ELSEVIER

Biological Conservation 86 (1998) 179–183

BIOLOGICAL CONSERVATION

Changes in otter *Lutra lutra* distribution in Central Spain in the 1964–1995 period

Y. Cortés [a], R. Fernández-Salvador [b,*], F.J. García [b], E. Virgós [c,**], M. Llorente [d]

[a] *Grupo de Investigación en Vida Silvestre, Departamento Geografía, Universidad de Cantabria, Avda. de los Castros s/n, 39005 Santander, Spain*
[b] *Departamento Biodiversidad y Biología Evolutiva (C.S.I.C.), Museo Nacional de Ciencias Naturales, C/ José Gutiérrez Abascal 2, 28006 Madrid, Spain*
[c] *Departamento Biología Animal I, Facultad Biología, Universidad Complutense, 28040 Madrid, Spain*
[d] *C/Félix Rodríguez de la Fuente 2, 28670 Villaviciosa de Odón, Spain*

Received 20 February 1997; received in revised form 8 December 1997; accepted 11 December 1997

Abstract

Surveys carried out in 1964, 1984 and 1995 of otter *Lutra lutra* distribution were compared in order to analyze its changes in distribution in Central Spain. These changes were studied from different areas defined by their physiognomy and human population density. During the 1960s, the species was well distributed throughout the study area but this was followed by a decline and a more recent recovery. Several negative factors (i.e. pollution, human disturbance, habitat destruction, hunting) extinguished or fragmentated some populations. During the last period (1990s) some populations have recovered, probably through recolonization from neighbouring areas supporting healthy populations. Variations in a water quality index and human density were considered to be potential explanatory causes of changes in otter distribution. The current otter distribution is probably very influenced by movements between different areas. High human population density and physical barriers (mainly mountains) can be considered as the principal factors limiting otter movements. This paper emphasizes the importance of studying local population dynamics in order to plan an effective long-term conservation strategy.

Keywords: Otter distribution; Central Spain; Distribution changes; Recovery

1. Introduction

As in many European countries, otter populations in Spain have progressively declined since the beginning of the century (Macdonald and Mason, 1994). Surveys carried out in Spain during 1964 (Blas Aritio, 1964) and 1984 (Delibes, 1990), demonstrated a marked reduction in the species' range resulting in its disappearance from large areas and fragmentation of its populations. The nationwide field survey of 1984 showed that only a third of the sampled sites were positive, a situation intermediate between countries such as Italy (6.2%), Denmark (9.2%) or England (9.6%) and those where the species was still widespread such as Ireland (92%) or Scotland (Macdonald and Mason, 1994).

Several factors were blamed for the retraction of the species; these include habitat destruction (Mason and Macdonald, 1986), persecution (Chanin and Jefferies, 1978; Green, 1991) and the presence of various pollutants in the environment (Chanin and Jefferies, 1978; Sandegren et al., 1980; Mason, 1989; Mason and Macdonald, 1992; Sjöasen et al., 1997). Reductions in stream flows, droughts and fish mortalities may also be important factors in Mediterranean habitats (Jiménez and Lacomba, 1991). The importance of each of these factors varies between regions and some authors suggest that retraction of otter distribution is caused by their combined effect (Chanin and Jefferies, 1978; Delibes, 1990; Lodé, 1993).

In this paper, changes in otter distribution in Central Spain over a 30-yr period and some potential explanatory factors are considered as a starting point for further studies on the ecological requirements for otter survival in this country.

