

NORWEGIAN UNIVERSITY OF LIFE SCIENCES



Preface

This Master thesis completes my Master degree in Ecology at the Norwegian University of Life Sciences. The thesis was written during the school year 2007/2008 following the fieldwork conducted in several periods during the hunting season and the pre-hunt taxation in 2007.

Funding for the study was provided by the Norwegian Institute for Nature Research and is a part of the project “Rypeforvaltningsprosjektet 2006-2011”.

I am deeply grateful to my supervisors Hans Christian Pedersen and Vidar Selås for providing the subject, for helping with the analyses and for giving comments on the manuscript. I also thank Henrik Brøseth for help with analyses and statistics. Finally, I would like to thank the scientists at the Norwegian Institute for Nature Research for good support and professional inputs.

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Ås, Desember 2008.

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Abstract

Selective hunting has been a major success in the cervid management in Scandinavia. However, when hunting for species with less age or sex specific dimorphic differences, selective hunting is very difficult. For the most important small game species in Norway, willow ptarmigan (*Lagopus lagopus*), selective hunting is problematic because ptarmigans are very difficult to age before the shot, implying that the method has to be based on post-shooting classification. The general idea today is to spare adult birds and direct the shooting towards juveniles, due to higher mortality in juveniles compared to adults, and consequently a higher possibility that the mortality is compensatory. However, if the adult birds tend to be the first to flush when a hunter encounter a brood, and the hunter tend to shoot the first birds that flush, there may actually be a higher hunting mortality on adults than on juveniles.

I examined whether hunters inflict a non deliberate selective hunting mortality upon populations of willow ptarmigan by using 273 aged wing samples from 43 different areas in Norway in 2007, with additional information on brood size and flushing sequence of the shot bird. Hunters more often shot the first birds that flushed when encountered, but the birds seemed to flush randomly with regard to age. Brood size was the only factor influencing the chances of shooting an adult or a juvenile, as the chances of shooting a juvenile bird increased with brood size. It is possible, however, that hunters tended to follow a brood after the first encounter, and thus increased the possibility to encounter scattered groups of birds without adults. Hunters might thus be able to select juvenile birds derived from their behaviour. I also examined time series of harvest statistics from Finnmark and Meråker to see whether the age distribution of shot birds in the bag changed throughout the most intensive first days of hunting. The results gave no significant change in age distribution, hence there appeared to be no selection of neither juvenile nor adult birds.

Managers and scientists usually have little knowledge of how the uncertainty in production estimates varies with the number of wing samples collected, and with different age ratios in the population. By using data from population simulations I was able to present data that shows how the estimate uncertainty decreases as the number of wing samples from the population increases, under different age ratios. Also, using a curve fitting procedure I was able to graphically display this result. The analysis suggests that grouse managers have to be more critical towards the applicability of wing samples to estimate ptarmigan production.

Sammendrag

Selektiv jakt på hjortedyr i Skandinavia har vært et meget suksessfullt forvaltningstiltak. For arter som viser mindre eller ingen alders- og kjønns-spesifikke dimorfiske forskjeller blir denne typen jakt vanskelig eller umulig. Aldersrettet avskyting på lirype (*Lagopus lagopus*) er i så måte problematisk fordi det er svært vanskelig å aldersbestemme individet før skuddet løsner. Dette medfører at metoden for aldersrettet avskyting på lirype må være basert på informasjon innehentet etter felling. På grunn av høyere dødelighet hos kyllinger sett i forhold til voksne, og dermed større sjanse for at jaktdødeligheten er kompensatorisk, er det ansett som en fordel å spare de voksne individene og rette avskytingen mot ungfugldelen av bestanden. Hvis det imidlertid viser seg at de voksne fuglene oftere tar til vingene før resten av kullet og at jegere som oftest skyter de første fuglene som flyr opp, kan man ha en ubevisst selektiv jakt som retter seg mot de voksne fuglene.

I denne studien undersøkte jeg om jegere gjennom vanlig jakt kan påføre populasjoner av lirype en ubevisst selektiv jakt ved å analysere 237 vingepøver fra 43 ulike områder i Norge i 2007. I tillegg hentet jeg inn informasjon om kullstørrelse og i hvilket nummer i rekkefølgen av fugl i oppflukten jegerne felte. Jegerne skjøt oftere de første fuglene som fløy opp, men disse fuglene var tilfeldig fordelt i forhold til alder. Kullstørrelsen var den eneste parameteren som ga innflytelse på aldersfordelingen, siden sjansen for å skyte ungfugl øker med økende kullstørrelse. Det er mulig at jegerne etter første oppflukt ofte fulgte etter kullet og på den måten økte sjansene for å støkke grupperinger av fugl som ikke innholdt voksne individer. Jegere kan dermed være i stand til å selektive kyllinger ut fra deres jaktutøvelse. Jeg undersøkte også tidsserier med jaktstatistikk fra Finnmark og Meråker for å se om aldersfordelingen på skutt fugl endret seg i løpet av de første mest intensive dagene med jakt etter jaktstart. Resultat ga ingen indikasjoner på endring i aldersfordelingen og ga dermed ingen støtte for hypotesen om selektiv jaktdødelighet på verken voksne eller kyllinger.

Forvaltere og forskere har vanligvis liten kunnskap om hvordan usikkerheten i produksjonsestimatene endrer seg med antall innsamlede vingepøver under ulike aldersfordelinger i populasjonen. Ved å bruke data fra populasjonssimuleringer kunne jeg presentere data som viser hvordan denne usikkerheten avtar når antall vingepøver øker. Resultatene antyder at man må være mer kritisk til anvendbarheten av vingepøver når man estimerer produksjonen i lirypepopulasjoner.

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1. Introduction

Selective shooting towards age and sex has been one of the most successful initiatives in the cervid management in Scandinavia (e.g. Andersen & Sæther 1996, Solberg et al. 1999, Sæther et al. 2001, Hjeljord 2008). The productive animals are spared and most of the harvest is directed towards calves and young individuals (Andersen & Sæther 1996, Solberg et al. 1999, Hjeljord 2008). Also within small game hunting, this selective harvest strategy is utilized. In some regions of the northern part of Finland hunters can only target female capercaillie (*Tetrao urogallus*) (Lindén 1991, Helle et al. 1999). When hunting for species with less age or sex specific dimorphic differences, however, selective hunting is very difficult or even impossible (Hudson & Newborn 1995).

