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# On the reproduction biology of otters (*Lutra lutra*) from Denmark

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## Abstract

The reproduction in Danish otters was inferred from examination of reproductive organs from 242 carcasses collected between 1982 and 1996. Estimated months of birth of collected cubs and evidence of breeding, determined in female reproductive organs, showed distinct seasonal patterns. 82 % of the cubs were born during summer and autumn months from June to November, although litters were born throughout the year. Mean litter size at birth was 1.7 ± 0.9 cubs per litter. Adult male otters showed continuous mating preparedness. No seasonal variation in paired testes weight for adult males was determined and males with high density of spermatozoa in testes smears occurred throughout the year. Adult males with spermatozoa present had a significantly higher body condition index compared to males without spermatozoa. As the imminent factor determining the breeding chronology, fish densities peaked in autumn, coinciding with maximum energetic demands on reproductive active females during the lactation period.

Key words: *Lutra lutra*, breeding pattern, reproduction, Denmark

## Introduction

Otters (*Lutra lutra*) living in different areas and habitats show large variation in the breeding pattern varying from an even distribution of births throughout the year (Stephens 1957; Sidorovich and Tumanov 1994) to a strictly seasonal occurrence (Erlinge 1967; Kruuk et al. 1987). In several populations, births have been reported throughout the year with a seasonal peak (Stubbe 1969; Wijngaarden and Peppel 1970). Temporal and spatial fluctuations in the availability of food resources determine birth patterns, timing the period of highest energetic requirements of reproductive females at peak lactation with maximum fish densities (Kruuk et al. 1987; Oftedal and Gittleman 1989; Heggberget and Christensen 1994).

Most studies focus on reproductive activities and status of females and cub recruitment (e. g. Sidorovich 1991; Beja 1996; Ansorge et al. 1997). Only short notes on male mating preparedness have been published (Heggeberget and Christensen 1994; Sidorovich and Tumanov 1994). Further knowledge, on male reproductive capacity and mating preparedness in seasonally and non-seasonally breeding populations, is important for conservation and management of otters.

In Denmark, otters are known to breed throughout the year (Jensen 1964), however, no detailed information on seasonal distribution of births and reproductive phases has been presented. The aim of this study is to investigate the breeding pattern in Danish otters.

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## Material and methods

Otter carcasses were collected between 1982 and 1996 in northern Jutland representing the main distribution area of the Danish otter population. Specimens originated from inland freshwater habitats and marine habitats with brackish waters. The majority of otters were killed in traffic. Mortality rates and the probability of finding otter carcasses were assumed to be the same throughout the year. Collection of adult otters was randomly distributed through seasons (n = 113, $\chi^2 = 5.7$, n. s.). Juveniles and subadults were collected primarily during autumn (n = 129, $\chi^2 = 44.3$, $P < 0.01$). Carcasses were subjected to a detailed necropsy and examination of health condition (Madsen 1996). Specimens were aged as juveniles (younger than 5 months), subadults and adults (older than 18 months) on skeletal criteria (Mason and Madsen 1993). Body condition index (CI) for the otters was calculated as the relation between body weight and total length according to Kruuk et al. (1987).

Age of juveniles was assessed from body weight (Stephens 1957), after calculating body weight from total length at normal body condition index (Kruuk et al. 1987). To establish female reproductive status length and diameter of uteri were measured and ovaries and uteri examined macroscopically of presence of corpora lutea, embryos, and placental scars (Heggberget 1988). Uterus horns were flushed with 2 ml water to collect blastocysts. The birth time of litter born by females was assessed from the colour of placental scars and appearance of the uterine tissue. Initially after birth implantation sites have dark pigmentation, while in the final stages implantation sites gradually become orange and white (Heggberget and Christensen 1994). Based on examination of a female killed with a cub at about 3 months of age, dark placental scars are estimated to persist for at least 3 months. Male reproductive capacity was assessed by paired testes weight including epididymes, and microscopic examination for presence of spermatozoa in testes smear (Madsen and Rasmussen 1985). Relative occurrence of spermatozoa in smear was valued as: none, low or high density. Determination of all parameters in all specimens was not possible.

