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Bird counts along an altitudinal gradient of Atlantic forest in northeastern Rio Grande do Sul, Brazil

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RESUMO. **Contagens de aves ao longo de um gradiente altitudinal de Floresta Atlântica no nordeste do Rio Grande do Sul, Brasil.** Durante o estudo de impacto ambiental de um trecho da Rodovia RST-453/RS-486 (Rota do Sol) no extremo nordeste do Rio Grande do Sul, foram realizados inventários da avifauna em cinco estações de amostragem representativas das principais formações vegetais presentes ao longo do gradiente altitudinal atravessado pela estrada (altitude entre o nível do mar e *c.*1000 m). Os inventários contemplaram observações *ad libitum* e contagens de trajeto. Um total de 253 espécies foi registrado ao longo do gradiente altitudinal, incluindo nove espécies ameaçadas de extinção ou regionalmente raras e três espécies novas ou apenas recentemente registradas para o estado. Além disso, 26 registros representaram extensões de distribuição no Rio Grande do Sul. Uma parcela representativa das espécies registradas (26,5%) foi constituída por táxons endêmicos da Mata Atlântica, parte dos quais tem seu limite meridional extremo de distribuição nas formações florestais da região. As contagens revelaram flutuações sazonais marcantes na abundância relativa de algumas espécies tidas como residentes ou parcialmente migratórias no Rio Grande do Sul. Essas espécies foram tentativamente classificadas em quatro categorias de migrantes locais ou de pequena escala: migrantes altitudinais, visitantes hibernais, residentes localmente migratórios e migrantes entre habitats. Por fim, os impactos potenciais da construção e operação da rodovia sobre a avifauna no âmbito local e regional são brevemente discutidos.
PALAVRAS-CHAVE: contagens de aves, Mata Atlântica, gradiente altitudinal, migração, conservação.

ABSTRACT. During the environmental impact assessment of a section of the RST-453/RS-486 highway (Rota do Sol) in the extreme northeast of Rio Grande do Sul State, southern Brazil, we surveyed birds at five stations representing the main vegetation types along the altitudinal gradient crossed (elevations ranging from near sea level to about 1000 m). Surveys included ad lib observations and line transects. A total of 253 species was recorded, including nine threatened or regionally rare taxa and three new or reconfirmed species for the state. Moreover, 26 records represented range extensions within Rio Grande do Sul. A relatively high percentage of species (26.5%) were Atlantic forest endemics, some at their southern limit of distribution in forests and woodlands of the region. Counts revealed marked seasonal differences in relative abundance of some species thought to be resident or partially migratory in Rio Grande do Sul. These were tentatively assigned to four categories of local or small-scale migrants: altitudinal migrants, winter visitors, locally migratory residents and between-habitat migrants. Finally, we briefly discuss the potential impacts of the construction and operation of the Rota do Sol highway on the avifauna at the local and regional levels.
KEY WORDS: bird counts, Atlantic forest, altitudinal gradient, migration, conservation.

Attempts to estimate the abundance of landbirds in Rio Grande do Sul have been scanty. This contrasts with the fact that the state's avifauna is relatively well known compared with other Brazilian states in terms of geographical distribution, owing primarily to the work of W. Belton (Belton 1984, 1985, 1994). Count results are currently available only for a few species (e.g., Spotted Nothura *Nothura maculosa* and Red-spectacled Amazon *Amazona pretrei*; Menegheti 1985, Varty *et al.* 1994, Martinez 1996) and for diurnal birds of prey along roadsides (Albuquerque *et al.* 1986). Doubtless this situation reflects the very small number of professional and amateur ornithologists trained in the field identification and censusing of landbirds in the state.

During the environmental impact assessment of the Tainhas - Terra de Areia section of the RST-453/RS-486 highway (Rota do Sol), in the extreme northeast of Rio Grande do Sul, we conducted bird counts over an altitudinal gradient of Atlantic forest as part of a multi-disciplinary inventory of the natural resources of this area. When concluded, the Rota do Sol will comprise a 750-km-long road complex crossing Rio Grande do Sul from west to east. Only the section between the settlement of Tainhas and the town of Terra de Areia remains to be paved (figure 1). This 54-km section connects the top of the state's northern highlands (Planalto) to the coast across the Serra do Pinto, a portion of the Planalto escarpment that still retains a significant forest cover (mostly secondary or disturbed). This part of the highway will incorporate much of the influx of summertime and weekend tourists seeking the beaches of northern Rio Grande do Sul and the neighboring state of Santa Catarina, and will carry a traffic of up to 9,000 vehicles/day in the summer.

This study provides indexes of relative abundance for bird species at each major habitat along the Rota do Sol between Tainhas and Terra de Areia. The data will be used

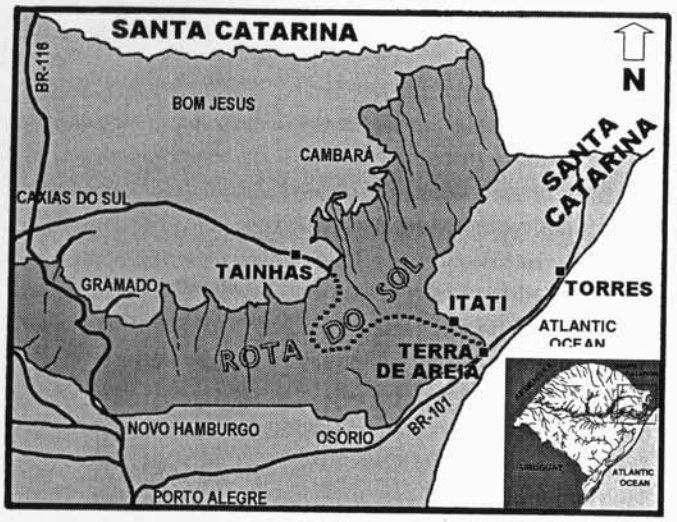

Figure 1. Northeastern Rio Grande do Sul, showing approximate location of localities cited in the text.

in a monitoring program - currently underway - to assess the effects of highway construction and utilization on local bird assemblages.

STUDY AREAS AND METHODS

Five sampling stations were established along the projected roadbed of the Tainhas - Terra de Areia section of the Rota do Sol, representing the five main vegetational formations in the area. Figure 2 presents a cross-section of the altitudinal gradient surveyed, with the approximate elevational range of the vegetation types. Two visits (winter and spring) were made to each station during the second half-year of 1995. The sampling effort (i.e., hours of field work) at each station was roughly proportional to the size of the habitat remnant under investigation. At each station we conducted ad lib observations and line transect counts.

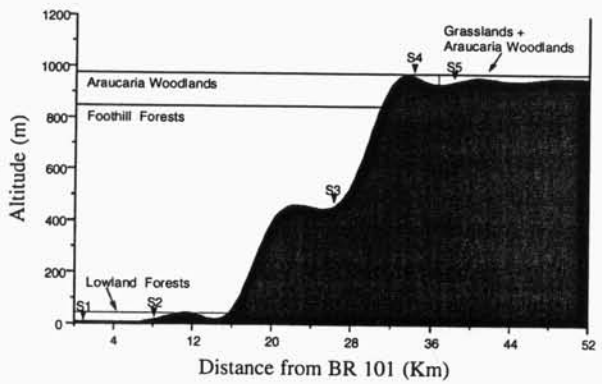

Figure 2. Cross-section profile of the altitudinal gradient surveyed between Tainhas and Terra de Areia, extreme northeastern Rio Grande do Sul, with approximate elevational range of vegetation types. Also shown is the position of the five sampling stations (S1 to S5) for avifaunal surveys. BR-101, a national highway through the town of Terra de Areia, marks the eastern end point of the Rota do Sol.

