

Habitat use by wild and captive-reared greater rheas *Rhea americana* in agricultural landscapes in Argentina

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Abstract From 1998 to 2000 we used radio telemetry to study habitat use by greater rheas *Rhea americana* in rural areas. Captive-born greater rheas preferred pastures to grasslands and did not use crops. No differences in habitat use were found between wild and captive-born greater rheas. Wild individuals preferred pastures, showed less preference for grasslands, and did not use crops. Rheas used pastures and grasslands for nesting but they did not use crops. No differences in nesting

success was detected between these habitats. Our results show that agroecosystems that include grasslands and pasture production would strongly contribute to the conservation of this species. However, poaching must be controlled to ensure long-term persistence of wild populations of greater rheas.

Keywords Agricultural landscapes, Argentina, captive-born, greater rheas, habitat use, preference, radio telemetry, reintroduction, *Rhea americana*.

Introduction

Grassland bird populations have undergone critical declines (McCoy *et al.*, 1999; Vickery *et al.*, 1999) as a result of human activities that have led to fragmentation and habitat loss (Villard *et al.*, 1999; Collingham & Huntley, 2000). This increasing environmental degradation, caused by agricultural expansion and forest exploitation, has drawn attention to the need for conservation actions in rural areas throughout the world (Ferguson, 1996; Sergio & Bogliani, 2000). The situation has become particularly critical in Latin America, where poaching and violation of hunting regulations are additional problems (Ojasti, 1984).

One bird species that has been affected is the greater rhea *Rhea americana*, a large (height 1.4 m, mass 20–25 kg) herbivorous, flightless bird that inhabits grasslands, shrublands and open woodlands in South America (Bruning, 1974). During the non-breeding period greater rheas forage both individually and in groups of 2–50 birds (Hudson, 1920; Reboresoda & Fernández, 1997). By the onset of the breeding period the social structure of a greater rhea population is composed of single males, reproductive groups and large flocks of yearlings with non-reproductive males (Bruning, 1974; Hanford & Mares, 1985; Codenotti, 1995). Despite the gregarious habits of the species, the groups are neither stable nor constant in time, and individuals are likely to change

groups throughout the year (Martella & Navarro, 1993; Martella *et al.*, 1994). The mating system of rheas combines polygynandry and promiscuity with cooperative care among males (Bruning, 1974; Hanford & Mares, 1985; Martella *et al.*, 1998).

In Argentina this species is typically associated with the Pampas grasslands, the most human-modified habitat in the country (Bertonatti & Corcuera, 2000). As a result, greater rheas occur in agroecosystems in which grassy plains and open brush areas have been replaced with crops and cultivated pastures (Martella *et al.*, 1996; Pereira *et al.*, 2003). In addition to this habitat modification, egg gathering, floods and hunting have also affected greater rhea populations, and the species is locally extinct in many areas (Bucher & Nores, 1988). The greater rhea is categorized as Lower Risk: near-threatened on the IUCN Red List (2003).

Because alfalfa *Medicago sativa* and wild dicotyledons are the most important items in the diet of wild greater rheas in agricultural areas of central Argentina, with alfalfa consumed particularly during winter when it is not available to domestic livestock, agricultural landscapes devoted to traditional cattle production would probably be able to support wild populations of greater rheas (Martella *et al.*, 1996). It is therefore necessary to develop detailed studies on habitat use of this species. To maintain viable greater rhea populations it is also important to evaluate the habitat use of captive-bred greater rheas released into the wild. Our work had the following specific objectives: (1) to study habitat use and preferences of captive-born greater rheas, (2) to study habitat use and preferences of wild greater rheas to determine if captivity and radio-tagging affect habitat use, and (3) to study nest-site selection.

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Study area

Fieldwork was conducted during two reproductive and non-reproductive periods of greater rheas at Las Dos Hermanas ranch, Córdoba province, Argentina (Fig. 1), from August 1998 to December 2000. The ranch was devoted to organic livestock and crop production (2,076 ha). An area of 1,700 ha was devoted to wildlife conservation, where hunting and plant extraction were prohibited.

