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THE GENERAL PATTERN OF SEASONAL DYNAMICS OF THE AUTUMN MIGRATION OF THE WOOD PIGEON *COLUMBA PALUMBUS* IN ITALY

Enrico Cavina, Rinaldo Bucchi and Przemysław Busse

ABSTRACT

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Given the scarcity of studies on the migration of the Wood Pigeon through Italy, the first systematic observations by a network of hunters, as citizen researchers, can be presented as a starting point for more in-depth analyses. Observations from the years 1998-2006 are analysed and presented in a generalized form. During this period more than 100 observation sites, covering most of Italy, were active for about 40 days every autumn. Migration over Italy was described in terms of the timing and intensity of migration. Special attention was directed to the long-term number dynamics and seasonal dynamics of the passage. The most intensive migration was observed within northern Italy, while lower intensity is visible more to the south of the peninsula. Following tendencies in numbers of observed migrants within the ten years of the study, we can find positive tendencies in most of the northern provinces, while three negative trends are visible in central Italy. The study of the seasonal pattern, in terms of the number dynamics of the passage and the frequency of pronounced peak days, strongly suggests that there are five or six waves of pigeons passing through Italy in different parts of the autumn that are quite stable between years. Every year the time of the passage includes a few peak days of migration.

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INTRODUCTION

Italy is a peninsular bridge through the Mediterranean Sea, between the European continent and the North African and Spanish coasts (35-47°N, 6-18°E). It is divided into Continental Italy (at 44°N), Peninsular Italy and Insular Italy. The Alps (barrier at the Continental North) and Apennine Mountains and their foothills, rivers and valleys are clear markers of the complex topography and hydrography of Italy and determine its seasonal climatology and weather.

Autumn migration of wood pigeons takes place mainly in October, but also during the first half of November. Wood pigeons arrive mostly from the eastern continental parts of Europe and western parts of the Asiatic Palearctic (Hobson 2009). This migratory route begins in Eastern Europe, Russia and Ukraine, but probably also in Asiatic areas east of the Urals. The breeding origin of many populations of wood pigeons arriving in Italy remains a problem to be better investigated.

The main route of migration from Eastern countries passes through Hungary, Slovenia, Austria and Croatia, and enters Italy by what is known locally as 'the East Italian Gate' in the region of Friuli Venezia Giulia, which includes the Carniche Alps and the Tagliamento and Fella River valleys. This corridor gives flying migrants direct access to continental Italy – the Po valley, south of the Alps up to the Maritime Alps, and the coast on the French border in the west and the Ligurian Sea (Genoa) in the south.

It should be emphasized that several different populations migrate through Italy: those that breed a great distance away, within eastern Russia, as well as others breeding in the forests of the Carpathian Mountains and the Balkans. These can all have different lengths of migration: they can be long-, medium-, or short-distance migrants. Thus the seasonal pattern of migration could be varied in terms of timing and intensity.

The seasonal phenomenon of migration is an important part of the historical tradition and culture of many thousands of Italian hunters. For this group of citizens, knowledge of migration has been limited to practical, uncoordinated observations, but for twenty years an idea has been developing among hunters to conduct systematic daily observations for potential scientific use. A better understanding of the properties of the migration may be useful in the practice of sustainable exploitation of huntable bird resources.

The aim of this paper is to provide a general picture of the autumn migration of this species in Italy and to suggest subsequent research for elucidating this phenomenon. This could encourage the formation of a network of observation sites maintained by birders and hunters.

MATERIAL AND METHODS

The source of the data is reports from Progretto Colombaccio (R. Bucchi) and Progetto Colombaccio Italia (S. Giannerini). Examples of the data are presented in Figures 1 and 2. The observation scheme was launched in 1997 and carried out until 2006, as a network of observation posts run by hunters during the hunting season. At sites selected by active hunters, wood pigeons were hunted and birds passing the site were counted simultaneously.

The counting routine consisted in recording flocks of wood pigeons using a few standard parameters: the number of pigeons by flock (flock size), direction of flight (according to the standard direction of the local migration stream and 'reverse migration', in the opposite direction), and the bag from the hunting. In this paper, flock size and bag numbers are not taken into account, but they can be used in future work.

Table 1 presents the periods of work, numbers of sites, numbers of observation days per season, and total numbers of pigeons observed. The observations were carried out essentially day by day, but due to Italian hunting law there were breaks in observation activity two days a week (Tuesday and Friday), when hunting is prohibited (Fig. 1). This meant that the 'continuous day by day' scheme was in fact a kind of sampling method. This resulted in less accurate data for determining the peak days of migration in a season. However, as the total data used cover ten seasons 1998-2006 (the 1997 season is excluded due to incomplete data), at a general level the results should be sufficiently accurate. Another parameter of the observation scheme that was insufficiently standardized was the number of observation sites operating each year. To analyse compatible values, the numbers of birds observed were recalculated to number/site/day and presented for the administrative regions (Tab. 2, Fig. 3). The regions are grouped into three areas from the north to the south of Italy.

