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Seasonal distribution of the Lined Seedeater *Sporophila lineola*

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Long-distance migration is more pronounced in Nearctic than Neotropical birds. However, recent studies (e.g. summaries in Sick 1983, 1985; Willis 1990) indicate that many more species of Neotropical birds undertake extensive migrations than was previously thought; but the migration patterns of most of them remain unknown. Even very basic data such as general schedules of movements and limits of wintering and breeding areas are scarce (Marantz & Remsen 1991).

One such species is the Lined Seedeater *Sporophila lineola*. It has two populations that can only be distinguished by voice: one that breeds in the Caatinga region of northeastern Brazil, and another that breeds in southeastern Brazil, Paraguay and Argentina (Vielliard 1987). The Caatinga population's song (*dit dit dit drdrdrdr*) is quite distinct from that of the southern population (*dididididdee* or *krrrrrrre*,

sometimes with no terminal 'chirp', sometimes with more than one) (Schwartz 1975, Vielliard 1987). The song of the southeastern population is, in turn, very similar to that of Lesson's Seedeater *S. bouvronides* (Schwartz 1975), a close relative which breeds in the Llanos region and migrates to the Amazon valley afterwards (Ridgely & Tudor 1989).

Schwartz (1975) and Thomas (1979) recorded the Lined Seedeater as a non-breeding species in the Llanos region between June–July and November–December, just when Lesson's Seedeater was observed breeding there. More interesting still are the reports that adult males of the Lined Seedeater sing during the migration period in Surinam (Haverschmidt 1968) as well as in north-central Venezuela (Schwartz 1975). In both cases, the described song is similar to that recorded for the Caatinga population (Vielliard 1987), whose seasonal movements were reported by Sales (1989). These observations suggest that there may be a migratory movement by Lined Seedeaters between the Caatinga and Llanos regions.

No vocal record of the southern population is known outside its breeding area. However, there is good evidence that it is also a seasonal migrant (Sick 1985, Ridgely & Tudor 1989). Details of its movements are unknown.

In this paper, I analyse the geographical and seasonal distribution of the two populations of the Lined Seedeater in order to: (a) identify their possible migratory routes; (b) delimit roughly their wintering and breeding areas; (c) define their basic migratory schedules; and (d) discuss their patterns of migration in relation to the climate and food availability in the breeding and wintering areas.

Methods

Because individuals of the Lined Seedeater sing during migration (Schwartz 1975), I attempted to collect data on this behaviour in several localities in Brazilian Amazonia between 1981 and 1993. In addition, I used records of vocal migrant birds in other areas gathered from literature to supplement my own data. These vocal records formed the basis upon which I traced the 'migration tracks' of the two Lined Seedeater populations. A 'migration track' is defined as the track or corridor generated by connecting the sites where vocal records of a determined population were collected with its respective breeding area, using the minimum-distance criterion. To test the hypothesis that these 'migratory tracks' adequately represent the migratory routes of the Lined Seedeater, I analysed the temporal distribution of records of Lined Seedeaters in the major regions along these 'migration tracks'. If the records in successive regions are complementary, the hypothesis that the 'migration tracks' are migratory routes is supported. Although there are several sources of bias (see Remsen & Parker 1990), the careful plotting of all available records of one species has been considered the simplest method for defining roughly the migration patterns of some South American species (Lanyon 1978,

Marini & Cavalcanti 1990, Remsen & Parker 1990, Marantz & Remsen 1991).

