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SHORT COMMUNICATION

Diet of wild boar (*Sus scrofa*) in a protected area of Argentina: the importance of baiting

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Abstract The wild boar is an invasive mammal in Argentina that generates habitat alteration, predation, and competition that threaten several native species due to its flexible and broad diet and its rooting behavior. We evaluated the diet of wild boar in El Palmar National Park (EPNP), assessing its composition, seasonality, and importance of baiting. Vegetable matter represented the major component of the diet, where corn was the most abundant food item, which is used as bait to hunt wild boars. Animal remains were also abundant and mostly consisted of birds. Wild boar diet exhibited marked seasonality that seems related to food availability, such as the occurrence of fruits in summer. Currently, the importance of bait in the diet could support and complement the diet of wild boar and improve their reproduction triggering the population growth. Also, the impacts on native biodiversity may be hidden due to the constant food subsidy of corn. We recommend the implementation of other control methods such as hunting with dogs or traps and the use of alternative baits, as odor baits, to avoid the supplemental feeding, or finally, if corn baiting is continuous, we suggest regulating their quantity and frequency. Further studies on wild boar diet and baiting methods should be conducted due to its multiple implications on wild boar populations and native ecosystems.

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Introduction

Depending on the type of habitat involved, wild boar may play different trophic functions in natural and anthropogenic ecosystems (Genov 1981), acting as an agricultural pest, predator, frugivore, and seed disperser (Geisser and Reyer 2004; Bueno et al. 2011; O'Connor and Kelly 2012). Its ample diet and foraging activities are known to cause damage that influences ecosystem structure and functions, which are exacerbated due to their broad dietary niche (Loggins et al. 2002; Wilcox and Van Vuren 2009).

Several reviews have listed the negative effects of wild boar on native plant and animal communities in their native and introduced range (Massei and Genov 2004; Nogueira-Filho et al. 2009; Barrios-García and Ballari 2012). For example, their rooting activities modify the structure of herbaceous vegetation, reduce the abundance of native trees, alter soil structure and processes, promote the establishment of exotic plants, and accelerate mineral leaching (Singer et al. 1984; Wirthner et al. 2011; Cuevas et al. 2012). Also, the wild boar affects wildlife by predation, destruction of bird nests, food competition, and habitat destruction (Long 2003; Cruz et al. 2005; Wilcox and Van Vuren 2009). Boars are omnivorous, with a strong preference for plant material (Schley and Roper 2003; Adkins and Harveson 2006; Cuevas et al. 2013). This species is highly plastic on its diet, and its ability to adapt to different food items allow it to colonize a variety of habitats (Baber and Coblentz 1987; Taylor and Hellgreen 1997).

In some cases, wild boar diet included supplemental feeding (additional food for wild animals) which is provided by humans for different purposes such as dissuasive feeding, baiting, or providing minerals and vaccination (Cellina

2008). Corn, that is highly palatable by boars, is one of the most used bait to attract boars to hunting areas or traps, and even to deter crop damages (Fournier-Chambrillon et al. 1995; Hahn and Eisfeld 1998; Calenge et al. 2004).

The diet of the wild boar has been described by many authors within its native (Genov 1981; Fournier-Chambrillon et al. 1995; Schley and Roper 2003; Baubet et al. 2004; Herrero et al. 2005; Herrero et al. 2006; Giménez-Anaya et al. 2008) and introduced range (Challies 1975; Wood and Roark 1980; Chimera et al. 1995; Herrero and Fernández de Luco 2003; Adkins and Harveson 2006; Skewes et al. 2007). Ballari and Barrios-García (2014) showed that the diet differs between both ranges: plant matter is more frequently consumed in the native range, whereas animal matter is on average more prevalent in the diet in its introduced range. In both distribution zones, impacts of wild boar on endangered or keystone species occurred through predation (Giménez-Anaya et al. 2008; Jolley et al. 2010).