Willow ptarmigan (*Lagopus lagopus*) is considered as one of the most important small game species in Norway and Sweden, both culturally, economically and for recreation (Bjerke 1993, Willebrand & Hörnell 2001, Steen 2004, Pedersen & Karlsen 2007). Like other grouse species in Scandinavia, the willow ptarmigan undergoes large cyclic or quasi-cyclic population fluctuations, mostly because of annual variations in reproduction (Marcström & Höglund 1980, Myrberget 1974, 1984a, Pedersen 1984, Lindström et al. 1995, Steen & Erikstad 1996, Lindström et al. 1997). Numerous earlier studies have found regular fluctuations of three to four years corresponding with the fluctuations of microtine rodents (e.g. Myrberget 1982, Steen et al. 1988). As a result of this, harvest managers have to wield a resource with varying and unpredictable harvest potential.

Andersen (1984) presented an idea of age directed shooting towards willow ptarmigan. Old cocks were assumed to be of higher quality than young cocks, and therefore were to be spared. However, the quality of territorial young cocks has been shown to be as good as the quality of older cocks (Pedersen 1988a, 1988b, 1990). The general idea today, is to spare adult birds and direct the shooting towards juvenile birds, due to the higher mortality in juveniles compared to adults, and hence the higher possibility to have compensatory mortality (e.g. Pedersen et al. 2004, Pedersen & Karlsen 2007). The problem is that ptarmigans are difficult to age before they are shot. Therefore the method has to be based on post-shooting classification, which then derives a daily quota that differs in accordance to the classification. E.g. with a quota for six birds, including two adults and four juveniles, the hunter must end

his hunting after shooting the two adult birds, regardless of the total number in the bag (Karlsen & Pedersen 2006, Pedersen & Karlsen 2007).

The demographic effects of a selective harvest towards a specific age and/or sex segment could be significant (Kokko et al. 2001, Milner et al. 2007). Interviews with a number of hunting guides conducted by Hörnell-Willebrand (2006) reveals that it is common to shoot one of the adult birds when hunters flush a brood. Hudson (1986) showed that, in North-England, there were more old red grouse (*Lagopus lagopus scoticus*) males in the bag than would be expected from estimates of age and sex distribution from taxation. Bunnfeldt et al. (in press) found in Scotland that more young than old red grouse were bagged at large bag sizes than would be expected from the pre-hunt taxation. DeStefano & Rusch (1986), however, did not find a skewed age and/or sex distribution in their hunting statistics of ruffed grouse (*Bonasa umbellus*).

If there is a non deliberate selective hunting mortality, this should be possible to perceive through a field survey of both bird and hunter behaviour. Also, this could be possible to trace as a change in the age distribution of shot birds throughout the first period of the hunting season. Within the first ten days of hunting, two thirds of the total hunting pressure is inflicted (Kastdalen 1992, Pedersen & Karlsen 2007). In this period, it is reasonable to suggest that there is no other significant influence on the proportion of adults/juveniles than hunting and predation. Predation, on the other hand, is expected to have considerable less effect on the adult/juvenile share than hunting throughout the first ten days. Considering the whole season, higher natural mortality on young birds is expected to even out the predominance of hunting mortality upon adult birds in the bag.

Traditionally, the management of harvesting in willow ptarmigan demanded only a management convened hunting period with no further extensive regulations (Steen 1989, Steen 2004, Pedersen & Karlsen 2007). Later management, mostly due to increased hunting pressure, introduced hunting restrictions, based partly on information on annual chick production and population density, which usually have been assessed through field surveys or from harvested birds and pre-hunt taxation (Pedersen & Karlsen 2007). When managers and scientists are designing a sampling scheme to optimise their collection effort, of e.g. harvested birds, to assess the productivity of the population, they usually have little knowledge of how the uncertainty in the estimate varies with the number of wing samples collected, under

different age ratios in the population. Using collected wing samples, grouse management is by large based on the assumption of a random withdrawal with regard to sex and age.

In this paper I first examine whether hunters through traditional hunting can inflict a selective hunting mortality upon populations of willow ptarmigan, by shooting more or less juveniles/adults than would be expected by a random withdrawal. If adult birds tend to flush earlier than juvenile birds in a clutch and if hunters tend to shoot the first birds that flushes, hunters can exert a non deliberate selective withdrawal by shooting a larger proportion of adult birds than would be expected if the shooting was non selective and random. If true, this would make it possible to suggest initiatives to direct the shooting towards juvenile birds, which due to higher mortality has lesser impact on the population size if shot. Thereafter I examine whether the age distribution in the bag changes throughout the first ten days of the hunting season, by using time series of harvest statistics from two different areas in Norway. Thirdly, I explore the uncertainty in chick production estimates from harvest data based on wing samples, by investigating how the estimate uncertainty changes as the number of harvested birds from the population increases, under different age ratios in the population.

2. Material and Methods

2.1 Selective hunting mortality

To address the hypothesis of non deliberate selective hunting mortality I made a hunter proclamation (appendix 1). This was distributed to a number of selected hunters, posted at universities, and published at strategic sites on the internet. The hunters were invited to send me collected wing samples from their hunting together with specific information about the situation in which each bird was shot, using a preformed scheme (appendix 2). I received a total of 273 birds from 43 different areas in Norway, all samples from 2007.

The age of each bird was evaluated on the basis of primary feather pigmentation and wing tip roundness on the feathers from each wing sample (appendix 3). This is a method based on Bergerud et al. (1963), which has been widely used in management and science (e.g. Myrberget 1974, 1984a, b, Pedersen 1984, Steen et al. 1988, Rørvik et al. 1998, Smith & Willebrand 1999). The birds were classified as juvenile (< 1 year) and adult (> 1 year). All age determination was conducted either by me or by personnel with relevant training (biologist and hunters), either in a lab or in the field. Then I used the information from the aged birds to check whether the birds were shot in a pattern when compared with brood size and/or number shot in the flushing sequence. A total of 149 aged birds were included in the analysis of the impact of the number shot in the flushing sequence, and 174 in the analysis of the impact of brood size. Due to shortage of wing samples from each area I pooled all the wing samples from the 43 different areas into the same analysis.

I defined a brood as all the birds in the flush, including both the adult and the juvenile birds. Biologically, I assume that a flushing of one bird should yield an adult without brood, and a flushing of two birds should yield a pair (cock and hen) without brood. I therefore removed brood sizes of one and two from the analyses. Flushes with a total of more than 15 birds were not considered to be a brood. This was because a ptarmigan hen on average lays about 10 eggs in a clutch and the maximum known number of eggs laid is 16 (Pedersen & Karlsen 2007). Therefore two broods with more than 15 individuals were considered to be flocks and were not included in the analyses. The dispersal of broods normally starts at about 25th of September and after this we can no longer consider flushed birds as member of the same brood (Smith 1997, Pedersen & Karlsen 2007). The hunt starts at 10th of September and two thirds of the total hunting pressure is inflicted within the 25th of September (Kastdalen 1992,

Willebrand 2005, Pedersen & Karlsen 2007). Therefore I excluded data from wing samples collected after this date from my analyses.

