

Studies of the Moulting Migration and Wing-feather
Moulting of the Goldeneye
(*Bucephala clangula*) in Denmark

by
PALLE UHD JEPSEN

Med et dansk resumé: Hvinandens (*Bucephala clangula*)
fældningstræk og svingfjærfældning i Danmark.

Резюме на русском языке
Миграции на линьку и линька маховых перьевгоголя
(*Bucephala clangula*) в Дании

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Author's address:
Palle Uhd Jepsen, Game Biology Station
Kalø, 8410 Rønde, Denmark

Introduction

The occurrence of the goldeneye (*Bucephala clangula*) during its wing-feather moult in Danish waters and lakes during the summer months has not previously attracted very much attention. The first review of summer observations and of definite and presumed moulting areas was given by JEPSEN & JOENSEN (1973). However, the course of the wing-feather moult of the goldeneye has not previously been examined in any detail.

Moulting goldeneye have been observed at many different places in Denmark, but by far the majority occur in Hjarbæk Fjord and other parts of the Limfjord. Since 1969, the Game Biology Station has carried out studies of the moult of the goldeneye in Hjarbæk Fjord in particular, as part of recording the value of the area for waterfowl. These latter studies were started in 1967 when the area was declared a game reserve.

The information in this report is particularly derived from studies at Hjarbæk Fjord, but it also includes two counts

made in other parts of the Limfjord in 1972 and various observations from other localities. The following points are considered for each sex- and age-group: 1) the moult migration, 2) variations in population size during the pre-moult period, the wing-feather moult, and the post-moult period, 3) the time of moulting, and 4) behaviour and habitat selection in the summer months.

Much of the information on distribution has been supplied by sportsmen and ornithologists, to whom the author is greatly indebted. Special thanks are due to cand. scient. LEO KORTEGAARD who in connection with this study visited several lakes in northern and Central Jutland, and to cand. scient. DORETE BLOCH who visited areas in Sealand and Lolland-Falster. Furthermore thanks are due to SIGVALD JØRGENSEN, a fisherman, who helped in various ways in Hjarbæk Fjord. The manuscript was translated into English by Dr. ROBERT RUSSEL.

Material and methods

POPULATION COUNTS FROM LAND

Most of the information included in this study was collected at Hjarbæk Fjord (56° 32' N, 09° 14' E), an arm of the Limfjord of approximately 24 km². Since October 1969 data on the total number present and the sex- and age-composition of the population (sample at least 10%) were collected. Counts were carried out 1-3 times per month. In three years (May 1 - November 1) the study area was visited a total of 43 times, and each count took 6-8 hours, excluding travelling time between observation points. The

study all together comprised 300 hours of observation. These observations are listed in Table 1.

From the rest of the Limfjord, observations were available in particular from Lovns Bredning immediately north of Hjarbæk Fjord, and from Vejlerne, Ulvedybet and Halkær Bredning. In addition, in 1972 counts were carried out on two occasions (July 13-14 and August 15-16) covering a large part of the Limfjord (see Fig. 2). The purpose of this was to get an impression of differences in sex- and age-

composition of local populations, and to get an understanding of the moult migration.

In July and August 1972, more than 50 North-, Central-, and West-Jutland lake and fiord areas were also visited, but many localities in East Denmark have not been visited. Further the author received information from sportsmen and ornithologists on very many areas. Fig. 1 shows the areas from which both positive and negative information was obtained in 1972. The size of the symbols employed

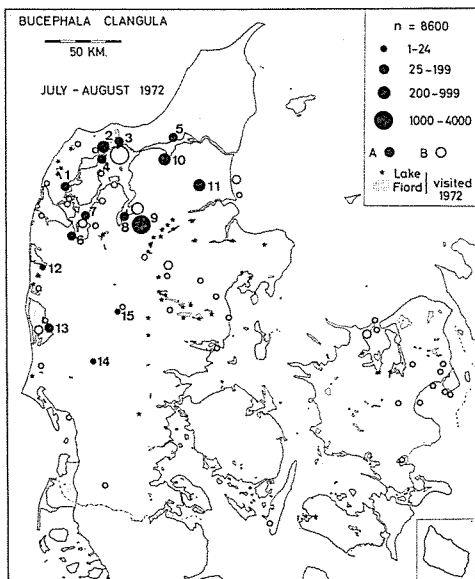


Fig. 1. The geographical distribution and numbers of goldeneye recorded in July and August 1972. A: areas in which flightless birds were observed, B: areas in which the presence of moulting birds was not definitely established. Stars and dotted areas indicate localities visited in 1972 and at which no goldeneye were observed. The number beside A-localities refers to Table 3.

Fig. 1. Den geografiske udbredelse og antallet af hvinænder registreret i juli-august 1972. A: Områder hvor afslåede fugle er observeret, B: Områder for hvilke det ikke er bevist at fældning finder sted. Stjerner og prikkede områder viser lokaliteter besøgt i 1972, hvor hvinænder ikke blev observeret. Nr. ved A-lokaliteter henviser til tabel 3.

represents the maximum number of goldeneye observed at a locality (see also JEPSEN & JOENSEN 1973).

It is possible that in some lakes a few birds have been omitted in counts, where

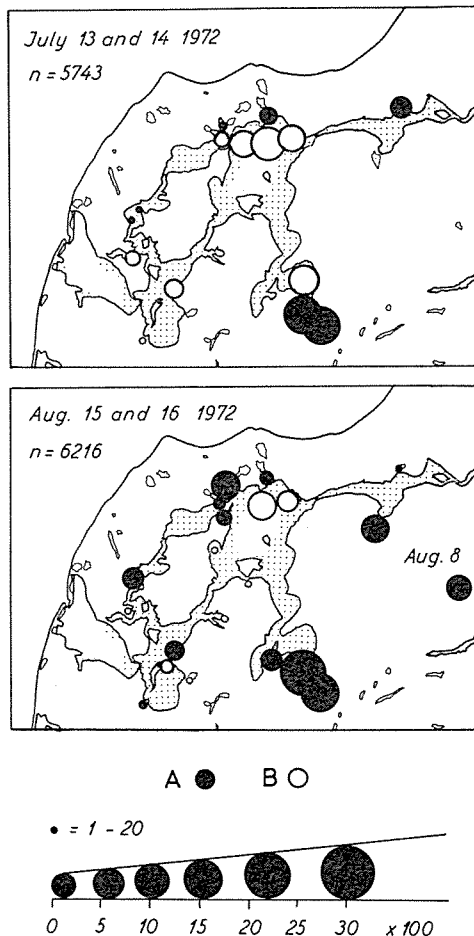


Fig. 2. The distribution and numbers of goldeneye recorded during two counts in the Limfjord in 1972. A: areas where flightless birds were observed, B: areas in which the presence of moulting birds was not definitely established. Areas visited are indicated by dotting.

Fig. 2. Udbredelsen og antallet af hvinænder registreret under to Limfjordstællinger i 1972. A: Områder hvor afslåede fugle er observeret, B: Områder hvor fældning ikke med sikkerhed er konstateret. Dækkede områder er vist ved prik-signatur.

visibility is reduced due to tall marginal vegetation. In certain fiord areas whole flocks of birds may be missed, and this is especially possible in the Central Limfjord. However, during the 1972 counts

goldeneye were not observed in areas where the depth exceeded 5–6 metres. Apart from a few shoals in the Limfjord, such shallow areas are generally within acceptable observation distance.

