POPULATION DYNAMICS – MONITORING

POPULATION DYNAMICS 1961-1990 OF COMMON LEAF WARBLERS (*PHYLLOSCOPUS SP.*) AT SOME CENTRAL EUROPEAN BIRD RINGING STATIONS

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ABSTRACT

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The paper is intended to give more general picture of population dynamics of Willow Warbler, Chiffchaff and Wood Warbler on bigger areas and to point at some problems arising when such data are evaluated. It contains evaluation of monitoring the numbers of migrating birds by autumn trapping results at 13 bird ringing stations dispersed throughout the central and northern Europe. The longest data series cover 30 years (1961-1990). Evaluation and presentation of data are based on methods discussed earlier (Busse 1990).

Studied species are not equally represented in the station catches and average numbers per season and per one station were: 460.0 (Willow Warbler), 136.6 (Chiffchaff) and 14.4 (Wood Warbler). Yearly fluctuations around smoothed (by five year moving average) number dynamics curves much are differentiated (CF values examined) at separate stations. When data pooled for species at six main stations were studied Willow Warbler and Chiffchaff show lower values (*CF* = 5.12 and 5.09 respectively) than Wood Warbler (9.58); these values are much lower than averages for stations. The population trends at the stations were differentiated with examples of both decrease and increase of numbers. However, regression coefficient values for long-term series of pooled data were all negative (Willow Warbler – *R* = -1.90, Chiffchaff – -2.45, Wood Warbler – -3.21) and statistically highly significant. Population dynamics curves for pooled data were positively correlated between Willow Warbler and Chiffchaff as well as between Willow Warbler and Wood Warbler (highly significant), but correlation between Chiffchaff and Wood Warbler was low and not significant. At the level of separate stations correlation were differentiated so much that further studies of the problem are necessary. Evaluation of migration monitoring data from number of stations covering larger territory and few species simultaneously points at number of new problems connected with interpretation of the results. These are interpretation of differences in numbers of birds caught at the stations, of the level of yearly fluctuations at stations and the pooled data, of correlation of number dynamics of the species between stations, and of correlations between species population dynamics.

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Number of papers evaluating the migration counts conducted at single or few bird ringing stations were published since this method of monitoring was accepted (Lindholm *et al.* 1983, Busse 1984, Baumanis and Rute 1986, Berthold *et al.* 1986, Busse and Cofta 1986, Peterson and Hedenström 1986, Svensson *et al.* 1986, Rabøl and

Lyngs 1988, Payevsky 1990, Sokolov 1991). Some of them tried to compare migration monitoring data with data from breeding censuses (e.g. Svensson *et al.* 1986, Pettersson and Hedenström 1986) but without too clear results. In more general remarks on such comparisons (Busse, in press a) it was stressed that "there are few conditions which should be observed when interpretation of population trends is performed – (1) the time series should be long enough to avoid interpretation of short-term changes and to find more general trends, (2) considered data should be collected in few places, instead of one station only, if one would like to conclude about welfare of the species, (3) the background for interpretation of the migration pattern of the species should be well known enough." The present paper is the second one (after Busse, in press b), in which I try to fulfil these conditions. However, the migration patterns of the species discussed are not known so clearly (despite of data in Zink 1973, Hedenström and Pettersson 1984, 1987) as to allow discussing the results too deeply and compare them with breeding census data. So, the paper is intended to give more general picture of population dynamics on larger areas and to point at some problems arising when such data are evaluated.

