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The effects of hunting on willow grouse *Lagopus lagopus* movements

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A recent increase in the area open to hunters in the Swedish mountains has directed attention to the possibility of overharvesting and greater wildlife disturbance. Using radio-telemetry, the movements of willow grouse *Lagopus lagopus* in a heavily hunted area were compared to movements in areas where hunting was prohibited. Although hunter density was higher than the regional average, no significant differences in movements, measured as rate or distance, between grouse in hunted and unhunted areas were found. Willow grouse did not move out of the hunted area, a common belief amongst many hunters. Seasonal migration was not induced by deliberate human disturbance. It is suggested that grouse reduce the risk of being killed by habitually moving within a familiar area with known escape sites (cover). Neither hunting, deliberate flushing or catch and release caused a change in the movement patterns of willow grouse. It is suggested that such disturbances were perceived as part of a naturally unpredictable predator environment, and not sufficient to alter grouse movements.

Key words: willow grouse, Lagopus lagopus, hunting, disturbance, movements, radio-telemetry, harvesting

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Attention has recently been drawn to the likelihood of human activities having a negative impact on wildlife and its habitats (Pomerantz et al. 1988, Götmark 1989, Hockin et al. 1992). Game hunting removes part of the population, and may induce stress on remaining individuals. Most studies conducted on harvesting examine the effects of the removal of individuals upon the subsequent dynamics of the population (Beddington & May 1977, Caughley 1985, Robertson & Rosenberg 1988, Barker et al. 1991, Ellison 1991). Research has been conducted on the effects of disturbance induced by hunting on surviving individuals in ungulates (Jeppesen 1987a, 1987b, Skogland & Grøvan 1988, McIlroy & Saillard 1989, Cederlund & Kjellander 1991, Ericsson 1993) and waterfowl (Madsen 1988, Maisonneuve & Bédard 1991, Frikke & Laursen 1994) but there is a lack of research on these effects in the galliformes (Baines & Lindén 1991).

It is not as common to find land open for public hunting in Europe as it is in North America. Since 1993 more than 60,000 km^2 of the state-owned Swedish mountain range has been open to the public for small game hunting. Debate surrounding this decision has focused on the risk of overharvesting willow grouse *Lagopus lagopus*, the principle quarry of many hunters. In 1992, a project was initiated to experimentally investigate how a willow grouse population responds to a substantial harvest by considering survival and movement patterns. In this paper we test the hypothesis that hunting induced disturbance stimulates surviving willow grouse to increase movements within or out of hunted areas as compared to grouse on unhunted areas.

Methods

The study was conducted in the area surrounding the Storulvån Hill Centre (63°10'N, 12°22'E) in the southern part of the central Swedish mountain range. The total study area was 92.9 km², divided into one hunted (treatment) area of 43.0 km², and two unhunted (control) areas of 35.1 km² and 14.8 km² (Fig. 1). Willow grouse are rarely found higher than 1,100 m a.s.l. in this region. Excluding areas above this height reduce the experiment area to 34.2 km² and the smaller control area to 10.1 km².

Up to the treeline at 800-860 m a.s.l., birch *Betula pubescens* var. *tortuosa* forests with undergrowth mainly comprising bilberry *Vaccinium myrtillus* and crowberry *Empetrum* spp. dominate the vegetation. Heath-type vegetation of bilberry, crowberry and heather *Calluna vulgaris* with dwarf birch *Betula nana* is common above the tree line. There are few areas of standing water but a well-developed stream network is present. Willow *Salix* spp. thickets occur near the water courses and on damp ground with cotton grasses *Eriophorum* spp., sedges *Carex* spp. and cloudberry *Rubus chamaemorus*.

The grouse hunting season runs from 25 August to the last day of February. In 1992, up to eight hunters were allowed on the experiment area at the same time. In 1993, the limit was increased to 15 hunters because of the gradually changing hunting system. No bag limits were imposed on the hunters. A public road running through the treatment area to the hill station gave hunters easy access until snow cover, after which the road was closed. A public road running through a hunting area makes it easily accessible and therefore more favoured by hunters (Fisher & Keith 1974, Lindén & Raijas 1986, Small et al. 1991). Most Swedish willow grouse habitat is therefore not as easily accessible as the ones in this area. All hunters completed questionnaires regarding time spent hunting in the treatment area, numbers of dogs used, estimated number of grouse encountered, bag size and shots fired. Only one questionnaire was not returned over two years. The control areas were guarded and two hunters were turned away when entering one control area.

