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Article

FACTORS DRIVING RODENT ABUNDANCE IN AGRICULTURAL LANDSCAPES OF CENTRAL ARGENTINA

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ABSTRACT. Changes in land use in the Pampean region have led to an increase in pastures and cultivated fields and a decrease in native grasslands, which mainly remain at the borders of cultivated fields. In the province of Buenos Aires, there is a trend to increase the size of fields, eliminate the edges between them, and increase the proportion of the area cultivated with soybeans. Borders function as corridors and refuges for native fauna, so this reduction may affect rodent abundance, although this effect may vary according to the habitat affinities of the species. Our goal was to evaluate the effect of the size of fields and the decrease in the proportion of border habitats on the rodent community. The study was conducted in the province of Buenos Aires, in Central Argentina. Rodents were surveyed in 12 fields and their borders. Overall rodent density and both species of *Calomys* showed negative effects of field size on their abundance, while for *A. azarae* there were no significant effects. *Calomys laucha* was more abundant in maize crop fields, and *Calomys musculinus* did not show an effect on habitat, but its abundance in crop fields increased with weed cover. *Akodon azarae* showed strong habitat selection for borders. In summary, changes in the agricultural landscape with an increase in cropland at the expense of natural and semi-natural habitats affect rodent communities, and this effect would have consequences through their trophic interactions, both as consumers of plant and insect species as well as food sources for mammalian and avian predators.

RESUMEN. DETERMINANTES DE LA ABUNDANCIA DE ROEDORES EN PAISAJES AGRÍCOLAS DE ARGENTINA CENTRAL. Los cambios en el uso de la tierra en la región Pampeana han conducido a un aumento de pasturas y campos cultivados y a una disminución de pastizales nativos, los cuales permanecen principalmente en los bordes de campos. En esta región existe una tendencia al aumento en el tamaño de los campos, a la eliminación de los bordes entre ellos y a un aumento en la proporción del área cultivada con soja. Los bordes funcionan como corredores y refugio para la fauna nativa, por tanto, su reducción puede afectar a la abundancia de roedores, dependiendo de las afinidades de hábitat de cada especie. Nuestro objetivo fue evaluar el efecto del tamaño de los campos y de la disminución en el área relativa de los bordes. El estudio se realizó en la provincia de Buenos Aires, Argentina central. Se muestrearon 12 campos y sus bordes. La abundancia total de roedores y las de ambas especies de *Calomys* mostraron efectos negativos del tamaño de los campos. *Calomys laucha* fue más abundante en los campos de cultivo de maíz, mientras que la abundancia de *Calomys musculinus* en campos aumentó con la cobertura de malezas. *A. azarae* mostró fuerte selección por los bordes. En resumen, los cambios en el paisaje agrícola, con un aumento de las áreas cultivadas a expensas de ambientes naturales y seminaturales afecta a las comunidades de roedores y este efecto puede trasladarse a otros niveles tróficos, debido a su papel como consumidores de plantas e insectos y como fuente de alimento para aves y mamíferos predadores.

Key words: Agroecosystems, borders, crop-field size, Pampean region.

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Palabras clave: Agroecosistemas, bordes, región pampeana, tamaño de los campos.

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INTRODUCTION

Land use changes associated with urbanization and the expansion of agriculture and livestock are important determinants of the decrease in biodiversity of grasslands (Sala 2001; Benton et al. 2003). Changes in agricultural landscapes included an increase in area dedicated to crops at the expense of natural and semi-natural habitats, a reduction in native vegetation, habitat connectivity and heterogeneity, and increased edge effects through an increasing patch-matrix contrast (Fischer & Schröder 2014). On the other hand, agricultural intensification was associated with increased use of agrochemicals and pesticides and an enlargement in the size of agricultural plots with a reduction in borders, semi-natural habitats, and in the length of linear features (Petit et al. 2002; Heroldová et al. 2007; Firbank et al. 2008; Gómez et al. 2015).

