METHODS

NEW TECHNIQUE OF A FIELD STUDY OF DIRECTIONAL PREFERENCES OF NIGHT PASSERINE MIGRANTS

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ABSTRACT

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Proposed new method to study directional preferences of the night migrants comprises a new field technique and puts special attention to inconsistency of directional behaviour pattern of an individual bird. The advantages of the field technique allows to use it in real field conditions both by professionalists and amateurs: the equipment is simple and cheap, the technique is very easy to learn in a standardised form, the experiment routine allows to collect really big amount of data as tests can be performed both in the night and day, diurnal tests in a full overcast have the same value as in good sky visibility, what is not a case in the night. Analysing local vectors in a directional behaviour patterns seems to be useful in the studies on local migratory directions and population composition of migrants.

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INTRODUCTION

As night migrants travel in darkness, field studies on their directional preferences are more complicated than of diurnal migrants, which can be directly observed during a passage. In radar studies in most cases separate species cannot be precisely identified and observed migration patterns can contain various species of similar size and flight characteristics, but migrating differently as to the origin and/or destination. Other methods of direct observations of the night migration are not efficient ("moon-watching") or, if they use artificial light such as a ceilometer or observations are made in strongly illuminated places (e.g. greenhouses – Svazas 1993) directionality of the passage can be much disturbed by attracting of flying birds from a wide area around. In few cases (e.g. Evans 1968, Petersen and Rabøl 1972, Rabøl 1985, Moore 1990, Ellegren and Wallin 1991) researchers used in a field a technique developed to study orientation and navigation abilities of birds – orientation cage experiments. In early Kramer's (Kramer 1949) and Sauer's (Sauer 1957) orientation experiments special cages with perches and complicated electric, then electronic counting devices were used. Most experiments were made in laboratory or quasi-laboratory conditions on caged birds and only a few studies were used in true field conditions using freshly caught birds (Evans 1968). New, simpler technique was introduced by Emlen and Emlen (1966) and then modified and commonly used in orientation experiments. Instead of complicated cages with perches and counting devices a conic cage was proposed (Fig. 1). The bird has a little space to stay at the bottom of the cage and when it would like to escape from the cage it must jump against conic wall and consequently fall down the wall to a starting position. At the beginning of the use of this method the bottom of the cage was a wet ink-pad while wall was covered with a white paper.

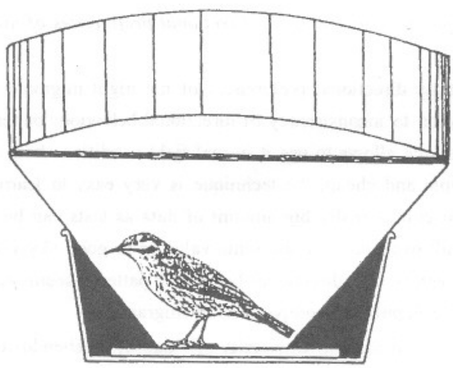


Fig. 1. Emlen's orientation cage (after Munro and Wiltschko 1992).

Footprints of the bird falling down after jumping were counted and created source data for further description of directional behaviour of the bird. Next modification – covering wall of the cage with correction paper and counting scratches of birds claws is in standard use now (e.g. Beck and Wiltschko 1981, Rabøl 1985, Hilgerloh 1989, Munro and Wiltschko 1989) as it avoids damaging of birds plumage by the ink from the ink-pad.

This technique can be more easily used in a field work and now practically all field cage experiments use Emlen's cages. The cage experiments met some criticism (e.g. Gerrard 1981) mainly because the bird is stressed by unusual situation and would like simply to escape rather than "migrate". In response to such objections birds were caged some time before experiments with intention to make the bird accustomed to a cage (Rabøl 1985, Ellengren and Wallin 1991). This caused that even birds caught at migration were disturbed in migration behaviour as they were forced to stop instead to continue normal migration.

The stress reactions of individuals have not been studied yet but there were suggestions that the bird in specially stressing situation can change its directional behaviour (Busse 1992). However, despite these problems cage experiments seem to be a good tool to study directional behaviour in the field, especially when stress of the experimental birds will be reduced as much as possible. Even if Emlen's technique is improved, it is man-power expensive as counting of scratches on the correction paper is a very time consuming and tiring procedure. This disadvantage remarkably limits possibilities of using this method in most bird stations manned by amateurs (not too many amateurs would like to sit down for many hours counting hardly visible scratches on the correction paper). Now it is the method mainly for professional teams being paid for the research.

BASICS OF THE NEW TECHNIQUE

Disadvantage mentioned earlier forced people from a few Baltic bird stations to look for a method not worse as to its usefulness, but simpler – more bird and user friendly. Some ideas were born during a Workshop of the SE Baltic Migration Network group held in Raunda, Latvia in November 1994. The first idea was that the birds behave directionally in a normal cage, with a flat bottom. Thus, it is not necessary to force them to jump against sloped wall and fall down many times – this must stress the bird much more than the fact of being caged. In 1995 during spring work at Przebendowo and Hel Operation Baltic stations a new design of the experiment cage was tested and during autumn work of the stations the experiment routine was standardised.