Grouse were captured between late July and mid August. Pointers were used to locate grouse which were then flushed into hand-held nets mounted on poles (2 m × 16 m). All grouse were tagged with patagial wingtags, and in 1993 adults were given coloured legbands. Necklace radio transmitters of 10-12 grams (Holohil Systems Ltd, Canada and Biotrack, UK) were used in preference to backpacks (Marcström et al. 1989, Small & Rusch 1989, Thirgood et al. 1995).

Grouse locations were obtained by telemetric triangulation. Bearings were taken between 500 m and 50 m away from tagged birds. The habitat and low grouse densities (4-19 individuals/km²) also ensured that observer disturbance was limited. Only two birds were flushed by

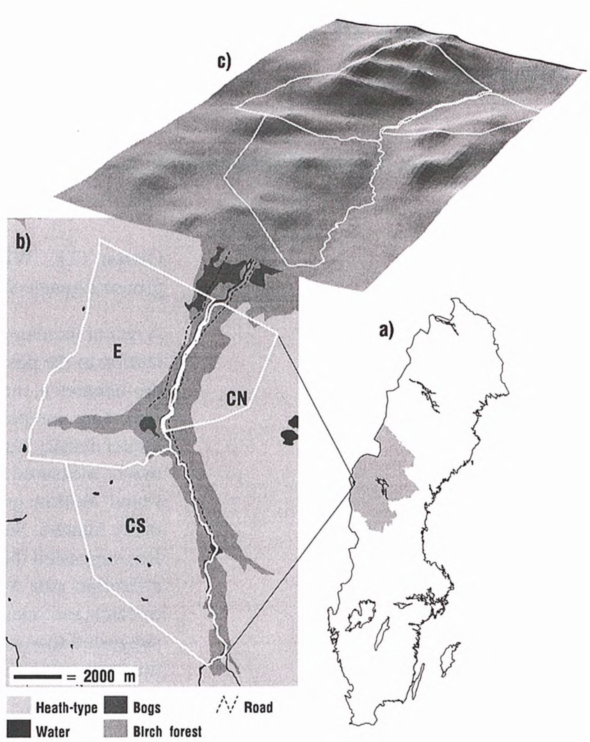

Figure 1. Study area including location in the county of Jämtland (grey) in central western Sweden (a); vegetation types and indication of treatment (experiment) 'E', northern control 'CN' and southern control 'CS' areas (b); and a three-dimensional view of the study area (c).

observers on the hunted area in the intensive period, one to check survival status and one in error. Known map locations were used as starting points for tracking in 1992. A portable Global Positioning System was used in 1993 to give observer location.

In 1992, three groups of willow grouse on each of the treatment and larger control areas were chosen for intensive daily tracking. All groups but one contained two or more radio-marked grouse. Fixes were taken from 25 to 31 August. In 1993, all radio-marked grouse inside the study area were located once a day from 25 August to 2 September. These two periods of seven and nine days were called detailed studies. Locations were then recorded on a weekly basis until 6 October after which hunting activity became very low.

We used three variables to describe the movement pattern of the radio-marked grouse: 1) rate of movement was calculated as the distance moved between two consecutive locations divided by the time interval (m/24 hrs); 2) rate of movement alone may not be sufficient to detect major directional changes in movement (Small & Rusch 1989), so the net distance between locations during the detailed studies was calculated to detect if the bird had moved to a new site; and 3) the sum of the distances moved between consecutive positions during the same period was estimated. There was no difference between 1992 and 1993 (P > 0.6), and therefore data from both years were pooled for each of the three variables.

Table 1. Number of hunters, time spent hunting per day and per km², and number of bagge grouse from hunter reports collected during autumn 1993.

Period	No of hunters	Hours/day hunted	Hours/km² hunted	No of willow grouse bagged	No of ptarmigan bagged
25/8-2/9	25	64.0	16.8	82	12
3/9-30	7	3.1	2.5	49	1
1/10-31/10	10	2.9	2.6	3	14

We do not know if hunters disturbed all radio-marked birds, but grouse were shot from broods or groups containing radio-marked individuals thus inferring disturbance. To analyse the effects of a known disturbance we deliberately flushed six radio-marked grouse once every other day between 13 September and 6 October in 1993, after the detailed study. We also used the data on movement of grouse immediately after capture and release in 1993 to further evaluate how a major disturbance could affect the movement of grouse. If there were two or more radio-marked individuals in a brood or group their movements could not be considered independent and the observations were treated as for a single bird.

