grasses—*Rottoboellia cochinchinensis, Orizya latifolia,* and *Ischaemum rugosum.* Crop and gizzard contents of 61 Dickcissels collected in March 1992 confirmed the species' granivorous diet; 99% of the dry mass was seeds (Table 1). Rice was the most abundant food item, followed by sorghum and wild grasses (*Rottoboellia cochinchinensis* and *Orizya latifolia*). The remains of insects and spiders were found in 23% of all samples; however, their combined dry mass comprised less than 0.05% of the total sample (Table 1). There were no statistically significant differences between crop and gizzard contents (percent dry mass of food items and percent food item occurrence) of males and females.

TABLE 1. Average percent (by dry mass) and percent occurrence of food items in crops and gizzards of male (N = 35) and female (N = 26) Dickcissels in March 1992 in the Venezuelan llanos

Food type	Average % per crop[a]		% occurrence in crops[b]	
	Males	Females	Males	Females
Plant matter				
Rice	50	46	54	58
Sorghum	28	26	46	50
Wild grass seeds[c]	16	16	49	58
Unidentified plant matter	5	11	89	100
Animal matter				
Insect parts	0.04	0.04	14	27
Spiders	0.01	0	6	0
Grit	0.28	0.59	71	81

[a] Proportion of food items in males and females was not significantly different; t-tests using Bonferonni adjustments.
[b] Frequency of occurrence of food items was not significantly different between males and females; $C^2 = 2.516$, df = 6, $P > 0.8$.
[c] Category comprised common grasses *Orizya latifolia* and *Rottoboellia cochinchinensis.* Three less common seed types were found in the crop and gizzard contents and remain unidentified; they are accounted for in the category "Unidentified plant matter."

Foraging

Dickcissels foraged in flocks that ranged in size from a dozen individuals to enormous aggregations of several hundred thousand. The birds took seeds directly from ripening stalks or from waste grain remaining after harvest (Fretwell 1986; G. Basili, pers. obs.). It was unclear what percentage of the rice and sorghum consisted of waste grain, but the largest feeding aggregations (> 250,000 birds) were observed in recently harvested rice fields. The largest aggregations in sorghum fields were of similar size, but they occurred in fields prior to harvest. Dickcissels also fed in fallow agricultural fields where wild grasses abounded (G. Basili, pers. obs.); aggregations in this habitat, however, were

TABLE 2. DICKCISSEL CROP AND GIZZARD CONTENTS TAKEN AT NOCTURNAL ROOSTS IN THE VENEZUELAN LLANOS, MARCH 1992

Roost	N	Number of individuals						
		Rice only	Sorghum only	Grass only	Rice & sorghum	Rice & grass	Sorghum & grass	Sorghum, rice, & grass
Weiss	11	7	1	1	–	1	1	–
Retejado	10	5	–	1	–	1	3	–
Pepe	15	–	6	1	–	1	5	2
Perez 2	10	9	–	–	–	1	–	–

never as large as those we observed in rice and sorghum.

A typical day of foraging is represented by the following account, recorded 26 January 1993. The site was a 20-ha recently harvested rice field 5 km from a nocturnal roost of 420,000 birds. It was bordered on one side by a strip of trees along a dry stream bed. Old fields with shrubs, grasses, and forbs comprised the remaining habitat mosaic. The first group of birds (1,000) arrived at 0717 and immediately began feeding. Small groups continued to arrive until 0755, bringing the total number of birds at the site to 5,000. During this time, many larger groups passed high overhead and continued to more distant feeding areas. The greatest distance between a roosting and feeding area was 20 km, although Dickcissels have been reported to feed up to 24 km from a roost (ffrench 1967). Birds fed until 1115, with groups (< 1,000 birds) periodically feeding in rice and then moving to rest in cover along the edges of the field. We observed no feeding from 1115 to 1415, but small groups (< 30 birds) moved to different roost sites bordering the rice. Feeding began again at 1415 as several thousand birds emerged from the woods and settled into the rice. In the afternoon, groups (< 1,000 birds) moved periodically between cover and rice, with the longest feeding bouts lasting about 30 min. Feeding continued intermittently until 1735, when birds from more distant areas began flying overhead toward the nocturnal roost. On several occasions, stragglers in high-flying groups spiraled down to the rice field to feed. Finally, small groups (< 500 birds) began to depart, and by 1810 the feeding area was deserted. This schedule was typical in all habitats where Dickcissels fed. In the month before their northward migration, however, Dickcissels became hyperphagic and spent more time foraging as they attempted to build fat reserves.

