Revista de la Facultad de Ciencias Agrarias
ISSN: 0370-4661
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Universidad Nacional de Cuyo
Argentina

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Revista de la Facultad de Ciencias Agrarias, vol. 45, núm. 1, 2013, pp. 211-224
Universidad Nacional de Cuyo
Mendoza, Argentina

Rev. FCA UNCUYO. 2013. 45(1): 211-224. ISSN impreso 0370-4661. ISSN (en línea) 1853-8665.

Diet selection by the lesser rhea (*Rhea pennata pennata*) in Payunia, Northern Patagonia (Mendoza, Argentina)

Selección dietaria del choique (*Rhea pennata pennata*) en Payunia, Patagonia Septentrional (Mendoza, Argentina)

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Originales: Recepción: 31/10/2012 - Aceptación: 04/05/2013

ABSTRACT

The lesser rhea (family Rheidae) is a flightless large bird of South America, threatened due to habitat loss, hunting and egg collecting, with special concern in Northern Patagonia. Diet and food availability were estimated throughout the year by micro-histological analysis and point-quadrat transects in a landscape inside and another outside the Payunia Reserve, the northernmost part of the *Rhea pennata pennata* distribution. Significant differences were detected by Kruskall-Wallis ANOVA, food selection by Chi-square test and Bailey's confidence interval. A strong food selection characterized the diet of lesser rheas, dominated by leaves of shrubs and forbs, complemented by dicot seeds and a few insects. This agrees with the documented low dietary overlap with other herbivores in Payunia. Dietary changes agree with the expected from the selective quality hypothesis. Food availability was better inside than outside the protected area, with probable conservation effects for lesser rheas. Seeds, forbs and soft grasses could be for lesser rheas some key food resources to survive during unfavorable seasons in arid environments without "mallines", as Payunia. Shrubby patches, with high availability of preferred food items (tall shrubs and forbs), stood out as key habitats.

RESUMEN

El choique (familia Rheidae) es un ave grande no voladora de Sudamérica, amenazada por pérdida de hábitat, cacería y colecta de huevos, con especial preocupación en Patagonia Septentrional. Se estimaron dieta y disponibilidad alimentaria a lo largo del año por análisis microhistológicos y transectas point-quadrat en un paisaje dentro y otro fuera de la Reserva Payunia, al extremo norte de la distribución de *Rhea pennata pennata*. Diferencias significativas se detectaron por ANOVA de Kruskall-Wallis, la selección alimentaria por test de Chi-cuadrado e intervalos de confianza de Bailey. Una fuerte selección alimentaria caracterizó la dieta del choique, dominada por hojas de arbustos y hierbas, complementada por semillas de dicotiledóneas y pocos insectos. Esto concuerda con el documentado bajo solapamiento con otros herbívoros en Payunia. Los cambios dietarios concordaron con lo esperado de la hipótesis de selección por calidad. La disponibilidad alimentaria fue mejor dentro que fuera del área protegida, con probables efectos de conservación para el choique. Semillas, hierbas y pastos tiernos serían recursos clave para que el choique sobreviva en épocas desfavorables en ambientes áridos sin "mallines", como Payunia. Parches arbustivos, con alta oferta

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Therefore, avoiding fire and woody plant removal is crucial for the conservation of lesser rheas in the northern of its range.

de ítems preferidos (arbustos altos y hierbas), destacaron como hábitats clave. Evitar incendios y remoción de leñosas resulta crucial para conservar el choique al norte de su distribución.

Keywords

arid environments • diet composition • food availability • feeding ecology • ratites • Rheidae

Palabras clave

ambientes áridos • composición dietaria • disponibilidad alimentaria • ecología alimentaria • ratites • Rheidae

INTRODUCTION

The lesser rhea (*Rhea pennata*, family Rheidae, order Struthioniformes) is a flightless large bird from arid and semi-arid plains of South America. *Rhea pennata pennata* is endemic of shouthern Argentine and Chile (14), where it is present in the ecoregions Patagonian Steppe, Low Monte and Southern Andean Steppe (3). *R. pennata* qualifies as Near Threatened (18), and a population decline is suspected owing to habitat loss, hunting and egg collecting (3). Desertification and road opening worsen the fragmentation and decline of lesser rhea populations (22). The lowest densities of *R. pennata pennata* are in Northern Patagonia (22), where this subspecies was considered ecologically extinct (26). Fires, woody plant removal, mining and oil activities are impacts that can result in habitat degradation for lesser rheas and other wild animals in Payunia, Northern Patagonia (8, 27).

Studies on selection of food and habitat by lesser rheas are specially relevant in the Payunia region, given that this region constitutes the northernmost part of the distribution range of *R. pennata pennata* (14) with important conservation concerns for the survival of lesser rheas, and that there are no "mallines" (flooded areas with very high plant productivity) (23). In environments of Patagonian Steppe where "mallines" are present, the lesser rhea showed a strong feeding preference for these habitats, covered by cyperaceous and gramineous species with nil shrub density (22).

Rheidae species are described as omnivores, with predominance of herbivory (22). Like ostriches (*Struthio camelus*), rheas are considered adaptable grazers/browsers (2). A dietary generalism with prevalence of dicots was reported for greater rheas (*Rhea americana*) (21), also for lesser rheas in central Patagonian Steppe and Low Monte (4, 7, 39), Central Andean Puna and Southern Andean Steppe(6, 28). Thinking on the conservation of rhea populations, the analyses of food availability and diet selection are relevant issues for management decisions (21), approach considered in studies on *R. americana* (11, 21, 43) and on *R. pennata* in southern Puna (28), as well as in the present study.

