ESTIMATING THE POPULATION SIZE OF BREEDING GREYLAG GEESE *ANSER ANSER* BASED ON VERTICAL AERIAL PHOTOGRAPHS

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Due to the unreliability of estimating the breeding population of Greylag Geese using ground counts at the nature reserve of Vejlerne, Denmark, vertical aerial photographs were taken in 1994 to estimate the number of nests and incubating geese. Reliability (based on ground truthing) of nest identification from the images was found to be 97 % correct. This gave a total population of 713 nests in the whole reserve compared to 831 (maximum) and 623 (minimum) pairs based on ground counts. The vertical aerial photographs provided excellent images of the incubating geese in homogeneous reedbeds, as occur at Vejlerne. The method is valuable for the long-term monitoring of breeding Greylag Geese in reedbeds due to the precise location of nests.

Keywords: Vertical Aerial Photographs, Greylag Geese, Estimating Breeding Population

Greylag Geese *Anser anser* were first recorded breeding in Vejlerne nature reserve, Denmark, in 1924-25 (Møller 1980). The population has since increased and is today the largest in the country (Olsen 1992); 623-831 pairs were recorded 1994 (Kjeldsen 1995). The numbers and distribution of breeding pairs have been determined every spring since 1978 using the same systematic procedure (eg Kjeldsen 1992, 1995). Mapping and counting commences when the whole population is considered to have arrived on the reserve. The method relies on the assumption that all breeding pairs are visible on the meadows before they disappear into the reedbed for nest building and subsequent incubation. This method of mapping of breeding pairs has been carried out in some places of Sweden also (Karlsson *et al.* 1982). However, the validity of this census method has been questioned for various reasons (eg Kjeldsen 1992, 1995).

First, breeding pairs are difficult to identify with certainty. Geese gather in flocks on the meadows which may include non-breeding, local birds and transients en route elsewhere. In 1987, birds with Norwegian neck collars were seen for the first time during early spring and geese so identified have been seen spring staging at Vejlerne every year since. Potential breeders are revealed by their behaviour since males aggressively protect the female and her feeding area from other geese (N.O. Preuss, *pers. comm.*). Hence, prolonged observations may produce more potential pairs than brief counts, and the number of breeders may therefore reflect census duration and observer experience. Secondly, in mild springs, the earliest breeding pairs disappear into the reedbed soon after arriving from the wintering grounds and thus may not appear on the distribution maps (eg Kjeldsen 1992, 1995). Under such conditions many pairs will probably never be recorded. In cold springs however, pairs tend to stay much longer on the meadows before disappearing into the reeds.

Mapping of breeding pairs is the only practical way to estimate the population size by means of ground counts because of the extent

and inaccessibility of the reedbeds.

In Vejlerne almost all Greylag Geese nest in reedbeds where the dense vegetation offers protection against predators. Birds utilise reed stems surrounding the nest site for nest material and this results in a cleared area around the nest (Witkowski 1983). In the Oostvaarderplassen, The Netherlands, where Greylag Geese also breed in reedbeds, nests are visible from the air, and direct aerial counts of nests have been carried out for some years (Zijlstra *et al.* 1991). Aerial photography has been used to census other breeding waterfowl populations (eg Kerbes 1973, Ferguson & Gilmer 1980, Kerbes *et al.* 1983, Reed & Chagnon 1987, Poole 1989, Bajzak & Piatt 1990, Reed *et al.* 1992) and it was decided to use vertical photography of the Vejlerne reedbeds as a more accurate method of censusing goose nests. This paper describes the techniques used, and assesses the results obtained.

Study Area

The nature reserve of Vejlerne, Denmark (**Figure 1**) (57°00-07'N, 8°50-9°10'E) is *c.* 6000 ha in extent and is one of the most important wetlands for breeding and staging waterfowl in Denmark. It consists of a number of large shallow brackish and freshwater lakes including 1500 ha of reedbeds and extensive meadows (Møller 1980). Common reed *Phragmites australis* dominates the reedbeds with smaller patches of reed-mace *Typha angustifolia* and *T. latifolia* and bulrush *Scirpus sp.* and, in some areas, willow scrub *Salix cinerea* and *S. aurita* occurs. Vejlerne is designated as a Wetland of International Importance under the Ramsar Convention and as an EU Special Protection Area (Møller 1980).