Seasonal densities of fish were determined by electrofishing at 5 freshwater localities (Taastrøm and Jacobsen 1999).

## Results

### Juveniles

Seasonal distribution of estimated time of birth for the collected cubs is shown in figure 1. The seasonal distribution of births was significantly different from an even distribution (n = 22, $\chi^2 = 48.8$, $P < 0.001$); 82 % of the cubs were born in summer and autumn

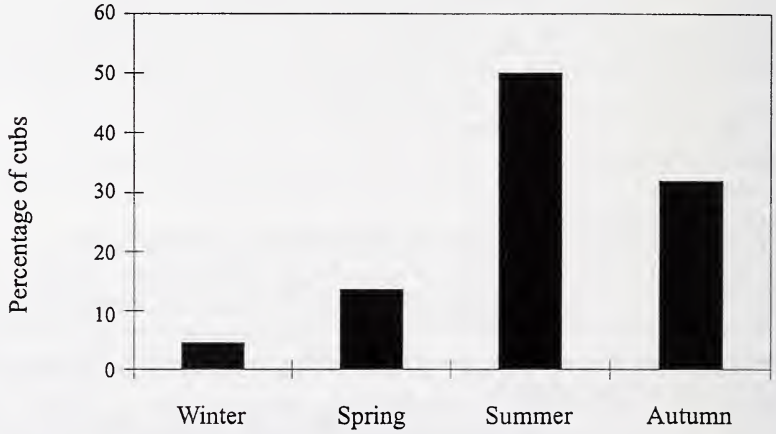


**Fig. 1.** Seasonal distribution of births for received Danish otter cubs (n = 22). Ages were assessed from body weight (Stephens 1957; Kruuk et al. 1987). Winter: December–February; Spring: March–May; Summer: June–August; Autumn: September–November.

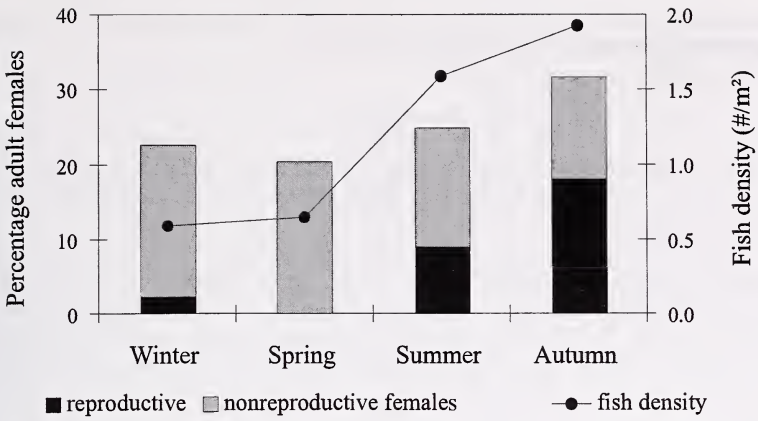


**Fig. 2.** Seasonal percentage of adult females with dark placental scars and fish densities in Danish freshwater habitats (Taastrøm and Jacobsen 1999). Percentages of reproductive females were calculated from numbers of all adult females collected each season (Winter, n = 10; Spring, n = 9; Summer, n = 11; Autumn, n = 14).

months from June to November. Highest frequency of births was seen in the three-month period of July, August, and September: 59 % in total. Siblings were counted as one.

## Females

Distribution of reproductive females with dark placental scars varied seasonally (n = 13, $\chi^2 = 73.3$, $P < 0.001$) peaking in autumn and winter (Fig. 2). In all females with placental scars, uterus had regressed to normal size (Heggberget 1988). Assuming parturition some two months earlier, these litters were born during the summer and autumn months corresponding with the main birth months of the cubs. Seasonal occurrence of reproductive females exhibited a good correlation with seasonal fish densities in different freshwater habitats in Denmark (Fig. 2) (Taastrøm and Jacobsen 1999).

Additional indications of reproductive activities determined from adult females correspond with estimated births in summer and autumn; a female killed in March had neck wounds and spermatozoa in her reproductive tract, and one pregnant female with small embryos was collected in April, and a female killed in January had old faded placental scars.