2. Study area

The study area includes the eastern third of the Tajo basin covering an area of 24 450 km^2 (Fig. 1). Situated in the middle of the Iberian Peninsula, it has a

* Corresponding author: Fax: (91) 564 50 78;
** e-mail: evirgos@eucmax.sim.ucm.es

0006-3207/98/$19.00
PII: S0006-3207(98)00009-3

Mediterranean climate and is characterized by a long summer drought (Rivas-Martínez, 1987) with irregular river flows (Solé, 1954). The high geographic and landscape diversity and the marked altitudinal and climatic gradients as well as the varied geography have led to a great number of different environments. These include the siliceous mountain region situated at the eastern end of the Sistema Central reaching altitudes >2000 m with woodland mainly of *Pinus sylvestris* and *Quercus pyrenaica*. Another limestone mountainous zone in the southern end of the Sistema Ibérico mountains is covered with *Quercus faginea*, *Juniperus thurifera* and various pine species. There are also transition areas of medium altitude, with vegetation shrub and sclerophilous *Quercus rotundifolia*. Finally, there are plains and areas of lower altitude (450 m) with argillaceous and gypsum soils, dominated by cereal crops, vineyards, olive trees and open fields.

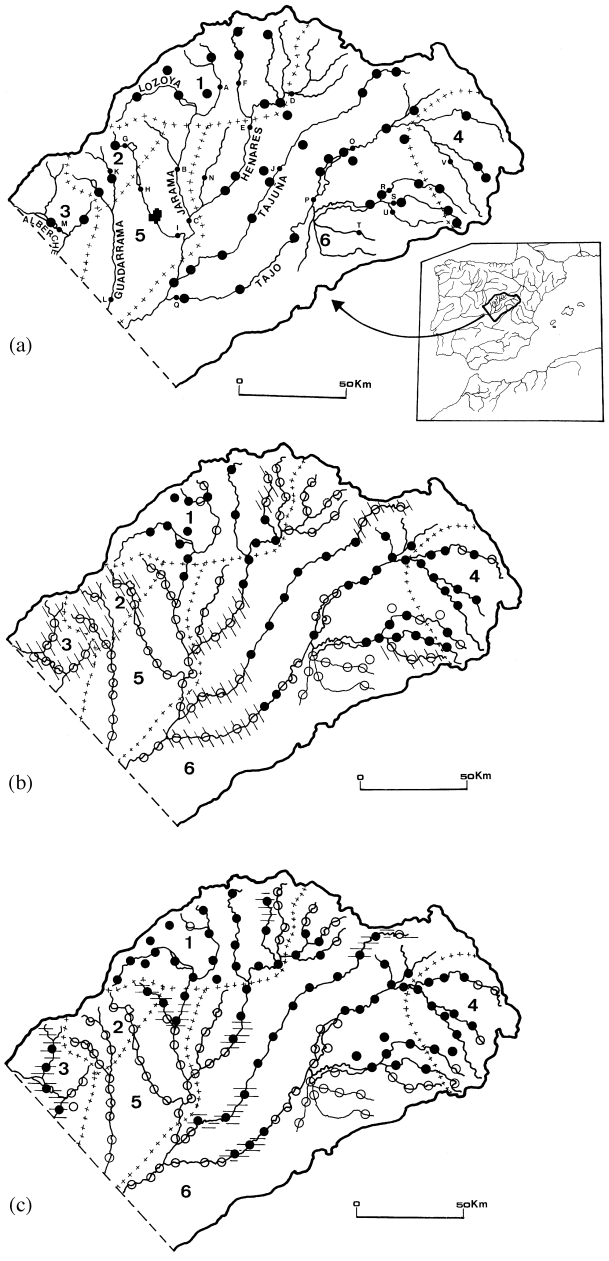

Fig. 1. (a) Location of the study area, showing the situation of the six zones (1 to 6), the water analysis stations (A to V), and otter distribution in 1964; (b) otter distribution in 1984; (c) otter distribution in 1995 (● positive and ○ negative records). The hatch lines in the 1984 map represent those areas lost by the otter compared with the preceding period. The hatch lines in the 1995 map represent the watercourses recolonized since 1984.

The hydrographic net comprises both high and low sections of the rivers with important variations in biological conditions (Hawkes, 1975; Prenda, 1995). The river Tajo is the longest of the Iberian Peninsula with main tributaries Jarama, Tajuña, Henares and Guadiela. Extensive unpopulated areas alternate with some large cities such as Madrid, with four million people.