Although rodents are integral parts of all terrestrial ecosystems, they are not often addressed in biodiversity studies because they are mainly viewed as agricultural and urban pests or disease transmitters. But more recently, small mammals have been reconsidered as useful indicators of the ecosystem sustainability (Butet et al. 2006). In grassland ecosystems, rodents contribute to controlling a large variety of pest insects and weeds, predate or disperse seeds of prairie plants, aerate, and enrich soils through burrowing and depositing urine and feces, and are a major food prey for numerous species of carnivores and generalist predators (Kaufman & Kaufman 1997; Pasitschniak-Arts & Messier 1998; Butet & Leroux 2001; Fischer & Schröder 2014). On the other hand, their negative effects are related to the consumption of crops and stored products (Myllymaki 1987; Singleton et al. 1999; Stenseth et al. 2003), to the dispersal of weed species, or as disease transmitters (Glass et al. 1997; Mills & Childs 1998; Fischer & Schröder 2014).

Several studies have shown that rodents are very sensitive to changes in land use and in the area used for crops (Grant et al. 1982; Bilenca & Kravetz 1995a; Angelstam & Pettersson 1997; Cole et al. 1998; Masters et al. 1998; Bilenca et al. 2007; Fischer et al. 2011; Fischer & Schröder 2014; Heroldová et al. 2007; Butet & Leroux 2001; Butet et al. 2006), but the effect varies according to the species that respond depending on their food habits, habitat affinities, range of movements, or social interactions (Bowers & Dooley 1991; Robinson et al. 1992; Bolger et al. 1997). Many rodent species use crop fields where they found food resources but leave fields after harvest if suitable habitats as grassy borders are nearby. Borders provide refuge and harborage and contribute to maintaining rodent populations in the agricultural landscape (Witmer et al. 2007). Movements from crops to grassy borders will depend on the size of crop plots because the risk of travel increases with distance, and the use of crops will be limited to areas near borders (Hodara et al. 2004). The enlargement of field plots has two consequences that may affect rodent density in agroecosystems, a reduction in the proportion of area covered by grassy borders, and a reduction in the proportion of the area used by rodents within crops. In consequence, the effect of agriculture on rodents must be studied on a landscape scale, including modified areas as well as remnants of (semi-) natural habitat patches (Fischer & Schröder 2014).

The Pampean Region of Argentina was not an exception concerning land use changes, main landscape changes were the incorporation of natural grasslands into livestock and agriculture, and since 1990s an expansion of the area dedicated to annual crops and a decrease in livestock (Viglizzo et al. 2001; Paruelo et al. 2005; Baldi & Paruelo 2008). Until 1880 less than 10% of the area of the pampas was occupied by annual crops, by 1930 crop occupation of land ranged between 20-60%, and by the 1980s, it was higher than 40-60% (Viglizzo et al. 2001) resulting in habitat loss and reduced spatial heterogeneity (Gavier-Pizarro et al. 2012; Bedano & Domínguez 2016; Serafini et al. 2019). Relicts of the original grassland remain in pastures with livestock, in riparian habitats, abandoned railway embankments, and under wire fences along crop field borders and roads. Linear habitats serve as a refuge for small mammals and may be interconnected to form corridors throughout cropland habitats (Ellis et al. 1997), but the original plant community was modified with the incorporation of many annual exotic species and a decrease in native perennial (Ellis et al. 1997). These borders, about four meters wide, have high plant cover throughout the year, independently of farming practices (Crespo 1966; Mills et al. 1991; Soriano et al. 1991; Busch & Kravetz 1992a; Bilenca & Kravetz 1995b, 1998a; Ellis et al. 1997; Busch et al. 2001c).

Along with an expansion of agriculture, during the 1980s there was an increase in soybean production at the expense of winter and other summer crops, soybean production increased from 6.5 million tons in 1988/89 to 39.9 million tons in 2011/2012 (Paruelo et al. 2005; Bolsa de Cereales de Buenos Aires https://www.bolsadecereales.com/estimaciones-informes). Farming practices associated with soybean production include no-tillage and weed control through herbicides, and in consequence, stubbles that with traditional farming were covered by weeds nowadays are covered by bare ground.

