DIFFERENTIATION OF DIRECTIONAL PREFERENCES OF SOME NOCTURNAL MIGRANTS ON AUTUMN MIGRATION ACROSS THE CENTRAL AND EASTERN EUROPE

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ABSTRACT

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During migration, birds behave directionally, therefore, the aim of this work was to show differentiation of directional preferences of migrating Blackcap (*Sylvia atricapilla*) and the Robin (*Erithacus rubecula*), as common nocturnal migrants, and especially to find more information on the SE flyway. Birds were tested with a new field method (Busse 1995) that enables to study directional behaviour of nocturnal migrants also during daytime. Data collected in 1996-1998 at 3 ringing stations were used in the case of the Blackcap: Bukowo (Poland, Baltic coast) – N = 234, Mierzeja Wiślana (Poland, Baltic coast) – N = 60, and Makarovka (near Kazań, Tatarstan, Russia) – N = 23; data from 4 stations, and collected only during first half of September 1998, were used for evaluation of the Robin preferences: Bukowo – N = 46, Mierzeja Wiślana – N = 51, Akcja Wisła (central Poland) – N = 75 and Zvenigorod (near Moscow, Russia) – N = 83. Birds from all stations have shown differentiation of directional preferences. For the Blackcap at Mierzeja Wiślana and Makarovka ESE direction was predominant (respectively: 43% and 33% of tested birds). Robins from all stations have shown a very strong (over 30% of tested birds at each station) ESE and SSE directions (Black Sea, Caucasus). This is quite new as for Polish stations. By now, W and SW directions were thought to be dominant, as it was shown at the most western station (Bukowo): WSW – 36% (Blackcap) and 32% (Robin).

Testing nocturnal migrants for their directional preferences gives local distributions of headings. Short and accidental sampling gives only rough estimation of the local pattern of migration. Careful designing of sampling leads to more exact picture of directional preferences. Analysing the data from many stations is a valuable source of information about big-scale migration pattern.

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INTRODUCTION

During migration, birds behave directionally flying from breeding area toward winter-quarter. In diurnal migrants, it is quite simple to follow direction of movement by means of visual observations. Nocturnal migrants move in darkness, thus the studying their directionality is much more complicated. Visual observations using strong searchlights or in illuminated areas, *e.g.* in the vicinity of glasshouses (Svazas 1994) are biased very much, especially in bad weather conditions, as the light attracts migrating birds that change local direction of flight toward the illuminated places. Since papers by Kramer (1949) and Sauer (1957), orientation cages have been used to follow directional preferences of nocturnal migrants. Usually such experiments were used to studying mechanisms of orientation and not directional behaviour of birds at different localities on the migration route. As the techniques were rather inconvenient in application and not adapted to fieldwork, most of experiments were performed on caged birds and only a few in the field (Evans 1968, Petersen and Rabøl 1972, Rabøl 1985, Moore 1990, Ellegren and Wallin 1991). This did not allow to study more extensively behaviour of birds during real migration. A few years ago, a new technique of such studies was proposed (Busse 1995) that allows to collect quite numerous data. In this technique, a new cage design was used that allows easily to estimate distribution of bird headings and new idea – testing nocturnal migrants during daytime – was applied. The method was checked on numerous data collected for the Robin in central Poland (Nowakowski and Malecka 1999). Apart from a field check of the method, some theoretical problems arose while evaluating the data (Busse and Trocińska 1999). As a number of bird stations using the method had grown since the first attempts, some preliminary results should be published.

The aim of this paper is to show some results of the study of directional preferences of common nocturnal migrants – the Blackcap (*Sylvia atricapilla*) and the Robin (*Erithacus rubecula*) – performed in distant bird stations. Beside the spatial distribution of headings over wide territory of central and eastern Europe, some methodical problems with interpretation of the data will be discussed.

MATERIAL AND METHODS

The data were collected at several bird ringing stations collaborating within the SEEN (SE European Bird Migration Network). The data on the Blackcap were collected in years 1996-1998 at Bukowo/Kopań (54°28'N, 16°25'E – the Operation Baltic station, Baltic coast, Poland), Mierzeja Wiślana (54°21'N, 19°19'E – the Operation Baltic station, Baltic coast, Poland) and Makarovka (55°18'N, 49°15'E – Tatarstan, Russia). The data on the Robin were collected only during first half of September 1998 at Bukowo, Mierzeja Wiślana, Wisła (51°57'N, 21°16'E – „Akcja

Wisła", central Poland) and Zvenigorod (55°44'N, 35°51'E – Biological Station of the Moscow University, near Moscow, Russia). Numbers of studied birds are presented in the Table 1.

