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Diurnal rhythm of colony attendance and optimal census time for the Black Guillemot *Cepphus grylle* in the Baltic Sea

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Counting the adult birds at breeding colonies is the only useful method for population monitoring in the Black Guillemot. Before the counts can be compared, however, information is needed on the optimal census time. Diurnal and seasonal rhythms of colony attendance were studied during three summers at Valassaaret, Gulf of Bothnia. The attendance always peaked in the early morning, soon after sunrise, and then declined sharply. Early morning counts should thus be preferred for monitoring, but counts conducted at other times of day can be transformed by use of correction factors to estimate the peak numbers. Counts made directly from the breeding islands are to be recommended in preference to undisturbed counts from a distance. Similar diurnal attendance patterns have been found in most study areas in Europe; in seasonal rhythm there seems to be more local variation. The biological significance of the pronounced early diurnal attendance peak at Black Guillemot colonies is discussed briefly.

1. Introduction

The degree of attendance by colonially nesting seabirds at their breeding places varies greatly according to the date of breeding, time of day and food availability. If population monitoring is to be based on numbers of adult birds counted at colonies, quantitative information is needed on variations in colony attendance for each species to enable the counts to be converted into population estimates.

Suomalainen (1939) was the first to draw attention to the regular diurnal rhythm of colony attendance in the Black Guillemot *Cepphus grylle*. Early in the morning all the members of a colony are gathered close to the shore of their breeding island, but in the afternoon and evening only a small fraction remain. Ten years later, Koskimies (1949) carried out more systematic censuses by counting 14–19 times a day, between 02 and 21–22 hrs local time, all the Black Guillemots within a restricted area at the Aspskär Islands, in the eastern Gulf of Finland. The census was repeated on five days during the breeding season, between 17 May and 7 July. This study confirmed the distinct diurnal rhythm of attendance by Black Guillemots: the average number of individuals observed during the morning peak, at about 05–06 hrs, was 20 times higher than the average minimum number present, at about 14–15 hrs. Since these two pioneer studies, no systematic censuses have been published from the Black Guillemot's Baltic breeding areas, except for a few data by Bergman (1971).

From oceanic coasts, however, several studies have been made on the colony attendance of both the Black Guillemot in Europe (Slater & Slater 1972, Ramsay 1976, Asbirk 1979, Cairns 1979, Petersen 1981, Munkejord 1983, Ewins 1985a) and the closely related Pigeon Guillemot Cepphus columba in North America (Drent 1965, Ainley & Lewis 1972, Nelson 1987, Vermeer et al. 1993). Although the ecological conditions on oceanic coasts, with pronounced tidal cycles, are very different from those prevailing in the Baltic, the high morning peak in colony attendance by guillemots occurs everywhere, with some local variations in timing and duration. This paper summarizes the results of systematic studies of Black Guillemot colony attendance in the Baltic during three summers (1960, 1981, 1992), and provides recommendations for estimating the population size there from single counts. Reliable population monitoring of Black Guillemots is important, as in several areas they are among the dominant species in the Baltic seabird community and are exposed to many threats (Hildén & Hario 1993).

2. Study area and methods

All field work was carried out in the bird sanctuary of Valassaaret/Valsörarna in the Quark archipelago, Finnish west coast (63°25′N, 21°04′E). This isolated island group consists of six large, partly wooded islands and about 60 smaller, barren skerries, and holds probably the densest population of Black Guillemots in Finland. About 2800 pairs in total and 100–250 pairs in the largest colonies were present in 1990 (Hildén 1991). The high density is due to an ideal nesting habitat: the moraine archipelago is made up by stones and boulders of all sizes, providing innumerable hollows and cavities as nest sites. For more detailed habitat description, see Hildén (1964, 1966) and Brearey & Hildén (1985).

The first two census tests, in 1960 and 1981, were made in a similar way, which disturbed the birds to some extent. At four times of the day (at 05, 11, 17 and 23 hrs, Finnish solar time), the Black Guillemots swimming in flocks close to the shores (roughly within 100 m) or sitting on elevated perches ashore were counted carefully from a suitable open look-out post on the top of the breeding skerry; this usually took less than 10 minutes.

