Phenotypic characteristics and moult commencement in breeding Dutch Herring Gulls *Larus argentatus* & Lesser Black-Backed Gulls *L. fuscus*

Muusse, M.[1*], Muusse, T.[2], Buijs, R.-J.[3], Altenburg, R.[4], Gibbins, C.[5] and Luijendijk, B.-J.[6]

**Correspondence author. Email: marsmuusse@gmail.com*
[1] *Ruysdaelhof 13, 2215 AJ Voorhout, The Netherlands;*
[2] *Billitonstraat 19, 3312 SB Dordrecht,The Netherlands;*
[3] *P. v. Dorpstraat 49, 4698 RV Oud-Vossemeer, Buijs Ecoconsult b.v., The Netherlands;*
[4] *De Waterdief 5, 1911 JN Uitgeest, The Netherlands;*
[5] *Drums, Aberdeen AB41 6AS, UK;*
[6] *Anemoonstraat 8, 3261 XB Oud-Beijerland, The Netherlands*.

Abstract
We describe ten phenotypic characteristics and moult commencement in an inland colony of Herring Gulls *Larus argentatus* and Lesser Black-backed Gulls *L. fuscus* in The Netherlands. All features were checked for difference between sexes and, when possible, known-aged birds were described. Both taxa exhibited wide variation in single characteristics, most apparent in the range of upperpart grey tone, iris speckling and the pattern on P10 and P9. Herring and Lesser Black-backed Gulls in this colony showed considerable overlap with birds from Scandinavia and from Britain, which justifies the name 'Dutch intergrade', sometimes used for breeding Lesser Black-backed Gulls in The Netherlands.

Introduction
Gulls with a large geographic distribution commonly show variation in plumage or biometrics across their range, which is often the basis for delineating subspecies. In the western Palaearctic, the *Larus argentatus-fuscus* complex has been the subject of many debates over species and subspecies boundaries. Based on recent molecular work, the most distinct populations are now classified as full species (Yésou 2002; Liebers *et al*. 2004; Collinson *et al*. 2008).

Full species status has been given to a number of closely related taxa, and against a background of identification problems and possible further taxonomic revisions, interest in inter- and intra- taxon variation has increased. Birds breeding in overlap zones have become a specific focus of interest as they may show intermediate features. Phenotypic characteristics (upperpart grey tone, primary patterns, biometrics, and soft part colour) of Herring and Lesser Black-backed Gulls have been compared across different European locations (Voous 1959; Barth 1968, 1975), and more locally on the German Friesian Islands (Goethe 1961; Noeske 2008). Mierauskas *et al*. (1991) compared yellow-legged Herring Gulls from the

eastern Baltic with Caspian Gulls *L. cachinnans* from southern Ukraine using wingtip pattern, vocalisations and bill dimensions, while Buzun (2002) compared West Siberian Gulls *L. heuglini* with other taxa using primary patterns, wing length, iris colour, orbital ring colour and primary moult. Timing of moult in Herring and Lesser Black-backed Gulls has been described using different approaches: various European locations (Stresemann & Stresemann 1966), western England (Verbeek 1977; Stewart 2006) and Finland (Hario 1984). Herring Gulls *L. a. argenteus* and Lesser Black-backed Gulls *L. f. graellsii* breeding in France, Belgium and The Netherlands show upperpart grey tone and biometrics which are intermediate between the British *L. a. argenteus* and *L. f. graellsii* and Scandinavian subspecies *L. a. argentatus* and *L. f. intermedius* (Barth 1968). Upperpart grey tone is the prime subject in most studies; nothing has been published to date on the moult pattern or detailed phenotypic traits of these intermediate birds.

The industrial complex Moerdijk in The Netherlands holds a mixed colony of Herring and Lesser Black-backed Gulls. Here we describe phenotypic variation and commencement of primary moult in both species breeding there, and discuss the implications of the variability found for field identification of their various subspecies.

Methods

Study colony: Moerdijk (51º41'N 04º36'E) is situated 50 km inland, 25 km south of Rotterdam. Colonisation by *Larus* gulls began in the early 1980s, and by 2006 an estimated 650 pairs of Herring Gulls and 2,900 pairs of Lesser Black-backed Gulls bred there. Ring recoveries suggest the first breeding gulls at Moerdijk probably originated from the very large colonies 50 km to the west at Maasvlakte and Dintelhaven (51º57'N 04º01'E). In recent years we have also found birds ringed as chicks in a newly established colony at Zeebrugge, Belgium (51º21'N 03º11'E), but ring readings show that the colony now mainly hosts locally-reared birds.

In 2005, 157 Herring Gulls and 434 Lesser Black-backed Gulls were trapped on nests using walk-in cages (Sibly & McLeery 1983) and colour ringed, and a further 158 and 604, respectively, were trapped and ringed in 2006. We only selected nests containing three eggs ('full nests'). Species were identified by a combination of leg colour, upperpart grey tone and orbital ring colour.

Phenotypic characters: We determined the upperpart grey tone and primary moult score of each bird in the field. Upperwing, underwing and head were all photographed, with images examined subsequently in Photoshop (CS2) to characterise each bird according to 11 features:

1. Grey tone of upperparts. Scored 1–20 on Agfa Grey Scale (similar to the Kodak 20 step grey scale) in 0.5 classes. See Goethe (1961) and Jonsson (1998a) for details on how to use grey scales and measurements. We first scored grey tone in the field (in the shade) and photographed each bird with the scale held next to its wing, to optimise parallel light conditions for feathers and Grey Scale simultaneously (Plate 7). Data were later validated from the photographs using Photoshop 'grey scale' mode to correct for brown hue and chroma.

