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Testing the surveys and visual and track censuses of Eurasian otters (*Lutra lutra*)

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Abstract

At the end of the 1970s otter surveys were developed to study the distribution of the Eurasian otter *Lutra lutra*. The method was quickly adopted and expanded to include other species of otter. Different methods to estimate otter density were also used. There is some uncertainty, however, as to the significance and precision of the results. Otter surveys, radio-tracking studies and otter censuses (tracks and visual) were conducted in the same areas simultaneously. Comparison of the home ranges of otters tagged with transmitters with the results from otter surveys carried out in the same areas showed very similar otter distribution. Some 71% of those sites examined in which only one otter lived were positive, and 97% of those sites with two or more otters. Differences were found between different watercourses. In small or average sites with waterways, one single otter was capable of marking many kilometres so that it could be detected in most of the conventional 600 m sites (here 71% of sites). The data obtained by radio-tracking showed that almost all otters can be seen by experienced observers, confirming the validity of visual censuses. A high correlation was found between the number of otters seen during visual censuses and the number of otters detected by means of the length of their footprints. Using new and old tracks (2-days-old or more) the number of otters was overestimated.

Key words: otters, otter surveys, density studies, *Lutra lutra*

INTRODUCTION

Otters (Lutrinae) are aquatic and semi-aquatic animals whose populations have undergone marked declines during the last century as a result of persecution, destruction of habitats, sensitivity to contamination and the availability of their prey (Foster-Turley *et al*., 1990). To ensure the successful management and conservation of otters, further studies are required. Determining the distribution of otter species and their abundance is an essential first step in this process. However, as otters live at low densities and are often nocturnal or crepuscular, their study is not straightforward.

At the end of the 1970s and beginning of the 1980s, the first standardized method of survey was developed, based on reliable data. The method was rapidly put into practice throughout Europe and north Africa (Crawford *et al*., 1979; Green & Green, 1980; Lenton *et al*., 1980; Chapman & Chapman, 1982; Mason & Macdonald, 1986). It was first applied to the Eurasian otter *Lutra lutra*, providing information on the western range of its distribution (see also Macdonald & Mason, 1994). The surveys were based on the identification of indirect but indisputable signs (mainly tracks and spraints) of the species. The sites were situated throughout a territory, running along 600–1000 m of riverbanks and waterways. Otters leave spraints in visible spots (e.g. stones, rocks, trunks) and in predictable places (e.g. under bridges, at junctions of rivers, in basins) which facilitates survey work. In this way, it is possible to differentiate between positive and negative sites (presence detected or not) and to count the number of signs.

The method was quickly adopted and was expanded to include other species of otter, such as the southern river otter *Lontra provocax* (Chehebar, 1985), *Lutra maculicollis* and *Aonyx capensis* (Rowe-Rowe, 1992) and the smooth-coated otter *Lutra perspicillata* (S. A. Hussain, pers. comm.).

The initial enthusiasm led to an attempt at the exhaustive mapping of otter distribution and an estimate of relative abundance and habitat selection (Macdonald & Mason, 1983, 1985). There followed a debate between those who were in favour of using the method in this way (Jefferies, 1986; Macdonald & Mason, 1987: Mason & Macdonald, 1991) and those who questioned the validity and precision of the results obtained (Kruuk, Conway *et al.*, 1986; Conroy & French, 1987, 1991; Kruuk & Conroy, 1987), because of temporal, spatial and individual variation apparent in otter sprainting behaviour (see also Mason & Macdonald, 1987; Jahrl, 1995; Kruuk, 1995; Kranz, 1996; Ruiz-Olmo & Gosálbez, 1997). Some findings were as follows:

(a) The number of spraints does not enable us to estimate easily the number of otters (although some findings tend to show that, on the whole, the more excrements that are found, the more otters there are in an area; Mason & Macdonald, 1993; Strachan & Jefferies,1996).

(b) The absence of signs does not necessarily imply absence of otters. There are 'false negatives', that can be a consequence of the ability of surveyors to locate them or of the otter behaviour.

(c) The number of signs in any one place does not necessarily correlate with the intensity of use, and therefore it does not seem to be a good method for studying habitat selection (Kruuk, Conroy *et al.*, 1986; Kruuk, 1995).

(d) The otter surveys are differently applied in different countries, and must be designed to suit particular circumstances (Mason & Macdonald, 1986; O'Sullivan, 1993; Romanowski, Brzezinski & Cygan, 1996; Romanowski & Brzezinski, 1997).

Recently, otter surveys have detected the recolonization of some regions in Europe (Green & Green, 1987; Andrews, Howell & Johnson, 1993; Brzezinski *et al.*, 1996; Rosoux, Tournebize & Cygan, 1996; Strachan & Jefferies, 1996; Ruiz-Olmo & Delibes, 1998), but some uncertaintly remains about the significance of the positive and negative sites identified in otter surveys and how precise the findings are. There are many difficulties in any technique used to establish the otter population density and to estimate their numbers. The techniques most frequently used are:

(a) footprints in snow or mud, and measuring their lengths (Reid *et al.*, 1987; Sidorovich, 1991, 1992);

(b) visual censuses, with groups of observers working in places where the otters are diurnal (Lejeune & Frank, 1990; Estes, 1991; Kruuk, 1995; Parera, 1996) or are crepuscular (Ruiz-Olmo, 1995*a*,*b*);

(c) holt censuses in marine environments in the north of Europe (Kruuk, Moorhouse *et al.*, 1989);

(d) intensity of use of certain stretches of river by counting the number of nights spent in them, as revealed by radio-tracking (Kruuk, Carss *et al.*, 1993);

(e) marking of captured individuals with radioisotopes (Kruuk, Groman & Parish, 1980);

(f) DNA fingerprint studies of hair, faeces or other remains (being developed in otters in different countries such as Great Britain, Spain and Denmark).