In spite an overall relatively large number of studies about wild boar diet, information on its feeding habits in South America is scarce, and obtaining such knowledge is essential for determining the ecological role of this introduced species in these novel systems. Specifically, diet and trophic studies are important to understand the behavior and the potential impacts of introduced species, as well as to develop, improve, and assess management strategies. Although the wild boar is one of the most widespread invasive alien species in the Argentine National Parks System (Merino et al. 2009), only two diet studies have been conducted, and both were in semiarid environments (Cuevas et al. 2010; Cuevas et al. 2013). El Palmar National Park (EPNP) was created in 1965 to preserve an emblematic plant species, the *yatay* palm (*Syagrus yatay*). Many potential impacts that threaten native biota (Gil 2008) have been reported since the first records of wild boar in this park in the 1950s (Aristóbulo Maranta pers. comm.), and since 1996, wild boars were controlled by hunting. In this paper, we evaluate the composition and seasonal variations of wild boar diet and the importance of baiting in EPNP.

Material and methods

Fieldwork was conducted at El Palmar National Park (EPNP) in Entre Ríos Province (31° 50′ S 58° 17′ W). This 8500-ha protected area is located in the northeast of Argentina, on the coast of the Uruguay River. The vegetation consists of a heterogeneous mosaic, including gallery forests, pastures and scrublands in floodplains of streams, grass xeric steppes in outcrops on sandy shrublands, and savannahs with *yatay* palms in highlands (Movia and Menvielle 1994). The protected area is surrounded by a matrix of forest eucalyptus plantations (*Eucalyptus globulus*), soybean crops (*Glycine max*) in summer and spring, and wheat crops in winter (pers. obs.). The climate is wet and warm throughout the year with no dry season (Cabrera 1976). The rainfall (1300-mm annual average) is more abundant in spring and summer but with a deficit of water in the soil due to the high potential evapotranspiration (de Fina 1974; Goveto 2005).

In EPNP, wild boar were hunted since 1996 only sporadically, and in 2006, a systematic Control Plan of Invasive Mammals including wild boar, axis deer (*Axis axis*), and black buck (*Antilope cervicapra*) was performed with different hunting methods. Hunting from high seats with bait stations is the most used method where soaked corn is used to attract boar to be hunted. These hunting fixed points, called "apostaderos," are located throughout the entire surface of the EPNP occupying different environments where hunters renewed daily corn supply to maintain a constant and fresh bait (Fig. 1).

Diet composition was determined by stomach content analyses of 107 wild boars harvested in 35 different apostaderos between October 2009 and December 2011. We collected 500 ml samples from each stomach, which were stored in 5 % formalin. Stomach volume was measured with a graduated cylinder (±10 ml). To remove gastric juices and unidentifiable particles, contents were washed with water through a 1.0-mm mesh sieve (Wood and Roark 1980). The material found in each stomach was classified in one of 11 main categories: *fruits*, *leaves*, *seeds*, *cacti*, *roots*, *supplementary feeding* (i.e., corn that is approved by the national park to be used as bait for hunting), *mammals*, *birds*, *herpetofauna*, *invertebrates*, and *non-organic material*. For each food item, we determined two parameters: (1) *percent volume* (% vol) (≥1 ml) that was obtained by water displacement using a graduated cylinder and calculating the percentage as the total volume of each item recorded in the sample divided by the total volume of all items identified in the stomachs and (2) *frequency of occurrence* (% frec) that was calculated as the number of stomachs in which the particular food item occurred divided by the total number of stomachs examined (N=107). Percent volumes that were smaller than 0.1 ml were considered as trace amounts. During the analysis of stomach contents, we also recorded percent volume and frequency of occurrence of native species that were of conservation value.

For the statistical analysis, we used the values of volume, and we grouped the items into 10 major categories (excluding non-organic material). Differences between food items were evaluated by using a Kruskal–Wallis test and subsequently a Tukey–Kramer test. Then, to determine differences in diet composition between seasons, we used permutational multivariate analysis of variance (PERMANOVA) using the Bray–Curtis dissimilarity matrix on log-transformed abundance data (Primer-E version 6.1.15, Anderson et al. 2008).

