DWARF EGGS OF HERRING GULLS *LARUS ARGENTATUS* AND LESSER BLACK-BACKED GULLS *L. FUSCUS* AT TEXEL, 2006-2020

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SUMMARY – Inspired by the observations of Kees Swennen on the occurrence of dwarf eggs in a particular cohort of Eider ducks during his years of studies on Vlieland, I investigated the occurrence of dwarf eggs in Herring Gulls and Lesser Black-backed Gulls on Texel based on a series of fifteen years of observation (2006-2020). Dwarf eggs (<50 cc) were found to be seven times more common in Herring Gulls (0.57%, n=2831) than in Lesser Black-backed Gulls (0.08%, n=3724), without any obvious explanation. Almost every year, one or a few dwarf eggs were found in Herring Gulls, always in nests in which some eggs of normal size. Neither the age nor the breeding experience of the females played any role as far as could be ascertained, and insofar the females were marked with colour rings and could be followed for several years, they were not sterile. The dwarf eggs are seen as accidental and as temporary disruptions to the-proper functioning of the sexual organs.

Dwarf eggs, or runt eggs as they are often referred to, are usually produced by a temporary disturbance to the reproductive organs, while some eggs are laid by birds with permanent abnormalities (Pearl & Curtis 1916). Dwarf eggs do not develop and their yolks are generally abnormal or missing. Although reported in many species, dwarf eggs are of uniformly low incidence, suggesting that the disturbances responsible for the production of a dwarf egg are accidental, occur rarely in most or all species, and are probably not affected by nutritional or behavioural factors (Koenig 1980a). As part of a long-term study of the reproductive success of Herring Gulls *Larus argentatus* and Lesser Black-backed Gulls *L. fuscus* in a large mixed colony at Texel, we measured the hatching success of hundreds of eggs of either species, for fifteen seasons in a row (2006-2020). Exceptionally small eggs were encountered occasionally, and most these eggs were collected after it became clear that they wouldn't hatch. Inspired by the work of Swennen (2020), published here in *SULA* simultaneously, I examined how frequent dwarf eggs were encountered, how (dis-)similar frequencies were between the two species, and whether clusters of egg deformities could be found, which could perhaps also be linked to particular cohorts or to individual gulls.

METHODS

This study was carried out in part of a large mixed colony of Lesser Black-backed Gulls (LBBG) and Herring Gulls (HG), in the Kelderhuispolder on Texel (Frisian Wadden Sea islands, The Netherlands 53°00'N, 4°43'E). Within the colony at large, approximately 11,500 pairs of Lesser Black-backed Gulls and just over 5000 pairs of Herring Gulls breed. Ecological data were collected from April to August, 2006-2020. Prior to egg-laying the colony was visited with increasing frequency until the first eggs were found in nests along a preset trail leading through the prime breeding habitats. Data on timing, clutch size and hatching success were collected annually from c. 75-100 marked nests in each species (52-96 HG nests, 63-120 LBBG nests). Only nests marked along the preset trail were used as the unbiased dataset to monitor the various breeding parameters (a randomly chosen subset of nests was subsequently followed until failure or fledging). During 2006-2020, a total of 2632 nests were marked (1144 HG, 1488 LBBG) of which 2415 were within the actual monitoring program found along the preset trail, meant to be followed from

