Ann. Zool. Fennici 45: 128–134 ISSN 0003-455X (print), ISSN 1797-2450 (online)
Helsinki 29 April 2008

Influence of agricultural intensity and urbanization on the abundance of the raptor chimango caracara (*Milvago chimango*) in the Pampean region of Argentina

M. Isabel Bellocq*, Julieta Filloy & Pablo I. Garaffa

*Departamento de Ecología, Genética y Evolución, FCEN, Universidad de Buenos Aires, and CONICET Ciudad Universitaria, Pab. 2, Piso 4, Buenos Aires (1428), Argentina (*e-mail: bellocq@ege.fcen.uba.ar)*

Received 1 Mar. 2006, revised version received 14 Jan. 2008, accepted 21 Jan. 2008

Bellocq, M. I., Filloy, J. & Garaffa, P. 2008: Influence of agricultural intensity and urbanization on the abundance of the raptor chimango caracara (*Milvago chimango*) in the Pampean region of Argentina. — *Ann. Zool. Fennici* 45: 128–134.

Chimango caracara (*Milvago chimango*) is a southern Neotropical species and the most common raptorial bird in the Pampean region of Argentina, where natural grasslands were completely transformed by agriculture and urbanization. We determined whether this species responds to the intensity of these human disturbances through changes in its abundance. To examine the response to agricultural intensity, both birds and land use were surveyed along 18 transects covering the regional agricultural gradient from pure arable to pure pastoral farming landscapes. To explore the effects of urbanization, birds were surveyed at 19 points along an urban–rural gradient. Results showed that chimango caracara did not respond to changes in agricultural intensity. No land use type was associated, either positively or negatively, with abundance in the arable or pastoral farming scenarios. In contrast, we observed a negative response to increasing urbanization, where a higher abundance was recorded in rural than in commercial or residential areas.

Introduction

Physical and biotic factors determine the abundance and distribution of a species (Brown 1984, Gaston 1994). However, human activities have replaced natural habitats, and seem to be the main threat to birds in the Neotropics (Caughley & Gunn 1996, Collar *et al*. 1997). Agricultural development may be the primary factor determining the pattern of abundance for many species. Many studies link the decline of bird populations to agricultural practices in several regions of the world (e.g., Fuller *et al*. 1995, Vickery *et al*. 1999, Silva 1999, Siriwardena *et al*. 2000, Vickery *et al*. 2001, Fernández *et al*. 2003). Furthermore, urbanization is increasing throughout the world, and many bird species respond to the intensity of urban development (Chase & Walsh 2006); while some species are able to survive and even increase in abundance in these newly created environments, others are seriously threatened (Gaston 1994). Bird responses to particular management practices are species-specific (Siriwardena *et al*. 2000), even within the

same genus (Filloy & Bellocq 2006).

Chimango caracara (*Milvago chimango*, Falconidae) is a Neotropical raptor whose distribution is limited to southern South America. Although it occurs in a variety of habitats including grasslands, shrublands and woodland (Donázar *et al*. 1993, Travaini *et al*. 1995), it is most abundant in the Pampean region of Argentina (Travaini *et al*. 1995) in the central area of the species' distributional range. In fact, chimango caracara is the most abundant raptorial bird in the Pampean region (Leveau & Leveau 2004a), and is thought to be tolerant to disturbed habitats and human activities (Morrison & Phillips 2000); some studies suggested that chimango caracara responds positively to human alterations of the habitat (e.g., Travaini *et al*. 1995). Yet, the relationship between population parameters and the intensity of human disturbances is still to be explored at the local and regional scales in the core area of its distributional range.

In the Pampean region, agricultural activities and urbanization are the main human disturbances that resulted in the complete alteration of the natural grasslands. After the introduction of wild live stocking from Europe during the 17th century, there was a progressive and almost complete human use of the Pampas for productive purposes (Molinari 1987). Human settlements, arable farming that partially replaced pastoral farming, and the development of intensive agriculture extremely modified the original grassland (Soriano 1991).

Our objective was to determine whether chimango caracara responds to the intensity of agriculture and urbanization through changes in its abundance. We predicted that the abundance of chimango caracara will decline with increasing agricultural intensity and urbanization. In order to explore the response to agricultural intensity, we used the agricultural gradient that occurs in the Pampean region. Within agricultural scenarios, pastoral farming is less intense and intrusive than arable farming (e.g., no chemical applications or mechanical treatments). If agricultural intensity was a primary factor modelling the special pattern of abundance, variations in the abundance of chimango caracara would occur along the agricultural gradient from pure arable to pure pastoral farming scenarios. Similarly, if urbanization influenced abundance, variations would occur along the urban–rural gradient.

