**Seasonal marking, habitat and organochlorine
contamination in otters (*Lutra lutra*):
a comparison between catchments in Andalucía and Wales**

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Summary. — Twenty 1 km stretches of riverbank in the catchments of the Rivers Severn (Wales) and Guadalquivir (south-west Spain) were searched for signs of otters (*Lutra lutra*) on six occasions between September 1986 and May 1988. Samples of spraints were collected in September 1986 for determination of organochlorine concentrations. Habitat was assessed on a 1-5 scale in 100 m lengths of the survey stretches.

All sites on the Guadalquivir and 18/20 sites on the Severn proved positive for otters, but there were differences in the level of marking both within and between catchments. Overall the level of marking was greater on the Guadalquivir. Most stretches were found positive in the first 200 m of search. There was a winter peak in marking activity on the Severn and less clear evidence of a seasonal peak in marking on the Guadalquivir.

Habitat quality was better overall on the Guadalquivir than the Severn. The number of spraints found was positively correlated with habitat on the Guadalquivir but not on the Severn. Levels of organochlorines in spraints were low.

Resumen. — A lo largo de seis ocasiones entre septiembre de 1986 y mayo de 1988, con periodicidad cuatrimestral, hemos buscado excrementos de nutria (*Lutra lutra*) en veinte tramos de 1 km de orilla en las cuencas de los ríos Severn (Gales) y Guadalquivir (suroeste de España), respectivamente. Varias muestras de excrementos fueron colectadas en septiembre de 1986 para determinar en ellas la concentración de pesticidas organoclorados. La idoneidad del habitat para la nutria fué valorada de 1 a 5 para cada 100 m en cada uno de los veinte tramos de cada cuenca.

Todos los tramos en el Guadalquivir y 18 de los 20 en el Severn dieron en alguna de las visitas resultados positivos respecto a la existencia de señales de nutrias, pero el grado de marcaje varió inter e intra cuencas. En conjunto se hallaron más excrementos en el Guadalquivir. La mayoría de los tramos con resultados positivos lo fueron en los primeros 200 m de búsqueda. El marcaje con heces muestra un pico invernal en el Severn, mientras que en el Guadalquivir no existe evidencia de estacionalidad.

En conjunto, la calidad del habitat es mejor en el Guadalquivir que en el Severn. El número de heces detectado se hallaba correlacionado positivamente con la calidad del habitat en el Guadalquivir, pero no en el Severn. Los niveles de pesticidas organoclorados en las muestras de excrementos de cada cuenca fueron bajos.

Résumé. — Vingt bandes de 1 km sur les berges de la Severn (Wales) et du Guadalquivir (SW de l'Espagne) ont été inspectées pour y trouver des signes de la présence de loutres (*Lutra lutra*) à six occasions de septembre 1986 à mai 1988. Des échantillons d'épreintes ont été collectés en septembre 1986 pour déterminer leur concentration en organochlorés.

Tous les sites sur le Guadalquivir et 18 sites sur 20 de la Severn ont montré la présence de loutres avec cependant des différences dans le niveau de marquage : celui-ci a été plus élevé sur le Guadalquivir. La majorité des résultats positifs ont été obtenus dans les premiers 200 mètres. En hiver, il y a un pic de l'activité de marquage sur la Severn et un pic moins marqué sur le Guadalquivir.

Le nombre d'épreintes qui ont été trouvées a montré une corrélation positive avec l'habitat sur le Guadalquivir mais pas sur la Severn. Le niveau de concentration des organochlorés dans les épreintes de chaque provenance est resté faible.

INTRODUCTION

The otter (*Lutra lutra*) has declined substantially in numbers over much of its European range (Mason and Macdonald 1986) and its plight has generated much recent public concern, not least because the presence of the species indicates a healthy aquatic environment (Macdonald and Duplaix 1983). However, comparatively little is known of the ecology of this secretive and largely nocturnal species. There are few published data on radio-tracking of the species (Green *et al.* 1984, Jefferies *et al.* 1986) and most information gained so far has been by recording the presence of scats (spraints). The detection of spraints forms the basis of current field survey techniques for otters (Macdonald 1983, Mason and Macdonald 1987 *a*) and the features of habitat considered of importance to otters have been determined by reference to presence/absence and distribution of spraints in Britain (Macdonald and Mason 1983), Spain (Adrian *et al.* 1985) and Greece (Macdonald and Mason 1985). A seasonality in the sprainting behavior of otters has been described for Wales (Macdonald and Mason 1987) and the Shetland Islands off northern Scotland (Conroy and French 1987). No such information is available for Spain.

