IS THE OTTER A BIOINDICATOR?

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Abstract

The Otter declined throughout its distribution area. Main causes were the humans and its activityies. Pollution, mainly due to bioaccumulable microcontaminants, or contaminants affecting the food availability, could be the main cause of this decline. For this reason, this mustelid is a candidate for acting as a bioindicator species. The distribution of the otter has been compared with a pollution visual index and the distribution of several Orders of Macroinvertebrates (used universally as bioindicator species) and two indexes based on the abundance and diversity of these animals. *Lutra lutra* was found significantly more frequently in sites with null or low apparent contamination, in both the periods 1984-85 and 1989-90.The otter tended to behave in the same way as the macroinvertebrate Orders as a whole, as the Plecoptera and as the BMWP and ASPT indexes. The otter appears to us to be a bioindicator species, useful for the conservation state of freshwater ecosystems. But they are not bioindicating the same thing: differences which can indicate to us clear differences in their biology, ecology and recent history can be appreciated. The otters are useful in establishing the conservational state of riparian ecosystems. The dinamics of otter's populations and the recovery of some of them as a response to a certain improvement in the water quality of the rivers, reinforces its role as bioindicator. The simultaneous use of the otter and macroinvertibrates presents a useful, complementary tool.

Key words: Bioindicators, Iberian Peninsula, macroinvertebrates, Otter, rivers.

Resumen

¿Es la nutria un bioindicador?

La nutria paleártica sufrió un importante proceso de rarefacción en toda su área de distribución. El declive fue muy rápido, siendo el agente causal último el hombre y sus actividades; el factor que explica mejor una regresión global y simultánea es la contaminación, principalmente la originada por los microcontaminantes de tipo bioacumulable o la que afecta a la disponibilidad de alimento. La posible sensibilidad de este mustélido a determinados niveles de contaminación han hecho que se le presente como especie bioindicadora. Se ha comparado la distribución de la nutria con la contaminación aparente (índice visual), con la distribución de determinadas especies de macroinvertebrados (utilizados universalmente como especies bioindicadoras) y con diversos índices basados en la abundancia y divesidad de estos animales. *L. lutra* fue encontrada con una frecuencia significativamente mayor en las estaciones con contaminación aparente nula o baja del Nordeste Ibérico, tanto en 1984-85, como en 1989-90. Además, en la cuenca del Ebro la nutria tendió a comportarse significativamente de la misma forma que el total de Órdenes de macroinvertebrados, que los Plecópteros, y que los índices BMWP y ASPT. Los resultados obtenidos están de acuerdo con la hipótesis de que la nutria se comporta como una especie bioindicadora del estado de conservación de los ecosistemas dulceacuícolas y de la contaminación del agua, aunque la información que da es diferente a la de los macroinvertebrados al presentar importantes diferencias de reproducción, ecología, comportamiento e, incluso, sensibilidad. La especie es útil para establecer el estado de conservación de los ecosistemas riparios. La expansión de la nutria como respuesta a una cierta mejora de la calidad del agua de los ríos refuerza su carácter de utilidad como bioindicador. Su utilización simultánea con los macroinvertebrados se presenta como una herramienta útil y complementaria a estos.

Palabras clave: bioindicadores, macroinvertebrados, Nutria, Península Ibérica, ríos.

INTRODUCTION

The Eurasian otter *(Lutra lutra* L.) has declined throughout its distribution area during the second half of the 20th century (Mason and Macdonald1986). In the Iberian Peninsula, the species has disappeared mainly from the East, particularly from the vicinities of large towns, industrial zones, large agricultural valleys and the coastline - those areas most densely populated by Man (Delibes 1990; Ruiz-Olmo and Delibes 1998). This process has been rapid, and in general, unobserved. Undoubtedly, the most recent causal agent of this situation has been human activitiy.

