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ECOLOGY AND CONSERVATION OF BOBOLINKS (*DOLICHONYX ORYZIVORUS*) IN RICE PRODUCTION REGIONS OF BOLIVIA

Rosalind B. Renfrew[1] & Ana Maria Saavedra[2]

[1]Vermont Institute of Natural Science, 6565 Woodstock Road, PO Box 1281, Quechee, VT 05059, USA. *E-mail*: rrenfrew@vinsweb.org.

[2]Museo de Historia Natural Noel Kempff Mercado, Casilla No. 2489, Santa Cruz, Bolivia.

Resumen. – Ecología y conservación del Charlatán (*Dolichonyx oryzivorus*) en arrozales de Bolivia.– Entre los peligros que enfrentan las poblaciones de aves migratorias fuera de la temporada reproductiva, con frecuencia se incluye la pérdida de hábitat, tanto en calidad como en cantidad. El Charlatán (*Dolichonyx oryzivorus*), especie migradora Neártica-Neotropical, enfrenta conflictos directamente asociados al hombre. Su anecdótica reputación como peste agrícola en Sudamérica sugiere una potencial amenaza; sin embargo, es poca la información existente sobre la situación o biología invernal durante el verano austral. En los periodos de Enero–Marzo de 2005 y 2006, hemos intentado averiguar si el Charlatán forrajea en cultivos agrícolas en Bolivia y si, eventualmente, debe ser considerado como dañino. Llevamos a cabo relevamientos sobre caminos en regiones de producción de arroz, soja y sorgo de los Dptos. Santa Cruz y Beni, así como también entrevistas a 47 granjeros y agrónomos. Hallamos Charlatanes en cuatro regiones de producción de arroz fuera del área de distribución conocida para la especie durante este período. Observamos grupos de unos 5000 individuos alimentándose de semillas y orugas, en cultivos de arroz y soja, respectivamente. Los grupos de forrajeo se conglomeraban en dormideros. El mayor dormidero albergaba más de 90 000 individuos, pero la mayor concentración registrada arrojó una cifra estimada en 140 000 aves dispersas en una superficie de 10 km^2. Tanto los dormideros como los sitios de alimentación resultaron efímeros. Las aves visitaban plantaciones en su primer año de producción, sugiriendo que la especie resultaría altamente móvil y sensible a los cambios en los usos de la tierra. A escala global, la especie siempre ha sido considerada una peste para los cultivos de arroz, y algunos han empleado tácticas de intimidación a fin de disuadir las aves. La especie ha mostrado preferencia por la variedad de arroz conocida como Grano de Oro, particularmente por aquellos granos en estado de formación de "masoso" o blando, 10–14 días antes de la cosecha. Es probable que durante el período no reproductivo se congreguen, también en grandes bandadas, en otras regiones de producción masiva de arroz causando mayor vulnerabilidad a la especie. La percepción y el control del Charlatán como peste, y su exposición a pesticidas presenta potenciales amenazas para la especie fuera de la época reproductiva.

Abstract. – Threats to migratory bird populations during the non-breeding season often include loss of habitat quantity or quality. The Bobolink *(Dolichonyx oryzivorus*) is a Nearctic-Neotropical migratory species that faces direct conflicts with humans. Its anecdotal reputation as an agricultural pest in South America suggests potential threats, yet there are few data regarding the species' status or biology during the austral summer. In January– March of 2005 and 2006, we explored whether Bobolinks feed in agricultural crops in Bolivia and whether they are considered to be pests. In regions of rice, soybean, and sorghum production within the Dptos. Santa Cruz and Beni, we conducted roadside surveys and interviewed 47 farmers and agronomists. We found Bobolinks in four rice-producing regions outside of their known range during the austral summer. We observed Bobolinks feeding on seed and caterpillars in rice and soybean, respectively, in flocks of up to 5000 birds. Daytime foraging flocks gathered at nighttime roosts; the largest nocturnal roost contained up to 90,000 Bobolinks, and the largest concentration was estimated to be 140,000 individuals in a 10 km^2 area. Roost and foraging locations were ephemeral, and new rice plantations were visited in their first year of production, suggesting that Bobolinks are highly mobile and responsive to land use changes. Rice farmers universally considered Bobolinks to be a pest in rice, and some used scare tactics to deter the birds. Bobolinks showed a preference for the Grano de Oro variety of rice, and fed on rice only in the "masoso" or soft stage of seed formation, 10–14 days before harvest. Large flocks of wintering Bobolinks likely occur in other regions of rice production in a clumped distribution that could render populations vulnerable. The perception and control of Bobolinks as a pest species and exposure to pesticides present potential threats to Bobolinks during the non-breeding season. *Accepted 12 October 2006*.