The aims of the present study were to :

1. determine the number and distribution of otter signs along stretches of two river catchments (the Severn and the Guadalquivir) on a seasonal basis ;
2. relate the distribution of otter signs to habitat features, in particular to bankside cover ;
3. obtain an index of organochlorine pollution in the otter populations by the analyses of spraints.

The last objective was considered important because pollution by organochlorines seems the most likely cause of the widespread decline in otter numbers (Mason and Macdonald 1986), while some concern has been expressed over organochlorine concentrations in aquatic organisms in the Doñana National Park in the lower Guadalquivir (Rico *et al.* 1987).

Fig. 2. — The Guadalquivir catchment in Spain showing the survey points for otters.

vegetation cover, broken rock or any other features considered as providing potential den sites or resting sites for otters and the nature of these features was noted e.g. *Phragmites* bed, dense *Rubus* thickets etc. For each 100 m the type of hinterland was also recorded (e.g. maquis, arable farming) and visible water pollution was also noted.

In September 1986 spraints were collected from positive 1 km stretches, wrapped in aluminium foil and deep frozen prior to organochlorine analyses. Samples from each stretch were bulked in the laboratory and allowed to thaw. Organochlorines were then extracted following methods in FAO (1983) and samples were cleaned following methods in HMSO (1979). Analyses were carried out using a Carlo-Erba 4300 gas chromatograph, with a tritium electron capture detector and using a capillary column. The detection level was 0.01 mg kg^{-1} .

RESULTS AND DISCUSSION

The mean number of spraints, and range, found on the six surveys at the 20 stretches on each catchment are given in Table 1. On the River Severn not all stretches were consistently found to be positive for otters but only two stretches in the headwaters (1 and 2) were negative on each visit. These stretches are known to be acidified and lack fish (Mason and Macdonald 1987 *b*). Signs of otters were sporadic on the downstream stretches (17-20) where habitat is degraded. On the Guadalquivir catchment, no stretch was negative on every visit, but signs were not always found on stretches 13 and 14 on the Guadaira, the

Fig. 1. — The Severn catchment in Wales showing the survey points for otters.

STUDY AREAS AND METHODS

Stretches were surveyed on the River Severn catchment from near its source in mid-Wales to the border with England in Shropshire. Otters were known to be resident on the catchment upstream of Welshpool (see Fig. 1). The headwaters of the Severn flow through extensive conifer plantations which give way to uplands used primarily for sheep grazing. Below Welshpool the river is embanked for flood prevention and riparian vegetation is sparse. The waters are considered as unpolluted throughout the study area apart from the headwaters of the Severn which are acidified.

In south-west Spain the survey stretches were located on the lower catchment of the River Guadalquivir (see Fig. 2). Stretches were chosen on the upper reaches of tributaries flowing from the maquis-covered sierras to the north and south of the main river where little agriculture is possible, and also on downstream stretches. The lower stretches of the tributaries and the main Guadalquivir flow through arable plains and are subject to organic and some industrial pollution.

Twenty 1 km stretches were walked both on the River Severn catchment and the Guadalquivir in September 1986 in January, April/May and September 1987 and in February and April/May 1988. Each 1 km stretch was sub-divided into 100 m lengths and within each length the numbers of spraints and sprainting sites were noted and the riparian habitat was assessed for its suitability for otters on a scale of 1-5. Scale 1 indicated a total absence of cover; scale 2 denoted the presence of some bankside vegetation but of a type offering no shelter for otters, while in grade 3 habitat it was considered that the animals could find temporary shelter only, either because vegetation cover would be seasonal or because security was limited. Grade 4 habitat offered ample cover and grade 5 habitat appeared to be ideal for the species. Habitat assessments included