Birds that shared the same nocturnal roosts did not necessarily feed on the same food items during the day. In Portuguesa and Cojedes, we often observed flocks leaving nocturnal roosts and dispersing to feed in different habitats, including rice, sorghum, and fallow fields. Variations in crop and gizzard contents in nocturnal roosts confirmed this observation. A single food type predominated at only one of four roosts where we had 10 or more samples on a single evening (Table 2). Crop samples were not obtained in Guárico, but because sorghum was not grown there on a large scale, rice and seeds of wild grasses were the dominant food types.

Foraging Dickcissels exploited certain areas and then shifted to new feeding sites without changing nocturnal roosts. Flight patterns of birds returning to roost often changed over time. For example, in one week most birds entered the roost from the south, but the next week they arrived from the west. In December 1991, morning flights of Dickcissels passed directly over a ranch where we were stationed. For the first 3 d, groups of less than 1,000 birds were present. On day four, numbers increased dramatically as enormous columns of hundreds of thousands of birds appeared, most flying past but thousands landing on the ranch to feed in old fields. Large numbers of Dickcissels persisted in the same flight pattern for 4 d. On day 9, numbers conspicuously diminished, and by day 10 Dickcissels were no longer present. We found that the same nocturnal roost was still active, but foraging sites had shifted just south of the ranch.

We observed feeding activity in a ripening 120-ha sorghum field in March and April 1992. Birds were present for nearly 4 wk, with peak numbers exceeding 100,000 in the final week. Even while the field was being harvested, Dickcissels dodged combines and fed on the remaining seeds. The day before harvesting, there were 100,000 birds feeding in the field; the day after harvesting was completed, the field was deserted, even though waste grain was still abundant. The nocturnal roost remained intact during this period, but foraging flights were directed toward different areas.

We used focal sampling to document individual feeding behavior on four food types (rice, sorghum, *Rottoboellia cochinchinensis,* and

TABLE 3. MEAN TIME REQUIRED FOR FREE-RANGING DICKCISSELS TO HANDLE ONE SEED OF FOUR GRASS SPECIES IN THE VENEZUELAN LLANOS, MARCH 1992

Food item	Mean time (sec) ± SE (N)		Females % slower than males
	Males	Females	
Rice	5.1 ± 0.4 (67)	6.8 ± 0.6 (38)	33.3
Sorghum	6.2 ± 0.4 (57)	8.1 ± 0.7 (25)	30.1
Orizya latifolia	5.9 ± 0.7 (25)	6.7 ± 0.5 (24)	13.6
Rottoboellia cochinchinensis	15.6 ± 0.8 (19)	16.2 ± 1.4 (6)	3.9

Orizya latifolia). Birds consistently fed while perched on stalks, except when eating *Rottoboellia cochinchinensis,* seeds of which were located on the ground. A two-way analysis of variance (ANOVA) to evaluate the effects of sex and food item on bite times revealed that females handled all food types more slowly than males ($F_{1,3} = 5.169$, $P = 0.019$; Table 3). In addition, the type of food item had a significant effect on processing time ($F_{3,253} = 47.552$, $P < 0.001$). Because its seed is encased in a hard capsule, *Rottoboellia cochinchinensis* took longer to process than other seeds. There was no significant interaction between sex and food item, implying that the effect of food items on handling time was the same in both sexes.

