Bird Migration Observed by Radar in Denmark October 1968 to September 1969

By
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(Med et dansk resumé: Fugletræk i Danmark observeret ved hjælp af radar i perioden oktober 1968 til september 1969.)

INTRODUCTION

Until 1968 no radarstudies of birdmigration in Denmark have been undertaken. In connection with research carried out in order to reduce the number of collisions between birds and aeroplanes, filming of a radarscope was however started in the autumn of 1968. The purpose of this was to develop a model for forecasting the number of migrating birds by means of some important meteorological parameters (NOER et al., 1970). In the following the variations throughout one year (Oct. 1968 – Sept. 1969) in the intensities and directions of the migration over the eastern parts of Denmark are described.

ACKNOWLEDGEMENTS

The studies of bird migration by means of radar were initiated in 1968 as part of a RDAF research programme for the reduction of bird-strikes, i. e. collisions between aircraft and birds. We want to thank the personel of the radar-station FLD 502, particularly lieutenant P. R. CLAUSEN, for providing exellent material for the studies, and personel of the Danish Defence Research Board for providing facilities for the analysis of the data. The authors also want to thank lieutenant colonel K. ABILDSKOV, civ. ing. JØRGEN CHRISTENSEN, mag. scient. ANDERS HOLM JOENSEN, and major E. P. SCHNEIDER for their great help in providing facilities and material for the studies of bird migration.

MATERIAL AND METHODS

The material was collected on a RDAF radarstation placed on the southern part of Zealand (Fig. 1). The radar used is operating in the L-band. A PPI-scope (60 miles range) was filmed continuously (with small breaks) throughout the year. The films analysed are 16 mm exposures obtained by the wellknown timelapse technique. This technique is described by e. g. EASTWOOD (1967). Every second revolution of the radar is photographed. In this way 24 hours are pressed into abt. 3 minutes when the film is displayed at normal speed. Using this method the migrating birds are seen moving at the screen as more or less discrete spots (echoes, angels). The species cannot be deduced by the shape or the size of the

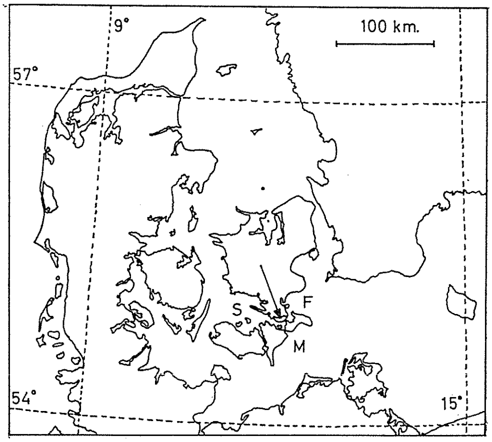

Fig. 1. The arrow shows the position of the radar-station. F, M and S denote the counting areas in Faxe Bugt, Møns Bugt and Smålandshavet.

Fig. 1. Pilen viser radarstationen. F, M og S optællingsområderne i Faxe Bugt, Møns Bugt og Smålandshavet.

echoes. Moreover, the vast part of the avian echoes are probably caused by a flock of birds rather than a single bird, – or even by several flocks. Especially at greater distances the resolution cell of a surveillance radar like the one used here has a size, which makes it probable that one echo may be caused by several flocks.

Counts of moving echoes have been made in three areas (F, M, and S at Fig. 1). Each area is 600 square kilometers and is a piece of the 30–50 km annulus around the radar site. The areas are all over water in order to minimize ground echoes and leading line migration. Furthermore, under normal conditions of propagation of the radarwaves, the radar horizon is running through these areas. They should therefore be in the most favorable position for observing the birds flying at lower levels, too.

Starting at midnight every 24 hours are divided into 6 periods of 4 hours each. In these periods the directions and densities of the movements are estimated in each of the three counting areas. For each 4-hours period, the peak densities for all movements in separable directions have been estimated. In most cases two »movements« must be separated by an angle of at least 45° in direction to be registrated as different. This is especially the case when movements of higher densities occur. Local movements have been excluded as far as possible. The movements are given in 16 directions (N, NNE etc.).

The density of the migration (here being defined as the number of echoes per unit of area) is classified as belonging to on of ten groups (intensity 0–9). We have chosen these groups on the basis of an exponential scale. Thus, if the nearest power of 2 to a given number of echoes in a movement in one sample area is 2^x, the intensity is said to be x. The resolution power of the radar is abt. 1 echo per square km. This makes it impossible to observe intensities higher than 9. Saturation of the scope has been observed at several occasions.