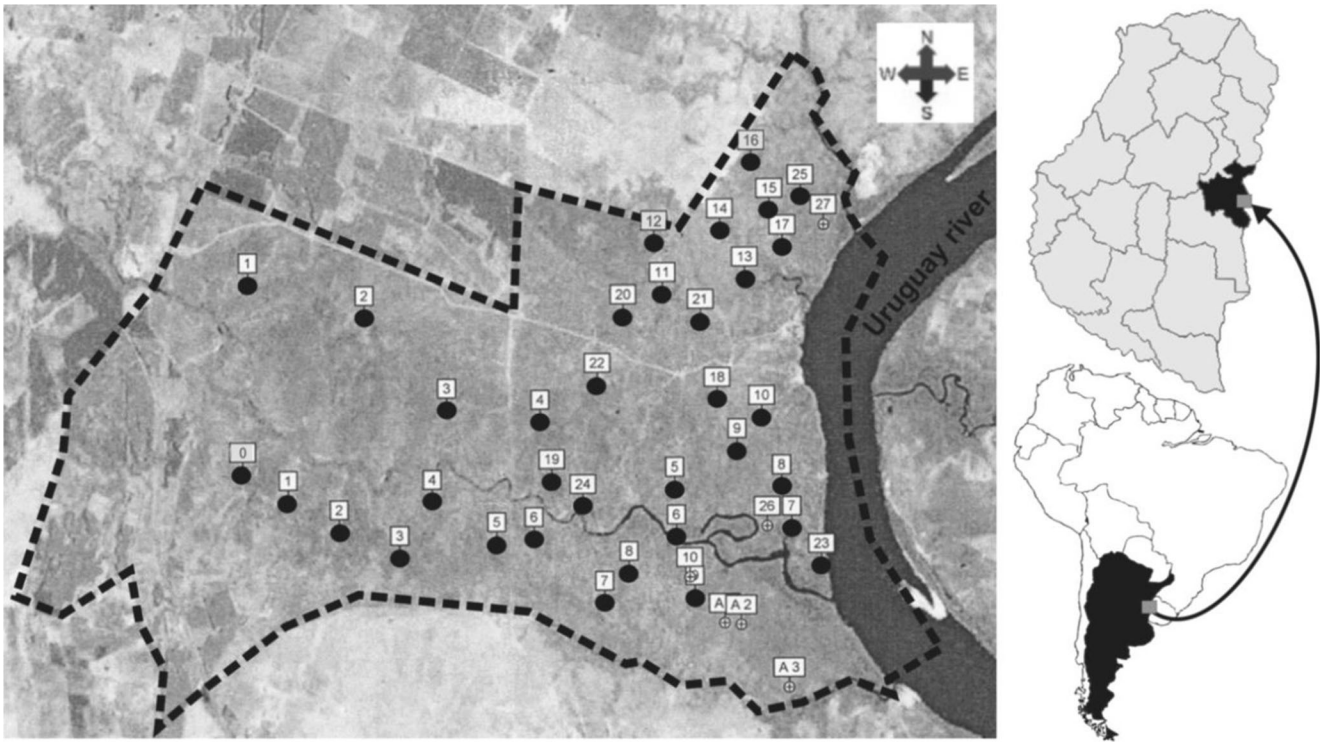

Fig. 1 El Palmar National Park (limit in *dotted line*) in Entre Ríos province, Argentina, and location of high seat stations ("apostaderos") to hunt (*black circles*)

Results and discussion

We identified 29 food items, where 81.2 % of volume was vegetable matter and 18.8 % of volume was animal matter (Table 1). In spite of that, both items showed similar frequencies (98.1 and 83.2 %, respectively). Almost 41.4 % of the total volume of plant material was corn (Fig. 2). Leaves were consumed at a greater volume (20.6 %) and more frequently (84.1 %) than the underground parts (roots) (4.5 and 42.1 %, respectively). The majority of the native plant items consumed were leaves of monocotyledonous plants, in comparison with aerial parts of dicotyledonous plants. Wild boar in the EPNP were omnivorous, but showed a marked tendency to consume more plant matter (Fig. 2), and these data were consistent with other studies, both in its native range (Baubet et al. 2004; Irizar et al. 2004; Herrero et al. 2006; Giménez-Anaya et al. 2008) and in its introduced distribution (Taylor and Hellgreen 1997; Herrero and Fernández de Luco 2003; Cuevas et al. 2010; Cuevas et al. 2013).