Regarding the optimal foraging theory, it is expected that animals focus their diet on a few profitable items when resources are abundant, and broaden their diet when

resource availability is low (20; 42). In arid environments, where nutritional stress can seasonally occur, animals more probably select the few foods that maintain an acceptable quality during the unfavorable season, according to the selective quality hypothesis (46). This last is expected for lesser rheas in Payunia, considering that there are no "mallines" as stable source of high food availability.

The objective of this study was to analyze throughout the year the lesser rhea's diet and food availability in a landscape inside and another outside of the Payunia Reserve, in the northernmost part of the distribution range of *R. pennata pennata*. Issues of particular interest were to detect: a) whether the diet focuses on a few foods in the unfavorable season following the selective quality hypothesis, b) whether the diet and availability change depending on the protection status of landscapes, and c) what might be the key foods that allow the persistence of lesser rheas in absence of "mallines".

MATERIALS AND METHODS

Study area and habitat characteristics

The study area (36° 30' S 69° 00' W, 1200 to 2000 m a. s. l., Mendoza, Argentina) is representative of Payunia, northern Patagonia (5). The climate is continental desert (12), with mean temperatures of 6ºC in winter and 20°C in summer, and 255 mm of annual precipitation. The terrain features gentle slopes and large plains, interrupted by basaltic steps and hills originated from volcanic activity (15, 16). The xerophilous vegetation is characterized by the absence of "mallines" and patches of tall shrublands and grasslands (23) related with the distribution of volcanic outcrops (24).

The lesser rhea is sparsely and heterogeneously distributed in the study area, with a mean density of 0.47 individuals/km² (Puig *et al*. 2012 personal communication). Based on the stable presence and relative abundance of lesser rheas, two sampling sites were selected corresponding to different landscapes (Huayquerías and Chachahuén). Huayquerías, an old peneplain associated with the Payún volcanic complex (3680 m a. s. l), belongs to the Payunia Reserve and it is co-dominated by open shrublands and grasslands. Chachahuén, a plateau and piedmont surrounding the Chachahuén complex (2065 m a. s. l.), is located outside this protected area and it is dominated by sandy grasslands with patches of lithosol scrubland (1, 8, 36). The proportions of low and tall shrubs in Huayquerías (17 and 13%, respectively) were twice than in Chachahuén (8 and 7%). Low to moderate abundance of cattle and horses occurred in both sampling sites (4 to 15 animals/km²). Chachahuén is more intensely affected than Huayquerías by poaching, fires, woody plant removal, opening of roads, mining and oil exploitation (8).

Field and laboratory design

Seasonal samplings were performed during 2008-09 in spring (September, November), summer (January), autumn (March and May) and winter (July). Throughout the study period, 60 droppings of lesser rheas were collected on each sampling site, and 60 transects were traversed to estimate plant cover and relative

frequencies of plant species by the point-quadrat method (13). Droppings of each site were randomly selected from all fresh faeces found along ten 500-m transects located 1 km apart. Ten 30-m transects of point-quadrat, separated from each other by more than 100 m, were randomly distributed within each site. Each dropping, treated as a sample unit, was oven-dried at 60°C during seven days, weighted, broken up and sorted under 10x stereo-microscopy into plant material, animal material and stones. Diet components (leaf, seed and animal material) and stones of each dropping were weighed. The leaf component was cleared with aqueous sodium hypochlorite (25% w/v), milled, passed through a 210-µm sieve and analyzed at 400x by the microhistological method (17), using as reference plant material collected previously in the study area (35) and during this research, stored in the Ruiz Leal Herbarium (IADIZA). Plant cuticle was identified to genus level, and to species level when possible.

Statistical analyses

Plant species were grouped into five categories according to life form: grasses, forbs, low shrubs, tall shrubs and succulents. Diversity in availability and diet was estimated by the Shannon-Wiener function (10). Kruskal-Wallis ANOVA and multiple comparisons of mean ranges (40) were applied to the proportions of food items in diet and availability, to detect significant differences between the two sampling sites and among all six sampling dates. The level of significance obtained was mostly $P \leq 0.001$; otherwise, it is mentioned in the text. Food selection was detected through significant differences between observed and expected dietary proportions by the χ^2 test (47). Bailey's confidence interval (9) allowed identify the selective use of main food items (those with frequencies ≥ 10% in availability or diet). Plant use was qualified as preference, non-selection or avoidance depending on whether availability fell respectively below, within or above the confidence interval of dietary frequency.

RESULTS

Diet of the lesser rhea

The lesser rhea's diet showed three components: leaves (93.61%), seeds (6.12%) and insects (0.06%). The remaining 0.20% of faecal dry weight were stones, with a higher proportion in early spring (H = 33.34, figure 1, page 215). Leaves were present in all faeces, seeds occurred in 47.5% of faeces, insects in 10.8% and stones in 10.8% of faeces. The leaf component comprised higher dietary proportions in spring- summer (H = 21.57 in Huayquerías, H = 13.54 p = 0.019 in Chachahuén, figure 1, page 215). Shrubs and forbs were the main plant categories eaten by lesser rheas throughout the year (table 1, page 216). Tall shrubs represented more than 45% of the diet in both habitats all over the year (mainly *Chuquiraga hystrix* and *Lycium chilensis*), followed by forbs (as *Hoffmanseggia* aff. *glauca* and *Lecanophora ameghinoi* in Huayquerías) and low shrubs (as *Prosopis alpataco* and *Acantholippia seriphioides* in Chachahuén). Species diversity within the leaf component of the diet showed no seasonal differences, and included 22 of the 37 plant species recorded in the study area.

