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RH: Lynx Pelt Length · Slough

DISCRIMINATING JUVENILE FROM ADULT LYNX AND DETERMINING LYNX POPULATION AGE RATIO WITH PELT LENGTH DATA

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ABSTRACT

Pelt length measurements of harvested lynx (*Lynx lynx*) are used in several jurisdictions to monitor the recruitment of kits into the population and implement harvest management strategies. I evaluated pelt lengths and found that the proportion of kits can be reliably determined from a pelt sample, and that there is a relationship between the proportions of kits in the harvest and in the population. I aged 90% of lynx correctly from pelt length data. Incorrect ages could not be attributed to specific age or sex classes. I estimated the dividing point (*D*) between kits and adults to be ≤90.5 cm for Yukon lynx pelt lengths. I calculated a correction factor (*CF*) to convert pelt-sample age ratios to population age ratios. A *CF* of 1.19 is required for a harvest season of

Nov. 1 to March 10, however the CF varies due to monthly harvest bias of kits. Harvest restrictions are recommended

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when the estimated proportion of kits in the population is <20%.

Key words: aging, harvest, lynx, Lynx lynx, management, pelt length, recruitment.

Population cycles of Canada lynx (*Lynx lynx*), are ultimately caused by fluctuations of its chief food, the snowshoe hare (*Lepus americanus*), but are proximally driven by changes in age-specific reproduction and mortality rates (Brand and Keith 1979, Poole 1994, Slough and Mowat in press). Recruitment rate data can be used to implement a population tracking harvest strategy (Caughley 1977) whereby harvest is decreased or curtailed for 3-4 years of low lynx recruitment and populations and increased when populations increase (Brand and Keith 1979). The proportion of kits (<12 mos.) in the population reflects recruitment rate, therefore techniques used to discriminate juvenile from adult lynx are useful in lynx harvest management.

Kits have been separated from yearling and adult lynx by applying several criteria to live, carcass, or pelt specimens. Growth and developmental characteristics typical of kits include incomplete ossification of epiphyses of the radius and ulna (Nava 1970), non-closure of the canine basal foramen (Saunders 1964), smaller body weight (Ward and Krebs 1985, B.G. Slough and G. Mowat, Yukon Dept. Renew. Resour., unpubl. data), shorter pelt length (Quinn and Gardner 1984, Stephenson and Karczmarczyk, 1989), and pelage characteristics such as paler, shorter, and silkier fur (R.O. Stephenson, pers. commun.), and shorter and thinner ear tufts and shorter neck ruff (Stephenson and Karczmarczyk 1989). Yearling lynx may be separated from adults (≥24 mos.) using the cementum annuli technique (Nava 1970, Crowe 1972) or by analyzing blood alkaline phosphatase levels, which are higher in yearlings (Weaver and Johnson 1995).

The use of pelt length criteria to age lynx is attractive because pelt measurements are readily available from fur auction houses (standard size classes; see Quinn and Gardner 1984) and management agencies that routinely record lynx pelt measurements during the mandatory sealing of pelts. Pelts are tagged or stamped when sealed to monitor harvest and control illegal trade.

Pelt lengths have been previously used to estimate age ratios in the harvest (Quinn and Gardner 1984), but not in the population. The relationship of the two depends on the differential vulnerability of age classes to trapping. I evaluated the relationship of lynx pelt length to age in a harvested sample of lynx from the south-central Yukon Territory (YT)and northern British Columbia (BC). I then developed a correction factor, based on age-specific trapping bias, to convert the estimated proportion of kits in the harvest to an estimate of the proportion of kits in the population derived from my study of live lynx in the south-central YT (Slough and Mowat in press). The correction factor was then applied to pelt length data from the south-central YT so that corrected age ratio estimates could be compared to actual age ratios. Finally, I discuss the application of lynx age ratio estimates to harvest management strategies.

STUDY AREA

I obtained lynx carcasses from fur trappers within a 100-km radius of a live-lynx study area in YT and BC from November 1986 to March 1994, to compare the population characteristics of adjacent harvested and unharvested sub-populations (Slough and Mowat in press). The lynx trapping season was November 1 to March 10. There were no quotas, but there was a registered trapping concession tenure system which limited the number of trappers, reduced competition for the resource, and provided conservation incentives to trappers (Slough et al. 1987).

METHODS

Determination of Lynx Age/Pelt Length Relationship

Trappers submitted lynx carcasses tagged with the date of capture and pelt length, recorded to the nearest cm or ½ inch. Carcasses were sexed and aged as kits by non-closure of the basal foramen in canines or, as yearlings or adults by cementum annuli analysis of canines.