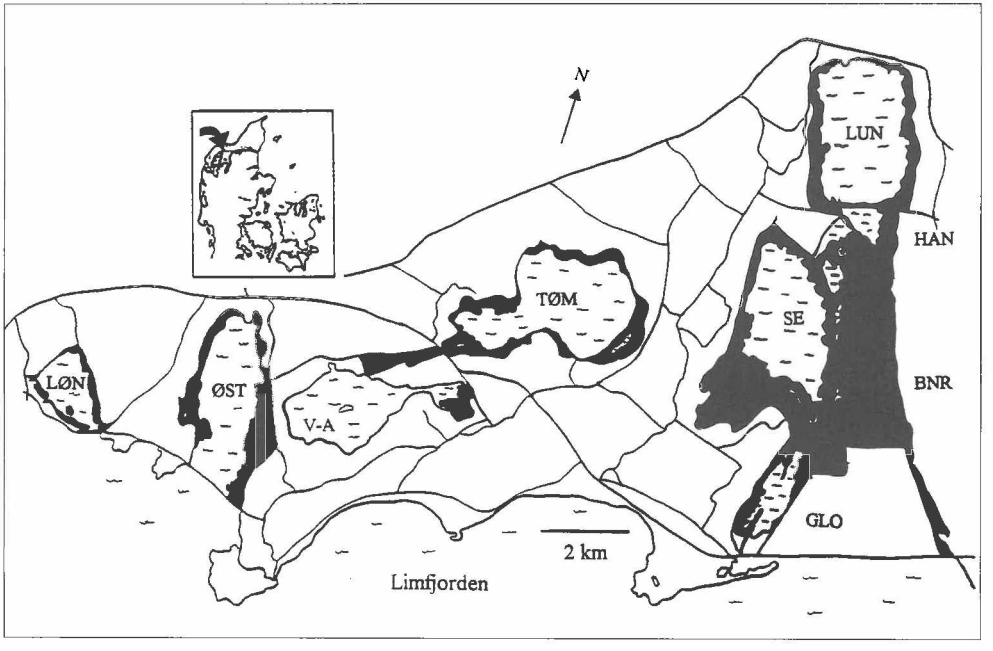


Figure 1. Map of Vejlerne, Denmark. Shaded areas denote reedbeds. LØN = Lønnerup Fjord, ØST = Østerild Vejle, V-A = Vesløs/Arup Vejle, TØM = Tømmerby Fjord, LUN = Lund Fjord, HAN = Han Vejle, SE = Selbjerg Vejle, BNR = Bygholm Nord Rørskov and GLO = Glombak Vejle.

Methods

Ground Counts

The ground counts were begun on 4 March 1994 when the whole breeding population was considered to have arrived. From 4-26 March, four total counts were undertaken and additional transect counts were carried out in parts of the reserve by observers at the field station of the reserve and the author, as in previous years (Kjeldsen 1992). Counts were carried out in the pre-nesting period when the pairs are visible on the meadows outside the reedbed. A maximum total of breeding pairs was obtained by adding the highest number from the different areas throughout the whole census period. A minimum total was obtained from the highest number of pairs counted in a single census day.

Aerial Photographs

The majority of geese were considered to be incubating during the second week of April 1994, and on 12 April, most of the reedbed was photographed from a Cessna 172 airplane. The photographs were taken vertically with a Rollei camera with a 50 mm lens attatched under the plane, using Ectachrome 200 ASA 60 mm x 60 mm color slide film. Flight speed was about 100 knots (180 km/t) at an altitude of *c.* 300 m (from previous experience of M. Zijlstra *pers comm.*). In the Oostvaadersplassen, flight counts are done from *c.* 300 m even though Greylag Geese remain on their nest when an airplane passes at only *c.* 50 m (M. Zijlstra *pers comm.*). Photography at lower altitude would increase the number of individual exposures and analytical time. Some 800 slides were taken, each covering an area of approximately 300 m^2. There was a slight overlap between the slides, which helped identifying the exposed areas. Further, to aid identification of ground areas during the subsequent image analysis, an additional flight was made on 25 April 1994 at *c.* 1,000 m, using the same equipment and techniques. These slides covered an area of *c.* 1,000 m^2.

Weather conditions during the flights were considered quite good: on 12 April visibility was 8 km, no precipitation or wind, temperature *c.* 13°C and cloud cover 0/8; on 25 April visibility was 10 km, precipitation zero, wind 4 SE (Beaufort), temperature *c.* 18°C and cloud cover 7/8.