Table 1
Number of tests performed

Site	Year	*N*	Total site
Sylvia atricapilla			
Bukowo	1996	74	
	1997	130	
	1998	30	234
Mierzeja Wiślana	1996	38	
	1998	22	60
Makarovka	1998	23	23
TOTAL			317
Erithacus rubecula			
Bukowo	Sept. 1998	46	46
Mierzeja Wiślana	Sept. 1998	51	51
Wisła	Sept. 1998	75	75
Zvenigorod	Sept. 1998	83	83
TOTAL			209

The birds caught using mist-nets were ringed and measured at the station laboratory and then, as soon as possible, they were tested for directional behaviour at the orientation stand situated nearby the station. In the majority of cases, the birds passed the test within one hour after catching, sometimes one hour later. All tests were performed during daytime. The procedure was consistent with the standard description of the method as presented in the original methodical paper (Busse 1995). A tested bird was located in a flat cage with walls covered with a transparent plastic foil, on which the birds made dots and scratches by bill while trying to escape. The bird in the test cage was isolated by round opaque screen so that it could not see any surroundings except for the sky. The only difference from the standard description was the duration of the test – as a standard it was 10 min instead of 15 min proposed in the original description. The raw data were noted as a set of numbers, representing numbers of scratches made in eight sectors of the cage's wall during the test by a tested individual.

The raw data were elaborated using the ORIENTIN 3.0 software that bases on non-standard use of the circular statistics as described and discussed in detail by Busse and Trocińska (1999). This procedure accepts multimodal distributions of headings, both situated on a line (axial) and at different angles. This means that the raw distribution of scratches is not forced to show only one directional heading, as it is a case in classic calculations, but it can be described by two, or more, local vectors. For every local vector, its direction and length are calculated. The second peculiarity of the elaboration process is that, when describing headings of the group of birds, local vectors of individuals are not summed up to one result vector using circular statistics, but they are shown as summarised distribution by 6°-sectors and then presented as a radar graph. For example: lengths of two local vectors of two individuals that fall within one sector (*e.g.* for indiv. *A* the local vector is 181°, length 68 and for indiv. *B* – 184°, length 47) are summed up into heading index 115 for sector 181-186°, while local vectors that fall within different sectors are not summed, *e.g.* if for above example, direction of the *B* vector is 188°, in the distribution of heading indices for these two we will have 68 for the sector 181-186° and 47 for the sector 187-192°. In such method, there is not one resultant direction for the group of birds, but the distribution of heading indices. The third special feature applied to the presentation of headings is the reversal of the return headings by adding 180° to those that point at direction nonsensical for the autumn migration (pointing at the northern part of the wind-rose). This is based on a finding that many birds show axial behaviour in the cage (Busse and Trocińska 1999), while they really migrate in the southern directions in autumn. Therefore, presented heading distributions are that called „smoothed, reversed" in mentioned above paper. To make it easier, distributions of heading indices by 45°-sectors (WSW, SSW, SSE, ESE) are discussed in the paper.

All statistical comparisons are performed using chi-square test, values of χ^2 are used for rough estimation of the size of distribution differentiation. Standardised squared deviation: $(x_i - x_o)$ ^ $2/x_o$ – a part of χ^2 calculations – is used to find the greatest deviations of observed distributions from the expected ones.

RESULTS AND DISCUSSION

The Blackcap

Distributions of heading indices of Blackcaps tested at different bird stations are differentiated very much (Fig. 1) – in all combinations of the stations, differences are significant at the level much above 0.001 ($p \ll 0.001$). The distributions located on the map (Fig. 2) show a heading pattern that is quite different from that, which is known from ringing recoveries. Scandinavian Blackcaps, as it is suggested by maps in Zink's atlas (Zink 1973), migrate toward Cyprus and Lebanon, and on the Polish Baltic coast, no Blackcaps heading to southwestern Europe were shown. However, a number of recoveries from last years (Busse 2000), when ringing in central Europe was being developed, confirm results from the tests performed at Bukowo station (36% of headings to WSW and next 24% to SSW). This suggests that more Blackcaps migrate using western migration route than it was thought earlier. Simul-