Three females had placental scars of different colours possibly indicating abortion or resorption of embryos. Overall, indications of breeding were found in 34 % of all adults. Based on numbers of embryos and newest placental scars, the average litter size was $1.7 \pm 0.9$, range 1 – 4 (n = 15). Including all placental scars the estimated litter size was $2.2 \pm 1.2$, range 1–4 (n = 15). Counts of corpora lutea resulted in litter sizes of $2.7 \pm 1.7$, range 1–5 (n = 7). No blastocysts were recovered. Seasonal variation of the body condition index of all adult females was not significant (n = 45, F = 1.01, P = 0.40) and no differences in body condition indices between reproductively active and nonreproductive females were established (n = 45, t = 0.405, P = 0.69).

All females classified as adults had mature reproductive organs. Alterations of reproductive organs were observed in four adult females. One female had severely convoluted uterine horns. One female had fibrous but normal sized uterus with two cysts on the uterus and an occlusion in the uterine body. Two females had small uterine cysts. No placcutal scars, embryos or corpora lutea were recorded in these four females. Immature females had thin and translucent uterine tissue. Some females aged as subadults showed

maturing uteri and had large follicles in ovaries. They were collected at all seasons, but most frequently in spring (n = 16, $\chi^2 = 41.4$, $P < 0.01$ ).

## Males

Paired testes weights of adult, subadult, and juvenile males differed significantly (Tab. 1). Within age classes specimens with different densities of spermatozoa showed different paired testes weights.

Adult males with spermatozoa in low and high densities were found throughout the year. Seasonal variation in paired testes weight for all adults was not found (n = 56, F = 0.31, P = 0.81) (Fig. 3), nor was any trend apparent for males with spermatozoa present (n = 48, F = 0.09, P = 0.97). No seasonal variation in body condition index occurred (n = 55, F = 0.51, P = 0.68). Paired testes weight and body condition index of adult males

**Table 1**. Paired testes weights for different age classes of male otters ($^aP < 0.001$ ). Paired testes weights for testes with different densities of spermatozoa within an age class($^bP < 0.001$ and $^cP < 0.01$).

| Age class | n | Mean ± SD (g) | Range (g) |
|---|---|---|---|
| Adults | 59 | $10.8 \pm 3.4^a$ | 3.8 – 17.4 |
| high | 31 | $12.7 \pm 2.8^b$ | 6.4 – 17.4 |
| low | 15 | $9.3 \pm 2.2^b$ | 4.8 – 13.0 |
| non | 8 | $7.1 \pm 2.9^b$ | 3.8 – 12.2 |
| Subadults | 47 | $5.5 \pm 3.2^a$ | 0.9 – 12.4 |
| high | 8 | $9.8 \pm 1.2^b$ | 8.1 – 12.4 |
| low | 17 | $6.1 \pm 2.6^{b,c}$ | 2.0 – 11.2 |
| non | 22 | $3.7 \pm 2.5^c$ | 0.9 – 9.8 |
| Juveniles | 10 | $0.9 \pm 0.5^a$ | 0.1 – 1.6 |