The study area consisted of a mosaic of habitat types including grasslands, pastures and crops (Fig. 1). Grasslands (1,700 ha, i.e. 45% of the total area) supported

grasses (*Stipa* sp., *Spartina densiflora*, *Distichis spicata*, *Cyperus* sp., *Juncus* sp., *Eleocharis* sp.), shrubs (*Cyclolepis genistoides*, *Artlipex undulata*, *Schinus fasciculatus*), salt flats (*Heterostachys ritteriana*, *Salicornia virginiana*) and saline marshes (*Paspalum vaginatum*, *Eleocharis palustris*) (Cantero *et al.*, 1994). Pastures (1,382 ha, i.e. 36% of the total area), which were devoted to livestock, had a combination mainly of alfalfa, with some *Festuca* spp., brome grasses (*Bromus* spp.), and clover (*Melilotus* spp.). Crops (694 ha, i.e. 19% of the total area), included sunflower *Heliantus annuus*, corn *Zea mays*, wheat *Triticum aestivum* and soybean *Glycine max*. All paddocks (management

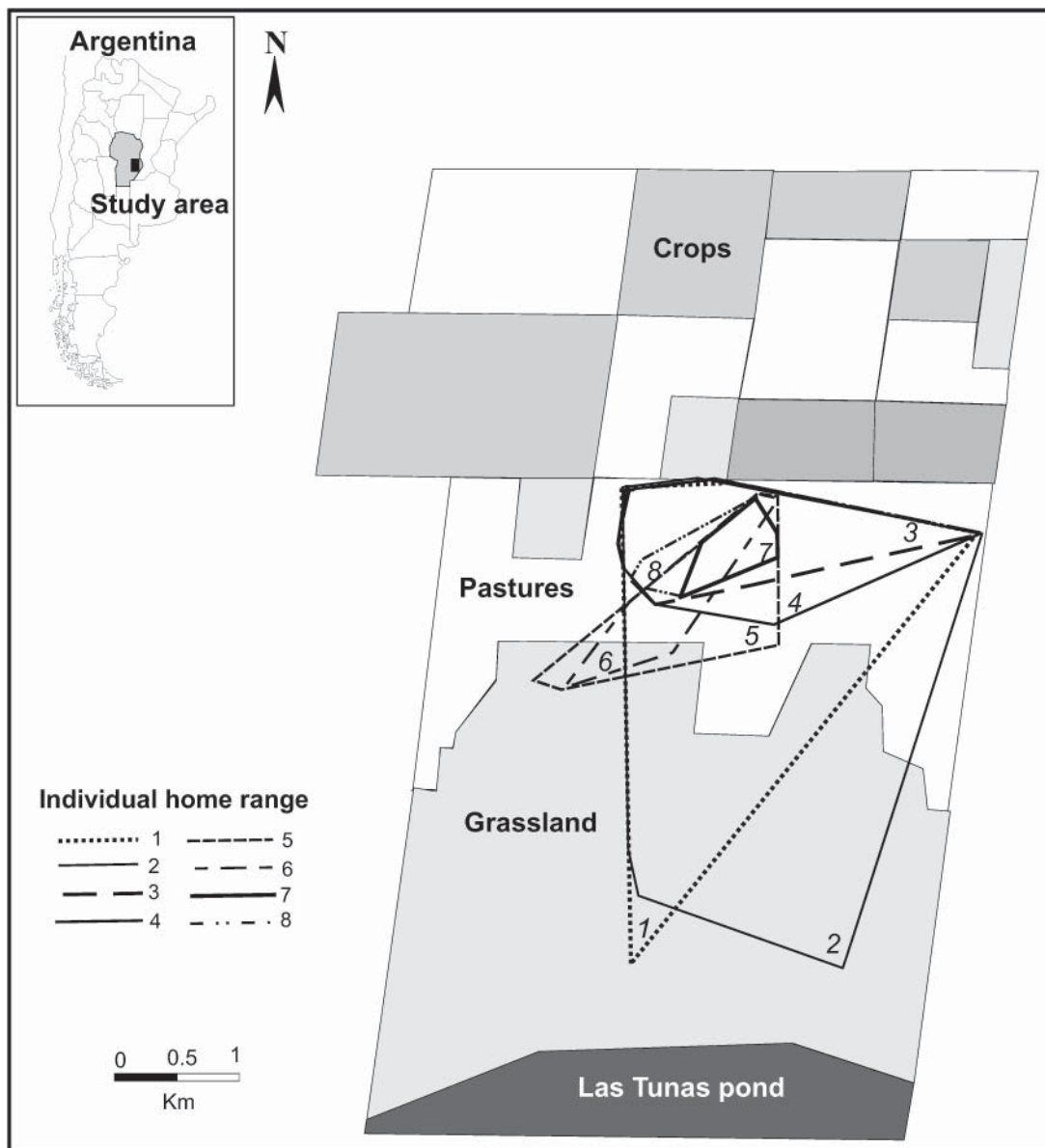


Fig. 1 Habitat types and home range of greater rheas in the study area at Las Dos Hermanas ranch, Córdoba, Argentina (1998–2000). Lines are minimal convex polygon for each numbered greater rhea (see Table 1).

units) were equally available to the rheas, which could easily cross the 6-wire fences separating the paddocks. We use the term 'availability' to refer to accessibility of resources in the total study area (*sensu* Jones, 2001).

Methods

Release and monitoring

Nineteen captive bred rheas produced from artificial incubation (Navarro *et al.*, 1998) were released into the field, following the IUCN guidelines for reintroduction (IUCN, 1998). Each greater rhea was marked with coloured leg bands, and eight were also equipped with transmitters on CB-4 expansion, break-away collars (Telonics, Mesa, Arizona, USA). The released rheas were young individuals (10 months of age) of undetermined sex and were released in pasture paddocks following 'soft' and 'hard' release protocols (Kleiman & Beck, 1994). In the soft protocol release 12 individuals were kept in corrals for 5 months so they could become familiar with the area before being released in October 1998. In the hard protocol release seven individuals were transported in wooden boxes from the breeding site and released on the same day, without any familiarization period in the release area (February and July 2000).