SAMPLING STATIONS

Station 1 (29°33'S, 50°03'W; ≈ 0 m elevation). Narrow semi-natural marsh near Terra de Areia. Habitats surveyed included wet areas (vegetation dominated by bulrush *Typha dominguensis,* reeds *Cyperus giganteus*, and ginger lily *Hedychium coronarium*; J. Larocca and R. Balbueno, pers. comm. 1996), a narrow strip of shrubby riparian forest, brushy second growth, and small plantations. Though doubtless originated from a pre-existing marsh, the presence of scattered snags indicates that the flooded area has increased considerably in recent years due to changes in the local drainage system with construction of side roads. We visited this area on 20 August and 02 December for a total of 8.95 hr, including 6.06 hr of censuses (3.33 hr in winter and 2.73 hr in spring).

Station 2 (29°30'S, 50°06'W; 20-35 m elevation). Small remnant of floodplain coastal Atlantic forest in the Rio Três Forquilhas drainage. This humid forest on poorly drained terrain was formerly continuous with the foothill forests on lower slopes of the nearby escarpment but is now almost isolated and surrounded by pastureland, second growth and small swamps. The vegetation appears old second growth and the rather uneven canopy is composed of 12-15 m tall trees. Slender palms (*Geonoma schottiana, G. gamiova, Bactris lindmaniana* and *Euterpe edulis*; J. Larocca and R. Balbueno, pers. comm. 1996) dominate the middle and lower growth, and the understory is rich in lianas and broad-leaved herbs. At this station, we accumulated 24.2 hr of field work, including 10.04 hr of censuses (4.88 hr in winter and 5.16 hr in spring), on 19-20 August and 02-03 December.

Station 3 (29°22'S, 50°11'W; 300-750 m elevation). Extensive and nearly continuous stands of foothill Atlantic forest on the Planalto escarpment. Dominant canopy trees include *Cabralea canjerana, Erythrina falcata, Ocotea puberula* and *Pachystroma longifolium* (J. Larocca and R. Balbueno, pers. comm. 1996). The absence of both a number of typical Atlantic forest plant species - such as the palm *Euterpe edulis* - and of a rich herb layer render this forest rather similar in physiognomy to woodlands of the escarpment southward and in the center of the state. Habitats surveyed included undisturbed forests, secondary woodlands and tall second growth, occasionally interspersed with small (< 2 ha) agricultural clearings. We worked at this station on 11-12 August and 12-15 October for a total of 71 hr, including counts for 20.8 hr (9.2 hr in winter and 11.6 hr in spring).

Station 4 (900-1000 m elevation). Temperate moist forest with an overstory of *Araucaria angustifolia* (araucaria or Paraná pine) bordering the top of the Planalto and extending down into foothill forests of the escarpment. As seen from satellite images, this area and the previous one lie within the largest nearly-continuous forest block still remaining in Rio Grande do Sul, which further includes the Aparados da Serra National Park and also extensive

woodland areas in São Francisco de Paula, such as the IBAMA National Forest. Much of the forest at station 4, however, now lacks araucarias due to logging in the past. The pines now occur in clumps at woodland edges or as young individuals scattered throughout the area. Other representative tree species are *Podocarpus lambertii, Cinnamomum glaziovii* and *Myrceugenia myrcioides* (J. Larocca and R. Balbueno, pers. comm. 1996). Habitats surveyed included disturbed *Araucaria* woodlands, bushy clearings and small peat bogs. Activities concentrated within a few kilometers of our camp at 29°18'39"S, 50°11'35"W. This area was visited on 02-03 September and 02-04 November. We did 55.35 hr of field work, including 21.45 hr of censuses (8.6 hr in winter and 12.85 hr in spring).

Station 5 (29°16'S, 50°15'W; 900 m elevation). Extensive short grasslands on gently rolling terrain at the top of the Planalto ("Campos de Cima da Serra"), interspersed with scattered *Araucaria* groves and narrow riparian woodlands along the Rio Contendas. Damp fields, swamps and small weedy ponds occur in the lower portions. All the habitats above were surveyed during fieldwork. We spent 26 hr in the field at this station, including 9.78 hr of censuses (5.75 hr in winter and 4.03 hr in spring), on 03-04 September and 04-05 November.

Census procedures. At each sampling station we conducted transect counts in winter and spring. All birds sighted or detected by voice were considered during the censuses, except primarily aerial species (e.g., vultures and swifts) in forest areas, because they are less visible than non-aerial species when counted from below the canopy. Counts were to unlimited distance, as long as birds were within the habitats sampled (especially at station 2). We used existing trails or natural paths inside dense forest as census routes and avoided as much as possible walking along woodland edges. The routes followed at each area were not pre-determined but a given route was not covered twice in the same visit. Counts were always conducted by both of us (throughout the day, whenever possible) and performed only under appropriate weather conditions. Count data were dictated onto a microcassette recorder and later transcribed to data sheets. Congeneric species which look very similar in the field were treated as a single taxon (e.g.: *Leptotila* spp.) even if distinguishable by voice. Data from winter and spring counts were separated because: (a) the routes covered in both seasons were essentially the same, resulting in counting the same individuals of resident species; and (b) this would show differences in the seasonal abundance of some species due to migratory movements. Winter and spring abundances of all species recorded during censuses are expressed as individuals per 10 hr of census. The overall number of species recorded at each sampling station always exceeded by a considerable margin that obtained from transect counts alone, due to the sampling constraints followed during the censuses.

RESULTS

Species richness. A total of 248 species was recorded at the five sampling stations (appendix 1). An additional five species (*Dendrocygna viduata, Rostrhamus sociabilis, Hylocharis chrysura, Chloroceryle amazona* and *Phaeoprogne tapera*) were observed incidentally outside the sampling areas, giving a total of 253 species recorded along the altitudinal gradient.

The cumulative species-time curves (figure 3) suggest that our sampling effort was sufficient to detect the majority of the species present. However, the interpretation of the curves is complicated by the addition, more or less halfway through the study, of a migratory component into the bird assemblages. The exclusion of migratory species from the analysis probably would have flattened out the curves considerably but this would not have provided any additional information as to the completeness of our inventories.

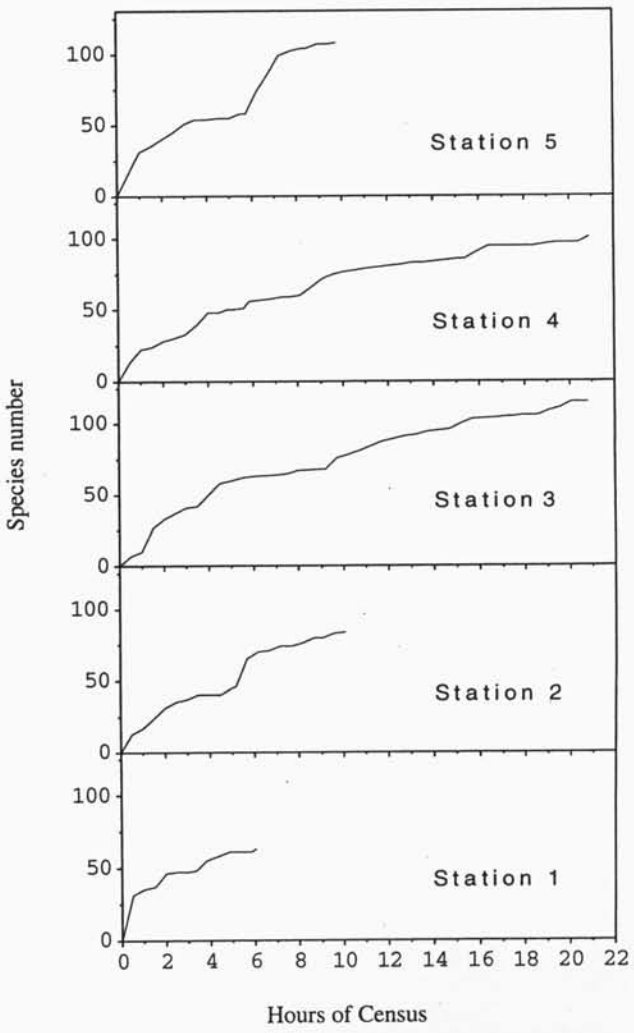

Figure 3. Curves showing the cumulative number of species recorded during transect counts at five sampling areas along an altitudinal gradient of Atlantic forest in northeastern Rio Grande do Sul. The main inflection near the midpoint of the curves reflects the arrival of summer residents (i.e., austral migrants) into the region.

