Mastozoología Neotropical, 28(1), Mendoza, 2021
Versión on-line ISSN 1666-0536
https://doi.org/10.31687/saremMN.21.28.1.0.11

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Sección Especial
EL ÚLTIMO NATURALISTA TIPÓLOGO:
CONTRIBUCIONES EN HONOR A ELIO MASSOIA (1936-2001)
Editores: Ulyses F. J. Pardiñas y Carlos Galliari
Artículo

URBAN RODENTS OF THE CITY OF DIAMANTE, ENTRE RÍOS, ARGENTINA

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ABSTRACT. Some native cricetid rodents are well adapted to modified environments; therefore, they could inhabit periurban or even urban environments. The city of Diamante is a small riverside city immersed in a matrix of wetland and croplands which are inhabited by cricetid rodents. This city could offer available habitats to island rodents principally during extreme flood events. The objective of this study was to determine the composition of the rodent assemblage in this small riverside city of Diamante, Entre Ríos, Argentina, not studied so far, after an exceptional magnitude flood mediated by an ENSO-El Niño event. Small rodents were live-trapped in autumn and spring 2016 in 127 sampling units (houses and vacant lots). The relationship among rodent abundance and the minimal distance to the Paraná river and to boundaries of the city, and the presence of dogs, cats, chickens and litter were explored by means of Generalized Linear Models. *Mus musculus* and *Rattus rattus* were captured in the 18.7% and 1.9% of the sampling units, respectively, while *R. norvegicus* and *Oxymycterus rufus* were found in the 0.9% of these. *Mus musculus* abundance was not associated with its presence in houses or vacant lots or with any other explanatory variables. This study showed that this riverside city does not harbor populations of native rodents, not even in extreme flooding periods.

RESUMEN. Roedores urbanos de la ciudad de Diamante, Entre Ríos, Argentina. Algunos roedores cricétidos nativos se adaptan bien a ambientes modificados; por lo tanto, podrían habitar entornos periurbanos o incluso urbanos. El objetivo de esta investigación fue determinar la composición del ensamble de roedores en una pequeña ciudad ribereña inmersa en una matriz de humedales y tierras de cultivo. El estudio se realizó en la ciudad de Diamante, Entre Ríos, Argentina, y fue el primero en su tipo. Ésta ciudad está rodeada de islas del río Paraná habitadas por roedores cricétidos y, durante esta investigación, se produjo una inundación mediada por el ENSO-El Niño de magnitud extraordinaria. Se realizó un muestreo de pequeños roedores en otoño y primavera de 2016 en 127 casas y baldíos de la ciudad. La relación entre la abundancia de los roedores y la distancia mínima al río Paraná y a los límites de la ciudad, y la presencia de perros, gatos, gallinas y basura fueron exploradas mediante Modelos Lineales Generalizados. *Mus musculus* y *Rattus rattus* se capturaron en el 18,7% y 1,9% de las unidades funcionales, respectivamente; mientras que *R. norvegicus* y *Oxymycterus rufus* se encontraron en el 0,9% de éstas. Ni el tipo de unidad funcional ni las demás variables explicativas se asociaron a la abundancia de *M. musculus*. Este estudio demostró que esta ciudad ribereña no alberga poblaciones de roedores nativos, ni siquiera en períodos de inundaciones extremas.

Palabras clave: comensales, delta, humedales, *Mus musculus*, *Rattus*.

Recibido: 29 septiembre 2020. Aceptado: 24 noviembre 2020. Editor asociado: U. F. J. Pardiñas & C. A. Galliari.

Key words: commensal, delta, *Mus musculus*, *Rattus*, wetlands.

INTRODUCTION

The transformation of natural or semi-natural ecosystems to urban ecosystems is a slow but generally irreversible process and is one of the most homogenizing anthropic processes on the environment (Matteucci et al. 1999; Morello 2000; Mckinney 2006). Therefore, as cities expand in the world, the processes of biological homogenization intensify because species that adapt to cities spread and establish themselves. Commensal species are adapted to intensely modified habitats and act as global homogenizing species (Mckinney 2006). Three species of commensal murine rodents, the black rat *Rattus rattus*, the Norwegian rat *R. norvegicus*, and the house mouse *Mus musculus* are currently distributed throughout the world including Argentina (Coto 1997). These species are mainly associated with environments such as poultry farms (Gómez Villafañe & Busch 2007; Miño et al. 2007; Gómez Villafañe et al. 2008; Leon et al. 2013), pig and daily farms (Lovera et al. 2015) and they are the most common species in cities, although their study continues to be scarce in the latter environments (Baker et al. 2003; Cavia et al. 2009; Rothenburger et al. 2017).

