Odderens *Lutra lutra* økologi og forvaltning i Danmark

The Ecology and Conservation of the Otter *Lutra lutra* in Denmark

PhD afhandling
Aksel Bo Madsen
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PhD afhandling, Århus Universitet, Afdeling for Zoologi

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Forord og tak

Med henblik på erhvervelse af Ph.D.-graden ved Århus Universitet indleveres denne afhandling til bedømmelse. Afhandlingen består af en sammenfatning og perspektivering af ni engelske artikler, hvoraf fem er publiceret, to indsendt, og to foreligger som manuskripter. Herudover er en odder forvaltningsplan selvstændigt publiceret. I sammenfatningen og i de ikke publicerede artikler, er der refereret til de øvrige upublicerede artikler ved det angivne romertal i indholdsfortegnelsen.

Udgangspunktet for afhandlingen er "Projekt Odder", som blev iværksat i 1984 af Foreningen til Dyrenes Beskyttelse og WWF Verdensnaturfonden i et forsøg på at vende odderens negative bestandsudvikling i Danmark. Projektet skulle bl.a. gøre offentligheden og myndighederne opmærksomme på, at en højt placeret dyreart i fødekæden og oprindelig del af den danske fauna var på randen af udryddelse. Miljøministeriets Vildtforvaltning og Skov- og Naturstyrelsen overtog efterfølgende projektet og videreførte dette, og Danmarks Miljøundersøgelser gav i et samarbejde med Århus Universitet og Forskerakademiet muligheden for, at jeg i det seneste år kunne anvende en del af min tid på sammenskrivningsfasen. Projektet har fra starten været målrettet, idet der sideløbende med den formidlingsmæssige del er iværksat og gennemført biologiske og økologiske undersøgelser til belysning af forskellige problemstillinger og på baggrund heraf forslag til, hvordan disse kan afhjælpes. Efterfølgende er de forskellige løsningsmodeller søgt implementeret i praksis i samarbejde med de administrative myndigheder (Skov- og Naturstyrelsen, Landbrugs- og Fiskeriministeriet, amter og kommuner).

Denne afhandling er ikke en enkelt persons arbejde. Som det fremgår, er nogle af artiklerne udført i samarbejde med kolleger fra såvel ind- som udland. Men herudover har adskillige personer og institutioner været medvirkende og bidraget til, at arbejdet kan afsluttes, og jeg vil derfor gerne her benytte lejligheden til at takke alle disse.

En forudsætning for gennemførelse af et arbejde af denne størrelsesorden er de økonomiske midler. Her skylder jeg Foreningen til Dyrenes Beskyttelse, WWF Verdensnaturfonden og UNIBANK A/S Miljøfond en meget stor tak for, at de gennem "Projekt Odder" muliggjorde iværksættelse af dataindsamlingen og etablering af faunapassager. Herunder vil jeg også takke Anders Holm Joensen, Naturhistorisk Museum, Århus som under projektets første år vederlagsfrit stillede kontor- og arbejdsfaciliteter til rådighed. Ligeledes en tak til konservatorerne samme sted for det gode samarbejde.

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En gruppe personer, som det vil være uoverkommeligt at nævne ved navn, men hvis indsats har været uvurderlig i forbindelse med denne afhandling, er de mange, som har ulejliget sig med at opsamle og viderebringe omkomne oddere, heriblandt en række vildtkonsulenter og konservatorer. Grundlaget for de fleste artikler er data, som har kunnet trækkes ud af dette meget værdifulde materiale. Her vil jeg også takke Hans Henrik Dietz, Statens Veterinære Serumlaboratorium, Per Henriksen og Bjarne Clausen for et udbytterigt samarbejde omkring obduktion af de mange oddere.

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Sidst, men ikke mindst, vil jeg takke min hustru Eva og børn Kathrine og Kristian for deres forståelse for, at dette arbejde skulle gennemføres og for deres evne til at tilføre mit liv andet end vildtøkologi og conservation. Uden jeres engagement, interesse og opbakning var jeg aldrig nået så langt.

English Summary

This report is a Ph.D. thesis on the subject "The Ecology and Conservation of the Otter *Lutra lutra* in Denmark". The thesis consists of a synopsis (in Danish), which reviews the background, summaries and discussions of nine scientific articles, and an otter management plan (in Danish). Five of the scientific articles have already been published, two are submitted and two are present as manuscripts. References quoted in the synopsis are placed at the end of the synopsis. References, not yet published are quoted by Roman numerals, (i.e. Madsen & Gaardmand VIII, Madsen IX) and can be identified in the table of contents.

Since 1967, the otter has been protected in Denmark, and today it is one of the most endangered mammal species. On account of only few hundred otters left, the Danish Animal Welfare Society and the World Wildlife Fund for Nature in 1984 initiated a research project on the otter. In 1989, the National Forest and Nature Agency continued the project, since 1992 in collaboration with the National Environmental Research Institute. The aim of the project was to identify factors responsible for the otter's decline and on this basis to give proposals for measures which in a short time could change the negative population development of the Danish otter population.

National field surveys were carried out in 1984-86 and 1991. After a nationwide otter protection campaign, a central collection of otter carcasses and otter observations from the whole country was established. Testing the number of delivered otter carcasses againts the proportion of positive sites and mean number of positive signs per positive site from the same areas, it is suggested that sprainting intensity is a good indicator of relative population strength. Furthermore, it is emphasized that national spraint surveys must be carried out in the months when sprainting activity is highest to ensure that as many sites as possible with otters are detected. It is particularly important in low density otter areas.

During the National Otter Survey in 1991 data was collected on 19 variables which represent elements of habitat structure, composition, organic pollution and human disturbance. A stepwise multiple logistic regression analysis was used to estimate probabilities of the presence of otters as a function of one or more explanatory variables. Seven variables were identified. All of them are directly or indirectly related to productivity and fish biomass in the water catchments. Human disturbance did not have a significant influence on the presence of otters in the surveyed area. The use of the otter as an indicator for the quality of water and habitat, as recommended by some authors, should be undertaken with care.

Necropsy was carried out on otter carcasses and the cause of death, body condition and health status was determined. Body condition for otters which died violently (by traffic and drowning in fish traps) in Denmark was comparable to findings in Shetland, where thriving populations exist. Samples of hair, liver, kidney and muscle were examinated for concentrations of cadmium, lead, mercury, organochlorine pesticide residues and PCBs. Current concentrations of contaminants are unlikely to pose a threat to the Danish otter populations.

Otters killed by traffic were examinated, and a survey of the accident sites carried out. Adult, sexually mature males are most frequently killed by traffic, and it is concluded that the most dangerous kind of road for an otter is a larger road with a relatively high vehicle speed and density. Based on the great variety in types of accident sites, it is impossible to eliminate all traffic killings. Appropriately sited fauna passages are an effective means of reducing the problem and two types are recommended to make existing roadbridges attractive for otters with relatively small expenses. Fauna passages are also used by species like stoat (*Mustela erminea)*, mink (*Mustela vison*), water vole (*Arvicola terrestris*), dipper (*Cinclus cinclus*) and grey wagtail (*Motacilla cinerea*).

Examination of otters drowned in fish traps were carried out and data on date of death, site, sex, age, and chest-circumference collected. The majority of the otters were subadult individuals. Otters drowned in both single and double fyke nets set in shallow water, particularly in lakes

but also in fiords/inlets and rivers/canals. Stop grids that fit into the inner end of the first fyke funnel of fish traps, were introduced and tested with positive results. Consequently, barriers are now compulsory in all fresh water areas and in certain salt water areas in Denmark to protect the otter. Drowning of other species can also be prevented using barriers in fish traps: e.g. goldeneye (*Bucephala clangula*), cormorants (*Phalacrocorax carbo*), coypu (*Myocastor coypus*) and beavers (*Castor fiber*).

A management plan for the otter has been worked out. The purpose of the plan is to gain the necessary knowledge and to establish comprehensive guidelines for the protection and consolidation of the Danish otter population and its habitats. Areas of interest to the otter have been pointed out and a national monitoring programme with a five year interval was started. Furthermore, the plan is an integral part of the strategy for maintaining the biological diversity in Denmark and Europe.

After 10 years work, there are positive indications of a successful enhancement of the living conditions for otters in Denmark. However, it is concluded that traffic killings and the absence of ecological corridors is a serious threat in consolidating the future for the Danish otter population. The success of this project is a result of a close collaboration between private persons, public authorities, administrative authorities and research institutes.

As co authors, of a native language different from mine, I wish to thank Dr. Chris Mason, University of Essex, U.K. very much for the profitable collaboration and the permission to include our joint papers in my Ph.D. thesis.

1 Synopsis

1.1 Baggrund og formål

Den europæiske odder (*Lutra lutra*) har, såvel i Danmark som det øvrige Europa, indenfor den sidste snes år været inde i en markant tilbagegang. Ødelæggelse af de naturlige levesteder (regulering af vandløb, afvanding af vådområder, intensiv vandløbsvedligeholdelse), menneskelige forstyrrelser, drukning i fiskeredskaber, trafikdrab, eutrofiering, miljøgifte, efterstræbelse og konkurrence fra minken (*Mustela vison*) har været foreslået som årsager til denne tilbagegang (Mason & Macdonald 1986, Macdonald & Mason 1994).

Individuelle forskningsmæssige interesser har betydet, at der har været fokuseret meget på enkelte problemstillinger (f.eks miljøgifte) som årsag til odderens tilbagegang, og dermed er andre nævnte faktorer til tilbagegangen blevet mere eller mindre negligeret.

I en forvaltningsmæssig sammenhæng er dette uholdbart, idet de administrative myndigheder netop skal vurdere og afveje de forskellige faktorers indflydelse udfra mere vide forskningsmæssige resultater og på denne baggrund foretage de nødvendige foranstaltninger (f.eks. henstillinger til lokalbefolkningen, lovgivning, rekreative begrænsninger og naturgenopretning).

Formålet med denne afhandling har derfor været, mere bredt at identificere problemstillinger og objektivt gennemføre biologiske og økologiske undersøgelser til belysning af odderens tilbagegang og krav til levested samt at give konkrete forslag til foranstaltninger, der indenfor en overskuelig fremtid kunne vende den negative bestandsudvikling. I store dele af sit udbredelsesområde, er odderen næsten umulig at observere direkte i sin naturlige habitat, dette gælder bl.a. i Danmark. Undersøgelserne er derfor baseret på mere indirekte metoder og følgende emner er belyst: (1.2) Forekomst og bestandsudvikling, (1.3) Habitatkvalitet og rekreative forstyrrelser, (1.4) Sundhedstilstand, kondition og miljøgifte, (1.5) Trafik og faunapassager, (1.6) Fiskeredskaber og spærreforanstaltninger samt (1.7) Forvaltningsmæssige aspekter og forvaltningsplan.

1.2 Forekomst og bestandsudvikling

Landsdækkende undersøgelser af odderens forekomst i Danmark er foretaget i 1984-86 (Madsen & Nielsen 1986) og 1991 (Madsen et al. 1992). Den geografiske udbredelse er primært begrænset til Midt- og Nordvestjylland, og kerneområdet er koncentreret til vandløb, søer og andre vådområder omkring Limfjorden.

Feltundersøgelserne er baseret på en standardiseret metode, som bygger på registrering af ekskrementer eller fodaftryk efter odder langs vandløb, søer og kyster. Kortlægningsmetoden giver umiddelbart mulighed for at sammenligne resultaterne fra forskellige lande og fra år til år (Anon. 1984). Metoden giver kun ringe mulighed for at sige noget kvantitativt om bestandens størrelse, men den giver et overordnet billede af udbredelsen, og anbefales endvidere af et sagkyndigt udvalg under Europarådet (Macdonald & Mason 1994).

Mange forskere har imidlertid diskuteret brugen af ekskrement-moniteringer som en metode til at bestemme udbredelse og tæthed af oddere (f.eks Jefferies 1986, Kruuk et al. 1986, Conroy & French 1987, Kruuk & Conroy 1987, Mason & Macdonald 1987, 1989 og O'Sullivan 1993). På baggrund af studier foretaget af Kruuk & Conroy (1987) og Kruuk et al. (1993) sættes der spørgsmålstegn ved værdien af ekskrementer som mål for tætheden af oddere.

Antallet og fordelingen af 194 indleverede omkomne danske oddere i perioden 1979-1993 (Madsen et al. VII) vurderes til at være et udtryk for den relative bestandstæthed i de tilsvarende landsdele (Madsen & Gaardmand VIII). Fordelingen af lokaliteter med odderforekomst og gennemsnittet af ekskrementer pr. positiv lokalitet fundet ved den landsdækkende monitering af odder i 1991 (Madsen et al. 1992) er positivt korreleret med fordelingen af indleverede oddere. Markeringsintensiteten (tætheden af ekskrementer) anses derfor som værende en god indikator for den relative populationstæthed.

Sammenlignes antallet af lokaliteter med odderforekomst ved undersøgelserne i Danmark i 1984-86 og 1991 har der generelt været tale om en fremgang. Denne udvikling har været mest tydelig i Viborg, Nordjylland og Århus amter. Sammenlagt er det gennemsnitlige antal positive lokaliteter på landsplan steget fra godt 23% til knap 38% i den femårige periode.

I 1980 anslog Schimmer (1981) antallet af oddere til kun at være ca. 200 dyr. Med udgangspunkt i de samme antagelser som Schimmer og en sammenligning mellem antallet af lokaliteter med odderforekomst fundet ved undersøgelserne i henholdsvis 1984-86 og 1991 vurderes antallet af oddere i Danmark i begyndelsen af 1990'erne til at være af størrelsesordenen 400 individer.

Lignende landsdækkende feltundersøgelser er bl.a. foretaget i England (Lenton et al. 1980), Wales (Andrews & Crawford 1986), Skotland (Green & Green 1980, 1987) og Irland (Chapman & Chapman 1982). I Irland blev 91,7% af i alt 2.177 undersøgte lokaliteter fundet positive i 1980-81. Til sammenligning med bestandsudviklingen i Danmark kan følgende resultater nævnes: i Wales sås en stigning i antallet af lokaliteter med odderforekomst fra 20% til 38% mellem 1977-78 og 1984-85 (Andrews & Crawford 1986), hvorimod Green & Green (1987) kunne fremvise en stigning i Skotland fra 57% til 65% i samme periode.

Genopdagelsen af oddere på Sjælland (Jensen & Jensen 1995, Leth & Byrnak 1996) er et eksempel på, at det er nødvendigt at udvise forsigtighed ved anvendelsen af ekskrement-moniteringer som et redskab til at identificere isolerede forekomster af oddere med meget lave tætheder. Det er derfor meget vigtigt, at moniteringer, som skal give et overordnet og længere tidsmæssigt tilbageblik af odderens forekomst gennemføres i perioder, hvor markeringsintensiteten er maksimal, vegetationen lav og uden snedække (Madsen og Gaardmand VIII). I Danmark bør månederne marts-maj foretrækkes.

1.3 Habitatkvalitet og rekreative forstyrrelser

Manglende optimale levesteder og menneskelige forstyrrelser har været nævnt som afgørende faktorer i relation til odderens tilbagegang (Mason & Macdonald 1986, Macdonald & Mason 1994). I forbindelse med den landsdækkende undersøgelse af odderens forekomst i Danmark i 1991 (Madsen et al. 1992) blev der indsamlet data om habitatkvalitet på de i alt 766 besøgte lokaliteter (Madsen IX). Disse data omfattede bl.a. registreringer af bredde, dybde, strøm og bundforhold, bredvegetationen, udnyttelsen af de tilstødende arealer, potentielle menneskelige forstyrrelser, pH og eutrofiering bestemt ved Saprobie-Index.

En stepwise multipel logistisk regressions analyse (SAS/STAT, SAS Institute Inc. 1990) blev anvendt til at estimere sandsynligheden for odder (udtrykt ved tilstedeværelsen af ekskrementer) i relation til 19 uafhængige habitat variable.

Syv af de 19 variable (amt, pH, træer, dybde, bundforhold, Saprobie-Index og rørvegetation) overholdt et i forvejen valgt signifikansniveau. I Danmark består en typisk odderhabitat af et vandområde med en dybde > 1 m, en varieret bund, pH > 7,0 Saprobie-Index på mellem II-III til III, tilstedeværelsen af rørvegetation og uden træer.

Menneskelige forstyrrelser (bedømt som tilstedeværelsen af fiskeri, bådsejlads, ruser og huse) og udnyttelsen af de tilstødende arealer (bedømt som tilstedeværelsen af skov, dyrkede marker, græsarealer eller uudnyttede arealer) på de undersøgte lokaliteter har ikke signifikant indflydelse på odderens forekomst.

Anvendelse af ekskrementer som en metode til bestemmelse af odderes habitatudnyttelse har været diskuteret af flere forfattere (Jefferies 1986, Kruuk et al. 1986, Conroy & French 1987, Kruuk & Conroy 1987, Mason & Macdonald 1987, 1989). I den gennemførte danske undersøgelse er ekskrementer anvendt som en indikator på odderens tilstedeværelse på de undersøgte lokaliteter og ikke som preference for en specifik slags træer eller buske som anvendt af Macdonald & Mason (1983).

Det blev forsøgt at indsamle data om fisketæthed på de undersøgte lokaliteter fra Danmarks Fiskeriundersøgelser, Afdeling for Ferskvandsfiskeri. Kvantitative data var kun tilgængelige på ørredfisk og ål, og disse alene var desværre ikke anvendelige i den logistiske regressionsanalyse. Selvom analysen ikke indeholdt data om fisketæthed og -tilgængelighed er de syv identificerede habitat variable direkte eller indirekte relateret til produktivitet, typisk for de lavere dele af et vandafstrømningsområde. Ifølge Erik Mortensen, Danmarks Miljøundersøgelser (pers. medd.) indeholder disse områder generelt også den største fisketæthed og biomasse pr. vandarealenhed. Denne angivelse stemmer også overens med oplysninger omkring den danske odders fødevalg (Hansen & Jacobsen 1992). I saltvand foretrækker odderen ålekvabber og ål, og i ferskvand består føden primært af ål, aborrefisk og karpefisk.

Odderens preference for vandløbsstrækninger med træer og buske som angivet af (Jenkins & Burrows 1980, Jenkins 1982, Adrian et al. 1985, Prauser 1985, Mason & Macdonald 1986, Bas et al. 1984, Lunnon & Reynolds 1991, Prenda & Granado-Lorencio 1996) kan ikke på nogen måde bekræftes af den gennemførte statistiske analyse (Madsen IX). Durbin (1993), som anvendte radio-telemetri på oddere, fandt heller ikke nogen sammenhæng mellem forekomsten af træer og tilstedeværelsen af oddere.

En tiltagende eutrofiering har ikke en negativ indflydelse på den danske odders forekomst, snarere tværtimod. Dette er i klar modsætning til Lunnon & Reynolds (1991), som fandt, at 80% af de lokaliteter, hvor der blev fundet oddere i Irland, bestod af ikke forurenede vandløbsstrækninger. En ikke helt gennemeskuelig definering af organisk og industriel forurening bedømt i felten på de enkelte besøgte lokaliteter kan være forklaringen på Lunnon & Reynolds konklusion.

I Danmark og andre steder i Europa er der en større tæthed af oddere, målt som andelen af positive lokaliteter ved landsdækkende feltundersøgelser, i tyndt befolkede områder (Mason & Macdonald 1986). Jefferies (1987) har i en review artikel beskæftiget sig med odderens direkte reaktioner overfor menneskelige forstyrrelser. Han konkluderer, at odderen foretrækker mere fredfyldte områder fremfor meget forstyrrede. Odderen synes, at være mest påvirket af menneskelige aktiviteter nær dens bo og specielt løse hunde reagerer odderen meget kraftigt på. Hunner med unger er særdeles følsomme overfor forstyrrelser.

Alligevel har de menneskelige forstyrrelser ikke nogen signifikant indflydelse på odderens tilstedeværelse på de undersøgte danske lokaliteter. En forklaring herpå kan være forskellen i døgnrytme, generelt er oddere nataktive og mennesker dagaktive.