A dividing point (D), for separating kit and combined yearling and adult age classes was derived from pelt lengths using a variance of the method of Dix and Strickland (1986) for aging fisher (*Martes pennanti*) from width ratios of canine teeth.

Estimation of Proportion of Kits in the Harvest

Yukon Dept. of Renew. Resour. staff, fur dealers and the Yukon Trappers Assoc. recorded lynx pelt length to the nearest cm or ½ inch in 1986-87 and 1987-88. An average of 62% of the annual harvest was sampled in this manner. Measurements (in cm) were taken from 94% of the harvest when mandatory lynx pelt sealing began in 1988-89 (6% of sealing documents reported incorrect or no pelt data). Lynx cannot be confidently sexed using pelt characteristics and trappers were not requested to provide this information when sealing pelts.

I estimated the proportion of kits in the annual harvest for the south-central YT (70,000 km^2, which included the live lynx study and carcass collection areas), from the 1986-87 to 1993-94 lynx pelt data as the proportion of pelt lengths < D.

Estimation of Proportion of Kits in the Population

I calculated a correction factor (CF) to convert the proportion of kits estimated in the harvest to an estimate of their proportion in the population. CF was the proportion of kits in the live population divided by the proportion of kits in the live-capture sample on or before the end of the trapping season (March 10) (CF = 50.4%/42.9% = 1.19). Five years data (from Slough and Mowat in press) were combined to increase the sample size (i.e., there were 197 kits in a total population of 391 lynx between 1987-88 and 1991-92, and 36 of 84 lynx live-captured to March 10 were kits). The trapping bias of new captures only (i.e., recaptures excluded) is analogous to the bias experienced during removal trapping. The proportion of kits in the harvested lynx population was therefore estimated as the proportion in the harvest × CF.

Statistical Analysis

Variation in pelt length measurements of sexes among age classes and sex and age classes among years were compared using one-way analysis of variance (ANOVA) followed by Tukey's Studentized Range tests (HSD). Differences in mean pelt lengths between sexes within age classes or between 2 age classes (i.e., kits and combined adults and yearlings) were assessed with Student's t-tests. Chi-square contingency analysis was used to determine if the estimated age ratios deviated from actual. A Pearson product moment correlation was used to measure the linear relationship between the estimated proportion of kits in the south-central YT lynx population and the proportion of kits in the live lynx study area over 8 years.

RESULTS

Lynx Age/Pelt Length Relationship

Pelt lengths and ages were reported for 130 kits and 582 older lynx carcasses (Table 1; 1 kit and 5 adults were not sexed). Pelt lengths differed among all age classes of females (F = 125.84; df = 2, 302; P = 0.0001; HSD, $P < 0.05$). Male kits were smaller than older males, but male yearlings and adults did not differ (F = 127.54; df = 2, 398; P = 0.0001; HSD, $P < 0.05$). Males were larger than females in all age classes (kits, t = 3.43, df = 127, P = 0.001; yearlings, t = 5.48, df = 324, $P < 0.0001$; adults, t =3.83, df = 249, P = 0.0002). Female yearlings were larger than male kits (t = 11.1, df = 177, $P < 0.0001$). Within sex and age class categories, pelt length did not differ among years (ANOVA, $P > 0.05$).

Data for both sexes, and adults and yearlings, were combined for the determination of the lynx age/pelt length relationship because sex is not normally recorded for pelts at the time of sealing, and adult and yearling males could not be differentiated. The frequency distribution of pelt length by age class shows a clear separation of the classes (Fig. 1). The formula of Dix and Strickland (1986) resulted in a D value of 90.5 cm, which correctly aged 89.2% of 130 kits and 90.1% of 582 adult lynx. Incorrect ages were not biased to any age class (χ^2 = 0.872, 1 df, P = 0.65) or to any sex within age classes (kits, χ^2 = 0.77, 1 df, P = 0.38; yearlings, χ^2 = 1.15, 1 df, P = 0.28; adults, χ^2 = 1.06, 1 df, P = 0.30).

Proportions of Kits in the Population

Estimates of the annual proportions of kits in the harvested lynx population are given in Table 2. The pelt estimates were significantly correlated with the proportion of kits found in the live lynx study sub-population. During years with no kits in the live lynx study area, kits comprised ≤24.2% of the harvested population as estimated from pelt length data. Kits comprised an estimated 29.3-44.1% of the harvested population during the 4 years of peak lynx recruitment on the live study area, when ≥63.5% of kits were surviving to 10 months (Slough and Mowat in press), and the March population contained 47.9-55.6% kits.