It is a wellknown fact that the number of bird echoes observed on a radar screen is decreasing with increasing range (Nisbet 1963). This phenomenon is known as the thinning effect. Control counts however indicated that the rate of thinning is fairly constant throughout the whole material used here. Hence no compensation for the thinning of echoes was appplied to our measures of the intensity, and this is thought to have given rise only to insignificant errors. Moreover, the maximum distance at which echoes are observed is varying with the flight height. At certain times of low level migration a rather sharply marked outer limit of the bird echoes can be observed. As this outer limit however on no occasions was within the sampling areas used, we have not tried to compensate for errors in the estimates of the intensities of low level migration, either.

RESULTS

The results are given in Table 1 (the diurnal migration) and Table 2 (the nocturnal migration). The day and night peak intensity expressed in number of echoes in each of the 16 directions are found in each of the three counting areas. These are added, and an average number of echoes in each direction is found for the areas. These daily directions and average intensities are summed in each ten days period throughout the year, and averages for day and night in these 36 periods are found.

Figs. 2–3 give a summary of the tables in vectorform, in which the average intensities for each direction per month are shown.

Compared with the experience from visible migration at different sites there seems to be only small differences in the directions and intensities of the three counting areas. As a rule, the number of echoes seems to be the greatest in F and least in S. The differences are however rather small. Fig. 4 gives the nocturnal spring pattern in the three areas (the sum of the average intensities for each direction in the period ult. March – ult. May). In the autumn, at least the nocturnal pattern mirrors the spring pattern. The SW-migration is most prominent in F and the SE-migration in M. This may be due partly to the temporary operating of an MTI (Moving Target Indicator) circuit on the radar.

For a decription of a MTI, see Eastwood (1967). The operation of a MTI will probably prevent some of the birds having the smallest Doppler-shift of the reflected radarwaves from being observed. These are of course the ones moving tangentially to the radar, and SW-migration may thus be discriminated in M and S, while SE-migration is discriminated in F. As the number af echoes discriminated by the MTI is unknown, we have not been able to compensate for this.

The tables and figures show the migration over the sea. Therefore, the method of sampling used here excludes a lot of details observed. It should be noted that migration following leading lines is at certain times a very prominent feature of the screen. E. g. is a huge emigration from Falsterbo (SW-point of Sweden) often observed – of course mainly in the autumn, but at several occasions also in the spring. Broadfront-migration is however always dominating. Starlings *(Sturnus vulgaris)* dispersing from roosts in the morning is a common phenomenon in parts of the year.

The results should be perceived a little cautiously. As the peak intensity is taken in directions which may have their maxima at different times, the total intensity for all the directions may have a greater value than the total intensity observed at any time. If the same movement is changing in direction we have chosen the start direction (and intensity). Furthermore, if migration occurs simultaneously in more than one direction, the respective intensities have been hard to state correctly. This fact may have placed too much weight upon the dominating direction(s) in the periods.

Tables p. 4 and 5.

Table 1. Diurnal migration. The mean activity in the 16 directions for the three counting areas in 10 days periods through the year. The heading »Days« denotes the total number of available counting days (nights) in the three counting areas together. »Mean echoes« is the sum of the intensities in the respective rows. The procedure of taking the peak intensity of each direction in the course of the day or night make comparisons between »mean echoes« difficult.

Tabel 1. Dagtrækket. Gennemsnitsaktiviteten for de tre optællingsområder i 10 dages perioder gennem året. Overskriften »Dage« oplyser om det totale antal tælledage i de tre områder tilsammen. »Gennemsnitlige antal ekkoer« er summen af intensiteterne i de respektive rækker. Disse bør sammenlignes med nogen forsigtighed fra periode til periode.

Table 2. Nocturnal migration. Same text as in Ta*l*.
Tabel 2. Nattrækket. Samme tekst som for Tabel ble 1.