Kanosejlads og sportsfiskeri er de vigtigste rekreative aktiviteter, målt som antallet af mennesker der færdes langs søer og vandløb. På baggrund af bl.a Jefferies konklusioner er det vigtigt at søer, større moseområder og afsidesbeliggende fjordområder beskyttes. Dette er iøvrigt i overensstemmelse med Madsen, Gaardmand & Mikkelsen (upubl. manuskript), som på baggrund af flere års registreringer af oddernes markeringsaktivitet langs forskellige typer vandløbssystemer konkluderer, at vandløbssystemer som indeholder sø-, mose- eller fjordområder er af betydelig større værdi for oddere end vandløbssystemer uden. En del af disse områder ligger iøvrigt et stykke fra hovedvandløbene og er i mange tilfælde ufremkommelige og derfor ikke attraktive for f.eks sportsfiskere.

Selvom kun syv variable, der indikerer habitatstruktur, anvendes i modellen til identificering af odderhabitater bør potentielle brugere kritisk evaluere berettigelsen heri i relation til deres lokale område. F.eks vil et meget stort antal sportsfiskere og sejlere på en vandløbsstrækning og samtidig intensiv fjernelse af bredvegetationen have en negativ effekt på odderen. Modsat kan en vis forstyrrelse dog tolereres på strækninger, hvor såvel føde- som skjulemulighederne er optimale (Macdonald & Mason 1994).

Ligeledes, vil de signifikante forskelle, på de i modellen udvalgte variable, mellem amter med forekomst af odder og amter uden, ikke forhindre at odderen breder sig til den øvrige del af landet. På den anden side vurderes det, at bærekapaciteten for oddere i disse områder ikke har det samme niveau som findes i Midt- og Nordvestjylland.

Den gennemførte danske analyse og resultater omkring total-PCB fundet i oddere i Spanien og på Shetlandsøerne (Smit et al. 1994) medfører, at anvendelsen af odderen som en god indikator for vand- og habitatkvalitet bør ske med forsigtighed.

1.4 Sundhedstilstand, kondition og miljøgifte

Undersøgelser er foretaget af 194 omkomne oddere fra perioden 1979-1993. Heraf kunne 145 individer veterinært obduceres (Madsen et al. VII). Den største del af de indleverede oddere var trafikdræbte eller druknet i ruser. Blyhagl blev fundet i 5% af de undersøgte dyr. For første gang i en fritlevende odderbestand er der blevet påvist distemper virus (hvalpesyge) og et tilfælde af *Angiostrongylus vasorum* larver. Infektiøse tilstande blev fundet i 22,1% af de obducerede dyr, selvom kun få oddere tilsyneladende er døde af disse infektioner. Undersøgelserne viser også, at odderne ikke er parasiteret af hverken endo- eller ectoparasitter, hvilket tilskrives dyrenes solitære levevis og lave bestandstæthed.

Hår- og leverprøver af 69 af de indleverede oddere er undersøgt for indhold af kviksølv, bly og cadmium (Madsen & Mason 1987, Mason & Madsen 1992). Koncentrationerne af disse tungmetaller er generelt lave og ens i hunner og hanner, men adulte individer har signifikant højere indhold af bly i leverprøver end juvenile.

De gennemsnitlige koncentrationer af Lindane, Dieldrin, *p,p*-DDE, *o,p*-DDD, *o,p*-DDT og total-PCB i lever og muskelprøver fra 73 af de indleverede oddere var ligeledes generelt lave (Mason & Madsen 1993). Et parallelt indsamlet materiale af ekskrementer fra 19 forskellige lokaliteter indeholdt tilsvarende lave koncentrationer. Oddere, som er døde af ukendte årsager, indeholder større koncentrationer af PCB end oddere som er omkommet i ruser eller i trafikken. Adulte oddere har større koncentrationer af PCB end juvenile. Koncentrationen af både PCB og DDE i lever- og muskelvæv har været signifikant faldende i perioden 1980-1990.

Påvisning af distemper virus er sammenfaldende med de perioder, hvor distemper virus blev fundet i spættet sæl (*Phoca vitulina*) og ved større udbrud i danske mink farme (Blixenkrone-Møller et al. 1989). Fund af blyhagl i de indleverede oddere indikerer, at der trods jagtfredning stadig skydes efter danske oddere. Lignende lovovertrædelser angives fra Østrig (Gutleb et al. 1995).

Den maksimale koncentration af bly i det danske materiale (13,49 mg/kg) er lavere end middelkoncentrationen angivet af Mason et al. (1986) for prøver fra England (18,75 mg/kg) og Sverige (31,20 mg/kg).

Indholdet af organochloriner og PCB var sammenlignelige med prøver fra Irland (Mason & O'Sullivan 1992), og koncentrationen af disse stoffer i odderekskrementer indsamlet i Danmark er lavere end et tilsvarende materiale indsamlet i Wales (Macdonald & Mason 1988). Baseret på individer omkommet af pludselige dødsårsager (trafik og rusedrukning), er der ikke signifikant forskel på konditionen hos oddere fra Danmark og Shetlandsøerne (Kruuk & Conroy 1991). Bl.a. Irland og Shetlandsøerne huser meget livskraftige bestande af oddere (Foster-Turley et al. 1990). Konditionen hos oddere indsamlet omkring 1960 (Jensen 1964) er iøvrigt af samme størrelsesorden som oddere indsamlet i perioden 1980-1993 (Madsen et al. VII).

13 (18%) af de danske oddere havde en koncentration af total-PCB større end 50 mg/kg angivet som en toksikologisk grænseværdi for bestande af oddere (Olsson et al. 1981, Mason 1989, Olsson & Sandegren 1991, Leonards et al. 1994). De Vries (1989) angiver den geometriske middelværdi (30 mg/kg) som en mere realistisk værdi, idet den aritmiske middelværdi (50 mg/kg) er influeret af få høje værdier.

Udover, at der er metodemæssige forskelle i de forskellige undersøgelser som gør sammenligning af PCB-indhold vanskelig påpeger Smit et al. (1994), at der udelukkende er blevet fokuseret på total-PCB, hvorimod isomer-specifikke studier mangler. PCB-isomer mønstre kan variere mellem individuelle oddere, og total-PCB er derfor ikke et tilstrækkeligt mål for PCB belastningen. F.eks er relativt høje koncentrationer af total-PCB fundet i oddere fra Spanien og Shetlandsøerne, der som nævnt huser tætte odderbestande. Koncentrationen i danske oddere af PCB 77, 126, 153, 169, som vurderes til at udgøre nogle af de giftigste, er dog også meget lav (Elmeros 1996).

Samlet må det konkluderes, at danske oddere generelt er i en sundhedsmæssig god tilstand, og at koncentrationen af tungmetaller og organochloriner er meget lavt og af en størrelsesorden som i dag er uden sundhedsmæssig betydning for bestanden. Det kan dog ikke udelukkes, at disse stoffer tidligere har haft en negativ indflydelse på oddernes reproduktionsevne og deraf følgende negative bestandsudvikling. Odderens egnethed som indikator for miljøgiftbelastningen i vore vådområder bør dog på ovennævnte baggrund indtil videre vurderes med forsigtighed.

Danmarks Miljøundersøgelser har indledt et samarbejde med Free University, Institute for Environmental Studies, Amsterdam med titlen "Development of Otter-based Quality Objectives for PCBs", hvor isomer-belastningen i tre niveauer af fødekæden (odder, fisk og sediment) undersøges. Disse undersøgelser kan måske give svaret på ovennævnte problemstillinger. Herudover foreslås det, at der fremover foretages stikprøveundersøgelser af de indleverede oddere, således at udviklingen især omkring distemper virus og beskydning kan følges. Beskydning i den omtalte størrelsesorden er dog næppe begrænsende i forhold til bestandsudviklingen.

1.5 Trafik og faunapassager

Undersøgelser er foretaget af 115 trafikdræbte oddere og efterfølgende besigtigelser af påkørselsstedet (Madsen VI). Andelen af trafikdræbte oddere er steget fra 40% til 52% i perioden 1980-1994, hvilket bl.a. skyldes at antallet af indleverede druknede oddere er faldet markant. Der er ikke signifikante forskelle mellem antallet af trafikdrab i sommermånederne sammenlignet med vintermånederne. Mere end halvdelen er trafikdræbte hanner (64,1%) og specielt adulte individer. Dette tilskrives, at hannernes home-range generelt er større end hunnernes.

Oddere trafikdræbes signifikant hyppigere på veje med stor trafiktæthed og -hastighed. Knap 48% af odderne er påkørt på steder, hvor en vej krydser et vandløb eller på dæmninger mellem to vådområder. Infrarød videomonitering af danske oddere (Madsen VI) afkræfter iøvrigt teorien om, at oddere foretrækker at passere vejbroer over vejbanen i stedet for at svømme under dem, som angivet af Reuther (1980 p. 126).

Overraskende trafikdræbes nogle oddere på lokaliteter der ligger mere end ½ km fra søer, vandløb og fjorde. Det er dog tilsyneladende ikke helt tilfældigt, idet det normalt er på steder, som ligger i den korteste afstand mellem to vandafstrømningsområder. På denne baggrund konkluderes det, at oddere ikke nødvendigvis er isoleret fra hinanden af store landarealer, og for en solitært levende art som odderen, kan disse "short cuts" være en vigtig faktor i forbindelse med opretholdelsen af en tilstrækkelig genetisk variation.

Baseret på variationen i trafikdrabslokaliteter konkluderes, at det er umuligt at forhindre alle trafikdrab af oddere, og der er ikke en enkelt løsning, som kan etableres på alle potentielle lokaliteter. Forskellige afværgeforanstaltninger er vurderet og testet. To forskellige og effektive faunapassager foreslås til lokaliteter, hvor veje krydser vandløb.

Lafontaine (1991) anslår, at omkring 5% af den franske odder bestand årligt trafikdræbes. I relation til danske forhold vurderes det, at mindst 12% af bestanden trafikdræbes, idet det antages, at de 25 indleverede trafikdræbte oddere om året (1994) kun udgør halvdelen af det reelle antal trafikdræbte individer, ud af en estimeret bestand på ca. 400 dyr.

Data omkring kønsratio og vejtyper er sammenlignelige med data indsamlet i Tyskland og Holland (Rogoschik et al. 1994, van Moll & Christoffels (1989). Derimod trafikdræbes 70,4% af de danske oddere på lokaliteter, der ligger mindre end 100 m fra vådområder i modsætning til kun 40,5% af de tyske oddere. Det synes ikke umiddelbart muligt, at give en forklaring på denne forskel.

I modsætning til Rogoschik et al. (1994) konkluderer Madsen (VI), at etablering af vildthegn til at lede oddere ind under en bro kun bør anvendes undtagelsesvist. Placeringen af vildthegnet kan være praktisk uhensigtsmæssig, vedligeholdelsen er forholdsvis stor og hvis ikke vildthegnet er rigtig opsat ledes dyrene istedet direkte ud i trafikken.

I Frankrig og på de Ydre Hebrider er afværgeforanstaltninger (bl.a fauna passager) i forbindelse med vejanlæg også etableret (Twelves & Kinross 1982, Lafontaine 1991,). Etablering af sikre passagemuligheder bl.a. for oddere ved større og mindre vejanlæg er allerede iværksat visse steder i Danmark. Dette er bl.a. et resultat af de tiltag som er prioriteret højt i IUCN's og Danmarks forvaltningsplan for oddere (Foster-Turley et al. 1990, Skov- og Naturstyrelsen 1996).

Taget i betragtning, at antallet af trafikdræbte oddere idag udgør 52% af de indleverede omkomne dyr og mindst 12% af bestandsstørrelsen, bør udbygningen af fauna passager intensiveres. Dette kan med fordel ske på de mest trafikerede veje i odderens udbredelsesområde, og det bør bemærkes, at faunapassager også anvendes af arter som lækat (*Mustela erminea*), mink, mosegris (*Arvicola terrestris*), vandstær (*Cinclus cinclus*) og bjergvipstjert (*Motacilla cinerea*).

1.6 Fiskeredskaber og spærreforanstaltninger

Det har længe været kendt, at odderen kan omkomme i forskellige former for fiskeredskaber (Jefferies et al. (1984) og for Danmarks vedkommende er dette bl.a. omtalt af (Jensen 1964). Stubbe (1977) angiver, at indførslen af de moderne ruser af kunststof, som ikke giver odderen mulighed for at bide sig ud, har forværret problemet.

Undersøgelser er blevet foretaget af 96 rusedruknede oddere (Madsen 1991). Alle de rusedruknede oddere er fanget i perioden marts - november, hvilket afspejler den sæsonmæssige variation i rusefiskeriet. Fordelingen mellem juvenile, subadulte og adulte oddere er henholdsvis 5%:46%:10%. Den mindste rusedruknede odder vejede 2,4 kg. Først ved den størrelse følger ungerne moderen på fangst. Som det ses, er det især subadulte oddere af begge køn, der findes omkommet, hvilket indikerer at disse lettere forvilder sig ind i ruserne uden at kunne komme ud.

Hovedparten (58%) af de druknede oddere er fanget i enkeltruser, som er placeret således, at en fouragerende odder faktisk ledes direkte ind i rusen, når den følger bredden af søen eller fjorden. De øvrige 42% i kasteruser og en enkelt i en ståltrådsruse. Halvdelen af de druknede oddere er fanget i søer og de øvrige i fjorde, vandløb og kanaler. De fleste individer findes i den inderste ende af rusen (fangstposen) og i søer og fjorde på dybder mellem 1 og 1½ m vand og i en afstand på mindre end 60 m fra land.

Den mest umiddelbare måde, at hindre rusedrukning af oddere på, er at undgå at dyrene kan komme ind i rusen. På det indsamlede materiale er der derfor foretaget forskellige kropsmål. På basis af omkredsen over skulderen, som udgør den største og mindst fleksible del på en odder, er den største og mindste diameter, forudsat et ægformet elliptisk tværsnit af dyret udregnet (jvf. Jefferies et al. 1984). På grundlag heraf er foreslået to forskellige spærreforanstaltninger. Et spærrenet anbragt i forreste bøjle i rusen, hvor sidelængden i de fleksible masker ikke må overstige 7,5 cm og en stoprist (ramme med et kryds) fremstillet af et stift materiale med 8,5 cm's sidelængde, som hindrer at odderne kommer ind i ruserne.

I en periode på 1½ år afprøvede 40 rusefiskere ialt 307 stopriste (Madsen 1991). Fangsten af ål var den samme i ruser med stopriste og ruser uden, og stopristen synes ikke at forværre problemer med grøde som sætter sig i indgangen til rusen. I samarbejde med firmaet PROCON under Århus Amt blev en produktion af stopriste herefter iværksat.

Resultaterne af de gennemførte test af stopriste er senere blevet bekræftet fuldt ud af Berg (1993) og Pedersen & Koed (1995), men ved lignende systematiske undersøgelser foretaget i England har man fundet signifikant mindre fangster af ål (målt i totalvægt) i forhold til ruser uden stopriste. Derimod var vægten af salgbare ål over 100 g ikke mindre (Vincent Wildlife Trust 1988).

Da rusedrukning må anses for at være en væsentlig dødelighedsfaktor for den lille og sårbare danske odderbestand er der i en årrække blevet arbejdet på at gøre stopriste/spærrernet i ruser lovbefalede. Siden 1987 er der af Landbrugs- og Fiskeriministeriet udstedt en række bekendtgørelser, der i stigende omfang påbyder anvendelse af stopriste, spærrenet og lign. i alle fiskeredskaber, hvori der anvendes ruser.

Med udgangspunkt i de seneste bekendtgørelser og odderens nuværende udbredelsesområde, skulle risikoen for rusedrukning af oddere være elimineret. Det vil dog være hensigtsmæssigt, at påbudet i saltvand udvides i takt med, at odderens udbredelsesområde bliver større. Efter indførsel af påbud om anvendelse af spærreforanstaltninger er antallet af indleverede druknede oddere da også faldet markant (Madsen et al. VII), selvom det ikke kan udelukkes at et sådant påbud kan afholde nogle, der ikke har benyttet dem i deres ruser fra at indsende en druknet odder.

Udover oddere kan spærreforanstaltninger også forhindre, at hvinænder (*Bucephala clangula*), skarver (*Phalacrocorax carbo*), sumpbæver (*Myocastor coypus*) og bæver (*Castor fiber*) drukner i ruser.

1.7 Forvaltningsmæssige aspekter og forvaltningsplan

Med det sigte, at fastholde og forbedre det nuværende udbredelsesområde og de naturlige spredningsmuligheder for den danske odder, er der udarbejdet en særlig forvaltningsplan, der giver de overordnede retningslinjer og den nødvendige baggrundsviden for at beskytte og sikre den danske odderbestand og dens levesteder (Skov- og Naturstyrelsen 1996).

I forhold til det øvrige Europa, er den danske bestand af oddere meget isoleret, idet positive registreringer af oddere i Tyskland findes i en afstand af ca. 60 km syd for den dansk/tyske grænse (Heidemann & Riecken 1988) og dermed næsten 175 km fra den nærmeste registrering i Danmark.

Antallet af oddere i Danmark er anslået til at være af størrelsesordenen 400 individer. Shaffer (1981) anbefaler en effektiv bestand på 500 kønsmodne individer for at opretholde en tilstrækkelig genetisk variation, således at bestanden er i stand til at kunne tilpasse sig svingninger i miljøet. Dette svarer til en reel minimums populationsstørrelse (MVP) på mellem 1200 og 1600 dyr (Wansink & Ringenaldus 1989), så i denne sammenhæng må den danske odderbestand betegnes som lille og sårbar.

Til forskel fra andre danske pattedyrarter er home-range for oddere i stor udstrækning lineær. Dette betyder, at oddere generelt bevæger sig over store afstande, og de enkelte individer vil således også være udsat for forholdsvis større risici end pattedyr, som bevæger sig i et mere to-dimensionelt home-range. Home-range for en enkelt odder kan være op til 78 km vandløb for hanner og 21 km for hunner (Kruuk et al. 1993, Kruuk 1995). Den maksimale naturlige tæthed vil derfor aldrig være særlig høj. Isolerede naturområder eller beskyttede områder vil sjældent være store nok til at kunne understøtte levedygtige, selvsupplerende odderbestande. Beskyttede områder må derfor nødvendigvis være forbundet af korridorer med en tilfredsstillende habitatkvalitet (Madsen IX), som tillader dyrenes vandringer og genetiske udveksling. Der synes f.eks ikke at være nogen fornuft i at fremme bestandene til at yngle, hvis ekspansionsmulighederne ikke kan ske til potentielle yngleområder. Derfor skal beskyttelse og forbedring af habitaten i forhold til oddere foretages i stor skala.

I forvaltningsplanen er der udpeget interesseområder for oddere med henblik på at opbygge et økologisk sammenhængende netværk af vigtige levesteder og spredningsveje for odder i Danmark og den øvrige del af det centrale Europa (Reuther 1994, Wolters 1994). Udpegningen af interessseområder medfører, at der disse steder bør tages ekstraordinære hensyn med henblik på at sikre og forbedre vilkårene for odderen. Det bedste udgangspunkt for en samlet koordineret forvaltning af interesseområder for odder vil derfor være, at de lokale myndigheder udarbejder konkrete handlingsplaner for de enkelte områder eller dele deraf.

Som følge af den positive holdning til odder i befolkningen foreslås det, at handlingsplaner i vidt omfang realiseres gennem frivillige aftaler. Skønnes mere indgribende foranstaltninger at skulle gennemføres, kan fredninger eller oprettelse af reservater/odderfristeder være nødvendige. De mere praktiske forhold i forbindelse med de enkelte forslag til beskyttelsesforanstaltninger fremgår af Madsen (1989). Udviklingen i odderbestanden bør fremover følges gennem et nationalt overvågningsprogram med 5-10 års mellemrum.

1.8 Konklusion

Sammenlagt er der ikke tvivl om, at den negative udvikling i odderbestanden herhjemme er standset og udviklingen er vendt. Foreløbige resultater fra en igangværende landsdækkende feltundersøgelse bekræfter dette (Mette Hammershøj, pers. medd., april 1996). Der synes således at være et velbegrundet håb om, at odderen, i hvert fald i en årrække, fremover kan sikres som fritlevende art i Danmark.