1970 Date Dato	Nos. of goldeneye Antal hvinænder	1971 Date Dato	Nos. of goldeneye Antal hvinænder	1972 Date Dato	Nos. of goldeneye Antal hvinænder
1.5.	1234 (276)	17.5.	783 (783)	3.5.	2045 (63)
22.5.	797 (279)	7.6.	465 (306)	19.5.*)	450 (287)
26.5.	912 (272)	21.6.	644 (416)	23.5.	498 (408)
3.6.	1238 (375)	2.7.	1763 (286)	2.6.*)	257 (257)
17.6.	902 (680)	21.7.	4424 (472)	20.6.	1484 (144)
29.6.	1928 (1703)	6.8.	2816 (654)	26.6.	2449 (520)
8.7.	2289 (1344)	25.8.	2613 (413)	6.7.	2671 (194)
24.7.	2661 (1266)	7.9.	3919 (427)	14.7.	3143 (155)
28.7.	3028 (1163)	16.9.	5468 (241)	18.7.	3592 (278)
13.8.	3705 (1041)	29.9.	5325 (256)	8.8.	3945 (245)
26.8.	2593 (604)	12.10.	3293 (322)	16.8.	4022 (723)
9.9.	2464 (748)	29.10.	4609 (545)	30.8.	2389 (217)
23.9.	1584 (340)			12.9.	1967 (145)
1.10.	1452 (290)			27.9.	1420 (140)
23.10.	1661 (765)			11.10.	1402 (214)
29.10.	1848 (753)				

Table 1. Number of goldeneye in Hjarbæk Fjord from May to October 1970-1972. Figures in brackets show the number of sex- and age-determined birds (Fig. 5). On dates marked with *) counting has only been carried out in a part of the fiord.

Tabel 1. Antal hvinænder i Hjarbæk Fjord fra maj til oktober 1970-1972. Tal i parentes viser antallet af køns- og aldersbestemte fugle (fig. 5). På datoer mærket med *) er tælling kun foretaget i en del af fjorden.

ANALYSIS OF SPECIMENS COLLECTED

101 goldeneye were drowned accidentally in fish traps in Hjarbæk Fjord in the months of July, August and September during 1969-1972 (now in the collection of the Game Biology Station, Table 2). Drowning of goldeneye in fish traps is apparently closely related to the transparency of the water, as the birds are almost exclusively caught during periods of algal bloom (especially green algae).

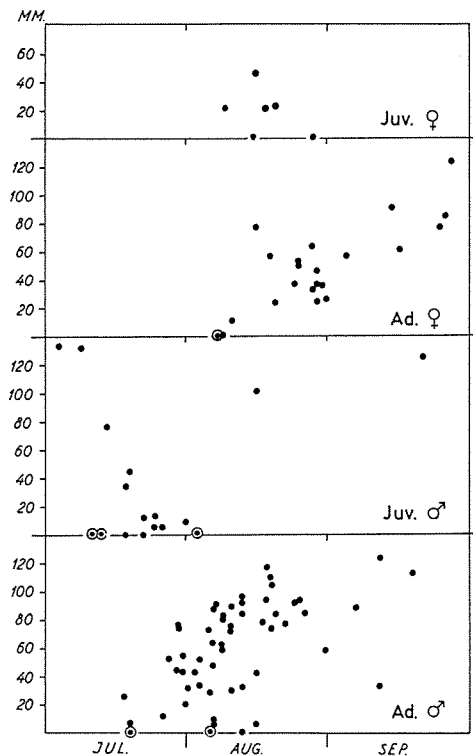
Flightless individuals are caught in particular, and this is possible due to their manoeuvrability under water being reduced. In addition it is mainly the flightless birds which seek food in the very shallow waters where the fish traps are positioned.

The data derived from the specimens collected included information on plumage and wing-feather moult stages, and

Fig. 3. The length of the primaries (follicle or rest of follicle and vane together) of 101 goldeneye from Hjarbæk Fjord. Open circles with dot indicate birds which have not yet moulted their primaries.

Fig. 3. Mål af håndsvingfjer (fjerskede eller rest af fjerskede + fane) på 101 hvinænder fra Hjarbæk Fjord. Fugle der endnu ikke har fældet håndsvingfjerene er vist med åbne cirkler med prik.

on the time and sequence of moult within sex- and age-groups. In Fig. 3 the measurements of flight feathers (follicle or rest of follicle and vane together) of the specimens collected are shown. As far as was possible the measure was taken from the outer primary of the right wing. Individuals which had not yet lost their primaries were given a value of zero (shown in the figure by a special symbol), as these birds might have been completely flightless if caught a few days later. Although the collection of specimens is not representative of the distribution of individuals in sex- and age-groups, it did provide information on the timing of the moult.



Sex Køn	ad. ♂			juv. ♂			ad. ♀			juv. ♀			Total I alt			Total I alt	
	J	A	S	J	A	S	J	A	S	J	A	S	J	A	S		
1969	5	5		5	1			2			1			10	9		19
1970	1	2	4	2	1		1	3			1			4	6	5	15
1971		2		1				2			1			1	5		6
1972	5	32		4	2			11	3		4			9	49	3	61
Total I alt	11	41	4	12	4		1	18	3		6	1		24	69	8	101

Table 2. The number of goldeneye from Hjarbæk Fjord during 1969-1972. J = July, A = August, S = September. In the collection of the Game Biology Station.

Tabel 2. Antal hvinænder fra Hjarbæk Fjord i perioden 1969-1972. J = juli, A = august, S = september. I Vildtbiologisk Stations samling.

SEX- AND AGE-DETERMINATION OF GOLDENEYE IN SUMMER PLUMAGE

The sex- and age-determination of goldeneye in summer plumage involves more uncertainty than when the birds are in winter plumage. The likelihood of a satisfactory classification is very much dependent on the observation conditions. Preferably, the birds should be within a distance of about 500 metres and in a good light (using a telescope with magnification 25 x or 40 x). It is also a definite advantage if there is a flat calm surface. The moult to the summer plumage begins in early June, and during a period of 3-4 weeks the plumage becomes very dark and many sex- and age-characteristics are lost.

The males and females are easily separated on their size difference alone. Age determination of males is possible with a fair degree of accuracy, but this is not true for females. For this reason a separate group of unclassified females has been included. In the material used, information has only been included from flocks in which all individuals or a representative sample could be classified.

Goldeneye were separated according to sex and age into the following categories, taking June as the month of hatching:

1. adult males (> 22 months old),
2. juvenile males (10-16 months old),
3. adult females (> 22 months old),
4. juvenile females (10-16 months old),
and
5. unclassified females.

Fig. 4 shows different stages of wing-feather moult in adult males and females and in juveniles. The summer plumage and field characters are described below.

Adult males

In the summer plumage, the white facial patches are partly or completely lost. The metallic head feathers are lost and re-

placed with brown ones, and at the same time feathers of the neck and back assume a blackish brown colour. The breast and lower ventral neck feathers remain white. In summer plumage the secondaries, large wing coverts and middle wing coverts are all white. The best field character for adult males in summer plumage is the wing-patch (speculum), which appears as a distinct white stripe when the birds is on the water.

