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IMPACT OF AGRICULTURE AND GRAZING ON PALE-SPOTTED (*NOTHURA DARWINII*) AND ANDEAN (*NOTHOPROCTA PENTLANDII*) TINAMOUS IN THE LERMA VALLEY, SALTA PROVINCE, ARGENTINA

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Resumen. – Impacto de las actividades agrícola y ganadera sobre la Perdiz pálica (*Nothura darwinii* y la Perdiz silbadora (*Nothoprocta pentlandii*) en el Valle de Lerma, Provincia de Salta, Argentina. – En el Valle de Lerma, Provincia de Salta, Argentina, gran parte de los pastizales y campos de cultivos poseen poblaciones de tinámidos. Se evaluó en que grado impactan estas actividades en dos poblaciones simpátridas: la Perdiz pálida (*Nothura darwinii*) y la Perdiz silbadora (*Nothoprocta pentlandii*). El área fue clasificada en nueve ambientes diferentes y sus superficies fueron estimadas mediante técnicas de foto interpretación. Las abundancias relativas de estas aves fueron estimadas mediante transectas al azar con el auxilio de un perro de caza. Las abundancias de ambas poblaciones de tinámidos fueron muy variables según el ambiente y la estación considerada. La Perdiz pálida prefirió lotes de alfalfa y, en grado menor, pastizales disturbados. La Perdiz silbadora prefirió pastizales invadido por arbustos leñosas y campos de cultivos en descanso. Estas especies, aunque simpátridas, muestran una fuerte diferencia en la preferencia de sus hábitat: la Perdiz pálida prefiere ambientes que se mantienen con frecuentes disturbios como el fuego y una moderada carga de pastoreo, la perdiz silbadora prefiere ambientes que están libres de estos disturbios desde hace por lo menos tres años. Estos resultados muestran la necesidad de diversificar los usos de la tierra para mantener en buenas condiciones a las poblaciones de perdices en el Valle de Lerma.

Abstract. – Most grassland habitats in the Lerma Valley, Province of Salta, Argentina contain tinamous. I evaluated how land use affects sympatric populations of Pale-spotted (*Nothura darwinii*) and Andean (*Nothoprocta pentlandii*) tinamous, by classifying the valley into nine different habitats, based on photo-interpretation. The relative abundances of these birds was estimated seasonally with the aid of pointing dogs. The relative abundances of both tinamou populations were highly variable according to the habitat and season. Pale-spotted Tinamous showed a preference for alfalfa fields, and to a lesser degree, for disturbed grasslands. Andean Tinamous preferred grasslands invaded by woody vegetation and fallow fields. These species, although sympatric, strongly differ in their habitat preferences: Pale-spotted Tinamous prefer habitats maintained by frequent fire and moderate grazing, whereas Andean Tinamous prefer habitats that have been free of these disturbance effects for at least three years. These differences illustrate the need for diversity in land uses to maintain both populations in the Lerma Valley. *Accepted 4 January 2004*.

Key words: Argentina, Tinamidae, Pale-spotted Tinamou, Andean Tinamou, *Nothura darwinii*, *Nothoprocta pentlandii*, agriculture, grazing.

INTRODUCTION

The Pale-spotted (*Nothura darwinii*) and Andean (*Nothoprocta pentlandii*) tinamous are distributed throughout much of the western region of Argentina (Meyer de Schauensee

1966, Olrog, 1984). In northwestern Argentina, these species occupy grasslands, shrublands, and semi-arid steppes, and often utilize cultivated fields (Bump & Bohl 1965, Banks & Bohl 1968, Bump & Bump 1969). In the Salta Province, these species are sympatric, occupying the majority of grasslands and agricultural habitats (Mosa 1989, 2000). In the Lerma valley, row crop agriculture and grazing practices produce a heterogeneous, seasonally dynamic landscape mosaic (Mosa 2000).

The tinamous, despite being common in the Neotropical region, have been little studied. Moreover, the effects of land use on tinamou abundance have not been assessed. I investigated the effects of different agricultural and grazing practices on the relative abundance of the Pale-spotted and Andean tinamous in the Lerma Valley of Salta Province, Argentina, to assess their implications for the conservation and management of these species.

STUDY AREA

The Lerma Valley in the Salta Province, Argentina (25°17' to 26°22'S, 65°25' to 65°42'W), covers 5000 km² and varies in elevation from 1200. to 4000 m a.s.l. The valley has a montane subtropical climate with a dry season that causes a noticeable water deficit during the autumn and winter, and a large annual temperature change (Bianchi 1980, 1996).

