FIRE - CARIBOU RELATIONSHIPS: (II) FECUNDITY AND PHYSICAL CONDITION OF THE BEVERLY HERD

DON. C. THOMAS
H.P.L. KILIAAN

Technical Report Series No. 310
Prairie & Northern Region 1998
Canadian Wildlife Service

This series may be cited as:

Thomas, D.C. and H.P.L. Kiliaan. 1998. Fire-caribou relationships: (II) Fecundity and physical condition of the Beverly herd. Tech. Rep. Series No. 310. Can. Wildl. Serv., Prairie & Northern Reg., Edmonton, Alberta. 96pp.

Issued under the authority of the
Minister of Environment
Canadian Wildlife Service

Catalogue No. CW69-5/310E
ISBN 0-662-26500-9
ISSN 0831-6481

Copies may be obtained from:
Canadian Wildlife Service
Prairie & Northern Region
4999-98 Avenue, # 200
Edmonton, Alberta
T6B 2X3

REPORTS IN THIS SERIES

1. Thomas, D.C. and H.P.L. Kiliaan. 1998a. Fire-caribou relationships: (I) Physical characteristics of the Beverly herd, 1980-87. Tech. Rep. Series No. 309. Can. Wildl. Serv., Prairie & Northern Reg., Edmonton, Alberta. 178pp.

2. Thomas, D.C. and H.P.L. Kiliaan. 1998b. Fire-caribou relationships: (II) Fecundity and physical condition of the Beverly herd. Tech. Rep. Series No. 310. Can. Wildl. Serv., Prairie & Northern Reg., Edmonton, Alberta. 96pp.

3. Thomas, D.C., H.P.L. Kiliaan, and T.W.P. Trottier. 1998. Fire-caribou relationships: (III) Movement patterns of the Beverly herd in relation to burns and snow. Tech. Rep. Series No. 311. Can. Wildl. Serv., Prairie & Northern Reg., Edmonton, Alberta. 176pp.

4. Thomas, D.C. and H.P.L. Kiliaan. 1998c. Fire-caribou relationships: (IV) Recovery of habitat after fire on winter range of the Beverly herd. Tech. Rep. Series No. 312. Can. Wildl. Serv., Prairie & Northern Reg., Edmonton, Alberta. 115pp.

5. Thomas, D.C. 1998a. Fire-caribou relationships: (V) Winter diet of the Beverly herd in northern Canada, 1980-87. Tech. Rep. Series No. 313. Can. Wildl. Serv., Prairie & Northern Reg., Edmonton, Alberta. 41pp.

6. Thomas, D.C. and H.J. Armbruster. 1998. Fire-caribou relationships: (VI) Fire history of winter range of the Beverly herd. Tech. Rep. Series No. 314. Can. Wildl. Serv., Prairie & Northern Reg., Edmonton, Alberta. 94pp.

7. Thomas, D.C. 1998b. Fire-caribou relationships: (VII) Fire management on winter range of the Beverly herd: final conclusions and recommendations. Tech. Rep. Series No. 315. Can. Wildl. Serv., Prairie & Northern Reg., Edmonton, Alberta. 100pp.

8. Thomas, D.C. 1998c. Fire-caribou relationships: (VIII) Background information. Tech. Rep. Series No. 316. Can. Wildl. Serv., Prairie & Northern Reg., Edmonton, Alberta. 104pp.

SUMMARY

This report details reproductive processes in barren-ground caribou *(Rangifer tarandus groenlandicus)* and how they are influenced by variables that reflect physical condition of caribou. Samples were obtained from 856 female caribou in the Beverly herd between March 1980 and 1987.

The pregnancy rate increased from 12% in yearlings (1.5-2 years old) to 91% in females over 11 years old. Fecundity (pregnancy rates) varied considerably in all age classes over the eight winters. In yearlings, it varied from zero to 33%; in females over 4 years old, from 78 to 100%. About 55% of calves were produced by age classes 3 through 6 years. Two of 854 reproductive tracts had developmental problems rendering those females barren, that is, incapable of producing young. One resorption was suspected in 420 pregnancies examined in March. Late conceptions, as assumed from occurrence of fetuses weighing less than 800 grams in mid March, occurred in 4.8% of females, including one estimated to have conceived in January.

The sex ratio of fetuses sampled in March was related to age of mother but not to her fatness. Young females (2-4 years) produced more female fetuses (61 M:100 F), whereas the opposite occurred in old (10+ years) females (207 M:100 F).

There was a strong relationship between fecundity and weight, back fat depth, kidney fat, femur marrow fat, mandibular water content, antler weights, and indices based on two or more of those variables.

Poor relationships were the rule for regressions based on means of condition variables and fecundity in individual samples from December for age classes 2.5-3, 3.5-4, and older than 4 years. The few regression points (five), the sometimes small sample sizes, and atypical results in the December 1982 sample were responsible for poor correlations. Some correlation coefficients as high as 0.96 were obtained for females 2.5 years old in December samples. Significant relationships between fecundity and most condition variables were found in the seven March samples and 12 combined December and March samples for females in age classes 2.5-3, 3.5-4, and older than 4 years. Exceptions were femur marrow fat and mandibular water content, which produced no and few significant fits, respectively. Fecundity was best predicted from combinations of condition variables including back fat depths and kidney fat, or those fat variables plus body weight, and possibly those combinations plus antler weights (not tested). An alternative approach was to compare sample means with curves depicting the relationship between means for condition variables and pregnancy rates of females older than 1 and/or 2 years in December and/or March, as appropriate. Strong relationships were found for all condition variables with this approach. Further statistical treatments of these data will be pursued and published.

RÉSUMÉ

Cette étude porte sur les différents processus de la reproduction chez le caribou de la toundra (*Rangifer tarandus groenlandicus*) et sur l'effet de diverses variables de l'état physiologique sur la reproduction, d'après l'analyse d'échantillons prélevés sur 856 caribous femelles du troupeau de Beverly entre mars 1980 et mars 1987.

Le taux de gravidité variait de 12 % chez les daguets femelles (1,5 à 2 ans) à 91 % chez les femelles âgées de plus de 11 ans. La fécondité (taux de gravidité) variait considérablement dans toutes les classes d'âge au cours des huit hivers qu'a duré cette étude. Elle variait de zéro à 33 % chez les daguets et de 78 à 100 % chez les femelles de plus de 4 ans. Environ 55 % des faons étaient issus des classes d'âge comprises entre 3 et 6 ans. Deux femelles sur 854 présentaient une stérilité consécutive à une malformation des organes reproducteurs. Sur les 420 femelles gravides examinées au mois de mars, une résorption du foetus a été suspectée. D'après le taux de foetus ayant une masse inférieure à 800 g à la mi-mars, 4,8 % des femelles ont présenté une conception tardive; parmi celles-ci, une semble avoir conçu en janvier.

Le rapport des sexes des foetus, déterminé au mois de mars, était relié à l'âge de la mère, mais non à son état physiologique. Les jeunes femelles (2 à 4 ans) ont produit davantage de foetus femelles (61 M : 100 F), alors que l'inverse a été observé pour les femelles âgées (10 ans et plus; 207 M : 100 F).

Une forte corrélation a été observée entre d'une part la fécondité et d'autre part la masse corporelle, l'épaisseur de la graisse dorsale, le taux de graisse rénale, le taux de graisse de la moelle du fémur, la teneur en eau de la mandibule, la masse des bois et les indices combinant plusieurs de ces variables.

Les régressions basées sur les moyennes de ces variables d'état physiologique et

de la fécondité ont permis de conclure à l'absence de corrélation claire entre ces paramètres dans les échantillons individuels prélevés en décembre pour les classes 2,5 à 3 ans, 3,5 à 4 ans et plus de 4 ans. Cette constatation s'explique par le faible nombre des points de régression (cinq), la taille parfois petite des échantillons et les résultats atypiques obtenus avec l'échantillon prélevé en décembre 1982. Des valeurs de r aussi élevées que 0,96 ont été obtenues pour des échantillons prélevés en décembre chez des femelles âgées de 2,5 ans. Par contre, des corrélations significatives entre la fécondité et la plupart des variables d'état physiologique ont été observées pour les 7 échantillons prélevés au mois de mars et pour 12 échantillons combinés prélevés en décembre et mars chez les femelles des classes d'âge 2,5 à 3 ans, 3,5 à 4 ans et plus de 4 ans. Faisaient exception à cette règle le taux de graisse de la moelle du fémur (aucune corrélation) et la teneur en eau de la mandibule (faible corrélation). Le meilleur indice de fécondité semble être une combinaison de variables d'état physiologique telles que l'épaisseur de la graisse dorsale et le taux de graisse rénale, ou ces paramètres combinés à la masse corporelle, et peut-être ces combinaisons combinées à la masse des bois (combinaison non testée). Une autre méthode consisterait à comparer les moyennes des échantillons aux représentations graphiques des relations entre les moyennes des variables d'état physiologique et le taux de gravidité des femelles âgées de 1 an et/ou de 2 ans en décembre et/ou en mars, selon le cas. De fortes corrélations ont été trouvées pour toutes les variables d'état physiologique au moyen de cette approche. Les données présentées dans cette étude feront l'objet d'analyses statistiques plus poussées et de publications ultérieures.

TABLE OF CONTENTS Page

REPORTS IN THIS SERIES i
SUMMARY ii
RÉSUMÉ iv
TABLE OF CONTENTS vi
LIST OF TABLES vii
LIST OF FIGURES ix
LIST OF APPENDICES xiv
ACKNOWLEDGEMENTS xvi
INTRODUCTION 1
METHODS 1
RESULTS 4
Age-specific fecundity 4
Annual variations in fecundity 4
Relative age-specific calf production 7
Reproductive abnormalities 9
Fetal weights 10
Fetal sex ratios 10
Relationships between condition variables and fecundity 13
Body weight (WT) 13
Back fat (BF) 16
Kidney fat (KF) 25
Riney's kidney fat index (KFIR) 31
Femur marrow fat (FEF) 31
Mandibular water (MAW) 40
Condition index "fat percentage" (FATP) 40
Condition index "dissectible fat" (DFAT) 45
Condition index A (CIA) 50
Condition index B (CIB) 54
Antler weights 61
Warble larvae 61
Femur lengths (FEL) 70
DISCUSSION 70
CONCLUSIONS 74
LITERATURE CITED 76
APPENDICES 78

LIST OF TABLES Page

1. Fecundity of age classes of caribou sampled from the Beverly herd from 1979-80 through 1986-87 5

2. Fecundity of female caribou >4 years old in December, March, and all samples obtained from the Beverly herd, 1980-87 7

3. Relative age-specific production of calves in the Beverly herd, 1980 through 1987, based on fecundity and a survival curve 8

4. Statistics of three female caribou with reproductive abnormalities in relation to mean values for normal females in the same sample from the Beverly herd 9

5. Weights of male and female fetuses collected from the Beverly herd of caribou in March, 1980 through 1987 12

6. The sex of fetuses in four maternal age classes of caribou sampled from the Beverly herd in March, 1980 through 1987 12

7. Whole body weights (kg) of pregnant and non-pregnant female caribou sampled from the Beverly herd in December (1982-86) and March (1980-87) 17

8. Whole body weights of pregnant and non-pregnant female caribou of the Beverly herd in pooled samples obtained from 1980 through 1987 17

9. Back fat depths of pregnant and non-pregnant female caribou sampled from the Beverly herd from 1980 through 1987 23

10. Weight of kidney fat in pregnant and non-pregnant female caribou sampled from the Beverly herd in December (1982-86) and March (1980-87) 23

11. Riney's kidney fat index (KFIR) of pregnant and non-pregnant female caribou obtained from the Beverly herd in December 1982-86) and March (1980-87) 33

LIST OF TABLES (continued) Page

12. Percent fat in marrow of femur bones of pregnant and non-pregnant female caribou of the Beverly herd in pooled samples from 1980 through 1987 . . . 37

13. Percent water in mandibular tissue of pregnant and non-pregnant caribou of the Beverly herd in pooled samples from 1982 through 1987 37

14. Condition index "fat percentage" (FATP) in pregnant and non-pregnant female caribou sampled from the Beverly herd in December (1982-86) and March (1982-87) 45

15. Condition index "dissectible fat" (DFAT) in pregnant and non-pregnant female caribou collected from the Beverly herd each December (1982-86) and March (1980-87) 49

16. Condition index A (CIA) of pregnant and non-pregnant caribou sampled in December (1982-86) and March (1980-87) from the Beverly herd 54

17. Condition index B (CIB) of pregnant and non-pregnant caribou sampled from the Beverly herd in December (1982-86) and March (1980-87) 58

18. Antler weights of pregnant and non-pregnant female caribou collected from the Beverly herd, 1982 through 1987 63

19. Mean number of warble larvae under skin of pregnant and non-pregnant female caribou sampled from the Beverly herd in December (1982-86) and March (1980-87) 67

20. Femur lengths of pregnant and non-pregnant female caribou in pooled samples from the Beverly herd, 1982 through 1987 67

21. Age-specific fecundity of the Beverly and Kaminuriak herds of barren-ground caribou 71

LIST OF FIGURES

Page

1. Fecundity of four age classes of caribou sampled from the Beverly herd from 1979-80 through 1986-87 6

2. Distribution of fetal weights of barren-ground caribou sampled from the Beverly herd in March 1980 through 1987 11

3. Relationship between mean body weights and fecundity of females >4 years old in individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87) 14

4. Relationship between mean body weights and fecundity of females 2.5-3 and 3.5-4 years old in individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87) 15

5. Frequency distributions of body weights of pregnant and non-pregnant female caribou >1 year old collected from the Beverly herd from 1980 through 1987 18

6. Relationship between body weight at 5 kg intervals and pregnancy rate of female caribou >1 year old in pooled samples from 1980 through 1987 19

7. Relationship between depth of back fat and fecundity of female caribou >4 years old in individual samples obtained from the Beverly herd each December (1982-86) and March (1982-87) 20

8. Relationship between depth of back fat and fecundity of female caribou 2.5-3 and 3.5-4 years old in individual samples obtained from the Beverly herd each December (1982-86) and March (1982-87) 21

9. Frequency of back fat depths in pregnant and non-pregnant female caribou >1 year old sampled from the Beverly herd from 1980 through 1987 24

LIST OF FIGURES (continued) Page

10. Relationship between depth of back fat at 2-mm intervals and pregnancy rate of caribou in pooled samples from December and March, 1980 through 1987 26

11. Relationship between mean kidney fat weights and fecundity of caribou >4 years old in individual samples from December (1982-86) and March (1980-87) 27

12. Relationship between mean kidney fat weights and fecundity of caribou 2.5-3 and 3.5-4 years old in individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87) 28

13. Frequency of kidney fat weights in pregnant and non-pregnant female caribou >1 year old sampled from the Beverly herd from 1982 through 1987 29

14. Relationship between kidney fat weight at 20-g intervals and pregnancy rate of female caribou older than 1 and 2 years in pooled samples from December and March, 1980 through 1987 30

15. Relationship between the Riney's kidney fat index (KFIR) and fecundity in individual samples obtained from the Beverly herd, 1980-87 32

16. Frequency distributions of Riney's kidney fat index (KFIR) of pregnant and non-pregnant female caribou >1 year old sampled from the Beverly herd in December and March, 1982 through 1987 34

17. Relationship between Riney's kidney fat index and the pregnancy rate of female caribou older than 1 and 2 years in pooled samples from December (1982-86) and March (1982-87) 35

18. Relationship between mean percent fat in femur marrow and fecundity of females >4 years old based on individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87) 36

LIST OF FIGURES (continued) Page

19. Frequency distributions of femur marrow fat in 2% classes in pregnant and non-pregnant female caribou >1 year old sampled from the Beverly herd from 1982 through 1987 38

20. Relationship between percent fat in femur marrow and pregnancy rate of female caribou >1 and >2 years old in pooled samples from winters 1981-82 through 1986-87 39

21. Relationship between mean percent water in mandibular tissue and fecundity of female caribou >4 years old in individual samples obtained in December (1982-86) and March (1982-87) 41

22. Frequency distributions of percent mandibular water (MAW) in pregnant and non-pregnant female caribou >1 year old that were sampled from the Beverly herd, 1982 through 1987 42

23. Relationship between percent mandibular water (MAW) and fecundity of female caribou >1 year old in pooled samples obtained from the Beverly herd, 1982 through 1987 43

24. Relationship between calculated mean fat percentage (FATP) (Huot and Goudreault 1985) values and fecundity of female caribou >4 years old in individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87) 44

25. Frequency distributions of calculated fat percentage (FATP) (Huot and Goudreault 1985) in pregnant and non-pregnant female caribou >1 year old that were collected from the Beverly herd, 1980 through 1987 46

26. Relationship between calculated mean fat percentage (FATP) (Huot and Goudreault 1985) values and fecundity of female caribou >1 year old in pooled samples from December (1982-86) and March (1980-87) 47

LIST OF FIGURES (continued) Page

27. Relationship between calculated mean dissectible fat (DFAT) (Adamczewski et al. 1987) and fecundity of female caribou >4 years old in individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87) 48

28. Frequency distributions for calculated dissectible fat (DFAT, Adamczewski et al. 1987) of pregnant and non-pregnant female caribou >1 year old in samples from the Beverly herd, 1980 through 1987 51

29. Relationship between calculated dissectible fat (DFAT) (Adamczewski et al. 1987) and fecundity of female caribou older than 1 and 2 years in pooled samples from the Beverly herd, 1980 through 1987 52

30. Relationship between condition index A (CIA) and fecundity of female caribou >4 years old in individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87) 53

31. Frequency distributions of condition index A (CIA) in pregnant and non-pregnant female caribou >1 year old in samples from the Beverly herd from 1980 through 1987 55

32. Relationship between condition index A (CIA) and fecundity of female caribou >1 year old in pooled samples from December (1982-86) and March (1980-87) 56

33. Relationship between condition index B (CIB) and fecundity of female caribou >4 years old in individual samples obtained in December (1982-86) and March (1980-87) from the Beverly herd 57

34. Frequency distribution of condition index B (CIB) in pregnant and non-pregnant female caribou >1 year old in pooled samples obtained from the Beverly herd, 1980 through 1987 59

LIST OF FIGURES (continued) Page

35. Relationship between condition index B (CIB) and fecundity of female caribou >1 year old in pooled samples obtained from the Beverly herd in December (1982-86) and March (1980-87) 60

36. Relationship between antler weight and fecundity of female caribou >4 years old in individual samples obtained from the Beverly herd each December 1982-86 and March 1982-87 62

37. Frequency distributions of antler weight of pregnant and non-pregnant female caribou >2 years old that were sampled from the Beverly herd, 1980-87 . . . 64

38. Relationship between antler weight and pregnancy rate of female caribou >1 year old in pooled samples from the Beverly herd, 1982 through 1987 65

39. Relationship between number of warble larvae and fecundity of female caribou >1 year old in individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87) 66

40. Frequency distributions of number of warble larvae under skin of pregnant and non-pregnant female caribou >1 year old that were sampled from the Beverly herd in December and March, 1982-87 68

41. Relationship between number of warble larvae and fecundity of female caribou >1 year old in pooled samples obtained from the Beverly herd in December (1982-86) and March (1982-87) 69

LIST OF APPENDICES

Page

1. Condition variables discussed in this report: descriptions, units, formulae, and sources 78

2. Age-specific fecundity of caribou sampled from the Beverly herd from 1979-80 through 1986-87 (sample sizes in parentheses) 80

3. Weights of male and female caribou fetuses sampled from the Beverly herd in March 1980 through 1987 81

4. Linear regression statistics of sample means for body weight/back fat (*x* axis) and fecundity (*y* axis) of caribou sampled from the Beverly herd, 1980 through 1987 82

5. Weights of pregnant and non-pregnant female caribou in individual samples obtained from the Beverly herd each December (1982-86) and March (1980-87) 83

6. Depths of back fat in pregnant and non-pregnant female caribou sampled from the Beverly herd in December (1982-86) and March (1980-87) 84

7. Back fat depths of pregnant and non-pregnant female caribou obtained in December (1982-86) and March (1980-87) from the Beverly herd 85

8. Linear regression statistics derived from sample means for kidney fat/kidney fat indices (*x* axis) and fecundity (*y* axis) of caribou collected from the Beverly herd, 1980 through 1987 86

9. Kidney fat in pregnant and non-pregnant female caribou sampled from the Beverly herd in December (1982-86) and March (1980-87) 87

10. Kidney fat indices of pregnant and non-pregnant caribou sampled from the Beverly herd in December (1982-86) and March (1980-87) 88

LIST OF APPENDICES (continued) Page

11. Condition index FAT in pregnant and non-pregnant female caribou sampled from the Beverly herd each December (1982-86) and March (1980-87) 89

12. Linear regression statistics derived from sample means for femur marrow fat/mandibular water (*x* axis) and fecundity (*y* axis) of caribou collected from the Beverly herd, 1980 through 1987 90

13. Percent fat in marrow of femur bones of pregnant and non-pregnant caribou sampled from the Beverly herd in December (1982-86) and March (1982-87) 91

14. Linear regression statistics derived from sample means for fat percentage (FATP) (*x* axis) and dissectible fat (DFAT) (*x* axis) and fecundity (*y* axis) of caribou collected from the Beverly herd, 1980 through 1987 92

15. Condition index "CONI" in pregnant and non-pregnant female caribou sampled from the Beverly herd each December (1982-86) and March (1980-87) 93

16. Linear regression statistics derived from sample means for condition index A (CIA) (*x* axis) and condition index B (CIB) (*x* axis) and fecundity (*y* axis) in caribou collected from the Beverly herd, 1980 through 1987 94

17. Linear regression statistics for sample means of antler weights (*x* axis) and warble larvae numbers (*x* axis) and fecundity (*y* axis) in caribou sampled from the Beverly herd, 1980 through 1987 95

18. Number of warble larvae under skin of caribou sampled from the Beverly herd in December (1982-86) and March (1980-87) 96

ACKNOWLEDGEMENTS

A large number of people contributed to this study by assisting in the collection of caribou from 1980 through 1987. At least 19 members of the Fort Smith Hunters and Trappers Association were involved and they are named in a separate report (Thomas and Kiliaan 1998a). Of those, special thanks go to Earl Evans who obtained most of the caribou with minimum damage to the sample parts required for this study. The Fort Smith Hunters and Trappers Association under presidents Jim Schaefer and Ken Hudson provided outstanding support for this work. The Northwest Territories Wildlife Service, Department of Renewable Resources, supported the extra sample of 40 caribou obtained in 1980. They also generously provided laboratory space in Fort Smith and assisted with logistics. Generous financial support was received from Indian and Northern Affairs Canada from 1982 through 1987. Guidelines were received at early stages from Dr. Kaye MacInnes and Rick Lanoville of that organization. The Canadian Wildlife Service (CWS) provided unusually long support for the study. Dr. George Scotter was particularly supportive throughout. Sam Barry provided advice on statistical methods and conducted some of the tests. Susan MacEachran arranged the drafting of the figures. We thank Frank Miller, Doug Heard, Mark Williams, Tim Trottier, Kevin Eberhart, Roger Edwards, and Harry Armbruster for reviewing this report.

INTRODUCTION

Results in this paper are part of a study conducted from 1980 through 1987 on effects of fire on winter range of the Beverly herd of barren-ground caribou. Study objectives, methodology, and data on physical characteristics of 856 female and 402 male caribou collected from March 1980 through March 1987 are presented in Report 1 of this series (Thomas and Kiliaan 1998a). The influence of maternal age and physical condition on fetal sex ratios was published (Thomas et al. 1989).

The purpose of this report is to document age-specific fecundity and calf production and to establish relationships between fecundity and condition variables. If significant relationships exist, it may be possible to estimate fecundity in a particular winter by measuring one or more condition variables in a relatively small sample of caribou, whereas large samples are needed to measure age-specific fecundity. Formulas used to estimate herd size from counts of caribou on the calving grounds include a fecundity variable. Therefore, any techniques that will facilitate estimation of fecundity will improve estimates of population size and, perhaps, caribou management.

Furthermore, the pregnancy rate of individual age classes is a sensitive indicator of environmental conditions including winter range. Summer range conditions, weather, and other factors are also important but severe loss of condition during winter will be reflected in reduced fecundity the next breeding season (Thomas 1982).

METHODS

Sampling techniques and laboratory methodology were detailed in Report 1 (Thomas and Kiliaan 1998a). Reproductive tracts of females sampled in November (1982) and December (1983-86) were frozen and returned to a laboratory for examination. Pregnancy was easily detected in samples collected in December because uteri were distended by fluid and embryos were visible. Their sex could not be ascertained except in a few large specimens. Therefore, only the sex of fetuses obtained in March was used in our analysis.

In the November 25-28 sample of 1982, pregnancy was obvious in some females because of enlarged uteri. Pregnancy was confirmed by the presence of filamentous membranes and early embryonic stages, some detectable by eye and others microscopic. In a few late conceivers, pregnancy was assumed if a corpus luteum was present. Examination was conducted by slicing ovaries fixed in AFA (acetic acid, formalin, and ethyl alcohol) for several days to 2 weeks. Ovaries were sliced transversely to the hilum (almost through) and at about 2 mm intervals. A "book" of slices was produced and corpora lutea were measured in two dimensions.

In this paper we explore relationships between fecundity (reproductive rate or fertility) and the following "condition" variables:

1) Body weight (not adjusted for variable blood loss);
2) Back fat depth (e.g. Dauphiné 1976);
3) Kidney fat (Riney 1955);
4) Kidney fat index (Riney 1955);
5) Kidney fat index (Mitchell et al. 1976);
6) Kidney fat/body weight; (Thomas and Kiliaan 1998a);
7) Kidney fat/femur length; (Thomas and Kiliaan 1998a);
8) Femur marrow fat content (Neiland 1970);
9) Mandibular water (Thomas et al. 1977, Thomas and Broughton 1978);

10) Condition index CONI (Connolly 1981);

11) Fat percentage FATP (Huot and Goudreault 1985);

12) Fat percentage FAT (Huot and Goudreault 1985);

13) Dissectible fat DFAT (Adamczewski et al. 1987);

14) Condition index A (Thomas and Kiliaan 1998a);

15) Condition index B (Thomas and Kiliaan 1998a);

16) Antler weights;

17) Number of warble larvae (Thomas and Kiliaan 1990); and

18) Femur lengths.

Details on formulae and units associated with these variables (**App. 1**), their derivations and statistics are in Thomas and Kiliaan (1998a).

Relationships between fecundity (dependent variable) and condition variables (independent variables) were examined in four ways: (1) relationships between means of condition variables and fecundity in samples from each collection for females older than 4 years (the largest grouping possible for fecundity) and for females 3.5-4 and 2.5-3 years; (2) a statistical comparison of condition variable means for pregnant and non-pregnant females in seven "standard" age classes (1, 2, 3, 4, 5, 6-11, and >11 years) adopted in this study and larger groupings (>2, >3, >4 years etc. as appropriate) wherever possible; (3) examination of frequency distributions of condition variables, at intervals through their ranges, in pregnant and non-pregnant females of breeding age (>1 year); and (4) pregnancy rate of females >1 and >2 years old, as appropriate, at intervals through the range of each condition variable.

Calculation of standard error (SE) was based on standard deviation (SD) values generated by REFLEX database packages, where *SD = sq. root* $[n\sum x^2 - (\sum x)^2]/n^2$. Standard error was calculated as SD/square root n-1. All variables except back fat had near-normal distributions within age classes for each sex. Statistical tests were described in Report 1 of this series.

RESULTS

Age-specific fecundity

Conceptions did not occur in 37 female calves, of which 32 were collected in March. Pregnancy rate in yearlings ranged from 0 to 33% where $n \geq 9$ (**App. 2**). In older females it ranged from 64 to 100% (minimum $n = 9$). A pooling of data for eight winters revealed a large jump in fecundity from 12% in yearlings to 71% in 2.5-3 year-old caribou (**Table 1**). Females with reproductive abnormalities were excluded from the standard age class groupings but were included in larger groupings, e.g., >2 years. They may be representative of a large sample but not the specific age class in which they happen to occur. There was a gradual increase in fertility with age with the highest pregnancy rate in the oldest (>11 years) class. The pooling of data for all caribou over 4 years old was justified. Other groupings appear in Table 1 because they are used to compare the results with those of other workers.

Annual variations in fecundity

Fertility varied widely over the eight winters from 1979-80 through 1986-87 (**Fig. 1**). Annual trends in fecundity were complicated by the split sample obtained in March 1984, one characterized by high fertility and the other low. The overall trend, as exemplified by females over 4 years old, was high fecundity (>90%) in 1980-81,

Table 1. Fecundity of age classes of caribou sampled from the Beverly herd from 1979-80 through 1986-87.

Age class (years)	Sample size All females	Sample size Normal females	Fecundity[1]
0.5- 1	36	36	0.0
1.5- 2	92	92	12.0
2.5- 3	120	120	71.7
3.5- 4	108	108	81.5
4.5- 5	83	82	85.5[2]
5.5-11	345	343	87.5[3]
>11	55	55	90.9
>2	711	708	83.7[4]
>3	591	588	86.1[4]
>4	483	480	87.2[4]
>5	400	398	87.5[4]

[1] The pregnancy rate (%) in unweighted data from all collections.
[2] Includes female with suspected resorption (Table 4).
[3] Excludes one barren (never pregnant) female and one female without a uterus because of their chance occurrence in the age class.
[4] Includes barren (sterile) female, a female without a uterus, and a suspected resorption.

1981-82, 1983-84 (subherd B), and 1984-85 (**Table 2**). Fertility was relatively low (<84%) in 1982-83, 1983-84 (subherd A), 1985-86, and 1986-87.

These trends generally were supported by data for younger females although sample sizes were small. An exception was 1979-80 when only 5 of 10 females 2.5-3 year old were pregnant. Therefore, the 1979-80 sample was characterized overall by relatively low fecundity. All data indicated that sharp declines in fecundity occurred from 1981-82 to 1982-83 and from 1984-85 to 1985-86. High fecundity in older groups was accompanied by relatively high fertility in yearlings.

Figure 1

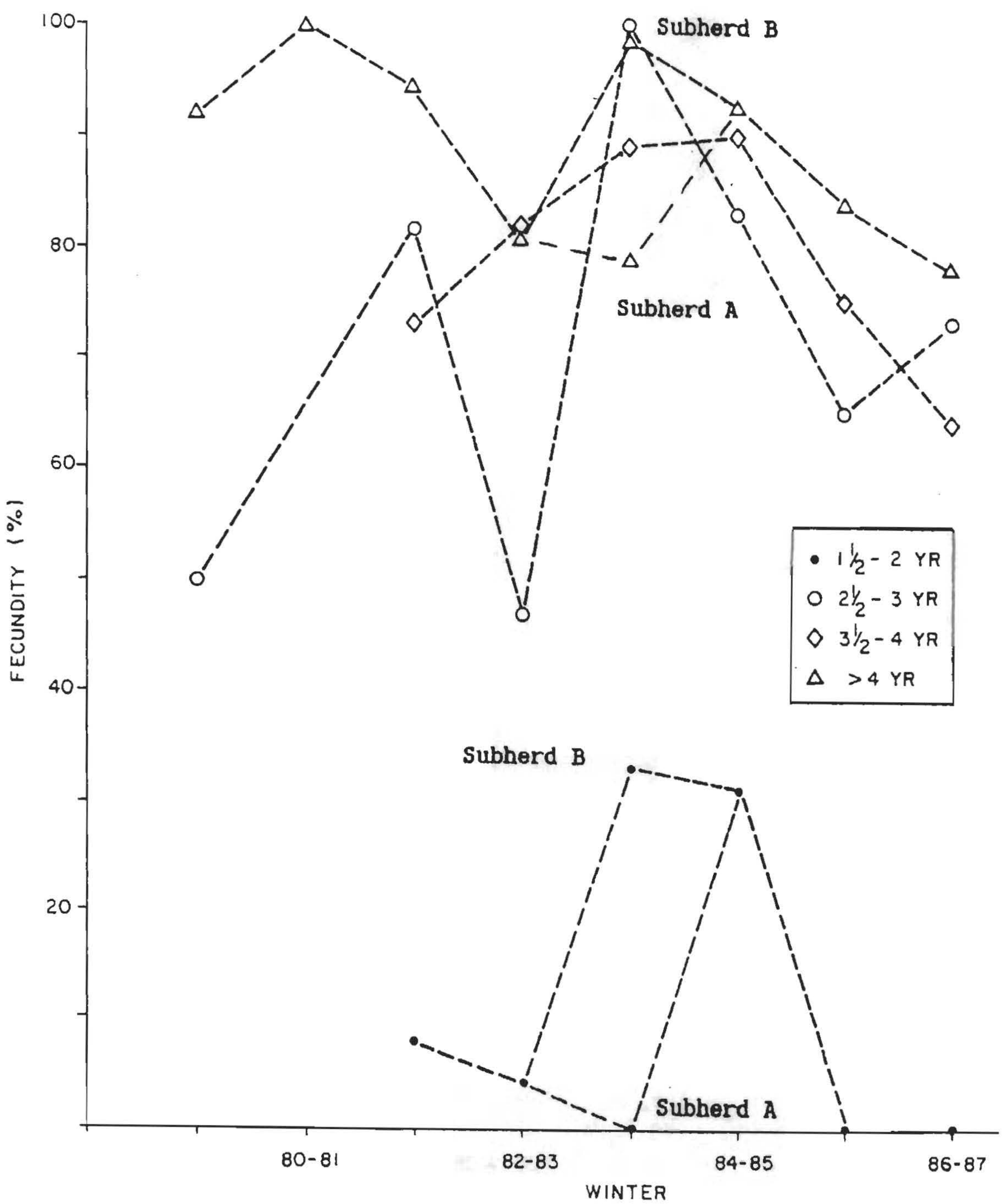

Figure 1. Fecundity of four age classes of caribou sampled from the Beverly herd from 1979-80 through 1986-87.