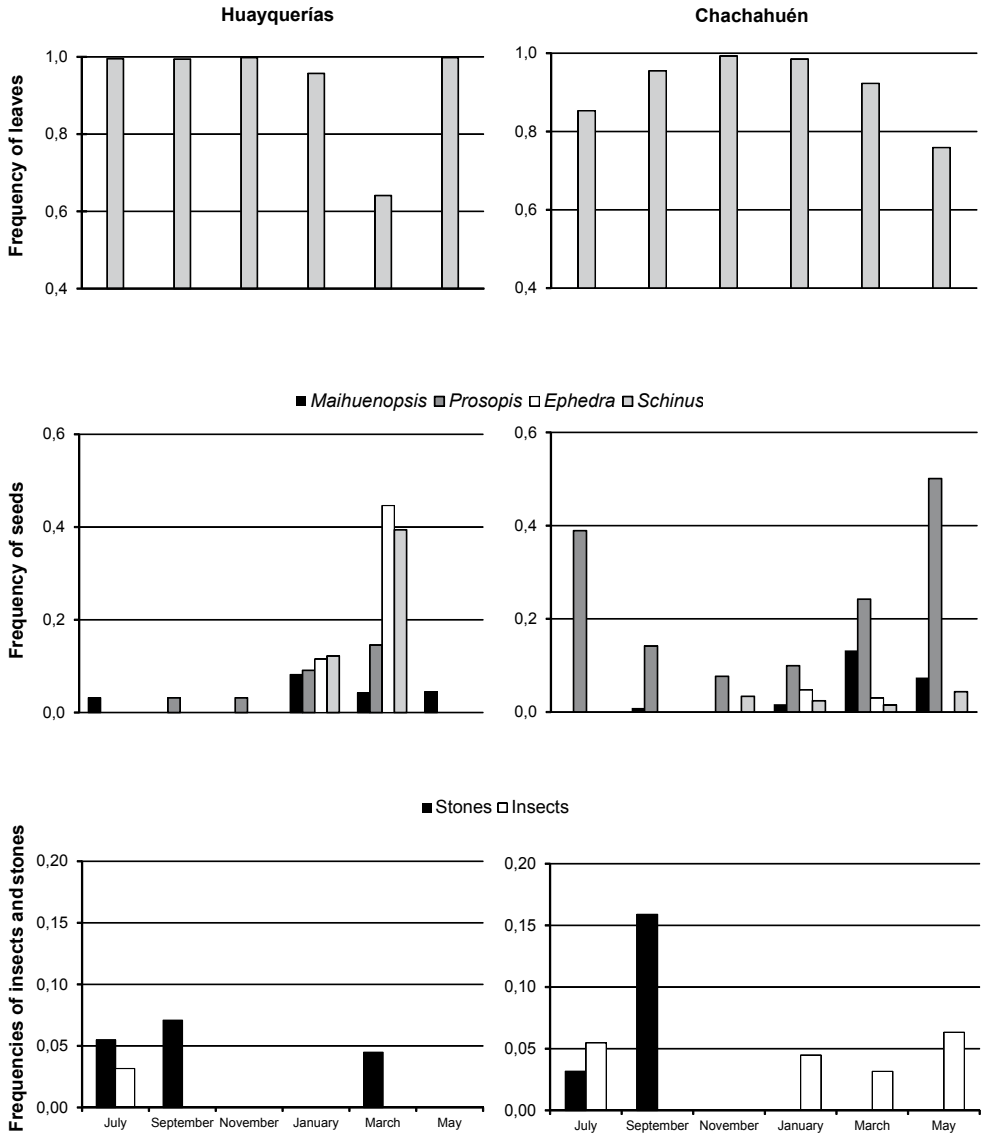


Figure 1. Seasonal proportions of dietary components and stones found in faeces of the lesser rhea. Proportions of the main species in the seed component, also proportions of insects and stones, were transformed using arcsin-square root to make them more visible.

Figura 1. Proporciones estacionales de componentes dietarios y piedras hallados en las heces de choique. Las proporciones de las especies principales en el componente semillas, también las proporciones de insectos y piedras, fueron transformadas usando arcoseno de raíz cuadrada para hacerlas más visibles.

Table 1. Seasonal values of the percentage of plant cover (Cov), diversity index (*Div*), relative frequencies of categories in food availability and in the diet leaf component.

Tabla 1. Valores estacionales del porcentaje de cobertura vegetal (Cov), índice de diversidad (*Div*), frecuencias relativas de categorías en disponibilidad y componente dietario foliar.