Particularly at station 2, we suspect that relatively more species (other than accidental or vagrants) would eventually be added with more extensive sampling, reflecting a higher species turnover compared with the other sampling stations, due primarily to its smaller size and greater influence of surrounding habitats on the composition of the local bird assemblage.

Among forest habitats, the foothill forest (station 3) was the most species rich (156 species), while richness at the opposite ends of the gradient (stations 2 and 4) was substantially lower and nearly identical (119 and 123 species, respectively). This situation, however, reflects present-day rather than original conditions. While the avifauna of the *Araucaria* woodlands on the top of the Planalto is still reasonably complete, a substantial number of species are presently missing from the lowland coastal forests due to habitat reduction and alteration. Several large and mid-sized birds are already locally extinct at station 2 or occur there only as occasional visitors (e.g., most raptors and parrots). Therefore, species numbers are not directly comparable among the three forest stations.

Our survey was not exhaustive, primarily because we worked at restricted sampling stations rather than along a continuous transect covering the entire span of the altitudinal gradient. An assessment of the overall species richness along the whole gradient, however, can be obtained by examining the distributional maps presented by Belton (1994) and Rosário (1996) and computing those taxa that were not recorded by us but should occur in the area (i.e., species reported by these authors for areas within a 30-km radius of our study sites). This procedure adds 85 species (appendix 2) to our total of 253, although some 13 of these (open water or water-edge birds) would probably not find appropriate habitats between Tainhas and Terra de Areia along the Rota do Sol. As we found three species (1.2% of the total) not expected to occur in the area (see under *Range extensions* below), one species (1.2% of 85) must be added to the total as a possible extra out-of-range record. This gives an overall total of about 339 species (294 "landbirds"), a number that probably expresses the richness of the avifauna along the whole gradient surveyed more realistically.

Altitudinal replacements. We noted the following cases of altitudinal replacement between congeneric or ecologically similar species (taxa from lower elevations listed first): *Pardirallus nigricans - P. sanguinolentus*; *Picumnus temmincki - P. nebulosus*; *Philydor atricapillus - Anabacerthia amaurotis*; *Formicarius colma - Chamaeza campanisona; Scytalopus indigoticus - S. speluncae; Phyllomyias burmeisteri - P. fasciatus*; and *Attila rufus - A. phoenicurus*.

It is not certain whether the *Pardirallus* rails actually segregate altitudinally in northeastern Rio Grande do Sul or simply occupy distinct habitats that are not equally represented along the elevational gradient between Tainhas and Terra de Areia. We may not have properly sampled swampy areas surrounded by arboreal vegetation on the slopes and at the top of the Planalto, so that *P. nigricans* may have gone unrecorded at higher elevations. In any case, Belton (1994) states that this species is absent from the highest portions of northeastern Rio Grande do Sul. The piculets (*Picumnus* spp.) overlapped to some extent at station 3, where *P. nebulosus* was scarce. These species are narrowly syntopic also on the Planalto escarpment in central-eastern Rio Grande do Sul, especially in winter (Bencke 1996a, G.B. pers. observ.). As to the attilas (*Attila* spp.), the species involved appeared to occupy distinct niches within their respective altitudinal ranges - *A. rufus* tending to remain in the lower strata of forest and to occupy woodland edges more often than *A. phoenicurus* - and hence may not be each others' closest ecological counterparts. In addition, they are separated by a broad elevational gap in the region and their overall size and bill shape differ considerably. We feel more certain of the other cases of altitudinal replacement reported above.

Migratory patterns. Apart from the regular long-distance austral and nearctic migrants (indicated by "M" in appendix 1), various species exhibited marked seasonal fluctuations in relative abundance, apparently not attributable to between-season variations in detection probability or to the effects of chance. We suggest four likely patterns of local or small-scale migratory movements to explain differences in seasonal abundance noted for these species. Waterbirds were excluded from this analysis because, in addition to seasonal climatic changes, unpredictable water level fluctuations in aquatic environments may influence their local abundance.

Altitudinal migration. Our abundance data suggest that *Euphonia cyanocephala* and *Colaptes campestris* may perform vertical movements across the altitudinal gradient surveyed. These species were absent, or present at lower numbers, in the higher-elevation sampling stations during the winter whilst their numbers at stations 1 or 2 increased accordingly in the same season. Less evidence of elevational migration exists for *Camptostoma obsoletum, Muscipipra vetula* and *Carduelis magellanica*, which exhibited similar patterns of abundance. The case of *Triclaria malachitacea* is particularly puzzling. As the count data for station 4 seem to indicate, this parrot may prove to be an inverted altitudinal migrant, with part of the local population moving up the slope into the temperate forests in the winter following the production of *Araucaria* seeds.

Although Sick (1984) mentioned the existence of altitudinal movements of *Stephanoxis lalandi* and *Sporophila caerulescens* in Rio Grande do Sul, we did not find any evidence in support of his statement.

Winter visitors. Serpophaga subcristata was more numerous during the winter everywhere along the altitudinal gradient. We suspect that the extra wintering individuals are austral migrants from more southerly portions of Rio Grande do Sul or from Uruguay and Argentina. Although Belton (1994) failed to detect any seasonal fluctuation in numbers of *S. subcristata* in the state, a growing literature now indicates that this tyrannulet is migratory in many parts of

its range (Short 1975, Negret 1988, Hayes *et al.* 1994, Parker *et al.* 1996, Chesser 1997). *Phylloscartes ventralis* exhibited a similar pattern of abundance where it occurred (stations 2 to 5) but we could not find any additional evidence of migratory movements for this species in the literature. Moreover, abundance estimates obtained for *P. ventralis* at some sampling stations include data for *Phyllomyias virescens* (see appendix 1), weakening the conclusions of any analysis.

Other species that also appear to have their winter populations augmented by the influx of southern migrants into the region are *Turdus amaurochalinus* and *Volatinia jacarina*. Both are known to exhibit migratory habits in several parts of South America, including Rio Grande do Sul (Sick 1984, 1997, Negret and Negret 1981, Ridgely and Tudor 1989, Belton 1994, Parker *et al.* 1996) and the former may prove to be an altitudinal migrant as well (Belton 1994:374).

Two additional observations further suggest that individuals of certain migratory species winter in the lowlands of extreme northeastern Rio Grande do Sul. In July 1995, during a preliminary brief visit to all sampling stations, we recorded one individual of *Myiophobus fasciatus* along the road between stations 1 and 2. It is not certain whether this bird was a winter visitor or a summer resident that had failed to migrate; there appears to be only one or two previous mid-winter records of this fairly common species in Rio Grande do Sul (see Belton 1994). Similarly, during the winter visit to station 2, we recorded a lone individual of *Megarynchus pitangua*, a noisy and conspicuous species not found there during the spring census and rare across the entire altitudinal gradient.

Local migration of residents. Chlorostilbon aureoventris, *Sicalis luteola* and *Molothrus bonariensis*, all regarded as year-round residents in Rio Grande do Sul in Appendix A of Belton (1994), were not found between Tainhas and Terra de Areia in the winter visits and may be locally migratory. According to Belton (1994), *C. aureoventris* is apparently only a summer resident over most of the state. Similarly, *S. luteola* has not been recorded on the Planalto during the winter. As for *M. bonariensis*, Sick (1997:791) noted that populations of this cowbird in southern Brazil seek other regions in winter; similar movements seem to occur also in the pampas of Argentina (Hudson 1920). Some other species were present in lower numbers during the winter and thus appear to be partially migratory in the study areas. These include *Knipolegus cyanirostris, Attila rufus*, *Tachyphonus coronatus* and *Thraupis sayaca*.