Det tog mere end 10 år, at vende den negative udvikling, og der er fortsat så få oddere, at der ikke skal meget til før en positiv udvikling kan blive vendt til det modsatte. I denne forbindelse, er der grund til at fortsætte indsatsen omkring etablering af faunapassager og økologiske forbindelseslinjer, idet trafikdrab og manglende spredningsmuligheder må betragtes som den alvorligste trussel mod den danske odderbestand. Der bør i denne sammenhæng iværksættes undersøgelser af odderes spredningsevne i fjord- og havområder, og bevægelser og markeringsaktivitet hos isolerede bestande af oddere med meget lave tætheder.

Projektet er et godt eksempel på, at forskning og overvågning på den ene side og rådgivning og aktiv forvaltning på den anden er uadskillelige parter, når det gælder opretholdelsen af den biologiske diversitet. Samtidig er det resultatet af en fælles indsats og et snævert samarbejde mellem private foreninger, administrative myndigheder og forskningsinstitutioner.

Det gennemførte projekt bør således også kunne bruges som model for tilsvarende bevarelsesprojekter for andre dyrearter, hvis fortsatte eksistens er i fare.

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2. Publicerede artikler/Published Articles

Der skulle gå tre år, inden jeg stod ansigt til ansigt med min første vilde odder. Efter en periode med meget hård frost skete det på en iskant ved afløbet fra Flynder Sø den 17/1 1987 ved højlys dag.

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Cadmium, lead and mercury in hair from Danish otters *Lutra lutra*

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Abstract

Hair samples from 52 specimens of otters, found dead in Denmark between 1979 and 1986 inclusive, were analyzed for cadmium, lead and mercury. Mean concentrations (dry weight) were 0.77 mg Cd kg^{-1}, 1.28 mg Pb kg^{-1} and 2.38 mg Hg kg^{-1}, all lower than for a sample of otters from Great Britain. Current concentrations of these metals in Danish otters are unlikely to have toxicological significance.

Introduction

The otter has declined substantially in both numbers and range over most of Denmark, being now largely restricted to parts of Central and Northwest Jutland (Madsen and Nielsen 1986). Declines have occurred similarly over much of northwest Europe and have been attributed particularly to pollution with organochlorines, especially PCBs (Olsson et al. 1981) and dieldrin (Chanin and Jefferies 1978). Metals are also elevated in some otters (Mason et al. 1986). The role of pollution and other factors in the decline of the species is reviewed in Mason and Macdonald (1986).

Now that the otter is so rare in Denmark, it is certain that very few specimens will become available for the assessment of current pollutant loads, while there appears to be no earlier information on pollutant burdens in Danish otters. Hair can be used as a biological monitor of blood metal concentrations (e.g. Hansen et al. 1983) and several authors have previously reported metal levels in otter hair (Cumbie 1975, Sheffy and St Amant 1982, Mason et al. 1986). We report here an analysis of cadmium, lead and mercury concentrations in hair from a sample of Danish otters.

Material and methods

Samples of hair were collected from 52 specimens of otters, mainly killed by traffic or drowned in eel traps between 1979 and 1986. The localities of all but one specimen, whose provenience was unknown, are shown in Figure 1. Of those animals sexed, 29 were males and 20 were females.

Samples were soaked in "Pyroneg" for 30 mins to remove superficial grease and metal contamination. They were then rinsed twice in double distilled water, washed twice in acetone and dried at room temperature in a dust-free atmosphere.

After weighing, samples were digested by the addition of 5 ml of a nitric/perchloric acid mixture (4:1 by volume, analytical grade reagents). Samples were left overnight at room temperature and then heated for 90 mins at 40°C and a further 120 mins at 140°C until the evolution of fumes ceased. Samples were allowed to cool, made up to a constant volume of 10 ml using double distilled water and stored at 4°C in 25 ml cell-counting pots until analyzed. Three replicates of all samples were digested to allow the calculation of analytical and sample variability.

Analyses were performed by atomic absorption spectroscopy, using either flame (Varian AA-375) or graphite tube atomisation (Varian AA-1275 with GTA-95 Atomiser System). Total mercury was determined by flameless atomic absorption. Detection limits for cadmium were 0.001 ppm, for lead 0.02 ppm and for mercury 0.01 ppm.

Fig. 1. Sites in Denmark from which otters, used in the analysis of cadmium, lead and mercury in hair, originated.

Results and discussion

The results of the analyses for cadmium, lead and mercury in otter hair are presented in Table 1.

The concentration of cadmium in hair from these Danish otters was low, the mean value (0.77 mg kg^{-1}) being considerably below the mean (1.12 mg kg^{-1}) reported by Mason et al. (1986) for a British sample. There appears to be no other data for comparison.

Similarly, the concentration of lead in the Danish sample is markedly lower than that recorded in the British sample (mean 13.05 mg kg^{-1}).

The concentration of mercury in the sample was also low, this element being below the level of detection in 21% of samples. The maximum value in the Danish sample (13.49 mg kg^{-1}) was below the mean concentration reported by Mason et al. (1986) for samples of otter hair from Britain (18.75 mg kg^{-1}) and Sweden (31.20 mg kg^{-1}). In *Lutra canadensis*, mean concentrations of mercury in hair were 30.4 mg kg^{-1} from Georgia (Cumbie 1975) and 6.47 mg kg^{-1} from Wisconsin (Sheffy and St Amant 1982). Sheffy and St Amant (1982) considered 1 to 5 mg kg^{-1} mercury in hair to represent natural background levels and only eight Danish specimens exceeded this level.

	Cadmium	Lead	Mercury
mean	0.77	1.28	2.38
standard error	0.09	0.20	0.45
range	ND - 2.67	ND -7.40	ND - 13.49

Table 1. Concentrations (mg kg^{-1} dry weight) of cadmium, lead and mercury in hair from 52 Danish otters (ND = below limit of detection)

There were no significant differences between males and females in the concentrations of cadmium, lead or mercury in hair (t-tests, $P > 0.05$). Concentrations of cadmium and mercury in hair were significantly correlated ($r = 0.45$, $P < 0.001$), but there was no significant relationship between lead and either cadmium ($r = 0.03$, n.s.) or mercury ($r = 0.05$, n.s.). No significant correlations were found between metals in a sample of otter hair from Britain (Mason et al. 1986.).

Of the 52 otters analyzed for metals in this study, 41 originated from the county of Viborg and 6 from the county of Ringkøbing, these two counties currently holding the majority of otters in Denmark. Madsen and Nielsen (1986) reported that 47.1% of survey sites in the county of Viborg and 25.5% of survey sites in the county of Ringkøbing were positive for otters, compared with 0-13.2% for other Danish counties. The counties of Viborg and Ringkøbing have relatively low human populations compared with the rest of Denmark. The county of Viborg (413.322 ha) has a large amount of inland water (10,700 ha) and protected areas (25,000 ha).

The concentration of metals in the sample of otter hair was lower than that from a sample of British otters and metals are unlikely to be of toxicological significance in this Danish population. Similarly, a small sample of otters analyzed for organochlorine residues was found to contain only small amounts (Madsen 1987). Otters from the county of Viborg could, possibly, form a nucleus from which adjacent counties may be repopulated. However, a substantial number of otters in Denmark are drowned in fish traps, e.g. 29 of 53 animals delivered to the Natural History Museum in Aarhus in the period 1980-85 (Madsen 1986). Destruction of riparian habitat has also been carried out on a large scale (Madsen and Nielsen 1986). Thus legislation to reduce otter mortality in fish traps and a programme of riparian habitat regeneration would therefore seem essential steps in the rehabilitation of the otter population in Denmark.

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Mortality and condition in otters *Lutra lutra* from Denmark and Great Britain

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Abstract

Seasonal changes in mortality and body condition of samples of otters from Denmark and Great Britain were studied. There was no significant seasonal difference in overall mortality in animals dying violently caused by traffic or fish traps or in animals dying from natural causes. A significant change with season in body condition was apparent in those animals that died violently but not in those dying from natural causes. Condition was lowest in July/August and may be due merely to the loss of insulatory fat as a response to warmer ambient temperature.

Introduction

In a study of coastal dwelling otters *Lutra lutra* on the Shetland Islands, off the northern coast of Scotland, Kruuk et al. (1987) observed a seasonal decrease in body condition, expressed as a function of weight over length. Body condition declined during the first half of the year and reached a minimum during May and June. Most of the natural mortality (through disease and/or starvation) occurred between March and June. Furthermore Kruuk et al. (1987) observed that, although otters are polyoestrus, 83% of the litters were born during May – August, when fish biomass in inshore waters is approaching its peak.

Communication no. 229 from Game Biology Station, Kalø, 8410 Rønde, Denmark.

In most inland waters fish would not be able to move out of the range of foraging otters. This might lead to less marked changes in availability of food for otters over the seasons and hence no seasonality in breeding, mortality or condition. Stephens (1957), Harris (1968), Mason and Macdonald (1986) compiled and analysed data on cubs without observing overt seasonality in breeding in mainland Britain. Macdonald and Mason (1987) found that regional seasonal trends might occur. There is, except that given by Kruuk et al. (1987) for the Shetlands, however, no information on seasonal changes in condition or mortality. The present paper examines these factors on the basis of data from Denmark and Britain.

Materials and methods

Information on lengths and weights of 201 otters, and where available causes of death, were obtained from the following sources:

1. Otters (N=81) examined by the Game Biology Station, Kalø, Denmark over the period 1960-1963 (Jensen 1964).
2. Otters (N=57) sent to the Natural History Museum, Århus, Denmark, over the period 1979-1989 (Madsen, unpublished).
3. Otters (N=31) killed on roads, drowned in fish traps or live-trapped for telemetry, Uist, Outer Hebrides, Scotland, 1978-1981 (Twelves 1982).
4. Otters (N=32) received from mainland Britain and the Orkney Islands, northern Scotland, for analyses of pollutant burdens 1982-1988 (Mason, unpublished).

In addition information on causes of death of 24 otters (Madsen and Mason, unpublished) for which no measurements were available, was used.
Body condition (K) of otters was calculated (Kruuk et al. 1987, following Le Cren 1951) as:

$$K=W/(a \times L^n)$$

where W=weight (kg) and L=total length (m). The constants were those calculated by Kruuk et al., viz. a=5.02 for females, 5.87 for males; n=2.33 for females, 2.39 for males.

Results

Fig. 1 shows mortality of otters related to months. Data from Jensen (1964) and Twelves (1982) were excluded, as the former included a substantial number of unspecified animals killed by hunters within a restricted period; the latter included some unspecified animals live-trapped for radiotelemetry. The timing of overall mortality did not differ significantly (Chi^2=3.57, d.f.=5, P)0.05).

Fig. 2 illustrates mortality in different months of otters dying violently (by traffic or drowning in fish traps) and naturally, respectively. The timing of violent mortality did not differ significantly (Chi^2=5.76, d.f.=5, P)0.05). Traffic accidents formed the bulk (82%) of deaths in March/April and fish traps the bulk (86%) in May/June, but seasonal variations in either type of mortality were not significant (Chi^2=1.40, 2.18 respectively, P) 0.05).

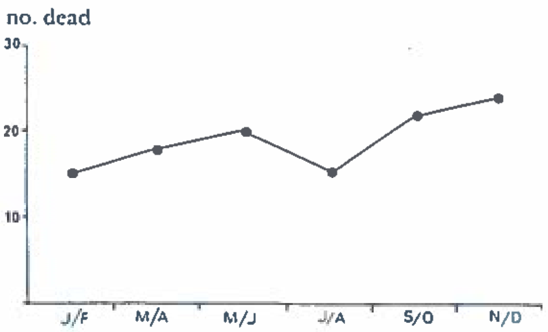

Fig. 1. Mortality of otters (N=113) related to months.

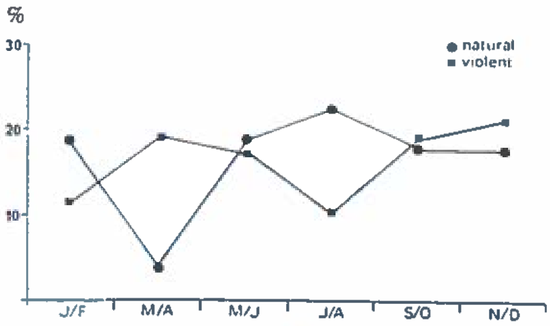

Fig. 2. Percent otters dying violently (N=86) or through natural causes (N=27) in relation to months.

To look for seasonal variation in natural mortality the smaller sample was combined into three periods, March/June, July/October and November/February, for analysis, but there was no significant difference (Chi^2=1.55, d.f.=2, P)0.05). Natural deaths were therefore equally distributed throughout the year.

To study condition, the four data sets were examined initially using analysis of variance, but there were no significant differences (F=0.96, P)0.05). The coastal data (from Uist and Orkney) did not differ significantly from mainland data (d=0.33, P)0.05) and males did not differ significantly from females in condition (d=1.6, P)0.05). The data for sexes and for regions were therefore combined for an examination of seasonal changes in condition.

The seasonal changes in body condition are shown in Fig. 3. An analysis of variance of the bimonthly data showed a significant difference (F=2.50, N=201, P(0.05), there being a decline in condition during July/August. When only violent deaths were considered the analysis of variance showed a greater level of significance (F=3.15, N=179, P(0.01).

To analyse the much smaller sample of natural deaths, data were combined into the same three

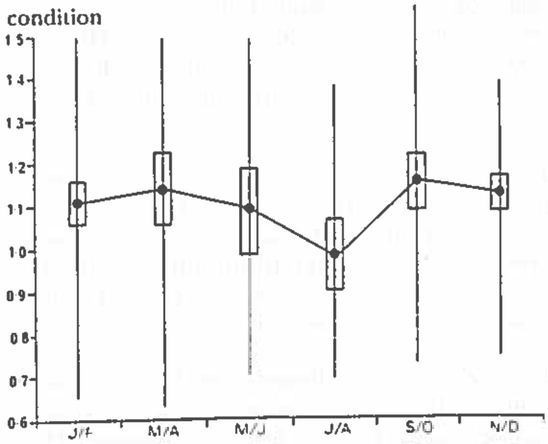

Fig. 3. Seasonal trends in body condition of otters (mean ± 2 SE and range, N=201).

periods as above November/February, March/June and July/October, but there was no significant difference (F=0.008, N=22, P)0.05). Therefore any change in condition would appear to be part of a natural cycle rather than reflect seasonal difficulties leading to mortality.

Condition of animals dying from natural causes was significantly lower (mean 0.87) than that of animals dying from traffic accidents and in fish traps (mean 1.15) (d=4.10, P(0.001).

Discussion

Kruuk et al. (1987) studied an otter population in the Shetland Islands which obtained the majority of its food from the intertidal zone. It was found that violent deaths (mostly traffic accidents) in otters were equally likely to occur at any time of year, but that natural mortality (starvation and/or disease) was concentrated in the period March/June. It was also suggested that there was a decline in body condition of otters to a minimum in May/June, but that this trend was not significant in animals which died violently. Kruuk et al. (1987) attributed the decline in condition and increased natural mortality in the March/June period to a difficulty in feeding in winter and early spring when the major prey species of fish move into deeper waters where otters could not catch them.

The results presented here differ in a number of ways from those of Kruuk et al. (1987). Otters were collected over a broad geographical area of Denmark and Britain and over a large time span (1960-1963 and 1978-1989) in contrast to the concentrated study in Shetland (1981-1985). The majority of otters came from freshwater habitats, though the coastal sample (from Uist and Orkney off the Scottish coast) did not differ significantly in body condition from the mainland sample. In freshwater, fish would have less opportunity of moving out of the reach of otters, so that marked changes in mortality and condition associated with food shortage might not be expected. Nevertheless there are some marked seasonal changes in the distribution and accessibility of food items, such as the winter spawning runs of salmonids, the partial hibernation of eels *(Anguilla anguilla)* in sediments during the winter or ice covered lakes in wintertime. The significance of these seasonal changes may well depend on the spectrum of resources available to otters, which itself will be influenced by such factors as geography, altitude and water chemistry.

In contrast to the study of Kruuk et al. (1987) there were no significant seasonal differences in natural mortality in the present study. Furthermore, there was no significant difference in the seasonal incidence of violent mortality as found by Kruuk et al. on Shetland.

The present study demonstrated a significant decline in body condition in July/August, condition otherwise varying little with season. This significant decline in condition was also apparent when only violent deaths were considered, but not when natural deaths were considered alone. Kruuk et al. (1987) reported a significant decline in body condition from winter to a minimum in May/June. This trend was also apparent in live otters and those killed in accidents, but was apparently not significant. The authors therefore infer that spring decline in condition is a particular feature of animals dying naturally, due to winter food shortage. Neither data nor statistical analysis are however presented to support this view and their analysis of seasonal changes of body condition used an incorrect value of degrees of freedom in the Kruskal-Wallis analysis of variance (see their Fig. 5), which is significant at P(0.05, not at P(0.01. It is possible that the number of data in subsamples may be too few to provide statistically significant differences with this lower level of significance for the full sample.

The condition index, based on functions of weight over length, was developed primarily for fisheries studies (Lagler 1956, Weatherley and Rogers 1978), to yield insights into food supply of the fishery, the timing and duration of the breeding cycle etc. It is primarily an index of fatness. In contrast to fish, otters are homeotherms and one major cause of changes in fatness and hence condition is the requirement for insulation. We suggest that the decline in condition in July/August could be a natural slimming response to the peak water and air temperatures which occur at that time. The decline in condition of Shetland otters to a minimum in early summer may also be a result of reducing fat in accordance with temperature rise. Although sea temperatures off the Shetlands vary rather less than freshwater habitats (Kruuk et al. 1987), air temperature is seasonally more variable and otters spend most of the day out of the water. The lower water temperatures in freshwater habitats in winter and spring compared to those of coastal Shetland may be the reason for the higher average condition of otters in our study during this period (compare Fig. 3 with Fig. 5 of Kruuk et al. 1987). Because of cycles in weight related to ambient temperature in homeotherms it may be necessary to develop a more subtle index of body condition, such as the bone marrow fat index used by Sinclair (1977).

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OTTER (Lutra lutra) MORTALITIES IN FISH TRAPS AND EXPERIENCES WITH USING STOP-GRIDS IN DENMARK

Aksel Bo Madsen

Abstract

Body measurement data and other information on drowned otters and fishermen's experiences with using stop-grids in fish traps in Denmark were studied.
The majority of the drowned otters were subadult individuals, of these the number of males and females was the same. The otters drowned in both single and double fyke nets set in shallow water, especially in lakes but also in fiords/inlets and rivers/canals.
The eel-catch was the same in fish traps with stop-grids as in fish traps without stop-grids. However, there is no doubt that the catch of other fish (primarily roach, bream and pike) was reduced. Stop-grids seem not noticeably to worsen the problem of water-weeds blocking the trap opening in fish traps set in lakes.
The results on stop-grids contrast remarkably with a systematic, English study.

1. Introduction

In Denmark, the otter is distributed in the lakes and rivers around and in the western part of the Lim Fiord (MADSEN and NIELSEN 1986). Unfortunately, this is the same part of the country where fish traps are most commonly used. Furthermore fish traps are set in exactly the same places as the otters like to forage.

The problem of otters drowning in fish traps in Denmark has been known for many years (JENSEN 1964; SCHIMMER 1981; MADSEN 1986). A review of otter mortality in fish traps collected from different sources (JEFFERIES et al. 1984) shows that it is a problem in many European countries. According to STUBBE (1977), the problem seems to have increased since the introduction of nylon fish traps in about 1960. Various otter guards have been designed but knowledge of their practical use was lacking.

In 1987, preliminary results from 15 fishermen using stop-grids in fish traps were collected (MADSEN 1987) and in 1988 a report on the effects of using otter guards on the fishing efficiency of eel fyke nets was published (THE VINCENT WILDLIFE TRUST 1988). Since then, more Danish fishermen have tested the stop-grid.

In the Netherlands, fishing effiency in fish traps mounted with stop-grids with a mesh-width of 80x80 mm has been tested (VAN MOLL 1988) but the results have not yet been published.

TWELVES (1983) collected data on otter mortalities in lobster creels of the Uist islands in the Outer Hebrides. Fyke netting casualties in fresh and brackish water are less well documented, for example, it is not known in which sites, depth and chamber the corpses are usually found.

The lack of dead otters in a reasonable condition and perhaps especially people's unknowing of the need to deliver otters is a problem in many European countries and important information is lost.