Juvenile males

These also lose the white facial patch, and in most specimens no white feathers occur at all in the summer plumage. In contrast to adult males, the feathers of the breast and front of the neck are usually greyish-white. The secondaries and the large wing coverts are grey or greyish-brown and this particular difference from adult males provides the best field character for this category. When a juvenile male is sitting on the water, only a small proportion of the white wing-patch is generally visible, and in many cases the wing appears quite dark.

Adult females

During the moult to summer plumage the white neck-band is lost, the neck and back feathers become grey or brown, whereas the breast and lower ventral feathers of the neck retain their white colour. The yellow-orange stripe across the bill behind the tip fades or disappears as the moult advances, and in July-August this stripe is only faintly visible in a very few specimens. Changes in bill colour in connection with moult to summer plumage are known in other ducks, for example the canvasback (*Aythya valisineria*) (HOCHBAUM 1944) and the ring-necked duck (*Aythya collaris*) (MENDALL 1958).

Juvenile females

In summer plumage, the breast and lower frontal neck feathers appear light to dark grey. The secondaries are white and the large wing coverts are white with black tips, but the middle wing coverts are grey or dark like the scapulars. In the field juvenile females usually appear quite dark and occasionally even blackish, and in many cases only a small white wing patch can be seen.

Unclassified females

The definite age determination of females is often extremely difficult, as some adults

appear very dark during the wing-feather moult, without evident wing-patches being visible. Until August 1971 juvenile females were not classified separately but included in the group »unclassified females«. In Fig. 5 however, juvenile females usually appear quite dark and occasionally even blackish, and in many cases only a small white wing patch can be seen.

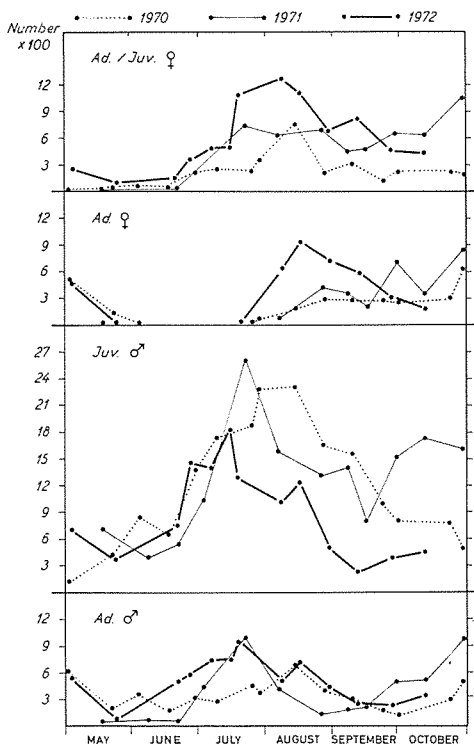


Fig. 5. The number of goldeneye in each sex- and age-category at Hjarbæk Fjord, May–October 1970, 1971 and 1972.

Fig. 5. Antallet af hvinænder indenfor køns- og aldersgrupperne i Hjarbæk Fjord fra maj til oktober 1970, 1971 og 1972.

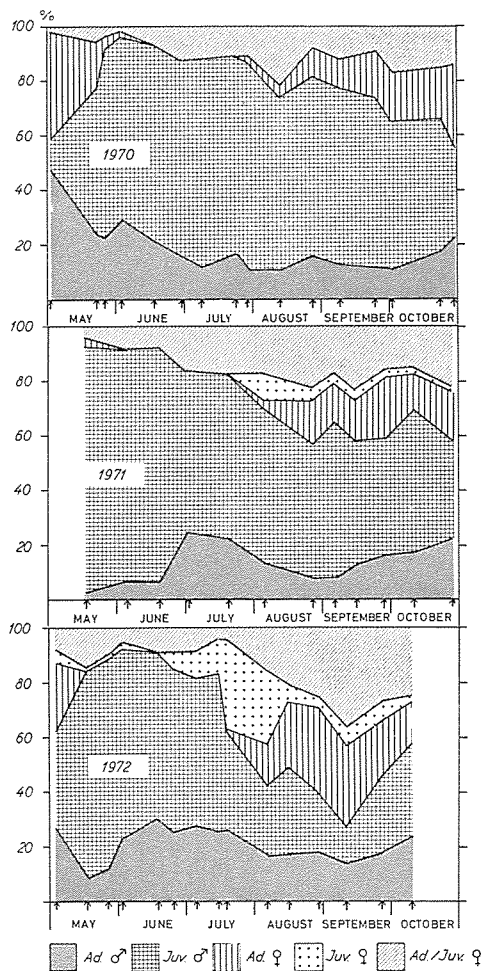


Fig. 6. The percentage sex- and age-distribution of goldeneye at Hjarbæk Fjord, May–October 1970, 1971 and 1972. Arrows indicate dates of observation.

Fig. 6. Den procentiske køns- og aldersfordeling hos hvinænder i Hjarbæk Fjord fra maj til oktober 1970, 1971 og 1972. Pile angiver observationsdage.

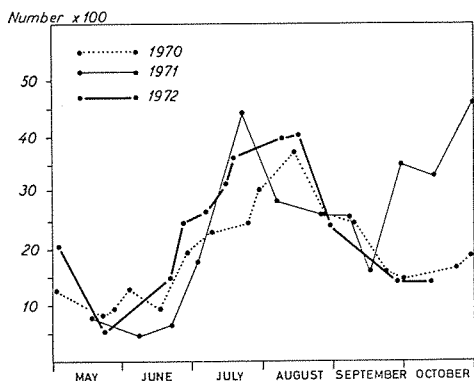


Fig. 7. The number of goldeneye at Hjarbæk Fjord, May–October 1970, 1971 and 1972.
 Fig. 7. Antallet af hvinænder i Hjarbæk Fjord fra maj til oktober 1970, 1971 og 1972.

fied females as one group all three summers, as the uncertainty in classifying this group is very large. This may give a wrong impression when making corrections for the proportion of the population which has not been sex- or age-determined (Figs. 5, 6 and 7). Note: It should be emphasized that juvenile females (13–16 months old) which have completed the wing-feather moult and have well developed new wing feathers, cannot be distinguished from older females in the field. Some juveniles of this age will be classified as adult, some as unclassified females. In males a distinction between 10–16 months old birds and older males is possible in the field at least until October.

OBSERVATION OF THE WING-FEATHER MOULT

The timing of the wing-feather moult in each sex- and age-group has been studied both from an analysis of the specimens collected and from field observations. The proportions of the population of each category in simultaneous moult on the observation days was estimated.

In field observations it is only possible to estimate the number of moulting birds rather approximately. However observations of single individuals often reveal whether the flight feathers have been lost. The shore observations were also frequently supplemented by observations from boats.

The finding of moulted secondaries gave information on the time of commencement of moult in the different groups, and windward coasts were regularly searched. During the moult there is constantly a proportion of the population which have either not lost their flight feathers, or which have completed the moult. Therefore throughout the whole moulting period there was present a representative number of goldeneye in identifiable plumage.

Results

POPULATION SIZE AND GEOGRAPHICAL DISTRIBUTION

The distribution map (Fig. 1) is derived from observations during July and August in 1972, and the size of the symbol indicates the maximum number of goldeneye seen.

