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Effects of cereal harvest on abundance and spatial distribution of the rodent *Akodon azarae* in central Argentina

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Abstract

The effects of corn and wheat harvest on abundance, movement, disappearance, sex ratio and age structure of *Akodon azarae* were studied in cropfield–border systems. Sampling occurred both before and after harvest, in crops, in their weedy margins (borders) and in surrounding areas. The abundance of *A. azarae* decreased in fields between before and after harvest and increased along borders. Rodents moved among habitat patches, movement being higher as a consequence of harvest. There was no difference among habitats in terms of disappearance and sex ratio but changes occurred in age structure because of harvest. In response to harvest *A. azarae* was able to move from crops to borders, decreasing the mortality effects. The ability to respond to habitat changes allows *A. azarae* to maximize fitness in periodically disturbed habitats.
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Keywords: Disturbance; *Akodon azarae*; Rodents; Agroecosystems; Cereals; Harvest; Habitat distribution; Movement

1. Introduction

Crop damage produced by rodents has been well documented, whereas the effects of farming practices on small mammals remain poorly know (Jacob, 2003). In Pampean agroecosystems, however, little is known both about crop damage and the effect of farming practices on rodents (Kravetz and de Villafañe, 1981; de Villafañe et al., 1988; Mills et al., 1991; Bilenca and Kravetz, 1995).

Agricultural activity has caused the fragmentation of the natural habitat of Pampean region of central Argentina. The landscape is now composed of a matrix of cropfields and pastures, surrounded by fenced weedy margins (borders) and various patches of natural pastures, railroad right of way, roads, streams and urban areas (Crespo, 1966). Some rodent species benefited from the changes because of increased food availability and decreased predator abundance (Crespo, 1966) and can reach densities

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leading to economic losses (Massoia, 1970; Quintanilla et al., 1973; Bilenca and Kravetz, 1995). The small rodent assemblage in Pampean agroecosystems includes *Akodon azarae* Fischer, *Calomys laucha* Olfers, *Calomys musculinus* Thomas, *Oligoryzomys flavescens* Waterhouse and *Mus domesticus* L. These species show different responses to habitat changes, *Calomys* spp. being best adapted to crop systems, while *A. azarae* and *O. flavescens* are more abundant in less disturbed habitats. *A. azarae* inhabits mainly field borders and is frequently found in fields before harvest (Bilenca and Kravetz, 1998; Hodara et al., 2000). The species is mainly insectivorous and can consume seed of corn, wheat and soybeans (Ellis et al., 1998). The abundance of *A. azarae* peaks in autumn with low numbers in spring and its reproductive season lasts from spring (October–November) to autumn (April–May) (Crespo, 1966; Pearson, 1967; Zuleta, 1989; Busch and Kravetz, 1992a,b).

This paper aimed to investigate the effects of corn and wheat harvest on the abundance, habitat distribution, mortality and displacement of *A. azarae* in agroecosystems.

2. Materials and methods

Fieldwork was conducted at Diego Gaynor (34°18′S, 59°14′W), Exaltación de la Cruz County District, Buenos Aires Province, Argentina. The study area was under a temperate climate with mean temperatures of 22.5 and 9.8 °C in summer and winter, respectively. The original vegetation consisted of 1 m high native grasses reduced to small relict grassland along field borders and roads, with introduced *Avena* spp., *Brassica campestris* L., *Cynodon dactylon* L., *Medicago* spp., *Stellaria media* L. (Bonaventura and Cagnoni, 1995), winter crops being mainly wheat and linen, summer crops sunflower and soybean.

Rodents were sampled both before and after harvest in four corn (plots Corn 1–Corn 2 between March and April 1998, Corn 3–Corn 4 between March and June 1999) and two wheat fields (plots Wheat 1–Wheat 2 between December 1998 and January 1999) of 3.4 ha average surface (range: 2–4.5 ha). In each plot, one to three samplings were conducted 1–48 days before harvest and one to two efforts, 1–28 days after harvest. Lines of Sherman live traps (8 cm × 9 cm × 23 cm) were located to cover the whole field (border and crop). A first line was located on each of the four field borders. Two additional lines were placed parallel two the four borders at 25 and 50 m within the crop and one line 25 m from the border in the surroundings. On each line, traps were placed at 10 m interval, the total number of traps ranging between 164 and 294 per field.