In 1960, when I worked alone, the procedure was repeated five times during the summer, between 30 May and 12 July, but the day-long census covered only one single islet (Trekantbådan, with some 45 pairs). The early morning count (at 04–06 hrs), however, was made at seven additional islets on all five census days; these colonies were inhabited by a total of about 380 pairs.

In 1981, when I performed the counts together with my students, the study included five adjacent colonies, with almost 450 pairs in total, but the test was made on one single day, 15 June. The census route took about one hour and was timed so that the third colony was visited at 05, 11, 17 and 23 hrs.

The third test, in 1992, again assisted by students, differed clearly from the previous two. Black Guillemots at two large colonies (about 475 pairs in total) were counted by telescope from a fixed spot at a distance of about 250 m, without disturbing the birds. The census area, a sheltered lagoon between the two colony islets (almost connected with each other) and the big island where the telescope stood, was defined using distinct land marks. Most birds attending the colonies gathered in this area; those seen outside were ignored. Birds were counted every hour during a 24 hour period on 13–14 June by six pairs of observers, each pair thus making four counts.

All the censuses were made under favourable weather conditions (calm weather or light wind, good visibility). Breeding birds and non-breeding or immature birds were not separated; it is known that often a considerable proportion of Black Guillemots frequenting colonies may not make any breeding attempt (Winn 1950, Ramsay 1976, Petersen 1981, Munkejord 1983, Ewins 1985a).

Black Guillemots at Valassaaret start egg-laying in late May, and the first chicks use to hatch around 20 June. Most pairs lay at the turn of May–June, on average. Thus the 1960 counts spanned the entire breeding season, while the 1981 and 1992 counts referred to the later part of the incubation period.

2. Results

2.1. Daily patterns

Results of the censuses made in 1960 and 1981 are presented in Table 1. In both years, attendance was always at its peak during the morning count, at 05 hrs, then declined to less than half between 11 and 23 hrs. The rhythm varied considerably, however, between both the census days and the colonies. The clearest deviations from the general trend occurred during the two late censuses, on 30 June and 12 July 1960. At this time, when most of the young had hatched, the number of adults present was still high at 11 hrs (85 and 89%), but very few were visible at 23 hrs (26 and 5%).

The pattern was similar but much more pronounced in 1992, when the birds were not disturbed during the counts (Fig. 1). The number of birds seen at the colony during the early afternoon (12.30–14.30 hrs) was less than 10% of the early morning peak (02.30–04.30 hrs). Attendance increased again during the late evening. The unexpectedly low count at 05.30 hrs most likely was caused by the difficult light conditions: the low sun was just behind the census area and shining dazzlingly straight into the telescope.

2.2. Seasonal variation in morning attendance

The stability of the morning attendance peak over the course of the breeding season was studied in eight colonies in 1960. There was considerable variation among them (Table 2). In general, the numbers remained fairly stable during the first three counts, on 30 May, 11 June and 21 June, and in two colonies the variation was small throughout the census period. In most colonies, however, the morning numbers were considerably higher during the last two counts, i.e. during the chick-rearing period. At Lnggrynnan, the number counted on 12 July was more than three times the count of 30 May.

3. Discussion

In many bird species, careful nest counts provide the most accurate estimates of breeding populations. For the Black Guillemot, however, this method is usually not applicable, as many nests are hidden in deep cavities and crevices and impossible to detect. Counting the adult birds attending a colony is thus the only useful method for determining colony size (though this does not necessarily equate to breeding population size). A premise for the reliability of such a census is,

Table 1. Numbers of Black Guillemots attending their breeding colonies at various times of day in the island group of Valassaaret, Gulf of Bothnia, in 1960 and 1981. The percentages show the proportion of the number in the early morning count (=100%).