Fruits of native species were consumed in large quantities by wild boar, especially *yatay* palm (Table 1). In agreement with previous studies, several authors emphasize the importance of fruits in wild boar diet, which is particularly relevant in periods of fruiting (Taylor y Hellgren 1997; Loggins et al. 2002; Herrero et al. 2005). Also, some studies suggested that under food scarcity, resource competition may occur between the wild boar and other animals (Wood and Roark 1980; Massei et al. 1996). Therefore, because these fruits are also consumed by native birds and mammals (pers. obs.), consumption by boar could cause a potential competition over these resources. Furthermore, during the fruiting periods, we found in wild boar stomachs entire fruits of *yatay* palm with pulp and seeds (each fruit may host 1–3 seeds of 2 × 1.5 cm), whereas in the other periods, we found samples with seed fragments (Table 1). Indeed, Goveto (1999) found that wild boars can act as seed dispersers of this native palm in mast period (summer) when boars used fruit pulp and excreted the seeds, and subsequently when fruits are scarce, they search for seeds on the ground, which are destroyed by chewing. In accordance with some authors, wild boar destroys most of the seeds it consumes and therefore negatively affects the recruitment of native plants (Campos and Ojeda 1997; Gomez et al. 2003; Sanguinetti and Kitzberger 2010). This interaction may have negative effects on the conservation of native plants species, especially the *yatay* palm. On the other hand, invasive alien plant species present in the wild boar diet were the narrowleaf firethorn (*Pyracantha angustifolia*), honey locust (*Gleditsia triacanthos*), and peach (*Prunus persica*), which were recognized mainly by the presence of fruits (Table 1). Because boar is an exotic seed disperser (Grice 1996; Lynes and Campbell 2000), and these species are already a conservation problem in EPNP, interactions with wild boar should be studied in further detail. Finally, among the vegetable items, it is important to highlight the presence of native cacti, including the *Echinopsis* and *Parody* genera that showed a low volume (Fig. 1), but were relatively frequent in the samples (27 %).

Table 1 Diet of wild boar in El Palmar National Park, Entre Ríos, Argentina, based on the analysis of the stomach contents of 107 animals culled from October 2009 to December 2011

Food items	% volume				
	Summer (20)	Autumn/winter (25)	Spring (62)	Mean (107)	SE (107)
Vegetable items[a]	85.9	91.5	72.6	81.2	13.2
Aerial parts	68.9	35.1	27.9	35.3	15.8
Fruits	50.7	7.4	3.0	12.9	13.2
Syagrus yatay (yatay palm)	45.5	7.0	tz	11.3	11.7
Hexachlamys edulis (ubajay)	3.6	0.2	2.4	1.2	4.4
Prunus persica (peach)[b]	1.5	tz	0.0	0.2	2.7
Pyracantha angustifolia (crataegus)[b]	0.0	tz	0.6	0.1	1.2
Gleditsia triacanthos (honey locust)[b]	0.0	0.1	0.0	tz	0.1
Undetermined	0.1	0.1	0.0	0.1	0.2
Leaves	11.2	19.3	24.2	20.6	10.9
Syagrus yatay (yatay palm)	0.0	0.0	tz	tz	0.0
Undetermined (monocotyledons)	11.2	19.3	24.2	20.6	10.9
Seeds	0.1	2.8	0.8	1.1	2.0
Syagrus yatay (yatay palm)	0.1	0.1	0.4	0.2	0.3
Hexachlamys edulis (ubajay)	0.0	0.0	0.1	tz	0.1
Pyracantha angustifolia (crataegus)[b]	0.0	0.2	0.0	0.1	0.3
Gleditsia triacanthos (honey locust)	0.0	tz	0.0	tz	0.0
Undetermined	0.0	2.5	0.4	0.8	1.9
Cactaceae	tz	2.4	0.2	0.7	0.6
Underground parts (roots)	0.5	4.4	5.8	4.5	3.8
Bait—*Zea mays* (corn)[b]	23.7	52.8	42.4	41.4	12.5
Animal matter	14.0	8.5	27.4	18.8	12.5
Mammals	0.6	1.7	0.9	1.0	1.1
Axis axis (axis deer)[b]	0.6	0.0	tz	0.2	0.7
Rodents	0.0	0.7	0.2	0.2	0.4
Indeterminate	tz	1.0	0.7	0.6	0.8
Birds	11.4	1.6	19.3	13.7	12.4
Columbiformes	11.4	1.5	18.7	13.4	11.5
Passeriformes	0.0	0.0	0.6	0.2	0.9
Feathers	tz	0.1	tz	tz	0.0
Undetermined	0.0	tz	0.3	0.1	0.4
Herpetofauna	0.0	0.2	0.0	0.1	0.1
Invertebrates	1.8	7.4	3.4	4.0	4.1
Arthropods	0.0	tz	tz	tz	0.0
Diptera larvae (fam. Tipulidae)	1.8	7.2	3.3	3.8	4.1
Other arthropod larvae	tz	0.2	0.1	0.1	0.1
Snails	0.0	tz	0.0	tz	0.0
Inorganic items (stones)	0.0	tz	tz	tz	0.0