Material and methods

Study area

The study was conducted in the Pampean region in central-eastern Argentina. The Pampean region covers approximately 550 000 km^2, and has a temperate climate with mean annual temperatures ranging between 13 and 17 °C and precipitation from 1100 mm yr^{-1} in the north to 600 mm yr^{-1} in the south. The natural vegetation is a gramineous steppe dominated by grasses such as *Stipa*, *Piptochaetium*, *Aristida*, *Melica*, *Briza*, *Bromus*, *Eragrostis* and *Poa*. Natural trees are virtually absent in the region but small and isolated woodlots are often found in association with cattle-shelters, windbreaks, *estancias* or towns.

Environmental gradients

To explore the relationship between the abundance of chimango caracara and agricultural intensity we surveyed the bird along an agricultural gradient. The study area covered approximately 300 km along a north–south axis, covering the complete agricultural gradient from low to high agricultural intensity (Fig. 1). The agricultural gradient is the result of geomorphologic characteristics of the region that influence land productivity, rather than climatic variability. Along the gradient, climatic variables are relatively constant: mean July temperature ranges between 7.5 and 9.5 °C and that of January between 21.5 and 23.5 °C; annual precipitation ranges between 800 and 1000 mm yr^{-1}. Thus, we assumed that the spatial variation in bird abundance was relatively independent of climate.

To investigate the response to urbanization, we surveyed an urban–rural gradient in a typical Pampean city and compared the bird's abundance among different intensities of urbanization. We used the urban–rural gradient of Junin (34°35´S, 60°57´W), a relatively large city for

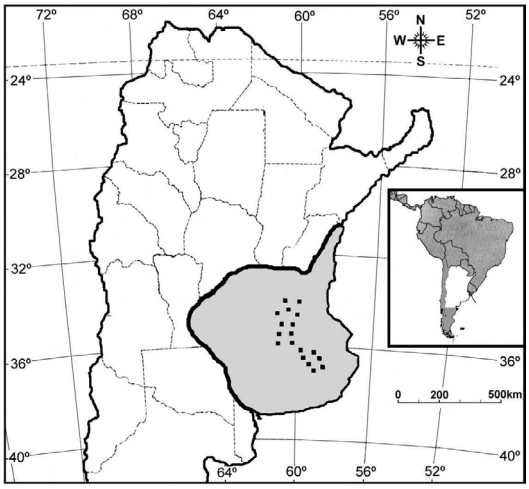

Fig. 1. Location of the survey transects (dots) in the Pampean region (shaded area) of Argentina.

the region (70 183 inhabitants) (INDEC 2001) with a gradient approximately 4.5 km long (from the city centre to the rural zone). The gradient covered four different locations from the city centre to the countryside, representing different uses and intensities of urbanization: commercial, residential, suburban, and rural.

Bird surveys

Following the agricultural gradient within the Pampean region, road surveys were conducted along 18 transects (Fig. 1). Transects were 25 km long and located on non-paved roads. In this environment, we surveyed birds using the point-count method with infinite radius (Bibby *et al.* 1992). Each transect was surveyed once with an observation stop every 1 km totalling 26 observation stops. At each observation stop, all individuals seen were recorded during 5 min. The same two observers conducted all surveys in November 1999 between 6:00 and 10:00. This sampling was designed to detect patterns at the regional scale and each transect is an experimental unit. Abundance was estimated as the number of individuals per transect. By summing all individuals recorded at the 26 observation stops per transect, we obtained a comparative measure of abundance that allowed us to describe the tendency of the spatial variation in abundance along the agricultural gradient.

For the urbanization study, we surveyed a single transect of 19 points (250 m apart) along a roadside starting in the city centre in November 2005. In this environment, we used the point-count technique with a 50 m fixed-radius and a count duration of 5 min., as previously used for urban areas (DeGraaf *et al.* 1991, Melles *et al.* 2003). Similarly to the agricultural gradient, the survey was performed by two observers between 6:00 and 10:00. The sampling was designed to identify patterns at the local scale; thus, each observation stop is an experimental unit and bird abundance was estimated as the number of individuals per observation stop.

