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Efficiency of conservation shortcuts: An investigation with otters as umbrella species

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Abstract

The use of shortcuts is widespread in conservation practices to help ensure biodiversity conservation with minimal expenditures. An umbrella species is a species whose conservation confers protection to a large number of naturally co-occurring species. The aim of this study is to test the usefulness of the umbrella species concept for conservation management. As our umbrella, we chose a wide-ranging and flagship species, the European otter (*Lutra lutra*). Otters are widely distributed predators with numerous genera and species, so otter occurrence could virtually be used as ''umbrella'' in every freshwater habitat. To test the usefulness of the concept, we investigated whether an umbrella species might protect other species in the long term. We compared (1) bird and amphibian species richness in 1993 and in 2003 on nine sites where otters were monitored for 20 years, and (2) bird, amphibian and mollusc species richness between the previous sites and nine bio-equivalent sites where no otter occurrence has been detected for 20 years. The study was carried out for two spatial scales: total otter home range and core areas (most intensely exploited areas). Our results show that species richness was significantly different between years on sites inhabited by otters. However, we showed that biodiversity did not differ between pairs of bio-equivalent sites inhabited or deserted by otters, whatever the estimation method. Our results cast doubt on the validity of umbrella species use as an objective tool for conservation. However, the keystone functional role that otters could play in ecosystems might be an interesting way to reconsider the purpose of the umbrella species concept.

Keywords: Umbrella species; Biodiversity conservation; European otter; *Lutra lutra*

1. Introduction

Facing the increasing loss of biodiversity, conservationists have developed shortcuts directing toward one or a few focal species (Simberloff, 1998). Depending on conservation goals, several concepts of focal species have been distinguished (Caro and O'Doherty, 1999). The umbrella species concept has been proposed as a way to manage entire communities by focusing on the area requirements of the most demanding species (Lambeck, 1997). The objective is that preserving a viable population of a large-bodied and wide-ranging species could protect other members of the natural community (Berger, 1997). Several definitions of umbrella species have been proposed, but recently, Roberge and Angelstam (2004) suggested a consensual definition: ''a species whose conservation confers protection to a large number of naturally co-occurring species''. The umbrella species concept is appealing because it could allow the management of communities with minimal expenditures. However, despite the widespread mention of umbrellas, the use of such a concept in conservation strategies has given rise to much controversy. Some authors thought the concept may be effective (Fleishman et al., 2000, 2001; Suter et al., 2002; Caro, 2003; Kerley et al., 2003), nevertheless, several studies showed the use of the concept was limited or ineffective (Berger, 1997;

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Martikainen et al., 1998; Andelman and Fagan, 2000; Caro, 2001; Poiani et al., 2001; Rubinoff, 2001). In fact, there is little evidence that the requirements of a single species can encompass those of an entire community (Andelman and Fagan, 2000).

To what extent are these concerns about the efficiency of the umbrella species use justified in biodiversity conservation? Actually, the umbrella species concept could be helpful especially for the definition of size and type of habitats to protect (Caro and O'Doherty, 1999). Nevertheless, few studies have rigorously tested the usefulness of the concept for conservation planning (Roberge and Angelstam, 2004), and only two studies investigated umbrella species in the long term (Berger, 1997; Caro, 2003).

The aim of this paper is to test the efficiency of the umbrella species concept in conservation management. We selected a top predator, the European otter (*Lutra lutra*), as an umbrella species considering its large spatial requirements. Otters form a widely distributed subfamily with numerous genera and species, so otter occurrence could virtually be useful as "umbrella" in every freshwater habitat. European otters usually exploit a linear home range reaching 5–20 km of river banks and encompassing the surrounding wetlands (Green et al., 1984; Chanin, 1985). Otters are sensitive to pollution (Mason, 1996; Yamaguchi et al., 2003), and the species suffered a severe decline in most European countries (MacDonald, 1996; Robitaille and Laurence, 2002).

To test the usefulness of the concept, we investigated whether an umbrella species might protect other species in the long term. We then asked the following questions: (1) Does the protection of the European otter over several years permitted an increase in biodiversity? We analysed bird and anuran diversities (as they are good indicators of habitat quality) in 1993 and in 2003 on nine sites where a long term monitoring of otter populations has been carried out (i.e. 20 years of survey). (2) Does otter presence favor an increase in biodiversity compared to ecologically similar sites where this species is absent? We compared species richness of the nine previous sites with species richness of nine bio-equivalent sites where otter was considered as absent for the last 20 years. Moreover, the efficiency of an umbrella species in providing long-term conservation for other species mainly depends upon the fact that their life cycles are mostly achieved inside the umbrella species range (Caro, 2003). Thus, measurements of species richness were carried out at two spatial scales considering the life history traits of species.