I "NUMERI" DELL'AUTUNNO 1997

giorni di caccia	*Ottobre '97*		*n° colombi avvistati*	*n° voli avvistati*	*n° catture*
1	01.10.1997	mercoledì	165	22	10
2	02.10.1997	giovedì	60	8	1
	03.10.1997	venerdì			
3	04.10.1997	sabato	367	39	9
4	05.10.1997	domenica	286	38	12
5	06.10.1997	lunedì	338	47	7
	07.10.1997	martedì			
6	08.10.1997	mercoledì	233	20	4
7	09.10.1997	giovedì	685	56	22
	10.10.1997	venerdì			
8	11.10.1997	sabato	947	85	23
9	12.10.1997	domenica	4.478	358	85
10	13.10.1997	lunedì	4.696	233	55
	14.10.1997	martedì			
11	15.10.1997	mercoledì	2.984	188	52
12	16.10.1997	giovedì	6.360	174	49
	17.10.1997	venerdì			
13	18.10.1997	sabato	970	63	30
14	19.10.1997	domenica	1.918	73	42
15	20.10.1997	lunedì	1.346	110	33
	21.10.1997	martedì			
16	22.10.1997	mercoledì	67	6	3
17	23.10.1997	giovedì	312	15	8
	24.10.1997	venerdì			
18	25.10.1997	sabato	893	75	14
19	26.10.1997	domenica	145	25	11
20	27.10.1997	lunedì	94	3	2
	28.10.1997	martedì			
21	29.10.1997	mercoledì	189	6	1
22	30.10.1997	giovedì	108	2	0
	31.10.1997	venerdì			
	sommano		*27.661*	*1.646*	*473*
	Novembre '97				
	16.11.1997		2.700	8	0
	sommano		*30.361*	*1.654*	*473*

Fig. 1. Example of source data sheet for Italy in 1997 (total, limited data). Numbering of hunting days is given in the first column, then dates (note dates of days without hunting/observations), followed by numbers of pigeons flying in normal direction of the passage, numbers for reverse movements and numbers of birds shot.

QUADRO RIEPILOGATIVO DEI DATI DI 10 REGIONI ITALIANE ANNATA 2006

	Regioni	rilevatori osservatori	gg medi osservazione	n° colombi avvistati	n°VOLI avvistati	n° CATTURE	DATI MEDI PER OGNI OSSERVATORIO E PER I TRE SETTORI: MEDIA STAGIONALE n° colombi	MEDIA STAGIONALE n° voli	MEDIA STAGIONALE n° catture	MEDIA GIORNALIERA n° colombi	MEDIA GIORNALIERA n° voli	MEDIA GIORNALIERA n° catture	CLASSI DI VOLO: V1 da 1 a 10 colombi	V2 da 10 a 50 colombi	V3 da 50 a 100 colombi	V4 da 100 a 300 colombi	V5 oltre 300 colombi
1	FRIULI E VENETO	7	17	72.438	2.141	552	10.348	305,9	78,9	623	18,4	4,8	44,9%	35,7%	12,5%	5,4%	1,5%
	1° SETTORE	7	16,6	72.438,0	2.141,0	552,0	10.348,3	305,9	78,9	623,4	18,4	4,8	45%	36%	12%	5%	2%
3	LIGURIA	17	17	86.398	2.553	519	5.082	150,2	30,5	297	8,8	1,8	38,7%	47,1%	10,6%	3,4%	0,5%
4	E.ROMAGNA	21	22	113.548	3.039	1.071	5.407	144,7	51,0	246	6,6	2,3	48,6%	32,8%	10,5%	6,5%	1,5%
5	TOSCANA	32	19	224.563	6.477	2.113	7.018	202,4	66,0	364	10,5	3,4	46,4%	37,0%	10,4%	4,4%	1,8%
	2° SETTORE	70	19,5	424.509	12.069	3.703	5.835,6	165,8	49,2	302,2	8,6	2,5	45%	39%	10%	5%	1%
6	UMBRIA	7	23	9.932	657	200	1.419	93,9	28,6	63	4,1	1,3	72,5%	23,0%	3,5%	1,1%	0,3%
7	MARCHE	24	18	41.514	2.558	676	1.730	106,6	28,2	96	5,9	1,6	63,2%	28,2%	6,5%	3,3%	
8	LAZIO	12	15	9.188	761	347	766	63,4	28,9	51	4,3	1,9	68,3%	29,0%	2,1%	0,4%	0,1%
9	ABRUZZO	3	10	10.180	261	100	3.393	87,0	33,3	329	8,4	3,2	50,2%	34,5%	11,5%	4,2%	0,8%
10	BASILICATA	1	14	796	69	76	796	69,0	76,0	57	4,9	5,4	59,4%	39,1%	1,4%	0,0%	0,0%
	3° SETTORE	47	16,5	71.610	4.306	1.399	1.826,9	87,7	29,7	134,7	5,7	2,0	64%	29%	6%	2%	0%
	TOTALE ITALIA	124	17,5	568.557	18.516	5.654	4.585	149	45,6	262	8,5	2,6	50%	36%	9%	4%	1%

* i dati della Regione Basilicata non sono stati considerati nei calcoli delle medie in quanto risulta essere un dato non confrontabile

Fig. 2. Example of source data sheet for provinces and areas as given for the main data set (1998-2006). In these years the basic data set is supplemented by data not used in the paper.