Table 1

Month	Period	Days	Mean Echoes	Direction															
				N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Jan.	I	30	58.2			1.5	2.9	0.9						1.1	32.0	15.7	1.2	1.5	1.4
	II	29	18.3		0.1	1.8	3.0	1.1			0.6			0.4	2.5	6.1	2.6	0.1	
	III	30	27.1		1.6	4.5	6.4	5.3	0.5	2.0				0.3	0.7	1.8	2.9	1.1	
Feb.	I	29	30.6	0.8	0.6	2.9	5.5	6.9	1.1	0.8	0.3	0.3	2.2	4.4	1.4	2.4	1.0		
	II	27	87.9	0.6	0.1	7.3	9.8	1.9					0.1	3.6	20.7	39.1	4.7		
	III	0																	
Mar.	I	0																	
	II	0																	
	III	30	102.5			10.0	70.3	11.5	0.7	0.3	0.5		0.1	0.2	1.8	4.4	1.1	0.5	1.1
Apr.	I	21	194.7	6.1	51.3	22.8	76.6	16.5		1.9		0.2		3.0	8.0	1.5	1.9	5.0	
	II	18	58.8	0.4	16.0	18.7	9.4	12.3	0.1	0.4				0.2	0.4	0.4	0.1	0.2	0.2
	III	24	180.1	11.3	85.3	61.3	4.0	5.4	1.4	1.5	0.1			1.4	2.5	2.0	1.2	2.7	
May	I	30	124.6	11.3	12.8	36.5	23.8	19.3	3.5	1.4	0.1	0.9		1.1	2.8	6.3	0.6	3.1	1.2
	II	30	31.8	3.2	6.4	5.4	2.4	8.3		1.1	0.1	0.3		0.4	0.9	1.9	0.3	0.6	0.5
	III	33	89.1	19.9		1.3	9.1	1.6	0.5	2.8	1.3			0.8	1.3	1.0	0.1	2.9	46.5
Jun.	I	30	35.8	0.3	0.3	1.6	4.7	1.6	0.2	3.2	0.9	0.5		5.1	5.2	0.7	0.1	4.9	6.5
	II	30	43.5	6.5		4.7	5.6	0.5		8.0			0.1	1.3	12.1	6.6	0.3	2.7	2.3
	III	30	40.9	3.3		1.6	4.7	1.0	0.8	5.3	2.2	0.2		5.1	11.6	1.0	0.3	3.3	0.5
Jul.	I	30	45.7	1.3	1.1	5.1	2.5	5.5	1.8	8.0	2.7	0.8	0.5	5.7	4.3	2.8	0.1	3.1	0.4
	II	30	57.9	0.2	4.1	2.4	7.8	2.3	4.7	11.6	5.9	0.6	0.6	3.4	5.8	3.7		1.3	3.5
	III	33	59.4	0.2	2.7	6.1	0.4	1.0	0.2	2.1	4.1	2.8	3.5	3.2	21.8	6.3	3.2	1.7	0.1
Aug.	I	30	36.5	0.1		0.8		0.8	0.1	1.1	1.9	3.1	6.9	4.8	6.7	7.5	2.0	0.7	
	II	24	55.9		0.8	1.0	0.2	1.7	0.5	1.3	7.2	10.0	4.2	12.7	4.2	7.3	2.5		2.3
	III	32	47.8	0.1	0.1	0.6	1.2	0.8		12.6	5.5	7.0	2.0	8.6	5.6	0.6	0.1	2.0	1.0
Sep.	I	30	64.3	0.2		0.7	0.1	0.5	0.3	1.9	10.5	23.5	9.7	2.1	8.3	5.9			1.5
	II	30	186.5	0.9		1.5	0.4	1.1	0.4	1.1	4.9	42.7	36.8	89.6	3.2	1.4	0.5	0.9	1.1
	III	26	48.1	0.3	0.5	1.5	1.8	1.6	0.6	2.3	1.5	4.9	0.8	11.2	7.5	0.6	10.5	0.8	1.7
Oct.	I	24	122.1				1.4	1.5	0.7	0.2	33.3	30.6	26.6	22.0	2.2	0.8	1.5		1.3
	II	27	95.4	0.6	0.3	1.6	1.4	1.2	0.1	1.2		19.0	61.8	5.6	0.9		0.1	1.5	0.1
	III	28	67.8		0.2	0.7	2.1	1.1	0.9	3.3	0.3	6.9		41.1	2.4	3.6	4.0	0.9	0.3
Nov.	I	30	52.4				4.0	1.5	1.3	6.3	4.3	2.1		7.0	9.8	14.1	1.2	0.8	
	II	3	106.8				42.7			10.7	10.7				32.0	10.7			
	III	27	47.4			0.4	18.1	2.5	0.2	0.2		4.7			0.6	1.6	2.7	2.6	13.8
Dec.	I	30	124.4			1.6	28.4	9.4	15.2	22.4	2.1		1.3	1.3	15.2	22.6	4.1	0.7	0.1
	II	30	109.8		0.5	2.1	16.5	20.0	17.1	16.0	1.3			4.3	5.6	11.1	0.8	9.3	5.2
	III	32	146.2	1.0		4.1	19.0	15.9	8.0	18.2	1.6		4.4	20.3	7.8	6.4	16.0	20.1	3.4