Hjarbæk Fjord

The number of goldeneye in Hjarbæk Fjord increases during the summer to a maximum in August; in 1972 4,050 individuals were counted in this month

Localities Lokaliteter	Water area ha. Vandareal ha	Depth m. Dybde m	Shorevegetation 0-2 Bredvegetation 0-2	Salinity 0-2 Salinitet 0-2	Lake character A-B Søtype A-B	Date Dato	Total number of goldeneye Antal hvinænder i alt	ad. ♂	ad. ♀	juv. ♂	juv. ♀	ad./juv. ♀	Not determined Ikke bestemt
1. Visby Bredning	abt. 2000	10	0	2		13.7.	16 (2)			4 (1)	5 (1)		7
- -	-	-	-	-		15.8.	100 (7)		23 (3)	1		5 (4)	71
2. Western Vejler ¹⁾	963	2	1	1	B	14.7.	84 (11)	1 (1)		17 (3)	17 (4)	1	48 (3)
- -	-	-	-	-	-	15.7.	526 (53)	1	1 (1)	1		4 (1)	519 (51)
3. Eastern Vejler ²⁾	263	1,5	2	1	B	14.7.	56						56
- -	-	-	-	-	-	16.8.	46 (7)	1	13 (4)	3	2	17 (2)	10
4. Skarresøerne	23	1,5	1	?		15.8.	63 (2)	1	8 (1)			2 (1)	52
5. Ulvedybet	550	2	2	2	B	14.7.	116 (12)			12 (2)	5 (2)	1	98 (8)
- -	-	-	-	-	-	16.8.	2	1					1
6. Kilen	340	4	1	2	B	13.7.	10						10
- -	-	-	-	-	-	15.8.	18 (3)		6 (2)	2		2 (1)	8
7. Kås Sø	62	2	1	1	B	13.7.	65						65
- -	-	-	-	-	-	15.8.	87 (20)		50 (15)	6		15 (5)	16
8. Bådsgård Vig	abt. 500	3,5	0	2		15.8.	84 (4)		5 (4)	2			77
9. Hjarbæk Fjord	2400	5	0	1	B	18.7.	3592 (360)	73 (4)	1	98 (4)	97 (2)	9	3314 (350)
- -	-	-	-	-	-	16.8.	4022 (167)	128	175 (28)	227 (10)	47 (3)	146 (16)	3299 (110)
10. Halkær Bredning	604	1	0	2	B	16.8.	484 (54)	5	50 (12)	4		138 (25)	287 (17)
11. Madum Sø	212	7	1	0	A	8.8.	231 (32)		12 (4)	10 (3)	21 (1)	40 (6)	148 (18)
12. Felsted Kog	1150	3	2	1	B	26.7.	9 (2)			2 (1)	1 (1)		6
13. Ringkøbing Fjord ³⁾		3	1	2	B	4.8.	30 (8?)						30 (8?)
14. Kvie Sø	30	2	0	0	A	11.8.	15 (5)	2 (1)	3 (2)	2	5 (2)		3
15. Søby Sø	76	5	0	0	A	25.7.	23 (2)			5 (1)	8 (1)		10

Table 3. Localities at which goldeneye in wing-feather moult were observed in July and August 1972.

Notes: 1) = Østerild Fjord and Arup Vejle, 2) = Glømbak and Hanvejle, 3) = Stavning and Havrvig shoals. - Marginal vegetation (reeds etc.): 0 = little or none, 1 = width of vegetation < 5 m., 2 = vegetation > 5 m. - Salinity: (Venice system): 0 = limnetic, 1 = oligohaline, 2 = mesohaline - polyhaline. - Lake character: A = oligotrophic, B = eutrophic. - The number of flightless birds is indicated in brackets. In most cases, the area of moulting localities were obtained from »Danmarks Areal« (1968).

II

Tabel 3. Lokalteter hvor der i 1972 ved tællinger i juli og august blev iagttaget hvinænder i vingefældning. 1) = Østerild Fjord og Arup Vejle, 2) = Glømbak og Hanvejle, 3) = Stavning og Havrvig grunde. - Bredvegetation (rørskov o. lign.): 0 = ingen eller spredt, 1 = brømme < 5 m, 2 = brømme > 5 m. - Salinitet (Venice system): 0 = limnetisk, 1 = oligohalin, 2 = mesohalin - polyhalin. - Søtype: A = oligotrof, B = eutrof. - Tal i parentes = fugle med tydelige tegn på vingefældning. Fældningslokaliteternes areal er i de fleste tilfælde taget fra »Danmarks Areal« (1968).

(Fig. 7), being much more than half of the total population in the whole Limfjord area, and approximately one-third of the average goldeneye population in July – August for the whole country.

The sex- and age-composition of the Hjarbæk Fjord population in 1970, 1971 and 1972 are seen in Figs. 5 and 6. The most striking change during this period was in the number of females, which increased considerably. In each year, maximum numbers occurred in August, being 900, 1,100 and 2,050 in 1970, 1971 and 1972 respectively. At the same time there was a reduction in the number of juvenile males in late summer. In early summer 1970 the number of adult males was relatively low apart from in May, when their numbers were large compared with other years. This difference can possibly be ascribed to conditions of the weather, as the winter of 1969/70 was severe and large areas of the local Danish waters were ice covered until mid-April. In 1970 the last adult females left Hjarbæk Fjord in the first week of June, a good two weeks later than is normal.

Also in 1970, most of the adult males left the fiord together with the females, but in the first few days of June a group mainly consisting of males arrived and many of these remained in the area. It was also found that the population level later in the summer was relatively low,

and this might have been due to relatively greater mortality occurring in the previous winter. It must be emphasized that in Fig. 6 the category ad. ♀ includes some juvenile (13–16 months old) females which have just completed their wing-feather moult. In Sept.-Oct. the categories juv. ♂ and juv. ♀ mainly consist of birds less than six months old (see page 7–9) on their first autumn migration.

The rest of the Limfjord

Localities immediately adjacent to the Limfjord were also included in population counts in 1972; these were Vejlerne (2 and 3), Ulvedybet (5), Kilen (6), Kås Sø (7), and Halkær Bredning (10) (see Fig. 2). In two counts the total numbers of goldeneye were 5,700 and 6,200 respectively, or approximately half the average summer population of the whole country in July–August. The distribution of the population in the different localities of the Limfjord shows striking differences between July and August.

The most obvious difference was in Halkær Bredning (10), where no goldeneye were observed in July but 484 were counted in August (Table 3, Fig. 2). There are several reasons for these population changes, the main ones being changes in the sex- and age-composition caused by the moult migration. This will be treated later.

THE MOULT MIGRATION AND WING-FEATHER MOULT

The majority of recoveries of goldeneye in Denmark are from the Limfjord area (NILSSON 1971), but there is no information at all on birds recovered when flightless. The consideration of the moult migration is thus exclusively based on indirect studies at Hjarbæk Fjord in particular.

HOCHBAUM (1944), SOWLS (1955), and SALOMONSEN (1968) report that the males of many species of duck migrate as complete groups to particular moulting areas. There is a very concentrated moult migration to Hjarbæk Fjord in July as observations have shown. In general, the flocks keep fairly much together during the first

few days, and on arrival almost all individuals are in complete summer plumage. The greatest influx of goldeneye observed was 1,600 on June 26 1972, the approximate composition of this flock was; adult males 30 %, juvenile males 50 %, juvenile females 5% and unclassified females 15 %.

