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Running head: IMPORTANCE OF LOCAL KNOWLEDGE FOR GROUSE HUNTERS

General Experience Rather than of Local Knowledge is Important for Grouse Hunters Bag Size

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Abstract

Wildlife harvest management require understanding of hunter behavioural interactions with the game. Hunter harvest is indicated to be more dependent on experience and attitudes than game abundance. We tested how the bag size of grouse hunter's was affected by having local knowledge of the hunting ground, grouse density and distribution or not. The local knowledge was acquired through, approximately a decade of conducting pre-hunt counts, and was tested against hunters without the local knowledge, but which had similar experience of counting grouse from other areas. Hunters with local knowledge were not more efficient in bagging grouse than hunters without local knowledge. Rather there seems to be the general variation in experience among hunters that regulated harvest rates, through number of grouse encounters hunters and gender of the hunters. The results add support to the concern of using bag statistics as an index for population changes of wildlife species.

Keywords: harvest, density dependence, human-wildlife interaction, hunting, willow grouse.

Introduction

Understanding the relationship between hunter success and knowledge of game abundance is needed to interpret harvest data correctly and ensure sustainable harvest levels. The behaviour of hunters can be compared to predators hunting for prey, and predator-prey theory may be used to understand hunter response to changes in prey abundance (Choquenot, Hone, & Saunders, 1999). The functional response (Holling, 1959) predicts a decrease in proportion of prey removed as prey abundance increases since there is a limit to how many prey a predator can handle per unit time (Sinclair, Fryxell, & Caughley, 2006). Additionally, optimal foraging theory (Pyke, Pulliam, & Charnov, 1977) predicts that a predator (hunter) should abandon a patch when the expected return reaches a lower threshold. Hutchinson, Wilke, and Todd (2007) examined patch leaving decisions in humans exposed to a simulated fishing in ponds with varying fish abundance, and found that subjects delayed the switch to another pond longer than expected from theory. This apparent irrational behaviour, termed the Concorde fallacy, is observed in both animals and humans, and may be an investment to gain enough experience to make more correct decisions in the future (Curio, 1987). The hours required to observe a deer by deer hunters in North America increased dramatically at low densities (Van Deelen, & Etter, 2003), and it can be expected that hunters extend their hunting day when encounters of game and catch per unit effort (CPUE) are less than expected from earlier experience.

In Scandinavia and North-America, hunting rights are commonly either managed by the state or large land-owners that often apply an open access policy to small game hunters (Bergström, Huldt, & Nilsson, 1992; Butler, Teaschner, Ballard, & McGee, 2005). These large areas can exhibit substantial spatial dynamics of hunters in relation to anticipated game abundance and previous experience from other areas. The accumulated local ecological knowledge (Brook, & McLachlan, 2008; Gilchrist, Mallory, & Merkel, 2005) over several years should probably make hunters more efficient and show higher CPUE rates compared to hunters with similar experience but from a different area.

Willebrand, Hörnell-Willebrand, and Asmyhr (2011) showed that variation in effort had a stronger effect than variation in density when explaining annual changes in harvest numbers of willow grouse (*Lagopus lagopus*) in Sweden. Hunters were relatively more efficient at low compared to high grouse densities, and they suggested that using harvest numbers from hunters that at least harvested one grouse could improve the relationship between grouse density and CPUE. Wam, Andersen, and Pedersen (2012) identified different willow grouse hunter typologies in Norway according to importance of bag size and crowding tolerance, and the different typologies would be expected to respond differently to changes in game abundance.

