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Evaluation of a density index for territorial male Hazel Grouse *Bonasa bonasia* in spring and autumn

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A density index for territorial male Hazel Grouse *Bonasa bonasia* in spring and autumn is presented and evaluated. One whistles with a hunter's whistle every 30 seconds for 6 minutes from census points located at 150-m intervals within the area to be censused, and responding Hazel Grouse are counted. Counts were conducted throughout days with little or no wind. The number of counted males was significantly and linearly correlated with the number of known territorial males on an intensive study area. There, 82% of the territorial males responded and were counted. Response rate appeared to be independent of density, based on counts in areas with a 20-fold variation in densities. When censuses were repeated, both results were similar. Within the conditions of these counts, no effects of weather or date were found. However, Hazel Grouse responded less at midday. Using this method, one can count Hazel Grouse at a rate of about 5 minutes per ha along transects and 5–9 minutes per ha on blocks of habitat, depending on plot size. I recommend that censuses be conducted during 4–5 weeks prior to laying in spring and during 4–5 weeks after brood dissolution in autumn.

1. Introduction

Estimates of relative density are necessary to address many biological problems, such as utilization of habitat, rate of increase, dispersal, and the reaction of a population to management treatments (Caughley 1977). Of course, density indices can provide data with much less effort and expense than determination of absolute densities (Bull 1981), and many biological problems do not require absolute counts of the total population (Caughley 1977). A density index is defined as any measurable correlate of density, and ideally is linearly related to absolute density (Caughley 1977). However, few density indices have been validated by comparison with actual population abundance (Rotella & Ratti 1986).

Many secretive birds that are otherwise difficult to detect in the field respond well to playback recordings of their calls (Johnson et al. 1981, Marion et al. 1981). Included in this group are several species of grouse, e.g. Blue Grouse *Dendragapus obscurus* (Stirling & Bendell 1966), Spruce Grouse *D. canadensis* (Schroeder & Boag 1989), and White-tailed Ptarmigan *Lagopus leucurus* (Braun et al. 1973). Hazel Grouse *Bonasa bonasia* respond well to an imitation of the territorial song in spring and autumn, something that hunters have known for a long time. Several variations of a density index have been described based on counts of responses to an imitated song, using a whistle developed for hunting, as an observer follows a transect (Donaurov 1947, Tomek 1965, Wiesner et al. 1977, Desbrosses 1988).

Density indices based on responses to an imitated song may be most appropriate for Hazel Grouse. Although male Hazel Grouse sing spontaneously during territory advertisement in both spring and autumn (Bergmann et al. 1982), they sing infrequently, with long intervals between bouts of song (Wiesner et al. 1977). This makes counts by mapping singing males without using song playback difficult, especially because of the difficulty in obtaining simultaneous responses from neighboring males (Pakkala et al. 1983). Pakkala et al. (1983) felt that they obtained a satisfactory result using this technique in spring, but they made 12 censuses of the area.

The reported methods of obtaining density indices of Hazel Grouse with an imitated song certainly do not yield comparable results, because the techniques described in the literature vary greatly: length of stop 3–5 minutes, undefined, and 125 seconds, and transect width 50, 80 and 110 m (Donaurov 1947, Wiesner et al. 1977, Desbrosses 1988, respectively). Also, although Wiesner et al. (1977) attempted to evaluate the accuracy of their technique, no determination of the efficiency of these census techniques has been made by comparing counts with a known number of males.

Here, I attempt to address these problems by describing a variation of this type of census and an evaluation of its efficiency in an area with radio-marked males, determining repeatability of the census, comparing responses of Hazel Grouse in different areas with different densities, and analyzing the influence of density, season, time of day, and weather on the results.