Starting with the settlement by Spanish people in the 16th century, natural communities in the valley have been converted for agricultural and grazing activities (Santillán de Andrés *et al.* 1968, Mata de Lopez 1990). Presently, agriculture and pastures occupy approximately 90% of the valley, mainly at the lower elevations. The most common crops are tobacco, corn, bean, perennial forage and vegetables, cultivated on small lots between 5 and 25 ha (Censo Nacional Agropecuario 1988). Cattle, grazed on natural grasslands and improved pastures, dominate grazing activity, followed in importance by horses, sheep and goats.

Grazing of natural grassland of varying intensities result in several different grassland communities (Falce 1977). The natural grassland community, or tall grassland (*sensu* Falce 1977), dominated by *Botriochloa barbinodis, Paspalum commune,* and *Setaria leiantha*, when under a moderate grazing pressure of no more than a cattle unit per 3 ha maintains a sufficient fuel load for winter and early spring fires to occur. These fires are important in maintaining this community. If grazing intensity increases to a cattle unit per 1 to 3 ha, the composition of plant species changes and insufficient biomass is available to support fires, resulting in a carpet grass community dominated by *Paspalum notatum* and *Axonopus affinis*. Where cattle densities are a cattle unit per hectare or greater, the natural grassland becomes degraded and dominated by *Cynodon dactylon*, a community referred to as "gramillar". When disturbance in the form of fire or moderate grazing pressure does not occur for a period of 3 to 4 years, herbaceous plants reach a height of 1 m (dominated by *Bidens subalternans, Sida spinosa*, *S. rhombifolia*, *Tagetes minuta* and *Heteropteris umbellate*), and begin to be invaded by woody plants (dominated by *Acacia caven* and *A. aroma*).

The variations in the type and intensity of land use in the Lerma Valley produces up to nine habitats used by tinamous. These included the four afore-mentioned grassland types: tall grassland (burned and unburned), carpet grass community, gramillar, and grassland invaded by woody plants. The other habitats are alfalfa fields (with *Echinochloa cruspavonis*, *Digitaria affinis*, and *P. notatum*), fallow fields (dominated by *B. subalternans*, *B pilosa*, *B. wandonii*, *S. spinosa*, *T. minuta*, *T. terniflora*, *Galactia latisiliqua* and *H.umbellate*), and

TABLE 1. Seasonal availability of habitat types used by tinamous in Lerma valley.

Habitat types	Area (ha)			
	Autumn	Winter	Spring	Summer
Tall grassland	5920	3947	3947	5920
Carpet grass	2368	2368	2368	2368
Gramillar	1578	1578	1578	1578
Grassland invaded by woody shrubs	2735	2735	2735	2735
Burned grassland	0	1973	1973	0
Alfalfa	3880	3880	3880	3880
Fallow	5034	5034	5034	0
Harvested corn	5138	5138	5138	4853
Harvested beans	14,542	14,542	10,354	16,357

TABLE 2. Mean vegetation height (cm) (±SE) in habitat types used by tinamous in Lerma valley

Habitat types	Height (cm) ± SE			
	Autumn	Winter	Spring	Summer
Tall grassland	46 ± 11	35 ± 11	40 ± 13	162 ± 15
Burned tall grassland	_	0	41 ± 11	_
Carpet grass	42 ± 5	31 ± 5	40 ± 5	46 ± 12
Gramillar	15 ± 5	11 ± 3	11 ± 5	16 ± 4
Tall grassland invaded by woody plants	63 ± 15	51 ± 21	45 ± 13	122 ± 44
Alfalfa fields	40 ± 10	37 ± 11	45 ± 13	44 ± 12
Fallow fields	24 ± 11	51 ± 15	72 ± 23	_
Harvested corn	_	253 ± 26	161 ± 42	_
Harvested beans	_	40 ± 5		_

row crops (corn containing *E. cruspavonis*, *S. spinosa*, and *T. minuta*, and beans containing *T. minuta*).

METHODS

I classified LANDSAT TM images (scale 1:100,000) from 1995 and aerial photos from 1996 (scale 1:10,000) into nine land cover types, and then digitized them in AUTOCAD V 12. In each habitat, I identified dominant plant species and measured the vegetation according to by season.