Few studies have investigated the dynamics of hunters to understand the effects of harvest regulations on game abundance (Guthery et al., 2004; Hardin, Brennan, Hernandez, Redeker, & Kuvlesky, 2005), and there is a lack of controlled experiments of hunter behaviour in areas with known game abundance. Since 1996 we have been counting willow grouse in the same management areas on state managed land in Sweden (Asmyhr, Willebrand, & Willebrand-Hörnell, 2012; Hörnell-Willebrand, 2005) using hunters trained in distance sampling (Buckland et al., 2004). Hunters in the counting crews tend also to hunt in the area they count, and there has been a low turn-over of hunters in the counting crews. Here we report an experiment where we tested if hunters that had participated in willow grouse counting in the hunting area for several years were more successful than hunters that had counted willow grouse elsewhere. We expected that the experimental contrast between hunters with and without local knowledge of willow grouse (hereafter referred to as grouse) density and distribution to be an important positive determinant for the daily bag size.

Study Area

The study was conducted in four areas (A-D) situated in the state owned mountain region of Jämtland County, Sweden. The size of the areas varied from 54-174 km^2 and their positions were on a south to north gradient in the county. Areas were selected to represent the different parts of state managed land in the alpine mountain range of the county, and were part of the nationwide monitoring program of grouse (for further details see Hörnell-Willebrand, 2005). State owned land in Sweden was opened for the public (national and international) to grouse hunting in 1993. All hunters with a valid license from the National Fund for Game Management can obtain a hunting permit. The areas are open for small game hunting from 25 August to the end of February with a daily bag limit of eight grouse per hunter. Grouse hunting is mainly performed as walked-up shooting with pointing dogs to locate and flush grouse (Bergström et al., 1992). The study areas are the same as in (Willebrand et al., 2011) study, where detailed description on harvest levels, hunting effort and grouse demography from 1996 to 2007 is given.

Methods

Pre-Harvest Willow Grouse Population

Pre-harvest density and breeding success of grouse has been estimated annually since 1996 in all four study areas. In early August, carefully recruited and trained dog handlers count grouse along line transects, evenly spaced and over entire management areas. Distance sampling was used to obtain the total and adult density each year (Buckland et al., 2004; Hörnell-Willebrand, 2005). Breeding success was calculated as chicks per pair from the ratio of chicks to adults observed during counts.

The Experiment

In 2007 and 2008, we monitored dedicated grouse hunters, which also were pointing dog enthusiasts, which were allowed to hunt over two constitutive days immediately before the start of the hunting season, 23 and 24 of August in 2007, and 22 and 23 of August in 2008. The hunters, both male (n = 44) and females (n = 11) were randomly drawn from those who had participated the longest in the counts and were certified to count grouse. All of the experimental hunters had counted grouse with their dogs in their counting area one to two weeks prior to the experiment.

In each of the four management areas, six to eight hunters were allowed to enter and hunt with their pointing dogs. Three or four had been counting grouse the year of the experiment and at least 10 of the previous years. In that way they both knew where the grouse usually were found in the hunting area and had detailed knowledge about grouse density and distribution for the years of the experiment. Half of the hunters had also counted grouse in a similar fashion but in another area and had no experience of grouse distribution in the hunting area. We emphasise that all hunters had at least six years, most of them over 10 years of experience with counting grouse. The hunters were hunting separately with their pointing dogs within the boundaries of the different hunting areas. All hunters kept a detailed diary of all events in a day, and recorded number of grouse encounters, number of grouse observed in each encounter, if there were a possibility to shoot grouse or not in the encounter and if they bagged grouse at the encounter. They were equipped with a GPS unit to record distance walked.

Analysis

We used a generalized linear model (GLM) with Poisson error to compare daily bag size of hunters with and without local knowledge. We started with a beyond optimal model including three continuous and three factors as predictors: the two hunter categories (with (1) and without (0) local knowledge), distance walked (km), chicks per pair, adult density km^{-2}, grouse encounters (possibility to bag grouse), failure by dog (dog flushed grouse before the hunter came within shooting distance), first (0) or second (1) day of the hunt, and the gender of the hunter; (male (1) and female (0)). All two-way interactions were initially included. All continuous explanatory was centred by subtracting the sample mean (Schielzeth, 2010) and standardized by dividing all centred input variable values by two standard deviations (Gelman, 2008), to increase the interpretability of effect sizes and comparison of effect sizes between both main effects and interactions. The final model was obtained by removing predictors and interactions one by one if the coefficient was insignificant ($p > .05$), beginning with the interaction terms. A predictor with an insignificant coefficient was not removed if included in a significant interaction. Model validation was done by plotting residuals against predicted values, response variable and explanatory variables (Zuur, Ieno, & Elphic, 2010; Zuur, Ieno, Walker, Saveliev, & Smith, 2009). The pseudo R^2 was calculated as a measures of predictive power of the model (Zuur et al., 2009).