Key words: Bobolink, *Dolichonyx oryzivorus*, migrants, wintering range, foraging flocks, rice, avian pest, austral summer, soybean, monocrotophos, pesticides, Bolivia.

INTRODUCTION

Effective conservation of Nearctic-Neotropical migrants requires careful assessment of potential threats to their survival during both the breeding and non-breeding seasons (Sherry & Holmes 1992, Donovan *et al.* 2002). Long-term declines of breeding populations of Bobolinks (*Dolichonyx oryzivorus*) have been documented (Sauer *et al.* 2004), and the species is of conservation concern in three U.S. Fish and Wildlife's bird conservation regions (regions 12, 13, and 23, U.S. Fish and Wildlife Service 2002). Basic aspects of Bobolink non-breeding biology, including winter distribution and habitat use, are largely unknown (Martin & Gavin 1995). Thus, possible threats to the species during its non-breeding period in South America, and their influence on survival, are also poorly known (Vickery & Herkert 2001).

Like other Icterids, the Bobolink is a flocking, primarily granivorous bird during its non-breeding season. Seed depredation by flocks of blackbirds sometimes culminates in significant localized crop loss (Avery 2002). Grain producers have experimented with various control measures for decades, and researchers continue to seek more effective ways to reduce crop loss from avian pests (e.g., Cummings *et al.* 2002, Avery *et al.* 2005). In Venezuela, active control of the Dickcissel (*Spiza americana*) as a pest has reduced the world population of this species (Basili & Temple 1999b).

Bobolinks are called the "rice bird" in South America, and their name suggests that they could be viewed and actively controlled as agricultural pests (Martin & Gavin 1995; "oryzivorus" means "rice eater"). However, knowledge about their use of cultivated crops and about landowner perceptions is based on limited observations (e.g., Pettingill 1983, Vickery & Casañas 2001). Recent studies in northeastern Argentina (Di Giacomo *et al.* 2003) and Paraguay (Renfrew, unpubl.) suggest that Bobolinks frequent both grazed and non-grazed grasslands more often than cultivated crops. However, field surveys in Argentina were biased towards grasslands, and rice (*Oryza sativa*) crops are currently limited in Paraguay.

Establishing conservation priorities for Bobolinks requires a more complete understanding of their dependence on cultivated crops and the perception held by landowners in the austral summer. By clarifying the species' status as a perceived pest, potential threats to its populations can be identified and evaluated. In order to expand knowledge of Bobolink distribution, use of cultivated crops, and landowner perception during the austral summer, we carried out a study in the Departments of Santa Cruz and Beni, Bolivia, a major rice-growing region of central South America. Our primary objectives were to: 1)

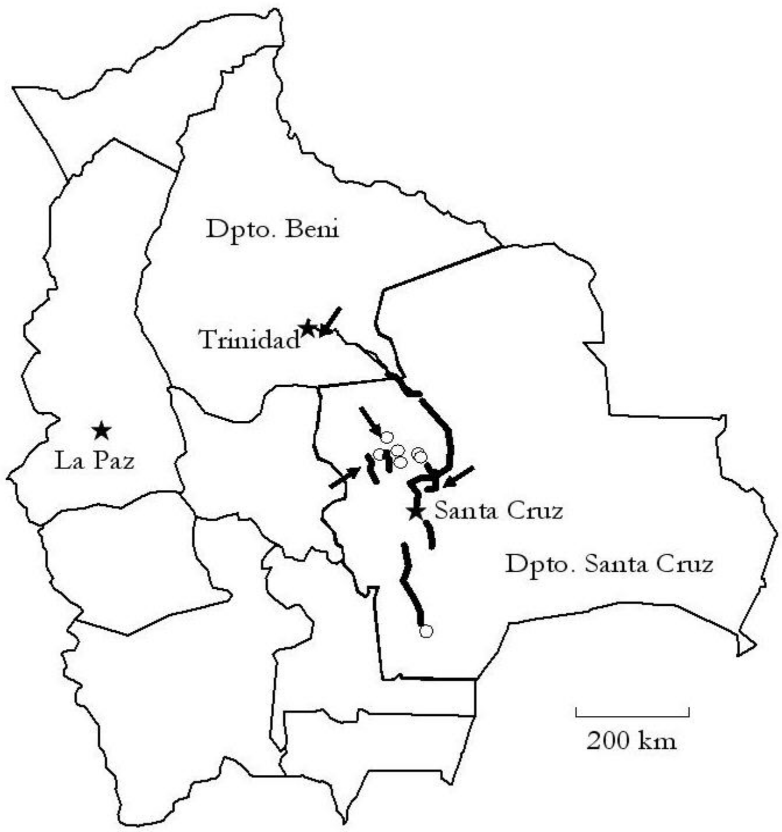

FIG. 1. Routes and points in Bolivia surveyed for Bobolinks in 2005 and 2006. Arrows point to the four rice-production regions where Bobolinks were found.

describe the distribution, habitat use, foraging ecology, and roosting behavior of Bobolinks; 2) assess perceptions of local farmers and agricultural technicians of the Bobolink as a pest species and the control methods used; and 3) ascertain potential threats to Bobolink populations during the austral summer.

