Ornis Hungarica 2:17-24. 1992

Study of spring migration by weather radar in Eastern Hungary

T. Szép

Szép, T. 1992. Study of spring migration by weather radar in Eastern Hungary. — Ornis Hung. 2:17-24.

The main characteristics of spring migration were studied by meteorological radar in the Eastern part of the Carpathian Basin for 8 days in 1987. The radar is situated at Napkor, 200 km ENE from Budapest, and it can detect the birds in a 25-100 km range. The echoes were displayed on PPI and were recorded on 35 mm film by time exposure. During the study 6546 bird echoes were recorded on 413 pictures. The intensity of bird echoes was high at sunrise and early afternoon. In 25 km range, the intensity of the echoes was high at sunset because of intensive migration of passerine birds. The average direction was northeast (42°), and its daily value varied between 33°-59° during the study. The changing of the direction might come from the change in the composition of migrating species. Above some areas, the bird echoes were concentrated, and these concentrations showed a close relationship to some topographical elements.

T. Szép, Hungarian Ornithological and Nature Conservation Society, Budapest, Költő u. 21.,H-1121, Hungary.

1. Introduction

The Carpathian Basin has an important role in the migration of Northern European, Northeastern European and North Asian birds. Old and recent observing, hunting, and ringing data show the importance of this area, especially of its eastern part (Haraszthy 1988). Data from direct observation of the migration by radar were not available until now in this region of Europe. These data can help to analyse more deeply the characteristics and dynamics of this behaviour (Eastwood 1967). In 1986, I started an investigation at Napkor Meteorological Radar Observatory to analyse how applicable that radar is for ornithological studies. The aim of this work is to describe some main characteristics of the spring migration based on radar data in Eastern Hungary.

2. Material and method

The weather radar station (OMSZ KEI) is situated at Napkor (47°58'N; 21° 54' E, 140 m ASL), and it is 200 km ENE from Budapest and 10 km E from Nyíregyháza which is the nearest town (Fig. 1). The MRL-5 type, Soviet made radar here is used for rainfall forecasting. I used a 10 cm wavelength with 1 microsecond pulse length, 500 kW peak power. The aerial diameter is 4.5 m and the radar beam is pencil shaped with a 1.5 beamwidth (Eastwood 1967). The radar sensitivity is -138.1 dBW.

The bird movements were detected by radar and displayed on the PPI (Plan Position Indicator) screen (range 25 km, 50 km and 100 km). The echoes were recorded on 35 mm film with a long time exposure. I used a 10 minute exposure time as described in

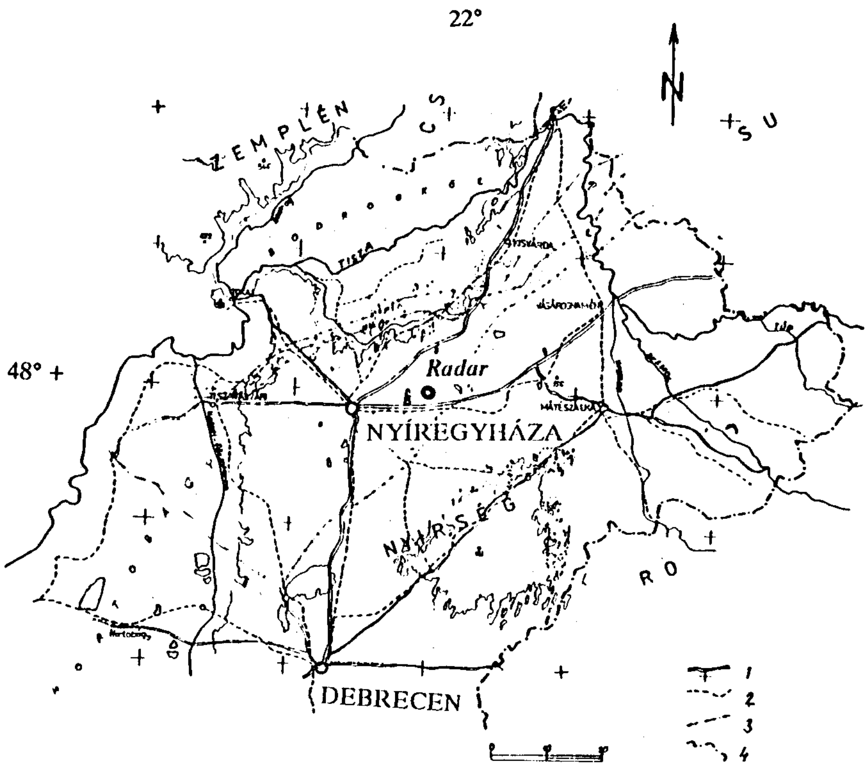


Fig. 1. Map of the study area (1: road; 2: railway line; 3: powerline; 4: state boundary).