	Huayquerías			Chachahuén		
	Availability		**Diet**	**Availability**		**Diet**
			July			
Cov and *Div*	82.6	*0.65*	*0.68*	75.7	*0.50*	*0.66*
Grasses	0.81		0.03 (0.00-0.11) [A]	0.90		0.01 (0.00-0.06) [A]
Forbs	0.09		0.13 (0.06-0.24)	0.00		0.08 (0.02-0.17) [P]
Low shrubs	0.05		0.12 (0.05-0.22)	0.07		0.44 (0.31-0.57) [P]
Tall shrubs	0.04		0.71 (0.58-0.82) [P]	0.03		0.47 (0.33-0.59) [P]
Succulents	0.00		0.00 (0.00-0.05)	0.00		0.01 (0.00-0.06)
			September			
Cov and *Div*	76.0	*0.60*	*0.75*	74.6	*0.52*	*0.67*
Grasses	0.86		0.10 (0.04-0.20) [A]	0.89		0.11 (0.04-0.21) [A]
Forbs	0.07		0.24 (0.14-0.36) [P]	0.02		0.07 (0.02-0.16) [P]
Low shrubs	0.04		0.08 (0.03-0.18)	0.04		0.14 (0.06-0.24) [P]
Tall shrubs	0.03		0.57 (0.43-0.69) [P]	0.05		0.68 (0.54-0.79) [P]
Succulents	0.00		0.00 (0.00-0.05)	0.00		0.00 (0.00-0.05)
			November			
Cov and *Div*	91.1	*0.71*	*0.54*	81.4	*0.52*	*0.69*
Grasses	0.76		0.06 (0.01-0.14) [A]	0.89		0.02 (0.00-0.09) [A]
Forbs	0.12		0.11 (0.04-0.22)	0.01		0.08 (0.02-0.17) [P]
Low shrubs	0.07		0.09 (0.03-0.19)	0.08		0.24 (0.14-0.37) [P]
Tall shrubs	0.06		0.74 (0.60-0.84) [P]	0.02		0.64 (0.50-0.76) [P]
Succulents	0.00		0.00 (0.00-0.05)	0.00		0.01 (0.00-0.07)
			January			
Cov and *Div*	83.8	*0.75*	*0.69*	70.4	*0.53*	*0.79*
Grasses	0.75		0.05 (0.01-0.13) [A]	0.84		0.03 (0.00-0.11) [A]
Forbs	0.08		0.19 (0.10-0.31) [P]	0.01		0.12 (0.05-0.23) [P]
Low shrubs	0.10		0.08 (0.02-0.17)	0.11		0.25 (0.15-0.37) [P]
Tall shrubs	0.08		0.68 (0.54-0.79) [P]	0.05		0.57 (0.43-0.69) [P]
Succulents	0.00		0.00 (0.00-0.06)	0.00		0.02 (0.00-0.09)
			March			
Cov and *Div*	82.4	*0.65*	*0.64*	66.7	*0.53*	*0.67*
Grasses	0.82		0.04 (0.00-0.12) [A]	0.86		0.03 (0.00-0.11) [A]
Forbs	0.01		0.13 (0.05-0.23) [P]	0.00		0.04 (0.01-0.12)
Low shrubs	0.09		0.09 (0.03-0.18)	0.11		0.28 (0.17-0.41) [P]
Tall shrubs	0.08		0.73 (0.59-0.83) [P]	0.03		0.63 (0.49-0.74) [P]
Succulents	0.00		0.02 (0.00-0.08)	0.00		0.02 (0.00-0.08)
			May			
Cov and *Div*	85.3	*0.62*	*0.74*	70.7	*0.54*	*0.75*
Grasses	0.83		0.02 (0.00-0.09) [A]	0.86		0.02 (0.00-0.09) [A]
Forbs	0.07		0.27 (0.16-0.39) [P]	0.00		0.12 (0.05-0.22) [P]
Low shrubs	0.06		0.09 (0.03-0.19)	0.10		0.35 (0.23-0.48) [P]
Tall shrubs	0.04		0.61 (0.47-0.73) [P]	0.03		0.48 (0.34-0.61) [P]
Succulents	0.00		0.00 (0.00-0.05)	0.00		0.03 (0.00-0.10)

Preferred categories ([P]). Avoided categories ([A]). Bailey's intervals in brackets.

Categorías preferidas ([P]). Categorías evitadas ([A]). Intervalos de Bailey entre paréntesis.