Season values are expressed in average. Numbers inside parentheses (headings) are numbers of samples

tz (trace) under 0.1 % volume, *SE* standard error

[a] Included corn

[b] Exotic species

The cactus group in this part of Argentina is considered to be endangered, mainly due to habitat destruction, their extremely narrow habitat requirements, and their low population sizes (Oldfield 1997). Thus, consumption of cactus should be taken with attention and monitored to assess the conservation of their populations in the area.

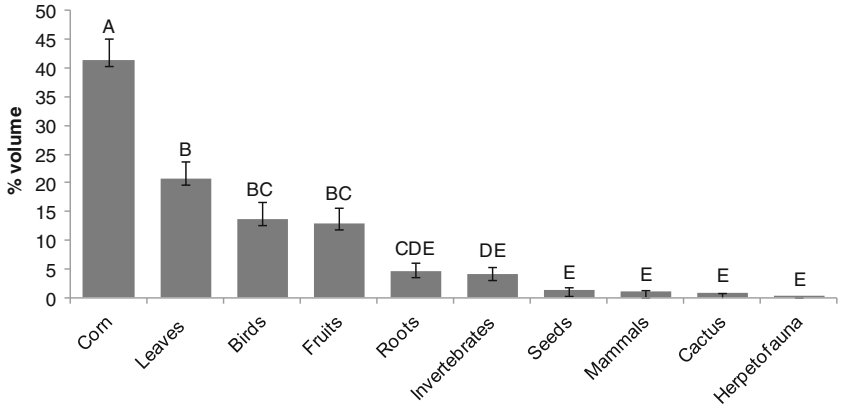

Fig. 2 Importance of different food items in wild boar diet in EPNP (N=107). Different letters indicate significant differences (pairwise comparison using Tukey–Kramer test)

The animal matter volume was dominated by remains of birds, mainly doves (Table 1). Invertebrates were recorded in a lower proportion, followed by mammals and herpetofauna (Fig. 2). The majority of the invertebrates were larvae of Diptera, in particular for Tipulidae family (crane flies, Table 1). The occurrence of animal matter at high frequency and volume in the stomach contents is consistent with numerous studies, especially with those in exotic range of wild boar (Howe et al. 1981; Herrero and Fernández de Luco 2003; Skewes et al. 2007). Animal matter can be obtained by wild boar in two ways: scavenging and predation (Thomson and Challies 1988; Herrero et al. 2005; Wilcox and Van Vuren 2009; Jolley et al. 2010; Giménez-Anaya et al. 2008). Doves, in particular, have a high mortality in chick and adult stages (Rodríguez and Zaccagnini 1998), and indeed we often observed dead chicks falling out of nests or dead adults from natural causes on the ground in different areas of the EPNP, so we can suppose that wild boar may have consumed many of the birds as carrion.