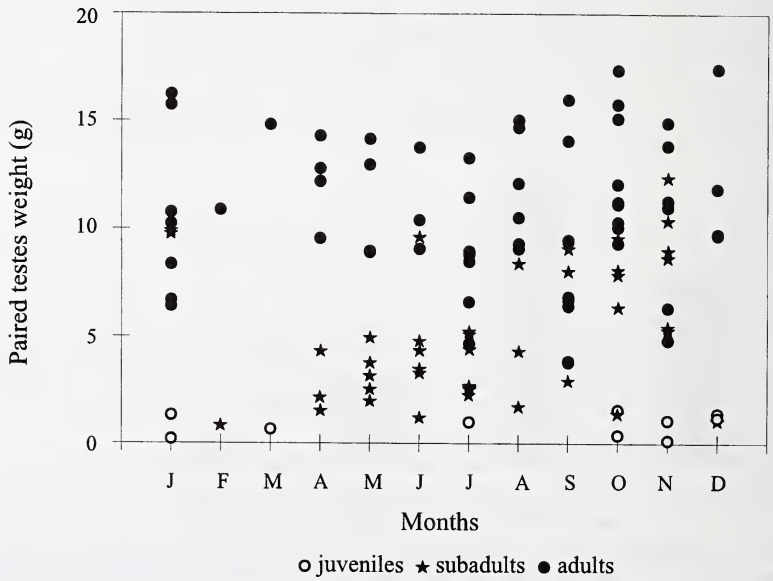


**Fig. 3.** Monthly variations of paired testes weights among Danish male otters (n = 115).

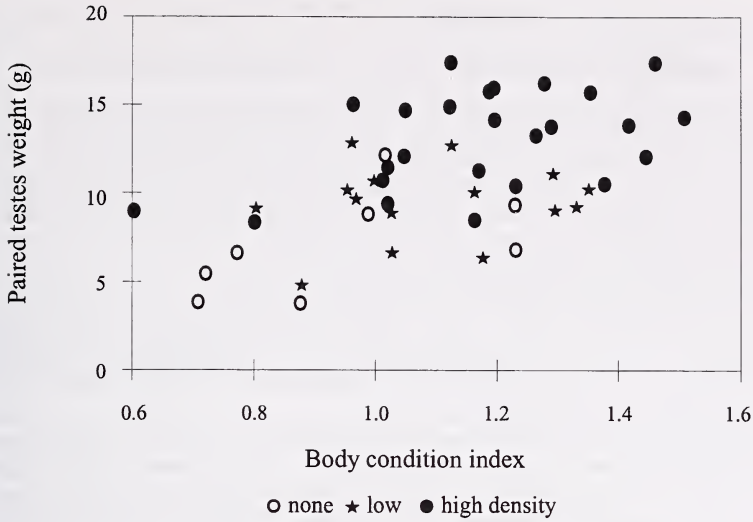


**Fig. 4.** Paired testes weight and body condition indices for adult Danish male otters (n = 48). Densities of spermatozoa are indicated as none, low, and high. Body condition index is in accordance with Kruuk et al. (1987)

were significantly correlated (n = 48, t = 3.38, P < 0.001) (Fig. 4). Adult males with spermatozoa present showed higher body condition indices than males without spermatozoa (n = 48, F = 18.8, P < 0.001).

For subadults with immature testes and no spermatozoa present, no differences between seasonal testes weights were established (n = 22, F = 0.22, P = 0.88). Paired testes weight for subadults with spermatozoa present varied throughout the seasons, peaking during winter (n = 23, F = 5.68, P < 0.01). Subadult males with high density of spermatozoa in the testes (n = 8) were found only among specimens collected in autumn and winter. The findings of subadults with high densities of spermatozoa indicate that maturation may occur at an age of 18 months.

No seasonal variation in body condition index (n = 53, F = 0.77, P = 0.68) was established among subadults. Despite different stages of sexual maturity in this age group, paired testes weight and body condition were significantly correlated (n = 42, t = 2.84, P < 0.01) and subadults with spermatozoa present had significantly higher body condition indices (n = 42, F = 7.24, P < 0.05).

## Discussion

Reproductive phases of females and cub recruitment have been examined in other populations. Litter sizes in Germany based on counts of corpora lutea reached 2.8. Based on embryos and placental scars they were 2.7 and 2.1 based on observed cubs per litter (Ansorge et al. 1997). In a Belarussian population, litter size was 2.7 at corpora lutea phase, 2.6 cubs less than one month of age and 2.4 cubs following females (Sidorovich 1991). Similar numbers of corpora lutea were counted in Danish otters, but the implantation frequency was lower and loss of embryos during gestation higher (20 %). An equivalent frequency of resorption or abortion of implanted embryos has been reported in Norwegian otters (Heggberget and Christensen 1994). Litter sizes estimated from numbers of embryos and placental scars in females represent maximum litter size at birth (Strand et al.

1995). Postnatal mortality rates between 12 % and 24 % further reduces litter sizes (Sidorovich 1991; Heggberget and Christensen 1994; Ansorge et al. 1997). Danish otters produce smaller litters compared to litter size estimated from observations of family groups in marine habitats (Kruuk et al. 1987; Heggberget and Christensen 1994; Beja 1996), and noticeable smaller litters than generally reported from freshwater habitats (Wijngaarden and Peppel 1970; Mason and Macdonald 1986; Beja 1996; Ansorge et al. 1997). Relatively low recruitment due to small litters in the Danish otter population is compensated by a higher proportion of reproductive active females (34 %), compared to 23 % of adult females in the stable high density freshwater population in the eastern part of Germany (Ansorge et al. 1997).

