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Habitat Use and Survival of the Spotted Tinamou (*Nothura maculosa*) in Agroecosystems in the Province of Buenos Aires, Argentina

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Changes in the composition and configuration of agricultural landscapes stemming from grassland conversion and agricultural intensification have contributed to the global declines of many grassland and shrubland birds. In both North America and Europe there exists a large body of research on the effects of agriculture on populations of terrestrial gamebirds. However, little research exists for these species in Argentina or Latin America in general. In Argentina the most important gamebird species is the spotted tinamou (*Nothura maculosa*). This species has become increasingly scarce in a significant portion of its range, possibly due to agricultural intensification over the last 15 years. Using radio telemetry, we examined habitat use, movements, and survival of spotted tinamous in 2 landscapes in the province of Buenos Aires, Argentina; one dominated by annual row crops and the other used for annual crops and grazing. During winter, individuals used in order of preference: fallow fields and areas with short herbaceous vegetation, followed by wetlands. Areas in winter wheat and field edges were used least in relation to their availabilty. Although birds generally maintained small home ranges, in some cases changes in cattle density and the structure of row crops caused birds to move considerable distances. Survival mid-winter to early spring was more than double in the mixed landscape ($\hat{s}$ = 0.73, SE = 0.19) compared with the landscape dedicated to row crops ($\hat{s}$ = 0.33, SE = 0.19). Considering how research in other parts of the world has demonstrated the effects of agricultural intensification on terrestrial gamebirds, these results are not unexpected and suggest a precarious future for the conservation of grassland and agroecosystem species in Argentina in light of present agricultural trends.

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Key words: agricultural intensification, conservation, *Nothura maculosa*, spotted tinamou, survival

Introduction

Globally, populations of grassland and shrubland birds have been declining due to habitat conversion and agricultural intensification (Askins 2000, Goriup 1988, Murphy 2003, Pain and Pienkowski 1997, Vickery and Herkert 1995). In agroecosystems of austral South America habitat loss and the intensification in management have been extensive and rapid, particularly in the pampas of Argentina starting in the early 1990's, typified by the increased use of external inputs, increased yields, and a shift towards agricultural production for export markets (Ferreyra 2001, Ghersa et al. 2002, Hall et al. 2001, Solbrig and Vera 2001, Viglizzo et al. 2001).

The spotted tinamou (*Nothura maculosa*) is a common bird of grasslands and agroecosystems in eastern austral South America, one of the most important terrestrial gamebirds in the region, and formerly common in agricultural systems (Bucher and Nores 1988, Bump and Bump 1969, Cabot 1992, Davies 2002, Menegheti 1985). In recent years, within the pampas of Argentina, the spotted tinamou has become increasingly conspicuous by their absence apparently stemming from the expansion and intensification of grazing and row crop practices.

All tinamous are relatively poorly studied; however, in austral South American grasslands the tina-

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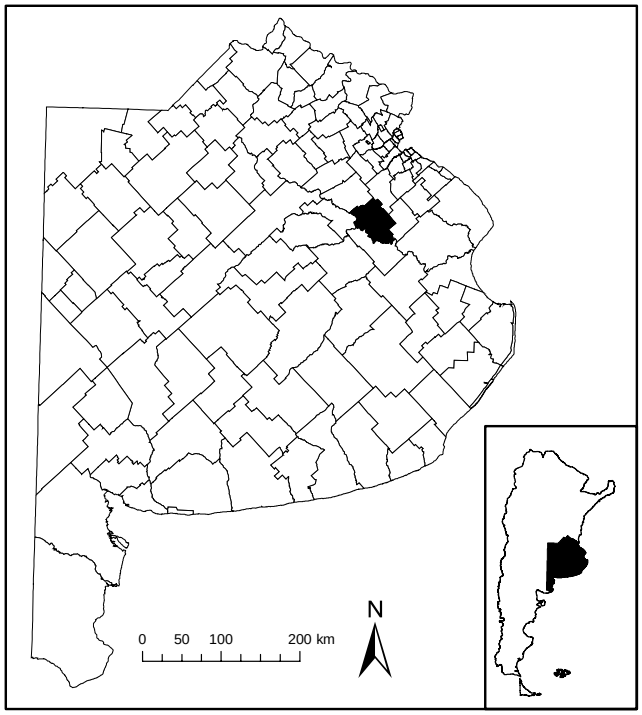

Figure 1: Map showing the location of the district of San Miguel del Monte in the Province of Buenos Aires, Argentina

mous replace the Galliformes and are their ecological equivalent, which allows for inferences to be drawn among the Galliformes and the Tinamiformes in regard to tinamou ecology (Thompson 2004). We used radio telemetry to investigate our theory of ecological equivalence. Based upon the observed effects of agricultural intensification on Galliformes and existing knowledge of the spotted tinamou that within pampean ecosystems we predicted that survival of spotted tinamous would be negatively correlated, and home range size positively correlated, with increasing land use intensity while habitat selection would favor areas most similar to natural grassland in vegetative structure (Bump and Bump 1969, Thompson 2004).