2. Methods

The study was carried out in the Pays de Loire region, Western France. The climate is temperate and influenced by the nearby ocean: precipitation range from 600 to 800 mm per year, and average temperatures vary from 6.5 °C (January) to 16 °C (July). All study sites were located on the Armorican massif, and altitudes vary from 0 to 80 m. The area is largely covered by wooded farmlands (i.e. field surrounded by hedges of oaks and ashes). The hydrographical system is quite extensive in the region, and includes the Loire River.

Firstly, to assess whether the protection of the European otter led to an increase in biodiversity, we selected nine sites (one pond and eight sites on streams) where otter occurrence was surveyed consecutively for several years. Otter distribution was mapped in the Pays de Loire region since 1984 (Lodé, 1993). The method consists in searching for otter spraints by prospecting riverbanks on 600 m around an access point to the river (Reuther et al., 2000). Each study site corresponded to a mean adult male home range, namely 6 km (6.09 ± 1.39 km) of linear bank for streams or perimeter for pond. In otters, home range occupation is heterogeneous and patches of habitats are most intensely exploited (Green et al., 1984). On each site, a core area was defined (2.84 ± 0.87 km in length), using sprainting variations (Chanin, 1985; Lodé, 1996). On this area, otter activity is intense and quasi-constant.

Secondly, to assess whether the activity of the European otter resulted in an increase in biodiversity, species richness of the nine previous sites was compared to nine ecologically similar sites where no otter activity has been detected since 1984. When no signs of otter presence have been detected for 20 years despite a regular survey, it is reasonable to assume that the species is absent or rare in the area. To use the comparative method, pairs of sites must share similar ecological features. Consequently, we examined hydrologic characteristics of watercourses (width, water quality, and connection with the river Loire), and climatic and geologic conditions. Moreover, we recorded bank cover (percentage of ground vegetation, shrub layer and canopy cover) on each site. Sites were prospected by bands of 100 m in length and 50 m wide by two people who walked down the bank. Sites surroundings (general context, e. g. farmland) have also been checked.

Species richness and biodiversity indices were compared between years for sites with otter occurrence, and between similar sites with and without otter occurrence. In the standard acceptation of the umbrella species concept, relationships between the umbrella and the community are poorly established (Zacharias and Roff, 2001). We then selected three taxa poorly affected by otter predation: birds, anurans and mollusks. In addition, mollusc species richness allowed us to assess whether the protection of a vertebrate umbrella species could benefit invertebrate cohabitants. Birds, amphibians and mollusks were selected because they co-occur with otters in freshwater habitats, nevertheless for birds and mollusks which can belong to more terrestrial systems, aquatic species have been distinguished. Fish form the bulk of otters' diet, however the species is an opportunistic predator and variations in otter's diet are observed throughout its range (Chanin, 1985; Clavero et al., 2003).

The method used to assess bird diversity consists in identifying breeding species in a fixed sampling spot where all birds seen or heard are recorded. Two point counts were carried out on each site: between 15 April and 15 May, and between 20 May and 16 June.

To assess anuran diversity we searched for calling males and clutches to identify breeding sites. Depending on species, clutches are laid from February (e.g. *Rana dalmatina*) to May (e.g. *Rana kl. esculenta*). Because censuses of calling males can misrepresent population size, we took into account the presence or absence of species rather than their relative abundances.

To assess mollusk diversity, largest and most common species (e.g. *Helix aspersa*) were identified *in situ*. Samples of soil and litter were gathered and sieved (5 mm-mesh) in order to collect smallest species. Remains (shellfish) left on river banks have also been checked.

Two diversity indices were estimated: the Simpson diversity index: $D = 1/\sum(n_i/N)^2$, and the Shannon–Weaver Diversity Index: $H' = -\sum(n_i/N)\cdot\log_2(n_i/N)$, where n_i represents the number of individuals in group i, N represents the total number of individuals.

Patterns of co-occurrence of species strongly depend on the scale of the study, and populations of different taxa are evolving at different scales (Wugt Larsen and Rahbek, 2003). Core areas were defined more on sprainting regularity than on sprainting quantity which strongly depends on consumed preys. For birds, the study was conducted at the two spatial scales, whereas for anurans and molluscs the study was conducted only on core areas.

3. Results

Sites can be paired with respect to their hydrological characteristics. Percentage of bankside cover did not differ significantly between sites (ground vegetation: Mann–Whitney, $U = 39.0$, $p = 0.93$, $n = 18$; shrub layer: $U = 38.0$, $p = 0.86$, $n = 18$; canopy cover: $U = 32.0$, $p = 0.49$, $n = 18$). Moreover, all sites were selected on the same general context which consists in dispersed habitats with cultivated lands and breeding farms. These results suggested that sites were similar and the comparative method can be applied to detect differences in the diversity of sites with and without otters.