The release site was chosen based on three criteria: (1) Habitat quality and availability of food items according to diet studies (Martella *et al.*, 1996; Comparatore *et al.*, 2001) so that abundant and appropriate food would facilitate the transition from captivity to the wild. (2) Relative protection from hunting; we selected a release site with difficult access to poachers. (3) Accessibility for monitoring of the released birds.

During the reproductive (September–March) and non-reproductive (April–August) periods, the birds were radio-located during 3–4 days per week each month to detect differences in habitat use. Unfortunately, two radio-collared greater rheas were killed by poachers 20–30 days after release, and another two individuals lost their radio-collars 10 and 25 days after being released. Consequently, most of the radio-tracking data corresponded to only 4 individuals. One observer with a Telonics hand-held antenna and a portable Telonics TR4 receiver (168–172 MHz) located the radio-tagged rheas by triangulation or by direct observation. Rheas were successively located 5–9 times per day at 1-h intervals. This interval was chosen to minimize dependency between successive locations and because it is a sufficient time for an individual to move from one place to another (White & Garrot, 1990). Individual home ranges were calculated, using a 95% minimum convex polygon, with the geographic information system CAMRIS (1998). Radio tracking was used to find greater rheas during

each tracking session. Later, visual observations were performed to compare behavioral traits, such as feeding and fights, between the captive-reared and wild greater rheas.

Analysis of habitat use

Locations recorded for each radio-tagged bird were classified according to habitat type, and this was used to estimate the percentage time each bird spent in each habitat. We carried out two analyses, for each of which comparisons were tested using the Friedman test (χ_r^2 ; White & Garrot, 1990): (1) To evaluate habitat use the percentage of each habitat type within each rhea's home range was compared with that of the study area to determine whether habitat occurrence within individual home ranges was non-random (i.e. differing significantly from that of the study area). (2) To evaluate any preferences the percentage of time spent by greater rheas in each habitat was compared with the percentage of each habitat occurring within individual home ranges.