Table 2

Month	Period	Days	Mean Echoes	Direction															
				N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Jan.	I	30	10.6												7.3	1.4	1.3	0.5	0.1
	II	30	3.0		0.2	0.9		0.1		0.1				0.2	0.3	0.4	0.5	0.3	
	III	30	13.4	0.1	1.1	4.4	0.5	3.6	0.4	0.3	0.2		0.5			1.0	0.5	0.1	0.7
Feb.	I	30	6.5	0.1	0.4	1.0	0.7	0.3	0.4	0.1	0.1	0.4	0.2	0.6	0.3	0.8	0.3	0.8	
	II	24	2.4								0.1			0.7	1.0	0.4	0.1	0.1	
	III	0																	
Mar.	I	0																	
	II	0																	
	III	30	89.0		2.4	18.1	34.3	15.1	8.6	4.4	1.2		0.3	0.3	0.3	1.4	1.1	0.4	1.1
Apr.	I	27	260.0	19.0	9.5	67.6	28.4	116.1	4.7			0.3	0.6	0.6	7.1	0.2			5.9
	II	18	278.5		35.6	32.0	72.2	138.1						0.1	0.1			0.4	
	III	28	318.3	57.7	80.0	128.0	52.6			0.1					1.0		1.1	0.1	
May	I	27	203.5	29.0	23.7	48.0	49.2	20.4	23.7	4.7		0.6		0.3	0.1	1.9	0.1	0.6	1.2
	II	25	165.0	17.9	5.1	109.0	25.0	1.8	1.3	1.3	0.6		1.3	1.6		0.1			
	III	30	281.4	42.7	29.9	47.6	9.5	2.4			0.1	0.7		0.3	0.8	2.3		73.6	71.5
Jun.	I	27	171.3	36.9	23.7	31.5	11.5	2.4		0.1		0.1	19.6	23.7	10.4	0.9	1.2	4.6	4.7
	II	26	177.2	15.4	24.6	41.8	0.6	0.6	0.3	2.3	0.3			54.5	22.5	7.7	4.9	1.5	0.2
	III	27	175.4	11.9	0.3	3.9	4.4	0.1	0.3	1.3	2.8	0.3	0.1	76.0	47.7	3.3	11.9	0.4	10.7
Jul.	I	30	117.8	13.3	12.8	12.9	6.5	3.5	1.3	2.5	13.9	2.5	6.9	29.2	3.2	4.5		2.1	2.7
	II	30	138.7	10.4	2.4	12.8	8.3	7.4	2.1	1.6	6.4	28.6	42.8	7.5	2.3	0.5	0.2	1.1	4.3
	III	30	160.8	8.1	0.1	12.1		2.2		2.1	8.8	5.5	11.7	22.9	41.6	24.4	17.7	2.4	1.2
Aug.	I	30	173.4	0.5				0.3		4.3	23.5	8.5	23.5	53.3	43.7	9.7	6.0	0.1	
	II	24	201.1			1.7	6.7	1.5	1.3	45.3	0.3	14.7	5.3	84.3	37.3		1.3		1.4
	III	30	332.3	0.5					4.5	101.2	4.3	61.9	68.3	63.5	3.2	8.5	8.8	7.5	0.1
Sep.	I	27	428.4			0.2	0.1			26.1	117.3	28.4	180.3	75.9			0.1		
	II	30	371.2	1.1	0.4		0.1		0.3	2.4	8.5	17.6	68.3	213.3	44.8	1.1	12.8		0.5
	III	27	111.6	3.6	3.9	2.5	0.1	1.0	2.4	10.1	40.3	0.3	0.3	9.2	4.7	0.6	23.1	9.5	
Oct.	I	26	272.0	0.1		1.2	2.6			9.8	91.2	38.2	44.3	71.5	9.8	2.4	0.9		
	II	27	231.1	0.1		0.2	0.1	0.5		67.0	49.9	23.7	64.5	19.3	3.0	0.1		2.5	0.2
	III	27	151.9	0.3		0.3		0.5	0.1	37.4	61.6	9.5		28.6	9.5	1.3	1.5		1.3
Nov.	I	27	118.4					0.3		0.3		2.4	19.0	11.0	45.5	15.8	24.1		
	II	0																	
	III	24	19.9		0.3	0.2	1.1	0.9		0.8	3.3	3.4		0.3	5.7	1.3	1.3	1.0	0.3
Dec.	I	30	21.9				0.5	0.2	0.1			0.1		1.6	13.3	2.4	2.7	1.0	0.5
	II	30	10.8	0.3		0.5		0.9	0.1	0.3	0.3	0.3		1.2	0.7	2.0	0.5	1.5	1.7
	III	33	21.5			0.1	0.1	0.2	1.1	0.4	0.5	0.7	15.3	1.8	0.4	0.6		0.1	0.2

DISCUSSION

The birdmigration over Denmark is a well-studied phenomenon. Through baning, observations of visible migration, and birds killed at lighthouses (HANSEN 1954) the relative number of the migratory species, the migratory pathways and migratory seasons are wellknown. This especially holds true for the eastern parts of the country.

