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Geographical variation in spotting patterns on Hazel Grouse *Bonasa bonasia* primary feathers: consequences for age determination

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The spotting pattern on the ninth primary feather (numbered from the proximal to the distal) has been reported to be a rather accurate indicator of age in Hazel Grouse *Bonasa bonasia*, separating first-year from older birds, in Finland and European Russia. However, the recommended criteria for separating age classes differed. We compared these studies with data from southern Poland and southcentral Sweden and found significant geographical differences in spotting patterns among adult grouse. The spotting pattern was most different between the population in Poland (*B. b. rupestris*) and the other three populations (all *B. b. bonasia*), and was a poor indicator of age there. In the Swedish population, the criteria recommended for Finnish birds were valid. We urge caution in using spotting patterns of primary feathers to determine age of Hazel Grouse in areas where the technique has not been verified.

1. Introduction

Accurate determination of age is important in wildlife research and management. In grouse, the juvenal primaries IX and X (numbered consecutively from proximal to distal primaries, and termed PIX and PX in this paper), which are retained by juveniles during the first year of life, are pointed and usually can be distinquished from the more rounded tips of adult primaries (Wright & Hiatt 1943, Helminen 1963). However, the juvenal PIX and PX of Hazel Grouse *Bonasa bonasia* are difficult to distinquish from adult feathers based on shape (Gaidar & Zhitkov 1974, Stenman & Helminen 1974). Gaidar & Zhitkov (1974) found that the number of white bars on the leading vane of PIX accurately distinguished between juvenile and adult Hazel Grouse; adults had ≤ 7 and juveniles had ≥ 8. Independently, Stenman & Helminen (1974) found that the

number of dark bars on the leading vane of PIX could be used to determine the age of Hazel Grouse; all adults had ≤ 7 and 89% of juveniles had ≥ 8. In addition, they reported that the width of the beige border of the tip of PI was more accurate than using PIX and that the length of PI could be used in some cases.

Although the results of these two studies appear to be the same, they are not. As there is one fewer dark bar than white spots on PIX (by definition, because the dark bars separate the white spots), Gaidar & Zhitkov's (1974) results showed that the best separation, using dark bars, was ≤ 6 for adults and ≥ 7 for juveniles. Thus, the number of dark bars that best separated adults and juveniles differed by one between these studies. Gaidar & Zhitkov (1974) studied Hazel Grouse from the Vyatka River Basin near Kirov in European Russia, and Stenman & Helminen (1974) from throughout Finland, about 1400 km away. Although Stenman & Helminen (1974) found no statistically significant differences in spotting patterns within Finland, the difference between the two studies, and the well documented clinal variation in coloration of Hazel Grouse over its range (Kleinschmidt 1949, Vaurie 1965) suggested that spotting patterns of primary feathers might vary as well. If so, the results of the published studies might not be applicable in other parts of the species' range. The objective of this study was to search for geographical variation in the spotting pattern of primary feathers and test the reliability of this technique of age determination using Hazel Grouse from southern Poland and southcentral Sweden.

2. Material and methods

Seventy-one male and five female Hazel Grouse were shot in the Carpathian Mountains in southern Poland, near Krynica in the Beskid Sądecki Mountains of the Jaworzyna Krynicka Range (49° N, 21° E) during September and October 1988–1990. All were lured into shooting range by using a whistle that imitated the territorial song. The number of dark bars on the right PIX were counted and each bird was examined for a Bursa of Fabricius using a 2 mm diameter glass probe with a small bulb at the end. Birds with a Bursa of Fabricius were considered to be juveniles, in their first year of life, and those without a bursa were considered to be adults (Schumacher 1921, Taber 1969). The females were excluded from this study so the bursa would not be confused with the oviduct. The number of dark bars on both PIX feathers was counted in the material from Poland. Most birds had either the same number of bars on both feathers (48%) or differed by only one bar (41%); 11% of the birds differed by two bars, and none differed by more than that (total n = 71).

Data were collected from 57 PIX feathers from both sexes of Hazel Grouse on the Grimsö

Table 1. Number of dark bars on the ninth primaries of adult and juvenile Hazel Grouse from four European populations. [a] Areas with the same superscript showed no significant difference in the number of dark bars on adult ninth primaries (Fisher protected least significant difference test, P > 0.05).

