The winter roosting ecology of the Black Grouse *Tetrao tetrix* in the Alps

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Tetraonids are sedentary birds that in winter have usually to cope with harsh environmental conditions, i.e. low temperatures and snow cover. When snow reaches depths of about 30 cm, the Black Grouse habitually digs burrows (also called igloos) for both diurnal and nocturnal roosting (Cramp and Simmons 1979). By considering the well-known thermo-insulative capacity of powdery snow, it has been suggested that snow roosting is useful for conserving energy, especially during cold winter nights. Indeed, thermal responses of individuals roosting in the snow supported this hypothesis and suggested marked energy savings (Marjakangas et al. 1984). However, given that the Black Grouse frequents snow-roosts even in mild weather, when it may not be necessary for energetic reasons, an anti-predator function has been also suggested (Bergerud and Gratson 1988, Marjakangas 1990). This hypothesis makes sense because predation mortality, mainly due to large birds of prey, is particularly high (Angelstam 1984, Caizergues and Ellison 1997); also, an increased vulnerability to predation during years with little snow has been detected (Spidsø et al. 1997). Snow-roosting may be restricted by lack of snow or by the presence of crusted snow. In such conditions, birds are forced to roost on the ground or in trees (Cramp and Simmons 1979) and roosting preferences may change, as observed in the hazel grouse *Bonasa bonasia* (Swenson and Olsson 1991). In this study we investigate how climatic (snow and temperature) and topographical (altitude, aspect, slope) features influence the grouse roosting site choice (igloo or alternative site).

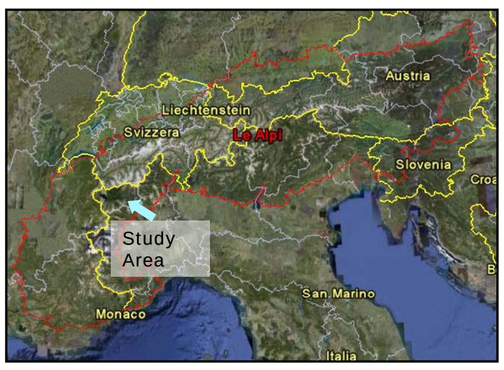

Figure 1. Study Area

Study Area

The research was carried out in the Mont Avic Natural Park (Aosta Valley) in the North-western Italian Alps. The area (about 20 km^2) is largely covered by coniferous forests ranging from 1100 to 2000 m a.s.l. The mountain pine *Pinus uncinata* and, to a lesser extent, Scots pine *Pinus sylvestris* are the dominant trees, occurring in mostly pure coniferous forests. Mountain pines grow both in form of trees and, to a lesser extent, in form of bushes. Another common conifer is the larch *Larix decidua*. Common broad-leaved trees are beech *Fagus sylvatica* and others like birch *Betula pendula* and rowan *Surbus ssp*. Common underbrush plants are alpen rose *Rhododendron ferrugineum*, juniper *Juniperus spp*., bilberry (*Vaccinium spp*.) and green alder *Alnus viridis*.

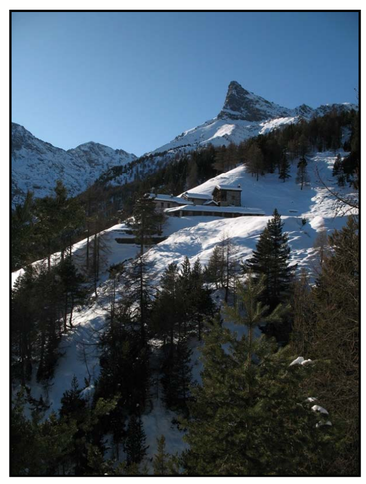

Figure 3. Mont Avic Natural Park

Figure 2. Unusual igloo with male black grouse marks on the entrance (down) and exit holes (up)