The earliest records of moulting birds and findings of lost flight feathers at Hjarbæk Fjord are in the latter half of June. During the next two months there is a great increase in the number of moulting birds and a maximum is reached in early August, when about 55 % of the total population are unable to fly. Subsequently the number of flightless individuals decreases again until the beginning of October when all birds had completed the wing-feather moult. The period in which the whole population accomplishes the summer moult thus has a duration of approximately 3½ months (Fig. 8A).

The earliest observation of moulting ever recorded during the study period was on June 18 1969 and concerned two juvenile males. The latest observation was on November 16 1972, of an adult female in the last stage of moulting.

The wing-feather moult of the goldeneye is not simultaneous in the different sex- and age-groups. From observations in the field and analysis of specimens collected (Fig. 3 and 8B), the following sequence has been found. 1) juvenile males, 2) adult males, 3) juvenile females (and possibly non-breeding adult females), and 4) adult females. A similar sequence has been recorded in other duck species (HOCHBAUM 1939, JOENSEN 1973).

The percentage proportion of the population in summer moult throughout the season is shown in Fig. 8A, while in Fig. 8B the percentage proportion of moulting birds in each sex- and age-group is shown.

The figures was derived from average values obtained during the period 1969–1972. At certain times up to 80 % of the individuals in the groups of adult males, adult females and unclassified females are

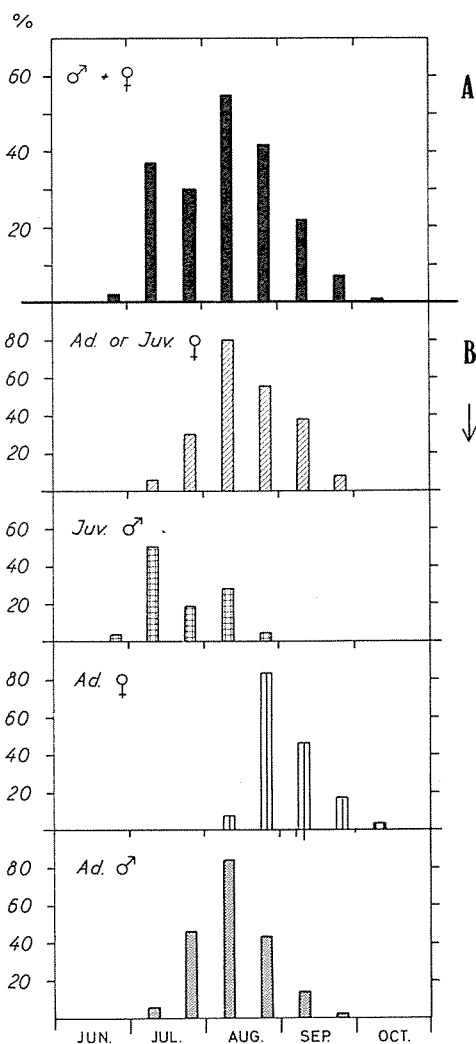


Fig. 8. The percentage of flightless goldeneye among those present in Hjarbæk Fjord. A: all categories, B: each category. Average of four years (1969–1972).

Fig. 8. Den procentiske andel af afslæede hvindænder blandt de observerede. A: Alle kategorier, B: Hver kategori for sig. Gennemsnit for 4 år (1969–72).

in moult, as opposed to only 50 % of juvenile males.

It was not possible to determine accurately the flightless period of a single individual, but it is estimated to be less than 4 weeks in duration. COTTAM (1939) states that the individual moulting period of most ducks is from 3–4 weeks long. In captivity canvasback moult in 3–4 weeks (HOCHBAUM 1944), and MENDALL (1958) reports that the same is true of the ring-necked duck. BALAT (1970) states that in the mallard (*Anas platyrhynchos*) the duration of the moulting period of a single individual is between 27 and 29 days, measured from the time when the flight feathers are lost until the bird is again capable of flight; however, TIMMERMANN & LEBRET (1951) mention for the same species a period of 23–24 days, and observations of mallard in captivity showed that the flightless period is between 24 and 26 days (BOYD 1960).

Juvenile males

At the same time as goldeneye pairs leave Hjarbæk Fjord during May, an increasing number of juvenile males begin to frequent the locality. The actual moult migration commences in mid-May, the date being fairly coincident from one year to another (Fig. 5). It is probable that the juvenile males have gathered from other areas of the Limfjord. The pre-moult distribution in June shows concentrations of goldeneye in Venø Bugt, Hjarbæk Fjord and Halkær Bredning (JEPSEN & JOENSEN 1973). However, the sex- and age-composition of the population in June is only known for Hjarbæk Fjord, where the majority are juvenile males; the same is probably also true of the populations in other localities.

Later in the summer (July), some juvenile males arrive together with adult males, these birds having probably al-

ready completed their wing-feather moult. This assumption is supported by the following observations:

1) At any point in time, a maximum proportion of only 50 % of the juvenile male population have been observed in moult, as opposed to 80 % in the other categories (Fig. 8B). 2) Only few juvenile males were found in fish traps, although it must be presumed that individuals in the different categories have equal chances of being caught and drowned whilst they are flightless (Fig. 3, Table 2). 3) Two specimens of juvenile males caught in early July (Fig. 3) possessed new and completely developed flight feathers.

It is possible that some juvenile males undergo wing-feather moult in other parts of Denmark, but for the majority the moult probably takes place in other waters. HAARTMAN (1945) mentions that in May and June, large flocks of goldeneye males are found off the coast of western Finland, and JÖGI (1970 and 1971) reports that about 10,000 males moult along the coast of Estonia. These authors do not state whether these birds are adult or juvenile males.

The average moulting period of juvenile males during the period of study was from about June 25 to August 25, culminating in mid-July when 50 % were flightless (Fig. 8B). Among the sea-ducks *Somateria mollissima*, *Melanitta fusca*, *Melanitta nigra*, *Aythya marila* and *Mergus serrator* moulting in Danish waters, *M. nigra* is the only species which begins its wing-feather moult so early in the year, and in which juveniles are the first category to begin moulting (JOENSEN 1973).

Adult males

Throughout the whole of the spring, adult males occur in Hjarbæk Fjord. Their numbers vary from year to year, and they

may be birds which have not paired. The actual moult migration begins in early July, but the time of arrival varies somewhat from one year to another. It can be presumably brought forward or delayed by the breeding conditions prevailing in any year, a feature known for the ring-necked duck (MENDALL 1958). According to HAARTMAN (1945) and DEMENT'EV et al. (1967), the males leave the breeding sites approximately 15 days after the commencement of incubation. The main moult migration usually consists of flocks of up to several hundred individuals, and often together with juvenile males and females and occasional adult females, the latter possibly consisting of unsuccessful breeders.

The moult migration of adult males appears to be directed towards quite specific localities. In counts in the Limfjord in 1972, only few adult males were observed outside Hjarbæk Fjord. At the other localities juvenile birds were dominant (Table 3).

In the beginning of July few adult males with flight feathers missing are seen, but the majority begin to moult in the latter half of July. The moult culminates in the first half of August when about 80 % of adult males are flightless (Fig. 8B).

Juvenile females

The moult migration of juvenile females to Hjarbæk Fjord is apparently very irregular, and takes place over a long period of time. In April and May very few juvenile females have been recorded in the fiord, but larger numbers arrive together with the moult migration of the adult males.

In July – August 1972 juvenile females were observed at several localities, where wing-feather moult occurred (Table 3).