box 1 – dwarf eggs

The production of eggs considerably smaller than normal has been reported in various birds, but has been well documented only for domestic fowl. Such eggs have been described as 'witch eggs', 'cock eggs', 'dwarf eggs', 'runt eggs' and 'wind eggs' – the latter term also being applied to infertile eggs (Rookledge & Heald 1966). The causes of dwarf egg production are relatively unknown, though they are almost certainly various (Mulvihill 1987). According to Ingersoll (1910), dwarf eggs are commonly infertile, but a yolk may be present, sometimes much reduced in quantity and only occasionally entirely lacking. Apart from a yolk, dwarf eggs frequently lack the normal complement of embryonic membranes (Pearl & Curtis 1916). Nonetheless, internal distinctions between normal and dwarf eggs are not consistent (Pearl & Curtis 1916, Koenig 1980b). Thus, dwarf eggs must be operationally defined as eggs which are 'abnormally' small and which are not expected to hatch because of some internal abnormality. To consistently identify dwarf eggs, cut off values based on egg size must be determined for each species. Koenig (1980b) used absolute size (length and width) to distinguish dwarf eggs from 'normal' eggs in woodpeckers: a size cut-off at 3.10 SD below the mean, because in a normal curve 0.1% of the values fall at over 3.10 SD below the mean. For future studies, when abnormal eggs are found, details such as the size and weight of the egg (also the sizes and weights of any normal eggs in the clutch), position of the abnormal egg in the laying sequence, the size of clutches containing abnormal eggs, and the age of females laying such eggs, would improve the overall analysis (Mulvihill 1987).

figure 1. Dwarf egg of a Herring Gull (left; nest ZM977, egg dimensions 40.2 x 32.3 mm, volume 21.0 cc) in comparison with an egg of average dimensions (right; nest ZM656, 70.0 x 48.0 mm, 81.2 cc), Kelderhuispolder, Texel. Foto C.J. Camphuysen. *Dwergei van zilvermeeuw (links; nest ZM977, afmetingen 40,2 x 32,3 mm, volume 21,0 cc) vergeleken met een gemiddeld ei (nest ZM656, 70,0 x 48., mm, 81,,2 cc). Kelderhuispolder, Texel.*

laying to hatching (1040 HG, 1375 LBBG). The 'extra' nests were selected for various reasons, such as for birds that were geared up with GPS loggers, for known (marked) individuals birds nesting away from the study plots, or (occasionally) for abnormal clutches (a potentially biased dataset in other words). The entire dataset held 6859 eggs (2997 HG, 3862 LBBG), while the nests selected for monitoring held 6552 eggs (2830 HG, 3722 LBBG). While all eggs found were checked for abnormalities, the frequency of occurrence of dwarf eggs was calculated on the basis of the 2415 nests selected for monitoring, the smaller subset (Table 1). All dwarf eggs found are listed in Table 2. The length (L) and breadth (B; long and short axes) of the eggs were measured in the field when first encountered, using a sliding caliper with an accuracy of 0.1 mm. Volumes (V) were calculated as $V = kLB^2$ (Barth 1968, Hoyt 1979), where the constant k was 0.5035 following Spaans & Spaans (1975). A three day rhythm in nest visits made that the laying sequence (A, B, or C eggs) was known for many of the eggs found in which case the eggs were marked accordingly. Nests were monitored every third day, until the eggs in all marked nests either died, were predated, or successfully hatched.

RESULTS

DWARF EGGS – Obviously, whether or not 'small eggs' would qualify as genuine dwarf eggs depends on the overall size distribution of 'normal' eggs produced. Koenig (1980b), from a woodpecker study, proposed that dwarf eggs are any eggs smaller than 3.10 standard deviation (SD) below the mean size of eggs of that species (box 1). That criterion would lead to dwarf eggs in Herring Gulls (mean egg volume 81.5 ± 8.1 cc, n=2970) being any egg <56.5 cc, and in Lesser Black-backed Gulls (73.0 ± 6.5cc, n=3871) any egg <52.8 cc. When plotting frequency distributions of egg volumes of either species, however, this cut-off is fairly arbitrary (figure 2). Egg volumes in both species are normally distributed as could be expected, but unusually small eggs in both species were found and these were all well below 50 cc in volume. Following this rule, sixteen eggs of Herring Gulls could be labelled as dwarf eggs (frequency of occurrence 0.57%, n=2831; table 1), while only three eggs of Lesser Black-backed Gulls would qualify as such (FO 0.08%, n=3724; table 1). Hence, dwarf eggs occurred seven times more frequently in Herring Gulls than in Lesser Black-backed Gulls. Within the total dataset, two more dwarf eggs for Herring Gulls were recorded, which would lead to a frequency of occurrence of 0.6% (no change in Lesser Black-backed Gulls; appendix 1).