Table 2. Fecundity of female caribou >4 years old in December, March, and all samples obtained from the Beverly herd, 1980-87.

	Fecundity (percent)					
	December		March		Both months	
Winter	Mean	(Sample)	Mean	(Sample)	Mean	(Sample)
1979-80			92	(12)	92	(12)
1980-81			100	(10)	100	(10)
1981-82			94	(51)	94	(51)
1982-83	86	(28)	78	(59)	80	(87)
1983-84[1]	79	(19)	78	(9)	79	(28)
1983-84[2]			98	(60)[3]	98	(60)[3]
1984-85	96	(26)	91	(69)	93	(95)
1985-86	82	(28)	85	(60)[4]	84	(88)
1986-87	81	(21)	76	(29)	78	(50)
All	85.2	(122)	88.1	(360)[5]	87.2	(483)[5]

[1] Subherd A, including Sifton Lake sample.
[2] Subherd B sampled at Porter Lake.
[3] Excluding one barren (never pregnant) female.
[4] Excluding a female with no uterus.
[5] Including the barren (sterile) female and female with no uterus.

Relative age-specific calf production

Relative calf production by individual age classes was obtained from the product of frequency of each age class in the population and its fecundity. The former was estimated from a smoothed age distribution of all females (Thomas and Kiliaan 1998a) and fecundity from Table 1. Results (**Table 3**) are expressed in terms of mean fecundity of each age class and fecundity from a pooling of all samples regardless of year of collection. The first case suffers from small sample sizes

Table 3. Relative age-specific production of calves in the Beverly herd, 1980 through 1987, based on fecundity and a survival curve.

Age class (years)[1]	June 8 Frequency[2]	Fecundity (%) based on:		Calf production/100F	
		Year means[3]	All samples[4]	Year means	All samples
2	16.1	8.6	12.0	1.4	1.9
3	14.4	71.4	71.7	10.3	10.4
4	12.8	77.8	81.5	10.0	10.4
5	11.3	82.5	85.5	9.3	9.6
6	9.8	86.3[5]	85.9[6]	8.4	8.4
7	8.4	86.3[5]	79.7[7]	7.3	6.7
8	7.1	86.3[5]	94.9	6.1	6.7
9	5.9	86.3[5]	92.3	5.1	5.4
10	4.7	86.3[5]	88.6	4.1	4.2
11	3.7	86.3[5]	85.0	3.2	3.1
12	2.7	89.7	90.0	2.4	2.4
13	1.8	89.7	91.7	1.6	1.7
14	1.0	89.7	100.0	0.9	1.0
15	0.3	89.7	100.0	0.2	0.3
16		89.7	50.0		
Totals	100.0	70.3	72.3	70.3	72.2

[1] Age (year) when calf produced (conceived 7 months earlier).
[2] Based on a survival curve (Thomas and Barry 1990a, Thomas and Kiliaan 1998a).
[3] Average of yearly means 1981-82 to 1986-87 (unweighted, where minimum $n \geq 10$).
[4] A pooling of data from all samples 1980-87 (weighted).
[5] Average for 6-11 year age class.
[6] Excluding females with reproductive tract malformations.
[7] Average for >11 year age class.

in most age classes in most years. The second method takes no account of sample size and fecundity variations from year to year. Nevertheless, results are similar for the two methods.

Table 4. Statistics of three female caribou with reproductive abnormalities in relation to mean values for normal females in the same sample from the Beverly herd.

Month/ year	Age class (years)	Condition	Weight (kg)	Back fat (mm)	Kidney fat (g)	Femur length (mm)
Mar 84	7	No ovaries	97.0	26	163	297
Mar 84[1]	6-11	Normal (pregnant)	88.1	21.5	127	274
Mar 86	6	No uterus	111.5	1	114	304
Mar 86	5	Resorption	91.5	21	119	271
Mar 86	6-11	Normal (pregnant)	87.6	12.8	107	279
Mar 86	6-11	Normal (not pregnant)	76.8	5.8	63	276

[1] Sample from subherd B (Porter Lake), in which all the other females 6-11 years old in the sample were pregnant.

Over half (55%) of the calves were produced by age classes 3 through 6 years. The analysis is based on an even sex ratio at all ages, which is not the case. In another paper (Thomas and Barry 1990b), the analysis was specific to production of calves of each sex. Most analyzes usually consider the production of females only and an even sex ratio at birth is assumed.

Reproductive abnormalities

A 7-year-old female collected in March 1984 had a small pale uterus characteristic of calves and nulliparous (never pregnant) yearlings. No ovaries could be found and presumably they never developed. A female nearing 6 years of age collected in March 1986 had no detectable uterus, although its ovaries had developed. A 5-year-old female in the same group as the female with no uterus had about a liter of yellow fluid in its uterus but no fetus. A resorption was suspected. Statistics for the three females (**Table 4**) reveal that the female with no ovaries was heavier, fatter, and larger than average.

Fetal weights

Fetal weights provide evidence of late conceptions. A plot of the frequency distribution of fetal weights (**Fig. 2**) revealed a normal distribution with many of the heavy fetuses arising from late-March samples in 1981 and 1984 (subherd A, Sifton Lake sample). Fetuses weighing less than 800 g were attributed to late breeders, probably females that cycled more than once before they became pregnant. They accounted for 4.8% of 420 pregnant females in March samples. One female aged 5 years conceived in January, based on its 9.2 g fetus collected on March 19, 1983.

Ages were grouped in 3-year classes to increase sample sizes and examine age effects of adult females and fetal sex effects on fetal weights (**Table 5**). Age of dam was unrelated to fetal weight. Only in the >10 years class was fetal weight influenced ($P < 0.01$) by sex.

The effect of age of young dams on average fetal weight was examined more closely by excluding larger fetuses obtained late in March in 1981 and 1984 (Sifton Lake sample of subherd A). Average weights increased through the first four age classes, that is, from age 2 to 5 years (**App. 3**).

Fetal sex ratios

Fetal sex ratios were evaluated in terms of age (**Table 6**) and condition of dams (females bearing fetuses). These results are presented in a separate paper (Thomas et al. 1989) and are only discussed briefly herein. Females 2-4 years old produced significantly more female fetuses than males; the opposite occurred in old (>11 year) females. The sex ratios when linked to age distribution of females produced a ratio

Figure 2

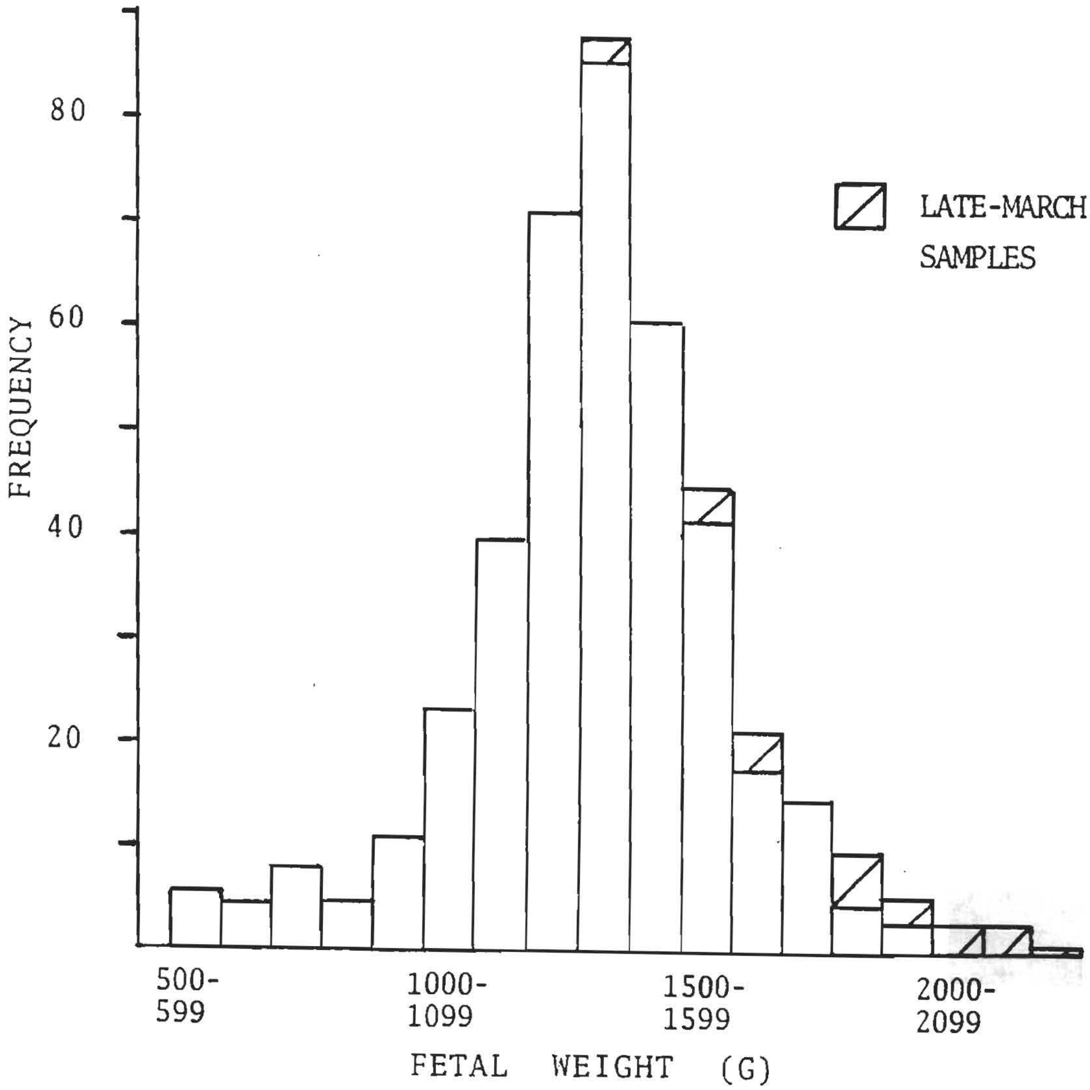

Figure 2. Distribution of fetal weights of barren-ground caribou sampled from the Beverly herd in March 1980 through 1987.

Table 5. Weights of male and female fetuses collected from the Beverly herd of caribou in March, 1980 through 1987.

Age class (yr)	Weight (g) of all fetuses[1]						Weight of fetuses >800 g[2]					
	Males			Females			Males			Females		
	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*
2 - 4	1335	276	48	1288	288	78	1348	264	47	1339	238	72
5 - 7	1404	276	77	1353	194	72	1436	229	74	1353	194	72
8 -10	1335	266	50	1318	225	48	1378	212	47	1344	189	46
>10	1399	267	31	1152	257	15	1449	190	29	**1235**[3]	156	13

[1] Excluding one weighing 9.2 g.
[2] Excludes late breeders.
[3] $P < 0.01$ *cf.* males.

Table 6. The sex of fetuses in four maternal age classes of caribou sampled from the Beverly herd in March, 1980 through 1987.

Age class (yr)	Number of fetuses[1]		Proportion males
	Males	Females	
2 - 4	48	79	0.39
5 - 7	77	72	0.52
8 -10	50	49	0.51
>10	31	15	0.67
Totals	206	215	0.49

[1] Excluding a 9.2 g male in a 5-year-old female estimated to have conceived in January.

close to unity. There was no relationship to maternal condition although there was a trend towards better condition in dams bearing female fetuses in March.

Relationship between condition variables and fecundity

Body weight (WT)

A regression of mean fecundity (dependent variable) on mean body weight (independent variable) of all females >4 years, the largest grouping possible, produced a significant relationship in March ($P < 0.05$) and in combined December and March samples ($P < 0.01$) (**App. 4**). A regression (**Fig. 3**) indicated an increase in fecundity from 73-74 to 99% as body weight increased from 80 to 88-89 kg.

A plot of sample means for age classes 2.5-3 years and 3.5-4 years (**Fig. 4**) indicated that the two classes could be grouped as could the December and March samples. The regression for such pooled samples was significant ($P < 0.01$) as were some of the component samples: 2.5-3 years in March, 2.5-3 years with both months combined, and 2.5-4 years in March. A weight of 80 kg equated to a fecundity of 88% in females 2.5-4 years old but to only 74% in females >4 years old.

Regression data for body weight and back fat were generated for December, March, and combined samples where applicable (App. 4).

In individual samples obtained in December, pregnant females usually were heavier than non-pregnant ones within age classes and significantly ($P < 0.05$) so in two cases (**App. 5**). With few exceptions, the same was true for samples obtained in March and in one case even after weights of pregnant individuals were adjusted for the weight of uterine contents (App. 5).

Pregnant females usually were substantially heavier than non-pregnant counterparts in the same age class in pooled samples from December, from March (**Table 7**), and from both periods (**Table 8**). All differences in Tables 7 and 8 were significant at $P < 0.01$, except for two significant at $P < 0.05$ and one

Figure 3

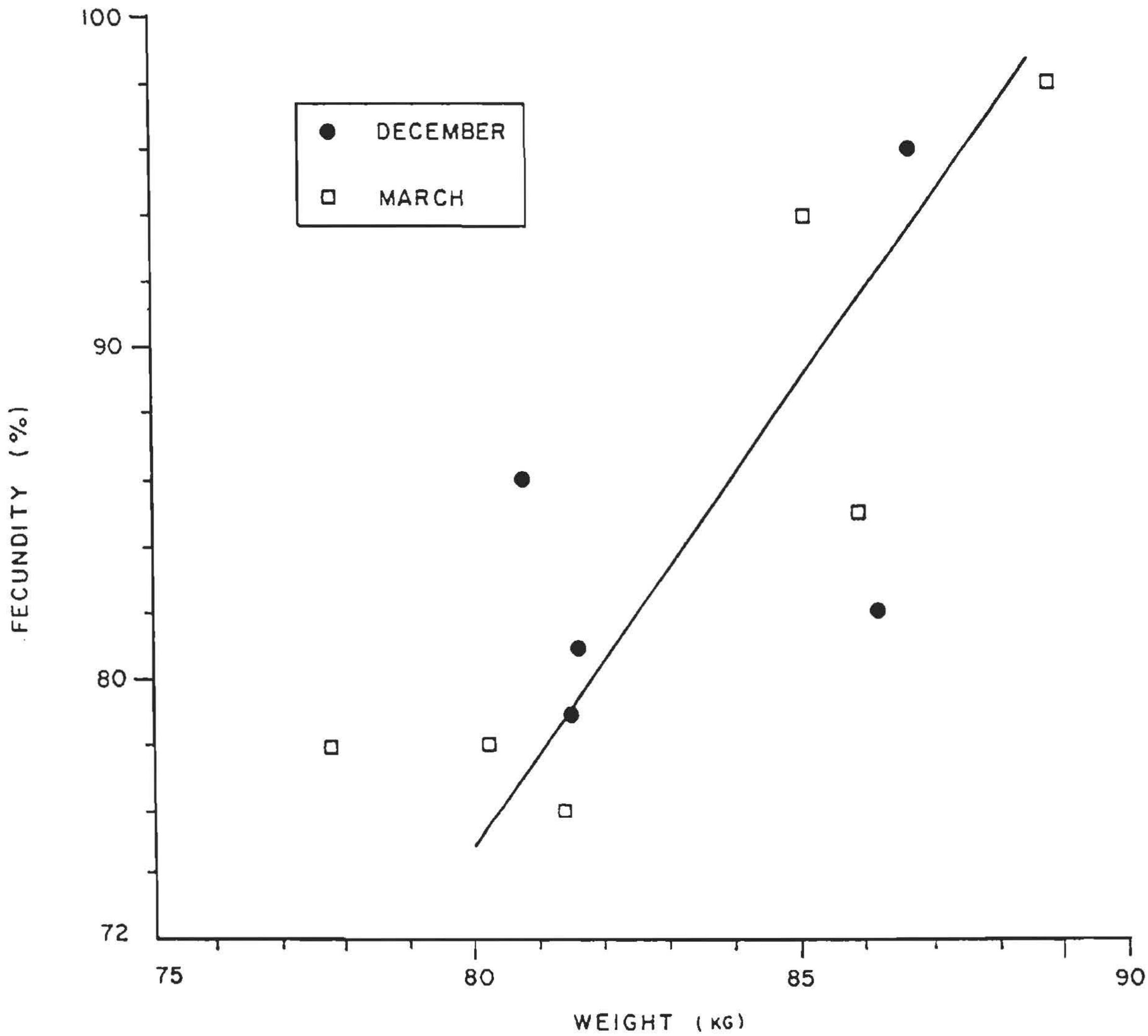

Figure 3. Relationship between mean body weights and fecundity of females >4 years old in individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87).

Figure 4

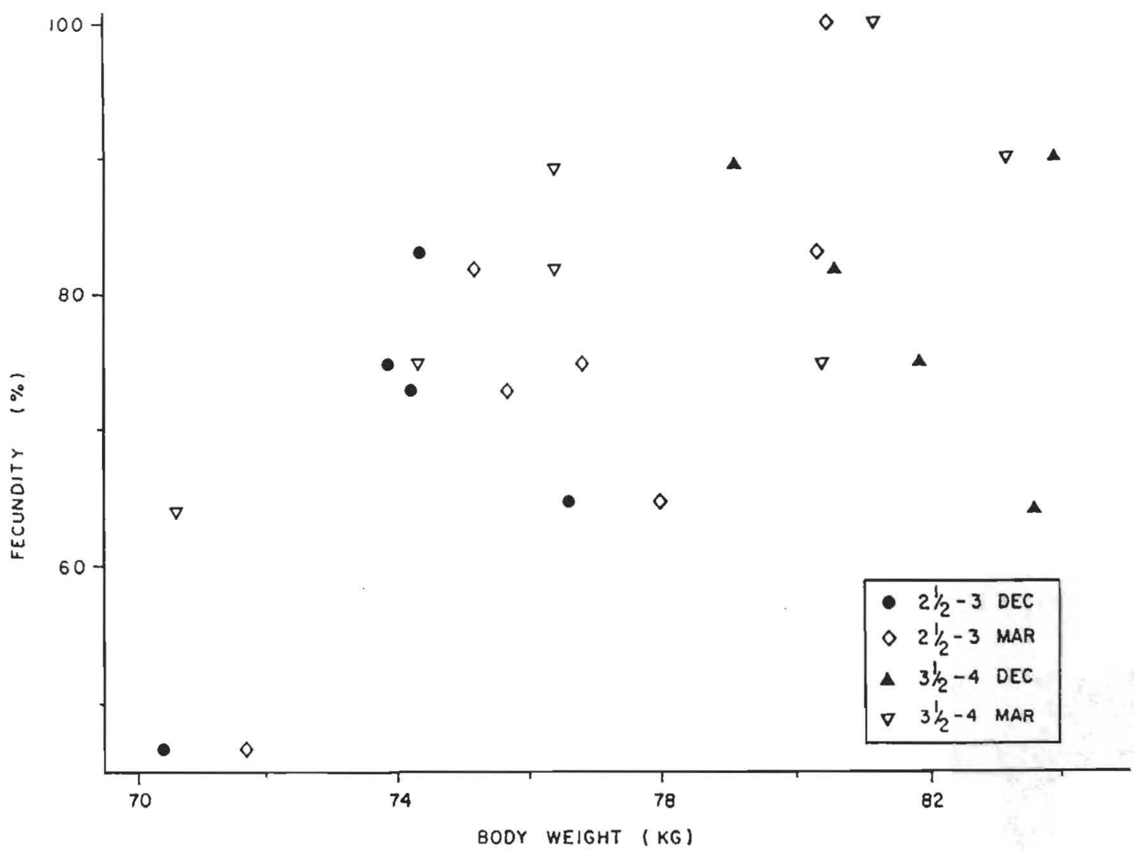

Figure 4. Relationship between mean body weights and fecundity of females 2.5-3 and 3.5-4 years old in individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87).

non-significant difference.

A frequency distribution of the body weights of pregnant and non-pregnant females >1 year old in 5 kg intervals revealed overlapping distributions but the modes were separated by 20 kg (**Fig. 5**).

A plot of pregnancy rate with body weight classes for females >1 year old yielded a classical sigmoid curve (**Fig. 6**). The inflection point was at 71-75 kg and the 95% pregnancy rate at 86-90 kg. The curve can be used to predict the pregnancy rate of females in the Beverly herd from the mean of a sample of body weights. Of course, ages of caribou in the sample must be representative of those in the population.

The points for females >2 years old produced almost an identical curve but there were no weights less than 61 kg.

Back fat (BF)

There was a correlation ($P < 0.01$) between average depths of back fat and fecundity of females >4 years old in samples from each collection period (**Fig. 7**). The fat correlation was better for March samples than those for December, partly because of the additional two data points (App. 4). A regression for combined December and March samples indicated that an increase from 8 to 20 mm in mean depth of back fat corresponded to an increase in pregnancy rate from 73-74 to 99%.

The regression of mean BF depths and fecundity of females 2.5-4 year old (**Fig. 8**) was also significant in March and combined December and March samples ($P < 0.01$). The regressions for 2.5-3 and 3.5-4 year old females were similar, as were regressions for December and March samples.

Table 7. Whole body weights (kg) of pregnant and non-pregnant female caribou sampled from the Beverly herd in December (1982-86) and March (1980-87).

Age class (yr)	Body weight in December						Body weight in March					
	Pregnant			Not pregnant			Pregnant			Not pregnant		
	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*
1.5- 2	66.5	0.4	2	61.5	1.5	24	72.1	2.1	8	**60.2**	0.8	57
2.5- 3	76.9	1.1	17	**71.2**[1]	1.6	13	79.8	0.8	66	**67.5**	0.9	21
3.5- 4	82.4	1.0	32	81.6	2.1	8	81.6	0.9	53	**69.6**	1.3	12
4.5- 5	84.2	1.5	22	**74.3**	1.0	3	85.2	1.0	48	**71.4**	2.5	8
5.5-11	85.7	0.8	64	**75.4**	1.8	14	86.3	0.4	227	**77.3**	1.7	29
>11	84.5	1.6	17	79.0		1	88.2	1.2	33	**78.5**	1.9	4
> 3	84.5	0.6	135	**77.3**	1.3	26	85.6	0.4	361	**74.8**	1.2	53
> 4	85.2	0.7	103	**75.4**	1.4	18	86.3	0.4	308	**76.6**	1.4	42
> 5	85.4	0.7	81	**75.6**	1.7	15	86.5	0.4	260	**77.5**	1.5	33

[1] **Bold** indicates significant difference between pregnant and non-pregnant females.

Table 8. Whole body weights of pregnant and non-pregnant female caribou of the Beverly herd in pooled samples obtained from 1980 through 1987.

Age class (yr)	Whole body weight (kg)					
	Pregnant			Not pregnant		
	Mean	SE	*n*	Mean	SE	*n*
1.5- 2	71.0	1.9	10	**60.6**[1]	0.7	81
2.5- 3	79.3	0.7	83	**68.9**	0.9	34
3.5- 4	81.9	0.7	85	**74.4**	1.7	20
4.5- 5	84.9	0.9	70	**72.2**	1.9	11
5.5-11	86.1	0.4	291	**76.7**	1.3	43
>11	87.0	1.0	50	**78.6**	1.5	5
> 3	85.3	0.3	496	**75.6**	0.9	79
> 4	86.0	0.3	411	**76.0**	1.0	59
> 5	86.3	0.4	341	**76.9**	1.2	48

[1] **Bold** indicates significant difference between pregnant and non-pregnant females.

Figure 5

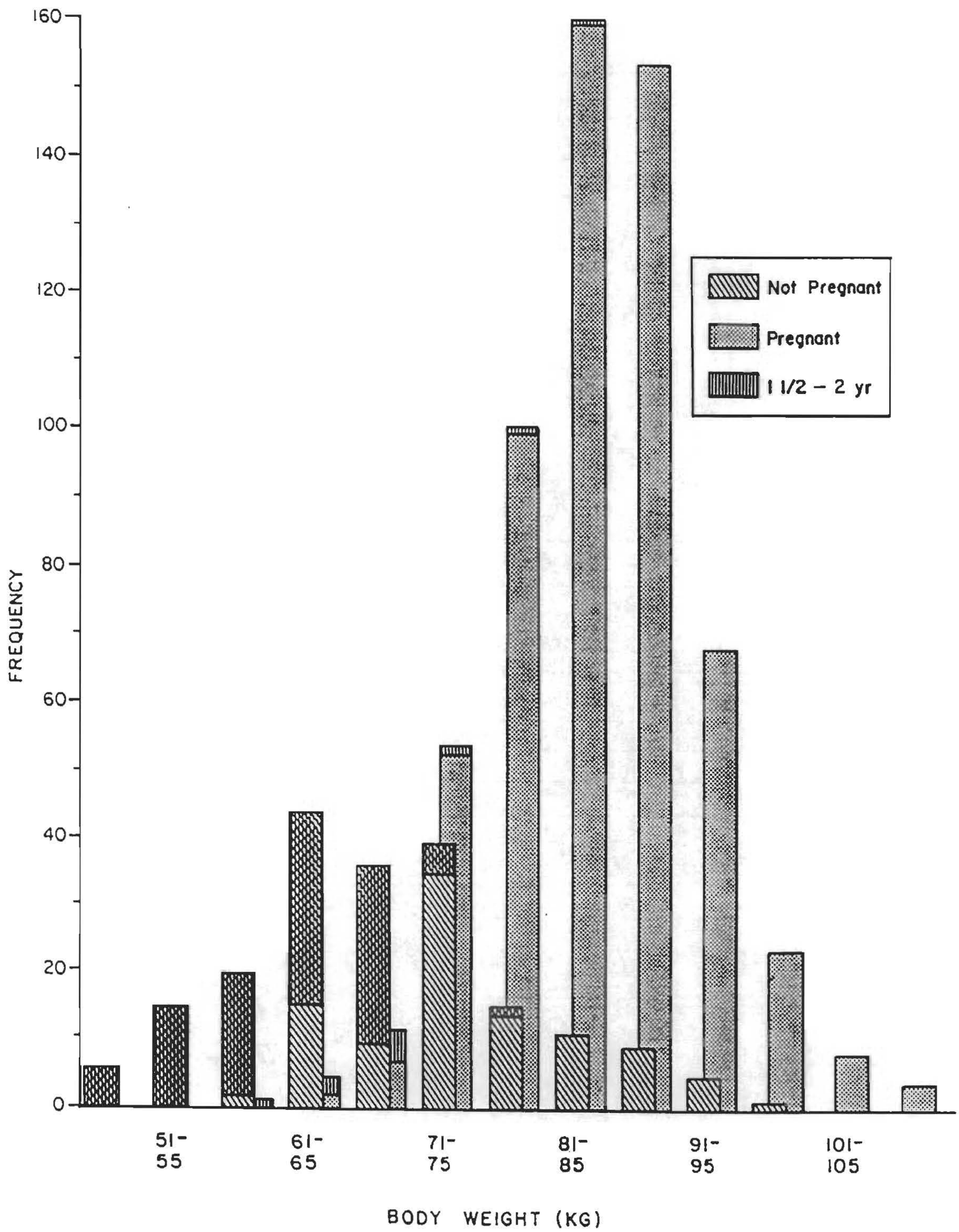

Figure 5. Frequency distributions of body weights of pregnant and non-pregnant female caribou >1 year old collected from the Beverly herd from 1980 through 1987.

Figure 6

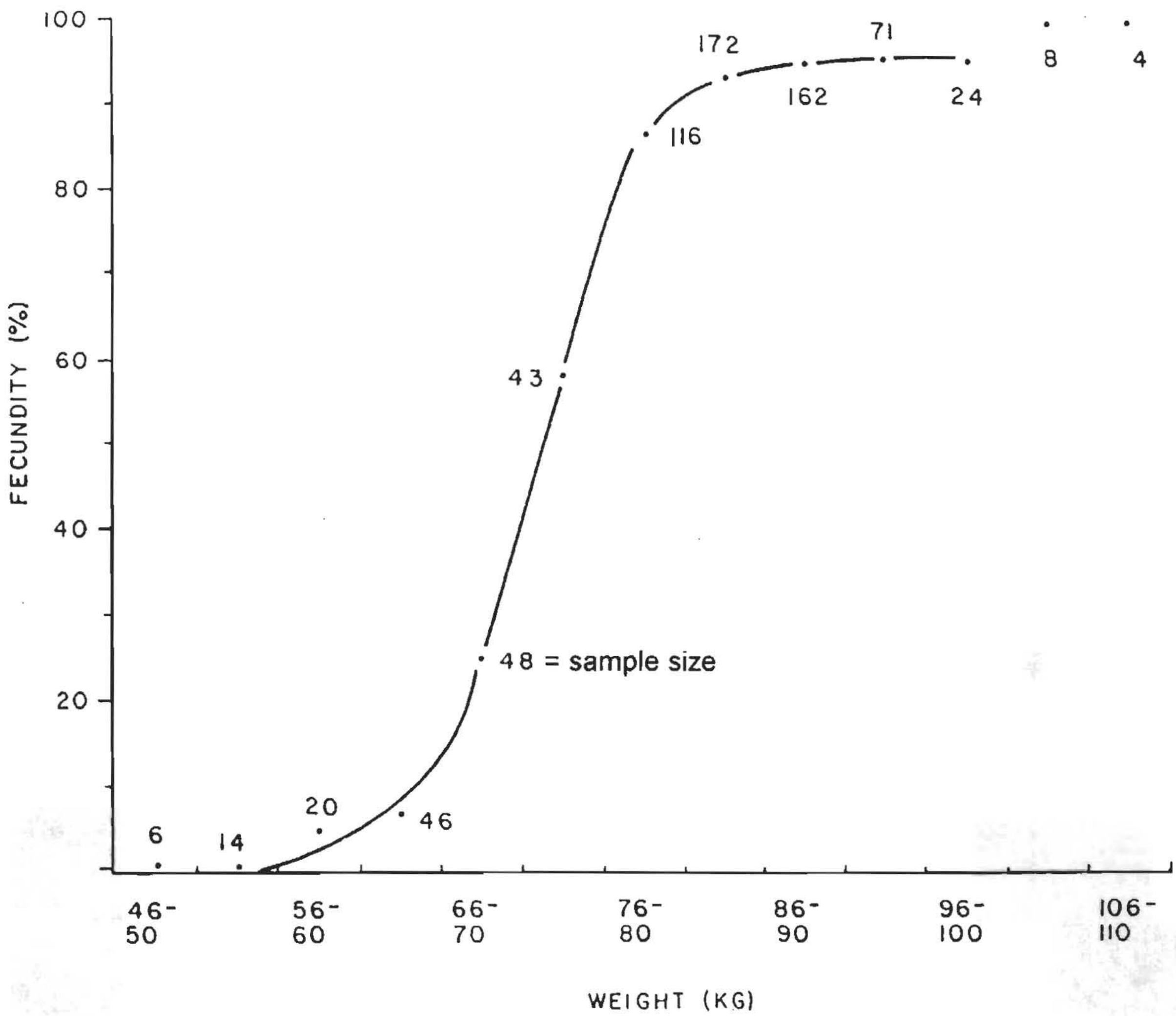

Figure 6. Relationship between body weight at 5 kg intervals and pregnancy rate of female caribou >1 year old in pooled samples from 1980 through 1987.

Figure 7

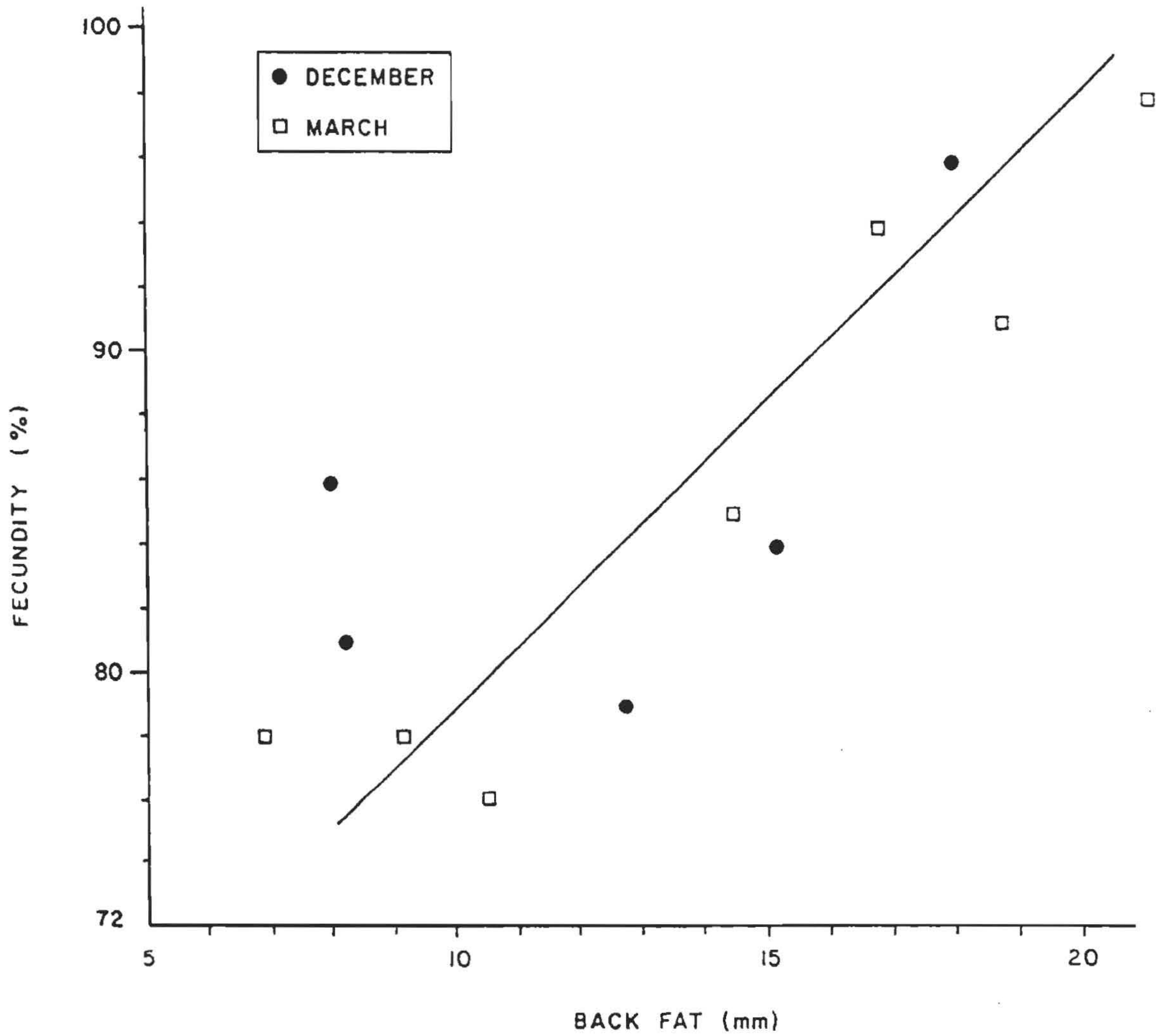

Figure 7. Relationship between depth of back fat and fecundity of female caribou >4 years old in individual samples obtained from the Beverly herd each December (1982-86) and March (1982-87).