DISCUSSION and RECOMMENDATIONS

Pelt length was an accurate criterion for distinguishing kits from yearling and adult lynx for estimating harvest age structure as found by Quinn and Gardner (1984). However, because lynx body size varies geographically, $\underline{D}$ may also vary. For example, live yearling and adult lynx from my study area in YT averaged 2 kg heavier and 6 cm longer and live kits were up to 1.5 kg heavier and 10 cm longer than live lynx reported for several locations across the range of the lynx (Quinn and Parker 1987, B.G. Slough, Yukon Dept. Renew. Resour., unpubl. data). Mean pelt lengths in YT were 13 to 18 cm longer than in Ontario (Quinn and Gardner 1984), but were similar to those observed in Alaska (81.8 cm and 102.4 cm for kits and adults, respectively) (Stephenson and Karczmarczyk 1989).

Bias in pelt length measurements may be caused by techniques used by trappers to stretch and dry pelts and by recording errors. Although there are many regional variations in the methods traditionally used to prepare pelts, fur buyers, brokers, and garment manufacturers demand a standard product (Hall and Obard 1987). Pelt handling techniques in Canadian jurisdiction are presently being standardized through trapper education (H. Slama, Yukon Dept. Renew. Resour., pers. commun.).

Quinn and Gardner (1984) recommended implementing a population tracking harvest strategy (Brand and Keith 1979) based on a subjective assessment of lynx recruitment and that trapping be curtailed when pelts <81 cm become scarce in the harvest. Stephenson and Karczmarczyk (1989) used a subjective dividing point of ≤86 cm in Alaska. Their data may be biased because 94% of their known-age pelts were obtained from a subjective assessment of pelt characteristics by fur buyers and fur sealers, based on preconceptions instead of objective carcass aging techniques. This type of bias may enhance the separation between kit and adult pelt lengths by reducing their standard deviations.

This study is the first to demonstrate a relationship between age ratios of the lynx harvest and population. The greatest discrepancy between the two occurred in 1992-93, the second full year of declining hare populations, when the proportion of kits in the harvested population may have been overestimated by up to 24.2%. This difference could have been due to real variation in age ratios between the trapped and untrapped sub-populations, sample size bias, or a smaller body length of lynx at that time. I believe that the length of pelts from some yearlings and adults were in the kit size class. Many lynx were in poor physical condition and weighed less than average in 1992-93. Three adult females weighted 3-4 kg less and 4 adult males weighed 2-3 kg less than the average during the other 7 years of live lynx study (B.G. Slough, Yukon Dept. Renew. Resour., unpubl. data). Age ratios of the carcass collection and live lynx study areas were not significantly different in 1992-93 (Slough and Mowat in press).

The correction factor I applied was useful for estimating the proportion of kits in the population from the proportion in the harvest. Depending on the duration and timing of harvest, this factor will need adjustment because kits become more vulnerable to trapping, relative to adults, as the season progresses (Parker et al. 1983, Quinn and Thompson 1985, Slough and Mowat in press). Therefore CF should be greater than 1.19 for seasons ending before March 10, and lower for seasons ending later. I calculated CF's for hypothetical seasons ending on February 28 and March 31 in YT (dividing the proportion of kits in population by the proportion of kits first captured on or before the season ending date; B.G. Slough, Yukon Dept. Renew. Resour., unpubl. data) as 1.21 and 1.02, respectively. I have too few data from earlier months to calculate CF's for earlier trapping seasons, but based on harvest compositions reported by Quinn and Thompson (1985) and Slough and Mowat (in press), I estimate CF's of 1.5 for January 31, 2.5 for December 31, and 4.0 for November 30. A correction factor of less than 1.0 (e.g., 0.5) may be needed during the year(s) of rapid lynx population decline, when there is little or no lynx recruitment and the pelt lengths of many adults are < D.

I recommend that furbearer managers attempt to estimate the annual proportion of kits in harvested lynx populations, and that when the proportion is <20%, a tracking or restrictive (e.g., limiting seasons or implementing quotas) harvest strategy be effected. Restrictions should not be necessary during the first or second full years of hare population decline, when trapping is largely compensatory to natural mortality (Poole 1994, Slough and Mowat in press). It should be noted that lynx age ratios may not reflect population trends if a population is decreasing due to overharvest or other factors.