Native cricetid rodents are not defined as commensal; however, there are some generalist species, such as *Oligoryzomys flavescens* and *Akodon azarae,* with good adaptability to modified environments (Cavia et al. 2009; Teta et al. 2012). Therefore, there are some records of their presence on periurban or even urban environments, as shown in Argentina - Buenos Aires (Cavia et al. 2009; Muschetto et al. 2018), Córdoba (Castillo et al. 2003; Gomez et al. 2008); and Jujuy (Calderón 1999). In the wetlands of Paraná River Delta islands and riparian natural areas near to the city of Diamante, Entre Ríos, at least five species of cricetid rodents were registered (Voglino et al. 2004; Massa et al. 2014; Vadell & Gómez Villafañe 2016; Massa et al. 2020). The riverside city of Diamante not only offers a constant supply of resources for rodents as an urban ecosystem (Cavia et al. 2015) but could also offer certain habitat opportunities for native cricetid rodents mainly in times of flooding of the Paraná river (Andersen et al. 2000) if they have the ability to migrate from Delta islands towards the near city coasts. According to this, the objective of this research was to determine the composition of the rodent assemblage in the urban area of Diamante, Entre Ríos, a small city immersed in a matrix of wetland and croplands.

MATERIALS AND METHODS

Study Area

The study was carried out in Diamante city (32°04.156' S; 60°38.195' W), head of the homonymous department of Entre Ríos province (Argentina) located on the coast of the Paraná river (**Fig**. 1). The city has an area of approximately 5.4 km^2 and has 19 930 inhabitants (INDEC 2010). It is crossed by several open ditches and it is limited to the west by the Paraná river, in the Delta and Islands of Paraná River ecoregion; and to the north, east and south by cultivated fields belonging to the Mesopotamian Pampa ecoregion and some patches of native forest, especially riparian. Urban development is very heterogeneous, comprising natural riparian environments and urban environments, both with different degrees of development. Also there are grain storage silos within the city, and an extensive periurban area with diffuse boundaries that include poultry farms.

This region is mainly shaped by the flooding regime of the Paraná river (Junk et al. 1989; Malvárez 1999; Neiff 1999; Casco 2003; Drago 2007). The annual hydrological cycle of the Paraná river is weather dependent, with a regime of pulsating floods, with a maximum discharge in February-March (summer) and dry spells during August-September (winter) (Neiff 1999; Camilloni & Barros 2000). An ENSO-Niño mediated flood occurred prior to the beginning of the study in December 2015, with duration of 145 days, ending in May 2016 (Vera & Osman 2018).

Rodent Capture

Small rodents were live-trapped during four consecutive days in May (autumn) and September / October (spring) 2016 in 127 sampling units. These units were classified into houses or vacant lots. The traps were located systematically to cover the whole urban area. There were sampled 49 houses and 15 vacant lots in autumn, and 55 houses and 8 vacant lots in spring and none of them were repeated.

Because the main objective of the study was to register the presence of cricetid species in the city, between one to eight Sherman live traps (23 x 8 x 9.5 cm) were placed on each sampling unit in autumn, accounting for an effort of 681 trap-nights. In spring, cage traps (15 x 15 x 45 cm) were added to capture rodents over 500 g, totaling an effort of 660 Sherman trap-nights and 174 cage trap-nights. Sherman traps were baited with a mixture of peanut butter, fat and rolled oats; and cage traps were baited with meat and carrot. The traps with capture were replaced for other ones without alter the total numbers of traps per night.

Species, according to external characteristics (Gómez Villafañe et al. 2005), sex, total length, weight and reproductive status of the captured individuals were recorded. Trap success (TS) was calculated as: number of individuals captured x 100/(number of traps × number of nights).