A total of 59 different bird species were recorded in 1993 and in 2003 on sites where otter occurrence was monitored for a long time (list of species available upon request). We performed Welch's approximate *t*-tests which do not assume the equality of the two sample variances. On each site, the number of bird species was significantly different ($t_{\text{Welch}} = 8.6$, $p < 0.0001$, 12 df), with a lower number of species encountered by site in 1993 than in 2003. Aquatic bird species richness differed marginally significantly between years ($t_{\text{Welch}} = 2.1$, $p = 0.05$, 15 df). When considering core areas, the number of species by site was significantly lower in 1993 than in 2003 ($t_{\text{Welch}} = 4.4$, $p = 0.001$, 11 df).

We encountered 59 bird species on sites where otters were present vs. 62 species on bio-equivalent sites with no otter occurrence. The number of species did not differ significantly between sites with or without otters ($t_{\text{Welch}} = 0.2$, $p = 0.81$, 13 df). Nevertheless, sites with otters had marginally significantly more aquatic species than bioequivalent sites with no otters ($t_{\text{Welch}} = 2.0$, $p = 0.07$, 15 df). In addition, our results showed no significant differences between the two types of sites when considering the total number of species on core areas ($t_{\text{Welch}} = 0.8$, $p = 0.43$, 15 df). Nevertheless, core areas of sites with otters had significantly more aquatic bird species than core areas with no otters ($t_{\text{Welch}} = 2.4$, $p = 0.03$, 12 df). Moreover, there was no significant relationship between mean number of species and total site length ($r_S = -0.61$; $p = 0.11$).

Seven anuran species were recorded in 1993 and in 2003 on sites with otter occurrence. Species richness did not differ significantly between years ($t_{\text{Welch}} = 0.8$, $p = 0.4$, 13 df).

Seven anuran species were encountered on sites with otter vs. six species on bioequivalent sites with no otter occurrence. Species richness did not differ significantly between sites ($t_{\text{Welch}} = 1.7$, $p = 0.11$, 15 df). Moreover, no significant correlation was found between mean number of species encountered and the length of the core area ($r_S = -0.22$; $p = 0.60$).

A total of 23 mollusk species were encountered on sites with otters vs. 24 species on bio-equivalent sites with no otter occurrence. Mollusk species richness did not differ significantly between sites neither when considering all species ($t_{\text{Welch}} = 1.2$, $p = 0.88$, 6 df) nor when considering aquatic species ($t_{\text{Welch}} = 1.4$, $p = 0.21$, 7 df).

The mean number of species recorded by site (Table 1) was significantly lower in 1993 than in 2003 on sites with otters ($t_{\text{Welch}} = 4.3$, $p = 0.001$, 12 df). Both the Simpson Diversity Index (D, Table 1) and the Shannon Diversity Index (H', Table 1) differed significantly between this two time periods (D: $t_{\text{Welch}} = 2.6$, $p = 0.02$, 13 df, and H': $t_{\text{Welch}} = 2.6$, $p = 0.02$, 15 df).

The mean number of species recorded on sites with otter occurrence and bio-equivalent sites without otters (Table 2) did not differ significantly ($t_{\text{Welch}} = 0.3$, $p = 0.79$, 15 df). In addition, neither the Simpson Diversity Index (D, Table 2) nor the Shannon Diversity Index

Table 1
Mean values and standard deviations of the number of species (S), Simpson Diversity Index (D) and Shannon Diversity Index (H') on sites with otter occurrence in 1993 ($n = 9$) versus in 2003 ($n = 9$), (***$p < 0.001$, *$p < 0.05$)

	Otter 1993	Otter 2003	t_{Welch}
S	22 ± 3	30 ± 5	4.3***
D	1.49 ± 0.10	1.39 ± 0.06	2.6*
H'	0.73 ± 0.08	0.65 ± 0.06	2.6*

Table 2
Mean values and standard deviations of the number of species (S), Simpson Diversity Index (D) and Shannon Diversity Index (H') on sites with otter occurrence ($n = 9$) versus bio-equivalent sites without otters ($n = 9$), (ns: not significant)

	Otter 2003	No Otter	t_{Welch}
S	34 ± 7	33 ± 9	0.3 ns
D	1.70 ± 0.31	1.79 ± 0.38	0.5 ns
H'	1.00 ± 0.30	1.02 ± 0.36	0.2 ns

(H', Table 2) differed significantly between this two categories of sites (D: $t_{\text{Welch}} = 0.5$, $p = 0.62$, 15 df and H': $t_{\text{Welch}} = 0.2$, $p = 0.87$, 15 df).

