Variation in the belly barrings of the Greenland White-fronted Goose *Anser albifrons flavirostris*

J. N. Kristiansen[1,2] A. J. Walsh[3], A. D. Fox[2] H. Boyd[4] & D. A. Stroud[5]

[1]University of Copenhagen, Zoological Institute, Dept. of Population Ecology, Universitetsparken 15, DK-2100 Copenhagen Ø, Denmark. e-mail: jnkristiansen@zi.ku.dk
[2]National Environmental Research Institute, Dept. of Coastal Zone Ecology, Kalø, Grenåvej 12, DK-8410 Rønde, Denmark. e-mail: tfo@dmu.dk
[3]Dúchas Heritage Service National Parks & Wildlife, Wexford Wildlife Reserve, North Slob Wexford, Ireland. e-mail: ajwalsh@iol.ie
[4]Canadian Wildlife Service, Ottawa, Ontario, Canada K1A OH3
[5]Joint Nature Conservation Committee, Monkstone House, City Road, Peterborough PE1 1JY, United Kingdom

Based on data from seven successive years from the wintering grounds in Ireland and one year from the breeding grounds in West Greenland, the variation in the black striation on the abdomen and breast, the so-called belly barring, of the Greenland White-fronted Geese Anser albifrons flavirostis was assessed. We analysed for sexual variation, age variation, year to year variation and seasonal variation [early winter (1 October – 31 December) and late winter (1 January – 31 April)]. Geese showed no sexual difference, no change with age after the first winter and no clear pattern in year to year variation. However, there was a highly significant seasonal variation, since individual birds became consistently darker in late winter.

Keywords: Greenland White-fronted Geese, Plumage variation (belly barring)

Among geese (*Anser* & *Branta*) highly pronounced individual plumage variation only occurs in the Lesser White-fronted Goose *Anser erythropus*, the White-fronted Goose *Anser albifrons* and to a lesser extent in the Greylag Goose *Anser anser* (Cramp & Simmons 1977). In these species the extent of the black striations on the abdomen and breast is highly variable between individual birds, a feature which can be so distinct that it has been used to identify individual birds within winters (Boyd 1953, D. Stroud *pers. obs.*). A few authors have earlier suggested that the variation of this belly barring differs with sex and age of the White-fronted Goose, however, analysis of quantitative data has been limited and

conclusions contradictory (Alpheraky 1905; Tucker in Witherby *et al.* 1939; Boyd 1954; Stroud 1981).

Here, we assess the variation in the belly barring of the Greenland White-fronted Goose *Anser albifrons flavirostris* which tends to have heavier markings than any other white-front subspecies (Dalgety & Scott 1948) in terms of potential sexual variation, age variation, year to year variation and seasonal (within year) variation.

Study Site and Methods

The majority of observations presented here come from the wintering grounds at Wexford Slobs, Ireland (52°22'N, 6°25'W) during 1990 to 1996, where up to 9000 birds winter during October-April (Fox *et al.* 1994). In addition, a few observations were recorded on the breeding grounds in Isunngua (67°05'N, 50°30'W), west Greenland, in 1992. The degree of belly barring of individually marked geese was scored using the system defined by Stroud (1981) which is based on a five-point scale: 1) less than 20% of feathers on the breast and belly tipped dark. Single black feathers may occur but with few, if any, transverse bars; 2) between 20 and 40% of the breast and belly is black arranged in bars and patches; 3) roughly equal proportion of dark and light feathers (40-60%); 4) 60-80% of the breast and belly are black; and 5) more than 80% of the breast and belly are black, some birds may even show complete coverage. Since Stroud (1981) described the system it has been improved and half scores (eg 1.5, 2.5 etc) are used by skilled observers. To keep observer error

Table 1a. Early winter. Sexual variation in belly bar scores of Greenland White-fronted Geese, 1990-1995, Wexford, Ireland. Differences were tested by Mann-Whitney U-tests. Corrected for ties.

Year	Median Male (range)	Median Female (range)	*N*	*U*	*P**
1990	3.0 (1.0-5.0)	3.0 (2.0-4.0)	130	1975.0	0.5628
1991	2.0 (1.0-3.0)	2.0 (1.5-3.0)	106	1368.5	0.9435
1992	2.0 (1.0-2.5)	2.0 (1.0-3.0)	105	1281.5	0.6382
1993	2.0 (1.5-2.5)	2.0 (1.0-2.5)	130	2065.5	0.8432
1994	2.5 (1.5-5.0)	2.25 (1.0-4.0)	159	3122.0	0.9378
1995	3.0 (1.0-5.0)	3.0 (2.0-5.0)	189	4172.5	0.4384

*Bonferroni correction of the significance level: 0.05/6 = 0.0083.

Table 1b. Late winter. Sexual variation in belly bar scores of Greenland White-fronted Geese, spring 1989-1996, Wexford, Ireland. Differences were tested by Mann-Whitney U-tests. Corrected for ties.

