Influence of different olive grove management on spider diversity

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Abstract: Spiders are known as one of the most important group of predators in olive agroecosystems, limiting the populations of insect pests and the damage they can cause. However, some agricultural practices are known to modify spider communities changing their species composition and abundance. To assess the influence of different management systems we collected data on spider fauna in three different olive groves and with three different methods. For the three sampling methods biodiversity indexes as Simpson's, Shannon's and Sørensen's were calculated in terms of spiders' families, in order to evaluate their temporal evolution and the relation to crop management systems. This purpose is accomplished in the context of generalized linear models and cluster analysis of dissimilarity matrices.

Keywords: Araneae, biodiversity indexes, cluster analysis, cultural practices, dissimilarity coefficients, GLM, *Olea europaea*

1 Introduction

All spiders (Araneae) are predators that feed primarily on insects and other arthropods (Wise, 1993). Many studies have revealed that spiders are a large fraction of the predator fauna in agroecosystems, both in terms of population density and in diversity of species (Ghavami, 2006), representing the most diversified group and, after the ants, the most abundant group of predators in olive groves (Morris *et al.*, 1999). It was observed that spiders are more sensitive than their prey to pesticides: thus the absence of these predators can induce pest outbreaks (Maloney *et al.*, 2003). Some cultural practices, as the use of pesticides, bring changes in spider composition (Santos *et al.*, 2007). The purpose of the present study was to characterize spider biodiversity of three olive groves subjected to different intensities of cultivation practices. The effect of three different sampling tools was also evaluated.

2 Materials and Methods

In May 2010 a research was initiated in three olive groves in the countryside of Valenzano (Bari, Italy) to assess the influence of different management systems on the spider fauna. The study was conducted until March 2011 in three olive groves: a private olive grove (field A) and two experimental groves (fields B and C) managed by the Faculty of Agriculture (University of Bari). Field A was abandoned, at least over the last decade, Field B was under minimized agronomical practices and Field C was under a larger number of farming practices (insecticide treatment and weed control). Spiders were collected fortnightly using three different sampling methods: 1) pitfall traps for collecting wandering spiders at ground level; 2) cardboard bands placed around the trunk for spiders sheltering between the bark anfractuosities; 3) frappage for sampling spiders living on the foliage of the olive trees. In each grove, five pitfall traps about 15 meters apart were placed. Pitfall traps, having a diameter of 12 cm and a height of 12 cm, were buried up to the top and filled to fourth with a mixture to preserve the animals collected. A cardboard band about 15 cm high, was wrapped in 3 to 4 laps around the trunk of five olive trees per field, at about one meter above the ground level. Collection by frappage was carried out on five trees per grove, selected randomly at each sampling. Two branches per tree were beaten over an entomological umbrella (1m x 1m), collecting all the spiders dislodged. Overall, five units were taken per each sampling method (pitfall, cardboard bands, frappage on plant) and olive grove (A, B, C). In the laboratory all the spiders collected were identified using dichotomous keys. Most of the spiders were released in the respective collection field after identification. As measures of α-biodiversity the Shannon and Simpson indexes were calculated for each date, field and sampling method (summarizing the five replications). While the Shannon index depends on the number of families identified and on the evenness of their abundance, the Simpson index measures the probability that two individuals randomly selected from a sample will belong to the same family. The variation of both measurements with time, habitat and sampling method was investigated by generalized linear models (GLM, Zuur *et al.*, 2009). In order to compare the different habitats and sampling methods a measure of β-biodiversity as Søresen index was also considered. This index measures the dissimilarity between pairs of objects and was calculated for each combination of habitats and sampling methods. Cluster analysis based on such a dissimilarity matrix was subsequently applied.

3 Results

GLM's for the Shannon and Simpson indexes were fitted considering the same set of effects: habitat, sampling method and linear time trend. Standard routines contained in the statistical environment `R` (R Development Core Team, 2008) were used throughout. The two response variable were both preliminary transformed in order to obtain tractable marginal distributions. The monotone transformation $1/(1+x)$

Effects	Shannon			Simpson		
	estimate	SE	p-value	estimate	SE	p-value
Field A	2.390	0.103	< 0.000	1.573	0.049	< 0.000
Field B	2.573	0.107	< 0.000	1.613	0.049	< 0.000
Field C	2.769	0.110	< 0.000	1.740	0.051	< 0.000
bands	-	-	-	0.037	0.044	0.402
beat	-	-	-	0.111	0.043	0.012
time trend	-0.036	0.007	< 0.000	-0.011	0.003	< 0.000

Table 1: GLM's for Shannon and Simpson indexes, parameter estimates.

allows for null values of the biodiversity indexes (two observations with only one spider family) and produces a switch from left to right skewness compatible with the Gamma distributional assumption (inverse link). Overall model and effects significance were used to select relevant covariates of the two models reported in Tab. 1. The highest number of spiders was collected in field B, the lowest (less than half) in field C (the one with a higher cultural pressure), while intermediate values were observed in A. Gnaphosidae, mainly collected by cardboard bands, were the family clearly dominant in the three olive groves, they were followed by Zodariidae, collected exclusively by pitfall traps. The highest values of both Shannon and Simpson indexes were observed in the olive grove subjected to more intensive cultivation practices (field C), as a consequence of the greater evenness of spider families. While both indexes are significantly influenced by the habitat, only the Simpson index shows a significant difference of the frappage (beat) sampling method with respect to the other two. A negative linear time trend was detected for the two transformed indexes, implying a slight decrease of the α-biodiversity across time.

In Fig. 1 the heat map relative to the Søresen index (Borcard *et al.*, 2011) highlights similarities between habitats for each sampling method. For the frappage sampling method, the intensive management in field C can be distinguished from the others. From a cluster analysis point of view this leads to a higher heterogeneity in relation with this sampling method.

4 Concluding remarks

The higher intensity of some cultural practices, in particular treatment with insecticides, caused a decrement in biodiversity of spiders on the foliage of olive trees soon after the treatments. To obtain a more complete description of the spider fauna of an agroecosystem as the olive grove, different collection methods should be used simultaneously. The three methods used in the course of this research seem to complement each other, allowing to detect a greater number of families.

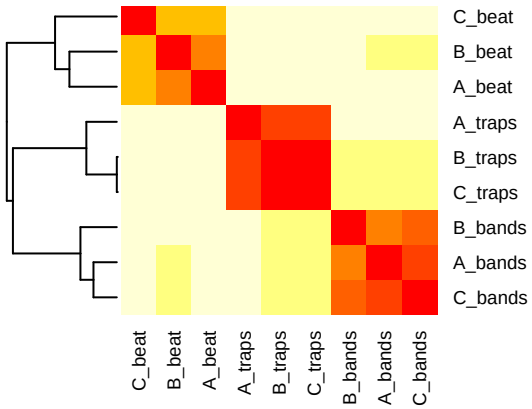

Figure 1: Heat map of the distance matrix based on Sørensen's index reordered according to the dendrogram.

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