2. Black on greater primary coverts. Scored as either present (+) or absent (-). A bird was scored positive only when pigmentation exceeded the width of the shaft.
3. Number of primaries with black pigmentation. Small black subterminal spots were included and scored positive.
4. P10 and P9 primary patterns. Six classes (Goethe 1961; Plate 1).
5. P10 black/grey division. Two classes: division between grey inner web and black outer web scored either sharp or diffuse on the underwing (Barth 1975; Plate 1).
6. P5 primary pattern. Five classes (Goethe 1961; Table 5).
7. Red gonydeal spot on upper mandible (Plate 4). Scored as present (+) or absent (-). Birds were scored positive when the modal red tone of the lower mandible was measured on the upper mandible. We used the Photoshop eye-dropper tool for scoring.
8. Black on lower and upper mandibles. Scored as present (+) or absent (-). Birds were scored positive when a black value was measured in Photoshop. Small black markings on the bill were scored the same as extensive black bands.
9. Iris speckling. Six classes (Plate 2). We did not score so-called brown-amber 'clouded' irides, as true black values are not present in such iris markings.
10. Orbital ring colour. Three classes. I: Yellow (ffff00–ffaa00 on colour scale in Photoshop). II: Orange (ffaa00–ff5500). III: Red (ff5500–ff0000).
11. Primary Moult Score for left wing (ranges from 0–50). Following Stewart (2006), we used six classes. 0: Old feather. 1: Missing feather, new feather in pin. 2: New feather visible, < 1/3. 3: New feather, 1/3 – 2/3. 4: New feather, > 2/3, but still waxy sheath. 5: New feather fully grown.

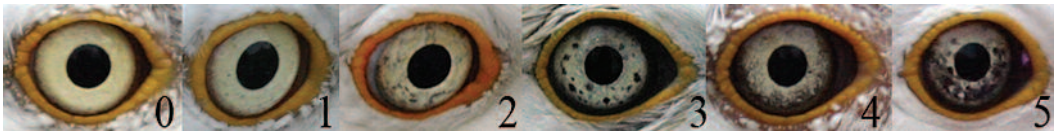
All data generated using these scoring protocols were analysed in SPSS 12 for Windows. Most birds were only trapped in one of the two years. For 17 Herring Gulls and 37 Lesser Black-backed Gulls trapped in both years, only the 2006 data were used. Where we refer to individual ringed birds, Herring Gulls are HG, Lesser Black-backed Gulls are LBBG, mint-green rings are 'm', yellow rings are 'y' and orange rings are 'o'. The notation for Herring Gull mint SO is therefore 'HG mSO'.

Table 1. Wing lengths (mm) and head+bill lengths (mm) of Herring *Larus argentatus* (HG) and Lesser Black-backed Gulls *L. fuscus* (LBBG) breeding at Moerdijk. Sexing in the field based on data from Texel and IJmuiden (F. Cottaar & C. J. Camphuysen *in litt.*), see column "CoCa wing" and column "CoCa head+bill". 95% C.I.: if wing length in a single Herring Gull is larger than 428 mm, there is 95% confidence this is a male in the Moerdijk population.

	n	Wing (mean ± SD)	95% C.I.	Head+bill	CoCa wing	CoCa Head+bill
HG male	165	413 – 465 (437.1 ± 9.3)	X > 428	X > 124	X > 425	X > 119
HG female	137	385 – 430 (414.8 ± 7.8)	X < 421	X < 113	X < 414	X < 117
LBBG male	460	410 – 462 (437.9 ± 8.7)	X > 429	X > 118	X > 425	X > 114
LBBG female	535	385 – 435 (414.9 ± 8.1)	X < 423	X < 108	X < 419	X < 112

Plate 1. P10 and P9 primary pattern classification in Herring *Larus argentatus* and Lesser Black-backed Gulls *L. fuscus* breeding at Moedijk. I: No mirror. II: Mirror on one web. III: Full subterminal black band, mirror on both webs. IV: Subterminal black present, but band broken. V: No subterminal black, mirror completely merged with tip. VI: '*thayeri*' pattern, medial band not reaching the feather-edge of the inner web. P10 division diffuse in V and sharp in VI.

Biometrics, sex and age: To establish sexes, all individuals were measured in the field using biometric data given by C. J. Camphuysen & F. Cottaar (*in litt*., Table 1). These data (which are from Texel and IJmuiden in The Netherlands) allow most Herring and Lesser Black-backed gulls to be sexed using wing length and head plus bill dimensions. In both species males are larger than females, with little overlap. The size difference between the sexes is maintained in individual pairs, as large females are known to pair with even larger males (pers. obs.). Thus, it is possible to confirm the sex of unringed individuals in direct comparison with their partner at the nest. If both the wing length and head+bill length of a Moerdijk individual fell within the overlap



Herring Gull (upper): 0 (0%); 1 (0–1%); 2 (1–5%); 3 (5–10%); 4 (10–20%); 5 (>20%).
Lesser Black-backed Gull (lower): 0 (0%); 1 (0–1%); 2 (1–5%); 3 (5–10%); 4 (10–20%); 5 (>20%)

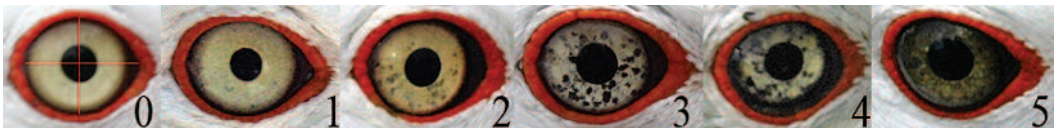


Plate 2. Classification for iris speckling in individual Herring *Larus argentatus* and Lesser Black-backed Gulls *L. fuscus* breeding at Moerdijk. The iris of LBBG 0 is separated into quarters to illustrate estimations of pigmented surface.

zones of both these measurements, the bird was then sexed in the field by direct visual comparison with the size of its mate, i.e. if clearly smaller it was female, and vice versa. When this was not possible, birds were left unsexed. Thirteen Herring and 43 Lesser Black-backed Gulls were not sexed in our study.

For the Moerdijk colony, 95% of the Herring Gull population is female when wing length is < 421 mm and 95% of the population is male when wing length is > 428 mm. For the Lesser Black-backed Gull population 95% is female when wing length is < 423 mm and 95% is male when wing length is > 429 mm.

We trapped 33 Herring Gulls and 76 Lesser Black-backed Gulls of known age, which ranged from 4–19 calendar years (cy).

