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Variations in length and breadth of eggs from a colony of black-headed gulls (*Larus r. ridibundus* Linnaeus) on the island of Texel *).

by

P. J. H. VAN BREE

INTRODUCTION.

In a previous paper (VAN BREE, 1952) I reported on variations in length and breadth of the eggs of black-headed gulls from a large colony on the island of Texel, the southernmost of the North Sea-islands of the Netherlands. The notes collected in that paper concerned 855 eggs picked up on June 13 1950. In the next two years I continued to measure the eggs from the same colony at approximately the same date. By the flood and ensuing disaster of February 1953 the situation of the breeding place was radically changed, and it would have been of little use to continue studying the eggs picked up in this place. Therefore I have now collected my notes for publication, even though the study is not finished and many problems remain waiting for a solution. However, so little is known about variation in length and breadth and connected matters of eggs of non-domestic birds, that I feel justified in publishing the findings of a not completed investigation.

THE COLONY.

Towards the North-East of the island of Texel, outside the dike, extensive mud and sand flats are found. These flats and the polder behind the dike are known under the same name "de Eendracht". The greater part of these flats is flooded at high tide, but small parts grown over with vascular plants keep dry during these periods. At spring tides stretches of the higher parts are also flooded, and, during storms, the flats are completely submerged.

Figure 1 shows an aerial view of the area in question. The straight line at an angle is the aforementioned dike. On the underside of the picture are cultivated fields in the polder; above the line are the flats on which the gull-colony is situated. Tidal streams are seen running

*) Received June 16, 1956.

FIGURE 1. Aerial view of the flats outside the dike of polder "de Eendracht" on the island of Texel.
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between the dry parts of the flats. The difference in height of the flats is also visible in the picture. The lower parts (dark grey) flooded during spring tides are called A, the higher parts (white) are called B. The areas differ not only in height, but also in the kind of plant-growth.

In area A the following plants have been found: *Salicornia europaea* L., *Spartina maritima* Fern., *Puccinellia maritima* Parl., *Obione pedunculata* Moq., and *Atriplex maritima* Grufb. The soil of this area is mostly blue-black coloured from pyrite and a large part of the soil is silt and mud.

In area B the following plant species have been found: *Limonium vulgare* Mill., *Artemisia maritima* L., *Obione portulacoides* Moq., *Juncus Gerardi* Loisl., *Glaux maritima* L., *Carax extensa* Good. and *Armeria maritima* Willd. Here the colour of the soil is mostly red-brown from oxydized iron. In this area there is more sand and less mud and silt than in the former one. The highest parts of this territory are a kind of ridges, and consist almost entirely of pure sand mixed with large numbers of shells.

All the flats under discussion are a sanctuary protected by the Society for Promotion of Nature Reserves in the Netherlands (Vereeniging tot Behoud van Natuurmonumenten in Nederland). This owing to its importance, not only as one of the largest colonies of black-headed gulls in the Netherlands, but also as a breeding place of many other, often rare, species of water and wading birds.

Black-headed gulls were found breeding all over the two areas in question. Furthermore there were arctic terns (*Sterna macrura*) and mallards (*Anas platyrhyncha*). Other bird species had a special preference for the site of their nests. Sandwich terns (*Sterna sandvicensis*), common terns (*Sterna hirundo*), oyster-catchers (*Haematopus ostrale-*

gus) and kentish plovers (*Charadrius alexandrinus*) preferred the higher parts of the flats, this is area B. Lapwings (*Vanellus vanellus*), avocets (*Recurvirostra avocetta*), common redshanks (*Tringa totanus*) and black-tailed godwits (*Limosa limosa*) were breeding in area A. In addition the little tern (*Sterna albifrons*) is a rare breeding species.

It is estimated that on the flats of "de Eendracht" during the years of investigation between 10.000 and 15.000 pairs of black-headed gulls were breeding. The breeding season of the black-headed gull generally seems to start here about 5—6 of May and closes towards the beginning of August. Hence, on the flats of "de Eendracht" breeding starts much later than is the rule in Great Britain (see notes in FISHER, 1947), where it is the beginning of April.