Techniques (b) and (c) are only useful where otters display diurnal or crepuscular behaviour, (c) in marine enviroments, and (d) and (e) for focal areas. Methods (a) and (f), and in part (b), may have more general use. However, none of these techniques has been shown to be entirely reliable. Are all the animals detected? Are some repeat observations? Is abundance correctly estimated? Are the census units (generally 10 km) correct?

In this paper we present data to evaluate the reliability of otter surveys and otter censuses using tracks and crepuscular observations.

METHODS

Study areas

The results presented here are drawn from 3 programmes (Fig. 1).

(1) The capture of wild otters was carried out in Extremadura, in south-west Spain. Otters living in this area are included in the great western and central Spanish and Portugese metapopulation (Ruiz-Olmo & Delibes, 1998; Trinidade, Farinha & Florêncio, 1998), and their translocation as part of a reintroduction programme to the Muga and Fluvià river basins in north-east Spain and control via radio-tracking.

(2) Radio-tracking of wild otters in the basin of the Bergantes River in east Spain as part of an ecological and behavioural study (Jiménez, Puiz-Olmo & Pascual, 1998; López-Martín, Jiménez & Ruiz-Olmo, 1998).

(3) A census programme conducted in the 2 areas mentioned above, and in the rivers Noguera Ribagorçana and Noguera Pallaresa (Pyrenees) (Ruiz-Olmo, 1995*a*).

Muga and Fluvià River Basins. These are found in the extreme north-east of the Iberian Peninsula (Girona Province). They are both short Mediterranean rivers (the principal branch of the River Muga is 65 km, the Fluvià 97 km), with irregular hydrological regimes. They are fed mainly by rainfall and have an average volume of 2.4 m^3/s (Muga) and 1.3 m^3/s (Fluvià). Riverine woodland dominates with *Fraxinus angustifolia* and *Populus alba*, although in many stretches this has been substituted by plantations of *Populus nigra* × *canadensis* and *Platanus orientalis*. The Aiguamolls de l'Emporda marshes, which occupy > 5000 ha, are situated between the 2 river mouths. Here, the dominant habitats are freshwater canals and lagoons, where reeds *Phragmites* sp. and bullrushes *Typha* sp. grow in abundance.

Rivers Bergantes, Noguera Ribagorçana and Noguera Pallaresa. Riber Bergantes is a tributary of the Guadalope, which in turn flows into the River Ebro. The principal watercourse is nearly 50 km long and runs through an arid mountainous area. The volume in the lower part varies between 0.5 and 3 m^3/s, and in the upper half there is almost no flow of water during the summer. Rivers Noguera Ribagorçana and Noguera Pallaresa lie in the Northern Ebro Basin in the Spanish Pyrenees, province of Lleida with 1–3 m^3/s (in most of the study area) and 8–12 m^3/s, respectively. The riverbed consists principally of mud and earth, stones and rocks, and contains many pools. In all 3 rivers, the vegetation on the

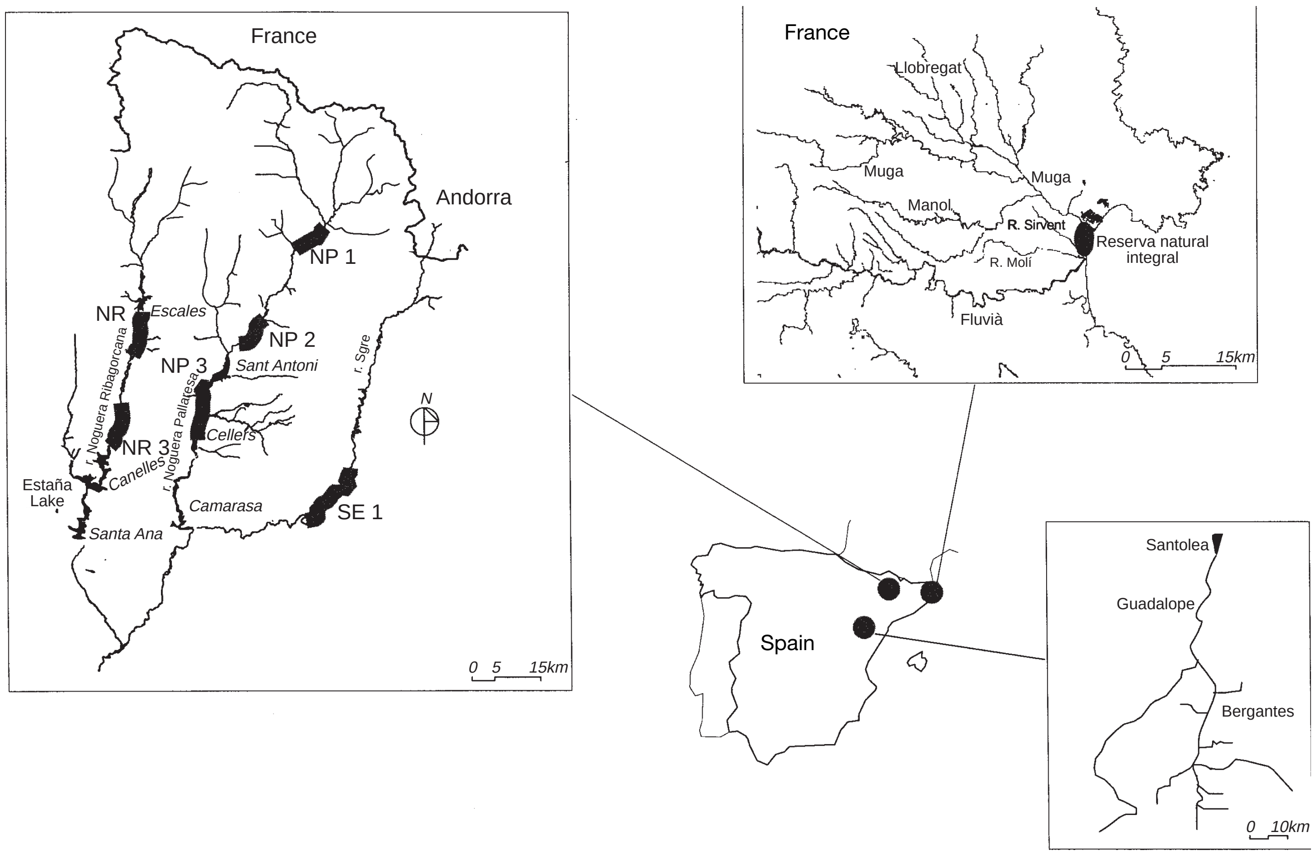

Fig. 1. Study area: (a) situation of the different study projects in north-eastern Spain; (b) relative situation of four main rivers used by the first four reintroduced otters, in Girone province (March–September 1996) (see Table 2).

