FEMALE SEXUAL MATURITY AND DELAYED IMPLANTATION PERIOD OF THE KURIL SEAL

SHINICHI HAYAMA*†, MASATSUGU SUZUKI*, HIROYUKI UNO** AND TADAYUKI YAMASHITA*

ABSTRACT

Sexual maturity and period of delayed implantation were studied in female kuril seal (*Phoca vitulina stejnegeri*) in Nemuro Peninsula, Hokkaido from 25 September to 1 December in 1982 and from 14 September to 1 December in 1983.

Average ages at the first ovulation and first pregnancy were calculated at 3.7 and 4.6 years respectively using the technique of DeMaster (1978). Furthermore, pregnancy rate in relation to the age was estimated and it was found out that 90.9% of the female Kuril seals at 6 years and older were pregnant.

The period of delayed implantation was estimated by the growth curve of the fetus and the presence of 3 newly implanted embryos, and this indicated that implantation occurred primarily in the late part of September. From this observation, it appears that the period of delayed implantation is approximately around 3 months because mating takes place in June.

INTRODUCTION

The kuril seal (*Phoca vitulina stejnegeri* Allen, 1902) is a synonym of *Phoca kurilensis* Inukai, 1942 (Shaughnessy and Fay, 1977), and is distributed from the Northern Kuril Islands to the Pacific coast of eastern Hokkaido. The population in the Kuril Islands was estimated at less than 2,000–2,500 including those in Shikotan and Habomai Islands (Belkin, 1964), while that in eastern Hokkaido at 200–250 (Niizuma, Naito, Itoo, Wada, Abe, Ohtaishi and Nishiwaki, 1980).

The age at sexual maturity in females is important in the conservation of this species and from the point view of general biology. However, there are no such data on the eastern Hokkaido population of Kuril seals. The purpose of this study is to determine the average ages at the first ovulation and pregnancy, and the period of delayed implantation in the Kuril seal.

* *Department of Veterinary Anatomy, Obihiro University of Agriculture and Veterinary Medicine, Obihiro, Hokkaido, 080 Japan.*

** *Institute of Applied Zoology, Faculty of Agriculture, Hokkaido University, Sapporo, Hokkaido, 060 Japan.*

† *Present address: Laboratory of Wild Animal Medicine, Nippon Veterinary and Zootechnical College, Musashino, Tokyo, 180 Japan.*

Sci. Rep. Whales Res. Inst.,
No. 37, 1986, 173–178

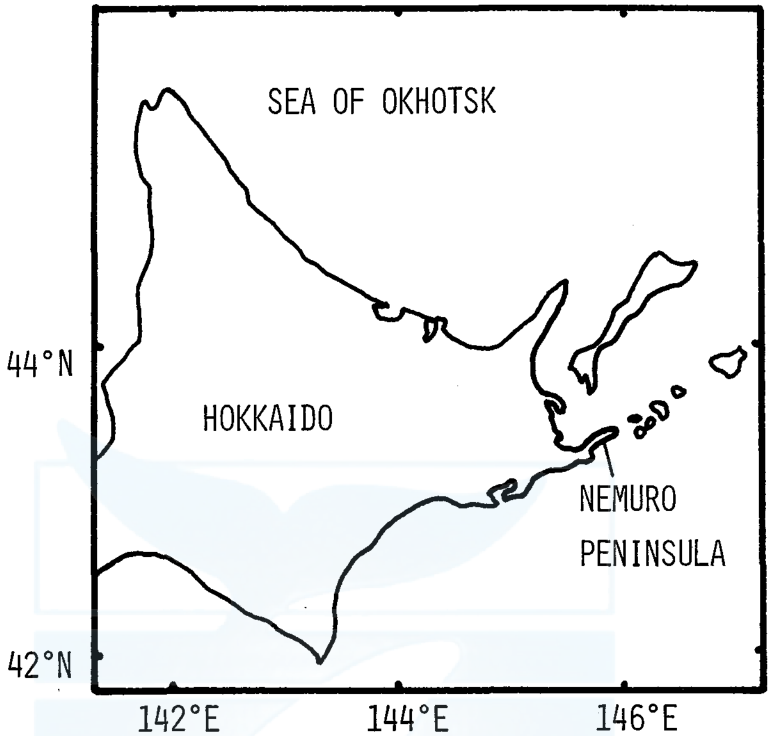

Fig. 1. Sampling was performed in Nemuro Peninsula.

MATERIALS AND METHODS

The field work was conducted at Nemuro Peninsula of eastern Hokkaido from 25 September to 1 December in 1982 and 14 September to 1 December in 1983. A total of 113 female Kuril seals and 29 fetuses used in this study were obtained from those caught accidentally by the salmon trap nets (Fig. 1).

The ovaries were collected and preserved in 10% formalin. Using routine procedures, ovaries were embedded in paraffin, and sections of 10 μm in thickness were taken at every 500 μm interval. These sections were deparaffinized and stained with aldehyde-fuchsin and Masson's trichrome staining method modified by Goldner (1938).