Comparing Experimental Results with Ordinary Hunting

The bag size of the experimental hunters was compared to the hunters entering the same areas the first two days of the official hunting season, 25 and 26 of August (further referred to as ordinary hunters). Data on the ordinary hunters were obtained from the county management agency. The hunting licenses and harvest records are obtained and reported through a web based system operated by the county management agency and their local dealers. The return rate of harvest reports was close to 90%. It is believed that the practice of banning non-respondents from hunting on state owned land within the county the following year is an important factor contributing to the high report rate.

Results

Pre-harvest Grouse Populations and Descriptive Characteristic of the Hunt

Density and breeding success in the grouse populations varied between years and areas (Table 1), and the adult density was not correlated with chicks per pair ($t = 0.30$, $p > .05$). The total bag consisted of 344 grouse. In area C in 2007 there was only hunted one day since a local landowner closed the road into the hunting area without any notice. The data from this area were therefore excluded from the analysis in that year, and we were left with 94 hunter/days and 322 bagged grouse. An average hunting day lasted for 5h 31 min (min: 2h 02 min, max: 9h 20 min), covered a distance of 11.9 km (min: 4.3 km, max: 19.3 km) and contained observation of 24 grouse (min: 0, max: 118) that were distributed on six encounters (min: 0, max: 17). Only 13 of the hunter days reached the daily bag limit of eight grouse, three hunters reached the bag limit both the first and second day of hunting. The average number of grouse encounters was almost identical during the counts and the hunting experiment (0.59 and 0.54 km^{-1} respectively).

Experimental Results

The final model contained six explanatory variables, and five interactions (Table 2). Grouse encounters was the most important variable explaining the variation in bag size, a unit increase in average number of grouse encounters resulted in an increase of two grouse in the bag. Number of encounters became even more important the second day of hunting, adding a third grouse to the bag with a one unit increase in average number of grouse encounters (Table 2). The number of grouse encounters was lower the second day of hunting, but the bag size of males was less affected by the number of grouse encounters than females due to a negative interaction between gender and encounters (Figure 2 & Table 2). Gender was one of the most important factors that affected the bag size, and the bag size of males was higher than females (Figure 1). Gender also significantly interacted with local knowledge and grouse encounters. Contrary to what we expected, the bag size of hunters with local knowledge was not higher than hunters without local knowledge. The experimental knowledge factor interacted significantly with gender which resulted in a similar effect on males independent on whether they had local knowledge or not (according to coefficients provided in Table 2: 1.28-1.87+1.76=1.39 and 1.28-0+0=1.28, respectively). Local knowledge even appeared to be negative for females, (-1.87 and 0, respectively). Average bag size for female hunters was 1.4 and 1.7 grouse per day, respectively with and without local knowledge, while average bag size for male hunters was 3.6 and 4.1 grouse per day, respectively with and without local knowledge. On average male hunters bagged 2.3 grouse more in a day than female hunters.

Number of grouse encounters was not correlated with neither adult density (r = 0.11, p > .05) or to chicks per pair (r = 0.11, p > .05). The bag size was positively density dependent to both pre-harvest adult density km^{-2} and chicks per pair. The positive effect of pre-harvest adult density, was however not present the second day of hunting. Also, the effect of number of grouse encounters was a so much stronger determinant for daily bag size that it outpaced the positive effect of pre harvest adult density km^{-2} (Table 2). Neither the distance walked by the hunter nor the frequency of the dog flushing the grouse before hunters could reach within shooting distance turned out significant for the bag size. The final model explained 60% (pseudo R^2) of the total variance in daily bag size.