The new cage is designed as on Figure 2 and the whole construction and experimental routine is given in an Appendix. The cage is a flat cylinder made of two wire circles connected by 8 vertical wires dividing side wall into eight identical sectors. The top of the cylinder is covered with nylon netting. Side wall of the cage is covered for an experiment with ultra thin uncoloured, transparent foil of a kind used for food product protection in the refrigerators. The cage is located horizontally on a ground covered with linen or other material of a neutral colour allowing the bird to walk freely. The cage is placed in the center of an open cylinder made of uniformly coloured and nontransparent plastic. Whole construction must be localised in a such a place where the outside cylinder wall can prevent the bird from seeing any landmarks, trees, wires etc. So, the bird can only see a wide angle of open sky. Outside of protecting wall the North must be fixed direction by a pole not visible to the bird. One of vertical wires of the experimental cage is situated against this pole during the

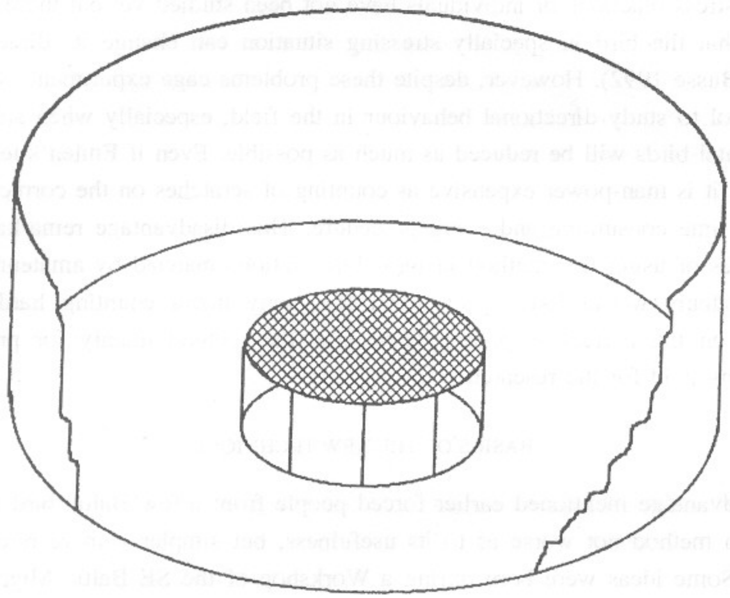


Fig. 2. New experimental stand. For dimensions see Appendix.

experiment. In the experimental cage the bird walks, runs or jumps against transparent foil wall. A bird's bill make signs on the foil or even holes as do claws when it jumps against the wall. The standard exposition time is 15 minutes. In that time the bird make up to four-five hundred (around 250 in average) holes, dots or scratches. Counting these signs in sectors with tipping counted ones with a pointed marker takes a few minutes per test. Good light conditions are needed for easy work. Counting must be done from the foil being stretched on the experimental cage – no storage of used foil as documents is possible. After the count foil is removed and replaced by a new one for the next experiment. For continuous work at one stand a few experimental cages are necessary.

Apart from different type design of the experimental cage the new technique contains important methodological novelty in the study of night migrants directional preferences – the experiments can be carried out both at night and day time. Daytime experiments were used for evaluation of directional preferences of diurnal migrants only (e.g. Munro, Wiltschko and Ford 1993). Observing birds at field stations during migration period suggested that at least in peak days night migrants move directionally during daytime. Checking this impression by carrying experiments during daytime confirmed it, even to wider extent than expected (see below) – the birds behave clearly directionally. This statement dramatically changes possibilities to use the technique for field testing of night migrants. Using this procedure of the day-time experiments allow to check much more birds than it is possible during night tests. Additionally classic night tests require handling the birds caught in the morning or during daytime in cages, which is connected with necessity to feed them and it also causes long lasting caging stress.

In the new technique practically one person can handle four birds per hour using one set of one screening wall and four experimental cages. This change in amount of data gives wide possibilities to study individual variation in directional preferences. That is especially important at stations situated at crossing of migration routes as it is common in the Baltic and the North Sea areas.

TESTING THE TECHNIQUE

Material

Testing of the new technique was carried out in spring 1995 at Przebendowo (few kilometres from the Baltic coast NW of Gdańsk) and Hel Operation Baltic station (narrow peninsula on the Gdańsk Bay) as well as in autumn 1995 at Bukowo-Kopań station located at the sea coast near Koszalin. At Przebendowo testing place was situated at the top of a naked hill a little bit dominating above surrounding fields. At Hel experiments were carried out at sea shore dunes and at Bukowo-Kopań on flat meadow a few hundred meters from the coastal dunes covered by a forest where bird catching area was situated. In all places the birds in the experimental cage could not see any landmarks.

Altogether 356 experiments were made (Table 1). Few individuals were tested several times in turn. The birds were tested according to developed standard procedure (see Appendix). Some experiments were made at night (about one hour after sunset) and most of them during daytime.

Evaluation of data

The main problem to solve by the means of the elaborated technique was to look at the possible differentiation inside of directional behaviour pattern of the individual, i.e. possibility of different directional choices instead of one assumed direction.

This was the result of earlier suggestion that an individual bird is able to choose different directions of migration because of different inherited directional programs (Busse 1992).