METHODS

We conducted our study from 26 January to 2 March 2005, and from 24 January to 7 March 2006 in the Departments of Santa Cruz and Beni, Bolivia. Rice harvest in this region comprised more than over half of the country's total of 204,530 tons (on 284,000 ha countrywide) in 2005 (FAOSTAT 2005), comprising a vast potential food source for Bobolinks.

We carried out roadside surveys of Bobolink flocks in a 500 (N-S) x 200 (E-W) km area in the western half of the two Departments (Fig. 1), targeting certain regions on the basis of information gained from interviews. In 2005, we surveyed approximately 1000 km of road once, and 500 km of additional road 1–8 times in major rice production regions. Two observers searched for flocks from each side of a pickup truck at a speed of 8 to 80 km/h, depending on road conditions. Sections of road traveled more than once in rice

TABLE 1. Bobolink foraging flocks and nighttime roosts in Santa Cruz and Beni Departments, Bolivia.

Regions	Flock type[a]	First date	Last date	Latitude-S	Longitude-W	Habitat	Maximum number of Bobolinks
Okinawa	F	11 Feb 05	25 Feb 05	17°8'49.95"	62°57'50.3"	Soybean	1000
	D, N	11 Feb 05	15 Feb 05	17°10'14.66"	62°57'58.33"	Idle grass	200
	F	16 Feb 05	16 Feb 05	17°6'40.49"	62°59'34.86"	Soybean	400
	F	16 Feb 05	16 Feb 05	17°6'21.1"	63°0'3.37"	Soybean	200
	N	12 Feb 05	18 Feb 05	17°10'49.83"	62°58'6.97"	Totora	10000
	F	23 Feb 05	23 Feb 05	17°6'46.54"	63°56'26.01"	Idle grass	20
	D	7 Feb 05	24 Feb 05	17°7'33.99"	63°56'6.28"	Shrubs and grass bordering rice	400
	F	4 Feb 06	22 Feb 06	17°10'49.83	62°58'6.97"	Sorghum	200
	N	25 Feb 06	25 Feb 06	17°22'35.16"	62°54'58.89"	Unknown, not rice	3000
San Juan	N	5 Feb 05	7 Feb 05	17°7'36.77"	63°56'25.46"	Rice	7000
	F	5 Feb 05	25 Feb 05	18°7'36.77"	64°56'25.46"	Rice	150
	F	6 Feb 05	8 Feb 05	17°6'45.18"	63°54'47.43"	Rice	800
	D, F	9 Feb 05	9 Feb 05	16°53'34.84"	63°39'41.72"	Idle grass adjacent to rice	200
	F	9 Feb 05	9 Feb 05	16°52'39.62"	63°39'45.63"	Rice	1000
	D	11 Feb 05	25 Feb 05	17°10'49.82"	62°55'50.03"	Totora, shrubs adj. to soybean	500
	D	16 Feb 05	16 Feb 05	17°7'52.38"	62°59'19.61"	Idle grass and shrub	100
	F,D	24 Jan 06	29 Jan 06	17°16'52.16"	63°51'6.76"	Rice	1000
	N	26 Jan 06	29 Jan 06	17°16'50.79"	63°50'51.26"	Upland pasture	3000
	N	30 Jan 06	31 Jan 06	17°16'46.34"	63°51'39.09"	Rice	1000
Trinidad	F	7 Feb 06	11 Feb 06	14°52'8.97"	64°52'45.18"	Rice	3000
	D, F	7 Feb 06	14 Feb 06	14°52'9.48"	64°52'44.99"	Wetland and rice	1000
	N	7 Feb 06	7 Mar 06	14°52'9.95"	64°52'2.48"	Paper reed	90000
	D	18 Feb 06	6 Mar 06	14°52'56.06"	64°50'59.07"	Wetland	5000
	D	28 Feb 06	7 Mar 06	14°52'39.98"	64°51'18.8"	Wetland and rice	100
	N	28 Feb 06	7 Mar 06	14°53'34.55"	64°50'9.8"	Paper reed	90000
	F,D	28 Feb 06	28 Feb 06	14°53'3.8"	64°51'24.64"	Rice	5000

[a]F = Daytime foraging flock; D = Daytime roost; N = Nighttime roost.

production regions were secondary, unpaved roads traveled at 5 to 30 km/h. In 2006, we repeated surveys along the same roads in two major rice production regions where we had found Bobolinks in 2005 (San Juan and Okinawa). We surveyed all potential habitat types encountered (rice, soybean (*Glycine max*), pastures, sorghum (*Sorghum bicolor*), and idle grassy and shrubby fields not under cultivation).