Habitat use of wild unmarked greater rheas was recorded monthly. We conducted a morning ground survey of the whole study area, by truck, recording the number of wild greater rheas (chicks, young and adults) in each habitat (pastures, grasslands and crops). The course and speed were adjusted to avoid counting each rhea more than once. The total frequencies of greater rheas within a given habitat during the reproductive and non-reproductive periods were then obtained by adding up the respective counts for each month. We determined use and preference by Bonferroni simultaneous confidence intervals (Neu *et al.*, 1974; White & Garrot, 1990). This method uses a χ^2 goodness of fit to test whether animals used each habitat in proportion to its availability, and a confidence interval to determine which habitat types are preferred. The confidence intervals for the observed proportion of use of grasslands and pastures (P_i) was calculated as

$$P_i - Z_{1-\alpha/2k} \sqrt{(P_i(1 - P_i)/n)} \leq P_i \leq P_i + Z_{1-\alpha/2k} \sqrt{(P_i(1 - P_i)/n)},$$

where Z is the upper standard normal value corresponding to the probability tail of the area, $1 - \alpha/2k$; k is the number of categories tested, and n was the total number of samples; the significance level was 0.05. To determine whether a habitat is 'preferred' the confidence interval is checked for overlap with the proportional availability of the corresponding habitat. Thus, if the lower bound of the interval is greater than the proportional availability, the animal has shown a preference for this habitat. In contrast, if the upper bound of the interval is lower than the proportional availability, the individual uses this habitat less than expected based on its availability.

We used Mann-Whitney U tests to detect differences in the number of rheas that used each habitat in the reproductive and non-reproductive periods.

During all reproductive periods we systematically searched for nests throughout the study area. The probability of detecting a nest is relatively low, because male rheas nest in concealed depressions on the ground. However, we tried to record the total number of nests and the number of successful nests in each habitat. We used a χ^2 goodness of fit test to determine whether habitats were used randomly for nesting, and a Fisher exact test to determine differences in nesting success. The latter test is preferable to a χ^2 goodness of fit test when frequencies are small (Zar, 1984).

Results

All captive-reared greater rheas stayed for 5 months in the alfalfa paddocks in which they were released, and then 4 (50%) of the radio-tagged rheas moved to pasture paddocks, joining groups of 8–30 wild adults and juveniles. The remaining radio-tagged rheas moved around pasture and grassland paddocks, joining groups of 3–8 wild adults. No fights were recorded between wild and released individuals. The analysis of habitat use showed that the eight radio-tagged captive-reared individuals did not use available areas randomly ($\chi_r^2 = 16$, $df = 2$, $P < 0.001$) (Table 1; Fig. 1). They preferred pastures to grasslands and did not use crops. Regarding preferences of use, the same individuals showed no preference for pastures over grasslands ($\chi_r^2 = 2$, $df = 1$, $P = 0.15$), although the highest proportion of radio-locations throughout the study occurred in pastures.

Habitat use by unmarked wild greater rheas was similar to that of radio-tagged captive-reared rheas. Wild individuals used habitats selectively throughout the study ($\chi^2 = 4.3$, $df = 1$, $P = 0.037$). They preferred pastures, used grassland less than expected based on

their proportional availability, and did not use crops (Table 2). We did not find significant differences between the number of greater rheas that chose pastures in the reproductive (105 individuals) or non-reproductive period (134 individuals, $U = 287.5$, $P = 0.51$). Similarly, no differences were detected between the number of rheas that selected grasslands in either period (57 and 72 individuals, $U = 130.5$, $P = 0.61$).