Gauthreaux (1970). The pictures showed moving radar targets in all studied range except the nearest area around the radar station where the dense surface echoes hide them (Fig. 2). I used different elevation angles at different ranges (3° for 25 km, 1° for 50 km and 0.3° for 100 km), and in this way I studied the birds' movement at low alti-

Tab. 1. Number of bird echoes (n), observation time (t)[minute] and echoe intensity (n/t) at different range during the study.

	at 25 km			at 50 km			at 100 km		
Day	n	t	n/t	n	t	n/t	n	t	n/t
25.03	73	42	1.7	135	58	2.3	169	112	1.5
26.03	453	149	3.0	926	285	3.2	1284	464	2.8
27.03	45	34	1.3	162	76	2.1	172	66	2.6
29.03	176	132	1.3	24	15	1.6	0	142	0.0
05.04	210	62	3.4	214	193	1.1	60	134	0.4
06.04	289	121	2.4	335	340	1.0	113	171	0.7
07.04	323	103	3.1	252	242	1.0	77	127	0.6
08.04	559	230	2.4	429	420	1.0	66	131	0.5

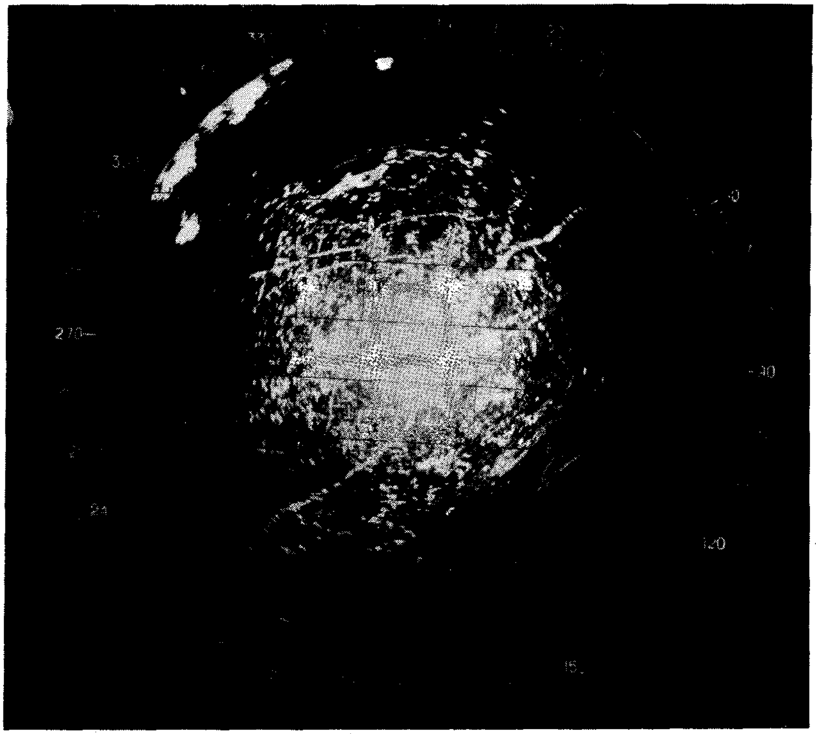


Fig. 2. Time exposure of a PPI display showing heavy bird migration over Northeastern Hungary between 0537-0547 local time, GMT+1, 25th March 1987. North is toward the top of the figure. Birds produce about 3-5 km long pale streaks, in this case toward the northeast. The angle of elevation of the radar beam is 1°, the range is 50 km and the revolution is 2/min. Tokaj hill and Zemplén mountains are situated at the northwest edge of the picture and the long line across the centre is a big 750 kW powerline (See the Fig. 1).

tude (100-2000 m). The average altitude of the echoes was between 400-800 m.