Table 1
Data used in the analysis: number of observation sites, period of work, number of observation days and number of pigeons observed following the migration direction

Year	*N* sites	Period of work	*N* days	*N* observed
1997	–	1 Oct–31 Oct	22	27,661
1998	60	26 Sep–5 Nov	27	178,400
1999	100	25 Sep–18 Nov	40	349,587
2000	107	25 Sep–19 Nov	40	507,175
2001	113	25 Sep–18 Nov	40	588,385
2002	124	25 Sep–17 Nov	39	807,867
2003	138	24 Sep–16 Nov	39	703,758
2004	129	22 Sep–11 Nov	34	820,464
2005	143	21 Sep–17 Nov	41	489,878
2006	124	23 Sep–12 Nov	37	568,557
Total			359	5,041,732

Fig. 3. Average daily numbers of migrating pigeons in different provinces of

Table 2
Basic data by provinces and areas. Yearly raw numbers of observed pigeons, numbers of observation sites, numbers of observation days and standardized values: number per site and number per site and day

AREA I	1998	1999	2000	2001	2002	2003	2004	2005	2006
Friuli/Veneto	43 224	22 283	47 817	53 736	130 641	99 176	134 712		72 438
Sites	4	5	8	6	7	8	11		7
Days	15	17	15	20	18	19	15		17
N/site	10 806	4 457	5 977	8 956	18 663	12 397	12 247		10 348
N/Site/Day	**720**	**262**	**398**	**448**	**1 037**	**652**	**816**		**609**
Lombardy		25 171	47 894	140 110	153 435	144 816	229 309		
Sites		2	1	3	4	5	3		
Days		17	13	17	13	8	8		
N/site		12 586	47 894	46 703	38 359	28 963	76 436		
N/Site/Day		**740**	**3 684**	**2 747**	**2 951**	**3 620**	**9 555**		
Piemonte		33 563	20 550	4 375	7 150	7 056			
Sites		2	2	1	1	2			
Days		8	7	9	14	8			
N/site		16 782	10 275	4 375	7 150	3 528			
N/Site/Day		**2 098**	**1 468**	**486**	**511**	**441**			
AREA II									
Liguria	8 229	76 667	62 986	71 223	201 075	120 681	92 393		86 398
Sites	3	16	15	19	20	21	20		17
Days	26	23	24	21	21	19	19		17
N/site	2 743	4 792	4 199	3 749	10 054	5 747	4 620		5 082
N/Site/Day	**106**	**208**	**175**	**179**	**479**	**302**	**243**		**299**
E. Romana	41 540	66 300	79 719	63 210	80 438	93 411	115 136		113 548
Sites	20	17	22	18	24	27	26		21
Days	17	19	18	19	19	17	19		22
N/site	2 077	3 900	3 624	3 512	3 352	3 460	4 428		5 407
N/Site/Day	**122**	**205**	**201**	**185**	**176**	**204**	**233**		**246**
Toscany	65 770	89 022	176 790	209 367	163 488	171 310	159 257		224 563
Sites	17	25	26	30	27	25	24		32
Days	17	21	19	21	22	24	19		19
N/site	3 869	3 561	6 800	6 979	6 055	6 852	6 636		7 018
N/Site/Day	**228**	**170**	**358**	**332**	**275**	**286**	**349**		**369**
AREA III									
Umbria	1 071	2 883		2 536	2 648	6 730	12 797		9 932
Sites	1	5		5	5	8	9		7
Days	15	20		16	16	19	18		23
N/site	1 071	577		530	530	841	1 422		1 419
N/Site/Day	**71**	**29**		**33**	**33**	**44**	**79**		**62**
Marche	7 624	11 862	28 554	13 948	28 337	34 619	56 257		41 514
Sites	3	8	11	9	11	21	20		24
Days	15	23	19	24	22	20	19		18
N/site	2 541	1 483	2 596	1 550	2 576	1 649	2 813		1 730
N/Site/Day	169	64	137	65	117	82	148		96
Lazio	9 149	16 922	34 598	25 009	32 120	23 406	17 107		9 188
Sites	11	16	20	20	21	18	13		12
Days	12	16	17	17	17	15	16		15
N/site	832	1 058	1 730	1 250	1 530	1 300	1 316		766
N/Site/Day	**69**	**66**	**102**	**74**	**90**	**87**	**82**		**51**
Abruzzo	1 793	4 814	8 267	4 871	7 870	2 137	2 474		10 180
Sites	1	1	2	2	3	2	2		3
Days	10	15	13	15	14	11	11		10
N/site	1 793	4 814	4 134	2 436	2 623	1 069	1 237		3 393
N/Site/Day	**179**	**321**	**318**	**162**	**187**	**97**	**112**		**339**
Basilicata					665	416	1 022		796
Sites					1	1	1		1
Days					11	15	13		14
N/site					665	416	1 022		796
N/Site/Day					**60**	**28**	**79**		**57**