Year	Median Male (range)	Median Female (range)	*N*	*U*	*P**
1991	3.0 (2.0-3.5)	3.0 (2.0-4.0)	30	75.0	0.2028
1992	2.0 (1.0-5.0)	2.0 (1.0-3.5)	135	2197.5	0.7564
1993	2.5 (2.0-4.0)	2.75 (2.0-4.0)	183	4026.0	0.7122
1994	2.5 (1.5-3.5)	2.5 (1.5-3.5)	154	2824.5	0.5422
1995	2.5 (2.0-5.0)	2.5 (2.0-4.0)	159	3043.0	0.7408
1996	3.0 (2.0-4.0)	3.0 (2.0-5.0)	40	189.0	0.9427

*Bonferroni correction of the significance level: 0.05/6 = 0.0083.

constant, all scoring was carried out only by AJW. Scoring was done only when birds were facing the observer in head-up or alert posture. During the period of the study (ie 1990-96) some 300 birds had individually coded neck collars each year enabling identification in the field. These birds were aged and sexed at capture. Sequential scoring of these individuals formed the basis of the present study. Most scorings were made at a distance using telescope or binoculars. Sixty scores were obtained from birds captured during a ringing expedition 12 July to 22 July, 1992; this season is referred to as "summer". Data were analysed for age variation (including only birds of known age), sexual variation (based on birds of known sex), year to year variation and seasonal (within year) variation. Seasons were defined as: early winter, 1 October – 31 December and late winter, 1 January – 31 April. When analysing for year to year variation we used only individual birds which had been recorded in two successive years in the same season (ie early winter or late winter). When analysing for seasonal differences we used only individual birds which had been observed in early winter and the following late winter. If birds had been scored more than once during a season, only one randomly selected belly bar score was used in the analysis to avoid pseudoreplication. Because of the high number of statistical tests Bonferroni adjustments of the significance level was carried out (Sokal & Rolf 1995).

Results

Table 1 summarises the results of the analysis of the sexual variation of the belly barring in early (1a) and late winter (1b):

Table 2a. Early winter. Correlation between extent of belly barring and age of Greenland White-fronted Geese in Wexford, Ireland, early winter. 1990-1995. Spearman rank correlation test.

Year	Age range (calendar years)	*N*	*r*	*P**
1990	2-8	55	-0.1027	0.4555
1991	2-8	40	0.0104	0.9488
1992	2-10	41	-0.2470	0.1195
1993	2-10	39	0.0055	0.9731
1994	2-11	55	0.1045	0.4475
1995	2-13	86	-0.2133	0.0487

*Bonferroni correction of the significance level: 0.05/6 = 0.0083

Table 2b. Late winter. Correlation between extent of belly barring and age of Greenland White-fronted Geese in Wexford, Ireland, late winter. 1991-1996. Spearman rank correlation test.

Year	Age range (calendar years)	*N*	*r*	*P**
1991	4-7	7	-0.4901	0.2667
1992	2-9	56	0.3488	0.0084
1993	2-11	69	0.1042	0.3941
1994	2-11	53	0.1570	0.4512
1995	2-13	67	0.1864	0.1310
1996	2-13	26	0.0628	0.7603

*Bonferroni correction of the significance level: 0.05/6 = 0.0083

there was no significant difference between sexes in any of the years. Furthermore, in July 1992 no sexual difference was detected (median male 4.0, range 2-5, n = 37, median female 4.0, range 1-5, n = 23; U = 397.50, P = 0.6742). In **Table 2**, the results of the correlation analysis between age and extent of belly barring are presented: early (2a) and late winter (2b). Only birds in their 2nd calendar year and older are included in the analysis because birds in their first calendar year show very few (and usually no sign) of belly bars (Cramp & Simmons 1977). There was no significant correlation in early winter between the extent of the belly barring and age (**Table 2a**). In late winter there was a weak but significant correlation in 1992, however none of the other years showed any significant correlation (**Table 2b**). A pair-wise comparison showed no clear pattern in

year to year variation of individual birds (**Tables 3a & b**), neither in early or in late winter. Sometimes birds seemed to change significantly from one year to the next and at other times no such change was detected. Given the above findings (ie that there were no consistent age or sex differences) we pooled the data when comparing within-year variation. In a pair-wise comparison the difference between seasons was highly significant in all years analysed (**Table 4**), each individual bird was lighter in early winter and became darker by the late winter.

Table 3a Early winter. Year to year changes of individual Greenland White-fronted Geese, 1990-1995, Wexford, Ireland. Differences were tested by Wilcoxon signed rank test (pairwise comparison). Corrected for ties.

	1990	1991	1991	1992	1992	1993	1993	1994	1994	1995
Median	3	1.5	2	2	1.5	2	2	3	2	3
Range	1-5	1.5-3	1.5-3	1-3	1-3	1.5-2.5	1-2.5	1-4	1-4.5	2-5
N	28		23		37		47		49	
T	371.00		-86.00		-17.00		-776.00		-832.00	
*P**	<0.0001		0.1735		0.7853		<0.0001		<0.0001	

*Bonferroni correction of the significance level: 0.05/5 = 0.01

Table 3b Late winter. Year to year changes of individual Greenland White-fronted Geese, 1991-1996, Wexford, Ireland. Differences were tested by Wilcoxon signed rank test (pairwise comparison). Corrected for ties.

