AUTUMN MIGRATION OF GOLDCREST (*REGULUS REGULUS*) AT THE EASTERN AND SOUTHERN BALTIC COAST

Magdalena Remisiewicz and Jánis Baumanis

ABSTRACT

Remisiewicz M., Baumanis J. 1996. *Autumn migration of Goldcrest (Regulus regulus) at the eastern and southern Baltic coast.* Ring 18, 1-2: 3-36.

Autumn passage of Goldcrest through the eastern and southern part of the Baltic coast was analysed on the basis of daily trapping totals of the species at seven coastal bird ringing stations: Kabli (Estonia), Pape (Latvia), Neringa (Lithuania), Rybatchy (Kaliningrad region of Russia), Mierzeja Wiślana, Hel, Bukowo (Poland). On the basis of this material the migration waves were defined for each of these stations according to the method presented by Busse (1996). These data are supported by visual observations and 339 direct recoveries of 29 stations situated mainly around the Batlic Sea. The migration of Goldcrest is generally described as irregular. This explains the fact that at all stations in years of high number of Goldcrests caught the migration started early and lasted long while in seasons of low intensity of migration its course was condensed. During autumn migration Goldcrests use two migration strategies – fast long-distance nocturnal flights or slow short-distance daily movements. Different strategies were used at different stages of the migration route even by individuals from the same group. This resulted in the complicated pattern of migration waves and mixing of groups of different origin at the stopover sites. No difference in migration speed was found between sexes. The strategy of migration chosen by birds can remarkably affect results of catching. Mass landings in the surroundings of catching site resulted in high peaks while the number of caught birds was low when birds passed over the station during the night. The pattern of migration routes of Goldcrest in the studied region based on recoveries showed that the main flyway goes along the coast. At almost each part of this route birds coming from Scandinavia can land as well as new groups coming from inland. Also frequent departures of Goldcrests crossing the sea while heading to larger Baltic islands or the Scandinavian coast were noted at northern stations. Some of them can suggest the occurrence of reverse migration. At the southern group of stations (Pape, Rybatchy, Mierzeja Wiślana, Bukowo) there exist some evidence of birds flying to the east. At Mierzeja Wiślana some groups of birds can leave the coast flying inland to south-west. The analysis of pattern of waves at all stations showed that some waves are more regular than others suggesting that groups coming to the coast from inland or from overseas occur more regularly than those flying along the coast. Localisation of direct recoveries within waves allowed to define the origin and follow the migration route of some groups through the studied stations. The most evident case was the occurrence of birds from wave IV at Kabli in wave V at Rybatchy and recoveries of birds from both these groups in wave VI at Mierzeja Wiślana. Birds from this group probably left the coast at this point going then to south-west. Generally clear mechanisms of isolation between different groups of Goldcrest, were not found but the case of a wave of unknown origin at Mierzeja Wiślana falling between two waves coming from Rybatchy and the results presented by Busse (1981) for Bukowo can suggest occurrence of this phenomenon, at least to some extent. For the Polish stations also 53 local recoveries from the beginning of the spring migration following the autumn ringing were analysed. It showed that only at Mierzeja Wiślana and Hel birds ringed during the previous autumn season occur among first spring catches and some of them stay after recapture in the area for about one month before they depart to the breeding grounds. These birds can refer to local breeders (ringed in first autumn migration waves) or to those of northern origin but spending the winter in a vicinity of Polish stations (ringed in the middle and later autumn migration waves).

M. Remisiewicz, Bird Migration Research Station, University of Gdańsk, Przebendowo, 84-210 Choczewo, Poland; e-mail: biomr@univ.gda.pl; J. Baumanis, Institute of Biology, 3 Miera Str., LV-2169 Salaspils, Latvia.

INTRODUCTION

Goldcrest is one of the smallest bird species of Palearctic commonly breeding there and occurring during the migration in mass numbers. The nominative subspecies of Goldcrest which is considered in this paper breeds generally in middle and upper temperate and boreal latitudes of this region reaching the Adriatic Sea coast to the south and Turkey in an isolated part of range. Wintering areas of this subspecies are partly situated within its breeding range and extend south towards northern Spain, Mediterranean, Black Sea coast and Volga – Kama region. Partly resident to migratory depending on area of breeding origin; it makes both nocturnal and diurnal movements (Cramp 1992). In Finland, for instance, shares of residents and migrants in the population are nearly equal and migratory tendency increases towards the north (Hilden 1982).

Opposite to typical irregular migrants which make conspicuous movements only in some years migratory flights of Goldcrest occur every year, but with different intensity. With development of bird trapping and ringing at numerous stations around the Baltic Sea it became possible to analyse migratory movements of this species (Pettersson and Wahlin 1975, Saurola 1978, Karlsson 1980, Hanssen 1981, Kania 1983). Analyses of recoveries of Goldcrests ringed at these stations show that wintering areas of birds passing these areas are generally the same and cover wide territory in Western Europe from British Isles to Italy and Spain (Kania 1983, Noskov and Rezvyi 1995, Payevsky 1971, Saurola 1978, Zink 1973).

Present paper is the consecutive publication based on the wide material existing on the species due to the activity of the ringing stations at the Baltic coast. The main aim of the study was to define migratory groups of Goldcrests occurring at the eastern and southern Baltic coast and routes of their migration in this region. We also wanted to show how wide and deep analyses are possible by use of different kinds of data collected at the ringing stations and by combining several methods of working on this kind of material.

MATERIAL AND METHODS

Data used in the study was collected during long-term activities of ringing stations along the eastern and southern coast of the Baltic Sea (Fig. 1). For more detailed analyses only some of them were selected: Kabli (Estonia), Pape (Latvia), Neringa (Lithuania), Rybatchy (Kaliningrad region of Russia), Mierzeja Wiślana, Hel and Bukowo (Poland). Migrating birds were trapped by mist-nets (at Polish stations) or by considerably enlarged and modified Helgoland trap – Rybatchy type trap (Erik 1967) at the other stations. Mist-nets remained open all the time throughout the trapping season. General construction of traps at each station was similar, the differences were mainly in their dimensions.

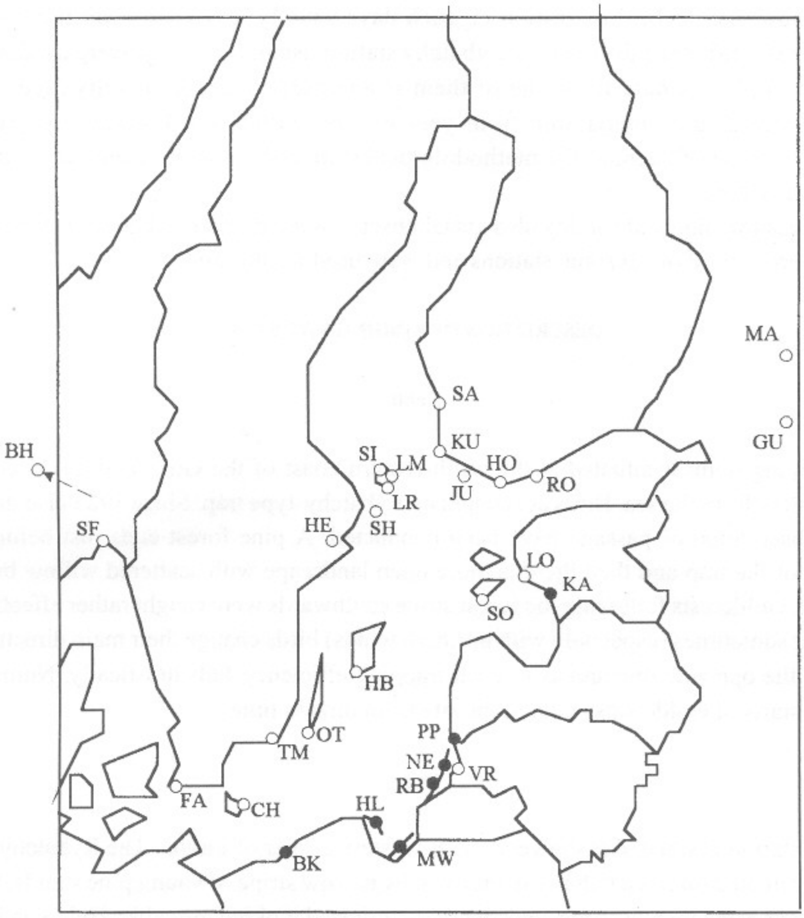


Fig. 1. Geographic distribution of ringing stations included into the study. Solid circles – station used for detailed studies, open circles – other stations regarded in the paper. BH – Blikshavn (52.12 N, 05.19 E), BK – Bukowo/Kopań (54.21 N, 16.17 E/54.28 N, 16.25 E), CH – Christiansø (55.19 N, 15.12 E), FA – Falsterbo (55.22 N, 12.52 E), GU – Gumbaritsy (60.41 N, 32.55 E), HB – Hoburgen (56.55 N, 18.08 E), HE – Hartsö Enskär (59.41 N, 17.28 E), HL – Hel (54.46 N, 18.28 E), HO – Hanko (59.49 N, 22.54 E), JU – Jurmo (59.49 N, 21.36 E), KA – Kabli (58.01 N, 24.27 E), KU – Kustavi (60.44 N, 21.01 E), LM – Lemland (59.50 N, 19.56 E), LO – Lao (58.14 N, 24.10 E), LR – Lågskär (59.48 N, 19.54 E), MA – Majacino (60.46 N, 32.49 E), MW – Mierzeja Wiślana (54.21 N, 19.19 E), NE – Neringa (55.27 N, 21.04 E), OT – Ottenby (56.12 N, 16.24 E), PP – Pape (56.11 N, 21.03 E), RB – Rybatchy (55.12 N, 20.46 E), RO – Rönnskär (59.56 N, 24.24 E), SA – Säppi (61.30 N, 21.21 E), SF – Store Fjärder (59.04 N, 10.32 E), SH – Svenska Högarna (59.27 N, 19.30 E), SI – Signildskär (60.13 N, 19.20 E), SO – Sôrve (57.54 N, 22.03 E), TM – Torhamn (56.04 N, 15.50 E), VR – Ventes Ragas (55.21 N, 21.13 E).

Rybatchy traps from time to time (1-10 days per season) were not in use due to stormy winds. However, as bird migration on such days usually was very weak it could not significantly influence the data. At Rybatchy station usually 1-3 traps were used, but in this paper only the data from one of them is analysed. Catching results used in the study (Table 2) are comparable from year to year within and between the ringing stations because of keeping the methodological standard of catching and recalculating the obtained data.

Besides trapping and ringing also visual observations (diurnal and nocturnal) to some extent were carried out at some stations and were used for the study.

DESCRIPTION OF RINGING STATIONS

Kabli

Trapping point is situated at the north-eastern coast of the Gulf of Riga on coastal dunes 100 m from the sea. Birds are caught by Rybatchy-type trap. Since 1983 also diurnal visual observation of passage have been conducted. A pine forest ends just before the opening of the trap and then there is more open landscape with scattered willow bushes behind it. Goldcrests following the forest stripe southwards were caught rather effectively. However sometimes (especially with northern winds) birds change their main direction of flight to the opposite one and as a result trapping efficiency falls drastically. Numerous evening starts of Goldcrests occur at the site from time to time.

Pape

The station is situated at the very south-western corner of Latvia. The Rybatchy-type trap was situated on coastal dunes overgrown by narrow stripe of young pine stands. Since 1993 onwards the trap has been considerably diminised looking more like Helgoland trap. The visual observations have been also carried out – nocturnal since 1975 and diurnal since 1983. The forest serves as a leading line for often extremely numerous and concentrated movements of Goldcrests flying on daytime. Several times per migration season intensive evening starts of Goldcrest occur in the surroundings of the trapping point. During nocturnal migration Goldcrests pass over the territory very dispersely but soon after birds landin the morning their movements immediately become concentrated along the belt of coastal pines. Northward movements of Goldcrests at Pape occur not so often as at Kabli.

Neringa and Rybatchy

Both stations are situated on the Courish Spit (ca. 1200 m in width at catching sites) 40 km apart. Trapping points are surrounded by dry pine forest going through the spit and mixed in some places with birch and alder trees. Migrating birds do pass above the spit in very high numbers and due to limited availability of foraging sites their passage is exceptionally fast.

Mierzeja Wiślana

Ringing site is situated at Wiślana Spit about 100 m from the coast of the Vistula Bay. About 50 mist-nets are situated in different habitats surrounding the station: young pine stand, mixed forest with pine domination and bushes. Catching of Goldcrests migrating along the Wiślana Spit is rather effective as because of favourable feeding conditions birds use the locality as a stopover site. Since 1961 the catching area has been moved a few times due to the change of habitat but not more than 500 m from the original localisation.