The comparison of the experimental hunters with ordinary hunters showed that hunters participating in the experiment had three times higher bag size on average, 3.4 and 1.1 grouse, respectively. The difference between the experimental and ordinary hunters became even more pronounced when the proportion of hunting days that resulted in zero bagged grouse is considered; 20% in the experiment and 64% in the first two days of the open hunting season.

Discussion

Hunters that had gained local knowledge of grouse distribution and abundance during more than a decade was contrary to our expectations not more effective in bagging grouse than hunters with similar experience but from other areas. We believe that the close to identical grouse encounter rates during the systematic line transect counts and during the active search by hunters is an important cue. These management areas contain a widespread availability of preferred habitat, and what appear as a random distribution of grouse (Lande, 2011). In this case, the harvest success will depend on the overall experience and skill of hunters and their dogs to locate and shot grouse, and previous knowledge on where grouse tend to be encountered provide little advantage (Kaltenborn, & Andersen, 2009; Lande, Herfindal, Finne, & Kastdalen, 2009; Schmidt, 1998). We speculate that the difference between genders can be attributed to attitudes that probably are formed early in life (Manfredo, 2008), and it was obvious in our discussions with the experimental hunters that the female hunters were more occupied with the performance of their dogs compared to the males. The hunter's success was positively affected by increasing grouse density and breeding success, but the estimates for these two parameters were the two lowest and a high number of grouse encounters counteracted the effect of adult density. As previously shown (Willebrand et al., 2011), hunter's success was at best weakly density dependent to grouse, and the range in both density and breeding success of the grouse populations in this study was similar to what is commonly reported from Scandinavia (Sandercock, Nilsen, Brøseth, & Pedersen, 2011; Willebrand et al., 2011).

The hunters in our experiment were more efficient than the ordinary hunters entering the areas after the experiment. Intense hunting can cause a redistribution of game, including grouse (Brøseth, & Pedersen, 2010), but we believe this to be an unlikely response in our experiment where only 4-8 hunters entered areas of 54 - 174 km^2. It has been suggested by grouse managers that grouse abandon hunting grounds with intense hunting, but radio marked willow grouse both in Sweden and Norway have shown that this is not the case (Brøseth, Tufto, Pedersen, Steen, & Kastdalen, 2005; Olsson, Willebrand, & Smith, 1996). The reduction of the grouse populations after the experiment could also be an explanation, but the overall CPUE of willow grouse hunters during a four day period was not found to be affected by the hunting during the immediately preceding four days hunting (Lindberget, 2009). In our experiment, hunters reduced the grouse population by 13% at the lowest density, but removed only 1% of the population at the highest density. The different harvest rates of experimental hunters did not seem to affect the success of ordinary hunters, and the harvest success of hunters the first days of the hunting in the open season was not different from the years when there had not been any experimental hunting. We suggest that the difference between experimental and ordinary hunters are attributed to other factors than grouse density, most likely that the experienced experimental hunters reach higher encounter and kill rates than ordinary hunters. About 7% of the hunters in the official statistics bag 5-7 grouse per day, and can probably be used as an estimate of the proportion of hunters that are as experienced as our experimental hunters among all grouse hunters.

Willebrand et al. (2011) concluded that hunting effort could be used to reduce the risk of reaching potentially unsustainable harvest levels, and suggested that bag statistics from successful hunters could provide a better proxy for population change than from the average hunter. Our results show that a high proportion of experienced male hunters and low game density could result in high harvest rates and the hunting success of experienced hunters do not track population change better than the bag statistics from ordinary hunters. A critical question is if there are thresholds where hunters will refrain to hunt due to low encounter rates. An absence of hunting thresholds at low densities and weak density dependence could potentially lead to overexploitation and risk an inevitable collapse as suggested in sport fisheries (Post et al., 2002; Post, Persson, Parkinson, & Kooten, 2008). We conclude that this study add support to the concern of using bag size as a proxy for game abundance we have raised earlier. Especially in areas where the hunting effort and average hunter experience may change from year to year.