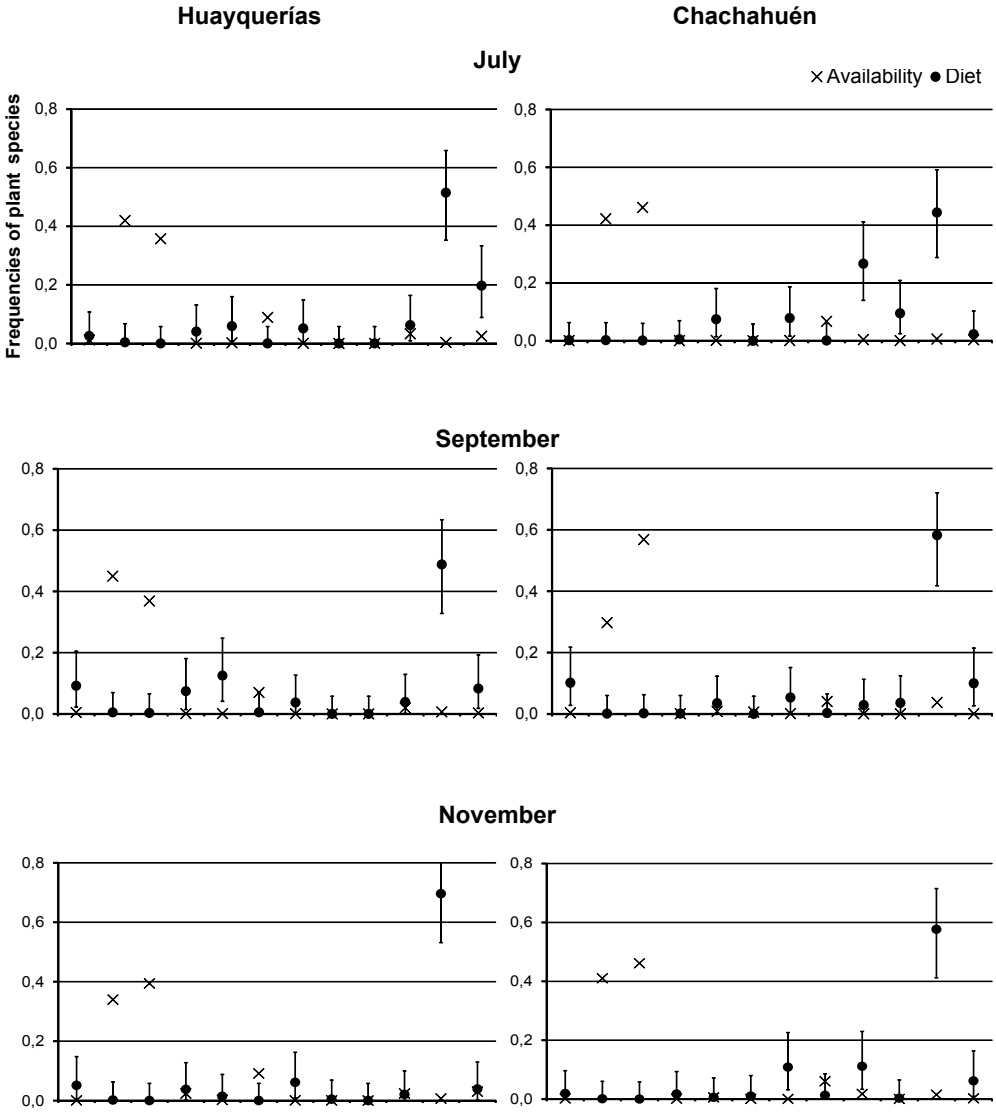
The tall shrub *C. hystrix* comprised more than 40% of the leaf component (figure 2, pages 218-219), with a higher proportion in late spring (H = 14.05 p = 0.015), whereas *L. chilensis* showed in Huayquerías a lower diet proportion in early spring (H = 28.77). The forb *L. ameghinoi* accounted for a higher proportion from late autumn to early spring (H = 51.57), and *H. glauca* showed in Huayquerías a higher proportion in autumn (H = 15.19 p = 0.010). The proportion of the low shrub *Senecio filaginoides* was higher in winter (H = 28.30). The proportion of grasses increased in early spring (H = 14.24 P = 0.014, especially *Bromus brevis* H = 18.47 P = 0.002). The leaf component comprised a higher dietary proportion in Huayquerías than in Chachahuén (H = 9.37 p = 0.002), with higher diversity (H = 7.80 p = 0.005, figure 2, pages 218-219), lower proportion of low shrubs (H = 37.75, especially *P. alpataco* H = 48.78), higher proportions of forbs (H = 25.51, *H. glauca* H = 34.58) and tall shrubs (H = 6.55 p = 0.011, *L. chilensis* H = 23.52).

Seeds were eaten all year round, with higher proportion in autumn (H = 15.95 P = 0.007) (figure 1, page 215). The major species in the seed component were *P. alpataco* (73.89%), the tall shrubs *Ephedra ochreata* (28.80%) and *Schinus* spp. (24.48%), and the succulent *Maihuenopsis glomerata* (7.29%). *E. ochreata* formed a higher proportion in autumn (H= 24.05, mainly in Huayquerías H = 9.93 P = 0.002) (figure 1, page 215), and *P. alpataco* in autumn-winter (H = 15.79 p = 0.008, mainly in Chachahuén H = 21.20).

Availability of the leaf component in the environment

Plant cover was higher in late spring (H= 27.97 in Huayquerías, H = 30.10 in Chachahuén), whereas diversity showed no temporal differences (table 1, page 216). Only the 22 species eaten by lesser rheas (59% of all those recorded on the sampling sites) were considered in food availability analyses. Grasses made up more than 75% of the vegetation in both habitats throughout the year (mainly *Panicum urvilleanum* and *Poa* spp.). Among tall shrubs, *C. hystrix* showed a lower proportion in winter (H = 11.53 P = 0.016 in Chachahuén, figure 2, pages 218-219), and *L. chilensis* was more available in summer (H = 19.93 in Huayquerías). Low shrubs showed a higher proportion in summer-autumn (H = 21.46 P = 0.001, table 1, page 216). The forbs proportion increased in Huayquerías at late spring (H = 15.19 P = 0.010, *Hoffmanseggia* in spring-summer H = 22.24). Lower proportions occurred in spring for *P. urvilleanum* (H = 14.34 p = 0.014 in Huayquerías, H = 30.90 in Chachahuén), and in summer- autumn for *Poa* spp. (H = 38.87).

