Colour phase and biometrics of Fulmars *Fulmarus glacialis* on Svalbard

Kleurfase en biometrie van Noordse Stormvogels op Spitsbergen

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Introduction

In the summers of 1988-90, 411 Fulmars *Fulmarus glacialis glacialis* were captured, measured and their plumage was described during a project in which the diet of this species was studied. Because biometrical data from large samples of 'fresh' (live) birds are scarce in literature, and as an aid in further studies of Fulmar energetics in the arctic region, the results are summarized in this note. Most birds were captured late June or July, and mainly in West-Spitsbergen (figure 1). Most individuals were captured when they flew along low cliffs in Isfjorden and Kongsfjorden, either moving towards or from the breeding colony elsewhere in these fjords (see Camphuysen 1993). A minority was caught at sea from the steaming ship.

Methods

Fulmars were classified as '*breeders*' and '*non-* or *failed-breeders*' on the basis of the primary moult (not started in successful birds, starting or advanced in non-/failed breeders). Although the latter category will comprise a mixture of age classes, for practical reasons the first category is referred to as *adults*, the latter as *immatures*. Standard biometrics included bill length (feathers to tip), tube length (feathers to end of tube), bill depth at base (1) and at gonys (2), head length (back of head to tip of bill), wing length (flattened, straightened wing), tarsus length, and weight (including possible food load). In 1990, special investigations included the assessment of wing span and surface area, according to methods described in Pennycuick (1989). Ful-

Catching Fulmars with a long-handled net from low cliffs, Kongsfjorden, Svalbard, summer 1988. *De vangst van stormvogels met een schepnet vanaf lage kliffen, Kongsfjorden, Spitsbergen, zomer 1988.* (photo G. Camphuysen-Jonker)

mars were sexed on the basis of biometrics, using the discriminant analysis decribed by Van Franeker & Ter Braak (1993). Most birds were caught and released, without the possibility to check the sex internally, but ten individuals were collected and sexed by dissection. Colour morphs were assessed on the basis of scores of five different fields in the plumage: head and neck, throat, chest, belly, and sides, and ranked as dark grey, medium grey, light greyish or pure white. The result was assigned to either light phase (LL double light), or 'coloured' (L, D, and DD) following the descriptions by Van Franeker & Wattel (1982).

Colour phase and biometrics

Of 411 individuals examined, only three birds were light phase (LL) individuals (0.7%). The remaining birds (99.3%) were 'coloured' according to Van Franeker (1995), of which 15.2% were L (largely white underparts),

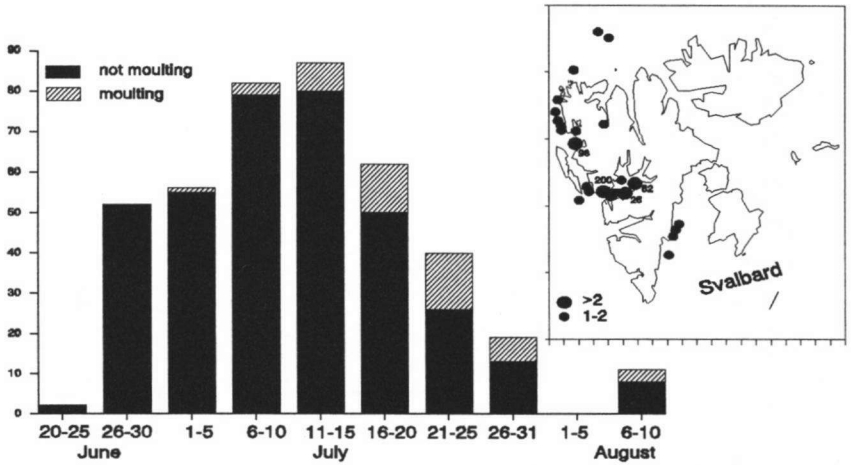

Figure 1. Catches of Fulmars (number of birds caught; n= 411) in Svalbard per 5-day periods, late June-early August 1988-90, and distribution of catches over the archipelago (inset). Moulting and non-moulting specimens are shown separately.
Figuur 1. Vangsten van Noordse Stormvogels (aantal vogels; n= 411) in Spitsbergen per vijfdaagse periode, eind juni-begin augustus 1988-90, en verspreiding van de vangsten over het gebied. Ruiende en niet-ruiende dieren zijn apart weergegeven.