Study Area

Our study sites were located in the district of San Miguel del Monte in the province of Buenos Aires, Argentina (Figure 1). San Miguel del Monte is located in the flooding pampa, a regional subdivision of the ~760,000 km^2 Río de la Plata grassland system that covers northeastern Argentina, Uruguay and southeastern Brazil (Soriano et al. 1991). Traditionally the flooding pampa has been used principally for extensive livestock production (Hall et al. 1988), however, since the early 1990's row crop agriculture has become an increasingly important land use.

We selected two study sites; one dedicated to row crops and the other used for used for a mix of row crops and grazing. The row crop site was 160 hectares, of which 85% was used for soybean, corn, and winter wheat production, and the remaining area comprised of wetlands or field borders. The site with mixed row crop and grazing uses was 230 hectares, 50% of its area used for soybean, corn, and winter wheat production, and the remainder, including wetlands, used for cattle grazing.

Methods

During July 2003, we fitted 4 birds with pendant-style transmitters (6.0 g, 2.2-2.3% of body mass) equipped with an activity switch (Holohil Systems Ltd., Ontario, Canada) at the row crop dominated site and 14 birds in June 2004 at the mixed use site. In 2004, no birds were radio-tagged at the row crop site because none were detected over a 2 month search in the autumn of that year. All birds were captured at night using spotlights and hand nets. Due to uncertainties in sexing birds related to age (Bump and Bump 1969), sexual differences were not included in the study. In both years birds were located 3 times per week from the date of capture until October 23 (mid-winter to early spring) dependent upon accessibility to the sites.

Due to mortality, insufficient number of radio locations, radio failure, or radio loss we used 3 birds from the row crop site and 8 from the mixed use site in our analysis. Locations were entered into a geographic information system (GIS) for each site using ArcGIS software (Environmental Systems Research Institute, Inc.). Minimum convex polygons (MCP) (Mohr 1947) were calculated for each individual using the Adehabitat Package Version 1.4 (Calenge et al. 2006) in R 2.3.1 (R Development Core Team 2006) and the proportion of radio locations and MCP in different habitat types determined using the GIS.

Within the row crop site we defined 6 habitat types; winter wheat, fallow, wetlands, corn stubble, tilled land, and field edges. For the mixed use site we identified 5 habitat types; winter wheat, fallow, wetlands, mowed fallow, and grazed pasture. We used compositional analysis (Aebischer et al. 1993), based upon radio locations and MCP, to evaluate habitat preferences. The compositional analysis was performed using BYCOMP.SAS (Ott and Hoovey 1997) and, to obtain sufficient sample size, we combined data from both sites and aggregated habitat types into 5 categories; winter wheat, fallow, wetlands, edge, and short herbaceous (corn stubble, tilled land, mowed fallow, and grazed pasture). Additionally, survival was estimated using Kaplan-Meier staggered entry design (Kaplan and Meier 1958, Pollock et al. 1989). Standard errors were used to determine statistically significance differences in survival and mean home range size.

Results

The mean 100% MCP from the row crop site was larger (19.0 ha, SE = 10.4 ha) than that from the mixed use site (15.9 ha, SE = 7.3 ha), although differences were not significant due to high variance. Survival ($\hat{s}$ = 0.73, SE = 0.19) was higher in the mixed use site over 20 weeks compared to the row crop site ($\hat{s}$ = 0.33, SE = 0.19) over 15 weeks (Figure 2). Mortality of the radio-tagged birds from both sites was attributed mainly to predation (91%).

At the row crop site winter wheat, wetlands, and field edges were used less, and corn stubble more, than their availability based upon both the mean proportions of MCP and radio locations within those habitat types (Figure 3). In tilled land the mean proportion of MCP and radio locations indicate approximately equal use in relation to availability, while in fallow, based on the mean MCP use was equal to availability, but considerably higher than its availability based upon the mean proportion of radio locations (Figure 3). As at the row crop site about half of the area of the mixed use site was in winter wheat, which was utilized less than its availability (Figure 3). Fallow, mowed fallow, and wetlands were all used more than their availability, while based upon the mean proportion of MCP, grazed pasture was used equal to its availability, and less than its availability based upon the mean proportion of radio locations (Figure 3).

