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TINAMOUS AND AGRICULTURE: LESSONS LEARNED FROM THE GALLIFORMES

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Resumen. – Tinámidos y agricultura: lecciones aprendidas de los Galliformes. – El 32% de las 47 especies del orden Tinamiformes viven en pastizales. Estas especies están distribuidas en las regiones tropicales y templadas, pero la mayoría se encuentran en las regiones australes de América del Sur. Las poblaciones de estas especies son susceptibles a la conversión de la tierra para agricultura y la intensificación del uso de la tierra después de la conversión. Existe poca información sobre los efectos de la conversión y uso de la tierra en las poblaciones de tinamúes, pero hay mucha investigación sobre sus efectos en los Galliformes. Al considerar los tinamúes que viven en pastizales como los equivalentes ecológicos de los Galliformes, se pueden hacer inferencias generales sobre los posibles efectos de la conversión y intensificación del uso de la tierra en estas especies. Es más eficiente ver los impactos potenciales del uso de la tierra como una función de la interacción de múltiples gradientes: el área de la vegetación natural, la estructura de la vegetación, la intensidad de la agricultura y ganadería, y el uso de herbicidas y pesticidas. Este modelo permite una cuantificación de la conveniencia de un lugar para cada especie, flexibilidad potencial de las especies a los cambios de hábitat, la comparación entre lugares y funciona como una herramienta para determinar rápidamente el valor de conservación de los lugares en el paisaje.

Abstract. – Species inhabiting grassland and steppes represent 32% of the 47 species of the order Tinamiformes. These species are both tropical and temperate in their distribution but the majority is confined to austral South America. Populations of these species are susceptible to land conversion for agriculture, as well as intensification of land use after conversion. Although little information exists on the effects of land conversion and use on tinamou populations, there is an extensive amount of research on these effects on gallinaceous birds. By viewing the grassland and steppe dwelling tinamous as ecological equivalents to the Galliformes, general inferences can be made about the projected impacts of land conversion and the intensity of use on these species. It is most efficient to view the potential impacts of land use as a function of the interaction of several gradients: area of natural vegetation, vegetation structure, intensity of cropping and grazing, and herbicide and pesticide use. This model allows for a quantification of site suitability by species, potential resilience of species, comparison among sites, and serves as a tool to rapidly assess the conservation value of sites within the landscape. *Accepted 29 December 2003.*

Key words: Tinamiformes, Galliformes, agriculture, grazing, agro-ecosystems, grasslands, gamebirds.

INTRODUCTION

Temperate and tropical grassland habitats (grasslands, steppes, savannas) have been, and continue to be, extensively converted for grazing and row crops (from here on agriculture) (White *et al.* 2000). Consequently, much of the biodiversity from these natural ecosystems is now associated with a landscape matrix of varying complexity, consisting of natural and man modified habitats. Increasingly, these agro-ecosystems have become less diversified in content and complexity (McNeely *et al.* 1995).

During the post-World War II era, grassland conversion and/or agricultural intensification have increased in intensity and extent (Fuller 2000). Although Europe and North America have been placed under high-input agriculture over the last half-century, other areas such as South Africa and Argentina have lagged behind until recently (Pero & Crowe 1996, Viglizzo & Roberto 1998). This process of land conversion and agricultural intensification has been attributed to the global declines of grassland and shrubland birds (Aebischer *et al.* 1999, Vickery & Herkert 1999, Murphy 2003, Peterjohn 2003).

Among the grassland dependent birds, the population declines of the gallinaceous gamebirds were some of the first to draw the attention of researchers and the public. The first, and one of the most thorough studies into the effects of farmland composition and management on galliform populations was on the declines of the Grey Partridge (*Perdix perdix*) in England (Potts 1980, 1986). This research highlighted the importance of the composition and configuration of the agricultural landscape and how it is managed, particularly the use of herbicides and pesticides. These have become major themes in the research of grassland birds (Vickery & Herkert 1999, Aebischer *et al.* 2000, Murphy 2003, Peterjohn 2003) and have been key topics of research for many gamebirds (Rands *et al.* 1988), including Northern Bobwhite (*Colinus virginianus*; Brennan 1999), prairie chickens (*Tympanuchus* spp.; Fuhlendorf *et al.* 2002, Geisen 1998, Ryan *et al.* 1998), Helmeted Guineafowl (*Numida meleagris*; Pero & Crowe 1996, Malan & Benn 1999, Ratcliffe & Crowe 2001) and francolins (*Francolinus* spp.; Little & Crowe 1998; Jansen *et al.* 1999, 2000).