78.3% were D (light grey underparts), and 5.8% were DD (dark grey all over). On average, darker individuals (D and DD) were slightly smaller than lighter birds (LL and L; table 1). Significant differences in mean bill length, bill depth (at base or gonys), tube length, head length, and tarsus length were found between LL/L (combined, only 3 LL phase birds were captured; n= 65), D (n= 322) and DD (n=24) phase Fulmars (One-way ANOVA; Fowler & Cohen 1986):

Bill length	$F_{2,405} = 11.38$, $p<0.01$
Tube length	$F_{2,395} = 8.51$, $p<0.01$
Bill depth (1)	$F_{2,406} = 8.71$, $p<0.01$
Bill depth (2)	$F_{2,408} = 6.52$, $p<0.01$
Head length	$F_{2,405} = 5.57$, $p<0.01$
Tarsus length	$F_{2,406} = 5.45$, $p<0.01$

In wing length and weight the observed variances were not homogeneous (F-test) and the differences were therefore not tested. Although the overlap in size was considerable, it is obvious that particularly the palest individuals (with white areas on the body) were slightly larger, as examplified in bill

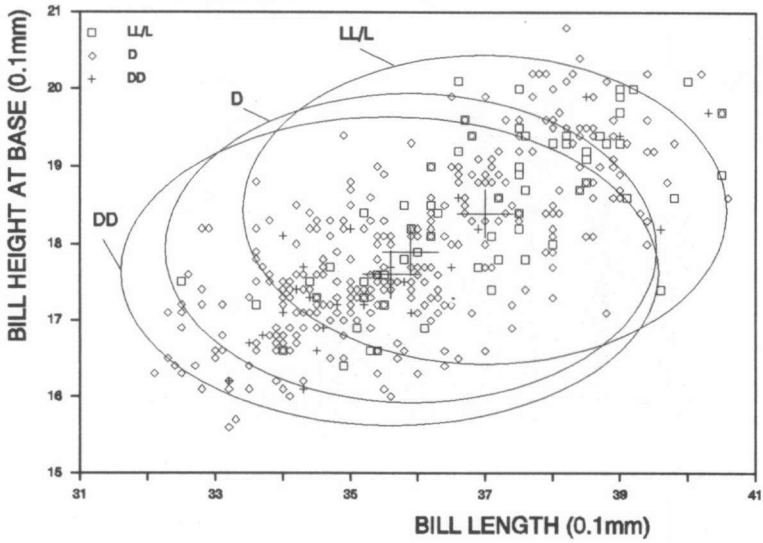

Figure 2. Relationship between bill length and bill depth (at base) in LL/L (n= 65), D (n= 319) and DD (n= 24) Fulmars, demonstrating differences in mean (crosses) and overlap (individual plots). The ellipses show the standard deviation times two for each group of birds.

Figuur 2. Relatie tussen snavellengte en snavelhoogte (aan de basis) voor LL/L (n= 65), D (n= 319) en DD (n= 24) Noordse Stormvogels, waarmee het verschil in gemiddelde (kruizen) en de overlap (individuele plots) wordt gedemonstreerd. De ellipsen geven tweemaal de standaarddeviatie weer voor elke groep vogels.

dimensions (figure 2). Not measured, but noted by all field workers during these three seasons, was that darker (*i.e.* smaller) individuals responded usually less aggressive to our handling, whereas L or LL phase (*i.e.* larger), were often fighting to the very end of the sessions.