Figure 8

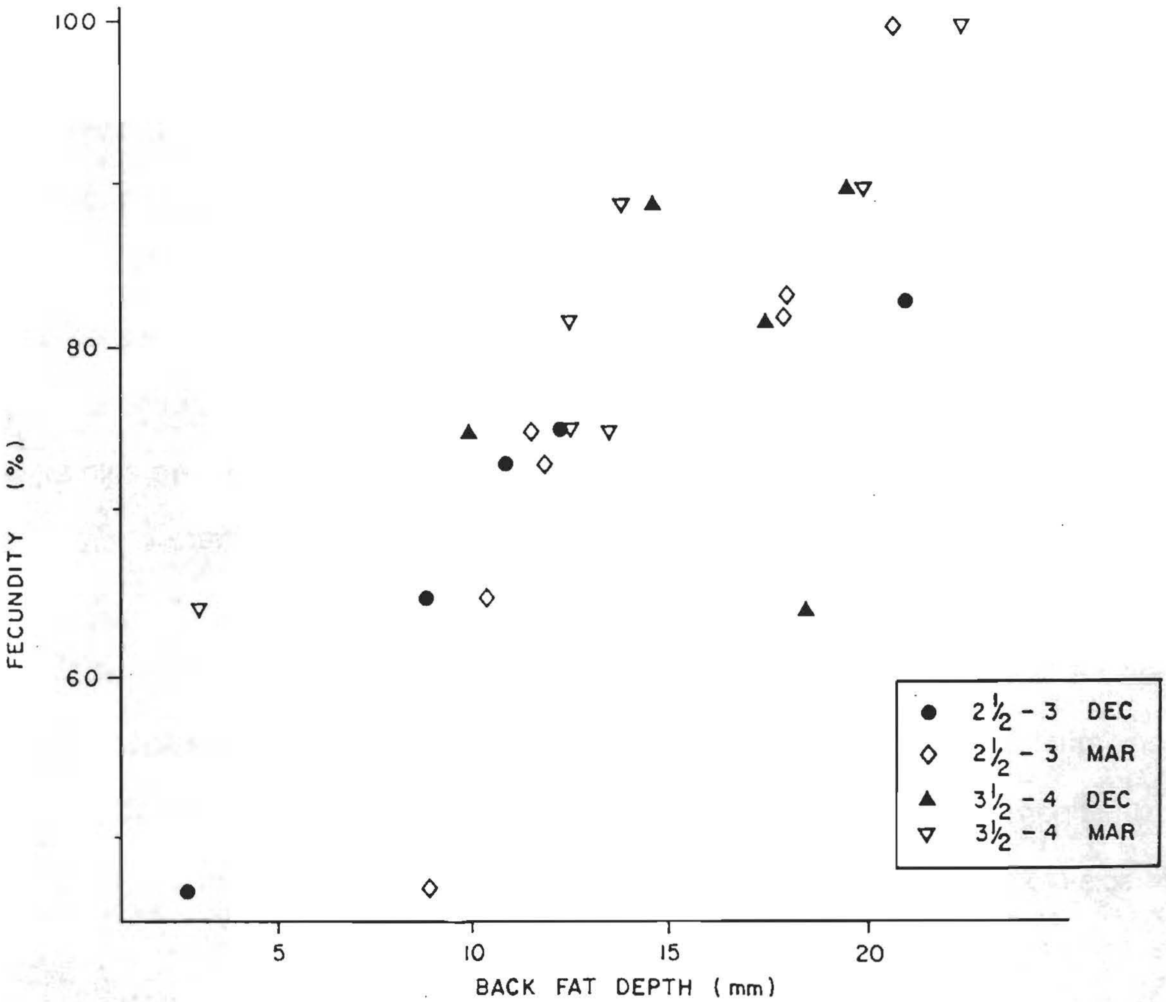

Figure 8. Relationship between depth of back fat and fecundity of female caribou 2.5-3 and 3.5-4 years old in individual samples obtained from the Beverly herd each December (1982-86) and March (1982-87).

We compared mean depths of back fat in pregnant and non-pregnant females. Wide variability in fat depths necessitated large sample sizes to examine possible differences in fecundity. For example, in December, depths of back fat in non-pregnant caribou varied from 0 to 22 mm and from 0 to 37 mm in pregnant females. There were no differences in BF depths with age after the yearling class in samples obtained in December 1983, 1984, and 1986. In December 1985, females 2.5-4.5 years old had similar values, with significantly higher values ($P < 0.05$) in older females. Age classes were grouped accordingly and the average depths of BF in pregnant and non-pregnant females were compared (**App. 6**). Most differences were significant. Inadequate numbers of non-pregnant females precluded comparisons in December 1983. Differences were even larger in March samples as we were able to group females >2 years old in the seven winters in which sample sizes were adequate.

A pooling of data for all December samples indicated the superior condition of pregnant females over non-pregnant ones (**App. 7**). The differential continued into March, thus permitting a pooling of data from both periods (**Table 9**) to increase sample sizes. All differences in Table 9 were significant ($P < 0.01$) except for the >11 year age class.

A histogram of frequency of back fat depths (4 mm intervals) in pregnant and non-pregnant females revealed distinctly different distributions (poisson and quasi normal) but considerable overlap (**Fig. 9**). A 2-mm-interval histogram contained 92, 42, 23, and 9 non-pregnant individuals in the first four intervals. The distribution of back fat depths in pregnant individuals indicates that presence of back fat was not always necessary for conception to occur.

A plot of back fat depths and fecundity of females older than 1 and 2 years

Table 9. Back fat depths of pregnant and non-pregnant female caribou sampled from the Beverly herd from 1980 through 1987.

Age class (yr)	Back fat depths (mm)					
	Pregnant			Not pregnant		
	Mean	SE	*n*	Mean	SE	*n*
1.5- 2	13.5	1.8	11	**3.5**[1]	0.4	80
2.5- 3	17.2	0.9	83	**2.6**	0.5	34
3.5- 4	17.3	0.9	84	**4.2**	1.3	20
4.5- 5	14.4	1.0	70	**1.9**	1.0	11
5.5-11	15.8	0.6	296	**3.0**	0.7	43
>11	15.1	1.5	50	7.2	3.0	5
> 2	16.0	0.4	583	**3.1**	0.4	113
> 3	15.8	0.4	500	**3.4**	0.6	79
> 4	15.5	0.5	416	**3.1**	0.6	59
> 5	15.7	0.5	346	**3.4**	0.7	48

[1] **Bold** indicates significant difference (*P* <0.05) between pregnant and not pregnant.

Table 10. Kidney fat of pregnant and non-pregnant female caribou sampled from the Beverly herd in December (1982-86) and March (1980-87).

Age class (yr)	Kidney fat (g) in December						Kidney fat (g) in March					
	Pregnant			Not pregnant			Pregnant			Not pregnant		
	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*
1.5- 2	70.0		1	49.7	3.4	23	111.9	6.7	8	**48.3**	2.1	54
2.5- 3	98.4	9.3	17	**49.8**[1]	4.8	12	108.5	4.2	64	**53.2**	4.4	21
3.5- 4	87.0	4.9	32	**50.5**	9.3	8	110.5	4.4	54	**49.2**	4.5	11
4.5- 5	88.3	6.3	22	**42.0**	7.4	3	114.2	5.4	47	**49.4**	7.1	7
5.5-11	87.7	3.3	64	**44.5**	2.1	14	113.8	2.3	228	**56.3**	4.4	29
>11	74.0	6.2	17	**42.0**		1	91.5	5.3	32	**66.0**	16.0	4
> 2	87.3	2.4	152	**47.2**	2.7	38	110.9	1.7	425	**54.2**	2.6	72
> 3	85.9	2.4	135	**46.0**	3.2	26	111.4	1.8	361	**54.6**	3.2	51
> 5	84.9	3.0	81	**44.3**	2.0	15	111.0	2.2	260	**57.5**	4.3	33

[1] **Bold** indicates significant difference (*P* <0.05) between pregnant and not pregnant.

Figure 9

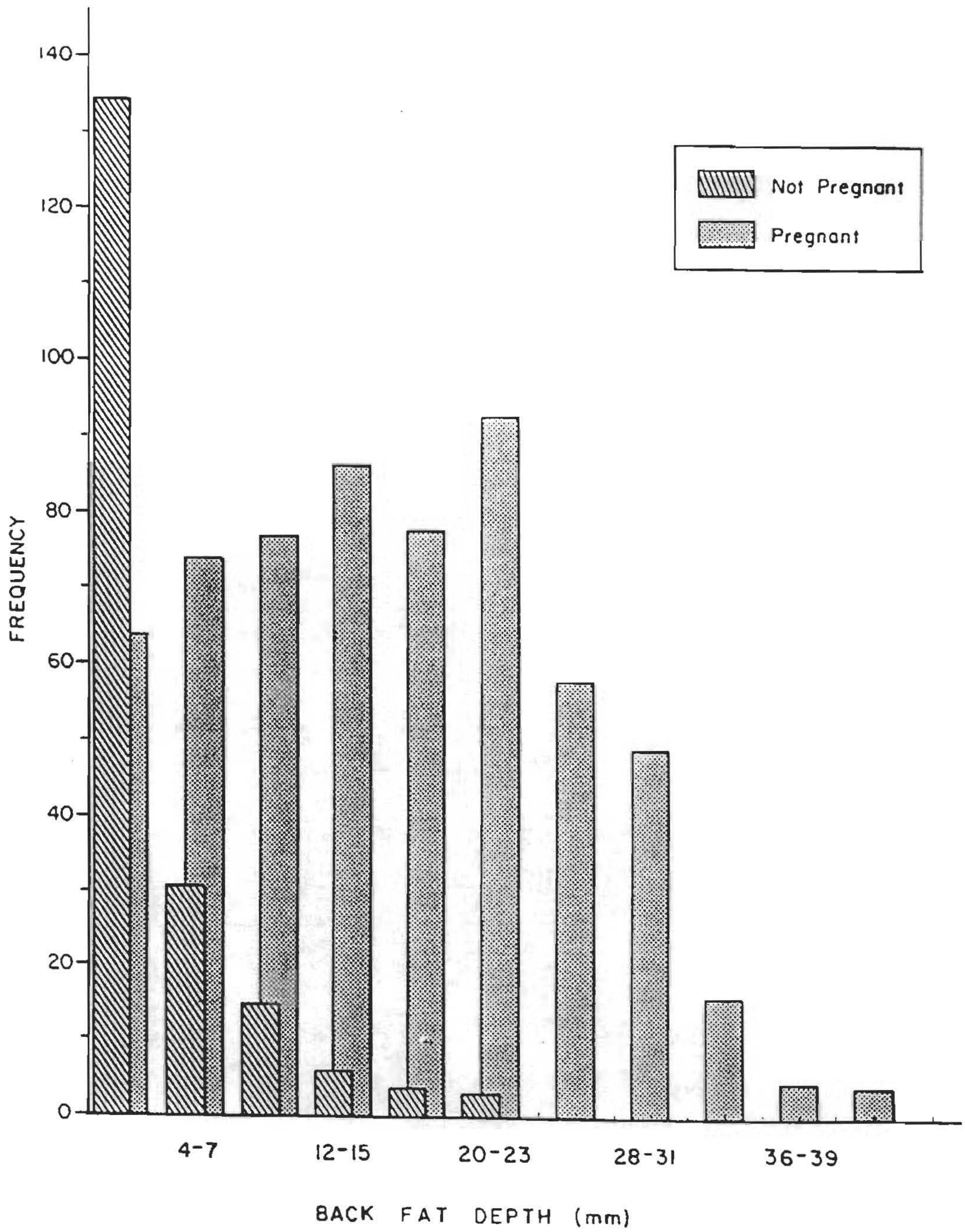

Figure 9. Frequency of back fat depths in pregnant and non-pregnant female caribou >1 year old sampled from the Beverly herd from 1980 through 1987.

indicated that two curves were required, that a pregnancy rate of 15-20% was possible with no back fat, and that maximum fertility was achieved by females >2 years old with ≥14 mm of back fat (**Fig. 10**).

Kidney fat (KF)

There was no relationship between kidney fat and fecundity in females >4 years old in pooled samples obtained in December (**Fig. 11**). However, the relationship was significant ($P < 0.05$) in March (**App. 8**). The poor fit in December was caused by high variability in the 1984 sample and, to a lesser extent, the 1982 sample. An increase from 90 to 120 g (33%) in KF in March corresponded to a 25% increase in fecundity. Significant ($P < 0.01$) linear relationships also occurred between the same variables in females 2.5-4 and 3.5-4 years old collected in March (**App. 8, Fig. 12**).

Kidney fat weights were greater ($P < 0.05$) in pregnant females than non-pregnant ones in December and March samples (**App. 9**). In most winters, KF weights increased in pregnant females but remained about the same in non-pregnant ones.

In pooled data from all years, differences in KF weights between pregnant and non-pregnant females was pronounced in December and March samples (**Table 10**). Some of the weights differed by a factor of two.

Frequency distributions of KF weights of pregnant and non-pregnant, breeding-age females (>1 year) showed normal distributions with moderate overlap and 40 grams between modes (**Fig. 13**).

The relationship between KF weights and pregnancy rate in individual samples indicated slight differences between age groupings of >1 year and >2 years and maximum fecundity in females >2 years with kidney fat of 100-120 g or more (**Fig. 14**).

Figure 10

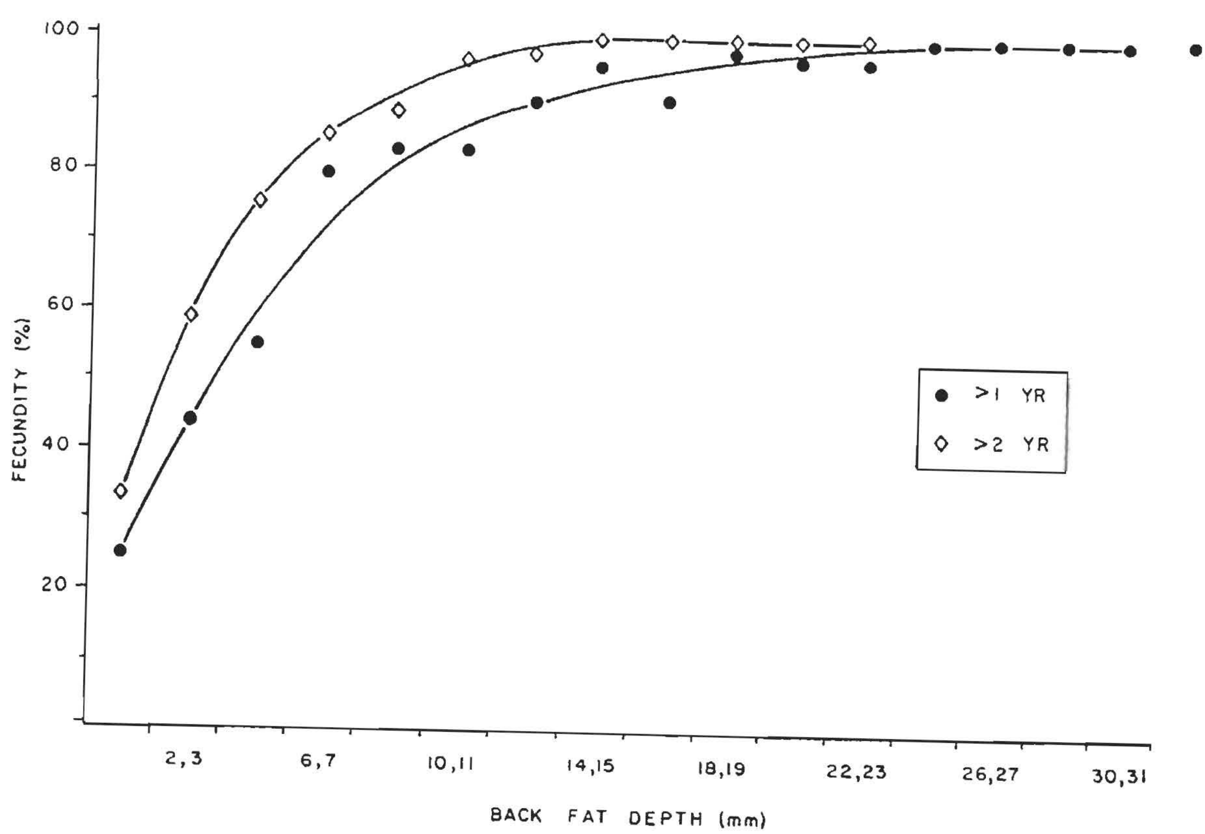

Figure 10. Relationship between depth of back fat at 2-mm intervals and pregnancy rate of caribou in pooled samples from December and March, 1980 through 1987.

Figure 11

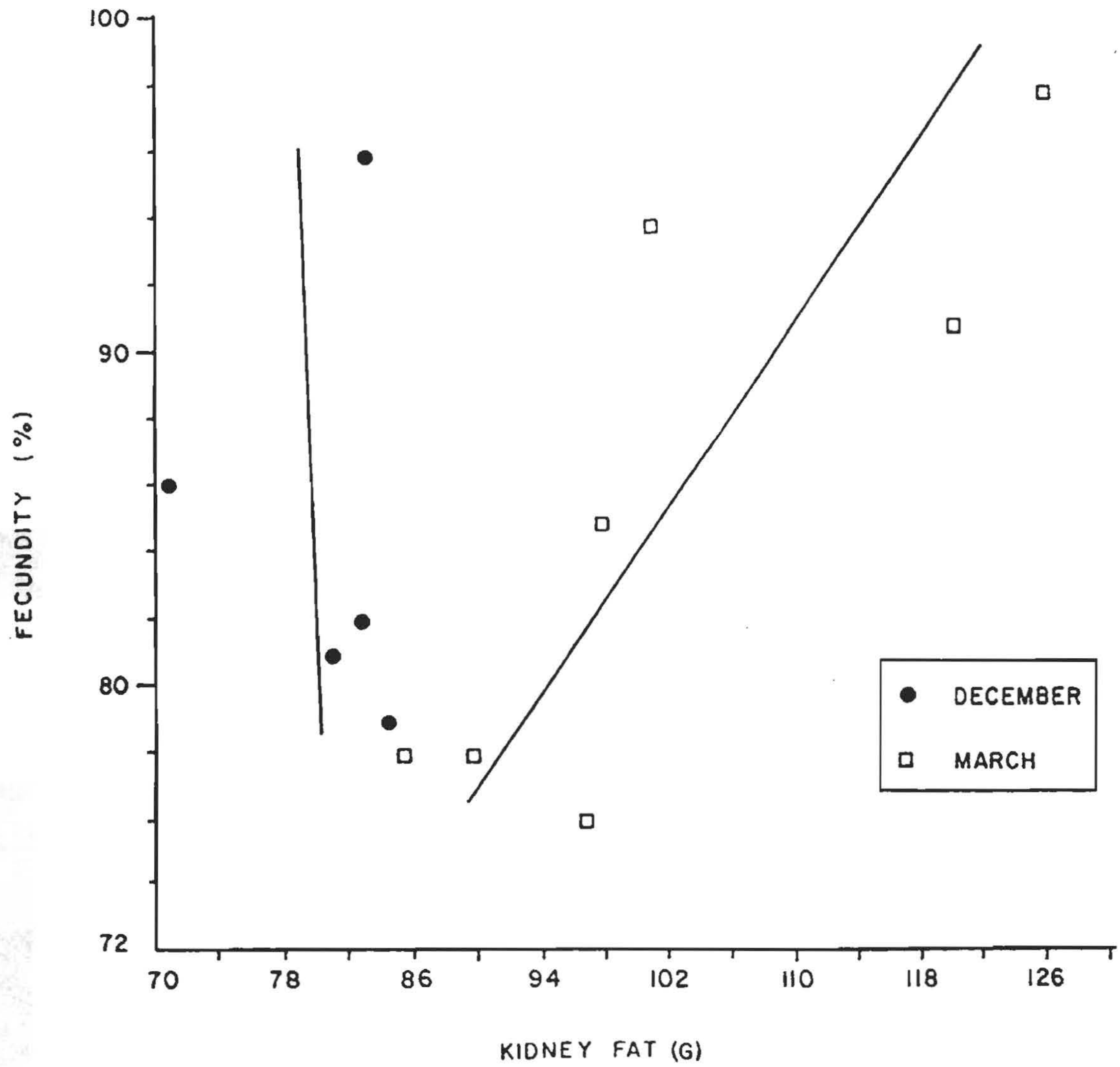

Figure 11. Relationship between mean kidney fat weights and fecundity of caribou >4 years old in individual samples from December (1982-86) and March (1980-87).

Figure 12

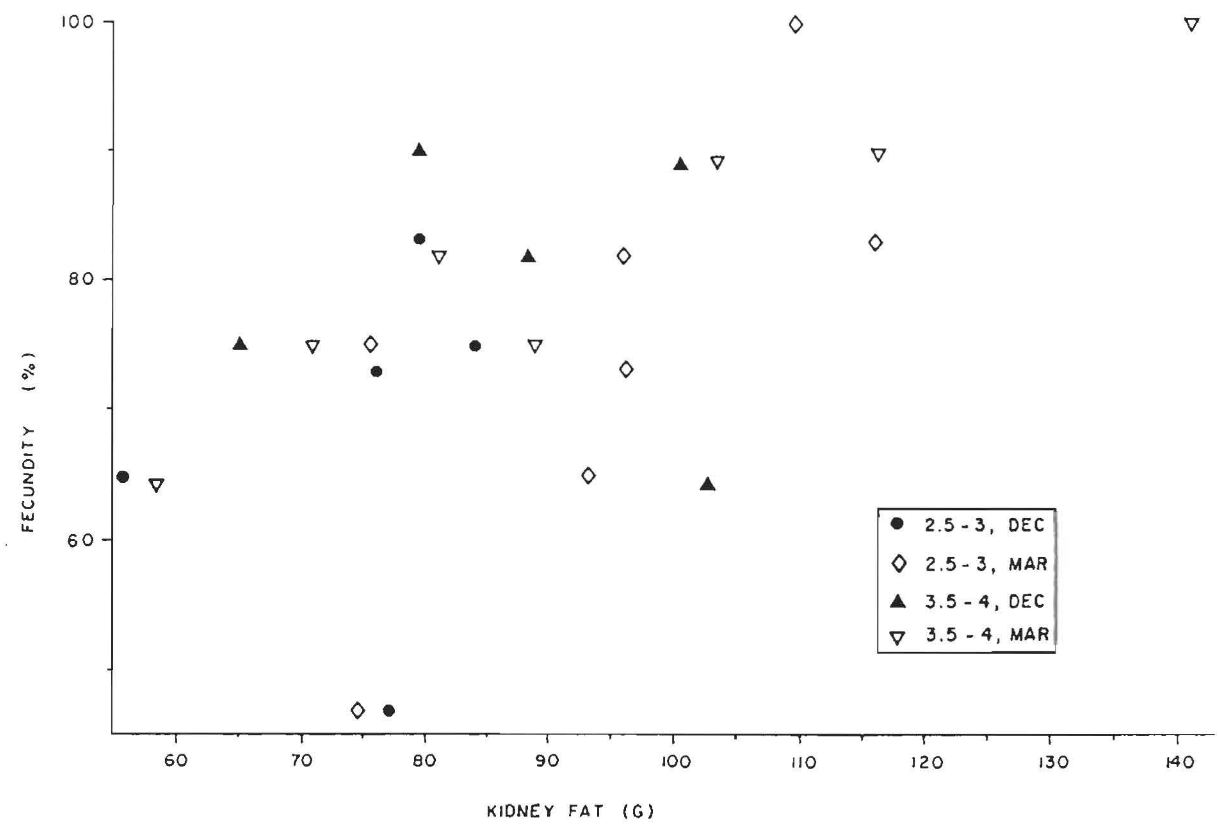

Figure 12. Relationship between mean kidney fat weights and fecundity of caribou 2.5-3 and 3.5-4 years old in individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87).

Figure 13

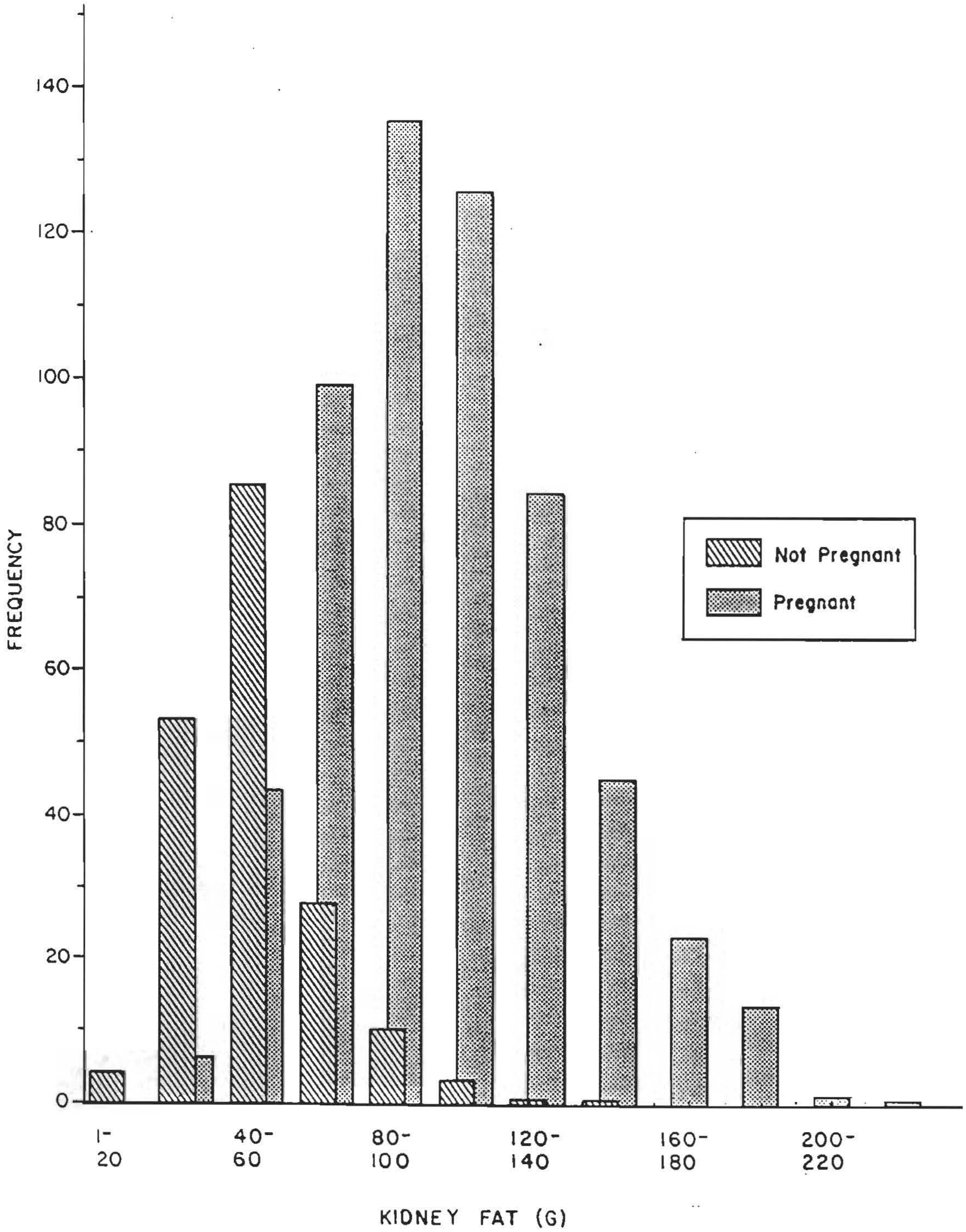

Figure 13. Frequency of kidney fat weights in pregnant and non-pregnant female caribou >1 year old sampled from the Beverly herd from 1982 through 1987.

Figure 14

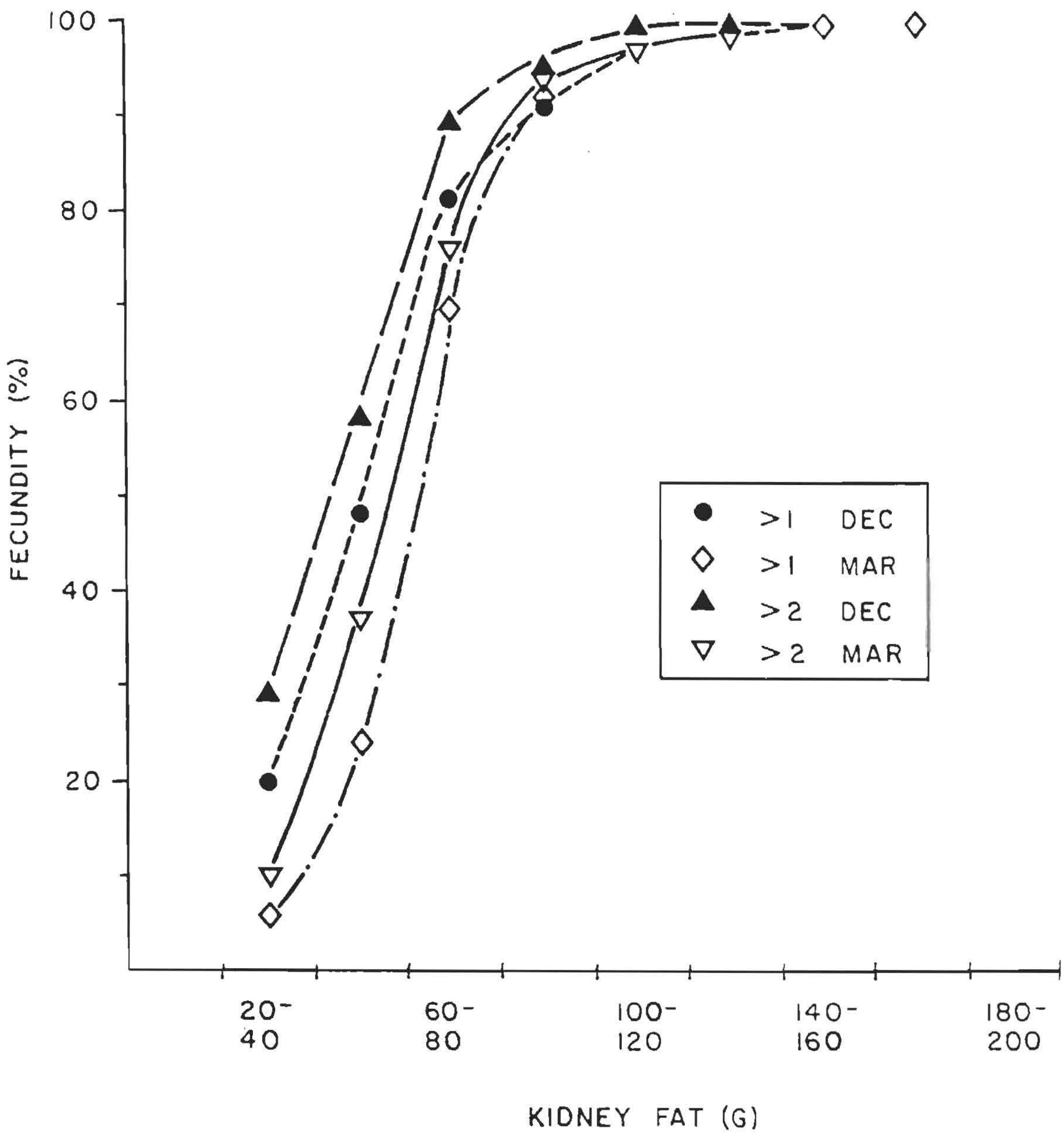

Figure 14. Relationship between kidney fat weight at 20-g intervals and pregnancy rate of female caribou older than 1 and 2 years in pooled samples from December and March, 1980 through 1987.

Riney's kidney fat index (KFIR)

The positive, significant ($P < 0.05$) relationship between mean KFIR (Riney 1955) and mean fecundity in March samples contrasted with the negative and non-significant regression for December samples (**Fig. 15**).