In 2006 we also surveyed each rice field within 3 weeks of harvest that we encountered along three routes: between the cities of Guarayos and Trinidad on 9 February (220 km, N = 20 stops); between Trinidad and the town of Sachojere on 18 February (32 km, N = 8 stops), and north of Trinidad towards San Javier on 17 Feb. (12 km, N = 2). At each stop, two observers listened and watched from the roadside for 5 min, using 7–10x binoculars.

For each flock encountered, we estimated the number of Bobolinks and recorded the flock type (daytime roost, foraging, or nighttime roost). When appropriate, foraging substrate (plant or insect species) was recorded. Bobolink flocks were monitored with 7–10X binoculars or scope (20x) to obtain a flock size estimate from both observers, and the mean was used to estimate the number of birds. When we observed Bobolink flocks in soybean fields, we walked two 400-m transects, perpendicular to and intersecting the flight path of the flocks immediately after they had passed. We estimated the density of moths in soybean by counting the number of individuals flushed per meter. Where the flock had perched, we spent approx. 15 min examining soybean leaves for insects and searching for damage to soybean fruit in an approx. 10-m diameter circle. We collected six samples of Bobolink feces on soybean leaves and examined them with a 20x hand lens.

When possible we revisited locations with Bobolink flocks between one and eight times; the four largest nighttime roosts were revisited on 3–21 dates subsequent to and within one month of their discovery. We estimated the number of Bobolinks in the largest nighttime roosts by having multiple observers (2–4) counting Bobolinks by the hundreds as they entered or left the roost. If the Bobolinks flew along one main path, multiple observers would simultaneously count all birds seen, and the range and average value were calculated. If Bobolinks flew from or towards different directions, 1–2 observers would count for each direction, and the counts from each direction were summed.

We conducted informal interviews with 31 rice, soybean, and sorghum farmers or farm workers, 10 agricultural technicians and agronomists, 2 grain processors, and 4 non-farming local residents. Acreage of farms ranged from 10–4000 ha. All farmers with rice visited by Bobolinks were interviewed; others were interviewed opportunistically. To ensure that interviewees could distinguish Bobolinks from other species, we asked each of them to describe the appearance, behavior, and calls of Bobolinks, or to locate the species in a field guide (De la Peña & Rumboll 1998). We questioned interviewees about the locations of Bobolink flocks, whether and why they perceived Bobolinks as a pest, what varieties of rice Bobolinks had been observed eating, what control measures they employed to reduce damage by Bobolinks, and the efficacy of these methods.

RESULTS

Distribution. Within the study area, we located Bobolink flocks in four rice-producing regions (Fig. 1). The two most southern regions, Okinawa and San Juan, consisted of extensive rice and soybean fields. The two more northerly regions, Ayacucho and Trinidad, were characterized by newly cultivated (1 to 4 year old) rice fields in areas dominated by