Sexratio

The sexes were separated by means of discriminant analysis, based on a combination of four measurements (Van Franeker & Ter Braak 1993):

head length + (2.38 * bill depth[2]) + (0.41 * tarsus) - (0.21 * bill length)

Van Franeker (*pers. comm.*) tested the results of this analysis with birds captured on Jan Mayen, Bear Island and Svalbard and concluded that over

Table 1. Biometrics of Fulmars on Svalbard (sample size, min, max and average). (A) adults and immatures, all colour phases combined; (B) light (LL) and coloured specimens (L, D, DD), all ages and sexes combined.

Tabel 1. Biometrie van Noordse Stormvogels op Spitsbergen (steekproef, min, max, gemiddeld). (A) adulte en onvolwassen exemplaren, alle kleurfasen gecombineerd; (B) lichte (LL) en gekleurde exemplaren (L, D, DD), alle leeftijden en geslachten gecombineerd.

	A adult		immature		B light	coloured		
	♀	♂	♀	♂	LL	L	D	DD
Bill length	237	125	31	14	3	62	319	24
Minimum	32.1	34.6	32.3	36.2	35.2	32.5	32.1	33.2
Maximum	39.6	40.6	38.4	39.8	39.6	40.5	40.6	40.3
Average	35.1	37.9	34.8	38.3	37.1	37.0	35.9	35.6
Tube length	231	121	31	14	2	60	314	22
Minimum	8.2	9.0	8.4	10.9	9.2	8.8	8.2	9.3
Maximum	13.2	14.0	13.0	13.3	10.9	13.5	14.0	12.4
Average	10.7	11.6	10.4	12.1	10.1	11.5	10.9	10.7
Bill depth at base (1)	237	125	31	14	3	62	320	24
Minimum	15.6	17.7	15.7	17.9	17.4	16.4	15.6	16.1
Maximum	19.0	20.8	18.9	19.9	20.1	20.1	20.8	19.9
Average	17.4	19.1	17.3	19.1	18.6	18.4	17.9	17.6
Bill depth at gonys (2)	237	125	31	14	3	62	320	24
Minimum	14.0	16.0	14.2	16.0	15.5	14.7	14.0	14.6
Maximum	16.9	18.7	16.9	18.2	16.8	18.5	18.3	18.7
Average	15.5	17.1	15.6	17.2	16.1	16.5	16.0	15.9
Head length	237	125	31	14	3	62	319	24
Minimum	82	92	83	94	89	85	82	84
Maximum	95	102	93	99	93	100	100	102
Average	89.1	96.0	88.3	96.3	91.0	93.0	91.1	90.6
Tarsus length	237	125	31	14	3	62	321	23
Minimum	49	53	50	54	53	49	49	51
Maximum	57	62	57	59	57	61	62	59
Average	52.9	56.4	53.0	56.0	55.2	54.9	54.0	53.6
Wing length	234	119	16	11	3	60	297	22
Minimum	300	322	312	324	315	305	300	317
Maximum	352	353	342	349	337	349	353	344
Average	323.8	337.2	324.1	339.5	325.3	332.5	327.6	328.7
Body weight	235	121	31	14	2	60	318	24
Minimum	490	590	505	665	610	560	490	540
Maximum	900	1170	750	890	740	1015	1170	845
Average	652.1	799.8	630.6	774.6	675.0	711.5	699.8	666.3

Fulmar with advanced primary moult. *Noordse Stormvogel met gevorderde hanpenrui.*
(photo G. Camphuysen-Jonker)

Fulmar without primary moult (fully grown, old primaries). *Noordse Stormvogel zonder handpenrui.* (photo G. Camphuysen-Jonker).

