Short communication

Decay rate of reindeer pellet-groups

Anna Skarin

Swedish University of Agricultural Sciences, Reindeer Husbandry Unit, P.O. Box 7023, S-750 07 Uppsala, Sweden (anna.skarin@rene.slu.se).

Abstract: Counting of animal faecal pellet groups to estimate habitat use and population densities is a well known method in wildlife research. Using pellet-group counts often require knowledge about the decay rate of the faeces. The decay rate of a faecal pellet group may be different depending on e.g. substrate, size of the pellet group and species. Pellet-group decay rates has been estimated for a number of wildlife species but never before for reindeer (*Rangifer tarandus*). During 2001 to 2005 a field experiment estimating the decay rate of reindeer pellet groups was performed in the Swedish mountains close to Ammarnäs. In total the decay rate of 382 pellet groups in three different habitat types (alpine heath, birch forest and spruce forest) was estimated. The slowest decay rate was found in alpine heath and there the pellet groups persisted for at least four years. If decay was assumed to take place only during the bare ground season, the estimated exponential decay rate was -0.027 pellet groups/week in the same habitat. In the forest, the decay was faster and the pellet groups did not persist more than two years. Performing pellet group counts to estimate habitat use in dry habitats, such as alpine heath, I will recommend using the faecal standing crop method. Using this method makes it possible to catch the animals' general habitat use over several years.

Key words: faecal pellet group count, habitat use, inventory method, *Rangifer*.

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Introduction

The pellet-group count method to estimate ungulate population densities has been used for at least fifty years (Neff, 1968). In later years the method has also been used to estimate population trends and habitat use (Guillet *et al.*, 1995; Skarin, *et al.*, 2004; Skarin, 2007). Two basic approaches to estimate pellet-group density are faecal standing crop (FSC) and faecal accumulation rate (FAR) (Campbell *et al.,* 2004; Hemami & Dolman, 2005). In the FSC method, the pellet group density is measured on a first visit to a plot, i.e. both old and fresh pellet-groups are counted, and related to a known pellet-group decay rate. In the FAR method, the pellet-group accumulation over a fixed time period is measured in previously cleared plots, and there is no need to estimate the decay rate of the pellet groups. With both techniques, defecation rate is needed for calculation of the absolute animal abundance. Thus, it is essential with reliable estimates of both defecation and disappearance rates of faecal pellet-groups (Harestad & Bunnell, 1987; Lehmkuhl *et al.*, 1994). Further, the decay rate is believed to be influenced by length of the bare-ground season (snow-free period), precipitation and also by the ground substrate (Wallmo *et al.*, 1962; Harestad & Bunnell 1987; Persson 2003). In this article I estimated decay rate of reindeer (*Rangifer tarandus tarandus*) faeces in a typical reindeer habitat in three different vegetation types: alpine heath, birch forest and spruce forest.

Material and methods

The reindeer pellet-group decay rates were estimated in *Ammarnäs* (66°00'N; 16°10'E) in the Scandinavian mountain chain. The study was performed in nine exclosures, three in each of the vegetation types: alpine heath, birch forest and spruce forest. The heath types were grass heath and dry heath. The birch forest exclosures were in meadow type forest with tall herbs, ca 0.5 m in two exclosures and > 1.0 m in the humid one, and the spruce forest exclosures with heaths (*Ericaceae* sp.) and mosses on the ground. Each exclosure was approximately 1 ha and excluded larger herbivores, such as reindeer and moose. Smaller mammals like fox and hare could pass the fences.

Fresh pellet groups were collected in forest areas about 200 km air route east of *Ammarnäs,* and deposited in the exclosures. A pellet group was defined to be fresh if it was still damp on the surface. Information about areas used by the reindeer the week before collection was also used (pers. comm.). In each exclosure 15–25 fresh pellet groups (1.5 dl ~ 130 pellets, representing the mean size of a pellet group; Skarin, 2007) were systematically deposited 0.5–1 m from each other and marked with a stick. In total 217 pellet groups were deposited in July 2001. Twenty-five pellet groups were deposited in each exclosure, but due to lack of pellets 20 and 22 pellet groups were deposited in two of the birch forest exclosures. Twenty-five new pellet groups were deposited in each of the three alpine heath exclosures in July 2002 and 2003. Fifteen new groups were placed in one of the birch forest exclosures in 2002.