The dwarf eggs found at Texel were recorded as 'dead' when the normal 27-28 days of incubation period was exceeded by at least a week, and most these eggs were 'rambling' when rocked (dried contents). The eggs were collected but the presence of a yolk was not investigated. None of the Herring Gull dwarf eggs hatched, one was predated and in one extra nest the success remained unknown (figure 3, appendix 1). The largest 'dwarf' egg in the Lesser Black-backed Gull was in fact of 'normal' length (64.7

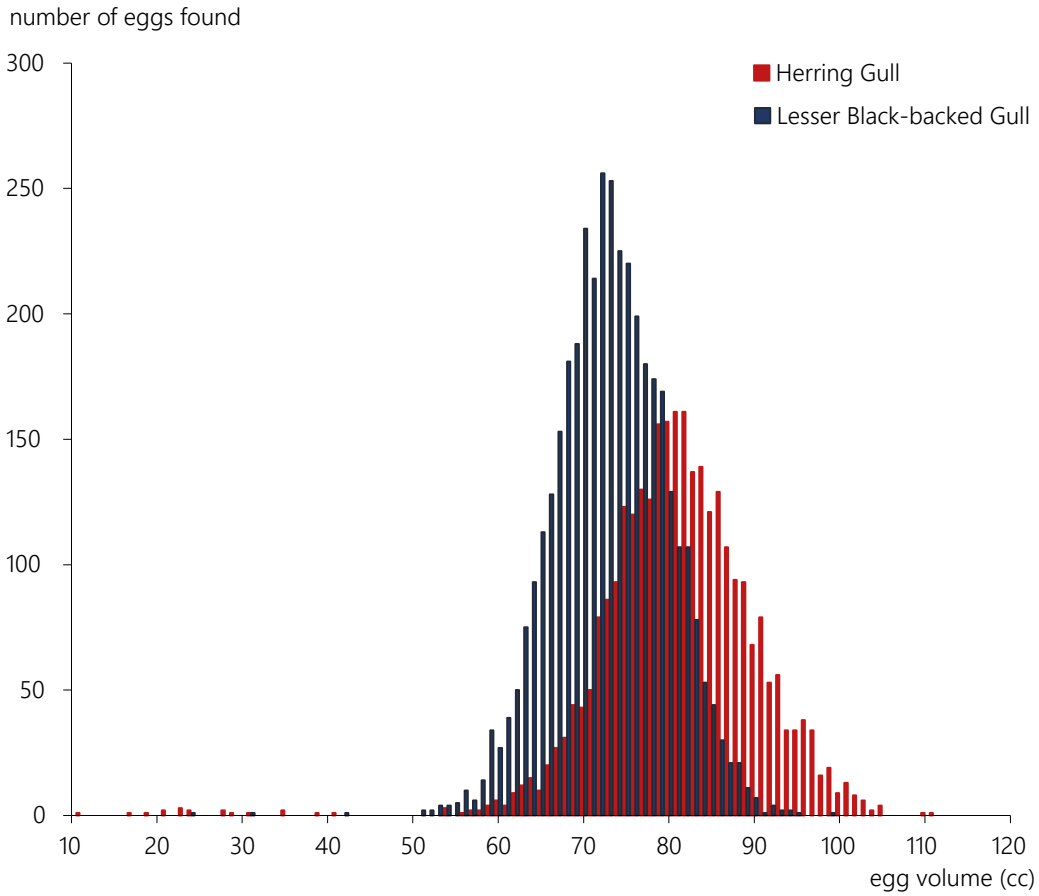

figure 2. Egg size (volume, cc) of the eggs of Herring Gulls (n= 2970) and Lesser Black-backed Gulls (n= 3871), Kelderhuispolder, Texel, 2006-2020 (n=2988).

Maten van eieren (volume, cc) van zilvermeeuwen (n=2970) en kleine mantelmeeuwen (n=3871) in de Kelderhuispolder op Texel, 2006-2020 (n=2988).