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Table 1.

Pre-Harvest Grouse Populations Breeding Success and Distance Sampling Density km^{-2} Estimates

Area	Year	Total	Adults	Chicks per Pair
A	2007	8.4 (27.6)	2.7	3.2
	2008	13.2 (24.1)	4.5	3.9
B	2007	35.7 (16.1)	10.3	5
	2008	21.1 (18)	8.8	2.8
C	2007	11.2 (32.7)	3.8	3.9
	2008	12 (31.5)	9	0.7
D	2007	19.4 (18.1)	5	5.8
	2008	7.2 (22)	3.2	2.5

Note. Numbers in parentheses refers to the coefficient of variation in percent.

Table 2.

The coefficients of the generalized Linear Model Explaining Daily Bag Size of Grouse for Experiment Hunters

Parameter	Effect Size	Std. Error
Intercept	0.18*	0.37
Chicks per Pair[a]	0.39***	0.14
Adult Density km^{-2}[a]	0.40**	0.19
Grouse Encounters[a]	1.97***	0.54
With (1) and Without (0) Local Knowledge	-1.87**	0.77
Male (1) and Female (0) Hunters	1.28***	0.14
First (1) and second (0) Day of Hunting	-0.17*	0.38
Adult density km^{-2}[a] : Grouse Encounters[a b]	-0.90***	0.30
Adult Density km^{-2}[a] : First (1) and second (0) Day of Hunting[b]	-0.54**	0.26

Grouse Encounters[a] : First (1) and second (0) Day of Hunting[b]	1.06***	0.30
Grouse Encounters[a] : Male (1) and Female (0) Hunters[b]	-1.34**	0.57
With (1) and Without (0) Local Knowledge : Male (1) and Female (0) Hunters[b]	1.76**	0.78

Note. The pseudo R^2 for the model is 0.60, residual deviance is 91.36 on 70 *df*.

[a]Continuous parameters that are centred and standardized. [b]Two way interactions.

