Year on year changes in Algerian mouse (*Mus spretus*) populations inhabiting citrus orchards in Spain treated with chlorpyrifos, a comparison with macchia habitat

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Introduction

The Algerian mouse, *Mus spretus* (Lataste 1883) is one of the most abundant rodents across Spain (Fig. 1). Its ecology is similar to the woodmouse. It is a small wild and endemic murine of Mediterranean area, distributed throughout Iberian Peninsula, South France and North of Africa. It is found in a variety of agro-ecosystems such as crops, orchards, grasslands, scrubland or forests (Palomo *et al.* 2009). The diet is characterized by a broad spectrum of food resources from arthropods to seeds of grasses and green vegetable matter, which can be exploited in terms of their availability in the environment (Palomo *et al.* 2007). Its population densities can range from 3 up to >70 individuals per ha, and fluctuate over the seasons due to phases of maximum reproductive activity depending on the region and habitat characteristics. The main sexual activity lies between March to October (Vargas 1984; Palomo 1982) and is affected by the summer drought and available food resources in each season (Orsini 1982; Torre 2002). This species shows a territorial behaviour where the spatial dispersion of individuals in an area is related to physical characteristics of the microhabitat that determine the distribution of their food resources, nesting places and protection from predators (Gray & Hurst 1997; Gray 1998).

The aim of this study was to analyse changes and potential effects on the population of *M. spretus* over time in orchards treated with chlorpyrifos during the main reproduction period.

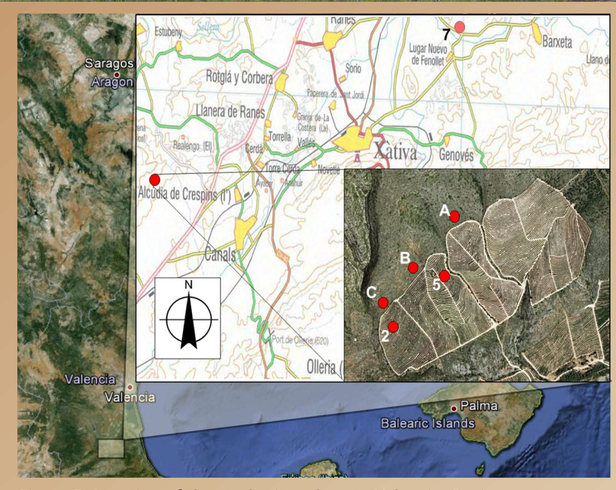


Figure 5: Location of the study sites close to Valencia, Spain.

Figure 1: Individual of *M. spretus*

Figure 2: Citrus trees in study orchard

Figure 3: Macchia as reference habitat

Figure 4: Ugglan trap for trapping

Methods

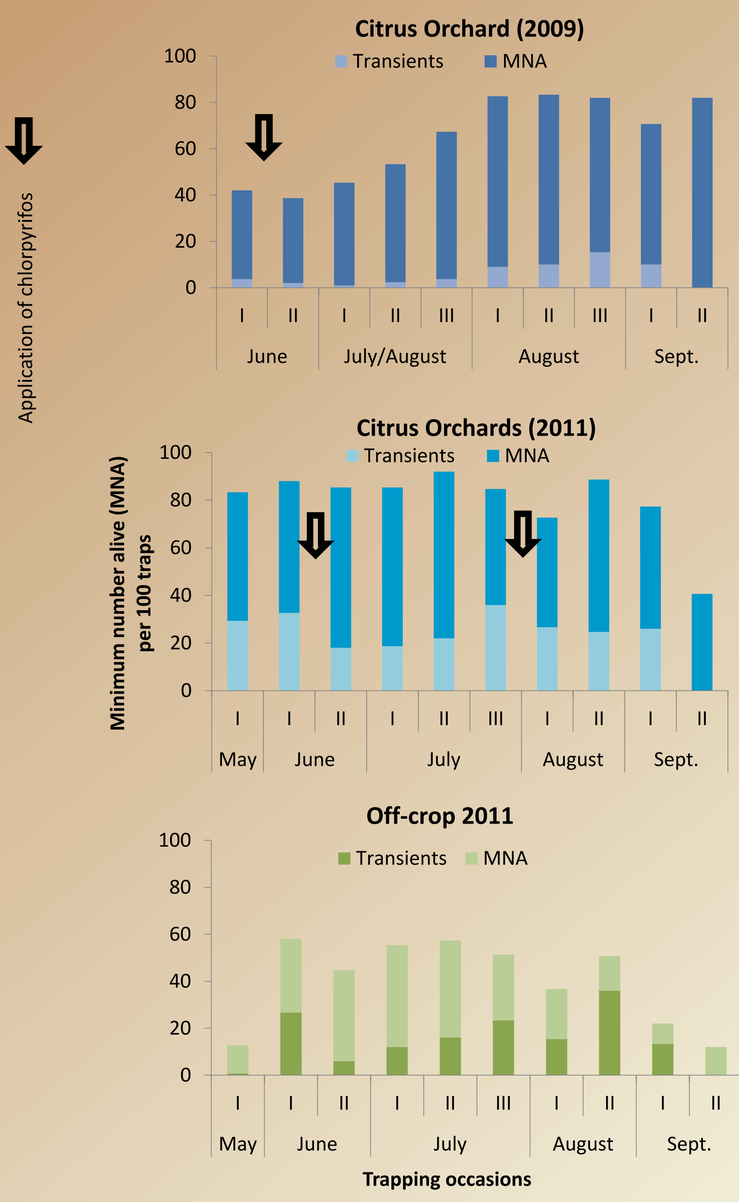
The study was conducted in citrus orchards and reference habitats close to Valencia (Spain) (Fig. 5), the primary citrus growing region in Europe. Three sites were chlorpyrifos-treated orchards (Fig. 2) and three were untreated off-crop reference sites with typical Mediterranean macchia (Fig. 3). The study was carried out in 2009 (from June to November) and 2011 (from May to October) with simultaneous regular trapping sessions at all study sites. Live trapping of small mammals (with 'Ugglan' multiple capture live traps, Fig 4) was carried out according to a 'Capture-Mark-Recapture (CMR)' design on treated and reference sites in order to assess the abundance of small mammals and their population development over time. Each captured individual (above 10 g) was individually marked with a Passive Integrated Transponder (PIT Friendchip™; 12 x 2.12 mm, 0.11 g) and then released at the site of capture. Chlorpyrifos was applied once in the citrus orchards between 22.06 and 30.06 in 2009, at least once in 2010, and twice between 22.05 and 13.08 in 2011. Chlorpyrifos is applied every year to almost the entire commercial citrus area of Spain, for the control of the red scale insect (a major pest which damages fruit and trees).