Both *Pitangus sulphuratus* and *Pipraeidea melanonota* appear to leave the high-elevation zones in winter, but not other areas along the altitudinal gradient. According to our abundance data, individuals resident on the highlands in the summer do not move downslope after the breeding season (i.e., do not undertake altitudinal movements) but seem to winter outside the region. Point counts conducted by A. K. at the Aracuri Ecological Station (about 150 km northwest of our study sites; 900 m elevation) also support our suspicion that both these species disappear from the higher zones of Rio Grande do Sul during the winter, as noted earlier for *P. sulphuratus* by Sick (1985) and Belton (1994).

Between-habitat movements. Our abundance data suggest that a small set of woodland or edge species (*Cyanocorax caeruleus, Zonotrichia capensis, Poospiza lateralis, Cacicus chrysopterus* and, perhaps, *Cyclarhis gujanensis*) may move from the gallery woodlands and *Araucaria* groves of the Planalto to the nearly continuous woodlands around station 4 for the winter. The extensive *Araucaria* woodlands on the Planalto edge may provide either abundant food resources (*Araucaria* seeds in the case of the jay) or shelter from cold winds in the winter for birds inhabiting the scattered woods of the adjacent open grasslands. The existence of these small-scale movements could be determined by banding studies. *Cacicus chrysopterus* may prove to be an altitudinal migrant as well.

Daily movements. Although not revealed by the count data, we noted daily movements of *Theristicus caudatus* across the escarpment during the counts at station 3. A few individuals of this species descended the slope early in the morning - possibly to forage in the lowlands or nearby valleys during daytime - and moved up again in the afternoon to roost at high-elevation sites. In the highlands of southern Brazil this species frequently roosts communally inside *Araucaria* groves (Scherer Neto 1982, Sick 1997).

NOTEWORTHY RECORDS

New and reconfined species.

Cichlocolaptes leucophrus. Pale-browed Treehunter. This species was listed by Belton (1978) for Rio Grande do Sul on the basis of a single specimen of doubtful origin collected by Rogers in the last century, but was later withdrawn from his list in view of the lack of sufficient evidence of its presence in the state (Belton 1984, 1994). We recorded this epiphyte-searching bird in *Araucaria* woodlands at station 4 at about 1000 m elevation [three observers (the authors plus Jan K. F. Mähler Jr.) had a good view of it on both occasions] and also noted it at the edge of lowland coastal forest at station 2 (Bencke *et al.*, in press).

Hypoedaleus guttatus. Spot-backed Antshrike. This antshrike has been confirmed in Rio Grande do Sul only recently (records in Belton 1994) and had no previous published record for the northeastern part of the state. We recorded it by voice at station 2 on 19 August and again on 02 December at *c.* 29°30'39"S, 50°06'27"W (coordinates from a Global Positioning System receiver). Prior to our observations, the Spot-backed Antshrike had been recorded by J. Albuquerque (*in litt.* 1995) farther south in the lower foothill forests of the escarpment near Osório (29°53'S, 50°16'W). In northeastern Rio Grande do Sul, this antshrike is uncommon and possibly restricted to the coastal lowlands and lower slopes of the adjacent escarpment.

Psilorhamphus guttatus. Spotted Bamboowren. The

Bamboowren had not been previously reported for Rio Grande do Sul (Belton 1994, Sick 1997). Between Tainhas and Terra de Areia, we recorded it on 12 August 1995, when the species' distinctive voice was heard at station 3 at about 350 m elevation (Bencke *et al.*, in press). Though not yet confirmed by a sight record, the discovery of *P. guttatus* in the state was not unexpected inasmuch as there is a record of this species not far from the Rio Grande do Sul boundary at Jacinto Machado, extreme southeast of Santa Catarina (Sick and Bege 1984; locality not included on map in Ridgely and Tudor 1994).

Rare and threatened species.

Amazona vinacea. Vinaceous-breasted Parrot. This globally threatened parrot (Collar *et al.* 1994) was recorded only twice in *Araucaria* woodlands at station 4, where it appears to have suffered a severe decline due to extensive removal of araucarias, possibly one of its main food-plants in winter.

Triclaria malachitacea. Blue-bellied Parrot. Fairly common in *Araucaria* woodlands and foothill forests throughout the altitudinal gradient between Tainhas and Terra de Areia. It should have formerly occurred in the lowland forests of the coastal plain as well, but these are presumably too small and fragmented today to hold populations of resident individuals.

Macropsalis forcipata. Long-trained Nightjar. This handsome nightjar has been infrequently reported from Rio Grande do Sul (Belton 1994) but is probably more widespread in state than the few records would indicate. On 14 October 1995, at 18:50 hrs, two males were observed for about 45 min at station 3 as they flew together over the canopy of foothill primary forest and nearby clearings. Their flight was of graceful glides with few wingbeats interspersed. The tail was usually held closed in flight and the long streamers were only rapidly spread out as the birds swerved in the air, presumably to catch aerial prey. Now and then one bird would ascend well above the canopy and fly down right away with an erratic glide, perhaps capturing large prey with this maneuver. Foraging in continuous flight ("screen" attack maneuver of Remsen and Robinson 1990) over the forest canopy, as do other primarily forest nighthawks such as *Lurocalis semitorquatus*, appears not to have been previously recorded among hunting tactics of *M. forcipata* (Nores and Yzurieta 1982, Olmos and Rodrigues 1990, Sick 1997). On 03 November another male observed at station 4 behaved quite differently. This bird flew low and slowly over a dirt road with its streamers pendent as described by Nores and Yzurieta (1982) and illustrated in Narosky and Yzurieta (1993). Another lone male was observed by G.B. at IBAMA National Forest (29°23'-29°27'S, 50°23'-50°25'W; 900 m elevation) in the cold evening of 08 June 1996 as it landed for a few minutes on a dirt road surrounded by tall primary *Araucaria* woodland and then flew straight up suddenly to disappear over the nearby canopy. Olmos and Rodrigues (1990) suggest that the male's foraging activities during the breeding season may be associated with reproductive displays in the crepuscular period. If this is true, our observation on 14 October (early breeding season in southern Brazil) may further suggest that males forage together to attract passing females more easily.

All previous records of *M. forcipata* in the state, summarized in Belton (1994), were from elevations below 300 m. Records above in conjunction with specimens collected by Kaempfer early in this century at Torres on the coastal plain near sea-level (Belton 1994) indicate that it is distributed throughout the entire altitudinal gradient in the northeast of Rio Grande do Sul. Straube (1989) reports a similar pattern of occurrence of *M. forcipata* along the Serra do Mar in Paraná.

Anabacerthia amaurotis. White-browed Foliage-gleaner. Until very recently this furnariid was known in Rio Grande do Sul from a single specimen collected early in this century near the center of the state (Belton 1994). Records from Terra de Areia add to the rediscovery of the species at Santa Cruz do Sul, reported in Bencke (1996b).

Myrmotherula unicolor. Unicolored Antwren. In Rio Grande do Sul this threatened species (Collar *et al.* 1994) is restricted to humid forests on the coastal plain of the extreme northeast (Belton 1994). We found *M. unicolor* only at station 2, where its population is possibly very small. Habitat requirements were much as described for the species in southeastern Brazil by Whitney and Pacheco (1995). This antwren appears to survive in small fragments of suitable habitat as it was readily found at station 2 throughout the fieldwork, but it may depend on the continued existence of mixed-species flocks.

Grallaria varia. Variegated Antpitta. Generally rare in state, this antpitta has been recorded from a few scattered localities in Rio Grande do Sul (Belton 1994, Bencke 1996a). During our survey it was recorded in *Araucaria* woodlands of station 4 at about 950 m elevation but was unaccountably absent from foothill forests of station 3. This is the highest locality for the species in state.