Logically, the brood size affect the likelihood of shooting an adult or a juvenile, and number shot in the sequence should be correlated to brood size, e.g. in a flushing of four birds, the sequence number can be at a maximum of four. In fact, there was a highly significant correlation between these two explanatory factors ($r = 0.66$; $P < 0.001$).

To address the hypothesis whether hunters shoot the first birds that flush, I made a sequence index, which is number shot in the sequence adjusted for brood size:

brood size - number shot in the sequence

brood size - 1

The index scales from 0 to 1, where 0 represents a bird being shot last in the sequence and 1 represent a bird being shot first in the sequence. The mean value will be 0.5 if the probability of being shot is independent of flushing number. I tested the relationship between age and this sequence index with a likelihood ratio test in a logistic regression model.

2.2 Changes in age distribution from harvest data

To address whether the age distribution of birds shot changes throughout the hunting season I conducted my analysis on two different time series; one from Finnmark from 1981 and 1983-1988, and one from Meråker, Nord-Trøndelag, from 1996-1998. All analyses were based on wing samples where the age determination was done according to the criteria's listed in appendix 3. All data from Finnmark and Meråker were collected by hunters through ordinary hunting. A total of 2774 wing samples were included in the analysis of Finnmark, and 619 in the analysis of Meråker.

Over the years, the date when the hunt started varied. In Finnmark the hunt started 15th of September in 1981, 1983-1985 and 10th of September in 1986-1988. In Meråker the hunt started 10th of September in 1996-1998. I did my analysis over the first ten days after the hunting started and not from one specific date. I established a lower limit of at least 20 wing samples per date to ensure an acceptable uncertainty in my analyses. All dates with 20 or more samples (juvenile + adults) were used. Two consecutive dates with less than 20 samples each, but with more than 20 samples when pooled, were also included in the analyses. I considered that there would not be a substantial difference whether a bird was shot e.g. the 15th or the 16th of September, but that a time span beyond this could influence the analyses.

If there was not a significant difference in the dataset between areas and from each year according to number of days from the hunting started I would be able to pool these data in the analysis. To address this I conducted an ANOVA-test by using GLM (General Linear Model) type III. Statistical analyses were conducted using Minitab Statistical Software, release 14.0, version.14.1. © 1972 - 2003 Minitab inc.

2.3 Uncertainty in harvest data based on wing samples

To address uncertainty in harvest data regarding age-ratio, I used the results from population simulations executed by Brøseth & Pedersen (pers. com.). They simulated harvesting from a willow ptarmigan population by creating a theoretic population of 1000 birds with two different age groups (juvenile and adult). From this population they conducted a random harvest of N birds, by using a Monte Carlo simulation with 1000 iterations. From each of the iterations they calculated the age ratio as the production estimate in the randomly drawn sample. To quantify the variation in the age ratio estimate they used the 5 and 95 percentile from this frequency distribution as a measure of variance, which means that 90 percent of the estimates are within the limits of these two values (90 % CI.) (Hagen 2003).

I used these values as a measure of variance in a curve fitting procedure. I used age ratio estimates for a wide range of sample sizes ($N = 1-500$), from which I fitted a curve to explore how the variability in the age ratio estimate decreases as the sample size increases. I repeated the simulation for different age ratio compositions of the population (50:50, 60:40, 70:30, 80:20 and 90:10) to explore how the production in the population affected the variability in the age ratio estimate.

The curve fitting procedure was executed in SPSS for windows v.16.0, release 16.0.1. The Monte Carlo simulations were performed in Resampling Stats (Version 4.0.7, © Resampling Stats Inc., Arlington, Virginia).

3. Results

3.1 Selective hunting mortality

The mean distribution of the sequence index was 0.61 (N = 87, SD = 0.367, 95 % C.I. = 0.528–0.685), which is significant different from 0.5 (Fig. 1). Therefore I conclude that hunters more often shot the first birds that flushed.

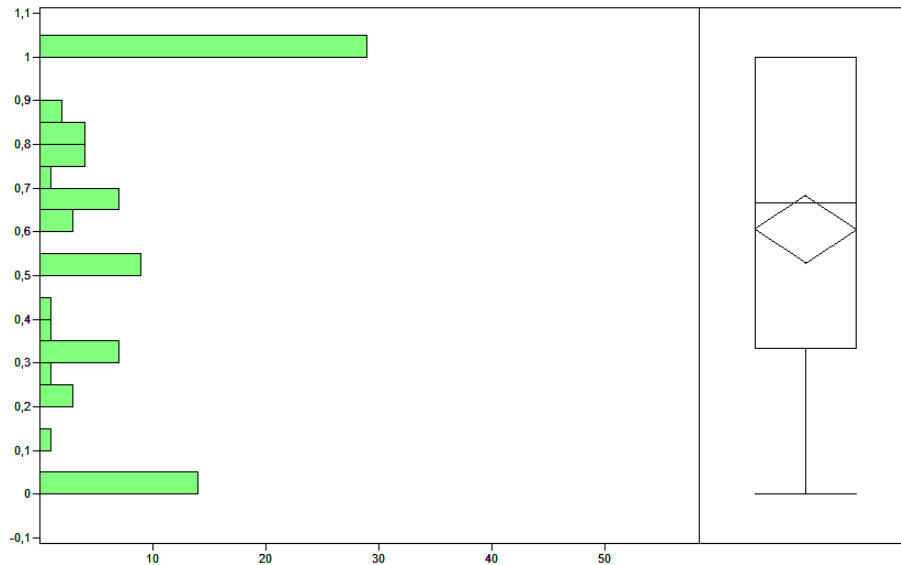


Figure 1. Distribution of index values with histogram on the left side and quantile box plot on the right side. The index scales from 0 to 1, where 0 represents a bird being shot last in the sequence and 1 represent a bird being shot first in the sequence.

By using a likelihood ratio test in a logistic regression model, there was a significant relationship between age of shot birds and brood size ($\chi^2 = 7.62$; $df = 1$; $P = 0.006$). As a result of the strong correlation between brood size and number shot in the sequence, I expected the same result for number shot in the sequence as was the case of brood size. In fact there was a significant relationship between age of shot birds and number shot in the flushing sequence ($\chi^2 = 4.85$; $df = 1$; $P = 0.028$). However, when using the sequence index as independent variable, I found no significant relationship with the age of the birds ($\chi^2 = 0.26$; $df = 1$; $P = 0.608$).

When I used a multiple logistic regression model with both number shot in the sequence and brood size as independent variables, the relationship between age and brood size was still significant ($\chi^2 = 8.55$; $df = 1$; $P = 0.004$), whereas there was no additional effect on age from number shot in the sequence ($\chi^2 = 0.28$; $df = 1$; $P = 0.595$).

