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SHORT COMMUNICATION

Possible effects of roadside verges on vole outbreaks in an intensive agrarian landscape

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Road verges are considered as refuge zone or habitat for a number of small mammals in intensive agrarian landscapes (Bellamy et al. 2000; Maisonneuve and Rioux, 2001; Pita et al. 2006) and also participate to the conservation of some endangered species (Santos et al. 2007). This refuge zone effect has been verified for *Microtus arvalis* (de La Peña et al. 2003), a rodent known to display regular population fluctuations (Briner et al. 2007), and local outbreaks (Murray, 1965; Delattre et al. 1992). Such variations in population size lead periodically to increased vole densities causing significant damages to crops, especially for vole densities over 200 individuals per hectare (Delattre et al. 1999).

We trapped voles in two successive springs (2006 and 2007) along roadsides to test and estimate the impact of roadside network densities on the variation of their inter-annual abundance. We found that if local vole densities were affected by local crop coverage, their abundance between years was partly impacted by roadsides structures. Such marginal areas possibly provide habitats for vole predators, and therefore help regulating vole populations and decreasing the intensity of occasional outbreaks (Delattre et al. 1999).

Our study area was located in central France, Seine-et-Marne department, about 50 km east of Paris (48°32′N, 2°39′E). It was mainly composed of agricultural fields used for intensive crop production (60.7% of landcover). Road networks represented important linear structures in the landscape (13,992 km long, i.e. 2.4 km km^{-2}) along with their verges (63.0 km^2, i.e. 1.07% of the total area of the department). We sampled 45 roadside verges, each one with five traps placed linearly every 20 meters along the road in the middle of the bank (for a total of 225 traps each year). We used *Barber* pitfall traps: 450 mL plastic pot (10.2 cm height, 7.5 cm diameter) fully inserted into the ground and containing a 155 mL solution composed of 75 mL of water, 75 mL of conservative (ethylene glycol), 5 mL of surfactant (dishware soap) and 15 g of NaCl. Each trap was protected from rain by a plastic transparent cover (15 cm × 15 cm) supported by wood sticks 10 cm above the ground. The traps were set up for 28 days during May 2006 and during May 2007. No trap was found dried out due to evaporation, and therefore all traps were considered as efficient. Note that the solution used to fill the traps was considered unattractive for some animals, such as invertebrates (Darren et al. 2001).

We calculated (1) the area covered by crop fields and (2) the roadside network area in an area of 500 m around each trapping site using ArcGis 9.1^{TM} software on landcover and road network layers (buffers). We used a geographical layer classifying roads into three categories according to their status; R_N: national roads (0.9 ha of verges for 1 km of road), R_D: departmental roads (0.7 ha km^{-1}), and R_L: local roads (0.3 ha km^{-1}). We reported the numbers of captured *M. arvalis* per

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group of five traps, then we studied their inter-annual variations with an ANOVA, according to local roadside network area (noted as A_{RN}, $A_{RN} = 0.9*R_N$ length + $0.7*R_D$ length + $0.3*R_L$ length). We further classified variations in four categories:

- *ABS*, **Abs**ence: *M. arvalis* was not detected during either year of survey;
- *SMI*, **S**table or **M**oderate **I**ncrease: the number of captures did not vary or increased by less than 75% between years;
- *COL*, Local **Col**onization: *M. arvalis* was not detected in 2006 but was captured in 2007;
- *OBK*, **O**ut**b**rea**k**: captures increased by more than 100% between the years.

We chose the level of 100% for the classification of an outbreak according to Giraudoux et al. (1997) and Duhamel et al. (2000). No decrease in numbers, and no increase between 75 and 100% was observed. We also analysed the log ratio of local abundance of both years, as $\log(N_{2007}+2)/\log(N_{2006}+2)$, with a Generalized Linear Model, to test for linear relationships beyond potential differences between categories. Because *M. arvalis* is a rodent species adapted to field habitats, we also investigated the impact of local crop coverage on its distribution (total captured and variation classes). We also ran a GLM to test the possible correlation between the two variables used in this study: roadside network areas and local field coverage. All statistical analyses were performed with R (Ihaka and Gentleman 1996).