The compositional analysis using the aggregated data from both sites, and based upon MCP, ranked short herbaceous habitat as the most utilized habitat in relation to availability, with fallow, winter wheat, and edge ranked equally as second, followed by wetlands (Table 1a). No habitats were used significantly more than others (P = 0.05) but fallow and short herbaceous habitat were preferred over wheat, fallow over wetlands, short herbaceous over fallow, and wetlands over short herbaceous (Table 1a).

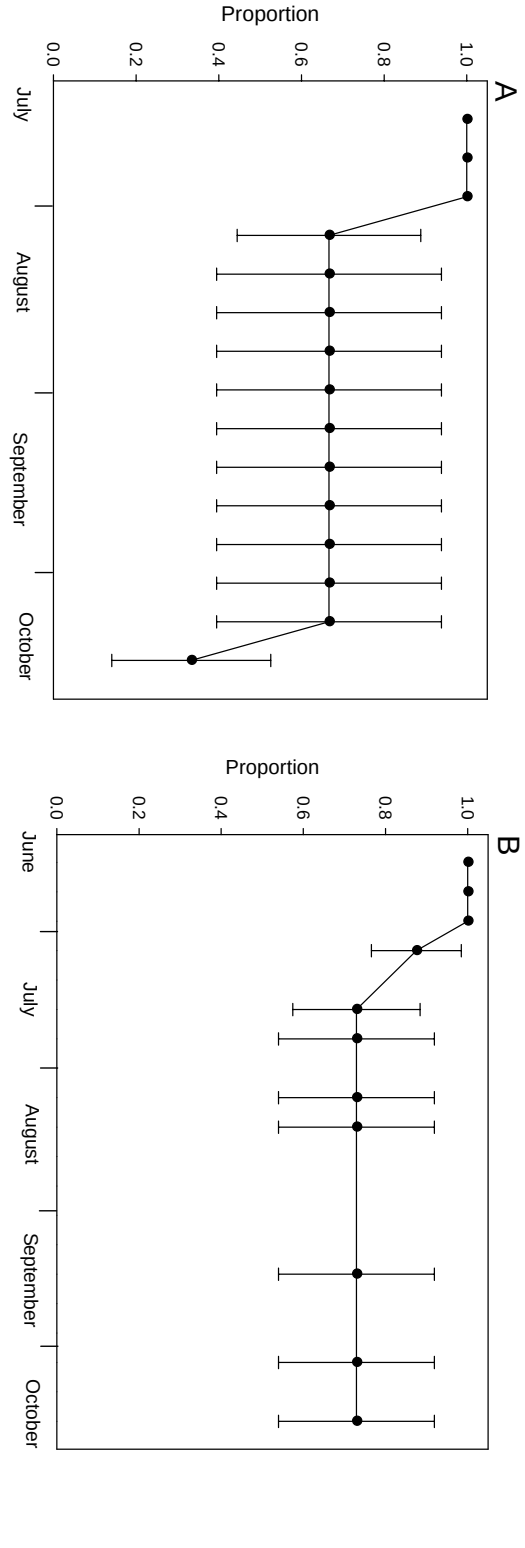

Figure 2: Estimated survival and standard error for spotted tinamous in the A) site dominated by row crops ($n = 3$) and B) the mixed grazing and row crop site ($n = 8$)