2. Material and methods

A variation of the whistle census was designed to count Hazel Grouse on blocks of habitat. Using this method, an observer walks as quietly as possible to census points, located at 150-m intervals within the area to be counted, where he uses a hunter's whistle to whistle for 6 minutes, repeating the song about every 30 seconds. I used the Scandinavian type of whistle, which is the best for imitating the Hazel Grouse song (Bergmann et al. 1982: Fig. 21d). After 6 minutes, the observer moves to the next point. When a Hazel Grouse responded, the time of day (standard time, not summer time), the type of response (song, flutter jump, flutter flight, or silent approach, see Scherzinger 1981), and the response time (time in minutes and seconds from the onset of whistling) were recorded. In analyzing the data, only the first response and its type were used. The direction to the responding bird was recorded on a map of the area to help in deciding if the same bird was encountered again from another point. The density index was the number of responding males per censused ha. If a pair were observed, only the male was counted. Censuses were conducted throughout the day, but only when wind speeds were no greater than would move leaves and small branches on trees. If large branches moved, the census was discontinued. Censuses were conducted throughout the day, and time, wind, sky condition, and temperature at the start and end of each census were recorded.

Censuses were conducted during spring and autumn in four areas: 77 census plots totalling 2028 ha on Grimsö Research Area, southcentral Sweden (59°42′N, 15°30′E), 35 census plots totalling 945 ha in managed forest near Białowieża National Park, northeastern Poland (52°45′N, 23°50′E), 45 census plots totalling 1215 ha in old-growth forest within the park, and one plot of 74 ha on the Lammi Biological Station, southern Finland (61°03′N, 25°03′E). Plots were forest stands, defined by forestry officials, except the forest reserve, in Sweden, 27-ha areas (600 × 750 m) containing 20 census points in Poland, and the entire 74-ha forest area in Finland. The Swedish area has been described by Cederlund (1981), the Polish areas by Wiesner et al. (1977), and the Finnish area by Pakkala et al. (1983). Hazel Grouse on the Swedish area were counted for two years; the other areas for only one year, except for 567 ha counted twice in spring 1990 within Białowieża National Park. In addition, Hazel Grouse on a forest reserve of 522 ha on the Swedish area were counted in three springs and two autumns. On a portion of this area (195 ha of forest), the majority of territorial

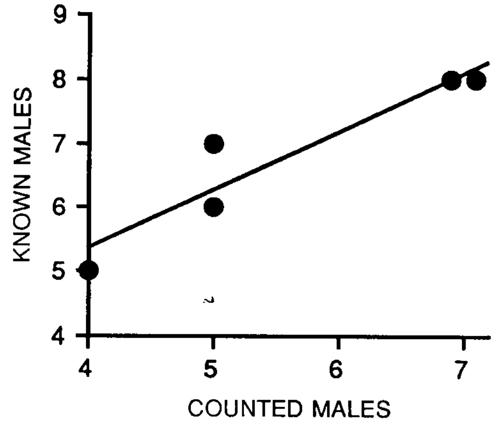

Fig. 1. Relationship between the number of known male Hazel Grouse and counted males during three spring and two autumn censuses on the intensive study area in Sweden (y = 1.67 + 0.92x, r^2 = 0.89).

male Hazel Grouse were radio-marked during each census. I compared the results of the census with the known number of males present. Known males that did not respond during the census were revisited within five days, when I used the hunter's whistle at about 50 m from them and recorded their response. This was done to determine if some territorial males never respond to the whistle.

For χ^2 tests based on a 2 × 2 contingency table, Yates' correction was used (Zar 1974).

3. Results

3.1. Census efficiency and repeatability

Essential assumptions for any density index are that they be accurate, directly related to true population density over a range of densities, and that they yield similar results when repeated. The results of the census technique described here were positively correlated with the known number of territorial males on the intensive study area in Sweden (Fig. 1, $r^2 = 0.89$, df = 3, P = 0.016). The mean accuracy of the census technique over five censuses was 82 ± 7.0% (SD). Accuracy in spring (80 ± 8.5%, n = 3) was similar to that in autumn (86 ± 3.5%, n = 2). During these five censuses, six known males (of 34) were not recorded. I approached to within 50 m of all of these within five days after the census and whistled. Five (83%) responded within six minutes. One male, radio-marked as a chick, was included in this group. He arrived on his future territory on 15 September, three days after leaving his mother. I whistled near him on 16 September without receiving a response. During the census on 19 September, he flutter-jumped after only 0.8 minutes. He responded again during a test on 7 October.