The impact of number shot in the sequence in the test is fully explained by brood size and therefore the number shot in the sequence has no additional impact on the age of shot birds, whereas brood size impacts the chances of shooting a specific age.

3.2 Changes in age distribution from harvest data

The time series from Finnmark showed no significant differences in the age distribution of shot birds when compared to days after the hunt started (ANOVA $F = 0.05$; $df = 1$; $P = > 0.05$). However the distribution was significantly different between years (ANOVA $F 9.50$; $df = 6$; $P = < 0.001$), and therefore I could not pool the data from each year (Fig. 2). Meråker revealed no significant differences in the age distribution either between days after the hunt started (ANOVA $F = 0.30$; $df = 1$; $P = > 0.05$) or years (ANOVA $F = 1.05$; $df = 2$; $P = > 0.05$). Therefore I pooled the corresponding data from each day from each year (Fig. 3), but still I found no significant difference in the age distribution between days after the hunt started ($\chi^2 = 8.25$; $df = 8$; $P = 0.409$).

Hence, there appeared to be no significant selection of neither juvenile nor adult bird through ordinary hunting within the first ten days either in Finnmark or Meråker. Thereby these results do not support the hypothesis of selective hunting mortality.

Both figure 2 and 3 shows no significant change in the age distribution throughout the first ten days of hunting.

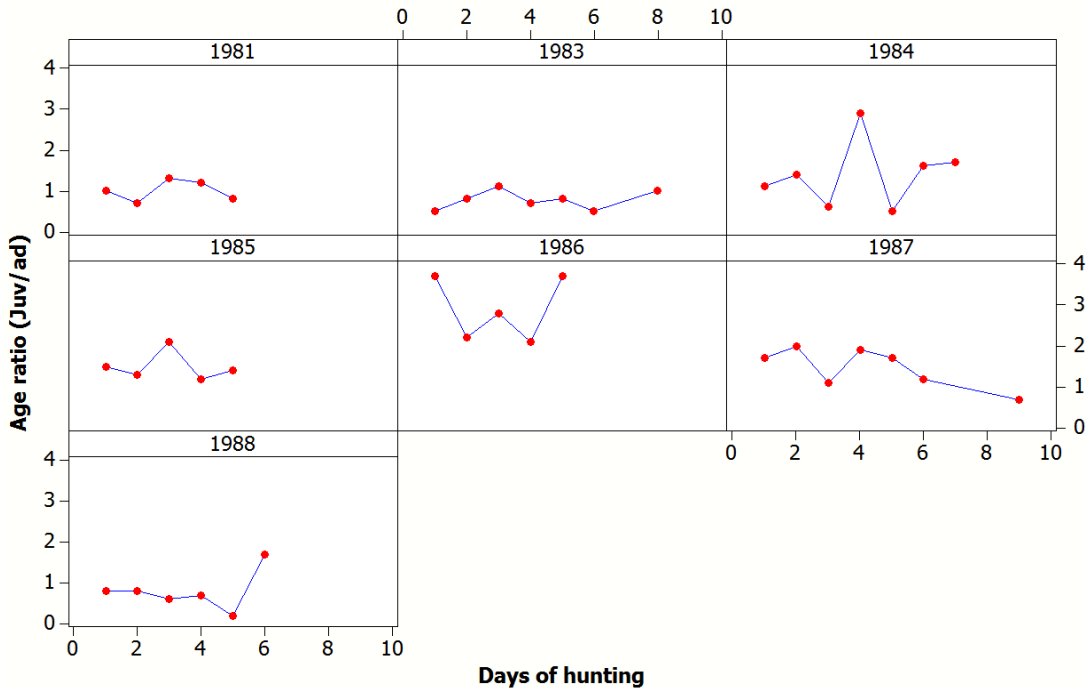


Figure 2. Yearly age ratio distribution from the bag during the first ten days of hunting in Finnmark.

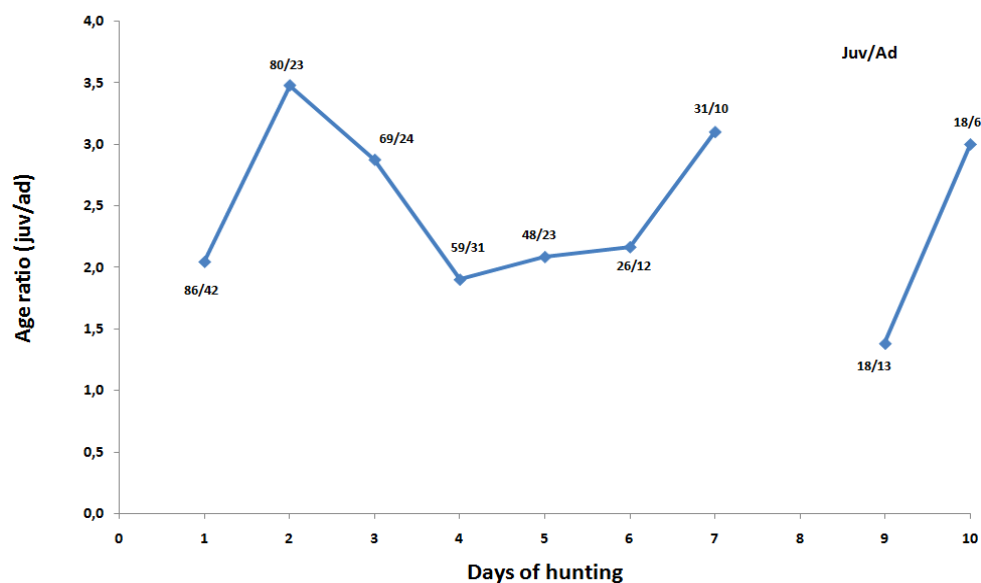


Figure 3. Age ratio distribution from the bag during the first ten days of hunting in Meråker from 1981, 1983-1985.

3.2 Uncertainty in harvest data based on wing samples

The best fit by the power curve to the simulated 90 % C.I. of the age ratio estimates is shown in Fig. 4. The equation describing power growth is: $y = a x^b$, where y is the 90 % C.I. for the age ratio estimate (production), x are the number of wing samples and, a and b are equation constants (Tab. 1).

Table 1. Constants used in the equation describing power growth.