Table 1

Number of experiments

	Spring		Autumn	Total
	Przebendowo	Hel	Bukowo	
Certhia familiaris	0	0	1	1
Erithacus rubecula	17	7	122	146
Ficedula hypoleuca	0	2	3	5
Ficedula parva	0	0	1	1
Fringilla coelebs	0	0	2	2
Muscicapa striata	0	0	11	11
Parus caeruleus	0	0	3	3
Parus major	0	0	1	1
Parus montanus	0	0	1	1
Phoenicurus phoenicurus	0	6	47	53
Phylloscopus collybita	0	0	6	6
Phylloscopus sibilatrix	0	0	1	1
Phylloscopus trochilus	0	0	6	6
Prunella modularis	0	1	1	2
Regulus regulus	0	0	20	20
Sylvia atricapilla	0	0	34	34
Sylvia borin	0	0	12	12
Sylvia communis	0	0	5	5
Sylvia curruca	1	0	8	9
Troglodytes troglodytes	0	0	2	2
Turdus iliacus	0	0	4	4
Turdus philomelos	1	0	30	31
Total	19	16	321	356

The assumption that the birds' directional behaviour in the orientation cage is the result of preference of one direction of migration is the logical basis for the standard treatment of the cage pattern data. In the papers on the topic (e.g. Viehmann 1982, Helbig 1991a) numbers of directional movement signs (hoping to the perch, footprints, scratches) are treated as vectors, which are summed up altogether to find one preferred direction described by the angle (azimuth) and the vector length treated as a measure of directive tendency. Consequently, it means that all other direction vectors other than the biggest one are treated as an "information noise" or a sign of a "nonsense" hopping of disoriented individual. In some cases the authors (e.g. Rabøl 1985, Helbig 1991a, 1991b, 1992) found, however, the cases of so clearly demonstrated bidirection distribution that they used a special procedure called "doubling the angles" (Batchelet 1981) to dump this strange situations and press them into the assumed model of one direction behaviour. Following this thinking leads to unification of evaluation procedures, but simultaneously to losing some of information, which might be important in the studies on local directional preferences during passage through different field stations.

Because of the problem we would like to solve therefore evaluation of the raw data was done with the procedure looking for signs of inconsistencies with unimodal model of directional behaviour. In the first stage it was checked if the distribution of raw data is significantly different from the uniform circular distribution. Results of these experiments (88-96 per cent of all results) were included. After recalculation to a per cent distribution raw data were presented at the raw data graphs (see Fig. 3, left side). Then local vectors were calculated by adding as vectors data from three sectors including local peaks in the data set, e.g. in a set: 8, **12**, 5, 1, 5, 20, **34**, 16 per cent, two local vectors taking **12** and **34** as a central sectors were calculated and presented as pointers at Figure 3 (this example bird is shown at Fig. 3C). The results of the classic summing up of vectors are given at Figure 3 (black dots) for the comparison. The aim of this paper is not, however, to discuss peculiarities of different methods of data treatment and therefore the problem of various methods of data evaluations based on different assumed models of bird's behaviour will be discussed in a separate paper.

Figure 3 shows examples of different local vector patterns and Table 2 contains distribution of these types in experiments done on different species. The table demonstrates clearly that bimodal behaviour is the most common in all species except Lesser Whitethroat (*Sylvia curruca*) – but note low number of experiments with this species. Threemodal distributions are equally frequent as unimodal ones. As an example only, types of local vector patterns in Song Thrush (*Turdus philomelos*) are presented at Figure 4.

Table 2

Number of local directions chosen by controlled individuals

	Number of directions					N
	0	1	2	3	4	
E. rubecula	0	29	64	25	4	122
Ph. phoenicurus	1	8	28	9	1	47
R. regulus	0	6	10	4	0	20
S. borin	1	3	5	3	0	12
S. curruca	0	3	2	3	0	8
S. atricapilla	0	6	23	5	0	34
T. philomelos	0	5	15	10	0	30
Total	2	60	147	59	5	273

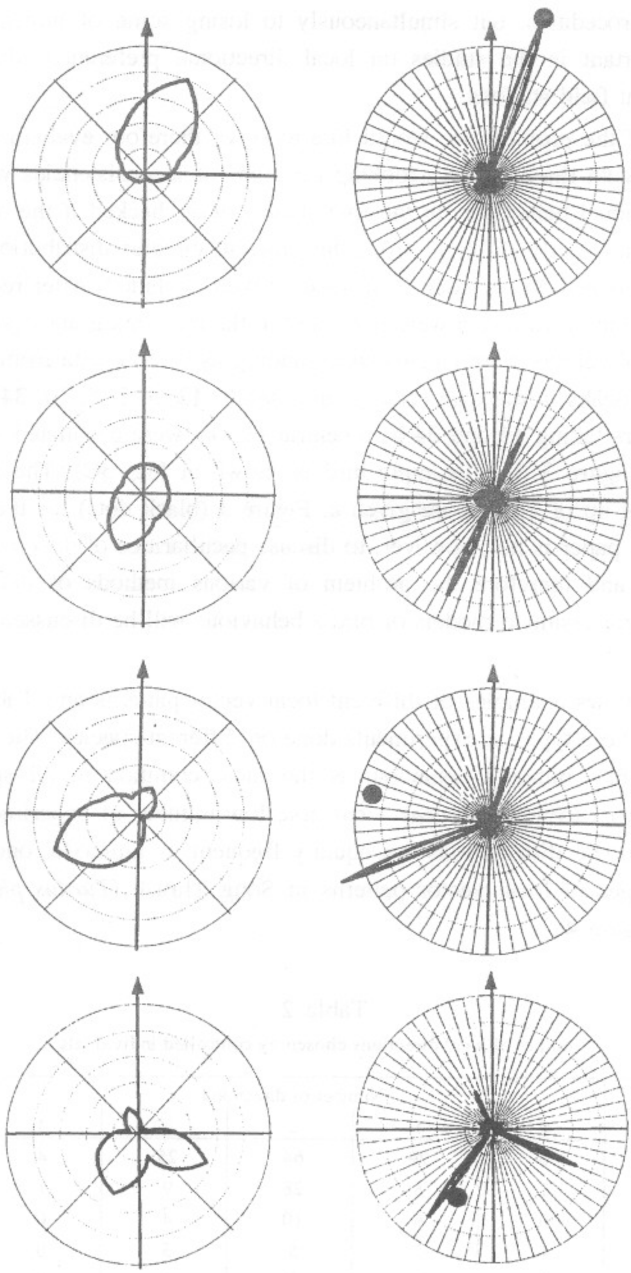


Fig. 3. Examples of directional behaviour of tested birds. Left side – distributions of raw data, expressed in percents of all counted marks; right side – local vectors (pointers) and total vector (dot). All raw data distributions significantly ($p < 0.01$) different from random.