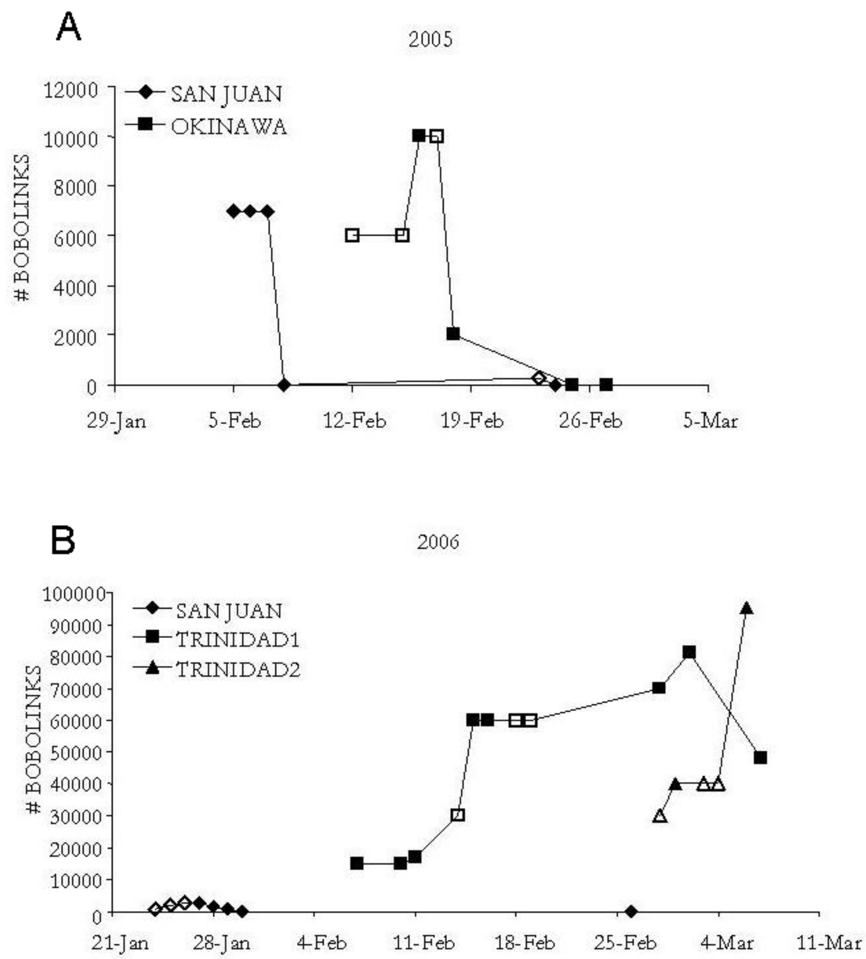

FIG. 2. Numbers of Bobolinks over time in nighttime roosts monitored in Bolivia. Filled symbols represent estimates based on counts, hollow symbols represent visits during which Bobolinks were present but a count was not conducted, and numbers were roughly estimated based on previous and/or subsequent counts.

wet tropical forest, and a mix of wet tropical forest and palm savannah, respectively. All of the flocks we observed consisted of >50% males. The sex ratio was highly skewed in Trinidad, where there were 3–4 males for every female. In both study years, we detected no Bobolink flocks along survey routes.

Foraging ecology. We found 13 daytime monospecific foraging flocks of Bobolinks in rice fields, soybean fields, fallow grasslands often with shrubs and, in one instance, a sorghum field (Table 1). Flock sizes varied from 20 to thousands of individuals. We observed Bobolinks foraging throughout the day within 10 km of nighttime roosts.

Although dry and wet (via natural water sources or irrigation) rice fields were often present in each region surveyed, we found Bobolinks foraging only in wet fields. Bobolinks fed only in rice that was approx. 10–14 days before harvest. At this time the rice grain is formed, but has a pliable texture. This stage, locally called "masoso", occurs after the liquid or "milk" stage (named after its appearance and texture), and before the grain is hard and ready for harvest. Although several varieties of rice were cultivated in our study region, we observed Bobolinks only in rice fields with a relatively high-quality variety called "Grano de Oro" ("Gold Grain," variety IAC-101). Epagri was the most common variety grown, and other varieties included Panacu, Sacia-2 (Tari), Yeri, CICA 8, Sacia-5 (Urupe), IAC-103 and IAC-104.

Bobolinks feeding on non-cultivated grasses were located along roadsides, on dykes and in fields adjacent to rice field used for foraging, and adjacent to nighttime roosts. The Bobolinks sometimes alternated foraging bouts between grasses and rice. Specifically, we observed Bobolinks feeding on several species of Poaceae, including but not limited to *Brachiaria* sp., *Echinochloa crusgalli*, *Leptochla filiformis*, *Leptochloa virgata*, *Paspalum virgatum*, and *Sorghum arundinaceum*.

We observed monospecific Bobolink flocks in soybean fields throughout the second half of February 2005 at Okinawa (Table 1). Adult Pyralidae moths (*Omiodes indicate*) were abundant (approx. 1–10 flushed per m walked) in these fields, as were bright green caterpillars, possibly Pyralid larvae. We observed a female Bobolink flying 0.5 m above the soybean canopy for 4–5 m carrying a bright green caterpillar in her beak. Except for non-feeding sentinels, Bobolinks perched below the soybean canopy after landing, making direct observation of foraging difficult. Feces left behind by the flocks on leaves were predominantly bright green, suggesting that they were composed of the caterpillar larva. We observed no damage to soybeans. Local agronomists confirmed that Bobolinks typically eat caterpillars in local soybean fields.

Roosting behavior. We found 10 daytime roosts and 8 nighttime roosts in the four regions where we located Bobolinks (Table 1). Some roosts were used during both day- andnighttime. Roosts were dynamic both within and between seasons. For example, the number of Bobolinks at nighttime roosts decreased over a period of days or weeks (Fig. 2). The San Juan and Okinawa diurnal and nocturnal roosts occupied in 2005 were not occupied during the same period in 2006.