Many causes of the decline have been highlighted in the literature (persecution, destruction of habitat, heavy water usage, decrease in prey populations); nowadays however, although all these causes have been prominent, pollution in particular has been responsible for a simultaneous global decline, such as that which occurred between the 1950s and the 1980s (Mason 1989). Although there is still no consensus, bioaccumulable microcontaminants, especially organochlorine compounds (polichlorobifeniles -PCBs- and pesticides -DDTs, dieldrins, lindane, ...) are most commonly accepted as having been responsible for the rapid and dramatic regression of *L. lutra* (Mason 1989; Mason and Macdonald 1986; Smit et al. 1994). Other authors, whilst not denying the effect of these compounds in particular cases, prefer to justify the process by basing it on a more ample spectrum of contaminants, for example heavy metals (Kruuk 1995). In some cases, this decline is not the direct effect of contamination on the otter but on the species which make up its diet: the disappearance of these species would impede the otter's permanent presence.

In Spain studies have been carried out on the content of organochlorine compounds in otter tissues (Ruiz-Olmo et al. 1995 and 1998) and the factors of biomagnification with respect to their levels in prey tissues (López-Martín and Ruiz-Olmo 1996). Likewise, it has been observed that the otter tends to inhabit areas in which the levels of organochlorine compounds in the muscular tissue of fish is less than 0.10 ppm of PCBs with respect to fresh weight (Ruiz-Olmo and López-Martín 1994; Ruiz-Olmo et al. 1998). However, causality has not been demonstrated. Nevertheless, the sensitivity of this mustelid to certain levels of contamination seems clear, and explains why it has been repeatedly proposed as a bioindicator.

Recently, the concept of a bioindicator species has been extended, it understood as species that is highly sensitive to variations in enviromental conditions, in such a way that its presence/absence or abundance can be used to establish tolerance levels in those conditions (Knopp 1954; Kothe 1962; Woodiwiss 1964; Pesson 1979; Helawell 1987). In terrestrial aquatic ecosystems Macroinvertebrates have been the most frequently used bioindicators of water quality and pollution (Valentine 1973;

Westman 1978; Salvasser et al., 1982; Brennan 1984), due to their high susceptibility to those factors, and because they are relatively easy to study. In the Iberian Peninsula, and specifically in the Ebro Basin and the North-east, they have been wodely used (Prat 1980; Prat et al. 1983; C.H.E., 1996a, b, 1997).

In what way is the otter a bioindicator? And what significance does this have ? As a bioindicator, the otter would behave in a similar way to macroinvertebrates. In the present study, the distribution of the otter and determined groups of macroinvertebrates is compared in order to attempt to demonstrate the role of the former as a bioindicator.

Study Area

In the dry low areas, the hydrographic network is poor and only consists of the main river and the final stretches of the main tributaries (Ega, Arga, Aragón, Gállego, Alcanadre, Cinca, Segre, Montsant, Najerilla, Iregua, Cidacos, Jalón, Huerva, Martín, Guadalope, Matarranya and Canaletes). The latter act as collectors of extensive subbasins, which have a much denser network of watercourses in the mountains.

The physiographical characteristics can be consulted in Riba et al. (1979), Ruiz (1982), Rivas-Martínez (1984, 1987), Santanach et al. (1986), Folch et al. (1989), Loidi and Bascones (1995) and Ceña et al. (1996).

For the study of the visual contamination index, data was also used from the remaining hydrographic basins of Catalonia (Muga, Fluvià, Ter, Daró, Tordera, Besós, Llobregat, Foix, Gaià, Francolí, Riudecanyes and Sènia).

Methods

Distribution of the Otter in Catalonia and the East of Aragón between 1984 and 1990

The data comes from the otter surveys carried out in the NE of the Iberian Peninsula in 1984-85 and in 1989-90 (Ruiz-Olmo 1995), following the standard method (Mason and Macdonald 1986). This was based on the surveying of sampling stations, a maximum of 600 m long, and are distributed homogeneously throughout the study area. Here, signs of the otter were searched for: foot-prints, spraints, marks and anal jellies. In this way, the presence-absence of *L. lutra* for each one of the stations was established. A total of 449 and 226 stations, respectively, were surveyed in the study area.

Distribution of the Otter in the Ebro Basin between 1994-97

The data comes mainly from the Second Spanish Otter Survey, carried out between 1994 and 1996 (Ruiz-Olmo and Delibes 1998), using the same standard method as in the former case, based on the search for indirect signs of the otter's presence in stations 600 m long. In this way, a total of 706 stations were surveyed. Other complementary information was added to this data, taken from surveys which were carried out between 1994 and 1997 in Catalonia, Aragón, Navarra and La Rioja, consisting of random sampling stations, in order to improve the existing information. In all the cases, the presence-absence of the otter was equally established.

