Wild reindeer calf recruitment variations; biology or methodology?

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Abstract: The two field methods, ground counts and aerial photography, currently used for calculating population estimates and calf recruitment for Norwegian wild reindeer (*Rangifer tarandus*) produce different results. Using population count data by both methods from the same years in various areas, I systematically compare estimates of sex and age components and decipher reasons for the discrepancies found in previous estimates made by each method. Data for aerial photography counts were found in the literature, while original data is presented for ground counts. Calf recruitment (calves/100 females) and the proportion of adult males (males 1+ years/100 animals 1+ years) in herds of reindeer in Norefjell-Reinsjøfjell (1993-98), Rondane North (1995-97) and Setesdal-Ryfylke (1995, 1998) were recorded from ground counts of post calving groups in June-July. The estimates for number of calves per 100 females 1+ years were lower and more variable than number of calves per 100 females 2+ years. A variable number of yearling females in the groups and difficulties in correctly sexing yearlings are contributing factors. The estimates for number of calves/100 females 1+ years were higher than calves/100 animals 1+ years due to the inclusion of young males in the latter. Among animals 1+ years in the post-calving groups, males (mostly yearling males) composed from 4.7 to 27.9%. Nevertheless, both calculation methods for calf recruitment were consistently higher for ground count data than when using counts from air photographs, confirming that the two methods do not produce comparable results. Explanations for this discrepancy are (1) that calves may be easier to overlook on air photographs than in ground composition counts and (2) that the yearling male components in the post calving groups are unaccounted for when using air photographs. June recruitment rates (calves/100 females 1+ years) in Rondane North were also estimated from composition counts recorded from ground counts in October and from air photographs of post calving groups in June/July. Rates ranged from 44 - 56 from ground counts in 1985-92 and 1995-97, compared to 37 - 65 from air photographs the same years. The air photograph method is based on the assumption that few males are present in the post-calving groups and that the variability in calf recruitment figures reflects variations in reproduction and postnatal calf mortality. The reported ground composition counts challenge the validity of the air photography method commonly used for assessment of calf recruitment or calf mortality in the post-calving wild reindeer groups. While aerial photography may be worthwhile for over-all population counts, ground observations might be necessary for more precise calculations of specific population components, such as age and sex proportions and calf recruitment estimates.

Key words: air surveys, calf recruitment, ground surveys, herd composition, *Rangifer*.

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Introduction

Mortality of calves is an important feature of the population dynamics in ungulates (Bolen & Robinson, 1995; Bertram & Vivion, 2002; Nybakk *et al.*, 2002; Valkenburg *et al.*, 2004). Correctly estimating calf recruitment is a vital component for the successful management of most large ungulate populations, including Norwegian wild reindeer (*Rangifer tarandus*). Wild reindeer and caribou calf mortality is high during the first weeks of life and low thereafter (Lenvik & Aune, 1988; Adams *et al.*, 1995). Two field methods, ground counts and aerial photography, are currently used for gathering base line data used to calculate population and calf recruitment estimates for reindeer. The Norwegian authorities mostly rely on the aerial photography method, and their population estimates and calf recruitment rates for some areas (e.g. Rondane and Hardangervidda) have varied considerably from

year to year. The method currently in use by The Norwegian institute for nature research (NINA) (Jordhøy *et al.*, 1996) for determination of early calf mortality or calf production is counting calves and females 1+ years in June/July after the postnatal mortality from air photographs (Skogland, 1984, 1985; Skogland & Jordhøy, 1992; Andersen *et al.*, 2005). This method is based on the assumption that the number of males 1+ years is negligible in the post-calving reindeer groups; an assumption that has never been critically tested. Estimates calculated from ground count data (correcting for males present in the post calving groups) may prove less variable. Therefore, using population count data by both methods from the same years in various areas, I systematically compare estimates of sex and age components of these populations in order to decipher reasons for the discrepancies found in previous estimates made by each method. The aerial photography counts and their respective population and calf recruitment estimates were found in the literature, while original data is presented for ground counts. I also tested the main assumption for the aerial photography estimates by comparing the male-ratios recorded in the post-calving groups in June/July from ground composition counts (Reimers, 1998 and Ims & Reimers, unpubl. data) in Rondane North, Setesdal-Ryfylke and Norefjell-Reinsjøfjell. I also compare the calf/female ratios recorded from ground and air surveys in Rondane North and Setesdal-Ryfylke.