Data for individual December and March samples frequently revealed significant differences in KFIR between pregnant and non-pregnant caribou in several age groupings (**App. 10**). Pooled data for December and March samples also revealed large differences and all were significant where $n > 1$ (**Table 11**).

Frequency distributions of KFIR in pregnant and non-pregnant females were similar to those for kidney fat (**Fig. 16**).

Plots of KFIR and fecundity for combinations of ages >1 year and >2 years and December and March samples indicated approximately zero fecundity at zero KFIR, 50% fecundity at 45-50 KFIR, and maximum fecundity at a KFIR of about 65 to 85 (**Fig. 17**). The spread between curves for December and March samples reflects the sharp increase in kidney fat between the two periods.

Other indices based on KF (KFIM - Mitchell et al. 1976), KF/WT, KF/FEL (femur length), and FAT (Huot and Goudreault 1985) produced results comparable to those for KF and KFIR (App. 8). They are not presented here except for the data for FAT in pregnant and non-pregnant females (**App. 11**).

Femur marrow fat (FEF)

A regression of fecundity and femur fat (FEF) means for females >4 years old in individual samples (**Fig. 18**) was not significant ($r = 0.56$ *vs.* tabular 0.58); nor were those for December, March, and combined December and March samples (**App. 12**).

Figure 15

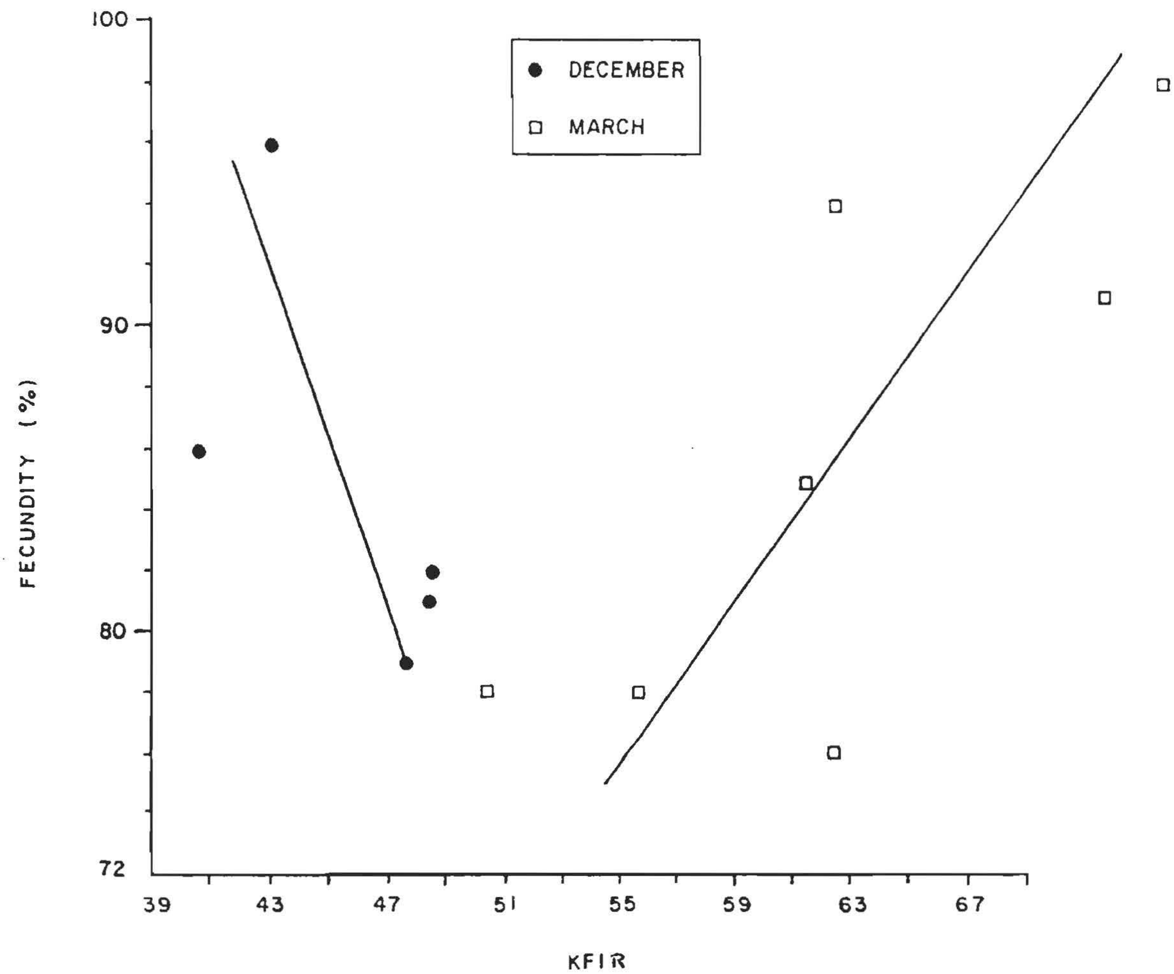

Figure 15. Relationship between Riney's kidney fat index (KFIR) and fecundity in individual samples obtained from the Beverly herd, 1980-87.

Table 11. Riney's kidney fat index (KFIR) of pregnant and non-pregnant female caribou obtained from the Beverly herd in December (1982-86) and March (1980-87).

Age class (yr)	KFIR[1] in December						KFIR[1] in March					
	Pregnant			Not pregnant			Pregnant			Not pregnant		
	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*
1.5- 2	39.3		1	36.6	2.5	23	79.6	5.9	8	**37.0**	1.5	54
2.5- 3	64.7	6.6	17	**33.2**[2]	2.4	12	76.4	3.0	64	**38.5**	3.1	21
3.5- 4	52.1	3.1	32	**31.4**	5.5	8	74.4	2.9	54	**35.2**	3.6	11
4.5- 5	51.8	3.8	22	**26.1**	3.6	3	73.9	3.5	47	**29.5**	3.1	7
5.5-11	49.1	1.9	64	**27.3**	1.5	14	69.1	1.4	228	**34.4**	2.6	29
>11	41.1	3.3	17	**26.9**		1	52.5	3.1	32	**38.5**	9.6	4
> 2	51.0	1.5	152	**29.9**	1.6	38	70.2	1.1	425	**35.5**	1.7	72
> 5	47.5	1.7	81	**27.2**	1.4	15	67.1	1.3	260	**34.9**	2.6	33

[1] *KFIR = 100 KF/KW*, where KF is weight of fat around both kidneys (grams) and KW is weight of both kidneys (grams) (Riney 1955).
[2] **Bold** indicates significant difference (*P* <0.05) between those pregnant and not pregnant.

In pooled samples obtained in December, significant differences in FEF between pregnant and non-pregnant females occurred only in large groupings (>1, >2, and >3 years) (**App. 13**). In March samples, significant differences also occurred in two of the six standard age classes of breeding-age females. Similar values in December and March samples allowed us to group early- and late-winter samples (**Table 12**).

Frequency distributions of FEF in pregnant and non-pregnant females showed almost cornplete overlap (**Fig. 19**). Both were slightly skewed, normal distributions. Relationships between FEF in 2% intervals and fecundity for all females >1 year old were strong except for a few erratic values caused by small sample sizes (**Fig. 20**).

Figure 16

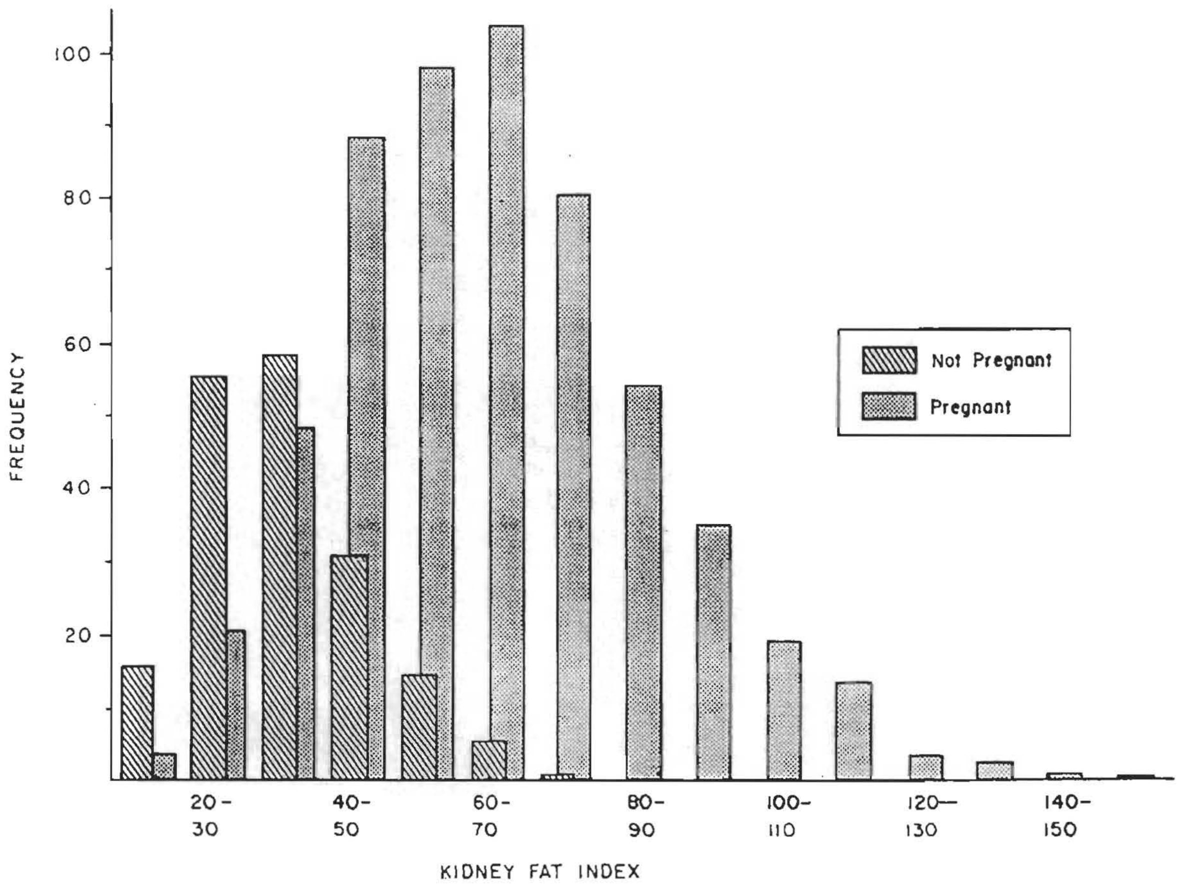

Figure 16. Frequency distributions of Riney's kidney fat index (KFIR) of pregnant and non-pregnant female caribou >1 year old sampled from the Beverly herd in December and March, 1982 through 1987.

Figure 17

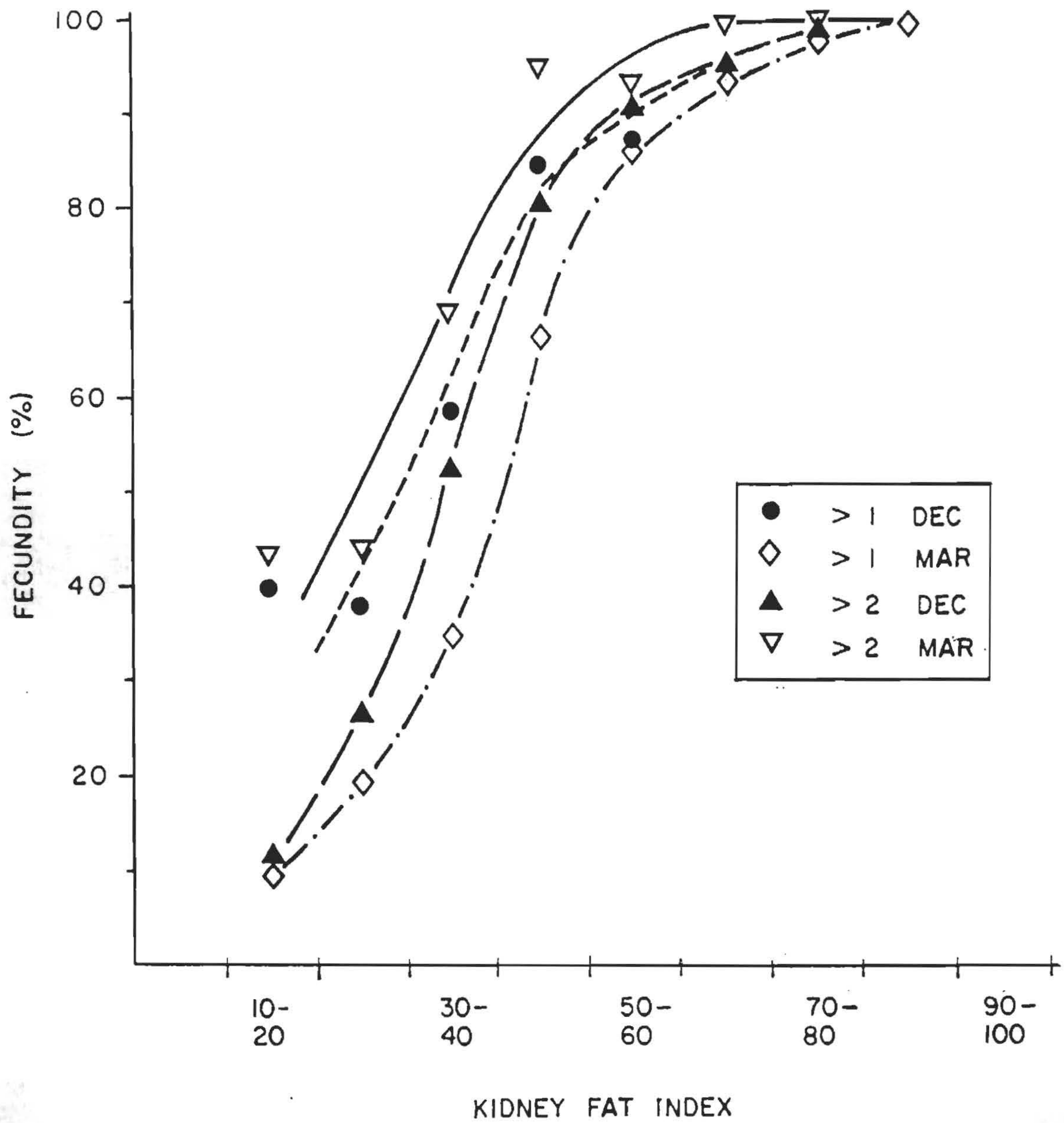

Figure 17. Relationship between Riney's kidney fat index and pregnancy rate of female caribou older than 1 and 2 years in pooled samples from December (1982-86) and March (1982-87).

Figure 18

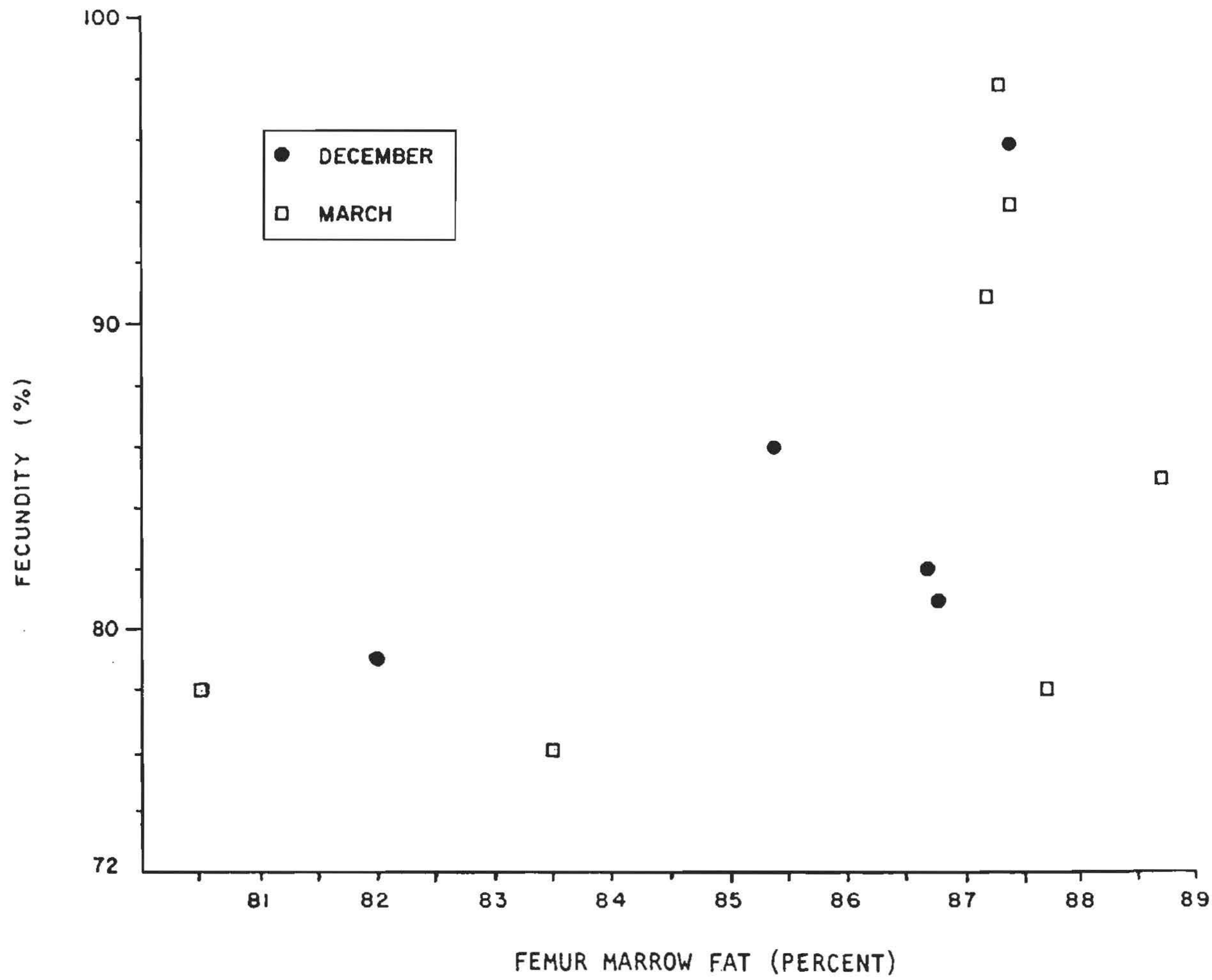

Figure 18. Relationship between mean percent fat in femur marrow and fecundity of females >4 years old based on individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87).

Table 12. Percent fat in marrow of femur bones of pregnant and non-pregnant female caribou of the Beverly herd in pooled samples from 1980 through 1987.

Age class (yr)	Fat in femur marrow (%)						Significance
	Pregnant			Not pregnant			
	Mean	SE	*n*	Mean	SE	*n*	
1.5- 2	88.7	0.8	8	**85.8**[1]	0.7	64	$P < 0.05$
2.5- 3	87.9	0.4	79	**83.8**	1.2	30	$P < 0.01$
3.5- 4	88.4	0.4	76	**83.9**	1.6	19	$P < 0.02$
4.5- 5	88.4	0.3	61	83.1	3.0	10	NS
5.5-11	88.0	0.2	254	**77.4**	2.2	38	$P < 0.01$
>11	86.4	0.4	42	85.6	1.7	5	NS
> 1	88.0[2]	0.1	521	**83.1**	0.7	166	$P < 0.001$

[1] **Bold** indicates significant difference (*P* <0.05) between those pregnant and not pregnant.
[2] One not "aged."

Table 13. Percent water in mandibular tissue of pregnant and non-pregnant caribou of the Beverly herd in pooled samples from 1982 through 1987.

Age class (yr)	Water in mandibular tissue (%)						Significance
	Pregnant			Not pregnant			
	Mean	SE	*n*	Mean	SE	*n*	
1.5- 2	41.1	0.25	9	41.1	0.71	60	NS
2.5- 3	35.6	0.61	69	**38.6**[1]	1.28	24	$P < 0.05$
3.5- 4	33.8	0.61	73	**41.6**	2.76	15	$P < 0.02$
4.5- 5	33.7	0.74	58	**36.8**	2.05	8	$P < 0.01$
5.5-11	33.2	0.44	237	**39.5**	1.37	38	$P < 0.001$
>11	33.6	0.83	40	35.7	3.48	4	NS
> 1	33.9	0.28	486	**40.0**	0.60	149	$P < 0.001$
> 2	33.7	0.28	477	**39.2**	0.87	89	$P < 0.001$
> 5	33.3	0.40	277	**39.2**	1.29	42	$P < 0.001$

[1] **Bold** indicates significant difference between those pregnant and not pregnant.

Figure 19

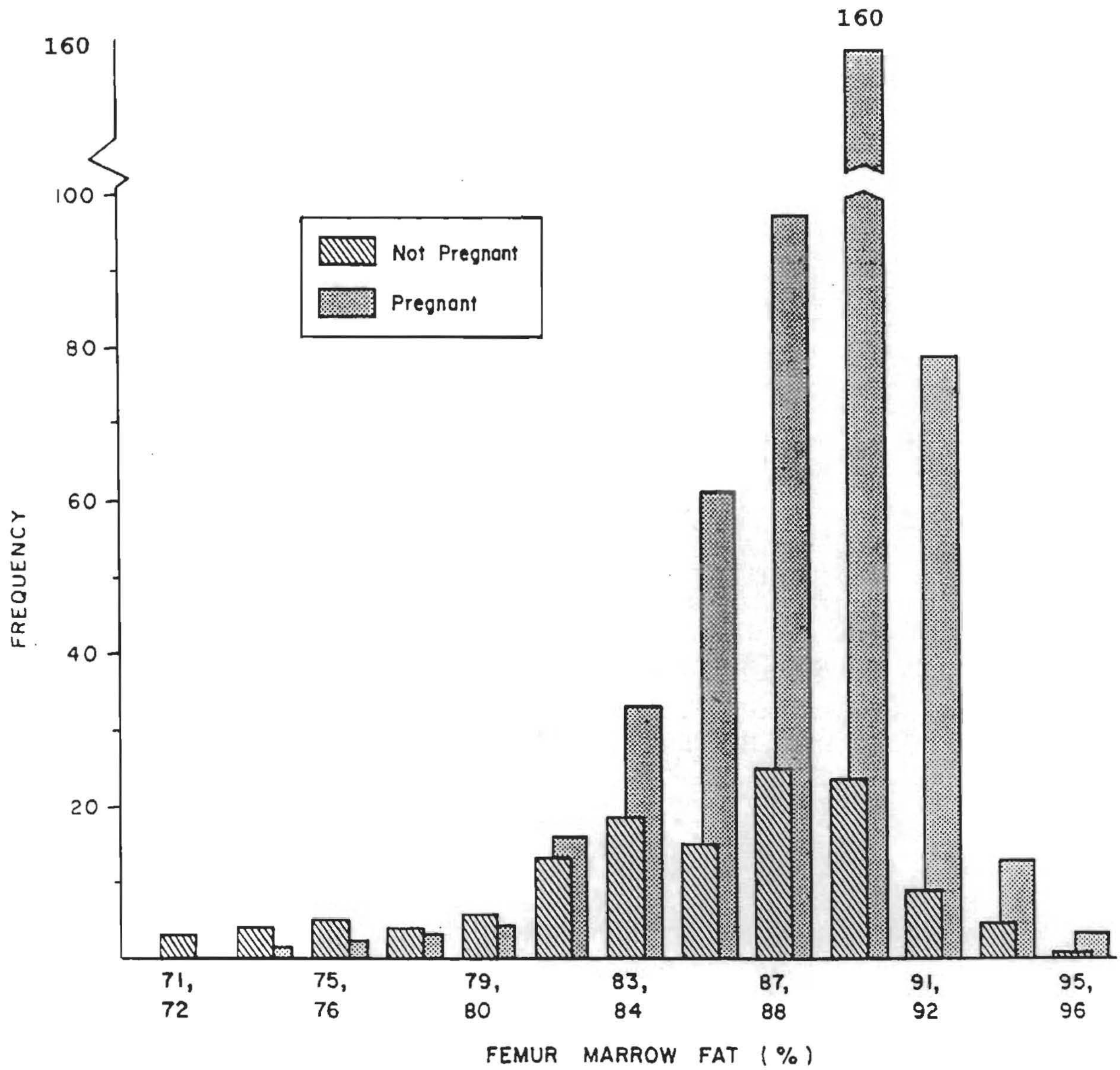

Figure 19. Frequency distribution of femur marrow fat in 2% classes in pregnant and non-pregnant female caribou >1 year old sampled from the Beverly herd from 1982 through 1987.

Figure 20

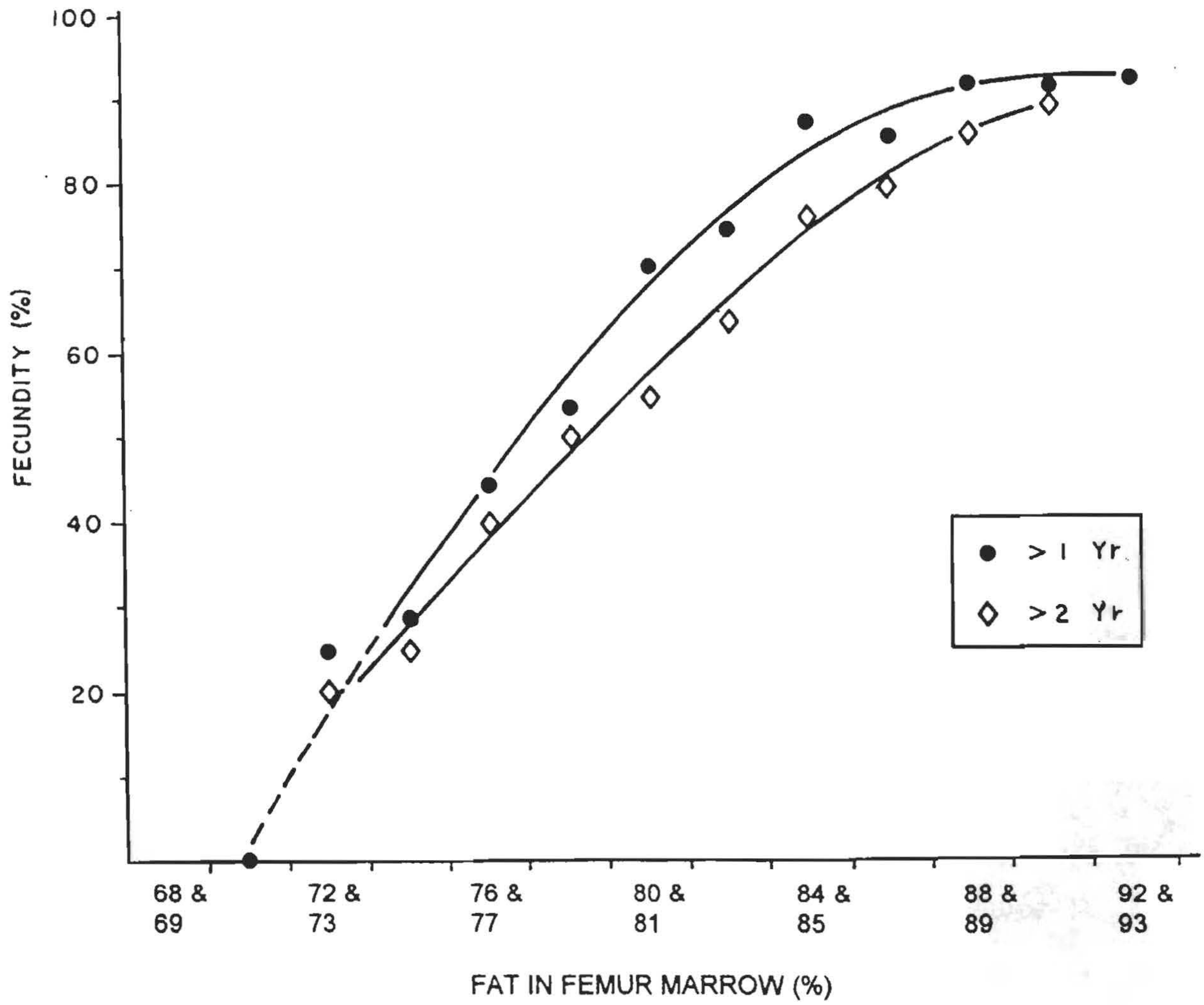

Figure 20. Relationship between percent fat in femur marrow and pregnancy rate of female caribou >1 and >2 years old in pooled samples from winters 1981-82 through 1986-87.

Mandibular water (MAW)

Fecundity-mandibular water regressions for March and March plus December samples (**Fig. 21**) were significant (App. 10) for females >4 years old. Regressions for MAW produced higher *r* values than those for FEF.

Differences ($P < 0.05$) in percent MAW occurred between pregnant and non-pregnant females in all cases except for the >11 years class in which one sample size was only four (**Table 13**). Variation within age groups was small.

Frequency distributions of MAW in pregnant and non-pregnant females >1 year old (**Fig. 22**) were offset about one interval (four percentage points).

Relationship between MAW intervals and fecundity of pooled females >1 year old was good, although there were two erratic values caused by samples of seven and two (**Fig. 23**).

Condition index "fat percentage" (FATP)

Fecundity and FATP (Huot and Goudreault 1985) in March samples of females >4 years old were significantly ($P < 0.05$) related (**App.14**) but not in December samples (**Fig. 24**).

FATP values for pregnant and non-pregnant females differed ($P < 0.05$) in all age classes where sample size was >4 (**Table 14**). Values are also given for CONI (condition index of Connolly 1981) (**App. 15**) but since FATP is based on CONI (App.1) fecundity-CONI relationships are not presented here because results were similar to those for FATP.

The frequency distributions (normal) of FATP at 1% intervals (e.g., 5.01-6%) for pregnant and non-pregnant females showed good separation (3%) of mode values (**Fig. 25**) with pregnant females having larger FATP values than non-pregnant ones.

Figure 21

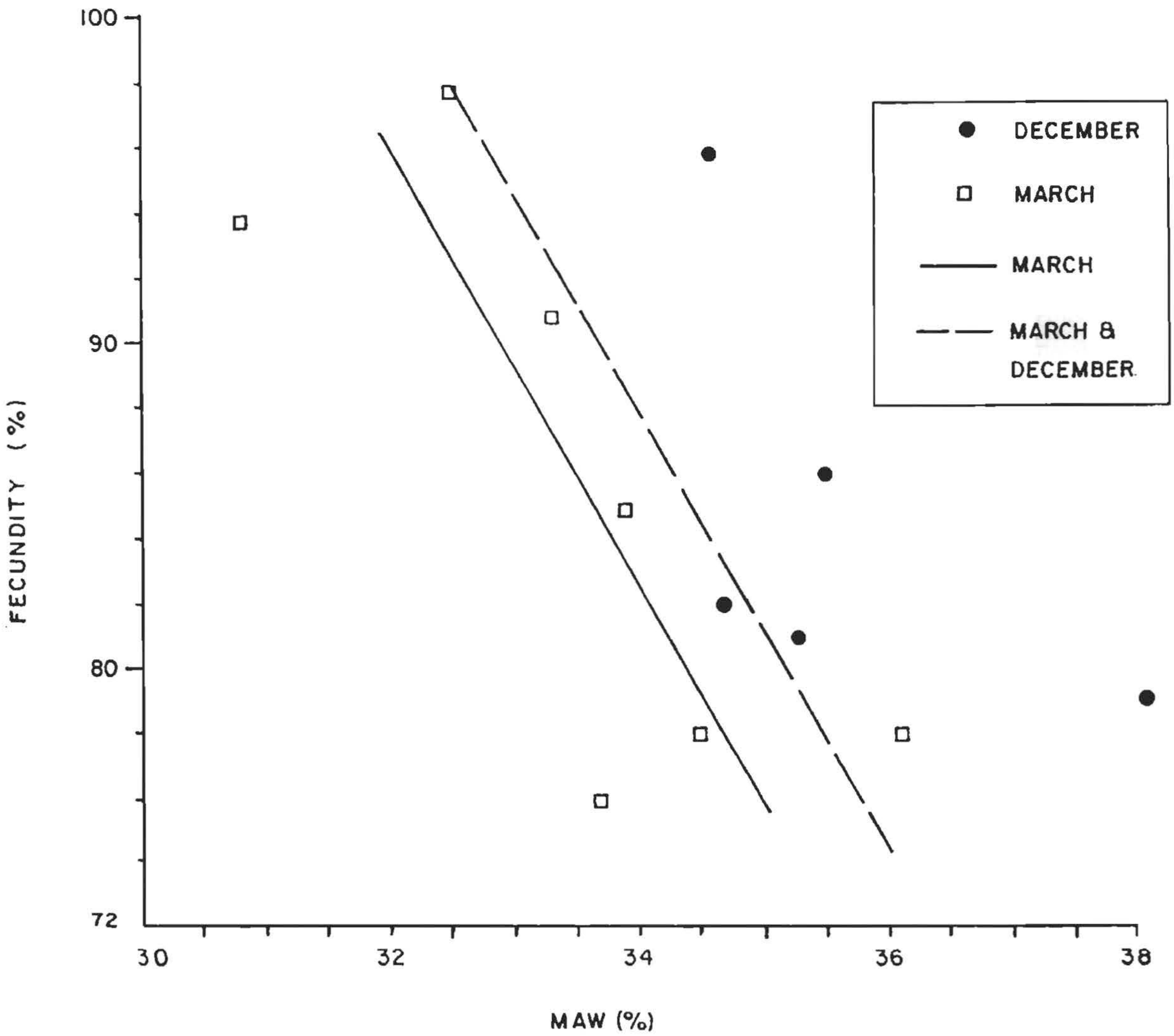

Figure 21. Relationship between mean percent water in mandibular tissue and fecundity of female caribou >4 years old in individual samples obtained in December (1982-86) and March (1982-87).