Another change in the Pampean landscape was the increase in the size of farm plots, increasing the proportion of the matrix of cultivated area in relation to field borders covered by spontaneous vegetation (Aizen et al. 2009), decreasing heterogeneity at a landscape scale (Serafini et al. 2019). Since 1945, small- and medium-sized farm plots have been replaced by large ones. The mean farm plot area in the Province of Buenos Aires changed from 504 ha in 2002 to 642 ha in 2018, because of a decrease in the number of small plots (between five and 200 ha) and an increase in larger plots (INDEC 2006, 2018).

In the agroecosystems of Argentina, an increase in the intensification of agriculture affects the diversity and abundance of small mammals (Coda et al. 2014, 2015; Gómez et al. 2015, 2018). Rodent species of the Pampean region differ in their habitat use, and in their adaptation to changes from the original grassland to agroecosystems. These species show habitat selection at macrohabitat (crop fields or borders) and microhabitat scales (selection for sites according to plant cover). *Akodon azarae*, *Oligoryzomys flavescens*, *Oxymycterus rufus*, and *Cavia aperea* occupy mainly field borders, with good plant cover throughout the year and low effects of agrarian labor (Fraschina et al. 2012; Coda et al. 2015). *Calomys laucha* is abundant in crop fields, probably because its population cycle is synchronized with summer crop phenology, especially maize (Kravetz et al. 1981b; Courtalon & Busch 2010); because crop soils are adequate for nesting in burrows; because crop fields provide abundant food resources for this species or because *C. laucha* is competitively displaced from border habitats by other species (Ellis et al. 1997; Busch et al. 2001b). *C. musculinus* is more evenly distributed between fields and borders (Busch & Kravetz 1992a; Busch et al. 2000, 2001b). *A. azarae*, *C. laucha*, and *C. musculinus* are strongly associated with total and green plant cover, which determines their habitat use at both macrohabitat and microhabitat scales (Ellis et al. 1997; Busch et al. 2000, 2001b).

Rodent populations are characterized by low density in spring with an increase in abundance towards a peak in autumn and winter (Crespo 1966). These changes are mainly determined by natural factors such as weather variations, habitat characteristics, and biotic interactions (Zuleta et al. 1988; Cittadino et al. 1998). They are also influenced by human land use, such as livestock, agriculture, poultry, and particularly the types of crops planted and tillage systems (Fraschina et al. 2012). Rodent habitat use changes throughout the year, depending both on variations in habitat quality and on population characteristics (Bilenca & Kravetz 1998a). *A. azarae* and *C. musculinus* increase the use of fields in the summer and early autumn when crops are mature (Mills et al. 1991; Busch et al. 2000, 2001b; Busch & Hodara 2010). *C. laucha*, although uses crop fields in a high proportion, moves to borders during harvest (Kravetz et al. 1981a) and is more abundant in crop areas near borders (Hodara et al. 2004). When crops are mature, they provide cover and food for rodents, but during agrarian labor, the rodents move from fields to borders to decrease predation risk and mortality (De Villafañe et al. 1988; Cavia et al. 2005). These movements are limited by the distance between fields and borders. Manrique (2000) and Hodara et al. (2004) found that the use of crop fields by rodents is limited to strips near borders of about 50 meters in width. Consequently, an increase in the size of crop fields may lead to a decrease in rodent density (individuals/ha) because of an increase in the unoccupied area by rodents, as was observed by de De Villafañe et al. (1977), de De Villafañe et al. (1988), and Fraschina et al. (2012).

In this work, we aimed to assess the effect of crop field size on total rodent abundance, and the abundance of *A. azarae*, *C. laucha*, and *C. musculinus* on fields and their borders during the pre-harvest period, when crops are mature. We also assessed the relative effects of habitat type: crop field or border; type of crop: maize or soybean; and weed plant cover because there may be interactions between these effects. Although there is previous information concerning the habitat use of these species, the effect of the size of crops and the distances that animals may travel to borders when crops are affected by agrarian labor has not been assessed.

MATERIALS AND METHODS

Study area

The study was conducted in the departments of Exaltación de la Cruz, San Andrés de Giles, Pilar, and Campana, Province of Buenos Aires, Central Argentina (**Fig.** 1 A). The region is characterized by a temperate climate, with a mean of 23.4 °C in summer (in January, the maximal can reach 41.5 °C) and 9.8 °C in winter (June and July are the coldest months) (Hall et al. 1992). From May to September, there is a probability of frosts (Fernández Long et al. 2005), which affect rodent survival.