banks (dominated by *Salix pupurea* with *Populus nigra*, alternating with reeds *Typho-Schoenoplectetum glauci*) is poor because of grazing. In the lower stretches of the Noguera Pallaresa the vegetation is, however, exuberant, and mainly formed by white poplar *Populus alba*, with *P. nigra*, *Fraxinus angustifolia*, *Ulmus minor* and *Salix purpurea*, with sections of reeds (*Typho-Schoenoplectetum glauci* and *Phragmition australis*). In mid and higher stretches of this river, the vegetation, which is scarce, is *Alnus glutinosa*, with *Populus nigra* and *Salix purpurea*.

Otter surveys

The objective of the study was to compare radio-tracking data in areas occupied by otters with the conventional results derived from an otter survey conducted in the same area. The otter survey methods are summarized in Lenton *et al.* (1980), Mason & Macdonald (1986) and Ruiz-Olmo & Delibes (1998). In Spain, sites had been surveyed to determine only the presence (positive) or absence (negative) of otters, a survey being halted as soon as traces of the species were found (Ruiz-Olmo & Delibes, 1998). For the present study, a network of 83 sites was inspected in the Muga and Fluvià Basins. Sites (600 m long) were inspected on 5 occasions (spring 1996, summer 1996, winter 1996–97, spring 1997 and summer 1997).

For comparison, data from the otter surveys carried out in 1984 by Ruiz-Olmo & Gosálbez (1988) ($n = 30$ sites), in 1989 by Ruiz-Olmo (1995*b*) ($n = 34$), and in 1994 by D. Saavedra (pers. comm.) ($n = 144$ sites) were used.

Radio-tracking

During the first part of the reintroduction project, 5 otters were captured and released into the north-east of Girona between November 1995 and March 1996 and were radio-tracked until September 1996. An attempt was made to radio-locate the otters daily from the ground, using 4-wheel drive vehicles. When the signal was lost, small Cesna planes were used. Up until the end of summer 1997, when the present study was concluded, a further 21 otters had been captured, 14 being released in the reintroduction basins.

When captured, otters were anaesthetized with ketamine (0.05 mg/kg) and metedomidine (0.05 mg/kg) for evaluation in the field. Sex, length, and weight were determined, and also potential wounds were inspected. From these data an antibiotic injection was calculated and administered. Also the body condition index K (Kruuk, Conroy, 1987), calculated for Iberian otters (Ruiz-Olmo, Delibes & Zapata, 1998), was determined, collecting only the otters with $K > 0.90$; the remaining animals were released at the capture site. Otters for

Table 1. Radio-tracked otters. M, males; F, females

Area	Animal	Weight (kg)	Period	No. of days of radio contact (until summer 1997)	Cause of loss
Muga and Fluvià river basins (reintroduction)	F1	5.1	14.11.95/18.12.95	35	Killed by fish net
	M1	3.8	01.12.95/09.07.97	588	Lost signal
	M2	4.0	01.12.95/27.06.96	210	Unknown
	F2	6.0	01.03.96/19.10.96	233	Lost signal
	F3	4.0	21.03.96/20.08.97	519	Lost signal
	F4	4.2	21.10.96/13.12.96	53	Lost signal
	M3	7.6	21.10.96/25.07.97	279	Lost signal
	F5	5.1	28.10.96/13.06.97	229	Lost signal
	M4	6.7	04.11.96/19.05.97	198	Lost signal
	M5	6.7	11.11.96/30.04.97	170	Killed by car
	F6	4.7	11.11.96/17.12.96	37	Unknown
	F7	4.8	02.12.96/25.01.97	55	Killed by car
	F8[a]	2.6	02.12.96/13.12.96	12	Lost signal
	F9[a]	2.3	02.12.96/10.12.96	9	Lost signal
	M6	7.5	26.11.96/17.12.96	22	Lost signal
	M7	7.6	10.12.96/11.12.96	2	Killed by car
	M8	7.8	27.12.96/30.05.97	155	Lost signal
	F10	4.8	27.12.96/13.01.97	18	Found in siphon
	F11	5.2	08.05.97/13.06.97	38	Lost signal
River Bergantes	M9	8.0	23.11.96/14.03.97	26	Lost signal
	F12	4.4	22.12.96/3.05.97	110	Killed by car
	M10	7.8	07.05.97/31.08.97	111	Lost signal

[a] Daugthers of F7.

reintroduction were injected with neuroleptics (Haloperidol and Trilafon) for the captivity period, and calmed in quiet rooms before transport. After reversal with Antisedans (0.05 ml/kg) the otters were transported in a safe plastic box to the Barcelona Zoo (Barcelona), where they were isolated in individual boxes. The otters were in the care of the veterinary services for 2–4 weeks, being evaluated regularly and provided with transmitters IMP/300/L (TELONICS, Mesa, Arizona, U.S.A.), and 203–12 (ATS, Bethel, Minnesota, U.S.A.) and Wagener (Germany), weighing between 36 and 40 g (0.5–1.6% of the otters' weight), using the same anaesthetics.

In the River Bergantes, 3 more wild otters were captured, tagged and released following the same protocol, the otters being transported to the Wildlife Recovery Centre of El Saler (Valencia).

Table 1 shows the otters that were radio-tracked, the number of radio-locations and days when radio-tracking was carried out.