Scytalopus indigoticus. White-breasted Tapaculo. This Atlantic forest endemic was previously known in Rio Grande do Sul only from one sight record by E. O. Willis at Torres and an old specimen collected by Ihering at Taquara in the late 1800s (Belton 1994). At station 2, we found this tapaculo in dense tangles of small bamboo, terrestrial ferns, broad-leaved herbs, young palms, and fallen branches along creeks and in areas of poorly-drained terrain inside or at the edge of the forest. It was also recorded not far from forest stands in well-lighted swampy areas with terrestrial ferns (*Blechnum* sp.), grasses, shrubs and a sparse overstory of small trees. At this site, we located at least seven territories of *S. indigoticus*, but potentially suitable habitats along the Rio Três Forquilhas were not surveyed.

Tangara cyanocephala. Red-necked Tanager. In Rio Grande do Sul, this tanager had not been recorded in recent years and was known from a few old specimens (Belton

1994). A small party of three was seen in the canopy of second-growth forest at station 3 at about 500 m elevation on 13 October 1995. This record indicates that the species is locally scarce in spite of the fact that substantial areas of suitable habitat still exist throughout the region.

Piprites pileatus. Black-capped Piprites. This globally threatened species (Collar *et al.* 1994) was previously reported from only two localities in Rio Grande do Sul (Belton 1994). We recorded it once on 03 November at 950 m elevation in *Araucaria* woodlands at station 4, a site that could harbor a large population of this species. In addition, this scarce piprites was registered (including tape-recordings) by G. B. in early June 1996 at IBAMA National Forest, where it appears to be more common (five records in a 4-day visit), perhaps due to the excellent state of the native woodland there.

Range extensions. Twenty-six taxa (marked with an asterisk in appendix 1) were not previously known to occur in the extreme northeast of Rio Grande do Sul between Tainhas and Terra de Areia, according to the distributional maps presented in Belton (1994). Four of these (*Philydor rufus*, *Anabacerthia amaurotis*, *Hypoedaleus guttatus* and *Hirundo rustica*) were not hitherto reported from the northeastern quarter of Rio Grande do Sul and had their known ranges in state significantly extended. However, only three of these were not expected to occur between Tainhas and Terra de Areia as *H. guttatus* had been previously recorded in southern Santa Catarina at localities near our study sites (Rosário 1996).

DISCUSSION

A rich and distinctive avifauna inhabits the altitudinal gradients of Atlantic forest in the extreme northeast of Rio Grande do Sul. Our study suggests that in this region over half (or up to 56%) of all bird species known for the state may occur along a single elevational transect spanning 1000 m of altitude. To some extent, this high species richness is a reflection of the variety of habitat types present along the gradient. As one goes up, vegetation grades from genuinely tropical forests interspersed with marshes in the coastal lowlands through foothill forests at mid-elevations to temperate woodlands and upland grasslands in the Planalto. Non-forest habitats (marshes and grasslands) thus substantially increase the overall bird diversity across the elevational habitat spectrum.

The distinctiveness of the local avifauna - especially in the regional context - can be addressed by examining the proportion of Atlantic forest endemics and of restricted-range Rio Grande do Sul species in the community. Several authors (e.g., Klein 1984, IBGE 1986, Leite and Klein 1990) set the southern limit of the Atlantic forest *stricto sensu* (moist evergreen broadleaf forest) at about 29°50'S latitude near Osório, in northeastern Rio Grande do Sul. Although situated only a few kilometers north of this distributional limit, the region between Tainhas and Terra de Areia still maintains a high degree of bird endemism. No less than 26.5% of the species effectively recorded across this altitudinal gradient are endemic to the Atlantic forest, a percentage only slightly lower than that reported for the Atlantic forest region as a whole (between 29 and 30%; Stotz *et al.* 1996, Goerck 1997). Moreover, about 6.3% of the land bird species recorded along this section of the Rota do Sol have a known distribution within Rio Grande do Sul of only 4,500 km² (approximately half a latlong) or less [G. B., unpublished data based on Belton (1994)]. In contrast, this percentage drops to 2.6% in an equally well-surveyed 650-m altitudinal gradient on the southern escarpment around Santa Cruz do Sul, in the center-east of the state (Bencke 1996a, G. B. unpublished). This happens because several Atlantic forest species have distribution ranges ending at the extreme northeastern corner of Rio Grande do Sul, especially birds of lowland forests (Belton 1994).

In conclusion, the pool of bird species present in the extreme northeast of Rio Grande do Sul is well representative of the Atlantic forest avifauna. Moreover, the forests and woodlands in this region constitute an important distributional limit for birds of this biogeographical region.

Across the elevational gradient surveyed, we were able to identify very few (possibly only 4-5) genuine cases of altitudinal replacement. This finding agrees with the general statement that mountain ranges in eastern South America are relatively small, low and isolated, and hence show little species turnover along the slopes when compared with the Andes (Willis and Schuchmann 1993, Stotz *et al.* 1996). Life zones in eastern South America are generally narrow, allowing less space for altitudinally replacing groups to occur across the gradient (Willis and Schuchmann 1993). In Rio Grande do Sul, this effect seems even more pronounced. Some congeneric species that segregate altitudinally in southeastern Brazil (e.g., *Chamaeza* spp.; Willis 1992) have completely overlapping distributions in the northeast of the state. *Chamaeza campanisona*, the lower montane species northward, is found almost throughout the entire altitudinal gradient, from forests at the foot of the escarpment about 50 m elevation up to *Araucaria* woodlands on the top of the Planalto. *Chamaeza ruficauda*, the upper montane species in southeastern Brazil, overlaps with it in foothill forests above 500 m but was not recorded at station 4 (where, however, it may have been simply overlooked).

Willis and Schuchmann (1993) also point out that there is a general tendency for lowland species to move up into the subtropical zone in eastern Brazil, apparently because a typical upland avifauna is partly lacking there. At the southern limit of the Atlantic forest, this is less clear due to the effect of high latitude, and an essentially reverse phenomenon becomes apparent. Species of higher elevations northward (e.g., *Stephanoxis lalandi*, *C. campanisona*, *Phylloscartes ventralis*, *Hemitriccus obsoletus*, *Carpornis*

cucullatus, Basileuterus leucoblepharus, Stephanophorus diadematus) are found at lower altitudes and over broader elevational ranges in the state in the absence of lowland counterparts or due to ecological release effects. While many of the upland species are widespread, several lowland (more tropical) species are lacking in Rio Grande do Sul (e.g., *Drymophila squamata, Conopophaga melanops, Phylloscartes paulistus, Todirostrum poliocephalum, Dacnis nigripes*) or barely reach the state (e.g., *Formicarius colma, Myrmotherula unicolor, Hemitriccus orbitatus, Manacus manacus*; Bencke *et al.* in press). A simple way to demonstrate the consistency of this pattern is to compare the representativeness of each altitudinal cohort (*sensu* Stotz *et al.* 1996) along the latitudinal gradient encompassed by the Atlantic forest. We expect lower-elevation cohorts of eastern Brazil to be poorly represented in Rio Grande do Sul compared with cohorts of more highland species. An unaccountable exception to this pattern appears to be *Phyllomyias fasciatus*, which is commonly found at sea level in northeastern São Paulo (G.B. pers. observ.) but is restricted to the highlands in Rio Grande do Sul (Belton 1994).