Due to the difficulty of observing tinamous, I used a relative index of abundance (Bibby *et al.* 1993, Menegheti 1985), which is the number of birds flushed per hour using a pointing dog. During 1996 and 1997, 544 h of surveys were conducted during all periods of the year. The intensities of the sampling varied according to seasons and the number of habitats: in autumn, 131 h were devoted to sampling, 163 h in winter, 166 h in spring, and 84 h in summer. Differences in detectability by habitat and time of year were not assessed (*sensu* Kellogg *et al.* 1982, Gutzwiller 1990); however, all efforts were made to standardize data collection.

I used a chi-square test to check for preferences among habitats according to seasons. Relative abundances in each habitat were compared to the expected abundance based upon the availability of each habitat type. Where significant differences were detected, I

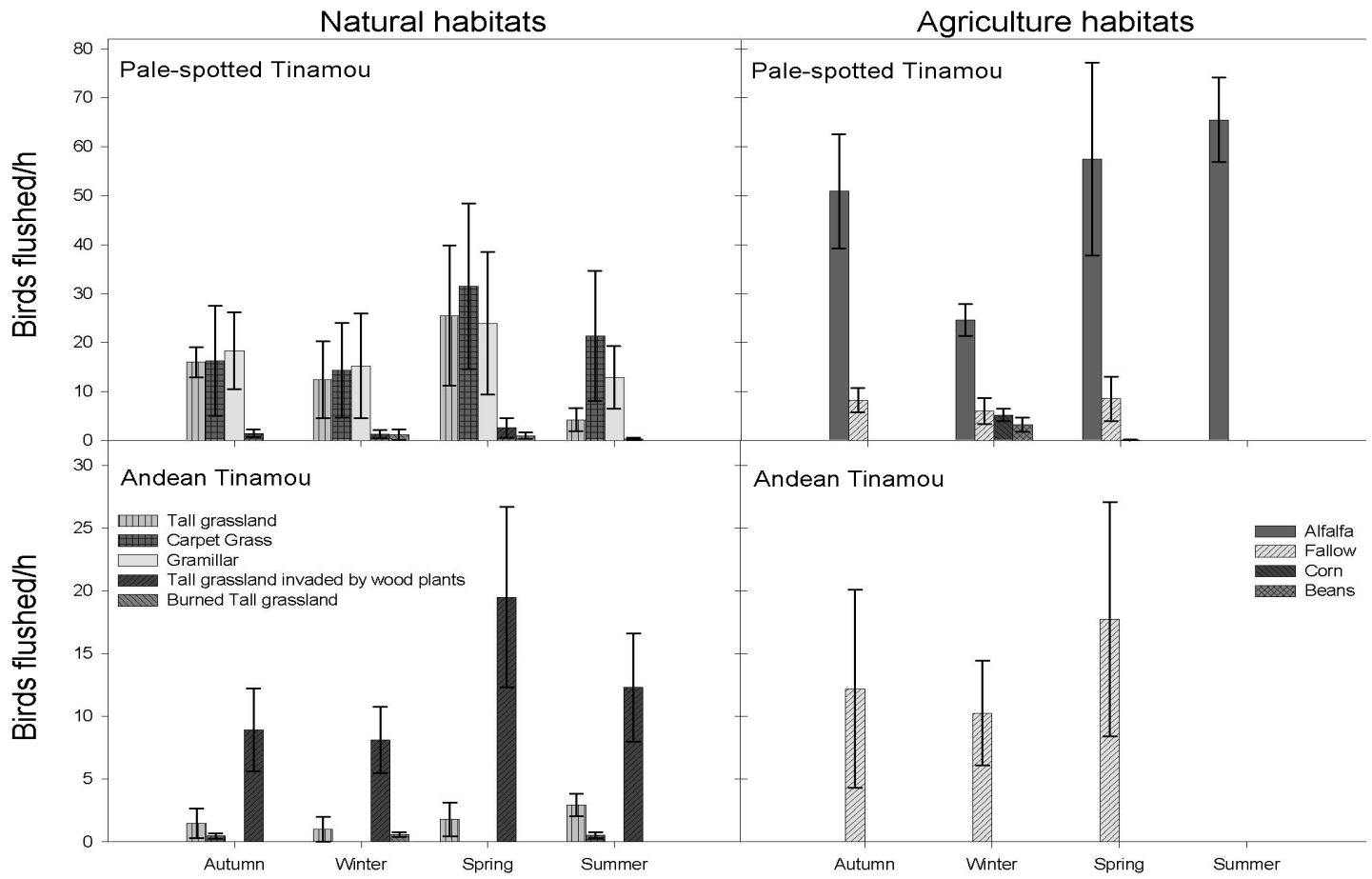

FIG 1. Relative abundance of Pale-spotted and Andean tinamous in natural and agriculture habitats. Error bars represent one standard deviation.

used a Bonferroni *Z*-test to determine if the habitats were used with greater or lesser frequency then expected.