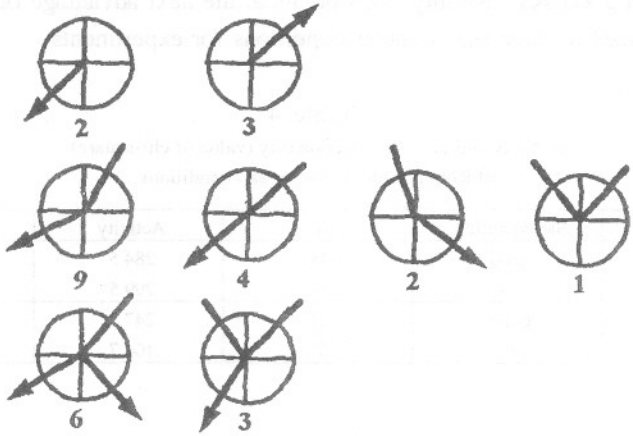


Fig. 4. Different types of local vectors patterns in the Song Thrush tests. Numbers of tests are given.

Comparison of day and night experiments

There is a very important question as to applicability of the described experimental routine to test night migrants during the daytime. As it was mentioned earlier, pilot experiments were carried out both at night and daytime. Table 3 contains example of the comparison between day and night results in the tests of the Robin (*Erithacus rubecula*). During the day activity is significantly higher than in the night, directionality as measured by chi-square calculated deviations from the uniform distribution, seems to be higher (but not significantly at the level of 0.05) as does percentage of birds showing directionality at level $p < 0.01$. Distributions of local vector patterns are not significantly different ($p = 0.40$).

Table 3

Comparison of a day and night experiments with Robins

	N	Activity	Chi-square	$p < 0.01$ %	No of directions			
					1	2	3	4
Day	87	283.3	220	96.5	20.7	55.2	21.8	2.3
Night	35	166.9	174	88.6	31.4	45.7	17.1	5.7

Table 4 gives some more information on the topic. In full overcast in the night both activity and directionality drop dramatically, what is not a case during daytime experiments. At days both activity and directionality are not significantly different from days with good sky visibility. This points at the next advantage of the technique – there is no need to have fine weather conditions for experiments.

Table 4

Activity and level of directionality (value of chi-square) of Robins under different sky conditions

	Sky visibility	*N*	Activity	Chi-square
Day	good	38	284.5	242
	no	31	299.5	191
Night	good	12	247.2	248
	no	7	104.7	74

Resulted directional patterns

As the examples of the resulted directional patterns obtained by means of described field technique and evaluation methods Figures 5-7 are presented. There are all local vectors of all individuals summed up. It should be mentioned that distributions obtained by summing up only the longest vectors for every individual give exactly the same picture. There can be found different patterns between species (Fig. 5), between seasons within the same species (Fig. 6 – but note that these patterns were obtained in different localities) and the periods of migration in the same season (Fig. 7). In the last case, the Song Thrush migration, the patterns shown here fit the hypotheses published earlier and based on ringing recoveries and measurements (Busse and Maksalon 1978, 1986; Busse 1988).

CONCLUSIONS

1. A new method to study directional preferences of the night migrants comprises a new field technique and a special consideration to inconsistency of directional behaviour pattern of an individual bird.
2. The advantages of the field technique allow to use it in real field circumstances both by professionalists and amateurs:

- the equipment is simple and cheap,
- the technique is very easy to learn in a standardised form,
- the experiment routine allows to collect really big amount of data, as tests can be performed both in the night and day,