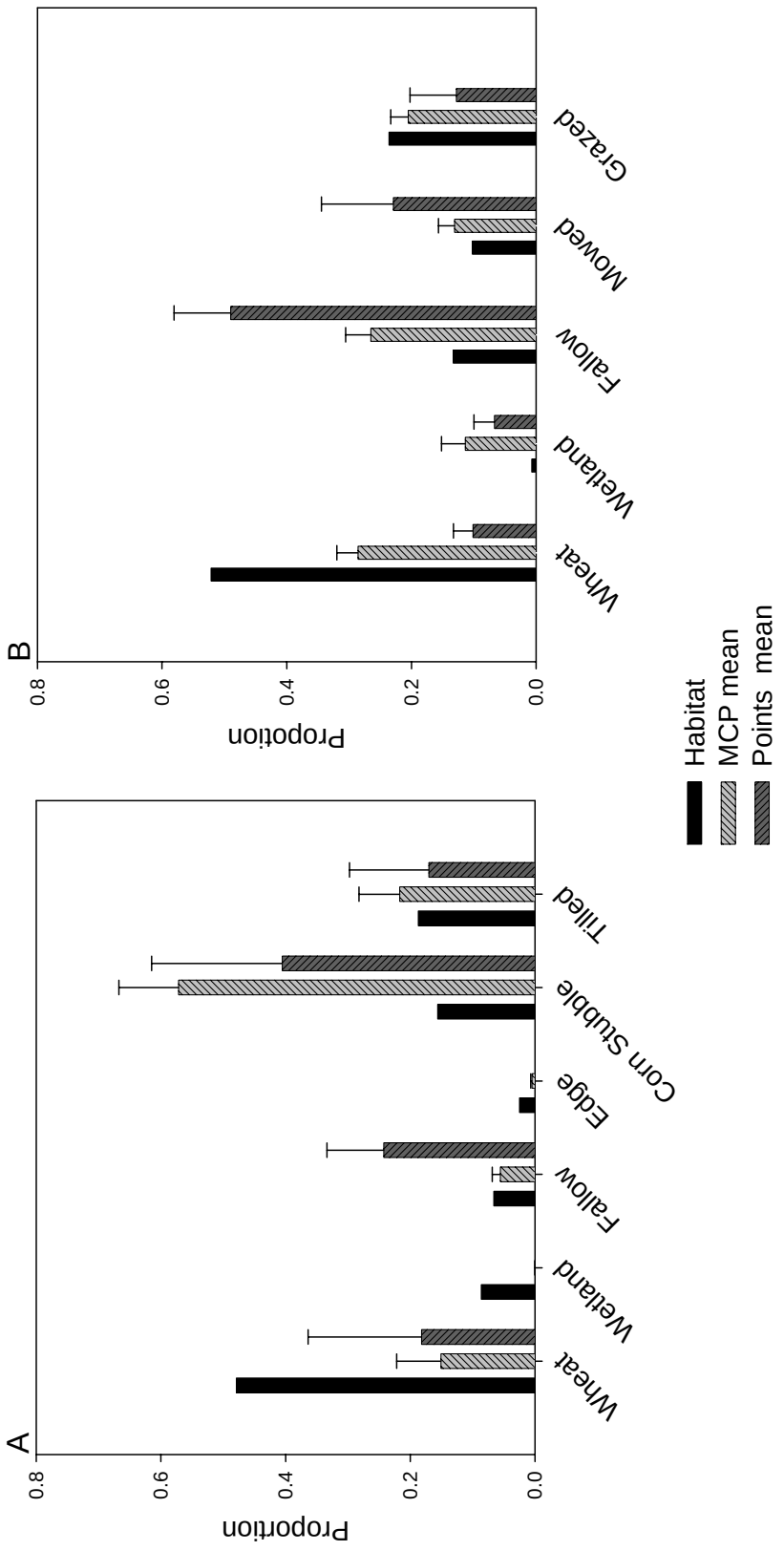

Figure 3: Proportional habitat use by spotted tinamous based on mean area of minimum convex polygon (MCP) and mean number of radio locations (Points) in relation to proportional availability of habitat types for A) the row crop site and B) the mixed use site. Error bars represent standard error.

Table 1: Results of compositional analysis based on a) minimum convex polygon (MCP) home ranges and b) radio locations. Higher ranking indicates greater use compared to availability. Within the matrix, (+) signifies that the row habitat is preferred over the column habitat, whereas a (-) signifies the opposite. Significant difference between habitats (P <0.05) is indicated by (+++) or (– – –).

a

Habitat	wheat	wetlands	edge	fallow	short herbaceous	rank
wheat	.	.	.	–	–	2
wetlands	.	.	.	–	+	1
edge	.	.	.	.	.	2
fallow	+	+	.	.	–	2
short herbaceous	+	-	.	+	-	3

b

Habitat	wheat	wetlands	edge	fallow	short herbaceous	rank
wheat	.	–	.	– – –	–	0
wetlands	+	.	.	–	–	1
edge	.	.	.	.	.	0
fallow	+++	+	.	.	+	3
short herbaceous	+	+	.	–	.	2

Note: Because of low or no use a P-value for edge habitat could not be computed.

The same analysis using radio locations ranked fallow and short herbaceous habitats as the first and second most utilized habitats, respectively, in relation to availability, followed by wetlands (Table 1b). Winter wheat and edge were equally the least used in relation to availability (Table 1b). Fallow was utilized significantly more than wheat (P = 0.05) while fallow, short herbaceous, and wetlands were preferred over wheat, fallow and short herbaceous were preferred over wetlands, and fallow over short herbaceous (Table 1b).

