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SEASONAL CHANGES IN LAMB:EWE RATIOS

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Abstract: Lamb:ewe ratios were calculated seasonally (birth, Jun, Sep, and late winter) over a 16 year period for marked individuals in a bighorn sheep population which experienced a phase of population growth (1981-91) and a period of stability (1975-80) during which adult ewes were experimentally removed. Despite fecundity rates that averaged 92% (range 82-100) over the 16 years, lamb mortality by September had reduced lamb:ewe ratios (ewes $\geq$ 2 yrs) to 63 lambs:100 ewes (range 36-82). Post-hunt and late winter ratios calculated during ewe removal years failed to accurately reflect additional lamb mortality since ratios actually increased because of a reduction in the number of ewes. June ratios were weakly correlated with yearling recruitment the following year. Post-hunt and late winter ratios were also correlated with yearling recruitment but only during non-removal years. None of the ratios were correlated with the percent change in population size the following year. Significant correlations were found, however, if lambs were excluded from the following year's population total. June ratios combined over 2 consecutive years (non-ewe removal years only) were significantly ($P < 0.01$) correlated with the percent change in the population between those years. Consecutive winter ratios were also found to be significantly ($P < 0.05$) correlated with changes in winter population size but again, only during years with no ewe removals.

Lamb:ewe ratios are commonly used as indicators of the health of bighorn sheep (Ovis canadensis) herds (Leslie and Douglas 1980, Wehausen et al. 1987, Hebert and Harrison 1988). High ratios are assumed to imply healthy, expanding herds of high quality while the reverse is applied to herds with low ratios (Geist 1971). Smith (1988) found that declining populations of mountain goats (Oreamnos americanus) in Alberta were associated with low kid:adult ratios. There have, however, been no studies where actual ratios have been used to correlate with known changes in population size. There have also been no attempts to document seasonal changes in lamb:ewe ratios. Most studies use winter ratios obtained from either ground or aerial surveys. Such ratios, however, do not accurately reflect fecundity because of unknown levels of lamb mortality which occurred between birth and whenever the ratio was calculated.

Further compounding the accuracy and interpretation of lamb:ewe ratios, are how animals are classified during surveys. It is usually difficult to distinguish yearlings (ewes and rams) and 2-year-old ewes from older reproductively mature ewes. These animals end up included in the "ewe" component of the lamb:ewe ratio. How this factor affects actual ratios has not been determined.

The purpose of this paper is to examine how lamb:ewe ratios change seasonally and are affected by the inclusion of non-reproducing individuals. Ratios are also examined for their usefulness as indicators of population change and recruitment. Funding support is gratefully acknowledged from the Alberta Fish and Wildlife Division, the Alberta Recreation, Parks and Wildlife Foundation, the Craighead Wildlands Wildlife Institute, and the University of Sherbrooke.

STUDY AREA AND METHODS

Ram Mountain is an isolated outcrop of sheep habitat in west-central Alberta. The study area ranges in elevation from 1082 to 2173 m, with treeline at about 1830 m, and includes approximately 38 km^2 of alpine and subalpine habitat used by sheep. It is surrounded on 3 sides by conifer covered foothills. On the fourth side, the North Saskatchewan River separates Ram Mountain from Shunda Mountain, a similar outcrop that supports a small population of sheep.

Sheep have been trapped since 1971 in a corral trap baited with salt. All sheep are trapped annually and marked with either individually identifiable ear tags or collars. Any unmarked animals were lambs which, if not captured in the year of their birth, were captured and tagged as yearlings the following year. The population has ranged in size from a low of 94 in 1977 to a high of 232 in 1991.

Lactation was determined each year by examining the udder at capture or by observing the ewe suckle a lamb. Ewes that were lactating in early June but were never seen suckling a lamb were assumed to have lost their lamb at or soon after parturition. This type of mortality was classified as neonatal mortality. Lambs were paired with ewes on the basis of suckling. The disappearance of marked lambs and the subsequent cessation of lactation in the respective mother was considered summer mortality.