Results

When the grouse season opened, the number of radio-marked grouse within the boundaries of the study area was 40 in 1992 (21 in experiment and 19 in control areas) and 43 in 1993 (22 in experiment and 21 in control areas). The ratio of young birds was 54% and the sex ratio was 52% in favour of males for the 83 tagged grouse.

Between 25 August and 1 September 1992, seven hunters reported 15 hunting days on the experiment area. During 2-30 September 11 hunters reported 36 hunting days and during 1-31 October 20 hunters reported 54 hunting days. Hunting activities were monitored in more detail in 1993 than in 1992. Hunting was most intense during the first nine days after the season opened in 1993; the hunting effort was 64.0 hrs/day (Table 1), totalling 576 hunting hours. Thereafter, hunting pressure declined to 3.1 hrs/day during 3-30 September and 2.9 hrs/day during 1-31 October. Pointers were used by 38 of 42 hunters. Grouse were flushed by 39 of 42 hunters and 26 hunters bagged 134 willow grouse and 27 ptarmigan *Lagopus mutus*.

Grouse in the experiment area did not exhibit significantly different rates of movement compared to grouse in the control areas (Mann-Whitney U-test, P = 0.98). There was no difference neither in net distance moved (Mann-Whitney U-test, P = 0.99, Fig. 2), nor in the sum of distances during the detailed studies (Mann-Whitney U-test, P = 0.87, Table 2). Only two radio-marked birds (<5% of birds tagged on the treatment area) left the experiment area during the first intensive period of hunting. One did sc in short steps into a nearby private hunting area and remained there until it began dispersal in mid-September The other made a movement of 2.6 km and remained outside the area until shortly after the end of the first hunting period. It then returned to a location within 300 metres of its position before leaving the area.

The six deliberately disturbed grouse were flushed 7.8 times on average. They did not move a significantly different net distance when compared to unflushed control birds, 746 metres and 1,140 metres (t = 0.93, df = 14, P =

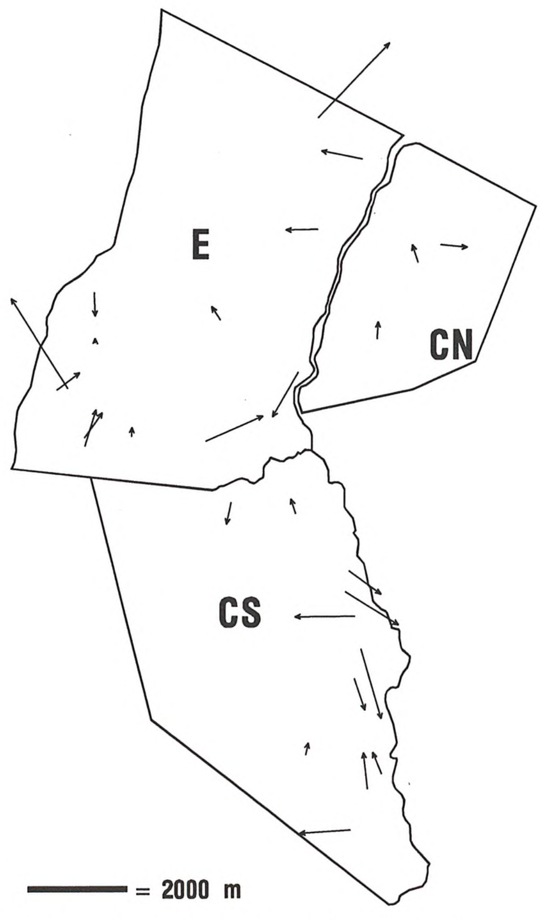

Figure 2. Movement of radio-marked willow grouse where arrows indicate direction and net distance moved between 25 August and 2 September in 1993 by singles or groups (treated as one observation).