The wardens of this bird sanctuary have strict orders to keep down any further increase of black-headed gulls in their territory in order to prevent these gulls to become a nuisance or even a pest. Black-headed gulls are known here to destroy the nests of sandwich terns and other birds. A method employed for regulation of the number of breeding gulls is to pick up and collect their eggs systematically and throughout a long

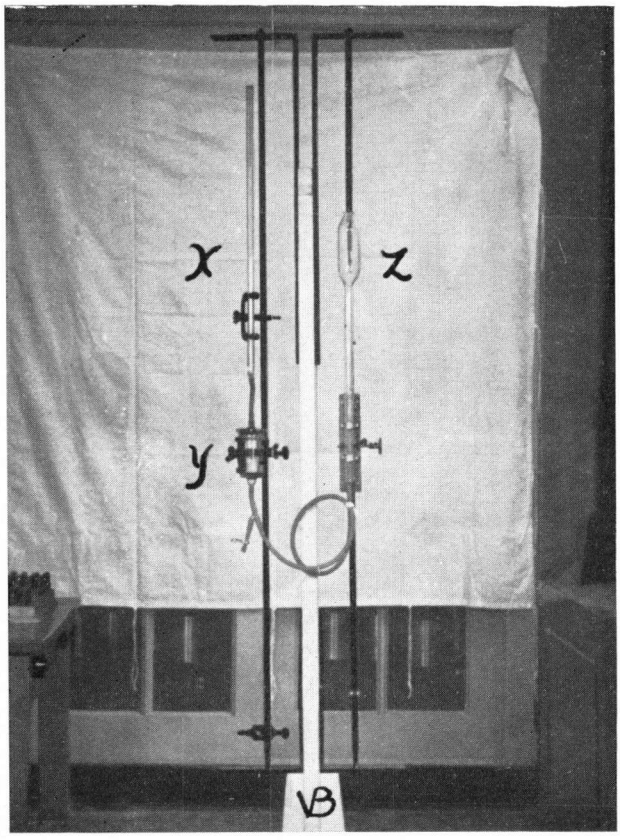

FIGURE 2. Apparatus for checking the volume of eggs. The egg, whose volume is to be ascertained, is put into container *y*. The use of the apparatus is described in the text (p. 248).

TABLE 1. Number of eggs collected in 1950, 1951 and 1952 from a colony of black-headed gulls on the island of Texel.

Year	Area	Nests with 2 eggs	Nests with 3 eggs	Number of eggs measured
1950	A + B	?	?	855
1951	A	31	31	155
1952	B	33	32	162
1952	A + B	25	8	74
Total		89 + ?	71 + ?	1246

period. Through this circumstance I have had the opportunity to use the eggs of this species in such large numbers as required for this study.

METHODS USED.

In 1950 eggs were picked up at random from the two territories, called area A and area B. Beforehand a definite route had been mapped out, where all eggs encountered were collected indiscriminately. In 1951 I started to make a distinction between the areas A and B, and the eggs from each area were kept separate. In the third year collecting took place in an even more detailed way, as the contents of each nest were put into a separate paper bag.

Length and breadth of each egg were measured with callipers to tenths of millimeters. I assumed a cross-section of an egg, taken at the place of its greatest breadth, to be a circle. All eggs were measured right after each collecting trip to the flats. This was done behind the dike in a little wooden shed, a shelter for the wardens of the sanctuary. In 1952 the eggs were sent to Amsterdam for fixing the volumes, after length and breadth had been taken in the field.

The volume of the eggs was established in the apparatus shown in figure 2. The apparatus consists of a large glass tubular container z, which is connected by means of a rubber tube to the bottom of an air-tight container y, with a ground perforated lid from which a rubber tube runs to a fixed calibrated glass tube x. On tube x the calibration shows differences of one tenth of a cubic centimeter. In measuring an egg, water is poured into the apparatus until it reaches the zero mark of tube x. This is done while there is still no egg in container y. The level of the fluid in z is marked down on the glass wall. Then part z is lowered until the level of the water is below the bottom of container y. The lid is taken off, the egg inserted, and the lid closed. Then, part z is moved upwards till the fluid has reached the starting level marked on the glass wall of z.

The volume of the egg can then be found by checking the level of the water in the calibrated tube x. Measuring the volume of eggs in this way is very easy and accurate; eggs lighter then water can also easely be ascertained. The volume of blownout eggs from collections, after the hole or holes in the eggshells have been closed with very thin tape, are also measurable in this apparatus.

The total number of eggs collected in 1950, 1951 and 1952 is 1246. They are summarized in Table 1. Of 57 eggs collected in 1952 volumes have been measured.

PROBLEMS.

The eggs were collected to get an answer to the following questions, relating to size variation. Originally attention was drawn to the first few questions only. Later on, while working, the others arose.