All monitoring was carried out by the same person in July, from one year after the deposit until four years had passed. Decay was estimated by judging how much of each initial pellet group that remained when seen from above (in per cent). Based on the experience from several extensive pellet-group counts (Skarin, 2006) I also did a subjective judgement if the pellet groups would have been visible in a regular pellet-group count. Precipitation records from the closest weather station *Biellojaure*, about 30 km air route southwest of *Ammarnäs,* were obtained from The Swedish Meteorological and Hydrological Institute.

The total mean of decay rate in each habitat type was calculated by averaging the decay estimates for each pellet group across number of years since the deposit. Further, a two tailed *t*-test was performed to compare the decay rate of pellet groups in the grass heath and the dry heath, both within the alpine heath exclosures. A regression model of decay rate was estimated on accumulated precipitation with habitat type as a fixed factor and exclosure nested within vegetation type.

The pellet groups were assumed to decay exponentially at a constant rate as: $P_t = P_0 e^{rt}$ where P_t is the per cent of the pellet group remaining at time t (weeks), P_0 is the original (non-decayed) pellet group (corrected for precipitation and exclosure), and r is the decay rate to be estimated (Harestad & Bunnell, 1987). The ex-

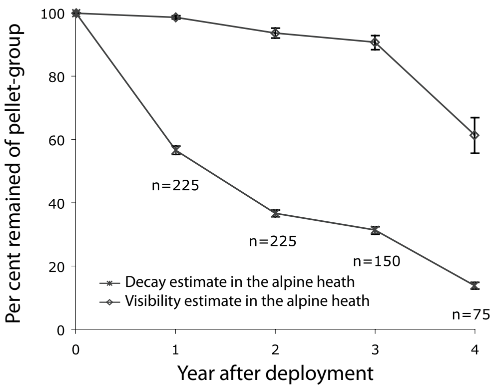

Fig. 1. The lower line shows the average per cent remained of a mean reindeer faecal pellet group in alpine heaths (dry heath and grass heaths) over four years. The upper line shows the (subjective) estimation of visibility i.e. if the pellet group would have been counted in a regular pellet-group count. The bars indicate the standard error for each mean value.

Table 1. Exponential decay rate (*r*) with the standard error of the mean (SEM), corrected for precipitation, calculated for the deposited reindeer pellet groups in the alpine heaths exclosures and birch forest exclosures, both assuming that the decay takes place all-year round (52 weeks/year) and only during the bare-ground season (19 weeks/year). Only the pellet groups that persisted more the two years were included in the decay rate estimation (i.e. 225 pellet groups in total in the alpine heath and 62 pellet groups in the birch forest).

Year of deposit	*r* (alpine heaths)	SEM	*r* (birch forest)	SEM
52 weeks decay				
2001	-0.0100	0.00022		
2002	-0.0093	0.00025		
2003	-0.0112	0.00040		
All years	-0.0100	0.00016	-0.017	0.0014
19 weeks decay				
2001	-0.0274	0.00060		
2002	-0.0254	0.00069		
2003	-0.0307	0.00108		
All years	-0.0274	0.00043	-0.045	0.0038

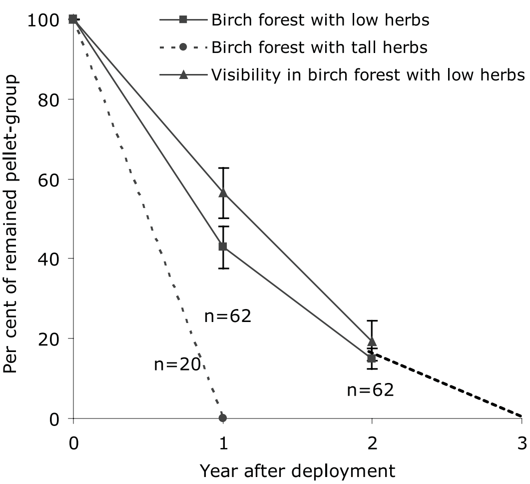

Fig. 2. The line for birch forest with herbs > 0.5 m shows the average of per cent remained of a mean pellet group. The dotted lines show the assumed decay rate since it was not possible to estimate the real decay rate as the pellet groups were gone. The bars indicate the standard error for each mean value.