Although we did not study distributional patterns over the full altitudinal gradient, our subjective impression was that ecotones (as opposed to competitive exclusion, as in the Andes; Terborgh and Weske 1975, Haffer 1992) may play a major role in defining the elevational limits of bird distributions near the southern limit of the Atlantic forest. Many species, notably suboscines, were characteristic of, and possibly restricted to, one of the three main forest types extant along the gradient: *Philydor atricapillus, M. unicolor, Myrmeciza squamosa, F. colma, Scytalopus indigoticus, Cnemotriccus f. fuscatus,* and *Attila rufus* in the lowland coastal forest; *Synallaxis ruficapilla, Anabacerthia amaurotis, Philydor rufus, Phyllomyias burmeisteri, Pachyramphus castaneus,* and *C. cucullatus* in the foothill forests; and *Amazona vinacea, Leptasthenura setaria, L. striolata, Heliobletus contaminatus, P. fasciatus, Attila phoenicurus,* and *Piprites pileatus* in the *Araucaria* woodlands. The clarification of this topic requires further research.

One particularly stimulating result of our count data, in part unpredicted, was the detection of several co-occurring patterns of seasonal fluctuation in species abundances, which led us to propose a number of different categories of migratory movements to explain them. The consistency of each of these migratory patterns needs to be tested against the possibility that they were produced or affected by limited quantitative surveys. An adequate understanding of local migratory movements, such as altitudinal and between-habitat ones, is clearly important in the planning and management of protected areas (Willis and Schuchmann 1993, Powell and Bjork 1995).

We hope that the results of this preliminary work will open new perspectives of ornithological research in the southern limit of the Atlantic forest *stricto sensu*, stimulating interest both in the study and conservation of birds in the extreme northeast of Rio Grande do Sul. Particularly in need of further study are the distributional and migratory patterns revealed or suggested in this paper, which should be confirmed not only with more extensive research along the Rota do Sol but also through the development of similar inventories in nearby areas, such as those currently being undertaken by the staff of PUCRS's Laboratory of Ornithology from Porto Alegre at the Pró-Mata reserve (*c.*4500 ha) in São Francisco de Paula. Follow-up surveys carried out by the authors during the monitoring program of the Rota do Sol, for example, have resulted in the discovery of some rare or threatened species not found during the environmental assessment of the area, such as *Phylloscartes kronei* (Bencke *et al.* in press) and *Spizaetus tyrannus*, and have helped clarify the migratory status of other species.

Conservation. The lowland Atlantic forest is one of the most endangered of all Rio Grande do Sul's ecosystems. This distinctive forest type is presently reduced to a few small to tiny remnants scattered throughout the narrow coastal strip between Torres and Osório. Apparently only two such remaining patches are currently receiving some form of protection (as private reserves). The rest have been heavily degraded and subjected to changes in floristic composition due to selective cutting and grazing.

In Rio Grande do Sul, the lowland Atlantic forest concentrates an expressive number of animal and plant species that are found nowhere else in the state. Examples are: *P. atricapillus, M. unicolor, F. colma, Platyrinchus leucoryphus, H. orbitatus, C. f. fuscatus* and *M. manacus* among birds (Belton 1994, Bencke *et al.* in press); *Scinax rizibilis, Hyla guentheri, H. microps* and *Phyllomedusa distincta* among amphibians (Garcia and Vinciprova 1998; G. Vinciprova pers. comm. 1999); and at least 20 species of plants (M. Sobral pers. comm. 1999). In addition, as revealed by this study, remaining patches of this ecosystem may serve as wintering areas for birds that perform altitudinal or latitudinal migrations. We strongly recommend that the remnants of lowland Atlantic forest in Rio Grande do Sul be identified, mapped and properly protected, and that a program to promote the enhancement of connections between them be initiated in order to safeguard what is left of this unique forest type in the state. The current plight of this ecosystem in Rio Grande do Sul indeed offers a dramatic example of how populations of ecologically very specialized and restricted-range species such as the Atlantic forest endemic birds may persist in such a reduced and highly fragmented habitat. We wonder how many species have already disappeared and how long populations of the remaining endemic species will persist in the state if the current trend of forest destruction continues. To protect the remnants of this ecosystem in Rio Grande do Sul means preserving the southernmost distributional limit of several Atlantic forest endemic taxa, among which are at least five globally threatened or near-

threatened birds (*Psilorhamphus guttatus*, *M. unicolor*, *H. orbitatus*, *P. kronei* and *P. leucoryphus*; Belton 1994, Bencke *et al.* in press).

At the opposite end of the gradient, extensive areas of upland grasslands are being converted to *Pinus* plantations with almost no intermediate patches of natural vegetation. This activity completely eliminates the habitat of some threatened species - such as *Heteroxolmis dominicana* and *Xanthopsar flavus* - over vast areas. The paving of the Tainhas - Terra de Areia section of the Rota do Sol will result in a substantial improvement of the local road system. This in turn will facilitate the transportation of timber and encourage the implementation of new forestry projects. Control of this activity will require constant monitoring of the landscape through satellite images and/or aerial photographs as it is expected that quantitative avifaunal surveys are unlikely to be effective in the monitoring of areas where native habitats are being converted to plantations, since birds rapidly disappear rather than gradually decrease in abundance as their habitat retreats.

The increase in the numbers of trucks and tourists that will result from the paving of the road between Tainhas and Terra de Areia will indubitably encourage the trapping and sale of wildlife by local people as a means of supplementing their incomes. Several species of parrots and tanagers (e.g., *A. vinacea*, *Triclaria malachitacea*, and *Tangara* spp.) may have their local populations severely reduced as a result of these activities. This concern, along with recommended counteractive measures, has been expressed in our environmental impact report to federal and state environmental agencies.

It has been recently recognized that the barrier effect may represent the most important ecological impact of roads (Forman and Alexander 1998). New roads often lead to deforestation and habitat fragmentation in forested landscapes, which in turn may have demographic and genetic consequences on populations. The Tainhas - Terra de Areia section of the Rota do Sol dissects the only (narrow) corridor of Atlantic forest *stricto sensu* extending into Rio Grande do Sul and potentially limits or interrupts local ecological flows. Moreover, because this section of the Rota do Sol is situated near the southernmost distributional limit of the Atlantic forest, it has the potential to isolate the remnants of this ecosystem extending south of the road, thus preventing recolonization processes by selectively limiting the southward dispersion of taxa. Whilst this effect is probably negligible for most animal groups under the current rate of utilization of the Rota do Sol, it will certainly become much more pronounced after the paving and widening of the road inasmuch as the magnitude of the barrier effect is known to be directly related to traffic level and road width (Mader 1984, Forman and Alexander 1998). Proposed mitigation efforts against this impact include the establishment of hundreds-of-meters-long tunnels, viaducts and wildlife passages along those sections of the road where major faunal corridors could be interrupted. An evaluation of the effectiveness of these mitigation structures should be among the highest priorities of the monitoring program currently being developed for the Rota do Sol.

The official licensing process of the Tainhas - Terra de Areia section of the Rota do Sol has resulted in the creation of two natural reserves (combined protected area *c.*6,000 ha) encompassing high-quality habitats plus a 52,300 ha area of restricted human intervention (APA, or Área de Proteção Ambiental) within the influence zone of the new road. One such protected area, albeit small (113 ha), is considered of utmost importance because it encompasses the only representative fragment of lowland Atlantic forest between Tainhas and Terra de Areia (station 2), where populations of such rare or threatened species as *S. indigoticus* and *M. unicolor* have been regularly found. Moreover, it is expected that the APA may function as a buffer zone for the Aratinga Ecological Station, the larger of the two natural reserves thus far created along the Rota do Sol, as the latter is completely included within the former. Still, the consolidation and effective protection of these reserves will largely depend on the interest and policies of governmental agencies.

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Appendix 1 (cont.)