In Denmark, we have a very good tradition for delivering dead otters to Museums which makes it possible for us to examine and collect data from this sparse material. This information is of scientific value, especially in the discussion of the mesh-width of otter guards.

This paper examines body measurement data and other information from otters drowned in fish traps and discusses fishermen's experiences in using stop-grids in fish traps.

2. Methods

Otters drowned in fish traps were examined and data on date of death, sex, age, weight, length and chest-circumference were collected.

Each animal was registered as either juvenile (not yet finished tooth replacement), subadult (epiphyseal closure of humerus and femur at their proximal and distal ends not finished) or adult (fully grown animals). For males, the length of baculum was also used (VAN BREE et al. 1966).

Working diameter, elliptical length and elliptical breadth are calculated on the basis of values detailed in JEFFERIES et al. (1984, page 18). Satisfactory data do not exist for all the otters delivered. Therefore, the number of individuals included in the calculation of each measurement is variable.

Contact with the fishermen who delivered the dead otters gave further information about the location, trap-type, depth, distance from land and in which chamber the corpses were found as well as evidence of attempts by the otters to get out of the trap.

In Denmark, the most used trap-types are single fyke nets usually with a 60 – 90 cm entrance and double fyke nets (two fyke nets each having a 50 cm entrance and a joint leader). Wire fyke net made from wire mesh and fitted with a wing to each side are used in some rivers.

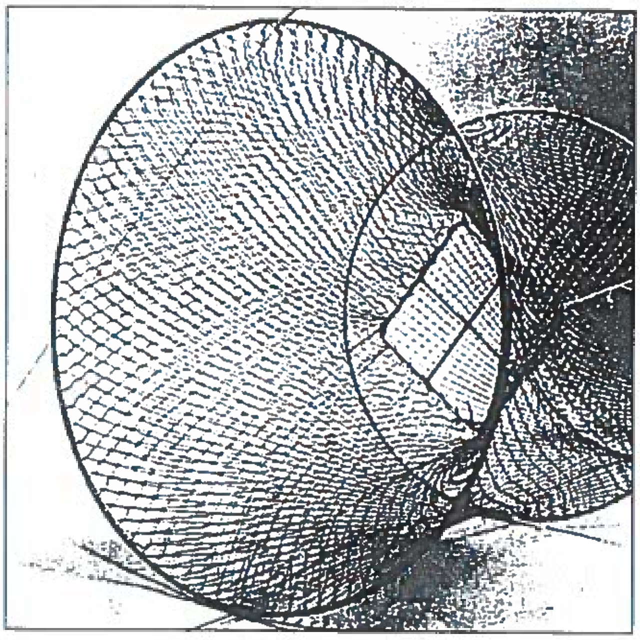

Figure 1: Fish trap mounted with a stop-grid. Foto: Merete Jepsen

Since 1986, stop-grids – a rigid, square, steel 85 mm bar length grid fitted to the inner end of the first fyke funnel (JEFFERIES et al. 1984) – (Figure 1) have been distributed without charge to any interested Danish fisherman.

Instead of testing the stop-grid in a systematic way, it was decided to involve experienced fishermen to take part in the study. This enables us at the same time to get information about the fishermen's attitudes towards such a blocking arrangement. The research is, therefore, based on questionnaires sent to 40 fishermen and is about their experiences in using the stop-grids in fish traps.

3. Results

3.1 Mortalities

During the period 1980 – June 1989, 96 otters were delivered to Museums and 41 of these were drowned in fish traps (Figure 2). The fact that all the otters were caught during the period from March to November is a result of seasonality of fishing activity in the places where the otters occur rather than seasonal otter activ-

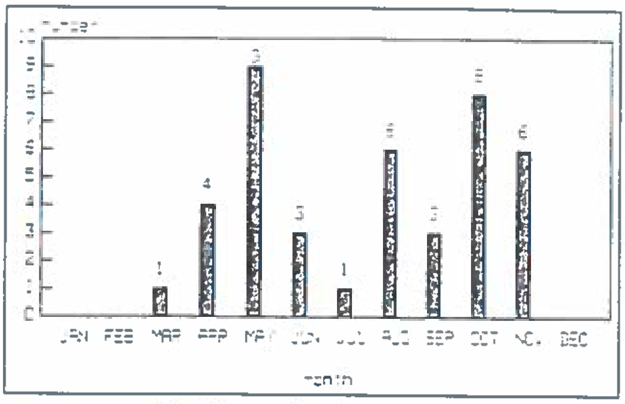

Figure 2: Monthly distribution of drowned otters from 1980 to June 1989.

ity. More otters were delivered in May and October than in other months of the year. However, such differences must be evaluated with caution given the small size of the samples.

Table 1 gives information about sex, age and body measurements for otters drowned in fish traps. 54% of the otters drowned were males and the distribution between juveniles, subadults and adults irrespective of sex is 5% : 46% : 10% respectively. This indicates that it is especially inexperienced otters (subadults) of both sexes which are caught in fish traps.

The dead otters weighed between 2.4 kg and 11.3 kg and were between 72.0 cm and 129.0 cm long. Circumferences of 29.5 – 50.0 cm, working diameter of 9.4 – 15.9 cm, elliptical length of 10.7 – 18.2 cm and elliptical breadth of 7.9 – 13.4 cm were recorded. These data are of particular interest because they form the basis of the size of otter guards used in fish traps. A rigid stop-grid of 8.5 cm would just allow the chest of the smallest otter (2.4 kg in weight, 72.0 cm in length, 29.5 cm in circumference) through the grid.

Figure 3 shows the sites (lakes, fiords/inlets, rivers/canals) and the different trap-types in which otters were found drowned.

Half of the otters delivered were drowned in lakes and the other half in fiords, in rivers and in canals. The number of otters drowned in fiord areas suggests that Danish otters forage here more than we had initially anticipated. In fiord areas, the distance from the fatal traps to adjoining streams is usually rather short.

The majority (58%) of the dead otters were found in single fyke nets. The reason for this may be that single fyke nets are, in most cases, set with one end starting from the land, so that the otter on foraging is led into the fish trap. Double fyke nets are set independently of the land. Only one accident by drowning in a wire fyke net has been recorded. Normally the entrance of this type of fish trap is too small for an otter to enter, but in this

Table 1: Sex, age and body measurements for otters drowned in fish traps.

Age group	Sex ratio: females	males	?	total
juveniles	1	1	–	2 (5%)
sub-adults	10	9	–	19 (46%)
adults	1	3	–	4 (10%)
?	5	9	2	16 (39%)
total	17 (41%)	22 (54%)	2 (5%)	41 (100%)

	Number	Range	Mean±SE
Weight (kg)	31	2,4 – 11,3	6,21 ± 2,04
Length (cm)	30	72,0 – 129,0	98,24 ± 11,80
Circumference (cm)	20	29,5 – 50,0	40,7 ± 5,4
Working diameter (cm)	20	9,4 – 15,9	13,0 ± 1,7
Elliptical length (cm)	20	10,7 – 18,2	14,8 ± 2,0
Elliptical breadth (cm)	20	7,9 – 13,4	10,9 ± 1,4

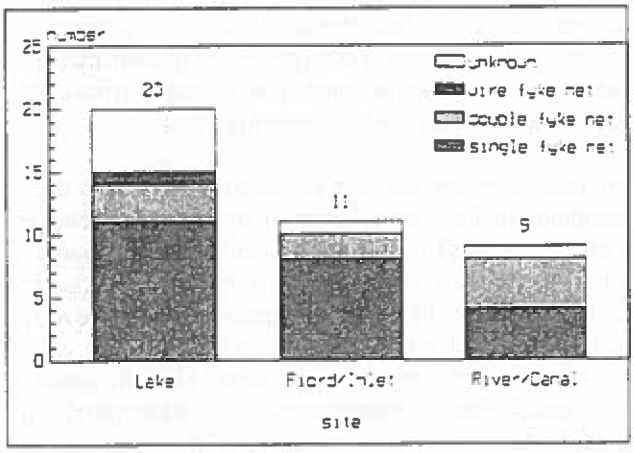

Figure 3: Sites and trap-types where otters were found drowned.

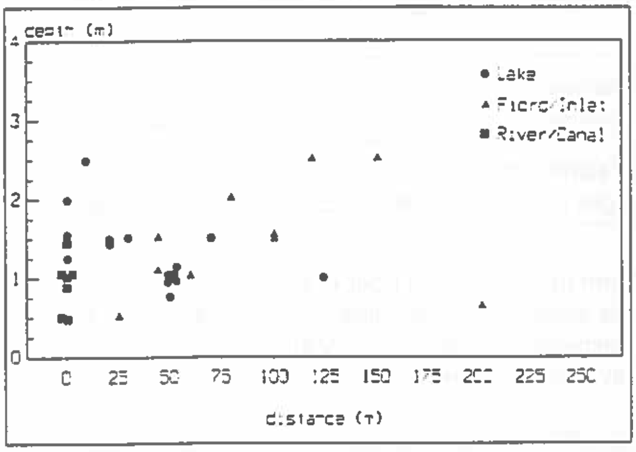

Figure 4: Depths and distances from land of fish-trapped otters.

case, the trap was a home-made one in which the entrance was larger allowing the animal to penetrate.

The relationship between depth and distance from land for the drowned otters is illustrated in Figure 4. Most of the otters drowned were foraging at depths of 1 – 1.5 m, whilst the greatest depth from which otter bodies were recovered (those of three subadults) was 2.5 m.

The distance from land to the fatal fish traps varied between 0 – 200 m but most of the otters were drowned less than 60 m from land.

The results do not indicate any connection between sex or age and depth and distance from land where otters were found drowned.

22 out of 31 otters were found drowned in the last chamber/cod end of the fish traps. Three otters were squeezed between two chambers. In three cases there were bitemarks on the fish traps and other indications that the otter had tried to get out.

In 22 of the fish traps, beside the otters, there were fish such as eel (*Anguilla anguilla*), viviparous blenny (*Zoarces viviparus*), perch (*Perca fluviatilis*), bream (*Abramis brama*), roach (*Rutilus rutilus*), trout (*Salmo sp.*), horke (*Acerina cernua*), pike (*Esox lucius*), herring (*Clupea harengus*) and sea scorpion (*Myoxocephalus scorpius*) in the fish trap.

The places where the otters were found, the fact that there are usually fish in the traps and the lack of bitemarks in either the trap itself or in the fish caught indicates that in most cases the otter gets caught in the fish trap accidentally and that death by drowning occurs rather quickly.

3.2 Stop-grids

The 40 fishermen involved in the study were distributed over 27 different localities (19 lakes, 7 rivers and 1 fiord) in northwest Jutland, in the centre of Jutland, on Funen and in south Jutland.

307 stop-grids placed in 252 fish traps (76 fyke nets and 176 double fyke nets) were tested. Some fishermen used both fish traps with stop-grids and fish traps without stop-grids, others used only fish traps mounted with stop-grids. The fishermen used the stop-grids from July 1986 – December 1987.

Table 2: 40 fishermeen's experiences in using stop-grids in fish traps during the period July 1986 – December 1987.

	greater	the same	smaller	don't know
The catch of eels	1(3%)	35(88%)	3(7%)	1(3%)
The catch of other fish	–	10(25%)	23(58%)	7(18%)
Waterweed/ algae problems	9(23%)	25(63%)	3(7%)	3(7%)

Even though the number of fishermen participating in this study has more than doubled since an earlier, preliminary investigation (MADSEN 1987), the results have not changed (Table 2).

35 (88%) of the fishermen found that the catch of eel was the same in fish traps with stop-grids as in fish traps without stop-grids. Only three fishermen (7%) found that the catch was reduced when using stop-grids.

On the other hand, there is no doubt that the catch of other species of fish [primarily roach (*Rutilus rutilus*), bream (*Abramis brama*) and pike (*Esox lucius*)] was reduced as indeed was expected. 23 (58%) of the fishermen found their catch of these species reduced but most said that the reduction was of no importance.

25 (63%) of the fishermen did not find that stop-grids made the problem of waterweeds and algae blocking the trap-opening worse. However nine (23%) of them were of the opinion that this problem was made worse.

The attitudes of the fishermen towards stop-grids were an important parameter in the investigation. 32 fishermen answered this question and 30 maintained that the stop-grid is a reasonable compromise between protection of the otter population on the one hand and protection of fishing interests on the other. In the duration of the experiment, no otters were recorded as having been drowned in fish traps mounted with stop-grids.

4. Discussion

Drowning in fishtraps is still the major cause of death in otters. Experiences show, however, that not all dead Danish otters are registered, therefore, the total of 41 recoveries must be looked upon as an absolute minimum. It is not known whether the actual figure is double or three times as big.

The results on sex ratio (41% females, 54% males) seem to agree with those of FAIRLEY (1972) where the sex ratio amongst 32 otters drowned in freshwater was equal. In a Dutch investigation (VAN MOLL 1988) 45% of the drowned otters were recorded as juveniles. This is in sharp contrast to data presented in this paper in which only two individuals or 5% were juveniles. The difference may be because both juveniles and subadults were collected into the one group "juveniles" in the Dutch study. However, the age group criteria used are not mentioned. In fact the smallest otter examined would not have avoided death in a fish trap even though a stop-grid had been mounted. A stop-grid with max. 70 mm bar length would have prevented this.

The results on sex and age are also different from data collected on the Uist islands in the Outer Hebrides (TWELVES 1983). In the Uists, 65% of the drowned otters of known sex and status were adult females in contrast to 8% in this study. The explanation for this may be that Danish traps have multiple funnels with wide entrances, permitting the passages of both sexes, whereas Scottish lobster creels are of a size that do not always allow males to pass through. The results of the test of stop-grids contrast with those of an English study in which the influence of four different blocking arrangements on the eelcatch was tested (THE VINCENT WILDLIFE TRUST 1988). This research shows that the eel-catch (weight and numbers) is lower when using stop-grids than when steel rings, front net-guards, grid-guards and control traps with no blocking are used. However, the stop-grid is simple and cheap to produce. It is easy to clean weeds and algae from it and it can be used in a considerably larger selection of traps than the other blocking arrangements.

In the light of the studies mentioned it is remarkable that the results of the Danish and English researches do not agree. As there are both advantages and disadvantages in using the different blocking arrangements tested, it is up to the individual fisherman which blocking arrangement he prefers. From the experiences of the Danish fishermen, we concluded that stop-grids are an effective method of preventing subadult and adult otters from drowning but there is still a risk for small juveniles. However, it are subadult otters which are most commonly drowned in Denmark. The stop-grids (85 mm bar length) or front net-guards (75 mm bar length) in fish traps are now mandatory for all hobby fishermen in nearly all areas of Denmark where the otter is found.

5. Acknowledgements

I would like to thank the staff of the Natural History Museum, Aarhus for placing the otter material at my disposal and all the fishermen who have delivered dead animals or tested the stop-grids. Thanks to Jane Nordstrand for contributing to the translation of the manuscript and to the World Wildlife Fund and the Danish Animal Welfare Society for financial support.

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Table 1. Concentrations of Hg (mg kg^{-1} fresh weight) in liver tissue from 69 otters collected in Denmark, 1980-90, given according to sex, age and cause of death.

		Sample size	Mean	Range
Sex				
	Male	34	2.39	0.14-12.37
	Female	35	2.21	0.03-10.94
Age				
	Juvenile	12	0.34	0.03-1.99
	Subadult	31	1.59	0.18-5.78
	Adult	26	4.15	0.92-12.37
Cause of death				
	Traffic	22	3.45	0.27-12.37
	Drowning	28	1.75	0.12-5.78
	Unknown	18	2.18	0.03-6.95
Overall Mean				
		69	2.30	0.03-12.37

Results, presented as arithmetic means and ranges, are given in mg kg^{-1} fresh weight of tissue. Statistical analyses (t-test, analysis of variance and the Tukey-Kramer method for comparisons among means) were conducted on logarithmically transformed data.

RESULTS

Concentrations of Hg were generally low (Table 1). Only 10 samples had Hg concentrations above 4 mg kg^{-1}, two of these above 10 mg kg^{-1}. Concentrations of Hg in males and females did not differ significantly ($t=1.62$, $P>0.05$), but they did between age groups ($F=52.5$, $P<0.001$); adults had significantly higher Hg concentrations than subadults, which had significantly more than juveniles. Concentration of Hg was also related to cause of death ($F=3.65$, $P<0.05$); traffic victims had more Hg than animals which died by drowning or from unknown causes. The latter two categories did not differ significantly.

DISCUSSION

Wren (1986) suggested that total Hg concentrations in livers of less than 4 mg kg^{-1} fresh weight were normal for otters; 59 (86%) of Danish samples were below this value. Kruuk and Conroy (1991) inferred that liver concentrations of Hg higher than 10 mg kg^{-1} might be associated with sub-lethal effects. Only two Danish otters, an adult male and an adult female, exceeded this threshold. The mean concentration and range in Danish otters was lower than those reported from Ireland (Mason and O'Sullivan in press), Great Britain (Mason et . al. 1986) and Shetland (Kruuk and Conroy 1991). Similarly, Hg concentrations in the hair of Danish otters were lower than in other studies (Madsen and Mason 1987).

Kruuk and Conroy (1991) found that Hg concentrations increased with age in otters. In the present study mean Hg concentrations in adults (more than 18 months old) were more than 12 times those of juveniles. The concentration of Hg in otters killed by traffic was greater than with other forms of mortality, but this is due to the fact that more adults than subadults or juveniles are the victims of traffic accidents (Mason and Madsen 1992).

In conclusion, the present results confirm the view of Madsen and Mason (1987) that Hg is unlikely to pose a significant threat to otter populations in their current range in Denmark.

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Organochlorine pesticide residues and PCBs in Danish otters (*Lutra lutra*)

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ABSTRACT

Tissues (71 liver, 2 muscle) of 73 otters found dead in Denmark between 1980 and 1990 were analyzed for organochlorine pesticide residues and PCBs. Geometric means of contaminant concentrations were generally low, but some otters had PCB concentrations considered to be of concern; a greater proportion of these came from isolated populations away from the main population centre in Limfjord. Animals dying of unknown causes had greater concentrations of PCBs than those dying by drowning or in traffic accidents. Adults had significantly higher concentrations of PCBs. Contaminant concentrations were strongly intercorrelated. Concentrations of DDE and PCBs declined significantly during the study period. A sample of otter spraints (faeces) collected in 1990 had low mean concentrations of contaminants. It is concluded that current concentrations of organochlorine pesticide residues and PCBs are unlikely to pose a threat to otter populations.

Key words: Lutra lutra; pesticides; PCBs, Denmark

INTRODUCTION

The otter (*Lutra lutra*), once a widespread species in Denmark, is now largely restricted to the Limfjord area in the northern part of Jutland, with isolated population fragments in the surrounding region (Madsen and Nielsen, 1986). Toxic chemicals are likely to have been responsible for this widespread decline, as they have been in losses of otter populations over much of lowland Europe (Mason and Macdonald, 1986; Mason, 1989a; Foster-Turley et al., 1990). In Denmark, river regulation, wetland destruction, drowning in fish traps and traffic mortality are additional threats to the remaining otter population (Madsen, 1990; 1991).

There have been no published analyses of the levels of organochlorine

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pesticides and PCBs in Danish otters, though concentrations of heavy metals in samples of hair from otters have been reported (Mason and Madsen, 1987). Such information is important in assessing both the current threat to otters posed by organochlorines and the likelihood of population expansion when concentrations decrease. We report here on the concentrations of organochlorine pesticides and PCBs from a sample of Danish otters collected between 1980 and 1990. Analyses of contaminants from a sample of spraints collected in 1990 are also presented.

MATERIALS AND METHODS

A total of 73 carcases was received. The total length (nose to tail) and weight of carcases were recorded on receipt. Animals were aged as juveniles (less than about 5 months old) if tooth replacement was incomplete, as subadults (5–18 months) if the epiphyseal closure of humerus and femur at their proximal and distal ends was not finished, or as adults (older than about 18 months). In males the length of the baculum was also used in ageing (van Bree et al., 1966).