The data were collected in the spring of 1987 (25.03.1987 - 27.03.1987, 29.03.1987, 05.04.1987 - 08.04.1987), and as far as possible during all part of the day. The starting and ending positions and path of each moving radar target on the pictures were digitalized and used for measuring the direction and height of the flight. The characteristics of moving radar targets, low speed (30-100 km/h) and point like echo, differ from the echoes of surface, weather phenomenon or airplanes (Eastwood 1967). These targets were echoes of flying birds or bird flocks. The numbers and species of birds taking part in the movements cannot be determined from the pictures.

I used the Nyíregyháza Meteorological Station data for measuring the wind parameters.

3. Results

During 8 days observation 6546 radar targets were identified as birds (64 hours observing time) on the 413 pictures (Fig. 3). Because the successive pictures may have

Fig. 3. Path of all bird echoes during the observation period in the study area. (Horizontal and vertical distance between the cross is 25 km.)

contained the same targets more than once, less separate targets were studied.

3.1. Daily distribution

In 26.03.1987, the continuous observation from 0504 to 2103 allowed me to analyse the daily distribution of the bird echoes in three different ranges (Fig. 4). As Fig. 4 shows, there was an intensive movement near sunrise which was followed by a smaller one at early afternoon (13-14 h local time, GMT+1). The distribution at the 25 km range differs from the other two (Fig. 4a). There is more intensive movement after sunset in this range than at the 50 km or the 100 km range. This difference can also be seen in the other day's data. The sensitivity of the radar is larger at 25 km range, and smaller echoes, such as of migrating passerines in small flocks (Gauthreaux 1970, Williams et al. 1977), are more visible on the PPI screen and on the pictures. On the night of 07.04 there was a large movement in the 25 km range, and next morning around the radar station many Nightingales (*Luscinia megarhynchos*) and Lesser whitethroats (*Sylvia curruca*) started to sing. It is possible that intensive passerine migration in different directions explains the differences observed at night.

3.2. Direction

Comparison of the mean flying direction values at different ranges (Fig. 5) indicates slight difference between the 25 km, the 50 and 100 km range data. The mean direction

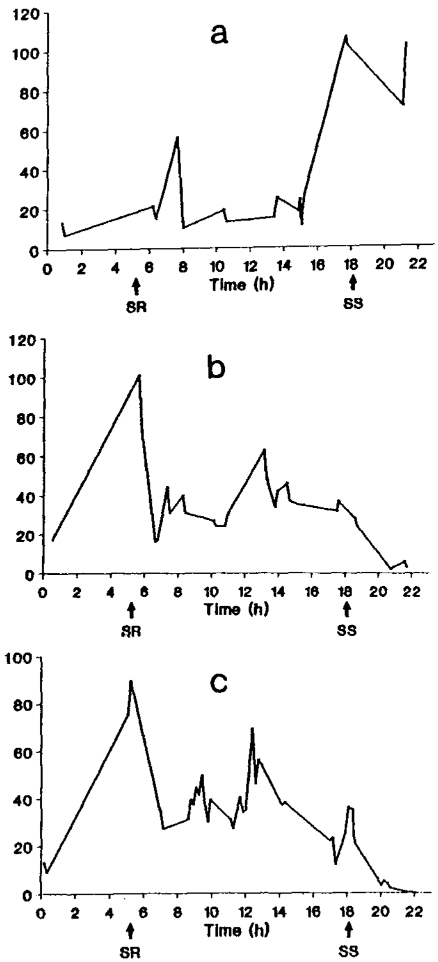


Fig. 4. Daily distribution of radar targets in 26.03.1987.
a. Number of targets at the 25 km range,
b. Number of targets at the 50 km range,
c. Number of targets at the 100 km range.
(SR: sunrise, SS: sunset.) Local time (GMT+1).

at 25 km range is closer to the north (38°) than that of the other ranges (46° at 50 km and 42° at 100 km). The average direction for all ranges is 42°, NE (Fig. 5d).