0.37), respectively. Although our deliberate flushing took place when several undisturbed grouse had begun to disperse, no dispersal movement was found amongst the flushed grouse. One frequently flushed juvenile did not begin dispersal until 22 days had passed after the end of the flushing test. Comparing rate of movement amongst grouse on the control area immediately after capture and release to an equivalent length in time in late August did not reveal any capture disturbance effect, the average difference being 104.9 metres ($t=0.81$, $df=13$, $P=0.432$). In all broods or groups where two or more individuals were radio-marked, the grouse reunited after release.

Table 2. Median and interquartile (middle 50% of the data) of the movement variables (metres) between experiment and control areas from 25 August to 31 August (1992) or 2 September (1993); years are pooled.

	Experiment area		Control area	
Rate of movement[a]	336	(272- 481)	374	(198- 481)
Net distance[b]	615	(401- 943)	640	(450- 807)
Sum of distances[b]	2,497	(2,075-3,670)	2,488	(1,578-3,766)

[a] m/day (over 24 hours).
[b] Only individuals surviving the whole period included.

Discussion

The movement pattern of willow grouse in the heavily hunted area was similar to grouse in the unhunted areas, and our study does not support the opinion of many hunters that willow grouse move away from frequently hunted areas to lower, quieter areas. The hunters bagged 20-30% of flushed grouse, and the bag of 130 during the detailed study in 1993 would require 400-650 flushes. With an estimated population size of less than 400 grouse in autumn, we consider the level of disturbance to be large.

The willow grouse is a short-lived game species (Steen 1989) and the main prey for many predators (Hagen 1952). The probability of successfully capturing prey in wildlife situations is thought to be as low as 10-30% (Walters 1986) and predators may try to increase their success rate by returning to the site of an earlier encounter (win-return strategy). Sonerud (1985) modelled antipredator behaviour, where grouse broods show age-dependant rates of movement. Broods containing juveniles not yet fledged should show greater daily movements than when fledged. This could reduce the impact of avian predators that continue to use previously successful hunting areas. The rate of movement of willow grouse in this study (200 - 500 m/day) will greatly reduce such a danger. Returning the next day would mean that the predator had to search through an area with a radius of up to 500 metres (0.79 km^2).

Movements may not be due to antipredator behaviour alone but could also be explained by foraging activities. Erikstad (1985) and Andersen (1986) found that broods moved to higher altitudes or between patchily distributed habitats tracking the progress in insect and vegetation development. However, our initial observations did not suggest a decrease in movement in relation to increased age in radio-marked broods. Neither did we observe any consistent difference in movement patterns between broods, broodless pairs or single grouse during these periods.

During summer and autumn, willow grouse respond to potential threats by moving into cover and crouching, flushing only if the threat moves closer. However, they do not fly very far before landing in cover, often using thickets of mountain birch. The sum of distances was about four times as large as the net distance moved for all birds. Thus, grouse remained in familiar areas although the rate of movement was high. A broodless adult male made a linear downhill movement of approximately three km when it was flushed five times during recapture in summer. It had returned to the location where first flushed when checked three days later. We propose that grouse reduce the risk of being killed by habitually moving within a familiar area with known escape sites (cover) which are large enough to reduce the risk of being killed by predators using a win-return strategy. Neither hunting, deliberate flushing nor catch and release caused a change in the movement patterns. We suggest that this level of disturbance was perceived as part of a naturally unpredictable predator environment and was not sufficient to alter the behaviour described.

Miquet (1990) showed that black grouse *Tetrao tetrix* changed movement patterns in areas with winter tourism, whereas a similar study on ptarmigan and red grouse *Lagopus lagopus scoticus* did not detect any change (Watson 1982). Papers on waterfowl and ungulates all indicate that hunting activity has some effect, either increasing or decreasing movements. However, a persistent effect, a change of distribution in time and space, was found only amongst migratory waterfowl on non-breeding grounds (Madsen 1988, Maisonneuve & Bédard 1991, Hockin et al. 1992, Frikke & Laursen 1994) and wild reindeer *Rangifer tarandus* where herds in poor condition increased travelling time between food patches which led to a further decrease in condition (Skogland & Grøvan 1988). Some ungulate species examined for hunting disturbance show a similar pattern to the willow grouse. If they are found by hunters or their dogs, they may leave the area where disturbed but will return within 24 hours, or in extreme cases within days (Jeppesen 1987a, 1987b, McIlroy & Saillard 1989, Cederlund & Kjellander 1991, Ericsson 1993).

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