The general presentation of the course of seasonal migration through Italy is based on raw numbers of daily migrating birds, as well as an analysis of variation in the course of the seasonal migration pattern. It is common knowledge among students of the seasonal pattern of passage of birds, irrespective of the species, that day-to-day numbers of migrants are typically extremely variable. Rushes of migration are noted in which more than 25% of the yearly number of migrants of a given species pass the observation site in one day, and fluctuations from one day to the next can reach 1,000% or more. Various terms have been used for such rushes, usually *peaks* or *waves* of migration, but frequently the precise meaning of these terms is not defined. The terms are commonly explained as 'a *day or days with clearly higher frequency in the course of the seasonal migration pattern*'. This makes comparisons of patterns difficult.

In this paper, we define the term *peak day* as a day within which the number of observed birds exceeds 5% of the individuals observed within the season (all birds observed from the beginning to the end of the observation period = 100%). This means that if during a period of two, three or more consecutive days the share of birds each day is above 5% of the total number of observed birds, all these days will be called 'peak days'. For a more precise description, peak days with different values are designated as 'low peaks' – 5.1-10.0% of the yearly total, 'moderate peaks' – 10.1-15.0% and 'high peaks' – >15%. Still the term 'peak' refers to one day. When we use the percentage value of the share of the day in the entire study, calculation of the Similarity Index (*SI* – discussed below) is natural and easily understandable.

We use the term *wave* of migration to refer to a period of several days in sequence in which the migration is more intensive than in periods with lower numbers (shares). The wave can contain both peak days and days with very low numbers. Within the entire period of seasonal migration, waves are usually smaller at the beginning and at the end of migration period than in the middle period of migration, and of course the probability that real peak days will occur then is lower.

To study whether two curves representing migration dynamics are similar or dissimilar in terms of the course of migration, we can use statistical tools, such as chi-square or similarity indices. The similarity index used in this paper is the Renkonen coefficient:

$$SI = Sum\ min\ [n\%_{d1},\ n\%_{d2}],$$

where: *SI* is the sum of minima in the daily pair of frequency values expressed as a percentage of the total samples compared ($n\%_{d1}$, $n\%_{d2}$). The Renkonen coefficient is commonly used to compare species population structure in botanical and zoological ecology. The logical and statistical structure of our problem exactly fits the assumptions of the Renkonen coefficient. Since in this paper the data for establishing the dates of peaks of migration were recalculated to daily percentage values, the results were ready to use for calculation of *SI* values. In this study, *SI* values were calculated to define the similarity of the migration dynamics in each year to the average dynamics for all ten years together. The level of statistical significance of the results was estimated by comparing the *SI* values with those obtained in a detailed study of the problem by Nowakowski *et al.* (2005), where the same method was used. The same procedure could be used to compare the synchrony of migration through different areas in Italy, but available data are still too limited.

RESULTS

Intensity of migration and multi-year number trends

The basic results for intensity of migration at sites situated in different areas and provinces of Italy are presented in Table 2 and Figure 3. The most intensive migration is observed within Area I in the northern part of Italy, where pigeons move over fairly open and flat landscapes, while lower intensity is visible more to the south of the Italian peninsula, where birds must travel along several valleys to cross the Apennine Mountains.

Examination of the tendencies in numbers of observed migrants within the ten-year study period reveals positive tendencies in most of the northern provinces, while three negative trends are visible in the central part of Italy (Fig. 4). Thus trends for

Fig. 4. Trends in numbers of pigeons as observed in different provinces

Areas I and II are positive (Fig. 5). The regression coefficient for Area II is statistically highly significant ($p < 0.01$, $F_6 = 18.25$), while for Area I it is not ($p > 0.05$, $F_6 = 1.35$). Note, however, that the slope is similar to that of Area II, and the lack of formal significance is due to the high variation within the data for that area (especially in 2004, when the number of birds observed far surpassed the numbers in other years). The trend for Area III is slightly, insignificantly negative ($p > 0.05$, $F_6 = 0.29$). At this time the number of birds observed in Area I is one order higher than in Areas II and III.