Hel

This catching point situated at the central part of the Hel Peninsula at the coastal dunes was working in autumn in years 1961-1986. First localisation was the place situated almost at the base of the Hel Peninsula. In later years because of the forest growth the station was gradually moved to younger stands towards the end of the peninsula. The last point was situated about 20 km to south-east from the original one. About 40-50 mist-nets were opened in young pine forest and stands. Catching of Goldcrests was rather effective at this locality during all the time of work of the station.

Bukowo

The ringing station is localised in the middle part of the Polish coast of the Baltic Sea. In years 1961-1984 the station called Bukowo I (54.21 N, 16.17 E) was localised at the narrow stripe of land cutting a large coastal lake Bukowo out from the sea. In year 1980 Bukowo I and the second station – Bukowo II localised about 3 km to the west were working. In 1982 a station Bukowo-Kopań was established at the narrow stripe of coastal forest between lakes Bukowo and Kopań about 15 km to the east of Bukowo I. Due to habitat changes in 1984 station Bukowo I was closed and since that time birds have been trapped only at Bukowo-Kopań. There is some difference between the coastline at both sites – Bukowo I was localised at the part of the coast going almost along the line west-east. Bukowo-Kopań is situated in the place where the course of the coast is SW-NE at a short distance. This can make some difference to birds coming from Sweden and landing there after crossing the Baltic Sea. However, because of the close localisation of both stations and similar habitats the results of catching are treated as coming out from the same locality. At both sites about 50 mist-nets were situated in young pine stands, pine forest, alder and alder-birch forest and also in bushes. Goldcrests use the locality as the stopover site, especially those landing after crossing the sea. Also numerous birds are caught during the day-time migration. Further in the text all localisations will appear generally as "Bukowo".

Table 1

Periods of trapping within standard period at seven studied stations in seasons used in the paper

Station	Kabli	Pape	Neringa	Rybatchy	Mierzeja Wiślana	Hel	Bukowo
1961	–	–	–	–	14.09-13.10	14.09-14.10	14.09-15.10
1962	–	–	–	–	21.08-01.10	30.08-31.10	09.09-14.10
1963	–	–	–	–	10.08-30.10	31.08-16.10	06.09-16.10
1964	–	–	–	–	17.08-25.10	05.09-22.10	03.09-15.10
1965	–	–	–	–	15.08-25.10	06.09-15.10	07.09-15.10
1966	–	–	–	14.08-01.11	17.08-26.10	03.09-15.10	05.09-15.10
1967	–	–	–	14.08-01.11	17.08-27.10	06.09-15.10	16.08-26.10
1968	–	09.09-01.11	–	14.08-01.11	17.08-25.10	05.09-16.10	16.08-25.10
1969	–	12.09-29.10	–	14.08-01.11	17.08-26.10	04.09-15.10	17.08-25.10
1970	–	15.08-21.10	–	14.08-01.11	16.08-01.11	06.09-30.09	05.09-11.10
1971	21.08-01.11	21.08-20.10	–	14.08-01.11	17.08-01.11	06.09-15.10	17.08-22.10
1972	14.08-27.10	14.08-24.10	–	14.08-01.11	14.08-01.11	03.09-17.10	14.08-28.10
1973	14.08-23.10	07.09-22.10	–	14.08-01.11	14.08-01.11	03.09-17.10	14.08-28.10
1974	14.08-01.11	13.09-01.11	–	14.08-01.11	14.08-01.11	02.09-17.10	14.08-27.10
1975	14.08-23.10	13.09-01.11	–	14.08-01.11	15.08-01.11	15.09-17.10	14.08-27.10
1976	14.08-01.11	16.09-01.11	–	14.08-01.11	14.08-01.11	01.09-18.10	14.08-01.11
1977	14.08-01.11	14.08-01.11	–	14.08-01.11	16.08-01.11	13.09-18.10	14.08-01.11
1978	14.08-01.11	30.08-01.11	–	14.08-01.11	14.08-01.11	02.09-17.10	14.08-01.11
1979	14.08-01.11	16.09-01.11	13.09-01.11	14.08-01.11	14.08-01.11	03.09-17.10	16.08-01.11
1980	27.08-27.10	16.09-01.11	14.08-01.11	14.08-01.11	14.08-01.11	02.09-17.10	14.08-01.11
1981	14.08-01.11	13.09-01.11	14.08-01.11	14.08-01.11	14.08-01.11	02.09-17.10	14.08-01.11
1982	31.08-01.11	12.09-01.11	28.08-30.10	14.08-01.11	14.08-01.11	–	14.08-01.11
1983	25.08-24.10	16.09-01.11	14.08-01.11	14.08-01.11	14.08-01.11	01.09-17.10	14.08-01.11
1984	23.08-29.10	17.08-01.11	25.08-30.10	14.08-01.11	14.08-01.11	01.09-17.10	14.08-01.11
1985	14.08-27.10	15.08-01.11	22.09-01.11	14.08-01.11	14.08-01.11	02.09-17.10	14.08-01.11
1986	24.08-01.11	15.08-01.11	04.09-01.11	14.08-01.11	14.08-01.11	02.09-19.10	14.08-01.11
1987	21.08-01.11	21.08-01.11	05.09-01.11	14.08-01.11	14.08-01.11	–	14.08-01.11
1988	16.08-25.10	22.08-01.11	08.09-01.11	14.08-01.11	14.08-01.11	–	14.08-01.11
1989	27.08-25.10	10.09-01.11	08.09-29.10	14.08-01.11	14.08-01.11	–	14.08-01.11
1990	22.08-30.10	14.08-01.11	13.09-01.11	14.08-01.11	14.08-01.11	–	14.08-01.11
1991		14.08-01.11	15.09-01.11	14.08-01.11	14.08-01.11	–	14.08-01.11
1992		21.08-01.11	19.09-01.11	14.08-01.11	14.08-01.11	–	14.08-01.11
1993		06.09-01.11	04.09-01.11	14.08-01.11	14.08-01.11	–	14.08-01.11
1994		24.08-01.11	16.09-01.11	–	14.08-01.11	–	14.08-01.11
1995		21.08-01.11	31.08-01.11	–	14.08-01.11	–	14.08-01.11
1996		30.08-01.11	29.08-01.11	–	14.08-01.11	–	14.08-01.11

At no Polish station numerous evening starts similar to these observed at Pape and Kabli were noted. Polish stations and methods of their work were described in more details by Busse and Kania (1970).

Terms of station activities used for analyses are shown in Table 1 and numbers of birds trapped at each station in seasons used for the study are presented in Table 2.

Table 2

Catching totals of Goldcrest within the term of standard period used for analyses from seven ringing stations

Year	Kabli	Pape	Neringa	Rybatchy	Mierzeja Wiślana	Hel	Bukowo
1961	–	–	–	–	896	914	121
1962	–	–	–	–	614	747	265
1963	–	–	–	–	659	131	131
1964	–	–	–	–	3169	373	429
1965	–	–	–	–	6572	1572	718
1966	–	–	–	127	1838	2281	1509
1967	–	–	–	394	6005	669	3662
1968	–	1063	–	48	1223	462	449
1969	–	1112	–	341	4254	725	1222
1970	–	1590	–	29	3937	292	365
1971	601	1068	–	451	4514	1240	1003
1972	1713	937	–	611	6039	4337	2227
1973	1892	2739	–	1144	10279	1344	3903
1974	3752	9702	–	2968	20452	4512	6971
1975	11242	10751	–	3205	16371	3012	3582
1976	222	1097	–	3832	9656	337	1110
1977	512	2711	–	9814	10800	3444	4475
1978	395	1378	–	2626	4385	1531	1897
1979	188	918	170	339	1530	340	463
1980	7182	5661	3410	19004	4559	3156	2206
1981	19647	3892	1416	11827	4860	918	7963
1982	1966	5869	3080	6396	1864	–	5051
1983	15986	20925	1942	36660	6653	1417	9009
1984	2767	3837	913	5206	1874	1116	3794
1985	938	1484	241	8633	2108	270	1285
1986	663	3483	434	10591	2162	281	1719
1987	291	3321	217	1443	988	–	208
1988	9481	24569	1094	7838	2317	–	3477
1989	2398	20133	2376	19824	6658	–	4605
1990	1028	4461	209	7641	10221	–	7393
1991	5125	22781	2284	16158	587	–	1320
1992	2559	–	1506	18643	1330	–	2045
1993	1714	–	1743	14041	2086	–	3692
1994	4185	–	822	–	1845	–	2635
1995	4417	–	1216	–	2151	–	6336
1996	4794	–	1136	–	1704	–	2655
Total	**105658**	**155482**	**24209**	**209834**	**167160**	**35421**	**99895**

Parallely to the catching results also the recoveries of birds retrapped during the same migration season (direct-recoveries) between stations situated around the Baltic Sea (Fig. 1) were used. In total 338 of such recoveries were at our disposal (see Table 5). For the inland migration direction of the wave VI at Mierzeja Wiślana, long-distance recoveries (10 recoveries from years 1961-1994) from the same autumn season and the following winter season were analysed. For Polish stations also local recoveries from the spring season next to the autumn ringing were also studied in order to define groups of birds wintering in the neighbourhood of the ringing stations (53 recoveries). Unpublished recoveries were kindly provided by Estonian, Latvian, Lithuanian ringing centres and those already published were taken from their reports.

METHODS OF ANALYSES

Catching results of the seven studied stations were used for drawing the migration dynamics. For the preparation and analyses of migration dynamics and defining migration waves the method presented by Busse (1996) was used and it will be only briefed here.

Daily numbers of Goldcrests caught at each station were recalculated to percent data in relation to the daily mean number of birds caught within given season to make the data comparable between years and stations. The standard period of catching common for all the stations (except Hel) was established for 14 Aug – 1 Nov. In the case of Hel the term of 30 Aug. – 17 Oct. was chosen as a standard period (see Table 1). Smoothing of raw percent data was done four times using the five-day moving average with coefficients of the normal curve of the standard deviation equal 1. The raw and smoothed curves of migration dynamics for each station were analysed in each year. On this basis migration waves and their dates were defined. Out of the dates obtained by this method the mean date of the beginning and closing of each wave throughout all the seasons was found. To give the reasons for this division into waves minima and maxima at raw and smoothed yearly curves were defined. In addition to the method which took into account only the most apparent minima and maxima (Busse 1996) all other minima and maxima were also counted to avoid the effect of blearing of waves resulting from the quick and condensed migration represented by Goldcrest. Dates of the most numerous occurrence of minima and the lowest numbers of maxima at both curves were considered as the dates of beginnings and closing of waves. The picture of distribution of the most apparent minima and maxima along the season allowed to distinguish only the most numerous waves while using both distinct and less visible minima and maxima allowed to define not only the above waves but also the first and the last ones. The percent data for each day of catching averaged for all the years of catching allowed to prepare a total percent curve for each station. Periods of waves defined after dividing this curve were also taken into account. The dates of beginnings and closing of waves obtained by all the above methods were compared. The maximum range between these dates was 6 days. The mean dates of these periods were considered as final ones defining general periods of waves at each of the stations. These dates were used to divide the total percent data for each station onto fragments. Each of them was four-times smoothed by the method mentioned above giving as the result a picture division of the percent total curve to one-peak normal curves (see Fig. 7 in the results). This pattern of waves was later analysed in order to find similarities and differences between migration dynamics at the studied stations.

Recoveries of Goldcrest used in the study were analysed in relation to the defined waves. The dates of ringing and recapturie of birds at the studied stations were classified to one of the waves in the season of catching. Then the distribution of recoveries in seasons of their frequent occurrence created a background to follow the passage of each wave of Goldcrest in these years. The days of recoveries were also localised within the overall pattern of waves at each station to provide material for generalizations on the origin and course of the migration of different groups of birds through the studied stations. In cases of the recoveries coming from seasons not divided into waves the control was classified to one of the waves of the overall pattern at the given station. Also dates of ringing of Goldcrests recovered at the same locality next spring were localised within waves of the season of ringing and then also placed in the relevant wave at the general pattern of waves for the given station.

RESULTS AND DISCUSSION

Goldcrest is one of the most numerous species caught at the majority of ringing stations along the Baltic coast as well as on islands. The irregular character of its migration can be illustrated by the remarkable year-to-year changes in numbers of Goldcrests caught at the studied stations (Fig. 2). Observed differences in numbers of migrating birds occur rather synchronically at almost all the stations. These changes are probably not only the effect of population number fluctuations as it is often stated in such cases for the regular migrants (Busse and Marova 1993, Aalto *et al.* 1995, Busse *et al.* 1995), but the effect of changes in migratory tendency of Goldcrests in subsequent seasons as well.