MATERIAL AND METHODS

Polish data were collected in the Operation Baltic research program by mist-netting birds at three stations in autumn - Mierzeja Wiślana (54.21N, 19.19E), Hel (54.46N, 18.28E) and Bukowo/Kopań (54.21N, 16.17E/54.28N, 16.25E) during 30 years (1961-1990, except Hel 1961-1986). All data are comparable within of station data set through all period of work (Busse, in press c). Simultaneously data from few other bird stations were used in the analysis (Fig. 1): 1. Falsterbo Bird Station (55.22N, 12.52E) - 1980-1988; 2. Helgoland Bird Station (54.00N, 8.00E) - 1953-1988, data from 1953-1960 are not used because of limitations in comparability (Moritz 1981, 1982a, 1982b, 1983; Moritz and Vauk 1979); 3. Mettnau-Reit-Illmitz Program: Mettnau (47.44N, 8.58E), Reit (53.28N, 10.06E), Illmitz (47.46N, 16.48E) - 1974-1983, data comparable (Berthold *et al.* 1986); 4. Ottenby Bird Station (56.12N, 16.24E) - 1961-1988, data nearly comparable (pers. comm.); 5. Pape (56.09N, 21.02E) - 1967-1989, data with limited comparability (A. Celminš, J. Baumanis pers. comm.) in the present paper the data were corrected according to the period of work - recalculated to per day values for migration period of the species; 6. Rybatchy (55.09N, 20.52E) - 1961-1986, data comparable (Payevsky 1990), 1985-1986 data from another catching place, close to previous one - recalculated for comparability reasons on the basis of relation obtained from the data of common, eight year period of work; 7. Sörve (57.54N, 22.03E) -

1981-1988, data poorly comparable because of period of work; 9. Tankar (63.57N, 22.51E) - 1972-1988, data roughly comparable because of unstable number of nets (T. Harju, pers. comm.), recalculated according to period of work, as for Pape. General problems of data comparability are discussed elsewhere (Busse 1990).

Data from six stations with the longest time-span covered (Mierzeja Wiślana, Hel, Bukowo, Helgoland, Ottenby and Rybatchy) are used for more detail ed discussion and this group of stations is called "main stations", while others (esp. Pape - 19 years) are used in a more limited way. In the paper all values describing the number of individuals