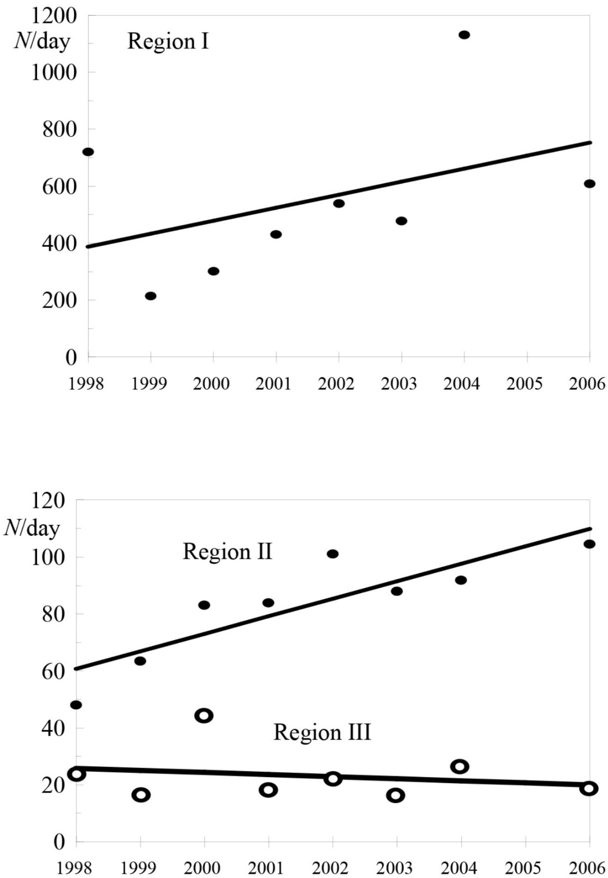


Fig. 5. Total number trends in 1998-2006 by areas. Dots – yearly values (number per day), lines – regression equation lines

Seasonal dynamics

Traditionally, when the sampling method is used, records are grouped to obtain a more general picture. In this way, Figure 6 shows the general pattern of the autumn migration of wood pigeons as one maximum, but asymmetric curve of the number of observed individuals. The shape of the distribution pattern of migration peaks is very similar. Both show clearly that the distribution is not normal, but probably composed of a few basic normal or quasi-normal distributions caused by internal group differentiation (migration in several migratory waves).

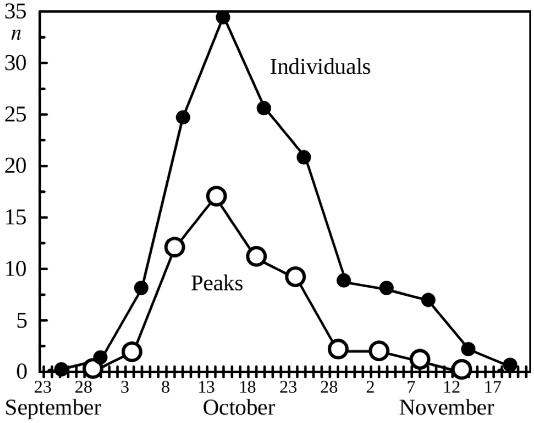


Fig. 6. Seasonal pattern of Wood Pigeon migration in Italy presented traditionally as numbers (Individuals - per station and day) grouped into pentades [5-day periods] (line with black circles) and as number of peaks in these pentades (line with empty circles)

A more detailed – day-by-day – analysis of the distribution of numbers and peaks confirms this supposition (Fig. 7). Both distributions show a clear multi-wave pattern. Comparison of these distributions using the *SI* (Similarity Index) gives an extremely high *SI*-value of 85.6, which is significant at the level of at least $p < 0.001$ (Nowakowski *et al.* 2005). Thus only day-by-day analysis is suitable for studying the problem of peaks and waves of migration. Distributions of peak days in different years are presented in Figure 8, where yearly patterns are shown against the background of the total pattern of migration.

The next step of the analysis is to answer the question, '*are the yearly patterns based on a common, repeatable general migration pattern?*' The first verification that the distribution of peaks corresponds to the basic structure of migration has already been presented in Figure 7, where the curves for the number distribution as well as the peak distribution clearly show at least five waves (a sixth wave is probably hidden in an asymmetric first wave at the beginning of the distribution). The second argument is even stronger – the analysis of the similarity of the yearly patterns with a common template of migration shows that all yearly courses of migration dynamics are in highly significant agreement (*p* at least at the 0.001 level) with the average course of migration (Table 3). This table also shows that the variance in *SI*-values for different years is quite low ($Avg = 67.7$, $SD = 6.01$, coefficient of variation $V = 8.87$). Comparison of the data in this table also shows that the number of birds observed at the average site influences the *SI*-value less (Pearson's $r = 0.61$, $p > 0.05$) than the number of sites ($r = 0.75$, $p < 0.05$). This underscores the importance of the number of observation sites when studying details of the migration dynamics pattern.