While all birds were trapped on nests, not all breeding birds are necessarily fully mature adults, as both Herring and Lesser Black-backed Gull may breed as subadults. It was important for us to age our sample birds precisely, given that some of the variation in the features we were recording (e.g. eye pigmentation, black in the bill) may be age related. Monaghan & Duncan (1979) examined three 5cy birds that showed extensive variation in plumage, but all three showed black markings on wing-coverts. Chabrzyk & Coulson (1976) found that 14% of Herring Gulls start breeding as 4cy birds (also see Drost *et al*. 1961). We used black on the primary coverts as the feature to separate adult and subadult Herring Gulls (Plate 1: I & II). When characteristics were affected by age, we distinguished between subadult and adult birds. Twenty-four Herring Gulls in our analysis were scored subadult (19 males, 4 females, one not sexed; the sex ratio for the total sample was 165 males and 137 females).

The presence of dark markings on the primary coverts is not useful for ageing Lesser Black-backed Gulls, as fully mature birds may still show obvious sharply demarcated black centres on the greater primary coverts (pers. obs. of birds ringed as pulli; Plate 3). We defined birds as subadult when the primary coverts showed extensive brown-black centres and diffuse edges. By doing so, we may have included delayed 6cy or older birds and excluded advanced 4cy or 5cy birds. However, in the absence of

Plate 3. Two examples of primary covert patterns to illustrate our division between 'subadult' and 'adult' Lesser Black-backed Gulls *Larus fuscus*. **Left:** the greater primary coverts in a subadult show extensive brown-black centres and diffuse borders; note the dark centres on the secondaries and brown-black P9 and P10. **Right:** neatly demarcated black markings on the primary coverts, which can be present in 'adult' birds; this bird was ringed as a pullus in June 1995, and photographed in its 12th calendar year.

any other safe criteria, primary covert markings were considered the most appropriate way to distinguish fully adult from subadult birds (Plate 3). Sixty-two Lesser Black-backed Gulls were scored 'subadult' (43 males, 18 females, one not sexed; the sex ratio for the total sample was 443 males and 515 females).

Results

Upperpart grey tone: Herring Gull upperparts were clearly paler (modal grey tone 5, range 3–7) than in Lesser Black-backed Gulls (modal 11, range 8–15), with no overlap in our sample birds (Figure 1). Some birds were excluded, as the grey tone value could not be confirmed afterwards in Photoshop, mostly due to sun reflection on the grey scale in the image.

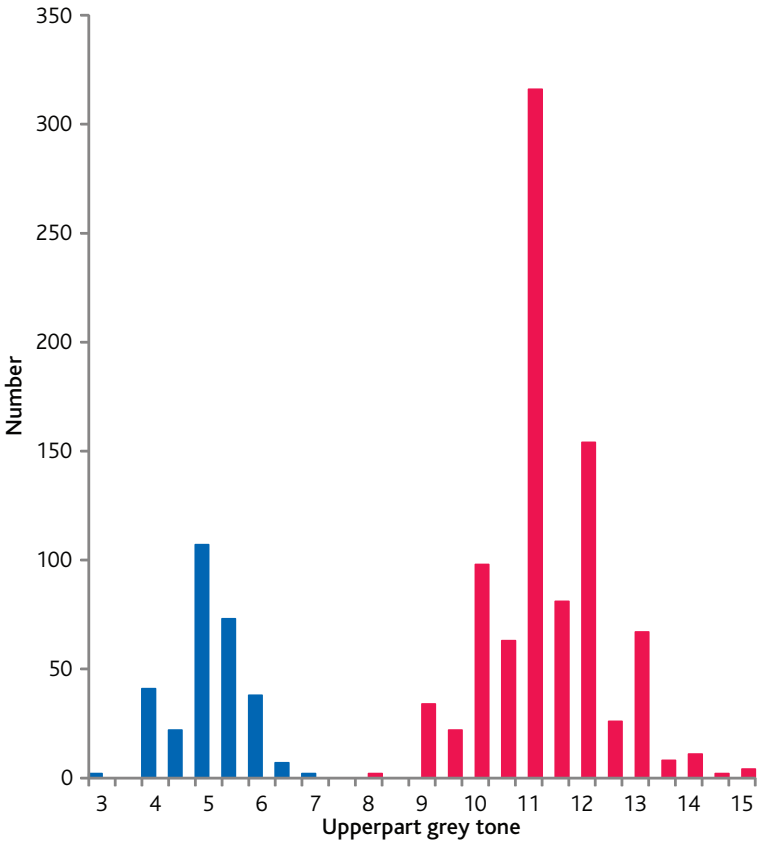


Figure 1. Upperpart grey tone in Herring *Larus argentatus* (blue, n = 292) and Lesser Black-backed Gull *L. fuscus* (red, n = 888) breeding at Moerdijk. Based on Agfa Grey Scale 0–20.

Black on greater primary coverts: Overall, 7.7% (22 birds) of Herring Gulls showed black on the primary coverts, more frequently in males (12%, n = 146) than females (3%, n = 128; 2 = 6.99, df = 1, P = 0.008). This difference may be due to an age-sex interaction with respect to colonisation, as males return to the colony to occupy territories at a younger age than females (Vercruijsse 1999). For Herring Gulls of known age (n = 33), the presence of black on the primary coverts was age-related, with more subadults showing black on these feathers than adults (b = -1.393, r^2 = 0.408, df = 1, P = 0.014; Table 2). Only one 6cy and one 7cy Herring Gull (8% of 26 known-age birds of 6cy or older) showed traces of black in the primary coverts. In these two individuals, one had black that only just exceeded the width of the feather shaft, while the other had more extensive black on the primary coverts. In all other respects, these birds appeared adults.

Most (75.5%) Lesser Black-backed Gulls showed black on the primary coverts (n = 962). Sixty-two birds showing primary coverts with extensive brown-black markings and diffuse borders were considered subadults, while 666 birds showed limited, neatly demarcated black markings and were considered 'mature adults' (Plate 3). We scored 54 mature birds of known age in 6cy–14cy, of which 41 (75.9%) showed neatly demarcated black pigmentation. We found no significant difference between the sexes. Our data from known-age Lesser Black-backed Gulls (n = 76) show that the presence of black on the primary coverts is not significantly related to age (Table 2).