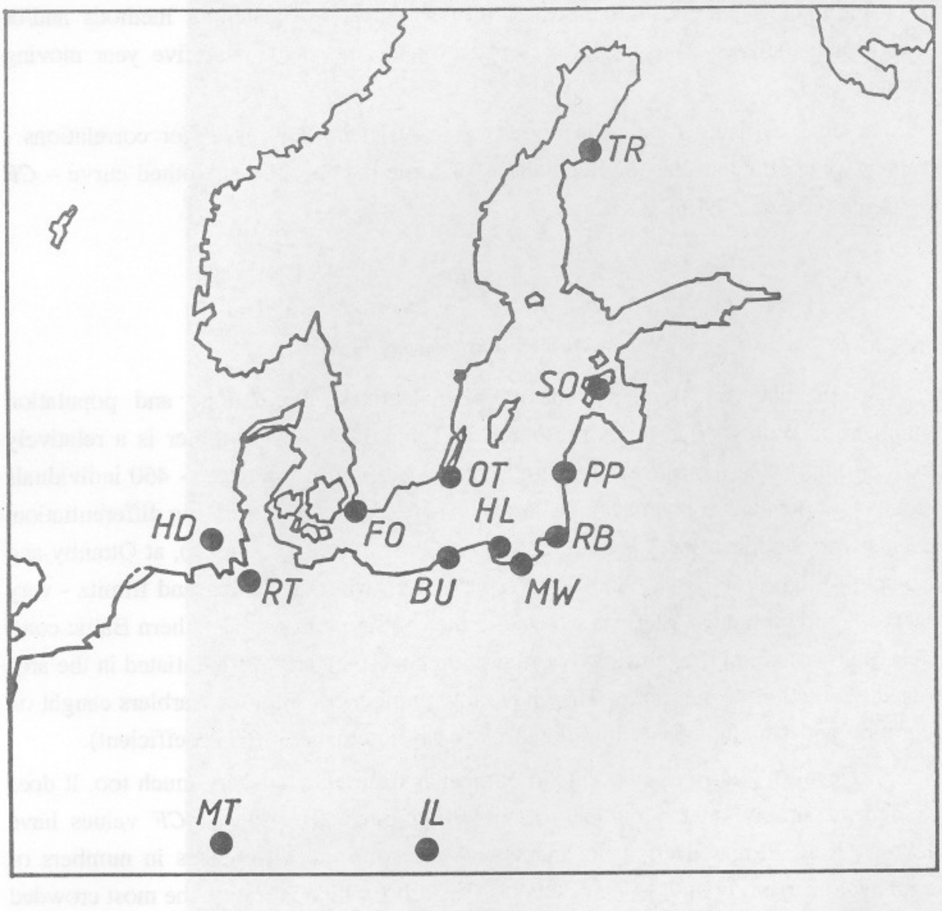

Fig. 1. Geographic distribution of the bird stations included into evaluation. BU – Bukowo/Kopań, FA – Falsterbo, HD – Helgoland, HL – Hel, IL – Illmitz, MT – Mettnau, MW – Mierzeja Wiślana, PP – Pape, RB – Rybatchy, RT – Reit, SO – Sörve, TR – Tankar

of the species are expressed as a percentage of the average number of the species at the station for the years 1974-1983, because these years are common for most of the studied series. Because the period 1974-1983 is used as the standard one in the paper, numbers for Polish stations presented here, as well as regression coefficients values, are not the same as in Busse (in press, a and c). The values given as common for a group of stations ("pooled data") were calculated as averages for all main stations, where every station had the same weight. As the basic data values are independent of real number of individuals caught (they are comparable between stations) they can be pooled for regional values. This method avoids suppressing trends observed at the stations where fewer individuals were caught because of peculiarities of catching methods and/or location and habitats. The graphs present raw and smoothed data (five year moving average).

For characterising trends the regression coefficient *R* is used, for correlations - Pearson's *r* coefficient and for fluctuations of basic data around smoothed curve – *CF* coefficient (Busse 1990).

RESULTS

Willow Warbler (*Phylloscopus trochilus*)

General data on frequency of trapping, number fluctuations and population dynamics of Willow Warbler is presented in Table 1. Willow Warbler is a relatively common migrant at the bird stations under consideration in the paper - 460 individuals were caught per station in an average season. There is, however, very big differentiation. At Falsterbo the mean level is extremely high (2031.8 ind. per season), at Ottenby and Rybatchy - high (756.6 and 685.4 ind. respectively), while at Tankar and Illmitz - very low (81.8 and 65.6 ind.). Stations situated at the central part of the southern Baltic coast (Hel, Bukowo) are in the "shadow" of migration pattern clearly differentiated in the area as to the direction of migration. They have low numbers of Willow Warblers caught on migration and simultaneously high level of yearly fluctuations (*CF* coefficient).

The level of yearly fluctuations in number is differentiated very much too. It does not depend simply on the number of migrating birds. The lowest *CF* values have Mettnau, Reit, Illmitz, Helgoland and Ottenby despite the differences in numbers of migrants. Surprisingly high value of CF has Falsterbo, which is station the most crowded by Willow Warblers.

Population dynamics at the stations is differentiated both as to trends (regression coefficient *R* – Table 1) and as to shape of population dynamics curves (Fig. 2). The trends at all stations are hardly comparable because of different time-span covered by the data. In the years 1974-1983, which are common to all but Falsterbo and Sörve stations, values of *R* are dispersed from -9.54 (raw data) and -7.64 (smoothed data) for