Abundance and Population dynamics

Population abundance of *M. spretus* depends on the seasonal availability of food resources, shelter and further extrinsic factors. As an estimation of the population size and development the sum of all individuals known to be alive during a specific trapping event (Minimum Number Alive/MNA) was calculated. This includes individuals that were captured just once (transients) in this specific trapping event and individuals captured repeatedly.

Q: Does the chlorpyrifos treatment influence medium-term and long-term population development and abundances?

The treatment had no negative effect on the population abundance during the study period. The population dynamic following the first treatment was different between years. Abundance increased after treatment in 2009 whereas it remained constant on a higher level with more transient individuals moving through the sites in 2011 (searching for new territories).

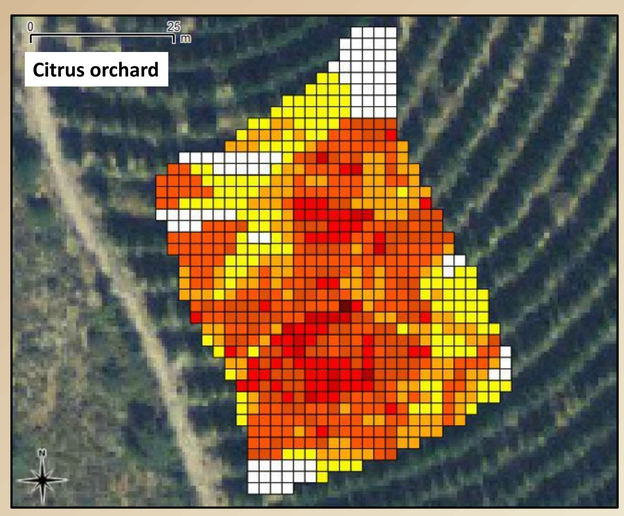


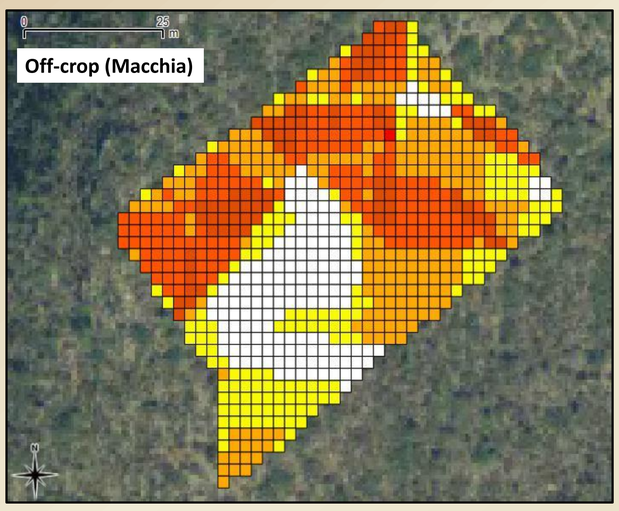
Density

A higher abundance results in the tendency of territory overlapping (Gray & Hurst 1997 and Gray *et al.* 1998). The extent of territories was calculated with at least 3 capture events in different traps as Minimum Convex Polygons (MCP). Density maps were estimated with the help of QGIS software using intersection plugin. The maps show the number of overlapping territories in a 2m grid corrected for time to ensure temporal overlapping.