Discussion

The mean range size of spotted tinamous at both sites was affected by movements related to changing habitat amounts and characteristics and cattle disturbance. At the row crop site as winter wheat reached ∼10cm in height birds began to utilize those areas, often exclusively and as the wheat matured to ∼25cm in height those areas were abandoned for areas with shorter vegetation. Within the mixed use site the largest movements by birds were related to disturbance by cattle.

The lower surival in the row crop dominated site is consistent with observations of Pinheiro and López (1999) who found lower abundances of spotted tinamous in agricultural land in southern Brazil compared to natural grasslands. Additionally, for the Galliformes there are multiple cases where increased intensification in land use has led to lower survival and declining populations (e.g. Berner 1988, Hill and Robertson 1988, Jansen et al. 2000, Malan and Benn 1999, Potts 1986). Based upon this, the observed differences in survival between the two sites are expected if the spotted tinamou is viewed as an ecological equivalent to the Galliformes. Admittedly, sample sizes are small, particularly for the row crop site; however, the rarity of spotted tinamous at the row crop site in 2003 and their absence from the site in 2004 suggest a real process rather than a statistical artefact.

Habitat preferences by the spotted tinamou, and the closely related Darwin's Tinamou (*Nothura darwinii*), within both natural and agricultural habi-

tats, favour areas with relatively low (10-30 cm) and sparse vegetation (J.J.Thompson pers. obs., Bump and Bump 1969, Isacch and Martinez 2001, Leveau and Leveau 2004, Mosa 2004) and explains the pattern of habitat use at both sites. For example, use of winter wheat was most frequent when plants were 10-25 cm tall. Although wheat was generally avoided once it reached >25cm in height, birds then used it as escape cover.

The most preferred habitats; fallow, mowed fallow, and corn stubble all shared in common a well developed ground cover of herbaceous vegetation, both living and dead, that was not in excess of 50 cm and with little or no emergent vegetation above that level. Tilled land was used more as it was colonized by herbaceous vegetation, particularly clover (*Trifolium* spp.), and vegetative cover increased.

Spotted tinamous are often common in pastureland (J.J.Thompson pers. obs., Bump and Bump 1969, Menegheti 1985, Pinheiro and López 1999), as are Darwin's tinamou (J.J.Thompson pers. obs., Bump and Bump 1969, Mosa 2004), due to the low vegetative structure that is maintained through moderate grazing. At the mixed use site, however, pastureland was overgrazed so that ground vegetation was cropped near to ground level, which explains a lower than expected preference for grazed areas. The preference for relatively short vegetation also explains the avoidance of field edges in the row crop site. Field edges consisted of tall (>1m) and dense grass and also contained woody vegetation, which were avoided by the birds.

The difference in the use of wetlands among the sites appeared to be a function of the water levels within wetlands at each site. At the row crop site wetlands contained water and were avoided, where as at the mixed use site, wetlands were dry and contained suitable herbaceous cover along their perimeter that was utilized by the birds. It should be noted that although wetlands were not used by individuals at the row crop site, much of the fallow areas were not put into production due to their proximity to wetlands, subsequently wetlands were indirectly responsible for the availability of preferred habitats.

The preferences and differences in habitat use within and between sites are consistent with the results of the compositional analysis since fallow areas and the habitats comprising the short herbaceous category, while more variable, are the habitats most similar in structure to natural grasslands. Similarly, the quality of wetlands varies annually dependent upon precipitation, reducing interannual use, while row crop fields and edge were avoided or used considerably less in relation to their availability.

The preferences in habitat, size of home ranges, and survival that we observed were consistent with our expectations based upon existing knowledge of tinamou ecology, and the response of Galliformes and other bird species to the intensification of agricultural land use (Thompson 2004). From this study and others (Canavelli et al. 2003, Bellis et al. 2004, Demaría et al. 2002, Fernandez et al. 2003) it is apparent that the intensification of agriculture that has occurred in Argentina has resulted in similar negative ecological effects as observed in other regions.

The continued expansion and intensification of agriculture in Argentina suggests that pampean agroecosystems will continue to be degraded, with the most ecologically valuable systems being maintained in areas only suitable for extensive livestock production. Moreover, within intensively managed systems, fallow and areas unsuitable for production (i.e. wetlands) will increasingly become critical for biodiversity conservation.

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