Higher plant cover and diversity were found in Huayquerías than in Chachahuén (H = 45.26 and H = 35.93, respectively), with lower proportion of grasses (H = 15.83, mainly *P. urvilleanum* H = 6.12 P = 0.013), higher proportions of forbs (H = 45.18, *Plantago patagonica* H = 39.30, *H. glauca* H = 9.20 p = 0.002) and tall shrubs (H = 13.77, *L. chilensis* H = 51.64). In Huayquerías was more available *E. ochreata* (H = 26.56), and less available *Hyalis argentea* (H = 87.16) and *C. hystrix* (H = 12.01).

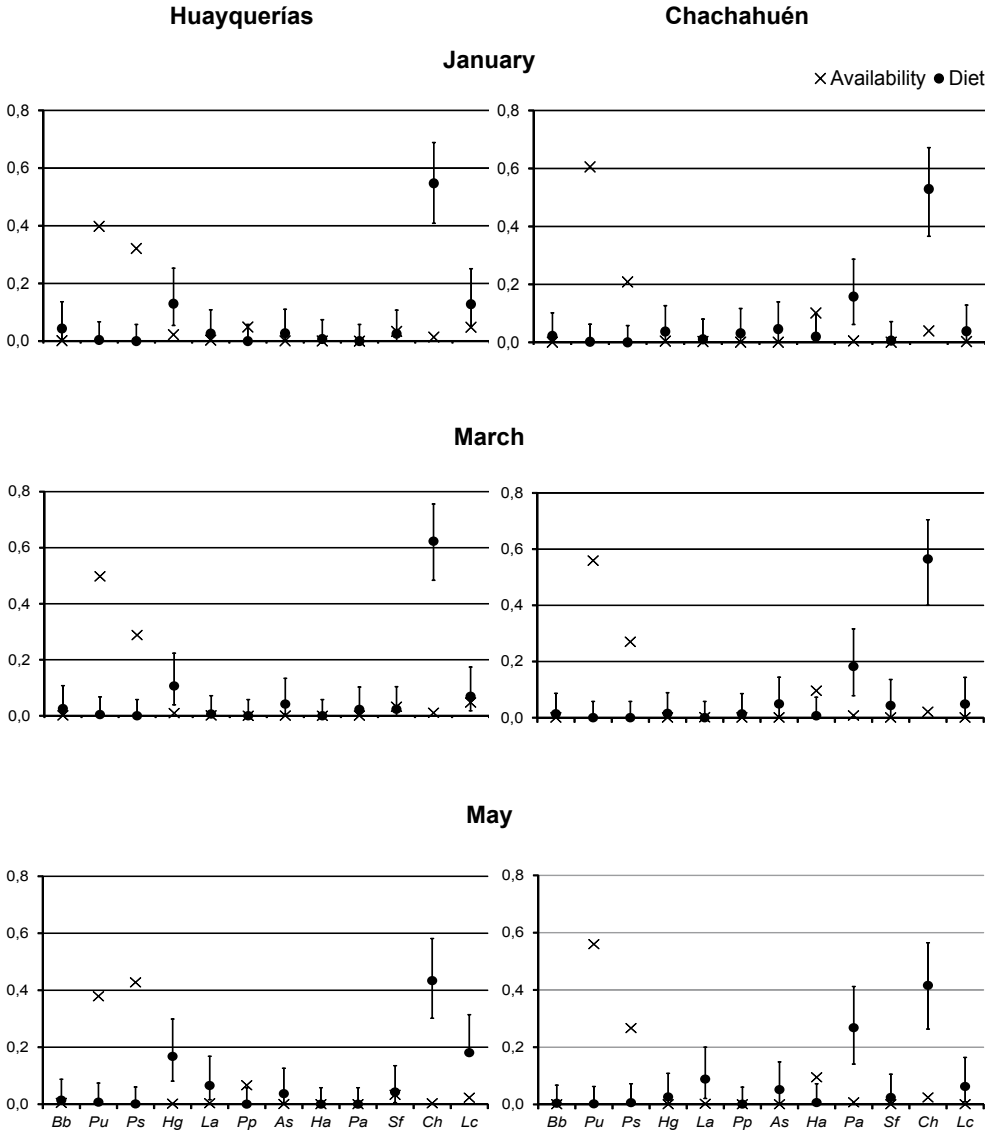


Bailey's intervals in vertical lines. Grasses: *B. brevis (Bb)*, *P. urvilleanum (Pu)*, *Poa spp. (Ps)*. Forbs: *H. glauca (Hg)*, *L. ameghinoi (La)*, *P. patagonica (Pp)*. Low shrubs: *A. seriphioides (As)*, *H. argentea (Ha)*, *P. alpataco (Pa)*, *S. filaginoides (Sf)*. Tall shrubs: *C. hystrix (Ch)*, *L. chilensis (Lc)*.

Intervalos de Bailey en líneas verticales. Pastos: *B. brevis (Bb)*, *P. urvilleanum (Pu)*, *Poa spp. (Ps)*. Hierbas: *H. glauca (Hg)*, *L. ameghinoi (La)*, *P. patagonica (Pp)*. Arbustos bajos: *A. seriphioides (As)*, *H. argentea (Ha)*, *P. alpataco (Pa)*, *S. filaginoides (Sf)*. Arbustos altos: *C. hystrix (Ch)*, *L. chilensis (Lc)*.