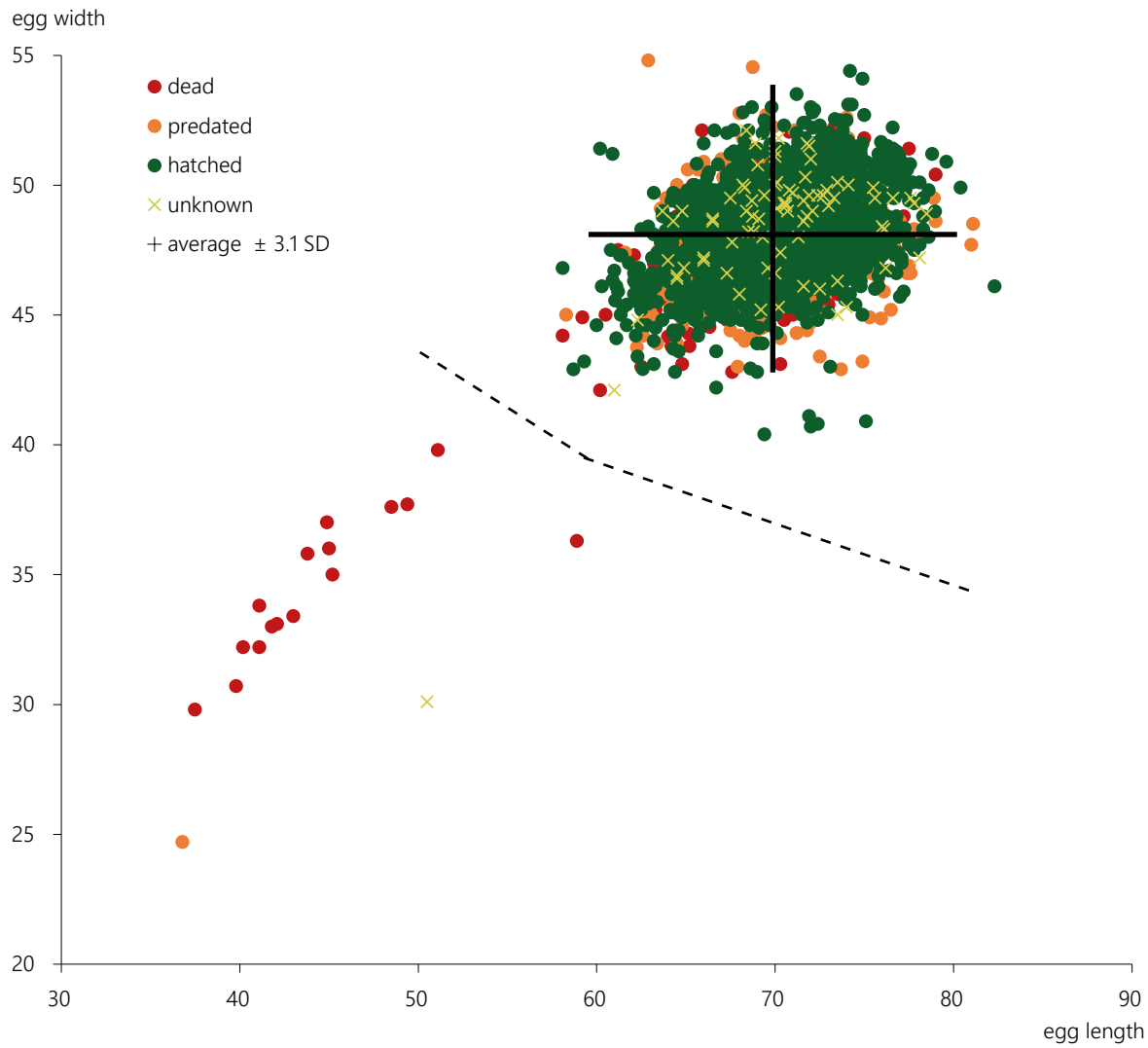

figure 3. Egg size (length x width, mm) of the Herring Gull, Kelderhuispolder, Texel, 2006-2020 (n= 2988), including hatching success or known failures, and the average size ± 3.1 standard deviation (black cross) for any eggs larger than 50 cc (see text). For the purpose of the present analysis, only 18 eggs qualified as 'dwarf eggs' (16 of which found in clutches within the monitoring program), *i.e.* all eggs <50 cc and in fact all genuine outliers are in the graph. All eggs to the NE of the dashed line are >50 cc. Of the dwarf eggs, 16 appeared to be addled (dead, apparently infertile), one was predated before that could be checked and the fate of the remaining egg was unknown.
Eiformaat (lengte x breedte, in mm) van zilvermeeuw in de Kelderhuispolder, Texel, 2006-2020 (n=2988). Uitkomstsucces en gemiddelde afmetingen ± 3,1 standaarddeviatie (zwart kruis) voor eieren <50 cc is ook gegeven. Alle eieren boven de stippellijn zijn groter dan 50 cc. Van de 18 dwergeieren waren er 16 dood/onvruchtbaar en een was gepredeerd voordat dat kon worden vastgesteld. Het lot van het andere ei is onbekend.

mm versus 66.4 ± 2.9 mm for an average egg, or 2.6% shorter), but unusually slender (35.7 versus 46.6 ± 1.5 mm for an average egg, or 23% slimmer, 7.4x SD), leading to an estimated egg volume of only 41.5 cc. This particular egg hatched, one of the other two more typical dwarf eggs died (C-egg, 31.4 cc) while the other became predated (C-egg, 23.7 cc; appendix 1). While excluding the egg that hatched, dwarf eggs of Lesser Black-backed Gulls were on average 62% smaller in volume than the average egg (range 43-68%, n=3871; 56% smaller when the small egg that hatched was included). In Herring Gulls, dwarf eggs were on average 68% smaller in volume than the average egg (range 50-86% smaller, n=2970).