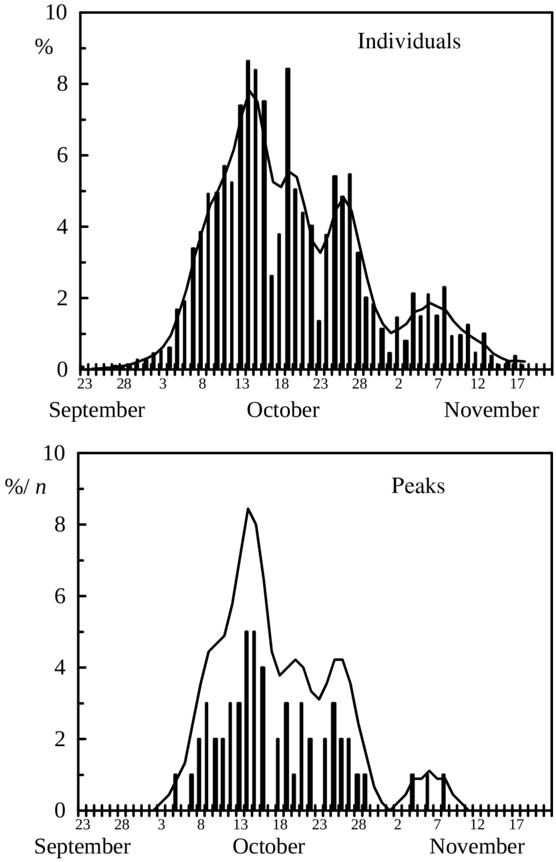


Fig. 7. Left panel: day-by-day total seasonal pattern of migration – numbers: bars – average daily numbers of pigeons (per station and day) for the whole 1998-2006 period, expressed for year as percentage share of the yearly total, line – daily data smoothed by 5-day moving average.

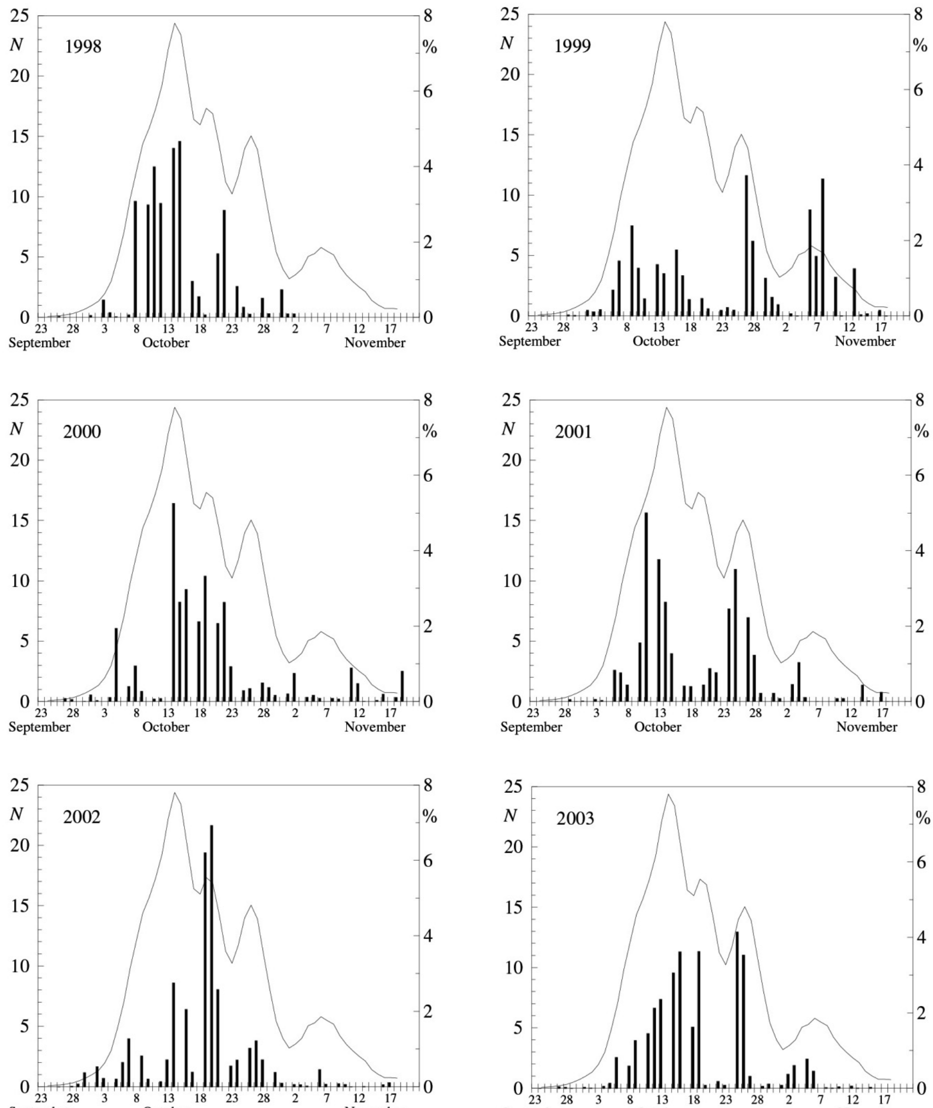
Table 3

Similarity Indices for yearly seasonal dynamics of the pigeons' passage. Numbers of observation sites and average numbers of birds observed per site in year are given.