Figure 2. Seasonal proportion of main species in food availability and in the diet leaf component.

Figura 2. Proporciones estacionales de especies principales en la disponibilidad alimentaria y el componente dietario foliar.



Bailey's intervals in vertical lines. Grasses: *B. brevis (Bb)*, *P. urvilleanum (Pu)*, *Poa spp. (Ps)*. Forbs: *H. glauca (Hg)*, *L. ameghinoi (La)*, *P. patagonica (Pp)*. Low shrubs: *A. seriphioides (As)*, *H. argentea (Ha)*, *P. alpataco (Pa)*, *S. filaginoides (Sf)*. Tall shrubs: *C. hystrix (Ch)*, *L. chilensis (Lc)*.

Intervalos de Bailey en líneas verticales. Pastos: *B. brevis (Bb)*, *P. urvilleanum (Pu)*, *Poa spp. (Ps)*. Hierbas: *H. glauca (Hg)*, *L. ameghinoi (La)*, *P. patagonica (Pp)*. Arbustos bajos: *A. seriphioides (As)*, *H. argentea (Ha)*, *P. alpataco (Pa)*, *S. filaginoides (Sf)*. Arbustos altos: *C. hystrix (Ch)*, *L. chilensis (Lc)*.

Figure 2 (cont.). Seasonal proportion of main species in food availability and in the diet leaf component.

Figura 2. (cont.). Proporciones estacionales de especies principales en la disponibilidad alimentaria y el componente dietario foliar.

Preferences within the leaf component of the diet

Plant categories were selectively used for lesser rheas in Huayquerías (χ^2= 1201 in winter, 960 in early spring, 889 in late spring, 553 in summer, 747 in early autumn and 896 in late autumn) and in Chachahuén (χ^2= 1280, 960, 2170, 924,1438 and 1169, respectively). In both habitats tall shrubs were preferred and grasses were avoided in all seasons, and most of the year forbs were preferred (table 1, page 216). Low shrubs, not selected in Huayquerías, were preferred in Chachahuén.

Plant species were selectively used in Huayquerías (χ^2= 8733, 6236, 8508, 2509, 4132 and 7900), and in Chachahuén (χ^2= 8165, 3094, 5006, 2236, 2868 and 3112). From grasses, *P. urvilleanum* and *Poa* spp. were avoided in all seasons, whereas *B. brevis* was preferred in spring (figure 2, pages 218-219). Among forbs, *L. ameghinoi* was preferred in late autumn and early spring, whereas in Huayquerías *H. glauca* was preferred in summer-autumn and *P. patagonica* was avoided from winter to late spring. From low shrubs, *A. seriphioides* was preferred in late spring, whereas in Chachahuén *P. alpataco* was preferred most of the year, *S. filaginoides* was preferred in winter and *H. argentea* was avoided in summer-autumn. The tall shrubs *C. hystrix* and *L. chilensis* were allways preferred.

DISCUSSION

With a strong food selection, lesser rheas focused their diet on tall shrubs (mainly *C. hystrix* and *L. chilensis*), followed by forbs (*H. glauca*, *L. ameghinoi*) and low shrubs (*P. alpataco*, *A. seriphioides*). An avoidance of grasses occurred throughout the year, despite that grasses (mainly *P. urvilleanum* and *Poa* spp.) prevailed in food availability. A prevalence of shrubs leaves and sprouts, considerable seeds proportion and slight omnivory evidence were detected within this generalist diet. Seasonal and spatial differences in the diet agree with the selective quality hypothesis (46). Dietary diversity increased when there was higher vegetation cover and diversity, sprouted perennials and seasonal herbs appeared. Seasonal changes in the number of preferred and avoided species suggest a selective behavior increase during late autumn - winter. Higher nutritional needs during unfavorable seasons when the leaf component is less available, would justify the higher use of forbs, as *L. ameghinoi* and *H. glauca*, and seeds of *E. ochreata* and *P. alpataco*. The persistence of *P. alpataco* fruits in the plant (35) offers a feeding source to lesser rheas when most plants are declining or dry, especially in landscapes where food availability was affected by impacts, as Chachahuén.

The best conservation conditions inside than outside the Payunia protected area (Huayquerías and Chachahuén, respectively) result in feeding advantages for lesser rheas. Plant cover and diversity, availability of tall shrubs (*L. chilensis*, *E. ochreata*) and forbs (*P. patagonica*, *H. glauca*), all of them were higher inside the protected landscape. Lesser rhea's diet showed differences accordingly, as in Huayquerías the foliar component occupied a higher dietary proportion with higher diversity, higher proportion of *H. glauca* and *L. chilensis*, besides a higher proportion of *E. ochreata* seeds. Despite all this, the persistence of lesser rheas in Chachahuén would be favored

by the availability of the tall shrub *C. hystrix*, main dietary item in this region, and the low shrub *P. alpataco*, whose leaves and seeds were more intensively used in Chachahuén.