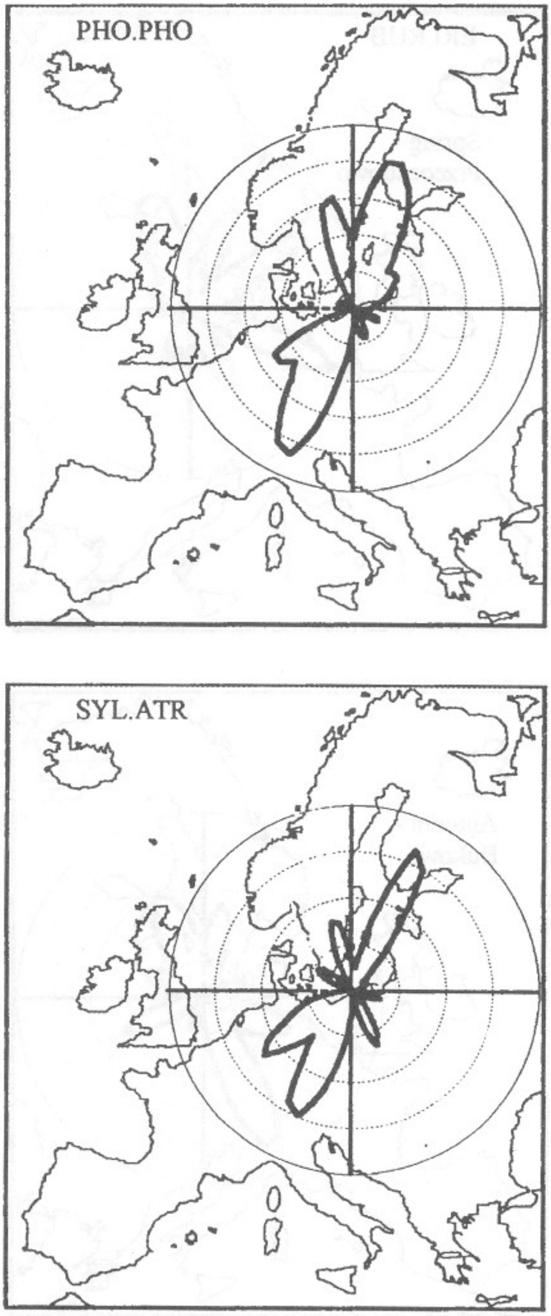


Fig. 5. Local vectors distribution for Bukowo-Kopań, autumn 1995 samples of the Redstart (PHO.PHO) and Blackcap (SYL.ATR).

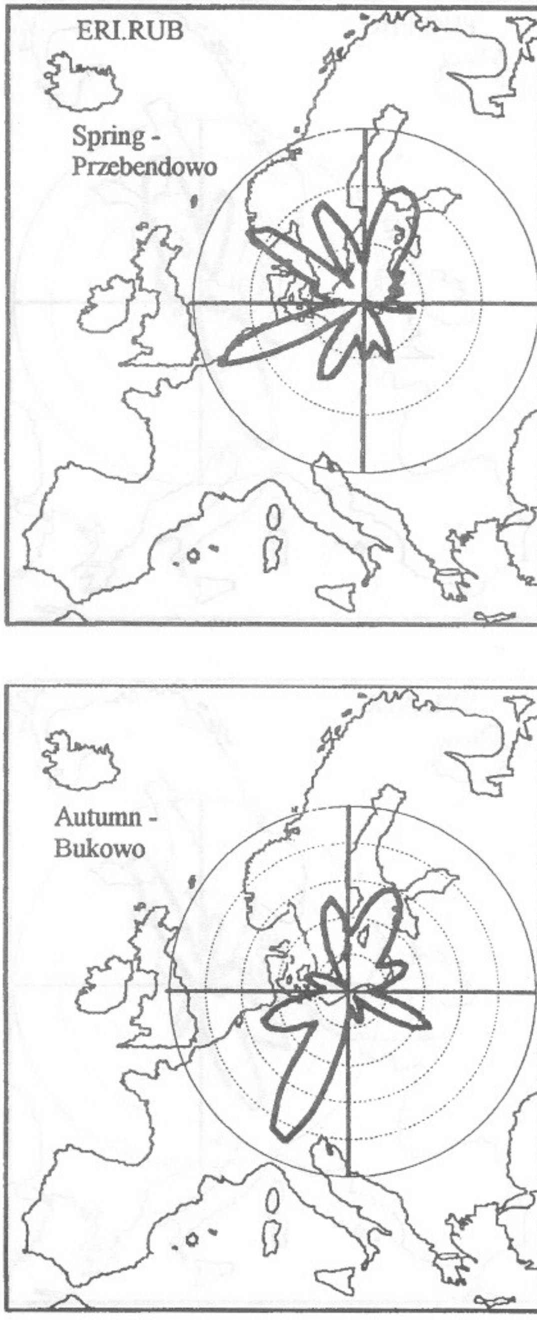
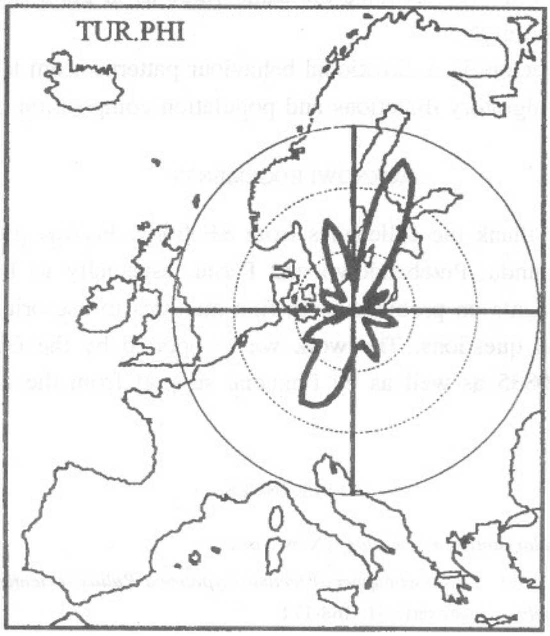
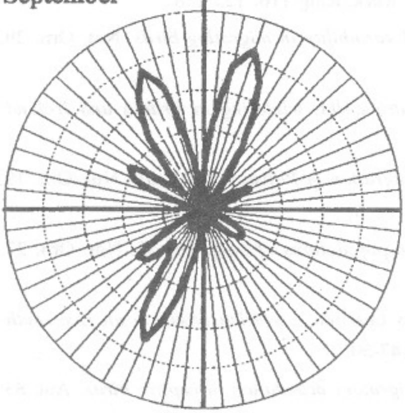


Fig. 6. Local vectors distributions for the Robin – Przebendowo, spring 1995 and Bukowo-Kopań, autumn 1995.