The migration of Goldcrest through the east and south Baltic coast usually starts in first half of September and continues probably till the end of November, lasting beyond the standard period of catching activity at the studied stations. Because of that it was difficult to find the precise periods of finishing the migratory activity. The phenology of beginning of Goldcrest's autumn migration at different stations is shown in Table 3. As it can be seen there at the southernmost stations migration of Goldcrest usually started earlier as compared with other localizations. Considerable differences between the dates of the earliest and the latest occurrence of the first migrants could be seen at each of the stations. This was connected with the intensity of the migration in a given year. Migration of Goldcrests started early and lasted long in seasons of their numerous occurrence. Good examples can be year 1990 when the migration started early and lasted in Pape intensively even up till the second week of November, and also year 1983 (see Figure 3). In years of low numbers of Goldcrest caught their migration began late, ended early and was con-

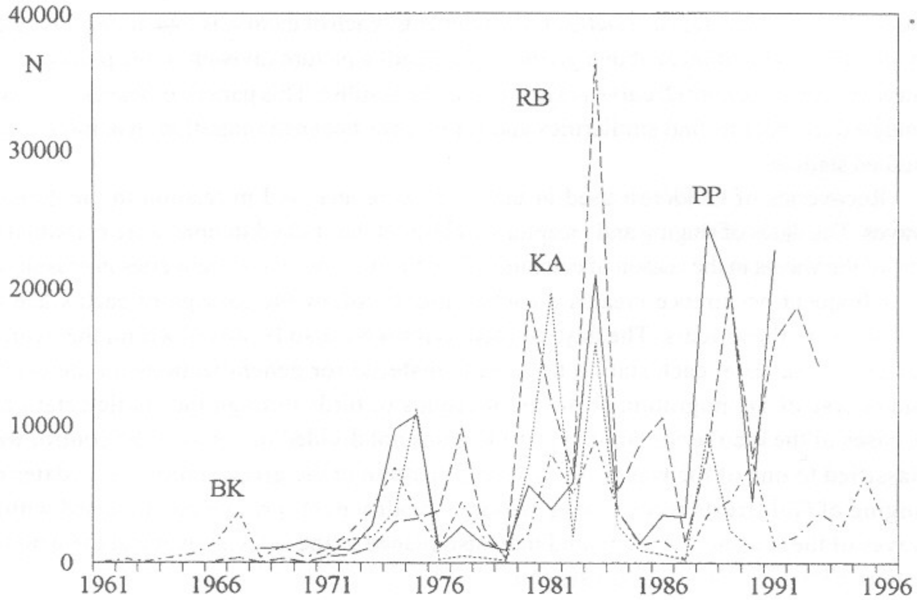


Fig. 2. Yearly catching totals of Goldcrest at four studied stations. Station symbols as on Figure 1.

Table 3

Phenology of beginning of autumn migration of Goldcrest at the Eastern and Southern Baltic coast in studied years. Station symbols like on Figure 1

Station	Usual dates	Earliest dates	Latest dates
Kabli	7-12 Sept.	2 Sept.	19 Sept.
Pape	4-8 Sept.	20 Aug.	24 Sept.
Neringa	15-21 Sept.	19 Aug.	3 Sept.
Rybatchy	8-13 Sept.	30 Aug.	26 Sept.
Mierzeja Wiślana	3-10 Sept.	25 Aug.	25 Sept.
Hel	3-10 Sept.	2 Sept.	17 Sept.
Bukowo	2-10 Sept.	18 Aug.	17 Sept.

densed like e.g. in 1971 (Fig. 4). Up to two first and two last waves could be absent in such years at some stations. The irregular occurrence of the first and the last waves in different years could not be the only cause of such rapid year-to-year changes in numbers of Goldcrest caught (as shown at Figure 2) as these waves were usually not very numerous and the middle waves gave the great majority of trapped birds.

Some peculiarities of Goldcrest migration

Despite its small size the Goldcrest has extremely high migration ability. It was found that almost 75% of these birds caught at Ottenby are able to cross the Baltic Sea without additional fat deposition and they are capable of very fast refuelling (Pettersson and Hasselquist 1985). The most distant flights of this species seem to be made by means of nocturnal migration.

According to observations at Pape up to four times per autumn migration season there occur mass scale evening starts of Goldcrest. Usually this phenomenon has been observed during peaks of migration season (waves IV and V). Just before twilight birds ready for nocturnal flights become very active and keeping southward direction move first from tree to tree and soon gradually rise up to the sky. The most intensive starting activities of birds begun 20-30 minutes after sunset. The time between the beginning and end of such activity was lasting up to 45 min. During such intensive evening starts more than one thousand of Goldcrests were counted per half an hour from the observation point at Pape. Most of the starting birds trapped at Pape had high initial fat score and body weight (up to 7.8 g). Intensive evening starts of Goldcrest seem to be associated with the development of high pressure synoptic situation although sometimes it is not certain whether there is a dependence on weather conditions.

Evidently long distance nocturnal flights are initiated mostly at points where birds start to cross migration barriers (mainly open water) thus passing some closer situated stations during the night. It seems striking, for instance, that there was only one direct recovery of Goldcrest from Hanko at Kabli but two were at Pape (distance twice as longer) and no one bird ringed at Lao was caught at Pape but six were at Rybatchy and single ones even at Polish and Swedish stations.

Although some authors (Karlsson 1980) tried to explain sea crossing of Goldcrest partly by possible ship assistance or wind drift effect it seems that this phenomenon occur independently. According to visual observations by means of moon-watching and spot lights at Pape active nocturnal migration of Goldcrests turns more evident when it becomes dark with a maximum intensity usually at midnight although sometimes increasing also towards the early morning hours. Usually birds were passing rather dispersely but during very intensive nocturnal migration also scattered groups of birds (3-5 together) sometimes were observed. Direction of nocturnal flights at Pape generally followed the coastline southwards but from time to time birds coming from north-west or west either going to south-west or west also were observed (crossing the sea). Flying height mostly seems to be dependent from wind direction and velocity being lowest at strong headwinds.

Mass scale landing of nocturnal migrants usually took place at early dawn but sometimes continued also at sunrise or even later.

From time to time on early morning hours at Pape Goldcrests were observed coming out from the open sea flying very low above water when approaching the coast. Several times landing of Goldcrests was observed also at nights, especially during those with bright moonlight or when sudden worsening of weather happened (dense fog, heavy rains, gusty headwinds). Depending on distance and time of nocturnal flights most Goldcrests after landing need to find foraging places for refuelling. At Pape where suitable habitat is rather limited birds after landing seem to find such places as quickly as possible. As a result very concentrated and active diurnal movements take place especially during the highest seasonal peaks when 2-3 hour long uninterrupted stream of moving birds often could be observed. It was found that the decrease in body mass during the first days at stop-over sites occur more often on days of mass migration and is caused probably by competition for limited food supply (Hansson and Pettersson 1989). Diurnal flights of Goldcrest started usually shortly before sunrise and most intensively continued at least during the next four hours. More often these movements were connected with continuous short distance flights from tree to tree but if wind was weak birds sometimes used to pass also open landscape even up to 100 m aloft. Such movements above the open area have never been observed at Polish stations. Besides normal southward movements at Pape from time to time also flights to the opposite direction were observed both during diurnal as well as nocturnal migration. Most conspicuous diurnal reverse flights noticed at Kabli were mainly associated with northern winds. Generally Goldcrest seems to be relatively less weather dependent migrant than any other even larger size species of birds. It must be mentioned that intensive nocturnal migration was observed at Pape even during heavy rain or strong wind. In 1973, the distinctive season because of unstable and often unfavourable weather conditions, numbers of migrating Goldcrests for instance at all stations were more or less normal.

Structural description of waves

Typically a wave contains a well expressed one-peak maximum which evidently indicates a separate group of birds involved. More often, however, waves have several peaks, neighbouring maxima are more or less joined or sometimes groups of birds are even completely mixed together. This is different to some other species of passerines, like e.g. Redstart (Busse 1972) or Meadow Pipit (Petryna 1976) where usually the migration waves are groups of birds of the same origin.

Following the route along the eastern coast of the Baltic structural composition of Goldcrests within waves may change considerably. First of all this naturally could be caused by gradual inflow of new birds from mainland gathering at coastal areas as well as those arriving sometimes in considerable numbers from the opposite side of the Baltic Sea. Moreover remarkable structural changes could occur also due to geographical migration barriers and different kind of movements which certain group of Goldcrests prefers to use at different stages of its route (fast nocturnal flight or much slower diurnal movements). Important role may be played, of course, by the influence of weather factors both stimulating as well as those forcing birds to interrupt the flight for some time or cause movements to opposite direction.

In general it seems likely that in years with lower numbers of birds passing through the stations and with smaller amount of birds from different regions waves may remain more evenly and similarly distributed at much longer distance along the migration route than in years with abundant influxes of migrants (compare Fig. 4 and Fig. 3).

In some cases complicated spatial and temporal changes of maxima occur in the pattern of the composition of waves. Very conspicuously it seems to be expressed in year 1983 with very abundant migration of Goldcrest at all stations (Fig. 3). Besides complicated mixing of three groups of birds at Rybatchy which departed from Kabli as rather well separated waves (III, IV, V) they seemed to be located in quite opposite order at Pape. It was clearly demonstrated also by two retraps of birds ringed at Hanko on the same day but arriving at Pape with a difference of 5 days. Those coming to Pape earlier probably were fast moving nocturnal migrants as on this morning (10 Oct.) a mass scale landing of Goldcrests from considerable height was very conspicuous. Evidently these birds could outrun Goldcrests which arrived later probably following some another longer way moving mainly by daytime.

In 1974 it was conspicuous that a strong wave (IV) starting from Kabli gradually decreased in strength along the route southwards (Pape, Rybatchy) and was not found at southern stations (Mierzeja Wiślana, Bukowo). According to direct recoveries of Goldcrests ringed at Pape birds from this wave could gradually disperse to another directions (one control in Ottenby) moving even to quite unusual sites (one direct recovery from Smolensk region eastward from Pape).

Influence of migration strategy on catching results

Strategy of migration preferred by birds at certain stage of the migration route can influence degree to which corresponding wave became reflected in trapping results.

Thus in 1994 according to catching data there was an extensive wave (V) of migrants at Pape containing some part of birds coming from Karelia (a direct recovery from Mayachino). Birds landed in mass numbers on morning of 8 Oct. at station's surroundings causing the highest seasonal trapping peak that day. Major part of these birds immediately continued southward diurnal flights sometimes at considerable height (up to 50 m). It seems that most of these birds continued diurnal movements mostly along the eastern coast of the Courish Bay (via Ventes Ragas) as this wave was represented at Neringa very insignificantly and birds arrived there some days later than usual.

On the other hand the next wave (VI) at Pape according to trapping results was very weak as birds forming it could overshoot the station during intensive nocturnal migration observed here on the night of 13/14 Oct. Moreover birds from the surroundings of the station could depart during a remarkable evening start which begun at Pape on 13 Oct. In contrary at Neringa this wave was represented by normal maximum of trapped birds and due to the high nocturnal speed of movement arrived here almost simultaneously with the birds from the previous wave.