3. Methods

Data on otter distribution in the 1960s come from two national questionnaires sent mainly to hunters and gamekeepers (Blas Aritio, 1964, 1970). Data for the 1980s (1984 National Survey; Delibes, 1990) and the current distribution were obtained using standard otter surveys like those used in other countries. The surveys were based on the 1:50 000 national maps (1–2 points at continuous water courses were chosen at each 10×10 km grid in the map, cf. Delibes, 1990). At each site, up to 600 m of bank were searched for otter signs (spraints and footprints). As soon as signs were found, the search was ended and if no signs were found in 600 m the site was considered negative (Macdonald, 1983; Mason and Macdonald, 1987). Sampling sites in 1984 and 1995 were the same, but some additional sites were sampled in 1995 in order to improve coverage of the area.

Because there was no uniform sampling in the 1960s, the potential range of the species and the percentage of positive and negative sites in this period were estimated from the available data. Those sampling sites that were not recorded in the 1960s, were assigned as positive or negative following the following criteria: (1) positive when it is located between two positive records; (2) negative when it is located between two negative records; (3) when a sample site was located between a negative and a positive record, then it was assigned to the category of the nearest site. Large areas without any information were not included in the analysis.

Data on water quality were obtained from M.O.P.T. (1984, 1992); (Table 1). Water quality levels were measured by the general quality index (G.Q.I.), defined as the mean value of 23 variables, namely: dissolved oxygen, dissolved solids, pH, conductivity, biological oxygen demand, chemical oxygen demand, bacteria count, Cl^-, $SO_4^=$, $PO_4^=$, $NO_3^=$, CN^-, Ca, Mg, Na, Cd, Cu, Cr, Hg, Pb, Zn, detergents and phenols. The

Table 1
Water quality index (G.Q.I) in 1983 and 1990

River	Analysis station (zone)	G. Q. I.	
		1983	1990
Jarama	A (1)	85.4	92.1
	B (5)	75.1	68.3
	C (5)	40.4	54.9
Henares	D (6)	74.0	75.1
	E (6)	74.6	88.0
Sorbe	F (1)	74.0	91.9
Manzanares	G (2)	87.9	85.3
	H (5)	83.9	84.1
	I (5)	39.7	48.8
Tajuña	J (6)	87.1	85.6
Guadarrama	K (2)	83.4	86.7
	L (5)	38.3	57.4
Alberche	M (3)	90.3	84.2
Torote	N (6)	79.6	87.8
Tajo	O (6)	83.1	77.0
	P (6)	85.4	89.4
	Q (6)	70.1	63.6
	V (4)	–	91.7
Guadiela	R (6)	85.7	87.6
Escabas	S (6)	84.9	83.8
Guadamejud	T (6)	64.6	65.7
Trabaque	U (6)	75.4	73.6

GQI varies from 0 to 100, values <60 indicating water quality deterioration (Mingo, 1981).

In order to analyse otter distribution trends, the study area was divided into six zones according to their physiognomy and degree of human disturbance (Fig. 1), expressed as the number of inhabitants per km^2 (Nomenclator Comercial, 1992): zone 1, mountainous and low population density (0.3 inhab km^{-2}); zone 2, mountainous and high density (85 inhab km^{-2}); zone 3, medium altitude and moderate density (22 inhab km^{-2}); zone 4, medium altitude with low population density (0.2 inhab km^{-2}); zone 5, plains with a very high density (2030 inhab km^{-2}); zone 6, open country with low population density (3 inhab km^{-2}).

In 1984, a total of 129 sites were sampled: 22 in zone 1, 8 in zone 2, 8 in zone 3, 15 in zone 4, 20 in zone 5, and 59 in zone 6. In 1995, 154 sites were sampled: 25 in zone 1, 11 in zone 2, 7 in zone 3, 16 in zone 4, 20 in zone 5, and 75 in zone 6.