When we observed entire feeding bouts, the longest bouts involved immature green sorghum, where a female ate 52 seeds in 241 sec and a male ate 80 seeds in just under 290 sec. Because birds were less conspicuous when feeding on rice and wild grasses, duration of feeding bouts on those items was more difficult to document. The longest bouts in rice (17 seeds in 54 sec) and *Orizya latifolia* (15 seeds in 40 sec) were both for males.

ROOSTING

Dickcissels not only fed in large flocks but roosted together at night in very large aggregations. In Portuguesa and Cojedes they roosted at night almost exclusively in sugarcane, a tall, sturdy grass with numerous horizontal leaves that provide ideal perches and cover from predators. When sugarcane was not available, as in Guárico, the birds roosted in dry cattails (*Typha* sp.), grass, shrubs, small acacia (*Acacia*) trees, and a fallow rice field.

Birds returning to roost in sugarcane did so in an orderly fashion; they wasted little flight time or effort before entering the roost. Birds returning to non-sugarcane roosts, however, appeared more reluctant to settle down and were often observed flying in several directions before finally entering the roost.

The same nocturnal roosts were often used every year. Of the 19 roosts located in our study area, at least 7 were used in multiple years. One was used for 4 yr (farm of R. Perez, near Caño Seco, Portuguesa) and another for 3 yr (farm of J. Pinero, near Retejado, Cojedes). Three sugarcane fields that were used by Dickcissels for only 1 yr were converted to other crops, thereby precluding their availability as roost sites.

Birds began arriving at nocturnal roosts about 1.5 hr before sunset and began departing 10–30 min after sunrise. In late March, as the migration period approached, birds departed earlier (sometimes before sunrise) and returned later.

It took nearly 1 hr for large roosts to fill in the evening, but in the morning they usually emptied in less than 30 min. Departures were spectacular as hundreds of thousands of birds left together in a burst of noise and wind. Sometimes they spiraled upward, forming tornado-shaped funnels, and at other times broad columns left in serpentine fashion, with the lead birds above those behind. Small roosts (< 100,000 birds) sometimes emptied in one flight, but in large roosts wave after wave emerged until only a few stragglers remained. Departures usually took place from one part of the roost, but in the largest roosts we observed up to three distinct routes and directions of departure.

We observed birds roosting on the ground, both in sugarcane roosts as well as other roosts. On several occasions, large numbers crowded together on furrows in sugarcane roosts. We also observed individual Dickcissels entering the roost after dark, their presence indicated by a distinctive buzzerlike flight call. Although ffrench (1967) found that small roosts were often quiet at night, at large roosts we could hear Dickcissels throughout the night, fleeing from predators such as Barn Owls (*Tyto alba*). In addition, we observed small groups (< 100 birds) returning to the roost at dawn prior to the departure of any individuals. We presumed these birds were unable to reach the roost the previous evening and were returning at first light to rejoin the larger flocks.

Large nocturnal roosts sometimes subdivided into dozens of daytime roosts which varied in size from a few tens of individuals to hundreds

of thousands. After foraging for a few hours, Dickcissels entered daytime roosts close to their food source and remained there until late-afternoon feeding bouts. When birds were inactive, we could locate daytime roosts by their loud chatter (when birds were alarmed, chatter immediately stopped, then resumed shortly later). Daytime roosts usually included isolated trees, forest stands, narrow forest strips along canals and streams, hedgerows, grasses, and sugarcane. Only rarely was sugarcane used as a daytime roost, but on several occasions we observed groups of fewer than 100 birds return to their nocturnal sugarcane roost after early morning feeding. Selection of daytime roosts was likely determined by proximity to feeding area and shelter from the sun.

In late March and April, Dickcissels often shared sugarcane roosts with other nearctic-neotropical migrants. Bobolinks (*Dolichonyx oryzivorus*), migrating north from Brazil, formed mixed-species roosting and foraging flocks with Dickcissels in the Venezuelan llanos. Bobolink flocks varied in size from a few to 5,000 individuals. Premigration flocks of thousands of Barn Swallows (*Hirundo rustica*) and Bank Swallows (*Riparia riparia*) were also observed roosting with Dickcissels, although the swallows arrived later and departed earlier than the Dickcissels.