When I compared the mean direction using all echo data during six days, there were differences in the daily directions (Fig. 6). The directions on 27.03., 05.04. and 06.04. are closer to east (51, 59, 51) than the average (Fig. 6b,c,d). The reason for these deviations may be the strong W, SW, and N wind at 27.03., but this is not too likely since on 07.04. and 08.04. there were the same strong winds, but the mean direction of these two days is different from the above mentioned three days' mean direction (Fig. 6e,f). In these two days, the decreasing mean direction coincided with increasing intensity of the small passerine migration, as the increasing echoes at 25 km range indicate (Tab. 1). The differences may come from the changing species composition of migrating birds.

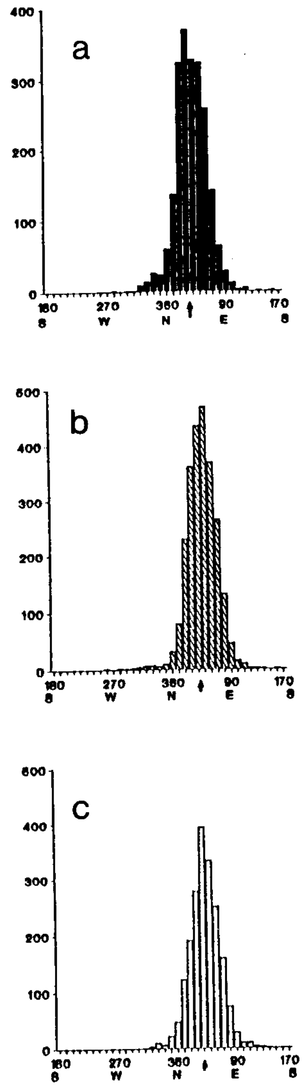
3.3. Migration over the studied area

When all echoes are drawn on the map of the studied area (Fig. 3) we can see whether there were preferred areas during the migration. The diverse topographic features explain some significant deviations among the areas. In the more elevated areas e.g., Nyírség Southeastern part of the study area, the birds flew at a higher altitude and their echoes were more visible than echoes from lower areas like Hortobágy where the birds often flew at lower altitudes and are blocked from the view of the radar.

The echoes were concentrated above some particular areas e.g., along the Debrecen-Mátészalka railway line, the echoes were very concentrated and created a thick line (Fig. 1,3). This observation suggests that the birds may follow topographical features while migrating through this area (Bruderer 1978, 1982).

4. Discussion

This investigation was the first direct observation of bird migration by radar in the Carpathian Basin. The time exposure method (Gauthreaux 1970) provided appropriate data to reveal some main characteristics of the spring migration over this



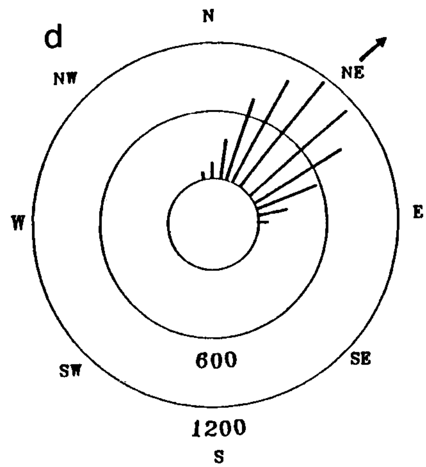


Fig. 5. Distribution of the direction of radar targets at different ranges. (Arrows shows the mean directions.)
a. Directions at the 25 km range (n=2128; mean=38°),
b. Directions at the 50 km range (n=2477; mean=46°),
c. Directions at the 100 km range (n=1941; mean=42°),
d. Directions at all ranges (n=6546; mean=42°). The diameters of circles shows the number of targets at different directions.

area. The time of the investigation coincided with the peak of the waterfowl (e.g., *Anser anser, Anser fabalis, Anas crecca*) and crane migration and partly with migration of the passerines (Haraszthy 1988, Kovács 1987).

The daily rhythms of the bird echoes showed a very high peak at sunrise and another lower peak in early afternoon. These data suggest that a large part of the observed birds might have come from a nearby roosting place like Hortobágy, to the SW of the radar site. The late peak near sunset in the 25 km range data shows the increasing passerine movement during this period. The typical passerine 'mist' on the pictures (Williams et al. 1977) confirms this assumption.