Animals were handled according to Argentinian National Law 14 346 for the protection of animal welfare

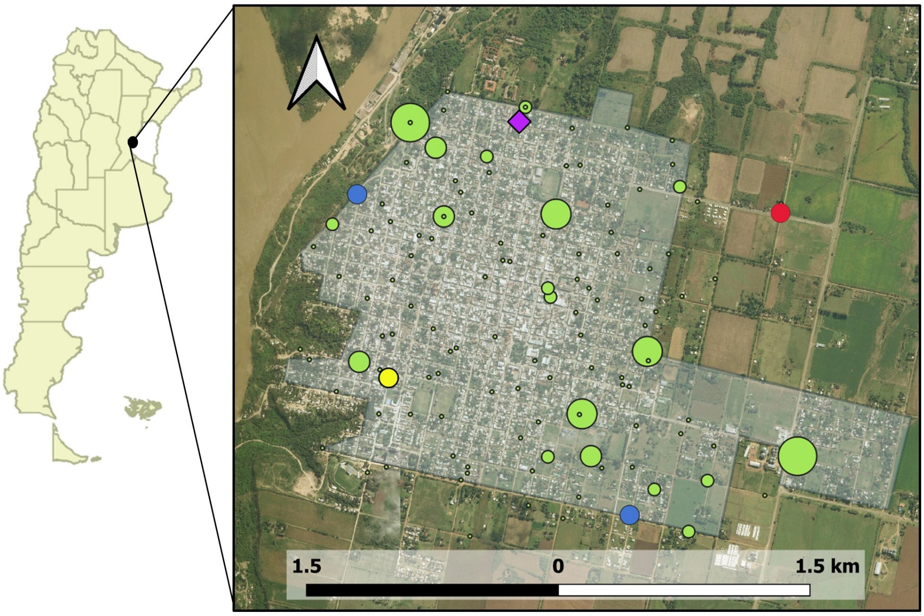

Fig. 1. Relative abundance of *Mus musculus* (light green circles, size proportional to trap success) and presence of *Rattus rattus* (blue circles), *Rattus norvegicus* (yellow circle), *Didelphis albiventris* (purple diamond) and *Oxymycterus rufus* (red circle) in the city of Diamante, Entre Ríos, Argentina in the autumn and spring of 2016.

and followed international guidelines appropriate for handling zoonosis reservoirs (Kelt & Hafner 2010; Sikes 2016). The captured rodents were removed because releasing potentially infected rodents to the houses is unethical.

Environmental characteristics

The minimal distance between each sampling unit, the Paraná river and the city boundaries were calculated using a layer of Instituto Geográfico Nacional (<http://www.ign.gob.ar/NuestrasActividades/InformacionGeoespacial/CapasSIG>; date: March 25th 2021) with the software QGIS 2.18.7 (Las Palmas; Qgis Development Team 2017). During each sampling session (autumn and spring) the presence of dogs, cats, pigs, and chickens, and the presence of litter or garbage were recorded in every sampling unit.

Statistical analyses

Mus musculus was the only species with an enough amount of abundance data to perform statistical analyzes. We explored the relationship between *M. musculus* abundance (n=127) and explanatory variables by means of the Generalized Linear Models (GLM) procedure of R version 3.6.3 (R Core Team 2020), with quasi-binomial error structure (overdispersion factor: 1.77, Burnham & Anderson 2002). The response variable TS was constructed with a cbind (success, failure) syntax. The link function was cloglog, recommended in cases of large amount of zeros in response variable (Mccullagh & Nelder 1989; Nicholls 1991; Crawley 1993). The explanatory variables were type of sampling unit (house or vacant lot), season of the year (autumn or spring), distance variables (minimal distance between each sampling unit and Paraná river, minimal distance between each sampling unit and city boundaries) and environmental characteristics (presence of dogs, presence of chickens and presence of litter). The presence of cats and and pigs were excluded of the analysis due to their high proportion of zeros.

We explored the association between the *M. musculus* presence and the same explanatory variables by means of Bernoulli GLM with error binomial structure and a cloglog link function (Zuur et al. 2009; Crawley 2012).