The increase of plant cover, the regrowth of perennials and the appearance of seasonal forbs would account for the highest dietary proportion of leaf component occurring in spring-summer. The softness of grasses in spring would justify that lesser rheas increased their use, and even preferred *Bromus brevis*, a grass with good forage quality (45), as occurs in southern Puna with *Bromus setifolius* (28). The hardness of plants before the regrowth would explain the higher presence of stones in faeces during early spring. Stones, also found in faeces of lesser rheas in Puna (6, 28), could help mechanically to the digestion process as in ostriches (25). Animals that lack teeth will swallow stones or grit which, in breaking down hard food, aid digestion (41).

The sustained use of seeds, most of the year with dietary proportions greater than 5%, suggest that they constitute a key food component for lesser rheas in Payunia. Seeds would be a nutritional support especially in autumn, when raised the highest dietary proportion and the preferred leaves (as *C. hystrix*, main food item for lesser rheas) decreased in availability and softness. The seed prevalence of *P. alpataco* and *E. ochreata* agrees with their proportions in the diet foliar component and availability. Greater rheas also eat seeds (21, 30), as well as ostriches (25). Seed intake could provide rheas with vitamins, minerals or amino acids that are not in the preferred leaves (21). The passage through the gut of greater rheas improves the germination of tree seeds protected with a hard endocarp (34). The ingestion of *P. alpataco* seeds by lesser rheas could contribute to the maintenance of these shrubby patches in Payunia, if germination speed increases with ingestion as occurred with *Prosopis nigra* seeds eaten by greater rheas (31). Parts of dicots preferred by lesser rheas in Payunia, as soft foliage and fruits of *P. alpataco* and flowers of *C. histrix*, are also especially searched by lesser rheas in the Patagonian Steppe (37). The preferred tall shrub *L. chilensis* would provide lesser rheas with food high in calcium (44). The preference of lesser rheas, ostriches and emus for forbs is attributed to their high digestibility (2, 38), as soluble cellular content prevail in forbs (21, 43). The high water content in the succulent *M. glomerata* would explain that lesser rheas prefer it, given the lack of natural water sources in arid environments such as Payunia (8), as well as Southern Puna (28).

The omnivory mentioned for Rheidae (22) was slightly expressed in the lesser rhea of Payunia, given that insects were a minor proportion in faeces. The low abundance of insects in these arid environments could explain the weak omnivory detected, considering that insects were suggested as a source of protein and vitamins for greater rheas (21). The wide dietary diversity, that included 60% of plant species present in the study area, allows confirming the generalism of this ratite. Furthermore, the diet diversity of lesser rheas was the highest among the wild and domestic herbivores present in Payunia (33). Lesser rheas avoided grasses, especially the predominant *P. urvilleanum* and *Poa* spp, which were preferred food items for wild ungulates and livestock that share feeding habitats in Payunia (32). Within the assemblage of herbivores in this region, lesser rheas showed the lowest dietary overlap and clearly separated from the other species due to the preference of shrubs (33).

The shrub stratum becomes particularly important for feeding of lesser rheas during the dormancy of plants and the droughts in arid environments as Payunia. The nutritional quality and water content of leaves usually diminish less in shrubs than in grasses during these climatic situations (19).

Additionally, forbs and soft grasses frequently are more abundant and larger under the protection of shrubby patches. In arid environments without "mallines" as Payunia, tall shrubby patches can play a similar key function for lesser rheas than the "mallines" in the Patagonian steppe, given that shrubby patches have a high availability of preferred food items (tall shrubs and forbs).

Fires and woody plant removal reduce availability of the shrub stratum in the Payunia region (8), and would strongly reduce availability and quality of food for lesser rheas. Recurring uncontrolled wildfires, especially when livestock overgrazing follows them, are relevant factors in desertification processes (29), with consequences to the decline of lesser rhea populations (22).

Regarding the risk that the lesser rhea becomes ecologically extinct in Northern Patagonia (26), strengthen the protected mega-landscape proposed between the Reserves La Payunia and Auca Mahuida (27), and avoidance of impacts affecting the shrubby patches come as essential tools to warrant the conservation of focal wild animals (33), as the lesser rhea in the northernmost part of its distribution range.

CONCLUSIONS

R. pennata pennata showed a strong food selection in Payunia. Dietary changes agree, not with the expected from the optimal foraging theory but with the hypothesis of selective quality, since food selectivity increased when vegetation seasonally decline.

The protection status of landscapes would affect the conservation of lesser rheas, given that plant cover, diversity and proportions of preferred food items in availability and diet were higher inside than outside the protected area. Several seeds (mainly of *P. alpataco* and *E. ochreata*) and profitable species (as the grass *B. brevis* and the forb *L. ameghinoi*) would favor the survival of lesser rheas during the unfavorable season in environments without "mallines" as Payunia, where this Rheidae does not found these habitats with stable and highly concentrated forage as occur in other sites of Patagonia Steppe.

Results evidence the dietary adaptation of lesser rheas to survive in arid environments, the relevance of shrubby patches, and the need of conservation efforts to favor its persistence in the northern of the distribution range, where populations are scarce and threaten by the increase of mining and oil activities.

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Acknowledgements

We thank M. I. Rosi for her assistance in field works and enriching suggestions on the manuscript, and N. Horak for her assistance in the English translation.

We are grateful for their kind hospitality to A. Rocher in Ea. El Peralito, and to E. Massino and Naiber family in Ea. Las Lajas.

We thank the anonimous reviewers for their valuable comments and suggestions.

This study was supported by the Consejo Nacional de Investigaciones Científicas y Técnicas of Argentina through a research grant.