STUDY OF THE REPRODUCTIVE ORGANS OF FEMALE MOOSE IN SWEDEN

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Abstract: Preliminary results of a 3 year study of moose ovaries, uteri and carcass weights are presented. The number of corpora lutea (NCL) was significantly correlated with carcass weight and age, but the correlation was greatest with carcass weight. The youngest animals had fewer corpora lutea than intermediate age cows. The data indicate that cows attain their maximum productivity by 4 years of age. This was evidenced in the age group 4-7 years old cows by having the greatest NCL and the greatest number of follicles (NF) greater than 5 mm in diameter. Cows greater than 7 years of age were less reproductive than cows 4-7 years old. But the small sample size in the older age class prevented a conclusion regarding reduced fertility with advancing age. The average NF in each age class did not correlate exactly with the average NCL. Females 2 years old had a large mean NF but a small mean NCL. Age, size of body and carcass weight had significant effects on ovarian weights. Ovaries from the left side were heaviest and also had the greatest NCL. Ovaries from the right side had the greatest NF however. Animals from the most northern locality were the heaviest (P < 0.1).

The recent rapid increase in the moose population in Sweden (Wilhelmson et al. 1979) has stimulated interest in population studies with moose. Computer simulations studies are being conducted (e.g. Sylvén et al. 1979) in order to gain a better understanding of moose population dynamics. A knowledge of the reproductive potential and of the influence of various environmental factors on fertility is a fundamental requirement for understanding population dynamics (Cheatum 1949). Therefore, a study of the reproductive potential of female moose in Sweden was initiated in 1978. The project was planned and is being conducted in cooperation with Korsnäs-Marma AB, one of the largest logging companies in Sweden. The first year of the study was a pilot project. This paper is a preliminary report and presents data primarily from 1979. A final report presenting the collated results from a three year study will be prepared in 1981.

MATERIALS AND METHODS

The method of evaluating reproductive activity was similar to that of Cheatum (1949), Markgren (1969) and Rajakoski and Koivisto (1966). The number of corpora lutea (NCL) and the number of follicles (NF) greater than 5 mm in diameter in each ovary were our measurements of reproductive activity. Carcass ovarian and uterine weights were also measured. Age classes of animals were determined by counting cemental annuli in the first molar (Wolfe 1969).

Moose were harvested between October 15 and December 14 in 1979 in four different localities in central Sweden (fig.1). The habitat types in the four areas were as follows: 1, taiga; 2, a mixture of taiga and arable land; 3, taiga; 4, mountain taiga. The moose carcasses were processed in four slaughterhouses, one in each area. The number of animals in each age and location class is presented in table 1 for each dependent variable.

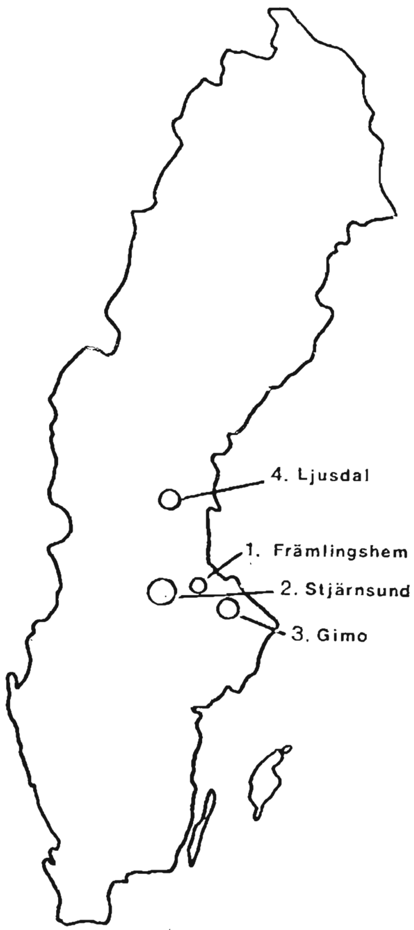

Figure 1. Approximate locations of areas in Sweden from which moose were harvested for ovarian study.

Table 1. Sample sizes within different age and location classes for measurements taken from moose carcasses.