Pop. age ratio	a	b
50:50	217	-0,581
40:60	199	-0,568
30:70	171	-0,551
20:80	161	-0,566
10:90	118	-0,563

Fig. 4 shows how the variability in the age ratio estimates decreases as the number of wing samples increases. Few wing samples derive a large variation which means that there is a great uncertainty regarding the production in the population. Under different age ratios this becomes apparent in a large spectre of variance. E.g. with 50 wing samples the 50:50 population has an uncertainty of ± 22.4 , which means that there is a 90 % probability that the

true share of juveniles lies within the range of 27.6–72.4 %. With the same amount of wing samples the 30:70 population has an uncertainty of ± 19.8 and the 10:90 population an uncertainty of ± 13.0 . With 500 wing samples the variance dropped considerably to ± 5.9 , ± 5.6 and ± 3.6 for the 50:50, 30:70 and 10:90 population, respectively. With a low production, as a large age ratio imbalance, the uncertainty is lower at few samples than is the case with a balanced age ratio.

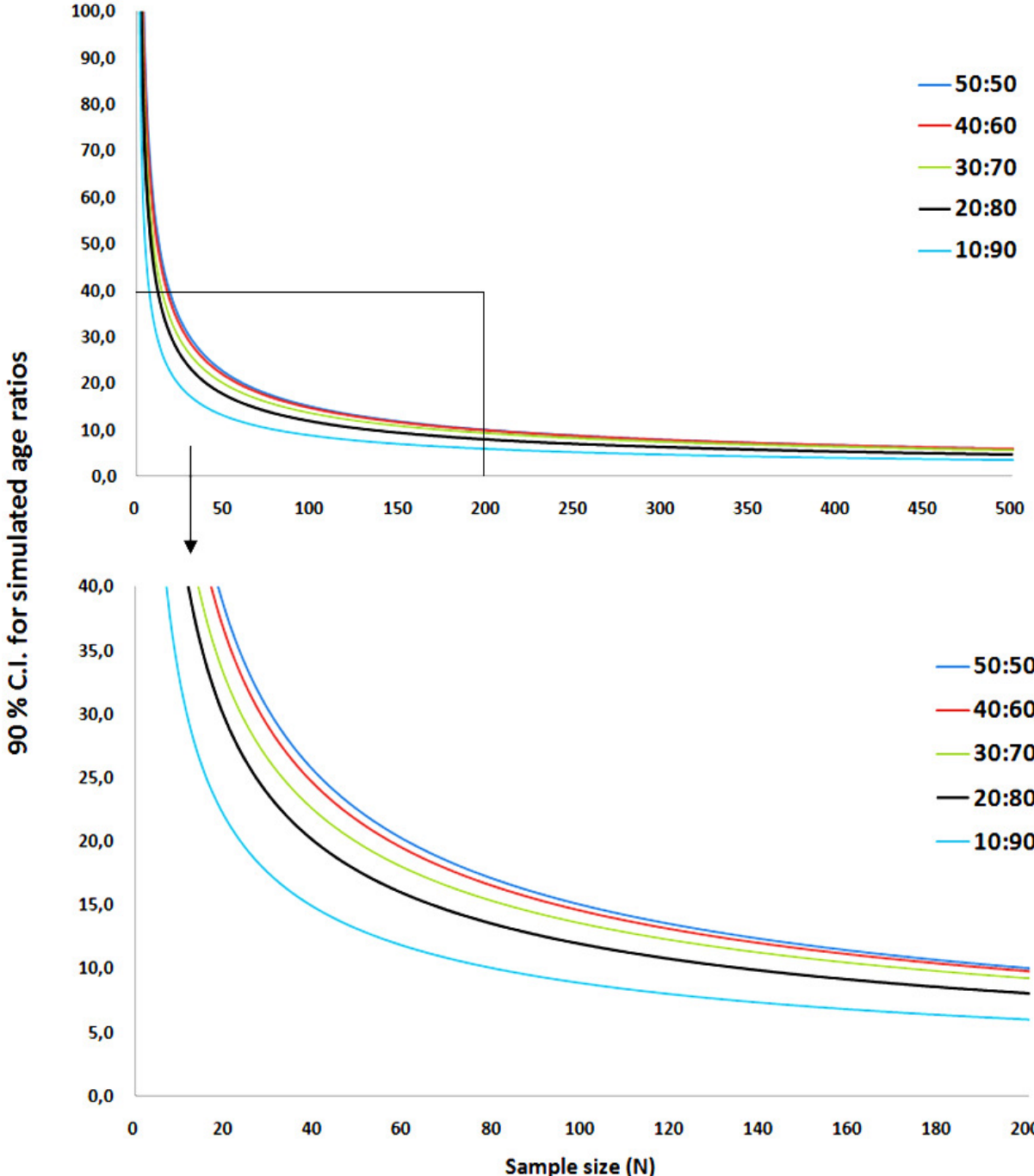


Figure 4. 90 % C.I. for the simulated age ratios according to the number sampled, representing the variability in production estimate for different age ratios in the population.

Fig. 5 shows the frequency distribution of simulated age ratios from respectively the 50:50 and 10:90 populations with a wing sample sizes of 50 and 500. The bars indicating the upper and lower C.I. clearly visualize the differences in variance.