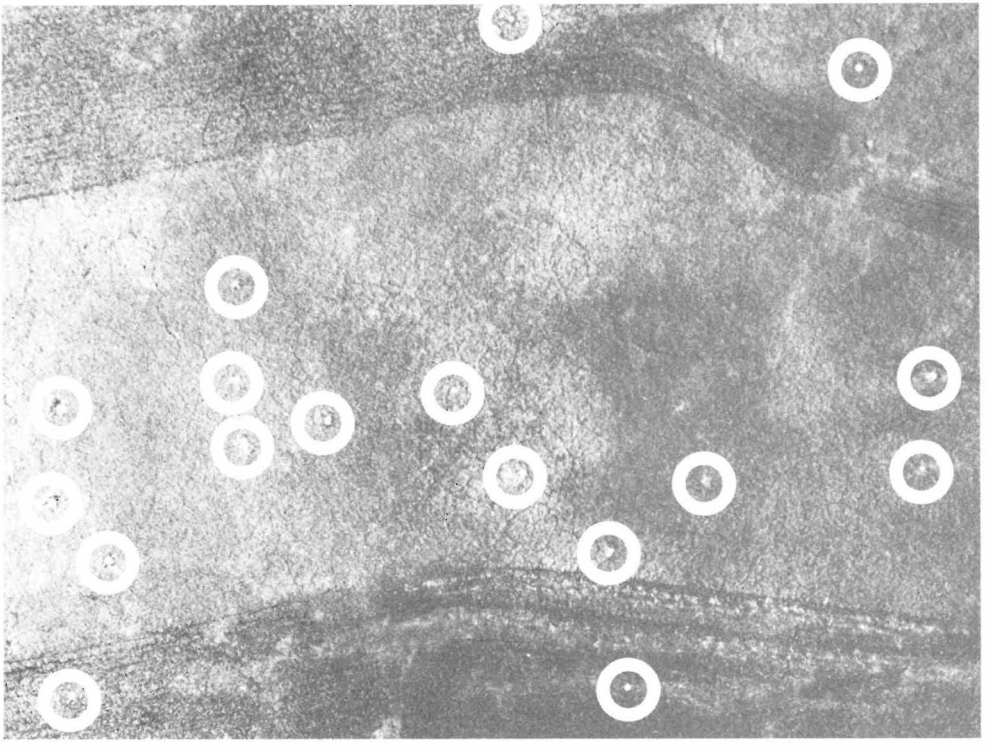
Photographic analysis

The slides taken at 1,000 m were projected on to paper and goose nests mapped onto them. All slides from 300 m were examined on a light table and the goose nests were mapped on the distribution maps derived at 1,000 m. A 6-10 x magnifying glass was used to identify goose nests on the slides from 300 m. Due to the way Greylag Geese build their nests in reedbeds (see above, Witkowski 1983) they appear as 'distinctive islands' and are thus easily identified on the slides (**Figure 2**). Usually, it was possible to identify the incubating goose on the nest (as a dark dot in the centre of the nest) but both nests with geese present and absent were included in the census (see below). Other large species breed in the area. Mute Swans *Cygnus olor* are easily identified due to their large size and colour. Both Bitterns *Botaurus stellaris* and Marsh Harriers *Circus aeruginosus* breed in the area; the latter, however, in small numbers (16-26 pairs in 1994: Kjeldsen 1995) and usually much later than Greylag Geese (Salomonsen & Rudebeck 1962, Kjeldsen 1995). The nest of a Bittern, on the other hand, could be mistaken as a goose nest.

Thirty-six hectares of reedbed were not covered by the photographs. The number of nests in these areas was estimated assuming that the relative proportion of nests in these particular areas compared to the rest was the same as in 1995 when the whole reserve was covered by direct aerial counts (Kjeldsen 1996). Areas were measured using a digital planimetre.

To assess the accuracy of correctly identified goose nests from the images, 139 nests were visited after the incubation period (15 May to 7 July 1994). All nests which appeared newly built, regardless of the presence or absence of a goose on the slides (eg no fresh green reed stems or stems from the previous year emerging through the nest and no sign of

Figure 2. Vertical aerial photograph of nests of Greylag Geese in reedbeds at Vejlerne, Denmark 12 April 1994 (altitude: *c.* 300 m). The light dots are goose nests (denoted by white circles) often surrounded by an open area. Usually it was possible using a magnifying glass to recongise the incubating goose which appeared as a dark dot in the centre of the nest (see text for technical details). Differing colours of reedbed areas is due to different harvest year and hence, different reed stem density.



decaying reeds on the top layer of the nest material) were recorded as representing a breeding pair of 1994. In addition most nests (*c.* 90%) from the present year contained remains of egg shells and down.

Results

The maximum number of breeding pairs obtained by the ground survey was 831 and the minimum was 623. **Table 1** summarises the number of nests identified (see **Figure 1**) from the aerial images, area and nest density in various parts of Vejlerne. Some 726 nests were counted directly from the slides whereas three and six nests were estimated for Østerild Fjord and Lund Fjord respectively in areas not covered by the photographs.