	Weight of carcass					Weight of uterus				
	Locality					Locality				
Age	1	2	3	4	Total	1	2	3	4	Total
1	15	11	15	5	46	10	5	15	5	35
2	4	7	2	3	16	3	5	1	2	11
3	3	2	3	4	12	2		3	4	9
4-7	8	13	3	3	27	5	7	3	3	18
≥8	2	2	1	2	7			1	1	2
Total	32	35	24	17	108	20	17	23	15	75

	NCL and NF per animal					NCL and NF per ovary and ovarian weight				
	Locality					Locality				
Age	1	2	3	4	Total	1	2	3	4	Total
1	11	7	15	5	38	22	14	30	10	76
2	4	5	2	3	14	8	10	4	6	28
3	2		3	4	9	4		6	8	18
4-7	8	10	3	3	24	16	14	6	6	42
≥8			1	2	3			2	4	6
Total	25	22	24	17	88	50	38	48	34	170

Ovaries collected from area 2 and those collected in December from all areas were preserved by freezing. These ovaries were thawed, cut with a scalpel into 2 or 3 slices and examined visually to count the NCL and NF. All other ovaries were fixed in 10% formalin and sectioned into slices about 1.5 mm thick using a razor blade mounted 1.5 mm above a plexiglass base (Hawley et al., in preparation).

The data were analyzed by least squares regression and analysis of variance (Barr et al. 1976; Harvey 1960; Helwig 1977). Individual animals were considered to be the random observational unit. When analysing the measurements made on both ovaries of individual animals, the analyses had a nested design.

Uterine weight could be affected by body weight and the length of time after conception. Since data collection commenced during the latter part of the breeding period of moose (Markgren 1969) the day of collection represented the length of time into the breeding cycle. Therefore, carcass weight (as an estimate of body weight) and day of collection (as an estimate of time after conception) were included in the model for uterine weight. The day of collection was counted starting with October 15 as day 1. The regression of carcass weight on age and locality included data from moose harvested in 1978 during 6 - 8 weeks commencing about October 15. Transforming all data to $\sqrt{x + 1}$ in order to more closely approximate normal distributions (Snedecor and Cochron 1967) did not alter the results of the analyses. Therefore, all data presented in this report are non-transformed.

RESULTS

A greater proportion of the variability in the NCL and the NF was accounted for by regression on carcass weight than on age class (Table 2).

Table 2. The coefficient of determination (r^2) for regressions of various traits on age class and carcass weight.

Trait	Independent variable	
	Age class	Carcass weight
Age class		.36
NCL per animal	.34	.48
NF per animal	.11	.18

Also, the mean carcass weight of yearlings which had ovulated (150 kg) was significantly greater ($P < 0.001$) than that of yearlings which had not ovulated (131 kg). Since carcass weight and age class were correlated (Table 2), only one was included as an independent variable in the regression. Because of the greater correlation of the number of reproductive structures with carcass weight, dependent variables were regressed on this variable. Age class was included as a discontinuous variable in the analyses of variance.

Carcass weight varied significantly with age (Table 3) and was greatest in the 4 - 7 year age class (Table 4). The effect of locality on carcass weight was significant at the 10% level but not at the 5% level. Adjusted mean carcass weight was numerically greater for animals from locality 4 (Table 5).

The weight of the uterus varied significantly with all effects except that of the age class x locality interaction. Uterine weight increased with carcass weight but did not vary regularly with age (Table 4). Cows 4 - 7 years old and those from locality 3 had the largest adjusted mean uterine weights.

The NCL was greatest in cows 4 - 7 years old (Table 4) and this was true for comparisons of either left or right ovaries. The effect of age was only significant for the NCL per animal and not for the NCL per ovary however (Table 3). Ovarian weight varied significantly with age (Tables 3 and 4) and was greater for the left side while the NF was greater for the right side (Table 6). The NCL and NF increased significantly with increasing carcass weight (Tables 3 and 4). The regressions of the NF

Table 3. Summary of the significance of effects in the analyses of variance and regressions.[a]

Trait	Age	Locality	Side of Body	Age x Locality	Animal	Regression on Carcass Weight	Regression on Day of Harvest
Weight of carcass	***	NS		NS			
Weight of	**	*					
uterus (g)	**	*		NS		*	*
NCL[b] per animal	**	NS		NS		***	
NF[b] greater than 5.0 mm per animal	NS	NS		NS		*	
Weight of ovary (g)	***	NS	**	NS	NS	**	
NCL per ovary	NS	NS	NS	NS	NS	**	
NF greater than 5 mm per ovary	NS	NS	*	NS	NS	*	

[a] Blank spaces in columns indicate effects not included in the model.

[b] NCL = number of corpora lutea; NF = number of follicles.

NS, Not significant; *P < 0.05; ** P < 0.01; *** P < 0.001.