Island, date		Time of day: 05 hrs		11 hrs		17 hrs		23 hrs	
		No.	%	No.	%	No.	%	No.	%
Trekantbådan	30 May 1960	85	100	40	47	32	38	27	32
Trekantbådan	11 June 1960	73	100	53	73	46	63	36	49
Trekantbådan	21 June 1960	80	100	41	51	35	44	43	54
Trekantbådan	30 June 1960	89	100	79	89	28	31	23	26
Trekantbådan	12 July 1960	95	100	81	85	25	26	5	5
Båtslagsbådan	15 June 1981	120	100	55	46	40	33	74	62
Trekantbådan	15 June 1981	114	100	67	59	50	44	80	70
Bredbådan	15 June 1981	167	100	31	19	39	23	51	31
Långgrynnan	15 June 1981	195	100	50	27	110	56	95	49
Bullergrynnan	15 June 1981	296	100	134	45	131	44	185	63
Total		1314	100	631	48	536	41	619	47

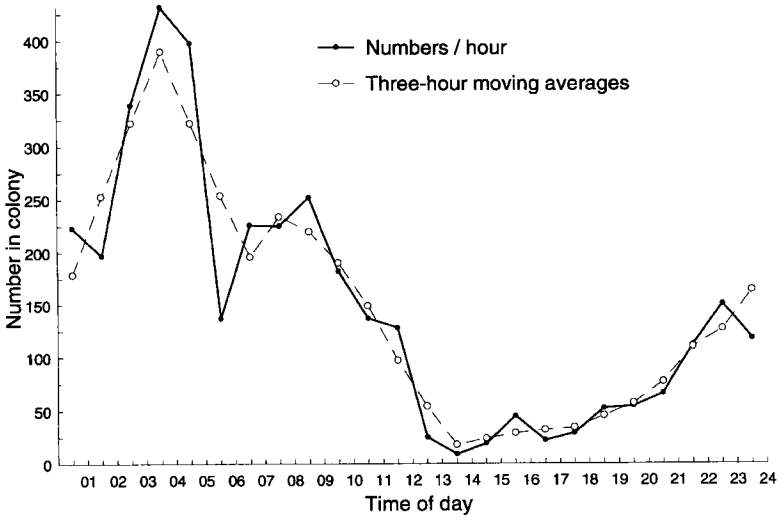

Fig. 1. Numbers of Black Guillemots at the colonies on Långgrynnan and Bullergrynnan at Valassaaret, counted by telescope without disturbing the birds every hour on 13–14 June 1992. The reason for the low count at 05.30 hrs is discussed in the text.

however, that we know the optimal time, both diurnally and seasonally, when the number of colony members is highest and the variance lowest.

Reliable census methods are needed for long-term monitoring of populations. Information on population fluctuations and their causes has become important, especially for seabirds, as many anthropogenic factors threaten their existence. Guillemots, for instance, are vulnerable to coastal oil pollutions (e.g. Ewins 1985b, Ainley & Boekelheide 1990); the worst catastrophe in Finland so far, in the Quark in 1984, destroyed about 30% of the Valassaaret population (Hildén & Pahtamaa 1992). This figure was obtained only because annual censuses had been conducted in this area.

In the present and several earlier studies, the numbers of Black Guillemots attending breeding colonies were found to fluctuate dramatically both diurnally and seasonally. Interpretation of census results thus depends decisively on the timing of the count. Despite this, the numerous quantitative surveys of seabirds in the Finnish archipelago (reviewed by Hildén & Hario 1993) have seldom taken this into account, and usually there is no mention of how numbers of Black Guillemots have been assessed. A similar situation exists in Norway (Munkejord 1983). In most cases early morning counts have probably not

Table 2. Numbers of colony attending Black Guillemots at eight breeding islands in five mornings at 04–06 hrs in 1960 at Valassaaret.

Island	Date					Mean ± SD
	30 May	11 June	21 June	30 June	12 July	
Ebbskärsgrynnan	27	28	32	28	24	28 ± 2.9
Båtslagsbådan	131	84	90	119	106	106 ± 19.6
Trekantbådan	85	73	80	89	95	84 ± 8.4
Båtslaget	59	56	65	85	86	70 ± 14.4
Rackelgrynnan	107	99	139	186	155	137 ± 35.6
Bredbådan	57	57	46	121	84	73 ± 27.1
Långgrynnan	68	78	75	103	223	109 ± 64.9
Bullergrynnan	155	167	153	215	206	179 ± 29.2
Total	689	642	680	946	979	787

been used. Rather, guillemots have been censused at various times of day and season, together with other seabird species, and the number observed at each island has then been converted to pairs by dividing by two. Such unsystematic census techniques naturally make any calculation of population sizes and trends unreliable.