Several animals from both areas whose transmitters emitted between 15 May and 15 July 1996 (when visual censuses were carried out) were located during 24 h radio-tracking periods (at least 1 radio-location every 30 min). Special attention was paid to observing the moment at which they left and returned to the rest sites.

Track and visual censuses

The visual censuses were carried out in accordance with the method described in Ruiz-Olmo (1995*a*), based on the positioning of 18–24 observers at a distance of 500 m apart (± 100 m) along a 9–12 km stretch of river. Each observer was stationed so they could observe the maximum length of the stretch and, at some points, both banks. The censuses were carried out between 15 May and 15 July, coinciding with maximum daylight, the time when otters present significant crepuscular activity in the study area. A census involves counts being carried out at dawn and dusk, lasting for *c*. 2 h each.

The track censuses were carried out following the method described in Sidorovich (1992). Several footprints were measured in each of the otter tracks found. The maximum length of the forefoot print was used (both without nail and with nail included) and the maximum length of the heel pad. Given the low densities of animals during the censuses distinguishing between individuals caused no difficulty. Recent footprints (< 1 day old, sometimes 2 days old) were differentiated from old prints. To differentiate them: (a) a footprint census was sometimes carried out before the visual census; (b) it was determined whether prints were in the new mud after the rain or on a wet morning; (c) footprints were examined to determine whether they were dry or not. In the study area, in late spring and summer, footprints dry after 1 or 2 days, and it is, therefore, relatively simple to distinguish fresh prints.

Eight visual and track censuses were carried out (both on the same day) in the north-east of Girona and in the Bergantes in 1997 and 1998, in stretches where the presence of at least 1 individual the preceding day had been detected using radio-tracking. Furthermore, 16

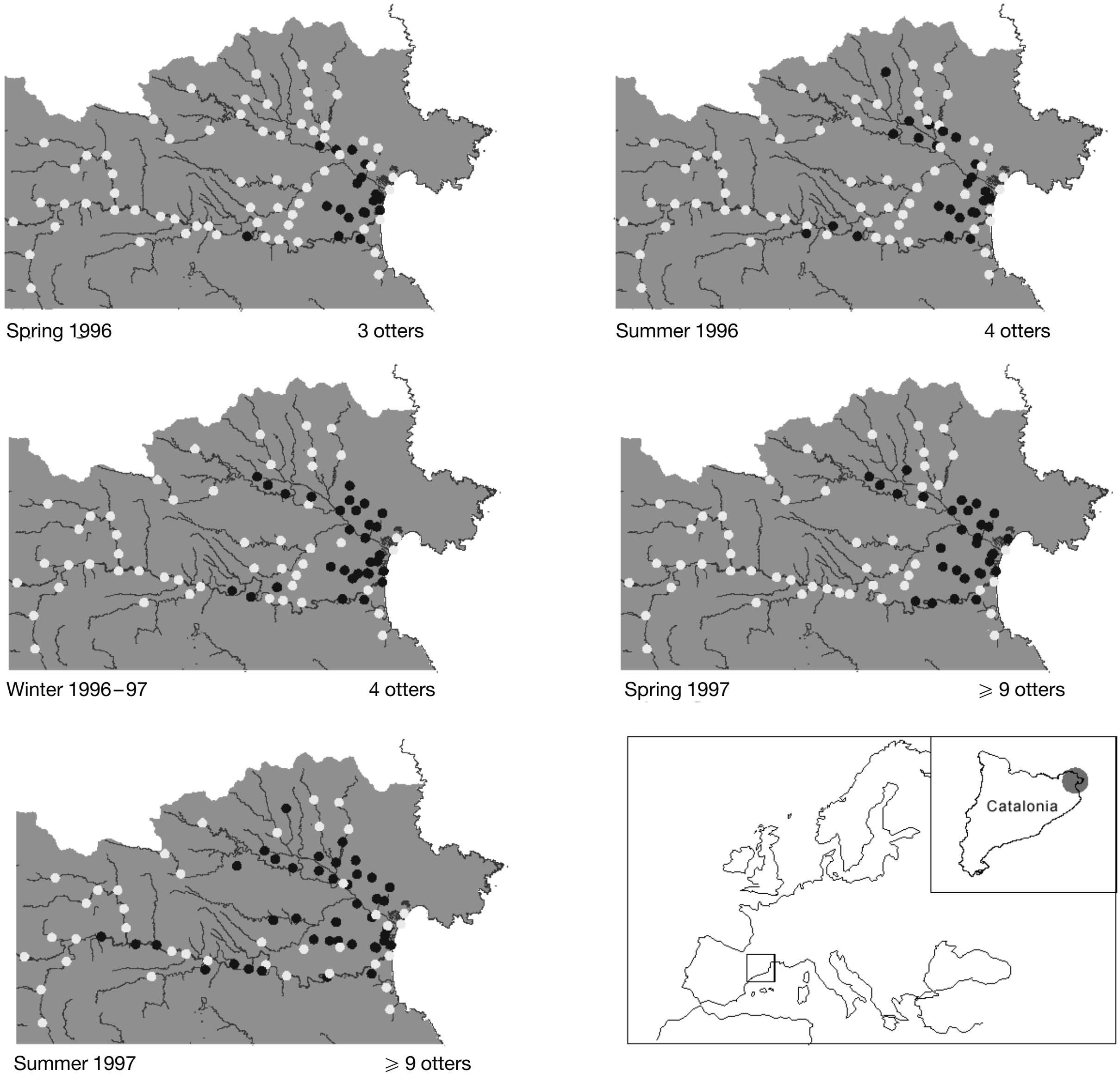

Fig. 2. Results of the five otter surveys carried out between spring 1996 and summer 1997 in the reintroduction area of north-eastern Girona. Black circles, positive sites (presence of otters); white circles, negative sites.

visual and track censuses were carried out in the Noguera Ribagorçana and Noguera Pallaresa rivers (with no tagged otters at that point) between 1995 and 1998. In total, 24 censuses were carried out, a total of 602 individual vigils over 1067 h.