Percentage changes in the distribution of positive and negative otter sites over the three periods for each zone and changes over the whole area were analysed by applying the Chi-squared test to a contingency table (Sokal and Rohlf, 1981).

In order to compare GQI values versus human population density values in the six zones, a Pearson correlation analysis was performed. The GQI value assigned to a zone was the average value of all data obtained from the sampling sites of that zone.

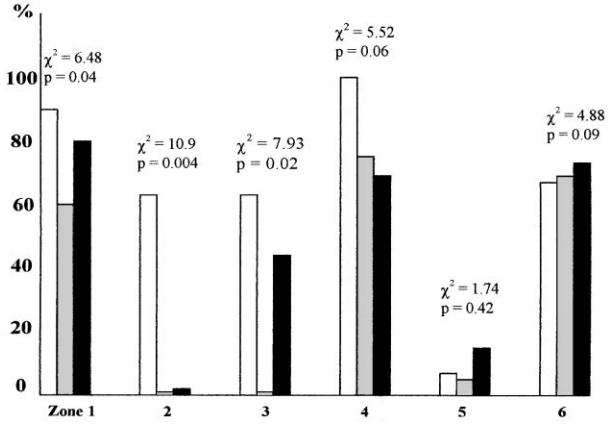

Fig. 2. Percentage of positive sites for otters in six zones over the study period (□ 1964; ■ 1984; ■ 1994) and χ^2 results with 2 d.f.

4. Results

The otter distribution has changed significantly along the three periods considered ($\chi^2=17.89$, 2 d.f., $p<0.001$). The percentage of positive sites in the 1960s was 66.7%; this value decreased to 37.2% in the 1984, but increased to 47.4% in the 1995 (Fig. 2). In the 1960s, otters were found throughout the study area, apart from zone 5. Between 1970 and 1984, they suffered a drastic reduction in the middle reaches of all the main rivers and also in the headwaters of the Henares, Tajuña, Guadarrama and Alberche. The third survey showed a small but important recovery in the middle reaches of the Tajuña and Henares in zone 6, the middle reaches of the Jarama in zone 5 and the upper reaches of the Alberche in zone 3. Otters also recolonised some of the higher tributaries of the Henares and Tajuña.

Differences between the distribution of positive and negative sites in the three periods were highly significant in zones 2 and 3. Marginal differences were found in zones 1 and 4, and no statistical differences were found in 5 and 6 (see Fig. 2). A negative, significant correlation between population density (no. of inhab per km^2) and GQI values was obtained for the six zones considered ($r=-0.91$, $n=6$, $p<0.05$).

5. Discussion

Otter distribution in our study area has experienced a recovery in the last 10 yr after two decades of global decline, although the species has not reached the former distribution limits of the 1960s. A similar recovery was recorded in certain areas of the United Kingdom such as England and Wales (Chanin, 1992; Macdonald and Mason, 1994; Strachan and Jefferies, 1996), but in other European countries otter populations have continued to decline (Lodé, 1993).

However, when we compare the changes that have occurred in the different zones considered we do not find a homogeneous pattern. For example, in zones 5 and 6 otters remained stable during the three decades analysed, while the remaining zones have followed the pattern described earlier, characterized by a global decline, followed by variable recovery.

Among the potential reasons suggested to explain changes in otter distribution, hunting does not seem to be of importance in our study area. This factor was considered in other countries as one of the main factors responsible for the decline of otters (Chanin and Jefferies, 1978; Green, 1991), but its role in Central Spain has not been so decisive. Available data (M.A.P., 1962) suggest that otters were not specially persecuted in the study area. Between 1955 and 1961 the capture of carnivores was actually promoted and regulated in Spain, but no records of otters were found among 12 468 individuals captured. The species was protected nationwide in 1973, so hunting was unlikely to be responsible for the decline although it may have been important for the decline of some low density local populations (e.g. zone 2; pers. comm. local gamekeepers).