The most striking factor affecting the colony attendance of Black Guillemots is the time of day. In my study area, a strong morning attendance peak appeared soon after sunrise (in June at about 03–05 hrs) and numbers remained fairly high until about 08 hrs. Thereafter numbers fell rapidly. Consequently, counts should always be made in the early morning.

The seasonal variation in diurnal attendance pattern complicates the optimal timing of census slightly. According to my observations, the early morning peak remained quite stable from late May to late June, and reasonably stable into the first half of July. At this stage of the breeding cycle, however, unpredictable increases in the number of birds at certain colonies may occur. The most probable reason for this phenomenon is that flocks of non-breeding birds roam within the area and are attracted to some colonies more than to others. Unfortunately, I have no data on the proportion of non-breeders in my study area.

A third methodological question in Black Guillemot censuses is whether they should be conducted from a distance, without disturbing the birds, or directly from the breeding skerries. There was a clear difference in the results obtained by these two methods. In disturbed counts, when an observer lands by boat on a skerry and walks to a look-out post, most of the birds incubating or sitting invisible in sheltered places are flushed on to the water, while in undisturbed counts such birds remain undetected.

However, if the counts are made at the optimal time of day, in the early morning, both methods give similar results, as most members of the colony are then visible. In practice, however, disturbed counts are to be recommended because they take less time. Only a few minutes are needed to land on the skerry and count the guillemots from a suitable look-out post, whereas the undisturbed counts require circling the islands from a distance without flushing the birds, which takes a much longer time. If counting takes place after the morning peak and a conversion factor (see below) is used to obtain a population estimate, the disturbed census is definitely better, since by then most of the birds are invisible in their nests and can be counted only if flushed on to the sea by the census taker.

The data available allow rough estimates of conversion factors needed to transform counts made outside the optimal census time into numbers which would have been seen at the peak time. For censuses conducted from the breeding skerries (disturbed counts) at different times of day (solar time), I recommend the following correction coefficients to be used on the Finnish coasts:

03–05	05–08	08–11	11–15	15–19	19–23
1.0	1.25	1.65	3.3	2.5	2.0

These coefficients refer to the period from late May to late June (for other areas in Finland they have to be somewhat modified in relation to the time difference in sunrise and sunset). In later counts (up to mid-July) the morning attendance peak lasted longer, so that the coefficient of 1.0 can be used from 03 to about 10 hrs, but some unpredictability may be caused by flocks of non-breeders that join the colonies (see above). Evening counts in July are quite unreliable, as usually very few adults are seen at the colonies. If the population size is presented as number of pairs (= the number obtained divided by two), it must be remembered that an unknown proportion of the birds always consists of immature non-breeders.

The same basic diurnal rhythm of colony attendance, with a strong early morning peak, has been reported from several areas. Considerable differences exist, however. In Denmark, for instance, the morning peak was prolonged throughout the summer, lasting from about 03 to 11 hrs (Asbirk 1979), and in the study colony of Bergman (1971) in the Gulf of Finland the peak was reached usually at 8–10 hrs, sometimes as late as 11–12 hrs. Some studies have found pronounced evening peaks (e.g. Petersen 1981).

Further variation in colony attendance is found as the season progresses. In Shetland, for example, the optimum census period is between late March and mid-May, during the pre-breeding period (Ewins 1985a). Along the Atlantic coasts,

Black Guillemots overwinter close to the breeding islands and start to come ashore in early March, i.e. two months before the onset of egg-laying. In my study area, the breeding islands are often surrounded by ice until mid-May and thus the period of pre-breeding colony attendance is very short. Local differences in the diurnal and seasonal attendance pattern are probably caused by several factors: light regime, tidal state, weather conditions, proportion of non-breeders, food supply and distance to the fishing grounds.

The biological significance of the pronounced early morning attendance peak at Black Guillemot colonies has remained obscure (Asbirk 1979). In my opinion, the main function of these morning assemblies off the colonies is social display, which involves threats, chasing, fighting, courtship, bill-dip, group flights, and so on. These behaviours may well assist many vital activities in the colony, like synchrony of nesting, mate selection, strengthening of pair bonds, copulations, nest defence and regulation of population size. After a few hours, the group display activity calms down, the incubating birds return to their nests and most of the other colony members disperse to the remote fishing grounds. In many birds, such sexual and social activities peak in the early morning. For Black Guillemots, at least in non-tidal areas, the morning hours are also best suited to "water games" because the sea is then often calm.