In this way, the watercourses and waterbodies in which the species was present in a habitual or sedentary manner during the period of the study were also established.

Distribution of the macroinvertebrates

414 sites distributed throughout the whole hydrographic Ebro Basin were surveyed during 1996. In all of them, the number of Orders of macroinvertebrates present was established, and the presence-absence of the follow Orders: Tricoptera, Plecoptera and Odonata. Likewise, the values of two biotic indexes were calculated which are used frequently in water quality studies:

a) BMWP (Biological monitoring working party) (Hellawell 1978; Armitage et al. 1983), modified by (Alba and Sánchez 1978) for catchments pertaining to the Iberian Peninsula. It is the sum of the value assigned to the existing taxonomic groups in the sample. Simplifying the five levels proposed by Alba and Sánchez (1978), in the current study the following types of watercourses have been considered:

I and II. BMWP<60. Water very clean or clean, in some cases some levels of pollution can be present.

III to V. BMWP<60. Polluted to heavily polluted waters. b) ASPT (Average Score per Taxon). This is calculated by dividing BMWP by the number of taxonomic groups which enter into the calculation. It represents the value of a theoretical taxon for each sampling station.

Index of Visual Apparent Pollution and Otter

During the Otter surveys carried out in NE Iberian Peninsula between 1984 and 1990 (Ruiz-Olmo 1995), an estimate of the apparent quality of water based on a visual index was carried out. This index was established according to the following criteria:

a) *Null*. Pollution not observed. Transparent water. Animal and plant communities apparently not altered.
b) *Low*. Slight organic contamination (mainly from humans and livestock) can be noticed but this does not affect the vegetation nor the fauna. An

increase can be observed in the production of fish or in the proliferation of algas and aquatic plants. Occasional foam or in low quantities.

c) *Medium*. Waters tending to be eutrophic in cases of organic contamination, with a proliferation of algas. There may be contamination of a chemical type. The substitution of fish and plant communities for other more generΩæ ones found downstream is noticeable. The water is usually more opaque, with little foam and, in some places, with a characteristic colour and smell.

d) *High*. Organic and/or chemical contamination very high. Some fish species still remain (mainly the most resistant species: carp, eel,...), but in generally low or very low densities. Water opaque with foam and floating materials, frequently with characteristic colour and smell.

e) *Very high*. Water coloured, smelly, dirty, highly frequent presence of foam and floating materials. No fish species present. Generally without well-developed riverside vegetation.

Analysis of the Results

The statistical analysis has been carried out by means of contingency tables, in those where the significance has been calculated through the chi-square test.

Results

Index of Apparent Pollution

The otter was detected with significantly greater frequency in the sites with null or low apparent pollution (figure 1), in both surveys in 1984-85 (X2 = 10,87; 1 g.l.; p < 0,01) and 1989-90 (X^2=44, 46; d.f.=2; p<0,001).

Comparison of the Otter and Macroinvertebrate Distributions

In figure 2, the main results that were found with regard to the otter's distribution in the Ebro Basin are shown, and the parameters related to the macroinvertebrates with those in which the connection was closest. The otter tended to behave in the same way as the macroinvertebrate orders as a whole (X^2=51,04; d.f.=1; p<0,0001), as the Plecoptera (X^2= 37,91; d.f.=1; p<0,0001), as the BMWP index X^2=27,35; d.f.=1; p<0,0001) and as ASPT index (X^2=17,53; d.f.=1; p<0,0001). With Odonata a similar tendency was given (X^2=15,58; d.f.=1; p=0,0001), although large extentions of the study area were found in which their distribution did not coincide with that of the otter. The Tricoptera were found throughout almost all of the study area.