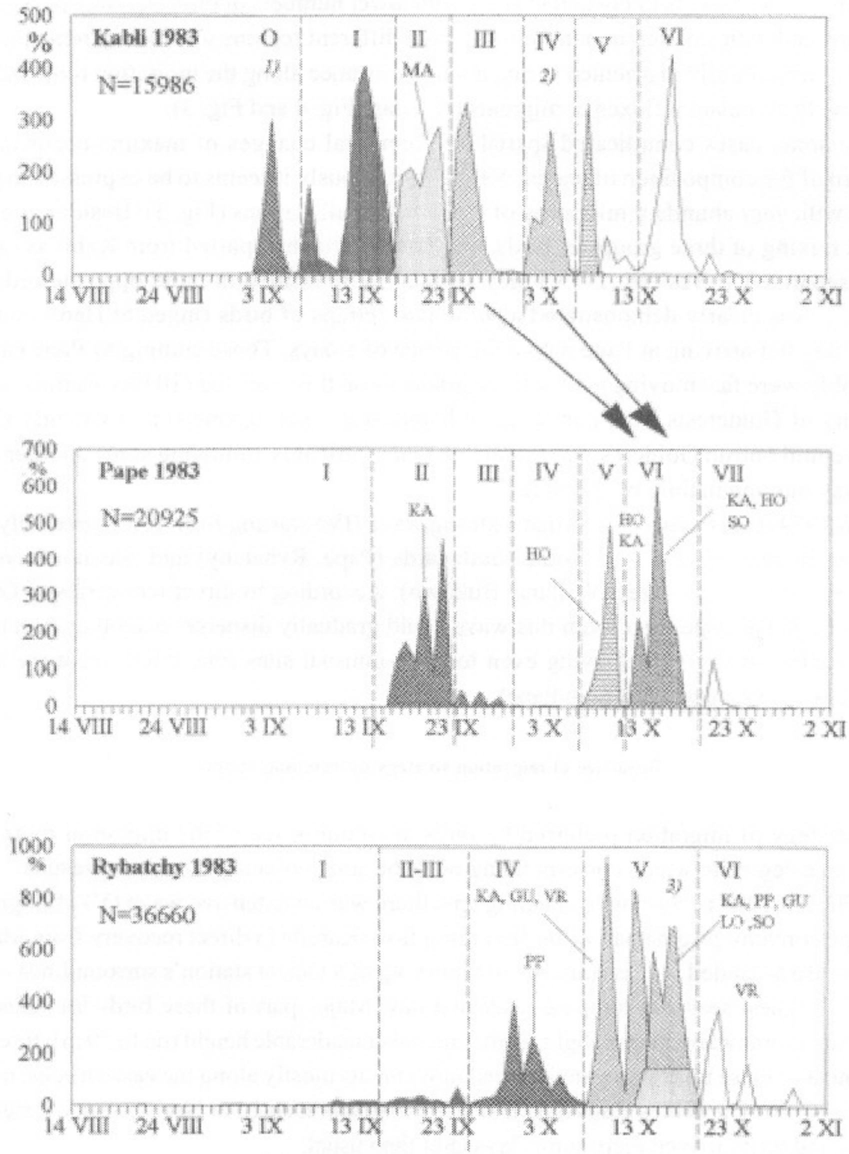
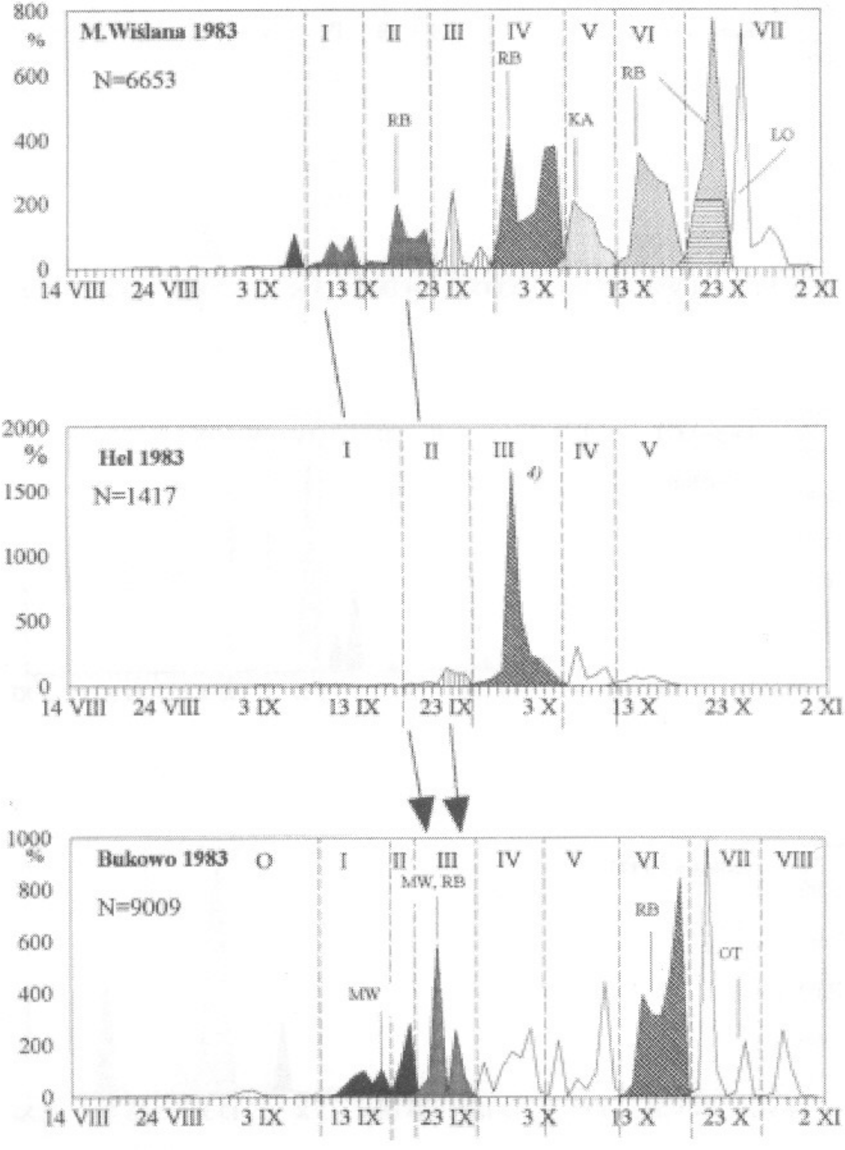


Fig. 3. Migration dynamics of Goldcrest and division into waves at some studied stations in 1983. Roman numbers are the numbers of waves. The same shading marks the same groups of birds. Arrows indicate groups of birds mixed at some station. Station symbols (as in Figure 1) show direct recoveries of birds



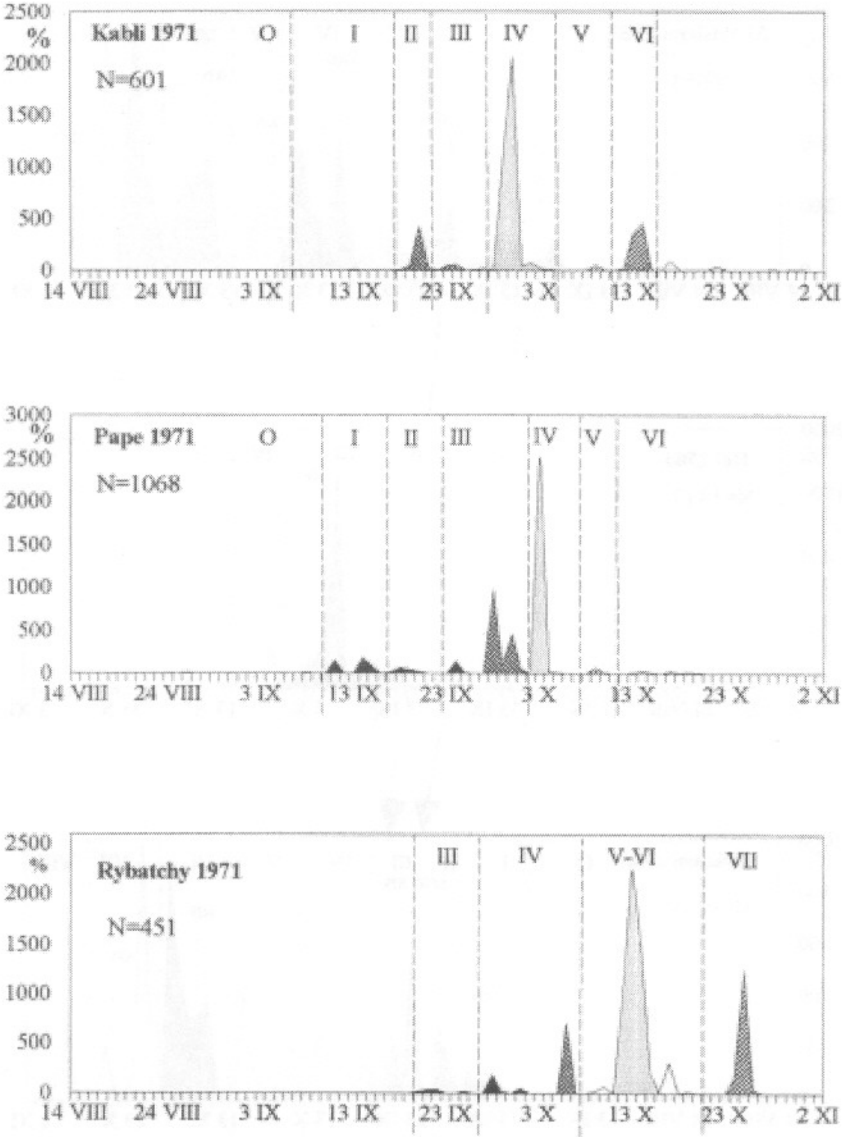
ringed at particular station elsewhere within the wave. Direct recoveries of birds ringed at given station and recaptured at some other station as comments:

1) Kabli (wave 0) – a) 04.09-27.09 SH
b) 04.09-03.10 SH
c) 04.09-22.09 OT

2) Kabli (wave IV) – a) 05.10-16.10 SI
b) 02.10-13.10 VR

3) Rybatchy (wave V) – 15.10-19.10 VR

4) Hel (wave III) – 30.09-06.10 RB


Kabli 1971
N=601
O I II III IV V VI
2500 % 2000 1500 1000 500 0
14 VIII 24 VIII 3 IX 13 IX 23 IX 3 X 13 X 23 X 2 XI
Pape 1971
N=1068
O I II III IV V VI
3000 % 2500 2000 1500 1000 500 0
14 VIII 24 VIII 3 IX 13 IX 23 IX 3 X 13 X 23 X 2 XI
Rybatchy 1971
N=451
III IV V-VI VII
2500 % 2000 1500 1000 500 0
14 VIII 24 VIII 3 IX 13 IX 23 IX 3 X 13 X 23 X 2 XI

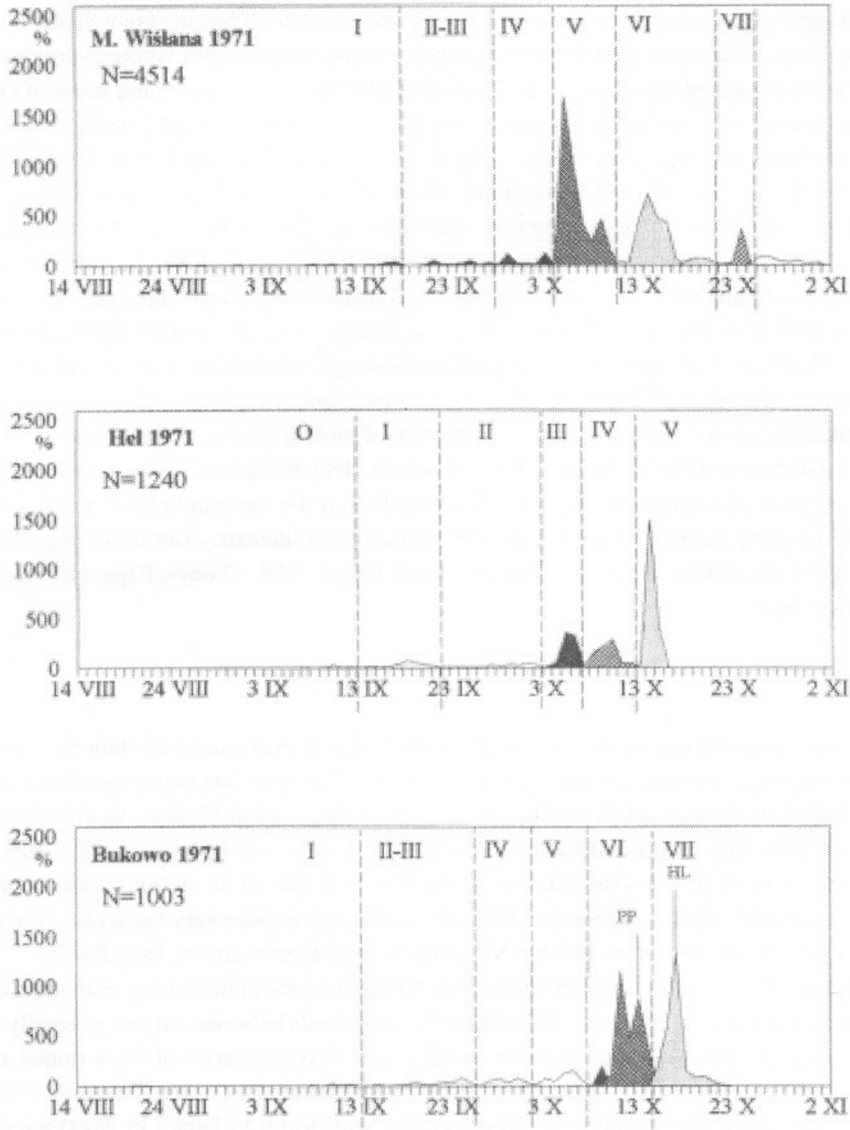


Fig. 4. Migration dynamics of Goldcrest and division into waves at some studied stations in 1971. Symbols as on Figure 3.