I used records from the following sources: (a) my personal observations in several sites in Brazil; (b) the complete list of observations made by G. F. Mees (*in litt.*) in Surinam; (c) label information on the adult male skin specimens of Lined Seedeaters from the following museums: American Museum of Natural History (AMNH), National Museum of Natural History (NMNH), Carnegie Museum of Natural History (CM), Museum of Zoology of University of Michigan (UMMZ), Museu de História Natural Bernardino Rivadávia (MHNBR), Museum of Natural Science, Louisiana State University (LSUMZ), Field Museum of Natural History (FMNH), Museu Nacional de História Natural, Bolivia (MBHN), Museu de História Natural Capão do Imbuia (MHNCI), Alexander Koenig Zoological Research Institute and Museum (AKZM), Museu Paraense Emílio Goeldi (MPEG), Museu de Zoologia da Universidade de São Paulo (MZUSP), Museu de História Natural Costa Lima (MHNCL), Museu Nacional, Rio de Janeiro (MNRJ) and Zoological Museum, University of Copenhagen (ZMUC). I considered only adult male specimens in this analysis because *lineola* females and immature males are evidently indistinguishable from those of *bouvronides*. To combine specimens and observation records, I considered all individuals recorded in a single observation day as equivalent to one specimen record. The list of all records used in this analysis is available on request.

Results

Caatinga population

The 'migration track' of the Caatinga population includes points in north-central Venezuela (Schwartz 1975), Surinam (Haverschmidt 1968, G. F. Mees *in litt.*) and eastern Pará, between the rivers Tocantins and Gurupi. In eastern Pará, I made long-term observations in Belém (01°27′S, 48°29′W, 1981–1984) and Paragominas (03°00′S, 47°18′W, 1990–91). At these sites, singing individuals were observed only between November and January. Adult males may sing in the same place for up to 5–7 consecutive days, only to disappear afterwards. This is an important point, because to one making only short-term observations this behaviour could wrongly suggest a breeding situation.

I analysed the specimens and sight records of the Lined Seedeater along this 'migration track' (Fig. 1). The Caatinga records (n=21) are between December and June. This period can be regarded as a rough estimate of the breeding season for this population. Records for eastern Pará (n=133) show two well-marked peaks: May–August, when Caatinga individuals are expected to be leaving their breeding area, and November–January when they are expected to be returning to start a new reproductive season (Fig. 1). Because I made long-term monthly observations in eastern Pará, the lack of records of Lined Seedeaters in February–April and September–October in this region indicates their absence rather than lack of sampling. The records for the region

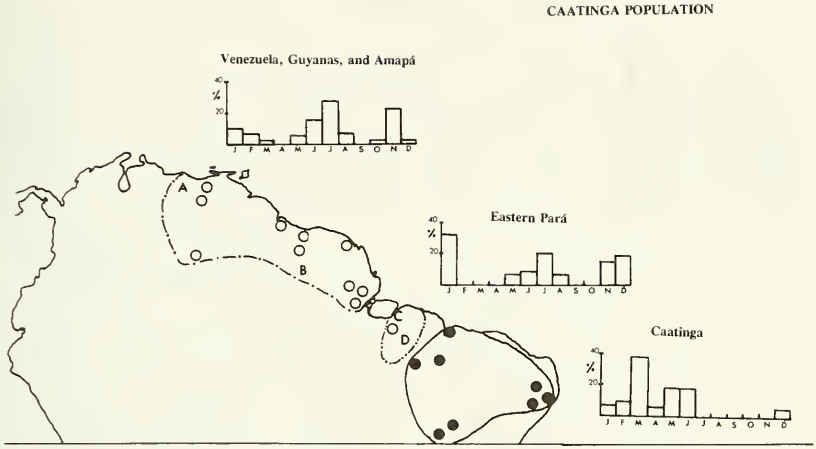

Figure 1. Seasonal distribution of specimen and sight records along the 'migration track' of the Caatinga population of the Lined Seedeater. Solid symbols represent possible breeding sites, open symbols localities where wintering individuals have been recorded. Sites where singing individuals were recorded are indicated by letters (A=central-north Venezuela, B=Surinam, C=Belém, D=Paragominas). In the graphs, vertical axis indicates percentage of the records, horizontal axis months.

formed by Amapá, the Guianas and north-central Venezeula ($n=56$) are quite similar to those for eastern Pará (Fig. 1), but there are two differences: (a) the presumed absence of Lined Seedeaters in this region in September but not in October and (b) a small number of records (specimens collected in Cayenne and housed in CM) in February (3) and March (1), whose dates fall within the breeding season of the Caatinga population. The first difference is clearly misleading, because in a year-round study at one site in the Llanos region Thomas (1979) recorded Lined Seedeaters there in September. The second difference is more intriguing. Perhaps these records are of delayed individuals of the Caatinga population or, alternatively, they are of individuals from the southern population.