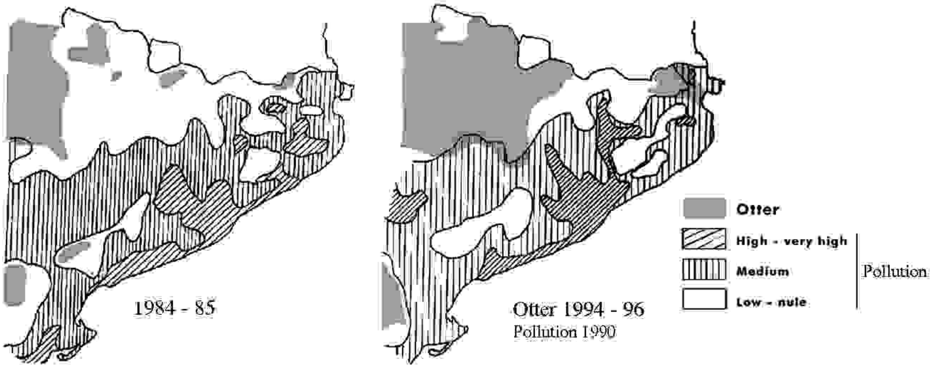

Figure 1. Distribution of the otter and index of apparent contamination in the NE Iberian Peninsula

Distribución de la nutria e índice de contaminación aparente en el norestede la Península Ibérica

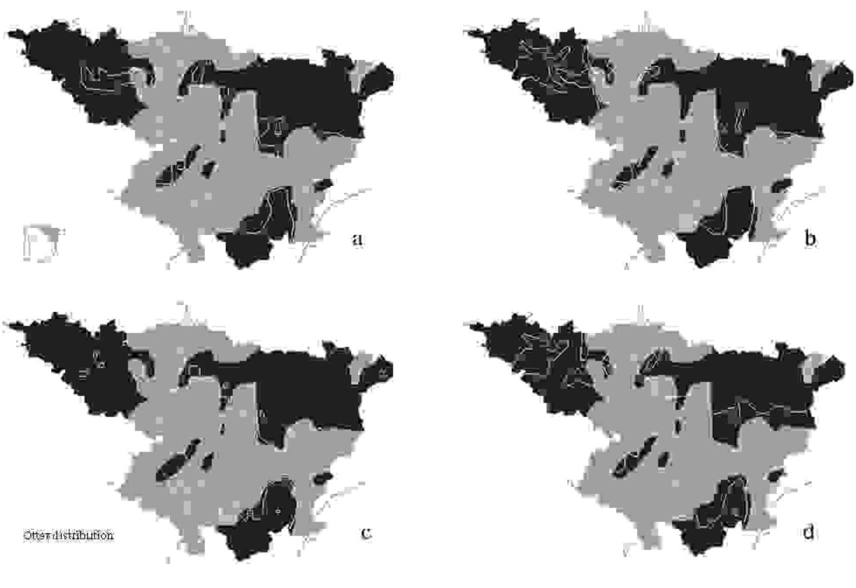

Figure 2. Comparison between the distribution of the otter in the Ebro Basin in 1994-97 (in dark grey) and: (a) BMWP >60, (b) ASPT > 4.5, (c) Number of families of macroinvertebrates > 12 and (d) Presence of Plecoptera. The white line indicates the referenced isocline with the maximum values towards the peripheral area, coinciding with the mountains

Comparación entre la distribución de la nutria en la cuenca del Ebro en 1994-97 (gris oscuro) y: (a) BMWP>60, (b) ASPT>4,5, (c) número de familias de invertebrados>12, y (d) presencia de Plecópteros. La línea clara indica la isoclina a la que se hace referencia, con las máximos valores hacia el área periférica, coincidiendo con las montañas

Discussion

The obtained results agree with the hypothesis that the otter is found in places which were less polluted. Furthermore, this mustelid tended to be found in the same places as several of the macroinvertebrates, especially those of the Orders Plecoptera This Order is used particularily for establishing water quality level, just as it has been pointed out in the Introduction, and the pollution levels (most noticeably the families Perliidae, Perlodidae, Cloroperliidae and Leuctridae). The otter's distribution area also coincided to a great extent with that of the sectors of the indexes ASPT and BMWP, exceeding values of 4.5 and 60 respectively.

These results confirm the fact that the otter behaves as a bioindicator of the state conservation of freshwater ecosystems and, more specifically, the quality of water and pollution levels. However, the fact that the otter's distribution and that of the macroinvertebrates, Plecoptera and the ASPT and BMWP indexes were not exactly the same, does not pass unnoticed. Although they tend to be similar, differences which can indicate to us clear differences in their biology, ecology and recent history can be appreciated. In short, they are not bioindicating the same thing.