Between 1972 and 1980, 12-24% of the total number of ewes one year of age and older, were removed from the population in September. Ewes were either shot or transplanted.

Ratios were calculated by dividing the number of lambs alive at a particular time by the number of ewes alive at that same time. All ratios and population sizes were based on actual numbers of marked animals which represented the entire population. Post-hunt ratios were ratios calculated after the annual ewe removals. Since field work was completed by October, mid-winter ratios were unknown, however, late winter ratios were calculated based on animals surviving to the following spring. Mid winter ratios would, therefore, fall somewhere between post-hunt ratios and late winter ratios. Linear regression was used to look for correlations between ratios and various population parameters.

RESULTS

Seasonal Lamb:ewe Ratios

<u>At birth</u>.--Bighorns normally do not produce their first lamb until 3 years of age. Considering only ewes 3 years and older, lamb:ewe ratios at

birth on Ram Mountain averaged 0.99 (range 0.82-1.36) between 1975 and 1991 (Table 1). Values greater than 1.00 were years when some 2-year-old ewes produced lambs. Most ewes of reproductive age therefore gave birth to a lamb each year. Including 2-year-old ewes, the average ratio was only 0.78 (range 0.65-0.91).

June.--The average ratio (ewes ≥ 2yrs) at birth declined from 0.78 to 0.67 (range 0.48-0.82) (Table 1). There was considerable annual variation in the level of neonatal lamb mortality. Neonatal mortality ranged from 4% in 1976 to 33% in 1977.

September.--By the end of summer, ratios (ewes ≥ 2yrs) had declined further to average 0.63 (range 0.36-0.82) (Table 1). This represented a drop from June of only 0.04, indicating that lamb mortality during the summer was very low. With the inclusion of yearlings in the ewe component of the ratio, the average ratio was 0.43 (range 0.25-0.54).

Post-hunt.--Following the hunting season for trophy rams and the removal of any ewes (only during 1972 to 1980), the ratio (ewes ≥ 2yrs) averaged 0.71 (range 0.36-1.13) (Table 1). This ratio was higher than the September average ratio of 0.63.

Late-winter.--At the end of winter, the ratio (ewes ≥ 2yrs) averaged 0.61 (range 0.24-1.00) (Table 1). By including yearlings in the ewe component of the ratio, the average dropped to 0.40 (range 0.17-0.59).

Table 1. Seasonal lamb:ewe ratios from Ram Mountain, 1975 to 1991.

	Lamb:Ewe Ratio			
Season	Mean	Range	N*	Ewe Component
At Birth	0.99	0.82-1.36	17	Ewes ≥ 3 yrs
	0.78	0.65-0.91	17	Ewes ≥ 2 yrs
Jun	0.67	0.48-0.82	17	Ewes ≥ 2 yrs
	0.45	0.34-0.56	17	Ewes and yrlgs
Sep	0.63	0.36-0.82	17	Ewes ≥ 2 yrs
	0.43	0.25-0.54	17	Ewes and yrlgs
Post-hunt	0.71	0.36-1.13	16	Ewes ≥ 2 yrs
Late winter	0.61	0.24-1.00	16	Ewes ≥ 2 yrs
	0.40	0.17-0.59	16	Ewes and yrlgs

* No. of years

Ratios as Predictors of Recruitment and Population Change

June and September ratios (ewes ≥ 2yrs) were positively correlated with the number of yearlings recruited to the population the following year (Table 2). Post-hunt and late winter ratios, however, were not correlated.

When all years (1975 to 1991) were combined, ratios (ewes ≥ 2yrs) calculated during any season were poor predictors of percent population change to the next year (Table 3).

However, if the following year's lamb crop was excluded from the calculation of percent population change, then June and September ratios were strongly correlated ($\underline{P} < 0.01$) with percent population change (Table 4). Post-hunt ratios were correlated as well but only during those years when no ewe removals occurred.

Table 2. Pearson correlations between seasonal lamb:ewe ratios[a] and yearling recruitment, 1975 to 1991.