	Adults				Juveniles				
Area[a]	Mean	SD	Range	n	Mean	SD	Range	n	Source
Finland[b]	3.59	1.94	0-7	130	8.67	1.24	3-11	346	Stenman & Helminen (1974)
Russia[b,c]	4.02	1.61	0-6	66	8.75	0.96	7-10	75	Gaidar & Zhitkov (1974)
Sweden[c]									
known	4.54	1.39	1-7	26					this study
assigned	4.83	1.38	0-10	18	8.85	1.91	3-11	13	this study
combined	4.66	1.84	0-10	44	8.85	1.91	3-11	13	this study
Poland[d]	6.00	0.88	4-8	45	8.46	1.56	6-11	26	this study

Wildlife Research Area, 70 km north of Örebro in southcentral Sweden (59–60° N, 15–16° E) during all months between September 1987 and September 1990. Fifteen of these were from birds that were shot and 42 were from birds captured in nets. Whenever a bird was captured, PI and PIX were collected from one wing and the bird was banded and fitted with a radio transmitter. When the bird was recaptured to replace the transmitter, the new PIX was collected. This yielded 26 known adult (replaced) PIX feathers; the others were assigned to an adult or juvenile category based on the coloration of PI, using the criteria of Stenman & Helminen (1974). They reported that this technique was more accurate (96.5%) than counting dark bars on PIX (89%) in Finland. We used the known age PIX's as a control to determine if the coloration of PI was an accurate technique for adults in Sweden.

Results were compared using analysis of variance, with a probability of 5% accepted as sufficient to reject the null hypothesis. When a significant difference was found, Fisher's protected least significant difference test was used to determine which of the factors differed from the others (Keppel 1982). Two-tailed tests were used throughout.

3. Results

The number of dark bars on PIX of known age adult Hazel Grouse from Sweden was not statistically different from those assigned as adults based on the coloration of PI ($t = 0.61$, $df = 42$, $P = 0.61$, Table 1). These groups were therefore combined for further testing. Using the data from Poland, Sweden, Finland and Russia, we found significant differences in the number of dark bars on PIX between juveniles and adults and among the four areas (Table 2). Within juveniles, no difference was found in the number of bars among the four areas, but differences were found for adults (Table 2). The number of bars on adult PIX's differed between Poland and all of the other areas. Among the other areas, the only significant difference in number of dark spots on adult PIX's was between Sweden and Finland (Table 1).

Table 2. Results of ANOVA tests comparing the number of dark bars on the ninth primaries of hazel grouse in two age classes (adult and juvenile) and from four areas.

ANOVA	Factor	Test results df	F value	P value
Two-factor	Age	1	650.2	< 0.0001
	Area	3	12.1	< 0.0001
One-group				
-juveniles	Area	3	0.42	0.74
-adults	Area	3	23.0	< 0.0001

The width and shape of the light band at the tip of PI was an accurate indicator of age in Finland (Stenman & Helminen 1974), but it was not useful in Poland. There, almost all of the birds, regardless of age, showed coloration patterns typical of juvenal PI feathers in Finland. In Sweden, two known-age adults had a PI typical of the adult PI feathers described by Stenman & Helminen (1974) and the agreement in number of bars on PIX between known-age adults ($n = 26$) and feathers assigned to the adult category ($n = 18$), based on the coloration of PI, suggested that the color pattern of PI was an accurate method, at least for determining adults, in Sweden.

The criterion for age determination using the number of dark bars on PIX given by Stenman & Helminen (1974), adults with ≤ 7 bars and juveniles with ≥ 8 bars, was the most appropriate to use in southcentral Sweden to separate adults and juveniles (Table 3). In southern Poland, however, there was considerably more overlap between adults and juveniles in the number of dark bars (Table 3). There, birds with ≤ 6 bars could be classified as adults and those with ≥ 9 bars as juveniles. Birds with 7 or 8 bars could not be accurately classified. Unfortunately, this group comprised 23% of the adults and 50% of the juveniles in our sample.