Trapping data may reflect the intensity of some waves to different extent depending on the position of station in relation to the distance between main sites where evening starts and their subsequent landings occur. Thus in 1984 after intensive evening starts of Goldcrests (wave III) from Kabli (especially on Sept. 27) (Vilbaste *et al.* 1985) remarkable nocturnal migration was observed passing over Pape at least on nights of 27/28 and 28/29 Sept. but trapping results represented this wave very poorly at Pape (overshooting). This group of birds, however, was caught in significant numbers at Neringa as well as at Rybatchy. In contrary mass scale landing of nocturnal migrants close to catching point always (if only not connected with reverse movements) make direct increasing effect upon trapping results. For instance in 1993 at Pape occurrence of the most abundant wave in the season (IV) was accompanied by conspicuous landing of Goldcrest observed at least three times (even during night time) resulting in seasons' highest trapping peak.

Intensive evening starts accelerate departure of birds from the locality and force them to make distant and fast nocturnal flights. It was evident at Pape in 1980 when the highest trapping peak of the season lasted only for two days as the surroundings of stations were deserted rapidly due to very numerous evening start of Goldcrests. Controls of ringed birds from this wave indicated high migration velocity (Pape – Hel – 2 days, Pape – Rybatchy – only one day).

MIGRATION SPEED BY RECOVERIES

As it was stated earlier in years of late start of migration at almost all stations very fast and compact passage was usually observed. In 1987 when very late migration of Goldcrest occurred at all the stations the birds passed Pape mainly within 12 days. In the northernmost stations migration finished already in the third decade of October. Total number of Goldcrest migrating that year was one of the lowest at almost all stations. Seasons peak wave (VI at northernmost stations) in 1987 moved through stations very fast and at the end of October evidently reached at least the Netherlands (one direct recovery from Pape).

On the other hand in year 1983 described earlier as a year of numerous, early and long-lasting migration (Fig. 3), speed of Goldcrest's movements between stations generally was to some extent lower than the average for all years. Two recoveries of birds ringed at an initial stage of the migration season (wave 0) demonstrated extremely slow movement flying from Rybatchy to Bukowo (24 days) and from Kabli to Pape (38 days) which is twice as long as normal. In general migration speed seems to be highest during peak of migration season.

Almost all Goldcrests trapped at ringing stations are birds making at these points rather slow movements in the daytime. Some part of them are birds trapped soon after they arrived and landed in the close surroundings of station after a long distance nocturnal migration. Another part of birds from the same wave which landed some distance before station gradually approach and pass through it during the remaining part of the day. The third part of birds could belong to quite another wave which due to some reasons (possibly physio-

Table 4

Differences in migration speed between pairs of Goldcrests simultaneously ringed or retrapped. Dates divided by slash are the different dates of ringing or recapture, * – female faster.

Station of ringing	Station of recapture	Dates of ringing	Dates of recaptures	Speed difference in days
Kabli	Pape	4 Sept.	17 Sept.	0
Kabli	Pape	28 Sept.	6 Oct.	0
Kabli	Pape	27 Sept./2 Oct.	16 Oct.	5
Kabli	Rybatchy	24 Sept./4 Oct.	15 Oct.	10
Kabli	Rybatchy	24 Sept./4 Oct.	17 Oct.	7
Kabli	Rybatchy	29 Sept.	10 Oct./15 Oct.	5
Kabli	Rybatchy	24 Sept.	10 Oct./15 Oct.	5
Kabli	Rybatchy	4 Oct.	15 Oct./17 Oct.	2*
Kabli	Mierzeja Wiślana	23 Sept./25 Sept.	2 Oct.	2
Kabli	Mierzeja Wiślana	8 Oct.	16 Oct./17 Oct.	1
Kabli	Svenska Högarna	1 Oct.	5 Oct./6 Oct.	1
Kabli	Svenska Högarna	1 Oct.	5 Oct./7 Oct.	2
Kabli	Svenska Högarna	1 Oct.	5 Oct./6 Oct.	1
Kabli	Svenska Högarna	4 Sept.	27 Sept./3 Oct.	6
Kabli	Signildskär	27 Sept./5 Oct.	10 Oct.	8
Kabli	Hoburgen	11 Oct.	14 Oct.	0
Jurmo	Kabli	28 Sept.	7 Oct./9 Oct.	2
Sörve	Pape	27 Sept./8 Oct.	15 Oct.	11*
Neringa	Rybatchy	7 Oct./8 Oct.	16 Oct.	1
Neringa	Rybatchy	23 Sept./28 Sept.	28 Sept.	5
Neringa	Mierzeja Wiślana	1 Oct./4 Oct.	9 Oct.	3
Ottenby	Neringa	3 Oct./12 Oct.	14 Oct.	9
Ventes Ragas	Rybatchy	13 Oct.	15 Oct./24 Oct.	9
Ventes Ragas	Rybatchy	20 Oct./25 Oct.	27 Oct.	5
Rybatchy	Mierzeja Wiślana	25 Sept./2 Oct.	6 Oct.	7
Rybatchy	Mierzeja Wiślana	20 Sept./25 Sept.	27 Sept.	3
Rybatchy	Mierzeja Wiślana	5 Oct./7 Oct.	11 Oct.	2*
Rybatchy	Mierzeja Wiślana	9 Oct.	14 Oct./16 Oct.	2
Rybatchy	Mierzeja Wiślana	4 Oct.	13 Oct.	0
Rybatchy	Mierzeja Wiślana	12 Oct.	17 Oct.	0
Mierzeja Wiślana	Bukowo	4 Oct./9 Oct.	13 Oct.	5
Mierzeja Wiślana	Bukowo	25 Oct./27 Oct.	31 Oct.	2

Table 5

Time span between ringing and recapture of direct recoveries from studied stations

Station of ringing	Station of recovery	n	Days min-max	Days $\bar{x}$
Ladoga region	Kabli	8	10-28	16.6
	Pape	5	5-31	13.1
	Neringa	2	15-21	(18.0)
	Mierzeja Wiślana	2	15-18	(16.5)
	Bukowo	2	24-31	(27.5)
Kabli	Pape	18	4-38	11.4
	Ventes Ragas	2	11-18	(14.5)
	Rybatchy	16	2-22	13.5
	Mierzeja Wiślana	12	7-19	11.0
	Hel	1	11	(11.0)
	Bukowo	3	8-18	(14.0)
Sörve	Pape	4	14-18	(10.7)
	Ventes Ragas	1	9	(9.0)
	Neringa	1	9	(9.0)
	Rybatchy	1	21	(21.0)
	Bukowo	1	5	(5.0)
Estonia (other stations)	Pape	2	2-3	(2.5)
	Rybatchy	7	4-17	10.1
	Mierzeja Wiślana	2	8-11	(9.5)
	Bukowo	1	5	(5.0)
Pape	Neringa	4	2-9	(5.0)
	Ventes Ragas	3	5-11	(7.3)
	Rybatchy	7	3-14	7.6
	Mierzeja Wiślana	10	3-24	8.5
	Hel	1	2	(2.0)
	Bukowo	1	11	(11.0)
Neringa	Pape	1	6	(6.0)
	Ventes Ragas	1	4	(4.0)
	Rybatchy	10	0-9	4.9
	Mierzeja Wiślana	10	1-11	5.8
	Hel	1	2	(2.0)
	Bukowo	1	6	(6.0)
Ventes Ragas	Rybatchy	11	1-11	5.2
	Mierzeja Wiślana	4	1-10	(5.0)
	Neringa	1	2	(2.0)
Rybatchy	Mierzeja Wiślana	31	1-12	5.9
	Hel	4	1-21	(6.5)
	Bukowo	9	4-24	10.7
	Ventes Ragas	1	4	(4.0)
Mierzeja Wiślana	Rybatchy	1	13	(13.0)
	Hel	2	3-6	(4.5)
	Bukowo	18	1-18	8.2
Hel	Rybatchy	3	1-6	(3.7)
	Mierzeja Wiślana	2	5-9	(7.0)
	Bukowo	3	1-6	(3.3)
Bukowo	Mierzeja Wiślana	1	4	(4.0)
Coastal Finland	Estonia	7	7-24	9.9
	Pape	4	10-22	(15.7)
	Rybatchy	1	6	(6.0)

Åland islands	Sörve	1	13	(13.0)
	Estonia (other stations)	6	9-24	13.4
	Pape	3	13-19	(15.0)
Ottenby	Pape	2	14-27	(20.5)
	Neringa	3	2-11	(6.5)
	Rybatchy	1	1	(1.0)
	Bukowo	2	8-9	(8.5)
Coastal Sweden	Sörve	1	16	(16.0)
	Pape	1	7	(7.0)
	Neringa	2	4-12	(8.0)
	Rybatchy	2	1-5	(3.0)
	Mierzeja Wiślana	2	5-9	(7.0)
	Bukowo	4	4-11	(6.5)
Christiansø	Bukowo	2	1-4	(2.5)
Store Fjärder	Kabli	1	41	(41.0)
	Pape	1	16	(16.0)
Blikshavn	Pape	1	20	(20.0)
Sörve	Coastal Finland	1	10	(10.0)
Estonia (other stations)		2	14-19	(16.5)
Sörve	Åland islands	1	7	(7.0)
Estonia		15	3-37	12.2
Pape		2	7-8	(7.5)
Estonia	Ottenby, Hoburgen	14	5-18	5.4
Pape		1	6	(6.0)
Neringa		3	1-4	(3.2)
Estonia	Coastal Sweden	9	3-19	13.6
Pape		1	3	(3.0)
Ventes Ragas		1	19	(19.0)
Estonia	Christiansø	6	6-17	10.6
Pape		1	11	(11.0)
Bukowo		2	3-9	(6.0)
Total		**338**		

logical or weather dependent) is moving several days by diurnal migration. It is pointed out by the difference in migration speed which may be developed by birds belonging even to the same group (Table 4). For instance from among Goldcrests ringed at Gumbaritsy within two following days one took 11 days to reach Kabli (563 km) while the other one reached more distant Lågskär in shorter time (723 km in 8 days). Moreover to Uttulippan in Sweden which is almost twice as long distance as to Kabli (1135 km) was covered by third bird in 13 days (Noskov and Rezvyi 1995). If in this case these birds could reach Kabli even by diurnal movements the two other overseas stations were probably reached mainly by nocturnal migration. The number of days needed by Goldcrest to cross the distances between studied stations and the differnces in speed between individuals are presented in Table 5.

It seems that no significant differences of migration speed exist between both sexes of Goldcrest. Comparing data when birds of different sexes moving between two stations were ringed or retraped on the same day one can find that there are cases of no difference between the time they spent on it or sometimes females were retraped even one or two days earlier than males (Table 4).

Estimation of the real time which birds spend flying between stations of ringing and recovery is rather problematic as very little is known on how long they may stay at rining and stopover sites. Although generally it is supposed to be not long lasting (Payevsky 1971, Pettersson and Hasselquist 1985) considerable deviations could be caused due to the part of the season, weather conditions, availability of foraging grounds and influence of certain migration barriers.

In other respects direct recoveries indicate that in general the migration speed between mainland stations could range from 20 to 50 km/day (supposedly mainly by diurnal flights) but during the overseas flights (mainly nocturnal ones) it exceeds 90 km/day.

A record speed of migration seems to be demonstrated by a Goldcrest which covered the distance of 645 km from Finland to Poland (Mierzeja Wiślana) in only one day (Mokwa 1997).

GENERAL DESCRIPTION OF MIGRATION ROUTES

The migration routes described below are presented at Figure 5. According to ringing recoveries most Goldcrests arriving to coastal areas of Estonia are those that departed mainly from Finland (partly also from Åland and neighbouring Swedish islands) and Karelia (at least from eastern coast of Ladoga lake where mass ringing was done). Presence of birds from the vast territories of north-western Russia also could be theoretically presumed (unfortunately, very low intensity of ringing activities there). These birds of eastern origin either fly directly to the Riga Bay or follow the southern (very probably also northern) coastline of the Finnish Bay.