1. Can it be supposed that the simultaneous distribution of the lengths and breadths of eggs of the black-headed gull is normal ?

2. Are the variances of the measurements of the eggs within the nests significantly smaller than the variances of the same measurements of all eggs considered as one sample ?

3. Is there a significant difference between the measurements of the eggs from nests with two eggs and from nests with three eggs ?

4. Is there a significant correlation between length and breadth of the eggs under discussion ?

5. Are there significant differences between the measurements of the eggs collected from different areas in 1951 ?

6. Are there significant differences between the measurements of eggs picked up in different years ?

7. Is there a significant correlation between the proportion of length and breadth of the eggs and their volume ?

8. Supposing that the first laid egg of a cluster has a more elongated shape than the eggs laid later, can there be found a confirmation of this theory from the collected material ?

RESULTS.

The results to be stated here are mainly the outcome of the statistical analysis of the collected material of measurements and volumes of the eggs of *Larus ridibundus* by Messrs. PH. VAN ELTEREN and J. F. HAASTRECHT, research-fellows of the Statistical Department of the Mathematical Centre of Amsterdam (Head of the Statistical Department, Prof. Dr D. VAN DANTZIG ; Chief of Statistical Consultation, Prof. Dr J. HEMELRIJK).

The first year I was able to analyse the material myself. Later on, however, when the object of the study became more complicated, my knowledge of intricate statistical methods proved insufficient. I am very glad that a grant from the Organization for the Furtherance of Pure Scientific Research (Nederlandse Organisatie voor Zuiver Wetenschappelijk Onderzoek) enabled the two statisticians aforementioned to make statistical researches of the material. I am greatly indebted to Messrs. VAN ELTEREN and HAASTRECHT, since, but for their help, I never could have compiled the present study.

The mathematical outcome of the analysis has been published in an extensive report (Report Nr S.118 of the Mathematical Centre of Amsterdam). In this report the applied tests are described, and to each chapter a list of consulted literature is annexed. Here I shall cite only the results and the definite answers given to my questions stated in the previous chapter.

1. For the simultaneous distribution of breadth and length no significant deviation from a two-dimensional normal distribution has been found. The distribution of b (breadth) and l (length), taken separately, may therefore be considered as approximately normal. Likewise for the distribution of b/l no significant deviations from normality have been found.

2. Within the nests the variances of b, l, and b/l appear to be significantly smaller than the variances of the same variables over the egg collections (1951 A, 1951 B and 1952) taken as a whole. Therefore the eggs from one nest can not be considered as a random sample from the collection.

3. Eggs from nests of two are significantly *longer* than eggs from nests of three. This may account for the fact that the egg index (b/l) is significantly smaller for eggs from nests of two than from eggs from nests of three, for in respect of breadth no significant difference was found. Likewise the volumina of eggs from nests of two did not significantly differ from those of eggs from nests of three.

4. Between length and breadth of the eggs a systematic positive correlation does exist; this correlation does not reach the same height in the different constituent groups of the collection. For eggs from nests of three it is significantly higher than for eggs from nests of two, and for the year 1952 significantly higher than for collection 1951 B.

5. For the year 1951 the eggs from the higher parts of the flats (area B) are significantly bigger (i.e. both longer and broader) than the eggs from the lower parts (area A).

6. Between the measurements of the 1951 and the 1952 eggs no significant difference could be found.

7. Considering the collection from nests of two eggs of 1952 it has been established that the egg with the larger volume systematically also has the larger egg index (b/l). For eggs from nests of three a similar fact could not be established, probably on account of the small number of observations concerning such nests.

8. Through the nature of the material it was not possible directly to verify the supposition that the first laid egg from a nest has a smaller egg index than the following ones. However, some phenomena were found that can be explained *inter alia* with this effect.

For the data found and supplied by the statisticians of the Mathematical Centre, see Table 2.

TABLE 2. Mean values of lengths, breadths, breadths/lengths and volumes of eggs of the black-headed gull collected in different years on the island of Texel. Data from Report S.118 of the Mathematical Centre of Amsterdam. (h (2) = number of nests with 2 eggs).