Repeatability was tested in Poland in spring 1990. Hazel Grouse on 21 plots were counted twice, 18 of them by different observers. All censuses took place in the last half of March; the second census was on average 7.4 days after the first. The first census yielded a mean of 1.95 ± 1.66 (SD) males per plot, each of which included 20 stops (27 ha). The second census yielded a mean of 1.52 ± 1.52 males. These results were not different (paired t test, t = 1.57, df = 20, P = 0.13), nor were there differences in time of day (paired t = 0.61, df = 20, P = 0.55) or temperature (paired t = 1.88, df = 20, P = 0.74) between the first and second censuses. During the second censuses, however, the skies were cloudier (χ^2 = 18.81, df = 2, P = 0.0001) and it was windier (χ^2_c = 8.68, df = 1, P = 0.003).

3.2. Effects of population density

The results from the intensive study area in Sweden suggested that variations in density did not affect the accuracy of this technique. However, the results spanned a narrow range of densities. If we assume that Hazel Grouse are more likely to be counted when they respond more quickly to the whistle, we can test whether density (or area) affects the accuracy of the technique by testing the response time in different areas. There were no differences in response time between years in Sweden either in spring (t = 0.77, df = 21, P = 0.45) or autumn (t = 0.08, df = 38, P = 0.94). Also, no differences were found among areas in either season (two-way ANOVA, effect of area, F = 0.27, df = 3, P = 0.85), even though densities varied between 0.6 and 13.5 males/100 ha in spring and between 0.9 and 20.3 males/100 ha in

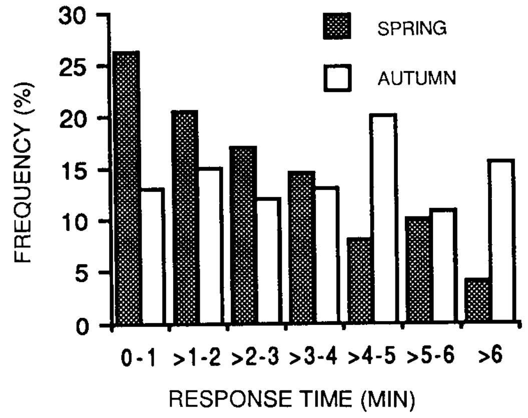

Fig. 2. Frequency of responses by Hazel Grouse to the hunter's whistle during 6-minute census periods in spring and autumn (all data combined).

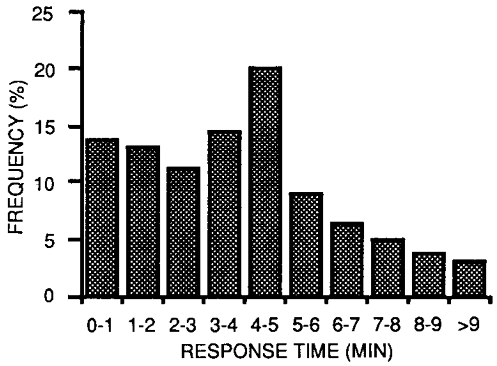

Fig. 3. Frequency of responses by Hazel Grouse to the hunter's whistle during 9.7-minute census periods in autumn in Poland (see text).

autumn (Table 1). Therefore, in the following analyses of quickness of response, I have combined the data from all the areas and years.

3.3. Type of response and response time

Hazel Grouse responded more quickly to the whistle in spring (mean of 2.49 ± 1.85 minutes, n = 152) than in autumn (mean of 3.68 ± 2.36 minutes, n = 206) in all four study areas (two-way ANOVA, effect of season, F = 14.84, df = 1, P = 0.0001). There was no significant interaction between area and season (F = 1.37, df = 3, P = 0.25). In spring, most of the responses were recorded in the first minute of the census stop, whereas in autumn most were recorded during the fifth minute (Fig. 2). In spring, only 3.9% of the responses were recorded after the 6-minute listening period, as the observers were moving to the next census point, compared to 15.5% in autumn. These estimates were probably minimal. However, the autumn censuses on the Polish areas provided a distribution of responses over a longer period. During these censuses, the observers spent an average of 3.7 ± 2.7 minutes at each census point after the 6-minute whistling period while they described vegetation. Responses of new birds were recorded during this period, and showed that 3.1% new birds were heard after 9 minutes (Fig. 3).