			N[b]	r	P
Jun ratio	vs	No. of yrlgs. the following May	16	0.54	<0.05
Sep ratio	vs	No. of yrlgs. the following May	16	0.54	<0.05
Post-hunt	vs	No. of yrlgs. the following May	16	0.09	NS
Late winter	vs	No. of yrlgs. the following May	15	0.16	NS

[a] Ewes ≥ 2 yrs [b] No. of yrs

Table 3. Pearson correlations between seasonal lamb:ewe ratios[a] and percent population change from one summer to the next summer, 1975 to 1991.

			N[b]	r	P
Jun ratio	vs	% Pop. change (summer)	16	0.14	NS
Sep ratio	vs	% Pop. change (summer)	16	0.09	NS
Post-hunt (includes removal years)	vs	% Pop. change (summer)	16	0.28	NS

[a] Ewes ≥ 2 yrs [b] No. of yrs.

June and September ratios were also correlated ($\underline{P} < 0.05$) with percent population changes from the previous year (Table 5). Post-hunt ratios were not correlated ($\underline{r} = 0.05$, $\underline{P} > 0.05$) except during non-removal years ($\underline{r} = 0.88$, $\underline{P} < 0.01$).

Table 4. Pearson correlations between seasonal lamb: ewe ratios[a] and percent population change, excluding lambs, 1975 to 1991.

			N[b]	r	P
Jun ratio	vs	% Pop. change (excludes lambs)	16	0.85	<0.01
Sep ratio	vs	% Pop. change (excludes lambs)	16	0.78	<0.01
Post-hunt (includes removal years)	vs	% Pop. change (excludes lambs)	16	0.31	NS
Post-hunt (post removal yrs only)	vs	% Pop. change (excludes lambs)	9	0.92	<0.01

[a] Ewes ≥ 2 yrs.
[b] No. of yrs.

Table 5. Pearson correlations between seasonal lamb: ewe ratios[a] and percent population change from the previous year, 1975 to 1991.

			N[b]	r	P
Jun ratio	vs	% Pop. change (summer)	17	0.56	<0.05
Sep ratio	vs	% Pop. change (summer)	17	0.46	<0.05
Post-hunt (post removal)	vs	% Pop. change from previous yr.	9	0.88	<0.01
Post-hunt (removal yrs.)	vs	% Pop. change from previous yr.	8	0.31	NS

[a] Ewes ≥ 2 yrs.
[b] No. of yrs.

Because the 2 apparent largest factors affecting change in population size from one year to the next, appeared to be a combination of recruitment and lamb production, lamb:ewe ratios (ewes $\geq$ 2yrs) from 2 consecutive seasons were combined and regressed with population changes between the 2 years. Consecutive year June ratios were significantly ($r = 0.58$, $N = 16$, $P < 0.05$) correlated with changes in percent population change. That correlation was stronger during post-removal years ($r = 0.87$, $n = 9$, $P < 0.01$) (Fig. 1). Two consecutive winter ratios were also significantly correlated ($r = 0.73$, $N = 8$, $P < 0.05$) with a change in the winter population but during post-removal years only (Fig. 2).

DISCUSSION

Lamb:ewe ratios varied considerably between seasons and between years on Ram Mountain. This variability was due to differences in lamb mortality and not to differences in adult mortality except during years when ewes were experimentally removed from the population. During these removal years, calculated post-hunt and late winter ratios were actually greater than the corresponding June or September ratios. Additional lamb mortality could, therefore, no longer be estimated from changes in the lamb:ewe ratio.

Ratios were not good indicators of fecundity. Most ewes 3 years or older produced a lamb each year but varying levels of lamb mortality reduced ratios such that by late winter ratios as low as 0.24 were seen. Obtaining true ratios was further compounded by the inability to correctly classify younger animals such as 2-year-olds or yearlings. Including these non-producers into the ewe component of the ratio, resulted in a further lowering of the calculated ratio.

It is important, therefore, to try and classify yearlings during any survey and to specify what age class of individuals were included in any age ratio calculations. This is important if comparisons are to be made with ratios reported in other studies.