Of papers concerning these objects could be mentioned: BRUUN (1961), BRUUN and SCHELDE (1957), CHRISTENSEN and SØRENSEN (1961), CHRISTENSEN and ROSENBERG (1964), HOLSTEIN (1946), RABØL (1967 and 1969), ROSENBERG (1959), and SALOMONSEN (1967). Furthermore, the migration in southern Sweden (Falsterbo) has been studied by RUDEBECK (1950).

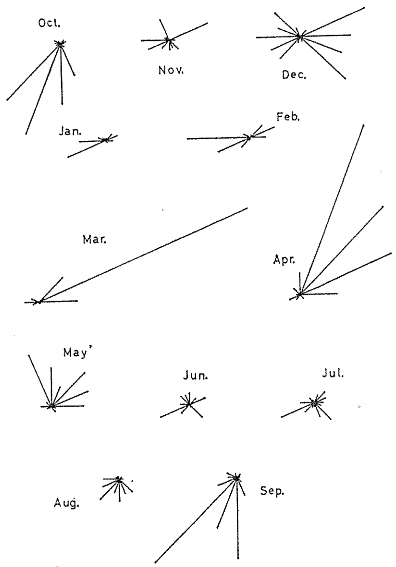

Fig. 2. Diurnal migration. The streaks show the monthly mean activity in 16 directions.

Fig. 2. Dagtrækket. Stregerne viser den gennemsnitlige månedlige aktivitet i 16 retninger.

In the following these experiences are included in the interpretation of the radar data.

The movements should be divided first according to day and night, and then to the season.

Diurnal migration

1. WINTER. In late November, December, January, and February there is a well defined bimodal distribution of the directions. The peaks are E-ENE, and W-WSW. This pattern is probably caused by wintering birds responding to the fluctuations of the weather in the period. As often observed in the field are the migratory directions SW-W on days of low temperatures and especially snowcover, and E-NE on days with sun, higher temperatures, and no snowcover (e. g. RABØL 1964, MØLLER and RABØL 1967, and NOER 1966). The dominating species observed on the screen are probably Woodpigeons *(Columba palumbus)*, Crows *(Corvus corone)*, Skylarks *(Alauda arvensis)*, Fieldfares *(Turdus pilaris)*, and Bramblings *(Fringilla montifringilla)*.

2. SPRING. From ult. March to ult. May there is a clear shift in the directions from ENE anticlockwise towards NNW (Table 1 and 2). The dominant species are undoubtedly passerine species. In ultimo March, and April numbers of Buzzards *(Buteo buteo)*, Lapwings *(Vanellus vanellus)*, and Woodpigeons are undoubtedly observed together with the passerines dominating at this time (Finches, Starlings, Skylarks etc.). The N-NNW migration in late May could at least partly be due to Swallows *(Hirundidae)*, and Swifts *(Apus apus)*.

In April the migration is least in the middle of the month in good accordance with the observations of the visible migration made at North Zealand and at Hesselø (peaks to 8.4. incl., and again from 21.4. and onwards). Large numbers of Tree pipits *(Anthus trivialis)* and finches were seen migrating in pr. May, and these species probably are partly responsible for the many echoes at the screen in this period. It should be stressed that the migration in 1969 (spring) probably was later than normal.

3. SUMMER. The migration in June and July is weak and scattered. Waders and Starlings are known to move SW-W in these months.

4. AUTUMN. The diurnal movements in August are of small dimensions. This is in good accordance with the field observations. Among the species represented Honey Buzzards *(Pernis apivorus)*, Swallows, and Yellow Wagtails *(Motacilla flava)* should be important. In September and October the intensities are greater, and it should be noted that the great majority of the echoes are moving S-SW. The dominating species should be Buzzard, Woodpigeon, Crow, Jackdaw *(Corvus monedula)*, Meadow Pipit *(Anthus pratensis)*, Starling, Finches, and Linnet *(Carduelis cannabina)*.

Nocturnal migration

1. WINTER. The nocturnal migration observed on the radarscreen is extremely weak during the winter months. This is however in good accordance with the small number of birds killed at the danish lighthouses (HANSEN 1954). The most abundant species are probably Fieldfare and Brambling.