Diet of wild boar showed seasonal variations in terms of volume (PERMANOVA, pseudo F=8.09, p=0.0001). Corn dominated the diet composition in spring and autumn/winter (47.5 and 58.1 %, respectively). In summer, fruits (vol) dominated wild boar diet (57.8 %). Leaves and birds were also important (30.5 and 13.1 % vol, respectively) in the spring diet. Ballari and Barrios-García (2014) indicated that food selection by wild boar is influenced by food availability, energy requirements, seasonal variation, and geographical variation. Specifically, availability of food resources influences not only wild boar diet but also population dynamics, habitat use, dispersal, reproduction, and interactions with other species (Massei et al. 1996; Bieber and Ruf 2005). In native range, crops are heavily used year-round by boar when they are available (Mayer et al. 2000; Schley and Roper 2003; Herrero et al. 2006; Chauhan et al. 2009), particularly when their nutritional value was the highest (Giménez-Anaya et al. 2008). Corn is one of the preferred crops by boar (Dardaillon 1986) and is commonly used as bait by hunters (Schley and Roper 2003; Cellina 2008). Baiting with corn could potentially prevent damage to native plant species or surrounding agricultural crops (Geisser and Reyer 2004; Cellina 2008), but this practice could also provide an abundant and continuous artificial food supply for wild boar during periods of natural food shortage. Consequently, it may actually distort the consumption of other food items, thus giving a misleading picture of the natural diet of the species of interest (Schley and Roper 2003). Thus, the permanent and abundant subsidy of corn in the study area may have several implications. First, it can "hide" some wild boar impacts on native biota because in a hypothetical scenario without supplementary feeding, wild boar could cause a greater impact on native species because it needs to replace the nutrients of corn. Second, in accordance with Massei et al. (2011), supplemental feeding could be increasing the reproductive output and thus population size of boars. In particular, the volume and frequency of corn found in this study are higher than those in most studies that evaluated the presence of supplementary feeding in wild boar diet (Fournier-Chambrillon et al. 1995; Baubet et al. 2004), so the effects of providing a massive corn subsidy should be further studied. Thus, the implementation of alternative control methods without supplemental feeding (eg. hunting with dogs, hunting in vehicle with reflector, fertility control, fencing and/or translocation) would be important to avoid adverse and unexpected negative effects, but this implementation should be carefully evaluated because they have advantages and disadvantages that depend on intrinsic (topography, abundance of wild boar, etc.) and extrinsic (budget, public acceptance, etc.) characteristics of the study area in question (Massei et al. 2011). The management methods implemented in El Palmar National Park should aim to control and reduce wild boar populations and minimize the negative effects of wild boar on the environment and native species. Therefore, in case of continuing with the actual method of corn baiting, we recommended decreasing its amount to a minimum and regulating the frequency of replacement of corn. Moreover, the implementation of new methods of baiting, like odor baits, could be important in order to avoid or minimize the contribution of supplementary feeding to boars.

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References

Adkins RN, Harveson LA (2006) Summer diets of feral hogs in the Davis mountains, Texas. Southwest Nat 51(4):578–580

Anderson MJ, Gorley RN, Clarke KR (2008) PERMANOVA+ for primer: guide to software and statistical methods. Primer-E Ltd, Plymouth

Baber DW, Coblentz BE (1987) Biology and control of feral pigs on Isla Santiago, Galápagos, Ecuador. J Appl Ecol 24:403–418

Ballari SA, Barrios-García MN (2014) A review of wild boar *Sus scrofa* diet and factors affecting food selection in native and introduced ranges. Mammal Rev 44:124–134

Barrios-García MN, Ballari SA (2012) Impact of wild boar (*Sus scrofa*) in its introduced and native range: a review. Biol Invasions 14(11): 2283–2300

Baubet E, Bonenfant C, Brandt S (2004) Diet of the wild boar in the French Alps. Galemys 16(n° especial):99–111

Bieber C, Ruf T (2005) Population dynamics in wild boar *Sus scrofa*: ecology, elasticity of growth rate and implications for the management of pulsed resource consumers. J Appl Ecol 42:1203–1213

Bueno C, Reiné R, Alados C, Gómez-García D (2011) Effects of large wild boar disturbances on alpine soil seed banks. Basic Appl Ecol 12:125–133

Cabrera ÁL (1976) Regiones fitogeográficas Argentinas. In Kugler WF (Ed.) Enciclopedia Argentina de agricultura y jardinería. Tomo 2. 2ª edición. Acme. Buenos Aires. Argentina. Fascículo 1. pp. 1–85

Calenge C, Maillard D, Fournier P, Fouque C (2004) Efficiency of spreading maize in the garrigues to reduce wild boar (*Sus scrofa*) damage to Mediterranean vineyards. Eur J Wildl Res 50:112–120

Campos CM, Ojeda RA (1997) Dispersal and germination of *Prosopis flexuosa* (Fabaceae) seeds by desert mammals in Argentina. J Arid Environ 35:707–714

Cellina S (2008) Effects of supplemental feeding on the body condition and reproductive state of wild boar (*Sus scrofa*) in Luxembourg. University of Sussex, Dudelange

Challies CN (1975) Feral pigs (*Sus scrofa*) on Auckland Island: status, and effects on vegetation and nesting sea birds. New Zeal J Zool 2(4):479–490