The earliest observation of flightless juvenile females was in mid-July, and for this group the moult period extended for about 3 months, until early October (Fig. 8B). Only 6 juvenile females were obtained as specimens from Hjarbæk Fjord (Fig. 3); in these birds, the oviduct was straight and narrow. The scarcity of specimens together with the fact that juvenile females are the most difficult category to identify in the field imply that information on the moult migration and moult of this group is rather insufficient.

Adult females

According to BERNHARDT (1940), goldeneye females leave their young 2–3 weeks after hatching. In Hjarbæk Fjord the first adult females on moult migration arrive in late July, which indicates that they leave the breeding areas about one month after hatching of their young. It is however not known, whether some females undergo wing-feather moult in or near the breeding areas.

The moult migration of adult females appears to be directed to a lesser degree than that of the males to a few specific localities. During counts in August 1972, adult females in moult were observed at several smaller fresh-water areas, sometimes in the company of juvenile females and occasionally with juvenile males. However adult males were very seldom observed at such localities (Table 3, Fig. 2). There was a similar predominance of females at several smaller regions of the Limfjord, e.g. at some of the lakes in the wetlands of Vejlerne (2, 3) and Kås Sø (7), and at the lakes of Madum Sø (11), Kvie Sø (14), and Søby Sø (15).

The first flightless adult females in wing-feather moult at Hjarbæk Fjord were observed at the beginning of August, and the moult culminated in the latter

half of August when approximately 80 % of the adult females were incapable of flight. For the majority of this group, the

moult period was completed during the first half of October (Fig. 8B).

BEHAVIOUR AND HABITAT PREFERENCE

Behaviour

The behaviour of the goldeneye during its moulting period was mainly studied at Hjarbæk Fjord. Feeding takes place during daylight hours, when the birds are widely dispersed. Before dusk they congregate into dense flocks of up to 1,000 birds.

In winter the males and females show a pronounced difference in habitat preference when feeding. In mid-fiord areas, there are higher percentages of males in the flocks than in those found off lee coasts, sheltered bays and stream outlets, where females generally predominate. Similar conditions are mentioned by NILSSON (1970) in areas off the south and west coast of southern Sweden. However, in the summer and particularly during the moult, a similar distribution pattern was not observed at Hjarbæk Fjord, where both sexes frequent shallow waters when feeding. Possibly this is caused by a reduction in the ability to dive during moulting. About 60–70 % of the moulting goldeneye feed at depths less than 1.5 m. No flightless birds were observed in 1972 in lakes of more than about 7 m. depth, (e.g. none in the deep lakes east of the Central Jutland ridge), whereas the species regularly occurs although in small numbers in the shallow lakes of Central- and West-Jutland (Fig. 1, Table 3).

In winter, feeding goldeneye prefer shoal waters of at most 6–7 metres' depth (NILSSON 1969a). According to DEWAR (1924), HAARTMAN (1945) and DEMENT'EV et al. (1967), the most usual diving depth is from 0.5 to 4.2 metres. In addi-

tion HAARTMAN (1945) found that females preferred shallower water than males, and this influences local distributions.

In the winter Hjarbæk Fjord also serves as a night roosting area for up to 3,000 individuals which spend the day in other areas. This type of movement has occasionally been observed in the summer months, particularly during strong wind. For example ROSENBERG (1968) reports that on August 4 1966 about 500 goldeneye moved from the area of the Limfjord into Østerild Fjord which is in the west of Vejlerne (2). KORTEGAARD (in prep.) mentions that during strong wind in the summer months, large numbers of goldeneye often move from the Limfjord to the lakes in Vejlerne.

Comparison of the sex ratio at different localities

During the wing-feather moult there are appreciable differences in the sex ratio of the species at different localities. Females for instance show a definite tendency to prefer smaller lakes and fiords, and this is emphasized when the sex ratio of the Hjarbæk Fjord population is compared with the ratios found in other local populations (Table 3, Fig. 9).

In the following examples, the male:female ratio has been calculated from the sex- and age-determined part of the population. On August 8 1972 population counts were carried out at Hjarbæk Fjord and Madum Sø; at Hjarbæk Fjord, the ratio was 3:4, while at Madum Sø it was 1:7. On August 18, the ratio at Hjarbæk

Fjord was 1:1, whereas at Kås Sø on August 15 it was 1:10, and at Halkær Bredning on August 16 it was 1:19.

Habitat preference

It appears evident that for their moulting areas in Denmark, goldeneye prefer sheltered arms of fiords, lakes and bays. The species moults both in fresh- and brackish-water, but almost exclusively in waters with little or no tall marginal vegetation (e.g. *Phragmites*). In contrast to surface-feeding ducks such as *Anas crecca* which moult well concealed in dense vegetation (KORTEGAARD in press), the wing-feather moult of the goldeneye takes place in open waters. Other diving ducks, such as the *Somateria mollissima*, *Melanitta fusca*, *Melanitta nigra*, *Aythya marila* and *Mergus serrator* also spend their moult period in open salt- or brackish-waters, the *M. nigra* even choosing completely unprotected waters many kilometres from the coast (JOENSEN 1965, 1973).

Although the goldeneye prefers oligotrophic fresh-water lakes as breeding area (RAJALA & ORMIO 1970), it appears to be less selective during the wing-feather moult. The character of the moulting areas in Denmark ranges from oligotrophic lakes of great clarity (Madum Sø) to strongly eutrophic areas of poor transparency such as Hjarbæk Fjord.

In Fig. 1, solid circles indicate the 15 localities at which goldeneye were observed in wing-feather moult in 1972. A brief habitat description of each moult area and the number of goldeneye observed in population counts in July and August is given in Table 3. The description of localities gives a representative picture of the variety of habitat used by goldeneye during the wing-feather moult.

Hjarbæk Fjord (Fig. 10 p. 23)

As mentioned previously, Hjarbæk Fjord

is by far the most important moulting area for goldeneye in Denmark, and a description of this area will emphasize the conditions which are also typical of many other moulting areas. In 1966 a dam was built which separated the fjord from the rest of the Limfjord. Due to this, the salinity of the surface water has fallen from 7–19 ‰ (Muus 1967) to about 0.35 ‰ in October 1972. The deepest part of the

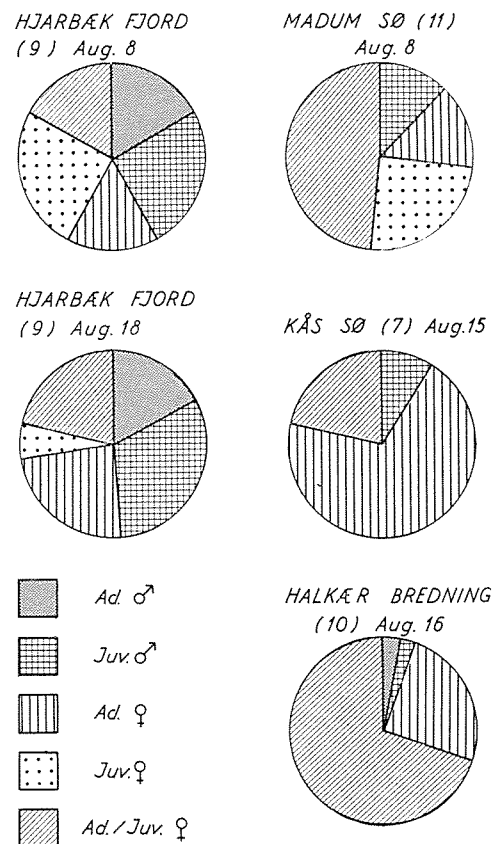


Fig. 9. A comparison of the sex- and age-composition of goldeneye populations at Hjarbæk Fjord and localities 7, 10 and 11 (see Fig. 1) in August 1972.