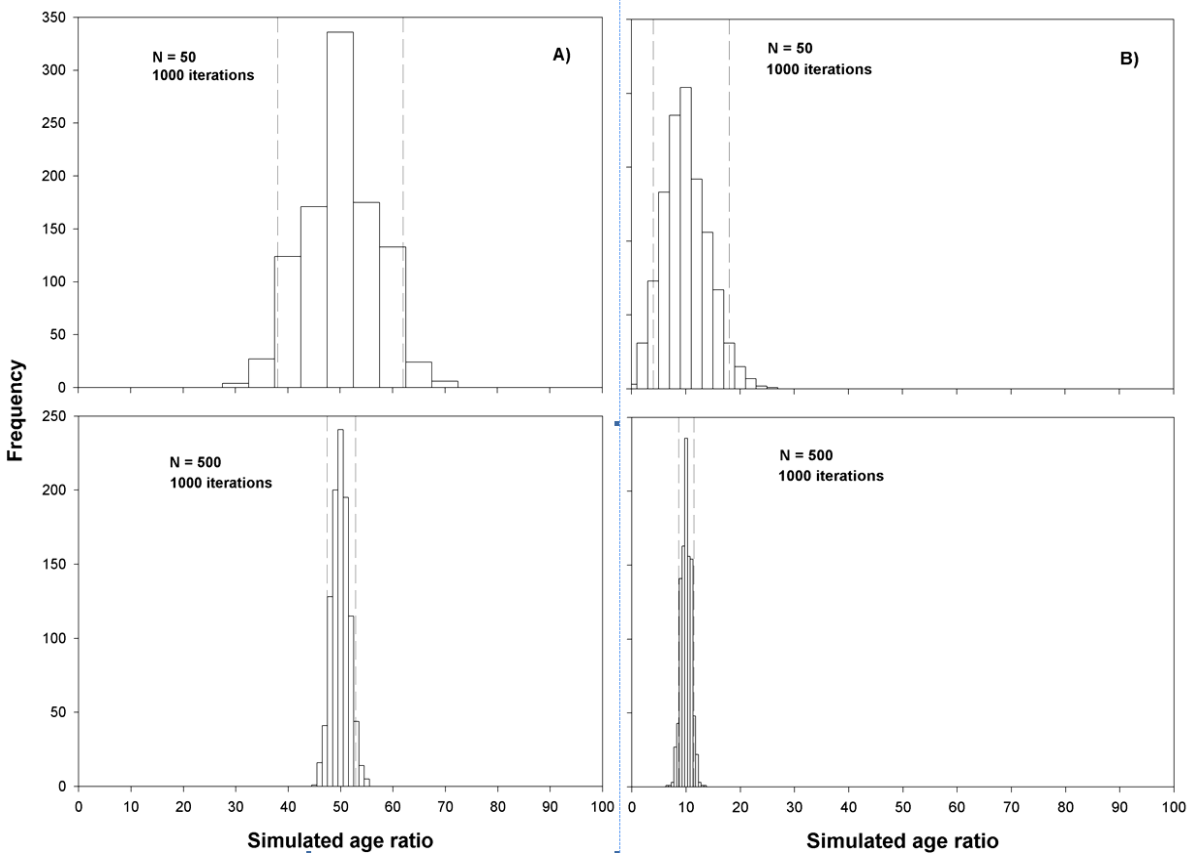


Figure 5. Frequency distribution of simulated age ratios, when 50 and 500 individuals are sampled, for a population with an age ratio of A) 50:50, and B) 10:90. The 5 and 95 percentiles are indicated by vertical broken lines representing the upper and lower limits of the 90 % C.I. used as the variability estimate.

4. Discussion

4.1 Selective hunting mortality

Increasing hunting pressure and temporarily small populations has raised the need for a more comprehensive and complex grouse management in Norway (Pedersen 1997, Solvang et al. 2005). Research on small game in Norway has traditionally focused on ecological topics, but the present grouse management requires more knowledge about a wide variety of factors that influence the populations, such as mortality, demography and anthropogenic influences. In order to develop sustainable harvest strategies, we should thus not only consider biological and ecological factors, but also anthropogenic factors, e.g. loss of habitat areas due to landscape fragmentation and extension of cabin areas (Andr en 1994, Br seth & Pedersen 2000) and acquire a more extensive understanding of the impact of hunting and hunters' behaviour.

In this study I found that hunters tended to shoot the first birds that flushed. However, the birds seemed to flush randomly with regard to age, and consequently the hunters did not inflict a selective hunting mortality derived from the behaviour of the birds. Many hunters have told me that they have registered the cock to flush before the rest of the brood. Although this might be correct, it is very difficult or even impossible to determine whether the flushing cock is the adult cock. It is though reasonable to expect the adult birds to induce a predator evasive behaviour within the rest of the brood. Interviews with hunter guides, performed by H rnell-Willebrand et al. (2006), indicate that it is common to shoot one of the adult birds when hunters flush a brood. The uncertainty is dependent on the ability to age shot birds. Harvest data, investigated by Pedersen et al. (1999), revealed a larger chick production compared to results from taxation when the population was small and there were few but large brood sizes. H rnell-Willebrand et al. (2006) found that hunters rarely find adults without broods at low densities. This could indicate that hunters follow the broods subsequent to the first flushing.

The probability that the hunter shoots a juvenile grouse will be greater when brood sizes are large, although H rnell-Willebrand et al. (2006) found that the risk of an adult bird to be shoot was less dependent on brood size than was the case for juvenile. From my results, hunters harvest ptarmigan randomly according to age, and under the assumption that a brood always consists of two adult birds (cock and hen) the chance of shooting an adult bird in a brood size of four birds is 50 %. In a brood size of eight birds the chance is reduced to 25 %.

One management initiative could be to urge hunters not to take the shot if the flushing brood consists of four or less birds, including single birds. This could reduce the chances of shooting an adult bird. The practical implementation depends on the pattern of the flush, e.g. whether the birds flush subsequently or simultaneously.

In my study, some hunters may have registered the conditions around the individually flush sequences correctly, but subsequent to the first flush followed the brood and then recorded the following flush as a new incident. It is plausible to suggest that the birds from the second flush could be scattered into single birds and groups without adults, and would not be together and behave as a complete brood. Consequently a group of juvenile birds could be shot and registered as a brood, and the results could be disproportionate to what would be expected if flushed for the first time. In a biological perspective, this could lead to a disproportionately high share of juvenile birds being shot as one of the first in the flush. Further surveys investigating this approach in a biological perspective, should gather information in areas with no preliminary hunting, and the hunters should only register "first time flushes" as broods.

From a management perspective, however, my data represents genuine circumstances of how hunters behave when harvesting ptarmigan. By following broods, which may give a greater chance of shooting a juvenile, hunters might be able to select juvenile birds as a result of their harvest pattern. I was not able to test for area specific behaviour in neither hunters nor birds due to the limited amount of data. Although area specific behaviour is possible to occur I anticipate that this would be confined to small areas with a relatively small amount of birds and that it would not have a considerable effect on the analyses. A better understanding of the hunters' behaviour when encountering broods of ptarmigan under different conditions, e.g. different densities, weather conditions, breeding success, brood sizes and distance to cabins and roads, is needed to better understand how hunters harvest from populations of ptarmigan (Hörnell-Willebrand et al. 2006).

I could not find any support for the hypothesis of selective hunting mortality in the time series from Finnmark and Meråker. There were no significant changes in the age distribution from the hunt started and ten days ahead. This is in accordance with earlier studies by Myrberget (1970; 1976) who found that the proportion of adult/juvenile birds in the harvest data remained the same from early September until winter in Norway. Also Smith & Willebrand (1999) could not find a different mortality between ages nor sexes between August and the end

of November in their four year study of radio tagged ptarmigans in Sweden. However, Pedersen et al. (1999), in their mortality analysis from three different areas in Norway, found that the mortality was greater early in the fall and that this mortality was considerably larger for juvenile than for adult birds. From my results the distribution seems arbitrary over such a short period as the first ten days, and gives no indications with regard to selective hunting mortality. It seems as though the mortality, both anthropogenic and natural, is equally inflicted upon adult and juvenile ptarmigans.

4.2 The applicability of harvest statistics

Hörnell-Willebrand (2005) pointed that conclusions from harvest statistics have to be treated with caution. She found that hunters bag young grouse disproportionately to what is present in the population, resulting in a long term average that underestimates the true value. In 2006, Hörnell-Willebrand et al. (2006) found that fluctuations of chick production appeared to be more irregular than estimated from harvest data based on wing samples, which are thereby less suitable for predictions in willow ptarmigan management.