Traps were placed for three consecutive nights and checked every morning, animals captured being recorded to species, body and tail length, weight, sex and reproductive condition. Each animal was individually marked and released.

Three habitat categories were analysed: crop, border and surroundings. Abundance was estimated per habitat category in terms of number of captures per trap-nights (Mills et al., 1991). Differences in abundance between corn and wheat fields, habitat categories and periods before and after harvest were analyzed with three-factor analysis of variance (Anova), using a two repeated measures design. Habitat category and period were considered repeated measures factors and crop type a fixed factor. If no significant interaction was detected the reduced model was fitted with main effects only (Zar, 1996), the Mauchley's sphericity test being made before the repeated measures Anova.

A minimum emigration rate between habitats was calculated as $ER = (N_N/N_S)/time$, N_S being the number of individuals caught in the source habitat in the previous sampling, N_N the number of animals recaptured in a new habitat and time the number of weeks between samplings. Animals recaptured more than once were assigned to the last capture before and to the first capture after harvest.

Disappearance from different habitats between before and after harvest was estimated by $D = [(N_B - N_A)/N_B]/time$, N_B being the number of animals marked before harvest in each habitat, N_A the number of marked animals in each habitat recaptured after harvest in any habitat and time the number of weeks between samplings. Disappearance included animals that died or emigrated from the trapping area between samplings. Disappearance among habitats in corn was analyzed with a one-factor test of variance (Anova) using a repeated measures design (Zar, 1996). The wheat plots were omitted for statistical analysis.
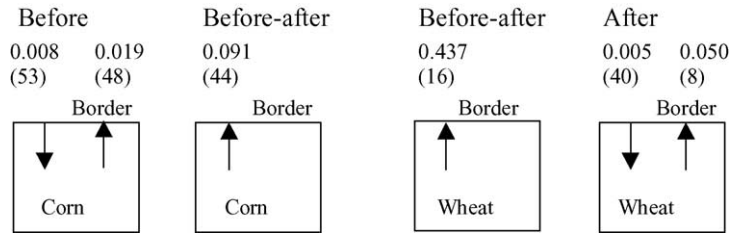
Fig. 1. Emigration of *Akodon azarae* between habitat categories comparing sampling in corn and in wheat crop (with number of individuals in the source habitat and direction of movement).

Sex ratios were compared before and after harvest in each habitat by means of a G-goodness of fit test (Zar, 1996). Rodents captured were classified into three age classes according to body length (Zuleta, 1989), i.e., juveniles had less than 3, subadults 4–5 and adults 6 months. Age classes before and after harvest were compared using a G-goodness of fit test (Zar, 1996), both sexes being counted together.

3. Results

On total 1214 rodents were caught in 13965 trap-nights, *A. azarae* making up from 75.8% ($N = 149$) to 91.4% ($N = 152$) of all rodents captured. A high proportion of unmarked *A. azarae* (66–100%) was still captured after one–three trapping sessions before harvest.

The relative abundance was similar under corn and wheat ($F = 2.365$, d.f. = 1, 4, $p = 0.199$) but differed significantly between before and after harvest depending on habitat categories ($F_{interaction} = 4.540$, d.f. = 2, 8, $p = 0.048$). Rodent numbers were significantly smaller after than before harvest in crops ($mean_{after} = 0.015 \pm 0.006$, $mean_{before} = 0.070 \pm 0.030$, $F = 5.548$, d.f. = 5, 8, $p = 0.046$). The reverse occurred in borders, where significantly more animals were caught after than before harvest ($mean_{after} = 0.166 \pm 0.036$, $mean_{before} = 0.107 \pm 0.047$, $F = 6.442$, d.f. = 5, 8, $p = 0.035$). The lines placed in the
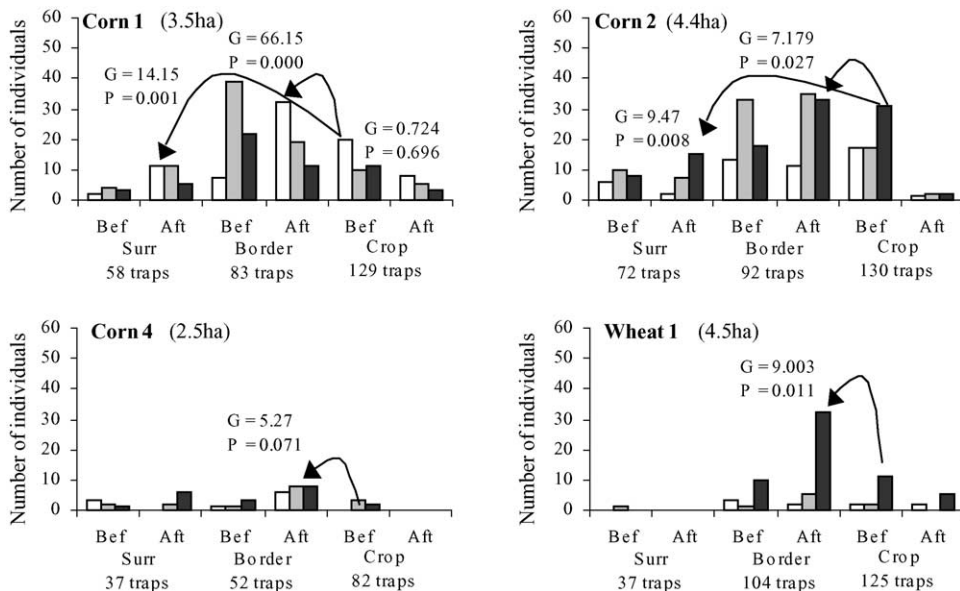