Otters living in adjacent freshwater and marine habitats may have different breeding chronology and litter sizes (Beja 1996). Within an individual otter's home range, however, utilisation of freshwater and marine centres vary depending on food availability (Sjöåsen 1997), and a separation of Danish populations in strictly marine or freshwater living otters would be questionable.

The continuous mating preparedness in adult males is consistent with unseasonal oestrus and ovulation bouts in females (Heggberget and Christensen 1994). Adult males with poor body condition indices and low paired testes weights all suffered from various infectious diseases (Madsen 1996) or were collected during a severe winter. The latter had probably lost conditions rapidly and still had spermatozoa present in testes.

As in this study, a considerable range in paired testes weights with spermatozoa was found in a small number of adult males from Russia and Belarus (Sidorovich and Tumanov 1994). Maturation at 18 months in Danish otters was equivalent to age of maturation observed in Germany (Stubbe 1969). In Russia and Belarus Sidorovich and Tumanov (1994) found immature testes in all 1–2 year old males, and in Norway females matured between 2 and 3 years of age (Heggberget 1988).

Paired testes weight appears to be a sufficient measurement of testicular activities for large samples, but with apparent differences in testes weights between populations and a wide weight range within populations, conclusions on mating preparedness in male otters from testes weights data alone must be interpreted cautiously.

Continuous oestrus cycle and non-seasonal breeding potential in otters may have evolved as a reproductive risk-reducing adaptation to an unpredictable, although seasonally changing environment (Heggberget and Christensen 1994). Additional adaptation to annual fluctuations of the environment include flexible population dynamics with social regulation of recruitment and population density-dependent fecundity of females (Kruuk et al. 1991; Sidorovich 1991). Seasonal variation in body condition of females correlated with food availability and breeding success on the Norwegian coast (Heggberget and Christensen 1994).

Assessed by the invariability of body condition index for Danish otters, food resources appear relatively stable. However, a seasonal birth peak has evolved correlating maximum energetic strain on reproductive females with peaking fish densities in Danish freshwaters.

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## Zusammenfassung

***Über die Fortpflanzungsbiologie von Fischottern (Lutra lutra) in Dänemark***

Die Geschlechtsorgane von 242 Totfunden dänischer Otter aus den Jahren 1982 bis 1996 wurden im Hinblick auf den Reproduktionszustand des jeweiligen Einzeltieres untersucht. Diese Ergebnisse ließen Rückschlüsse auf die Fortpflanzungsbiologie der dänischen Otterpopulation im Vergleich zu den aus der Literatur bekannten Mustern von Otterpopulationen anderer Länder zu.

Der Nachweis erfolgter Geburten anhand von makroskopischen Untersuchungen weiblicher Geschlechtsorgane wies deutlich saisonale Unterschiede auf. Schätzungen des Geburtsmonats tot aufgefundener Jungtiere konnten diese Saisonalität noch untermauern: 82 % der Jungtiere wurden in den Sommer- und Herbstmonaten zwischen Juni und November geboren, wobei grundsätzlich Geburten zu allen Jahreszeiten nachgewiesen werden konnten. Die durchschnittliche Jungtieranzahl betrug 1,7 ± 0,9 zum Zeitpunkt der Geburt.

Adulte männliche Otter scheinen im Allgemeinen das ganze Jahr über paarungsbereit zu sein. Zwar wurden Schwankungen der Spermiendichte im Hodensekret adulter Männchen festgestellt, diese konnten jedoch ebensowenig wie die ermittelten Hodengewichte saisonalen Mustern zugeordnet werden. Dagegen bestand eine signifikante Korrelation zwischen dem Hodengewicht und dem Konditionsindex, wobei adulte Männchen mit im Hodensekret enthaltenen Spermien höhere Konditionsindizes aufwiesen. Saisonale Variationen der Konditionsindizes aller Otter für verschiedene Altersgruppen, Männchen oder Weibchen, konnten nicht beobachtet werden.