At western Estonian coastal region migration pattern of Goldcrest seems to be much more complicated than elsewhere along the whole Eastern Baltic flyway. There are signs that at least three general directions prevail for birds departing from Kabli. Main of them goes southwards along the eastern coast of the Riga Bay which probably also could be crossed straight at some places. Another direction leads to Åland islands and to neighbouring Swedish coastal area where birds ringed at Kabli (some also at Pape) were rather often retrapped. Flights to this area could be partly connected with diurnal reverse migration so often observed at Kabli but nocturnal migration cannot also be eliminated especially when crossing the sea. Time lapse between ringing and retrapping of these birds (3-37 days; $\overline{x} = 8.4$; see Table 5) at least should be in favour of both. There are more than 20 direct recoveries of birds ringed at Estonian stations and retrapped at Gotland, Öland and southernmost Swedish coastal area. Flight speed of these birds (3-19 days; $\overline{x} = 7.6$; see Table 5) allow to assume that at least some of them could make nocturnal flights crossing the Baltic Sea straight to these stations. However, possibility that birds could first arrive at Swedish coast elsewhere (even through Åland islands) and then after following along it southwards fly to the islands should not be excluded. These movements most likely could be initiated by intensive evening starts often occurring at Kabli.

Also Estonian islands (especially Saaremaa) could be defined as a cross-road for Goldcrests flying later to Åland islands, Swedish coast or to north-western corner of Latvia (Cape Kolka).

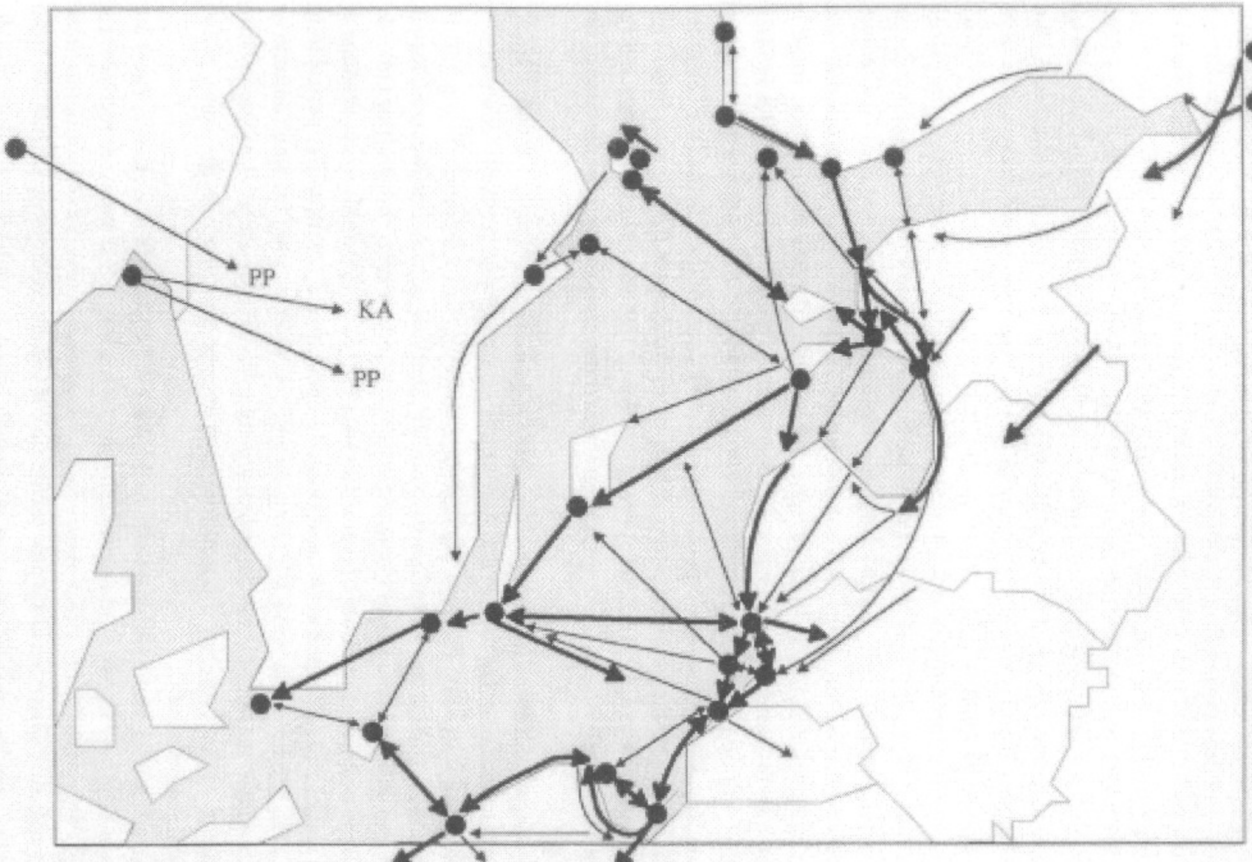


Fig. 5. Migration routes of Goldcrests in the region of the south-eastern Baltic coast. Thick arrows – migration directions defined on the basis of frequent direct recoveries, thin arrows – presumed migration directions, solid circles – stations included in the study (for station's description see Figure 1).

Following the western seacoast of Latvia these birds join on the way those coming from Kabli along the Riga Bay move southwards through Pape and form a powerful and concentrated migration route. At Klaipeda it seems to divide into two branches: one of them leads to Ventes Ragas along the eastern coast of the Courish Bay (supposedly birds flying mainly in daytime) but another one after crossing ca 1 km of open water continues movements above the Courish Spit through Neringa and Rybatchy. Crossing open water of the Courish Bay often seems to occur also at Ventes Ragas (a Cape projecting to the aouth-western direction at this site may stimulate it) and as a result some part of birds after Neringa but before Rybatchy again join the first group. This presumption can be supported by the fact that only one bird was retraped at Neringa with Estonian ring (ringed at Sôrve) but at Ventes Ragas – 3 and at Rybatchy – even 23. There were also 11 direct recoveries from Ventes Ragas to Rybatchy.

After possible threefold deviation at the area of the Courish Spit these migration branches may join again at some places at Kaliningrad region but may deviate again before reaching Poland. One group of birds may fly along the mainland while the second one goes along the Wiślana Spit. Migration along the Wiślana Spit is very prominent and birds are caught there during their daytime movements. The other migration route is documented by the results of catching at the Operation Baltic station Nowa Pasłęka (54.23 N, 19.44 E) working in years 1961-64 and 1966 localised at the south-western coast of the Vistula Bay. Birds moving along the south-eastern coast of the Vistula Bay can cross the water landing at the Wiślana Spit similarly as in the case of the Courish Spit. This could be supported by one direct recovery of Goldcrest ringed at Nowa Pasłęka and re-trapped at Mierzeja Wiślana. These three migration routes can join again at the base of the Vistula Spit.

Birds ringed at Mierzeja Wiślana were retrapped at Hel and at Bukowo which allow to expect that the majority follow the southern Baltic coast and probably continue the migration along it in some distance after passing Bukowo. But supposedly some part of birds, especially from wave VI and partly from VII and VIII at Mierzeja Wiślana, leaves the coast and goes into mainland in the region of southern coast of the Gulf of Gdańsk. This is suggested by low number of recoveries (4) of birds ringed at Mierzeja Wiślana at all those waves and retrapped at Hel and Bukowo in comparison with earlier period (6 in wave III, 5 in wave IV, 3 in wave V). Long-distance recoveries from the same autumn or following winter season of birds ringed at Mierzeja Wiślana in wave VI all come from the mainland of Germany on the north through France and Spain to the coast of the Adriatic Sea to the south.

From the Hel Peninsula Goldcrests go to the west and are caught in Bukowo. There are few records of birds ringed at Bukowo which crossed the Baltic Sea and were recovered at Bornholm. This could be the effect of reverse flights after crossing the sea similar to those occurring at Kabli. There are also some recoveries of Goldcrests coming to Bukowo from Christiansø, Falsterbo and Ottenby but no recoveries of birds coming directly from Scandinavia at Hel and Mierzeja Wiślana occur. This would suggest that birds coming from the opposite coast of the Baltic Sea avoid direct flight to the region of the Gulf of Gdańsk and go towards places on the southern Baltic coast situated some distance closer to the starting points.

Analyse of recoveries between stations Bukowo-Kopań and Bukowo I show that at least part of Goldcrests continue the passage after Bukowo-Kopań along the coast in western direction and the majority of recoveries of Goldcrests ringed at Bukowo come from the directions leading to all wintering areas described earlier.

All along the coastline from Estonia to Poland new birds join the main southward migration route. Most of them evidently arrive from mainland situated to the east (numerous direct recoveries of birds ringed at Gumbaritsy and Mayachino) but some amount also from territories overseas (recoveries of birds ringed at Finnish and Scandinavian stations).

On the other hand Goldcrests partly also depart from the southward route crossing the Baltic Sea in the opposite direction at many points.

REVERSE MIGRATION

As many other migratory bird species also Goldcrest from time to time demonstrate a tendency to make flights in quite opposite direction. From the stations analysed Kabli seems to be the one where this phenomenon occurs most conspicuously. In autumn 1985, for instance, approximately half of migrating Goldcrests counted moved to the north (Vilbaste *et al.* 1985). At stations where Rybatchy traps (oriented to catch birds arriving from the north) were used, trapping totals in such cases were as a rule minimal.

There are recoveries at Finnish coastal stations of birds ringed in Estonia but one can only guess whether these are directly connected with reverse movements observed at Kabli. Much more questionable remain direct recoveries of birds with Estonian rings (one also with Latvian ring from Pape) at Åland islands. At our disposal there are a few controls confirming existence of reverse flights between stations at more southern part of the migration route: Bukowo – Mierzeja Wiślana (1 recovery), Hel – Mierzeja Wiślana (2 recoveries), Hel – Rybatchy (2 recoveries), Neringa – Pape (1 recovery)(see Table 5). They can be both signs of reverse migration as well as of eastward migration suggested by Kania (1983). All these recoveries except one come from the first period of the Goldcrest migration through the above stations when birds from Sweden usually do not occur there. So these recoveries should rather be treated as cases of opposite migration which is sometimes demonstrated by some individuals. However, the case of one bird which was ringed at Falsterbo, retrapped at Bukowo (wave VI) and caught again at Mierzeja Wiślana (wave VII) as well as an analysis of recoveries between Bukowo II and Bukowo I station, situated about 2 km to the east (Busse 1981), suggest the existence of eastward migration of Goldcrest in the second half of the migration period. The occurrence of recoveries at Bukowo of birds going east described by Busse (1981) falls at the period of the second part of wave VI and wave VII when birds coming from Falsterbo and Ottenby occur there. One can mention also a bird which moved 739 km to the east from Pape (ringed in wave IV) reaching Smolensk region in Russia.

Taking into account birds ringed in southern Sweden and in southern Norway recovered at the above stations it seems not possible to eliminate the influence of probable wind drift effect (Karlsson 1980). However, it was found that for considerable part of birds ringed at Norwegian stations the initial direction of flights ranged between south and south-east (Hanssen 1981). How distant are in reality the described opposite movements of Goldcrest and wheather it connected with birds changing from time to time their initial direction of flight or do those birds maintain it throughout the migration movements is not clearly known.

GENERAL PATTERN OF WAVES IN RELATION TO FLYWAYS

General description of migration dynamics

Comparing the shapes of summary migration dynamics between the stations (Fig. 6) it is very difficult to find many similarities. It is caused by the facts that:

1. groups of migrating Goldcrests do not occur at all subsequent stations but can fly over some stations to land at more distant site from their starting point,

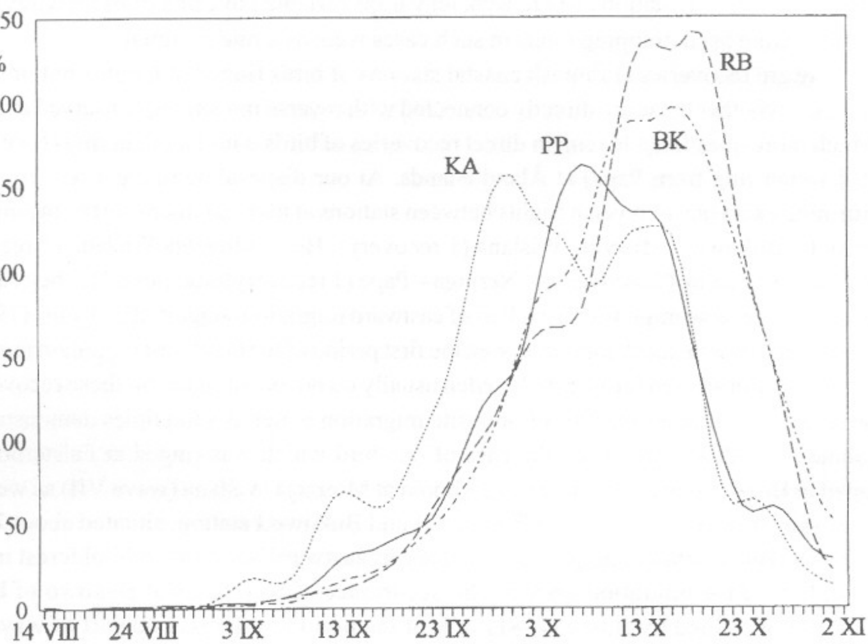


Fig. 6. Percent total curves presenting pooled many-years daily migration dynamics of Goldcrest caught at studied stations. Station symbols as on Figure 1.