My study suggests that grouse managers have to be more critical towards the applicability of wing samples to estimate production. The estimated production has a certain level of uncertainty. These results offers managers and scientists a crucial aspect in demonstrating that wing samples wield an uncertainty which is additive to the uncertainty in the production estimation itself. I anticipate that the amount that is shown to be needed from my analysis is higher than many researchers would have used in earlier studies, especially when considering the additive effect.

In conclusion, a large amount of wing samples is crucial to establish a valid estimation of the production in a ptarmigan population. My results also imply that the size of the source population from which we are estimating the age ratio will affect the variability of our estimate. It is also possible to suggest that the results from the age ratio simulation are transferable to sex ratio estimation.

5. References

- Andersen R. 1984. Viltstelltiltak for lirype – en oversikt. Pp. 157-165 in Steen, J.B., red. Rypeforskningsrapport 1983. NJFF, Hvalstad.
- Andersen, R. og Sæther, B-E. 1996. Elg i Norge. Teknologisk forlag, Oslo.
- Andrèn, H. 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. - *Oikos* 71: 355-366.
- Baines, D. & Lindén, H. 1991. The impact of hunting on grouse population dynamics. - *Ornis Scandinavica* 22: 245-246.
- Bergerud, A.T., Peters, S.S. & McGrath, R. 1963: Determining sex and age of willow ptarmigan in Newfoundland. - *Journal of Wildlife Management* 27: 700-711.
- Bjerke, T. 1993. Jegeren. En samfunnsfaglig kunnskapsoversikt. – NINA Utredning 044:1-51.
- Brøseth, H. & Pedersen H.C. 2000. Hunting effort and game vulnerability studies on a small scale: a new technique combining radio-telemetry, GPS and GIS. *Journal of Applied Ecology*. 2000, 37, 182-190.
- Bunnenfeldt, N., Baines, D., Newborn, D., Milner-Gulland, E.J. In press. The interaction between demography and shooting in red grouse. – *Journal of Avian Biology*.
- DeStefano, S & Rusch, D.H. 1986. Harvest rates of ruffed grouse in north eastern Wisconsin. – *Journal of Wildlife Management*. 50:361.367.
- Hagen, P.C 2003. Innføring i sannsynlighetsregning og statistikk. Cappelen Forlag, Oslo.
- Helle, P., Kurki, S. & Lindèn, H. 1999. Change in the sex ratio of the Finnish capercaillie *Tetrao urogallus* population. – *Journal of Wildlife Biology* 5: 25-31.
- Hjeljord, O. 2008. Viltet. Biologi og forvaltning. Tun Forlag, Oslo.
- Hudson, P.J 1986. The biology and management of a wild game bird. – The game Conservancy Trust, Fordingbridge.
- Hudson, P.J. 1992. Grouse in space and time. - Game Conservancy Trust, Fordingbridge.

- Hudson, P.J. & Newborn, D. 1995. A manual of Red Grouse and Moorland Management. – Game Conservancy Ltd, Hampshire
- Hörnell-Willebrand, M. 2005. Temporal and Spatial Dynamics of Willow Grouse *Lagopus lagopus*. Swedish University of Agricultural Sciences, Umeå. Johnson, K.H. & Braun, C.E. 1999. Viability and conservation of an exploited sage grouse population. - *Conservation Biology* 13: 77-84.
- Hörnell-Willebrand, M., Marcström, V., Brittas, R. & Willebrand, T. 2006. Temporal and spatial correlation in chick production of willow *Lagopus lagopus* in Sweden and Norway. *Journal of Wildlife Biology*. 12: 347-355.
- Kastdalen, L. 1992. Skogshøns og jakt. Norges Bondelag. Rapport. 46 s.
- Karlsen, D.H & Pedersen, H.C. 2006. Rettet avskytning på lirype. - *Jakt* 7: 36-40.
- Kokko, H., Lindstrøm, J. & Ranta, E. 2001. Life histories and sustainable harvesting. – *Conservation of Exploited Species*. Cambridge University Press, Cambridge.
- Lindén, H. 1991. Patterns of grouse shooting in Finland. - *Ornis Scandinavica* 22: 241-244.
- Lindström, J., Ranta, E., Kaitala, V. & Lindén, H. 1995. The clockwork of Finnish tetraonid population dynamics. - *Oikos* 74: 185-194.
- Lindström, J., Ranta, E., Lindén, M. & Lindén, H. 1997. Reproductive output, population structure and cyclic dynamics in capercaillie, black grouse and hazel grouse. - *Journal of Avian Biology* 28: 1-8.
- Marcström, V. & Höglund, N. 1980. Factors affecting reproduction of willow grouse, *Lagopus lagopus*, in two highland areas of Sweden. - *Swedish Wildlife Research* 11: 285-314.
- Milner, J., Nilsen, E.B. & Andreassen, H.P. 2007. Demographic side effects of selective hunting in ungulates and carnivores. - *Conservation Biology* 21: 36-47.
- Myrberget, S. 1970. On the part played by predation in the short term variation in the population of willow grouse, *Lagopus lagopus*, in Norway. *Proc. Int. Congr. Game Biology*. 9 458-464.

- Myrberget, S. 1974. Variation in the production of willow grouse *Lagopus lagopus* (L.) in Norway, 1963-1972. - *Ornis Scandinavica* 5: 163-172.
- Myrberget, S. 1976. Hunting mortality, migration, and age composition of Norwegian Willow grouse (*Lagopus lagopus*). *Norw. Journal of Zoology*. 24: 47-52.
- Myrberget, S. 1982. Fluctuations in microtine populations in an island area in northern Norway. *Fauna norvegica*. Ser. A. 3: 7-11.
- Myrberget, S. 1984a. Population cycles of willow grouse *Lagopus lagopus* on an island in northern Norway. - *Fauna norvegica* Ser. C, *Cinclus* 7: 46-56.
- Myrberget, S. 1984b. Population dynamics of willow grouse *Lagopus lagopus* on an island in North Norway. - *Fauna norvegica* Ser. C, *Cinclus* 7: 95-105.
- Pedersen, H.C. 1984. Territory size, mating status, and individual survival of males in a fluctuating population of willow ptarmigan. - *Ornis Scandinavica* 15: 197-203.
- Pedersen, H.C. 1988a. Territorial behaviour and breeding numbers in Norwegian willow ptarmigan: a removal experiment. *Ornis Scandinavica* 19: 81-87.
- Pedersen, H.C. 1988b. Reproductive behaviour in Willow ptarmigan with special emphasis on territoriality and parental care. Dr.philos. avhandling. Universitetet i Trondheim.
- Pedersen, H.C. 1990. Reproductive behaviour and breeding numbers in a fluctuating population of Norwegian Willow Grouse *Lagopus lagopus*: summary of a 10-years study. *Fauna norvegica*. Ser. C, *Cinclus* 13: 1-10.
- Pedersen, H.C. 1997. Jakt som mortalitetsfaktor hos lirype – et litteraturstudium. – NINA Oppdragsmelding 388:1-28.
- Pedersen, H.C., Steen, H., Kastdalen, L., Svendsen, W. & Brøseth, H. 1999. Betydningen av jakt på lirypebestander. Fremdriftsrapport 1996-1998. NINA Oppdragsmelding 578:1-43.
- Pedersen, H.C., Steen, H., Kastdalen, L., Brøseth, H., Ims, R.A., Svendsen, W. & Yoccoz, N.G. 2004. Weak compensation of harvest despite strong density-dependent growth in willow ptarmigan. *Proc. R. Soc. Lond. B*. 271: 381-385.
- Pedersen, H.C. & Karlsen, D.H. (2007) *Alt om rypa*. Tun forlag, Oslo.