Figure 22

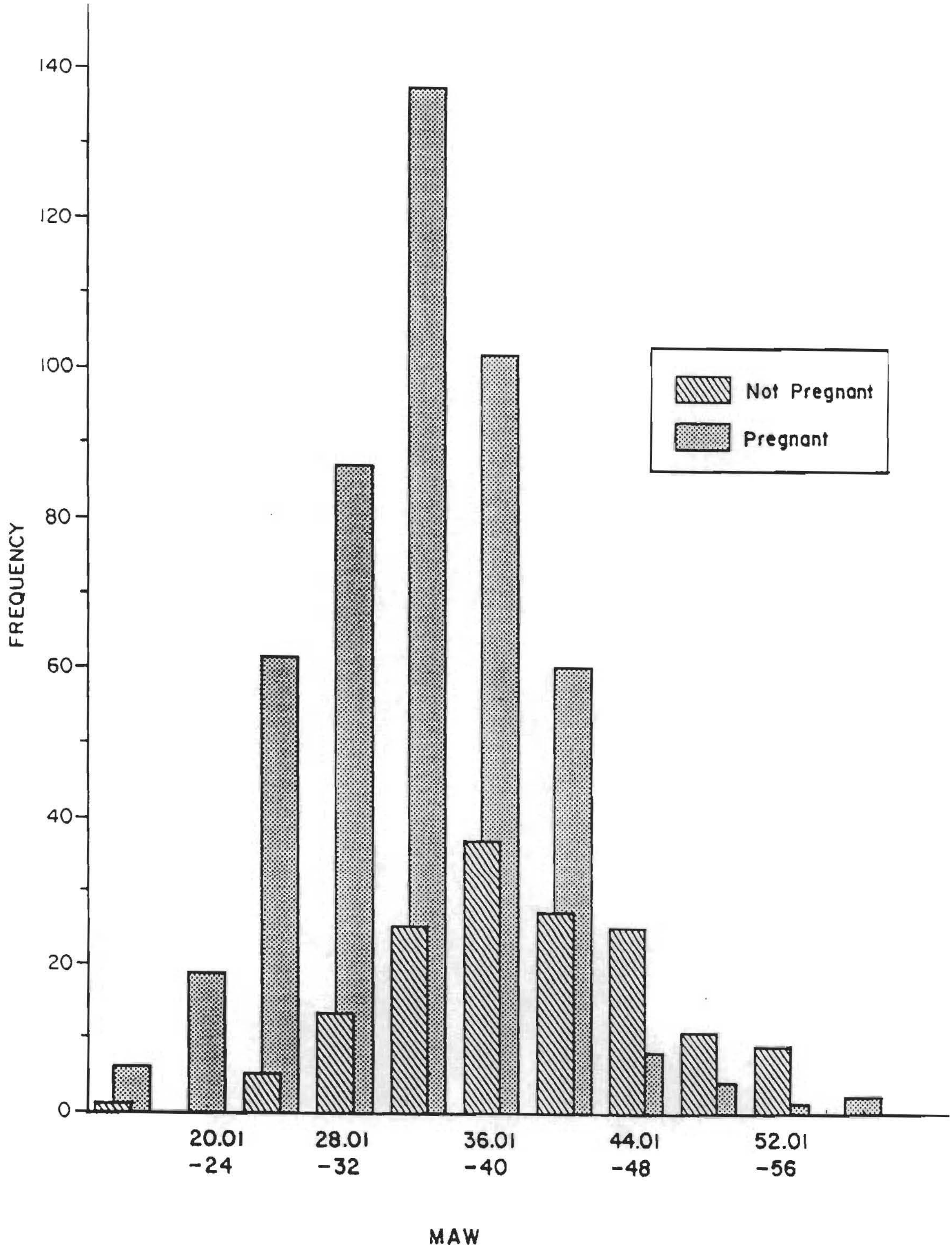

Figure 22. Frequency distributions of percent mandibular water (MAW) in pregnant and non-pregnant female caribou >1 year old that were sampled from the Beverly herd, 1982 through 1987.

Figure 23

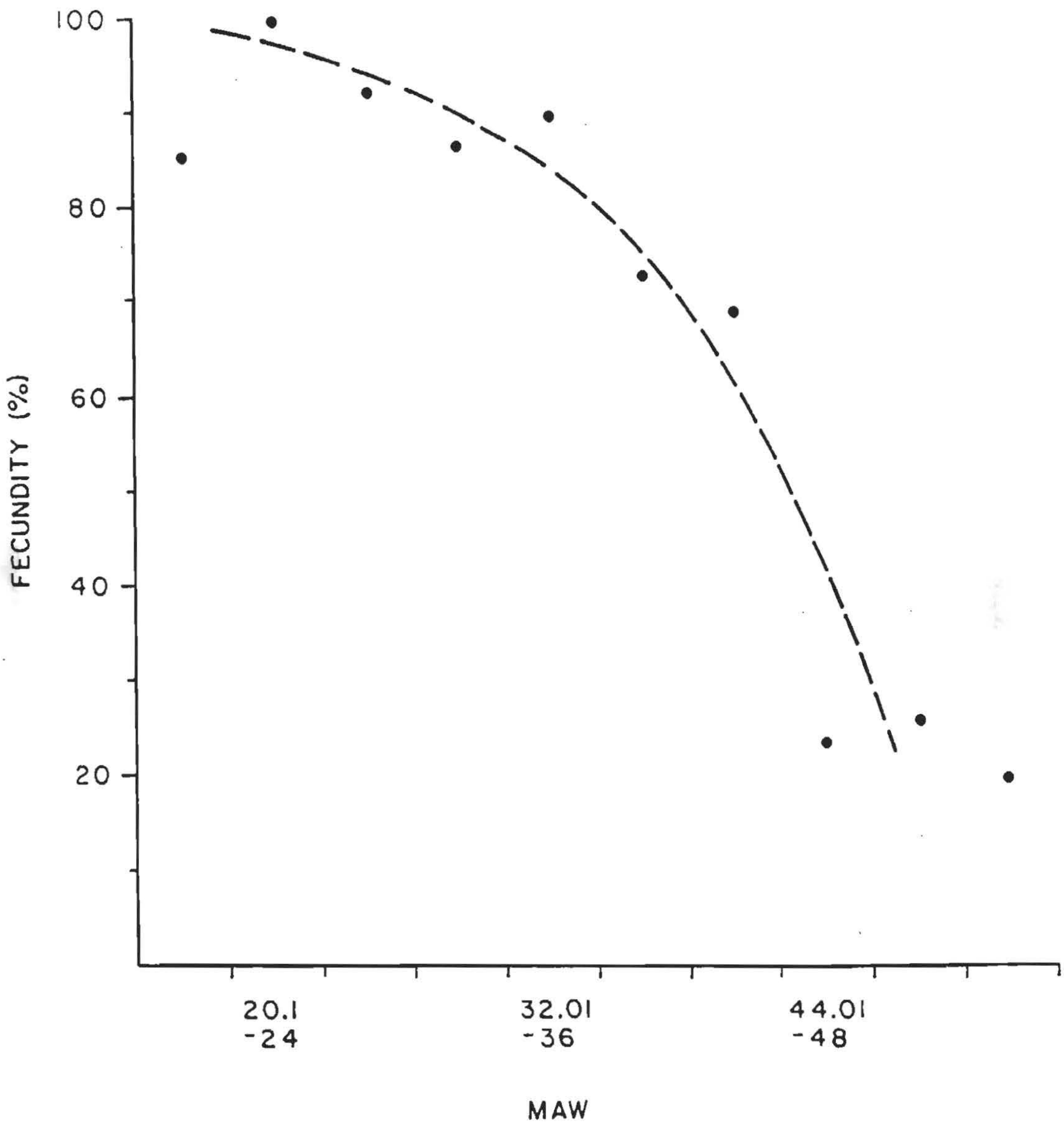

Figure 23. Relationship between percent mandibular water (MAW) and fecundity of female caribou >1 year old in pooled samples obtained from the Beverly herd, 1982 through 1987.

Figure 24

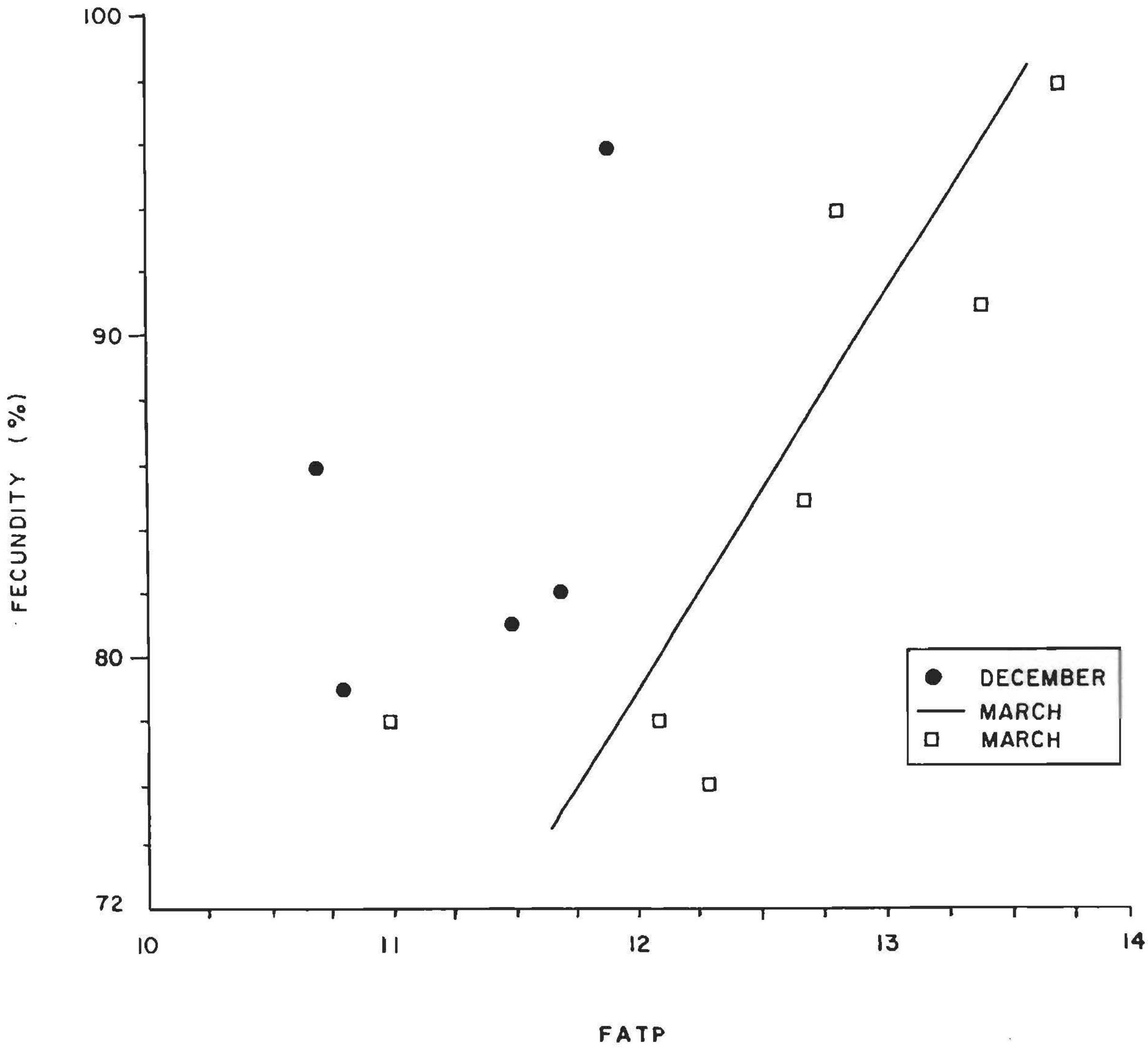

Figure 24. Relationship between calculated mean fat percentage (FATP) (Huot and Goudreault 1985) values and fecundity of female caribou >4 years old in individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87).

Table 14. Condition index "fat percentage" (FATP) in pregnant and non-pregnant female caribou sampled from the Beverly herd in December (1982-86) and March (1982-87).

Age class (yr)	FATP[1] in December						FATP[1] in March					
	Pregnant			Not pregnant			Pregnant			Not pregnant		
	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*
1.5-2	10.6		1	10.0	0.26	22	14.6	0.54	6	**10.3**	0.20	39
2.5-3	12.7	0.61	17	**9.6**	0.38	10	14.0	0.29	60	**10.2**	0.40	19
3.5-4	11.8	0.32	28	**9.4**	0.52	8	13.9	0.26	48	**10.2**	0.41	10
4.5-5	12.0	0.34	16	8.0	0.45	2	13.7	0.33	43	**9.4**	0.55	7
6-11	11.6	0.22	51	**8.7**	0.42	12	13.4	0.15	197	**9.1**	0.43	26
>11	10.7	0.41	13	9.4		1	11.7	0.31	28	10.3	1.05	4
> 1	11.7	0.16	126	**9.5**	0.19	55	13.5	0.11	382	9.8	0.17	106
> 2	11.7	0.16	125	**9.1**	0.25	33	13.5	0.11	376	**9.7**	0.24	66
> 5	11.4	0.19	64	**8.7**	0.39	13	13.2	0.40	225	**9.3**	0.40	30

[1] *FATP = 0.845 + 0.091 ([KFIR - 20] + FEF)*, where *KFIR = 100 x kidney fat (g)/kidney weight (g)* and FEF is percent fat in femur marrow (Huot and Goudreault 1985).
[2] **Bold** indicates significant difference (*P* <0.05) between those pregnant and not pregnant.

Curvilinear relationships between FATP and fecundity for December and March were sufficiently different that separate curves were required (**Fig. 26**). Fecundity increased from 0 to 100% as FATP increased from 6 to 13% in December samples.

Condition index "dissectible fat" (DFAT)

The relationship between the means for DFAT (Adamczewski et al. 1987) and fecundity of females >4 year old (**Fig. 27**) in individual collections was significant

Figure 25

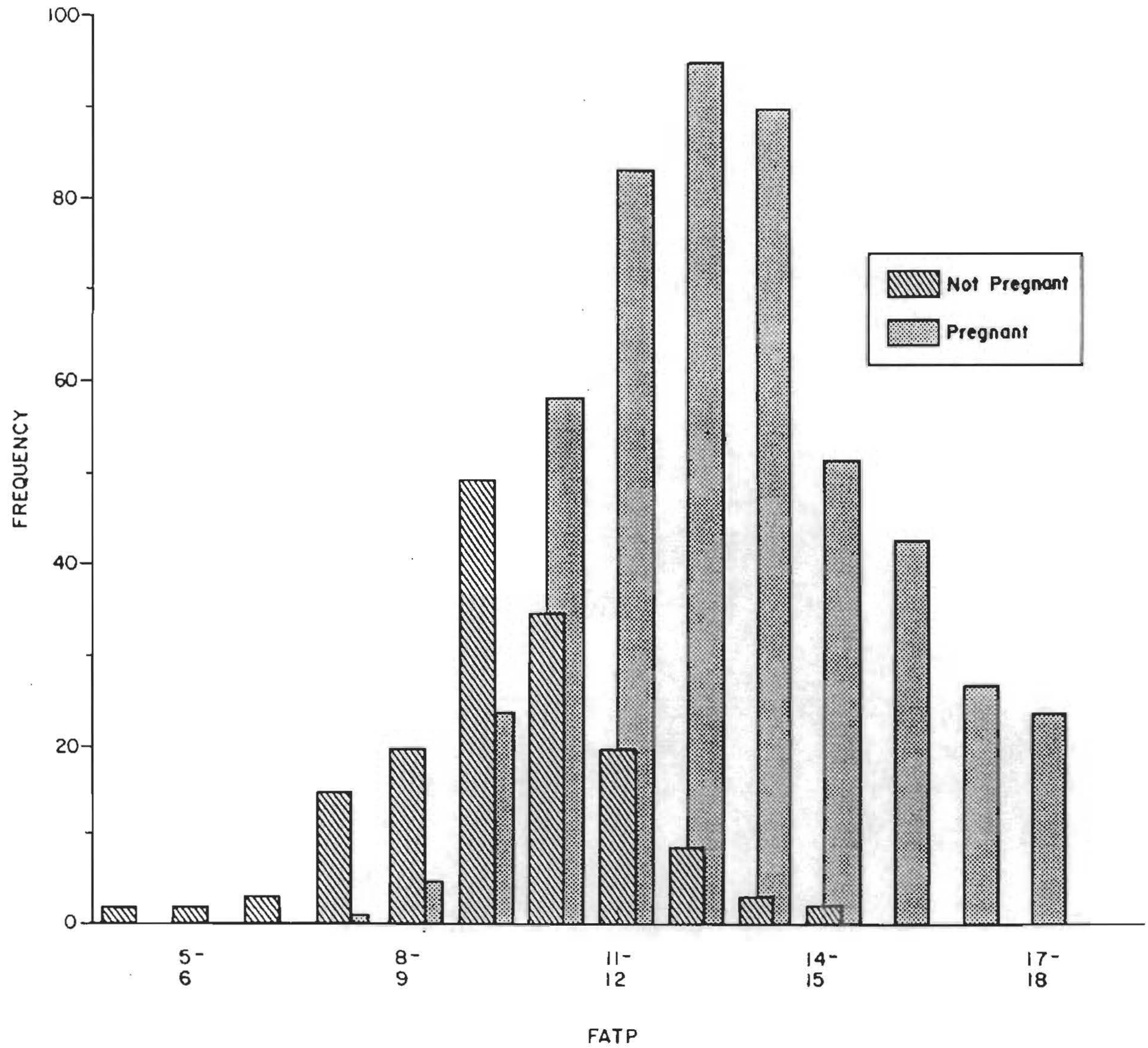

Figure 25. Frequency distributions of calculated fat percentage (FATP) (Huot and Goudreault 1985) in pregnant and non-pregnant female caribou >1 year old that were collected from the Beverly herd, 1980 through 1987.

Figure 26

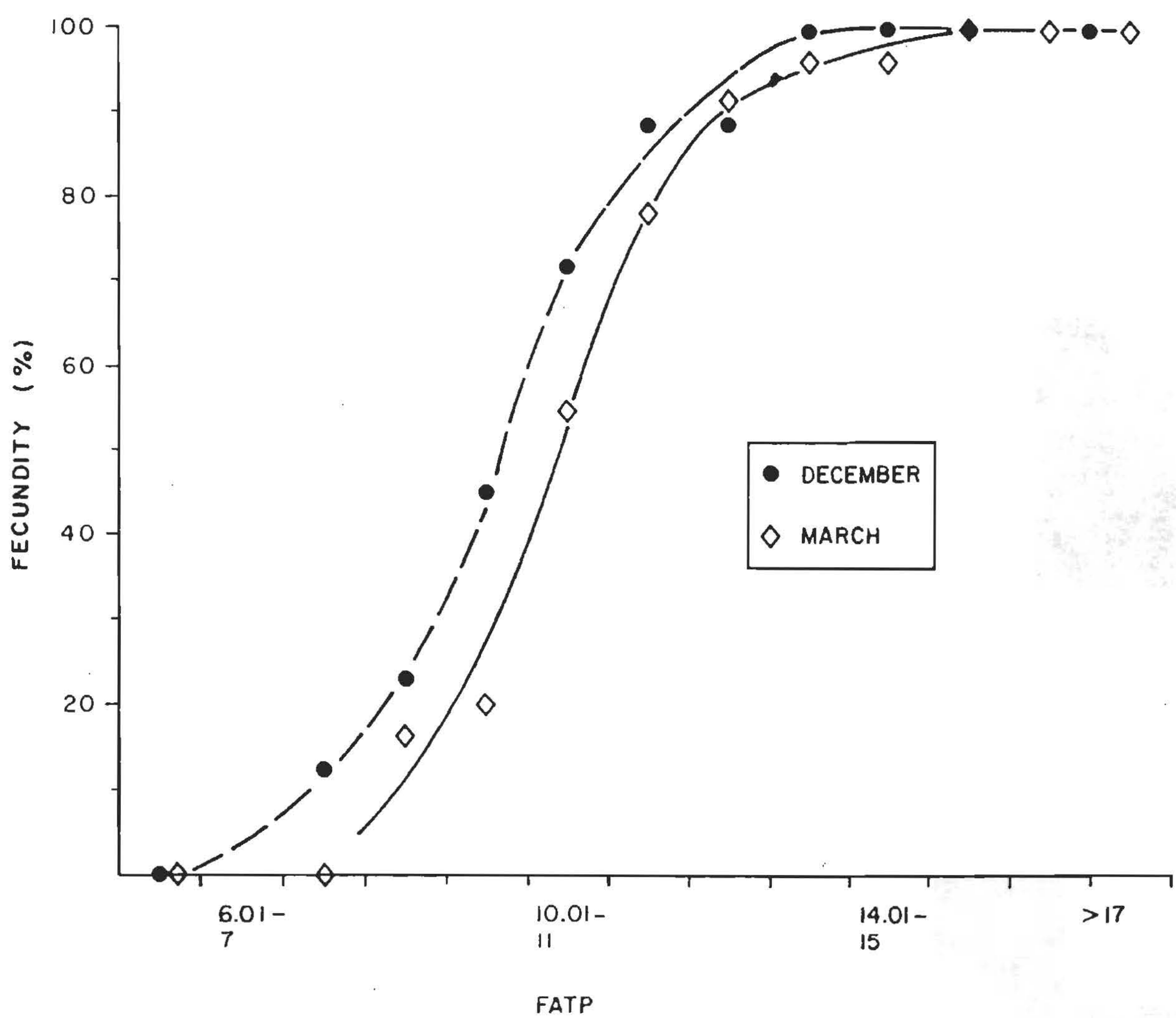

Figure 26. Relationship between calculated mean fat percentage (FATP) (Huot and Goudreault 1985) values and fecundity of female caribou >1 year old in pooled samples from December (1982-86) and March (1980-87).

Figure 27

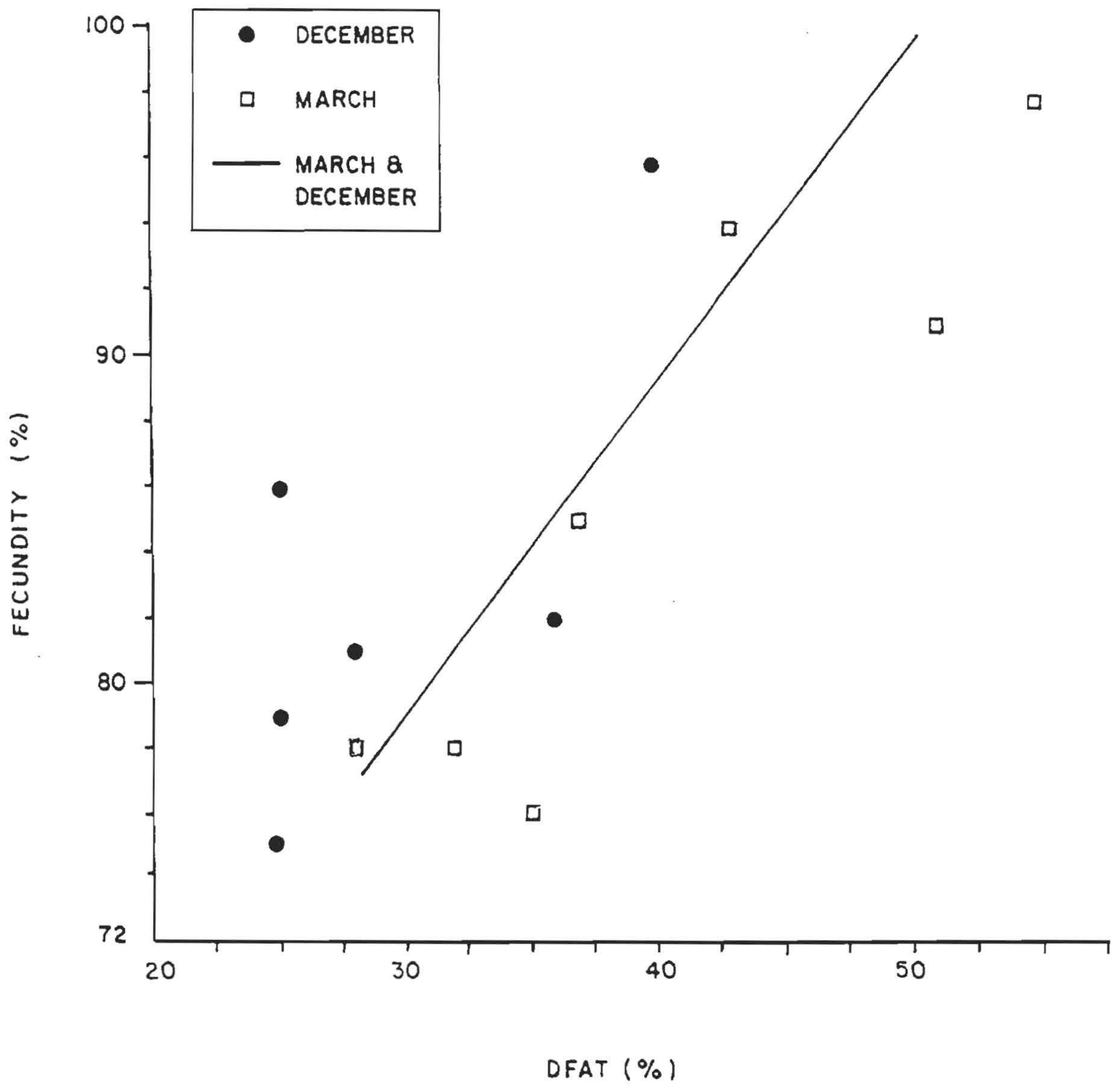

Figure 27. Relationship between calculated mean dissectible fat (DFAT) (Adamczewski et al. 1987) and fecundity of female caribou >4 years old in individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87).

Table 15. Condition index "dissectible fat" (DFAT) in pregnant and non-pregnant female caribou collected from the Beverly herd each December (1982-86) and March (1980-87).

Age class (yr)	DFAT[1] in December						DFAT in March					
	Pregnant			Not pregnant			Pregnant			Not pregnant		
	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*
1.5- 2	3.67		1	1.71	0.18	23	4.43	0.32	8	**1.31**	0.08	54
2.5- 3	4.51	0.47	17	**1.53**[2]	0.20	12	4.54	0.19	64	**1.34**	0.15	21
3.5- 4	3.90	0.32	32	**1.98**	0.51	8	4.67	0.20	54	**1.26**	0.17	11
4.5- 5	3.42	0.31	22	**1.02**	0.23	3	4.53	0.26	47	**1.32**	0.36	7
5.5-11	3.62	0.20	64	**1.10**	0.11	14	4.62	0.12	228	**1.66**	0.19	29
>11	3.75	0.46	17	1.78		1	3.76	0.28	32	2.30	0.82	4
> 1	3.76	0.14	153	**1.54**	0.11	61	4.54	0.08	433	**1.45**	0.08	127
> 2	3.77	0.14	152	**1.43**	0.14	38	4.54	0.08	425	**1.51**	0.11	72
> 4	3.60	0.16	103	**1.13**	0.10	18	4.52	0.10	307	**1.67**	0.18	40
> 5	3.65	0.19	81	**1.15**	0.11	15	4.51	0.11	260	**1.74**	0.20	33

[1] *DFAT* = [(*1.151 DBF*) + (*26.401 KF*)] - *0.246*, where DBF is depth of back fat (cm) and KF is kidney fat (kg) (Adamczewski et al. 1987).

[2] **Bold** indicates significant difference ($P < 0.01$) between those pregnant and not pregnant.

($P < 0.01$) for March and combined December and March samples (App. 14). In the 2.5-3 year class, relationships were significant in all collections; in the 3.5-4 year class, only in March samples. In pooled 2.5-4 year group, March data and pooled December and March data produced significant regressions (App. 14).

Values of DFAT were much higher in pregnant caribou than their non-pregnant counterparts in both December and March (**Table 15**). Higher values in March were caused by increase in kidney fat from December to March.

A frequency distribution of DFAT values in pregnant and non-pregnant caribou indicated some overlap (**Fig 28**). Most females with DFAT values >2-3 kg were pregnant; almost all with values >3-4 kg.

Curves for pregnancy rates *vs.* DFAT in pooled samples of females >1 year and >2 years old were similar (**Fig. 29**) and indicated an increase from 0 to 95% as DFAT increased from 0 to 3.5 kg.

Condition index "A" (CIA)

The CIA was based on body weight, back fat, kidney fat, and femur fat with size adjusted by femur length (App. 1). There was a significant ($P < 0.01$) relationship between CIA and fecundity in March samples of females >4 year old using means from individual collections from 1982 through 1987 (**Fig. 30, App. 16**). The relationship in December collections was not significant ($r = 0.17$).

Regressions of CIA and fecundity in age classes 2.5-3 and 2.5-4 years were all significant in both collection periods and combined collection periods (App. 16). Regressions in age classes 3.5-4 years and >4 years were significant for March and combined samples but not for December samples (App. 16).

Values for pregnant females were 50-100% higher than for non-pregnant ones (**Table 16**). Values increased from December to March in some age classes and in grouped data for ages >1 year and >2 years. In non-pregnant females, there was little change in CIA values from December to March.

There was almost complete overlap of the normal frequency distribution of CIA in pregnant and non-pregnant females but the modes differed by 12 units (**Fig. 31**).

The relationship between CIA and pregnancy rate in all females of breeding age was slightly different for December and March collections (**Fig. 32**).

Figure 28

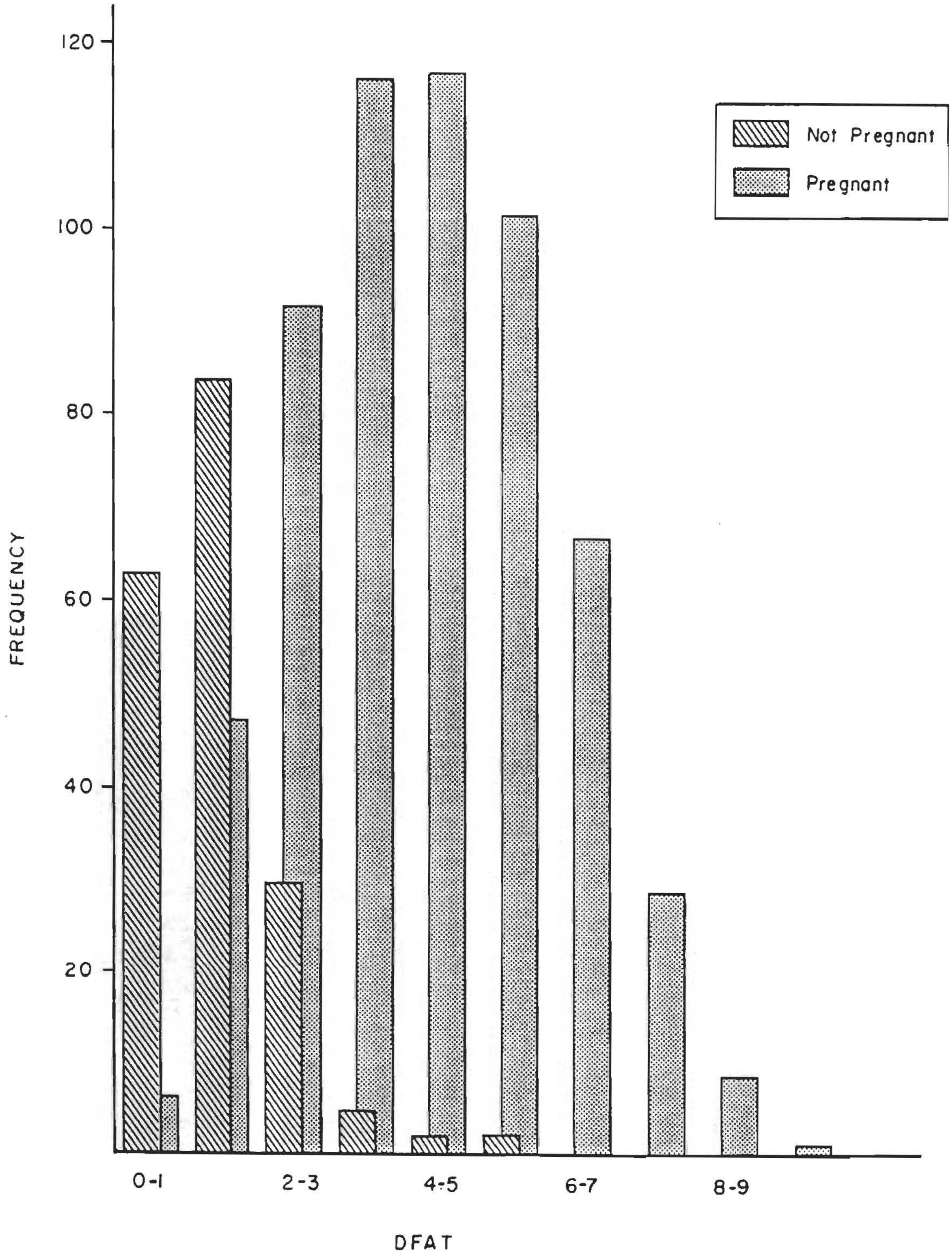

Figure 28. Frequency distributions for calculated dissectible fat (DFAT, Adamczewski et al. 1987) of pregnant and non-pregnant female caribou >1 year old in samples from the Beverly herd, 1980 through 1987.