At Ram Mountain, June and September lamb:ewe ratios were good predictors of recruitment to the next year. Such predictive value was lost, however, if ratios were determined following the hunting season in years of ewe removals. Despite the correlation of summer ratios with recruitment, there was no correlation with percent population change the next year.

While not useful in predicting population changes between consecutive years, ratios were, however, useful in predicting population changes between one year and the previous year. This was due to the large influence the number of lambs born the following year had on population change. There was also a good correlation between summer ratios and population change the following year but only if the followings year's lamb crop was not included in the population total.

Post-hunt and late winter ratios could be used to predict similar changes in population size but only during years when there were no ewe removals. The additional ewe "mortality" in those years altered the ratios enough to negate the correlation.

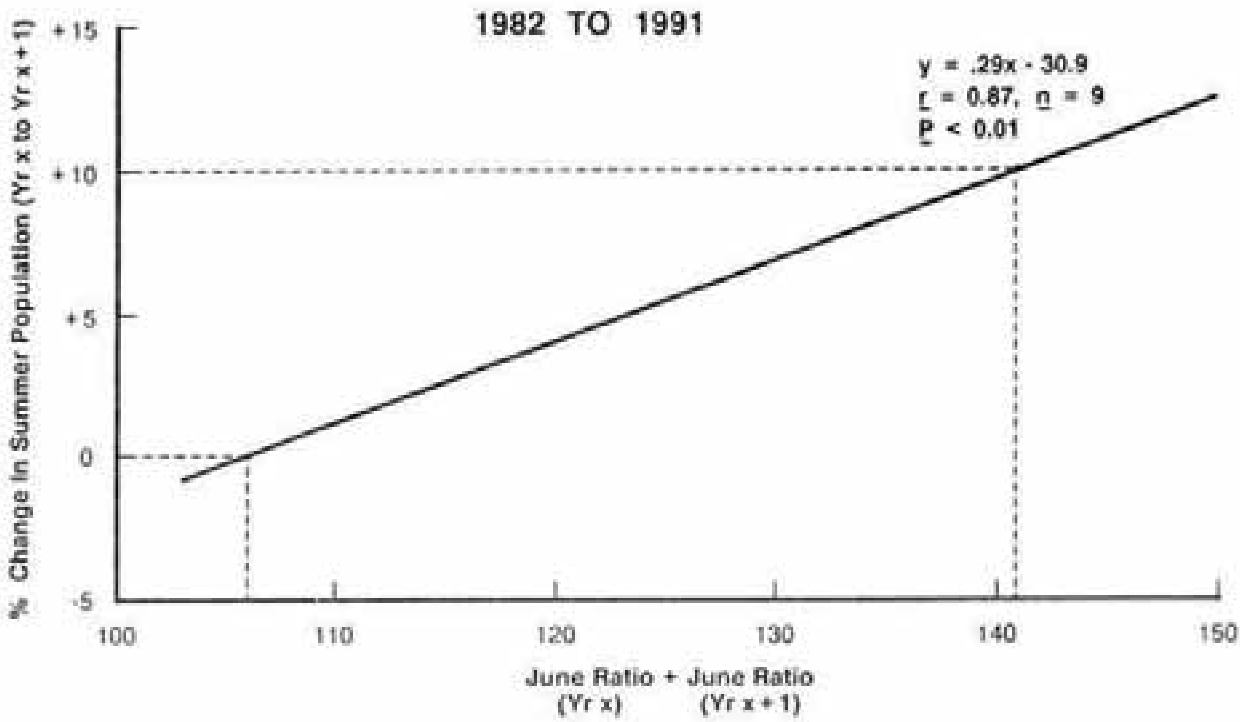

Fig. 1. The relationship between population change and consecutive year June lamb:ewe ratios.