GIANT EGGS – Following Koenig's criterion for dwarf eggs the other way around, any Herring Gull egg over 106.5 cc and any Lesser Backed-backed Gull egg over 93.2 cc could qualify as 'giant' egg. For the

table 1. Occurrence of dwarf eggs (<50 cc) in Herring Gulls and Lesser Black-backed Gulls in monitoring plots in the Kelderhuispolder colony at Texel, 2006-2020. Bottom row: dwarf eggs encountered in all marked nests (see Methods). fo = frequency of occurrence
Dwergeieren (<50 cc) van zilver- en kleine mantelmeeuwen in proefvlakken in de Kelderhuispolder op Texel, 2006-2020. Onderste rij: dwergeieren in alle gemerkte nesten (zie methode). fo = frequentie van voorkomen

	Herring Gull			Lesser Black-backed Gull		
year	**nests**	**eggs**	**dwarf eggs**	**nests**	**eggs**	**dwarf eggs**
2006	42	114		63	186	
2007	57	149		84	233	
2008	74	213	1	98	278	
2009	65	175	1	116	328	
2010	59	167	1	91	256	
2011	56	160	1	98	279	
2012	70	187	2	101	265	
2013	81	223	2	95	241	
2014	83	219	1	94	268	
2015	79	196	1	96	235	1
2016	85	230	2	85	223	
2017	81	221	1	91	228	
2018	58	159		73	199	
2019	78	208	3	95	250	2
2020	72	210		95	255	
total	**1040**	**2831**	**16**	**1375**	**3724**	**3**
fo			**0.57%**			**0.08%**
all nests	**1144**	**2997**	**18**	**1488**	**3862**	**3**
fo			**0.60%**			**0.08%**

former species, only two eggs were that large (110 and 111 cc respectively), for the latter species four eggs fell outside the +3.1 SD range (94, 94, 95, and 99 cc), but in fact none of these eggs were truly exceptional (figure 2). Even the largest of the eggs found in either species were 'only' 36.2% (HG) and 35.6% (LBBG) larger than the mean values reported above, considerably less than the 66.3% difference reported by Swennen (2020), and in fact very close to the next nearest large values within the normally distributed sample (figure 2). They were therefore not considered as 'giant' eggs, but rather as the high end of the distribution given the current sample size.