Crop fields cover more than 88% of the area, and the size varies from four to 120 ha. Their borders, thin corridors along wire fences where a spontaneous and particular flora is present (Soriano et al. 1991), and which range between two and four m in width, cover about 2% of the area. The other natural habitats of the area, like woodlots, riparian habitats, pastures, and railway embankments, cover about 7% of the total area, and poultry farms represent only 0.33% of the total area (Fraschina et al. 2014).

The main summer crops in the area are soybean, maize, sunflower, and sorghum, whereas in winter dominant crops are wheat, oatmeal, and barley (Paruelo et al. 2005). Plant height and cover in crop fields show strong seasonal variations depending on both climatic and agricultural factors, while most borders maintain high plant cover throughout the year, with small seasonal variations in cover, floristic composition, and phenological stages (Hodara et al. 2001). Dominant native plant species at these borders are grasses like *Nassella neesiana*, *Nassella papposa*, *Paspalum dilatatum*, *Bromus unioloides*, *Solidago chilensis*, *Senecio grisebachii*, and exotic *Carduus acanthoides*, *Cirsium vulgare*, *Cynara cardunculus*, and *Lolium perenne*. A more detailed description of the vegetation of the area is found in Ellis et al. (1997) and Busch et al. (2001a).

Study design

Trapping and handling of rodents were performed according to the procedures and protocols of the Argentine National Law for Animal Care 14 346 and the Ethics Committee for Research on Laboratory, Farm and Wild Animals of the National Council for Scientific and Technological Research (CONICET, resolution 1047, section 2, annex II). The protocol was approved by the Institutional Committee for Animal Handling and Use of the Facultad de Ciencias Exactas y Naturales-Universidad de Buenos Aires (CICUAL; protocol number 125-2019).

We conducted samplings in both maize and soybean plots in March 2012, when crops were mature, and fields were covered by weeds. We selected this moment before harvest because rodents are more evenly distributed between fields and borders than in other periods of the year, when captures in fields, except for *C. laucha*, may be very low (Mills et al. 1991; Bilenca & Kravetz 1998b). We conducted rodent samplings in 12 plots (**Fig.** 1 B) that included both the crop field and its borders. We selected six fields cultivated with maize and six with soybean, with sizes ranging from 1.8 to 119.6 ha. The minimum and maximum distances between plots were 2 and 30 km, respectively. We selected crop fields through the analysis of satellite images, Google Earth images (version 2012), and posterior confirmation in the field to cover both maize and soybean plots and a range of sizes. Rodent trappings were conducted by placing grids of traps within crop fields (approximately in the center of each plot) and lines in one of its borders, in a paired design. Because of the different sizes of crop fields, this resulted in distances between the field grid and the nearest border ranging from 31 to 290 meters.

We placed 49 Sherman-type traps (8 x 9 x 23 cm) in each field grid (in an array of 7 x 7 traps) and a line of 25 Sherman-type traps along one of their borders, adjacent to a road (**Fig.** 2). Traps were spaced 10 meters apart from each other, and a mixture of peanut butter, fat, and rolled oats was placed as bait. Traps were checked every morning for three consecutive days. For every individual captured, we registered species, sex, capture site, body and tail length, body mass, and reproductive status. They were individually marked with ear tags and then released at the site of capture.

The Trapping Success Index (TSI = number of different individuals captured / number of traps x number of nights) was used to estimate rodent abundance. We recorded total rodent density and of the most abundant species, *C. laucha*, *C. musculinus*, and *A. azarae* in each border and crop field sampled. For total rodent density, the TSI for habitat i (crop field or border) was calculated as = number of different individuals of all species captured in habitat i / number of traps in habitat i x number of nights. For each species, we estimated the TSI as = TSI of species i (*A. azarae, C. musculinus*, or *C. laucha*) in habitat j (crop field or border) = number of different individuals of species i captured in habitat j / number of traps in habitat j x number of nights.

We recorded crop field size and the distance between each side of the capture grid and the borders of the crop field (**Fig.** 2), and then estimated the shortest and the mean distance to borders for each grid. All these values were estimated through Google Earth images.