Figure 29

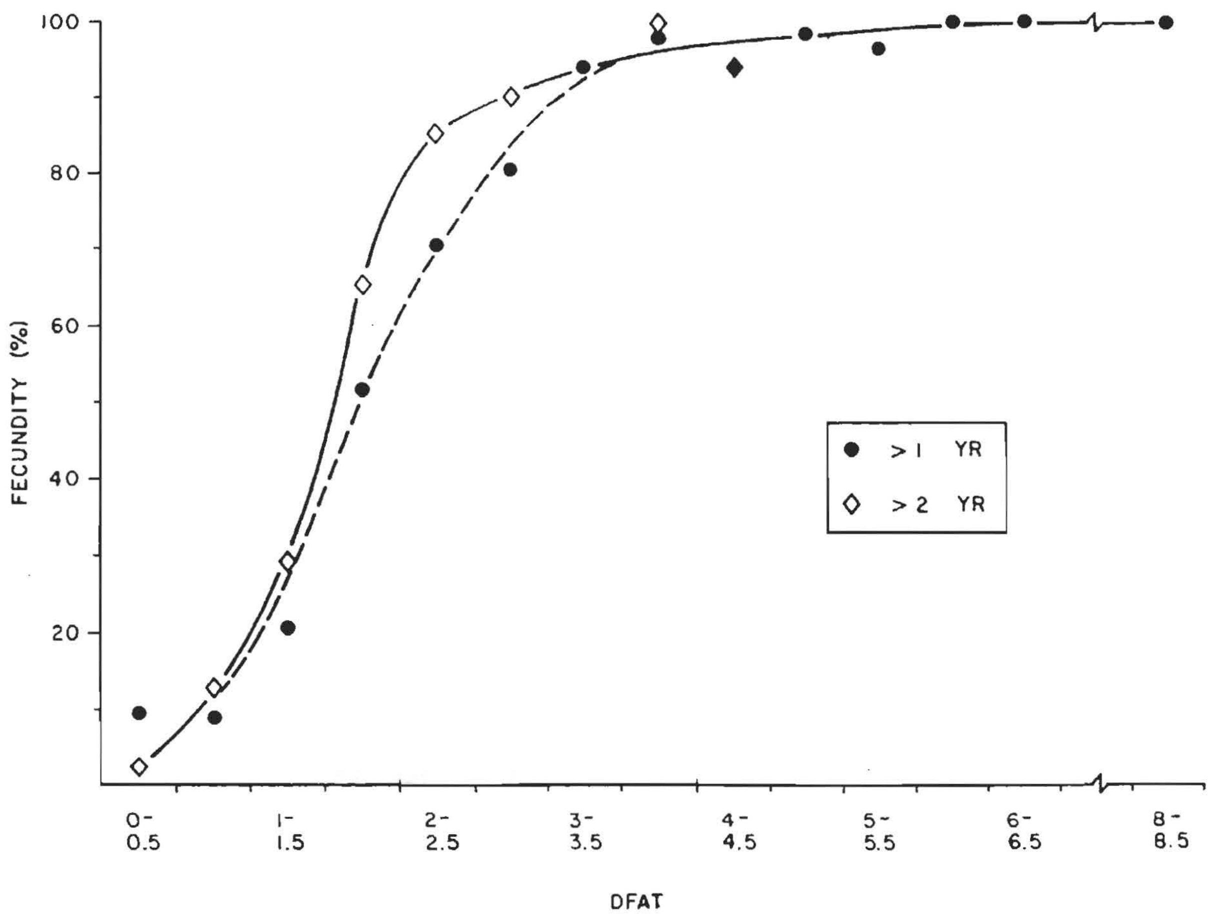

Figure 29. Relationship between calculated dissectible fat (DFAT) (Adamczewski et al. 1987) and fecundity of female caribou older than 1 and 2 years in pooled samples from the Beverly herd, 1980 through 1987.

Figure 30

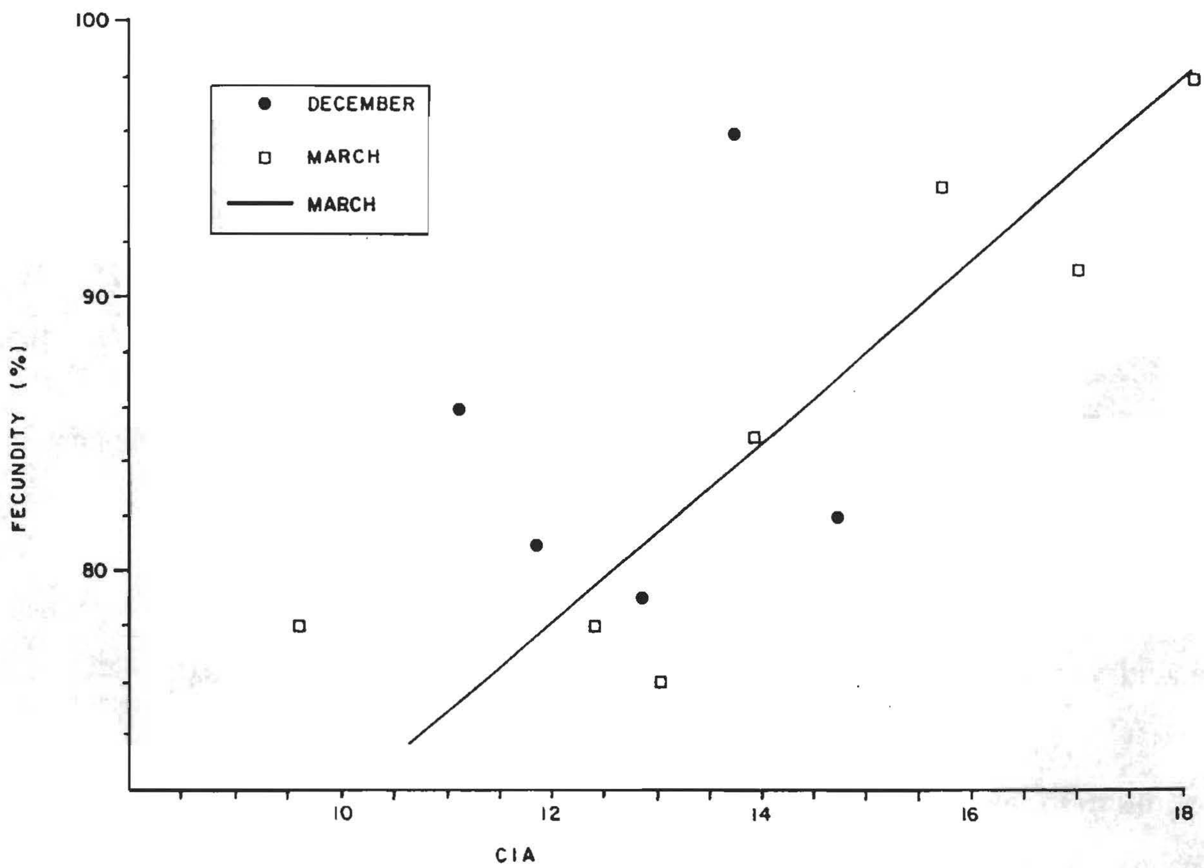

Figure 30. Relationship between condition index A (CIA) and fecundity of female caribou >4 years old in individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87).

Table 16. Condition index "A" (CIA) of pregnant and non-pregnant caribou sampled in December (1982-86) and March (1980-87) from the Beverly herd.

Age class (yr)	CIA[1] in December						CIA[1] in March					
	Pregnant			Not pregnant			Pregnant			Not pregnant		
	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*
1.5-2	11.0	2.99	2	9.3	0.48	21	13.7	1.39	7	**7.7**	0.27	49
2.5-3	16.2	1.14	17	**8.4**[2]	0.64	12	16.0	0.48	62	**8.0**	0.38	20
3.5-4	14.6	0.83	32	**10.6**	1.28	8	16.2	0.54	50	**7.5**	0.52	12
4.5-5	12.8	0.87	21	**6.4**	0.42	3	15.3	0.60	46	**8.0**	0.82	8
6-11	13.7	0.58	64	**7.5**	0.43	13	15.9	0.31	225	**8.3**	0.56	29
>11	14.4	1.41	16	10.5		1	14.6	0.66	30	**10.9**	2.00	4
> 1	14.1	0.39	152	**8.8**	0.33	58	15.8	0.21	403	**8.1**	0.23	123
> 2	14.1	0.39	150	**8.5**	0.44	37	15.8	0.22	396	**8.3**	0.29	72

[1] *CIA = 100* [(*WT/10*) + *BF* + (*KF/10*) + (*FEF/10*)]/*FEL*, where WT is whole body weight (kg), BF is depth of back fat (mm), KF is kidney fat (g), and FEL is femur length (mm) (Thomas and Kiliaan 1998a).

[2] **Bold** indicates significant difference (*P* <0.05) between those pregnant and not pregnant.

The sample that deviated from the curvilinear regression contained only nine females. Fecundity increased from 0 to 100% as CIA increased from 5 to 18 units.

Condition index "B" (CIB)

A regression of Condition index B (CIB) (App. 1) and fecundity of females >4 years old, using means for individual collections (**Fig. 33**), produced significant relationships for March and combined December and March samples (App. 16). Regressions for younger females were all significant with only one exception (December sample, age class 3.5-4 years).

Differences in CIB were large between pregnant and non-pregnant females in all age classes (**Table 17**). Largest differences were in the March collections.

Figure 31

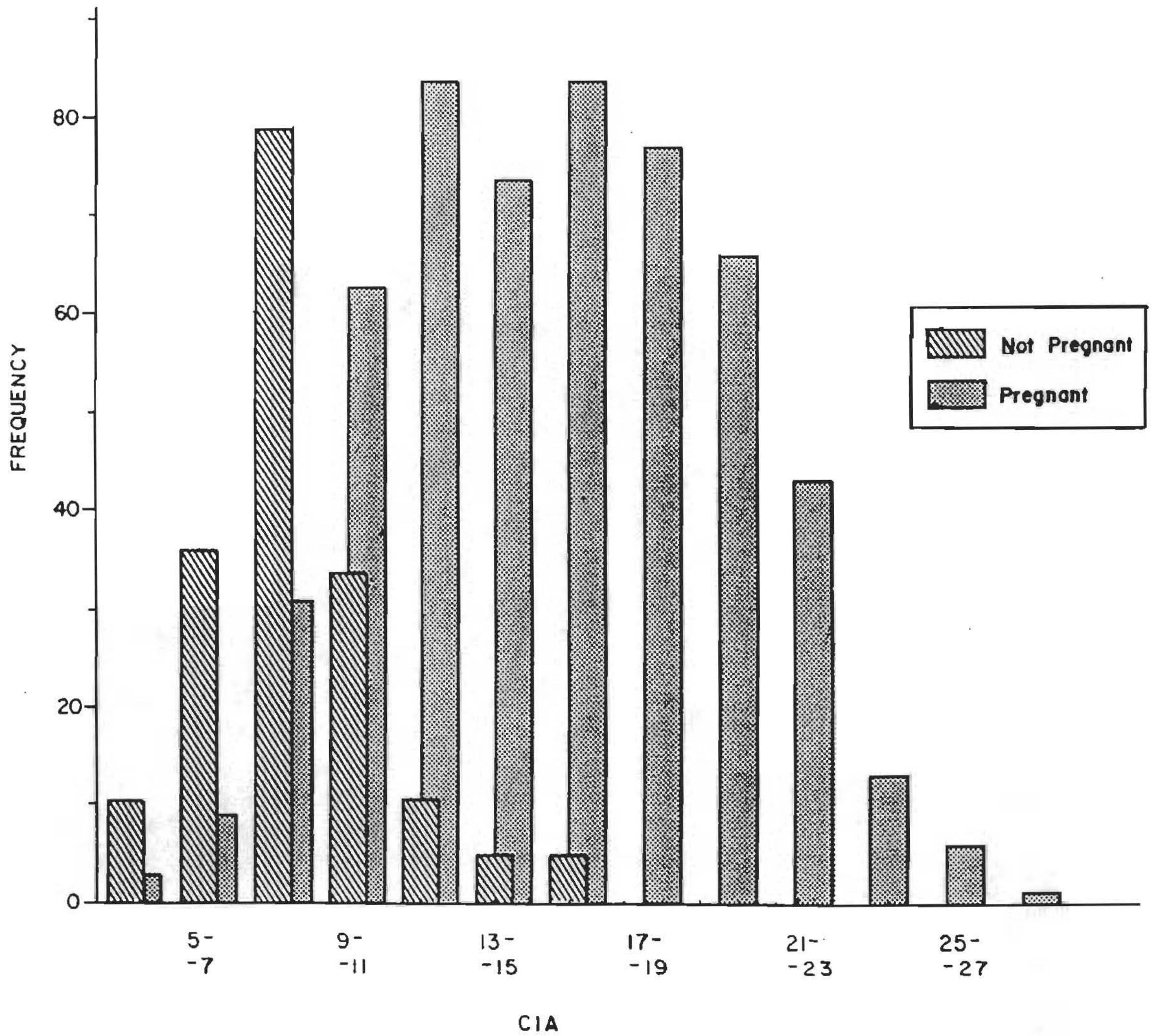

Figure 31. Frequency distributions of condition index A (CIA) in pregnant and non-pregnant female caribou >1 year old in samples from the Beverly herd from 1980 through 1987.

Figure 32

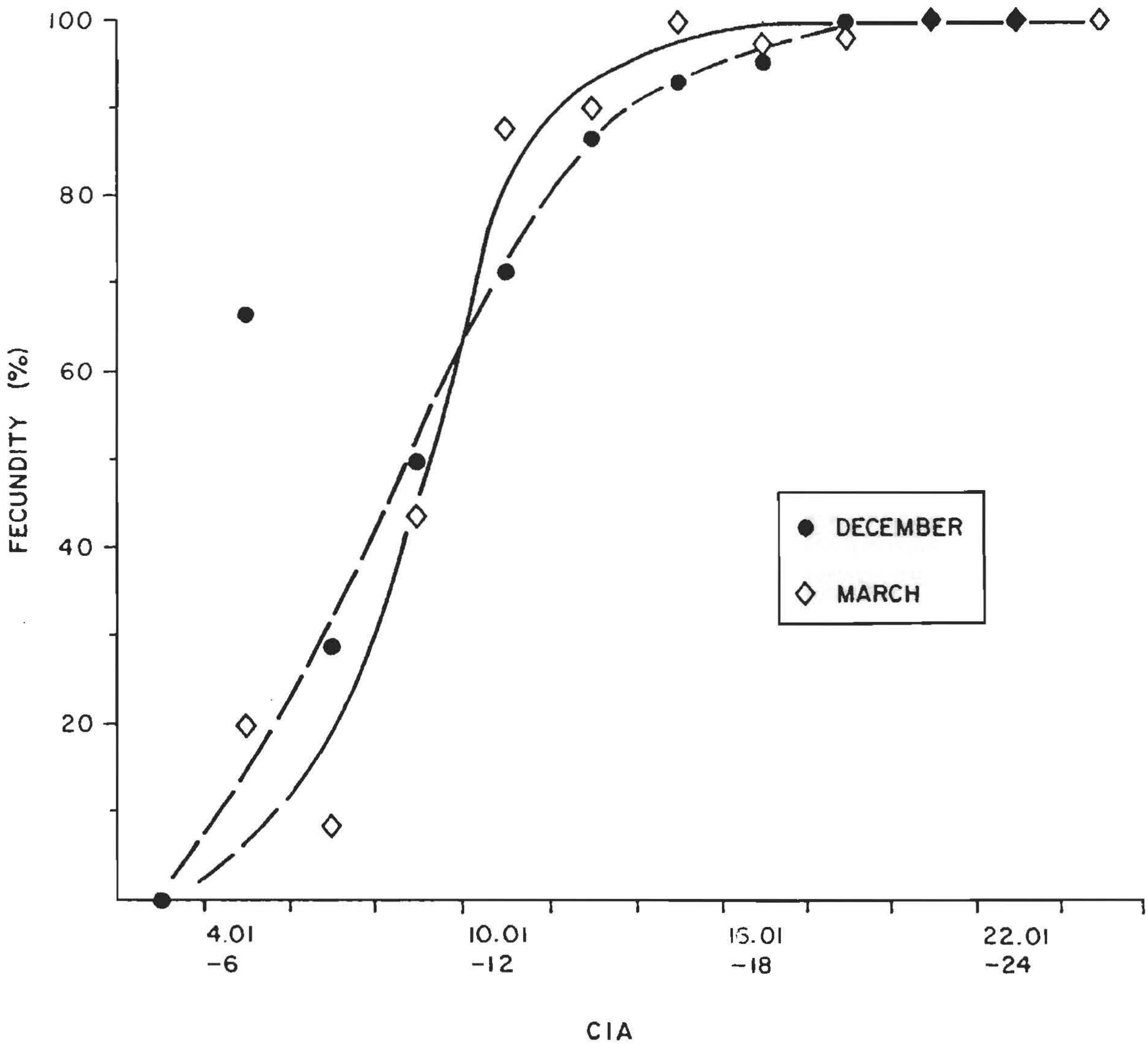

Figure 32. Relationship between condition index A (CIA) and fecundity of female caribou >1 year old in pooled samples from December (1982-86) and March (1980-87).

Figure 33

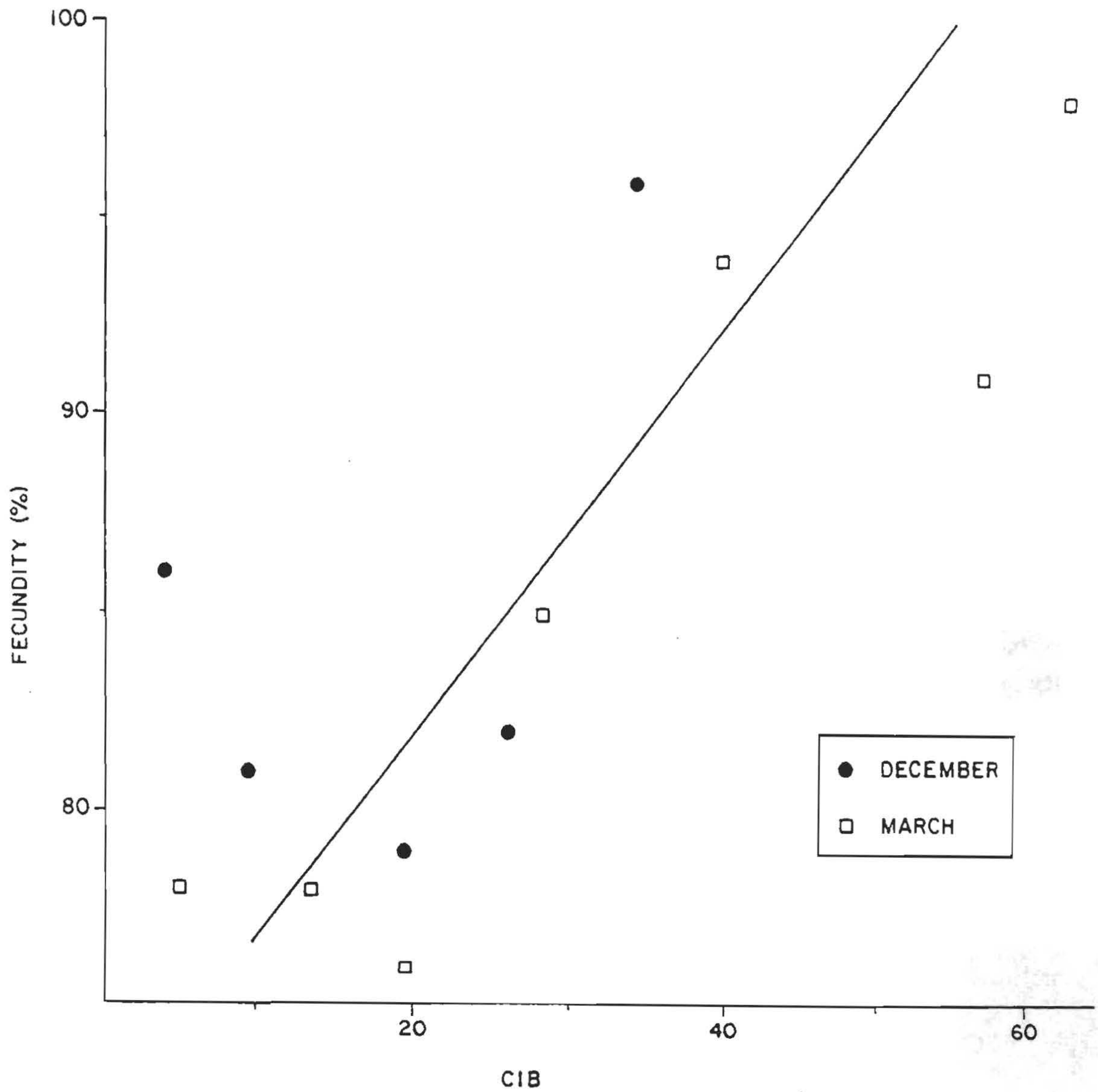

Figure 33. Relationship between condition index B (CIB) and fecundity of female caribou >4 years old in individual samples obtained in December (1982-86) and March (1980-87) from the Beverly herd.

Table 17. Condition index "B" (CIB) of pregnant and non-pregnant caribou sampled from the Beverly herd in December (1982-86) and March (1980-87).

Age class (yr)	CIB[1] in December						CIB[1] in March					
	Pregnant			Not pregnant			Pregnant			Not pregnant		
	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*
1.5- 2	7.0		1	-32.4	3.7	23	32.5	6.7	7	**-40.4**	2.0	53
2.5- 3	33.6	9.2	17	**-26.1**[2]	4.7	12	38.0	3.9	63	**-32.7**	3.1	21
3.5- 4	31.0	6.5	30	**-7.6**	11.6	8	40.6	4.1	53	**-32.3**	4.2	11
4.5- 5	21.6	6.4	22	**-32.0**	6.1	3	44.7	5.4	45	**-28.9**	9.0	7
6-11	27.1	4.1	63	**-29.4**	3.3	14	45.7	2.5	221	**-17.2**	4.6	29
>11	27.0	10.0	17	-14.0		1	31.3	5.8	32	**-4.5**	18.5	4
> 1	27.7	2.8	150	**-26.9**	2.5	61	42.5	1.7	421	**-30.4**	2.0	126
> 2	27.8	2.8	149	**-23.6**	3.3	38	42.6	1.7	414	**-24.4**	2.6	72
> 5	27.1	3.9	80	**-28.4**	3.3	15	43.8	2.3	253	**-15.6**	4.5	33

1 *CIB = (WT - 75) + 2(BF - 10) + 0.5 (KF - 70)*, where WT is body weight in kg, BF is depth of back fat (mm), and KF is kidney fat weight (g) (Thomas and Kiliaan 1998a).

2 **Bold** indicates significant difference (*P* <0.05) between those pregnant and not pregnant.

A histogram of frequencies of pregnant and non-pregnant females in 20 unit intervals of CIB revealed a 60 unit difference between modes (**Fig. 34**). A regression of pregnancy rate and CIB in 20-unit intervals revealed a strong relationship (**Fig. 35**).

There was an excellent fit between fecundity and CIB in 20-unit intervals (Fig. 35). Fecundity was approximately 0, 50, and 95% at CIBs of -50, -20, and 30, respectively. The CIB formula (App. 1) could be modified so that fecundity of 50% corresponds to a CIB of 0% rather than about 83% with the present formula.

Figure 34

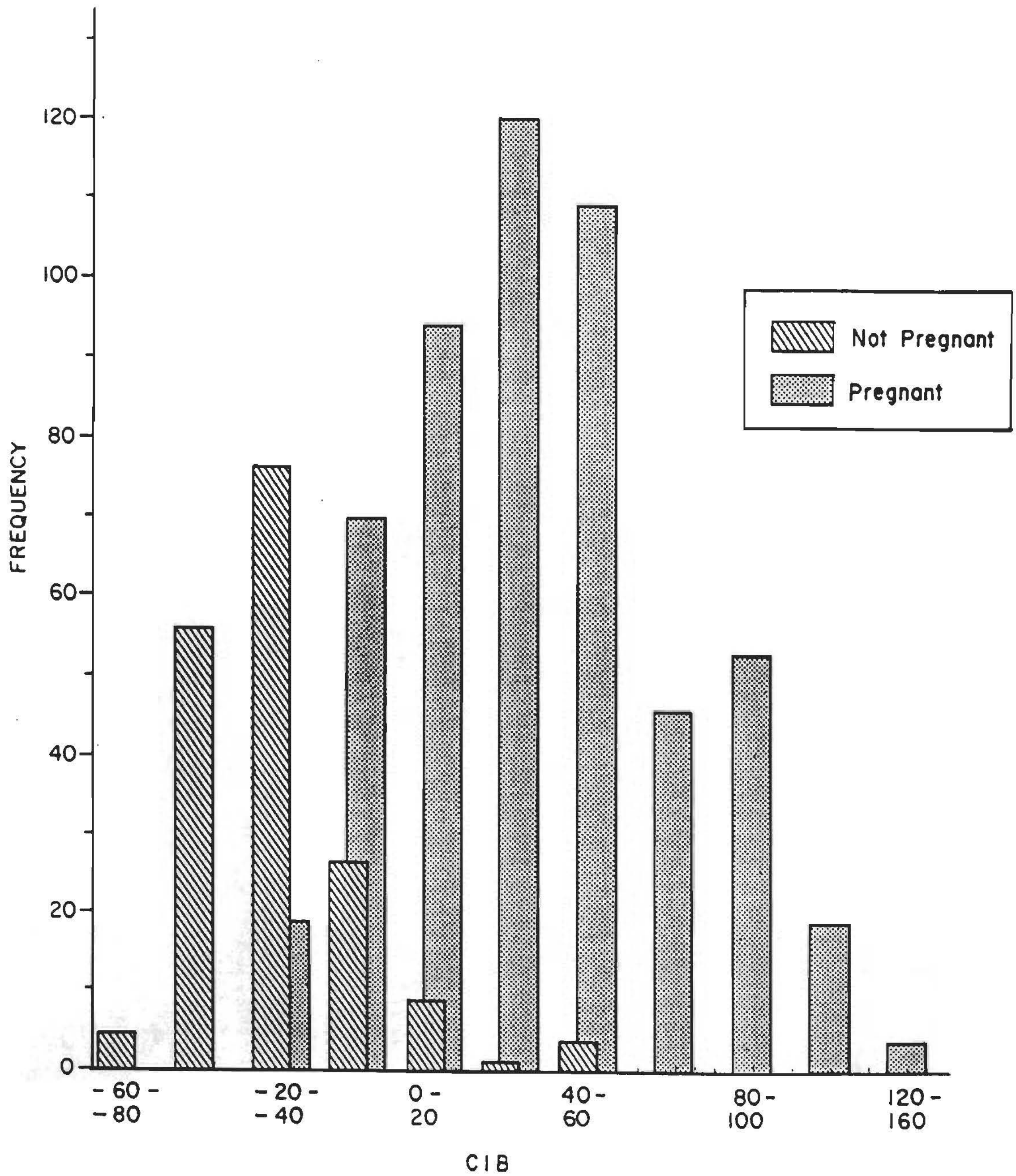

Figure 34. Frequency distributions of condition index B (CIB) in pregnant and non-pregnant female caribou >1 year old in pooled samples obtained from the Beverly herd, 1980 through 1987.

Figure 35

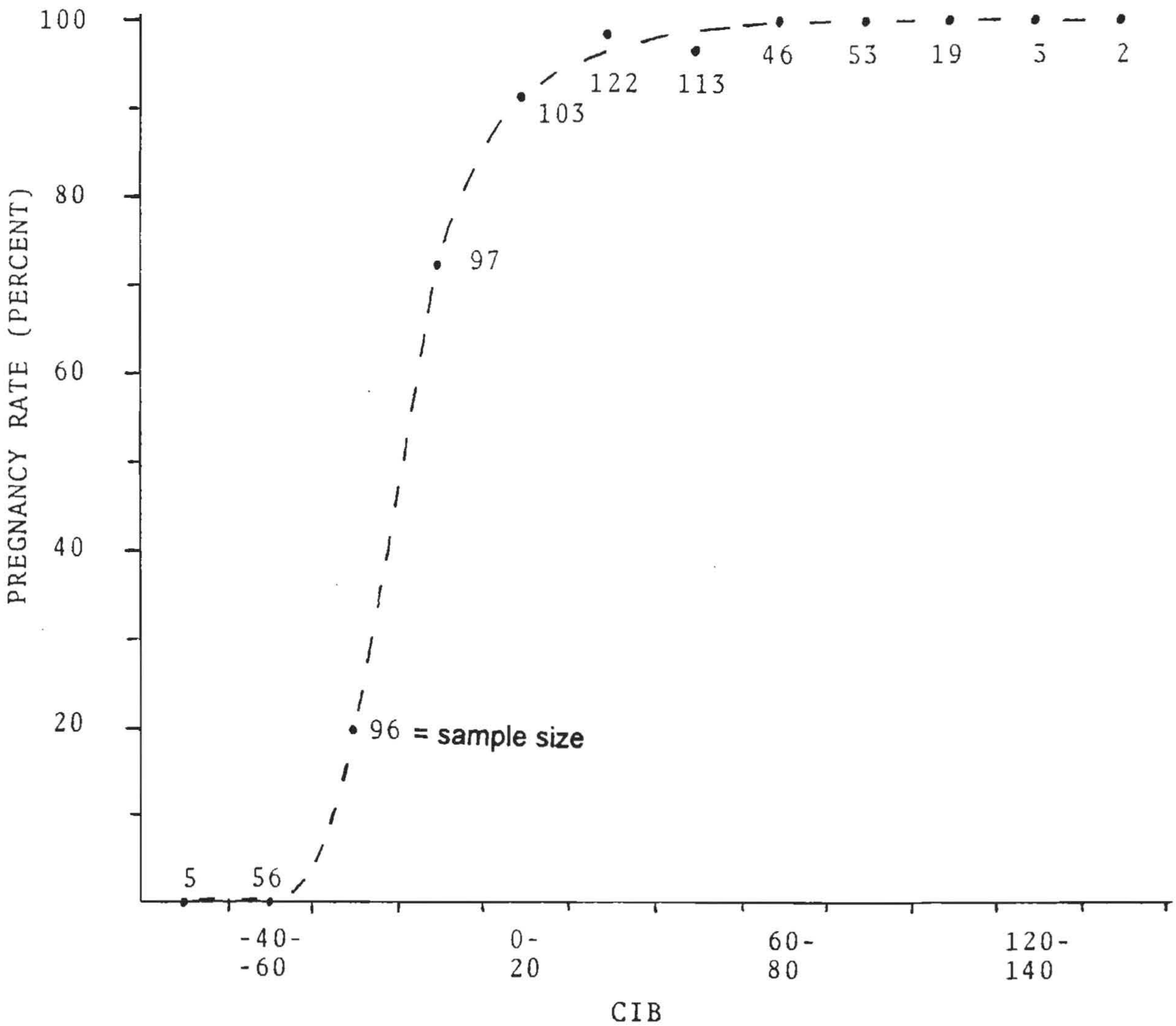

Figure 35. Relationship between condition index B (CIB) and fecundity of female caribou >1 year old in pooled samples obtained from the Beverly herd in December (1982-86) and March (1980-87).

Antler weights

A regression of fecundity on antler weights using data for females >4 years old from individual collections (**Fig. 36**) revealed a significant ($P < 0.05$) relationship for combined December and March samples (**App. 17**). December 1982 and March 1984 samples were not aligned with the others or the fit would have been much better.

Because of small sample sizes in young age classes, data were pooled for each winter period. Significant regressions occurred in 2.5-3 year and 2.5-4 year age classes (App. 17).

Antler weights continued to increase with age in females (**Table 18**). Although pregnant females had heavier antlers than non-pregnant ones in all age classes, differences were not always statistically different because of high variability. Females in age classes 2.5-3, 3.5-4, and 4.5-5 years had similar antler weights so we grouped them. We also pooled age groups 5.5-8 years and 8.5-11 years for the same reason.

Frequency distributions of antler weights of pregnant and non-pregnant females (**Fig. 37**) were similar to those of other condition variables.

A curvilinear relationship was found between antler weights in 50 g intervals and fecundity of females >2 years old (**Fig. 38**).

Warble larvae

Numbers of warble larvae and fecundity were not significantly related using sample means for females >4 year old in individual collections (App. 17). In five of six collections obtained in March, numbers of larvae varied from only 31 to 34, though the pregnancy rate varied from 76 to 98% (**Fig. 39**).