Land-use survey and quantification

While driving each 25 km transect along the agricultural gradient, we recorded the distance covered by each land-use type on both sides of the road. We distinguished cultivated corn, dried corn, wheat, sunflower, oats and ploughed fields as composing primarily the arable farming scenario. The pastoral farming scenario consisted of short and tall grasslands (grasses 0–30 cm and > 30 cm, respectively). We also recorded the presence or absence of cattle grazing within these grasslands. For each transect, we calculated the percentage ($P_{\%}$) of each land-use type by adding the distances covered by the land-use type on both sides of the road (D_R and D_L for right and left side of the road, respectively) multiplied by 100 and divided by two times the transect length ($P_{\%} = 100 \times (D_R + D_L)/2 \times 25$). For each transect, we also estimated the total percentage of land used for arable farming by adding the percentages of all land-use types that characterized the arable farming landscape. Similarly, the total percentage of pastoral farming per transect was calculated by adding the percentages of land-use types related to pastoral farming, such as grazed and ungrazed grasslands and pastures.

Based on land use each bird point count of the urban gradient was assigned to one of the following four categories that indicate decreasing degrees of urbanization in a typical Pampean city: commercial, residential, suburban, and rural. The city centre has a mix of institutional

and commercial uses and is characterized by high buildings, shopping areas and high population density during the day. Residential areas are typically located around the city centre and are characterized by houses with front- and backyards and some trees on the sidewalks. Suburban areas have no paved roads and sidewalks; but have larger lots, fewer houses, and industrial areas. The rural zone is characterized by farmlands with cultivated fields, pastures, cattle, and small isolated groups of introduced trees.

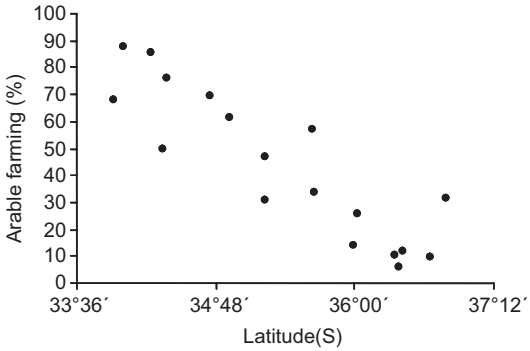

Fig. 2. The proportion of land use for arable farming at different latitudes along the north–south gradient of agricultural intensity in the Pampean region of Argentina. Modified from Filloy and Bellocq (2007).

Data analyses

We tested the existence of a north–south agricultural gradient. We performed a Cox-Stuart tendency test (Siegel & Castellan 1988) to evaluate the decreasing tendency of the percentage of land used for arable farming with increasing latitude.

To test whether chimango caracara responded to agricultural intensity, we used simple regression models (linear and non-linear) (ter Braak & Looman 1995) between bird abundance and the proportion of land used for arable farming along the gradient. We identified the best fit model by selecting the model with the highest coefficient of determination and significant regression coefficients. As we compared transects in space, we controlled data for spatial autocorrelation. To avoid spurious associations between bird abundance and the environment, we generated a correlogram and tested Moran's Index (Legendre & Legendre 1998).

We used a multiple regression analysis to explore possible associations between land use variables and abundance within both the arable and pastoral farmland scenarios. We considered the percentage of land-use types that compose either the arable or the pastoral farming scenario as environmental variables. If the regression model was significant, partial correlation analyses were used to identify individual associations between abundance and each independent variable, removing interactions among the independent variables.

To test for differences in the mean number of individuals among categories of land use indicating different degrees of urbanization we used a one-way ANOVA and performed multiple comparisons using the Scheffé test.

Results

Pattern of abundance along the agricultural gradient

The 300 km extension of our survey included the complete agricultural gradient (Cox-Stuart: $K = 0$, $P \leq 0.004$) (Fig. 2). This gradient ranged from 87% arable and 6% pastoral farming in the north to 5% arable and 91% pastoral farming in the south. An increase in the proportion of arable farming implied the complementary decline in the proportion of pastoral farming, as land is almost exclusively devoted to either arable or pastoral activities. Consequently, a positive response to arable farming reflects a negative response to pastoral farming and vice versa.