4. Discussion

We have documented significant geographical variation in the spotting pattern on primary feathers of adult Hazel Grouse. The Hazel Grouse in south-

ern Poland belong to a different subspecies, *Bonasa bonasia rupestris*, than those of the other three populations, which are all members of the subspecies *B. b. bonasia* (Bergmann et al. 1982). In Poland, the coloration pattern of their primaries was clearly different from the other populations. The number of dark bars on the PIX of adults in Poland was significantly different from the other three populations, and the coloration of the tip of PI showed little difference between adult and juvenal primaries, in contrast to the situation in Finland (Stenman & Helminen 1974). Within the other three populations, there was no significant difference among juveniles in the number of bars on PIX, but the Swedish adults differed significantly from those in Finland.

The geographical variation in spotting patterns of adult, but not juvenal, ninth primaries has serious consequences for using the number of spots on PIX as a technique for age determination of Hazel Grouse. We recommend the criteria of Stenman & Helminen (1974), both using the coloration pattern of PI and number of dark spots on PIX, to separate juvenile from adult Hazel Grouse in southern Sweden. In fact, the relatively small variation in number of bars on adult primary feathers from Finland, Russia, and Sweden could be an artifact of differing age structures of adult birds. Swenson (1992) has shown that the number of bars decreases with age in adult Hazel Grouse. However, neither these criteria, nor those of Gaidar & Zhitkov (1974), are appropriate for the population we studied in southern Poland. Further studies of the spotting patterns of Hazel Grouse PIX relative to age in other parts of the species' range are required, but it is apparent that age criteria developed in one part of the range cannot be used in another part of the range without first being verified. Geographical variation in coloration patterns also complicates age determination in Spruce Grouse *Dendragapus canadensis* in North America (Szuba et al. 1987) and may be a general phenomenon in grouse.

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Table 3. Proportion of adults in samples of Hazel Grouse from four populations according to the number of dark bars on the ninth primary. [a]Assigned-age birds, based on molt of retrices (Stenman & Helminen 1974); data from O. Stenman and M. Helminen (pers. comm.).[b]known-age birds (Gaidar & Zhitkov 1974). [c]known-age and assigned-age birds using color of PI (this study). [d]assigned-age birds using presence or absence of the Bursa of Fabricius (this study).

Number of dark bars	Finland[a] % adults	n	Russia[b] % adults	n	Sweden[c] % adults	n	Poland[d] % adults	n
0	100	15	100	6	100	1	–	–
1	100	5	100	1	–	–	–	–
2	83	18	100	3	–	–	–	–
3	100	19	100	15	86	8	–	–
4	97	34	100	14	100	6	100	1
5	85	27	100	22	100	10	100	11
6	60	20	100	9	100	12	92	25
7	27	30	0	9	100	3	54	13
8	0	85	0	19	0	1	30	10
9	0	148	0	29	0	7	0	4
10	0	70	0	18	25	4	0	3
11	0	5	–	–	0	1	0	4

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Selostus: **Pyyn yhdeksännen käsisulan värin maantieteellinen vaihtelu**

Yhdeksännen (toiseksi uloimman) käsisulan värin on osoitettu olevan hyvä tuntomerkki pyyn iänmäärityksessä. Suomessa ja Venäjällä tehtyjen tutkimusten mukaan ensimmäisen elinvuoden yksilöt voidaan tämän perusteella erottaa vanhemmista linnuista. Kriteerit ikäluokkien erottamiseksi eivät kuitenkaan ole yhtenevät. Vertasimme näiden tutkimusten tuloksia Etelä-Puolasta ja eteläisestä Ruotsista koottuun aineistoon. Havaitsimme, että tutkitussa ominaisuudessa on huomattavia maantieteellisiä eroja aikuisten pyiden välillä. Puolalaiset pyyt (*B. b. rupestris*) erosivat huomattavasti kaikista muista kolmesta tutkitusta populaatiosta (kaikki *B. b. bonasia*). Puolalaisten pyiden sulan väri on huono ikätuntomerkki. Suomalainen kriteeri pätee ruotsalaisiin pyihin. Varoitamme käsisulkien värin käyttämisestä pyyn iänmäärityksessä alueilla, missä menetelmän toimivuutta ei ole kriittisesti koeteltu.

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