RESULTS

The area of different land covers used by one or both species varies seasonally for seven of the habitat types: tall grassland, carpet grass, gramillar, grassland invaded by woody shrubs, alfalfa, and row crops (corn and beans) being present throughout the year, and the remaining two types, fallow fields and burned tall grassland, present during the winter and spring (Table 1). Total area of available habitat ranged from 38,983 ha during spring to 49,481 ha in summer, and vegetation height generally reached a maximum during summer (Table 2).

Both species exhibited seasonal variations in relative abundance and habitat use (Fig. 1). The χ^2 test indicated that both species were non-randomly distributed among all habitats ($P < 0.001$); there are differential preferences in habitat types according to species and seasons (Table 3). In autumn, Pale-spotted Tinamous were mostly detected in alfalfa whereas, in winter, encounters increased in tall grass, carpet grass, and gramillar. In spring, tall grass, carpet grass and alfalfa were preferred. In summer, birds were found only in alfalfa. Andean Tinamous showed a preference throughout the year for grasslands containing woody shrubs and fallow fields. Agricultural fields were generally avoided with the exception of alfalfa.

DISCUSSION

Habitat preference by both species of tinamous in the Lerma Valley is likely attributable to preferences in vegetative structure. The seasonal pattern of habitat use is a function of life history requirements and habitat availability within the landscape. Pale-spotted Tinamous prefer natural grasslands (tall grassland, carpet grass, and gramillar) and alfalfa fields. Conversely, Andean Tinamous prefer grasslands with woody shrubs and fallow fields, which have dense vegetation, and are generally higher and denser than the habitats preferred by Pale-spotted Tinamous (Mosa 2000). The increases in relative abundance in most of the habitats during the spring can be attributed to recruitment, with observed variations during other periods being a function of habitat preference and seasonal needs.

This research illustrates the ecological separation of Pale-spotted Tinamous and Andean Tinamous in the Lerma Valley. Although there is some overlap in habitat use, Pale-spotted Tinamous appear to prefer habitats maintained by disturbance, mainly fire and moderate grazing, but also including agriculture crops. The preferred habitat of the Andean Tinamou, grassland with woody shrubs, occurs in the absence of fire and/or grazing disturbance (Falce 1977), and the preference for fallow fields is likely due to similarities in vegetational structure and composition.

From a management perspective, these differences in habitat preferences are important because they indicate the need for a diversity of land uses within the valley to maintain the populations of both species. The diversity of land uses and the high heterogeneity of the landscape, stemming from relatively small land holdings, are likely important for the maintenance of present population levels, despite relatively high hunting pressure (unpubl. data). This research highlights the importance of habitat diversity, disturbance, and the intensity of land use on two tinamou species. Given the importance of tinamous as game birds in austral South America, this research may be of service in assessing and managing populations of these and other grassland tinamou species.

TABLE 3. Relative abundance of Pale-spotted and Andean tinamous in relation to habitat availability by season, according to Bonferroni´s *Z*-test ($P = 0.05$) (+ = birds encountered with greater frequency than expected, - = birds encountered with lower frequency than expected, NP = habitat type not present).

Habitat types	Autumn		Winter		Spring		Summer	
	Pale-spotted	Andean	Pale-spotted	Andean	Pale-spotted	Andean	Pale-spotted	Andean
Tall grassland	-	-	+	-	+	-	-	-
Carpet grass	-	-	+	-	+	-	-	-
Gramillar	-	-	+	-	-	-	-	-
Grassland invaded by woody shrubs	-	+	-	+	-	+	-	+
Burned grassland	NP	NP	-	-	-	-	NP	NP
Alfalfa fields	+	-	+	-	+	-	+	-
Fallow fields	-	+	-	+	-	+	NP	NP
Harvested corn	-	-	-	-	-	-	-	-
Harvested bean	-	-	-	-	-	-	-	-

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