ponential decay rate was only estimated on the pellet-groups that persisted for at least two years (i.e. in the alpine heaths and the birch forest but not in the spruce forest). The analyses were performed with SAS 8.2 software (SAS Institute Inc., © 1999–2001). It was not possible to estimate whether the decay took place all-year round or only during the bare-ground season. Thus, two exponential decay rates were estimated for each of the alpine heath and birch forest: one with the assumption that decay took place during the bare-ground period and one during the whole year. The bare-ground period was assumed to be 19 weeks each year (Pershagen, 1969). The data from the alpine heaths was separated on year of deposit. This was not possible for the birch forest data since there were too few observations.

Results

Pellet-group persistence

After one year on average 57% ± (standard error of the mean/SEM) 1.2 of the pellet group remained (i.e. 57% of the pellet group surface could be seen from above) in the alpine heaths (Fig. 1). After two years on average 37% ± 1.0 remained, and after four years almost all of the pellet-group had disappeared (14% ± 1.1 remained). There was no difference in decay rate between the pellet-groups placed in the grass heath compared to the dry heath the first two years of decompositions (two-tailed *t*-test assuming equal variances; first year: t = 0.61, df = 223, P = 0.54; second year: t = 1.06, df = 223, P = 0.29). The third year the pellet group in the dry heath had decomposed more than the pellet groups in the grass heath (t = 2.68, df = 148, P = 0.008), and the fourth year it was the other way around (t = -2.87, df = 73, P = 0.005). Thus, it was not possible to differentiate pellet-group decay rate between the two heath types.

The regression model of decay rate on precipitation, habitat type and exclosure were found significant and therefore this was corrected for in the estimation of the exponential decay rate. The average exponential decay rate in the alpine heath exclosures was -0.100 ± 0.00016 pellet groups/week if the pellet-groups decay the whole year (Table 1). If the pellet groups are assumed to decay only during the bare-ground season (19 weeks/year) the average exponential decay rate was -0.027 ± 0.00044 pellet groups/week.

Every pellet group in the birch forest with herbs >1.0 m had decayed before the inspection one year after the deposition and were therefore not accounted for since there was such a large difference from the other birch forest exclosures. The pellet-group decay was somewhat higher in the birch forest (Fig. 2) than in the alpine heaths the first year when only 43% ± 5.3 of the mean pellet group remained. After the second year 15% ± 2.6 remained, but had disappeared completely the third year. The exponential decay rate was -0.017 ± 0.0012 pellet groups/week calculating with decay only during the bare-ground season and -0.046 ± 0.0033 pellet groups/week with decay during the whole year.

In the spruce forest, a mean pellet group had diminished to half its size (54 % ± 4.7 remained) after one year and after two years it was completely gone. Here the decay rate was not calculated since the pellet group had decayed before the inspection the second year.

Visibility of pellet groups

The decay rate of the pellet groups in the alpine heath was higher than the rate of reduction in visibility (Fig. 1). After four years 61% ± 5.7 of the pellet groups were still visible although they had decayed significantly.

The visibility of pellet groups decreased linearly, with a break-point after three years when the visibility decreased considerably. Thus, the first year three years the rate was -0.0017 ± 0.00053 pellet groups/week and the last year it was -0.015 ± 0.0073 pellet groups/week, assuming pellet groups decay only during the bare-ground season. Assuming that the pellet groups decayed all-year round the reduction in visibility was -0.00063 ± 0.00019 pellet groups/week the first three years and -0.0056 ± 0.0027 pellet groups/week the fourth year.

The reduction in visibility of the pellet groups in the birch forest exclosures was much nearer the decay rate estimate than in the alpine heaths (Fig. 2). In the birch-forest 56% ± 6.3 of the pellet groups were judged to have been counted in a regular pellet-group count after one year (the birch forest with herbs > 1.0 m not included). The second year only 19% ± 5.1 would have been counted as a pellet group during an inventory.