September



October

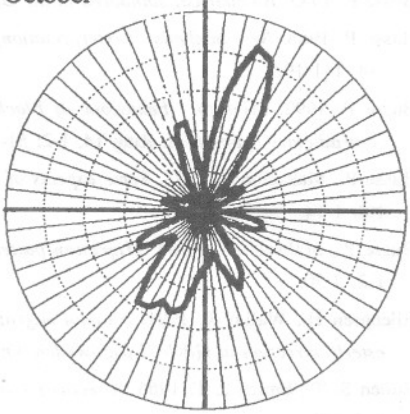


Fig. 7. Local vectors in the sample of the Song Thrush, Bukowo-Kopań 1995: total distribution and the distributions for September and October caught birds.

– diurnal tests in a full overcast have the same value as in good sky visibility, what is not a case in the night.

3. Analysing local vectors in a directional behaviour patterns seem to be useful in the studies on local migratory directions and population composition of migrants.

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REFERENCES

Batschelet E. 1981. *Circular statistics in biology.* New York.

Beck W., Wiltschko W. 1981. *Trauerschnäpper (Ficedula hypoleuca Pallas) orientieren sich nicht-visuel mit Hilfe des Magnetfelds.* Vogelwarte 31: 168-174.

Busse P. 1970. *Measurements of weight and fatness in migrating populations of birds.* Not. Orn. 11, 1-4: 1-15.

Busse P. 1983. *Biometrical standards in the Operation Baltic work.* Ring 116: 125-138.

Busse P. 1988. *New methods of interpretation of biometrical variability in migrating birds.* Not. Orn. 29, 3-4: 151-192.

Busse P. 1992. *Migratory behaviour of Blackcaps (Sylvia atricapilla) wintering in Britain and Ireland: contradictory hypotheses.* Ring 14, 1-2: 51-75.

Busse P., Maksalon L. 1978. *Some aspects of Song Thrush migration at Polish Baltic coast.* Not. Orn. 19, 1-4: 1-14.

Busse P., Maksalon L. 1986. *Migration pattern of European populations of Song Thrush.* Not. Orn. 27, 1-2: 3-30.

Ellengren H., Wallin K. 1991. *Autumn migrating Bluethroats Luscinia s. svecica orient in an east-southesterly direction at Gävle, East Sweden.* Ornis Svecica 1: 47-50.

Emlen S. T., Emlen J. T. 1966. *A technique for recording migratory orientation of captive birds.* Auk 83: 361-367.

Evans P.R. 1968. *Reorientation of passerine night migrants after displacement by the wind.* Brit. Birds 61: 281-303.

Gerrard E. C. 1981. *Instinctive navigation of birds. Broadford.*

Helbig A. J. *1991a. Inheritance of migratory direction in a bird species: a cross-breeding experiment with SE- and SW-migrating Blackcaps (Sylvia atricapilla).* Behav. Ecol. Sociobiol. 28: 9-12.

Helbig A. J. 1991b. *Experimental and analytical techniques used in bird orientation research.* In: Berthold P. (ed.) *Orientation in Birds.* Basel.

Helbig A. J. 1992a. *Onthogenetic stability of inherited migratory directions in a nocturnal bird migrant: comparison between the first and second year of life.* Ethology, Ecology and Evolution 4: 375-388.

Helbig A. J. 1992b. *Population differentiation of migratory directions in birds: comparison between ringing results and orientation behaviour of hand-raised migrants.* Oecologia 90: 483-488.

Hilgerloh G. 1989. *Orientation of Trans-Saharan Passerine Migrants in Southwestern Spain.* Auk 106, 3: 501-502.

Kaiser A. 1993. *A new multi-category classification of subcutaneous fat deposits of songbirds.* J. Field Ornithol. 64, 2: 246-255.

Kramer G. 1949. *Uber Richtungstendenzen bei der nächtlichem Zugunruhe gekäftiger Vögel.* In: *Ornithologie als Biologische Wissenschaft.* Heidelberg.

Moore F. R. 1990. *Evidence of Redetermination of Migratory Direction Following Wind Displacement.* Auk 107, 2: 425-428.

Munro U., Wiltschko W. 1992. *Orientation studies on Yellow-faced Honeyeaters Lichenostomus chrysops (Meliphagidae) during Autumn Migration.* Emu 92: 181-184.

Munro U., Wiltschko W., Ford N. S. W. 1993. *Changes in the Migratory Direction of Yellow-faced Honeyeaters Lichenostomus chrysops (Meliphagidae) during Autumn Migration.* Emu 93: 59-62.

Petersen F. D., Rabøl J. 1972. *Comparison of the Overcast and Starry Sky Orientation in Nightmigrating Passerines.* Dansk Orn. Foren. Tidsskr. 66: 113-122.

Rabøl J. 1985. *The orientation of vagrant passerines on the Faroe Islands, September 1984.* Dansk Orn. Foren. Tidsskr. 79: 133-140.

Sauer E. G. F. 1957. *Die Sternorientierung nächlih zeihender Grasmücken (Sylvia atricapilla, borin und curruca).* Zeit. Tierpsychol. 14: 29-70.

Svazas S. 1993. *The pattern of diurnal and nocturnal migratory activity of autumnal bird migrants in the inland part of Lithuania.* Ring 16, 1-2: 48-54.

Viehmann W. 1982. *Interrelation of Magnetic Compass, Star Orientation, and the Sun in the Orientierung of Blackcaps and Robins.* In: Papi F. and Wallraff H. G. (eds.) *Avian Navigation.* Berlin-Heidelberg-New York.

APPENDIX

STANDARD DESCRIPTION OF THE FIELD METHOD TO STUDY DIRECTIONAL PREFERENCES OF BIRDS

The equipment (see Fig. 2 in the text)

1. Circular, untransparent, uniformly coloured screen protecting the bird in an experimental cage against visibility of any landmarks, trees, wires etc. Its diameter is 110 cm and height 40 cm.