Figure 36

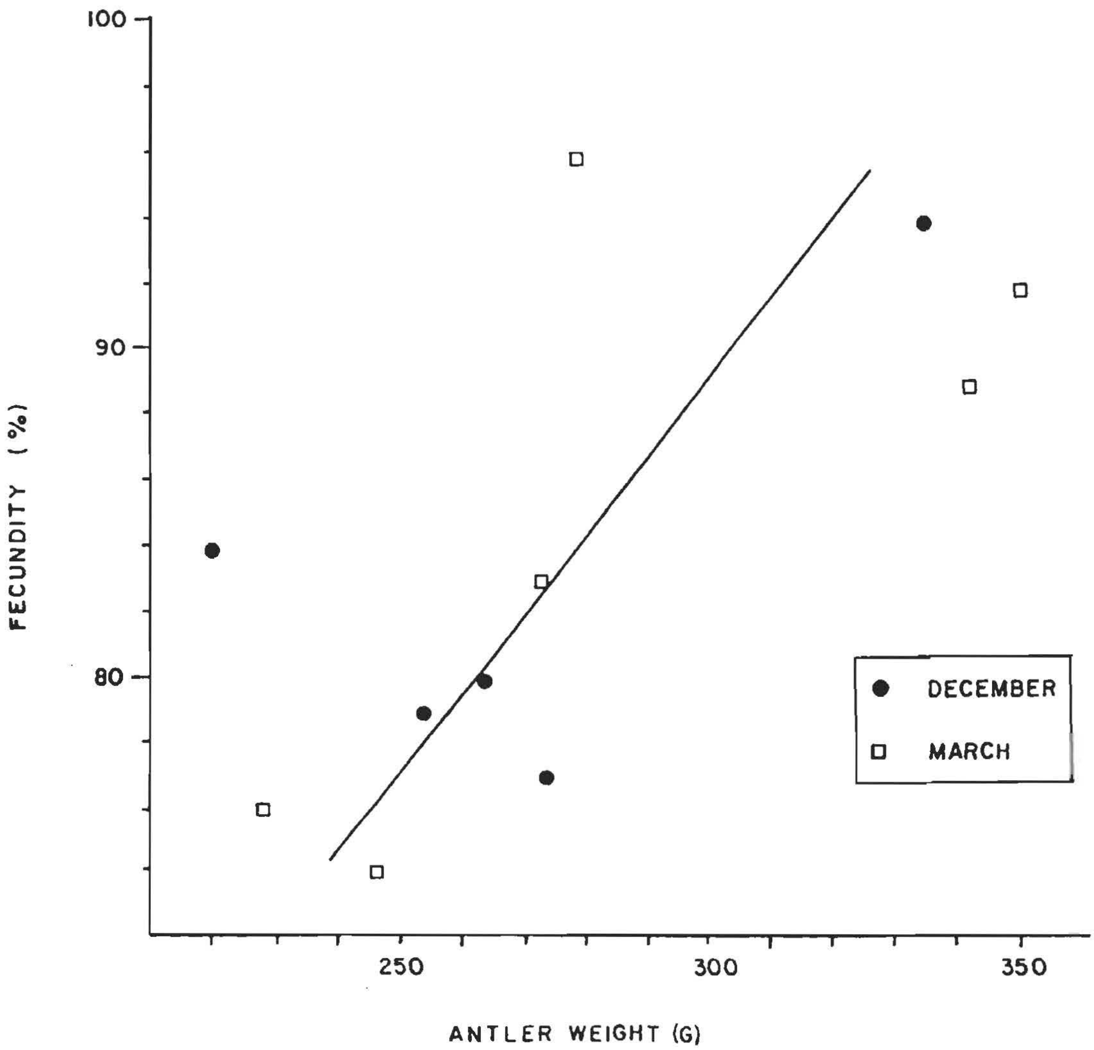

Figure 36. Relationship between antler weight and fecundity of female caribou >4 years old in individual samples obtained from the Beverly herd each December 1982-86 and March 1982-87.

Table 18. Antler weights of pregnant and non-pregnant female caribou collected from the Beverly herd, 1982 through 1987.

Age class (yr)	Antler weight (g)						Significance
	Pregnant			Not pregnant			
	Mean	SE	*n*	Mean	SE	*n*	
1.5- 2	160	24	7	112	8	54	NS
2.5- 3	216	10	70	[1]**164**	15	24	*P* < 0.01
3.5- 4	229	11	72	211	25	18	NS
4.5- 5	233	10	64	**157**	33	11	*P* < 0.05
5.5-11	295	7	258	232	26	39	NS
>11	357	20	47	305	72	5	NS
2.5- 5	226	6	206	**179**	13	53	*P* < 0.01
5.5- 8	283	9	169	231	31	28	NS
8.5-11	316	12	89	236	44	11	NS

[1] **Bold** indicates significant difference (*P* <0.05) between those pregnant and not pregnant.

Number of warble larvae was related to caribou age in December and March (**App. 18**). We selected age groups within which means were not different and compared numbers of larvae in pregnant and non-pregnant females (**Table 19**).

Histograms of percent frequency of warble larvae in pregnant and non-pregnant females indicated a trend towards fewer larvae in pregnant females (**Fig. 40**). For example, in March collections, frequency in pregnant females declined steadily from a mode (most-frequent occurrence) in the 0-10 class, whereas the distribution for non-pregnant females was more uniform across larvae number classes.

Fecundity tended to gradually decline in pooled December and pooled March collections as numbers of warble larvae increased (**Fig. 41**).

Figure 37

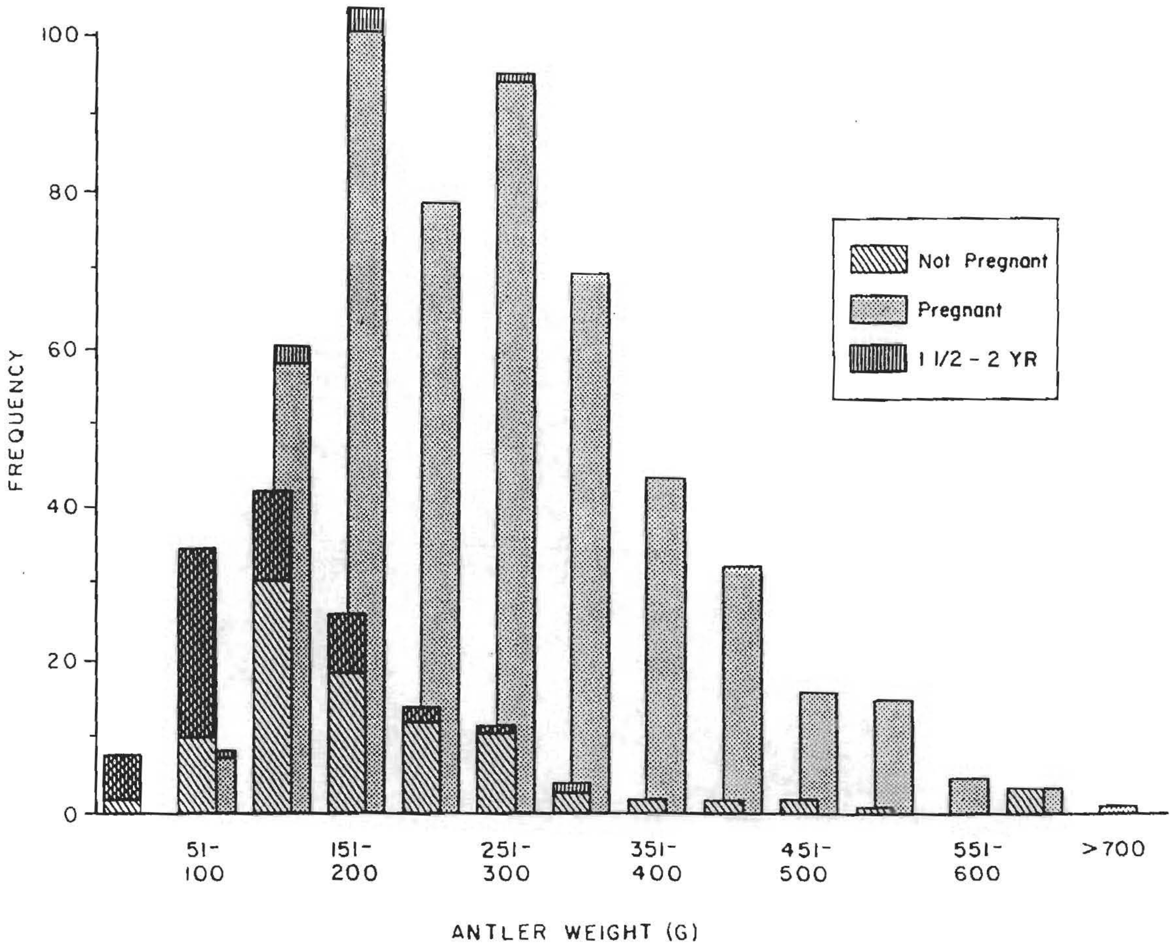

Figure 37. Frequency distributions of antler weight of pregnant and non-pregnant female caribou >2 years old that were sampled from the Beverly herd, 1980-87.

Figure 38

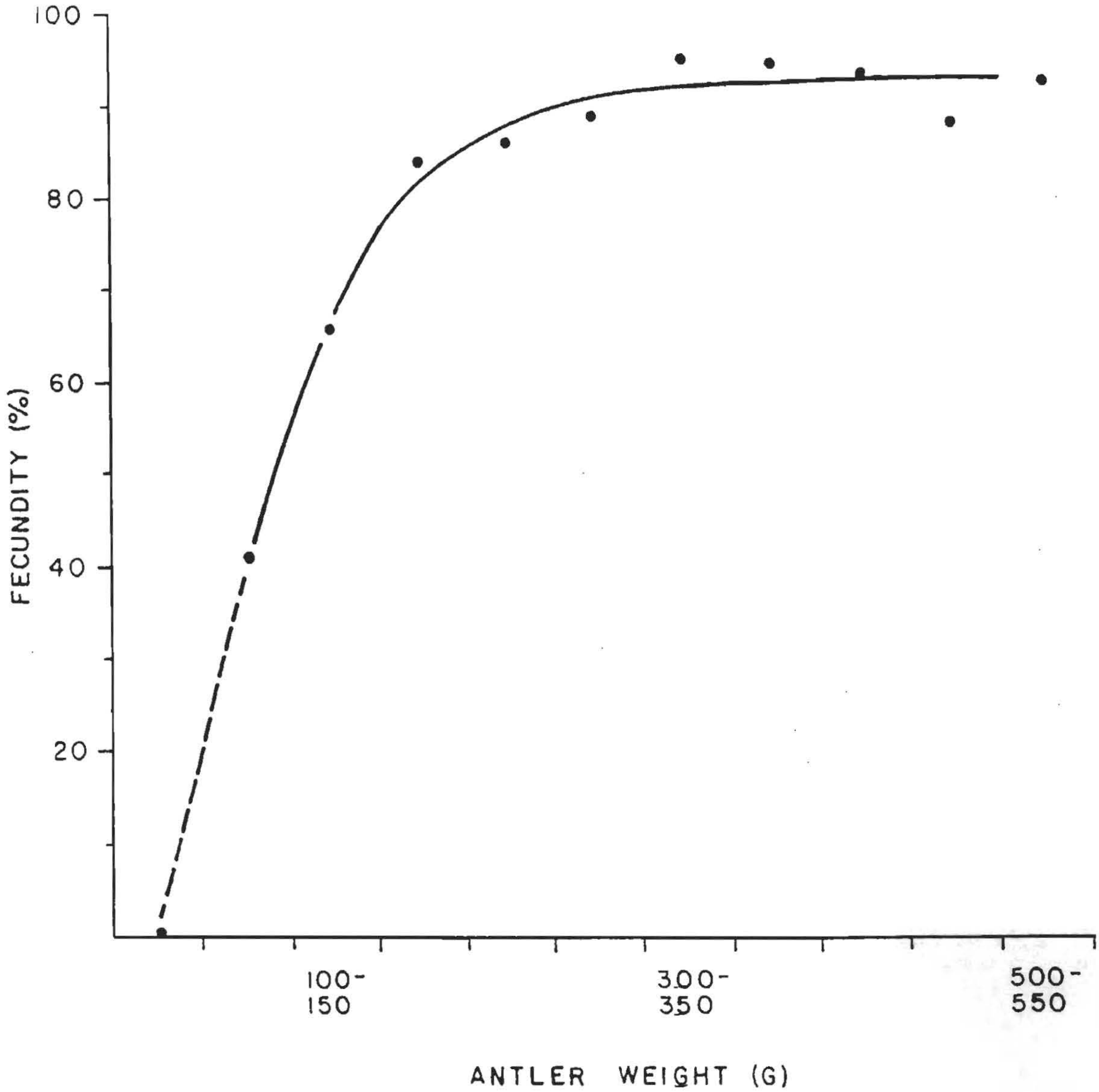

Figure 38. Relationship between antler weights and pregnancy rate of female caribou >1 year old in pooled samples from the Beverly herd, 1982 through 1987.

Figure 39

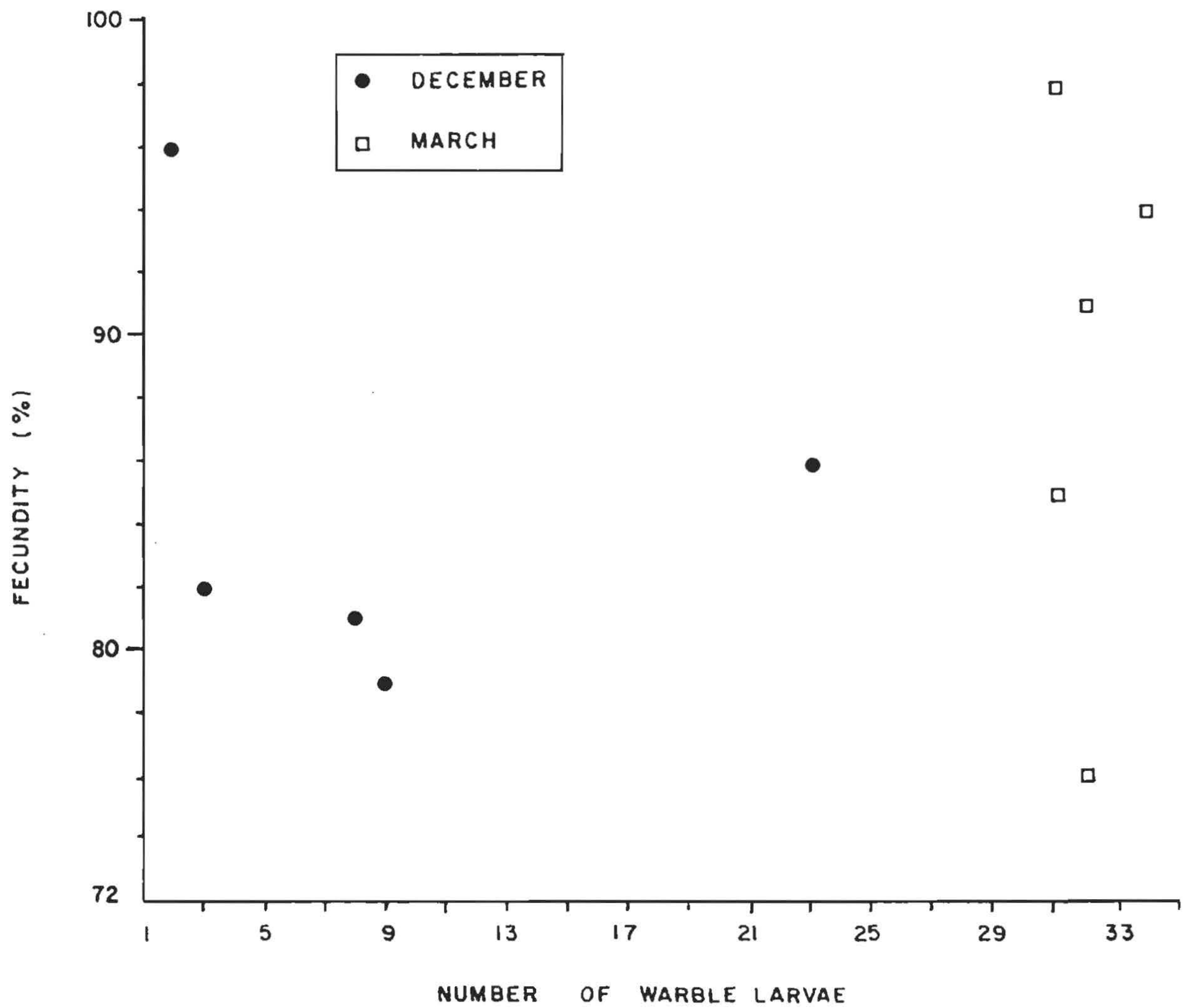

Figure 39. Relationship between number of warble larvae and fecundity of female caribou >1 year old in individual samples obtained from the Beverly herd in December (1982-86) and March (1982-87).

Table 19. Mean number of warble larvae under skin of pregnant and non-pregnant female caribou sampled from the Beverly herd in December (1982-86) and March (1980-87).

Age class (yr)	Month	Number of warble larvae						Significance
		Pregnant			Not pregnant			
		Mean	SE	*n*	Mean	SE	*n*	
1.5	Dec	20.0	11.3	2	24.0	4.3	24	NS
2.5	Dec	11.3	2.4	17	17.7	5.8	13	NS
3.5-7.5	Dec	8.6	2.3	97	12.1	3.5	22	NS
>7.5	Dec	4.6	1.4	34	7.0	3.5	4	NS
2	Mar	109.9	17.3	8	114.0	13.0	51	NS
3, 4	Mar	40.3	3.3	110	[1]**64.4**	10.2	33	$P < 0.05$
>4	Mar	31.9	2.3	297	**59.3**	9.3	38	$P < 0.05$

[1] **Bold** indicates significant difference between pregnant and non-pregnant females.

Table 20. Femur lengths of pregnant and non-pregnant females caribou in pooled samples from the Beverly herd, 1982 through 1987.

Age class (yr)	Femur lengths (mm)						Significance
	Pregnant			Not pregnant			
	Mean	SE	*n*	Mean	SE	*n*	
1.5-2	271.9	0.6	161	266.4	1.0	70	NS
2.5-3	276.9	0.4	237	[1]**273.3**	1.3	32	$P < 0.02$
3.5-4	277.5	0.5	152	277.2	1.3	20	NS
4.5-5	278.6	0.8	110	277.5	2.0	11	NS
>5	277.6	0.4	318	276.5	1.1	46	NS
>2	277.6	0.3	546	**275.8**	0.7	109	$P < 0.01$
>3	277.7	0.3	465	**276.8**	0.8	77	$P < 0.01$

[1] **Bold** indicates significant difference between pregnant and non-pregnant females.

Figure 40

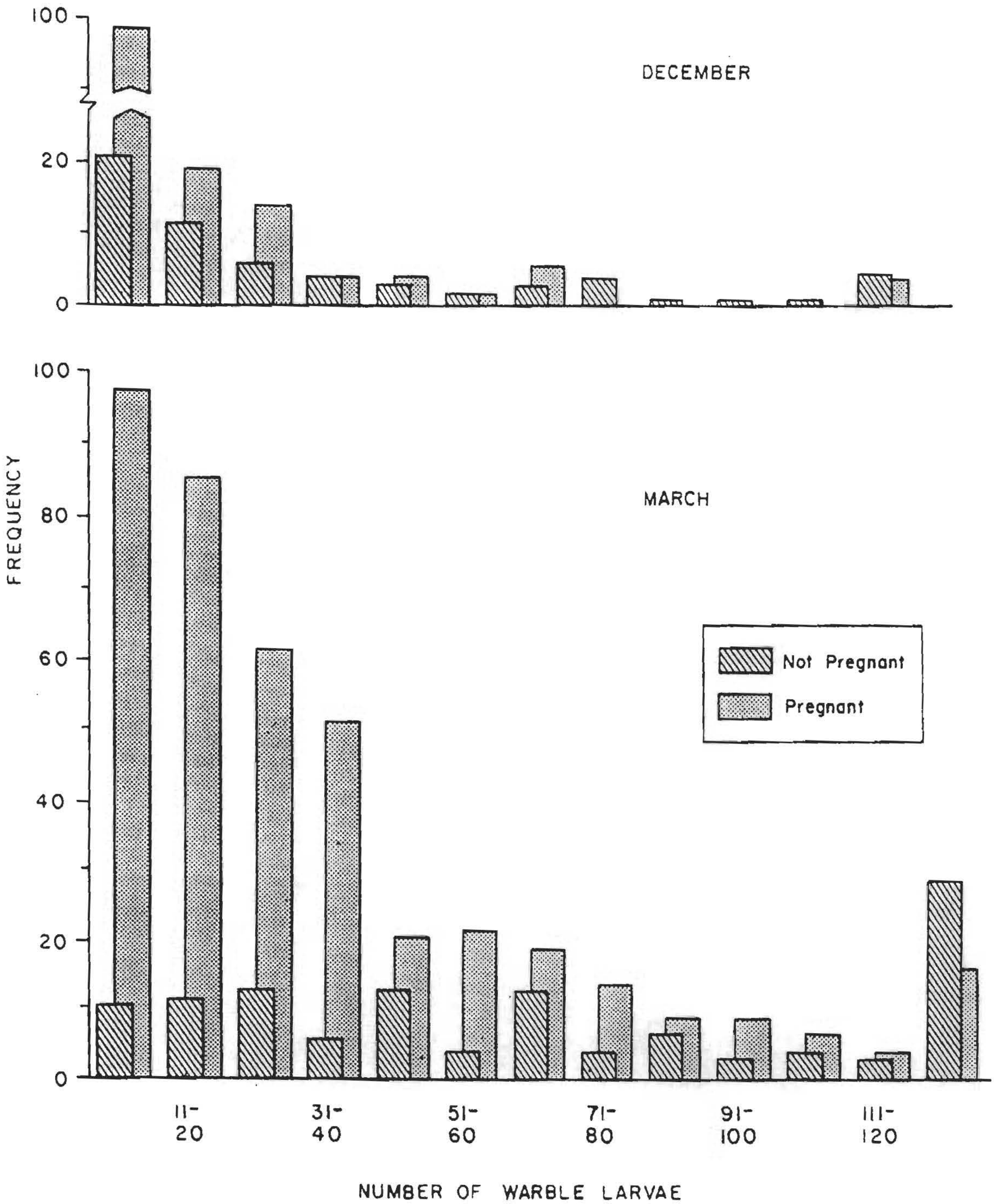

Figure. 40. Frequency distributions of number of warble larvae under skin of pregnant and non-pregnant female caribou >1 year old that were sampled from the Beverly herd in December and March, 1982-87.

Figure 41

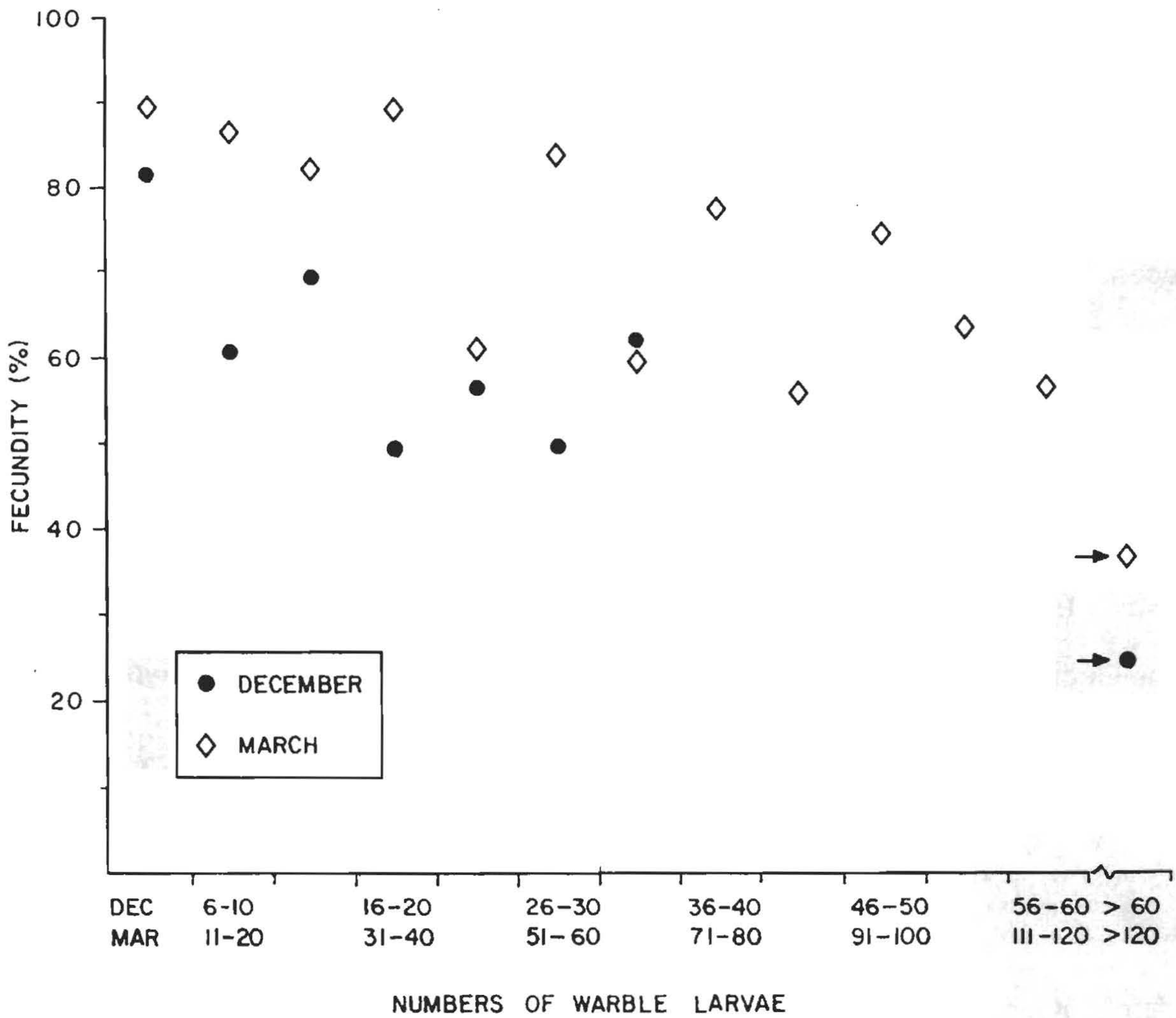

Figure 41. Relationship between number of warble larvae and fecundity of female caribou >1 year old in pooled samples obtained from the Beverly herd in December (1982-86) and March (1982-87).

Femur lengths

Femur bones were longer in pregnant females compared with non-pregnant ones in age classes 2.5-3, >2, and >3 years (**Table 20**). Large females may be more productive than small ones.

DISCUSSION

Fecundity of the Beverly herd from 1980 through 1987 was similar to that of the adjacent Kaminuriak herd in 1966-68 (**Table 21**). Compared with Dauphiné's (1976) results, fecundity was higher in young females in the Beverly herd but slightly lower in older (e.g., >5 years) caribou. Gates (1985) reported that 8 of 9 yearling females and all 140 older caribou were pregnant in samples from the Kaminuriak herd in 1981-82 and 1982-83.

Parker (1981) reviewed age-specific fecundity in several caribou herds. His values for the George River herd in April 1980 were higher than others: 43% in 21 yearlings, 90% in 2.5-3 year olds (n = 20), and 95% in older females. In 1986-87, fecundity in the George River herd was markedly lower at 0 of 5 yearlings and 67% and 76% in 2.5-3 year (n = 30) and >3 years (n = 83) caribou, respectively (Couturier et al. 1990). Pronounced differences in fecundity of Kaminuriak, George River, and Beverly herds confirm that fecundity is highly variable in migratory caribou of mainland Canada as well as on the Arctic Islands (Thomas 1982). A previous estimate of fecundity for the Beverly herd (McEwan 1963) was based on samples obtained from 1957 through 1962, including the severe winter of 1961-62. There were reports from a trapper of abortions in caribou late in that winter (Scotter 1965). McEwan's (1963) results included a combination of fetal rates, ovarian analysis, and lactation as criteria of pregnancy. That, and a possibility of ages being incorrect by 1 year, (F.L. Miller

Table 21. Age-specific fecundity of the Beverly and Kaminuriak herds of barren-ground caribou.

Age class	Beverly herd[2]		Karninuriak herd[3]	
(years)[1]	Fecundity (%)	Sample size	Fecundity (%)	Sample size
1	0	37	0	48
2	12.0	92	1.8	57
3	71.7	120	47.8	69
4	81.5	108	82.0	50
5	85.5	83	95.5	22
6-11	87.5	345	91.4	197
>11	90.0	55	81.8	8
>1	75.5	803	70.2	406
>2	83.7	711	81.4	349
>3	86.1	591	89.6	280
>4	87.2	482	91.3	730
>5	87.5	400	90.9	208

[1] Subtract 0.5 year for age at conception.
[2] This study, 1980-87.
[3] From 1966 through 1968 (Dauphiné 1976).

pers. commun. and, e.g., only three caribou in the 3.5-4 year class) and small sample sizes, weaken his data particularly for young age classes. The high pregnancy rate in old females does not equate with rates for younger females, for example. Overall fecundity of 69 females >3 years old was 78%, reduced from 83% because of suspected absorptions (McEwan 1963). The rate was 85% (*cf.* 86% in this study) in 72 females >3 years old if the 1961-62 sample is excluded. However, unless there was a high incidence of absorptions or abortions, the lower rate (69%) in 1961-62 relates to events before the rut in October 1961 and not during winter 1961-62.

There was no decline in fecundity with age in the Beverly herd (McEwan 1963, this study) in contrast with declines in the Kaminuriak herd (Dauphiné 1976) and apparently in the George River herd in 1980 (Parker 1981). Parker's results were influenced by chance sampling of 3-year-old females in superior condition and an insufficient number of old caribou.

The incidence of absorptions and abortions is difficult to measure. Early loss of embryos would go undetected unless large numbers of uteri and ovaries were examined in November and December. Such mortality could be caused by genetic defects or physiological disfunction because caribou in poor condition do not become pregnant (Thomas 1982). Our fetal mortality rate of 1 in 420 applies to the gestation period between about months 2 and 5. Dauphiné's (1976) rate of 0-2% is not too helpful. All five cases could have been artifacts because of poor fixation or multiple cycling. McEwan (1963) lists 3 cases in 52 (49 pregnant) but details are missing including the criteria used to identify absorptions.

The >4 years age category of females should reflect annual variations in fecundity caused by environmental factors. Females in young age classes (2.5-4.5 years) may have their energy reserves depleted by successfully rearing one calf or two calves in consecutive years and thus fail to breed the following October (Dauphiné 1976). High pregnancy rates in young females in one winter could be followed by low rates the following year with equivalent environmental conditions. Therefore, assessing environmental conditions by performance of females 2-5 years old must be done with caution. Pregnancy rate in yearlings probably is a sensitive indicator of environment in the preceding 2 or 3 years but obtaining adequate sample sizes is a problem.

The relationship between fecundity and numbers of warble larvae is rather weak but it indicates that warble flies are a factor in the ecology of caribou in the Beverly herd. An analysis of data for 1985 (Thomas et al. 1986) indicated that development of larvae in caribou may be age related with progressively later development in older females. Caribou may also learn to avoid flies or egg deposition. Warble parasitism seemed to influence young females to a greater extent than old ones. This age response is predicted because, in general, older females have higher stores of energy. Differences in body weight, back fat depths, and kidney fat indices between those with less and more than the median number (five) of larvae in December 1985 approached significance (Thomas et al. 1986). A fuller account of possible negative effects of warble flies on caribou is in a separate paper (Thomas and Kiliaan 1990).

A significant relationship between fecundity and antler weights has at least two management implications. First, antler weights can be used in field situations to quickly assess fecundity and herd quality (nutritional status and health). The only samples required from caribou are antlers and one or more teeth (incisors or first molar) but preferably mandibles. (Mandibular water content is a further indicator of the nutritional status of sampled herds). High variability in antler weights means that large sample sizes are needed to predict other variables. Antlers can be obtained from hunters at any time after velvet is shed. There is no problem with tissue preservation.

Secondly, larger antlers in old females offers a potential for them to be selectively shot in times when caribou herds are in decline. Such selection would have an effect of reducing natural mortality (old females are subject to predation before they die of old age) and the sex ratio of calves would be altered towards a higher proportion of females (Thomas et al. 1989).

CONCLUSIONS

1. Average fecundity (pregnancy rate) of the Beverly herd from 1980 through 1987 was comparable to that of the Kaminuriak herd in 1966 through 1968, being somewhat higher in young females and lower in those over 5 years old.

2. There was no decline in fecundity in old (>11 years) females in contrast with the results from some previous studies.

3. Fecundity varied considerably from year to year: from 0 to 33% in yearlings, 47 to 100% in the 2.5-3 year class, and 79 to 100% in females >4 years.

4. Intra-uterine mortality between about 2 and 5 months was exceedingly low, involving one suspected resorption in 420 pregnant females (March samples). Furthermore, pregnancy rates in December and March samples were comparable.

5. Light (<800 g) fetuses comprised 4.8% of 420 fetuses obtained in March collections. One weighing 9.2 g was estimated to have been conceived in January by a 5.5 year-old female.

6. Regressions of mean values in December for fecundity and condition variables in age classes 2.5-3, 3.5-4, 2.5-4, and >4 years yielded significant relationships for back fat (2.5-3 and 2.5-4 years), dissectible fat (2.5-3 years), condition indices A and B (2.5-3 and 2.5-4 years), and mandibular water (2.5-3 years). Most condition variables produced significant regressions with fecundity for all age classes in March samples and pooled December and March samples, in part because of a larger number of data points.

7. Comparison of condition variables in pregnant and non-pregnant females in six basic age classes and in larger age groupings produced significant differences in most cases where sample sizes were adequate.

8. Plots of percent fecundity with condition variables produced curves that can be used in future to predict fecundity from condition variables including body weight, back fat depth, kidney fat weight, femur marrow fat content (%), mandibular water (%), antler weights, and condition indices based on two or more of these variables.

9. Relatively large females, based on femur lengths, were more likely to be pregnant than small ones.

10. Pregnant females had fewer warble larvae under their skin in March than non-pregnant females.

LITERATURE CITED

Adamczewski, J.A., C.C. Gates, and R.J. Hudson. 1987. Fat distribution and indices of carcass composition in Coats Island caribou (*Rangifer tarandus groenlandicus*). Can. J. Zool. 65:368-374.

Connolly, G.E. 1981. Assessing populations. *In*: Mule and black-tailed deer of North America. O.C. Wallmo (ed.). University of Nebraska Press, Lincoln and London. 605pp.

Couturier, S., J. Brunelle, D. Vandal, and G. St-Martin. 1990. Changes in the population dynamics of the George River caribou herd, 1976-87. Arctic 43:9-20.