The number and size of corpora lutea and corpora albicantia were recorded. The body length of fetuses was measured from the tip of snout to the end of tail on straight line along the body axis in millimeter. The age was estimated by counting cementum annuli in the canine tooth after being decalcified, and stained with hematoxylin (Mansfield and Fisher, 1960; Bigg, 1969; Naito and Nishiwaki, 1972).

DeMaster (1978) presents a technique to calculate the average age of sexual maturity for marine mammals. The estimate of the average age of sexual maturity in female is as follows:

$$f(x) = t(x)/n(x),$$

where x = age of female, $f(x)$ = estimated probability of ovulating at or before age x, $t(x)$ = number of females in sample of age x who have ovulated, and $n(x)$ = number of females of age x in sample. With this definition of $f(x)$, the estimated probability of first ovulating at age x is,

$$P(x) = f(x) - f(x-1),$$

where $P(x)$ = estimated probability of first ovulation at age x. The average age of sexual maturity is then calculated as,

$$\bar{x} = \sum_{x=0}^{w} (x)\, P(x),$$

where $\bar{x}$ = average age of sexual maturity and w = maximum age in sample.

In addition to estimating the average age of sexual maturity, this procedure can be used to estimate the average age of first pregnancy. However, because the probability of a female being pregnant may never reach unity, there exists a positive probability that at age x a female will reproduce for the first time, even if the difference between the probability of being pregnant for two consecutive age-classes is 0. Therefore, the estimate of the average age at first pregnancy is,

$$z(x) = y(x)/n(x),$$

where $z(x)$ = estimated probability of being pregnant at age x, $y(x)$ = number of females pregnant at age x in sample, and $n(x)$ = number of females in sample. For $x \leqq$ a, where a equals the age at which $z(x)$ reaches its maximum,

$$r(x) = z(x) - z(x-1),$$

where $r(x)$ = estimated probability that a female is first pregnant at age x, and for $x >$ a,

$$r(x) = z(a)\ (1-z(x))^{x-a}$$

The average age at first pregnancy is calculated as before, except that $r(x)$ replaces $P(x)$, and $z(x)$ replaces $f(x)$.

RESULTS AND DISCUSSION

The youngest mature (having experienced ovulation) and the oldest immature appeared at the age of 2 and 4 years respectively (Table 1). Average age at first ovulation was 3.7 years. Average age at the first pregnancy was 4.6 years and the apparent pregnancy rate of females at 6 years or older (n=22) was 90.9%.

In Table 2, the average age at sexual maturity of female harbour seal (*Phoca vitulina richardsi*) was calculated using the data of Bigg (1969, British Columbia), Pitcher (1977, Prince William Sound), and Pitcher and Calkins (1979, the Gulf of Alaska). Due to the limited sample size of the present study, the difference between the two subspecies may not be significant.

The period of delayed implantation in harbour seals was estimated previously as 11 weeks (Fisher, 1954), 2 to 3 months (Harrison, 1960), 2 months (Bigg, 1969), and 11 weeks (Pitcher and Calkins, 1979).

TABLE 1. NUMBER OF OVULATED (NON-PREGNANT) OR PREGNANT FEMALES

Year	1982			1983			Total no. females
Age	No. female samples	Ovulated	Pregnant	No. female samples	Ovulated	Pregnant	
0	14	0	0	23	0	0	37
1	1	0	0	12	0	0	13
2	2	1	0	8	1	1	10
3	9	2	0	10	1	4	19
4	5	1	1	3	1	2	8
5	2	1	1	2	0	2	4
6	4	0	4	0	0	0	4
7	2	0	2	0	0	0	2
8	1	0	1	0	0	0	1
9	1	0	1	0	0	0	1
10	1	1	0	1	0	1	2
10+	3	0	3	9	1	8	12
TOTAL	45	6	13	68	4	18	113

TABLE 2. AVERAGE AGES (YEAR) AT THE FIRST OVULATION AND PREGNANCY OF HARBOUR SEALS COLLECTED IN BRITISH COLUMBIA (BIGG, 1969), PRINCE WILLIAM SOUND (PITCHER, 1977), THE GULF OF ALASKA (PITCHER AND CALKINS, 1979), AND KURIL SEALS IN HOKKAIDO

	Hokkaido	British Columbia	Prince William Sound	Gulf of Alaska
First ovulation	3.7	3.3	3.7	5.0
First pregnancy	4.6	3.3	4.4	5.6

The relationship between fetal length (Y in cm) and the date of catching (X, number of days after the 1st of October) for the present 29 data is expressed by the following least squares regression (Fig. 2).

$$Y = 3.91\ X + 28.04 \qquad r = 0.898$$

This regression cuts the axis of time at -8 (22 September) when implantation seems to occur. Mating takes place in June in this population (Naito and Nishiwaki, 1972), and this was confirmed when 3 mature female kuril seals collected between 24 September and 29 September had newly implanted embryos.