Material and methods

The June/July group compositions were recorded from the ground in Norefjell-Reinsjøfjell (1993-98), Rondane North (1995-97) and Setesdal-Ryfylke (1995, 1998). At this time, most adult males have segregated in separate groups (e.g. Thomson, 1977; Skogland, 1989). However, some few adult males and a variable number of yearling males may occur in the nursing groups. During ground counts, 1+ years animals were sexed primarily by the presence/absence of a penis or dark female vaginal opening, and aged on basis of head form, antler status and body size. Sex determination of yearlings is difficult at this time, as winter fur in all stages of shedding frequently hide the sex organs. This implies that a significant proportion (40% to 99%) of yearlings were unclassified. In a few cases, I was able to classify most of the yearlings in a group and determined a sex distribution of 65% females and 35% males. These percentages were applied to the unclassified portion of yearlings in order to meet a full classification of the groups in all areas and all years.

In June/July, nearly all yearlings of both sexes and all 2+ years males and barren females have new antlers with beam length at least 3-4 times the length of the 2-4 cm long antler knobs of females that were judged to have given birth. Most of the latter female group had calves at heel, and those without and with small antler knobs and an adult appearance were judged to have lost their calf. The antler shedding schedule is assumed to follow from Espmark (1971), who found that males and most barren females shed their antler before the start of the calving season, while the pregnant females retain their antlers till after parturition. However, Espmark (1971) and Lent (1965) reported that pregnant *Rangifer* females occasionally shed the antlers before calving, while some barren females shed their antlers at a "normal time" when the lactating females shed. Females in the former category will develop an antler size in June/July comparable to those of a barren female, and hence, be judged not to be reproducing that year, whereas females in the latter category develop antler size comparable to lactating females and hence, to have lost their calf. It is not known what proportion of females that deviate from the general shedding schedule in different areas, but assumingly, (Lent, 1965; Espmark, 1971) and following many years of personal experience on various calving grounds, indicate that the figure is small (educated guess: less than 3%), and hence do not interfere with the results reported here.

Antlerless females (Reimers, 1993; Cronin *et al.*, 2003) may also interfere with ground recordings of recruitment rates. Although recorded in all wild reindeer areas in Norway, the numbers are few, less than 5% of the 1+ years females (Reimers, unpubl. data). Also, as ground registration requires close inspection of individual females, I feel confident that antlerless females were not included in the recruitment data base.

I also recorded post-hunt group composition from the ground during pre-rut and rut in October in Rondane North through 1983-92 and 1995-97. At this time, both sexes and all age classes are

mixed. Animals were categorized on the basis of sex organs, antlers, rutting behaviour and general appearance as calves, 1+ years males and 1+ years females. Pre-hunt (August) estimates of calves/100 females 1+ years in year *n* were calculated by applying the October group composition on population size estimates (Wegge, 1997) in February/March year *n+1*, and adding the number of calves and females harvested year *n* (Reimers, 1994).

In June/July 1985-97, the Norwegian institute for nature research (NINA) made composition counts in Rondane North from air surveys. Nursing groups were photographed from helicopters or small fixed-wing aircrafts on slide positive films with a subsequent counting of animals distributed on the categories calves, females/young animals and males 2+ years (Jordhøy *et al.*, 1996; Andersen *et al.*, 2005). Calf recruitment estimates are then calculated as calves per 100 female/younger animals excluding males 2+ years. A number of factors, including weather (temperature, light), fur moulting stage, group behaviour, area use, vegetation, topography etc., influence timing of photography events and quality of the pictures. Today, GPS and digital cameras have simplified and improved the air photography method (Andersen *et al.*, 2005).