2. SPRING. Just like the diurnal migration the nocturnal migration during April and May is turning anticlockwise from E and NE against NNW and even NW. As the diurnal migration only for a lesser part consist of the same species as the nocturnal, some common cause(s) should be responsible for this characteristic pattern. Winddrift is probably not a primary cause but the following factors could be of importance: 1) Different species (the SE-NW migrating species are known to migrate later in the spring than are the SW to NE migrating ones) 2) The southern breeding populations in Sweden are known to migrate earlier than the northern populations

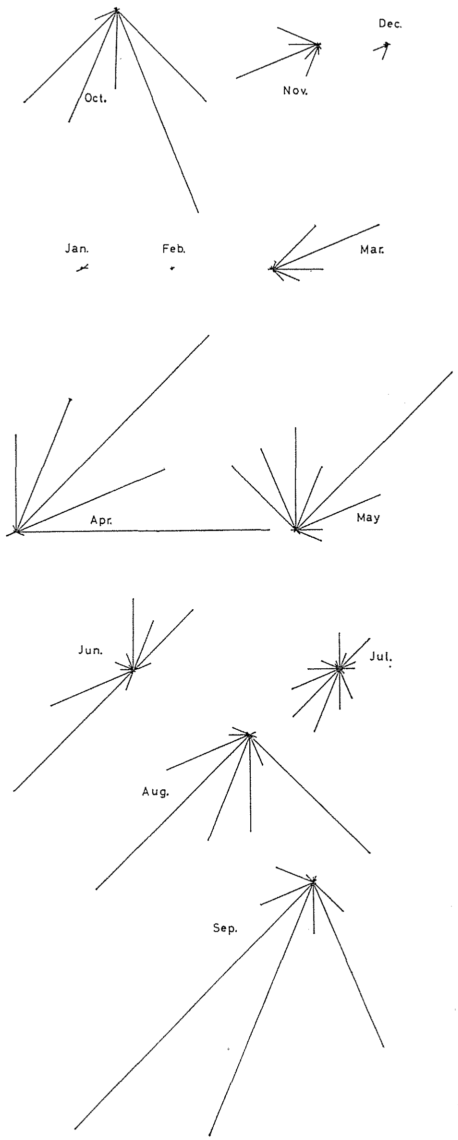

Fig. 3. Nocturnal migration. The streaks show the monthly mean activity in 16 directions.

Fig. 3. Nattrækket. Stregerne viser den gennemsnitlige månedlige aktivitet i 16 retninger.

(of Norway and Northern Sweden), and 3) The same populations are involved in a greater part of April-May. The goal areas of these birds are moving north during the season, and this is making the headings of the birds more northerly, too. Such evidence has been found for some autumn migrating species (RABØL and PETERSEN, in print.).

The species involved in pr. and med. April are probably mostly trushes and Robins *(Erithacus rubecula)*, and maybe Goldcrests *(Regulus regulus)*. The minute echoing area of the latter makes it howver probable that this species is not observed, though it is a fairly common migrant in the area at this time of the year. The E-component of the migration in this period is remarkably big, considered that east of the radarsite there is little land. These echoes may be due to ducks. Throughout the winter large numbers of ducks are present in the coastal areas of Denmark (JOENSEN 1968). In the first half of April several duck species (e. g. the Eider *Somateria mollissima))* are known to move into the Baltic Sea from their wintering areas in Denmark and the southeastern part of the North Sea. A characteristic pattern of echoes of migrating ducks like the one described by BERGMAN and DONNER (1964), has however never been observed on our radar, even though the birds are known to be present in the area during the period.

The May echoes should be chats and warblers. The dominating NNW and NW migration in late May could not alone be accounted for by the traditionally perceived NW-migrating species. (e. g. Lesser

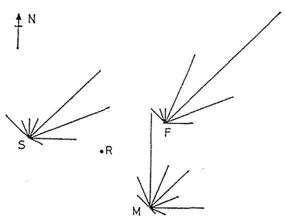

Fig. 4. The nocturnal migration in the three counting areas in the period ult. March – ult. May. The streaks are proportional in lenght to the mean activity in the 16 directions.

Fig. 4. Forårsnattrækket i de tre optællingsområder.

Whitethroat *(Sylvia curruca)* and Redbacked Shrike *(Lanius collurio))*. In fact the number of resting Lesser White throats at Hesselø in the spring of this year culminated in medio May, where NE-moving echoes are totally dominating the radarscreen. In this connection it should be stressed that the number of grounded nightmigrants on Hesselø in medio April was extremely small – whereas the radarintensity of this period is big. These facts could show that the relations between the number of birds migrating over an area, and the number of grounded migrants in the same area is not necessarily a simple one.

3. SUMMER. In June the NE-component of the migration is decreasing through the month, and the SW-component is increasing. This could easily be explained. In the first half of the month the spring migration of many passerine species, especially warblers, is still present. The SW-movements later in the month and in July probably reflects ducks on moult migration, waders and young gulls (especially Blackheaded Gull *(Larus ridibundus)*.