Number of primaries with black pigmentation: On average, Herring Gulls had 5.9 primaries with black pigmentation (SD 0.51, n = 287; Table 3), and sexes differed significantly, for all birds (male 6.0, n =147, female 5.8, n = 128; Mann-Whitney U = 8163, Z = -2.448, df = 4, P = 0.014), and when subadults were excluded (male 6.0, n = 145, female 5.8, n = 128; Mann-Whitney U = 8105, Z = -2.339, df = 4, P = 0.019). The presence of black was not significantly age-related in known-age birds (n = 33).

The average number of primaries with black pigmentation in Lesser Black-backed Gull was 6.9 (SD 0.61, n = 931). The sex difference was significant for all birds (male 7.0, n = 433, female 6.8, n = 498; Mann-Whitney U = 100938, Z = -1.992, df = 4, P = 0.046), but not when subadults (62 birds, 70% males) were excluded. In known-age Lesser Black-backed Gulls, the number of primaries with black was age-related (subadults: mean 7.2, SD 0.68, n = 62; adults: mean 6.7, SD 0.64, n = 53; Mann-Whitney U = 1000, Z = -4.071, df = 4, P < 0.001; Table 4), although a few 10cy and 12cy birds had 8–9 primaries with black.

Due to feather wear and moult in the inner primaries, some birds had to be left out of this analysis.

P10 and P9 primary patterns: In Herring Gulls, the most frequent pattern in both sexes was a broken subterminal band on P10 (Figure 2, Plate 1), with no difference between sexes in the frequency distribution of P10 pattern categories. Half of the Herring Gulls showed a complete subterminal band and a mirror covering both webs on P9, again with no difference between sexes in the frequency of different P9 patterns. Three males of the 24 subadults showed no mirror on P10. When all

Table 2. Black pigmentation on primary coverts in known-age Herring *Larus argentatus* and Lesser Black-backed Gulls *L. fuscus* (retrapped birds excluded) breeding at Moerdijk. Values are % for their own age-class. Age in calendar years (cy).

	Herring Gull			Lesser Black-backed Gull		
Age	**No**	**Yes**	**n**	**No**	**Yes**	**n**
4 cy		100	2		100	13
5 cy	40	60	5	14	86	8
6 cy	67	33	3	20	80	5
7 cy	80	20	5	17	83	7
8 cy	100		5	8	92	14
9 cy	100		3	50	50	4
10 cy	100		1	57	43	7
11 cy	100		3	50	50	6
12 cy					100	5
13 cy	100		1	33	67	3
14+ cy	100		5		100	3
Whole sample	92	8	286	24	76	962

Table 3. Number of primaries with black pigmentation in Herring *Larus argentatus* (HG) and Lesser Black-backed Gulls *L. fuscus* (LBBG) breeding at Moerdijk. Values are %.

		Number of primaries with black					
		5	**6**	**7**	**8**	**9**	**Total**
HG	male	7	40	6	-	-	53
	female	11	33	3	-	-	47
	Total	17	73	9	-	-	100
LBBG	male	-	10	30	6	1	47
	female	0	13	35	5	0	53
	Total	0	23	65	11	1	100

Table 4. Number of primaries with black pigmentation in Lesser Black-backed Gulls *L. fuscus* of known age (ringed as pullus) breeding at Moerdijk.

	Age in calendar-years											
No.	**4 cy**	**5 cy**	**6 cy**	**7 cy**	**8 cy**	**9 cy**	**10 cy**	**11 cy**	**12 cy**	**13 cy**	**14 cy**	**Total**
6	0	3	2	4	6	0	2	2	1	2	1	23
7	6	1	3	3	8	4	4	4	2	1	2	38
8	6	3	0	0	0	0	1	0	1	0	0	11
9	1	1	0	0	0	0	0	0	1	0	0	3
Total	13	8	5	7	14	4	7	6	5	3	3	75

Table 5. P5 primary pattern of Herring *Larus argentatus* and Lesser Black-backed Gulls *L. fuscus* breeding at Moerdijk. Values are %. Category 1: Complete subterminal band. 2: Subterminal band broken, but black on both webs. 3: Subterminal black present on one web, sharply defined. 4: Subterminal black present on one web, diffuse marking. 5: No black present.

	Cat. 1	**Cat. 2**	**Cat. 3**	**Cat. 4**	**Cat. 5**	**Total**
Herring Gull	12	21	32	15	18	287
HG, subadults excluded	12	22	32	15	19	265
Lesser Black-backed Gull	95	5	-	0	0	967
LBBG, subadults excluded	94	5	-	0	0	905

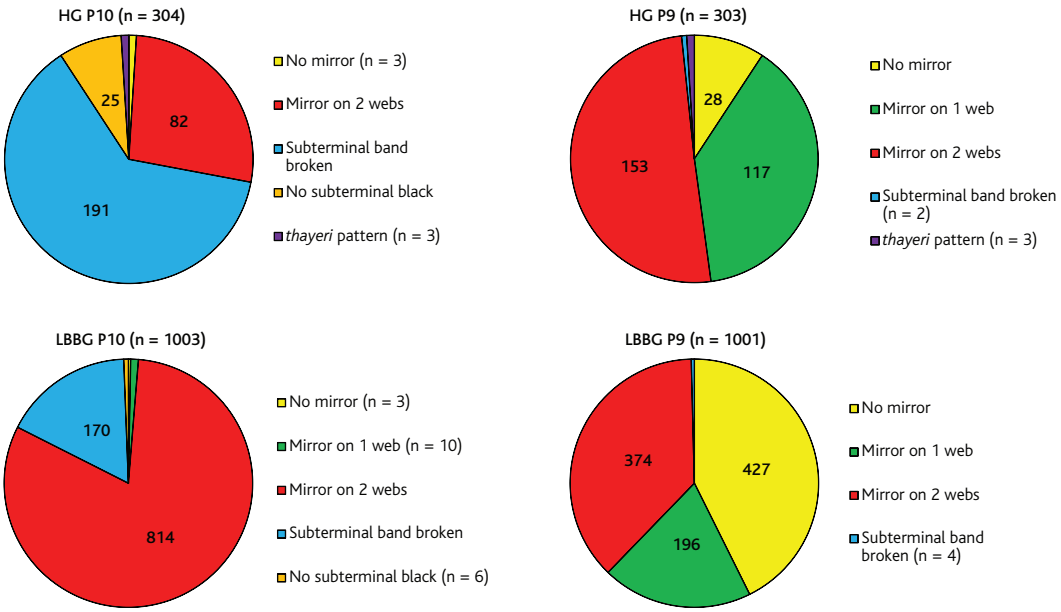


Figure 2. Distribution of P10 and P9 patterns in Herring *Larus argentatus* (HG) and Lesser Black-backed Gulls *L. fuscus* (LBBG) breeding at Moerdijk.

subadults were excluded from the sample, the difference between sexes remained non-significant. Twenty breeding Herring Gulls were trapped in both 2005 and 2006, of which 16 remained in the same P10 pattern category, one showed less black and one showed more black in 2006. For P9, 12 birds remained in the same category, four birds showed less black, and one showed more black. Due to wear in the primary tips, some birds could not be scored adequately in both years.