We recorded 11 nests, with a mean of $20 \pm SE 0.98$ eggs per nest, during the study; six were located in pastures and five in grasslands. No preferences of use were detected at any particular site ($\chi^2 = 0.37$, $df = 1$, $P = 0.54$). Seven nests (64%) were successful in the production of at least one chick. Four of them were located in pastures and 3 in grasslands, and no significant differences between habitats were found in the nesting success ($F = -0.27$, $df = 1$, $P = 0.57$). In the post-reproductive period males with groups of chicks of 4–60 days of age also used habitats selectively ($\chi^2 = 201.11$, $df = 1$, $P < 0.001$): they preferred pastures, showed less preference for grasslands and did not use crops (Table 2).

Discussion

Greater rheas showed a selective use of habitats. Wild greater rheas used pastures and grasslands and they did not use crops in the reproductive, post-reproductive or non-reproductive periods. Similarly, captive-reared greater rheas used pastures and grasslands but did not use crops, demonstrating that captivity and radio-tagging do not appear to affect greater rheas' behavior with respect to habitat use.

A preference for pastures corresponds to the rheas' food requirements. Pasture paddocks were cultivated mainly with alfalfa, which is the preferred food item of greater rheas (Martella *et al.*, 1996), possibly because of its high protein and fibre content, and its year-round availability (Medina, 1999). Conversely, grasslands were

Table 1 For each of the eight captive-reared and radio-tagged greater rheas released in Las Dos Hermanas ranch, Córdoba, Argentina, their home range size, % of the three habitat types within their minimum convex polygon (MCP) home range (see text for details), and % of their radio locations recorded in each habitat type.

Rhea no.	Home range size (km ²)	% of MCP home range			% radio locations		
		Crops (19% of area)	Grasslands (45% of area)	Pastures (36% of area)	Crops	Grasslands	Pastures
1	4.5	0	0.05	99.95	0	4.70	95.30
2	4.14	0	11.80	88.20	0	19.23	80.77
3	2.81	0	0.00	100.00	0	0.00	100.00
4	2.82	0	0.00	100.00	0	0.00	100.00
5	2.3	0	0.39	99.61	0	40.00	60.00
6	2.24	0	0.16	99.84	0	15.00	85.00
7	0.93	0	0.00	100.00	0	0.00	100.00
8	1.17	0	0.00	100.00	0	0.00	100.00

Table 2 Sightings (no. observed) of wild greater rheas on grasslands, pastures and crops on Las Dos Hermanas ranch, Córdoba, Argentina, during the non-reproductive, reproductive and post-reproductive (i.e. accompanied by chicks) periods. The number of sightings expected in a particular period (no. expected) was calculated by multiplying the proportion of each habitat in the total area (P_{10}) by the total number of rheas observed in that period. Bonferroni simultaneous confidence intervals (see text for details) were calculated for the observed proportion of use of each habitat.

Habitat (proportion of total area, P_{10})	Non-reproductive period			Reproductive period			Post-reproductive period		
	No. observed	No. expected	95% CI on P	No. observed	No. expected	95% CI on P	No. observed	No. expected	95% CI on P
Grasslands (0.45)	72	93	0.28–0.42	57	73	0.27–0.44	19	73	0.06–0.17
Pastures (0.36)	134	74	0.65–0.73*	105	58	0.56–0.73*	144	59	0.83–0.94*
Crops (0.19)	0	39		0	31		0	31	
<i>Total</i>	206			162			163		

*Indicates a preference for this habitat (see text for details).

composed mostly of gramineous species, which are eaten in low quantities throughout the year and are not a preferred food item (Martella *et al.*, 1996). The low digestibility for rheas of seeds such as soybean and wheat (M. Martella, pers. obs.), and the greater obstruction of vision by tall plants such as sunflower and maize that reduces the ability to detect and escape from predators, probably explain the absence of greater rheas' from crops. Besides providing abundant food resource, pastures are open areas with few obstacles, facilitating vigilance and escape. Previous studies of this species showed that feeding and vigilance are incompatible behaviors (Lombardi, 1994; Martella *et al.*, 1995; Reboreda & Fernández, 1997).