	1991	1992	1992	1993	1993	1994	1994	1995	1995	1996
Median	3	2.5	2	3	2.5	3	2.5	3	2.5	3
Range	1-3.5	2-4	1.5-4	1-3.5	1.5-3.5	2-3.5	1.5-3.5	2-4	2-4	2-4
N	10		61		41		44		12	
T	17.00		-1605.00		-565.00		-606.00		-6.00	
*P**	0.4316		<0.0001		0.0002		0.0003		0.8501	

*Bonferroni correction of the significance level: 0.05/5 = 0.01

Table 4. Seasonal variation in belly bars (pairwise comparison) of Greenland White-fronted Geese, Wexford, Ireland, 1991-1995. Differences were tested by Wilcoxon signed rank test. Corrected for ties.

Year	Median		Range		*N*	*T*	*P**
	early winter	late winter	early winter	late winter			
1991/92	1.5	2.0	1.0-3.0	1.0-5.0	54	-683.5	<0.001
1992/93	2.0	2.5	1.0-3.0	2.0-4.0	87	-2850.0	<0.0001
1993/94	2.0	2.5	1.0-2.5	1.5-3.5	66	-1403.0	<0.0001
1994/95	2.0	2.5	1.0-4.5	2.0-4.0	83	-1960.5	<0.0001

*Bonferroni correction of the significance level: 0.05/4 = 0.0125

Discussion

The present study supports and confirms the findings of Boyd (1954), who studied European White-fronts *A. a. albifrons* in winter, in that the extent of belly barring did not differ between the sexes and did not change with age amongst birds older than two years of age, as had already been suggested by Tucker (in Witherby *et al.* 1939). Alpheraky (1905) claimed that extent of dark feathers on the abdomen and breast of Greylag Geese, Lesser White-fronted Geese and White-fronted Geese increased with age (although this was not based on quantitative data). However, from the results of the present study we can now assert that this is not the case for Greenland White-fronted Geese. Stroud (1981) suggested a difference between sexes of Greenland White-fronted Geese on the summering grounds, although this was not quite statistically significant. Our results from the summering ground in 1992, with a larger sample (60 c.f. 50) confirm no such difference at this time of the year in a sample from another season.

Very little is known about body moult in geese (Owen 1980, Hohman *et al.* 1992) however, for some species body moult begins either during wing moult or immediately after wing moult on the breeding grounds and extends into autumn or even winter (Owen 1980; Hohman *et al.* 1992; Gates *et al.* 1993). Since the outer pennaceous portion (outer edges) of the body feathers is somewhat lighter than the rest of the feather it is likely that a new fresh body plumage will appear relatively light. As this lighter part of the feather wears away, the remainder (ie darker) part of the feathers will predominate, making the plumage appear darker. In this study each individual bird was lighter in the early winter season, which therefore might be due to their new and fresh plumage at this time of the year. Furthermore, the extended day length often predominated by strong sunlight during the arctic summer might also contribute to bleaching and paling the feathers. Only closer observations of the moult and the effect of sun exposure and mechanical wear on feathers (eg using captive birds) will identify the precise mechanism involved with any certainty.

Why do individual birds exhibit such

variability, especially in the light of the present results showing that birds get darker in late winter just prior to breeding? Does it reflect body condition and/or social status as demonstrated amongst passerines (Rohwer 1975, 1977; Rohwer & Rohwer 1978)? Alternatively, it might be that the differences are simply used for individual recognition between birds (families). However, the scoring system used in the present study is of course subjective and is only based on the relative amounts of light and dark feathers on the belly and breast and does not take the actual individual "fingerprint" pattern into account. Boyd (1954) claimed that although the markings on any one bird in successive years tended to remain constant, the resemblance was not likely to be exact enough to serve as a reliable means of identification. In detailed studies of spring staging Lesser White-fronted Geese in northern Norway, it was considered that the barring on this species varied too much between years to be of use for identification of individuals (I.J. Øien pers. comm.) On Islay, Scotland another wintering ground for Greenland White-fronted Geese, despite slight year to year changes, it was possible to identify individuals in a flock studied in detail for four successive years (D.A. Stroud pers. comm.). The pattern of markings on individual birds tended to develop slightly from year to year leading to a gradual but identifiable modification of the basic pattern over time. Our results showed inconsistency in year to year variation with significant increase or decrease in belly bars sometimes, and no change at other times. Hence, based on this we are unable to confirm or reject the different statements.

Apart from demonstrating the causalities of the seasonal differences in the belly barring future studies should also aim to assess its significance in terms of position in social dominance hierarchies, reproductive success, assortative mating (ie if birds with similar extend of the belly barring tend to mate as suggested by H. Boyd (*pers obs.*)), individual recognition and heritability of patterns.

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