Table 1. Response times of male Hazel Grouse to an imitation of their song in spring and autumn on four census areas.

Area	Response time (min) Mean ± SD	(N)	Density (males/100 ha)
Spring			
Sweden	2.72 ± 1.47	(23)	0.6
Poland, park	2.55 ± 1.77	(65)	3.0
Poland, outside	2.36 ± 2.18	(54)	3.3
Finland	2.20 ± 1.33	(10)	13.5
Autumn			
Sweden	3.19 ± 1.88	(40)	0.9
Poland, park	3.61 ± 2.69	(106)	4.6
Poland, outside	4.14 ± 1.97	(53)	5.8
Finland	3.99 ± 1.96	(7)	20.3

Table 2. Types of responses (in %) by Hazel Grouse to imitation of the song in spring and autumn (all areas combined).

Type of response	Spring (N=152)	Autumn (N=206)
Song	84	52
Flutter jump	4	21
Flutter flight	10	17
Silent approach	2	9

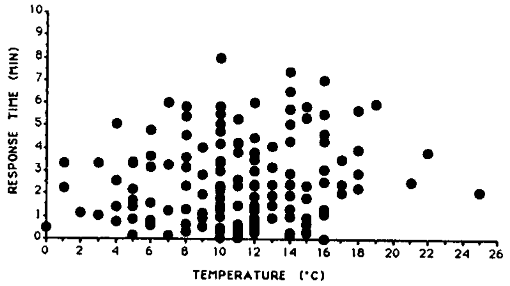

Fig. 4. Relationship between response time of Hazel Grouse to the hunter's whistle and temperature in spring (r^2 = 0.02).

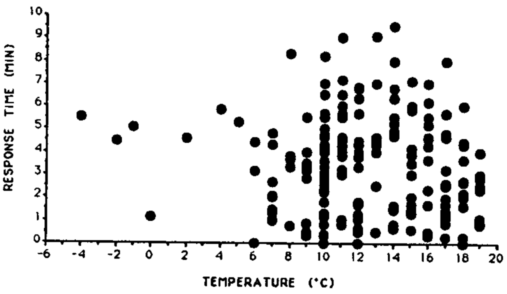

Fig. 5. Relationship between response time of Hazel Grouse to the hunter's whistle and temperature in autumn (r^2 = 0.003).

The most common type of response was the territorial song in both spring and autumn, but the frequencies of response types differed between the two seasons ($\chi^2 = 41.94$, df = 3, P = 0.0001). Nonvocal responses (flutter jump and flutter flight) and silent approach were more common in autumn (Table 2). The response time did not vary among response types (two-way ANOVA, effect of response type, F = 1.15, df = 3, P = 0.33), but did between seasons (two-way ANOVA, effect of season, F = 4.24, df = 1, P = 0.04). There was no interaction between response type and season on response time (F = 0.28, df = 3, P = 0.84).

3.4. Effects of weather, date, and time of day

The effects of weather could be examined only within the conditions during our censuses, and they only occurred during good weather conditions. Combining all data for each season, no effects were found of sky condition and windiness on response time (Table 3).

Regressions of response time against temperature showed no significant relationships (spring, r^2 = 0.022, df = 151, P = 0.07, Fig 4; autumn, r^2 = 0.003, df = 205, P = 0.43, Fig. 5). Hazel Grouse responded about 1 minute later at temperatures >17°C (3.49 ± 1.48 minutes, n = 9)

Table 3. Effects of weather and date on response time of Hazel Grouse to the hunter's whistle.

Factor	Test	Statistic	df	P
Spring				
Cloudiness	Two-way ANOVA	F = 0.37	3	0.78
Windiness	Two-way ANOVA	F = 0.22	2	0.80
Cloudiness × windiness	Two-way ANOVA	F = 0.26	6	0.95
Date, Sweden	Regression	r^2 = 0.09	22	0.17
Date, Poland	Regression	r^2 = 0.02	118	0.12
Autumn				
Cloudiness	Two-way ANOVA	F = 0.31	4	0.87
Windiness	Two-way ANOVA	F = 0.20	2	0.82
Cloudiness × windiness	Two-way ANOVA	F = 0.66	8	0.73
Date, Sweden	Regression	r^2 < 0.001	39	0.71
Date, Poland	Regression	r^2 < 0.001	158	0.84

