INFLUENCE OF HYDROPERIOD, SUN EXPOSURE AND FISH PRESENCE ON AMPHIBIAN COMMUNITIES IN A HUMAN DOMINATED LANDSCAPE

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INTRODUCTION

Many studies outlined the importance of wetland features in determining amphibian distributions. However, habitat features can interact among them or with processes active in the landscape: in human dominated landscapes, human activities strongly modify the habitat features, and relationship between habitat features. These interactions can therefore influence the distribution of species living in the landscape, like the amphibians.

For example, water permanence should have at least partially a positive effect on community richness. Some amphibian species require long time for larval development: the effects of pond drying can be dramatic for these species, especially if the wetlands dry during the breeding season: only the species with fast growing tadpoles should prefer temporary wetlands for breeding (Skelly et al., 1999). However, many studies recognized the negative effects of fish presence on amphibians, since they predate larval stages of many amphibian species, and only few species can survive in fish inhabited wetlands. As a consequence, wetlands with fish frequently have very poor amphibian communities (Hecnar and McClosely, 1997). In human dominated landscapes, humans frequently introduce fish for sportive fishing also in semi-permanent, fish-free wetlands. Thus, it is possible that communities living in temporary wetlands are richer than those living in the permanent ones, since short-hydroperiod wetlands are the only ones without fish.

Again, human exploitation of landscape for agriculture can be negative for amphibians, since it decreases the terrestrial habitat available (Joly et al., 2001). However, the decrease of canopy cover can improve the sun exposure of wetlands, and therefore it could favor the abundance of thermophile species (Werner and Glenmeier, 1999).

Aim of this study was to investigate how hydroperiod, fish presence, sun exposure and agricultural use of landscape factors influence amphibian communities in a landscape strongly modified by humans. To better evaluate the ecological meaning of the relationship between these factors and amphibian presence, we focused our attention on the effects of human activities on these factors and on the relationship between factors.

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STUDY AREA AND METHODS

We investigated a surface area of 520 km^2 in the river Po floodplain, (Lombardy region, Northern Italy). This area surrounds the city of Milan and is one of the European areas with the largest agricultural and industrial development. The landscape is dominated by the presence of urban suburbs and agriculture. Only a few little wooded fragments still exist and the wooded surface is less than 5% of the landscape. We studied amphibian distribution in 84 wetlands (ponds, temporary pools and ditches). Each wetland was surveyed after dusk at least once every 3 weeks, during late winter, spring and early summer (February/June 2002). In each survey we detected adult presence, calling males, tadpoles, and spawn. We deep-netted each wetland for tadpoles in May, sampling banks and bottom. We recorded sun exposure as the percentage of wetland surface directly exposed to the sunshine between 11.00 a.m. and 1.00 p.m. (UTM) in May. We considered a wetland temporary if it dried up during the amphibian breeding season (February – June). We recorded fish as present if we observed them at least once during our surveys. We also recorded percentage of crop surrounding each wetland in a 250 m array surface on the basis of field surveys and of 1:10000 technical regional map, using a Geographic Information System.

Likelihood ratio test of logistic regression was used to evaluate the relationship between wetland features and the presence/absence of each species; linear regression and analysis of variance were used to evaluate the effects of habitat features on community richness.

RESULTS

Seven taxa of amphibians live in the study area: the Italian crested newt *Triturus carnifex*, the smooth newt *Triturus vulgaris*, the common toad *Bufo bufo*, the green toad *Bufo viridis*, the Italian tree frog *Hyla intermedia*, the Italian agile frog *Rana latastei* and the pool frog *Rana synklepton esculenta*. Since we observed *B. bufo* and *B. viridis*, respectively, only in one and three wetlands, we excluded them from some analysis. The average species richness per wetland is 1.3. The analyzed wetland features have a strong effect on the composition and richness of amphibian communities (Table 1). Two species (*H. intermedia* and *R. s. esculenta*) live mainly in sunny wetlands; newts are associated to temporary wetlands; fish presence seems to have a negative effect on the distribution of *T. carnifex*, *T. vulgaris*, and *H. intermedia*; only *R. latastei* distribution seems to be negatively affected by the abundance of surrounding crops. The richest communities live in sunny wetlands, in temporary wetlands and in wetlands without fish. We did not find a significant relationship between crop percentage and community richness (Table 1).