DWARF EGG SPECIFICATIONS IN HERRING GULLS

Dwarf eggs were so rare in Lesser Black-backed Gulls, that any particular pattern in their frequency is unlikely. In Herring Gulls, however, eighteen specimens were found, and their structural size was highly different from that of the majority of the eggs measured (figure 3, examples in figure 4a-c). For as far as the laying sequence within a clutch was known, three were A-eggs, four were B-eggs and five were C-eggs, and all occurred in clutches with otherwise normal-sized eggs (*e.g.* figure 4a). Dwarf eggs were

Figure 4a. Three-egg clutch (ZM435) of Herring Gull with two normal eggs and one medium-sized dwarf egg, Kelderhuispolder, 9 May 2010. Biometrics: (A) upper left 68.7 x 51.2 mm (90.68 cc), (B) upper right 70.0 x 50.7 mm (90.6 cc), (C) bottom 45.2 x 35.0 mm (27.9 cc). Foto: C.J. Camphuysen

Twee normale eieren en een middelgroot dwergei van zilvermeeuw.

Figure 4b. Two-egg clutch (ZM558) of Herring Gull with one abnormally coloured (blue) egg of normal size and one very small dwarf egg, Kelderhuispolder, 15 May 2011. Biometrics: (A) right 36.8 x 24.7 mm (11.3 cc), (B) left 67.5 x 44.4 mm (67.0 cc). The male bird of this pair, a young recruit (4 cy), was captured and colour-ringed M.APT. Foto: C.J. Camphuysen

Tweelegsel van een zilvermeeuw met een abnormaal gekleurd ei en een zeer klein dwergei.

Figure 4c. Incomplete clutch (ZM977) of Herring Gull with a normal egg and a small dwarf egg, Kelderhuispolder, 27 May 2015. Biometrics: (A) left 69.5 x 52.7 mm (97.2 cc), (B) right 40.2 x 32.2 mm (21.0 cc); the later produced (normal) C-egg (not shown) measured 70.7 x 48.5 mm (83.7 cc). Foto: C.J. Camphuysen

Nog niet voltallig legsel van een zilvermeeuw met een normaal en een klein dwergei.

once found in a full 3-egg relay (five normal eggs produced alongside the dwarf egg by that female), once as an A egg in a nest where four eggs were produced following the predation of the normal sized B-egg, all others were found in nests with a mean clutch size of 2.79 eggs (normal HG clutch size at Texel 2.70 ± 0.1, n=1007). A total of eight colour-ringed females were involved (appendix 1), all of which hatched eggs, either that same season, or in earlier or later years, and at least six of these females were known to have successfully fledged chicks in some years (a total of 9 fledglings). The exact age of none of the females was known, but all produced dwarf eggs when in fully adult plumage (>5cy), and age estimates based on colour-ring histories ranged from >5 calendar year (cy) to >14cy (most >6-8 cy). One female (colour ring F.AWN) produced dwarf eggs in two seasons (2017, 2019) with the same male (K.ABZ), while all other eggs laid hatched. That same male 'experienced' a dwarf egg with an earlier partner (F.ANT) in 2015 and that nesting attempt failed completely. KABZ was a recruit in 2014, possible (not ringed at the time) with that same earlier female F.ANT. Both females fledged young in other years. The only hint that recruits (hence, unexperienced young birds) were involved came from a nest found in 2011, evidently at the periphery of the main colony with poor nest cover, with a male bird in 4 cy plumage (M.APT), and where one dwarf egg and a normal sized bright blue egg were produced (nest ZM558, see figure 4b). Both eggs were predated. There is no information of the plumage of that (unringed) female, unfortunately, and the male bird has never been seen since. In contrast to the material published by Swennen (2020), there is no evidence for a particular cohort or period in which dwarf eggs occurred particularly frequently (table 1). Dwarf eggs occurred virtually annually.