Q: Do densities of M. spretus territories differ between orchards and off-crop habitats?

Yes, the density of territories inside the citrus orchards was considerably higher than outside in the off-crop sites.





Number of overlapping territories	Proportion of total trapping area % Citrus Orchard	Off-crop
0	10.00	22.88
1	15.95	18.14
2	18.32	26.38
3	27.36	22.11
4	16.71	10.34
5	9.10	0.15
6	2.25	-
7	0.15	-
8	0.15	-

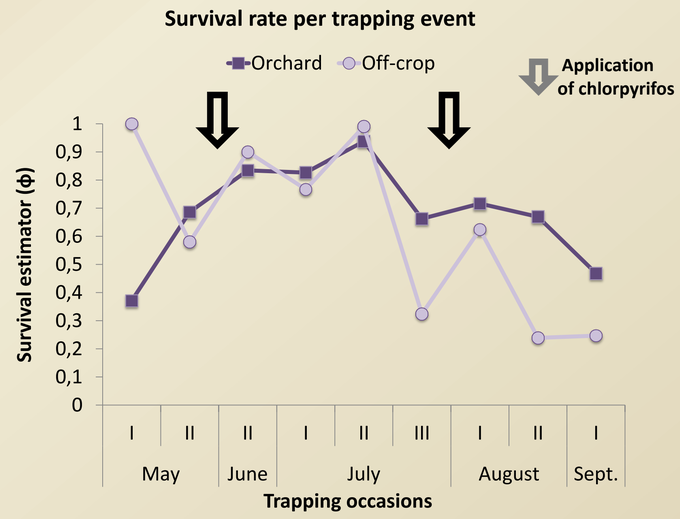
Estimation of survival

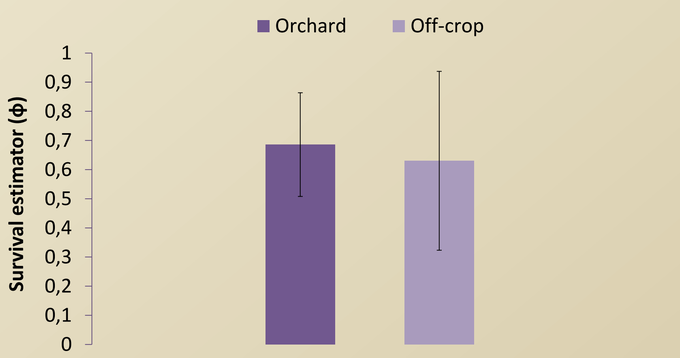
Application of chlorpyrifos was tested as an extrinsic factor that potentially influences the survival of *M. spretus*. Survival of *M. spretus* in orchards and off-crop was calculated using Mark software and POPAN model according to Cooch & White (2011). The best fitted model was p(t)ϕ(g*t)b(g*t), for details see below.

Q: Do survival rates of M. spretus differ between areas treated with Chlorpyrifos and areas without treatment?

There was no difference in apparent survival between treated citrus orchard and off-crop habitat. Survival rates in orchards increased from the start of the trapping period until session III in July, followed by a gradual decline, which coincides with the results found in off-crop habitats.

Survival model: p(t)ϕ(g*t)b(g*t)
p - Capture probability given the animal is available for capture
t - Time
ϕ - Apparent survival
g - Different habitat (e.g. Orchard and Off-crop)
b - Probability of entry into the population for this occasion





Discussion & Conclusion

The density of *M. spretus* was higher in citrus orchards than in off-crop habitat (macchia). The irrigation within the orchards promotes an associated ground cover vegetation, which offers seeds and invertebrates as a food source, providing a favorable habitat structure in the orchard. Differences in population dynamics after treatment with chlorpyrifos indicate that the carrying capacity was reached early in 2011. The carrying capacity reflects the maximum population density that can survive with the resources of a determinate habitat. According to Odum & Barrett (2006) the birth rate slows down at this level or the emigration rate increases. The population dynamic in 2011 could be explained by the concept of carrying capacity. In adjacent off-crop habitats the abundance fluctuated over the study period according to the seasonal changes in reproduction cycle and food and nesting places available (Orsini, 1982; Torre, 2002).

- **The treatment of chlorpyrifos during the main breeding period had no negative effect on the abundance and survival rate of *M. spretus* during the study period.**
- **Population abundance and density of *M. spretus* was higher in orchards than in off-crops, probably due to more stable and abundant food and water resources present in orchards.**
- **It is important to know about the population dynamics to correctly interpret potential effects on small mammal populations from pesticide uses.**

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