2. Experimental cage – a cylinder cage made of two wire circles connected by eight vertical wires distributed evenly. These define sectors used when counting results. Diameter of the cage: 36 cm, height – 10 or 12 cm; the higher cages are used for testing thrushes, but using them for smaller birds is allowed as differences between results obtained in these two heights were not found. The top surface of the cage is covered with nylon netting of 10 mm mesh. Side wall is covered with a stripe of ultra thin plastic foil of a kind used for protecting food in refrigerators (sold in rolls).

3. Piece of linen to cover smooth ground or not too slimy plate of neutral colour as a bottom surface under experiment cage.

4. Forms for noting the collected data.

5. Pointed colour marker.

The experiment stand

The place of experiments should be a flat area, top of a hill etc., without trees, wires, poles, which can be visible for the bird above the protecting screen.

The experimental routine

Tests can be done at any time, both at night and day. The weather limitation in experiments is a rainfall or snow as well as wet fog with a moist condensing on a foil at experiment cage. When strong wind (> 5°B) experiments are not recommended. Caught birds can be tested just after catching and ringing or handled in not transparent bags or cages normally up to two hours.

1. Preparing the cage for the experiment includes covering its vertical side wall with a stripe of a foil from a roll of width adequate to the height of the cage (around 2 cm wider): fixing the beginning of the stripe to one of vertical wires of the cage by

means of pieces of transparent tape, then covering side of the cage with stretched foil fixing its end to the same wire where it began; cutting the stripe off the roll after fixing the end. The foil should be handled carefully to avoid making scratches, holes etc. which could be then counted as a signs of the bird's activity. The cage could be prepared in advance, but longer storage of prepared cages in a moist air is not recommended as this could cause coming off the tape used to fix the foil.

2. Locate the experiment cage in the center of the protecting screen with one of wires directed to the North pointed out by previously fixed pole outside of the screen (not visible to the bird). It is handy always to direct to the North the wire where the foil stripe is fixed; this protects against wrong identification of sectors when noting the results.

3. Transport the bird to the experimental stand in not transparent bag or cage, then remove it and put under the experimental cage inside the screen protecting against visibility of landmarks. Direction of putting the bird into the cage seems not to influence the results, but the custom of putting it from one side (e.g. always the South) could be a rule. After putting the bird in the observer should quickly go away, note the time (exactness 1 minute) and after decided experiment time come quickly back and free the bird by quick removing of the cage. If the bird is intended to be used for next sessions one must catch it by hand (what is not too easy and many of them escape; few extra holes in a foil can be obtained). During experiment time the bird should neither be disturbed by sudden noises nor see anything else besides the sky. When bigger birds i.e. thrushes are tested the cage should be fixed to the ground as they can move the cage when hopping.

4. After the end of the test the results of the experiment should be counted. Longer storage of used cages is not recommended because of a danger of comming off or accidental damaging of the foil. However, as counting the signs made by the bird is much easier and quicker in good light conditions, cages from the night experiments are stored till next morning (if one has enough cages for all planned experiments). There is no possibility to handle and store used foils after removing them from the cage.

Count signs of the bird activity sector by sector. Starting always from NNE direction is convenient. All signs of activity are counted equally that is holes and dots made by a bill as well as holes and scratches made by claws of the bird. Sometimes these signs of different origin are not easy to separate, so "equality of rights" is the best solution. Behaviour of the bird in a cage is to some extent species specific and in one species bill signs are more common, while claws in other. Some practice is needed, but individual differences between observers are, if any, in number of counted signs and not in their distribution. Every counted sign must be instantly marked with colour marker to avoid double counting.

5. Filling the experiment form (Fig. A 1) consists of filling few boxes with the information additional to the main data: Species, Ring no, Status (A – freshly ringed, first test, B – next test…; R – retrap), Sex/age, Fatness (the fat-scale used is specified below), Date – hour of catching, Experiment time (from – to, given as hour and minutes), Day/night (D, N), Sky visibility (0 – none, 1 – small: cloudiness 7 to 9, 2 – medium: 4 to 6, 3 – good: 0 to 3), Sun/moon (S – the Sun, M – the Moon visible, "–" nothing of them), Wind direction (accuracy to 1/8 of the wind-star; 0 – no wind), Wind force (0 – no wind, 1 – 1 to 2° Beaufort, 2 – 3 to 4° B, 3 – over 4° B).

The existing input software is adapted to specified set of additional data.

Species			
Ring			
Status			
Sex/Age			
Fat-Weight			
Date-hour			
Experiment	from	to	
Day/Night			
Sky			
Sun/Moon			
Wind dir.			
Wind force			

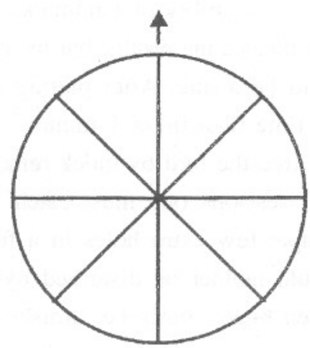

Fig. A1. The page of a notebook used in the field.

Fat determination

The fat scale after Busse (1983) modified to meet degrees 6 to 8 of the scale proposed by Kaiser (Kaiser 1993).