Statistics

Chi-square (χ^2) for contingency tables was used to compare the number of positive and negative sites from the network of 83, after the otter surveys and radio-tracking findings (Siegel, 1956). We used the conditioned probability (Alonso, Ocaña & Cuadras, 1979) to estimate the probability of finding otters in several surveyed sites (Fig. 5); for each new site surveyed, the results of the previous sites was taken into account.

The results of the visual and track censuses were compared by a regression and Pearson correlation analysis resulting in a linear function as the best adjustment.

RESULTS

Distribution of otters in the Muga and the Fluvià

Figures 2 & 3 show the increase in the percentage of positive sites in the Muga and Fluvià river basins, from zero in the three previous otter surveys to the reintroduction of the otter in autumn 1995, to almost 50% of the sites in summer 1997.

Between November 1995 and March 1996, five otters were released, one of which died shortly after release (killed by a car in December) while another died in June

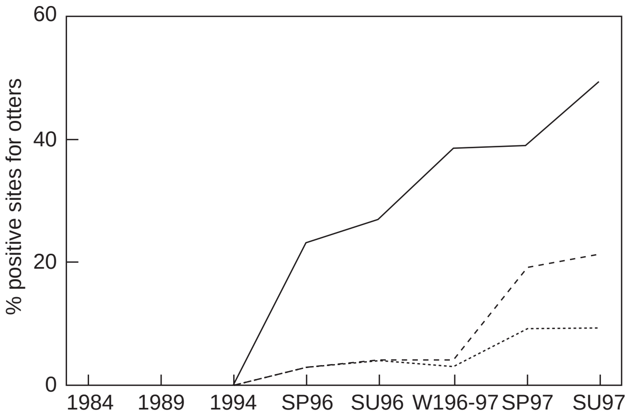

Fig. 3. Changes in the percentage of positive sites (presence of otter) (____) in the reintroduction area of north-eastern Girona. Minimum number of otters (……) and number estimated (------) in the same area.

1996. With only four otters surviving, 23.2% of the sites were positive in early 1996, occupying *c*. 80 km of rivers and 940 ha of marshes. With a similar number of animals (four at the begining) in winter 1996, the percentage rose to 39% ($\chi^2 = 4.65$, 1 d.f., $P = 0.030$) occupying 135 km and 940 ha. In spring 1997 it remained at 39.2%, not statistically different from the previous period ($\chi^2 = 0.0055$, 1 d.f.; $P = 0.955$), despite the release of a further 14 individuals (with transmitters running).

From April to May 1996, all four otters living in the whole reintroduction study area tended to use a different stream during a 5- to 6-month period (Table 2, Fig. 4), and were still tagged with their transmitters in working order. The female F2 reproduced in July 1996 (with a single young) and the transmitter stopped functioning in October 1996. From October 1996 the female and her young occupied a separate area from the rest of the otters, detected because otter spraints and adult and cub footprints were found in a new area not used by the remaining two radio-tracked otters.

Thus it was possible to determine the exact number of otters living in given stretches between April and September 1996. Subsequently, as the transmitters ceased to function and new otters were released in October 1996, it became impossible to know how many individuals were present in each area.

Comparison between otter survey and radio-tracking data

Comparison of the home ranges of tagged otters with the results from the otter surveys carried out in the same areas (Fig. 4) showed very similar distributions ($\chi^2 = 110.9$, 1 d.f., $P = 0.0001$), but were not exact; otter signs (footprints and spraints) were found in site surveys done outside the home ranges as estimated by radio-tracking: 37.5% of site surveys proved positive ($n = 144$). The fact that otters were not found on all the days can explain this finding. Similarly, 24.5% of survey sites, which proved negative for otters, were inside the home ranges of otters ($n = 119$).

Of the site surveys that were examined in which only one otter lived, 70.9% were positive ($n = 86$), 100% in these where two otters existed ($n = 19$) and 92.3% in those where there were three or more otters ($n = 13$). Taken together, those surveys of sites examined in areas with two or more otters turned out to be positive on 96.9% of occasions ($n = 32$), a significant difference compared with those in which there was only one otter ($\chi^2 = 3.51$, 1 d.f., $P = 0.006$).

No significant differences were found between young and older otters. However, the differences were significant between medium-size watercourses (15–40 m average width) and small watercourses (5–15 m) ($\chi^2 = 52.51$, 1 d.f. $P < 0.0001$), and between medium watercourses and lakes and marshes ($\chi^2 = 6.63$, 1 d.f., $P = 0.010$). The lowest values were recorded in the medium rivers where the otters were detected in 55.5% of the surveys of sites done inside the home ranges ($n = 54$). However, in the small rivers (93.3% of positive site surveys; $n = 106$) and lakes and marshes (90.5%; $n = 21$) the differences were not significant.

Our results show that the survey of two or three sites is sufficient to find otters with 100% efficiency (Fig. 5); only medium rivers needed a total of seven sites to be surveyed to find otters with 100% certainty (however, with three and four sites, otters will be detected 92%, and 97% of the time, respectively).

The length of watercourse occupied by otters released during the first part of the reintroduction project (discounting the marshes which are measured in units of area) were 3 km in 35 days (F1), 90 km in 588 days (M1), 3 km in 210 days (M2), 35.5 km in 233 days (F2) and 64 km in 519 days (F3). The otters always left spraints and prints over large distances (dozens of km), enabling easy detection.