An apparently key factor to explain changes in otter distribution seems to be the degree of indirect human impact in the environment, expressed as human population density. In general, areas showing high human population density are less suitable for otters (Delibes and Rodríguez, 1990) because of habitat loss (Prauser and Röchert, 1991), increase of direct disturbance (Mason and Macdonald, 1986) and increase of pollution (Sandegren et al., 1980; Mason and Macdonald, 1992), among others. Perhaps the most harmful of the results of human activities is the presence of pollutants in the environment. Compounds such as heavy metals and organochlorines may directly affect the reproductive potential of the species, (Olsson and Sandegren, 1991; Mason and Macdonald, 1992), whilst indirectly, the prey abundance may be reduced mainly by organic pollution (Mason and Macdonald, 1992). Unfortunately, the absence of data on levels of organochlorines and heavy metals prevents the evaluation of the importance of this factor. In contrast, we have shown a significant negative correlation between human population density and water quality, since G.Q.I. values are related to fish abundance which was considered a key factor for otter distribution and abundance (Kruuk, 1995); values <60 indicate that water is unsuitable for fish life, and we suggest that water quality may have been responsible in the past and at present for the distribution of the species.

The relevance of human population density to the decline of otters is obvious when areas with similar physiognomy but different degree of human influence are compared. The pattern of change in otter population is similar in high mountain areas (zones 1 and 2) and low mountain areas (zones 3 and 4), with a marked decline during the first period (1964–1984) in highly populated zones (2 and 3), but less marked in less populated zones (1 and 4).

The recovery pattern during the last decade is not so clear. While there was no recovery in zone 2, it was noticeable in zone 3. Absence of changes in zones 5 and 6 during the three decades may be attributed to the constancy of environmental conditions in both zones. Zone 5 has always shown unsuitable characteristics for the otter because of the high level of industrial activities and high human population density ($2030\,km^{-2}$). Zone 6, with a low human population density ($3\,km^{-2}$), has experienced minimum changes (Valenzuela, 1987).

Differences observed between zones in the recovery process could be related to individual displacements between populations, as observed in other species suffering population fluctuations as a result of extinction and recolonization processes (Gilpin and Hanski, 1991). For example, barriers may be important causes affecting inter-population connectivity (Forman and Godron, 1986). In the study area, these barriers are represented by mountains (inter-catchement movements), large towns and also reservoirs (intra-river movements), mentioned as negative factors for movement of species in Mediterranean habitats by Ruiz-Olmo et al. (1991).

In our study, barriers could explain differences in otter recovery for zones 2 and 3, which are very similar in physiognomy and human density levels, although with very different human distribution pattern: large cities with an aggregate distribution in zone 2; medium-size cities distributed homogeneously in zone 3. In zone 2 there was no noticeable recovery in the last decade, while zone 3 experienced a marked recovery (Fig. 2). Doubtless, high mountains (>2000 m) and large cities in the low section of the rivers of zone 2 are important obstacles for individuals coming from other zones. In contrast, there are no mountain barriers in zone 3 and the human population is homogeneously distributed, without large cities that could impede otter movements from higher and lower sections of the Alberche river, bordering the study area (see Bueno and Bravo, 1990; Fernández-Salvador, unpublished data).

From our results, it follows that a conservation plan for the otter in the study area should suggest planning controls to limit the indiscriminate proliferation of new houses (usually weekend houses) and associated infrastructures in zones containing good otter populations. Another important measure would be the improvement of riparian habitats and water quality in those river sections that could be used as corridors for the movement of individuals between populations (De Jongh, 1991).