However, the relationship between some of these factors are strong, and they can not be considered independent. Fish presence is associated with permanent wetlands (likelihood ratio: $\chi^2_1 = 9.830$, $P = 0.0017$); wetlands surrounded by high crop percentage are those with the higher sun exposure (linear regression: $F_{1,82} = 7.683$, $P = 0.007$). Therefore, we used the residuals of the relationship between sun exposure and surrounding crop percentage as an independent variable and species richness as a dependent variable. Species richness strongly depend on the residuals of the relationship crop % — sun exposure (linear regression: $F_{1,82} = 12.607$, $P = 0.0006$): we found the richest communities in the wetlands with high sun exposure but with relatively low percentage of surrounding crops. The other pairwise relationships (sun exposure/crop % vs. fish presence/water permanence) are not significant ($P > 0.05$).

DISCUSSION

The analyzed wetland features strongly influenced amphibians communities. However, our results show a different pattern from studies performed in more natural landscapes (e.g., Skelly et al., 1999). Newt presence and community richness are strongly associated with temporary water. This pattern can be explained by the strong association between fish presence and water permanence: almost all the wetlands that do not dry annually are occupied by fish, since in this landscape fish are frequently released in almost all the wetlands for sportive fishing. The abundance of fish in this landscape is likely one of the causes of the low average species richness (Hecnar and McCloskey, 1997). Moreover, amphibians have to breed in temporary wetlands: this habitat is unpredictable, quickly evolving and frequently not protected by law. The conservation of a network of ponds with different hydroperiod, and possibly avoiding fish introduction, should be an important action for amphibian protection in agricultural landscape (Beja and Alcazar, 2003).

The most striking result of our study is the lack of relationship between agricultural exploitation of terrestrial habitat and amphibian presence: the percentage of surrounding crop seems to have negative effects only on *R. latastei*, a red-listed frog living in lowland broadleaf woods. The positive effect of sun exposure on amphibians communities can explain this pattern. Sun exposure is positively related to percentage of crop since woods are cut to increase the availability of land for agriculture. Higher sun

TABLE 1. Effects of Sun Exposure, Water Permanence, Fish Presence, and Percentage of Surrounding Cultivated Fields on Amphibian Communities

	Sun exposure		Water permanence		Fish presence		% surrounding crop	
	Effects on the presence/absence of five amphibian species (likelihood-ratio test)							
	χ^2_1	P	χ^2_1	P	χ^2_1	P	χ^2_1	P
Triturus carnifex	0.939	0.333	9.994	**0.0016 (–)**	6.258	**0.012 (–)**	1.475	0.225
Triturus vulgaris	0.518	0.472	3.765	**0.05 (–)**	7.211	**0.0072 (–)**	0.311	0.577
Hyla intermedia	28.988	**<0.0001 (+)**	2.952	0.086	7.241	**0.0071 (–)**	1.546	0.214
Rana latastei	2.017	0.155	0.445	0.505	2.017	0.155	5.634	**0.018 (–)**
Rana synklepton esculenta	17.637	**<0.0001 (+)**	1.852	0.174	2.588	0.108	0.116	0.733
	Effects on the richness of amphibian communities (ANOVA/linear regression)							
	$F_{1,82}$	P	$F_{1,82}$	P	$F_{1,82}$	P	$F_{1,82}$	P
Community richness	11.658	**0.001 (+)**	6.131	**0.015 (–)**	6.186	**0.015 (–)**	0.013	0.908

(+), indicate a significant positive association between the variable value and species presence/community richness; (–), indicate a negative association; in bold, significant results.

exposure causes higher water temperature and more light, and it can enhance tadpole growth rate: many species are thus more abundant in sunny wetlands (Skelly et al., 1999). Therefore, the effect of sun exposure could have masked the negative effects of loss of terrestrial habitat caused by agriculture: the negative effects of habitat loss are evident only after taking into account the strong relationship between sun exposure and crop presence. However, the positive effects of sun exposure do not reduce the concern for amphibian conservation in agricultural landscapes: only two species (*H. intermedia* and *R. s. esculenta*) benefit from high sun exposure, and these thermophile species are the most widespread and adaptable. The other five species, less favored by this factor, are now really rare in this landscape.

In a human modified landscape, the effects of relationship between the habitat features analyzed (hydroperiod, fish presence, sun exposure and terrestrial habitat) are extremely important for a correct interpretation of the distributional pattern of amphibians. In Europe almost all the landscapes have been strongly modified: the analysis of relationship between habitat features and processes active in the landscape can be extremely important to correctly understand the forces driving the species distribution.

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