Fig. 2. Individuals of different age classes captured before (Bef) and after (Aft) harvest in corn and wheat (Surr, surroundings; (□) juveniles; (▨) subadults and (■) adults; (←) probable movement of individuals between sampling).

surroundings did not register any difference between samplings.

Rodent movements were detected directly in two corn and one wheat plots. Individuals moved from corn crop to border both before harvest and between before and after harvest. In wheat rodents moved from crop to border both between before and after harvest, and between after harvest. Emigration between habitat categories was higher between before and after harvest samplings than among different before or after harvest samplings (Fig. 1). Movement from borders to the crops occurred before harvest in corn and after harvest in wheat. One animal moved from a surrounding line to the border of corn before harvest. Another evidence of movement from fields to borders and surroundings was the change in abundance after harvest, which decreased in crops and increased in borders.

There was no significant difference among habitat categories in terms of disappearance and no significant change in sex ratio between samplings. In four out of six fields, age classes more abundant in crops before harvest increased in borders and surroundings after harvest (Fig. 2), providing another evidence of movement from crops to borders.

4. Discussion

Corn and wheat harvest resulted in a decrease of *A. azarae* abundance in crops and an increase in borders. Since there were no significant differences in disappearance of *A. azarae* among habitat categories and that the only movement detected between before and after harvest was from crops to borders, abundance changes were hence the consequence of movement and not of high mortality in crops. Changes in age structure at the borders confirm this movement.

Before harvest *A. azarae* was distributed in both crops and borders. During harvest many individuals moved from crops to borders or decreased their home range. Even if food availability increases because of seed spilling (Ylönen et al., 2003), *A. azarae* still avoids using low cover habitats (Busch et al., 1997). A behavioral response to predation risks after habitat changes is frequently observed in small mammals (Lima and Dill, 1990; Jacob and Hempel, 2003) and includes changes in habitat distribution (Kravetz and de Villafañe, 1981; Mills et al., 1991) and foraging

behavior (Jacob and Brown, 2000). The displacement of *A. azarae* to borders may increase competition after harvest, as all individuals leaving the crops are not likely to successfully establish in borders.

Sexes and age classes of *A. azarae* appear to respond similarly to harvest. Differences in displacement may be due to different balances between costs and benefits of moving for different individuals (Gaines and McClenaghan, 1980). In absence of any control plot without harvest and despite the low number of replicates, the changes in habitat distribution observed after harvest are assumed to be due to farming practices and not to environmental parameters.

The ability to respond to habitat changes allows *A. azarae* to maximize fitness in periodically disturbed habitats. Exploitation of both crop and border may favour the maintenance of high abundance. *A. azarae* is mainly insectivorous and damage is therefore unlikely to occur.

References

Bilenca, D.N., Kravetz, F.O., 1995. Daños a maíz por roedores en la región Pampeana (Argentina), y un plan para su control. Vida Silvestre Neotropical (Costa Rica) 4, 51–57.

Bilenca, D.N., Kravetz, F.O., 1998. Seasonal variation in micro-habitat use and feeding habits of the pampas mouse *Akodon azarae* in agroecosystems of central Argentina. Acta Theriol. 43, 195–203.