Contaminant analysis was carried out on the livers of 71 animals and the muscle of two. Mason (1989b) has shown that the concentrations of organochlorine contaminants in these otter tissues are equivalent. Tissues were stored deep frozen (-20°C) prior to analysis. Tissue samples were thinly sliced, weighed and homogenized in 10 ml acetone/hexane (35:10), the filtrate being collected into a separatory funnel containing 25 ml phosphoric acid/NaCl solution (11.7 g NaCl in 1 l 0.1 M orthophosphoric acid). The sediment was resuspended in two further 10 ml aliquots of hexane/diethyl ether (9:1) and decanted after 5 min. The separatory funnel was shaken and the aqueous phase was decanted and re-extracted in hexane. The solvent phase extracts were evaporated to dryness at 50°C in the air-flow of a fume cupboard and the weight determined. The extract was re-dissolved in hexane and cleaned up in a column of sodium sulphate and alumina. Organochlorine concentrations were determined with a Varian 3300 gas chromatograph, with a tritium electron capture detector and using a 25-m capillary column. The column temperature was 280°C, the injector 300°C and the detector 310°C. PCB concentrations were determined against an Aroclor 1260 standard. Blanks were run every 20 samples and standards, with or without added lard, every 4 to 9 samples. Recovery rates were always greater than 80% and the detection level was 0.01 mg kg^{-1}

Samples of spraints were collected from 19 localities in the main area of distribution of otters in October and November 1990. Spraints collected from individual localities were combined to provide a sample, which was wrapped in aluminium foil and stored deep frozen. Sample preparation and analysis were as for tissues.

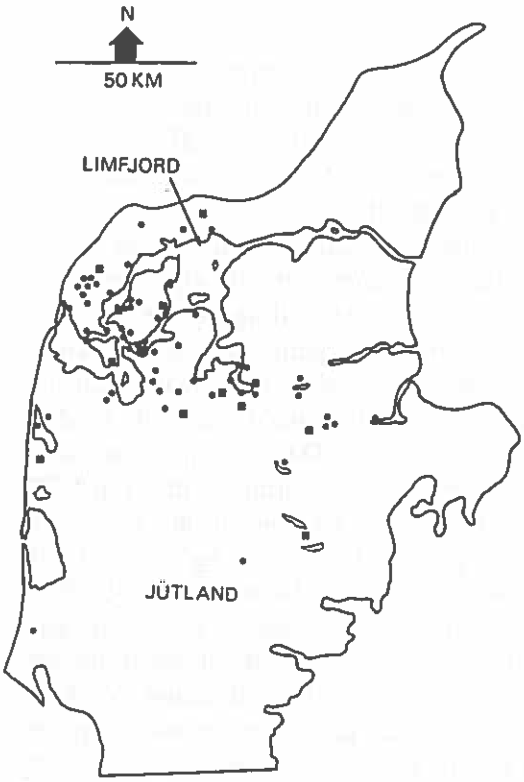

Fig. 1. Map of Denmark showing localities from where otters were received (locality of one specimen unknown). PCB concentrations in otter tissues: ●, <50 mg kg^{-1}; ■, >50 mg kg^{-1} fat.

TABLE 1

Causes of mortality of otters from Denmark

Age	Percentage			*n*
	Drowned in fish traps	Traffic accident	Unknown	
Juvenile	30.8	15.4	53.8	13
Subadult	71.0	22.6	6.4	31
Adult	10.3	55.2	34.5	29
Overall	39.7	34.2	26.1	73

RESULTS

Otter carcases were received from 73 localities in Denmark (Fig. 1) and causes of death were determined (Table 1). More subadults than adults died by drowning in fish traps, while more adults were victims of traffic accidents. More than half of the small sample of juveniles died of unknown causes; differences were significant ($\chi^2 = 29.7$, $P < 0.001$).

Statistical analysis of contaminant data was carried out on log $(n + 1)$ transformed data. Mean concentrations of contaminants did not differ significantly for males and females (*d*-tests, $P > 0.05$); data for the two sexes were therefore combined (Table 2). Of the organochlorine pesticides, dieldrin, *p,p*-DDE and *o,p*-DDT were ubiquitous, while lindane was detected in 86% and *o,p*-DDD in 67% of samples. Concentrations of pesticide residues were, however, generally low. Dieldrin and *o,p*-DDT concentrations were above 10 mg kg^{-1} fat in only one sample, while 7 samples had p,p-DDE above 10 mg kg^{-1} fat. By contrast total PCB concentrations were considerably higher. Concentrations were greater than 50 mg kg^{-1} in 14 (19%) of samples, above 30 mg kg^{-1} in 22 (30%) and above 10 mg kg^{-1} in 51 (70%).

PCB concentrations were considered in relation to age of otter and cause of death (Table 3). Analysis of variance revealed that PCB concentration differed significantly with age ($F = 5.10$, $P < 0.01$) and cause of death ($F = 9.46$, $P < 0.001$). Comparisons between pairs were made using the Tukey-Kramer method (Sokal and Rohlf, 1981). Adults had a significantly greater mean PCB tissue concentration than subadults and PCB concentrations in tissues of animals dying from unknown causes were significantly

TABLE 2

Concentrations (mg kg^{-1} fat) of organochlorine pesticide residues and PCBs in a sample ($n = 73$) of otter tissues from Denmark

nd, below limit of detection.

Compound	Geometric mean	Range
Lindane	0.81	nd–9.76
Dieldrin	1.10	0.04–12.56
p,p-DDE	2.88	0.12–98.41
o,p-DDD	0.06	nd–0.80
o,p-DDT	0.56	nd–18.52
Total PCBs	16.76	0.47–275.78

TABLE 3

PCB concentrations (mg kg^{-1} fat) in otter tissues in relation to age and cause of death

	Mean	Range	*n*
Age			
Juvenile	18.80	2.04–87.34	13
Subadult	9.94	0.47–79.40	31
Adult	24.30	1.66–275.80	29
Cause of death			
Drowning	10.06	0.47–112.72	29
Traffic	13.73	1.66–106.56	25
Unknown	38.59	5.59–275.80	19

higher than in animals which died by drowning or collisions with traffic. No further significant differences were found.

Linear regression was used to examine the relationship between tissue concentrations of contaminants and the year of death. No significant relationships were found between year of death and the concentrations of lindane and dieldrin. However, concentrations of DDE and total PCBs declined significantly over the study period ($b = -0.04$, $F = 4.38$, $P < 0.05$; $b = -0.057$, $F = 0.55$, $P < 0.05$, respectively). Average annual declines over the study period of 7% for PCBs and 6% for DDE were predicted from the regression equation.

The inter-relationship between the main contaminants in otter tissues were examined. Significant correlations were found between all contaminants (Table 4). Lindane showed the weakest correlation with other contaminants.

TABLE 4

Inter-relationships (correlation coefficients) between contaminant concentrations in otter tissues ($n = 73$)

	Dieidrin	DDE	Lindane
PCB	0.56**	0.65**	0.29*
Dieldrin		0.59**	0.32**
DDE			0.27*

Significance levels: *< 0.05; ***P* < 0.01.

TABLE 5

Concentrations ($mg\,kg^{-1}$ fat) of organochlorine pesticide residues and PCBs in a sample ($n = 19$) of otter spraints from Denmark

nd, below limit of detection.

Compound	Geometric mean	range
Lindane	nd	
Dieldrin	0.16	0.01–0.47
p,p-DDE	0.52	0.02–2.67
o,p-DDD	0.11	nd–0.39
o,p-DDT	0.08	nd–0.60
Total PCB	2.23	0.36–45.95

The concentrations of contaminants in otter spraints were analyzed (Table 5). Apart from *o,p*-DDD, concentrations in spraints were lower than those from tissues. Lindane was not detected in spraints. The ranking of major contaminants in spraints was as for tissues i.e., PCB > DDE > dieldrin > lindane.

DISCUSSION

Significantly more subadult (i.e. age 5–18 months) than adult otters were drowned in fish traps, with juvenile mortality being intermediate. Inexperienced subadults may be more likely to explore fish traps, especially when they become independent of their mother at around 1 year old. Experienced adults may have learned to avoid fish traps. In contrast, more adults and especially males were killed by traffic (Madsen, 1990). As they become mature at 2 years of age, otters may become more mobile, both in patrolling their extensive home range and in searching for mates.

Concentrations of organochlorine pesticide residues in tissues of the sample of Danish otters were generally low and mean concentrations were similar to a sample from Ireland (Mason and O'Sullivan, 1992), where otters are thriving over much of the country (Foster-Turley et al., 1990). Mean concentrations of PCBs were also similar in samples from the two countries.

Much concern has been expressed over the role of PCBs in the decline of the otter (for review, see Mason, 1989a). Experiments with the closely related mink (*Mustela vison*) showed that, on a diet containing added PCBs, pup mortality was severe when tissue concentrations of PCBs in their mother exceeded 50 $mg\,kg^{-1}$ fat (Jensen et al., 1977). The steady decline of otter populations in western Europe is consistent with a failure in recruitment and several endangered or recently extirpated populations of otters (e.g. southern Sweden, The Netherlands, eastern England) had mean concentrations of PCBs in tissues exceeding 50 mg kg^{-1} fat (Mason, 1989a). The concentration of 50 mg kg^{-1} fat in tissues has therefore been taken as a yardstick against which to assess the threat posed by PCBs to otter populations (Olsson et al., 1981; Mason, 1989a; Olsson and Sandegren, 1991). De Vries (1989) has pointed out that the geometric mean 30 mg kg^{-1} fat may be a more realistic critical value, for the arithmetic mean (50 mg kg^{-1}) is influenced by a few high values. Thirteen (18%) of Danish otters had tissue concentrations exceeding 50 mg kg^{-1} and 21 (29%) had tissue PCB concentrations greater than 30 mg kg^{-1}. Thus, while the geometric mean was well below the critical value, nevertheless a proportion of the population may be at risk from the effects of PCBs. It should be noted that, in the current stronghold of the otter in the immediate environs of the Limfjord, 7 of 54 otters (13%) had concentrations of PCBs in tissues greater than 50 mg kg^{-1} fat, whereas of 19 otters recovered away from Limfjord, where populations are scattered, 6 (32%) had concentrations greater than 50 mg kg^{-1} (Fig. 1).

Animals dying from unknown causes had significantly greater concentrations of PCBs than those dying violently in fish traps or traffic accidents. Kruuk and Conroy (1991), in a study on the Shetland Isles, also found that animals dying non-violent deaths (equivalent to our category of unknown causes) had higher concentrations of PCBs than those dying violently. Adult otters from Denmark contained significantly greater concentrations of PCBs, whereas Kruuk and Conroy (1991) found that PCB concentrations in otters were not age-related.

Concentrations of pesticide residues and PCBs were all inter-correlated (Table 4). The weakest correlations were found with lindane, which is less persistent than other organochlorines. Kruuk and Conroy (1991) found correlations between PCBs and DDE only, and such correlations are widespread in marine mammals (Reijnders, 1980). In a sample of Irish otters (Mason and O'Sullivan, 1992), DDE, dieldrin and PCB concentrations were highly inter-correlated.

The concentrations of contaminants in otter spraints collected in 1990 were low, with mean concentrations similar to or lower than those from thriving otter populations in Wales (Macdonald and Mason, 1988 and unpublished data). Mason et al. (in press) have used a two-stage model, in part based on that of de Vries (1990), to estimate tissue concentrations of PCBs in otters from concentrations in spraints. From the geometric mean in spraints (Table 5) a mean tissue concentration of 7.06 mg kg^{-1} was predicted. The measured mean tissue concentration of PCBs in otters collected in 1989–90 ($n = 19$) was 7.99 mg kg^{-1} fat. In view of the current low concentrations of contaminants in Danish otters, at least in their stronghold in the Limfjord region, and the decline over time in concentrations of PCBs and DDE, population expansion may be expected and indeed appears to be occurring (Madsen et al., in press). Attempts to reduce the significant mortality (Madsen, 1989) due to fish traps and traffic should enhance the rate of expansion (Madsen, 1990; 1991). It would, however, be prudent to analyze fish tissues for contaminants in the likely areas of otter population expansion in order to assess any likely problems that might be encountered.

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3. Afsendte artikler/Submitted Articles

OTTER (*LUTRA LUTRA*) MORTALITY IN RELATION TO TRAFFIC, AND EXPERIENCE WITH NEWLY ESTABLISHED FAUNA PASSAGES AT EXISTING ROAD BRIDGES

by

AKSEL BO MADSEN

Key-words: Lutra lutra, otters, traffic mortality, ecological corridor, fauna passages, Denmark

1. Introduction

The otter (*Lutra lutra*), once widespread in Denmark, is now largely restricted to the Limfjord area in northern Jutland, with isolated populations in surrounding regions (Madsen & Nielsen, 1986; Madsen et al. 1992). Death by drowning in fish traps and traffic mortality are serious threats to the remaining otter population in Denmark and other European countries.

It seems impossible to estimate the actual number of otters killed on the roads. Otters are strong, tenacious animals, capable of living many days and travelling long distances with mortal injuries; hence many carcasses may never be found. Nevertheless, Lafontaine (1991) suggested that 5% of the otter population in France is killed by traffic every year. This proportion is not insubstantial, and Green (1991) and Stubbe (1993) state that road mortality is probably the largest and fastest growing cause of unnatural mortality.

Otter deaths in fish traps can be prevented by the use of a stop grid at the net entrance (Madsen, 1991). Many authors have dealt with the number of otters killed on roads (Jensen, 1964; Van Wijngaarden & Van de Peppel, 1970; Von Müffling, 1977; Stubbe, 1977, 1980; Hodl-Rohn, 1978; Heidemann, 1981; Wlodek, 1984; Braun 1986; Skarén & Kumpulainen, 1986; Van Moll & Christoffels, 1989; Green 1991).

Few accounts of measures to prevent otters from being traffic killed are reported (Madsen, 1989; Anonymus, 1984; Green, 1991; Striese & Schreyer, 1993; Rogoschik et al. 1994). In France and the Outer Hebrides of Scotland, otter underpasses have been established (Lafontaine, 1991; Twelves & Kinross, 1982) but experimental investigations of these measures are needed.

In Denmark, local authorities have established 45 fauna passages since 1990 at existing road bridges to prevent otters and other mammals from being killed by traffic. After implementation, selected types of the fauna passages were tested. The establishment of the fauna passages was a result of the conservation priorities for Denmark set out in the IUCN Conservation Plan for Otters (Foster-Turley et al., 1990).

This article is an updated, revised and extended version of a preliminary paper about otters and traffic (Madsen, 1990). The article presents data on traffic-killed otters, information about the scene of the accidents and research into the effects of newly established fauna passages for otters at existing road bridges.

2. Material and methods

The study is based on material from the following sources:

(1) 115 Danish otters killed by cars in 1980-1995 were necropsied and information about date of death, sex and age were collected. 88 animals were aged as juveniles (less than 5 months old) if tooth replacement was incomplete; as subadults (5-18 months) if the epiphyseal closure of humerus and femur at their proximal and distal

ends was not complete; or as adults (older than 18 months). In males, the length of the baculum was also used in ageing (Van Bree et al., 1966).

(2) The scenes of accident were examined on the basis of a 1:50.000 scale map, and information on type of road and locality was recorded. Death localities at bridges, culverts and dams were visited, and further information was collected about the dimensions of underpasses and their surroundings.

Tunnel effect (TE) of the bridge/culvert was calculated according to Reed & Ward (1987) as:

$$\frac{H \times W \text{ (or open-end surface area)}}{L}$$

where H = distance from water surface to the lower edge of bridge/culvert, W = width of the bridge/culvert and L = length of the bridge/culvert.

Data on the mean daily traffic in the years 1980-1993 at the site of accident were taken from reports by the Danish Ministry of Transport, Directorate of Traffic (Vejdirektoratet, 1981-1995). The proportion of different road types in the four counties (Nordjylland, Viborg, Ringkøbing and Århus) with traffic killed otters according to Statistisk Årbog (Statistical Yearbook) (1995).

(3) Ten newly established fauna passages of six different types were monitored in the period 1990-1993:

Type 1.
Granite boulder under the bridge sloping downwards into the water.

Type 2.
Floating pontoon bridge made from wood with a core of polystyrene mounted to the road bridge.

Type 3.
Bunch of timber spruce (fascine) and big granite boulders placed in the corner of the road bridge.

Type 4.
Fencing (1 m high and 12 m in length) in a sluice formation on both sides of the road bridge to steer the otters travelling and banks of concrete (25 cm wide) under the bridge.

Type 5.
Culvert (40 cm wide) placed next to an existing water culvert (2.5 m wide) and fencing (0.5 m high and 75 m in length) in a sluice formation on both sides of the road along the crash fence.

Type 6.
Fencing (1 m high and 12 m in length) in a sluice formation on both sides of the road bridge to guide the otters travelling.

The investigation was primarily based on search and determination of spraints and footprints in the fauna passages and on adjoining banks. At each site, a distance of 300 m as a maximum was searched on each side of the bridge. Tracking by footprints was only possible in a few cases.

The effect (%) of the different fauna passages was calculated as:

$$\frac{MF}{MB} \times 100$$

where MF = no of monitorings with spraints found on the fauna passage, MB = no of monitorings with spraints found on the banks on both sides of the bridge/culvert.

Infrared video monitoring, at selected bridges, was used to test the effectiveness of the monitoring based on tracks. The system consisted of a photosensitive video camera (BISCHKE/CCD-502 with Zoom Optic 12,5 - 75 X magnification), 2 infrared lamps (Dennard 300 Watt), motion detector (Panasonic WJ-250/G), video recorder (Panasonic Time Lapse Recorder AG-6024), pan/tilt head (Widemech 600, 220 VAC) and a black/white monitor (IKIGAMI 9").

The video camera and the infrared lamps were placed 60-70 m from the fauna passage, connected by a 90 m cable to a car, housing the video recorder, motion detector and monitor. The zoom and the pan/tilt function was operated from the car. A generator in a closed trailer situated 250 m from the fauna passage was used when stable 220 VAC was not available.

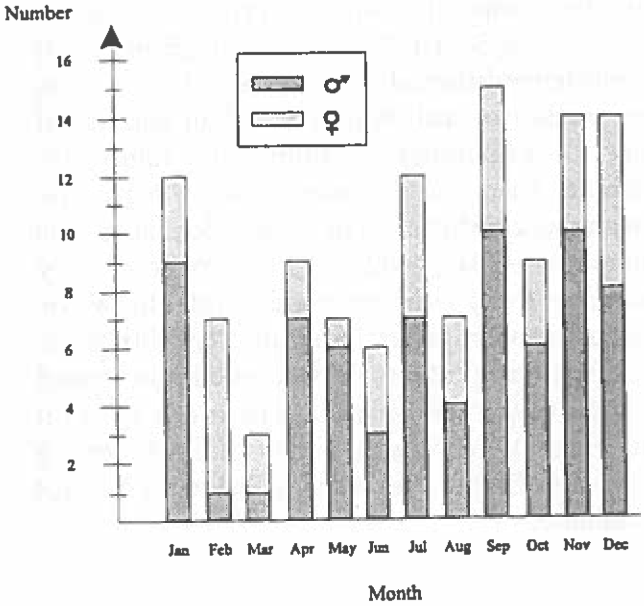

Fig. 1. Monthly distribution of 115 otters killed by traffic in 1980-1995.

3. Results

3.1 Monthly distribution

During 1980-1995, 115 traffic killed otters were brought in and the proportion of road killings has increased from 40% in 1980 to 52% in 1994.

Otters were killed throughout the entire year (fig. 1). No significant differences were found in numbers between the winter months October-March and the summer months April-September (χ^2=0.08, d.f.=1, N.S.), the same pattern was found between the proportion of males to females in these periods (χ^2=2.99, d.f.=1, N.S.).

Table 1. Sex and age distribution of 88 otters killed by traffic.

Age/sex	Males	Females	Total
Juveniles	4	1	5 (5.7%)
Subadults	17	11	28 (31.8%)
Adults	30	21	51 (58.0%)
Unknown	3	1	4 (4.5%)
Total	54 (61.4%)	34 (38.6%)	88 (100%)

3.2 Sex and age

A total of 51 (58.0%) of the traffic killed individuals were adults, 28 (31.8%) subadults and only 5 were juveniles (table 1).

A significant number of males (61.4%) was traffic killed (χ^2=4.55, d.f.=1, P<0.05), adult males in particular; this maybe due to males' greater activity than females in the home-range. A significant difference was found in age distribution between the two sexes (χ^2=11.85, d.f.=3, P<0.01).