*p > .05. **p < .05. ***p < .01

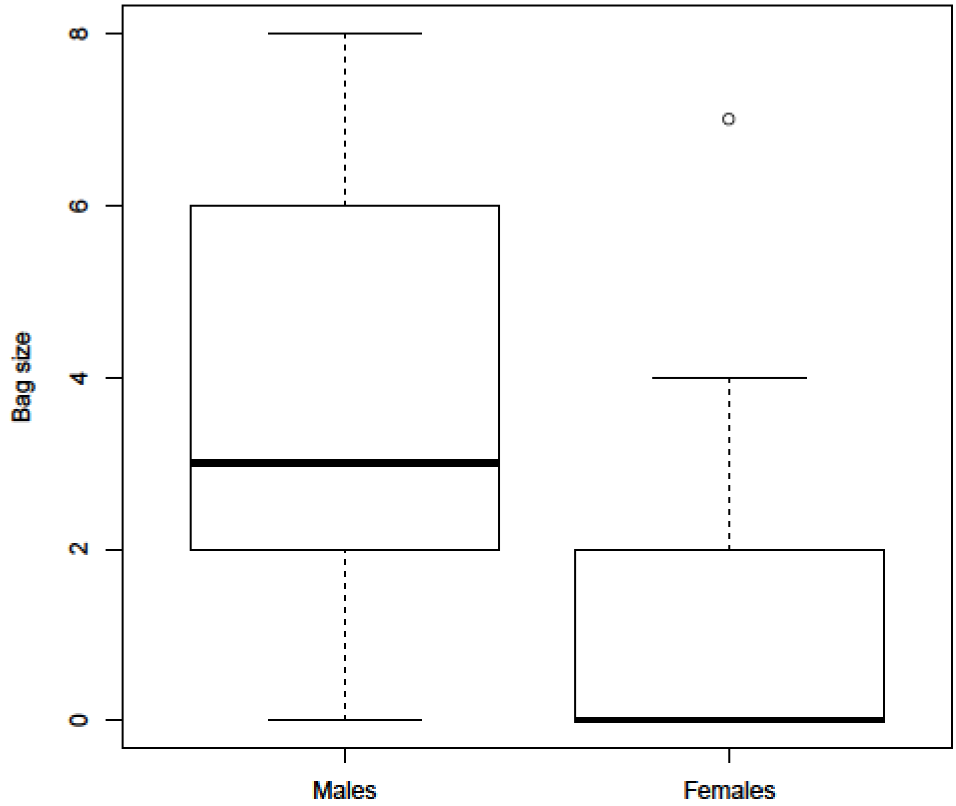

Figure 1. Box plot depicting the difference between genders in daily bag size of willow grouse. The daily bag limit for the hunters was eight grouse per hunter.

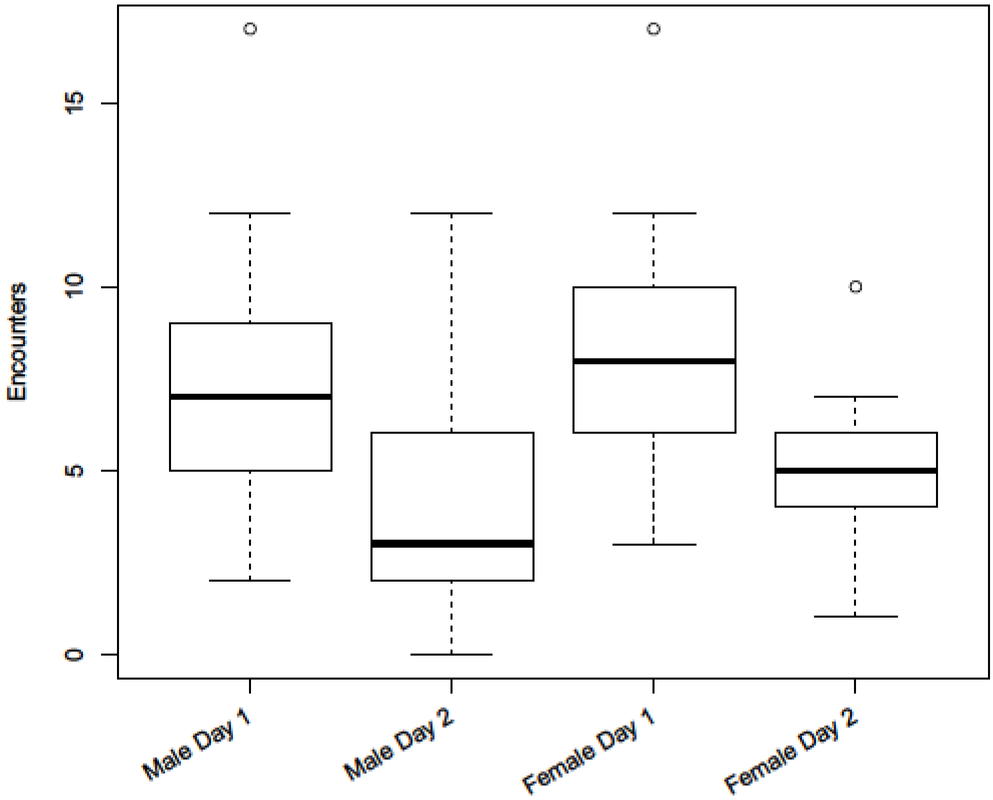

Figure 2. Box plot depicting difference in number of grouse encounters achieved between genders, day one and two of the hunt.