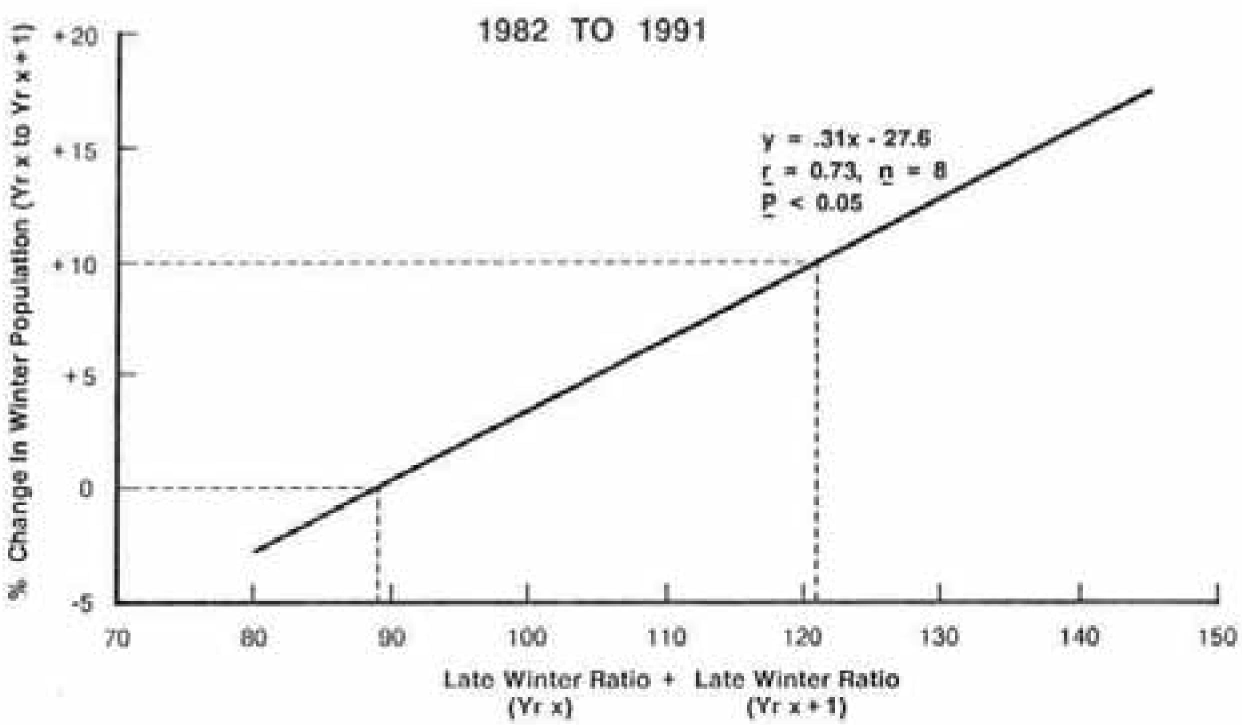

Fig. 2. The relationship between winter population change and consecutive year late winter lamb:ewe ratios.

Those factors contributing most to a change in population size from one year to the next would be recruitment from the previous year, lamb production during that year, and mortality over the previous winter. Since summer ratios were good predictors of both recruitment and population change (from the previous year), it would follow that a combination of ratios taken over 2 consecutive years would be good predictors of population change between those years. This was the case at Ram Mountain, but was applicable only to years of no ewe removals. Similarly, consecutive winter ratios could be used to predict changes in winter population size.

Overwinter mortality could also be expected to have a significant influence on population change. In order for there to be a correlation between ratios and population change, adult mortality rates would have to be consistent on an annual basis. Such was the case at Ram Mountain where annual survival rates averaged 83% with a range of only 80-86% over 10 years. Most of the predictive value of lamb:ewe ratios would thus be lost for populations experiencing large fluctuations in annual adult mortality.

The relationships found in this study were developed based on actual ratios and not from estimates of lamb:ewe ratios based on a sample of the population. Such detailed information is not usually available for most bighorn populations and managers must rely on data gathered during ground or aerial sampling. Such surveys vary in their ability to accurately sample the population. If only a small proportion of any herd is actually sampled, the bias of the subsequent age ratio will likely increase, further weakening the value of such ratios as indicators of population change.

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