Methods

The study area was systematically surveyed during seven winters (December-March 1992-93, 1993-94, 1994-95, 2002-2003, 2003-04, 2009-2010 and 2010-2011). The presence of roosting birds was ascertained along transects conducted in any snow depth conditions by visual contacts or indirect signs like igloos and/or heaps of droppings within a fixed width of 30 metres from the transect line. To avoid the risk that bias is introduced as a result of selecting for easy access, independent routes within each sector were random positioned (Bibby et al. 2000). Moreover, to diminish the risk of pseudo-replication of data (i.e. to consider the same grouse), each transect route was visited only once per winter, and never for two consecutive winters. All presence data were geo-referenced (a GPS e-Trex Garmin personal navigator was used from 2002) and later mapped and layered on topographic maps through GIS (ESRI ArcGIS 9.2). We created a 30 m grid and computed topographic variables (i.e. average aspect, slope, curvature, elevation, exposition and their respective standard deviation). We analyzed the effect of topographic structure We analyzed the effect of topographic structure onto the selection of

Climate data were provided by Aosta Valley Snow and Avalanches Department, and come from 4 different stations nearby Mont Avic Natural Park (Champorcher, Gressoney, Val d'Ayas and Pila).

We performed a model selection based on GLMs using the R package MuMIn (Multi Model Inference) using the type of roost (igloo or alternative refuge) as a binomial dependent variable and a set of weather predictors (i.e. minimum and maximum temperature, thermal excursion, snow depth and presence of snow crust) referring to the conditions of the day up to three days before before the transect as independent variables. We also run GLMs to identify topographic variable driving the roosting site selection, using a binomial dataset for roosts and topographic metrics as indipendent variables. Models were selected using AICc.

Results

During seven winters we collected data on 337 roosts (231 alternative refuges and 106 igloos).

Results of generalized linear models for roost type and weather conditions are shown in Table 1. The models that performed best were those with weather variables referring to two days before the sampling. Igloos were selected as roosting strategy when there was a thick layer of snow, without snow crust (higher maximum and minimum temperatures). Results of generalized linear models for roosts and topographic conditions within a 30 m cell are shown in Table 2. The MuMIn procedure selected four models with AICc < 2. The grid cells where a roost was found were caracterized on average by: East and South exposition, an higher curvature, higher elevation and slope.

Presence of Igloo					
Estimate	Std.	Error	z	value	Pr(>|z|)
(Intercept)	-4.603	0.780	-5.898	0.000	***
Snow Crust	-2.829	0.426	-6.638	0.000	***
Snow Depth	0.026	0.007	3.668	0.000	***
Max Temp	0.161	0.063	2.569	0.010	*
Min Temp	-0.346	0.067	-5.124	0.000	***

Table 1. GLM of Igloo presence according to weather conditions of two days before the sampling

GLM	(int.)	E	ASPECT	MEAN_CURV	MEAN_DEM	MEAN_SLOP	O	S	AICc	delta
1	-8.739	0.552	NA	0.201	0.002	0.044	NA	1.306	2017.261	0.000
2	-9.096	0.742	0.002	0.198	0.002	0.044	NA	1.377	2017.277	0.016
3	-8.835	0.684	NA	0.199	0.002	0.044	0.316	1.437	2018.224	0.964
4	-9.102	0.791	0.001	0.197	0.002	0.044	0.178	1.442	2018.984	1.723

Table 2. GLM of roosts presence according to topographic structure

Discussion

Our analysis confirmed the influence of meteorological and topographic conditions in the roost ecology of black grouse. Igloos are selected with increasing snow depth and also with mild maximum temperature, while the formation of snow crust (due to the melting of the snow during the day and cold temperatures in the night) is the main limiting factor for igloo roosting.

Looking at the topographic characteristics of the cells where igloos where formed we can identify a preference of higher altitudes exposed at South and East (although the main food resource, mountain pine, is spread in all expositions), with the presence of natural hollows that allow the drift of snow.

Considering climate change scenarios in the next future, it is likely that the favorable conditions for igloos will be reduced, if the maximum temperature will increase but the minimum will remain similar for example, or if the snow cover will be reduced, causing the black grouses to be more exposed to predators and spend more energies bilancing the outdoor temperature (Bergerud and Gratson 1988, Marjakangas 1990).

Acknowledges

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