Roost Size

We counted Dickcissels in 16 roosts that ranged in size from 20,000 to 2,950,000 birds. The median count was 580,000, and nearly 40% of all roosts were larger than 1 million birds. In Trinidad, ffrench (1967) reported 66,000 ± 15,000 birds in the Oropuche Lagoon roost in 1962.

Because most Dickcissels overwinter in Venezuela, we think roost counts provide a unique opportunity to estimate the total Dickcissel population. Between 24 January and 20 February 1993, we located and estimated the sizes of all roosts in Portuguesa, Cojedes, and Guárico. We discovered five roosts with a total Dickcissel population estimated at more than 6 million birds. Four roosts in the Acarigua area were estimated to hold 2,370,000; 1,945,000; 590,000; and 420,000 individuals, respectively. One roost near Calabozo contained 1,125,000 individuals. Since these estimates represent a majority of the entire Dickcissel population, approximately 30% of the entire population can be found roosting together in a single sugarcane field.

Radio Telemetry

In January and February 1993 we monitored 14 individuals with radio transmitters. All radios were mounted on birds at the same roost, and at that time the next closest roost was 10 km away. Birds with transmitters were most easily detected at densely populated nocturnal roosts. They were sometimes located in daytime roosts, but this proved more difficult as birds were widely distributed on the landscape. Shortly after we began the telemetry work, the roost where we fitted birds with transmitters began to get smaller and a new roost formed 5 km closer to the main feeding areas. An additional roost was discovered nearby, bringing the total to four nocturnal roosts within 100 km^2.

Individual birds were not strictly faithful to a single nocturnal roost. All 14 birds with transmitters used multiple nocturnal roosts; eight individuals used two roosts, five individuals used three roosts, and one individual used four roosts. Of the eight birds that used two roosts, five switched roosts once and remained at the new location, whereas three individuals moved back and forth between the two roosts. The exchange of birds between neighboring roosts suggests that individual roosts do not represent distinct subpopulations.

Nocturnal telemetry observations confirmed that Dickcissels made nighttime flights and used several feeding areas. One individual left a roost at 2200 and flew to a neighboring roost 10 km away, where it was detected at 0200. Birds with transmitters did not always return to the same daytime roosts, indicating flexibility in daily choice of feeding areas.

Causes of Mortality

Overwinter mortality is an important factor in the dynamics of the Dickcissel population. We observed 17 species (14 avian, 3 mammalian) preying on Dickcissels in Venezuela: Merlin (*Falco columbarius*), Aplomado Falcon (*F. femoralis*), Peregrine Falcon (*F. peregrinus*), Bat Falcon (*F. rufigularis*), American Kestrel (*F. sparverius*), Pearl Kite (*Gampsonyx swansonii*), White-tailed Kite (*Elanus caeruleus*), Roadside Hawk (*Buteo magnirostris*), Short-tailed Hawk (*B. brachyurus*), Gray Hawk (*B. nitidus*), Harris' Hawk (*Parabuteo unicinctus*), Long-winged Harrier (*Circus buffoni*), Barn Owl, Short-eared Owl (*Asio flammeus*), jaguarundi (*Felis yagouaroundi*), grison/huron (*Galictis vittata*), and tayra (*Eira barbara*). On Trinidad, ffrench (1967) noted three predators, all avian, of Dickcissels.

Merlins, also migrants, were the most common diurnal predators in Venezuela. We generally found one to five Merlins at every roost. Barn Owls were the most conspicuous nocturnal predators. Although Peregrine Falcons were not common in the llanos, they appeared at Dickcissel roosts in March and April, presumably on

their migration north. On 15 April 1995, 19 Peregrine Falcons hunted at a large Dickcissel roost near the village of El Cruce southeast of Acarigua. Jaguarundis were the most common mammalian predators we observed.