The trapping method worked well; no trap was found empty or filled with so many animals that it would have become ineffective (0–5 individuals per trap), and 167 *M. arvalis* were trapped (47 in 2006 and 120 in 2007). Excluding sites without any capture (6), the effect of roadside network areas on vole dynamics was significant ($F_{2,36} = 3.346$ and $P = 0.0465$): non-outbreaking persisting populations (*SMI*) were observed in sites with the highest roadside network densities (3.61 ha ± 0.75 SE). Population outbreaks (OBK) and new colonisation (COL) occurred at sites with lower network densities (OBK: 2.16 ha ± 0.33 SE.; *COL*: 1.93 ha ± 0.36 SE; Fig. 1).

We found no effect of local crop cover on *M. arvalis* variation classes ($F_{2,36} = 0.8781$, $P = 0.4243$), though a positive effect was detected if considering the number of individuals trapped during the two years ($F_{1,43} = 4.919$, $P = 0.0319$). We found weak linear relationships between yearly variation in local vole abundance and linear roadside length ($t = -1.91$, $DF = 37$ and $P = 0.063$) or roadside area ($t = -1.99$, $DF = 37$ and $P = 0.054$.) that both tended towards significance. We finally noticed that field cover and roadside areas were not correlated ($F_{1,43} = 2.658$, $P = 0.11$).

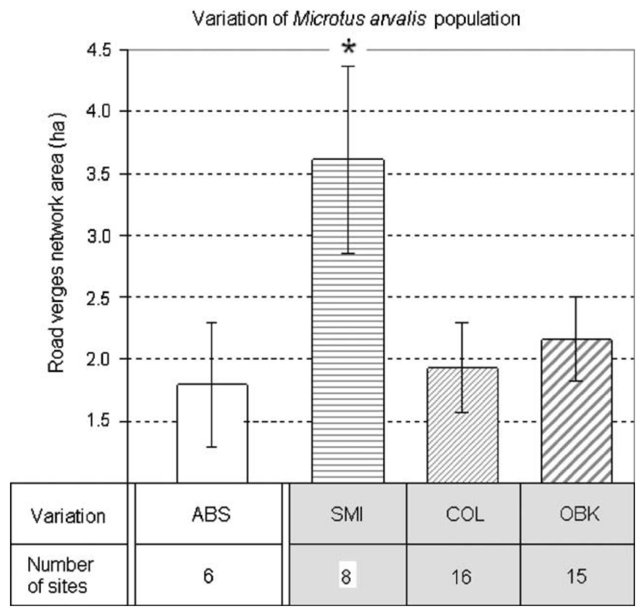

Fig. 1. Impact of road network on variations of *M. arvalis* populations, ($F_{2,36} = 3.346$, $P = 0.0465$*). *ABS*: absence (sites excluded from analysis), *SMI*: no/moderate increase of captures (<75%), *COL*: colonization in 2007, *OBK*: increase of captures by more than 100% (outbreak).

We observed important differences in vole populations sizes between the two years of sampling in the studied agrarian landscape. Traps did not appear to be particularly attractive to voles. However, this potential influence on the number of voles caught was the same in both years and thus should not have affected the pattern of the result.

Because road verges are mowed intensively, i.e. three times a year, the results are in accordance with previous reports on the effects of such mowing treatments on vole population variations (Meunier et al. 1999). Moreover, we highlighted a positive effect of roadside areas on vole outbreak regulations: variations in population size were not spatially homogeneous, and large roadsides seemed to stabilize vole populations, while local colonization or outbreak occurred where roadside verges were smaller. The fact that the relationship between variation in local vole abundance and roadside length only tended towards significance could be due to the comparatively small data set. Our results are in accordance are in accordance with previous studies reporting that *M. arvalis* outbreaks in agrarian landscapes can be controlled by predation if marginal areas provide habitats for predators such as cats (Hansson 1988), polecats (Rondinini et al. 2006) or raptors (Meunier et al. 2000).

We found a strong effect of local land cover (field cover) on *M. arvalis* abundance. The number of individuals trapped at all sites during the two years was positively correlated to the proportion of land covered by crops. To conclude, we strongly encourage

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maintenance and development of large verges along existing roads to prevent vole outbreaks and avoid agrarian damages by stabilizing their population dynamics.

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