	Year	Mean in mm Nests with 2 eggs	Mean in mm Nests with 3 eggs	h(2)	h(3)	Standard deviation
	1950	36,72		—	—	1,18
b	1951 A	36,70	36,34	31	31	1,19
	1951 B	36,93	36,98	33	32	1,10
	1952	36,92	37,03	25	8	1,14
	1950	51,60		—	—	1,98
l	1951 A	51,26	50,55	31	31	2,16
	1951 B	52,21	51,26	33	32	2,18
	1952	51,72	50,80	25	8	1,75
b/l	1951 A	0,717	0,720	31	31	0,032
	1951 B	0,708	0,722	33	32	0,024
	1952	0,709	0,730	25	8	0,028
		Mean in cm^3	Mean in cm^3			
Vol.	1952	33,39	33,29	19	7	2,59

DISCUSSION.

It is the opinion of the author that measurements and weights of eggs as given in regional ornithological handbooks and even in oological papers in most cases are inadequate. For example: the mean measurements of eggs of Netherlands *Larus ridibundus* differ as much as 52,1 mm × 37,1 mm and 53,4 mm × 37,0 mm; VAN PELT LECHNER (1910—1913), DE VRIES (in EYKMAN c.s. 1937—1949) and HELLEBREKERS (1950). In the first place the authors do not give data about *where* the eggs they weighed and measured had been collected, except that is was done in a rather large region, in this case the Netherlands. Furthermore they do not state *how* the eggs at their disposal had been collected. Knowing a little about the method eggs for oological purposes are generally collected, has made me rather sceptical on that score.

Unfortunately it is almost impossible to gather a sufficiently large number of eggs of a certain bird species without disturbing the population size. Even when collecting in a small area is distributed over a number of years, the difficulty remains that most oologists tend to collect, apart from "normal" eggs, those that are "aberrant" in colour, shape and size. Terms as melanism, erythrism, cyanism, albino eggs, dwarf eggs and giant eggs are of common and wide-spread use in oology.

As I have previously stated (VAN BREE, 1952) it is of no use to speak of giant and dwarf eggs. These eggs fall within the limits of normal size-distribution. All "aberrant" shapes and colorations are pathological results and only as such they may be significant. I do not pretend to say that giving of mean measurements is useless, but while stating them,

one should give as much particulars as possible as to where and how the eggs have been collected. Giving maxima and minima of measurements is, in my opinion, superfluous, unless the available material is absolutely too small to be worked out statistically, but where possible giving the standard deviation is an absolute necessity.

Still, that exact data on mean length and breadth of eggs may in some cases be used as indicative of interesting phenomena, will be discussed in the following paragraphs.

In the introductory chapter on "The Colony" (p. 245) two ecologically different areas have been described. It is noticeable that a difference has also been found in the mean values of length and breadth of the eggs collected in these two areas. See question 5 (p. 249) and the answer thereto (p. 250). The mathematical outcome of the analysis may have the following two biological explanations, which are not to be considered as alternatives.

Firstly: the difference in egg-size may be attributed to two kinds of gulls, for instance old and young birds, the more dominating or experienced ones taking over the most suitable territory, that is the high area B.

Secondly: in the beginning of the breeding season the average dimensions of the eggs are equal in both areas. Then, on account of the fact that many eggs on the low-lying area A are likely to be washed away during spring tides or to be ruined by any other fatal raise of the water-level, the birds nesting in this area start to lay new eggs. This may happen two or three times, resulting in a corresponding smaller average size of the successive eggs. In this connection. Mr. D. BOOT, head warden of the nature reserves on the island of Texel, informed me that the egg size of *Larus ridibundus,* in the course of the nesting time varies as follows. At first size increases, but afterwards the eggs grow smaller, so that at the end of the breeding season the eggs are considerably smaller than in the beginning. Confirmation of this observation may be found in ROMANOFF & ROMANOFF (1948).

A primary increase in size seems to be a general trend, not only in *Larus ridibundus* but in many other bird species as well. See figure 3, in which is pictured the increase of length and breadth of eggs of a certain population of mallards (*Anas platyrhynchus*). Unfortunately, I have no material at my disposal to show the decrease in size, therefore I must depend on the notes of the aforementioned authors. I have discussed the second possibility more exhaustively because I think it is the more probable one, but, of course, there is no proof of it.

A great number of eggs is needed for determining the mean values of length and breadth. See question 2 and answer (p. 250). As a matter of fact this holds true not only for the eggs of *Larus ridibundus,* but for every other bird species.