Results and discussion

Based upon winter surveys during the study period, the reindeer population including both sexes and all ages numbered around 1000 animals in Rondane North (Wegge, 1997), 3-4000 animals in Setesdal-Ryfylke (Jerstad, 1996) and 500-600 animals in Norefjell-Reinsjøfjell (Reimers, 2005). Hence, accumulated sample size of post calving groups (which exclude most males 2+ years) as per cent of total winter populations (which includes males), ranged between 60% and 80% in Rondane North, between 10% and 27% in Setesdal-Ryfylke and between 22% and 100% in Norefjell-Reinsjøfjell (Table 1). Thus, total sample size includes most females, calves and yearling males in all years in Rondane North and Norefjell-Reinsjøfjell, but is too low to give a precise estimate in Setesdal-Ryfylke.

Table 1. Group composition in wild reindeer herds in southern Norway estimated from ground counts in June-July. Number of reindeer groups in parenthesis. Different groups are pooled and figures represent percentages in total sample within area and year. Number of groups is in parenthesis.

Area	Year	Sample size[3]	Calves/100 females 1+ years	Calves/100 females 2+ years	Males/100 animals 1+ years[4]
Rondane North[1]	1995	795 (2)	58.8	66.7	5.4
	1996	848 (3)	54.9	66.7	12.2
	1997	600 (1)	44.7	66.9	16.2
Setesdal - Ryfylke[1]	1995	1095 (9)	62.3	No data	8.3
	1998	400 (1)	53.4	73.0	8.9
Norefjell - Reinsjøfjell[2]	1993	398	58.6	81.8	8.5
	1994	552	69.2	81.5	18.1
	1995	419	69.0	82.9	27.9
	1996	274	62.1	79.4	10.4
	1997	449	67.2	86.4	5.5
	1998	110	75.5	82.1	4.7

1. Include reindeer groups ≥ 50 animals.
2. All reindeer groups were < 50 animals.
3. Sample size include calves and males.
4. Males mostly yearlings.

The post-calving groups in Norefjell-Reinsjøfjell (1993-98), Rondane North (1995-97) and Setesdal-Ryfylke (1995, 1998) examined from the ground in June/July were all mixed, but with few males 2+ years present. Importantly though, all groups included yearling males (Table 1). Among the animals 1+ years, males made up 4.7% – 27.9% in Norefjell-Reinsjøfjell, 5.4% – 16.2% in Rondane North and 8.3% and 8.9% in Setesdal-Ryfylke. Although males were definitely present in the post calving groups, these male percentages are rather crude, as unclassified yearlings (distributed with 65% females and 35% males) made up between 47% and 99% of total number of yearlings in the groups, and yearlings composed on average between 12% and 43% of 1+ years animals in the groups (Table 2). For this reason, and because the yearling component in the groups vary, number of calves per 100 females 1+ years was variable between groups, areas and years (Table 2). Consequently, this method of recruitment estimates does not accurately reflect herd recruitment rates.

As age and sex identification of females 2+ years in the field is uncomplicated, a more precise recruitment measure is obtained through number of calves per 100 females 2+ years. However, because body weight relates strongly to first year breeding in reindeer (Reimers, 1983) and calves are known to enter pregnancy in Norefjell-Reinsjøfjell (Reimers, 2005), the 2+ years female group in Norefjell-Reinsjøfjell most certainly contain a few yearling females (Finstad, 2005). Females in Rondane North do not enter pregnancy as calves (Reimers, 1983), and based upon body weights (Jordhøy *et al.*, 1996), probably not in Setesdal-Ryfylke. Thus, calves per 100 females 2+ years represent the best estimate for calf survival/mortality from birth until June/July in Rondane North and Setesdal-Ryfylke. As the parous yearling females are difficult to distinguish from older females in Norefjell-Reinsjøfjell, the calf recruitment rate based upon calves per 100 females 2+ years is slightly overestimated in this area. Therefore, more accurate recruitment rates may be obtained by considering area/year-

Table 2. Group composition (± SE) in wild reindeer groups ≥ 50 animals in wild reindeer herds in southern Norway estimated from ground counts and aerial photographs in June-July. Number of groups is in parenthesis.