3.3 Type of localities

A total of 28 otters (24.3%) were killed at bridges/culverts and four of these otters were killed at sites where underpasses were established. At dams between two wetlands with no possibility of moving underneath the dam 27 otters (23.5%) were killed (fig. 2). No difference in number was found between otters killed at rectangular bridges and at culverts.

26 otters (22.6%) were killed at sites less than 100 m from wetlands. Twelve of these sites were classified as blackspots; i.e. two to four otters were killed at exactly the same place.

In a distance more than 100 m from wetlands 32 (27.8%) of the otters were found killed. A careful examination of the accident site on maps for the 15 individuals found more than 500 m from wetlands reveals positions of small brooks and contours in the landscape. It is remarkable how these sites of accidents are situated along the shortest distance between two wetlands (bogs,

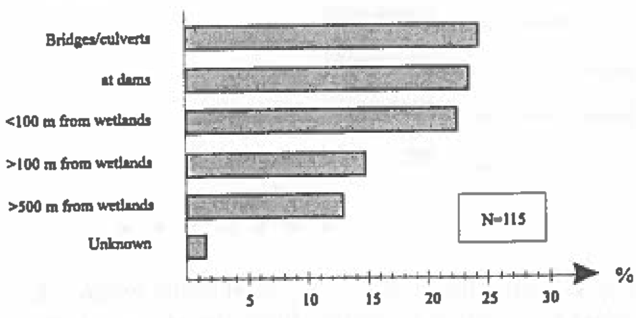

Fig. 2. Distribution of road kill sites of 115 otters.

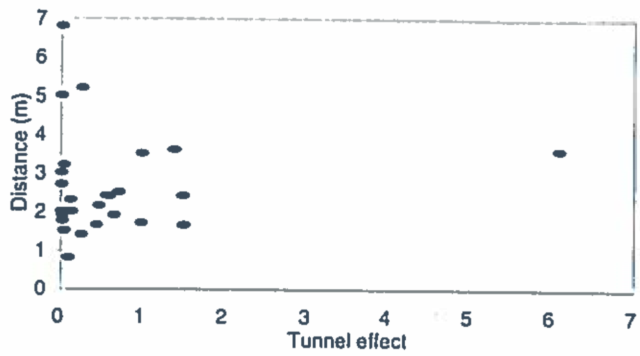

Fig. 3. Tunnel effect (TE) related to distance between water surface and roadway at bridges/culverts where 28 otters were traffic killed.

lakes, rivers or streams); the contour lines show gullies leading towards the road and to be continued on the other side.

In cases where accident sites are situated above bridges or culverts, the otter may pass in the water under the road. In fig. 3, the relationship between the distance from the water surface to the roadway and the tunnel effect (TE) at each bridge/culvert is illustrated. Most otters (75%) were killed at sites with a TE lower than 1.5 and a distance of less than 3 m from the water surface to the roadway. Irrespective of including or excluding the site with a TE of 6.09, no correlation is observed between tunnel effect and distance from water surface to the roadway (r^2 = 0.01/0.05, respectively).

3.4 Type of roads

A total of 72 otters (62,6%) were killed on primary roads and secondary roads wider than 6 m (fig. 4). A significant difference was found between the proportion of traffic killed otters

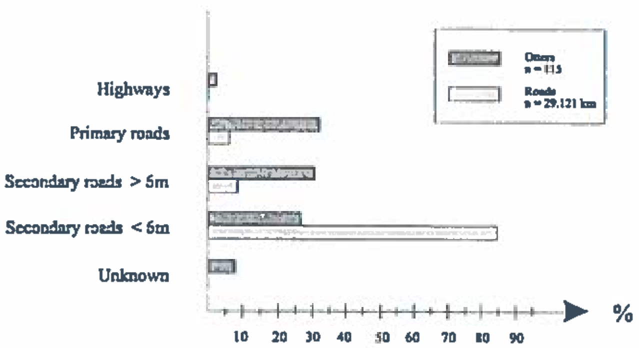

Fig. 4. Distribution of four types of roads where 115 otters were killed by traffic. Road type is based on an administrative classification.

and the proportion of road types at accident sites (χ^2=256.38, Df=2, P=0.0). Using Bonferroni Confidence Intervals (Neu et al. (1974) for the proportion of individuals killed in each road type, a preference is found for highway/ primary road and secondary road > 6 m . The mean daily traffic at 75 of the accident sites was found to be 2840, 4632 and 10600 for secondary roads > 6 m, primary roads and highways, respectively. In general, the velocity follows the same pattern with an allowed maximum speed at highways in Denmark on 110 km/h. Data on the proportion of heavy lorries and fast moving cars implicated in the collision was not available.

3.5 Test of fauna passages

The fauna passages and the surroundings were monitored for tracks between 4 and 11 times depending on the time of establishment (table 2.). Furthermore, four of the fauna passages were video monitored between 2 and 10 nights amounting to a total of 209 hours with 22 cases of otter crossings.

The otters used all the examined fauna passages to a varying degree. Seven fauna passages come into use not later than four weeks after the establishment. The fauna passages at Morup Mølle (1) and Storå (4) seem to be very effective. The low use of the fauna passage at Tegå (3) may be due to the reduced need for the otter to use the fauna passage as the bridge is wide and high (TE = 3.0).

In one case, an otter was recorded by video monitoring on the roadway at Strømmen (10). The fencing in a sluice formation here seems to be too short to guide the otter safely under the road culverts, but it seems impossible to construct it in any other way. Video monitoring at Flyndersø (2) indicates that otters may visit a fauna passage under a road bridge without sprainting at all. The results based on tracks therefore only give a minimum number of crossings under the bridge.

At Lyngholm (6), the distance from the water surface to the fauna passage at low water level, has been at least 30 cm. This does not prevent

Table 2. Locality, type and time of establishment of the fauna passages, the number of monitorings and the effect of the fauna passage.

Locality	Type of fauna passage	Established month/year	Number monitored (video nights)	Effect of fauna passages in %
1. Morup Molle	granite boulder	04-1990	10	100
2. Flynderso	granite boulder	05-1991	8	63
3. Tegå	pontoon of tree	06-1990	11	10
4. Storå	pontoon of tree	10-1991	6	100
5. Hvidbjerg Å	pontoon of tree	10-1991	6	83
6. Lyngholm	timber fascine	04-1990	11	70
7. Skals Å	fence/concrete	09-1990	10	40
8. Visby Å	culvert (40 cm)	04-1992	4	50
9. Stubber Å	fence	10-1991	7	71
10. Strommen	fence	10-1991	7	29

the otter from sprainting on the fauna passage, indicating that a passing otter is attracted by the dry place under the bridge in spite of the level.

Maintenance of the different fauna passages and floating water weeds were insignificant. Otherwise, the maintenance of fencing after passing humans was a recurrent problem.

In addition to otters, stoats (*Mustela erminea*), minks (*M. vison*) and water voles (*Arvicola terrestris*) were registered using all the different types of fauna passages. Furthermore, Stone martens (*Martes foina*) and a feral cat (*Felis catus*) were recorded using the dry culvert at Visby Å (8).

4. Discussion

More than half of the traffic-killed otters were adults in agreement with results obtained from Holland by Van Moll & Christoffels (1989). Following Jensen (1964) estimations based on the weight and length of the baculum indicate that it is predominantly sexually mature males that were killed in the traffic and it is probably a result of difference in home-range compared with females. The sex ratio (1.6:1) in our study is comparable with data from Germany (Rogoschik et al., 1994).

The results of the video monitoring disprove the theory that otters prefer to cross a bridge above a stream by the road, instead of swimming as stated by Reuther (1980 p. 126).

The data concerning road type at road kill sites are applicable with results obtained by Rogoschik et al. (1994). Otherwise, the accident sites' distance from a water source is quite different; e.g. 70.4% of the Danish otters compared to 40.5% of the German otters are killed less than 100 m from a water source.

Based on the Danish results, establishment of effective fauna passages at bridges/culverts and fencing along the roads in a distance up to 100 m from a water source and similarly at dams may at a maximum reduce the number of traffic killed individuals by 70.4%. Without fencing, establishment of fauna passages at bridges/-culverts and dams may only reduce the traffic killings by 47.8%.

Twelve sites were unfortunately classified as black spots or multiple road kill sites in agreement with Mason & Macdonald (1986) and Rogoschik et al. (1994). The main part of multiple road kill sites are located near water sources indicating that bridges/culverts could be a profitable starting point for preventive measures.

From Great Britain, Jefferies (1988) describes a few examples of "short cuts" over watersheds into adjacent river systems especially from radio-tracked individuals. The present study conclude that "ecological corridors", in relation to otters extend between water catchments only; 15 examples of "short cuts" show how otters at some rivers are not isolated from their neighbours by large areas of land. In this study only few otters were killed at the same site in a distance of more than 500 m from wetlands. Even though the otter seems to prefer to move along water courses in the lower parts of a valley, a hilly terrain does not present a hindrance to movement. In such cases, the animals may have followed traditional routes from one catchment area to another.

For extremely solitary animals as otters, living apart from each other in different water catchments, "short cuts" may be important means of exchanging genetic material.

Based on direct observations, Madsen (1990) report that the otter is unable to estimate the speed and risk of passing cars, and experienced otters may not have learned to avoid traffic as they seem to have learned to avoid fish traps (Madsen, 1991). Likewise, the necropsy of the carcass and investigation of the skeleton from a great number of the traffic killed otters (Madsen et al., in prep.) indicates that the collision between car and the otter has caused immediate death. This result also conforms to the preference for otter killings at Highways/Primary roads and Secondary roads > 6 m with a high vehicle speed and traffic density.

Striese & Schreyer (1993) report that otters mark on a bank under a bridge with a slope of 45°, and Madsen (1993, 1990) mentions that otters are attracted by dry bankets beside streams. The present study confirms this, although the bankets are vertical.

Different measures have been suggested and used to reduce road mortality for otters. Road signs warning motorists have been used on the Shetlands and on Orkney, but they seem to have little effect (Green, 1991). Maintenance of game-mirrors placed at bridges to warn otters of passing cars are considerable (Madsen, 1990) compared to the more effective fauna passages.

Based on experiences in the present study, establishment of fencing also emphasizes the necessity of maintenance. This is not discussed in the advising part of Rogoschik et al. (1994). Furthermore, it should be remembered that a fence may force the otter on to the road instead of leading the animal under the bridge.

Otters crossing roadways may be avoided, primarily by luring them under roadsystems on stones, banks or through tunnels and in extreme cases by forcing them away from the road by means of fences.

5. Conclusions

Based on the great variety in types of accident sites for otters, it is impossible to eliminate all traffic killings, and no general solution can be offered suiting all traffic killing sites.

Provision of appropriately sited fauna passages is an effective means of reducing otter traffic killing at a limited expense. It is possible to make existing road bridges attractive for otters and reduce the number of traffic killed individuals.

At accident sites and other sites with otters intersecting a flowing water way (e.g. ducts under a road), the following two types of fauna passages are recommended:

1. Fauna passages made of granite boulder give the best visual impression and may be preferred at sites where the difference between high and low water level is minimal, the stream is shallow and the ground solid (fig. 5a).

2. Fauna passages made of a floating pontoon bridges of hard-wood, 30 - 35 cm wide, 10 cm high and with the length of the bridge, with a core of polystyrene may be preferred at sites where the difference between high and low water level is extreme, the stream is deep and the ground soft (fig. 5b).

At accident sites which do not intersect with a flowing water way, or as an additional measure to fauna passages, it is possible to implement guiding mechanisms as fencing. But in many sites, it is practically and technically impossible to establish a safe leading fence. The maintenance of the fence is a considerable problem and the visual impression rarely harmonizes with the surroundings. Fencing is only recommended in extreme cases.

To ensure that fauna passages for otters are established at the right sites, it is advised to be necessary to contact the person who deli-

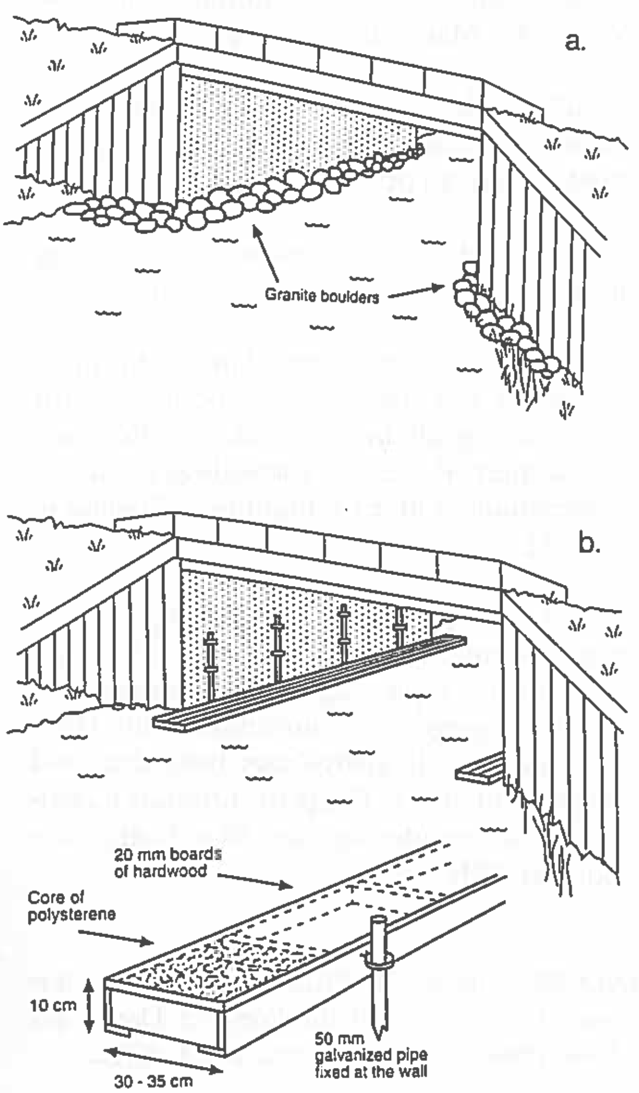

Fig. 5. Fauna passages made of granite boulders (a) and floating pontoon bridges of hardwood with a core of polystyrene (b) recommended for existing road bridges.

vered the carcasses to verify information on the precise death locality.

Traffic mortality is a major cause of unnatural death for European otters. Roads are barriers to otters, and the expansion of road building may present a serious threat to a highly dispersed and sparse population of otters. This threat may be reduced by the use of properly sited fauna passages at a relative small expense.

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SUMMARY

Like other wild animals, many European otters are killed in the road traffic. This paper presents an evaluation of the following sources: data from 115 otters killed by cars in 1980-1995, examination of the scenes of accident and tests of ten fauna passages established at existing road bridges.

No significant differences were found in traffic killings between the winter months October-March and the summer months April-September. Adult sexually mature males are most frequently killed by traffic, probably as a result of their greater activity in the home-range compared to the females. Nearly half of the otters were killed at bridges/culverts or dams. It is concluded that the most dangerous kind of road for an otter is highway/primary road and secondary road > 6 m with a relatively high vehicle speed and traffic density, and preventive measures must therefore be started here.

Many otters are killed at sites up to several kilometres from wetlands, probably taking "short cuts" between watersheds. "Short cuts" may be a way in which genetic material can be exchanged between distinct solitary living animals as otters. Provision of appropriately sited fauna passages is an effective means of reducing the number of traffic killed otters. Two types of fauna passages are recommended for being useful to make existing road bridges attractive for otters at a relatively small expense.

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Survey of Danish free living otters (Lutra lutra). A consecutive collection and necropsy of dead bodies.

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Key words: European otter, Lutra lutra, necropsy, causes of death, Denmark.

Summary

During 1979-1993 194 dead Danish otters (Lutra lutra) were received. Of these, 145 were necropsied and the cause of death, sex, age and body condition determined.

Traffic mortality (45.4%) and drowning (32.5%) constituted the major cause of death.

Shot gun lead pellets were detected in 5% of the otters.

Inclusion bodies indicating distemper virus infection were found for the first time in a free living otter population.

Angistrongylus vasorum larvae were found in the lungs of free living otters for the first time. No ectoparasites were found.

Infectious agents were detected in 22.1 % of the otters although only few otters appeared to have died from infections.

The age distribution was not significantly different between the two sexes.

Body condition for otters which died violently in Denmark was comparable to findings in Shetland, where thriving populations exist.

The results showed a considerable decrease in number of otters found drowned in fish traps coinciding with the introduction of stop grids in fish traps in 1986.

The results suggest that the existing otter population in Denmark is healthy and in good condition but it can not be excluded that the large number of otters killed by traffic threatens the continued expansion of the species.

Introduction

The Euroasian otter (Lutra lutra), is a highly endangered mammal in Denmark as well as in much of Europe (Macdonald & Mason 1994). In 1991 a national survey (Madsen and others 1992) concluded that the geographical distribution of the otter in Denmark was largely restricted to the middle and northern part of Jutland (vide Figure 1.).

It has been claimed that contaminants such as the organochlorine pesticide dieldrin, polychlorinated biphenyls, and mercury have been responsible for the rapid decline in otter populations in Europe (Macdonald & Mason 1994). Decreasing otter population in Denmark was thought mainly to be due to river regulation, wetland destruction, drowning in fish traps, and intensified traffic (Madsen 1991).

Otter carcasses have been collected annually in several European countries. In Germany eg. more than 50 otters were found dead each year, but only a small number of these were necropsied (Zogall & Reuther 1992). Likewise only 24 of 113 dead otters collected in Shetland were necropsied (Kruuk & Conroy 1991).

In this paper necropsy results of carcasses submitted from a population of free living otters are evaluated to assess current threats to otters.

Materials and methods

Dead otters were received from hunters, motorists, anglers, forestmen etc. The otters were usually followed by written information about circumstantial evidence like killed on a road, died in a fish trap etc. Carcasses were frozen immediately upon arrival and stored at -18^0 C until necropsy was performed.

Necropsy

After thawing the length (nose to tail) and weight was recorded. The animals were pelted followed by a routine necropsy procedure, including a search of the subcutis for lead pellets. Otters were aged as juveniles (less than about 5 months old) if tooth replacement was incomplete, as subadults (5-18 months) if the epiphyseal closure of humerus and femur at their proximal and distal ends was not complete or as adults (older than about 18 months). In males the length of the os penis was also used in ageing (van Bree and others 1966). The craniums were cleaned from muscles etc. and the upper and lower jaw was inspected by a dentist.

Laboratory tests

Lungs and gut contents were examined for parasites, eggs and larvae from parasites using McMaster and modified Baerman techniques (Henriksen 1965, Henriksen & Korsholm 1984). Scrapings of epithelial lining from thrachea, lungs, and urinary bladder from otters necropsied later than 1988 were examined for viral inclusion bodies using S3-staining and a routine immunohistochemical method to detect distemper virus. Bacteriological examinations (Aerobic cultures on blood agar), were performed on material from the digestive tract, lungs and kidneys.

The body condition (K) of otters was calculated using the equation $K=W/(a \times L^n)$ where W=weight (kg) and L=total length (m) according to Le Cren (1951). The constants were those calculated by Kruuk and others (1987) viz. a=5.02 for females, 5.87 for males; n=2.33 for females, 2.39 for males.

Results

194 otters were received of which 145 were necropsied. 52 otters were X-rayed. For some of the animals complete data were not received. Therefore, the number of individuals in the various examinations is inconsistent (Table 1).

The geographical origins and densities of the otters are given in Figure 1. The vast majority came from the Limfjord area. One individual found in 1979 came from the island of Funen. Half of the otters were found in or close to marine habitats. The annual number of carcasses received varied from two in 1979 to 31 in 1993 (Figure 2). Major causes of death were identified as traffic mortality (88=45.4 %) and drowning (63=32.5 %).

Table 1. Salient data and the number of animals included.