Chauhan N, Kuldeep SB, Kumar D (2009) Human wild pig conflict in selected states in India and mitigation strategies. Acta Silv Lign Hung 5:189–197

Chimera C, Coleman MC, Parkes JP (1995) Diet of feral goats and feral pigs on Auckland Island, New Zealand. New Zeal J Zool 19:203–207

Cruz F, Donlan CJ, Campbell K, Carrion V (2005) Conservation action in the Galápagos: feral pig (*Sus scrofa*) eradication from Santiago Island. Biol Conserv 121:473–478

Cuevas MF, Novillo A, Campos CM, Dacar MA, Ojeda RA (2010) Food habits and impact of rooting behaviour of the invasive wild boar, *Sus scrofa*, in a protected area of the Monte Desert, Argentina. J Arid Environ 74(11):1582–1585

Cuevas MF, Mastrantonio L, Ojeda RA, Jaksic FM (2012) Effects of wild boar disturbance on vegetation and soil properties in the Monte Desert, Argentina. Mamm Biol 77(4):299–306

Cuevas MF, Ojeda RA, Dacar MA, Jaksic FM (2013) Seasonal variation in feeding habits and diet selection by wild boars in a semi-arid environment of Argentina. Acta Theriol 58:63–72

Dardaillon M (1986) Seasonal variations in habitat selection and spatial distribution of wild boar (*Sus scrofa*) in the Camargue, Southern France. Behav Process 13:251–268

de Fina A (1974) El clima de la República Argentina. In: Enciclopedia Argentina de Agricultura y Jardinería, 2. Buenos Aires: Ed. Acme

Fournier-Chambrillon C, Maillard D, Fournier P (1995) Diet of the wild boar (*Sus scrofa* L.) inhabiting the Montpellier garrigue. Ibex J Mt Ecol 3:174–179

Geisser H, Reyer HU (2004) Efficacy of hunting, feeding, and fencing to reduce crop damage by wild boars. J Wildlife Manag 68:939–946

Genov P (1981) Food composition of wild boar in north-eastern and western Poland. Acta Theriol 26:185–205

Gil G (2008) Monitoreo del plan de control de mamíferos exóticos invasores en el Parque Nacional El Palmar. Informe Final. Período 2006–2007. Administración de Parques Nacionales, Argentina, p 80

Giménez-Anaya A, Herrero J, Rosell C, Couto S, García-Serrano A (2008) Foods habits of wild boar (*Sus scrofa*) in a Mediterranean coastal wetland. Wetlands 28:197–203

Gomez JM, Garcia D, Zamora R (2003) Impact of vertebrate acorn- and seedling-predators on a Mediterranean *Quercus pyrenaica* forest. For Ecol Manag 180:125–134

Goveto L (1999) Manejo adaptativo de las poblaciones de jabalíes en las áreas protegidas. Administración de Parques Nacionales. Dirección Nacional de Conservación de Áreas Protegidas. Delegación Regional Centro, Argentina, p 46

Goveto L (2005) Ocurrencia histórica de fuegos en la sabana del Parque Nacional el Palmar: evidencias climáticas y florísticas. Tesis de Magíster Scientiae. Facultad de Agronomía. Universidad de Buenos Aires. Buenos Aires, Argentina

Grice A (1996) Seed production, dispersal and germination in *Cryptostegia grandiflora* and *Ziziphus mauritiana*, two invasive shrubs in tropical woodlands of northern Australia. Aust J Ecol 21:324–331

Hahn N, Eisfeld D (1998) Diet and habitat use of wild boar (*Sus scrofa*) in SW-Germany. Gibier Faune Sauvage, Game Wildl 15(2):595–606

Herrero J, Fernández de Luco D (2003) Wild boars (*Sus scrofa*) in Uruguay: scavengers or predators? Mammalia 67:485–491

Herrero J, Irizar I, Laskurain NA, García-Serrano A, García González R (2005) Fruits and roots: wild boar foods during the cold season in the southwestern Pyrenees. Italian J Zool 72:49–52

Herrero J, García-Serrano A, Couto S, Ortuño VM, García-González R (2006) Diet of wild boar *Sus scrofa* L. and crop damage in an intensive agroecosystem. Eur J Wildl Res 52:245–250