Conflicts between Dickcissels and Venezuelan Farmers

The greatest cause of overwinter mortality in Venezuela appears to be deliberate chemical poisoning by farmers, who consider Dickcissels pests. We observed numerous birds that showed signs of pesticide poisoning (e.g., loss of balance, respiratory problems, paralysis), and on one occasion we discovered a roost that 3 d earlier had been fumigated with a cannon sprayer attached to a tractor. Approximately 1,000 Dickcissels and unknown numbers of migratory Bank and Barn swallows were killed. We confirmed that at least five other nocturnal roosts had been chemically targeted since 1989 (G. Basili, pers. comm. with farmers). One farmer acknowledged that every few years he had sprayed a roost on his property with an aerial application of parathion (spraying is done in early morning prior to the birds' departure to feeding areas). The chemical is so effective that most roosting birds are killed. The farmer described dead Dickcissels as "knee-deep." He estimated that control efforts on his property have killed more than 1 million birds over the years, and neighboring farmers and agricultural workers corroborated his statements.

DISCUSSION

Winter Distribution

The present concentration of Dickcissels in the states of Portuguesa and Guárico, Venezuela, is best explained when one reviews the condition of the llanos before mechanized agriculture changed the landscape. We believe Dickcissels historically foraged on the seeds of grasses and forbs, resources that were more uniformly distributed on the landscape (Levey and Stiles 1992). After entering the llanos of northern South America, Dickcissels probably dispersed widely in search of productive feeding areas. Museum specimens support this idea and indicate that until the first half of the twentieth century Dickcissels occurred throughout the llanos of northern South America (Venezuela, Colombia, Brazil, Guyana, and Trinidad), including savannas of the Amazon basin. Since the 1950s, the llanos have become an agricultural region dominated by rice and sorghum. Seeds are no longer distributed uniformly but are superabundant and clumped. Instead of dispersing over a wide area, most Dickcissels remain concentrated, taking advantage of the concentrated food. A few birds still disperse to historical parts of their winter range (e.g., appearing every few years in Trinidad), but most now congregate in agricultural regions of central Venezuela.

Our research suggests that most Dickcissels overwinter in the vicinity of Acarigua. This may represent a population shift since Fretwell (1977) indicated that most birds wintered near Calabozo, approximately 220 km east of Acarigua. Our research suggests that the agricultural areas around Acarigua and Calabozo remain the center of abundance from November through April. We did not find a December movement of Dickcissels out of Venezuela (cf. Fretwell 1977).

"Short-stopping" (Hestbeck et al. 1991) of Dickcissels may also now be occurring on the species' southward migration through Central America, as evidenced by large roosting flocks in Central American agricultural areas. Early in their fall migration, Dickcissels have been observed flocking with blackbirds (Icteridae) and feeding on rice in the Arkansas Grand Prairie (Meanly 1971). Although few Dickcissels overwinter in the United States, a large proportion of those that do can be found in the rice lands of the alluvial plain of the Mississippi River and coastal prairies of Texas and Louisiana (Root 1988). This suggests that some Dickcissels may be short-stopped before leaving the United States. Dickcissels appear to be able to adapt to rapidly changing agricultural landscapes along their migration route (e.g., Slud 1964). Thus, we think the winter range of Dickcissels will vary as agricultural practices change in Venezuela and elsewhere in northern South America, as well as in the countries through which Dickcissels migrate.

Roosting

Nocturnal roosts in Venezuela were much larger than roosts reported from Trinidad (ffrench 1967). Sugarcane, when available, appeared to be the preferred habitat for night roosting. Sugarcane was introduced to Venezuela in 1520 but was not intensively cultivated until the 1920s (Gomez-Alvarez 1975). Dickcissels have quickly selected sugarcane as preferred roosting habitat. When sugarcane was not available, Dickcissels roosted in bamboo, cattail marshes, grasses, and shrubs (ffrench 1967; Orians and Paulson 1969; G. Basili, pers. obs.). We suspect that these latter habitats are similar to preagriculture roost sites.