The data indicate very heavy migration at the end of March mainly in the long range observations. These presumably were echoes of migrating waterfowl flocks. At the end of the observation period (07.04.-08.04.), the composition of migrating birds changed. The increased number of fine passerine echoes on the short range pictures shows that the main passerine migration had started.

The observed average NE (42°) direction is closer to N than Bruderer (1971) found in Switzerland (60°), the nearest

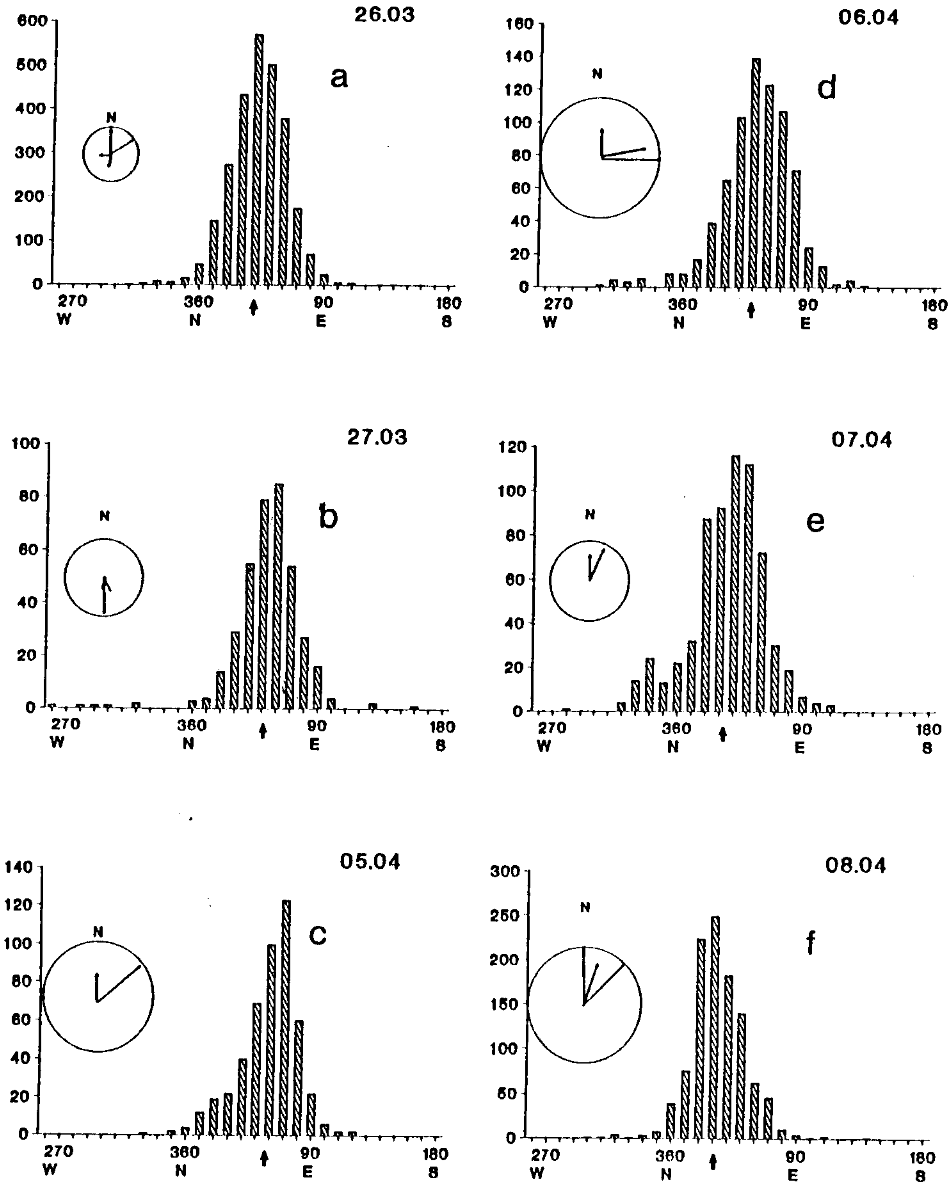


Fig. 6. Distribution of directions of radar targets on different days. The diameter of the circle with arrows show the average wind speed and direction during the observations.
a. Direction at 26.03 (n=2663; mean=41°)
b. Direction at 27.03 (n=379; mean=53°)
c. Direction at 05.04 (n=484; mean=59°)
d. Direction at 06.04 (n=737; mean=51°)
e. Direction at 07.04 (n=652; mean=35°)
f. Direction at 08.04 (n=1064; mean=33°)

place of another recent radar study. The daily average direction varied between 33°-59° and the reason may be the changing composition of migrating species. The increased passerine migration might cause the decreasing average direction during the late days. The data also show some preferred migration paths.

