# Who ate my lamb chops?

## Seasonal and inter-annual variability in wolverine *Gulo gulo* depredation

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## *Introduction*

**In Norway wolverines *Gulo gulo* are highly involved in conflicts with man because of their depredation on free-ranging domestic sheep *Ovis aries* during summer. Wolverine depredation on livestock has been the main reason for their population control. But why sheep depredation losses increase in late summer and why certain grazing areas have higher depredation losses over the years compared to other grazing areas, has never been clear. A better understanding of the seasonal and inter-annual depredation patterns could enhance the conservation of the Norwegian wolverine population considerably.**

## *Methods*

**Only sheep grazing areas overlapping with wolverine distribution were included. Since wolverine mainly kill lambs (ratio = 9 lambs : 1 ewe) and since this ratio is constant over the grazing season, we concentrated on lamb kills. A mixed-effect model was used accounting for the random effects of different years per grazing area with number of killed lambs per total released as response variable. We compared southern Norway, where mainly sheep are grazed, with northern Norway, where both sheep and domestic reindeer are grazed. See Table 1 for the variables used within the model.**

**Table 1. Variables used within the analyses. Data sources are given in superscript and explained below.**

| Variables used | |
|---|---|
| Number of sheep per km$^2$ of the grazing area[1] | % overlap where management took out (females with) cubs (10km radius buffer)[4,5] |
| Number of sheep released within the grazing area[1] | % overlap where wolvenis were killed (10km radius buffer (excl. removal of (females with ) cubs)[4,5] |
| % of forest within the grazing area[2] | Number of different bite marks found on lamb carcasses[6] |
| % above the tree line within the grazing area[3] | Number of sheep that were hidden (i.e., covered, dragged into water etc.)[6] |
| Number of registered wolverine kills[4] | |
| % overlap with wolverine reproductions (10km radius buffer)[4,5] | |

1 Norwegian Institute of Land Inventory (NIUOS) (2001-2004)
2 Topographic map 1:250,000 Norwegian State Mapping Authority (Statens Kartverk)
3 Tree cover map MODIS
4 Rovbase, national large carnivore monitoring database (2000-2005)
5 Norwegian Institute for Nature Research (NINA) (2000-2005)
6 Registration forms on wolverine kills from State Nature Inspectorate (SNO) of Hedmark, Oppland and Sør Trøndelag county (2000-2005)

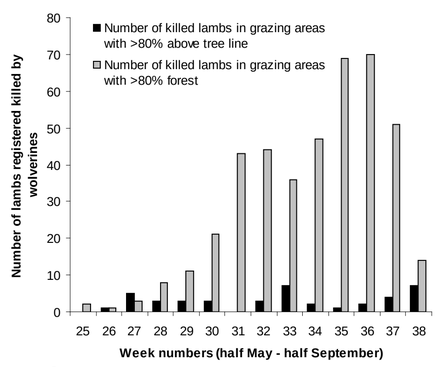


**Figure 1.**

## *Results*

- **A clear seasonal depredation pattern (i.e., high depredation which increases in late summer) was found in grazing areas with over 80% above tree line, whereas no apparent patterns were found in grazing areas with over 80% forest.**
- **In late summer no increase in number of hidden carcasses was found (i.e., possible securing food sources before the onset of winter) (Figure 2).**
- **Cubs are more independent in late summer (Landa, unpublished data) and might therefore be responsible for the peak of killed lambs (Figure 3). However no increase in number of different bite mark locations on the carcasses, as a measure of killing experience, was found.**
- **In northern Norway inter-annual lamb depredation was best explained by temporal high density of wolverine individuals whereas in southern Norway inter-annual lamb depredation was best explained by locally established, reproducing adult females together with a temporal high density of wolverine individuals (Table 2).**

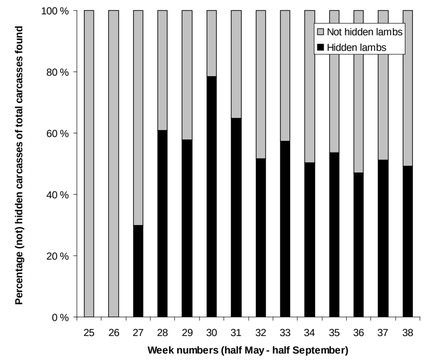


**Figure 2.**

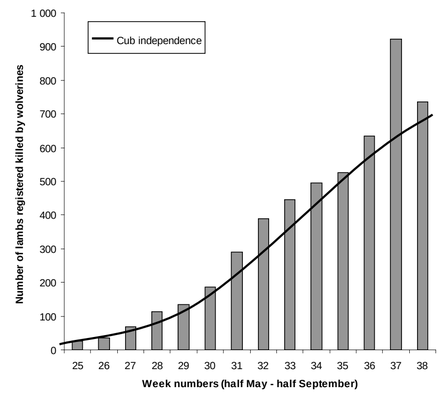


**Figure 3.**

**Table 2. Mixed effect models explaining inter-annual depredation proportions, while controlling for year and grazing area.**

| Model | Variable | t-value | p-value | AIC | LogLik | obs. | groups |
|---|---|---|---|---|---|---|---|
| Northern Nowray | Intercept | -39.214 | 0.000 | 1004.071 | -494.035 | 247 | 71 |
| | % overlap with subadults and cubs shot during grazing season | 4.469 | 0.000 | | | | |
| | % overlap with adult males and females shot during grazing season | 1.940 | 0.054 | | | | |
| | % overlap with adult males and females shot during previous winter | 1.453 | 0.148 | | | | |
| Southern Norway | Intercept | -34.801 | 0.000 | 1925.248 | -953.624 | 537 | 143 |
| | Lamb per km$^2$ | -4.393 | 0.000 | | | | |
| | % overlap with reproduction this year | 8.075 | 0.000 | | | | |
| | % overlap with reproduction next year | 5.941 | 0.000 | | | | |
| | % overlap with subadults and cubs shot during grazing season | 2.216 | 0.027 | | | | |

## *Conclusions*

- **A temporal high density of wolverine individuals together with locally established, reproducing adult females best explains the inter-annual depredation patterns.**
- **No particular individual (adult females or cubs) was found to be responsible for the peak of killed sheep during the grazing season. The peak may however be explained by the sheep migration pattern itself (i.e. using higher elevations later during the grazing season) together with wolverine individuals already using these high alpine areas.**

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