- Reynolds, R.E. & Sauer, J.R. 1991. Changes in mallard breeding populations in relation to production and harvest rates. - *Journal of Wildlife Management* 55: 483-487.
- Rørvik, K.-A., Pedersen, H.C. & Steen, J.B. 1998. Dispersal in willow ptarmigan *Lagopus lagopus* – who is dispersing and why? – *Journal of Wildlife Biology* 4: 91-96.
- Smith, A.A. 1997. Dispersal and movements in a Swedish willow grouse *Lagopus lagopus* population. *Journal of Wildlife Biology* 3: 279.
- Smith, A. & Willebrand, T. 1999. Mortality causes and survival rates of hunted and unhunted Willow Grouse. – *Journal of Wildlife Management* 63: 722-730.
- Steen, J.B., Steen, H., Stenseth, N.C., Myrberget, S. & Marcström, V. 1988. Microtine density and weather as predictors of chick production in willow ptarmigan, *Lagopus l. lagopus*. - *Oikos* 51: 367-373.
- Steen, J.B. 1989. Rypeliv og rypejakt. Gyldendal Norsk Forlag, Oslo.
- Steen, H. & Erikstad, K.E. 1996. Sensitivity of willow grouse *Lagopus lagopus* population dynamics to variations in demographic parameters. – *Journal of Wildlife Biology* 2: 27-35.
- Steen, J.B. 2004. Ryper og rypejegere. Gyldendal Norsk Forlag, Oslo.
- Solberg, E.J., Sæther, B.-E., Strand, O. & Loison, A. 1999. Dynamics of a harvested moose population in a variable environment. – *Journal of Animal Ecology* 68: 186-204.
- Solvang, H., Pedersen, H.C., Storaas, T., Moa, P.F & Breie, H. 2005. Årsrapport for rypetaksering 2005. Rapport, 15. Høgskolen i Hedmark.
- Sæther, B.-E., Heim, M., Solberg, E.J., Jakobsen, K., Stacy, J., Sviland, M. & Olstad, R. 2001. Effekter av rettet avskyting på elgbestanden på Vega. - NINA Fagrapport 49: 1-39.
- Willebrand, T. & Hörnell, M. 2001. Understanding the effects of harvesting willow ptarmigan *Lagopus lagopus* in Sweden. – *Journal of Wildlife Biology* 7:205-212.

Appendix

Appendix 1. Hunter proclamation

Opprop til alle rypejegere!

For å kunne undersøke om vi gjennom vanlig rypejakt foretar en bevisst eller ubevisst selektiv jakt ved at vi skyter mer eller mindre kyllinger enn det kyllingproduksjonen tilsier trenger vi din hjelp.

Dette er viktig informasjon for å kunne vurdere om det går an å styre avskytinga i en rypebestand mot ungfugldelen.

Men, som sagt så trenger vi din hjelp til å skaffe oss data. Her er hva du trenger å gjøre når du tar opp ryper og feller ei eller flere med et velrettet skudd:

- 1) Noter totalt antall ryper i oppflukten (hvis du ikke greier det, er også informasjon av typen 3-4 eller 7-8 eller *mindre enn 4* eller *flere enn 4* viktig).
- 2) Noter (om mulig) om du skjøt den første som lettet, eller den andre eller om alle lettet omtrent samtidig og du bare plukket ut ei rype.
- 3) Aldersbestem den/de felte rypene i hver oppflukt (hvis du føler deg sikker på metoden).
- 4) Det aller beste er om du kan ta en vingeprove av alle felte ryper, slik at det framgår hvilken rype i hvilken oppflukt på hvilken dato vingeproven er fra. Vingeproven tas fra en vinge per fugl ved å kutte slik at de tre ytterste vingefjæra henger sammen (se skisse). Bruk den vingen som er minst ødelagt.
- 5) Noter også hvilket område du har jaktet i. Hvis du jakter i flere, noter hvilke observasjoner og vingeprover som er fra hvilket område.
- 6) Når du har avslutta jakta kan du sende/levere informasjonen til Hans Chr. Pedersen, NINA, Tungasletta 2, 7485 Trondheim eller Håkon Solvang, Høgskolen i Hedmark, 2480 Koppang. Eller sende som vedlegg på e-mail til hans.pedersen@nina.no eller hakon.solvang@hihm.no

Takk for hjelpa og skitt jakt!

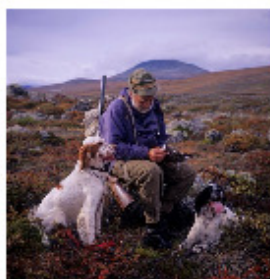


Foto: Dag H. Karlsen

Appendix 3. Method for age determination of willow ptarmigan

Metode for aldersbestemmelse av lirype

Henrik Brøseth

1. Når de tre ytterste håndsvingfjærene ikke er utvokst:

- Håndsvingfjær nr. 8 er ikke fullt utvokst **Ungfugl**
- Håndsvingfjær nr. 9 og/eller 10 er ikke fullt utvokst **Voksen**
(i enkelte tilfeller kan håndsvingfjær nr 9 og/eller 10 være fjorårs håndsvingfjær som ikke er mytet, disse er da skittenhvite og slitt sammenlignet med håndsvingfjær nr 8) **Voksen**

2. Når de tre ytterste håndsvingfjærene er utvokst:

- Mer pigment på håndsvingfjær nr 9 enn nr 8 **Ungfugl**
- Like mye pigment på håndsvingfjær nr 8 og 9, eller mer pigment på nr 8 enn nr 9 **Voksen**
- Mer glans på nr 8, enn nr 9 og 10 **Ungfugl**
- Ingen forskjell i glans på de tre ytterste håndsvingfjær **Voksen**

Tilleggsinformasjon: tuppen på håndsvingfjær nr 10 er ofte rundere hos voksenfugl.