Most (80%) Lesser Black-backed Gulls showed a complete subterminal black band across P10, with the mirror covering both the inner and outer web of the feather. For P9, there was no dominant pattern (Figure 2). There was no significant difference between sexes for either the P10 or P9 patterns. Three subadults showed no mirror on P10. When all subadults were excluded, the difference between sexes remained non-significant. Of 43 Lesser Black-backed Gulls caught in both years, 35 birds remained in the same P10 category, three showed less black and one showed more black in 2006. For P9, 32 birds remained in the same category and seven showed less black in 2006. As with Herring Gulls, some birds could not be scored adequately in both years due to wear.

Neither species showed marked differences between the sexes in the sharpness of the division between the grey inner and black outer webs of P10. In total, 56% of Herring Gulls and 58% of Lesser Black-backed Gulls showed a diffuse gradient on the underside of P10, which agrees with Barth (1975).

P5 primary pattern: Only 18% of Herring Gulls completely lacked black on P5, with the most frequent pattern (32%) being a sharply defined black mark on the

outerweb (Table 5). Males had higher values (more black on P5) than females (male n = 147, female n = 128; Mann-Whitney U = 7406, Z = -3.136, df = 4, P = 0.002), which remained significant when subadult birds were excluded (male n = 130, female n = 124; Mann-Whitney U = 6540, Z = -2.678, df = 4, P = 0.007). Of 20 Herring Gulls trapped in both years, 12 remained in the same P5 category, one showed more black in the second year and seven showed less black (including one 4cy and one 5cy bird, but also one 14cy bird).

Almost all (95%, n = 967) Lesser Black-backed Gulls had a complete black subterminal band on P5, but 5% had this band broken at the shaft, resulting in two black markings on P5; only one bird had no black on P5. There was no sex difference in P5 pattern, either for all birds, or when subadults were excluded. Of 43 Lesser Black-backed Gulls caught in both years, 37 remained in the same category, one showed more black in 2006 and one showed less black on P5.

Table 6. Bill markings in Herring *Larus argentatus* and Lesser Black-backed Gulls *L. fuscus* breeding at Moerdijk. Values are %.

		Herring Gull				Lesser Black-backed Gull			
		Male	Female	Total	n	Male	Female	Total	n
Red on	no	54	43	96	264	25	14	39	359
upper mandible	yes	-	4	4	10	22	39	61	567
	total	54	46	100	274	47	53	100	926
Black on	no	30	25	55	152	7	12	19	173
upper mandible	yes	23	21	45	122	41	41	81	754
	total	54	46	100	274	47	53	100	927
Black on	no	27	29	56	154	12	20	32	294
lower mandible	yes	26	17	44	119	35	33	68	630
	total	54	46	100	273	47	53	100	924

Table 7: Iris speckling and orbital ring scores for Herring *Larus argentatus* (HG) and Lesser Black-backed Gulls *L. fuscus* (LBBG) breeding at Moerdijk. Values are %.

		Speckling							Orbital ring			
		0	I	II	III	IV	V					
		0%	0-1%	1-5%	5-10%	10-20%	>20%	Total	yellow	orange	red	Total
HG	male (147)	10	31	11	2	0	0	54	2	51	0	54
	female (125)	13	26	7	0	-	-	46	4	43	-	47
	Total (272)	22	57	18	2	0	0	100	6	94	0	100
LBBG	male (431)	10	24	9	3	1	1	47	-	0	47	47
	female (488)	13	31	8	1	0	0	53	-	0	53	53
	Total (919)	24	55	17	3	1	1	100	-	0	100	100