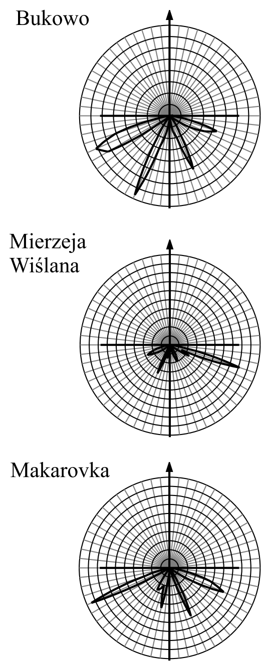

Fig. 1. Total distributions of headings of Blackcaps (*S. atricapilla*) tested at three ringing stations.

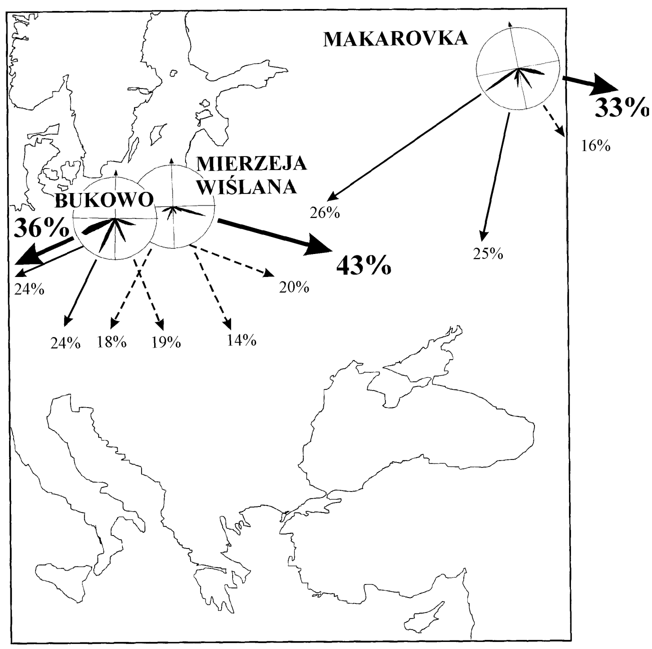

Fig. 2. The Blackcap headings distributions located at an appropriate positions on the map of eastern Europe. Percent shares of four main sectors are given.

taneously, headings to ESE dominate at Mierzeja Wiślana (43%) and at Makarovka (33%). Such statements, however, needs expanding studies for wide territories of Russia and Ukraine, where up to now, ringing has not been developed enough.

Local patterns of headings used at above pictures are derived from preliminary data collected in not very regular studies. Tests were performed in different years (Table 1) and in different parts of the migration season (see p. 121). Particularly data from Makarovka were collected in a very short period of early stage of migration season. This fact obliges to a careful treatment of presented pattern. The most numerous data were collected at Bukowo station in 1997 and they cover the whole of autumn migration season. As it was already suggested in the first paper presenting the field method (Busse 1995), the heading patterns in different parts of the season could be various. So, let us look how much the part of the season influences the heading patterns.

The radar graphs presented at Figure 3 show that the heading patterns in subsequent parts of the season are much differentiated. After chi-square test, differences are statistically highly significant – $p \ll 0.001$ – both when comparing whole distribu-

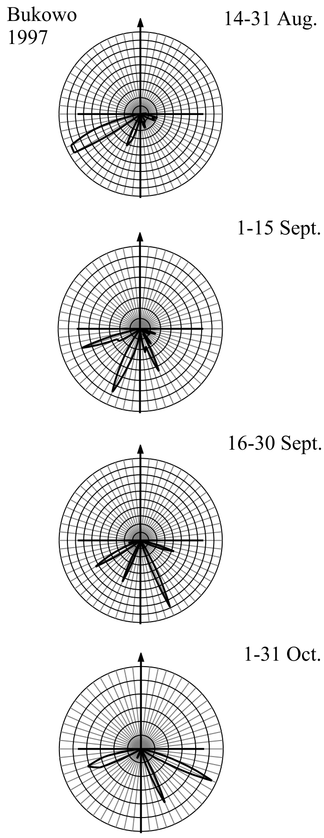

Fig. 3. Distributions of headings of Blackcaps tested in different parts of the migration season at Bukowo in 1997.