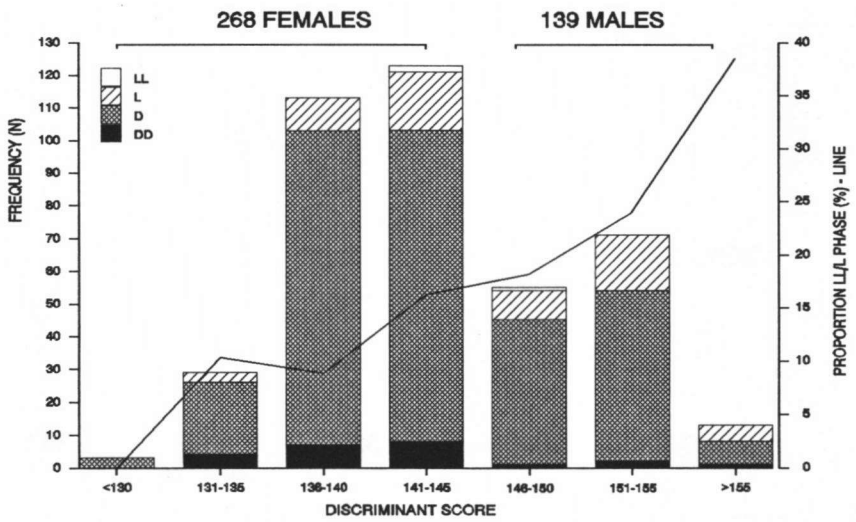

Figure 3. Discriminant scores in 407 Fulmars and the proportion of LL/L phase birds (line, %) for different classes.
Figuur 3. Discriminant scores bij 407 Noordse Stormvogels en het aandeel exemplaren dat als LL of L werd geklassificeerd (lijn, %).

95% of the Fulmars would be sexed correctly. A value of 146.3 was used as a cut-off point between males (larger) and females (smaller). All dissected birds were sexed correctly by this method (4 ♀♀ with discriminant scores ranging from 135.88 to 141.86; 6 ♂♂ with scores from 146.85 to 151.97). It may be concluded that the sexratio in the overall sample (*i.e.* all birds captured) amounted to 1.9 ♀ : 1 ♂, which is significantly different from an expected ratio of 1 ♀ : 1 ♂ ($\chi^2 = 20.98$, df=1, $p < 0.001$). Considering the fact that lighter birds occurred more frequently in individuals sexed as males (figure 3), it may be concluded that the data are biased towards darker females.

Primary moult, wing span and wing surface area

The proportion of birds moulting primaries increased during the the season (figure 2), and this was interpreted as an increase in visiting non-breeders to the colonies plus an increase in failed breeders still visiting the breeding sites. This suggestion was confirmed by the observation that substantial food loads, obviously meant to feed a chick, were exclusively found in non-moul-

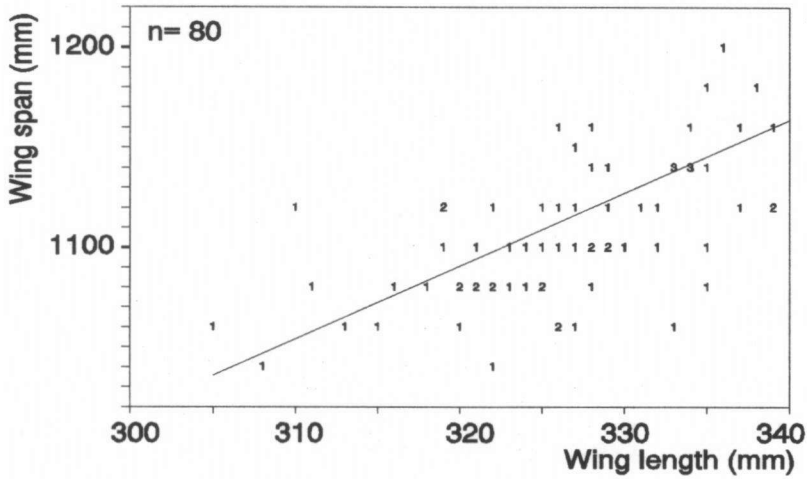

Figure 4. Relationship between wing-length (mm) and wing span from 80 Fulmars measured on Svalbard, summer 1990. Figures indicate frequencies of certain combinations.