Table 1

General data on Willow Warbler number dynamics at different bird stations

Station	Period / No of years	Ind. per season	*CF*	*R*			
				1961-86	1974-83	1980-88	Max.
Mierzeja Wiślana	1961-90	395.3	15.87	−6.53**	−9.54*	—	—
	30			−6.29**	−7.64**	+8.28**	−4.12**
Hel	1961-86	159.2	42.89	—	—	—	—
	26			−6.93**	−2.01~	–	−6.93**
Bukowo	1961-90	178.4	15.37	−0.42~	+5.04~		—
	30			−0.57~	+3.91*	−16.68**	−1.95**
Helgoland	1961-88	315.6	6.09	+1.86*	−1.98~	—	—
	28			+2.02**	−2.65**	−5.83**	+1.41**
Ottenby	1961-88	756.6	6.54	+0.95~	+2.88~	—	—
	28			+0.74~	+4.52**	−0.30~	+0.75~
Rybatchy	1961-86	685.4	11.46	−0.59~	−1.15~	—	—
	26			−0.69~	−1.87**	—	−0.69~
POOLED N = 69 194			5.12	−1.98*	−1.11~	—	—
				−1.97**	−0.95~	—	−1.90**
Pape	1971-89	240.3	36.98	—	+22.40*	—	—
	19			—	+14.99**	+1.62~	+6.32**
Tankar	1972-88	81.8	16.80	—	+3.69~	—	—
	17			—	+2.24~	+2.00~	+2.26**
Reit	1974-83	456.7	4.02	—	−0.78~	—	—
	10			—	−0.29~	—	−0.29~
Mettnau	1974-83	422.3	2.34	—	−3.25~	—	—
	10			—	−2.75**	—	−2.75**
IIlmitz	1974-83	65.6	4.29	—	−1.22~	—	
	10			—	−1.25**	—	−1.25**
Falsterbo	1980-88	2031.8	13.62	—	—	—	—
	9			—	—	−6.80**	−6.80**
Sörve	1981-88	224.8	11.3	—	—	—	—
	8			—	—	—	—

Explanations: *CF* – coefficient of fluctuations; *R* – coefficient of regression, calculated from raw (above) and smoothed data;

statistical significance: ** – $p < 0.01$, * – $0.05 > p > 0.01$, ~ – $p > 0.05$.

Mierzeja Wiślana to +22.40 (raw) and +14.99 (smoothed) for Pape. However, this ten year period is clearly insufficient for estimation of long-term population trends - some of these values differ very much from the values calculated for more than 25 year series for the same stations. The extreme example is Bukowo station, where instead of R = +5.04 (raw data) or +3.91 (smoothed data) for 10-year period 1974-1983, the R value for 30 years (1961-1990) equals -1.80 (raw) and -1.95 (smoothed), because of