Ground truth data revealed that only four nests of 139 visited were incorrectly identified as active goose nests. These four nests were obviously not active in 1994 but were old nests from previous years. This gives a correction factor of 4/139 x 100=2.88%. Adjusting the total by the correction factor gives an actual nest number of 735 - (0.0288 x 735)=714 nests. Incubating geese were present on 610 nests whereas geese were absent from 103 (14 %).

Discussion

Census techniques

When censusing breeding Greylag Geese nesting in reedbed areas the size of Vejlerne, there will be shortcomings with any kind of ground survey. Some problems of mapping breeding pairs have already been mentioned but there is also the problem of whether the minimum or maximum estimate is the most accurate. The maximum number accounts for the spread of breeding phenology therefore includes both early and late breeders. However, if birds have a regular diurnal pattern of activity, time of the day may also affect the number of pairs observed during a ground count. The major problem involved in censusing the local breeding population by means of ground counts however, is probably the fact that unknown proportions of foreign and non-breeding local birds will be present. Also, the spring weather conditions during the pre-nesting period are important as this influences the time spent by the geese on meadows before incubation. The reason for carrying out the traditional mapping of breeding pairs in Vejlerne however, has been lack of alternatives. Ground surveys of nests have been carried out where Greylag Goose nests are easily detectable eg, on islands with low vegetation (Young 1972, Newton & Kerbes 1974). This method however, is impossible in large reedbeds as occur at Vejlerne. Counts of nests, though, do provide the best measurement of a breeding population, and even though some potential breeders may fail before nest construction, gives more direct information on the number of pairs contributing to the production of a population. In the present study, counts of nests by means of vertical aerial photographs turned out to be an excellent technique, at least in homogeneous reedbeds where nests were easily detected from slides. The technique however, might have limited use in more heterogeneous wetland areas (eg areas of mixed reeds, bulrush, willow etc.), but from ground surveys no nests were ever recorded in these areas. Hence almost all breeders nested in the more uniform reedbed vegetation, so the number of nests obtained

Table 1. Results from an aerial photographic census of Greylag Goose nests in each locality of Vejlerne, Denmark.

Locality	Number of nests	Reedbed area (ha)	Nest density (nests/ha)
Lønnerup Fjord	0	23	0
Østerild Fjord	3	105	0.03
Vesløs/Arup Vejle	28	75	0.37
Tømmerby Fjord	186	161	1.16
Glombak Vejle	46	1038	0.45
Bygholm Nord Rørskov & Bygholm Engen	368	493	0.75
Lund Fjord	6	89	0.07
Han Vejle	9	10	0.90
Selbjerg Vejle	89	401	0.22
Total	735	1460	0.50

from the slides may be considered close to the actual number of breeders in the whole of Vejlerne and this is likely to be more accurate than any of the ground estimates, and thus the most exact estimate ever. In spite of high resolution and accuracy of the vertical aerial photographs, there remain a number of advantages and disadvantages with the technique which should be considered and discussed. Vertical photography only gives a momentary image and necessitates that the census is carried out at peak incubation time. A census carried out too early will under estimate numbers and a late census may miss hatched clutches which have left the nest site. A late census remains preferable though, because abandoned nest sites can still be recognised. 'Freezing' of the image however, brings several advantages. Counting time is not limited, enabling repeated counts to minimise the biases and to count dense aggregations accurately (Watson 1969, Leonard & Fish 1974). Further, obtaining the exact positions of nests can be of great value in further analysis and long-term monitoring. However, the image comes from a fixed angle and may miss obscured nests eg, goose nests under willow bushes (Caughley 1974). Finally, the procedure is susceptible to technical failure (Watson 1969). Although nests of Greylag Geese in this study were never confused with those of other species, it is important to take account of this depending on which species occur in the reedbed area being censused. To enhance usefulness of the method, use of a Global Positioning System with the aerial photography is recommended. In this way, the exact co-ordinates of each slide can be obtained, hence facilitating the analysis procedure and making a second flight at higher altitude unnecessary and making the census less costly.

Breeding population

Although a total of 713 nests in 1,500 ha of reedbed is high compared to other areas of high densities (eg the Oostvaadersplassen with *c.* 300-350 pairs in *c.* 2,000 ha of reedbed in 1995: M. van Eerden & M. Zijlstra, *pers comm.*), nest density varied from zero nests/ha (Lønnerup Fjord) to 1.16 nests/ha (Tømmerby Fjord) between areas. Hence, it might be that there is still potential for expansion of the breeding population at Vejlerne. Other factors however, such as protection against nest predators, the structure of the reedbed, and accessibility to feeding sites may also be of great importance to fulfil demands of a satisfactory nest site. To follow the population trend of Greylag Geese and the distribution of nests at Vejlerne in future years, regular aerial surveys will be an important censusing technique.

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