Area	Year	Method	Sample size	Calves/100 animals 1+ years	Yearlings/100 Animals 1+ years	Calves/100 females 1+ years	Calves /100 females 2+ years
Rondane North	1995	Air[1]	988 (3)	31.0±14.7			
		Ground	795 (2)	56.0±2.8	12.4±3.9	59.1±2.5	67.8±5.8
	1996	Air[2]	780 (1)	39.8			
		Ground	848 (3)	44.6±5.1	22.3±4.8	51.4±4.5	65.3±2.5
	1997	Air[3]	755 (2)	31.8±7.9			
		Ground	597 (1)	37.0	42.4	44.7	66.9
Setedal-Ryfylke	1995	Air[1]	2769 (15)	31.5±2.1			
		Ground	1095 (9)	56.8±3.3	No data	61.1±3.3	No data
	1998	Air[4]	1761 (13)	48.7±3.0			
		Ground	400 (1)	48.6	31.6	53.4	73.0

Data from: [1]Jordhøy & Strand (1996), [2] Jordhøy & Strand (1997), [3]Jordhøy & Strand (1998) [4]Jordhøy & Strand (1999). These figures are presented as calves /100 females and young males (mostly yearlings) and interpreted as calf recruitment figures (Jordhøy *et al.*, 1996; Andersen *et al.*, 2005).

Table 3. Composition in wild reindeer groups ≥ 50 animals in reindeer herds in southern Norway estimated from ground counts and aerial photographs in June-July. Number of groups is in parenthesis. Groups within area and year are pooled and figures are based on accumulated samples.

Area	Year	Method	Sample size	Calves/100 animals 1+ years	Calves/100 females 1+ years
Rondane	1995	Air[1]	988 (3)	37.3	
North		Ground	795 (2)	55.6	58.8
	1996	Air[2]	780 (1)	39.8	
		Ground	848 (3)	48.2	54.9
	1997	Air[3]	755 (2)	28.5	
		Ground	597 (1)	37.0	44.7
Setesdal – Ryfylke	1995	Air[1]	2769 (15)	30.9	
		Ground	1095 (9)	57.3	62.3
	1998	Air[4]	1761 (13)	46.6	
		Ground	400 (1)	48.6	53.4

Data from: [1]Jordhøy & Strand (1996), [2] Jordhøy & Strand (1997), [3]Jordhøy & Strand (1998) [4]Jordhøy & Strand (1999). These figures are presented as calves/100 females and young males (mostly yearlings) and interpreted as calf recruitment figures (Jordhøy *et al.*, 1996; Andersen *et al.*, 2005).

ling specific natality rates, and report the results as calves/100 females 1+ years or calves/100 females 2+ years (no parous yearlings) as appropriate. Each area has unique population characteristics that will interact with these estimates, such as mature calves or proportion on young males in nursing groups. The challenge is obviously to adapt and present the most realistic estimates for each area with the least amount of bias, which is likely the main cause of the large amount of variation in the present system and in the literature. As indicated in Table 2, herd group composition varies and calls forth whether average group estimates, accumulated estimates or weighted mean estimates most correctly describes composition. As it has been difficult to carry out a complete and repeated composition survey in any wild reindeer area, the question remains unanswered.

In Rondane North (1995-97), average number of calves per 100 animals 1+ years recorded from the ground were consistently higher than those recorded from air photographs the corresponding years suggesting higher recruitment rates in the former (Table 2). In Setesdal-Ryfylke (1995, 1998), calves per 100 animals 1+ years were 56.8, and 48.6, compared to 31.5 and 48.7 recorded from air photographs the corresponding years (Table 2). Recalculating these figures using accumulated composition counts does not change this trend, confirming higher values in ground counts compared to figures recorded from aerial photography (Table 3). These deviations between ground and aerial photography counts are unfortunate, as the two methods measure the same thing and should therefore be as similar as possible. Per cent calves/100 animals in both tables (Tables 2 and 3) are calculated on basis of 1+ years animals excluding 2+ years males that are possible to identify from the ground, and according to Andersen *et al.* (2005) also from aerial photography. Hence, the discrepancy is most likely related to (1) the true calf segment in the groups and whether they are identified on aerial photographs or on the ground and (2) sample size differences with the two methods. Air surveys enable a more complete view of entire groups, but group size at this time of year (mid-summer) are generally large and frequently densely packed due to disturbance from insects and/or the aircraft/helicopter. Identification