The factors we must keep in mind are different. The otter has a longer biological cycle: sexual maturity at 2-3 years (Mason and Macdonald 1986) with 1-4 young per litter (Ruiz-Olmo 1994; Kruuk 1995); the macroinvertebrates can have thousands of descendants per generation (Blas et al. 1989). The latter, then, respond much more quickly to changes than the otter due to its greater capacity for recolonisation. The otter would be absent in some areas in which the habitat quality (water included) allows its presence, but would not yet have arrived because it occupies the nearer areas of its actual distribution.

However, the distances the otter moves are much greater, with individual home ranges of up to 100 km and daily movements of up to 20 km (Kruuk 1995; Ruiz-Olmo et al. 1995 b; Saavedra et al. 1997). On the contrary, macroinvertebrates usually complete their larval phase over short distances, displacing themselves with short flights (Blas et al. 1989). These differences mean that otters can move more easily than macroinvertebrates to distant places if they are suitable. Here lies another of the characteristics which makes otters less comparable. Being a top predator, the otter can move to places which at first seem suitable, where it can live but not complete its biological cycle because of the bioaccumulation of microcontaminants, disappearing from these points as if they were holts (Ruiz-Olmo 1995). On the contrary, the macroinvertebrates would be more tolerant to pollution, because they are found in lower levels of the food chain. If this was true, the otter would have to be more sensitive to contamination than the macroinvertebrates. Figure 2 shows that the otter's area of distribution is generally more restricted than of the macroinvertebrates, which would agree with this hypothesis: the otter would be a bioindicator of more extreme pollution situations than macroinvertebrates. However, one final factor has to be evaluated. The otter may be missing from some areas for reasons other than pollution and water quality: the lack of sufficient food (Kruuk 1995; Ruiz-Olmo et al. in press), high altitude (Ruiz-Olmo 1998), the destruction of habitat, or simply because an isolated stretch is insufficiently large enough for a viable population of otters (Ruiz-Olmo et al. 1991). These situations can explain the absence of the otter from some areas in which the presence of Plecoptera would make us expect its presence. But, why is the otter missing from areas in Navarra, Rioja, Zaragoza, Teruel, Lleida or Tarragona where fish are abundant, the habitat well-conserved and the effect of isolation non-existent ? Again, the otter's greater sensitivity to determined types of pollution could constitute the most plausable explaination, since it would disappear before the macroinvertebrates, although one might hope that in this case, other factors are being superimposed.

The otter, then, appears to us to be a bioindicator species, sensitive to levels of pollution. However, we can never lose sight of its sensitivity to the state of the conservation of the riparian and aquatic ecosystems and the food availability, which although are of a less global effect, are also factors which affect this mustelid (Mason and Macdonald 1986; Macdonald and Mason 1994; Kruuk 1995).

The otter is a bioindicator affected by various factors and therefore very useful in establishing the state of the conservation of riparian ecosystems. It should be remembered that this species does not depend solely on water, since it is also sensitive to the destruction of its habitat in general.

To summarise, it can be concluded that whilst macroinvertebrates indicate a lot about the precise conditions of one place in particular, the otter responds to variations on a much greater scale, integrating the factors of much wider effects than the macroinvertibrates and explaining variations in the conditions of the environment on a regional scale.

Not only do we expect a bioindicator species to respond by suffering as a result of changes, in the sense of environmental degredation. In the face of improvements in water quality and the state of conservation of its habitat, a bioindicator species has to respond positively to this change. In recent years the quality of the water in many parts of the Iberian Peninsula has been improving due to purification (C.H.E. 1996 a and b; Junta de Sanejament 1997) and the substitution of pesticides and other substances for other less persistent, less bioaccumulable and less toxic types, which also decrease the levels released into the biosphere (Stout 1986; Olsonn and

Reutegard 1986; Bignert et al. 1993; Mason 1998). In the face of such a situation, one could hope for an improvement in the otter populations. This is being observed in Spain (Ruiz-Olmo and Delibes 1998), and also in other parts of Europe (Andrews et. al. 1993; Green and Green 1987; Rosoux et. al. 1996; Strackan and Jefferies 1996). This fact serves to confirm the role of the otter as bioindicator. The simultaneous use of the otter and macroinvertibrates presents a useful, complementary tool.

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