No spatial autocorrelation was found in the data at any distance between transects (Moran's $I_s = 0$, $P > 0.05$). Regression analysis showed that the abundance of chimango caracara was independent of agricultural intensity ($F_{1,16} = 0.310$, $P = 0.585$) (Fig. 3). Results showed no response of abundance to changes in the proportion of land used for arable farming in the core area of the species' distributional range. Multiple regression analysis showed no significant associations to land-use variables either in the arable ($F_{6,11} = 0.768$, $P < 0.610$) or pastoral scenarios ($F_{4,13} = 0.972$, $P < 0.456$).

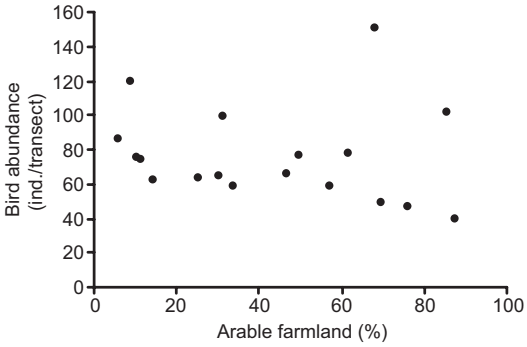

Fig. 3. The abundance of chimango caracara is independent of agricultural intensity in the Pampean region.

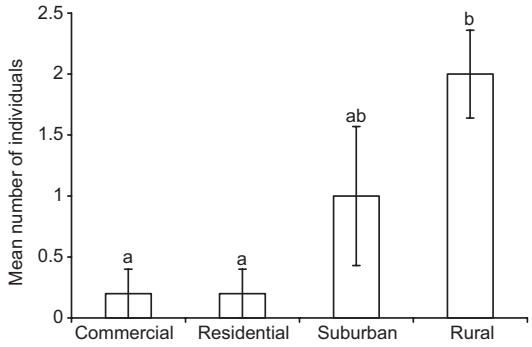

Fig. 4. The abundance of chimango caracara (individuals per observation point, mean ± SE) in four categories representing decreasing degrees of urbanization along an urban–rural gradient in the Pampean region. Different letters above the bars represent statistically significant differences.

Pattern of abundance along the urbanization gradient

Chimango caracara occupied urban areas. The first individual was recorded as close as 500 m from the first observational spot located in the city centre where the gradient began. Yet, land use at that locality represents the highest degree of urbanization (a mix of institutional and commercial uses).

Chimango caracara responded to the urban-rural gradient. Abundances differed among land uses which indicates different degrees of urbanization ($F = 8.019$, $P = 0.002$). It was rare in the city centre and residential areas (0.2 individuals/observation point), and abundance increased towards the suburban (1.0 individuals/observation point) and rural areas (2.0 individuals/observation point) (Fig. 4). Pair-wise comparisons revealed that the abundance of chimango caracara was significantly higher in the rural area than in the commercial and residential areas ($P < 0.01$ for each comparison).

Discussion

Response to agriculture

We studied the relationship between chimango caracara abundance and the intensity of human disturbances in the core area of the species' distributional range. Although the species occupies a wide range of habitats (Donázar *et al.* 1993), it is typical to grasslands and open areas. Road surveys conducted along a 2230 km transect across three biogeographic regions in Argentina (Pampean in the east through the Espinal to the Monte in the west) showed that the maximum abundance occurred in the Pampean region (Travaini *et al.* 1995); then abundance declined progressively from east to west. Studies conducted in insular habitats in Chile revealed that deforestation and land clearing may benefit this raptor (Morrison & Phillips 2000).

Agriculture appeared to be unimportant in the observed abundance pattern of chimango caracara in the Pampean region of Argentina. Agricultural development is the major human disturbance in the Pampean region. If the species were favoured (or not) by human disturbances, its abundance would be positively (or negatively) associated with agricultural intensity. However, we found that abundance was independent of agricultural intensity in the core area of its distributional range. Consequently, we found evidence that agricultural development neither favoured nor threatened the species, and that chimango caracara is tolerant to the main human disturbance in the region.