4. AUTUMN. The nocturnal migration in September and October is seen to be of much bigger dimensions than the contemporary diurnal migration – and further it displays two distincts tops around SE-SSE and SSW-SW. In August the dominating species are undoubtedly chats and warblers (esp. the Willow Warbler *(Phylloscopus trochilus)*. In September the most prominent species should be trushes, Redstarts *(Phoenicurus phoenicurus)*, and Robins. In October trushes, Robins, and maybe Goldcrests ("maybe" for the same reasons as given above) are dominating. The strong SE-component in October is somewhat surprising and is maybe not a typical feature of the month. It could be partly due to winddrift of birds heading S and SW by the strong westerly winds which

dominated most of the month. In November the number of echoes is drastically decreasing towards the minute winter night activity.

CONCLUSION

The echoes observed on the radarscreen fit well into the known pattern of birdmigration in Denmark. It is obvious that the echoes observed reflect bird movements. It should be concluded that radarstudies of the bird migration could be a very useful *supplement* to other ways of investigating bird migration, such as observations of visible migrations and trapping of birds.

SUMMARY

The bird migration over the southeastern parts of Denmark in the period Oct. 1968 to Sept. 1969 is described as it has been observed on a PPI-screen of a surveillance radar operating in the L-band.

The radarscope has been filmed by means of 16 mm. pictures and the wellknown timelapse technique. The maximum intensity (number of echoes per unit of area) for each of 16 directions (N, NNE etc.) has been estimated in 4-hours periods throughout the day and night, and the average maximum intensity in each directions has been calculated for tendays periods throughout the year.

A brief discussion of the material is given, mentioning some of the probably most frequently observed species.

It is concluded that the movements observed fit rather well into the pattern of birdmigration over Denmark known from other fields of investigation (field observations, ringing etc.).

DANSK RESUMÉ

Fugletræk i Danmark observeret ved hjælp af radar i perioden oktober 1968 til september 1969.

Fugletrækket over Danmark må siges at være velkendt med hensyn til artssammensætningen, træktider og regionale forskelle. Vi ved også en del om forskellige topografiske og meteorologiske faktorers udløsende og retningsgivende indflydelse på trækket. Indtil nu har radar-observationer ikke bidraget til dette mangesidige kendskab, der udelukkende stammer fra observationer af dagtræk, ringmærkning og fyrfald. Denne artikel skulle gerne være den første i en længere serie af »radarartikler«, der måtte bidrage til en udbygning af vor viden om trækket over Danmark.

Artiklen hviler på nogle foreløbige analyser af fugletræk set på radarskærmen på en sydsjællandsk radarstation (Fig. 1). Vi har beskrevet trækkets *størrelse* og *trækretningerne* gennem året.

Til en begyndelse skal vi kort forklare radarens virkemåde. Bortset fra PREUSS (1962) og SALOMONSEN (1967) er dette vist ikke tidligere beskrevet på dansk i forbindelse med fugletræk.

En radar udsender impulser med bestemte mellemrum. Disse bevæger sig med lysets hastighed. Samtidig roterer radaren med en bestemt hastighed vandret om sin egen akse. En radarsender kan altså sammenlignes med et fyrtårn, der udsender én roterende lyskegle. I radarens tilfælde er denne »kegle« blot hugget op i småstykker (impulser) med en bestemt afstand mellem stykkerne. En genstand, der rammes af en sådan impuls, vil tilbagekaste energi. Afhængigt af den tilbagekastede energimængde og radarmodtagerens følsomhed, vil ekkoet kunne opfanges. Det bliver herefter omsat til en lysplet på et oscilloscop (en fjernsynsskærm). Placeringen af lyspletten på scopet angiver retning og afstand fra radaren til den eller de genstande, der (evt. tilsammen) har produceret ekkoet. En masse genstande (flyvemaskiner, master, højdedrag og også fugle) kan registreres af radarmodtageren. Lyspletter, der hidrører fra flyvende fugle, kan ikke direkte ses bevæge sig. Dertil er deres hastighed for lav. Ved at optage et billede af skærmen med bestemte mellemrum og senere køre disse billeder som en film, kan man imidlertid opnå at få sådanne lyspletter til at bevæge sig. Udfra antallet af lyspletter pr. arealenhed og pletternes bevægelsesretninger kan trækkets størrelse og retninger bedømmes. Man kan ikke udfra størrelsen eller

udseendet af en lysplet sige noget om arten eller antallet af fugle (eller flokke), der alene eller tilsammen har frembragt pletten.

I tabellerne og på figurerne har vi angivet det gennemsnitlige radartræks størrelse og retning pr. måned eller trediedele måned gennem året.