2. a wave often does not move as one group throughout the stations – birds forming one wave at some station may disperse to different waves at some other station or birds from different waves at one station can form one wave at the other station,

3. birds from overseas and from inland come during all the season to the coast at different places all along the eastern and southern Baltic coast,

4. at all stations Goldcrests coming in each of the waves can leave the coastline going inland or cross the sea.

All these phenomena were partly described earlier at the examples of chosen years (see Fig. 3 and 4) on the basis of direct-recoveries.

Despite the complicated course of Goldcrest migration some regularities can be found in the picture of migrations waves. As it can be seen from Figure 7 at all stations up to three first waves and the last one (except of Hel where catching was finished in the middle of Goldcrest migration) are not very numerous. The middle waves create the great majority of caught birds.

Regularity of waves

Comparison of dates of beginnings and ends of each wave in different years within each station show that the difference in these dates can be between 3 and 8 days. The most regular waves (3-4 days of difference) at majority of stations are the most numerous ones. However, at Hel no time span in terms of waves occurrence was shorter than 6 days. On the basis of recoveries we can expect that there is a connection between the regularity of the waves terms and occurrence of groups of birds coming from inland (Mayachino, Gumbaritsy) at Kabli, Pape, Neringa and Bukowo, from Finland – at Kabli and from Sweden – at Pape, Neringa and Bukowo. Especially worth noting is the case of wave VI at Bukowo (Fig. 7). This wave had distinctively two peaks occurring almost in all years. However, they were situated so close that in the picture of total dynamics for all years they gave one peak and were classified as one wave. Similar case happened also in the next wave (VII) but not in all years two peaks occur clearly. Both these waves were the only ones where birds ringed at Ottenby and Falsterbo were retrapped. Moreover, in wave VI such recoveries came from its second peak which is also the period of occurrence of local eastward migration described by Busse (1981). The period of beginning of the second peak of this wave was rather regular (4-day span). Such evident case of two peaks within wave was not found at any other station but it is highly probable that due to a very condensed passage of different groups of Goldcrest maxima given by birds of different origin were difficult to separate (see Fig. 3 and 4). In the case of Hel where much lower regularity of waves was found the cause of that could be the lack of direct migrants from Scandinavia and Ladoga region as described earlier. There were also no records of Goldcrests ringed in inland parts of Russia at this station. This is easy to explain as the first coast met by birds coming from east to the region of Gulf of Gdańsk is the coast of the Vistula Bay and the Vistula Spit. The

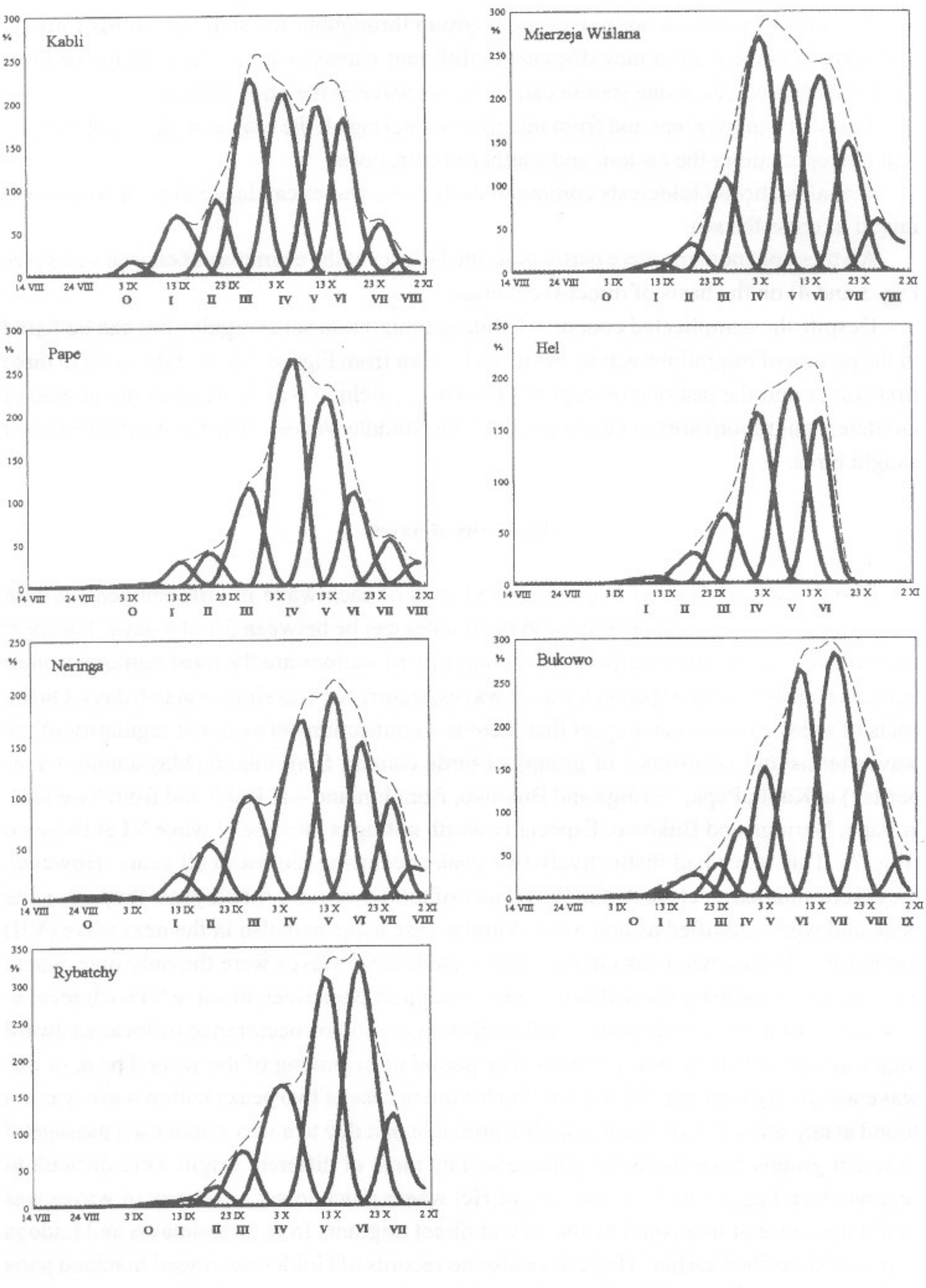


Fig. 7. Division of percent total trapping curves (dashed lines) into waves (thick lines). Roman names are the numbers of waves.

difference in regularity of waves can lead to the assumption that migration of Goldcrest along the coast is much less regular than over the sea and from inland to the coast.

Origin and migration directions of waves

Analysing direct recoveries between stations and their localisation within the waves in some cases it is possible to define the origin and a part of the migration route of some groups of birds. The use of general pattern of waves from different stations and distribution of recoveries obtained by these stations within the waves gives the material which allows to make some generalisations about the course of migration of different waves.

The best results were obtained in cases of most numerous waves as there were more recoveries concentrated within them. The pattern of recoveries and probable course of Goldcrest migration within these waves is shown at Figure 8 and only cases of two or more recoveries between given waves are presented. However, there were more cases of single recoveries between the illustrated waves, (not shown at the figure), which supported presented connections. The pattern of migration presented here supports earlier statements that Goldcrests follow eastern and southern Baltic coast probably not as stable groups. This could be connected with different migration strategies chosen by individuals or groups of birds. Nevertheless, in some cases a strong group of migrants seems to fly together or the route is regularly repeated in subsequent years. This statement is based on remarkable concentration of recoveries between waves at some stations: recoveries evidently connect wave IV at Kabli with wave V at Rybatchy and wave V at Rybatchy with wave VI at Mierzeja Wiślana (Fig. 8). At almost each station the influence of birds coming from the opposite side of the Baltic and from the east can be also seen. High number of birds in peak waves presented at Figure 7 is probably the effect of meeting groups of birds flying along the coast with those coming to the coast from other directions at the same time. Especially worth noting is the difference between direction of migration of wave VI at Mierzeja Wiślana and earlier waves. Birds forming waves IV and V at this station migrate mainly to the west giving single recoveries at Hel (not shown at Figure 8) and more at Bukowo evidently following the coastline thenafter to the west. Most birds from the next wave (VI) probably leav the coast after passing Mierzeja Wiślana and go inland, as there was a complete lack of recoveries of birds from this wave at Bukowo and all long distance recoveries of this group came from inland from the directions leading to main known wintering areas of this species. Next waves at Mierzeja Wiślana give again recoveries at Bukowo. It is, of course, possible that some part of birds from waves before and after the wave VI also go from Mierzeja Wiślana inland, but only in case of this wave VI it seems evident that probably the whole group choose the same general course of migration.

For other waves at all the stations it was not possible to describe the course of the migration in such detail, but some connections between waves at different stations were found and are presented in the Table 6. Direction specified there as "inland" refers to the

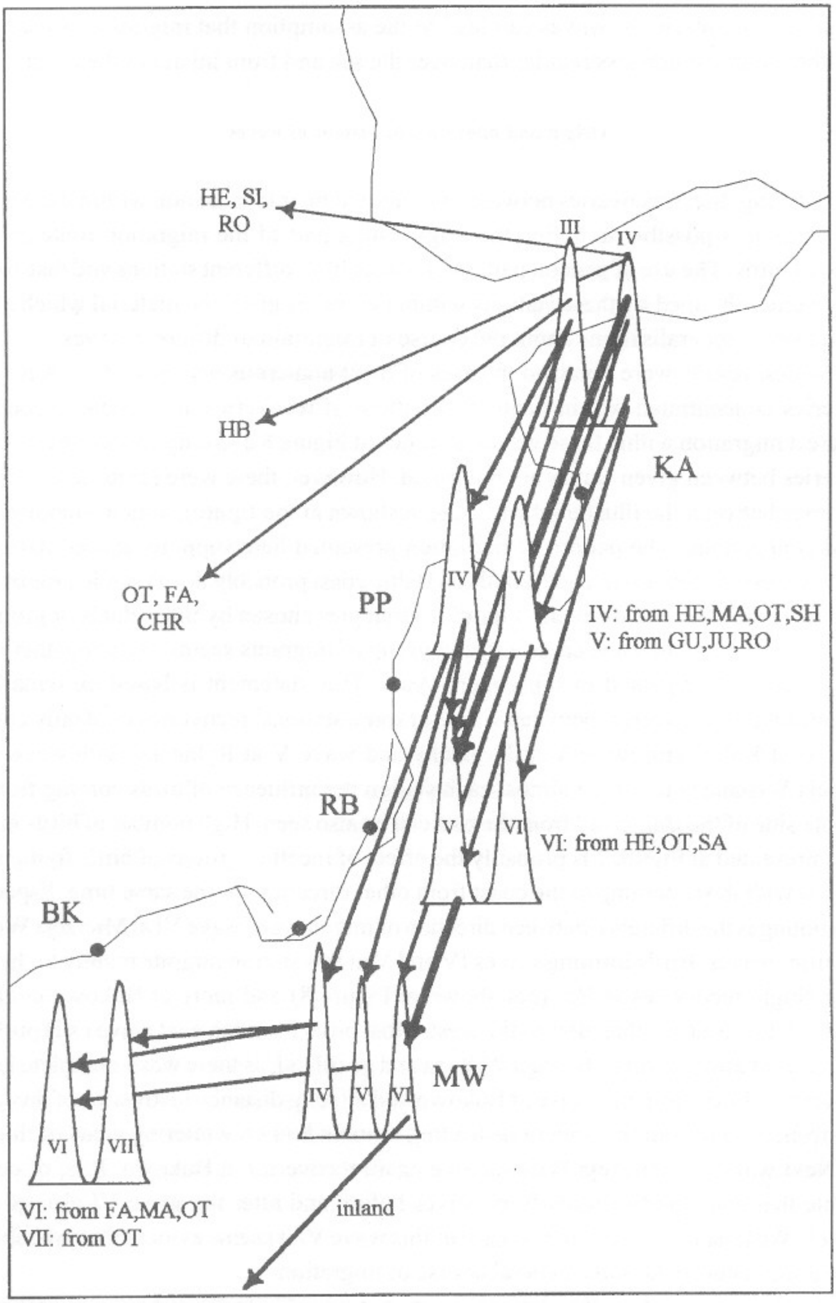


Fig. 8. Pattern of the migration of chosen waves at selected points based on direct recoveries. Solid circles mark stations; station symbols are as on Figure 1. Thick arrows – more than five recoveries, thin arrows – up to five recoveries. Normal curves described by Roman numbers show chosen waves.

case of wave VI at Mierzeja Wiślana described above. Direction to the west is expected on the basis of short-distance recoveries between different stations at Bukowo.