Fig. 9. Sammenligning mellem køns- og aldersforholdet blandt hvinænder i august 1972 i Hjarbæk Fjord og lokaliteterne 7, 10 og 11 (se fig. 1).

fiord is about 5 m. deep, but large areas are very shallow (0–2 m.).

There is very little tall marginal vegetation, larger areas of reeds only occurring in the eastern part of the fiord and at stream outlets. The fiord bottom is mainly sand or sand mixed with clay, and the deeper parts have no bottom vegetation. The vegetation in the shallow waters along the western shore is dominated by *Ruppia* sp., and *Potamogeton pectinatus* grows in the eastern part of the fiord. At stream outlets there are rich growths of *Elodea canadensis* (JEPSEN 1970). Larvae of *Chironomidae* and *Trichoptera* and the mollusc *Potamopyrgus jenkinsii* dominate in the lower fauna of the fiord bottom. A preliminary analysis of the stomach contents of the birds caught in fish traps showed that these items were among the preferred food of the goldeneye during moult (JEPSEN in prep.).

Salt- and brackish-water habitats

The western and central sections of the Limfjord are almost polyhaline (18–30 ‰), while localities more distant from the main currents in the fiord are mesohaline (5–18 ‰), see localities 8 and 10 (Fig. 1). Like Hjarbæk Fjord, several other areas are separated from the main fiord by dams, and these areas are usually oligohaline (0.5–5 ‰). This is true of localities 2, 3 and 7, although certain lakes in 2 and 3 are almost limnetic in character.

Moulting goldeneye were observed in West Jutland in 1972 at Nissum- and Ringkøbing Fjord, and in some years they have also been observed at Stadil Fjord. These fiords are brackish, with a salinity of up to 15 ‰.

During counts from aircraft in previous years, flocks of goldeneye were observed in July and August in the Kattegat around Læsø and along the east coast of Jutland. It was not possible absolutely to determine whether flightless birds were present in these flocks, but the behaviour of the birds suggested this was the case (JEPSEN & JOENSEN 1973).

Fresh-water habitats (Fig. 11 p. 23)

Fresh-water lakes are the smallest moulting areas as regards size, and are mainly moulting areas for females (Table 3, Fig. 1). The largest number of goldeneye in wing-feather moult in 1972 were observed at Madum Sø (No. 11 in Fig. 1). The lake is oligotrophic and has an area of 212 ha. The maximum depth is 7 metres, but large parts of it are considerably shallower. The lake is one of the most typical *Lobelia* lakes in Denmark. Along the shores, there are occasional growths of *Phragmites communis* and *Heleocharis palustris*. Up to 2 metres out from the shore, the vegetation is dominated by *Lobelia*, with or without *Littorella* (JØRGENSEN 1948). Madum Sø may be characterised as one of the few lakes in Denmark which closely resembles the breeding habitat preferred by the goldeneye.

Discussion and summary

In recent years, the total number of moulting goldeneye in Denmark has been at least 12,000–14,000 birds, of which the majority (9,000 or more) are found in the

Limfjord. In Denmark, the most important moulting area is Hjarbæk Fjord, part of the Limfjord system, where more than 4,000 goldeneye moulted in 1972.

The moult migration

Descriptions of the moult migration are especially based on field observations at Hjarbæk Fjord. There are no recoveries in Denmark of flightless ringed goldeneye.

The majority of goldeneye recovered in Denmark outside the moulting period were ringed in Sweden and Finland, and only a few individuals from Norway (very few ringed compared to the other countries mentioned) and the U.S.S.R. feature in the records. The ringed birds were predominantly adult females and progeny of that year captured at the breeding sites, and no difference has been discerned as to the direction of migration of these two groups. Goldeneye ringed in Central Sweden mainly migrate to Denmark, and particularly in the Limfjord there are many recoveries (NILSSON 1971), and it is reasonable to assume that the moulting goldeneye mainly come from these areas. A sizeable proportion of the goldeneye from South-west Finland also migrate to Danish waters (NILSSON 1969b). The majority of recoveries from Denmark occur in the autumn and winter months, coincident with the shooting season (October 1–February 29) for diving ducks, and thus do not give direct information on the moult migration. It is however probable that some of the birds recovered in September and October have completed their wing-feather moult in Denmark.

The wing-feather moult

The wing-feather moult takes place within the following periods by the different categories of goldeneye.

1. Juvenile males: late June until late August, culminating in mid-July.
2. Adult males: early June until mid-September, culminating before mid-August.

3. Juvenile females: mid-July until late September, culminating in mid-August.

4. Adult females: early August until mid-October, culminating in late August.

The moulting period of the species thus covers a period of about 3½ months.

Moulting habitats

During the wing-feather moult the birds are physically handicapped, and the moulting area must be able to satisfy certain requirements, and certain physical features appear to be deciding factors (see HILDEN 1964 regarding habitat preference of ducks in summer):

1. The depth of the water: Characteristic of moulting areas is the presence of considerable shallow areas of 0–2 m. depth.
2. Within these depths, there should be available food items in sufficient amounts. The reduced manoeuvrability of the goldeneye during its wing-feather moult is presumably the reason for feeding in very shallow waters. At Hjarbæk Fjord goldeneye were observed on several occasions to seek food by dabbling in 10–20 cm. water, and this behaviour was never observed at other times of year.
3. As moulting areas, the goldeneye prefers open waters without tall marginal vegetation and protected against disturbance and predation. When goldeneye are disturbed their evasive response is to dive or to move out to deeper water.

There appears to be a clear difference between the sex- and age-categories as regards choice of moulting area. The moult migration of adult males is directed towards a few specific localities at which they arrive in relatively large flocks. In

contrast, the moult migration of adult females appears to be more diffuse and to a larger number of areas, and the migration is composed of smaller flocks. As for juvenile birds, the males congregate at particular localities during the early summer. It is presumably those birds which have spent the winter and spring in Danish

waters which also undergo wing-feather moult in Denmark. A large number of juvenile males however also arrive with the adult males on their moult migration, but the majority of these juveniles have already completed their moult, probably in other Scandinavian countries and in the archipelagoes in the Baltic Sea.

Dansk resumé

Hvinandens (*Bucephala clangula*) fældningstræk og svingfjærfældning i Danmark.