Abundance models were based on a Quasi-Akaike's information criterion corrected for over-dispersion data (QAICc; Burnham & Anderson 2002). Presence models were based on Akaike's information criterion (Burnham & Anderson 2002). QAICc and AIC tables, respectively, were calculated with AICcmodavg (Mazerolle 2020) package of R. Univariate models were tested and abundance or presence models with ΔQAICc (or ΔAIC) > 2 respect to the null model and with variables that have a parameter different from zero, were selected. Coefficients and confidence intervals of selected models were calculated with MuMIn package (Barton 2020).

RESULTS

Four rodent species, the murids *M. musculus* (33), *R. rattus* (2), *R. norvegicus* (1), the cricetid *Oxymycterus rufus* (1) and one marsupial *Didelphis albiventris* (1, family Didelphidae) were captured in Diamante city (**Fig**. 1). *M. musculus* and *R. rattus* were captured in the 18.7% and 1.9% of the sampling units, respectively, while *R. norvegicus* and *O. rufus* were found in the 0.9% .

In autumn, the overall TS was 3.12%. Twenty one *M. musculus* were captured in the 18% of the houses and in the 26.7% of the vacant lots. The 52.4% of the *M. musculus* were female and the 47.6% males. The 36% of the female and the 50% of the males were reproductive. A non-reproductive female of *R. norvegicus* was captured in a house.

In spring, the overall TS was 1.93%. Twelve *M. musculus* were captured in the 12.7% of the houses and in the 12.5% of vacant lots. The 36.3% of the *M. musculus* were females and the 63.6% males. All females and the 71.4% of the males were reproductive in spring. Two female *R. rattus* were captured in two houses and, one non-reproductive male of *O. rufus* in a vacant lot.

The type of sampling unit, the distance to the river or to the city boundaries and the presence of animals or litter were not associated with *M. musculus* abundance (**Table** 1) or presence (**Table** 2). However, we were able to identify that the three units with the highest trap success were a house with a garden located very near a grain storage silo, a vacant lot located in front of the river and a house with a car repair shop (**Fig**. 1).

The cricetid *O. rufus* was captured on the edge of the cane field on the eastern boundary of the urban area (**Fig**. 1). The opossum was captured in the north boundary of the city, in a house with a lot of trees and near a forested ditch (**Fig**. 1).

DISCUSSION

The city of Diamante is a small and very heterogeneous urbanization, with large patches of vegetation and a large proportion of river coast. Therefore, the city landscape could offer available habitats to cricetid rodents that inhabit on surrounding islands of the Paraná River Delta (Maroli 2019), principally during extreme flood events, as occurred during this research. However, no native rodents were detected within the city showing a very clear change in the composition of rodent species from natural to rural and urban environments. The presence of the native rodent *O. rufus* in a very forested vacant lot located on the edge of the city supports this idea. *O. rufus* is one of the most abundant species in the cricetid rodent assemblage in the Diamante islands area (Vadell & Gómez Villafañe 2016; Maroli 2019) and is present in the rodent communities on the edges of cultivated fields in the Pampean region (Fraschina et al. 2012).

The dominant murid species in the urban environment was *M. musculus*, according to similar studies carried out in Río Cuarto, Córdoba, representing over 50 % of the total captures (Castillo et al. 2003; Gomez et al. 2008), and from Buenos Aires, where this species was one of the two dominant species in neighborhoods and parks (Cavia et al. 2009). Although it was expected to obtain a greater trap success of small rodents using Sherman traps (like autumn), in spring the study was extended by placing cage traps and the trap success of *M. musculus* remains greater than other rodent species. In this study, similar to other ones carried out in urban areas or environments with certain environmental stability (Gómez Villafañe & Busch 2007; Vadell et al. 2014) an absence of reproductive recess was observed. However, a small variation in reproduction was recorded, with a higher proportion of active males and females in spring. Additionally, no spatial clustering was detected in the houses with rodents. This could mean that the urban area of Diamante, with its structure of low houses and a large amount of herbaceous cover and trees in some sectors, would constitute a homogeneous environment for these rodents.