Type of data presented	Number of animals
Total received	194
Origin stated	193
Sex determined	192
Age determined	178
Length and weight determined	158
Necropsied	145
X - rayed	52

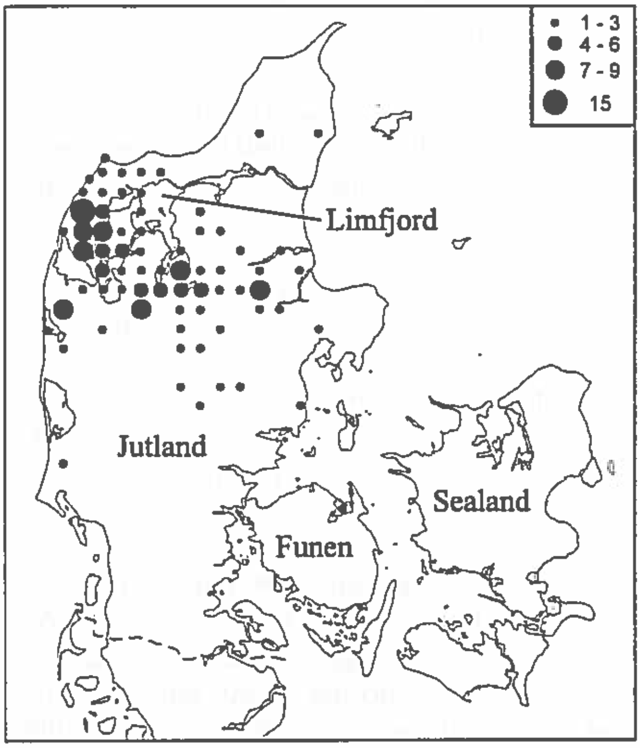

Figure 1. Geographical distribution of dead otters (N=193).

No significant difference was found in age distribution between the two sexes, (χ^2=0.43, d.f.=2, N.S.) (Table 2). Considerably more males (113) than females (79) were received during the survey. The weight and length of adult males were significantly larger than for adult females (t=9.60, df=65, $P < 0.001$, weight; t=20.35, df=67, $P < 0.001$, length). The condition index (K) of the otters had an overall mean value of 1.12, animals that died violently (traffic accidents and fish traps) had a value of 1.16 (Table 3).

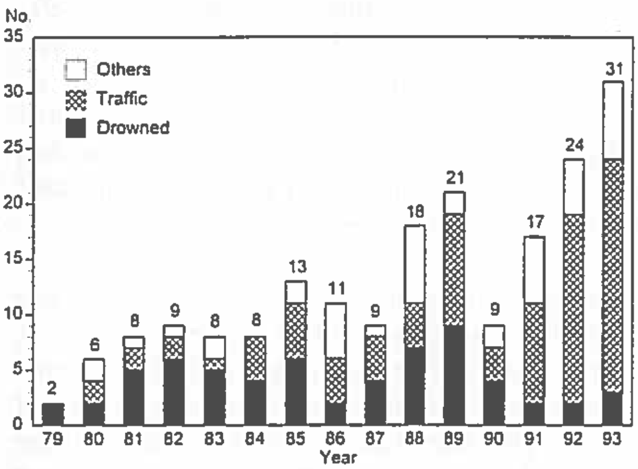

Figure 2. Annual number of dead otters and cause of death (N=194).

Table 2. Sex and age distribution of dead otters.

	Females	Males	Unknown	Total
Juvenile	8	12	-	20 (10.3%)
Subadult	30	48	-	78 (40.2%)
Adult	34	44	2	80 (41.2%)
Unknown	7	9	-	16 (8.3%)
Total	79 (40.7%)	113 (58.2%)	2 (1.0%)	194 (100%)

The results of necropsy and the corresponding pathological findings are detailed in Table 4. No ectoparasites were found. Signs of endoparasites were found in only 5 individuals viz. two with one egg of Ascaridae per gram in the intestinal tract, one with one egg of Strongylidae per gram in the intestinal tract and one with Angiostrongylus vasorum larvae in the lungs. Two tapeworm Cestedae eggs per gram were found in the intestinal tract of one individual.

Inclusion bodies were found in 6 individuals, three females and three males of different age. These otters were all collected in the Limfjord area. The six otters were not believed to have suffered from clinical distemper.

Due to often severe decomposition bacteriological examination could only be applied to eight otters. Pneumonia due to bacterial infection was found in 5 individuals four females and one male of which two were juveniles. One abandoned juvenile died from bacterial peritonitis two weeks after taken into captivity. Local infection with Streptococcus sp. was recorded in one animal.

Table 3. Weight and length of adult otters and calculated condition indices (K).

	x	s.d.	range	n
Weight (kg)				
Male	9.07	1.35	5.45-11.40	37
Female	6.02	1.17	3.36-7.60	30
Length (cm)				
Male	112.9	5.06	90.0-130.0	36
Female	103.0	3.17	95.5-110.0	33
Condition index (K)				
Non-violent	0.94	0.18		30
Violent	1.16	0.16		124
Sum	1.12	0.18		154

Table 4. Numbers and types of pathological findings recorded at necropsy of dead otters (N=145).

Pathological findings	Number of animals	
Parodontal disease	11	(7.6%)
Endoparasites	5	(3.4%)
- Ascaridae	2	
- Strongylidae	1	
- Angiostrongylus vasorum	1	
- Cestedae	1	
Viral infections	6	(4.1%)
- distemper virus	6	
Bacterial diseases	7	(4,8%)
- pneumonia	5	
- peritonitis	1	
- Streptococcus sp.	1	
Kidneystone	3	(2.1%)
Gallstone/enlarged gall bladder	2	(1.4%)
Hepatitis	2	(1.4%)
Hypertrophied suprarenal gland	2	(1.4%)
Tumour in spleen/enlarged spleen	2	(1.4%)
Tumour in the small intestine	1	(0.7%)
Umbilical hernia	1	(0.7%)
Blindness	1	(0.7%)
Total	43	(29.7%)

Kidney stones consisting of ammonium urate were found in three adults, two males and one female, and two otters had a gall bladder enlarged by gall-stones. Two otters showed hypertrophy of the suprarenal glands. A small intestinal tumour possibly a leiomyoma (severe decomposition) and a minor umbilical hernia was seen in two otters, respectively. The eyes of one adult, male otter were completely opaque, probably causing total blindness.

Lead pellets were found in 9 otters (5%) in numbers from one to five pellets except for one individual carrying 14 pellets. The lead pellets were generally found in the pelt or subcutaneously and none were found in or close to vital organs. Parodontal disease was detected in 11 otters indicating a relatively high proportion of diseased animals.

Discussion

Based on condition (K) of violently dead otters there was no significant difference between otters from Denmark (Table 3) and from Shetland (Kruuk & Conroy 1991, K=1.08 ± 0.15 S.D., n=49), (t=2.99, d.f.=171, N.S.) where thriving populations exist. The results agree with condition indices estimated by the authors from Danish data collected by Jensen (1964) (K=1.13 ± 0.16 S.D., n=81).

The increase in the annual numbers of submitted otters during the survey period (Figure 2) might indicate an expanding population of otters (Madsen and others 1992) but a greater public awareness of otters can not be excluded as the underlying cause of the increasing number of submissions.

The present results show that males achieve a larger overall size than females. Mason & Macdonald (1986) classified animals weighing more than 4 kg as adults. In our study adults were classified as individuals with fully developed growth. One female with pneumonia but no emaciation weighed as little as 3.36 kg confirming that the weigth and length alone may not be used as an indicator of age.

No ectoparasites and only small numbers of endoparasites were found. This indicates that in the present situation the otter is not parasitized very often, probably due to their solitary living and the relative scarcity of the species. However, decaying before collecting the dead otters combined with freezing might have disintegrated some parasites and larvae.

Except for the larvae of Angiostrongylus vasorum all other endoparasites recorded have been described earlier to occur in otters (Jefferies and others 1990, Schierhorn and others 1991, Weber 1991). Otters forage on frogs which might act not only as paratenic but also as intermediate hosts for A. vasorum (Bolt and others 1993, 1995). None of the parasites recorded were considered to have influenced the health status of Danish otters.

Distemper virus in captive Eurasian otters was described by Geisel (1979) and Steinhagen & Nebel (1985). Our study is the first to record distemper virus in a free living population of otters. The fact that the infected otters were collected from the Limfjord area in a period when distemper virus was present both in the common seal Phoca vitulina (Blixenkrone-Møller and others 1989) and in major outbreaks of distemper in farmed mink in this area indicates a wide range of host species for distemper virus. Negative findings in the remaining material may indicate a low propagatory rate of the virus in the population, but may also relate to the solitary life of otters and hence a low contact between animals.

Two cases of hepatitis probably causing severe health problems were seen. Pneumonic changes were found in five of 145 necropsied free living Danish otters. This corresponds to the findings of Kruuk & Conroy (1991) who found one case among 24 necropsied otters. Pneumonia has not hitherto been recorded in captive animals (Rogoschik & Brandes 1991). One individual was recorded as blind in our study. Williams (1989) also reported blind otters from Britain during the period 1957-80.

Based on our study we would argue that only the two animals with hepatitis, and the five animals with pneumonia were likely to have died because of the diseases detected. In addition, one animal with peritonitis definitely died from this disease.

Since 1967, the Danish otters have been protected by law. During the period 1967-1982, fish farmers could be granted a special permission to kill otters at fish ponds but this exemption was terminated in 1982. However, this study shows that totally protected animals are still shot at. To the less experienced hunter an otter may be mistaken for a free living mink of which more than 3.500 are shot annually in Denmark (Asferg 1996).

The level of PCB in otters from Denmark (Mason and Madsen 1993) is at the same level as found in 1988 among young common seals in the Limfjord area (Storr-Hansen and Spliid 1993) and much lower than the 50 mg/kg which causes reproductive failure among mink in laboratory studies and which is assumed to be a critical level for otters as well (Keymer and others 1988, Smit and others 1994).

It is seen (Figure 2) that the number of otters dying in fish traps has decreased. It is believed that this is the successful effect of a 1986 compulsory use of stop grids in fish traps for fishermen (Madsen and Soegaard 1994). It should be noted that traffic mortality constitutes 45% of the total mortality (males as well as females, young as well as adults) indicating the need for preventive measures where roads are crossing rivers in Denmark.

In conclusion, our results suggest that the population of otters seems healthy and in good reproductive condition, although traffic mortality may constitute a threat to the spread of the population.

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4. Manuskripter/Manuscripts

Otter (*Lutra lutra*) monitoring based on spraint surveys, carcasses and reported observations

by

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Keywords: otter, *Lutra lutra*, spraint surveys, carcasses, observations, low density, Denmark

Abstract

Eurasian otters *Lutra lutra* are difficult to observe directly in their natural habitat. Reliable methods for assessing distribution and abundance are of considerable importance, because of the tenuous status of the species. The standard procedure of surveying otter distribution is compared and evaluated against the proportion of otter carcasses and the number of reported observations.

The number of otter carcasses from different regions is positively correlated with the proportion of positive sites and the mean number of otter signs per positive site recorded during otter surveys from the same areas, suggesting that sprainting intensity is a good indicator of relative population strength.

Otherwise, the reappearance of the otter on the island of Sjælland, after 10 years of absence, is in contrast to the result of the national surveys and the geographical distribution of otter carcasses. Findings in this study therefore stress the need for care in the interpretation of spraint surveys as a means of detecting isolated pockets of otters with very low densities.

It is of crucial importance that spraint surveys are carried out in the months when sprainting activity is highest and the herbaceous vegetation low to ensure that as many sites as possible with otters are detected. Surveying must also be carried out in areas with no evidence of otters for some years.

Introduction

Eurasian otters *Lutra lutra* are difficult to observe directly in their natural habitat. Reliable methods for assessing distribution and abundance are therefore of considerable importance, because of the tenuous status of the species. Monitoring results are of particular interest to conservationists working in low density otter areas maximizing the management policies.

Many authors have discussed the use of spraint surveys as a method of assessing distribution, density and habitat utilisation of otters (e.g. Jefferies 1986, Kruuk *et al.* 1986, Conroy & French 1987, Kruuk & Conroy 1987, Mason & Macdonald 1987 and O'Sullivan 1993). At present, authors agree that surveys using the standard methodology give a reliable picture of otter distribution whereas disagreement is still going with use of surveys as a measure of otter density and habitat utilisation.

With only a few hundred otters left, the World Wide Fund for Nature and Danish Animal Welfare Society carried out surveys in Denmark in 1984-86 and 1991. After a nationwide otter protection campaign, a central collection of otter carcasses and otter observations from the whole country was established. The reappearance of the otter on the island of Sjælland after 10 years of absence inspired the authors to examine and compare the information from different sources.

This article compares and evaluates survey results with the number of otter carcasses and reported observations.

Materials and methods

The study is primarily based on information coordinated (national surveys) and collected (otter carcasses and reported observations) from the whole country, exclusively by the first author as follows:

1. National surveys
National surveys were carried out in 1984-86 (1,154 sites, Madsen & Nielsen 1986) and 1991 (767 sites, Madsen *et al.* 1992). The technique used was the standard method used in otter surveys in Europe as given by Anon (1984). At each survey site a maximum of 600 m bank was searched for signs of otters. Only spraints (faeces) or clear footprints were accepted as evidence of otter presence.

2. Otter carcasses
In Denmark, privates are not allowed to store otters without permission from the National Forest and Nature Agency. Therefore game consultants and taxidermists collect the dead otters and forward the carcasses to a central collecting site, the Natural History Museum, Århus. Information on date of death and geographic origin for each otter was given. A total of 194 otter carcasses were received during 1979-1993 (Madsen *et al.* VII).

3. Reported observations
Direct observations of otters were reported (telephone, letters) by individual persons. Based on information on size and colour, some observations were sorted out as mink (*Mustela vison*). In total, 467 observations of otters were reported during 1984-1994.

4. Surveys in the county of Vestsjælland
In December 1994, one spraint was collected by a biologist from the northern inflow to Lake Tissø and in January and February 1995, both spraints and footprints were found at the same site (Leth & Byrnak 1996). All spraints were confirmed by the authors. During the period 2 to 25 March 1995, a systematic survey was carried out. 106 sites were visited in the county of Vestsjælland and the border areas to the county of Storstrøm by very experienced surveyors (Jensen & Jensen 1995).

Results

National surveys

National surveys in 1984-86 and 1991 showed the geographic distribution of the otter in Denmark to be largely restricted to the counties of Nordjylland, Viborg, Ringkøbing and Århus (Fig. 1).

The number of positive sites (%) and mean number of otter signs per positive site (200 m stretch) in 1991 in the different counties is positively correlated ($r=0.89$, $t=2.75$, $P<0.05$). (Table 1).

Figure 1. Map of Denmark showing the counties and the distribution of the Otter (*Lutra lutra*) according to Madsen & Nielsen (1986) and Madsen *et al.* (1992)

Table 1. The number of otter carcasses received during 1979-1993 (Madsen *et al.* VII) compared with the proportion of positive sites, mean number of otter signs per positive site (200 m stretch) in the national otter survey 1991 (Madsen *et al.* 1992) and number of reported otter observations during 1984-1994 (Madsen unpubl. data).

county	otter carcasses	% positive sites	mean number	reported observations
Nordjylland	14	27.8	4.57	52
Viborg	127	79.0	8.43	99
Ringkobing	33	26.5	6.45	58
Århus	16	17.8	3.83	81
Ribe	1	0	-	22
Vejle	1	0	-	36
Sønderjylland	-	0	-	35
Fyn	1	0	-	25
Vestsjælland	-	0	-	20
Frederiksborg	-	0	-	17
København	-	0	-	4
Roskilde	-	0	-	3
Storstrøm	-	0	-	15
Unknown	1	-	-	-
Total	194			467

Otter carcasses

The majority (65.5%) of otter carcasses came from the county of Viborg, fewer from the county of Nordjylland, Ringkøbing and Århus (Table 1). One individual originated from the island of Fyn in 1979, one from the county of Ribe in 1982 and one from the county of Vejle in 1986.

Game consultants and taxidermists are distributed evenly across the country, and the readiness of people to collect dead otters and forward the individuals is estimated to be the same in the different regions of the country. Based on this, the number of otter carcasses is likely to be a reasonable indicator of population size of otters in the counties of Denmark.

The number of otter carcasses from the different counties is positively correlated to the proportion of positive sites recorded during the 1991 otter survey (r=0.98, t=6.93, P<0.01). According to the positive correlation betweeen positive sites and mean number, the number of otter carcasses was also positively correlated with the mean number of otter signs per positive site in 1991 in the counties of Nordjylland, Viborg, Ringkøbing and Århus (r=0.83, t=3.17, P<0,05).

Reported observations

The reported observations were given from all counties; but a relatively larger number came from the counties of Nordjylland, Viborg, Ringkøbing and Århus. A high human population density could give a high number of observations. Unfortunately, the number of reported observations showed no correlation with population density in the same areas (r= -0.412, t=-1,498, n.s.).

The number of reported otter observations was positively correlated with the number of otter carcasses from the same areas (r=0.78 t=4.20, P<0.01).

Surveys in the county of Vestsjælland

During the national survey in 1984-86, 98 sites were visited in April 1986 in the county of Vestsjælland (Fig. 2) without any positive result. Four sites around Lake Tissø were revisited in February 1989 also without any positive result. During the national survey in 1991, 37 sites with reported otter observations were surveyed in March again without any positive result. In total, 35 sites were visited in both surveys.

Even though high water levels impeded the standard procedure at many localities in the

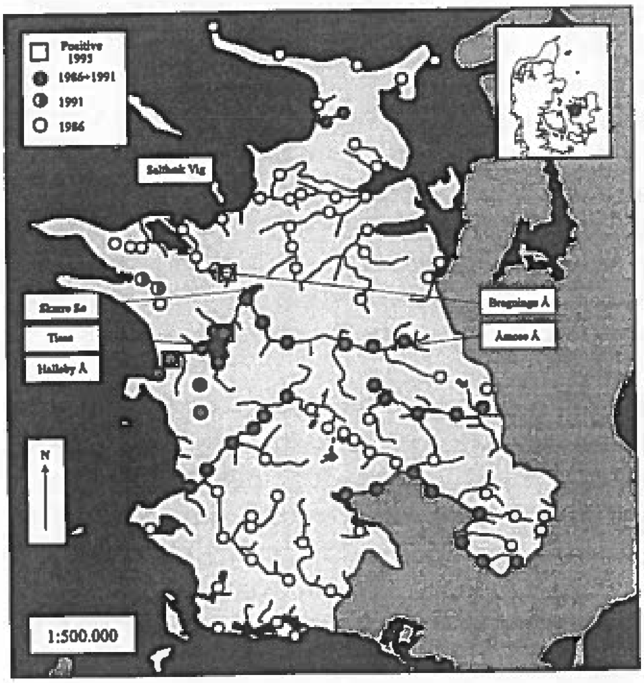

Figure 2. Surveyed sites in the county of Vestsjælland, Denmark 1986 (Madsen & Nielsen 1986) and 1991 (Madsen *et al.* 1992) and positive sites found in 1995 (Jensen & Jensen 1995).

spring survey in 1995 in the county of Vestsjælland, 3 (3%) sites were found positive. The positive sites were found in two different catchments, Halleby Å - Lake Tissø and Bregninge Å - Saltbækvig, indicating that more than one otter was living in the area. Both catchments were connected to the coast. One of the positive sites was the same as found in December 1994.

Discussion

Our results confirm a good relationship between the national surveys carried out in 1984-86 and 1991 and the geographic distribution of otter carcasses. Spraint surveys of otters in the western part of Germany agree with the Danish survey results, as the nearest positive sites are found 60 km south of the border (Heidemann & Riecken 1988) and nearly 175 km from the nearest positive site in Denmark.

Beside this, the number of otter carcasses is positively correlated with the proportion of positive sites, the mean number of otter signs per positive site and the number of reported otter observations, suggesting that sprainting intensity is a good indicator of relative population strength. In Scotland, Green (1991) found correspondingly that the number of road casualties in an administrative region correlated with the proportion of positive sites in the most recent national survey. According to Green (pers. comm.), dead animals are an important sign of an expanding population. The results are in contrast to Kruuk & Conroy (1987), based primarily on studies on marine otters at the Shetland Islands, who state that the number of spraints not equal *k* x the number of otters.

Comparing the survey results and the distribution of otter carcasses with reported observations given by individual persons, the geographical divergence is extreme and subsequent surveying could not confirm the observations. Similar results are seen between otter observations from private persons and valid records of otters based on surveys in Germany (Heidemann & Riecken 1988).