The meteorological radar at Napkor is appropriate to study of bird migration at one of the most important areas in Central Europe. Long-term radar investigations with development of equipments and methods, combined with simultaneous field observations would help to explore other important characteristics of the migration in the eastern part of the Carpathian Basin. Studying distribution of bird flocks in the migration season, analysing the number, direction and distribution of different groups of species would be very important for scientific and nature conservational reasons as well.

Acknowledgements. I wish to thank the Central Weather Forecasting Institute of the Meteorological Office (OMSZ KEI), Ferenc Dombai, Ferenc Tóth and the staff of the Napkor station, for use of the radar and assistance in many aspects of my work. I am indebted to the two reviewers kindly commented on earlier versions of this paper, to Kevin Anderson and Erzsébet Pappné Timkó for the provided assistance to the manuscript and to the Hungarian Ornithological Society providing the necessary material.

Összefoglalás

A tavaszi vonulás vizsgálata metorológiai radar segítségével Kelet-Magyarországon

A Kárpát-medence keleti részén folyó tavaszi madárvonulás radarornitológiai módszerrel vizsgált főbb jellemzőit mutatja be a cikk. 1987-ben 8 napon keresztül, a Napkori Radarmeteorológiai Obszervatórium berendezéseivel 25-100 km-es körzetben vizsgáltam a madarak jeleit.

Madárjeleket a képernyőről (PPI) készített hosszú expozíciós idejű felvételek segítségével rögzítettem. A vizsgálat során készített 413 képről 6546 madárjelet azonosítottam és használtam fel az elemzésekhez. A madárjelek intenzitása a napfelkelte és a koradélutáni időszakban volt a legerősebb. 25 km-es körzetben a naplemente körüli időszakban is erőteljes mozgás mutatkozott, amelynek feltételezhető oka a kistestű énekesmadarak intenzív esti vonulása. Az átlagos irány 42° (ÉK) volt, mely 33° és 59° közötti értékeket vett fel a vizsgált napok során. A napi átlagos irányokban mutatkozó változások okai főként a vonuló madarak faji összetételében mutatkozó változások lehetnek. A vizsgált körzetben a madárjelek néhány terület felett igen sűrűn helyezkednek el, amely a Debrecen-Mátészalka közötti út és vasút esetében felveti, hogy a vonuló madarak bizonyos topográfiai elemeket követnek.

References

Bruderer, B. 1971. Radarbeobachtungen über den Frühlingszug im Scweizerischen Mittelland. — Orn. Beob. 68: 89-158.

Bruderer, B. 1978. Effects of Alpine topography and winds on Migrating birds. pp. 252-265. In: Schmidt-Koenig & Keeton (eds.). Animal Migration, Navigation, and Homing. — Springer-Verlag, Berlin.

Bruderer, B. 1982. Do migrating birds fly along straight lines ? pp. 3-14. In: Papi & Wallraff (eds.). Avian Navigation. — Springer-Verlag, Berlin.

Eastwood, E. 1967. Radar Ornithology. — Methuen and Co. Ltd., London.

Gauthreaux, S. A. 1970. Weather radar quantification of bird migration. — BioScience 20: 17-20.

Haraszthy, L. 1988. Magyarország madárvendégei. — Natura, Budapest.

Kovács, G. 1987. Staying and summering of cranes (*Grus grus*) in the Hortobágy in 1975-1985. — Aquila 93-94: 153-169.

Williams, T. C., Berkeley, P., & Harris, V. 1977. Autumnal bird migration over Miami studied by radar: A possible test of the wind drift hypothesis. — Bird Banding 48: 1-10.

Williams, T. C., Williams, J. M., Ireland, L. C., & J. M. Teal,.1977. Autumnal bird migration over the western North Atlantic Ocean. — American Birds 31: 251-267.

Received 8 August 1991, revised 10 December 1991, accepted 5 January 1992