Grassland tinamous (Tinamiformes) represent 32% of the 47 species and, in most of South America, occupy the majority of niches in grassland habitats associated with the galliforms in other regions (Davies 2002, del Hoyo 1992 *et al.*). Despite their diversity and importance in sport, commercial, and subsistence harvest, little research has focused on these birds. Furthermore, as in the rest of the world, the grassland habitats that these birds occupy have been, and continue to be, under intensive agricultural pressure. For example, the pampas of Argentina and Uruguay have been nearly completely converted to row crops and grazing over the last 150 years (Hall *et al.* 1992), and for the past decade have been subjected to rapidly increasing intensification (Viglizzo & Roberto 1998).

Despite this continuing land conversion, and increasingly intense utilization, there is a conspicuous lack of research into their effects on biodiversity in grassland ecosystems within South America. For tinamous however, it is possible to make inferences based upon the extensive body of research into the impacts of land conversion and agriculture on galliforms. Here I draw from examples on the effects of agricultural land conversion and intensification on grassland bird species in general, and galliforms in particular, highlighting the major environmental gradients that impact these birds, for the purpose of assessing the quality of grasslands and their associated agro-ecosystems for tinamous, as well as to direct future research.

CASES IN THE GALLIFORMES

Due to their importance as gamebirds, the Galliformes are a well-studied order and subsequently population dynamics are well documented for many species (e.g., Fuller *et al.* 2000). Over the last half-century however, as with many grassland species, galliforms associated with grasslands and agro-ecosystems have exhibited significant population declines across several continents. Important examples are the Northern Bobwhite (Brennan 1999) and prairie chickens (Johnsgard 1983, Houston 2002) in North America, the Helmeted Guineafowl (Pero & Crowe 1996, Malan & Benn 1999, Ratcliffe & Crowe 2001) and the francolins (Little *et al*. 1995; Jansen *et al*. 1999, 2000) in South Africa, and the Gray Partridge in Europe (Potts 1980, 1986).

The decline of populations of these species is mostly attributed to changes in the extent, intensity, and type of land use. Interestingly, several of these species initially increased their ranges and/or populations as a function of anthropogenic changes to the landscape. These changes, however, eventually passed a threshold where populations began to decline. The key to making inferences to the tinamous and applying them for research and management is to understand the major factors associated with land use that have both positively and negatively impacted galliform populations in grasslands and agro-ecosystems (Johnsgard & Wood 1968, Johnsgard 1983, Johnson & Knue 1989, Pero & Crowe 1996, Brennan 1999, Malan & Benn 1999, Ratcliffe & Crowe 2001, Houston 2002).

AGRICULTURAL CHANGES

As discussed by Fuller (2000), the intensification in agriculture that has occurred has been largely due to increased mechanization, the use of chemical fertilizers, pesticides and herbicides, and decreased diversity of crop types. Mechanization allows for the cultivation of more area and larger fields, the large-scale application of fertilizers, pesticides and herbicides, and more frequent tilling or cutting of hedgerows and field borders.

The use of fertilizers eliminates the need to leave fields fallow or in pasture, eliminates the need for manure, thus eliminating the need for cattle and associated pastures, and has led to the management of pastures for silage rather than for hay. The increase in management for silage allows for higher stocking levels of livestock since forage can be subsidized with high quality fodder. High livestock densities have been contributing to decreases in populations of several galliform species (Jansen *et al.* 1999, Robbins *et al.* 2002). Furthermore, mechanization has allowed for more frequent cutting of these pastures for silage, leading to increased loss of nests and young.

The use of petrochemicals, associated with the decrease in landscape complexity and diversity, had major implications for populations of birds in agro-ecosystems due to impacts on brood survival (Palmer 1995, Fuller 2000). In particular, the indirect effects of herbicides and the direct effects of insecticides greatly decrease the quality of agricultural land as brood habitat, and subsequently brood survival (*sensu* Potts 1986). Furthermore, the use of fertilizers on silage pastures leads to a decrease in floral diversity and structure, and is associated with a decrease in invertebrate diversity (Fuller 2000).

ASSESSING THE AGRICULTURAL IMPACTS

The aforementioned factors interact synergistically to decrease the complexity and the diversity of the landscape and the quality of habitats within the landscape. Although the degree to which each factor interacts to affect a species is species dependent, these factors can be generalized into several principal gradients, each consisting of several components. These gradients are: 1) pesticide and herbicide use, 2) vegetation structure, 3), intensity of land use, and 4) area of natural vegetation (i.e., not being managed for row crops or silage).