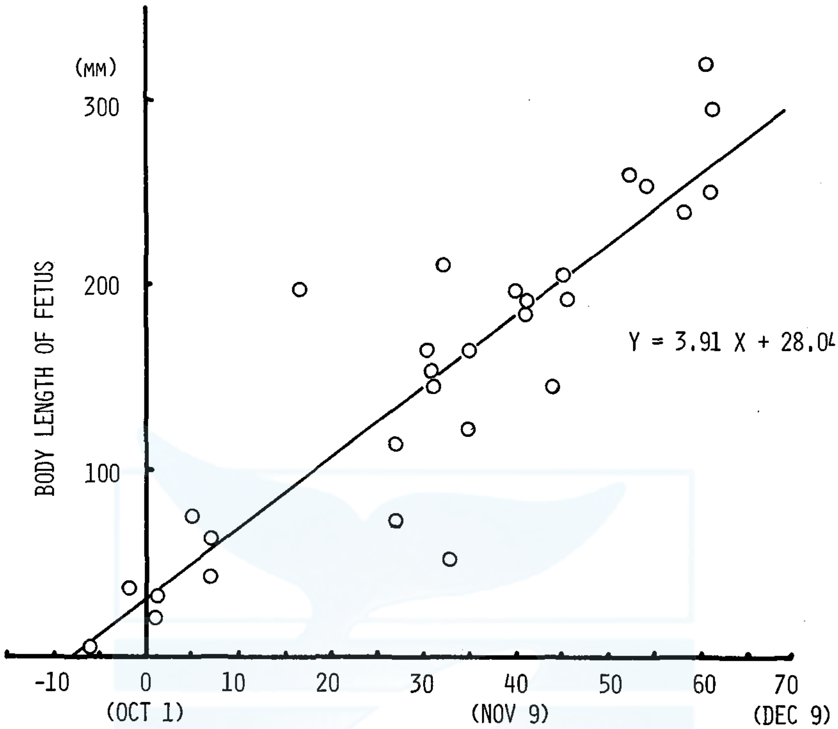

Fig. 2. The growth curve of prenatal Kuril seal.

ACKNOWLEDGEMENTS

Mr J. Shimazu, Shimazu Fur Co., Mr N. Kanazawa Fur Co. and Mr S. Taguchi, Kyouei Fisheries Co. helped us in collecting specimens. Drs J. Yamada and N. Kitamura, Department of Veterinary Anatomy, Obihiro University of Agriculture and Veterinary Medicine, gave us valuable advice. Mr N. Hachiya, Faculty of Department of Dentistry, Hokkaido University, helped us in age determination. Dr A.A. Rayos, Department of Veterinary Obsterics and Gynecology, Obihiro University of Agriculture and Veterinary Medicine, made careful revision to the manuscript. The members of the Marine Mammal Research Group and the Kuril Seal Research Group gave us their help and kind advice. We wish to express our sincere gratitude to all these persons.

This work was primarily supported by Nippon Life Insurance Foundation.

REFERENCES

BELKIN, A. N., 1964. A new species of seals, *Phoca insularis* sp. n. from the Kuril Islands. *Doklady Akad, Nausk SSSR.*, 158(2): 1217–1220 (in Russian).

BIGG, M.A., 1969. The harbour seal in British Columbia. *Bull. Fish. Res. Bd. Can.*, 172: 33.

DEMASTER, D.P., 1978. Calculation of the average age of sexual maturity in marine mammals. *J. Fish. Res. Bd. Can.*, 35: 912–915.

FISHER, H.D., 1954. Delayed implantation in the harbour seal, *Phoca vitulina. Nature, Lond.*, 173: 879–880.

GOLDNER, J., 1938. A modification of the Masson trichrome technique for routine laboratory purpose. *Amer. J. Path. Bd.*, 14: 237–243.

HARRISON, R.J., 1960. Reproduction and reproductive organs in common seals (*Phoca vitulina*) in the Wash. East Anglia. *Mammalia.*, 24: 372–385.

MANSFIELD, A.W. and H.D. FISHER, 1960. Age determination in the harbour seal, *Phoca vitulina. Nature, Lond.*, 186: 192–193.

NAITO, Y. and M. NISHIWAKI, 1972. The growth of two species of the harbour seal in the adjacent water of Hokkaido. *Sci. Rep. Whales Res. Inst.*, 24: 127–144.

NIIZUMA, A., Y. NAITO, T. ITOO, K. WADA, H. ABE, N. OHTAISHI and M. NISHIWAKI, 1980. Number and present status of the Kuril seal, *Phoca kurilensis* Inukai 1942, along the Pacific coast of the eastern Hokkaido. *J. Mammal. Soc. Japan.*, 8(2,3): 97–104.

PITCHER, W.K., 1977. Population productivity and food habits of harbour seals in the Prince William Sound-Copper River Delta area, Alaska. *Final report to U.S. Marine Mammal Commission No. MMC-75103. USDC NITS.* PB-226 935: 36.

PITCHER, W.K. and D.G. CALKINS, 1979. Biology of the harbour seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. *Final report prepared by U.S. Dept. Interior Bureau of Land Management.* 72 pp.

SHAUGHNESSY, P.D. and F.H. FAY, 1977. A review of the taxonomy and nomenclature of North Pacific Harbour seals. *J. Zool., Lond.*, 182: 385–419.