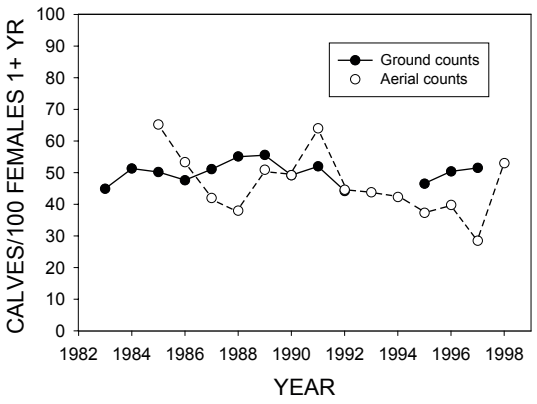

Fig. 1. Calf/100 females 1+ years was recorded from the ground during the rut in October and after the hunting season and from NINA's air surveys in June/July in the Rondane North wild reindeer population. Pre-hunt (August) estimates of calves/100 females 1+ years in year *n* were calculated by applying the October group composition on population size estimates (Wegge, 1997) in February/March year *n+1*, and adding the number of calves and females harvested year *n* (Reimers, 1994).

of calves and young males may in such situation be difficult, resulting in low calf and high "female" counts and hence, a low calf/100 animal 1+ years. On the other hand, ground counts may suffer from the same difficulties, but most frequently, groups move in such a way that segments or even the entire group pass in single file or are at some time sufficiently dispersed to enable accurate composition counts. Other limitations to the ground count method are the total number of reindeer groups encountered. Field conditions, including reindeer movement patterns, weather and the size of the mountain range often limit sampling the entire population.

Figures for calf/100 female 1+ years from ground recordings during the rut and corrected for harvested calves and females ranged from 44 - 56 (average 50.3 ± standard deviation SD 3.4) in 1985-92 and 1995-97 in Rondane North. This was compared to 37 - 65 (average 46.6 ± SD 11.3) recorded from aerial photographs of post-calving groups in June/July during the same years (Fig. 1). F test for variance equality (S-PLUS 2000) gives a significantly higher variability in the aerial recruitment estimates than in the ground counts (F=10.99; P=0.0008; num df=10, denom df=10). Variation in the air photography figures has been ascribed to changes in mortality and recruitment (Jordhøy *et al.*, 1996). Skogland *et al.* (1991) suggested that the low calf recruitment figures in 1987-88 (Fig. 1) was related to the Tsjernobyl accident and high (20%-25%) calf mortality caused by nuclear radiation. These figures contrast with ground recordings, which indicate stable or somewhat increased calf recruitment during the same years (Fig. 1).

Conclusions

The yearling male component in the post-calving groups measured from ground counts in June/July 1995-98 in Rondane North, Setesdal-Ryfylke and Norefjell-Reinsjøfjell varied between 5% and 28%. These results contradict the assumption that there are so few males present in the post-calving groups that they are un-important and not included in calculating population recruitment rates. This also challenges the calf recruitment method and present data in use in NINA's National Cervid Monitoring Program.

Early calf survival or calf mortality in wild reindeer populations is most accurately estimated on basis of antler size and presence/absence of calf at foot from ground counts during June/July of females 1+ years in areas with parous yearling females and 2+ years in areas with no parous yearlings. However, these estimates are difficult to record, even for experienced personnel and may be challenging to implement in routine monitoring programs. It is recommended that routine recruitment data be obtained in October, at a time when animals of both sexes and all age classes are thoroughly mixed and sexing of yearlings is easier. Pre-hunt estimates of calf production may be calculated from October composition counts, harvest data and population size estimates.