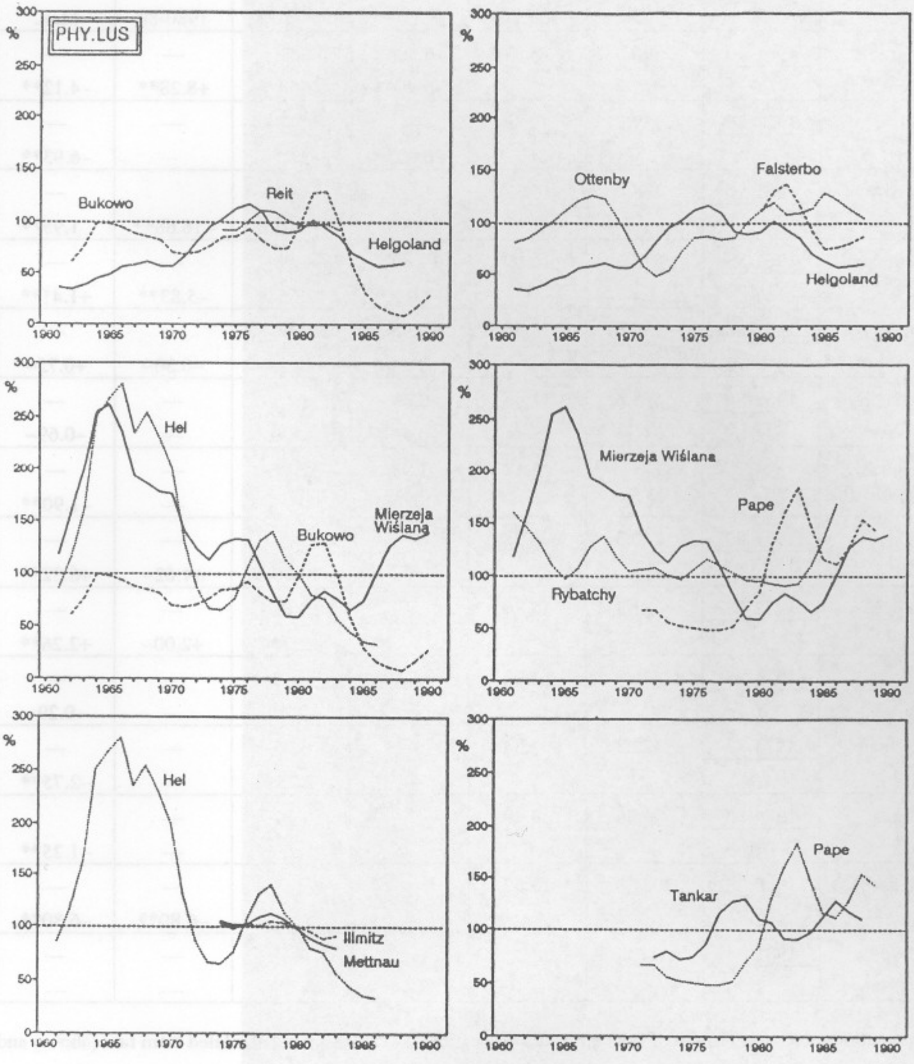

Fig. 2. Population dynamics of Willow Warbler at different stations (smoothed data)

situation in the mid of the 80-ies when there was dramatical crash in the Willow Warbler number (*R* for 1980-1988 is -16.68!). Generally at the stations with longest series of data *R* values are between -6.93 (smoothed, Hel) to +1.41 (smoothed, Helgoland).

The shapes of population dynamics curves for stations are differentiated even more than *R* values. Mentioned crash in number of the Willow Warbler at Bukowo was accompanied by similar trends at Falsterbo, Helgoland and Hel, while in the same time numbers at Mierzeja Wiślana, Ottenby and Pape increased. The numbers of Willow Warblers at Hel and Mierzeja Wiślana changed paralelly in the 60-ies and then differentiated much. Rybatchy and Pape had very unlike shapes of dynamics curves and those for Pape and Tankar were negatively correlated. All these differentiations can be explained as the result of various recruitment areas of birds as well as different location of stations in relation to migration pattern. These both are not known well enough to discuss them now.

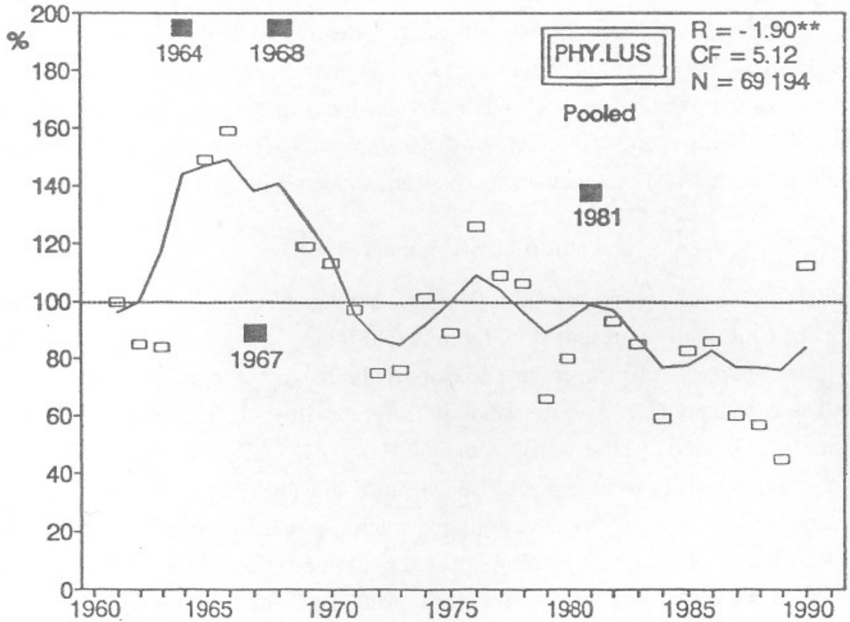

Fig. 3. Population dynamics of Willow Warbler – data pooled for six main stations. Raw data (squares) and smoothed data (line); extreme deviations of raw data from the smoothed curve are pointed by filling the raw data sign. *R* – regression coefficient, with statistical significance symbols (** – $p < 0.01$, * – $0.05 > p > 0.01$, ~ – $p > 0.05$), *CF* – coefficient of fluctuations, *N* – total number of individuals caught at the stations included.