tion and any pair of periods (Table 2). Table 3 points the systematic change of dominating headings in the course of the season. Dominance is defined here as a percent input of the directional class into χ^2 value within the period. The higher is standardised squared deviation for the directional sector the higher is difference between the observed and the expected frequency, when the random distribution is assumed. In August, dominance of WSW sector is 48.5%, in the first half of September, SSW – 46.1%, while in the second half of September it reaches 66.6% (SSE) and in October 68.2% (ESE). Thus, the time-dependent bias could be expected if the caught birds are not sampled randomly. Oversampling in some periods of migration season can bias result pattern with overestimation of directions dominating in these terms. In 1997, sampling in subsequent periods was not the same – 57.0, 23.4, 18.4 and 32.3% of birds caught were tested (Fig. 4). Subsequently, it could be expected an overestimation of WSW direction (dominating in August) and underestimation of SSE headings (dominating in second half of September when much lower percentage of caught birds was tested). Thus, it seems that careful sampling strategies should be applied if more subtle differences are expected (*e.g.* between stations located not far away). Short and differentiated periods of work, and accidental testing will give only rough estimations of heading patterns.

Table 2
Observed and expected heading indices of Blackcaps tested in subsequent periods

Period 1997	Ringed	Tested	Heading indices				
			WSW	SSW	SSE	ESE	Total
Observed:							
14-31 Aug.	128	73	2623	850	558	609	4640
1-15 Sept.	141	33	579	767	550	162	2058
16-30 Sept.	76	14	278	138	269	146	831
1-30 Oct.	31	10	255	19	140	249	663
Total	376	130	3735	1774	1517	1166	8192
Expected:							
14-31 Aug.			215.5	1004.8	859.2	660.4	
1-15 Sept.			938.3	445.7	381.1	292.9	
16-30 Sept.			378.9	179.9	153.9	118.3	
1-30 Oct.			302.3	143.6	122.8	94.4	

Table 3
Dominance of Blackcaps headings in different directions in subsequent periods. Sign - observed deviation direction; bold - dominating heading

Period 1997	Heading indices/deviation from expected*				Chi-square value	Dominance %
	WSW	SSW	SSE	ESE		
14-31 Aug.	**2623** **121.7** ++	*850* *23.8* –	*558* *105.6* – –	*609* *4.0* –	251.1	WSW **48.5**
1-15 Sept.	*579* *137.6* – –	**767** **231.7** ++	550 74.8 +	*162* *58.5* –	502.6	**SSW** **46.1**
16-30 Sept.	*278* *26.9* –	*138* *9.8* –	**269** **86.1** ++	146 6.5 +	129.3	SSE **66.6**
1-30 Oct.	*255* *7.4* –	*19* *108.1* – –	140 2.4 +	**249** **253.4** ++	371.3	ESE **68.2**

* standardised squared deviation

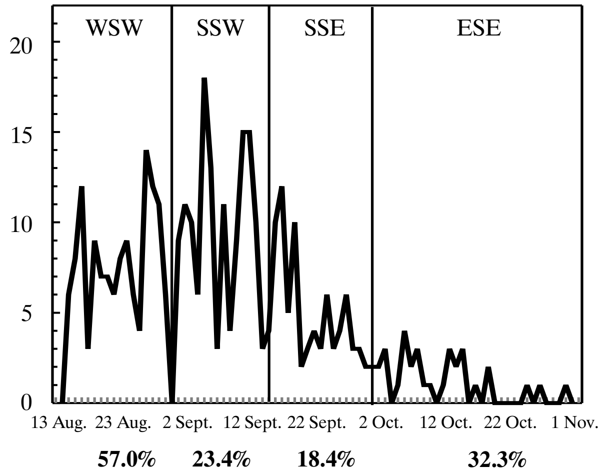

Fig. 4. Migration dynamics (catching results) of the Blackcap at Bukowo in 1997. Headings dominating in subsequent periods are given at the upper part of the graph. Below the graph percentages of tested individuals in relation to that caught are listed.