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LITERATURE CITED

Brand, C. J., and L. B. Keith. 1979. Lynx demography during a snowshoe hare decline in Alberta. J. Wildl. Manage. 43:827-849.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley & Sons, New York, NY. 234pp.

Crowe, D. M. 1972. The presence of annuli in bobcat tooth cementum layers. J. Wildl. Manage. 36:1330-1332.

Dix, L. M., and M. A. Strickland. 1986. Sex and age determination for fisher using radiographs of canine teeth: a critique. J. Wildl. Manage. 50:275-276.

Hall, G. E., and M. E. Obbard. 1987. Pelt preparation. Pp. 842-861, In M. Novak, J. A Baker, M. E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ont. Trappers Assoc., North Bay.

Nava, J. 1970. The reproductive biology of the Alaska lynx. M. S. Thesis. Univ. Alas., Fairbanks. 141pp.

Parker, G. R., J. W. Maxwell, L. D. Morton, and G. E. J. Smith. 1983. The ecology of the lynx (Lynx canadensis) on Cape Breton Island. Can. J. Zool. 61:770-786.

Poole, K. G. 1994. Characteristics of an unharvested lynx population during a snowshoe hare decline. J. Wildl. Manage. 58:608-618.

Quinn, N. W. S., and J. F. Gardner. 1984. Relationships of age and sex to lynx pelt characteristics. J. Wildl. Manage. 48:953-956.

———, and G. R. Parker. 1987. Lynx. Pp. 682-685, In M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ont. Trappers Assoc., North Bay.

———, and J. E. Thompson. 1985. Age and sex of trapped lynx, Felis canadensis, related to period of capture and trapping technique. Can. Field-Nat. 99:267-269.

Saunders, J. K. 1964. Physical characteristics of the Newfoundland lynx. J. Mammal. 45:36-47.

Slough, B. G., R. H. Jessup, D. I. Mckay, and A. B. Stephenson. 1987. Wild furbearer management in western and northern Canada. Pp. 1062-1076, In M. Novak, J. A Baker, M. E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ont. Trappers Assoc., North Bay.

______, and G. Mowat. in press. Population dynamics of lynx in an untrapped refugium and interactions between trapped and untrapped sub-populations. J. Wildl. Manage. 00:000-000.

Stephenson, R. O., and P. Karczmarczyk. 1989. Development of techniques for evaluating lynx population status in Alaska. Alaska Dept. Fish and Game, Fed. Aid in Wildl. Restoration Res., Final Rep., proj. W-23-1, study 7.13. 95pp.

Ward, R. M. P., and C. J. Krebs. 1985. Behavioural responses of lynx to declining snowshoe hare abundance. Can. J. Zool. 63:2817-2824.

Weaver, J. L., and M. R. Johnson. 1995. Hematologic and serum chemistry of captive Canadian lynx. J. Wildl. Dis. 31:212-215.

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Table 1. Mean pelt length (cm) of known-age lynx carcasses from the south-central Yukon Territory and northwestern British Columbia, November 1986 to March 1994.

		Pelt length		
	Age class	$\bar{x}$	SD	n
Male	Kit	84.6	6.4	67
	Yearling	100.8	8.4	214
	Adult	103.0	8.1	120
Female	Kit	80.6	6.9	62
	Yearling	96.1	6.8	112
	Adult	98.9	8.6	131
Combined	Kit	82.7	7.0	130
	Adult	99.9	8.4	582

Table 2. Estimated proportion of kits in the harvested lynx population, based on a kit/adult pelt length dividing point (D) of ≤90.5 cm and a harvest bias conversion factor (CF) of 1.19, and the proportion of kits in a live lynx study sub-population (from Slough and Mowat in press), south-central Yukon, 1986-87 to 1993-94.

Season	Estimated % of lynx kits in harvested population[a]	No. lynx pelts	Estimated % of kits in live lynx sub-population[a]	Live lynx sub-population estimate
1986-87	8.2	202	0	8
1987-88	29.0	242	23.5	17
1988-89	29.3	516	53.1	32
1989-90	30.5	871	47.9	73
1990-91	44.1	518	49.3	134
1991-92	32.6	569	55.6	135
1992-93	24.2	162	0	13
1993-94	13.2	45	0	6

[a] $r = 0.80$, $n = 8$, $P = 0.016$

Figure 1. Frequency distribution of lynx pelt length for 130 kits and 582 adults from the south-central Yukon Territory and northwestern British Columbia, November 1986 to March 1994.