In small to medium size wild reindeer areas, ground composition counts in June-July are possible to conduct by one or more experienced person(s) during 2-3 days, either by use of telescopes or video camera recording (Reimers, unpublished data). Recruitment data based upon calves/100 females 1+ years ought to return reasonably accurate data for herd management purposes, while figures on calves/100 females 2+ years produce data on re-

cruitment and early calf mortality that may be used for scientific purposes.

In larger areas (> 1500 km^2), economy, logistics and reindeer group distribution may prevent efficient ground composition counts. While aerial photography may be worthwhile for over-all population counts, ground observations might be necessary for more precise calculations of specific population components, such as age and sex proportions and calf recruitment estimates.

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Estimerte rekrutteringsvariasjoner for villreinkalver avhenger av metodevalg

Abstract in Norwegian/Sammendrag: De to metodene som i dag anvendes til bestemmelse av kalvetilvekst i juni-juli hos villrein (*Rangifer tarandus*) i sørnorske villreinområder, flyfotografering av fostringsflokkene og strukturtellinger fra bakken, gir forskjellige resultater. Ved å sammenligne populasjonsdata innsamlet ved de to metodene i samme områder og i samme år, har jeg søkt å finne årsakene til at de to metodene har produsert ulike rekrutteringsdata.
Populasjonsdata fra flyfotograferingsmetoden er samlet fra publiserte kilder, mens originale data presenteres for bakkestrukturtellingene. Kalvetilvekst (kalver/100 simler 1 år+) og andelen bukk (bukker 1 år+/100 dyr 1 år+) i reinsflokker i Norefjell-Reinsjøfjell (1993-98), Rondane Nord (1995-97) og Setesdal-Ryfylke (1995, 1998) ble registrert gjennom strukturtellinger fra bakken av fostringsflokker i juni-juli. Kalvetilvekst basert på kalv per 100 simler 1 år+ var lavere og mer variabel enn tilvekst basert på kalv per 100 simler 2 år+. Et variabelt antall åringssimler i flokkene og problemer med kjønnsbestemmelse av åringer er viktige årsaker til variasjonene. Antall kalv per 100 simler 1 år+ var gjennomgående høyere enn antall kalv per 100 dyr 1 år+ på grunn av at yngre bukker er inkludert i den siste kategorien. Bukker (hovedsakelig åringsbukk) utgjorde fra 4.7 til 27.9% av dyr 1 år+ i fostringsflokkene. Begge beregningsmåtene (kalv per 100 simler 1 år+ og kalv per 100 dyr 1 år+) ga høyere rekrutteringstall enn tilsvarende tall basert på flyfotos og bekreftet at de to metodene ikke produserte samme resultat. Forklaring på denne forskjellen i rekrutteringsestimat kan tenkes å henge sammen med (1) at kalvene er lettere å overse på flyfotos enn fra bakken og (2) at andelen åringsbukk i fostringsflokkene ikke kan bestemmes på flyfotos og følgelig heller ikke korrigeres for. Beregnet kalverekruttering i juni ble også estimert i Rondane Nord på basis av bakkestrukturtellinger i oktober og sammenlignet med tilsvarende tall beregnet på basis av flyfotos fra juni-juli de samme årene. Rekrutteringsratene (kalv per 100 simle 1 år+) målt på bakken varierte fra 44 til 56 i 1985-92 og 1995-97 sammenlignet med 37 til 65 målt på flyfotos. Flyfotograferingsmetoden er basert på antagelsen om at det er få bukker i fostringsflokkene i juni-juli, og at variasjonen i rekrutteringstallene reflekterer årlige variasjoner i tilvekst og tidlig kalvedødlighet. Bestandsstrukturdata registrert ved bakkeregistreringsmetoden utfordrer holdbarheten i flyfotometoden som anvendes til bestemmelse av kalverekruttering og tidlig kalvedødlighet i de forskjellige villreinområdene. Mens flyfotografering synes overlegen for bestemmelse av bestandsstørrelse, synes bakkeregistrering å være nødvendig for en mer presis beregning av populasjonsparametere så som alders- og kjønnssammensetning og tilveksttall i villreinbestandene.