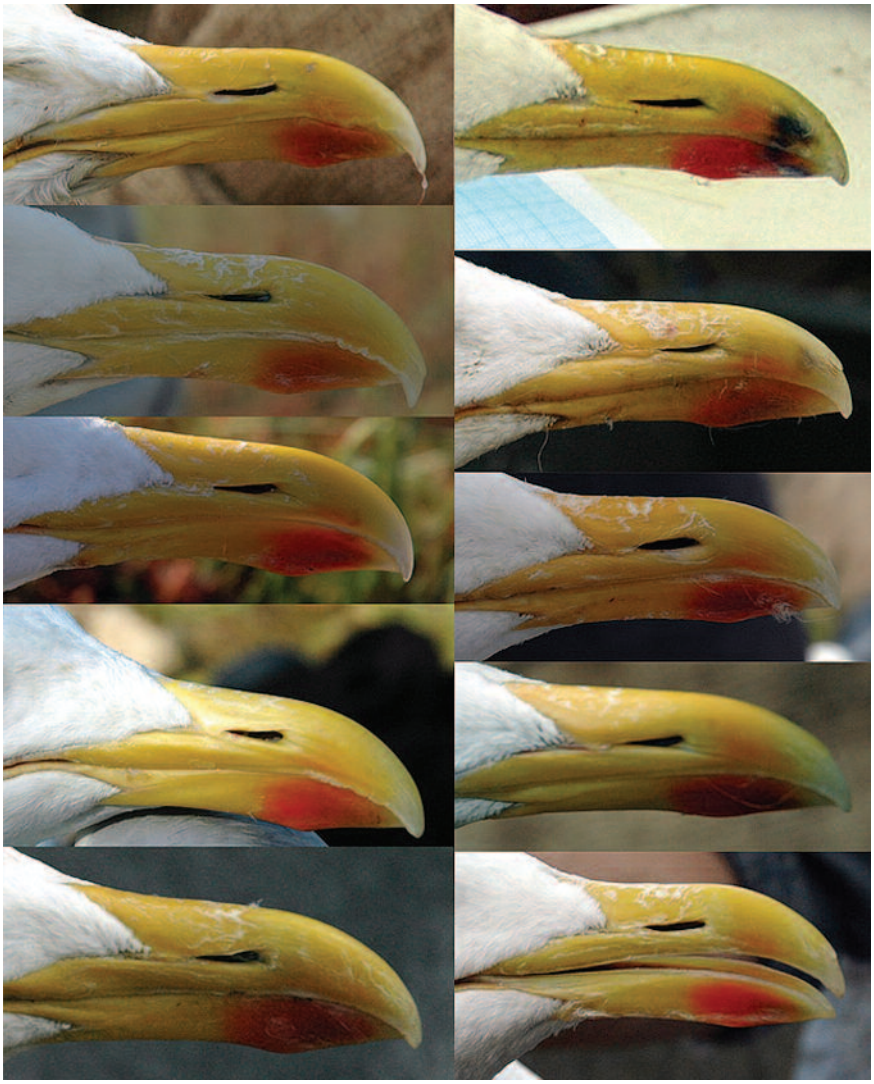


Plate 4. Examples of Herring Gulls *Larus argentatus* breeding at Moerdijk, scored negative (left) and positive (right) for red on the upper mandible.

Red and black on the bill: In Herring Gulls, red on the upper mandible was found on ten females (3.5% of our sample), but not on any males (Table 6, Plate 4), and this sex difference was highly significant (male n = 147, female n = 127; χ^2 = 12.013, df = 1, P = 0.001). Over half (61%) of Lesser Black-backed Gulls had red on the upper mandible, more frequently in females than males (male n = 434, female n = 492; χ^2 = 69.643, df = 1, P < 0.001).

The frequency of black on the bill in Herring Gulls did not differ significantly between the sexes for either the upper mandible or the lower mandible; 28% showed black on both mandibles, with no difference between the sexes. Subadults more frequently showed black on both mandibles (adult n = 280, subadult n = 24;

Mann-Whitney U = 2148, Z = -3.721, df = 1, P < 0.001). When subadults were excluded, or when we only considered known-age Herring Gulls, the sex difference for black on both mandibles remained non-significant.

In Lesser Black-backed Gulls, 63% of all birds had black on both mandibles. Black on the bill was found more frequently in females (Table 6), for both the upper mandible (male n = 435, female n = 492; χ^2 = 12.802, df = 1, P < 0.001) and lower mandible (male n = 433, female n = 491; χ^2 = 17.758, df = 1, P < 0.001). Excluding subadults, 62% showed black on both mandibles, and the difference between the sexes in red and black markings remained significant (red on upper mandible: male n = 391, female n = 475; χ^2 = 70.638, Z = -7.276, P < 0.001; black on both mandibles: χ^2 = 79.572, Z = -4.176, P < 0.001).

Some individuals of both species have not been included for all categories as images did not allow scoring, e.g. due to mud on the bill.

Iris speckling and orbital ring colour: Most Herring Gulls showed some degree of iris speckling (Table 7), over half being in category I (0–1%), with males having a more densely speckled eye than females (male n = 147, female n = 125; Mann-Whitney U = 7742, Z = -2.496, df = 5, P = 0.013). Seven males scored category III or higher, versus only one female. Immature Herring Gulls, especially 3cy and 4cy birds, clearly more often have dark irides than full adults (pers. obs. of ringed, known-age birds), but the difference between the sexes remained significant when subadults were excluded (male n = 130, female n = 121; Mann-Whitney U = 6847, Z = -1.967, df = 5, P = 0.049).

Most (78%) Lesser Black-backed Gulls had no or extremely limited iris speckling (1% or less: categories 0 and I), but males had more speckling than females (male n = 431, female n = 488; Mann-Whitney U = 92841, Z = -3.391, df = 5, P = 0.001); 36 males (including eight subadults) fell into category III or higher, but only eight females. When subadults were excluded, the difference between sexes remained significant (male n = 414, female n = 486; Mann-Whitney U = 90245, Z = -2.948, df = 5, P = 0.003).

Almost all (94%) Herring Gulls showed orange orbital rings, with only 18 having yellow and one bird (not sexed) a red orbital ring (Table 7). Four Lesser Black-backed Gulls scored orange, while all other 915 (99%) individuals had red orbital rings.

Commencement of primary moult: On 2 May 2006, the earliest date of fieldwork in the colony, four of the seven Herring Gulls trapped had commenced their complete moult. Two of these probably started the complete moult in late April, as they already had dropped both P1 and P2 by early May. On 21 May 2005, the latest date we trapped Herring Gulls, 27 out of 37 birds had commenced the primary moult. Most Herring Gulls started moult in May: in the first half of the month 46% (n = 211), and in the second half 65% (n = 94) were in active primary moult.

Of 48 Lesser Black-backed Gulls caught on 2 May 2006, seven showed active primary moult. The last project day was 10 June 2006, when eight Lesser Black-backed Gulls

were caught of which only two had commenced primary moult. A minority of Lesser Black-backed Gulls started moult in May: in the first half of May 6% (n = 747), and in the second half 33% (n = 257) of the birds were in active primary moult.

In our sample, the highest primary moult score (PMS) attained by a Herring Gull was 11 (P1–P2 fully grown, P3 missing), found in mSL on 21 May 2005. Seventeen Lesser Black-backed Gulls arrived in the colony in spring with arrested primary moult: fresh, fully grown primaries recently replaced on the wintering grounds (Plate 9). We found 13 Lesser Black-backed Gulls that had replaced P1, and four that had replaced both P1 and P2 in winter. None of these birds was in active moult when caught on the nest, and for this reason were excluded from Figure 3.

Discussion

Herring and Lesser Black-backed Gulls breeding at Moerdijk showed considerable variation in each of the 11 plumage and moult characters studied, which has important implications for our interpretation of their origin and subspecific classification, as well as the field identification of Herring and Lesser Black-backed Gull taxa more generally.