In each crop field, we randomly selected five sites of 1 m^2 where the percentage cover of weeds (spontaneous vegetation) was registered.

Data analysis

We conducted Generalized Linear Mixed Models (GLMM) to study the effect on rodent abundance (TSI) at each habitat (crop field or border, n = 24) of the explanatory variables “average distance to borders”, “crop type (soybean or maize)”, “habitat (crop field or crop field border)”, and “weed cover” considered fixed factors. The average distance to borders and the shortest distance to borders were highly correlated ($r = 0.75$, $p = 2.1 \times 10^{-5}$, Pearson Correlation Analysis), so we included only the first in the models. We considered the plot (crop field and its neighboring border) as a random factor because we considered each crop field and its border in pairs. We assumed a binomial error structure and a logit-link function (Bolker et al. 2009; Zuur et al. 2009; Crawley 2012). According to Zuur et al. (2009), we used the binomial distribution because we are modeling the probability of success (capture), which has a maximal value determined by the trapping effort (trap nights).

We conducted a Backward Stepwise Regression (Crawley 2012), including first all variables in the model, and then we removed non-significant variables with decreasing p-value. We also included models with relevant interactions. We selected the model with the lowest AICc, because of the low sample size concerning the number of

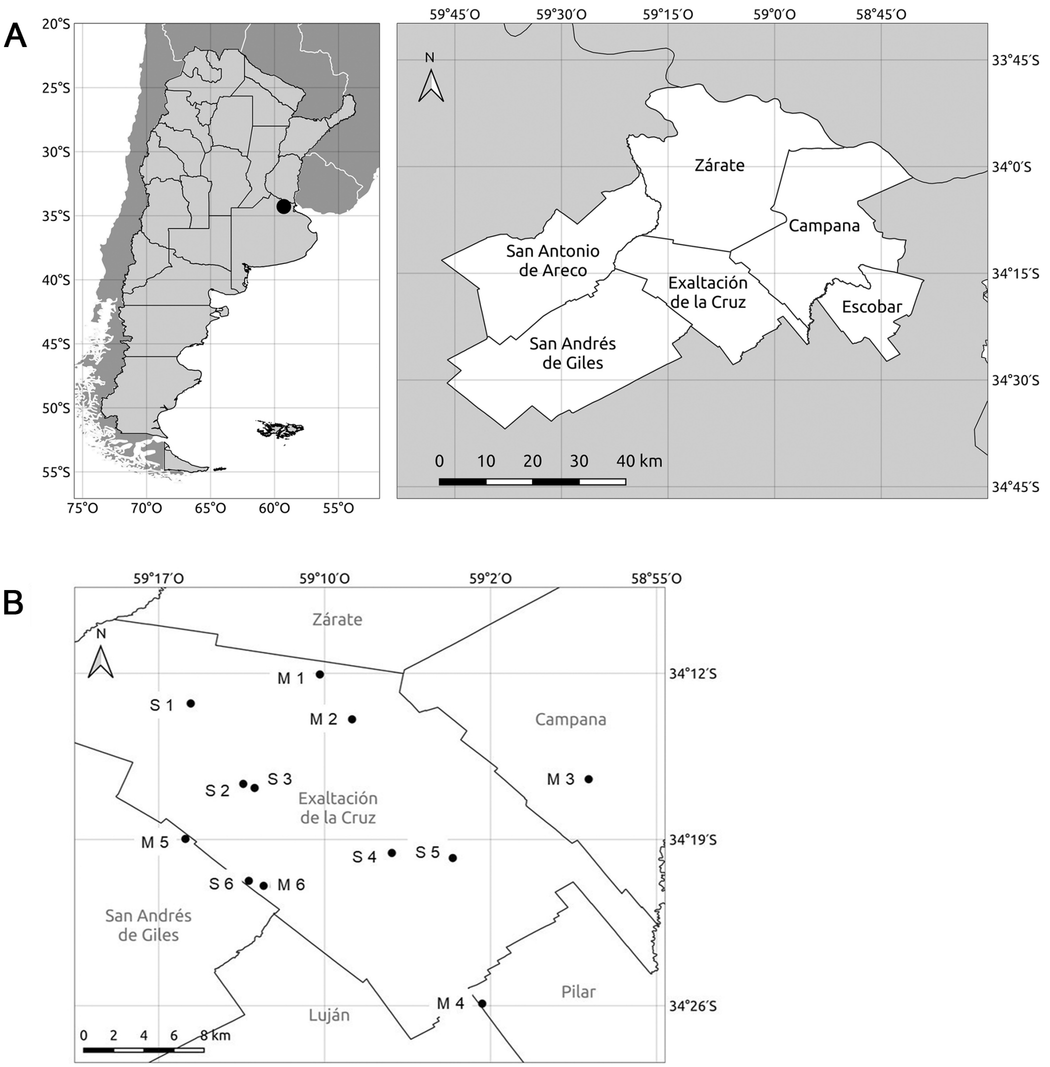