This study emphasizes the importance of studying the mechanisms which may explain changes in the distribution and density of otter populations. The problems that affect local populations are diverse and sometimes different between neighbouring zones in such a way that it

is important to emphasize local studies without forgetting that every population may be in communication with others. A global strategy is also needed in order to study interactions between populations, applying the theoretical tools provided by island biogeography and metapopulation and source–sink theories (Harrison, 1994). Bearing in mind the aim to plan a long term species conservation strategy, we recommend further research to assess the relative importance of intrapopulation as against interpopulation processes (Harrison, 1994), as suggested by Prauser and Röchert (1991).

Acknowledgements

R. Baquero, N. Preciado, J. Gisbert and J.G. Casanovas cooperated in field work. J. Gisbert made the figures and R. García-Perea reviewed the English translation. The elaboration of this paper was partially supported by the Project no. 121/RN-16 (Museo Nacional de Ciencias Naturales, CSIC/Castilla La Mancha) and by the Project PB92/0238 (DGICYT). We would like to thank P.R. Beja, J.W.H. Conroy, M. Delibes, J. Ruiz-Olmo and two anonymous referees for their valuable suggestions.

References

Adrián, M.I., Wilden, W., Delibes, M., 1985. Otter distribution and agriculture in southwestern Spain. Congress International Union Game Biologist, 17th, Brussels, 17–21.

Blas Aritio, L., 1964. Estudio de la distribución de algunas alimañas españolas incluidas en la clase Mammalia. Serie cinegética. SNPFC, Madrid.

Blas Aritio, L., 1970. Vida y costumbre de los mustélidos españoles. Pesca Cont., Caza y Parques Nacionales, Madrid.

Bueno, F., Bravo, C., 1990. Avila. In: Delibes, M. (Ed.), La Nutria en España. ICONA, Madrid, pp. 61–62.

Chanin, P.R.F., 1992. The otter in Britain from 1900–1990. In: Proceedings of the National Otter Conference. Homerton College, Cambridge.

Chanin, P.R.F., Jefferies, D.J., 1978. The decline of the otter, *Lutra lutra*, in Britain: an analysis of hunting records and discussion of causes. Biological Journal of Linn. Society London 10, 305–328.

Delibes, M., 1990. La Nutria (*Lutra lutra*) en España. ICONA. Serie Técnica, Madrid.

Delibes, M., Rodríguez, A., 1990. La situación de la nutria en España: una síntesis de los resultados. In: Delibes, M. (Ed.), La Nutria en España. ICONA, Madrid, pp. 157–167.

Forman, R., Godron, T.T., 1986. Landscape Ecology. John Wiley and Sons, New York.

Gilpin, M.E., Hanski, I., 1991. Metapopulation Dynamics: Empirical and Theoretical Investigations. Academic Press, London.

Green, R., 1991. The impact of hunting, poaching and accidents on otter survival and measures to protect individual animals. In: Reuther, C., Röchert, R. (Eds.), Proceedings V. Int. Otter Coll. Hankensbüttel, 1989, Habitat, Vol. 6, pp. 171–190.

Harrison, S., 1994. Metapopulations and conservation. In: Edwards, P.J., May, R.M., Webb, N.R. (Eds.), Large-Scale Ecology and Conservation Biology. Blackwell Science, Oxford, pp. 111–128.

Hawkes, H.A., 1975. River zonation and classification. In: Whitton, B.A. (Ed.), River Ecology. Blackwell Scientific Publication, London, pp. 312–374.

Jiménez, J., Lacomba, I., 1991. The influence of water demands on otter (*Lutra lutra*) distribution in Mediterranean Spain. In: Reuther, C., Röchert, R. (Eds.), Proceedings V. Int. Otter Coll Hankensbüttel, 1989, Habitat, Vol. 6, pp. 249–254.

De Jongh, A.W.J.J., 1991. Restoration and development of otter habitats: ahead to a substitute past. In: Reuther, C., Röchert, R. (Eds.), Proceedings V. Int. Otter Coll. Hankensbüttel, 1989, Habitat, Vol. 6, pp. 209–211.

Kruuk, H., 1995. Wild Otters. Oxford University Press, Oxford.