Year	Sites	Pbserved	Similarity
1998	60	2 973	58.4
1999	100	3 496	59.3
2000	107	4 718	65.6
2001	113	5 207	69.3
2002	124	6 517	64.6
2003	138	5 074	72.8
2004	129	6 360	78.6
2005	143	3 407	69.4
2006	124	4 585	69.7
Avg	**115**	**4 704**	**67.5**
SD	**23.5**	**1 182**	**6.01**

DISCUSSION AND CONCLUSIONS

In-depth studies on seasonal differentiation in the intensity of migration are relatively scarce. Frequently the problem of a very high level of fluctuations in numbers of observed/caught individuals of migrating species is treated as a stochastic variation caused by the unpredictable influences of various physiological properties of birds, sensitivity to weather, habitat, and climate. This kind of explanation of the peaks and breaks observed in seasonal dynamics patterns is convincing mainly when the data



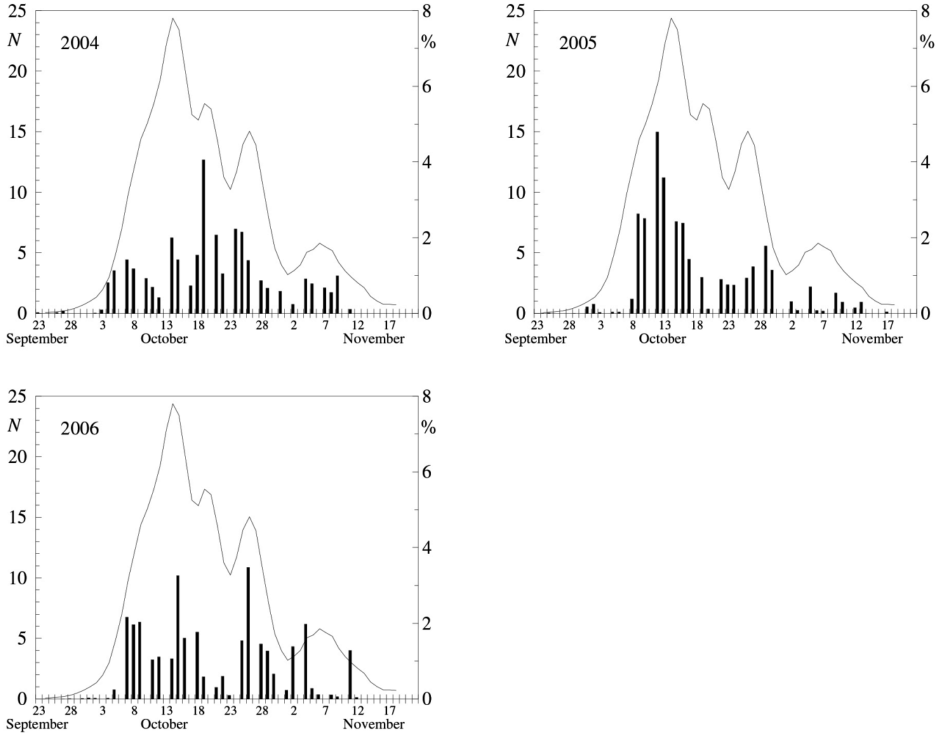


Fig. 8. Time distribution of migratory peaks (bars – left scale) within certain years shown against a background of the general migration pattern (line – right scale – corresponds to smoothed percentage pattern in Figure 7 – left panel)

come from single years or a short time series. If the time series is long enough, the stochastic variation should lead to a chaotic distribution of peaks in the summarized seasonal patterns, most likely in a form close to the Gaussian, normal distribution (if only one bird population is passing the observation site). In the most common case, when we have different populations (in terms of source areas, destination winter quarters and/or direction of migration), a general normal distribution is very unlikely. This is very well confirmed by the long-term data (since 1961) of Operation Baltic in Poland, e.g. ten years of data for many species ringed/observed – Busse and Halastra 1981; thirty years of data for the Willow Warbler *Pylloscopus trochilus* – Piotrkowska 1995 and for the Blackcap *Sylvia atricapilla* – Busse 1996, Kopiec 1997, Kopiec-Mokwa 1999; and fourteen years of data for the Robin *Erithacus rubecula* – Nowakowski *et al.* 2005, as well as data from other areas, e.g. a nineteen-year study on many species from Hungary – Gyuracz *et al.* 2017, or a ten-year study of many species from Palestine – Awad *et al.* 2017. There are many, many examples of multi-wave distributions. Thus the results obtained in the current study suggesting several waves in the seasonal dynamics of the Wood Pigeon are very well grounded.