If we use combined data from the six stations with the longest data series to evaluate the welfare of the species in the region we obtain a picture showing statistically significant, but not too high ($R = -1.90$) decrease in Willow Warbler number (Fig. 3). It is worth stressing the low level of fluctuations as shown by *CF* value for the pooled data. This common value (5.12) is much lower than average *CF* value at all the included stations (16.37). It means that there is a kind of compensation of number of migrants passing through different stations. At the moment it is not clear what is the mechanism of this phenomenon - fluctuations of number at breeding grounds and compensation mechanisms at level of a breeding distribution and young production or shifts in migration pattern.

Despite generally low level of fluctuations in pooled data there are few years, when the yearly values deviated much from the smoothed curve. They are pointed at Figure 3. The high value for 1964 was caused by very strong migration at Hel (+172% from the smoothed curve value for this station) and Bukowo (+84%); for 1968 - high catches at the stations neighbouring in the East: Rybatchy (+116%) and Mierzeja Wiślana (+81%); for 1981 - good migration through the western route: Ottenby (+42%), Bukowo (+56%) and Helgoland (+56%). Very low total value for 1967 had the best expression at Hel, where the number of Willow Warblers was 190% under the local moving average and Mierzeja Wiślana (-78%). These territorial coincidences shows that such deviations are not simply "measurement errors" and that they should be studied deeper in the future.

Chiffchaff (*Phylloscopus collybita*)

General data on frequency of trapping, number fluctuations and population dynamics of Chiffchaff is presented in Table 2. Chiffchaff is less common on migration than Willow Warbler and in average 136.6 individuals were caught per season at one station. The extreme values were remarkably different - the highest level was recorded at Mettnau (897.9 ind. per season), while at Hel only 17.6 individuals per season. Relatively high numbers were at Pape, Reit, Illmitz and Falsterbo (over 100 ind.). The differences can be caused by local conditions, catching intensity and technique as well as differentiated location in relation to migration pattern of the species. This is, however, a problem for separate analysis taking under consideration more species.

Level of yearly fluctuations in numbers of Chiffchaff is similar to that of Willow Warbler if we take under consideration the average of values calculated for six main stations separately ($CF = 17.82$). However, there are extreme deviations in other stations - at Tankar *CF* reached value 114.8, which was caused by enormous number in 1984 (over 5 times more individuals caught than in average); at Reit *CF* equals only 2.85, what is unusually low value for this coefficient, while at Mettnau, where there was 5

Table 2

General data on Chiffchaff number dynamics at different bird stations

Station	Period / No of years	Ind. per season	*CF*	*R* 1961-86	*R* 1974-83	*R* 1980-88	*R* Max.
Mierzeja Wiślana	1961-90	50.8	16.85	–2.03~	–14.80**	—	—
	30			–2.14**	–11.76**	–0.57~	–2.59**
Hel	1961-86	17.6	27.65	—	—	—	—
	26			–7.04**	9.67~	—	–7.04**
Bukowo	1961-90	35.5	15.53	–6.75**	–6.53~	—	—
	30			–6.33**	–6.58**	–10.63**	–6.01**
Helgoland	1961-88	37.8	13.89	–0.36~	5.62~	—	
	28			0.17~	5.27**	–0.53~	0.72~
Ottenby	1961-88	42.4	17.71	1.28~	0.93~	—	
	28			1.58**	2.38~	–5.43*	1.52**
Rybatchy	1961-86	34.8	12.3	2.51~	–7.40~	—	
	26			2.38**	–7.99**	—	–2.38**
POOLED N = 6 198			5.09	–2.12*	–5.82~	—	
				–2.02**	–4.98**	—	–2.45**
Pape	1971-89	103.8	29.58	—	5.38~	—	
	19			—	8.07**	–4.58**	1.72~
Tankar	1972-88	81.8	114.8	—	16.95*	—	
	17			—	22.25**	–0.28~	12.68**
Reit	1974-83	183.6	2.85	—	2.48~	—	
	10			—	2.81~	—	2.81~
Mettnau	1974-83	897.9	9.77	—	–2.86~	—	
	10			—	–2.25~	—	–2.25~
IIlmitz	1974-83	143.6	4.82	—	–1.67~	—	
	10			—	–1.45*	—	–1.45*
Falsterbo	1980-88	106.3	9.7	—	—	—	
	9			—	—	10.83**	10.83**
Sörve	1981-88	39.6	25.05	—	—	—	
	8			—	—	—	–2.43~