Pesticide and herbicide use includes chemical strength, amount applied, and frequency of application. Vegetation structure includes

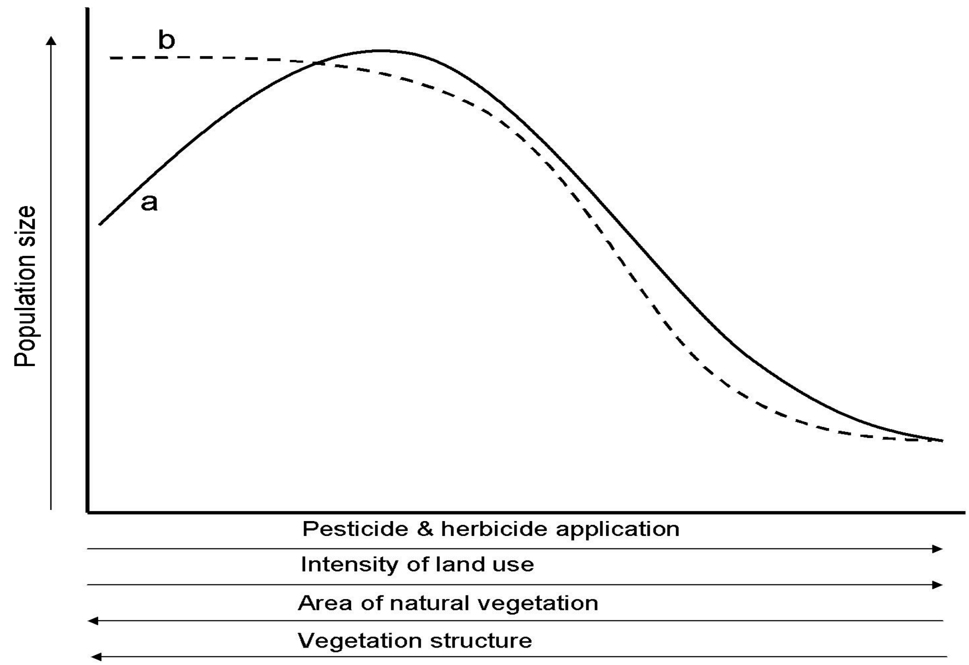

FIG. 1. Graphical model of the effects of increasing agricultural intensification on grassland Galliformes. This may also serve as a model for grassland tinamous in South America.

measures of height, density, and species diversity. Intensity of land use is represented by field size, crop diversity, crop rotation, and livestock densities and grazing rotations. Area of natural vegetation not only includes grazing and fallow land, but vegetation and crop stubble within row crops. The intensity of land use and area of natural vegetation together represent a measure of landscape composition that has been illustrated to be important for many galliforms (Potts 1986, Aebischer & Potts 1998, Malan & Benn 1999, Niemuth 2000).

It is necessary to realize that the importance that each of these gradients has for a species will not only depend upon the species but upon the temporal needs of individuals and, subsequently, dietary and habitat requirements need to be assessed for all stages of a species life cycle. This is particularly important since agro-ecosystems are dynamic environments, and subsequently need to be assessed and measured at regular intervals throughout the year.

These gradients act synergistically to impact populations, but it can be hypothesized that there are two general responses that can be expected based upon the aforementioned examples, with the magnitude of the response dependent upon the species (Fig. 1). The first is where populations initially increase as a function of cultivation and/or grazing, when not intensive or extensive; however, populations begin to decline rapidly after the combined effects of the gradients pass a certain magnitude (Fig. 1a). Such population responses have been documented for Helmeted Guineafowls (Pero & Crowe 1996) and Greater Prairie-Chickens (*Tympanuchus cupido*; Johnsgard & Woods 1968, Johnsgard

1983, Johnson & Knue, 1989, Houston 2002).

The second response is where populations remain stable despite initial land conversion and management but, as in the first example, decline after the combined impacts of the gradients reach a certain threshold (Fig. 1b). This response has been evident with the population declines of the Northern Bobwhite in the United States, associated with land conversion in the 19th and early 20th centuries (Brennan 1999), and with the Redwing Francolin (*Francolinus levaillantii*) stemming from over grazing (Jansen *et al*. 1999).

RESEARCH DIRECTIONS

To successfully apply this model to the conservation and management of tinamous in agricultural landscapes there needs to be quantitatively rigorous population estimation of species along various intensities of each of the proposed gradients (*sensu* Conroy & Carroll 2001). This will allow for an assessment of the impacts of different land use regimes on populations and provide baseline data to assess long term population trends.