species appearing to be largely confined to the upper reaches (11 and 12). Downstream the river was organically polluted. On the Guadamar the upstream stretches (18 and 19) also produced consistently more signs than the downstream stretches (16 and 17). At all sites the river is reduced to pools in the summer but these contain abundant fishes in 18 and 19, where the river flows. From similar observations in Portugal it was suggested that heavy marking by isolated pools in drying river beds may be the result of the defence of a resource which is becoming increasingly limited (Macdonald and Mason 1982). The lower stretches of the Guadamar receive both acid mine drainage and agricultural pollution (Cabrera *et al.* 1984). The Viar appeared to hold a thriving otter population throughout most of its length with a slight reduction in the number of signs found at stretch 10, which is close to the confluence with the Guadalquivir and is an agricultural area, with high disturbance and poor habitat. The situation on the Hueznar appeared to be similar to that on the Viar, again with a reduction of signs in the lowest reaches. Stretches 9, 10 and 15 all produced fewer signs.

Overall, 115 out of 120 surveys proved positive for otters on the Guadalquivir as did 90 of 120 surveys on the Severn. The distances at which stretches were proved positive was recorded and this is shown in Fig. 3. Some 90.4 % of surveys in Spain and 83.3 % of those in Wales were found positive within the first 200 m of search, while a 600 m search found 96.5 % and 95.4 % of surveys

Fig. 3. — The percentage of sites found positive for otters within the first 100 m or in subsequent 100 m stretches of a survey distance of 1000 m in Spain ($n = 115$) and Wales ($n = 90$).

positive in Spain and Wales respectively. This confirms the efficiency of the standard survey technique in detecting the presence of otters (Mason and Macdonald 1987 *a*).

TABLE 1. — Numbers of otter spraints (mean and range of six surveys) found on 20 1 km stretches of the catchments of the rivers Severn (Wales) and Guadalquivir (Spain). For location of survey stretches see Figs. 1 and 2.

Stretch No.	Severn		Guadalquivir	
	Mean	Range	Mean	Range
1	0		49	27-69
2	0		132	30-228
3	8	3-16	65	1-150
4	5	3-9	83	53-127
5	20	1-39	89	32-140
6	43	19-77	93	10-280
7	10	6-10	97	34-195
8	6	1-14	70	53-106
9	4	0-13	22	5-35
10	11	1-25	35	13-54
11	28	12-57	29	6-61
12	19	4-42	27	0-47
13	23	10-50	6	0-12
14	34	15-66	5	0-16
15	10	0-20	13	4-24
16	6	3-9	7	2-18
17	1	0-5	7	2-15
18	3	0-10	37	16-95
19	1	0-1	41	11-91
20	2	0-9	79	33-143

TABLE 2. — Total number of spraints and sprainting sites recorded on 20 1 km stretches of river in the catchments of the Guadalquivir and Severn on six survey occasions.

Date	September 1986	January 1987	April/May 1987	September 1987	February 1988	April/May 1988	Average
Guadalquivir							
Spraints	784	1126	1269	1312	680	94	978
Sprainting sites	312	402	392	529	274	275	364
Severn							
Spraints	106	353	142	18	289	362	237
Sprainting sites	65	130	60	71	73	108	85

As can be seen from Tables 1 and 2 many more spraints were found on Spanish rivers but the results are not fully comparable since, on most stretches in Spain both banks were searched, while in Wales one bank only was walked. The total numbers of spraints and sprainting sites found in both areas are given in Table 2. The total number of spraints found in Spain on each sampling occasion was 2.0-8.9 times the number found in Wales in the equivalent sampling period, while the number of sprainting sites recorded was 2.7-7.5 times greater. Thus the greater number of sites and signs recorded on the Spanish rivers was not due merely to the fact that both banks were searched on most Spanish survey stretches. The Spanish survey area may support a greater density of otters than

the Welsh survey area, but such a conclusion needs to be treated with caution, as marking behaviour of otters is not well known. Moreover, Taylor *et al.* (1988) have suggested that otters whose diet consists of substantial amounts of crayfish leave more spraints due to the indigestible nature of the exoskeleton. Crayfish (*Procambarus clarkii*) form a major component of the diet of otters in much of the Guadalquivir catchment (Adrian and Delibes 1987, Delibes and Adrian 1987). Crayfish do not feature in the diet of Severn otters.