Dickcissel Mortality

Humans kill Dickcissels, sometimes accidentally but most often intentionally. Accidental Dickcissel mortality occurred during our study

when sugarcane roosts were harvested while they were still occupied by Dickcissels. Prior to harvest, fields were burned to eliminate excess, nonvaluable leaf material. Roosts burned at night have been known to kill some birds (ffrench 1967; G. Basili, pers. comm. with farmers 1991–1994). We only observed one roost being burned; it was in the late afternoon when birds were settling in for the evening, and no mortality was discovered. The impact of roost-burning while birds are present remains unclear but warrants further investigation.

People eat Dickcissels throughout their range in Venezuela. Children hunt them with slingshots and by throwing short stalks of sugarcane into dense flocks arriving at nocturnal roosts. Some people enter roosts at night and club the birds with sticks and bats. When shotguns are used to protect crops from Dickcissel depredation, birds that are shot are eaten. The most unusual hunting method we observed was a vehicle driving rapidly through flocks flying low across farm roads. It seems unlikely that this cause of mortality has a major effect on the Dickcissel population, yet these daily events may be important when summed over the species' 7-mo stay in the llanos.

The fact that Bobolinks, Barn Swallows, and Bank Swallows occupied Dickcissel roosts in March and April is an important conservation issue because these species now share the same risk of intentional chemical poisoning. This became apparent when we discovered dead Barn and Bank swallows among dead Dickcissels following an April control operation. Because Bobolinks feed with Dickcissels in rice, Bobolinks are also susceptible to control operations in feeding areas. These observations, and knowledge of rice and sorghum depredations on the Bobolink's main wintering grounds in Brazil and Argentina (Sick 1986), raise the question of whether Bobolinks are subject to similar threats of chemical poisoning as Dickcissels.

Farmers and Dickcissel Population Trends

Most farmers use nonlethal controls to keep birds out of their fields, but some farmers use toxic agricultural chemicals to kill Dickcissels (Basili and Temple 1998). We think that events on the wintering grounds in Venezuela could have been responsible for most of the 40% Dickcissel population decline reported in North America since the late 1960s (Peterjohn et al. 1995). When the decline was most precipitous (1966–1978), crop production was still limited. At this point there were many Dickcissels but few crops on the landscape, possibly resulting in severe crop depredation. During this period, Dickcissels were considered a major problem for Venezuelan farmers (J. L. Mèndez-Arrocha, pers. comm.), and lethal control of Dickcissels was most flagrant (G. Basili, pers. comm. with farmers). We think lethal control may have been responsible for the rapid Dickcissel decline observed in North America between 1966 and 1978.

By the early 1980s, crop production in Venezuela had increased dramatically, yet Dickcissel populations in North America were reduced. The impact of Dickcissels on regionwide crop yields probably became less important, but on local scales the threat of Dickcissel depredation remained high and some farmers still suffered substantial economic hardships (Basili and Temple 1998). Because of this history, lethal control persists in Venezuela, and it continues to play a critical role in Dickcissel population dynamics.

If our ideas concerning the dynamics of the Dickcissel population are correct, Dickcissels may be in jeopardy. Because the population has declined rapidly, and because single roosting aggregations sometimes comprise approximately 30% of the species' entire population, Dickcissels continue to be vulnerable to catastrophic mortality. Lethal control of Dickcissels is still practiced (Basili and Temple 1998).

There appears to be a major conservation problem regarding the Dickcissel's central wintering area in Venezuela, and it is reasonable to infer that the entire population may be limited as a result. These results support Sherry and Holmes's (1995:86) statement that "understanding the whole migratory phenomenon is essential for effective conservation and management." Once reasonable inferences can be made about population limitations, that knowledge should be applied to conservation action. In the case of the Dickcissel, we recommend that conservation efforts be directed primarily toward reducing lethal control in the Venezuelan llanos while also addressing the concerns of local farmers. If the predicament of Dickcissels wintering in Venezuela is ignored, a critical opportunity for effective and efficient management and conservation of Dickcissels, and other migratory birds, will be lost.

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