Table 6

Connection of waves between stations based on two and more recoveries. Symbols of stations the same as on Figure 1, the Roman numbers mark number of wave at the station. In case when it was not possible to define the wave of migration, only the symbol of station is given.

Stations and waves connected by recoveries				Expected direction after last station
	KA 0	SH		
	KA 0	PP II		
MA, SA	KA V	CHR		
	KA V	MW VI		inland
JU, HA	KA VI			
GU	KA VII			
MA	PP III	MW IV	BK VI	west
SO	PP VI			
	RB I	MW II		
	RB II	MW IV	BK VI	west
	RB III	MW IV	BK VI	west
	RB IV	MW VI		inland
	RB IV	HLVI		
	RB IV	BK VII		
	MW 0	BK II		
	MW III	BK VI		west
	BK VIII			west
	BK IX			west

The described characteristics of Goldcrest migration suggests lack of such strong mecha-nisms of avoidance between different groups of migrants as were found e.g. at Coal Tit (Busse 1978). All the above facts show that different groups of Goldcrests mix rather easily along the migration route. Only at Mierzeja Wiślana it was very evident that in waves IV and VI the recoveries of birds coming from Rybatchy were numerous. Opposite to that in wave V there was only one recovery from Rybatchy, one from Pape, one from Kabli and one from Svenska Hogarna. So it is very difficult to define the origin of this wave (V) in contrast to the previous (IV) and the following (VI) one. However, the beginning date of this wave is the most regular one throughout all the seasons among other waves at Mierzeja Wiślana. Results of Busse (1981) suggest some avoidance between groups of Goldcrests migrating through Bukowo to south-west and south-east. Both groups comes in wave VI which was described earlier as consisting of two peaks and containing birds originating from Sweden. So, in this case some mechanisms of isolation between birds coming from this region and from north-east could be suspected. This phenomenon needs further investigation.

Analyses of local recoveries of birds caught in the spring season next to the autumn of ringing gave interesting results. Only birds caught at the beginning of the spring season, before 6 April, which is the period of the beginning of the first big wave of spring migrants at the Polish Baltic coast (Busse 1976) were taken into account. More than one such birds ringed in autumn waves 0, IV, VI, VIII occurred at Mierzeja Wiślana and at Hel in 0, I, II and IV but no one was found at Bukowo. Some of these birds were caught several times during the spring at the same site and some of them stayed in the area for up to one month untill they disappeared not later than on 26 April. Kania (1983) presented two hypotheses to explain the occurrence of such local recoveries. The first one suggests that part of Goldcrests wintering at the southern Baltic coast depart to the north late after passing the majority of migrants. The other one says that some part of birds can stay at the southern Baltic coast for breeding. The hypothesis of their breeding in this region can be real in case of local spring recoveries of birds ringed in autumn at waves 0 at Mierzeja Wiślana and 0, I and II at Hel. These waves can be formed by local breeders as they are not very numerous and no evidence of birds coming into these waves from other areas exists. However, in cases of waves IV and VI at Mierzeja Wiślana and IV at Hel which fell in the middle of the migration season there were many recoveries of birds coming to these stations from other areas so rather the first hypothesis seems to be right. In wave IV at Mierzeja Wiślana there were several recoveries of birds ringed at Rybatchy but no recoveries suggesting their origin. However, possibility that they breed not very far from Rybatchy cannot be excluded. Wave VI at Mierzeja Wiślana according to recoveries could contain some part of Goldcrests breeding in Estonia, Finland and Ladoga region. Also in cases of the local spring recoveries of birds ringed in the last wave (VIII) of previous autumn the hypothesis about their wintering in the region of Mierzeja Wiślana seems to be right.

Our analyses showed how complicated the problem of studying the migration of Goldcrests around the Baltic Sea can be, even possessing such considerable amount of data. In fact many questions about the origin of different groups of Goldcrest, their flyways and migration strategies remain open. Therefore the continuation of research on the species is planned within the Baltic Network and the SE European Bird Migration Network.

ACKNOWLEDGEMENTS

We would like to acknowledge to Kasa im. Józefa Mianowskiego – Fundacja Popierania Nauki which supported the work on this publication. We are grateful to Dr. A. Leivits, Dr. R. Patapavicius and Dr. V. A. Payevsky who provided the ringing data and to Estonian, Latvian and Lithuanian Ringing Centres for supplying the recoveries. Finally we would like to express our thanks to Prof. P. Busse for his support in work on the material and preparation of this paper.

REFERENCES

Aalto P. Ader A., Baumanis J., Busse P., Latja A., Leivits A., Miettinen J., Ojanen M., Pakkala H., Tynjälä M., Vilbaste E. 1995. *Autumn migration of the Willow Tit (Parus montanus)*. Ring 17, 1-2: 5-11.

Busse P., Kania W. 1970. *Operation Baltic 1961-67. Working methods*. Acta Orn. XII, 7: 232-267.

Busse P. 1972. *Autumn migration of the Redstart, Phoenicurus phoenicurus (L.) along the Polish coast of the Baltic*. Acta Orn. XII, 6:194-241.

Busse P. 1976. *The Spring Migration of Birds at the East Part of Polish Baltic Coast*. Operation Baltic Paper No. 27. Acta Zool. Cracov. XXI, 6: 122-267.

Busse P. 1978. *Wave and population structure during Coal Tit autumn migration in 1974*. Not. Orn. XIX, 1-4: 15-24.

Busse P. 1981. *Finding of local passage direction as the result of an analysis of retraps and short distance direct – recoveries*. Not. Orn. XII, 3-4: 31-39.

Busse P., Marova I. 1993. *Population dynamics 1961-90 of Common Leaf Warblers (Phylloscopus sp.) at some Central European bird ringing stations*. Ring 15, 1-2: 61-80.

Busse P., Baumanis J., Leivits A., Pakkala H., Payevsky V. A., Ojanen M. 1995. *Population number dynamics 1961-90 of Sylvia species caught during autumn migration at some North and Central European bird stations*. Ring 17, 1-2: 12-30.

Busse P. 1996. *Modelling the seasonal dynamics of bird migration*. Ring 18, 1-2: 97-119.

Cramp S. (ed.) 1992. *The Birds of the Western Palearctic, Vol. VI*. Oxford Univ. Press. Pp. 668-685.

Erik W. W. 1967. *[The big trap for mass bird-trapping]*. In: *Migracii ptic Pribaltiki XL*: 51-55. [In Russian].

Hanssen O. J. 1981. *Migratory movements of Scandinavian Goldcrests Regulus regulus (L.)*. Fauna Norv. Ser. C. Cinclus 4, 1:1-8.

Hansson M., Pettersson J. 1989. *Competition and fat deposition in Goldcrests (Regulus regulus) at a migration stop-over site*. Vogelwarte 35,1:21-31.

Hilden O. 1982. *Winter ecology and partial migration of the Goldcrest Regulus regulus in Finland*. Ornis Fenn. 59, 2-3: 99-122.

Jogi A. 1957. *Lindude rongastamine Esti NSV-s aastail 1938-1955*. Abiks loodusevaatlejale 33. 82 Pp.

Kania W. 1983. *Preliminary remarks on the migration of North European Goldcrests Regulus regulus*. Ornis Fenn., Suppl. 3: 29-30.

Karlsson L. 1980. *Kungsfågelns höstflyttning over Falsterbo: tidtabell, könskvot och årliga fluktuationer*. Anser 19, 3: 139-146.

Kastepõld E., Kastepõld T. 1992. *Väljaspool Eestit rongaststud lindude taasleuid Eestis 1981-1990*. Tallinn. 177 Pp.

Kastepõld T., Kastepõld E. 1991. *Lindude rõngastamine Eestis aastail 1968-1979*. Tallinn. 140 Pp.

Kastepõld T. 1970. *Estonia Matsalu 1970 (Raport nr. 1)*. Loodusvaatlusi.

Kastepõld T. 1971. *Estonia Matsalu 1971. Bird-ringing report nr. 2*. Loodusvaatlusi.

Kastepõld T. 1972. *Estonia Matsalu 1972*. Loodusvaatlusi 2.

Kastepõld T. 1973. *Estonia Matsalu 1973. Rõngastusaruanne nr. 4*. Loodusvaatlusi 2.

Kastepõld T. 1974. Estonia Matsalu 1974. *Rõngastusaruanne nr. 5*. Loodusvaatlusi 2.

Kastepõld T., Kabal R. 1975. *Estonia Matsalu 1975. Rõngastusaruanne nr. 6*. Loodusvaatlusi 2.

Kastepõld T., Kabal R. 1976. *Estonia Matsalu 1976. Rõngastusaruanne nr. 7*. Loodusvaatlusi 2.

Kastepõld T., Kabal R. 1977. Estonia Matsalu 1977. *Rõngastusaruanne nr. 8*. Loodusvaatlusi 2.

Kastepõld T., Kabal R. 1978. *Estonia Matsalu 1978. Rõngastusaruanne nr. 9*. Loodusvaatlusi 2.

Kastepõld T., Kabal R. 1979. *Estonia Matsalu 1978. Rõngastusaruanne nr. 10*. Loodusvaatlusi 2.

Kastepõld T., Kabal R. 1980. *Estonia Matsalu 1978. Rõngastusaruanne nr. 11*. Loodusvaatlusi 2.

Kastepõld T., Kabal R. 1981. *Estonia Matsalu 1981. Rõngastusaruanne nr. 12*. Loodusvaatlusi 2.

Kumari A. Jogi A. 1974. *Lindude rõngastamine Eesti NSV-s aastail 1956-1967*. Abiks loodusevaatlejale 67. 239 Pp. Loodusevatlusi II, 1970-1993. Tallin.

Mokwa T. 1997. *Ciekawsze wiadomości powrotne*. Biuletyn obrączkarski 14: 23-28.

Noskov G. A., Rezvyi S. P. (eds). 1995. [*Atlas of bird migration according to ringing and recovery data for Leningrad region*]. In: Tr. S-Peterbursk. obstch. estestvoispitatelei T. 85, 4. Pp. 232. [In Russian].

Payevsky V. A. 1971. [*Atlas of bird migrations according to ringing data at the Kurische Nehrung*]. Tr. Zool. instituta, T. L: 3-110. [In Russian].

Patapavičius R. 1979-1988. *Paukščiu žiedavimas Lietuvoje*. Vilnius.

Petryna A. 1976. *The autumn migration of Meadow Pipit on the Polish coast of the Baltic*. Not. Orn. XVII, 3-4: 51-74.

Pettersson H., Wahlin L.1975. *Kungsfågelns höststräck vid Enskär*. Fäglar i Sörmland 8, 1-2: 63-69.

Pettersson J., Haselquist D. 1985. *Fat deposition and migration capacity in Robins Erithacus rubecula and Goldcrests Regulus regulus at Ottenby, Sweden*. Ring. and Migr. 6: 66-76.

Saurola P. 1978. *Arvokkaat hippiäislöydöt*. Lintumies, 13: 121-126.

Vilbaste H., Leivits A., Leibak E. 1985. *Operatsiooni "Baltika" Eesti sektsiooni tööst 1985 aasta sügisel*. Loodusevaatlusi 1985, I: 19-33.

Vilbaste H., Leivits A., Leibak E.1984. *Operatsiooni "Baltika" Eesti sektsiooni tööst 1984 a. sügisel*. Loodusevaatlusi 1984, I: 100-114.

Zink G. 1973. *Der Zug Europäisher Singvögel. Ein Atlas der Wiederfunde beringter Vögel. Wintergoldhähnchen – Regulus regulus*. I/1973. Vogelvarte Radolfzell.