We observed Bobolink flocks congregating at nighttime roosts within 1 h of dusk, approaching from different directions in flocks of hundreds or thousands for 30–45 min. Within 1 h of dawn and during a period of approximately 30 min, most or all Bobolinks departed from nighttime roosts in distinct flocks of hundreds or thousands, heading in various directions.

Nighttime roosts were usually composed of thousands or tens of thousands of Bobolinks. These roosts were monospecific in all but one case, in which approximately 10,000 Bobolinks in Okinawa roosted with < 200 Unicolored Blackbirds (*Agelaius cyanopus*) in 2005. All nighttime roosts were located in inundated wetlands, which included cultivated rice. Roosts were also located in wetlands dominated by totora (*Schoenoplectus californicus*) or a non-native sedge known as paper reed (*Cyperus papyrus*). The latter habitat supported the largest roosts that we found.

The two nighttime roosts in Trinidad, located within 5 km of each other, together were used by 130,000–140,000 Bobolinks. Between 28 February and 7 March, the estimated number of Bobolinks at these two roosts shifted; one increased from 40,000 to 90,000 individuals, while the other decreased from 90,000 to 48,000 birds.

The numbers of Bobolinks in daytime

roosts varied from approximately 100 to several thousand individuals. Roosts were composed of tall grasses, reeds, and shrubs along ditches and roadsides or in wetlands. Daytime roosts that did not double as nighttime roosts were adjacent to foraging areas or nighttime roosts. Some daytime roosts served as stopovers between nighttime roosts and foraging areas. Occasionally Bobolinks foraged in daytime roosts, perching and feeding in the same plants, but their activity was dominated by preening and vocalizing.

Perceptions and control methods. All interviewees in Okinawa and San Juan reported that Bobolinks were a "plague" in rice from mid-January to mid-March. Owners of smaller farms (< 25 ha) said they did not have Bobolinks visiting their fields, but owners of larger rice farms claimed to incur damage, citing from 20–100% crop loss from Bobolink depredation in a given field. Eight of the nine farmers interviewed in the new rice production area of Trinidad said that they were not concerned about Bobolink seed predation. Farmers and agronomists did not believe that Bobolinks reduced caterpillar populations in soybean fields enough to benefit soybean production.

Based on interviews, Bobolink use of rice is not a recent phenomenon in Bolivia, and their presence is associated with rice production. Four farmers interviewed in San Juan had cultivated rice with their family since they were children, for 35–50 years at the same location, and each reported that Bobolinks had been far more abundant >30 years earlier on less acreage than they currently use for growing rice. An agronomist in Trinidad stated that his family cultivated the first and only rice farm within at least a 100-km^2 area in 1993–94, and that they had thousands of Bobolinks feeding in their fields. According to farmers in Trinidad, Bobolinks arrived during the first year of rice production in 2004. In a region, 100 km NE of Santa Cruz, vast plantations of rice had been completely replaced by soybean beginning in 2000. Farmers reported that Bobolinks had previously been a pest in rice crops, but that the species has been absent since the conversion to soybean production.

We directly observed and were informed of several measures undertaken by some farmers to minimize crop damage by Bobolinks. The most commonly used practices that we observed employed scare tactics such as shooting firearms or small fireworks, and making loud noises by clapping, yelling, or banging metal objects. In one case, smoke was used to deter Bobolinks. Our observations indicated that Bobolinks suffered little or no direct mortality from these measures. Farmers claimed, without quantitative evidence, that such control measures reduce crop losses by 20–50%. Other measures reported to us included placing severed cow heads on stakes to draw vultures that scare pest birds, hanging reflective tape that moves in the wind, mirrors, and intentional poisoning with pesticides.

All but one farmer reported that they used monocrotophos (MCP), an organophosphate, as their sole or main pesticide to combat insects in rice. Cypermethrin was the second most common insecticide used, in conjunction with or alternating with MCP. Insecticides were applied by plane, tractor or backpack, and rates of application varied from twice per growing season to once every two weeks, accor ding to interviewees.

DISCUSSION

Distribution. Our observations of Bobolinks were northwest of both their "principal wintering area" (Martin & Gavin 1995) and their depicted historical winter range (InfoNatura 2004). The species has been described as resident in northeastern Argentina and transient elsewhere (Ridgely & Tudor 1989). Our findings suggest that some Bobolink flocks have been overlooked in Bolivia; Bobolink populations in the Japanese colonies that have been present for at least 35 years had not been previously recorded. The range of Bobolinks may have recently expanded range or shifted northwestward. The large flocks in the Trinidad area, for example, may be the result of the recent emergence of substantial rice production in the region.