Table 2. Rivers used by the first four released otters in the basins of the rivers Muga and Fluvià, the littoral marshes and other small rivers (see Fig. 1), during the first 7 months. Otters living alone in a river or body mass are in bold and underlined

	March				April				May				June				July–September		
	F2	F3	M1	M2	F2	F3	M1	M2	F2	F3	M1	M2	F2	F3	M1	M2	F2	F3	M1
Muga-Mugueta-Llobregat										**X**				**X**				**X**	
Reserva Natural Integral 2	X	X		X	X	X		X				**X**							
Rec del Molí	**X**				**X**											**X**			
Rec Sirvent			**X**			**X**			**X**				**X**				**X**		
Fluvià						**X**					**X**				**X**				**X**

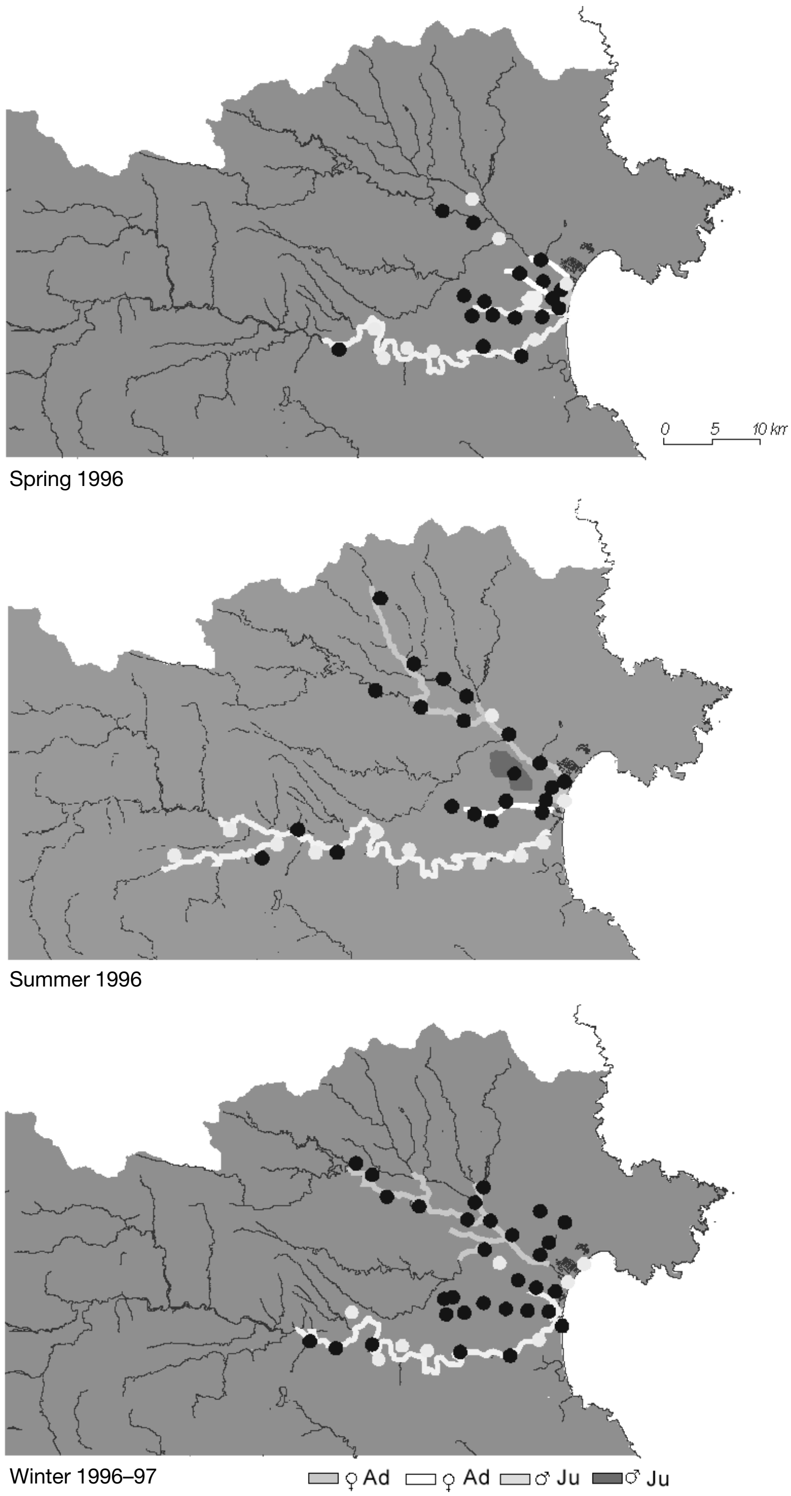

Fig. 4. Changes in home ranges of the first reintroduced otters in north-eastern Girona, and position of the positive (black circles) and negative (white circles) sites during the otter surveys carried out in the same season. Only sites inside the home ranges are presented. ad, Adult; ju, Juvenile.

The average number of sprains per latrine (1.25–2.5) did not vary significantly throughout the five surveyed periods (Mann–Whitney U, $P > 0.05$).

Detection of the otters during the visual censuses

All the otters tagged with transmitters and present in the stretches where censuses were carried out ($n = 7$) were seen during the standard visual censuses. The otters were active outside the rest sites during the standard otter visual census period during dawn (76.2%; $n = 21$) and during dusk (95.5%; $n = 22$). In a standard census which includes consecutive dawn and dusk watches, 100% of the otters would have been

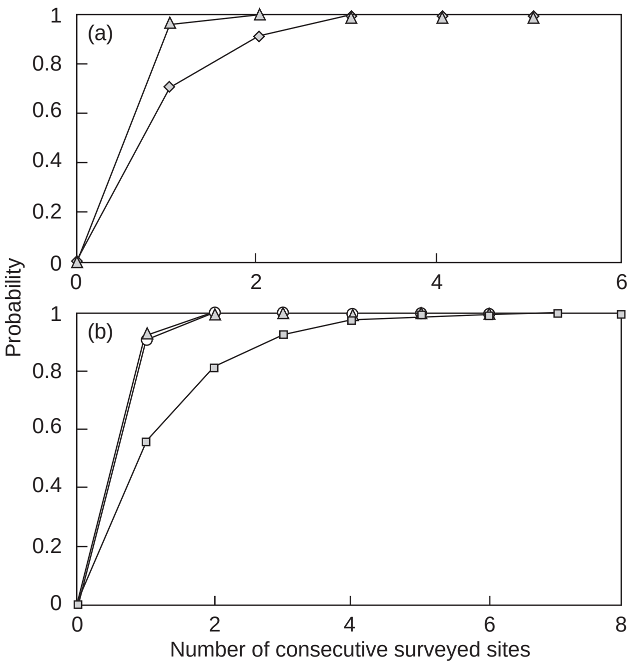

Fig. 5. Conditioned probability of finding otters in consecutive surveyed sites in the same stream: (a) comparing rivers with a single otter (triangle) or with two or more otters living together (squares); (b) comparing small size (< 15 m wide) rivers (triangles), medium size (15–40 m wide) rivers (squares) and lakes and marshes (circles).