Explanations: *CF* – coefficient of fluctuations; *R* – coefficient of regression, calculated from raw (above) and smoothed data;

statistical significance: ** – $p < 0.01$, * – $0.05 > p > 0.01$, ~ – $p > 0.05$.

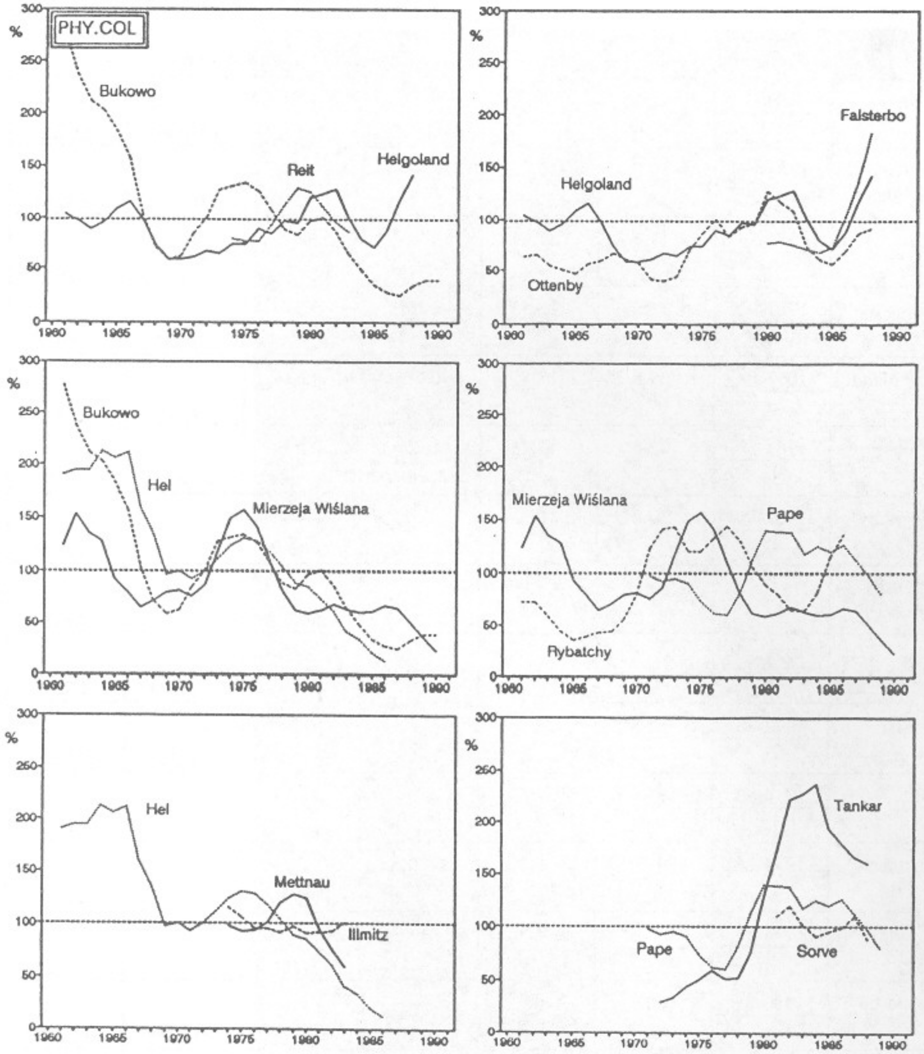

Fig. 4. Population dynamics of Chiffchaff at different stations (smoothed data)

times more Chiffchaffs this coefficient is three times higher. The CF value for pooled numbers at six main stations is much lower than the above mentioned average and equals only 5.09, which is just at the level for Willow Warbler. This points at the same