The most striking result of our study was the range of upperpart grey tones recorded, which ranged from Kodak 3 to 7 in Herring Gulls. Barth (1968, 1975) defined the 'British form' of Herring Gull as having Munsell 5.7 and higher (in our analysis Kodak 5.5 and lower). He demonstrated a large variation in Herring Gulls from The Netherlands (Barth 1975), despite a sample size of only 20 birds, and considered 75% of his Dutch birds as belonging to the pale 'British form'. At Moerdijk, 78% of 295 Herring Gulls matched this definition. Herring Gulls in Finnmark belong to the darkest populations in Europe (Malling Olsen & Larsson 2004). Both Barth's research (1975) on Dutch birds and our Moerdijk data show several individuals as dark as average nominate *argentatus* from East Finnmark (Kodak 7).

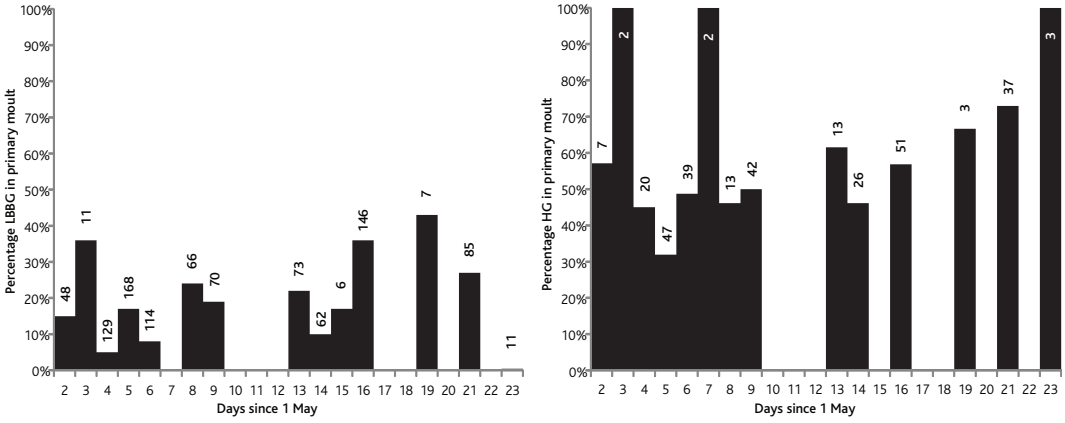


Figure 3. Primary moult scores (PMS) in May for actively moulting Lesser Black-backed *Larus fuscus* (left: n = 187, out of 997 birds examined) and Herring Gulls *L. argentatus* (right: n = 60, out of 314) breeding at Moerdijk. Daily sample sizes are shown. Lesser Black-backed Gulls showing arrested moult are not included, for they were not in 'active moult'. On day 23, 11 Lesser Black-backed Gulls were all scored PMS0 (no active moult).

Upperpart grey tone is the prime characteristic for separating *graellsii*, *intermedius* and *fuscus* Lesser Black-backed Gulls (Barth 1968). The Moerdijk birds ranged from Kodak 8 to 15, the modal grey tone of 11 being close to the population mean of 11.7 for *intermedius* from southwest Sweden (Barth 1975) and clearly darker than British *graellsii* (Barth 1975: Munsell 3.3 or higher; Howell & Dunn 2007: Kodak 9–11; Malling Olsen & Larsson 2004: Kodak 8–10). This magnitude of variation at Moerdijk is clearly visible in the field, without quantitative assessment using scales (Plate 5).

Plate 5. Upperpart grey tone of Lesser Black-backed Gulls *Larus fuscus* breeding at Moerdijk. Left: grey tone 11 (modal); right: grey tone 15 (dark).

Could these darker upperparts in Dutch birds be a result of recruitment from southwest Scandinavia? Despite intensive ringing programmes in southern Norway and southwest Sweden, genuine *intermedius* has only very rarely been found breeding in The Netherlands in the past 20 years (N. van Swelm, F. Cottaar & K. Camphuysen pers. comm.). Ring recoveries show that it is the paler British *graellsii* that can be found breeding annually (although in small numbers) in several Dutch colonies. Nominate *fuscus* from the heartland of its range (southwest Finland and northeast Sweden) shows grey tones of 13–17 (mean 14.4) (Barth 1968; Jonsson 1998b). In our Dutch sample, six birds out of 888 (0.7%) showed grey tones of 14.5 or 15.0, matching average nominate *fuscus* in the darkness of the upperparts. The dark upperparts of some Dutch birds may be an historic influence from the first colonists, which may have originated from Scandinavia (colonisation started in the north of the country, on Terschelling in 1926; Teixeira 1979).

Malling Olsen & Larsson (2004) argued that the irides of adult Herring and Lesser Black-backed Gulls were clear yellow. However, we found that about 20% of individuals of both species had obvious iris speckling (category 2–5: > 1%, obviously visible in the field), even when subadults were excluded. Speckling can occasionally occur as a result of injury, but many birds had both eyes heavily speckled so injury is an unlikely explanation. We conclude that iris speckling is part of the Dutch population variation in breeding Herring and Lesser Black-backed Gulls. This suggests that caution is needed when the presence of iris speckling is used in identification of west and east European taxa, i.e. *argenteus* versus *cachinnans* (Mierauskas *et al*. 1991) or *graellsii* versus *heuglini* (Buzun 2002).

Immature Herring and Lesser Black-backed Gulls often show a (small) black band on the bill in summer (Buzun 2002; Malling Olsen & Larsson 2004), and so in this respect they differ from adults. However, in the Moerdijk colony black bill markings were common in adults of both species, with 57% of Lesser Black-backed Gulls and 25% of Herring Gulls showing black on both mandibles. Due to differences in

methodology and scoring, it is difficult to compare our data with those of others, but black was very prominent on the bill of some individuals (Plate 4); our data indicate that black bill markings are not necessarily just a feature of non-breeding and/or subadult birds in The Netherlands.

The extent of the red gonys spot may be used as a feature to separate Herring Gulls from other taxa. Malling Olsen & Larsson (2004) state for *L. argentatus*. "... gonys-spot normally restricted to lower mandible, but may reach upper mandible''. Our data for Herring Gulls allow this to be quantified explicitly for the first time; only ten females out of 274 (4%; Table 6) showed red on the upper mandible.