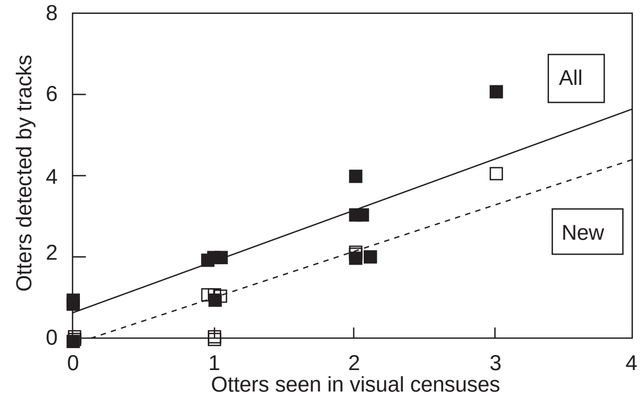

Fig. 6. Linear function relationship and correlation between the number of otters detected by new tracks (1 or 2 days old) and all tracks (new and old), and the number of otters seen during visual censuses in the same stretches and day ($n = 16$). (a) $y = 1.27x - 0.348$, $r = 0.921$, $n = 16$, $P < 0.001$ for new tracks; (b) $y = 1.39x + 0.44$, $r = 0.863$, $n = 16$, $P < 0.001$.

seen if they had been in the field of vision of a census taker.

Comparison of visual and footprint censuses

Figure 6 shows that a high correlation exists between the number of otters seen during the visual censuses and the number of otters detected by means of the lengths of their footprints. If only recent footprints are used (those from the previous night) a virtually identical density is obtained (otters/km surveyed). If all otter footprints are used (old and new), the number of otters seen is overestimated by about two times. A few otters were not seen but were detected by their footprints because an individual was not active that day, or appeared later and returned before daybreak, or was simply not spotted by an observer. However, other otters were sometimes seen and not detected by their prints. The average value of the censuses carried out using both methods (when using only recent prints) produced very similar results.

DISCUSSION

Usefulness of the otter surveys

In the introduction, the use of otter surveys and their limitations was discussed. Until now, we have not known how to interpret indirect signs indicating the presence or absence of otters. The reintroduction programme of the Eurasian otter to north-east Spain has enabled us to study an artificially designed population. During the early months we knew the exact number of otters constituting the population and the number of otters that lived in the different waterbodies. One of the most striking results is that in waterways of small or average width, a single otter is capable of marking many km so that it can be detected in most of the sites (71% of sites monitored by conventional surveys). Thus, if one site is negative, it is highly probable that the otter will be detected at the next site several km away, if the area is actually occupied by this individual. The survey of several consecutive sites without otters must be interpreted to mean that they are absent in the area. This result is of special importance on the margins of the species' distribution, where a single individual can be easily detected in such waterways. An example is provided by the decrease in the number of otter signs with altitude (Green & Green, 1980; Chapman & Chapman, 1982; Ruiz-Olmo & Delibes, 1998), which is actually attributable to a decrease in the number of individuals (Ruiz-Olmo, 1998). This means that the non-detection of otters in one area over time suggests that they are absent altogether.

Frequently we talk about isolated otters in small mountain streams or in areas far from human activity. Otters have large home ranges, normally consisting of 5–100 km and will often move up to 200 km a day (Green, Green & Jefferies, 1984; Jefferies *et al.*, 1986; Kranz, 1995; Kruuk, 1995; Ruiz-Olmo, Jiménez & López-Martín, 1995; Jiménez *et al.*, 1998). A single otter is therefore capable of marking many km. Thus the traditional image of the single otter (or 'a pair') living in a short stretch (often in hills or mountains), and difficult to locate, is not realistic.

The results for wetlands are similar. However, in large rivers of widths > 20 m, the rate of detection decreases. Even so, we found signs of otters in approximately half of the sites along a river that was 15–40 m wide. In large rivers, otter surveys in areas with only one otter are less efficient. Larger rivers, nevertheless, provide a wider habitat, and greater availabilty of places for depositing spraints. Thus, it seems that an increase in the density or the number of otters in these big rivers would lead to greater detection. Our results tend to confirm this. In the stretches in which two or three otters are present, the probability of detecting the otter in a conventional surveyed site is nearly one. Two or three animals alone are capable of providing sufficient signs for otters to be found in almost all the places that they occupy. The density of otters in fresh water is frequently low, about 0.05–0.6 otters/km (Sidorovich, 1991, 1992; Ruiz-Olmo, 1995*b*). In other words, the presence of between one and four otters in one fluvial stretch can be considered standard, and otters must be detected after very few surveyed sites.

A further factor needs to be considered: the otters' use of the stretches. Kruuk, Carss *et al.* (1993) demonstrated a differential use according to food availability, while López-Martín *et al.* (1998) stressed the importance of availability of food, river pools and cover. Our results refer to sedentary otters occupying one stretch for months. However, there are otters which do not have clearly defined home ranges, or which use determined stretches only for dispersion. If otters were not detected in a given area does not imply that they were absent from that area. One of our animals was detected mainly in those sites which constituted its core area. The sites in the Fluvià River in which it was not detected actually corresponded to stretches that it used infrequently and then only for moving between core areas.