No clear seasonal trend in marking activity was found in Spain. On the Severn, previous detailed studies had shown that more signs are found in the winter and early spring (Macdonald and Mason 1987) and, whilst this pattern emerged in the present study, the winter peak in 1988 was not so distinct, for the February 1988 survey was carried out at a time of heavy spates in a very wet winter.

Fig. 4. — The percentage of 100 m lengths of twenty 1 km stretches of river in the Severn and Guadalquivir catchments in habitat grades 1-5.

The increase in marking activity in the winter in Wales is reflected not only in the total number of signs but in the number of spraints found at individual sprainting sites. Thus, in the winters proportionally more spraint sites are marked with more than 5 spraints (see Table 3). Data collected from the Severn in 1982 and 1983 are included for comparison. In Spain however, there appears to be some increase in the proportion of heavily marked sprainting sites in May of both 1987 and 1988. It has been suggested elsewhere in southern Spain that most spraints occur in summer, with fewest in late winter/early spring (López-Nieves and Hernando 1984). The summer peak was related to the drying up of rivers.

During both surveys the riparian habitat was graded in terms of its suitability in offering secure shelter for otters. Fifteen of the stretches on the Guadalquivir and 14 on the Severn contained at least one 100 m length classified as grade 4 or 5. However, of the two hundred 100 m lengths assessed in Spain, 72 were of grade 4 or 5 while in Wales the total was only 38. The percentages of 100 m lengths in grades 1-5 are shown in Fig. 4. Overall the habitat on the Spanish rivers was significantly better than in Britain ($X^2 = 39.2$, $p < 0.001$).

Note was made of those riparian features which justified gradings of 4 or 5. On the Severn the dominant features comprised stands of mature bankside

TABLE 3. — The percentage of sprainting sites in Wales and Spain at which more than five spraints were deposited.

Survey Date	No. Sprainting Sites	% with < 5 spraints
River Severn, Wales		
September 1982	26	7.6
January 1983	50	18.0
April 1983	52	5.7
September 1983	41	4.8
January 1984	68	14.7
April 1984	71	9.8
September 1986	65	1.5
January 1987	130	13.4
April 1987	60	6.6
September 1987	71	5.8
January 1988	73	21.9
April 1988	108	15.7
River Guadalquivir, Spain		
September 1986	312	8.2
January 1987	402	10.2
May 1987	392	17.0
September 1987	529	7.9
February 1988	274	5.8
May 1988	275	11.4

Acer, *Fraxinus* and *Quercus* (50 %), conifer plantations (20 %), *Salix* shrub and thickets of *Rubus* (both 11 %) and riparian deciduous woodland (7 %). In Spain, the variety of features offering secure shelter was greater, namely *Rubus* (29 %), general cover of maquis (21 %), *Tamarix* (14 %), *Nerium oleander* (11 %) and broken rock (9 %). Other important plant species were *Salix* ssp. (6 %), *Arundo donax* (4 %) and tangles of vines (4 %). Thus, overall, otters on the Severn catchment could find most shelter from bankside trees while in Spain more cover was provided by scrub species.

Correlations between overall habitat quality and mean numbers of signs found in each 1 km stretch were investigated. In Spain there was a significant correlation between bankside cover and numbers of signs (Spearman $r_s = 0.46$, $p < 0.05$), but this was not found in Wales. In south-western Spain, Adrian *et al.* (1985) have previously found a highly statistically significant relationship between the presence of otter spraints and the presence of both bankside cover and natural vegetation in the immediate hinterland. Similarly in a survey of 250 km of river in Wales and the West Midlands of England, Macdonald and Mason (1983) showed a strong statistical relationship between sprainting activity and measures of riparian vegetation. A number of other studies have shown similar relationships (Mason and Macdonald 1987 *a*). The lack of a relationship in Wales in the present study was possibly due to the influence of acidification on the upper reaches of the catchment, where ideal habitat was unused by otters because of the lack of fish. It is also worth noting that previous studies have generally used a more subtle assessment of cover and it may be that otters

TABLE 4. — The percentage of spraint samples from the Severn (n = 17) and Guadalquivir (n = 19) containing organochlorine residues.