Many raptor species were found to be either positively or negatively associated with certain elements of the agricultural landscape such as fields with a specific grain crop, riparian areas, human settlements or ploughed field (Smallwood *et al.* 1996). However, information on chimango caracara is very scarce. Because this

species is primarily a carrion feeder, we expected associations between its abundance and certain land use types such as fields where cattle graze or recently ploughed fields. However, no studied land use type seemed to be important in determining the abundance distribution of this species at the regional scale. It is possible that chimango caracara, as a generalist and opportunistic feeder, finds the Pampean region a favourable environment as a whole. Nonetheless, Leveau and Leveau (2004b) found higher abundances of chimango caracara in tall pastures and ploughed fields than in cultivated fields in a study conducted at the local scale.

Response to urbanization

Raptors are probably the most studied birds in urban environments (Chace & Walsh 2006). Some species of hawks, kites, and kestrels were not sensitive to urbanization or had higher reproductive success in urban environments (Cade *et al*. 1996, Tella *et al*. 1996) while others were found to be scarce in urban plots (Berry *et al*. 1998). There is little information, however, on the responses of caracaras in general and on that of chimango caracara in particular to urbanization (Leveau & Leveau 2004a).

Our results showed that chimango caracara is tolerant to moderate levels of urbanization. The city of Junin is relatively large as compared with other cities in the region. No individuals were recorded in the first 500 m from the city centre where the central plaza is located; yet, we were still in the commercial area when we first recorder the species. Surveys conducted in the city centre, residential and suburban areas in a larger coastal city (Mar del Plata) of the region showed no records of this species in the commercial area of the city centre (Leveau & Leveau 2004a). An east–west road survey conducted in northern Patagonia along approximately 1200 km showed that chimango caracara occurred in urban areas (Donázar *et al*. 1993). Patagonian cities are younger and more open than Pampean cities which may explain the urban records.

Abundance was higher in rural than in urban areas. This result agrees with a previous survey conducted in the city of Mar del Plata, which showed no individuals in the urban area, 11% of the total number of individuals in the suburban area and 89% in a mixed suburban-rural area (Leveau and Leveau 2004a).

In summary, our study showed no response in the abundance of chimango caracara to changes in agricultural intensity, and a negative response to increased urbanization. Further studies on additional population parameters, such as reproductive success, are necessary to better understand how this species responds to human disturbances.

Acknowledgements

We thank an anonymous reviewer for valuable comments made to the manuscript. This research was funded by the Consejo Nacional de Investigaciones Científicas y Técnicas of Argentina and the University of Buenos Aires.

References

Berry, M. E., Bock, C. E. & Haire, S. L. 1998: Abundance of diurnal raptors on open space grasslands in an urbanized landscape. — *Condor* 100: 601–608.

Bibby, C. J., Burgess, N. D. & Hill, D. A. 1992: *Bird census techniques*. — Academic Press, London.

Brown, J. H. 1984: On the relationship between abundance and distribution of species. — *Am. Nat*. 124: 255–279.

Cade, T. J., Martell, M., Redig, P., Septon, G. A. & Tordoff, H. B. 1996: Peregrin falcons in urban North America. — In: Bird, D. M., Varland, D. E. & Negro, J. J. (eds.), *Raptors in human landscapes*: 3–13. Academic Press, London.

Caughley, G. & Gunn, A. 1996: *Conservation biology in theory and practice*. — Blackwell Scientific Publications, USA.

Chace, J. F. & Walsh J. J. 2006: Urban effects on native avifauna: a review. — *Landscape Urban Plan*. 74: 46–69

Collar, N. J., Wege, D. C. & Long, A. J. 1997: Patterns and causes of endangerment in the New World avifauna. — *Onithological Monographs* 48: 237–260.

DeGraaf, R. M., Geis, A. D. & Healy, P. A. 1991: Bird populations and habitat surveys in urban areas. — *Landscape Urban Plan*. 21: 181–188.

Donázar, J. A., Ceballos, O., Travaini, A. & Hiraldo, F. 1993: Roadside raptor surveys in the Argentinean Patagonia. — *J. Raptor Res*. 27: 106–110.

Fernández, G. J., Posse, G., Ferreti, V. & Gabelli, F. M. 2003: Bird–habitat relationship for the declining Pampas meadowlark populations in the southern Pampas grasslands. — *Biological Cons*. 115: 139–148.

Filloy, J. & Bellocq, M. I. 2006: Spatial patterns of *Sporophila* (Seedeaters) abundance in the southern Neotropics: Contrasting agricultural development and geograph-

ical position. — *Biodivers. Conserv.* 15: 3329–3340.