Southern population

I recorded individuals singing the southern population song at only one place in central Amazonia, Santarém (02°26'S, 54°42'W), where I observed adult males singing in the tops of small trees in várzea savannas in September and October 1985. This is the only vocal record known for this population outside its breeding area. Because no record of the Caatinga population song is known from central and western Amazonia, I have included all this region, from the left bank of the river Tocantins to southern Colombia and eastern Peru, in the 'migration track' of the southern population.

Again, specimen and sight records were plotted to verify whether they are complementary amongst the major regions along this

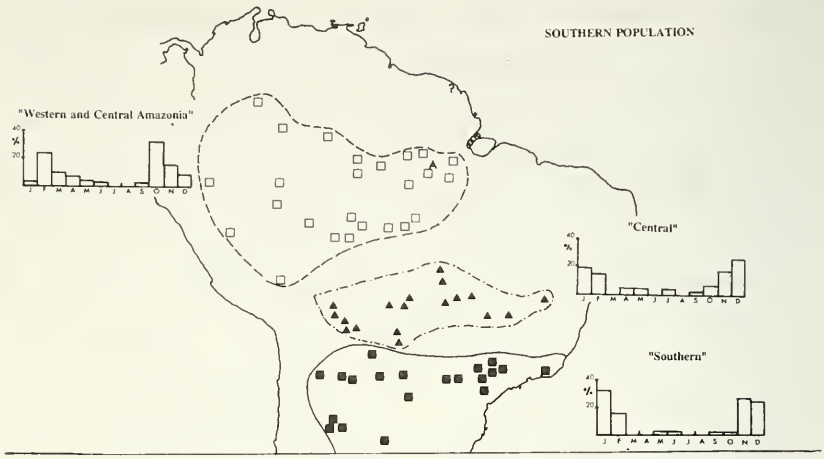

Figure 2. Seasonal distribution of specimen and sight records along the 'migratory track' of the southern population of the Lined Seedeater. Solid squares represent possible breeding sites; solid triangles and open squares represent records of wintering individuals. Some localities with solid triangles may also be breeding sites. Question mark represents the doubtful records in French Guiana which may be of individuals from the southern population. A= Santarém, the only locality in Amazonia where singing individuals of the southern population were recorded. In the graphs, vertical axis indicates percentage of the records, horizontal axis months.

'migration track'. Records for the 'southern' region (southeastern Brazil, Paraguay and Argentina), where the Lined Seedeater is known to breed (Hartert & Venturi 1909, Sick 1985, Ridgely & Tudor 1989), are mainly between November and February with a few records (2,4%; n=83) between May and October (Fig. 2). The Lined Seedeater was recorded for the 'central' region (which includes Minas Gerais, Goiás, Mato Grosso do Sul, Mato Grosso, Tocantins and Bolivia) almost all year (n=39), but mainly (69% of records) between November and February (Fig. 2), a pattern similar to that of the 'southern' region. This may indicate that besides being a passage zone for migratory individuals coming from the south, the 'central' region is also, at least in part, a breeding area. In central and western Amazonia (Fig. 2), Lined Seedeaters are recorded almost year-round but mainly between February and November (91,9%; n=112). The absence of specimen records in June and August is clearly fortuitous, as local residents in Santarém informed me that Lined Seedeaters are found there during these months. I regard this information as reliable because the Lined Seedeater is a well-known cage-bird and my informants live very close to where I made my observations. Hence, the records in central and western Amazonia are somewhat complementary to those from the 'southern' and 'central' regions (Fig. 2). This pattern supports the hypothesis that these three regions form a single 'migration track' for the southern populations of the Lined Seedeater.