In my first publication on this subject I tried to explain how breadth does not increase at the same rate as length. This was considered as reasonable on account of the oviduct putting a more restricted limit to the breadth of the egg than to its length. After a certain period, however, the elasticity of the oviduct becomes a less restrictive factor. The volumes of later coming eggs are also smaller (ROMANOFF & ROMANOFF, 1948).

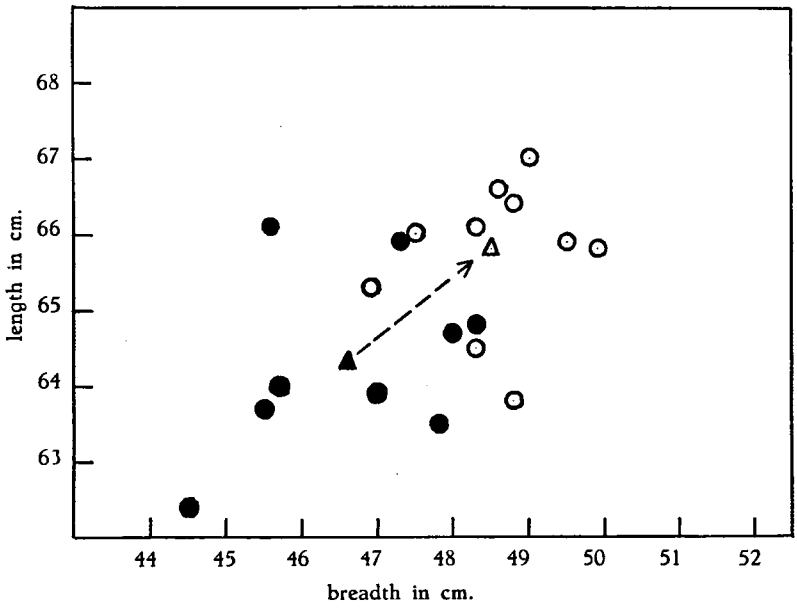

FIGURE 3. Lengths and breadths of eggs of the same population of mallards (*Anas platyrhynchus* L.) laid on 17-III-1952 (●) and on 30-IV-1952 (o). The triangles show the mean length and breadth on each date.

For these suppositions I have tried to find proofs.

Having due regard to the outcome of the mathematical analysis, I think certain tendencies have been indicated that might be considered as proof of my hypotheses, particularly the answers to the questions 3, 7 and 8 (p. 250).

In spite of a noteworthy difference in flowering time of the plants growing on the flats in 1951 and 1952, no difference was found between the measurements of the eggs collected in these years. From data, kindly furnished by the Royal Meteorological Institute of the Netherlands (K.N.M.I.), I have tried to correlate differences in flowering time with differences in weather condition during those years. Unfortunately, due to the complexity of the meteorological material I did not succeed.

It would be interesting to know something about the annual variation in mean length and breadth of eggs collected in this colony or in definite parts of this colony at the same date in successive years. The data given here for 1951 and 1952 are too few to have any significance. Later work on this subject might perhaps clarify this matter.

SUMMARY.

An investigation was made in order to ascertain the mode of variation of length and breadth of eggs of the black-headed gull (*Larus r. ridibundus*) from a colony on the northeastern side of the island of Texel in the Netherlands. The colony can be divided into two ecologically different areas. A difference could be shown in the measurements of eggs collected in these areas. Two possible explanations of this coincidence are given.

Methods of egg collecting and measuring are discussed, and data and tables of the findings during 1950, 1951 and 1952 are furnished. On account of the flood and disaster of 1953 the investigation was broken off before its completion. The fact that mean measurements and weights must be used with due caution is emphasized.

ACKNOWLEDGEMENTS.

First of all I want to thank Prof. Dr H. ENGEL, Director of the Zoological Museum in Amsterdam, and Prof. Dr J. TEN CATE, Director of the Physiological Laboratory of the Municipal University of Amsterdam, for the help and encouragement given.

Besides I want to express my thanks to the Committee of the Society for Promotion of Nature Reserves in the Netherlands for permitting me to do field-work in their bird sanctuary. The assistance given to me by Mr. D. BOOT, head warden of the Society on the island of Texel, has been of great value. The same holds for the help I received from Mr. M. DIJKER, warden on the flats.

I also want to thank Mr. B. M. HILGERSOM, Jr, who made from a schematic drawing a smoothly working apparatus for checking the volume of eggs.

The work done by the Mathematical Centre in Amsterdam has already been referred to.

I am also indebted to Mrs. S. STORM for valuable assistance in translating the results of this study into english.

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