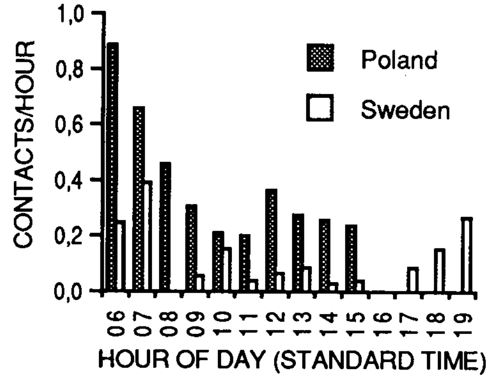

Fig. 6. Hazel Grouse contacts per hour during 1-hour periods in spring in Poland and Sweden.

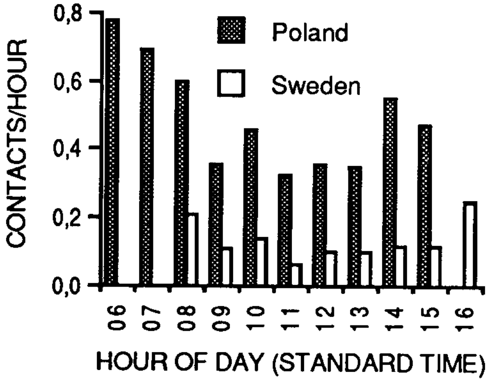

Fig. 7. Hazel Grouse contacts per hour during 1-hour periods in autumn in Poland and Sweden.

than at lower temperatures (2.42 ± 1.86 minutes, n = 143) in spring, but this difference was not statistically significant (t = 1.00, df = 151, P > 0.20).

No effect of date of census on response time was apparent during this study (Table 3). Visual examination of the data showed no bell-shaped tendencies. The censuses were conducted within the following dates: 14 April – 17 May and 1 September – 24 October in Sweden, and 16–29 March and 22 September – 10 October in Poland.

Censuses appeared to be less effective during midday in both spring and autumn and in both Sweden and Poland (Figs. 6–7). Using the data from Poland, where sample sizes were greatest, the censuses were analyzed by 15-minute periods. In spring, Hazel Grouse were first encountered in 11.3% of 397 periods during 0500–0859 hours, compared with 7.0% of 934 periods during 0900–1359 hours, a decline that was significant ($\chi^2_c = 6.47$, df = 1, P = 0.01). In autumn, Hazel Grouse were first encountered in 17.8% of 259 periods during 0500–0859 hours, compared with 9.3% in 176 periods during 0900–1559 hours, also a significant decline ($\chi^2_c = 7.08$, df = 1, P = 0.008). Although birds were encountered at a lower rate during midday than in the morning, there was no corresponding difference in response time during these periods in Poland (t = 0.96, df = 117, P > 0.20). In spring, response times averaged 2.13 ± 1.82 minutes (n = 48) during 0500–0859 hours, and 2.69 ± 2.03 minutes (n = 71) during 0900–1359 hours. In autumn, a similar result was recorded; response times averaged 3.97 ± 2.38 minutes (n = 43) during 0500–0859 hours, and 3.74 ± 2.54 minutes (n = 92) during 0900–1559 hours (t = 0.28, df = 133, P > 0.50). This suggests that the lower efficiency at midday was because fewer Hazel Grouse responded to the whistle then, rather than because they responded more slowly.

3.5. Effective distance of the whistle

An attempt was made to determine the effective distance of the whistle using data from the Polish areas, where 27-ha rectangles were used and the grouse were recorded as responding from either inside or outside the plot. Assuming that the density of Hazel Grouse was the same inside and around the plot, I determined the effective distance of the whistle by first calculating the density within the plot. Using the number of birds responding outside to solve for the area censused outside the plot, I then solved for the width of a band of that area around the plot. The mean values from 80 census plots were used for each season, and gave an effective distance of 78 m in spring and 58 m in autumn.