Filloy, J. & Bellocq, M. I. 2007: Patterns of bird abundance along the agricultural gradient of the Pampean region. — *Agr. Ecosyst. Environ.* 120: 291–298.

Fuller, R. J., Gregory, R. D., Gibbons, D. W., Marchant, J. H., Wilson, J. D., Baillie, S. R. & Carter, N. 1995: Population declines and range contractions among lowland farmland birds in Britain. — *Cons. Biol.* 9: 1425–1441.

Gaston, K. J. 1994: *Rarity.* — Chapman and Hall, London.

INDEC, 2001: *Censo Nacional de Población, Hogares y Viviendas 2001*. — Instituto Nacional de Estadísticas y Censos (INDEC), Ministerio de Economía y Producción, República Argentina.

Legendre, P. & Legendre, L. 1998: *Numerical ecology.* — Elsevier, Amsterdam.

Leveau, L. M. & Leveau, C. M. 2004a: Efectos de la urbanización en la distribución y abundancia del chimango *Milvago chimango* en Mar del Plata, Argentina, durante un ciclo anual. — In: *Proc. I Sym. Argentino sobre Investigación y Conservación de Rapaces*: 12–13. Museo de La Plata, La Plata, Argentina.

Leveau, L. M. & Leveau, C. M. 2004b: Riqueza y abundancia de aves en agroecosistemas pampeanos durante el periodo post-reproductivo. — *Ornitología Neotropical* 15: 371–380.

Melles, S., Glenn, S. & Martin, K. 2003: Urban bird diversity and landscape complexity: species–environment associations along a multiscale habitat gradient. — *Cons. Ecol.* 7: 5–26.

Molinari, R. L. 1987: *Biografía de la Pampa: 4 siglos de historia del campo argentino*. — Fundación Colombina V Centenario, Bs. As.

Morrison, J. L. & Phillips, L. M. 2000: Nesting habitat and success of the chimango caracaras in southern Chile. — *Wilson Bull.* 112: 225–232.

Siegel, S. & Castellan, N. J. 1988: *Nonparametric statistics for the behavioural sciences*, 2nd ed. — Mc Graw-Hill, London.

Silva, J. M. C. 1999: Seasonal movements and conservation of seedeaters of the genus *Sporophila* in South America. — *Studies Avian Biol.* 19: 272–280.

Siriwardena, G., Crick, H. Q. P., Baillie, S. R. & Wilson, J. D. 2000: Agricultural land-use and the spatial distribution of granivorous lowland farmland birds. — *Ecography* 23: 702–719.

Smallwood, S. K., Nakamoto, B. J. & Geng, S. 1996: Association analysis of raptors on a farming landscape. — In: Bird, D. M., Varland, D. E. & Negro, J. J. (eds.), *Raptors in human landscapes*: 177–190. Academic Press, London.

Soriano, A. 1991: Río de la Plata Grasslands. — In: Coupland, R. T. (ed.), *Natural grasslands (Ecosystems of the World)*, 8th ed.: 367–407. Elsevier, Amsterdam.

Tella, J. L., Hiraldo, F. & Antonio, J. 1996: Costs and benefits of urban nesting in the lesser kestrel. — In: Bird, D. M., Varland, D. E. & Negro, J. J. (eds), *Raptors in human landscapes*: 53–60. Academic Press, London.

ter Braak, C. J. F. & Looman, C. W. N. 1995: Regression. — In: Jongman, R. H. G., ter Braak, C. J. F. & van Tongeren, O. F. R. (eds.), *Data analysis in community and landscape ecology*: 29–77. Cambridge University Press, Cambridge.

Travaini, A., Rodríguez, A., Ceballos, O., Donázar, J. A. & Hiraldo, F. 1995: Roadside raptor surveys in central Argentina. — *Hornero* 14: 64–66.

Vickery, J. A., Tallowin, J. R., Ferber, R. E., Asteraki, E. J., Atkinson, P. W., Fuller R. J. & Brown, V. K. 2001: The management of lowland neutral grasslands in Britain: effects of agricultural practices on birds and their food resources. — *J. Appl. Ecol.* 38: 647–664.

Vickery, P. D., Tubaro, P. L., Da Silva, J. M. C., Peterjohn, B. G., Herkert, J. R. & Cavalcanti, R. B. 1999: Conservation of grassland birds in the western hemisphere. — *Studies in Avian Biol.* 19: 2–26.