DISCUSSION

The frequency of occurrence of dwarf eggs was low in both gulls, as could be expected from earlier field studies of a large variety of wild birds or domestic fowl (Koenig 1980a, Mallory *et al.* 2004, Mulvihill 1987, Pearl & Curtis 1916, Rookledge & Heald 1966). Reported frequencies of occurrence in large samples of waterfowl ranged from 0.02% (diving ducks) to 0.05% (swans and geese; Mallory *et al.* 2004). Rather higher frequencies were reported for North American woodpeckers (0.54%), and particularly high frequencies (4%) were reported for the communally nesting Acorn Woodpecker *Melanerpes formicivorus* (Koenig 1980a). The frequency of occurrence of dwarf eggs in Lesser Black-backed Gulls (0.08%) on Texel was in line with levels found in the large study of Anatidae, even if the clutch containing one small egg that hatched was eliminated from the dataset (0.05%). The frequency found for Herring Gulls (0.57%) was comparatively high. That dwarf eggs occurred seven times more frequently in Herring Gulls than in Lesser Black-backed Gulls is something we could only speculate about.

Eijkelenboom (2012) reported the find of three dwarf eggs (recalculated volumes 18.0, 20.1, and 27.8 cc) in a colony of Lesser Black-backed Gulls in 2010 and concludes that dwarf eggs are 'therefore' apparently not rare. In the absence of the total number of eggs examined, it is impossible to calculate the frequency of occurrence. Four further finds were mentioned in the same paper, following a personal communication of R.J. Buijs, all in Lesser Black-backed Gulls (2004-2009).

Brouwer (1928) discussed the occurrence of dwarf eggs in Herring Gulls following his find of four dwarfs (recalculated volumes 26.7, 26.9, 31.1, and 42.7 cc) in 521 nests at Schiermonnikoog in 1926. Assuming a similar clutch size as we find today (2.7 eggs nest-1), this would mean a frequency of occurrence of ~0.36%. One particularly large egg was found in the same colony (89.5 x ~50 mm; the egg was pipping when found), 'a bit larger than de maximum size reported in literature', without referring to it as a giant egg. With a volume of ~112.7 cc, this is indeed a very large egg, although only marginally larger than the upper extremes found at Texel (110-111 cc; figure 2). An egg length of nearly 9 cm is, however,

indeed quite exceptional (maximum lengths at Texel 81.0, 81.1, and 82.3 mm). Leege (1911-1915) reports dwarf eggs in a Herring Gull colony almost every single year (as on Texel nowadays), but without actual counts a frequency of occurrence is difficult to calculate.

The production of a normal egg requires the correct functioning of the avian reproductive tract. When part of this system is temporarily or permanently impaired, aberrations in normal egg formation may result (Romanoff & Romanoff 1949 in Mallory *et al.* 2004). Pearl & Curtis (1916) reported that, physiologically, dwarf eggs in domestic fowl were often produced following a temporary disturbance to the reproductive organs; only a minority of the eggs were laid by birds with permanent abnormalities. Our results corroborate that suggestion: in all cases where females could be followed, dwarf eggs were produced as 'incidents', and there were no indications that any of the birds were (permanently) sterile. Also, there was no indication that more recruits (perhaps sexually immature birds) were involved than 'experienced' or at least returning breeders; chick production of the known females was even slightly above average when overseeing colony results over the entire study period (0.72 ± 0.3 fledglings pair-1, n=15).

In the absence of particular clusters of events, this being a single individual or a particular cohort of birds, the production of dwarf eggs in the Herring Gull colonies at Texel must be seen as 'accidental', fairly frequent, without a common (environmental) cause.