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Selostus: **Vuorokausirytmi ja laskentojen ajoitus Itämeren riskiläyhdyskunnissa**

Aikuislintujen laskenta yhdyskunnissa on riskilän kohdalla ainoa käyttökelpoinen kannanarviointimenetelmä, koska pääosaa pesistä on mahdoton löytää. Laskenta edellyttää kuitenkin tarkkaa tietoa siitä, mihin aikaan vuorokaudesta ja pesimäkaudesta se tulisi suorittaa, jotta linnuista suurin osa olisi näkyvissä. On myös muistettava, että osa linnuista on pesimättömiä.

Kolmena kesänä (1960, 1981, 1992) tehtiin Merenkurkun Valassaarilla laajoja laskentasarjoja riskilän vuorokautisen ja pesimäkautisen rytmin selvittämiseksi. Taulukossa 1 on esitetty lintujen lukumäärä neljään aikaan vuorokaudesta, v. 1960 yhdellä luodolla viitenä laskentapäivänä (30.5.–12.7.) ja v. 1981 viidellä luodolla yhtenä päivänä (15.6.). Linnut laskettiin venekierroksella pesimäluodon laelta. Selvä huippu oli aina klo 5:n laskennassa (normaaliaikaa), kun taas klo 11, 17 ja 23 lintuja oli näkyvissä keskimäärin alle puolet aamuisesta. Vaihtelu sekä yhdyskuntien että laskentapäivien välillä oli kuitenkin melkoinen.

Taulukossa 2 on esitetty aamulaskentojen (klo 4–6) lukumäärät kahdeksalla luodolla pesimäkauden eri aikoina v. 1960. Kolmessa ensimmäisessä laskennassa määrät pysyivät varsin tasaisina, mutta kahdessa viimeisessä useimmilla luodoilla lintuja oli aikaisempaa huomattavasti enemmän. Tämän otaksutaan johtuvan pesimättömien yksilöiden kiertelystä ja keskittymisestä tiettyihin yhdyskuntiin pesimäkauden loppupuolella.

Kesällä 1992 riskilän vuorokausirytmi tutkittiin eri tavalla, laskemalla suuren yhdyskunnan linnut niitä häiritsemättä kaukoputkella toiselta saarelta (kuva 1). Lukumäärän pudotus aamuhuipun jälkeen oli nyt paljon jyrkempi, alle 10%:iin iltapäivän tunteina. Tämä johtuu siitä, että aamuisen parveutumisen loputtua pääosa luodolle jääneistä linnuista on näkymättömissä pesissään, kun taas laskijan noustessa maihin ne pakenevat veteen.

Saaristolintujen laskennoissa Itämerellä on vain harvoin ilmoitettu, miten riskilöiden parimäärät on saatu. Tämä heikentää tulosten käyttökelpoisuutta. Laskennat tulisi suorittaa varhain aamulla; muina vuorokauden aikoina saatuja tuloksia voidaan muuntaa todenmukaisemmiksi käyttämällä korjauskertoimia (s. 65). Paras laskentakausi Merenkurkussa on toukokuun lopusta kesäkuun loppuun. Laskennat itse pesimäluodoilla ovat nopeampia ja luotettavampia kuin kaukaa tehdyt.

Kaikkialla riskilän laajalla pesimäalueella on todettu vuorokausirytmin selvä aamuhuippu, mutta sen ajoituksessa ja kestossa on melkoista alueellista vaihtelua. Pesimäkautinen rytmi vaihtelee vielä enemmän; esim. Atlantin rannikoilla paras laskentakausi on jo keväällä paljon ennen

pesinnän alkamista. Aamuisten "kokousten" biologiseksi merkitykseksi arvellaan sosiaalista soidinta, joka palvelee monia yhdyskunnan keskeisiä toimintoja, kuten pesinnän samanaikaistamista, parinmuodostusta ja kannansäätelyä.

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