Bonaventura, S.M., Cagnoni, M.C., 1995. La vegetación de los bordes de caminos en agroecosistemas. Physis (Buenos Aires) 50, 63–71.

Busch, M., Alvarez, M.R., Cittadino, E.A., Kravetz, F.O., 1997. Habitat selection and interspecific competition in rodents in pampean agroecosystems. Mammalia 61, 167–184.

Busch, M., Kravetz, F.O., 1992a. Competitive interactions among rodents (*Akodon azarae*, *Calomys laucha*, *C. musculinus* and *Oligoryzomys flavescens*) in a two-habitat system. I. Spatial and numerical relationships. Mammalia 56, 45–56.

Busch, M., Kravetz, F.O., 1992b. Competitive interactions among rodents (*Akodon azarae*, *Calomys laucha*, *C. musculinus* and *Oligoryzomys flavescens*) in a two-habitat system. II. Effect of species removal. Mammalia 56, 541–554.

Crespo, J.A., 1966. Ecología de una comunidad de roedores silvestres en el partido de Rojas, Provincia de Buenos Aires. Revista del Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (Buenos Aires) 1, 79–134.

de Villafañe, G., Bonaventura, S.M., Bellocq, M.I., Percich, R.E., 1988. Habitat selection, social structure, density and predation in populations of Cricetine rodents in the pampa region of Argentina and the effects of agricultural practices on them. Mammalia 52, 339–359.

Ellis, B.A., Mills, J.N., Glass, G.E., McKee, K.T., Enria, D.A., Childs, J.E., 1998. Dietary habits of the common rodents in agroecosystem in Argentina. J. Mamm. 79, 1203–1220.

Gaines, M.S., McClenaghan Jr., L.R., 1980. Dispersal in small mammals. Ann. Rev. Ecol. Syst. 11, 163–196.

Hodara, K., Busch, M., Kittlein, M.J., Kravetz, F.O., 2000. Density-dependent habitat selection between maize cropfields and their borders in two rodent species (*Akodon azarae* and *Calomys laucha*) of Pampean agroecosystems. Evol. Ecol. 14, 571–593.

Jacob, J., 2003. Short-term of farming practices on populations of common voles. Agric. Ecosyst. Environ. 95, 321–325.

Jacob, J., Brown, J.S., 2000. Microhabitat use, giving-up densities and temporal activity as short- and long-term anti-predator behaviors in common voles. Oikos 91, 131–138.

Jacob, J., Hempel, N., 2003. Effects of farming practices on spatial behaviour of common voles. J. Ethol. 21, 45–50.

Kravetz, F.O., de Villafañe, G., 1981. Poblaciones de roedores en cultivos de maíz durante las etapas de madurez y rastrojo. Historia Nat. (Argentina) 1, 213–232.

Lima, S.L., Dill, L.M., 1990. Behavioural decisions made under the risk of predation: a review and prospectus. Can. J. Zool. 68, 619–640.

Massoia, E., 1970. Mamíferos que contribuyen a deteriorar suelos y pasturas en la República Argentina. Instituto Nacional de Tecnología Agropecuaria (Argentina) 14–17.

Mills, J.N., Ellis, B.A., Mc Kee, K.I., Maiztegui, J.I., Childs, J.E., 1991. Habitat associations and relative densities of rodent species in cultivated areas of Central Argentina. J. Mamm. 72, 470–479.

Pearson, O.P., 1967. La estructura por edades y la dinámica reproductiva de una población de roedores de campo, *Akodon azarae*. Physis (Buenos Aires) 27, 53–58.

Quintanilla, R.H., Rizzo, H.F., Fraga, C.P., 1973. Roedores perjudiciales para el agro en la República Argentina. E.U.D.E.B.A., Buenos Aires.

Ylönen, H., Jacob, J., Runcie, M.J., Singleton, G.R., 2003. Is reproduction of the Australian house mouse (*Mus domesticus*) constraided by food? A large-scale field esperiment. Oecologia 135, 372–377.

Zar, J.H., 1996. Biostatistical Analysis, third ed. Prentice Hall, New Jersey.

Zuleta, G.A., 1989. Estrategias de historia de vida en el ratón de pastizal pampeano *Akodon azarae*. Doctoral Thesis, Universidad de Buenos Aires, Buenos Aires, Argentina, 256 pp.