Granivorous Dickcissels likely shifted their movements and distribution in Venezuela as grasslands were converted to cultivated crops beginning in the 1950's (Temple & Basili 1999b). In our study, roost and foraging locations were ephemeral and closely linked to the presence of rice in the "masoso" stage. We thus predict that intra-seasonal variability of Bobolink foraging and roosting locations depends on the spatial and temporal variation of rice production. Our observations suggest that Bobolinks readily adapt to changes in food resource distribution. Birds were feeding in rice in Trinidad that was in its first year of production, consisting of formerly forested land that had been cleared in the previous year. Conversely, in other regions Bobolinks disappeared when rice was replaced with soybean. Bobolinks appear to maintain traditional sites in areas that have consistently produced some rice, such as the Japanese colonies, but they have left regions that have converted from rice to other cultivated crops such as soybean.

Agronomists predict that rice production will continue to increase in the Trinidad area, and farmers confirmed that they would be expanding acreages planted to rice. If rice production continues to shift northward in Bolivia, the distribution of Bobolinks may follow accordingly. Regardless, the Trinidad area and the Dpto. Santa Cruz will likely continue to harbor substantial populations of Bobolinks, as long as rice is produced.

Foraging ecology. The enormous flocks of Bobolinks that we found inhabiting areas of rice production and feeding on rice seed is consistent with most descriptions of their habitat during the austral summer. Historically a bird of the Pampas grasslands, Bobolinks are reported to be found in rice and sorghum fields, pastures, and marshes (Ridgely & Tudor 1989). A recent survey in northeastern Argentina concluded that Bobolinks were "a scarce visitor in grasslands and marshes" and not common in cultivated crops (Di Giacomo *et al.* 2003), but the authors added that more surveys were needed in cultivated crops. Effective monitoring of Bobolink populations in rice will require that surveys be synchronized with the "masoso" stage of rice seed formation.

Some of the non-cultivated grasses on which we observed Bobolinks feeding are similar to those used in North America. Meanly & Neff (1953) captured Bobolinks in areas of rice production in Arkansas, and found 7% and 63% of individuals (N = 30) contained *Bracharia* sp. and *Paspalum* sp., respectively (all individuals contained rice, which comprised 76% of the total stomach content volume).

Bobolinks as a pest. The true impact of seed predation on rice growers is unknown, but the perception that Bobolinks are pests is widespread in Bolivia. Basili & Temple (1999a) found that actual seed predation by Dickcissels was much lower in rice and sorghum than was perceived by farmers, although damage to a specific field can be extensive. Given that Bobolinks are approximately the same size as Dickcissels, and appear to be much less concentrated (Basili & Temple 1999a) in our study area, we expect that their actual impact on rice is minimal, with the possible exception of fields producing the Grano de Oro variety.

If seed predation is heavy in particular fields, additional research to assess Bobolink seed preferences and underlying mechanisms may elucidate ways for farmers to reduce impacts. In Bolivia, Bobolinks preference for the Grano de Oro (IAC-101) variety over others such as Epagri could be due to structural difference between rice varieties. For example, some farmers claimed that the Epagri seed head bends considerably and has leaves that fold over the head, making it more difficult to access than the relatively erect, open seed head of Grano de Oro. Varieties that are taller or more stable for perching may be favored, although, according to agronomists at the San Juan Cooperative, Grano de Oro (height = 89 cm) is shorter than Epagri (height = 95cm). The flavor, consistency, or nutritional value of the seed may influence Bobolink preference. Farmers describe Grano de Oro as sweeter and softer than other varieties. It is considered to be a high-quality rice, used in making a rice food preparation called "Gojan." Regardless of the mechanisms behind dietary preferences, planting a less desirable variety may reduce or eliminate seed predation by Bobolinks.

Our observations suggest that Bobolinks may occasionally serve as a beneficial species in soybean, at least in our study area. Although Bobolinks are primarily granivorous outside of the breeding season, their diet includes some insects (Meanley & Neff 1953). We present here the first description of foraging by Bobolinks in soybean fields, and of intensive feeding on insects during the non-breeding season. However, we found no Bobolinks in soybean in regions lacking rice production. Bobolinks may secondarily forage on insects in soybean only in regions that maintain rice cultivation, and then only when insect prey are locally abundant.

The scare tactics employed by Bolivian farmers are similar to those used to combat Dickcissels in Venezuela (Basili & Temple 1999a). Although these methods can be effective with persistence, they are costly in terms of labor and ammunition. Repellants are being explored in North America as an alternative to scare tactics and toxic bait (e.g., Cummings *et al.* 2002, Tobin 2002, Avery *et al.* 2005). Research assessing the impact, nature, and control of bird damage to cultivated crops is critical to finding safe and effective measures (Bruggers *et al.* 1998).