Areas of frequent use and sedentary presence must be distinguished from areas in which otters move quickly over large distances across unsuitable watercourses, without food, water or cover, until they reach the next core area, frequently coinciding with an area of good quality habitat (Jiménez *et al.*, 1998; López-Martín *et al.*, 1998). These areas of sporadic presence where, for example, an otter which has been run over might sometimes be found, far from the habitual areas of detection, are not well defined by the otter surveys. On the other hand, areas with stable otter populations tend to be detected with greater frequency. Thus, if an isolated individual, either wandering or a newcomer to an area, leaves a spraint in an atypical place as it passes through, this should be interpreted with caution before further data can be found. If the report is not repeated, the diagnosis is then clear: the otter is just moving.

The four otters released during the first autumn–winter, were detected at 40% of the surveyed sites in the basins where they were reintroduced, along 80 km of fluvial basin and some 940 ha of wetlands. However, in summer 1997, when 19 otters had been reintroduced, and with a minimum of nine individuals remaining in the population (11 estimated by radio-tracking and by tracks), there was no notable increase in the percentage of positive sites and the length of the occupied basin (135 km and 940 ha of wetlands). This indicates that a linear relationship does not exist between the number of otters and the number of positive sites, since a few individuals spread their signs over large areas and those which are being released tend to occupy the same areas, presumably sites that offer the most favourable conditions. Ruiz-Olmo (1995*b*) reported that in the recolonization of a Pyrenean basin, the otters initiated this process in those stretches with the greatest availability of food and the lowest altitude.

The comparison of the rate of increase in positive sites found in our study area, and those from other studies from Britain (Mason & Macdonald, 1993; Strachan & Jefferies, 1997) and Spain (Ruiz-Olmo & Delibes, 1998), show some interesting findings. When a river is recolonized by otters (naturally or after reintroduction), the presence of the species in most of waterbodies of the basin is reached quickly, often in 1–4 years, which is explained by their large individual home ranges.

Estimation of abundance

It is not easy to establish how many otters live in one specific sector of a habitat. The large distances covered, the use of home ranges according to the availability of food over time, the particular social structure of otters and their chiefly linear habitat (Kruuk, 1995), make any decisions concerning the area or length of the census, the best time to carry out the census and which otters to count, particularly difficult. Thus, use of the time spent by the otter (number of nights radio-tracking, Kruuk, Carss *et al.*, 1993; number of radio-locations, López-Martín *et al.*, 1998) is certainly more precise and in closer agreement with the ecological reality of the species. But, this involves methods that are difficult to apply in management and which eventually tell us very little about the numbers and density of otter populations.

We found that when there were several otters in an area, more otter signs were detected. Thus, the number of spraints could provide a rough idea of otter abundance. However, in north-east Spain, Ruiz-Olmo & Gosálbez (1997) usually found between one and three spraints per latrine, which is consistent with the data recorded in the present study for only one otter living at each stretch. Another parameter to be considered is the density of signs (not quantified in our study), which according to Ruiz-Olmo & Gosálbez (1997) is narrowly correlated with the number of latrines. Therefore, our results, which require further confirmation, indicate that even if there are more otters present, more latrines and more spraints, there is a rapid saturation of spraints, without linearity.

Most studies consider 10 km stretches of river when conducting censuses of otters (Ruiz-Olmo, 1995*a*; Sidorovich, 1991, 1992). In *Lontra canadensis*, studies were carried out on river stretches > 100 km (Reid *et al.*, 1987). As otters need space, these 10 km stretches appear to be short, since a single otter can cover > 20 km/day and even 100 km on some days. Thus, footprints can be found in many 10 km stretches. In line with our results, if we count all these stretches with footprints more than a few days old, we might estimate that up to 10 otters are present when only a single otter is living in the area. In contrast, if we only consider 1 day-old tracks, or the otters seen in one activity period (with average daily movements of 4–7 km, range 0–20 km; Green *et al.*, 1984; Jefferies *et al.*, 1986; Ruiz-Olmo *et al.*, 1995; Dülfer, Foerster & Röche, 1998; Jiménez *et al.*, 1998; in *Lontra canadensis* with a maximum of 42 km in a single night; Melquist & Hornocker, 1983), the use of 10 km stretches as a census unit seems to be sufficient, although 20 or 30 km stretches may give more accurate results. It must be assumed that the same otter might be counted in two units, but also that a resident otter can wander outside this unit. The estimated density is similar to the results of the census. Precision can be improved by consecutive census and the subsequent calculation of mean and standard error. The fact that both recent print and visual censuses give similar results (and show a high level of correlation) gives greater consistency to the results. However, the data obtained by radio-tracking also indicate that most otters can be seen by experienced observers, which confirms the validity of the visual censuses. Ruiz-Olmo (1995*b*) demonstrates that significant differences exist in the capacity to see otters during censuses, with the possibility of observation almost doubling with an experienced census taker. The visual censuses also allow us to apply different indices to the estimates of the abundance (e.g. otters observed/km, otters/ha, otters observed/h), all of which are highly correlated (Ruiz-Olmo, 1995*a*). Indices which use the number of observations per unit of time constitute an interesting form of estimation of the use of the different stretches (see the index proposed by Kruuk, Carss *et al.*, 1993).

In conclusion, our study affirms that fresh footprint and visual censuses provide information that is close to the real number of otters. Several studies using visual censuses conducted in the centre of Spain (Bravo, Bueno & Sánchez-Aguado, 1998) and in the Czech Republic (R. Dülfer, pers. comm.) present good results, though they always need to be carried out in the standard form by experienced census takers and according to established periods and procedures.

However, in areas or periods of high otter density (> 0.6 otters/km), it is possible to underestimate the real number of individuals if footprint censuses are used, as in areas where there are two individuals of the same sex and similar in size, footprints may be confused. This will not normally occur with visual censuses. In contrast, in areas of low otter density (< 0.1/km), individuals are not easily detected in visual censuses because they can go outside the census stretch.

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