Howe TD, Singer FJ, Ackerman BB (1981) Forage relationships of European wild boar invading northern hardwood forest. J Wildl Manag 45:748–754

Irizar I, Laskurain NA, Herrero J (2004) Wild boar frugivory in the Atlantic Basque country. Galemys 16(n° especial):125–133

Jolley D, Ditchkoff SS, Sparkling BD, Hanson LB, Mitchell MS, Grand JB (2010) Estimate of herpetofauna depredation by a population of wild pigs. J Mammal 91:519–524

Loggins RE, Wilcox JT, Van Vuren DH, Sweitzer RA (2002) Seasonal diets of wild pigs in oak woodlands of the Central Coast region of California. Calif Fish Game 88:28–34

Long JL (2003) Introduced mammals of the world: their history, distribution and influence. CSIRO, Collingwood

Lynes B, Campbell S (2000) Germination and viability of mesquite (*Prosopis pallida*) seed following ingestion and excretion by feral pigs (*Sus scrofa*). Trop Grasslands 34:125–128

Massei G, Genov PV (2004) The environmental impact of wild boar. Galemys 16(n° especial):135–145

Massei G, Genov P, Staines B (1996) Diet, food availability and reproduction of wild boar in a Mediterranean coastal area. Acta Theriol 41:307–320

Massei G, Roy S, Bunting R (2011) Too many hogs? A review of methods to mitigate impact by wild boar and feral hogs. Hum Wild Interact 5:79–99

Mayer JJ, Nelson EA, Wike LD (2000) Selective depredation of planted hardwood seedlings by wild pigs in a wetland restoration area. Ecol Eng 15:S79–S85

Merino ML, Carpinetti BN, Abba AM (2009) Invasive mammals in the national park system of Argentina. Nat Areas J 29(1):42–49

Movia CP, Menvielle MF (1994) Vegetación. In: Ciccero y P, Balabusic A (eds) Plan de manejo Parque Nacional el Palmar. Administración de Parques Nacionales, Argentina

Nogueira-Filho SLG, Nogueira SSC, Fragoso JMV (2009) Ecological impacts of feral pigs in the Hawaiian Islands. Biodivers Conserv 18(14):3677–3683

O'Connor S-J, Kelly D (2012) Seed dispersal of matai (*Prumnopitys taxifolia*) by feral pigs (*Sus scrofa*). New Zeal J Ecol 36:228–231

Oldfield S (1997) Cactus and succulent plants—status survey and conservation action plan. IUCN/SSC Cactus and Succulent Specialist Group. IUCN, Gland, p 10+212

Rodríguez EN, Zaccagnini ME (1998) Manual de capacitaciones sobre manejo integrado de aves perjudiciales a la agricultura. Food and Agriculture Organization of the United Nations, Argentina, p 147

Sanguinetti J, Kitzberger T (2010) Factors controlling seed predation by rodents and non-native *Sus scrofa* in *Araucaria araucana* forests: potential effects on seedling establishment. Biol Invasions 12:689–706

Schley L, Roper TJ (2003) Diet of wild boar *Sus scrofa* in Western Europe, with particular reference to consumption of agricultural crops. Mammal Rev 33:43–56

Singer FJ, Swank WT, Clebsch EEC (1984) Effects of wild pig rooting in a deciduous forest. J WildlManag 48:464–473

Skewes O, Rodríguez R, Jaksic FM (2007) Ecología trófica del jabalí europeo (*Sus scrofa*) silvestre en Chile. Rev Chil Hist Nat 80:295–307

Taylor RB, Hellgreen EC (1997) Diet of feral hogs in the western South Texas Plains. Southwest Nat 42:33–39

Thomson C, Challies C (1988) Diet of feral pigs in the podocarp-tawa forests of the Urewera Ranges. New Zeal J of Ecol 11:73–78

Wilcox JT, Van Vuren DH (2009) Wild pigs as predators in oak woodlands of California. J Mammal 90:114–118

Wirthner S, Frey B, Busse MD, Schütz M, Risch AC (2011) Effects of wild boar (*Sus scrofa* L.) rooting on the bacterial community structure in mixed-hardwood forest soils in Switzerland. Eur J Soil Biol 47:296–302

Wood GW, Roark DN (1980) Food habits of feral hogs in coastal South Carolina. J Wildl Manag 44:506–511