Didelphis albiventris was captured in a site located in the limits of the urban and periurban environments. It is a species that can be present both in natural environments (Massoia et al. 2000; Tarragona et al. 2011) as well as in agroecosystems (Pérez Carusi et al. 2009; Lovera et al. 2015) acting, many times, as an epidemiological link between both environments (Gómez Villafañe et al. 2004; Pérez Carusi et al. 2009; Jansen et al. 2017; Vieira et al. 2018).

This study showed that Diamante city does not harbor populations of native rodents, despite it being a small city immersed in a matrix of wetlands and croplands in which these area present. The absence of native rodents in the city was documented at a time of extreme flooding of the Paraná river (Vera & Osman 2018), which would allow to affirm that native rodents do not disperse towards the mainland of Diamante when their habitat on the islands is extremely disturbed.

Table 1

Summary of model-selection results for univariate models explaining variation in *Mus musculus* abundance in Diamante city (Entre Ríos, Argentina, 2016). QAICc: Quasi-likelihood Akaike's criterion corrected for small samples; ΔQAICc: difference of the QAICc value of each model from the QAICc value of the best model; QAICcWt: Akaike weight; Cum.Wt: cumulative Akaike weight; Quasi.LL: Quasi log-Likelihood. K: number of parameters. 95% confidence interval limits (CI) of the estimates. Models are listed in decreasing order of importance.

Model	Explanatory variable	QAICc	ΔQAICc	QAICcWt	Cum.Wt	Quasi.LL	k	CI 95%
1	Null	103.98	0.00	0.18	0.18	-49.94	2	-4.08; -3.38
2	Litter	104.04	0.07	0.17	0.35	-48.92	3	-0.02; 1.38
3	Autumn	104.37	0.40	0.14	0.49	-49.09	3	-3.91;-3.05
	Spring							-1.39;0.08
4	Presence of chickens	104.41	0.43	0.14	0.63	-49.11	3	-4.26; 0.15
5	Vacant lot	104.55	0.57	0.13	0.77	-49.18	3	-3.91;-2.59
	House							-1.42; 0.14
6	Distance to city border	105.46	1.48	0.08	0.85	-49.63	3	-0.002; 0.001
7	Distance to river	105.62	1.64	0.08	0.93	-49.71	3	-0.0003; 0.0007
8	Presence of dogs	105.73	1.75	0.07	1.00	-49.77	3	-0.98; 0.42

Table 2

Summary of model-selection results for univariate models explaining *Mus musculus* presence probability in Diamante city (Entre Ríos, Argentina, 2016). AIC: Akaike's criterion corrected for small samples; ΔAIC: difference of the AIC value of each model from the AIC value of the best model; AICWt: Akaike weight; Cum.Wt: cumulative Akaike weight; LL: log-Likelihood. K: number of parameters. 95% confidence interval limits (CI) of the estimates. Models are listed in decreasing order of importance.

Model	Explanatory variable	QAICc	ΔQAICc	QAICcWt	Cum.Wt	Quasi.LL	k	CI 95%
1	Litter	96.68	0.00	0.28	0.28	-46.34	2	-0.06; 1.91
2	Distance to river	97.56	0.89	0.18	0.47	-46.78	2	-0.0001; 0.0012
3	Null	98.03	1.35	0.14	0.61	-48.02	1	-2.34; -1.38
4	Distance to city border	98.99	2.31	0.09	0.70	-47.49	2	-0.003; 0.001
5	Presence of dogs	99.01	2.33	0.09	0.79	-47.50	2	-0.46; 1.57
6	House	99.40	2.73	0.07	0.86	-47.70	2	-1.51; 0.79
	Vacant lot							-2.61; -0.59
7	Spring	99.41	2.73	0.07	0.94	-47.70	2	-1.40; 0.57
	Autumn							-2.34; -1.08
8	Presence of chickens	99.67	2.99	0.06	1.00	-47.83	2	-3.46; 1.02

ACKNOWLEDGMENTS

This research has been funded with grants of CONICET (Argentina) and the University of Buenos Aires. The authors are grateful for the kindness of the residents of the town of Diamante who allowed traps to be placed in their homes and to Eliana Burgos, Ricardo Ojeda Adame and Matías Jesús Almeida for their support during fieldwork, and Leonardo Scarpa also for their help with GIS. This work is dedicated to the memory of Daniela Montes de Oca.

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