Organochlorine Residue	Severn	Guadalquivir
Lindane	47.1	42.1
Dieldrin	17.6	15.8
Total DDT compounds	47.1	36.8
PCBs	52.9	68.4
Total Organochlorines	88.2	84.2

may respond to particular features of their habitat (e.g. mature ash *Fraxinus excelsior* and sycamore *Acer pseudoplatanus*) in Wales (Macdonald and Mason 1983), which were not quantified in the present study.

Overall, 17 bulked samples of spraints from the Severn and 19 bulked samples from the Guadalquivir were analysed for organochlorine residues. The percentage of samples containing residues are given in Table 4. There were no significant differences in the proportion of samples in the two catchments containing various organochlorine residues (X^2 , $p > 0.05$). Maximum concentrations (mg kg^{-1} in lipid) in spraints were for the Severn: Lindane, 1.75; total DDTs, 4.01; Dieldrin, 2.8; PCBs, 1.69 and for the Guadalquivir: Lindane, 2.33; total DDTs, 0.57; Dieldrin, trace; PCBs, 2.73. The overall low levels of contaminants are not surprising, for the majority of samples in both catchments were collected in areas of low human population and little industry or intensive agriculture. Concentrations of total organochlorines in spraints from the Severn, where the otter population appears to be expanding, have been shown to be 3.5-5.4 times lower than in spraints from catchments further east in England where otter populations are low or endangered (Macdonald and Mason 1988).

Several studies of the contamination by heavy metals of biota in the lower Guadalquivir and Doñana National Park have been made (Hernández *et al.* 1982, 1984; Baluja *et al.* 1983, 1985; Rico *et al.* 1987; Cabrera *et al.* 1987; Albaiges *et al.* 1987; López Fernández *et al.* 1980). Elevated levels of organochlorines have been reported in ciconiformes (Hernández *et al.* 1984). However in view of Den Boer's (1983) findings that a dietary intake of only $0.025 \text{ mg PCB d}^{-1}$ is sufficient to inhibit the reproduction of mink (*Mustela vison*) under experimental conditions, the observations of Rico *et al.* (1987) may be particularly significant. They recorded mean levels of PCBs in various fish and amphibians from the Doñana National Park during 1985-1986 of $0.15\text{--}1.08 \text{ mg kg}^{-1}$ wet weight. Two otters killed in the Park had PCB concentrations of 2.4 and 2.5 mg kg^{-1} fresh weight in liver (L. Hernández, unpublished observations), equivalent to approximately $40\text{--}50 \text{ mg kg}^{-1}$ in lipid. Concentrations of PCB exceeding 50 mg kg^{-1} lipid in tissues of mink are associated with reproductive problems (Olsson *et al.* 1981). A single otter analysed for pollutants from the River Severn had only $4.4 \text{ mg PCB kg}^{-1}$ lipid in its liver, but animals from nearby catchments have contained up to $113 \text{ mg PCB kg}^{-1}$ lipid (Mason *et al.* 1986).

In conclusion it would appear that the catchments of both the Guadalquivir and the Severn hold thriving otter populations but, nevertheless, they are not able to fully utilize the available habitat. On the Severn acidification of the upper reaches and severe habitat degradation in the lower stretches are significant. In the Guadalquivir mine and organic pollution in the lower reaches of tributaries

and on the main river appear to be limiting, while pollution by organochlorines, particularly by PCBs, in the lower Guadalquivir and the Doñana National Park, merit further investigation.

Otters on the River Severn show a distinct seasonality in marking behaviour, most spraints being deposited during the winter. Seasonality is less clear in Spain. It has been suggested that the peak in Wales is related to the dispersal of young animals (Macdonald and Mason 1987), implying seasonal breeding in this polyoestrus species. Seasonal peaks in births have been recorded in the Shetland Islands (Kruuk *et al.* 1987). It would be of great interest to further investigate sprainting behaviour in Spain, with an increased sampling intensity of stretches of river, preferably in several different regions.

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