1. Det totale antal fældende hvinænder i Danmark har i de senere år været mindst 12.000–14.000, hvoraf hovedparten godt 9.000 ses i Limfjorden (JEPSEN & JOENSEN 1973). Landets vigtigste fældningsbiotop for arten er Hjarbæk Fjord, en del af Limfjorden, hvor der i 1972 fældede omkring 4.000 hvinænder. Vildtbiologisk Station har siden 1967 foretaget registreringer af fugle i Hjarbæk Fjord, der er vildtreservat. Undersøgelserne har siden 1969 bl. a. omfattet studier af hvinandens fældningstræk og svingfjærfældning. I 1972 er der derudover indsamlet oplysninger fra andre lokaliteter især i Jylland (fig. 1), hvor Limfjordsområdet har været grundigst dækket med to tællinger fra land i juli og august (fig. 2).
2. Antallet af hvinænder i Hjarbæk Fjord fra maj til oktober 1970, 1971 og 1972 ses i tabel 1 og fig. 7. Der har i alle tre sæsoner været foretaget køns- og aldersbestemmelse på en stor del af bestanden (fig. 5 og 6). Feltobservationerne er suppleret med et skindmateriale fra 101 hvinænder der ved uheld er druknet i fiskeredskaber (tabel 2 og fig. 3). Fig. 4 viser vingekendetegn hos forskellige kategorier under svingfjærfældningen.
3. Genmeldinger af hvinænder ringmærket i udlandet giver kun sparsomme oplysninger om fældningstrækket, idet der ikke foreligger oplysninger om fugle genmeldt som afslæede. Behandlingen af fældningstrækket i denne sammenhæng er derfor baseret på observationer især i Hjarbæk Fjord (fig. 5).
4. Tidspunktet for hvinandens svingfjærfældning er ikke sammenfaldende for køns- og alderskategorierne. Fig. 8A viser den procentiske del af bestanden i fældning og fig. 8B viser procentdelen af fældende fugle inden for de enkelte kategorier.
5. Hvinanden er med hensyn til fødesøgning dagaktiv. Under svingfjærfældningen søger fuglene ind på lavt vand under fourageringen. I Hjarbæk Fjord ses 60–70 % på vanddybder under 1,5 meter.
6. I fældningsperioden ses kun få adulte hanner udenfor Hjarbæk Fjord. Juvenile hanner fælder mere spredt på forskellige lokaliteter, og en del der ankommer til Hjarbæk Fjord sammen med adulte hanner på fældningstræk, har allerede overstået svingfjærfældningen muligvis udenfor Danmark. Hunner synes i høj grad at vælge mindre lokaliteter f. eks. ferskvands-

søer som fældningsbiotop. Fig. 9 viser en sammenligning i kønsforholdet mellem Hjarbæk Fjord og andre lokaliteter i august 1972. Tabel 3 beskriver skematisk de lokaliteter hvor der i

1972 blev iagttaget hvinænder i fældning og viser samtidig antallet af hvinænder fordelt på køn og alder ved tællinger i juli-august.

Резюме на русском языке

Миграции на линьку и линька маховых перьевгоголя (*Vicephala clangula*) в Дании

1. Общее число линяющих гоголей в Дании за последние годы составляло по меньшей мере 12.000–14.000. Большинство их, немного более 9.000, встречаются в Лимфиорде (JERSEN и JOENSEN 1973). Главным в стране биотопом линьки этого вида является Ярбек-Фиорд, представляющий собой участок Лимфиорда, в котором в 1972 г. линяли около 4.000 гоголей.

Станция Исследования Биологии Дичи с 1967 г. производила регистрацию водоплавающих птиц в Ярбек-Фиорде, являющемся заповедником дичи. С 1969 г. исследования также включали изучение миграций на линьку и линьку маховых перьев гоголя. В 1972 г. кроме того собраны сведения из других местностей Ютландии (фиг. 1), из которых район Лимфиорда наиболее основательно исследован двумя учетами с суши в июле и августе (фиг. 2).

2. Число гоголей в Ярбек-Фиорде с мая по октябрь 1970, 1971 и 1972 годов показано в приложении 1 и фиг. 7. В течение всех трех сезонов проводилось определение по полу и возрасту значительной части популяции (фиг. 5 и 6). Наблюдения на поле дополнены материалом шкурок 101 гоголя, погибших при несчастных случаях в рыболовных снастях (табл. 2 и фиг. 3). Фиг. 4 показывает отличительные приметы крыльев разных категорий в течение процесса линьки.

3. Сообщения о гоголях, помеченных за границей, дают только немного сведений о ми-

грациях на линьку, так как не имеется сведений о птицах, потерявших перья.

4. Периоды линьки маховых перьев у гоголей разных половых и возрастных категорий не совпадают. Фиг. 8 А показывает процентную долю линяющих птиц популяции, а фиг. 8 В показывает процентную долю линяющих птиц по отдельным категориям.

5. При розыске пищи гоголь активен днем. Во время линьки маховых перьев птицы фуражируют предпочтительно на мелководных участках. В Ярбек-Фиорде 60–70% из них встречаются на местах, где глубина воды составляет менее 1,5 м.

6. В течение периода линьки вне Ярбек-Фиорда встречается только немного взрослых самцов. Молодые самцы линяют более вразброс по разным местностям, и часть их, прилетающая в Ярбек-Фиорд вместе с мигрирующими на линьку взрослыми самцами, уже закончила линьку маховых перьев, может быть вне Дании. Самки в качестве биотопа для линьки очевидно предпочитают небольшие водяные пространства, напр. пресные озера. Фиг. 9 показывает сравнение соотношений полов в Ярбек-Фиорде и в других районах в августе 1972 г. Табл. 3 схематически характеризует местности, в которых в 1972 г. наблюдались линяющие гоголи, и одновременно показывает численность гоголей с разбивкой по полу и возрасту по учетам в июле-августе.

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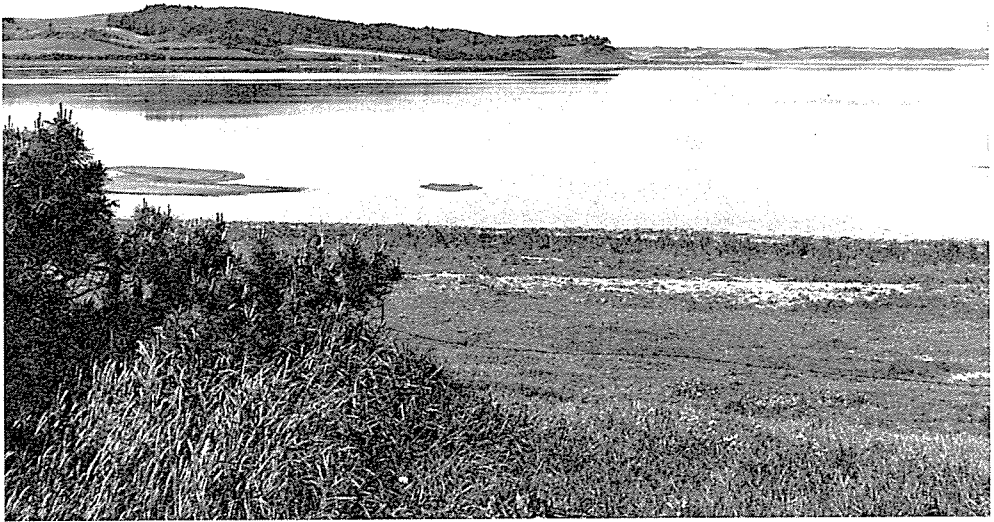


Fig. 10. A view of the eastern part of Hjarbæk Fjord, locality no. 9 in Fig. 1.
Fig. 10. Parti fra den østlige del af Hjarbæk Fjord, lokalitet nr. 9 på fig. 1.

(Photo:
P. Uhd Jepsen)



Fig. 11. A view of Madum Sø, locality no. 11 in Fig. 1.
Fig. 11. Parti fra Madum Sø, lokalitet no. 11 på fig. 1.

(Photo: P. Uhd Jepsen)

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