3.6. Time requirements of the method

The time required to obtain each density index was recorded. I analyzed the spring data from Poland because standard plots of 20 stops (5 × 4 points, 27 ha within the rectangle) were surveyed there. Each plot required an average of 4 hours (240.3 ± 61.4 minutes, n = 99) to cover. Each stop required 12 minutes (6 minutes to whistle and count and 6 minutes to walk to the next stop). At this rate, it took 8.9 ± 2.3 minutes per ha, excluding the area covered outside the 27-ha cenus area.

4. Discussion

Any accurate density index requires that the following assumptions be valid: the index of density is directly related to true population density over a range of densities, and it is repeatable. These assumptions appear to be valid for the index described here. Known density was linearly correlated with the density index ($r^2 = 0.89$, n = 5). The mean accuracy of the density index was high and the variance was low (82 ± 7.0%), based on the known number of territorial males. Moreover, the response time was similar in all study areas each season, even though the highest densities were more than 20 times greater than the lowest, and the original and repeat censuses gave similar results.

Many authors have noted that some male Hazel Grouse do not always respond to the whistle (Pynnönen 1954, Tomek 1965, Wiesner et al. 1977). My estimate of the response rate, 82%, was similar to the response rate obtained when I revisited males that were not counted in the original census (83%). This suggested that about 18% of males do not respond at any one time, and not that 18% of the males never respond. Wiesner et al. (1977) estimated that 30% of the males did not respond in their study by noting that signs of Hazel Grouse were often found where no males responded to the whistle. Their estimate may have been biased high for 2 reasons: a male may have been present within his territory, but beyond the effective distance of the whistle, or the bird that left the sign may have been killed prior to the census. I obtained data on only 1 known juvenile male in autumn. He did not respond to the whistle the day after arriving on his future territory, but did respond only 3 days later. Also, I have only captured resident territorial males using the whistle to lure them into nets (n = 14). Together, this suggests that juvenile males do respond to this technique shortly after acquiring a territory, but that nonterritorial males may respond at a lower rate if at all.

Female Hazel Grouse also sing (Potapov 1987). This could potentially bias this method. However, data from the literature suggest that this is not a problem. Tomek (1965) reported that a female came to his whistle only once, Desbrosses (1988) found that all 46 responding Hazel Grouse that were identified to sex were males, and Malchevskii & Pukinskii (1983) noted that of 150 Hazel Grouse shot in autumn by luring with the whistle, only 3 were females. We have recorded 1 and 3 females responding alone to our whistles in spring and autumn, respectively, but we do not have reliable data on the number of males responding.

Robbins (1981b) reported that most weather variables, except wind, had little effect on the detectability of birds during the breeding season. Similarly, weather did not affect the response times of Hazel Grouse within the limits we set. Tomek (1965) also reported that weather did not seem to affect Hazel Grouse response rates, except that wind lessened the effectiveness of the whistle census. I recommend using the criteria given in the material and methods section.

For most birds during the breeding season, activity reaches a peak during the hour centered at sunrise or in the following hour, and declines gradually to a low point at midday (Järvinen et al. 1977, Robbins 1981a). This is apparently not the case for Hazel Grouse, because they leave their roosts relatively late in the morning and enter them early in the evening (Klaus et al. 1976). While at their roosts, Hazel Grouse rarely respond to the whistles (Klaus et al. 1976). Czájlik (1981) found that Hazel Grouse began singing 50 min after sunrise and stopped 30 min before sunset in Hungary. According to Klaus et al. (1976), Hazel Grouse in spring leave their roosts at full daylight about 20 min after passerines begin to sing and fly up to their roosts at the beginning of twilight. Tomek (1965) and Wiesner et al. (1977) reported that Hazel Grouse responded well to the whistle throughout the day, but Donaurov (1947) and Pynnönen (1954) reported that the response rate was less at midday. Desbrosses (1988) provided data from spring in France showing that responses were less between 1000 and 1400 hours (1100 and 1500 hours summer time). He recommended that counts not be conducted between 1000 and 1600 hours. Data from Poland gathered during this study confirmed that censuses are less effective in midday (Figs. 6–7), with significantly lower rates of contact than earlier. However, there was no significant difference in response time, suggesting that fewer males responded at midday, rather than that they responded more slowly. In spite of the lower activity at midday, Hazel Grouse still react to the whistle then (Figs. 6–7), a common characteristic of forest birds (Robbins 1981a), and the detection rate of 82% of known males was based on censuses conducted throughout the day. This suggests that the midday drop in response rate is not too critical for this method. However, for more accurate determinations of density, one should avoid midday (1000 or 1100 to 1500 or 1600 hours).