SPECIES	Station 1		Station 2		Station 3		Station 4		Station 5	
	W	S	W	S	W	S	W	S	W	S
M. semitorquatus						X				
Falco sparverius	6	7.3			X					
F. femoralis										X
Ortalis motmot			X	6.1	1.1	2.1				
Penelope obscura								1.6	5.2	2.5
*Odontophorus capueira**				S	1.1	7.5		0.8		
Pardirallus sanguinolentus									1.7	7.4
P. nigricans	6	3.7	3.9	8.2						
Aramides saracura	X	3.7	5.8	6.1	1.1		2.3	7	12.2	17.4
Laterallus sp.	18	7.3		2						
Cariama cristata										5
Jacana jacana	6	7.3								
Vanellus chilensis	21	18.3	X	X	X	X	1.2	X	5.2	17.4
Gallinago undulata									X	X
G. paraguaiae	6	7.3	X	X					1.7	X
Columba picazuro									58	5
C. cayennensis[M]								0.8		
C. plumbea						5.3		1.6		
Columbina talpacoti		X		4.1						
C. picui		X		2						
Leptotila spp.		3.7	9.7	8.2	3.3	12.8		9.3	1.7	17.4
Leptotila verreauxi		X	X	X	?	X	X	X	?	X
L. rufaxilla			X	X	?	X	X	X	?	?
Geotrygon montana				2						
Pyrrhura frontalis				2			18.6	9.3		
Pionus maximiliani							3.5	2.3		
Pionopsitta pileata						3.2	5.8	4.7		
Amazona vinacea							?	3.1		
Triclaria malachitacea					4.3	6.4	4.6	0.8		
Piaya cayana	X		3.9	4.1	2.2	3.2		1.6		
Guira guira		11		2	X	X		X		2.5
Crotophaga ani	21	X								
Tapera naevia	3			2		3.2				
Otus choliba				X		X				
O. sanctaecatarinae			X	X	X	X		X	?	X
Pulsatrix perspicillata							X	X		
*Strix hylophila**								X		
*Glaucidium brasilianum**					X	X				
Speotyto cunicularia	X	X								7.4
*Nyctibius griseus**[M]				X						
Lurocalis semitorquatus[M]				X		X		X		X
Macropsalis forcipata						X		X		
Streptoprocne zonaris				X	X	X		X		
Cypseloides fumigatus						X		X		
Chaetura meridionalis[M]						X		X		
*C. cinereiventris**					X	X				

Appendix 1 (cont.)

	Station 1		Station 2		Station 3		Station 4		Station 5	
SPECIES	W	S	W	S	W	S	W	S	W	S
Phaethornis eurynome						X				
Stephanoxis lalandi					13.0	4.3	8.1	6.2		
Chlorostilbon aureoventris						4.3		X		?
Thalurania glaucopis			X	2	X	3.2				
Leucochloris albicollis					2.2	5.3	7	5.4	5.2	
Amazilia versicolor					X					
Trogon surrucura					2.2	10.7	7	7.8		
*T. rufus**					1.1			1.6		
Ceryle torquata			X						3.5	5
C. americana										7.4
Ramphastos dicolorus					3.3	4.3	1.2	5.4		
Picumnus temminckii				4.1	2.2	X				
P. nebulosus					X	X	1.2	2.3	1.7	2.5
Veniliornis spilogaster			X	2	1.1	4.3	8.1	3.9		5
Piculus aurulentus						1.1	1.2	3.9		
Colaptes melanochloros		X	1.9	2				X		2.5
C. campestris	12	X	3.9	4.1		X	2.3	1.6	3.5	17.4
Celeus flavescens			1.9		2.2	2.1				
Cinclodes pabsti									3.5	2.5
Furnarius rufus	3	22	1.9	8.2						
Leptasthenura setaria							22.1	3.9	6.9	2.5
L. striolata							3.5	2.3	3.5	
Synallaxis ruficapilla				S	5.4	4.3				
S. spixi	3		X	2	X	X	X		1.7	2.5
S. cinerascens					2.2	X	3.5	7.8		
Cranioleuca obsoleta					X	2.1	5.8	6.2	5.2	17.4
Certhiaxis cinnamomea		3.7								
Phacellodomus erythrophthalmus		12	11							
Limnoctites rectirostris									1.7	
Anumbius annumbi								0.8		7.4
Syndactyla rufosuperciliata			1.9		7.6	4.3	5.8	9.3	1.7	7.4
Cichlocolaptes leucophrus				X				1.6		
Lochmias nematura			X		2.2	X	1.2	X	3.5	7.4
*Anabacerthia amaurotis**					1.1	X				
Philydor atricapillus			3.9	4.1						
*P. rufus**					4.3	2.1				
Sclerurus scansor					4.3	2.1				
Heliobletus contaminatus						X	5.8	6.2		
Xenops rutilans				2	1.1	X				
Sittasomus griseicapillus				2	8.7	6.4	9.3	7.8		
Xiphocolaptes albicollis			X		1.1	1.1	3.5	4.7	1.7	2.5
Dendrocolaptes platyrostris			3.9	4.1	5.4	4.3	1.2	7		2.5
Lepidocolaptes fuscus			3.9	8.2	1.1	3.2				
L. falcinellus			X		3.3	2.1	16.3	17.9	3.5	9.9
Campylorhamphus falcularius			3.9			X				
*Batara cinerea**			1.9		1.1	1.1	3.5	2.3		

Appendix 1 (cont.)

SPECIES	Station 1		Station 2		Station 3		Station 4		Station 5	
	W	S	W	S	W	S	W	S	W	S
*Mackenziaena leachii**			X	S	7.6	2.1		0.8		
*Hypoedaleus guttatus**			3.9	X						
Thamnophilus ruficapillus	12	7.3	X	X	1.1	X			3.5	
T. caerulescens			5.8	6.1	9.8	6.4	7	13.2	1.7	X
Myrmotherula unicolor			3.9	6.1						
Dysithamnus mentalis			3.9	4.1	1.1	1.1				
Drymophila malura					9.8	7.5		0.8		
Pyriglena leucoptera				2						
Myrmeciza squamosa			1.9	6.1						
*Formicarius colma**			1.9							
Chamaeza campanisona			S	S	3.3	5.3	3.5	3.9		
*Chamaeza ruficauda**						1.1				
*Grallaria varia**								3.1		
Hylopezus nattereri				S	8.7	3.2		2.3		
Conopophaga lineata			X	4.1	8.7	3.2		4.7	1.7	
*Scytalopus speluncae**					3.3	5.3	4.6	5.4		
S. indigoticus#*			X	X						
Psilorhamphus guttatus					1.1					
Phyllomyias fasciatus[M]						X	10.5	14		
P. burmeisteri[M]					1.1	4.3				
P. virescens					X	X	?	?		
Camptostoma obsoletum	9	3.7	3.9	4.1		3.2	5.8	7	1.7	7.4
Elaenia flavogaster	3	X								
E. parvirostris[M]		3.7		6.1		1.1		1.6		14.9
E. mesoleuca[M]						1.1		24.9		17.4
E. obscura	3	3.7								
Serpophaga nigricans									5.2	X
S. subcristata	15		5.8	2	3.3	X	2.3	0.8	8.7	2.5
Mionectes rufiventris			1.9			2.1				
Leptopogon amaurocephalus					1.1	1.1				
Phylloscartes ventralis			X		8.7	2.1	50	30.3	6.9	
Hemitriccus obsoletus					2.2	3.2	1.2	3.9		
Todirostrum plumbeiceps	6	X	11.6	8.2	3.3	4.3				
Tolmomyias sulphurescens			X		4.3	4.3				
Platyrinchus mystaceus			7.7	6.1	4.3	2.1				
Myiophobus fasciatus[M]		7.3		X		X				5
Lathrotriccus euleri[M]				6.1		5.3		16.3		
Cnemotriccus fuscatus[M]				2						
Xolmis cinerea									X	2.5
Heteroxolmis dominicana							X		17.4	12.4
Knipolegus cyanirostris						1.1	1.2	5.4		12.4
Satrapa icterophrys	X		1.9					X		X
Hirundinea ferruginea[M]						4.3				
Machetornis rixosus	3	3.7							3.5	
Muscipipra vetula			5.8		2.2	2.1				
Attila phoenicurus[M]								7.8		

Appendix 1 (cont.)