Here we have five or six groups of pigeons passing through Italy in different parts of the autumn, and the time of the passage, including a few peak days, is quite stable between years. Yearly peaks in different waves, as well as the waves themselves, are not regularly of the same relative number sizes, but it is quite normal that different groups of migrants have their own number size and migration variation.

The general problem here that should be solved in the future is what the waves found for pigeons really mean. If, as is common in many bird species within the Baltic area, directions of migration are differentiated (e.g. Goldcrest – Busse 1981, Remisiewicz and Baumanis 1996), the waves could contain different migratory populations migrating one by one or they may be composed of a mix of individuals belonging to different migratory populations (Busse and Maksalon 1978). Birds migrating the same way, but with various areas of origin, can form more or less uniform waves migrating sequentially – as was supposed for the Coal Tit migrating in the 1974 irruption (Busse 1978). This was suggested by some signs of separation mechanisms during observations of movement through a few bird stations along the Baltic coast. A similar case was found for the Goldcrest on the central part of the Polish Baltic coast (Busse 1981). Finally, Blyumenthal (1971) explained the typical occurrence of waves in migration as the result of bioenergetic mechanisms. From the general population pattern of migration of Wood Pigeon in central and southern Europe (Fig. 9) estimated on the basis of analysis of radioisotopes (Hobson 2009) and bird recovery atlases for Italy (Spina and Volponi 2008), the Czech Republic and Slovakia (Cepák *et. al.* 2008), and Germany (Bairlein *et al.* 2014), we can rule out the formation of subsequent waves by different migratory populations (birds from the southern flow vs.

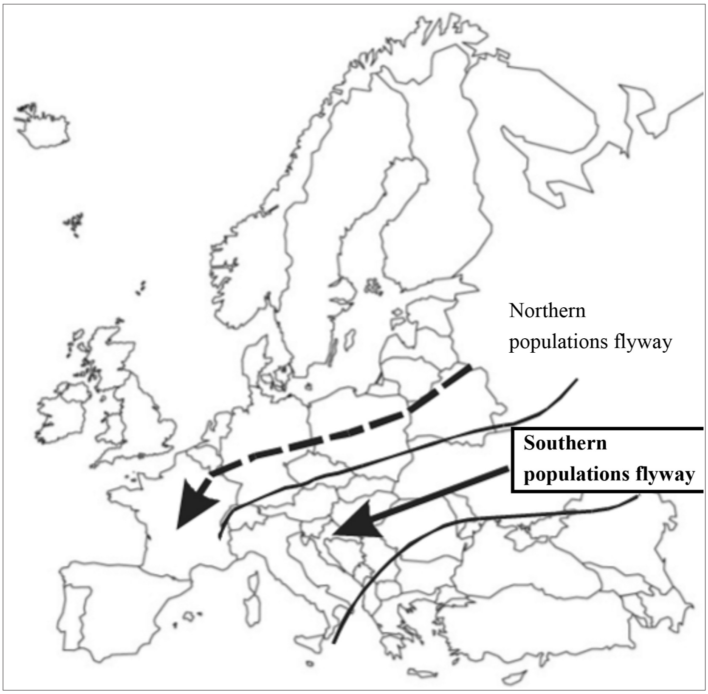


Fig. 9. General spatial pattern of Wood Pigeon migration in Europe as a rough estimation from stable isotopes analysis and bird recovery atlases (cited in the text).

those belonging to the northern flow). Therefore, what we have in the area studied is a wave structure caused by sequential starts of groups originating in more or less distant territories along the same flyway; or, any mechanism that sorts birds according to inherited migration distance may play the main role in the creating the wave. Inherited tendencies may, however, be modified by climate change and/or selection pressure, as shown for partial migrants. Which explanation better fits wood pigeon migration is to be discovered in the future, as it could be important for sustainable exploitation of the pigeon as a hunting resource.

Because our data for Italy are very general, it is not yet possible to discuss whether these populations travel over the entire country or pass over different regions. We still we do not know whether we have been studying different subpopulations or the entire stream is differentiated only by the time of migration of subgroups of inhabitants of the same area. Another problem with the seasonal dynamics awaiting more in-depth study is the occurrence of peak days of migration within waves of migration. Valuable attempts to study the causes of peaks observed in migration are presented online by Cavina (2015) and seem to be worthy of further work. Therefore we need more data, from more years and more sites in various regions, to be able to draw a detailed picture of the wave and population structure of pigeon migration.

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