Based on the data of otters killed and on the official game bag record, Jensen (1964) found evidence of otters in the county of Vestsjælland (Åmosen, Skarresø og Saltbækvig) in 1960 and Schimmer (1981) estimated in 1980, on the basis of questionnaires, that only few individuals were found in Saltbækvig, Åmosen and Halleby Å.

Apparently, otters survived in these areas for more than 10 years without any evidence during two surveys and in a period with large number of dead otters from other parts of Denmark being sent in. The death date for the last dead otter received from Sjælland was October 1967 (Hans Baagøe, Zoological Museum, Copenhagen, pers. comm.).

Otters escaped from captivity and reintroduction to the county of Vestsjælland is impossible. Only one institution placed in the county of Århus has a licence to keep *Lutra lutra* and nobody has permission from the National Forest and Nature Agency to reintroduce otters. The southern distribution of the otter in Sweden is limited to an area east and north of the Lakes Vänern and Vättern (Sandegren *et al.* 1989). Positive evidence of otters on Fyn goes back to a dead otter delivered in 1979 and one spraint found on the central part of Fyn in 1985 (Christian Engelstoft Nielsen, pers. comm.). Likewise, it seems to be impossible for otters from these areas to reach the county of Vestsjælland.

Only one of the catchments surveyed in 1991 holding otters today indicated that some individuals could have been present there without being noticed by the observer. Kruuk *et al.* (1986) suggested that otters with low densities may not deposit spraints at typical sites, but the authors provided no evidence.

Mason & Macdonald (1989) point out that 96% positive sites on a 1000 m stretch were found within the first 600 m. Spraints from otters in negative localities in the county of Vestsjælland may have been found on stretches beyond the 600 m which were not visited in our surveys or in other national surveys. According to O'Sullivan (1993), an extention of the survey length will only increase the percentage of positive sites recorded by a small fraction, and a similar increase in survey intensity within 10 km square grids will only have a minimal effect on an overall otter distribution survey result.

Isolated pockets of otters with low density can be difficult to detect. Their presence may be confirmed in subsequent surveys as reported by Macdonald & Mason (1988). However, it is not possible to select areas where to repeat a survey; all negative sites must be revisited. Based on our reported observations e.g. no areas seem to be more conspicious to survey for otters for detecting isolated pockets than others.

Conroy & French (1989) state that the counting of spraints at their lowest numbers (in the troughs) is more likely to give the best relative index of the long term breeding population. This can be used in areas with well established otter populations. But to ensure that the survey also gives a good picture of otter distribution in areas with fragmented, low density populations, as in the main part of Europe, it is of crucial importance that counting takes place in the months when spraint intensity is highest. In Sweden and Britain, the period between October and April is mentioned (Erlinge 1968, Mason & Macdonald 1986). In Shetland too, most spraints were found in late winter/early spring, fewest in mid/late summer (Conroy & French 1989). In Denmark the month March-May is preferred (Madsen, Gaardmand & Mikkelsen unpubl. report).

Conclusions

On the basis of our studies and experiences we conclude:

* Sprainting intensity is a good indicator of relative population strength, but otters may be present even when no spraints are found.

* Otter surveys must also be carried out in areas without any evidence of otters for some years. In areas with assumed isolated populations, surveys have to be carried out more frequently.

* It is of crucial importance that spraint surveys are made in the months when sprainting activity is highest and the herbaceous vegetation low to ensure that as many sites as possible with otters are detected.

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Habitat quality factors and the presence/absence of otters (*Lutra lutra*) in Denmark

by

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Abstract

The purpose of the present study was to examine the relative influence of different habitat quality factors on otters and to develop a predictive model to provide insight into the distribution of the otter in Denmark.

During the National Otter Survey in 1991 data was collected on 19 variables which represent elements of habitat structure, composition, organic pollution and human disturbance.

Multiple logistic regression analysis was used to estimate probabilities of the presence of otters as a function of one or more explanatory variables.

Seven variables (county, pH, depth, trees, bottom, Saprobie- Index and reeds) were identified. All of them are directly or indirectly related to productivity and fish biomass in the water catchments.

Human disturbance did not have a significant influence on the presence of otters in the surveyed area. However, it is noted that there is a requirement for the protection of quiet and secure places to enable the otter to rear cubs in seclusion all year round.

Although variables used in the model may be suitable for identifying otter habitats, potential users should critically evaluate the reasonableness of each variable, in relation to their local environment.

The use of the otter as an indicator for the quality of water and habitat, as recommended by some authors, should be undertaken with care.

Introduction

The otter (*Lutra lutra*) has, over the past three decades, declined rapidly throughout much of the Western Palearctic (Macdonald & Mason 1994). Today the animal is rare or extirpated in many European countries, and in Denmark the otter is one of the most endangered mammal species.

It has been claimed that contaminants such as the organochlorine pesticide dieldrin, polychlorinated biphenyls and mercury have been responsible for the rapid decline in otter populations in Europe (Macdonald & Mason 1994). However, Madsen & Mason (1987) and Mason & Madsen (1992, 1993) suggested that current concentrations of organochlorine pesticide residues, PCB and heavy metals as Cd, Hg, and Pb were unlikely to pose a significant threat to the remaining Danish otter population.

Several other factors are thought to have contributed towards the decline in otter abundance (cf. Macdonald & Mason 1994). These include increased human disturbances, habitat destruction caused by drainage schemes, increasing water pollution, drowning in fish traps and traffic accidents.

The demand for conservation measures for otter populations is very urgent. Today it is compulsory to use stop grids in fish traps in Denmark to protect the otter (Madsen 1991, Madsen & Søgaard 1994) and fauna passages have been established to prevent otters from traffic killings (Madsen VI). In addition to this, it is essential to determine which factors may be limiting the present population of otters and consolidation of their habitats.

Some authors have dealt with evaluating habitat and environmental factors for the presence of the otter in freshwater areas (Adrian *et al.* 1985, Mason 1989, Mason & Macdonald 1989, Lunnon & Reynolds 1991, Durbin 1993, Prenda & Granado-Lorencio 1996). Dubuc *et al.* (1990) identified four composite habitat variables predicting the occurence of river otters *Lutra canadensis*. No unambiguous conclusion exist and the minimum habitat requirements of the species are still not fully understood.

The purpose of the present study was to examine the relative influence of different habitat quality factors on otters and to develop a predictive model to provide insight into the distribution of the otter in Denmark.

Materials and methods

Collection of habitat quality factors

A National otter survey was conducted in 1991 (Madsen *et al.* 1992) according to the standard method used in otter surveys in Europe (Anon. 1984). The geographic distribution of the otter in Denmark was largely restricted to the counties of Nordjylland (NJ), Viborg (VI), Ringkøbing (RK) and Århus (AR).

In all, 766 sites were visited by three surveyors in the period March - May, without snow and a low herbaceous vegetation, to ensure that as many sites as possible with otters were detected (Madsen VIII). Efforts were made to standardize the work of the three surveyors and each were issued with a manual of definitions, instructions and standard recording forms.

At each survey site a maximum of 600 m of bank was searched for signs of otters. Only spraints (faeces) or clear footprints were accepted as evidence of otters. In the surveyed stretch, data on 19 variables to represent element of habitat structure and composition were collected (Table 1). The parameters chosen are primarily related to the terms water, cover and human disturbance, which are considered to be the essentiel habitat requirements for the presence/absence of otters.

Data on organic pollution (Saprobie-Index) were collected from the local water authorities (e.g. Nordjyllands Amt 1989, Vejle Amt 1993). The Saprobie-Index, developed for freshwater by Kolkowitz & Marsson (1902, 1909), is based on the number and biological diversity of water insects.

Statistical analyses

Multiple logistic regression analyses using the SAS/STAT package (SAS Institute Inc. 1990) was used to estimate probabilities of otters (presence of spraints) as a function of one or more independent variables. Variables, if not significant on a 0.3 level in a stepwise selection and if not significant on a 0.2 level in a backward selection were dropped subsequently from a model including all variables to be tested.

This procedure ensures that variables entered into the model is suggested in relation to the variables excluded from the model. Those variables that were selected by the stepwise procedures were ultimately used in model development.

The linear logistic model has the form

$$\mathrm{logit}(p) = \log(p/(1-p)) = \alpha + \beta'x$$

where α is the intercept parameter, and β is the vector of slope parameters.

To test for differences in the selected significant variables between counties with otters (NJ, VI, RK, AR) and counties without, Mann-Whitney U-test and χ^2 test were used for the non-parametric dataset. Yates' correction is used in the 2 by 2 contingency tables.

Table 1. Nineteen independent variables included in the stepwise multiple logistic regression analysis of the presence/absence of otters.

Variable	Variable description
COUNTY	NJ, VI, RK, AR, RI, VE, SJ, FY, VS, RO, KO, FR, ST
Site character:	
WIDTH	< 1m, 1-2m, 2-5m, 5-10m, 10-20m or > 20m
DEPTH	< 0.5m, 0.5-1m or > 1m
STREAM	no current, slow, moderate, high or fresh
BOTTOM	solid ground, soft ground or varied ground
Bankside vegetation:	
TREES	presence/absence of trees
SHRUBS	presence/absence of shrubs
REEDS	presence/absence of reeds (*Phragmites communis*)
Adjacent areas:	
FOREST	presence/absence of forest
FIELDS	presence/absence of agricultural field
GRASS	presence/absence of grass
UNUTILIZ	presence/absence of unutilized areas
Sprainting possibilities:	
MARK	bad, reasonable or good
Potential human disturbance:	
HOUSES	presence/absence of houses in a distance < 200m
BOATING	presence/absence of boats in water or on the bank
ANGLING	presence/absence of anglers or signs for angling
FISHTRAP	presence/absence of fish traps in water or on the bank
Acidification:	
PH	a sample of 100 mL water was collected in a sterile container and measured imidiately on locality by PHep - Electronic Indicator (accuracy +/- pH 0.2)
Organic pollution:	
SAPRO	Saprobie-Index given as I (unpolluted), I-II, II (weak pollution), II-III, III (strongly polluted), III-IV and IV (extraordinary strongly polluted).

Results

The analysis was carried out in two steps. In the first step the effects of the geographical bias in the distribution of otters in Denmark were examined. Out of 766 observations, 370 were deleted due to missing values for explanatory variables. In all, 396 observations were included in the first step. Not surprisingly, there was a significant association of otter presence with the counties of NJ, VI, RK and AR (χ^2=64.64, P<0.0001).

In the second step, 267 observations from these counties were included. Seven of 19 variables (COUNTY, PH, DEPTH, TREES, BOTTOM, SAPRO and REEDS) were significant on a 0.3 level (stepwise) and 0.2 level (backward), respectively and could enter into the model (Table 2).

The estimated logit of the probability of otter presence can be calculated using parameter estimates as:

$$\text{logit}(p) = \alpha + \beta'x = 12.13 - 1.12{*}COUNTY - 1.23{*}PH - 0.48{*}DEPTH + 1.05{*}TREES - 0.43{*}BOTTOM + 0.82{*}SAPRO - 0.60{*}REEDS$$

In Denmark, an otter habitat typically consists of a water area with a depth > 1 m, a varied bottom, pH > 7.0, Saprobie Index on II-III to III, presence of reeds and without trees. These variables indicate water areas with a rather high productivity. It should be noted that reeds entry into the model was due to the use of the 0.3 and 0.2 level cut off, but the presence of reeds was not significant (P<0.05).

Human disturbance (estimated as the presence of angling, boating, fish traps and houses) and the utilization of the adjacent areas (estimated as

Table 2. Results of the stepwise multiple logistic regression analysis relating otter (presence of spraints) to habitat variables. The Score Chi-Square for the null model represents the variation if no independent variables are included in the model. Parameter estimates for the variables and the constant term are computed in a model including all significant factors. N.S. = the variable is not significant on the 0.3 level.

Variable	Score Chi-Square	Pr > Chi-Square	Parameter Estimate
Null model	93.6370	-	-
INTERCPT	-	-	12.1344
COUNTY	52.8484	0.0001	-1.1211
PH	16.6712	0.0001	-1.2325
DEPTH	10.9707	0.0009	-0.4756
TREES	10.2699	0.0014	1.0509
BOTTOM	4.0143	0.0451	-0.4332
SAPRO	3.9108	0.0480	0.8169
REEDS	1.7573	0.1850*	-0.6027
BOATING	0,7370	N.S.	-
HOUSES	0.0145	N.S.	-
WIDTH	0.0818	N.S.	-
SHRUBS	0.0993	N.S.	-
FIELDS	0.6579	N.S.	-
GRASS	0.0085	N.S.	-
ANGLING	0.0301	N.S.	-
MARK	0.4211	N.S.	-
FISHTRAP	0.1055	N.S.	-
FOREST	0.0019	N.S.	-
STREAM	0.0297	N.S.	-
UNUTILIZ	0.6356	N.S.	-

* = N.S, Goodness of Fit (Likehood Ratio) χ^2=218.51, D.F.=224, P=0.59

the presence of forest, agricultural field, grass or unutilized areas) do not have a significant influence on the presence of otters.

The mean pH was significantly smaller in the counties with otters than in counties without otters (Z=5.83, d.f.=1, P<0.0001).

The mean depth of water areas was significantly larger in the counties with otters (Z=2.04, d.f.=1, P=0.04) and the Saprobie-Index was significantly larger in the counties with otters (Z=2.10, d.f.=1, P=0.04).

A significantly smaller number of trees on the bankside was found in counties with otters (χ^2=71.46, d.f.=1, P<0.001).

A significantly larger number of sites with varied bottom was found in the counties with otters (χ^2=47.08, d.f.=2, P<0.001), but no significant difference was found in the number of sites with the presence of reeds between counties with and without otters (χ^2=0.11, d.f.=1, N.S.).

Discussion

The use of spraints as a method to assess habitat utilisation of otters have been discussed previously by Jefferies (1986), Kruuk *et al.* (1986), Conroy & French (1987), Kruuk & Conroy (1987) and Mason & Macdonald (1987a). In the present study, spraints are used as an indicator of otter presence in the surveyed stretch, and not as a preference for special kinds of trees, as used by Macdonald & Mason (1983a) and opposed by Kruuk *et al.* (1986). This decision is based on the fact that the different habitat quality factors were features of the whole surveyed stretch and that the dependent variable was otter presence in the stretch not preferences exhibited within a stretch.

Productivity and fish biomass

The model did not include data on fish density and availability of prey, but the identified seven composite habitat variables predicting the occurence of otters in Denmark, are all directly or indirectly related to productivity typically for the lower parts of a water catchment. These water areas in general, also contain the largest fish density and biomass per unit of water area of the whole water catchment (Erik Mortensen, National Environmental Research Institute, pers. comm.). In Danish saltwater areas, the otter prefers eelpout and eel, whereas the freshwater diet is primarily eel, cyprinids, percids and frogs (Hansen & Jacobsen 1992). These fish species are dominating in the lower parts of a water catchment. Otherwise, the upper reaches of a water catchment are not ignored by otters; Madsen (VI) describe examples of "short cuts" over water catchments through small upper streams. Based on data on fish availability, Prenda & Granado-Lorencio (1996) also find that fish biomass in Spain was greater downstream.

Kruuk *et al.* (1993) demonstrated, that the use of streams by otters was closely correlated with their width, otters spent more time per length of river the wider it was. However, in terms of utilization of area of water the picture was different: otters spent considerably more time per area of water in narrow streams than in the wider ones, in an inverse linear relationship, and this could be explained by differences in fish biomass per unit of water area.

Olsson & Sandegren (1991) argue that, in Sweden, eutrophic waters are proving essential to otter survival because inputs of pollutants are more greatly diluted in the increased biomass than they are in oligotrophic waters. Even if eutrophication could be beneficial to otters, severe organic pollution can kill the fish communities in rivers, so depriving otters of a food supply. Gross pollution and a coincident absence of otters, has been described from Italy, Algeria, coastal Israel (Macdonald & Mason 1983b, Macdonald *et al.* 1985, 1986), France (Bouchardy 1986) and Bulgaria (Spiridonov & Spassov 1989) and is probably widespread.

Habitat structure and composition

Higher levels of otter activity (as assessed by numbers of signs) have been found on rivers with well vegetated banks compared with bare, "improved" banks in Wales (Jenkins 1982, Mason & Macdonald 1986), Scotland (Jenkins & Burrows 1980, Bas *et al.* 1984) and Ireland (Lunnon & Reynolds 1991). In Spain the presence of otters appears correlated positively with bankside coverture and natural vegetation in the surroundings and negatively with pollution, level of disturbance, changes on the riverbank and cultivation (Adrian *et al.* 1985).

Prauser (1985) working on the River Wümme in Germany found, by cluster analysis of habitat variables, that otter activity was correlated with bankside habitat and the presence of boggy and marshy areas by the river. Green *et al.* (1984) while radio-tracking animals in Scotland found many resting sites above ground associated with *Salix* scrub, *Rhododendron* and *Polygonum cuspidatum*.

The present study is widely in contrast to these authors, as otters in Denmark are found on strectches with a significantly smaller number of trees and at that the presence of bushes and human disturbances do not have a significant influence on the presence of otters. These results agree to a great extent with Durbin (1993), who analyzed in detail, also by radio-tracking, the relationship between otter use of streams, bank vegetation and stream characteristics, in the river Don and tributaries, Scotland, in areas of mixed agriculture and woodlands. Durbin concluded, that the distribution of trees along banks did not affect habitat use by otters. The only preference noted was for fishing on sections with riffles and boulder substrates. This preference may be related to the fact that the Scottish streams studied were inhabited mostly by salmonid fish in contrast to the preferred parts of Danish water catchments, dominated primarily by eel, cyprinids and percids.

Mason & Macdonald (1987b, 1989) suggest that acidification, resulting in the reduction or elimination of fish populations, also reduce the carrying capacity for the otter. This result is in accordance with the present study with highly significant correlations between otter presence and increasing pH. Mason & Macdonald (1989) state that such reduced otter populations then being potentially more vulnerable to other environmental stresses.

Human disturbance

In Denmark and other European countries a negative relationship is found between the percentage of positive otter sites and human population density (Mason & Macdonald 1986 p. 82). To date, only Jefferies (1987) have reviewed the otters direct reaction to human disturbance. Jefferies concluded, that generally, the otter is indeed very shy in that it takes great care to remain unobserved by humans and the females appear to be less tolerant of disturbance than the males. Females with cubs are not tolerant of disturbance at all.

However, the present study suggests, that the presence of human disturbance did not have a significant influence on the presence of otters on the surveyed stretch. An explanation for this condition could be a difference in circadian rhytm, in general otters are nocturnal and humans are diurnal.

Angling and canoeing is the most important recreational activity occuring along Danish water catchments, as measured by the number of people using that habitat. With the conclusion of Jefferies (1987) in mind, it is extremely important that sufficient quiet and secure places are required to be protected to enable the otter to rear cubs in seclusion through the whole year. Water catchments containing lakes, moors and fiord areas are preferred. Many of these areas are away from main rivers and so overgrown as to be unlikely to be used recreationally by e.g. anglers.

Although seven variables, indicating habitat structure and composition, used in the model may be suitable for identifying otter habitats, potential users should critically evaluate the reasonableness of each variable, in relation to their local environment. Of course a huge number of e.g. anglers or boats on a river stretch and simultaneously intensive removing of riparian vegetation will affect the otters in a negative direction.

The effects of human disturbance vary in inverse relation to the level of security offered by the habitat. With readily accessible safe shelter otters will tolerate significant levels of disturbance and can be found living in urban areas (Macdonald & Mason 1994).

Indicator of habitat quality

Wolters (1994) and Lunnon & Reynolds (1991) argue, that the otter is at the peak of the food pyramid of wetland ecosystems and its presence may be taken as a good indicator of water and habitat quality. The present study and results on total-PCB found in otters from Spain and the Shetland Islands (Smit *et al.* 1994) state that using the otter as an indicator for the quality of water and habitat should be undertaken with care. The conclusion of Lunnon & Reynolds (1991) could be a misdefinition of pollution types, apparently estimated in the field, and a confusion between industrial and organic pollution.

In spite of the significant differences in variables selected by the stepwise logistic regression between counties with otters and counties without otters, it should not be assumed that the expansion of the otter distribution, to these areas, has been precluded. On the other hand the carrying capacity of the otter population in these areas will be unlikely to reach the levels found in the middle and northwestern part of Jutland, Denmark.

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