The Robin

Following the above discussed rules of fieldwork, Robins were tested at four stations in the same time that covered term of the first wave of Robins migrating in autumn 1998 (Fig. 5). Obtained distributions of headings are different significantly – $p \ll 0.001$ – in any relation (Fig. 6, Table 4). The most similar are distributions for Robins migrating through Zvenigorod and Mierzeja Wiślana (χ^2-value 198.2),

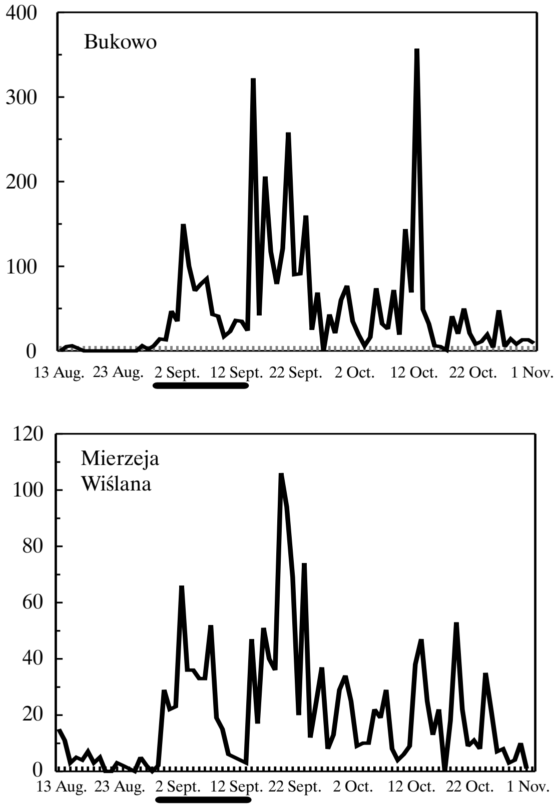

Fig. 5. Migration dynamics of the Robin (*E. rubecula*) at the Polish Baltic coast stations in 1998. Thick line – the period when Robins were tested.

where SSE direction dominates very much. Zvenigorod is the most different from Bukowo (χ^2-value 1489.8). At Bukowo and Wisła, there is a high share of headings more to the east (ESE), while at Bukowo, WSW headings are well represented, too.

Table 4
Values of chi-square when comparing distributions of headings at ringing stations ($df = 3$, $p \lll 0.001$ in all cases)

	Bukowo	Mierzeja	Wisła
Mierzeja	**817.7**		
Wisła	**1111.3**	**269.1**	
Zvenigorod	**1489.8**	**198.2**	**405.3**

The draft pattern of the Robin migration directions in central and eastern Europe based on presented material (Fig. 7) looks very different from what could be expected after studying the map of ringing recoveries from Robins ringed during migration on the Polish Baltic coast (Fig. 8). It is understandable, if we take into

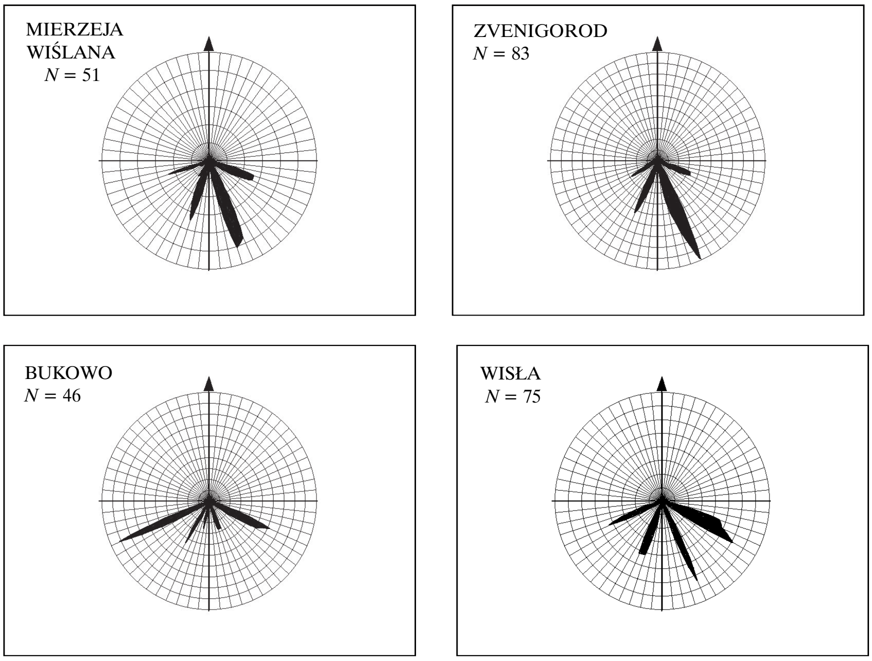

Fig. 6. Distributions of headings of Robins tested at four stations in the first half of Sept. 1998.