Fig. 1. A. Location of the departments of the province of Buenos Aires, where the samplings were carried out. **B.** Location of the 12 plots sampled (S: soybean crop field, M: maize crop field; the numbers indicate the replicates of each crop field type) .

parameters included (Burnham & Anderson 1998). For the statistical analysis, Matrix (Bates & Maechler 2018) and lme4 (Bates et al. 2015) packages of the R software, version 3.6.1 (R Core Team 2023) were used.

RESULTS

During the study, we captured a total of 114 individuals: 53 *C. laucha*, 26 *C. musculinus*, 20 *A. azarae*, nine *O. rufus*, four *M. musculus*, and two *O. flavescens* with a total capture effort of 2664 traps nights (900 in borders and 1764 in crop fields). Higher densities (TSI) were found in borders than in crop fields (**Fig**. 3A y B) and in maize (**Fig**. 3A) with respect to soybean (**Fig**. 3B). In borders, we captured six species, whereas in crop fields, we captured four (**Fig**. 3A y B).

We performed models for total rodent abundance (including all species captured) and separately for *A. azarae*, *C. musculinus*, and *C. laucha*, since they were the most abundant species. The best model for total rodent abundance according to the AICc (Model 2, Appendix, Table 1) showed a negative effect of the

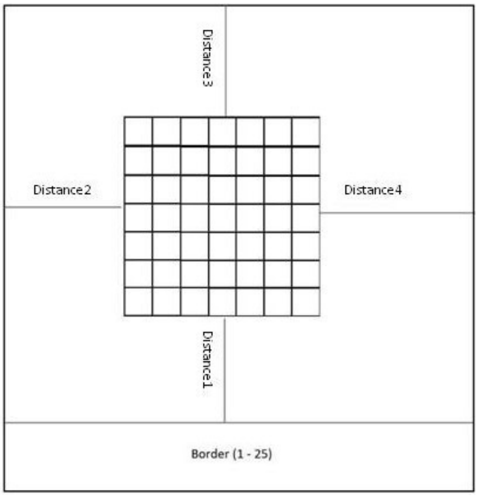

Fig. 2. Location of traps in crop fields and their borders. In the center of the crop field, there is a grid with 49 Sherman traps, and on one border, a transect with 25 Sherman traps. Distance 1 corresponds to the distance from the trap grid to the sampled border.