Such research only yields the effects of land use; however, and given the small amount of information on tinamou biology, research needs to concentrate on understanding the mechanisms that drive population dynamics by researching the basic biology of each species throughout the year. Moreover, if the model of Galliformes as an inference holds true, there should be an emphasis on understanding the reproductive biology and the factors that affect chick survival, since these appear to be key factors in determining population size (Potts 1980, 1986, Palmer 1995).

Given the rapid and continued conversion of grassland systems to agriculture throughout South America and the intensification of that agriculture, there looms a growing crisis for the conservation of biodiversity within these systems. As pointed out by Jansen *et al*. (1999), gallinaceous gamebirds can serve as excellent indicators of ecosystem health. Given that tinamous serve as ecological equivalents to the galliforms, research into the effects of land use will not only serve to conserve and guide management of these species, but will contribute to conservation of the increasingly threatened biodiversity associated with South American grasslands and agroecosystems.

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REFERENCES

Aebischer, N. J., & G. R. Potts. 1998. Spatial changes in Grey Partridge (*Perdix perdix*) distribution in relation to 25 years of changing agriculture in Sussex, U.K. Gibier Faune Sauvage, 15: 293–308.

Aebischer, N. J., A. D. Evans, P. V. Grice, & J. A. Vickery. 2000. Ecology and conservation of lowland farmland birds. British Ornithologistsí Union, Hertfordshire, UK.

Brennan, L. A. 1999. Northern Bobwhite (*Colinus virginianus*) *In* Poole, A., & F. Gill (eds). The birds of North America, No. 397. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Conroy, M. J., & J. P. Carroll. 2001. Estimating abundance of Galliformes: Tools and application. Pp. 204–215 *in* Woodburn M., P. McGowan, J. Carroll, A Masavi, & D. Z. Zang (eds.). Galliformes 2000: Proceedings of the 7th

International Galliformes Symposium, Kathmandu and Royal Chitwan National Park, Kathmandu, Nepal.

Davies, S. J. J. F. 2002. Ratites and tinamous. Oxford Univ. Press, New York, New York.

del Hoyo, J., A. Elliott, & J. Sargatal. 1992. Handbook of the birds of the world. Volume 1: Ostrich to ducks. Lynx Edicions, Barcelona, Spain

Fuhlendorf, S. D., A. J. W. Woodward, D. M. Leslie, Jr., & J. S. Shackford. 2002. Multi-scale effects of habitat loss and fragmentation on Lesser Prairie-Chicken populations of the US Southern Great Plains. Landsc. Ecol. 17: 617–628.

Fuller, R. A., J. P. Carroll, & P. J. K. McGowan. 2000. Partridges, quails francolins, snowcocks, guineafowl, and turkeys. Status survey and conservation action plan 2000–2004. Specialist Group, IUCN, Gland, Switzerland and Cambridge, UK, and World Pheasant Association, Reading, UK.

Fuller, R. J. 2000. Relationships between recent changes in lowland British agriculture and farmland bird populations: an overview. Pp. 5–16 *in* Aebischer, N. J., A. D. Evans, P. V. Grice, & J. A. Vickery (eds). Ecology and conservation of lowland farmland birds. British Ornithologistsí Union, Hertfordshire, UK.

Giesen, K. M. 1998. Lesser Prairie-Chicken (*Tympanuchus pallidicintus*). *In* Poole, A., & F. Gill (eds). The birds of North America, No. 364. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Hall, A. J., C. M. Rebella, C. M. Ghersa, & P. H. Culot. 1992. Crop systems of the pampas. Pp. 413–450 *in* Pearson, C. J. (ed.). Ecosystems of the World. Elsevier, Amsterdam, Netherlands.

Houston, C. S. 2002. Spread and disappearance of the Greater Prairie-Chicken, *Tympanuchus cupido*, on the Canadian prairies and adjacent areas. Can. Field-Nat. 116: 1–21.

Jansen, R., R. M. Little, & T. M.. Crowe. 1999. Implications of grazing and burning of grassland on the sustainable use of francolins (*Francolinus* spp.) and on overall bird species conservation in the highlands of Mpumalanga province, South Africa. Biodivers. Conserv. 8: 587–602.

Jansen, R., R. M. Little, & T. M. Crowe. 2000. Habitat utilization and home range of the Redwing Francolin (*Francolinus levaillantii*) in highland grasslands, Mpumalanga province, South Africa. Afr. J. Ecol. 38: 329–338.