No significant differences were found in response time due to date during this study. Birds often show seasonal variation in responses to imitated calls (McNicholl 1981), and this has been documented for Hazel Grouse (Pynnönen 1954). Pynnönen (1954) stated that Hazel Grouse in southern Finland responded best to the whistle from mid-April to early June and from mid-September to mid-October. Desbrosses (1988) had different recommendations for different elevation zones in France. The dates of the censuses should correspond to the behavior of Hazel Grouse. I recommend that censuses be conducted over 4 to 5 weeks prior to laying in spring (mid-May in southcentral Sweden) and the same period after brood dissolution in autumn (second-third week in September in southcentral Sweden).

The longer response time and greater frequency of "silent approaches" in autumn suggest that the autumn and spring censuses may not be equally efficient, even though data from the intensive study area suggested that they were. The 6-minute census period seemed to be adequate during the spring. However, extending the census period to 8 minutes in autumn would increase the number of detected males by about 14% (Fig. 3), and probably yield densities more comparable with spring densities.

This technique can be used to census plots consisting of several points located at 150-m intervals, or to census a transect. When a transect is used, it is very important to know its effective width. Previous estimates of effective width are: 50 m (Donaurov 1947), 80 m (Wiesner et al. 1977), and 110 m (Desbrosses 1988). My data yielded estimates of 78 m in spring and 58 m in autumn. These estimates are biased low because there was certainly some movement of Hazel Grouse from outside the census plot into the plot before they were discovered. The lesser bias was probably in spring, because birds responded significantly sooner and with fewer "silent approaches" than in autumn. Thus, the effective width was somewhat more than 78 m, similar to the estimate made by Wiesner et al. (1977). Although the effective width may be less in autumn, it was not possible, using my data, to determine if it really is, because of the difference in behavior between spring and autumn.

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Selostus: **Reviirillisten pyykoiraiden *Bonasa bonasia* suhteellisen tiheyden arviointi keväällä ja syksyllä**

Tutkimuksessa esitetään menetelmä reviirillisten pyykoiraiden runsauden arvioimiseksi keväällä

ja syksyllä. Tutkittavalla alueella pysähdytään joka 150 m:n päässä toisistaan olevissa pisteissä kuudeksi minuutiksi; pisteessä vihelletään pyypillillä pyyn laulunsäe 30 sekunnin välein ja tehdään merkintä pyyn esiintymisestä. Laskentoja tehtiin tyyninä ja heikkotuulisina päivinä koko päivän ajan. Intensiivisen tutkimuksen alueella (Etelä-Ruotsi) menetelmän antamaa tulosta verrattiin alueen todelliseen reviirikoiraiden määrään: tulosten välillä oli tilastollisesti merkitsevä, lineaarinen korrelaatio. Laskentatehokkuus oli tässä vertailussa 82%. Pyiden regointi pilliatrappiin oli tiheydestä riippumatonta, päätellen eri tahoilta kerätyistä aineistoista, joissa tiheysero oli 20-kertainen. Tietyllä alueella suoritetut kaksi pillilaskentaa antoivat olennaisesti saman tuloksen. Säätila ja (vuoden)ajankohta eivät vaikuttaneet laskentatulokseen aineistonkeruussa noudatettujen rajojen puitteissa. Pyiden reagointi vihellykseen oli keskipäivän aikaan laimeampaa kuin aamulla ja illemmalla. Kuvatulla menetelmällä yhden hehtaarin inventointiin kuluu aikaa noin 5 minuuttia, jos laskenta tehdään linjana. Jos halutaan tutkia tietty alue, aikaa kuluu hehtaaria kohti 5–9 minuuttia näytealan koosta riippuen. Tutkimustulosten mukaan pyypillilaskenta on paras suorittaa keväällä 4–5 viikkoa ennen munintaa ja syksyllä 4–5 viikkoa poikueen hajoamisen jälkeen.

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