average distance to borders ($p = 0.0038$), soybean crop fields ($p < 0.0001$), and the crop field habitat ($p = 0.0024$; Appendix, Table 2). Models that included the interactions between the average distance to borders and type of crop (Model 3) and the average distance to borders and habitat (Model 4) showed △AICc < 2 with respect to Model 2 (Appendix, Table 1). The interaction term was not significant for the relation between the average distance and habitat ($p = 0.662$), but there was a significant interaction between the effect of the average distance and the type of crop ($p = 0.048$). We estimated the slopes and their confidence intervals of the relation between the average distance to borders for maize and soybean by means of the library emmeans (Russell 2023), the slope for maize crop fields was −0.0082 (Confidence interval −0.0012 - −0.00439) and for soybean was −0.0017 (Confidence interval −0.0070 - +0.0034), showing that there is a significant effect for maize but not for soybean (the confidence interval includes 0). The difference between slopes was statistically significant ($p = 0.048$). The best model for the abundance of *A. azarae* (Model 4, Appendix, Table 3) included only the effect of the type of habitat (Appendix, Table 3), showing a higher abundance in crop field borders ($p = 0.0005$; Appendix, Table 4). The best model for *C. musculinus* (Model 2, Appendix, Table 5) included the average distance to borders and soybean crop fields with a negative effect ($p = 0.001$ and $p = 0.004$, respectively, and $p = 0.004$) and the weed cover in crop fields with a positive effect ($p = 0.0259$, Appendix, Table 6). Model 3, which included the interaction between average distance to borders and crop type, showed a △AICc < 2 concerning Model 2 (Appendix, Table 5), but the interaction term was not statistically significant ($p = 0.088$). The best model for *C. laucha* abundance (Model 2, Appendix, Table 7) showed a negative effect on the average distance to borders and soybean crop fields and a positive effect on crop field habitat ($p = 0.0396$, $p < 0.001$, and $p = 0.0076$, respectively; Appendix, Table 8). Models that included interactions between the average distance to borders and habitat (Model 3) and between habitat and crop type (Model 4) showed △AICc < 2 concerning Model 2 (Appendix, Table 7), but in both cases, interaction terms were not statistically significant ($p = 0.768$ and $p = 0.424$, respectively).

DISCUSSION

We found an effect of crop field size in the two species that are more abundant in this habitat (*C. musculinus* and *C. laucha*), while *A. azarae*, which selects borders, did not show this effect, showing that land use affects species differently depending on their habitat affinities, as was also shown by Serafini et al. (2019). This effect was also observed by Fischer et al. (2011) in winter wheat fields in Germany and was previously described for the studied species by Busch et al. (2000, 2001c), Courtalon & Busch (2010), Ellis et al. (1997), and Kravetz et al. (1981b).

Another effect was related to the use of crop areas versus crop field borders. *A. azarae* abundance was higher in borders independently of the crop type and the weed cover in crop fields. The low number of *A. azarae* may have prevented the detection of more effects, but our results agree with previous works where this species was described as a strong selector for borders (Busch et al. 1997, 2001b; Hodara et al. 1997), and the low proportion of captures in crop fields (1/20) shows that the use of these habitats, independently of their characteristics, is low. *C. laucha* also showed an effect of habitat type, with higher abundance in crop fields, while *C. musculinus*, which is not a strong habitat selector (Busch et al. 2000), varied its abundance depending on the weed cover, which may offer both protection from predators as well as food.

Total rodent abundance was higher in maize with respect to soybean fields, as was previously observed by Mills et al. (1991), and showed a negative effect of the distance of the crop trap grid to borders with