Dauphiné, T.C. Jr. 1976. Biology of the Kaminuriak Population of barren-ground caribou. Part 4: Growth, reproduction and energy reserves. Can. Wildl. Serv. Rep. Ser. No. 38. 69pp.

Gates, C.C. 1985. The fall and rise of the Kaminuriak caribou population. *In*: Meredith, T.C., and Martell, A.M. (eds). Proc. 2nd N. Am. Caribou Workshop. McGill Subarctic Res. Pap. No. 40:215-228.

Huot, J. and F. Goudreault. 1985. Evaluation of several indices for predicting total body fat of caribou. McGill Subarctic Res. Pap. No. 40:157-175.

McEwan, E.H. 1963. Reproduction of barren-ground caribou *Rangifer tarandus groenlandicus* (Linnaeus) with relation to migration. Ph.D. thesis, McGill University, Montreal. 99pp.

Mitchell, B., D. McCowan, and I.A. Nicholson. 1976. Annual cycles of body weight and condition in Scottish red deer. J. Zool. Lond. 180: 107-127.

Neiland, K.A. 1970. Weight of dried marrow as indicator of fat in caribou femurs. J. Wildl. Manage. 34:904-907.

Parker, G.R. 1981. Physical and reproductive characteristics of an expanding woodland caribou population (*Rangifer tarandus caribou*) in northern Labrador. Can. J. Zool. 59:1929-1940.

Riney, T. 1955. Evaluating condition of free-ranging red deer (*Cervus elaphus*) with special reference to New Zealand. New Zealand J. Sci. Tech. 36:429-463.

Scotter, G.W. 1965. Study of the winter range of barren-ground caribou with special reference to the effects of forest fires. Can. Wildl. Serv. Prog. Rep. No. 3. 81pp.

Thomas, D.C. 1982. The relationship between fertility and fat reserves of Peary caribou. Can. J. Zool. 60:597-602.

Thomas, D.C., S.J. Barry, and H.P. Kiliaan. 1989. Fetal sex ratios in caribou: maternal age and condition effects. J. Wildl. Manage. 53:885-890.

Thomas, D.C. and E. Broughton. 1978. Status of three Canadian caribou populations north of 70° in winter 1977. Can. Wildl. Serv. Prog. Note No. 85. 12pp.

Thomas, D.C. and H.P.L. Kiliaan. 1990. Warble infestations in some Canadian caribou and their significance. Rangifer, Spec. Issue No. 3:409-417.

Thomas, D.C. and S.J. Barry. 1990a. A life table for female barren-ground caribou in north-central Canada. Rangifer Spec. Issue 3:177-184.

Thomas, D.C. and S.J. Barry. 1990b. Age-specific fecundity of the Beverly herd of barren-ground caribou. Rangifer, Spec. Issue No. 3:257-263.

Thomas, D.C., H.P.L. Kiliaan, and C. Dong. 1986. Physical status of the Beverly herd of barren-ground caribou in December 1985. Can. Wildl. Serv. Rep. 27pp.

Thomas, D.C., R.H. Russell, E. Broughton, E.J. Edmonds, and A. Gunn. 1977. Further studies of two populations of Peary caribou in the Canadian Arctic. Can. Wildl. Serv. Prog. Notes No. 80. 14pp.

(Additional references on p. i)

Appendix 1. Condition variables discussed in this report: descriptions, units, formulae, and sources.

1. Body weight: whole body weight (kg) as measured on a dial scale and not adjusted for variable loss of blood.

2. Back fat depth: maximum depth (mm) measured along an anterio-lateral cut originating at the base of the tail (e.g., Dauphiné 1976).

3. Kidney fat: weight (g) of trimmed fat around both kidneys (Riney 1955).

4. Riney's kidney fat index: *KFIR = 100 x weight kidney fat (g)/weight of kidneys (g)* (Riney 1955).

5. Mitchell's kidney fat index: KFIM = *(weight of kidney fat + weight of kidneys)/weight kidneys* (Mitchell et al. 1976). *Multiplied by 10.*

6. KF/WT = *(Kidney fat/body weight) x 100*, grams and kilograms, respectively.

7. KFFEL = *(Kidney fat/femur length) x 10*, grams and centimeters, respectively.

8. Femur marrow fat content, *FEF = {(95 - %water)/97} x 100* (Neiland 1970).

9. Mandibular water: percent water by weight in dried marrow and other tissues ventral to the molariform teeth.

10. Condition index CONINDEX or *CONI = (KFI - 20) + FEF*, where KFI is Riney's (1955) kidney fat index and FEF is femur marrow fat content (%) (Connolly 1981).

Appendix 1 (continued)

11. Fat percentage *FATP = 0.845 + (0.091 x CONI)*, an estimate of percent fat content in a "field dressed" carcass (Huot and Goudreault 1985).

12. Fat percentage *FAT = (ln KFI x 3.37) - 3.29*, an estimate of percent fat content of a "field dressed" carcass (Huot and Goudreault 1985).

13. Dissectible fat *DFAT = ([0.1151 DBF] + [0.026401 x KF]) - 0.246*, an estimate of dissectible fat (kg) in a caribou, where DBF is depth (mm) of back fat and KF is kidney fat weight (g) (Adamczewski et al. 1987).

14. Condition index A, *CIA = (WT + 10 BF + KF + FEF)/FEL*, where WT is body weight (kg), BF is depth (mm) of back fat, KF is weight (g) of kidney fat, FEF is femur marrow fat (%), and FEL is femur length (cm).

15. Condition index B, *CIB = (WT - 75) + 2(BF - 10) + 0.5 (KF - 70)*, where WT is body weight (kg), BF is depth (mm) of back fat, and KF is weight (g) of kidney fat.

16. Antler weights (g): both, or *single antler weight x 2*.

17. Warble larvae: total on hide or total on half of hide x 2 (Kelsall 1975) where numbers are large (>50).

18. Femur length: measured to nearest millimeter with a vernier caliper.

Appendix 2. Age-specific fecundity of caribou sampled from the Beverly herd from 1979-80 through 1986-87 (sample sizes in parentheses).

Age (yr)	Pregnancy rate (percent) 1979-80	1980-81	1981-82	1982-83	1983-84[1]	1983-84[2]	1984-85	1985-86	1986-87
1.5- 2	0 (4)	100 (1)	8 (13)	4 (23)	0 (10)	33 (9)	31 (16)	0 (13)	0 (3)
2.5- 3	50 (10)	0 (1)	82 (11)	47 (15)	0 (8)	100 (11)	83 (29)	65 (20)	73 (15)
3.5- 4	50 (2)	100 (3)	75 (4)	82 (17)	100 (3)	90 (31)	75 (28)	64 (11)	
4.5- 5		100 (1)	90 (10)	40 (10)	100 (5)	92 (12)	100 (15)	79 (14)[4]	94 (16)
5.5-11	92 (12)	100 (9)	97 (35)	85 (67)	71 (1)	100 (43)[3]	89 (64)	87 (60)	69 (32)
>11				83 (6)	90 (10)	100 (5)	100 (16)	79 (14)	100 (2)
> 2	71 (24)	93 (14)	91 (66)	77 (119)	80 (45)	99 (74)[3]	90 (156)	79 (136)[5]	75 (76)
> 3	86 (14)	100 (13)	93 (55)	81 (104)	81 (37)	98 (63)[3]	92 (127)	82 (116)[5]	75 (61)
> 4	92 (12)	100 (10)	94 (51)	81 (87)	79 (28)	98 (60)[3]	93 (95)	84 (88)[5]	78 (50)
> 5	92 (12)	100 (9)	95 (41)	86 (77)	74 (3)	100 (48)[3]	91 (81)	85 (74)[5]	71 (34)

[1] Samples from subherd A: Tent Lake (December) and Sifton Lake (March).
[2] Subherd B, Porter Lake sample (March).
[3] Including female 5 years old with resorbing fetus.
[4] Excluding one female 7 years old that was "barren" (had never become pregnant).
[5] Excluding a female 6 years old that had no uterus.

Appendix 3. Weights of male and female caribou fetuses sampled from the Beverly herd in March 1980 through 1987.

Age class (yr)	Weight (g) of all fetuses[1]						Weight of fetuses >800 g[2]					
	Males			Females			Males			Females		
	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*
1.5-2	1160	32	6	1121	61	2	1160	32	6	1021	61	2
2.5-3	1287	55	22	1247	46	42	1287	55	22	1294	33	35
3.5-4	1440	68	20	1355	46	34	1454	57	18	1321	36	29
4.5-5	1452	34	26	1401	39	21	1435	31	25	1401	40	21
> 5	1368	25	132	1303	21	114	1397	19	120	1318	18	108
All	1390	20	215	1310	17	214	1387	16	191	1320	14	195
> 1	1371	20	206	1307	17	213	1387	16	191	1320	14	195
> 2	1377	20	200	1310	17	211	1395	16	185	1323	14	193
> 3	1388	21	178	1326	18	169	1409	16	163	1330	15	158

[1] Includes fetuses probably conceived late in the breeding season.
[2] Also excludes fetuses collected in late March, 1981 and 1984 (subherd A, Sifton Lake).

Appendix 4. Linear regression statistics of sample means for body weight/back fat (*x* axis) and fecundity (*y* axis) of caribou sampled from the Beverly herd, 1980 through 1987.

Age class (yr)	Month	Regression variable[1] *a*	*b*	*r*	Significance
Body weight (kg)					
>4	Dec	63.01	0.24	0.57	NS
	Mar	49.42	0.40	**0.83**[2]	$P < 0.05$
	Dec + Mar	53.18	0.36	**0.58**	$P < 0.01$
2.5-3	Dec	67.00	0.10	0.60	NS
	Mar	65.71	0.15	**0.79**	$P < 0.05$
	Dec + Mar	64.77	-0.15	**0.73**	$P < 0.01$
3.5-4	Dec	87.72	-0.07	0.40	NS
	Mar	55.43	0.27	0.73	NS
	Dec + Mar	69.01	0.13	0.34	NS
2.5-4	Dec	64.93	0.17	0.49	NS
	Mar	62.78	0.18	**0.72**	$P < 0.01$
	Dec + Mar	64.27	0.17	**0.58**	$P < 0.01$
Back fat depth (mm)					
>4	Dec	-16.84	0.34	0.54	NS
	Mar	-34.66	0.57	**0.94**	$P < 0.01$
	Dec + Mar	-30.09	0.51	**0.82**	$P < 0.01$
2.5-3	Dec	-22.45	0.49	**0.96**	$P < 0.01$
	Mar	- 3.77	0.24	**0.89**	$P < 0.01$
	Dec + Mar	-10.57	0.32	**0.88**	$P < 0.01$
3.5-4	Dec	13.27	0.03	0.10	NS
	Mar	-24.42	0.47	**0.92**	$P < 0.01$
	Dec + Mar	9.67	0.30	**0.60**	$P < 0.05$
2.5-4	Dec	-11.59	0.34	**0.75**	$P < 0.05$
	Mar	- 9.08	0.29	**0.83**	$P < 0.01$
	Dec + Mar	- 9.56	0.30	**0.78**	$P < 0.01$

[1] Where *a* is the *y* intercept, *b* is the slope, and *r* is the regression coefficient.
[2] **Bold** indicates a significant regression.

Appendix 5. Weights of pregnant and non-pregnant female caribou in individual samples obtained from the Beverly herd each December (1982-86) and March (1980-87).

Age class (yr)	Month/ year	Whole body weight (kg)								
		Pregnant			Pregnant adjust[1]			Not pregnant		
		Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*
2.5-3	Dec 86	78.1	1.8	5				**67.7**[2]	1.4	3
3.5-4	Dec 84	84.4	2.3	8				82.5	5.5	3
3.5-4	Dec 85	82.1	2.0	9				81.0	2.8	4
> 3.5	Dec 86	87.6	1.5	23				**79.8**	1.5	5
> 3.5	Nov 82	82.4	1.3	23				71.3	1.8	4
5.5-10.5	Dec 83	82.2	2.3	13				74.3	4.9	4
5.5-10.5	Dec 86	80.8	2.2	7				74.8	3.3	4
1.5- 2	Mar 84	72.7	4.3	3	69.6	4.3	3	58.4	2.0	8
1.5- 2	Mar 85	73.6	2.7	4	70.6	2.7	4	63.5	2.5	5
2.5- 3	Mar 80	76.1	2.3	5	72.8	2.4	5	68.6	1.3	5
2.5- 3	Mar 83	75.8	2.4	6	72.5	2.4	6	67.6	1.4	6
2.5- 3	Mar 85	81.8	1.6	19	78.2	1.6	19	70.7	3.0	3
2.5- 3	Mar 86	80.8	2.3	11	77.5	2.2	11	67.7	2.5	3
3.5- 4	Mar 83	78.6	3.1	8	75.2	3.1	8	70.3	3.5	3
> 4	Mar 82	86.0	0.8	47	82.7	0.8	46	**71.7**	2.2	3
>11	Mar 85	88.8	1.9	40	85.5	1.0	40	89.3	2.5	6

[1] Adjusted for weight of the uterus and its contents in March samples.
[2] **Bold** = $P < 0.05$ (*vs.* adjusted weight in March samples).

Appendix 6. Depths of back fat in pregnant and non-pregnant female caribou sampled from the Beverly herd in December (1982-86) and March (1980-87).

Age class (yr)	Sample period	Depth of back fat (mm)						Significance level
		Pregnant			Not pregnant			
		Mean	SE	*n*	Mean	SE	*n*	
> 4	Dec 82	9.2	1.8	24	**1.0**[1]	0.4	4	*P* < 0.05
> 2	Dec 82	15.7	1.9	27	**1.3**	0.7	7	*P* < 0.01
> 2	Dec 84	20.4	1.7	39	9.5	4.0	6	NS
2.5-4.5	Dec 85	12.6	2.4	14	**4.0**	0.9	9	*P* < 0.01
> 5	Dec 85	18.8	2.2	20	**4.5**	1.5	4	*P* < 0.05
> 2	Dec 86	12.5	1.7	28	**2.9**	0.8	7	*P* < 0.01
> 2	Mar 80	5.6	1.5	17	**0.7**	0.2	7	*P* < 0.02
> 2	Mar 82	18.2	1.4	52	**2.3**	0.7	6	*P* < 0.001
> 2	Mar 83	12.3	1.0	60	**1.9**	0.7	22	*P* < 0.001
> 2	Mar 84	19.4	0.9	87	**5.7**	2.6	3	*P* < 0.05
> 2	Mar 85	19.9	0.8	102	**4.3**	1.3	9	*P* < 0.001
> 2	Mar 86	12.7	0.9	74	**5.9**	1.9	15	P < 0.01
> 2	Mar 87	13.3	1.1	28	**1.7**	1.2	12	*P* < 0.001

[1] **Bold** indicates significant difference between pregnant and non-pregnant females.

Appendix 7. Back fat depths of pregnant and non-pregnant female caribou obtained in December (1982-86) and March (1980-87) from the Beverly herd.

Age class (yr)	Back fat in December (mm) Pregnant Mean	SE	*n*	Not pregnant Mean	SE	*n*	Back fat in March (mm) Pregnant Mean	SE	*n*	Not pregnant Mean	SE	*n*
1.2- 2	14.5	2.5	2	5.8	0.9	24	13.3	2.1	9	**2.6**[1]	0.4	56
2.5- 3	18.7	2.5	17	**4.1**	1.0	13	16.8	0.9	66	**1.6**	0.5	21
3.5- 4	17.2	1.8	30	**7.8**	2.6	8	17.4	1.0	54	**1.8**	0.7	12
4.5- 5	11.6	1.6	22	**1.3**	0.3	3	15.7	1.2	48	**4.2**	2.3	9
5.5-11	13.7	1.2	65	**1.5**	0.5	14	16.4	0.6	231	**3.7**	0.9	29
>11	17.8	2.9	17	8.0		1	13.7	1.6	33	**7.0**	3.8	4
> 2	15.1	0.8	151	**3.8**	0.8	39	16.3	0.4	432	**2.8**	0.5	74
> 3	14.7	0.9	134	**3.7**	1.0	26	16.2	0.5	366	**3.3**	0.7	53
> 4	13.9	1.0	104	**1.8**	0.6	18	16.0	0.5	312	**3.7**	0.8	41
> 5	14.6	1.2	82	**1.9**	0.7	15	16.1	0.6	264	**4.1**	0.9	33

[1] **Bold** indicates significant difference between pregnant and non-pregnant females.

Appendix 8. Linear regression statistics derived from sample means for kidney fat/kidney fat indices (*x* axis) and fecundity (*y* axis) of caribou collected from the Beverly herd, 1980 through 1987.

Age class (yr)	Month	Regression variable[1] *a*	*b*	*r*	Significance
Kidney fat					
2.5-3	Dec	7.68	0.87	0.68	NS
	Mar	42.81	0.69	0.73	NS
3.5-4	Dec	102.93	-0.20	0.14	NS
	Mar	-90.56	2.25	**0.95**[2]	$P < 0.01$
2.5-4	Dec	60.40	0.27	0.24	NS
	Mar	4.40	1.14	**0.75**	$P < 0.01$
>4	Dec	67.96	-0.09	0.10	NS
	Mar	-18.20	1.41	**0.82**	$P < 0.05$
Kidney fat index					
>4	Dec	17.89	-0.04	0.70	NS
	Mar	0.90	0.72	**0.77**	$P < 0.05$

[1] Where *a* is the y intercept, *b* is the slope, and *r* is the regression coefficient.
[2] **Bold** indicates significant difference between pregnant and non-pregnant females.

Appendix 9. Kidney fat in pregnant and non-pregnant female caribou sampled from the Beverly herd in December (1982-86) and March (1980-87).

Sample period	Age grouping	Kidney fat (g) Pregnant Mean	SE	*n*	Not pregnant Mean	SE	*n*
Nov 82	>2	78.3	3.9	31	**56.5**[1]	7.3	6
Dec 83	>2	96.6	6.7	22	**45.4**	3.1	7
Dec 84	>2	85.7	4.5	38	**53.2**	10.2	6
Dec 85	2.5-3.5	75.4	7.4	14	**41.0**	6.1	8
Dec 85	>5	94.3	5.4	19	44.8	3.5	4
Dec 86	>5	80.7	6.7	9	**46.8**	5.1	4
Mar 80	3, 4	71.6	5.6	5	**46.8**	6.5	5
Mar 82	>2	102.6	3.6	49	**70.0**	11.6	6
Mar 83	>2	99.9	4.8	58	**48.7**	3.7	21
Mar 84	>2	121.2	3.8	87	**53.0**	0.4	3
Mar 85	>2	123.8	3.0	100	**59.3**	8.7	9
Mar 86	>2	102.0	4.0	74	**63.7**	6.5	15
Mar 87	>2	111.6	6.3	29	**45.0**	4.8	12

[1] **Bold** indicates significant difference between pregnant and non-pregnant females.

Appendix 10. Kidney fat indices of pregnant and non-pregnant caribou sampled from the Beverly herd in December (1982-86) and March (1980-87).

Sample period	Age group (year)	Kidney fat index[1]						Significance
		Pregnant			Not pregnant			
		Mean	SE	*n*	Mean	SE	*n*	
Dec 82	>2	45.0	2.4	31	35.1	4.4	6	NS
Dec 83	>2	58.5	4.6	22	**27.9**[2]	2.9	7	$P < 0.01$
Dec 84	>2	47.3	2.9	38	32.1	6.5	6	NS
Dec 85	2.5,3.5	44.1	4.8	12	26.9	6.6	5	NS
Dec 85	>5	55.7	3.2	19	**25.4**	1.4	4	$P < 0.01$
Dec 86	>5	45.9	4.1	9	31.7	2.9	4	NS
Mar 80	3, 4	53.6	8.1	5	35.9	6.3	5	NS
Mar 82	>2	65.0	2.2	49	44.7	8.3	6	NS
Mar 83	>2	63.6	3.1	58	**32.4**	2.6	21	$P < 0.001$
Mar 84	>2	73.1	2.5	87	**28.5**	8.5	3	$P < 0.05$
Mar 85	>2	77.7	2.2	100	**31.7**	5.1	9	$P < 0.001$
Mar 86	>2	66.4	2.5	74	**43.6**	4.5	15	$P < 0.001$
Mar 87	>2	754.8	4.1	29	**32.0**	3.9	12	$P < 0.001$

[1] Riney (1955).
[2] **Bold** indicates significant difference between pregnant and non-pregnant females.

Appendix 11. Condition index FAT in pregnant and non-pregnant female caribou sampled from the Beverly herd each December (1982-86) and March (1980-87).

Age class (yr)	FAT[1] in December						FAT in March					
	Pregnant			Not pregnant			Pregnant			Not pregnant		
	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*
1.5- 2	10.4		1	9.9	0.3	23	13.0	0.3	8	**10.0**[2]	0.2	54
2.5- 3	11.9	0.4	17	**9.7**	0.3	12	12.7	0.2	64	**10.1**	0.3	21
3.5- 4	11.2	0.2	32	**9.0**	0.8	8	12.6	0.2	54	**9.8**	0.3	11
4.5- 5	11.2	0.3	22	8.8	0.5	3	12.6	0.2	47	**9.2**	0.4	7
5.5-11	11.0	0.2	64	**9.0**	0.2	14	12.3	0.1	228	**9.6**	0.3	29
>11	10.4	0.3	17	9.0		1	11.3	0.2	32	9.8	1.0	4
> 1	11.1	0.1	153	9.5	0.2	61	12.4	0.1	433	9.7	0.1	127
> 2	11.1	0.1	152	9.2	0.2	38	12.4	0.1	425	9.7	0.2	72
> 5	10.9	0.2	81	9.0	0.2	15	12.2	0.1	260	9.6	0.3	33

[1] *FAT = 3.73 ln KFIR - 3.29* (Huot and Goudreault 1985).

[2] **Bold** indicate s significant difference between pregnant and non-pregnant females.

Appendix 12. Linear regression statistics derived from sample means for femur marrow fat/mandibular water (*x* axis) and fecundity (*y*) of caribou collected from the Beverly herd, 1980 through 1987.

Age class (yr)	Month	Regression variable[1] *a*	*b*	*r*	Significance
Femur fat (%)					
>4	Dec	70.28	0.18	0.57	NS
	Mar	70.14	0.19	0.56	NS
	Dec + Mar	70.08	0.19	0.56	NS
3.5-4	Dec	88.54	-0.03	0.20	NS
	Mar	85.91	0.03	0.30	NS
	Dec + Mar	85.74	0.02	0.10	NS
2.5-3	Dec	84.98	-0.01	0.06	NS
	Mar	90.04	-0.03	0.46	NS
	Dec + Mar	86.38	0.00	0.01	NS
2.5-4	Dec	83.97	0.02	0.14	NS
	Mar	89.25	-0.01	0.10	NS
	Dec + Mar	85.72	0.02	0.10	NS
Mandibular water (%)					
>4	Dec	45.92	-0.12	0.57	NS
	Mar	45.75	-0.14	**0.76**[2]	$P < 0.05$
	Dec + Mar	46.75	-0.15	**0.60**	$P < 0.05$
3.5-4	Dec	28.98	0.11	0.35	NS
	Mar	40.55	-0.07	0.39	NS
	Dec + Mar	38.39	-0.03	0.10	NS
2.5-3	Dec	31.25	0.09	**0.89**	$P < 0.05$
	Mar	40.73	-0.06	0.61	NS
	Dec + Mar	38.24	-0.02	0.20	NS
2.5-4	Dec	31.16	0.09	0.47	NS
	Mar	41.22	-0.07	0.54	NS
	Dec + Mar	38.46	-0.03	0.14	NS

[1] Where *a* is the y intercept, *b* is the slope, and *r* is the regression coefficient.

[2] **Bold** indicates a significant regression.

Appendix 13. Percent fat in marrow of femur bones of pregnant and non-pregnant caribou sampled from the Beverly herd in December (1982-86) and March (1982-87).

Age class (yr)	Fat in femur marrow (percent)											
	Sampled in December						Sampled in March					
	Pregnant			Not pregnant			Pregnant			Not pregnant		
	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*
1.5- 2	88.0		1	84.6	0.9	22	88.7	0.9	7	86.4	0.9	42
2.5- 3	85.2	0.9	17	82.9	1.9	11	88.7	0.4	62	**84.4**[1]	1.5	19
3.5- 4	86.7	0.7	28	82.9	1.7	8	89.4	0.4	48	84.7	2.5	11
4.5- 5	88.0	0.7	16	77.0	4.2	2	88.6	0.4	45	84.7	3.4	8
5.5-11	86.8	0.6	52	78.9	3.7	12	88.3	0.2	202	**76.7**[2]	2.8	26
>11	85.6	0.7	13	87.0		1	86.8	0.5	29	85.3	2.1	4
> 1	86.6	0.3	127	**82.6**[2]	1.0	56	88.4	0.2	393	**83.3**[2]	0.9	111
> 2	86.6	0.3	126	**81.2**[2]	1.6	34	88.4	0.2	386	**81.6**[2]	1.4	68
> 3	86.8	0.3	109	**80.5**[2]	2.1	23	88.3	0.2	324	**80.5**[2]	1.8	49

[1] $P < 0.05$, pregnant *vs.* non-pregnant females.

[2] $P < 0.01$.

[1&2] **Bold** indicates significant differences between pregnant and non-pregnant groups.

Appendix 14. Linear regression statistics derived from sample means for fat percentage (FATP) (*x* axis) and dissectible fat (DFAT) (*x* axis) and fecundity (*y* axis) of caribou collected from the Beverly herd, 1980 through 1987.

Age class (yr)	Month	Regression variable[1]			Significance
		a	*b*	*r*	
FATP[2]					
>4	Dec	8.06	0.04	0.48	NS
	Mar	5.78	0.08	**0.78**[4]	$P < 0.05$
	Dec + Mar	5.88	0.07	0.58	NS
3.5-4	Dec	14.42	-0.04	0.44	NS
	Mar	2.73	0.13	**0.92**	$P < 0.01$
	Dec + Mar	6.05	0.08	0.54	NS
2.5-3	Dec	9.14	0.04	0.40	NS
	Mar	10.97	0.03	0.04	NS
	Dec + Mar	9.59	0.04	0.44	NS
2.5-4	Dec	11.20	0.00	0.06	NS
	Mar	8.46	0.06	**0.62**	$P < 0.05$
	Dec + Mar	8.82	0.05	**0.45**	$P < 0.05$
DFAT[3]					
>4	Dec	-2.76	0.07	0.68	NS
	Mar	-4.76	0.10	**0.90**	$P < 0.01$
	Dec + Mar	-4.60	0.10	**0.76**	$P < 0.01$
3.5-4	Dec	4.62	-0.01	0.17	NS
	Mar	-5.75	0.12	**0.97**	$P < 0.01$
	Dec + Mar	-2.25	0.07	0.70	NS
2.5-3	Dec	-1.35	0.06	**0.90**	$P < 0.05$
	Mar	0.53	0.04	**0.83**	$P < 0.05$
	Dec + Mar	-0.32	0.05	**0.85**	$P < 0.01$
2.5-4	Dec	0.45	0.04	0.58	NS
	Mar	-1.32	0.07	**0.82**	$P < 0.01$
	Dec + Mar	0.76	0.06	**0.75**	$P < 0.01$

[1] Where *a* is the y intercept, *b* is the slope, and *r* is the regression coefficient.
[2] FATP (Huot and Goudreault 1985) in App. 1.
[3] DFAT (Adamczewski et al. 1987) in App. 1.
[4] **Bold** indicates significant regression.

Appendix 15. Condition index CONI in pregnant and non-pregnant female caribou sampled from the Beverly herd each December (1982-86) and March (1980-87).

Age class (yr)	CONI[1] in December						CONI in March					
	Pregnant			Not Pregnant			Pregnant			Not Pregnant		
	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*
1.5- 2	107.3		1	100.5	2.8	22	151.2	6.0	6	**103.6**[2]	2.2	39
2.5- 3	129.9	6.7	17	**96.5**	4.2	10	144.8	3.2	60	**103.1**	4.4	19
3.5- 4	119.9	3.5	28	**94.3**	5.7	8	143.3	3.0	48	**102.4**	4.5	10
4.5- 5	122.1	5.0	16	**78.7**	5.0	2	141.4	3.6	43	**100.1**	7.9	8
5.5-11	117.8	2.3	51	**86.3**	4.6	12	137.8	1.6	197	**91.0**	4.7	26
>11	108.3	4.5	13	93.9		1	118.8	3.4	28	103.7	11.6	4
> 1	119.4	1.8	126	**94.9**	2.1	55	138.8	1.2	382	**100.1**	1.9	106
> 2	119.5	1.8	125	**91.1**	2.7	33	138.6	1.2	376	**97.3**	2.6	66
> 3	117.8	1.7	108	**88.7**	3.3	23	137.5	1.3	316	**94.9**	3.2	47

[1] *CONI = (KFI - 20) + FEF*, where KFI is the kidney fat index and FEF is percent fat in marrow of femurs (Connolly 1981).

[2] **Bold** indicates significant difference ($P < 0.05$) between pregnant and non-pregnant females.

Appendix 16. Linear regression statistics derived from sample means for condition index A (CIA) (*x* axis) and condition index B (CIB) (*x* axis) and fecundity (*y* axis) in caribou sampled from the Beverly herd, 1980 through 1987.

Age class (yr)	Month	Regression variable[1] *a*	*b*	*r*	Significance
CIA[2]					
> 4	Dec	9.80	0.04	0.17	NS
	Mar	-11.09	0.30	**0.89**[4]	$P < 0.01$
	Dec + Mar	-5.71	0.23	**0.71**	$P < 0.01$
3.5-4	Dec	17.06	-0.04	0.24	NS
	Mar	-7.64	0.27	**0.92**	$P < 0.01$
	Dec + Mar	0.89	0.16	**0.65**	$P < 0.05$
2.5-3	Dec	-0.82	0.20	**0.93**	$P < 0.05$
	Mar	5.02	0.12	**0.88**	$P < 0.01$
	Dec + Mar	2.62	0.15	**0.88**	$P < 0.01$
2.5-4	Dec	4.83	0.11	**0.64**	$P < 0.05$
	Mar	1.60	0.16	**0.81**	$P < 0.01$
	Dec + Mar	2.68	0.15	**0.75**	$P < 0.01$
CIB[3]					
> 4	Dec	-58.59	0.91	0.49	NS
	Mar	164.30	2.29	**0.92**	$P < 0.01$
	Dec + Mar	-139.83	1.95	**0.77**	$P < 0.01$
3.5-4	Dec	45.49	-0.23	0.17	NS
	Mar	-174.32	2.41	**0.96**	$P < 0.01$
	Dec + Mar	-96.67	1.50	**0.69**	$P < 0.05$
2.5-3	Dec	-79.10	1.23	**0.93**	$P < 0.05$
	Mar	-48.99	0.93	**0.85**	$P < 0.05$
	Dec + Mar	-64.53	1.09	**0.87**	$P < 0.01$
2.5-4	Dec	-54.39	0.95	**0.64**	$P < 0.05$
	Mar	-85.62	1.37	**0.82**	$P < 0.01$
	Dec + Mar	-74.38	1.23	**0.77**	$P < 0.01$

[1] Where *a* is the *y* intercept, *b* is the slope, and *r* is the regression coefficient.
[2] Condition index A (Thomas and Kiliaan 1998a and App. 1).
[3] Condition index B (Thomas and Kiliaan 1998a and App. 1).
[4] **Bold** indicates a significant regression.

Appendix 17. Linear regression statistics for sample means of antler weights (*x* axis) and warble larvae numbers (*x* axis) and fecundity (*y* axis) in caribou sampled from the Beverly herd, 1980 through 1987.

Age class (yr)	Month	Regression variable[1] *a*	*b*	*r*	Significance
Antler weights (g)					
> 4	Dec	-65.11	3.94	0.64	NS
	Mar	-61.22	3.99	0.71	NS
	Dec + Mar	-0.00	4.05	**0.70**[2]	$P < 0.05$
3.5-4	Dec + Mar	125.10	1.28	0.55	NS
2.5-3	Dec + Mar	-10.13	2.97	**0.91**	$P < 0.05$
2.5-4	Dec + Mar	31.47	2.43	**0.81**	$P < 0.01$
Warble larvae					
> 4	Dec	28.02	-0.22	0.17	NS
	Mar	72.01	-0.42	0.48	NS
3.5-4	Dec	-8.28	0.18	0.50	NS
	Mar	132.96	-0.99	0.54	NS
2.5-3	Dec	16.55	-0.03	0.07	NS
	Mar	54.27	0.03	0.02	NS
2.5-4	Dec	18.74	-0.11	0.22	NS
	Mar	77.92	-0.32	0.24	NS

[1] Where *a* is the *y* intercept, *b* is the slope, and *r* is the regression coefficient.

[2] **Bold** indicates a significant regression.

Appendix 18. Number of warble larvae under skin of caribou sampled from the Beverly herd in December (1982-86) and March (1980-87).

Sex/age class (yr)	Number of warble larvae					
	December			March		
	Mean	SE	*n*	Mean	SE	*n*
F 0.5-1	18.8	3.7	5	**124.7**[1]	13.9	29
F l.5-2	23.7	4.0	26	**114.2**	11.5	59
F 2.5-3	14.1	2.9	30	**45.7**	5.1	82
F 3.5-4	5.8	1.5	38	**46.2**	4.9	61
F 4.5-5	12.2	7.0	25	**28.3**	3.8	56
F 5.5-8	10.5	2.5	58	**36.1**	3.7	153
F 8.5-11	4.2	1.2	22	**37.1**	4.9	91
F >11	5.4	2.3	18	**35.9**	5.4	36
F >5	8.2	1.6	98	**36.4**	2.7	280

[1] **Bold** indicates a significant (P <0.05) difference between December and March samples.