Discussion

Migratory patterns

The basic migratory patterns of the Lined Seedeater populations are simple. The population that breeds in the Caatinga region between January and May–June (Sales 1989) migrates to the Llanos region and Guianas across eastern Pará. The southern population that is known to breed in southeastern Brazil, Paraguay and Argentina between December and February (Hartert & Venturi 1909, Ridgely & Tudor 1989) migrates through the 'central' region to central and western Amazonia (and possibly French Guiana).

There are still three points that deserve further investigation. First, it is not certain whether the records in February and March in French Guiana are of migrants from the southern population or delayed individuals from the Caatinga population. If the former is the case, then this region would be unique in that slight spatial, but not temporal, overlap exists between the wintering areas of the two populations of the Lined Seedeater. Second, the presence of the Lined Seedeater almost all year in central and western Amazonia is intriguing. Sick (1985) reported Lined Seedeaters in southeastern Brazil (Espírito Santo and Paraná) between December and March–April. Records in March–April do not agree with the pattern derived here from specimen records (Fig. 2). Because detailed observations at one specific site, such as those made by H. Sick in Espírito Santo, provide a more accurate picture of the seasonal distribution of a species than the crude pattern generated by specimen records (Remsen & Parker 1990), it is possible that populations from the southern region have different migration schedules: the northernmost population may arrive in and leave its breeding area later than the more southerly populations. Such a difference in timing could explain the species' presence year-round in central and western Amazonia. Third, the status of the population that occurs in the 'central' region still needs to be determined. Cintra & Yamashita (1990) reported that the occurrence of the Lined Seedeater in the Pantanal region is seasonal (January–May), but they made no mention of whether it breeds there. Only detailed year-round field studies in the above-mentioned critical areas can adequately resolve these three questions.

So far as I can determine, regular migratory movement between Caatinga and Llanos, such as that exhibited by the Caatinga population of the Lined Seedeater, is not shared with any other species of bird. In contrast, the pattern shown by the southern population is, at least in part, quite similar to that reported for *Sporophila caerulescens* (Remsen & Hunn 1979) and many other species of birds besides seedeaters (Sick 1985).

The trophic basis for migration

As Remsen & Hunn (1979) and Sick (1985) have pointed out, the migratory movements of many species of the genus *Sporophila* are undoubtedly attuned to wet and dry seasons and the effect of these on grass seed production in the breeding areas. This effect is much more

important for species that are stem-gleaner specialists, i.e. those that feed mainly on seeds still borne on the stalks, than to species that are able to feed on fallen seeds on the ground (Remsen & Hunn 1979). This hypothesis is fully supported by the seasonal movements of the Lined Seedeater, a stem-gleaner specialist.

The Caatinga population breeds when rains reach their maximum peak in this region (January to May; Nimer 1979) and migrates during the well-marked regional dry season (June to December). The breeding season of the southern population is also well correlated with the maximum rainfall in that region (November–December to January–February; Nimer 1979), but the period of migration can be only partially predicted by the regional dry season (May–June to September–October). These two simple correlations suggest that migrations of the Caatinga population are probably determined more by the rainfall pattern than are those of the southern population.

Remsen & Hunn (1979) suggested that in western Amazonia, the production of grass seeds should be almost continuous, presumably as a result of the almost daily rainfall there. However, Junk (1970) pointed out that in the várzea grasslands of this region (a habitat commonly used by Lined Seedeaters during migration; D. C. Oren, pers. comm.) the production of grass seed is highly seasonal. Unfortunately, phenological data from western and central Amazonia are inadequate to evaluate or reconcile this apparent contradiction. On the other hand, the presence of Lined Seedeaters, from the Caatinga population, in the Llanos is well correlated with the peak of the production of grass seed reported for this region (Sarmiento 1979). This period (June–January) also coincides with the breeding season of other seedeater species (e.g. *S. bouvronides*; Schwartz 1975, Thomas 1979). Thus, at least for the Caatinga population of the Lined Seedeater, the development and maintenance of its migratory behaviour can be viewed as an optimization strategy in which individuals take advantage of the best of two worlds (Ramos 1990).

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