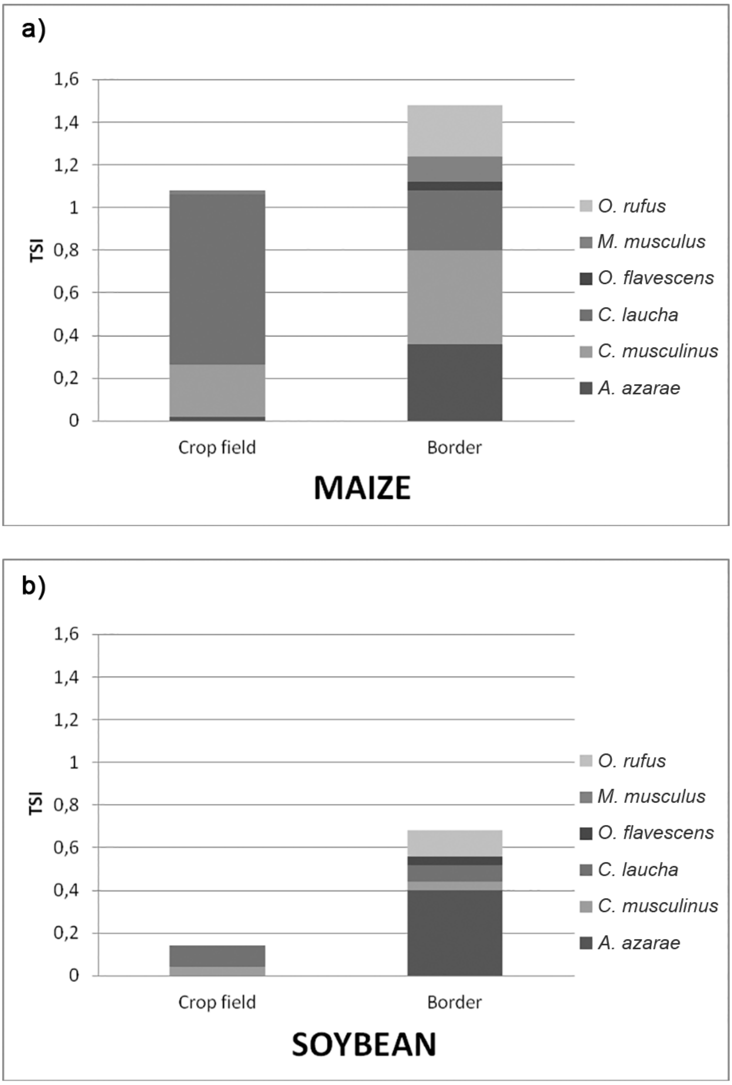

Fig. 3. Trap Success Index (TSI) for the six rodent species captured in crop fields and borders of a) maize and b) soybean crops. Total abundance is observed as the summation of the Trap Success Index of all the species.

decreasing density in large crop fields. Both species of *Calomys* showed effects of the type of crop, with lower density in soybean than in maize crops and a negative effect of the distance to borders that increases with the crop field size. Both *Calomys* species depend on the possibility of changes in habitat use depending on the relative conditions of crop fields and borders, which vary seasonally as well as according to agrarian labor (Mills et al. 1991; Busch & Kravetz 1992b).

We described the effect of the size of fields on habitat use by the studied species, founding that an increasing crop field size along with a decrease in the proportion of area covered by borders may have a negative effect on both species of *Calomys* because of an overall reduction in favorable habitat (crop fields near borders). *A. azarae* would also be affected because of a decrease in its main habitat, longitudinal undisturbed corridors as crop fields and road borders.

Table 1

Summary results of the models with the lowest AICc for the relation between total, *A. azarae*, *C. musculinus*, and *C. laucha* abundance and the explanatory variables.

	df	Habitat (crop field/crop field border)	Crop type (soybean or maize)	Average distance to borders (field size)	Weed cover in crop fields
Total abundance	5	P = 0.0024 Higher in crop field borders	P < 0.0001 Lower in soybean	P = 0.0038 Negative relation	NS
A. azarae abundance	3	P = 0.0005 Higher in crop field borders	NS	NS	NS
C. musculinus abundance	5	NS	P = 0.004 Lower in soybean	P = 0.001 Negative relation	P = 0.0259 Positive relation
C. laucha abundance	5	P = 0.0076 Higher in crop fields	P < 0.001 Lower in soybean	P = 0.0396 Negative relation	NS

The effects on rodents would have top-down effects on the abundance of species that they consume, such as plants and invertebrates. Ellis et al. (1998) suggested that, in the Pampean agroecosystems, rodents, especially *A. azarae*, may play an important role in the control of insect pests. On the other hand, rodents are the main food source for median and small carnivores, such as owls and wild cats. For the barn owl, Bellocq & Kravetz (1994) reported that field borders are the preferred hunting habitat because of the presence of rodents, as was observed by Schulz (1986), who also pointed out the role of this kind of habitat in raptors reproductive success. The role of borders in providing rodent food for predators was also pointed out by Šálek et al. (2010) and Butet & Leroux (2001), who reported decreased reproductive success in the Montagu's harrier in association with decreasing vole densities.

Our study has the limitations of the temporal window used, the pre-harvest period of the main two summer crops in the area. We selected this moment because there is a higher use of crop fields than in other seasons, and in consequence, it could be assessed the effects of type of habitat, crop type, field size, and weed cover on rodent abundance. In other seasons, the data would have been insufficient.

In summary, changes in the agroecosystem landscape with a decrease in heterogeneity and an increase in cropland at the expense of natural and semi-natural habitats affect rodent communities, and this effect would have consequences through their trophic interactions, both as consumers of plant and insect species as well as food sources for mammalian and avian predators.

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ONLINE SUPPLEMENTARY MATERIAL

Supplement 1