The size and number of mirrors and the number of primaries with black pigmentation have been cited as possibly useful field marks for separating the various Lesser Black-backed Gull taxa, and *heuglini*. For example, Buzun (2002) described *heuglini* as tending to show a mirror on P9 less frequently than *graellsii*, and on average having more primaries with black pigmentation. In our sample, however, almost half of breeding Lesser Black-backed Gulls (42%) lacked a mirror on P9. The mirror on P9 and even P10 may be absent in breeding birds, although the absence of the latter was only found in subadults which showed other immature features such as dark wing-coverts and tail markings (e.g. LBBG o32, Plate 7). Of our sample birds, 11.5% (n = 982, subadults excluded) had eight or nine primaries with black subterminal markings, thus extending as far as P2. The variability shown by our Dutch-breeding birds suggests the need for caution when using these aspects of the primary pattern in field identification.

In Black-headed Gulls *Chroicocephalus ridibundus* the black extent on the wing tends to decrease with age (Allainé & Lebreton 1990). The number of primaries with black was also age-related in Lesser Black-backed Gulls in our sample. Furthermore, the pattern on P9 and P10 may vary from year to year in both

Plate 6. Bill markings in individual Herring Gulls *Larus argentatus* breeding at Moerdijk: oHL (11cy) and oKL (10cy) with vestigial black markings; m6T (probably 4cy) with extensive black; oHJ represents the small group of females in which the red gonydeal spot continues on the upper mandible.

Plate 7. Primary patterns of individual Lesser Black-backed Gulls *Larus fuscus* breeding at Moerdijk: oNL (mirror on P8); o65 (12cy) with black on P2–P10; o32 (4cy) lacking mirrors on P9 and P10.

Plate 8. *Thayeri* patterns in the primaries of Herring Gulls *Larus argentatus* breeding at Moerdijk.

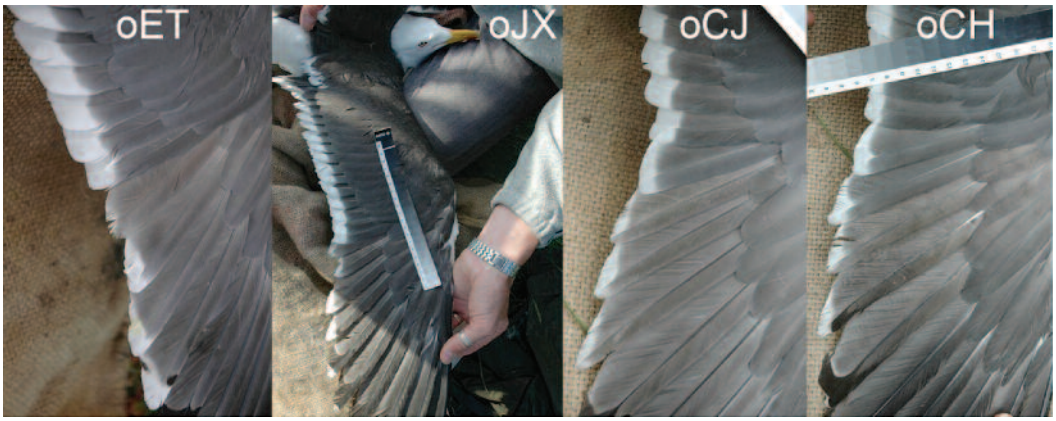


Plate 9. Arrested primary moult in Lesser Black-backed Gulls *Larus fuscus* breeding at Moerdijk. Innermost primaries old, central and outer primaries replaced significantly later leading to a perceptible change in the age/wear of adjacent feathers.

Herring and Lesser Black-backed Gull, with single birds of both taxa even showing more black in 2006 than they did in 2005. Finally, there may also be differences between patterns on the right and left wing, but we did not record this.

Interesting primary patterns in Herring Gulls include birds showing *thayeri* patterns on P9 and P10. This *thayeri* pattern on P9 is quite common (> 20% of birds) in nominate *argentatus* from Finnmark (Barth 1975). A *thayeri* pattern on P9 or P10 has been found on 3.8% (6/160) of Herring Gulls in north Germany (Goethe 1961) and 0.8% (1/133) of Belgian birds (Adriaens & Mactavish 2004), while we found it on 1.8% (5/273). Normally, *thayeri* patterns are associated with limited subterminal black markings in the wingtip (no subterminal black marks on P10 or lacking black in P5 or even P6). Our data show that this is not necessarily the case for Dutch Herring Gulls: for example, HG mNH had a *thayeri* pattern on P10 but also a near complete black subterminal band on this feather (Plate 8), and thus in this respect resembled American Herring Gull *Larus smithsonianus* (Adriaens & Mactavish 2004). Adult Herring Gull NLA 5.363.004 (Plate 8) was exceptional, as it combined *thayeri* patterns with a red orbital ring (the only Herring Gull in our sample), as is commonly found in southeast Scandinavia (Barth 1968; Jonsson 1998a); its origin is unknown (it was not ringed as pullus), but it has bred at Moerdijk for at least five years.

Primary moult strategies vary at the population level among Lesser Black-backed Gull taxa (Verbeek 1977; Hario 1984; Jonsson 1998b). Our sample found that Dutch birds occasionally moult inner primaries on the wintering grounds (and hence showed arrested moult), as described for some British birds (Stewart 2006). It is difficult to be exact about the timing of this moult, but the fresh condition of the feathers suggested replacement in late winter. Another small group of birds showed inner primaries that were obviously older than the outer primaries. In these birds, moult was apparently arrested (e.g. to migrate south in autumn) and continued much later, leaving a distinct difference in feather wear. We found five birds with P1 obviously older than P2–P10 (Plate 9) and seven with P1–P2 much older than P3–P10. These 12 birds match the moult strategy described for adult nominate *fuscus* (Jonsson 1998b), which is a long-distance migrant. We have limited data on the wintering grounds of these 12 birds in particular, although singles have wintered in Valencia (Spain), Malaga (Spain) and Agadir (Morocco), and two were seen on migration in Spain and Portugal; the other birds have never been recorded outside The Netherlands and may winter at locations with no or few observers, such as West Africa. Further studies are required to determine whether moult pattern is an individual, population or subspecific trait and, hence, the extent to which it can be used in the identification of out of range individuals.

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