Beziehungen zwischen der Hauptphase der Jungtieraufzucht und der Fischdichte der dänischen Gewässer waren auffällig. Letztere erreicht ihren Höhepunkt im Herbst, die Zeit des maximalen energetischen Bedarfs laktierender Otterweibchen. Somit ist anzunehmen, daß die Fischdichte einen bedeutenden Faktor für die Saisonalität der Reproduktion dänischer Otter darstellt.

## References

Ansorge, H.; Schipke, R.; Zinke, O. (1997): Population structure of otters, *Lutra lutra*. Parameters and model for a Central European region. Z. Säugetierkunde **62**, 143–151.

Beja, P. R. (1996): Seasonal breeding and food resources of otters, *Lutra lutra* (Carnivora, Mustelidae), in south-west Portugal: a comparison between coastal and inland habitats. Mammalia **60**, 27–34.

Erlinge, S. (1967): Home range of the otter *Lutra lutra* L. in southern Sweden. Oikos **18**, 186–209.

Heggberget, T. M. (1988): Reproduction in the female Eurasian otter in central and northern Norway. J. Mammalogy **69**, 164–167.

Heggberget, T. M.; Christensen, H. (1994): Reproductive timing in Eurasian otters on the coast of Norway. Ecography **17**, 339–348.

Jensen, A. (1964): Odderen i Danmark. Danske Vildtundersøgelser **11**, 1–64.

Kruuk, H.; Conroy, J. W. H.; Moorhouse, A. (1987): Seasonal reproduction, mortality and food of otters (*Lutra lutra* L.) in Shetland. Symp. Zool. Soc. Lond. **58**, 263–278.

Kruuk, H.; Conroy, J. W. H.; Moorhouse, A. (1991): Recruitment to a population of otters (*Lutra lutra*) in Shetland, in relation to fish abundance. J. Appl. Ecol. **28**, 95–101.

Madsen, A. B. (1996): Odderens *Lutra lutra* økologi og forvaltning i Danmark Ph. D. thesis. National Environmental Research Institute.

Madsen, A. B.; Rasmussen, A. M. (1985): Reproduction in the Stone Marten *Martes foina* in Denmark. Natura Jutlandica **21**, 145–148.

Mason, C. F.; Macdonald, S. M. (1986): Otters, conservation and ecology. Cambridge: Cambridge Univ. Press.

Mason, C. F.; Madsen, A. B. (1993): Organochlorine pesticide residues and PCBs in Danish otters (*Lutra lutra*). Sci. Total Environ. **133**, 73–81.

Oftedal, O. T.; Gittleman, J. L. (1989): Patterns of energy output during reproduction in carnivore. In: Carnivore Behaviour, Ecology and Evolution. Ed. by J. L. Gittleman. London: Chapman and Hall. Pp. 355–378.

Sidorovich, V. E. (1991): Structure, reproductive status and dynamics of the otter population in Byelorussia. Acta Theriol. **36**, 153–161.

Sidorovich, V. E.; Tumanov, I. L. (1994): Reproduction in otters in Belaruse and north-western Russia. Acta Theriol. **39**, 59–66.

Sjöåsen, T. (1997): Movements and establishment of reintroduced European otters *Lutra lutra*. J. Appl. Ecology **34**, 1070–1080.

Stephens, M. N. (1957): The otter report. London: Universities Federation for Animal Welfare.

Strand, O.; Skogland, T.; Kvam, T. (1995): Placental scars and estimation of litter size: an experimental test in the arctic fox. J. Mammalogy **74**, 1220–1225.

Stubbe, M. (1969): Zur Biologie und zum Schutz des Fischotter *Lutra lutra* (L.). Arch. Naturschutz Landschaftsforsch. **9**, 315–324.

Taastrøm, H.-M., Jacobsen, L. (1999): The diet of otters (*Lutra lutra* L.) in Danish freshwater habitats, compared to prey fish populations. J. Zool. (London) (in press).

Wijngaarden, A. van; Peppel, M. van den (1970): De otter, *Lutra lutra* (L.) in Nederland. Lutra **12**, 3–70.

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