Similar patterns of habitat use by this species were observed in an agroecosystem in central Argentina (Bazzano *et al.*, 2002), and in agricultural areas of southern Brazil (Codonotti & Alvarez, 2000). In the latter region greater rheas also showed a preference for cultivated meadows over natural meadows, and used lands cultivated with crops least of all. This preference for habitats that include both native vegetation and man-modified patches is also exhibited by the kiwi *Apteryx australis*, another ratite species (Taborsky & Taborsky, 1995).

Greater rheas used pastures and grasslands for nesting, rather than crops. The more frequent human presence in crops (for weeding, pest control, harvesting and other activities) could deter nesting there. Greater rhea males used pastures and grasslands equally for nesting, perhaps because microhabitat characteristics were not a major contributor to nesting success. In species such as the greater rhea, in which only one sex incubates, individuals must offset the costs of caring for and defending the nest with keeping a favourable energy balance (Flint & Grand, 1999). In this context, considering the high energetic costs of incubation in this species (Fernández & Reboreda, 2003) and that predation on eggs occurs when males move away from the nest to feed, we suggest that nest-site selection is determined by a trade-off between

the amount of time the nest has to be neglected by the male and nest concealment. Although nests built in pastures are closer to food resources (alfalfa and wild dicotyledons) than nests built in grasslands, nest concealment is lower. Thus, males that nest in pastures could compensate for low nest concealment and higher vulnerability to predation with reduced time away from the nest. Conversely, males that build nests in grasslands need to move longer distances to feed, but the better nest concealment that grasslands offer compensate for the greater amount of time that the nest is neglected. The main predators of rhea eggs are armadillos *Chatoephraactus villosus*, lizards (*Tupinambis* spp.), foxes *Ducysson gymnocercus*, feral dogs *Canis familiaris* and raptors (*Milvago chimango* and *Polyborus plancus*). Nest concealment is important for reducing risk of predation not only when predators use sight to detect nests, but also when they use olfactory and/or auditory cues (Bowman & Harris, 1980; Martin & Ruper, 1988; Filliater *et al.*, 1994; Candolin & Voigt, 1998; Hooge *et al.*, 1999; Thogmartin, 1999; Liebezeit & George, 2002; Mezquida & Marone, 2002).

Our results show that agroecosystems that included pastures and grasslands would favour the conservation of this species. Unfortunately, higher crop yields in recent years have encouraged farmers to produce crops (INDEC, 2000), and the area devoted to crops in Argentina is > 40 million ha (INDEC, 2000), 91% of which corresponds to areas of original native grasslands (Bertonatti & Corcuera, 2000). This tendency to modify land use occurs not only in Argentina but also in savannahs and grasslands elsewhere in South America within the range of greater rheas. Therefore, agricultural policies need to be developed to encourage grassland conservation and pasture production over crops, both for the preservation of greater rheas and for other grassland bird species such as tinamous (*Nothura darwini* and *N. plentandii*; Mosa, 2003), upland goose *Cloephaga picta*, ashy-headed goose *C. poliocephala* (Del Hoyo *et al.*, 1992),

pampas meadowlark *Sturnella defilippii* (Tubaro & Gabelli, 1999; Gabelli *et al.*, 2004), and plover *Bartramia longicauda* (S. Salvador & M. Nores, pers. comm.). These species have been forced to adopt agricultural land as secondary habitats mainly to meet their food requirements.

Due to the presence of a ranger devoted to protecting fauna and flora, only a few greater rheas were poached during our study. However, poaching is a relatively common activity in the rural areas of Argentina and has caused severe damage to wild populations of greater rheas (Demaría, 1994; Martella *et al.*, 1996; Navarro & Martella, 2002; Bellis *et al.*, in press). Consequently, target areas for the conservation of this species should include not only suitable habitats but also protection from poaching.

Conservation of greater rheas on agricultural land is feasible if a landscape with a combination of pasture and grassland patches is maintained and poaching is controlled. The similarities in habitat use between wild and reintroduced individuals suggests that captive breeding for the supplementation of wild populations could contribute to the maintenance of viable populations of the species.

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Biographical sketches

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