Man bemærker:

1) Lyspletterne repræsenterer med rimelighed trækkende fugle. Der er flest forår og efterår. De bevæger sig mest NV-Ø om foråret og SØ-V om efteråret.

2) Vinterdagtrækket er ret stort og går enten ØNØ-Ø eller VSV-V følgende temperaturgradienten. Vinternattrækket er meget ringe. I god overensstemmelse hermed fyrfalder også meget få fugle om vinteren.

3) Gennem marts-april-maj til først i juni er der en klar tendens for både dag- og nattræk til at dreje fra Ø-NØ mod N og endog NV. Årsagen hertil er sikkert kompleks. De sydsvenske populationer trækker sikkert før igennem Danmark end de nordskandinaviske fugle. Det kan også være et spørgsmål om forskellige arter. »Målområde-hypotesen« kan også blandes ind i årsagsdiskussionen. Fuglene trækker mod et målområde, der i forårets løb forskyder sig mod en stadig nordligere position.

4) I de »egentlige« træktider forår og efterår er nattrækket større end dagtrækket. Om efteråret er SØ-komponenten langt mere fremtrædende nat end dag.

Da radar i sin tid kom frem, blev det af mange opfattet som de vises sten. Nu lå løsningen af fugletrækkets gåder lige om hjørnet. Nu kunne man lige så godt lade være at se på dagtræk mere. D. v. s. det kunne man selvfølgelig godt gøre. Man fandt bare ikke ud af noget. Optællinger eller fangster af rastende fugle gav heller ikke noget »rigtigt« billede af det egentlige fugletræk.

Med tiden har man fået et mere afbalanceret syn på radartræk.

Radartræk er et vigtigere *alternativ* til andre former for trækstudier. Det er en værdifuld *supplerende* måde at se på fugletræk.

Når man som i denne analyse bruger en såkaldt PPI-radarskærm, ved man ikke, hvad en lysplet står for. Ved andre radar-registreringsformer kan man udfra ekkoets pulsering gætte på slægt, men sjældent art. Man må ikke glemme, at der går en masse værdifuld information tabt, når man omsætter en til flere fugle, af en til flere arter, fordelt på en til flere flokke til en enkelt lysplet på et oscilloscop.

Radarens væsentligste fordele er 1) den øgede aktionsradius og (ved en anden teknik end den her anvendte) 2) registrering af træk i større højder end ved hjælp af blå øjne og kikkerter, og 3) man kan »se« træk om natten. Men det er altså fordele, man opnår på bekostning af andre vigtige egenskaber.

Med hensyn til radarstudier af fugletræk vil vi herhjemme i de næste år beskæftige os med 1) højdefordelingen af de trækkende fugle, 2) trækkets størrelse som en funktion af en lang række vejrfaktorer, 3) omvendt træk og 4) korrelationer mellem samtidige feltobservationer af dagtræk og træk på radarskærmen.

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Fra Zoologisk Museum

XXIV

Af

FINN SALOMONSEN

Tolvte foreløbige liste over genfundne grønlandske ringfugle

(With a Summary in English: Twelfth Preliminary List of Recoveries of Birds ringed in Greenland.)

Nærværende liste omfatter genfangster fra midten af 1967 til slutningen af 1969, d. v. s. omkring 2½ år ligesom den elvte liste (i D.O.F.T. *61,* 1967, p. 151). Antallet af genmeldinger er også omtrent det samme, nemlig 120, mod 130 i den elvte liste. Der gøres opmærksom på, at genfangsterne, som altid i disse lister, kun omfatter de i udlandet genmeldte grønlandske ringfugle. Der må især gøres opmærksom på de mange genfangster af Bramgæs (i alt 39), hvoraf størstedelen er ringmærket af englænderen R. MARRIS, og af Lomvier (i alt 57), ringmærkt af A. LUND-DROSVAD, N. O. PREUSS og PAVIA KORNELIUSSEN.

En fortegnelse over de tidligere genfangstlister er givet i den ovennævnte elvte liste. For at bringe overensstemmelse mellem disse og de danske og udenlandske ringlister og for at spare plads er vi ved udarbejdelsen af de grønlandske ringlister nu gået over til den internationale fortegnelsesmåde. Denne anvender følgende forkortelser:

+ = Skudt eller dræbt af mennesker *(shot or killed by man).*
× = Fundet død *(found dead).*
× (m) = Fundet som mumie eller skelet *(found as mummy or skeleton).*
v = Fanget og frigivet med ring *(caught and released with ring).*
( ) = Fanget og frigivet uden ring *(caught released without ring).*
/?/ = Ukendt genfangstmåde *(unknown way of recovery).*

Når genmeldingsdato står i parentes, er den nøjagtige genfangstdato ikke kendt, men brevdato benyttet.