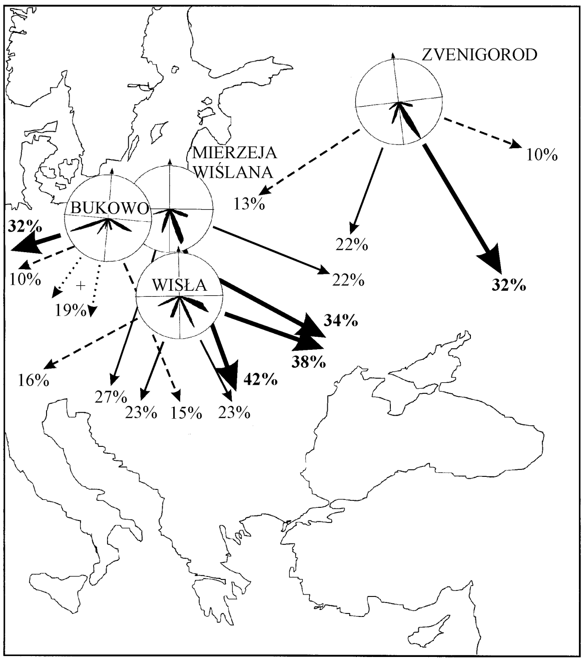

Fig. 7. The Robin headings distributions located at an appropriate positions on the map of eastern Europe. Percent shares of four main sectors are given.

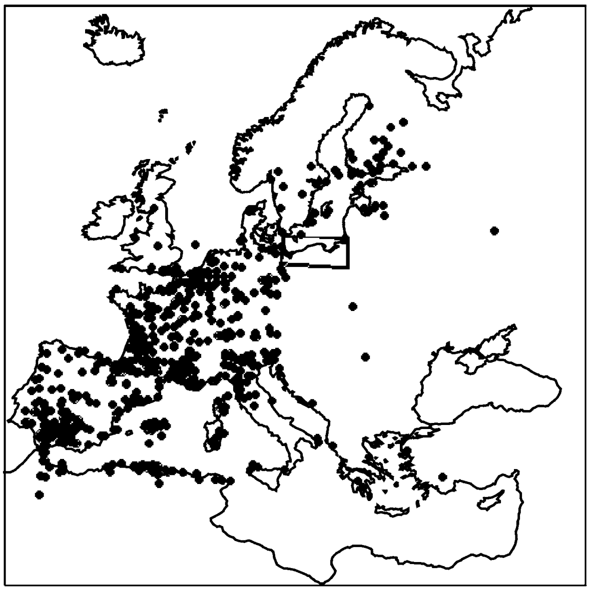

Fig. 8. Ringing recoveries of Robins ringed at the Operation Baltic stations 1961-1997. After Remisiewicz *et al*. 1997.

consideration the fact that the number of ringing recoveries received from the area depends not only on how much ringed birds migrate to an area in question, but, even more, on constraints defined by human population density and its social and cultural traditions. This problem was skipped in the past, later on – extensively discussed in some papers (Busse and Kania 1977, Busse 1981, Kania and Busse 1987, and elsewhere), but still underestimated in opinions of researches studying bird migration. The fundamental statement that must be remembered when analysing recovery maps is: „lack of recoveries does not mean lack of birds in the area". One of the areas with very low detectability of ringed birds is southeastern and eastern Europe. Thus, only intensive studies within this area, with testing birds for their directional preferences, could give information on migration patterns of nocturnal migrants.

CONCLUSIONS

1. Testing nocturnal migrants on their directional preferences gives local distributions of headings. Short and accidental sampling gives only rough estimation of the local pattern of migration.
2. Careful designing of sampling leads to more exact picture of directional preferences.
3. Analysing data from many stations is a valuable source of information about large-scale migration pattern.

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