Figuur 4. Relatie tussen vleugellengte en spanwijdte, gebaseerd op metingen aan 80 Noordse Stormvogels op Spitsbergen, zomer 1990. De getallen geven de frequentie van het voorkomen van bepaalde combinaties weer.

ting individuals heading towards the colonies throughout the season (Camphuysen *unpubl. data*). Non-moulting individuals, presumably all breeding birds, were separated from moulting birds to provide biometrics for the adult Fulmar population on Svalbard (table 1).

Flight energetics can be calculated on the basis of a number of parameters, of which weight, wing span and surface area are the most important (Pennycuick 1989). Weight is a parameter which is usually readily available in literature, whereas wing span and surface are often not available. The wing span of 80 Fulmars was measured according to methods described by Pennycuick (1989) and compared with ordinary wing length (flattened, straightened wing). It appeared that wing span of Svalbard Fulmars can be estimated on the basis of wing length using the following formula:

$$\text{wing span} = (3.66 * \text{wing length}) - 79.33$$

The surface area of non-moulting Fulmars was measured twice. A bird with a span of 1180 mm was found to have a surface of 0.1203 m^2, a second indi-

vidual with a span of 1100 mm had a surface of 0.1134 m². The former bird, a ♂ with a weight of 860 g, must be considered rather large for Svalbard Fulmars, the latter, a large ♀ with a weight of 655 g bird is more typical for a 'medium sized' representative from this population.

Discussion

Pennycuick & Webbe (1959) observed breeding Fulmars on or near ledges in Svalbard and estimated the fraction of light phase birds (LL) at 0.2% for sitting individuals (n= 5352) and 0.7% for flying birds (n= 148), which is in the same order of magnitude as described from our recent catches. His fractions of L (5.0/16.2%), D (85.1/73.0%), and DD (9.7/10.1%) are also quite similar, considering the fact that varying light conditions may have influenced his distant observations. Both studies lead to the conclusion that around 99.5% of the Fulmars on Svalbard are 'coloured' birds. The data now presented suggest that pale (LL and L phase) individuals occur more frequently in males than in females.

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Samenvatting

Tijdens de zomers van 1988-90 werden 411 Noordse Stormvogels gevangen op Spitsbergen voor een dieet onderzoek. De vogels werden gemeten en hun kleed werd beschreven. Omdat grote sets biometrische gegevens van afgelegen populaties zoals deze zelden beschikbaar zijn in de literatuur werd besloten de gegevens hier te publiceren. In aanvulling op de 'normale' biometrische gegevens werden maten verzameld aan de hand waarvan berekeningen van de energiehuishouding van deze vogels in vlucht uitgevoerd kunnen worden (spanwijdte en vleugeloppervlakte). De vogels werden gesexed door middel van een discriminant analyse en het resultaat kon worden bevestigd aan de hand van een tiental inwendig onderzochte exemplaren. Opvallend was dat lichte exemplaren (LL) en zwak 'gekleurde' vogels (L) gemiddeld groter waren dan donkere 'gekleurde' (D en DD) Noordse Stormvogels. Onder de tijdens dit onderzoek gevangen vogels waren 1.9 maal meer wijfjes dan mannetjes en 99.3% kon worden gerekend tot 'gekleurde' vogels.

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Measuring the tarsus of a Fulmar, Kongsfjorden, Svalbard, summer 1988. The dark 'mask' of this bird is caused by stomach oil disrupting the feathers of the head. *Het meten van de tarsus bij een Noordse Stormvogel, Kongsfjorden, Spitsbergen, zomer 1988. Het donkere 'masker' werd veroorzaakt door maagolie die de kopveren hebben doordrenkt.* (photo G. Camphuysen-Jonker)