Lodé, T., 1993. The decline of otter (*Lutra lutra*) populations in the region of the Pays de Loire, western France. Biological Conservation 65, 9–13.

Macdonald, S.M., 1983. The status of the otter (*Lutra lutra*) in the British Isles. Mammal Review 13, 11–23.

Macdonald, S.M., Mason, C.F., 1994. Status and conservation needs of the otter (*Lutra lutra*) in the western Palaearctic. Council of Europe, 67.

Mason, C.F., 1989. Water pollution and otter distribution: a review. Lutra 32, 97–131.

Mason, C.F., Macdonald, S.M., 1986. Otters. Ecology and Conservation. Cambridge University Press, Cambridge.

Mason, C.F., Macdonald, S.M., 1987. The use of spraints for surveying otter (*Lutra lutra*) populations: an evaluation. Biological Conservation 41, 167–177.

Mason, C.F., Macdonald, S.M., 1992. Pollution and otter distribution in a European context. Proceedings of the National Otter Conference, Cambridge, pp. 17–20.

Mingo, J., 1981. La vigilancia de la contaminación fluvial. M.O.P.U., Madrid.

M.A.P., 1962. Control de animales dañinos. Información estadística. Años 1953 a 1961. Servicio Nacional de Pesca Fluvial y Caza, Madrid.

M.O.P.T., 1984. Medio Ambiente en España. Direc. Gral. Medio Ambiente. Madrid.

M.O.P.T., 1992. Medio Ambiente en España. Direc. Gral. Medio Ambiente. Madrid.

Nomenclator Comercial, 1992. Pueblos de España. Madrid.

Olsson, M., Sandegren, F., 1991. Is PCB partly responsible for the decline of the otter in Europe? In: Reuther, C., Röchert, R. (Eds.), Proceedings V. Int. Otter Coll. Hankensbüttel, 1989, Habitat, Vol. 6, pp. 223–227.

Prauser, N., Röchert, R., 1991. Habitat destruction and otters: suggestions towards a more systematic approach. In: Reuther, C., Röchert, R. (Eds.), Proceedings V. Int. Otter Coll. Hankensbüttel, 1989, Habitat, Vol. 6, pp. 201–207.

Prenda, J., 1995. Ecología del río Guadalete. Quercus 110, 40–43.

Rivas-Martínez, S., 1987. Memoria del mapa de series de vegetación de España. ICONA. Serie Técnica, Madrid.

Ruiz-Olmo, J., Jimenez, J., Lacomba, I., 1991. Length of hydrographic basins and population viability of the otter in rivers in Eastern Spain. In: Reuther, C., Röchert, R. (Eds.), Proceedings V. Int. Otter Coll. Hankensbüttel 1989, Habitat, Vol. 6, pp. 255–258.

Sandegren, F., Olson, M., Reuthergarrdh, L., 1980. Der Rúchgagn der Fischotterpopulation in Sweden, In: Reuther, C., Festetics, A. (Eds.), Der Fischotter in Europa: Verbreitung, Bedrohung, Erhaltung. Oderhaus and Gottingen, pp. 107–113.

Sjöasen, T., Ozolins, J., Greyerz, E., Olson, M., 1997. The otter (*Lutra lutra*) situation in Latvia and Sweden related to PCB and DDT levels. Ambio 26, 196–201.

Solé, L., 1954. Geografía de España y Portugal. Vol. II. España, Geografía Física. Montaner and Simón, Madrid.

Sokal, R.R., Rohlf, F.J., 1981. Biometry. 2nd ed. W.H. Freeman and Company, San Francisco.

Strachan, R., Jefferies, D.J., 1996. Otter survey of England. The Vincent Wildlife Trust, London.

Valenzuela, M., 1987. Población y asentamientos humanos. In: Fernández Galiano, E., Ramos, A. (Eds.), La Naturaleza de Madrid, Comunidad de Madrid. Consejería de Agricultura y Ganadería, Madrid.