4. Discussion

The European otter usually occupies a large home range, an essential quality for an umbrella species. Moreover, most common criteria for selecting umbrella species are medium rarity, sensitivity to human disturbance and mean percentage of co-occurring species (Fleishman et al., 2000, 2001). Otter satisfied all criteria, and with numerous genera and species all around the world, otters could be helpful in conservation management, for instance to delineate areas of conservation. However, the usefulness of the umbrella species concept in conservation management is not well supported by this study.

Our results showed an increase in species richness between 1993 and 2003 on sites with otter occurrence. This results from an increase in bird species richness, whereas anuran species richness did not differ. Bird community composition in riparian zones mainly depends on landscape characteristics as riparian vegetation structure (Sanders and Edge, 1998; Jansen and Robertson, 2001). Birds could belong to more terrestrial communities than the proportion that otter use them. Functionally, this group may form different assemblages compared to the freshwater proportion of habitat used by otters. On sites with otter occurrence, management efforts were realized especially for preserving bankside vegetation. The conservation of good quality habitats for otters could then benefit some other species in the long term. Nevertheless, no differences were observed between bio-equivalent sites with and with no otters whatever the taxa or the estimation method. Only aquatic birds were positively associated with otter presence on core areas. In fact, our results suggested that the increase in species richness was due to the global amelioration of habitat quality in the time period considered and was not associated with the presence of otters. Consequently we could allege that the European otter is a poor umbrella species.

It could be objected that sampling is not large enough to be representative. Nevertheless, three taxonomic groups were taken into account on 18 study sites whereas most of the previous studies investigating the umbrella species concept considered one or two taxa (Berger, 1997; Martikainen et al., 1998; Rubinoff, 2001; Fleishman et al., 2001). In addition, sites were selected for their similarity and general context was checked to be equivalent between sites with and without otters.

It can be assumed that biodiversity did not differ between sites with and without otter occurrence because taxa like amphibians and molluscs are not sensitive to the same environmental features than otters. Anuran distribution is mainly affected by the amount and distribution of suitable breeding habitats (Parris and MacCarthy, 1999). Mollusc community composition is largely influenced by climatic factors and habitat heterogeneity (number of substrate type present) (Harman, 1972). In fact, the conservation of otters' habitats did not benefit these species because they seem to be affected by ecological factors which did not influence otter distribution. Through usually considered as fish-eaters, otters are opportunistic predators which can compensate for the lower abundance of fish by preying more on other aquatic preys like crayfish, amphibians and aquatic invertebrates (Clavero et al., 2003). It could be noticed that the umbrella species concept does not imply ecological requirements a priori. In addition, pairs of sites with and without otter occurrence were selected for their ecological similarity. Here, there is no ecological evidence that otter's home range is more diversified than a bio-equivalent site without otters.

Actually, the umbrella species concept seems to be quite unrealistic because this concept purports to join the advantages of a flagship species (supposing no ecological requirements) and the effectiveness of a keystone species conservation (supposing an understanding of ecological processes). Fleishman et al. (2000, 2001) suggest that by selecting a set of species used together, umbrella species might constitute effective tools for conservation management. Additionally, Martikainen et al. (1998) proposed that the assumed umbrella species and 'target species' must share similar ecological requirements, in spite of the fact that large area theoretically provides habitats for a larger number of species. Thus, the protection of the Capercaillie (*Tetrao urogallus*) could only benefit mountain birds (Suter et al., 2002). Otters are habitat specialists so their home range probably encompasses fewer species than ranges of more generalist carnivores.

Conditions for applying in concrete terms the umbrella species concept should be however definitively reviewed. Focalizing on ecosystem engineers might be an interesting way to reconsider the purpose of the umbrella species concept. Ecosystem engineers are species whose activity is supposed to promote biodiversity by creating new habitats (Jones et al., 1994), like beavers (*Castor canadensis*) or elephants (*Loxodonta africana*). These species might be good umbrellas for sympatric species. Indeed Caro (2003) found that elephants were good umbrella species for reserve design in East Africa.

Anyway, the efficacy of umbrella species (per se) use is dubious for preserving biodiversity. The only way to improve the efficacy of umbrella species should be to take into account most of functional links between umbrella species and other background species, thus changing the umbrella species acceptation. Undoubtedly, the conservation of otters remains a priority in freshwater management considering (i) the important decline the species suffered during the last decades and (ii) the functional role that otters could play in aquatic ecosystems.

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