SPECIES	Station 1		Station 2		Station 3		Station 4		Station 5	
	W	S	W	S	W	S	W	S	W	S
A. rufus			X	6.1						
Myiarchus swainsoni[M]				4.1		3.2		11.7		9.9
Pitangus sulphuratus	9	18.3	7.7	6.1	X	X		3.9		12.4
Legatus leucophaius[M]				2		3.2				
Myiodynastes maculatus[M]				2		2.1		8.6		2.5
*Megarynchus pitangua**[M]			1.9					1.6		
Empidonomus varius[M]				4.1		X				
Tyrannus melancholicus[M]		3.7		8.2		1.1		0.8		9.9
T. savana[M]		18.3		X		X		0.8		9.9
Pachyramphus castaneus					X	X				
P. polychopterus[M]				8.2		X		5.4		
P. validus[M]						X		2.3		
Tityra cayana[M]				6.1				1.6		
Schiffornis virescens						3.2				
Piprites pileatus[M]								1.6		
Chiroxiphia caudata			13.5	16.4	7.6	18.2	4.6	2.3		
Carpornis cucullatus					1.1	7.5				
Procnias nudicollis[M]								7.8		
Cyanocorax caeruleus						2.1	4.6	1.6		7.4
Tachycineta leucorrhoa	6	11							5.2	7.4
Progne chalybea[M]				X				0.8		
Notiochelidon cyanoleuca	X					X	3.5	2.3	6.9	
Stelgidopteryx ruficollis[M]		3.7		X						2.5
*Hirundo rustica**[M]		X								
Troglodytes musculus	12	25.6	X		X	X	X		3.5	5
Platycichla flavipes[M]						2.1		6.2		
Turdus subalaris[M]						X		2.3		2.5
T. rufiventris			13.5	12.3	2.2	4.3	27.9	26.5	5.2	22.3
T. amaurochalinus	3		21.3	8.2	1.1	4.3	1.2	1.6		2.5
T. albicollis			9.7	16.4	9.8	16.0	10.5	19.4		
Mimus saturninus	X						X		3.5	X
Anthus hellmayri									12.2	7.4
Cyclarhis gujanensis	3		3.9	2	10.9	9.6	31.4	18.7	5.2	9.9
Vireo olivaceus[M]				12.3		11.8		27.2		12.4
Hylophilus poicilotis				2	1.1	3.2	7	5.4		
Zonotrichia capensis		11		2	X	3.2	23.2	0.8	13.9	34.7
Ammodramus humeralis	3	11								5
Haplospiza unicolor						2.1				
Donacospiza albifrons	3	7.3				?			1.7	
Poospiza nigrorufa						X				
P. lateralis					6.5	1.1	55.8	10.9	5.2	14.9
Sicalis flaveola				X			X	X	5.2	X
S. luteola		65.9								2.5
Emberizoides ypiranganus									5.2	22.3
Embernagra platensis	15	3.7							15.6	12.4
Volatinia jacarina	24	3.7		2						

Appendix 1 (cont.)

SPECIES	Station 1		Station 2		Station 3		Station 4		Station 5	
	W	S	W	S	W	S	W	S	W	S
Sporophila caerulescens		3.7		2						X
Coryphospingus cucullatus			3.9							
*Saltator fuliginosus**					1.1	2.1				
S. similis			3.9	16.4	13	17.1	1.2	12.4		2.5
*S. maxillosus**					X	?		0.8		
Cyanocompsa cyanea						?				
Pyrrhocoma ruficeps			5.8			1.1				
Hemithraupis guira						X				
Tachyphonus coronatus			X	6.1	X	5.3				
Trichothraupis melanops						2.1				
Habia rubica			5.8	10.2	2.2	X				
*Piranga flava*M*						X				
Thraupis sayaca		X		4.1	X	X		0.8		7.4
T. cyanoptera			?	2	X	X				
Stephanophorus diadematus					2.2	6.4	15.1	14.8	X	5
Pipraeidea melanonota					1.1	X	1.2	4.7		7.4
Euphonia chlorotica	6									
*E. chalybea**						3.2				
E. cyanocephala			3.9			4.3		0.8		
E. pectoralis			X	4.1	X	X				
Chlorophonia cyanea			X		X	3.2				
Tangara preciosa			3.9		1.1	5.3	19.8	11.7		X
T. cyanocephala						3.2				
Dacnis cayana	12				X	X				
Parula pitiayumi	6	7.3	7.7	10.2	13	10.7	22.1	15.6	6.9	7.4
Geothlypis aequinoctialis	24	22	X	6.1		2.1				X
Basileuterus culicivorus	3		13.5	6.1	19.6	15.0	7	9.3		
B. leucoblepharus			X		17.4	10.7	23.2	21		5
Coereba flaveola	3		X	4.1						
Cacicus chrysopterus					10.9	3.2	20.9	7.8		7.4
Icterus cayanensis	9									
Xanthopsar flavus										X
Agelaius ruficapillus	?									
Pseudoleistes guirahuro		11							15.6	27.3
Amblyramphus holosericeus	6	14.6								
Molothrus bonariensis		3.7		2		X				7.4
Carduelis magellanica					3.3	X		X		2.5
Passer domesticus	6									
Unidentified	33	22	38.7	22.5	16.3	33.2	24.4	36.6	30.9	52.1
Total of species	75	119	156	123	107					

Note: The voice of *Phyllomyias virescens* was erroneously attributed to *Phylloscartes ventralis* during the counts. The abundance of the latter species at station 3 (and certainly also at station 4) is thus overestimated.

APPENDIX 2

Bird species expected to occur along the Rota do Sol highway between Tainhas and Terra de Areia [according to the distributional maps presented in Belton (1994) and Rosário (1996)] but *not* recorded during the present study (see text for criteria).

Crypturellus noctivagus
Rollandia rolland
Podilymbus podiceps
Phalacrocorax brasilianus
Ardea cocoi
Nyctanassa violacea
Ixobrychus involucris
Botaurus pinnatus
Plegadis chihi
Mycteria americana
Ciconia maguari
Cairina moschata
Anas flavirostris
Netta peposaca
Chauna torquata
Sarcoramphus papa
Cathartes burrovianus
Circus buffoni
Accipiter striatus
Buteogallus urubitinga
Heterospizias meridionalis
Geranoaetus melanoleucus
Buteo albicaudatus
Spizaetus tyrannus
Aramus guarauna
Pardirallus maculatus
Porphyriops melanops
Gallinula chloropus
Porphyrula martinica
Fulica leucoptera
Himantopus himantopus
Pluvialis dominica
Eudromias ruficollis
Bartramia longicauda
Tringa solitaria
Calidris melanotos
Tryngites subruficollis
Zenaida auriculata
Ara maracana
Nyctidromus albicollis
Hydropsalis torquata
Streptoprocne biscutata
Ramphodon naevius
Anthracothorax nigricollis
Aphantochroa cirrhochloris
Selenidera maculirostris
Ramphastos toco
Dryocopus galeatus
D. lineatus
Phleocryptes melanops
Limnornis curvirostris
Automolus leucophthalmus
Dendrocincla turdina
Tachuris rubrigastra
Pseudocolopteryx flaviventris
P. sclateri
Phylloscartes difficilis
Myiornis auricularis
Hemitriccus orbitatus
Todirostrum poliocephalum
Platyrinchus leucoryphus
Pyrocephalus rubinus
Xolmis irupero
Hymenops perspicillatus
Arundinicola leucocephala
Tityra inquisitor
Phibalura flavirostris
Tachycineta leucopyga
Alopochelidon fucata
Riparia riparia
Hirundo pyrrhonota
Mimus triurus
Anthus lutescens
Sporophila collaris
Paroaria coronata
Cyanoloxia glaucocaerulea
Thraupis bonariensis
T. palmarum
Tangara seledon
Euphonia violacea
Agelaius thilius
Leistes superciliaris
Pseudoleistes virescens
Molothrus badius
Gnorimopsar chopi