Johnsgard, P. A. 1983. The grouse of the world. Univ.of Nebraska Press, Lincoln, Nebraska.

Johnsgard, P. A., & R. E. Woods. 1968. Distributional changes and interaction between Prairie Chickens and Sharp-tailed Grouse in the midwest. Wilson Bull. 80: 173–188.

Johnson, M. D., & J. Knue. 1989. Feathers from the prairie. North Dakota Game and Fish Department, Bismarck, North Dakota.

Little, R. M., & T. M. Crowe. 1998. Habitat fragmentation limits the distribution of Cape Francolin, *Francolinus capensis*, on deciduous fruit farms in South Africa. Afr. J. Ecol. 36: 140–147.

Little, R. M., J. S. A Perrings, T. M. Crowe, & A. Witt . 1995. Notes on the diet of the Helmeted Guineafowl (*Numida meleagris*) on deciduous fruit farms in the western Cape province, South Africa. S. Afr. J. Wildl. Res. 25: 144–146.

Malan, G., & G. A. Benn. 1999. Agricultural landuse patterns and the decline of the Helmeted Guineafowl *Numida meleagris* (Linnaeus 1766) in KwaZulu-Natal, South Africa. Agric. Ecosyst. Environ. 73: 29–40.

McNeely, J. A., M. Gadgil, C. Leveque, C. Padch, & K.Redford. 1995. Human influences on biodiversity. Pp. 711–822 *in* Heywood, V. H., & R. T. Watson (eds.). Global biodiversity assessment. UNEP-Cambridge Univ. Press, Cambridge, UK..

Murphy, M. T. 2003. Avian population trends within the evolving agricultural landscape of eastern and central United States. Auk. 120: 20–34.

Niemuth, N. D. 2000. Land use and vegetation associated with Greater Prairie-Chicken leks in an agricultural landscape. J. Wildl. Manage. 64: 278–286.

Palmer, W. E. 1995. Effects of modern pesticides and farming systems on Northern Bobwhite quail brood ecology. Ph.D. Diss., North Carolina State Univ. Raleigh, North Carolina.

Pero, L. V., & T. M. Crowe. 1996. Helmeted Guineafowl *Numida meleagris* in KwaZulu-Natal: a case for non-sustainability. S. Afr. J.

Wildl. Res. 26: 123–130.

Peterjohn, B. G. 2003. Agricultural landscapes: can they support healthy bird populations as well as farm products? Auk 120: 14–19.

Potts, G. R. 1980. The effects of modern agriculture, nest predation and game management on the population ecology of partridges (*Perdix perdix* and *Alectoris rufa*). Adv. Ecol. Res. 11: 2–79.

Potts, G. R., 1986. The partridge: pesticides, predation and conservation. Collins, London, UK.

Rands, M. R. W., P. J. Hudson, & N. W. Sotherton. 1988. Gamebirds, ecology, conservation and agriculture. Pp. 1–17 *in*: Hudson, P. J., & M. R. W. Rands (eds.). Ecology and management of gamebirds. Blackwell Scientific Press Professional Books, Oxford, UK.

Ratcliffe, C. S., & T. M. Crowe. 2001. Habitat utilization and home range size of Helmeted Guineafowl (*Numida meleagris*) in the midlands of KwaZulu-Natal province, South Africa. Biol. Conserv. 98: 333–345.

Robbins, M. B., A. T. Peterson, M. A. Ortega-Huerta. 2002. Major negative impacts of early intensive cattle stocking on tallgrass prairies: the case of the Greater Prairie-Chicken (*Tympanuchus cupido*). N. Am. Birds, 56: 239–244.

Ryan, M. R., L. W. Burger, Jr., D. P. Jones, & A. P. Wywialowski. 1998. Breeding ecology of Greater Prairie-Chickens (*Tympanuchus cupido*) in relation to prairie landscape configuration. Am. Midl. Nat. 140: 111–121.

Vickery, P. D., &. J. R. Herkert. 1999. Ecology and conservation of grassland birds of the Western Hemisphere. Stud. Avian Biol. 19: 1-299.

Viglizzo, E. F., & Z. E.Roberto. 1998. On tradeoffs in low-input agro-ecosystems. Agric. Syst. 56: 253–264.

White, R., S. Murray, & M. Rohweder. 2000. Pilot analysis of global ecosystems: Grassland ecosystems. World Resource Institute, Washington, D.C.