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appendix

Small eggs in Herring Gulls and Lesser Black-backed Gulls that qualified as 'dwarf eggs' according to the <50 cc criterium. Shown are species, nest, year, overall clutch size, laying sequence (where known), egg length and width (mm), egg volume (cc), whether or not the egg hatched or was predated, any known parents (colour ring codes) and remarks. 'Extra nests' were dwarf eggs encountered outside the normal monitoring routines (see Methods).

species	nest	year	clutch	egg[1]	length	width	volume	fate	male	female	remarks
HG	ZM999	2007	2	B	42.1	33.1	23.2	dead			extra nest
HG	ZM234	2008	3	1/2	44.9	37.0	31.0	dead			
HG	ZM302	2009	3	C	43.8	35.8	28.3	dead			
HG	ZM435	2010	3	C	45.2	35.0	27.9	dead		FAHV	
HG	Anon11	2011	3	1/3	50.5	30.1	23.0	unknown			extra nest
HG	ZM558	2011	2	A	36.8	24.7	11.3	predated	MAPT		
HG	ZM607	2012	4	A	41.8	33.0	22.9	dead			
HG	ZM660	2012	2	1/2	58.9	36.3	39.1	dead	MANW		
HG	ZM705	2013	6	1/6	48.5	37.6	34.5	dead	MAKV		relaid 3 eggs
HG	ZM751	2013	2	B	49.4	37.7	35.4	dead			
HG	ZM856	2014	3	C	43.0	33.4	24.2	dead	MARF	FANR	
HG	ZM977	2015	3	B	40.2	32.2	21.0	dead	KABZ	FANT	
HG	ZM1016	2016	3	1/2	37.5	29.8	16.8	dead	MARC	FASC	
HG	ZM1044	2016	3	1/3	39.8	30.7	18.9	dead	MALN	FAWX	
HG	ZM1168	2017	3	C	41.1	33.8	23.6	dead	KABZ	FAWN	
HG	ZM1312	2019	3	C	41.1	32.2	21.5	dead	MASC	FAWU	
HG	ZM1352	2019	2	B	45.0	36.0	29.4	dead	KABZ	FAWN	
HG	ZM1363	2019	3	A	51.1	39.8	40.8	dead	MAWH	FBCF	
average					44.5	33.8	26.3				
SD					5.5	3.6	7.8				
min					36.8	24.7	11.3				
max					58.9	39.8	40.8				
LBBG	KLM1310	2019	3	C	41.9	38.6	31.433	dead	MASF		
LBBG	KLM1372	2019	3	1/3	64.7	35.7	41.518	hatched	MAMZ		
LBBG	KLM926	2015	3	C	42	33.5	23.732	predated			
average					49.5	35.9	32.2				
SD					13.1	2.6	8.9				
min					41.9	33.5	23.7				
max					64.7	38.6	41.5				

[1] Laying sequence as A, B, or C egg, and where unknown *e.g.* 1/3 (one egg out of 3 laid so far, etc.).

SAMENVATTING – DWERGEIEREN BIJ ZILVERMEEUWEN EN KLEINE MANTELMEEUWEN OP TEXEL IN 2006-2020

Geïnspireerd door de waarnemingen van Kees Swennen over het voorkomen van dwergeieren bij een bepaald cohort eiders gedurende zijn jarenlange studies op Vlieland, is het voorkomen van dwergeieren bij zilvermeeuwen en kleine mantelmeeuwen op Texel onderzocht op basis van een vijftien jaar lange waarnemingenserie (2006-2020). Dwergeieren (<50 cc, figuren 2-3) bleken zeven keer vaker voor te komen bij zilvermeeuwen (0,57%, n=2831) dan bij kleine mantelmeeuwen (0,08%, n=3724), zonder dat er een voor de hand liggende verklaring kon worden gegeven voor dit verschil. Bij zilvermeeuwen zijn bijna jaarlijks een of enkele dwergeieren gevonden, altijd in nesten waarin ook eieren van 'normale' afmetingen lagen. De leeftijd noch de broedervaring van de vrouwtjes speelde voor zover kon worden nagegaan een rol en voor zover de vrouwtjes met kleurringen gemerkt waren (appendix 1) en meerdere jaren konden worden gevolgd, bleken zij beslist niet steriel te zijn. De dwergeieren worden daarom gezien als toevallige en in elk geval tijdelijke verstoringen van de werking van de geslachtsorganen.

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