Table 4. Adjusted overall means and standard errors ($\mu \pm SE$) and adjusted means of carcass weights, uterine weights, number of corpora lutea (NCL), number of follicles greater than 5 mm (NF) per animal and ovary weights.

		Age				
	$\mu \pm SE$	1	2	3	4-7	≥8
Carcass wt. (kg)	165.4±2.1	142.4	169.1	171.4	173.8	171.6
Uterine wt. (g)	153.5±12.4	99.5	156.4	143.6	216.8	151.2
Ovary wt. (g)	2.74±0.12	1.67	2.25	3.06	3.58	3.14
NCL	0.88±0.08	0.61	0.76	1.09	1.28	0.66
NF	1.60±0.15	1.47	1.80	1.51	1.99	1.22

Table 5. Adjusted mean and standard error ($\mu \pm SE$) and adjusted mean carcass weights for each locality.

		Locality			
	$\mu \pm SE$	1	2	3	4
Carcass wt. (kg)	165.4±2.1	159.8	163.7	164.1	174.0

Table 6. Adjusted overall means and standard errors ($\mu \pm SE$) and adjusted means of ovarian weight, number of corpora lutea (NCL) and number of follicles greater than 5 mm (NF) for ovaries from each side of the body.

		Side	
Item	$\mu \pm SE$	Left	Right
Ovary wt. (g)	2.74 ± 0.12	2.94	2.54
NCL	0.44 ± 0.07	0.52	0.36
NF	0.77 ± 0.11	0.59	0.95

per animal and per ovary on carcass weight were similar to those of the NCL per animal and per ovary on carcass weight, respectively. The NF in the ovaries did not parallel the NCL exactly in the younger age classes (Table 4).

DISCUSSION

The NCL per animal and the NF per animal were very similar in their deviations from the means in the two oldest age classes. The reduction in both values in the oldest age class suggests a reduction in reproductive potential with advanced age but the data for the oldest age class are too limited to warrant this conclusion at this time. Among the younger age classes, the NCL and NF per animal had different patterns of variation. In particular, 2 year old cows had greater than the average NF but less than the average NCL (Table 4). This suggests that ovulation and implantation were less than would be expected based on the NF. However, a high proportion of 3 year old cows have calves. The relatively low NCL in our sample of young cows may have been an artifact of the time of sampling. The majority of our samples were collected in October. The peak of the moose breeding season in central Sweden usually occurs in early October and young cows may have a later estrous than older cows (Markgren 1969).

A disparity between NCL and NF per animal was not evident in 1 year old cows. It is possible that in yearlings active follicles may be smaller than the 5 mm criterion used in this study.

The data indicate that cows attain their maximum productivity by 4 years of age. This agrees with the observations of Yazan (1964). Markgren (1969) was of the opinion that the most fertile age span was from 6 - 11 years.

However, the data of Stålfelt (1974) indicate that female moose attain a high level of productivity as young as 2 - 3 years of age.

The significant effect of locality on uterus weight may be attributable to the occurrence of a few extremely large uteri in pregnant moose from locality 3. Other dependent variables were not significantly affected by locality, suggesting that there were no reproductive differences among moose from the four localities. It is possible, however, that this absence of significance was due to too small a sample size in each area.

The area which yielded moose with numerically the greatest mean carcass weight (locality 4) was farther north than the other areas. The data of Stålfelt (1974) also indicate that the body weight of moose in Sweden increases with increasing latitude. Within the research area, carcass weight was a good measurement of reproductive condition. This agrees with the observations of Markgren (1969) and Yazan (1964).

The data collected thus far indicate that the left ovary of moose is reproductively more active than the right. The greater mean weight of ovaries on the left side could be attributed to the predominance of corpora lutea in ovaries on the left side. In cattle, the right ovary is heavier than the left. This is not necessarily due to a predominance of corpora lutea in the right ovary since the right ovary of non-pregnant heifers has a greater weight and a greater NF 1 mm in diameter than does the left (Rajakoski 1960). Our results agree with those of Rajakoski (1960) in that there were on average more follicles in the right ovary. The inverse relationship between the mean NCL per ovary on one side and the mean NF on the same side in our study suggests that follicles regressed in the ovary with the corpus luteum. The growth of the corpus luteum may have physically compacted large follicles in the same ovary. This could have excluded some follicles from the count. The absence of significance of the effect of most variables on NCL and NF per ovary was attributed to the loss of residual degrees of freedom when the data were segregated as to the side of the body because of the nested design.

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