Discussion

Most of the reindeer pellet group decay may be assumed to happen during the bare-ground season when the temperature and the moisture level is higher (Lehmkuhl *et al.*, 1994). For example, moose pellet groups in the Swedish boreal forest have been found to persist over the winter (Persson, 2003). The decay rate dependence on summer precipitation also indicates that the reindeer pellets decay mostly during the bare-ground season.

Further, the mean decay rates (-0.010 (whole year) and -0.027 (summer only) pellet-groups/week) found for the pellet groups in the alpine heath exclosures were low compared to what has been found for other ungulate species (Harestad & Bunnell, 1987; Hemami & Dolman, 2005). However, the persistence of at least four years agrees with the results from Helle *et al.* (1990), who found that the reindeer pellet groups persisted almost 5 years in pine forest with lichen. The long persistence time might be due to the short bare-ground season when most of the decay is assumed to take place (Persson, 2003). The persistence was probably also an effect of the low moisture level in the alpine heath. Even though the bare-ground season was of the same length the decay rates in both the birch and the spruce forest were considerably higher than in the alpine heaths, which might be explained by higher moisture level in the forests (cf. Harestad & Bunnell, 1987; Lehmkuhl *et al.*, 1994). Further, the vegetation that concealed pellet groups in the forest exclosures likely interacted with moisture and increased the decay rate.

The long persistence time in the visibility estimation might be somewhat over-estimated, since the pellet group was marked with a stick and the investigator knew that the pellet group was lying there. However, this may not pose a problem in the forest exclosures since the reduction in visibility and the decay rate where rather close to each other. In the alpine heath the larger difference between the visibility estimation and decay rate estimation might also be explained by the low vegetation not covering the pellet groups as in the forest exclosures.

In using the FSC method for counting pellet groups with the purpose to estimate animal densities, different decay rate factors should be used in the forests compared to alpine heaths. Further, population densities estimations from the pellet group numbers using FSC count should be avoided in the alpine heaths or in similar habitat types. The decay rate is low and the faeces can be observed as long as there is anything left of the pellet group. Nonetheless, if this method is used, it may be more correct to use the average reduction in visibility rather than the average decay rate in order not to underestimate the population density. Thus, if a pellet-group count is performed in a habitat where the pellet groups persist for a long time and there is little overgrowth it might be better to do a faecal accumulation rate (FAR) count, i.e. pellet groups are counted in cleared plots after a defined time period. This has also been suggested to be a more cost-effective method in population density estimations (Campbell *et al.*, 2004). However, for habitat use estimations in landscapes of alpine heath type (i.e. vegetation types with a similar and low decay rate, such as grass heath and dry heath) the FSC method are used with preference in front of the FAR method, since this will give a more general habitat use covering several years.

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Nedbrytningshastighet av renspillning

Abstract in Swedish / Sammanfattning: Inom viltforskningen har spillningsinventeringar använts under flera årtionden för att uppskatta habitatval och populationstäthet hos olika djurslag. För att kunna använda data från spillningsinventeringar krävs ofta att man vet hur lång tid det tar för spillningen att brytas ner. Nedbrytningshastigheten är olika beroende på marktyp och djurslag. Nedbrytningshastighet på spillning har studerats för bland annat olika typer av hjortdjur, men det har inte studerats på ren (*Rangifer tarandus*) tidigare. I området kring Ammarnäs genomfördes under åren 2001-2005 ett fältexperiment för att uppskatta nedbrytningshastigheten av renspillning. Under tre somrar lades totalt 382 renspillningar ut i hägn i tre olika typer av habitat (fjällhed, fjällbjörkskog och granskog). Det visade sig att nedbrytningshastigheten var långsammast på fjällheden, där spillningshögarna fortfarande var kvar efter fyra år. Den exponentiella nedbrytningshastigheten beräknades till -0.027 högar/vecka om nedbrytningen antas ske under barmarksperioden. I skogshägnen gick nedbrytningen snabbare och alla högar var borta inom två år. Vid spillningsinventeringar på kalfjällsområdet eller områden med liknande marktyp, där syftet är att studera djurens habitatval över en längre tid rekommenderas att använda den så kallade ”faecal accumulation rate”-metoden, där man inventerar orensade ytor. Det ger en generell bild av hur djuren använt området under en längre period, eftersom nedbrytningen av spillning är långsam i sådana habitat.