Potential threats and conservation. As for Dickcissel populations in Venezuela, it is likely that Bobolinks are most vulnerable at nighttime roosts in areas where they are perceived as pests (Basili & Temple 1999). The two nighttime roosts we observed in Trinidad supported the largest flocks of Bobolinks described to date. Bobolink foraging flocks may be on average larger in cultivated crops than in non-cultivated, grazed or non-grazed grasslands, as is the case for the Dickcissel (Basili & Temple 1999b). Pettingill (1983) noted Bobolink flocks composed of hundreds to thousands of individuals in Argentine rice fields. The flocks we observed feeding in rice (Range = 150–5000, N = 6) were larger than reported flocks in grasslands in Argentina (Range = 160–365, N = 39; Di Giacomo *et al.* 2003) and Paraguay (Range = 17– 225, N = 5; Renfrew unpubl.). Although Bobolink concentrations were not nearly as high as those of Dickcissels, effective control measures employed in multiple large nighttime roosts or foraging areas could reduce populations (Basili & Temple 1999).

Exposure to non-target pesticides represents another potential threat to Bobolinks in South American cultivated crops. MCP has been banned in Argentina due to its extreme toxicity to birds (Goldstein *et al.* 1999a, Hooper 1999), but its use is still allowed in the rest of South America (restricted in Brazil and Peru). Bobolinks may absorb toxic loads by eating seed and/or through their feet (e.g., Henderson *et al.* 1994) while perching on rice stalks. Impacts of pesticides on birds include direct mortality, impairment of an individuals' ability to successfully migrate, or reduced productivity during the subsequent breeding season (Gard & Hooper 1995, Hooper *et al.* 2003).

Land use trends within the South American range of Bobolinks suggest that conflicts with rice farmers and other threats posed by agriculture could intensify. Loss of native grasslands, coupled with expansion of cultivated crops into formerly forested areas, may increasingly encourage Bobolinks to redirect their foraging to crops. Over 77% of the 337,000 ha that annually undergo land use changes in Bolivia occur in the Department of Santa Cruz (Killeen *et al.* in prep.), where we found Bobolinks. Habitat changes include conversion of grasslands, wetlands and shrublands to cultivated crops, as well as conversion of pasture to cultivated crops (T. J. Killeen pers. com.). Simultaneously, native grasslands in part of the Bobolink's Argentinian range are being rapidly replaced by development and agriculture (Krapovickas & Di Giacomo 1998).

If Bobolinks are attracted to new available food resources provided by expanding agriculture, their populations in regions like Trinidad may increase. Conversely, if rice production continues to expand but Bobolink populations remain stable, Bobolinks may become more widely dispersed over a larger area, resulting in less impact per hectare of rice grown. Regardless, flocks in rice will likely remain at least in the thousands, as this appears to be consistently observed during the austral summer (Hartert & Venturi 1909).

Protection of some areas supporting large Bobolink roosts may be important for conservation of Bobolink populations. It is important, however, to first understand the consistency of specific roost locations. There are no quantitative data that describe roost longevity, either intra- or inter-annually. Potential roost habitat was abundant at our study sites, and is unlikely to be a limiting factor. Available data on the temporal and spatial consistency of Bobolink flock locations are anecdotal. The location and timing of Bobolink occurrence at a specific roost location likely depends on crop production decisions at a local scale.

Outreach in farm communities may be the most effective conservation strategy. If real impacts of Bobolinks on rice yield are less than perceived impacts, research to document actual impacts, followed by dissemination of findings, may reduce farmer concerns. An outreach campaign in Argentina that educated farmers about viable alternatives to MCP provides a successful model for other countries that wish to address the problems associated with its use (Goldstein *et al.* 1999b).

CONCLUSIONS

Our preliminary findings provide baseline information on the distribution, habitat use, and foraging ecology of Bobolinks in the Depts. of Santa Cruz and Beni in Bolivia, and identify potential population-level threats. Additional research needed to guide conservation of Bobolinks during the austral summer includes, but is not limited to: (1) locating other large nighttime roosts, (2) modeling actual crop losses from Bobolink seed predation, (3) describing intra- and inter-annual use of roosts, (4) investigating diet and foraging substrate preferences, (5) assessing the relative importance of agricultural products in Bobolink diet, and (6) evaluating whether patterns of pesticide and land use affect the species' conservation status. Finally, conservation of Bobolinks in South America will benefit endemic bird species that use rice fields and grasslands, many of which are threatened or endangered in South America (Di Giacomo 2005).

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