Determination of fatness goes through three levels (Fig. A 2):

Level I – belly

Level II – furculum

Level III – pectoral muscles

Key to fat determination:

I.1. Belly is without visible fat or with reddish traces only –

2. Belly with unfused bands of fat (intestinum is visible) T2

3. Belly has a fused cover of fat; intestinum is not but the liver is visible T3

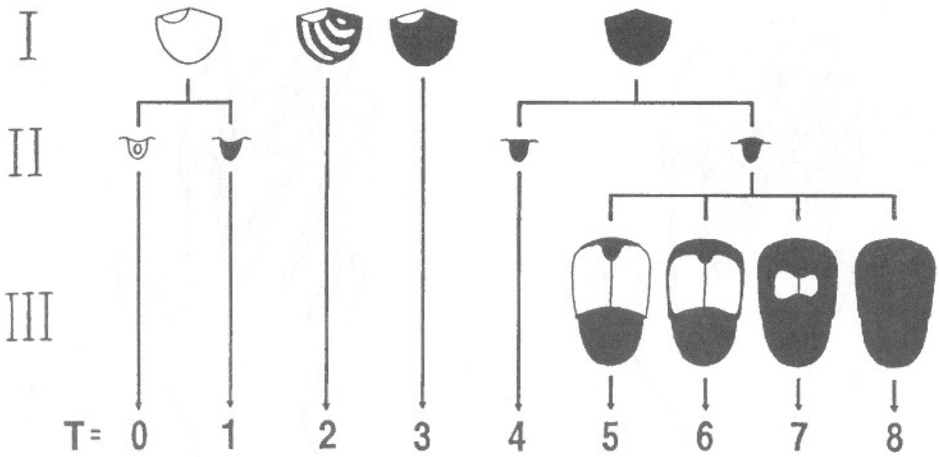

Fig. A2. Visual key to the fat determination.

4. Belly is completely covered with fat, a very narrow band of the liver may be visible but, if it is, the roll of fat is immediately above it – II B

II. A.1. Air -sack is visible within furculum (some fat may occur) **T0**

2. All the interior of furculum is covered with fat **T1**

II. B.1. Fat in furculum flat or concave **T4**

2. Fat in furculum forms a convex cushion – III

III. 1. Sides of pectoral muscles without stripes of fat **T5**

2. Sides of pectoral muscles with stripes of fat **T6**

3. Pectoral muscles partly covered with fat **T7**

4. Pectoral muscles nearly completely covered with fat **T8**

Note: In some species loss of fat does not follow exactly the same sequence in which it was attained, this causes problem with fat determination in some specimens. Anyhow always follow exactly the key, as specific differences are covered by species-specific validation of the scale Busse (1970).

Technique of fat determination

1. Lay the bird on its back on the flat of the hand (Fig. A3 – A and B); the neck should be between the second and third finger of the hand; the second and the third finger of the second hand gently part the bird's legs; the proper position of bird is very important.

2. Blow the belly with a continuous stream of air and choose one of four possibilities under section I of the key; if you choose the second or the third subsection – you have determined fatness as T2 or T3 respectively.

3. If your choice is II A or II B, you must direct your blowing to the furculum and choose one of the two subsections under II A (fatness T0 or T1) or II B (fatness T4 or higher – III).

4. If your choice is III, look at pectoral muscles and choose fatness T5 – T8.

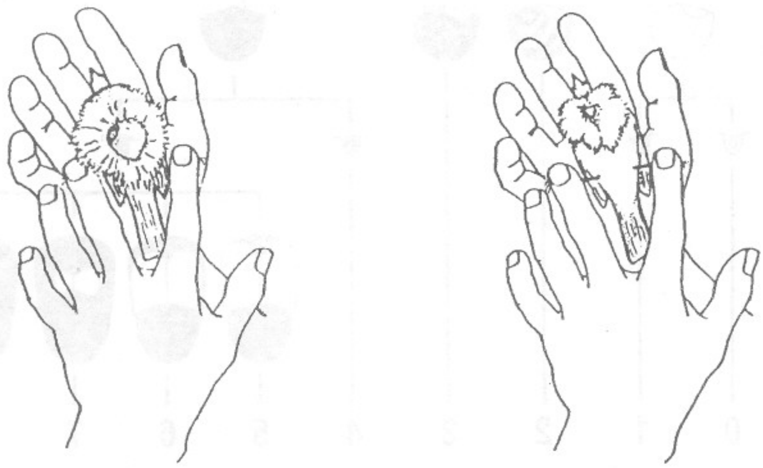

Fig. A3. Technique of the fat determination.

The most common mistakes in classification

Mistakes are usually made when someone has the tendency to a "liberal" interpretation of rules, e.g. the bird has a thick cover of yellow fat on the belly but a part of intestinum visible; this should be T2 but is classified as T3 because it "looked like a fatty bird". Some mistakes are possible when the bird is not properly handled when the furculum contents is evaluated.

Note that sometimes fatness of an individual bird properly determined twice at the same time may not be the same. This is because in border cases different tension of the bird's belly muscles at the moment of blowing may expose (or not) the intestinum or the liver from under the fat layer. Difference in determination cannot, however, exceed one degree of fatness.

After filling up the experiment form the foil is removed from the cage and the cage can be prepared for the next test. One person working on one experiment stand can without problems work out four birds per hour (with counting results and preparing cages) if the experiment stand is not too far from the station. Working on two stands require some help of a second person serving with the birds.

Handling the data

The routine of handling the data depends on aims of the study. The software to input and preliminary preparing the data for import to the spreadsheet is available. The equipment sets, notebooks and the software are available from "Jessica Bird-Nets Poland" S.J. (Przebendowo, 84-210 Choczewo, Poland).