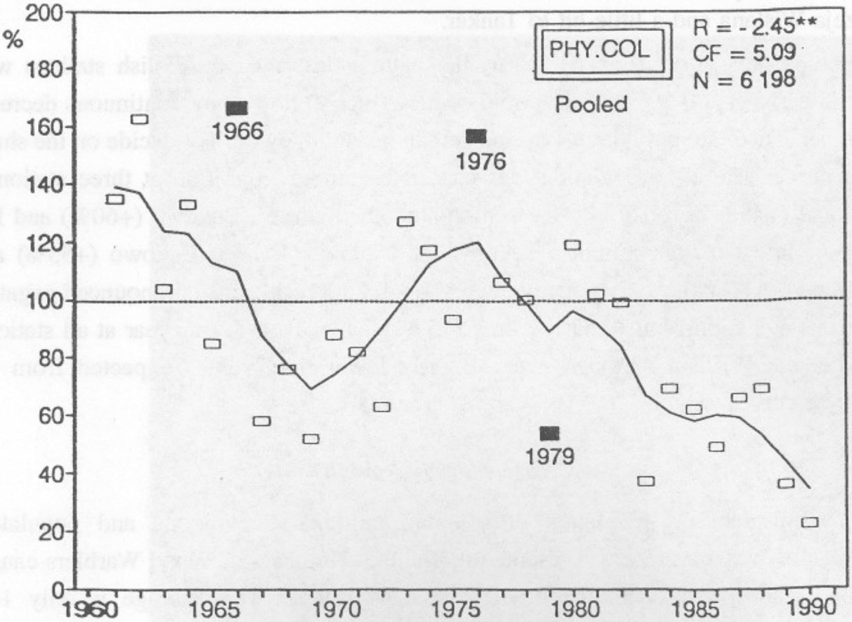

Fig. 5. Population dynamics of Chiffchaff – data pooled for six main stations. Explanations as Fig. 3.

compensation problem as it was stressed in the discussion of Willow Warbler number fluctuations.

Number trends in Chiffchaff are more differentiated than those in Willow Warbler. In the comparable period 1974-1983 they are negative at 5 stations (*R* between –14.80, raw, Mierzeja Wiślana to –1.45, smoothed, Reit) and positive at 6 ones (*R* from 0.93, raw, Ottenby to 22.25, smoothed, Tankar). For six main stations the long-term trends (these for more than 25 years) are partly positive (Helgoland, Ottenby, Rybatchy – *R* up to 2.38) and partly negative (Mierzeja Wiślana, Hel, Bukowo – *R* up to –7.04). *R* coefficient calculated for pooled data is –2.45 and it is statistically significant.

The shapes of number curves for stations (Fig. 4) can be grouped as follows: (1) Helgoland, Ottenby and Falsterbo - similar shapes of curves, especially in the 70-ies and the 80-ies, with final increase of numbers in late the 80-ies, (2) Bukowo, Hel, Mierzeja Wiślana – common peaks in early the 60-ies and mid of the 70-ies, followed by continuous decrease since 1975. Rybatchy and Pape have very different curves and clearly unlike Mierzeja Wiślana - the only similarities to others are mid 80-ies increase at Rybatchy similar to that at Ottenby and Pape's curve shape in the 80-ies, similar to Mierzeja Wiślana and a little bit to Tankar.

Pooled data curve (Fig. 5) follow the pattern described for Polish stations with peaks in early the 60-ies and in the mid of the 70-ies, followed by continuous decrease in number. There are only three extreme deviations and they did not decide on the shape of the curve. The 1966 deviation was caused by strong migration at three stations - Helgoland (+48% in relation to the station smoothed curve), Bukowo (+60%) and Hel (+206%); in 1976 high numbers occurred at Ottenby (+77%), Bukowo (+55%) and Helgoland (+51%); the 1979 negative deviation did not result from pronounced negative deviations at stations, but Rybatchy only (–57%) – however, in this year at all stations, but Mierzeja Wiślana, numbers were slightly lower than values expected from the smoothed curves.

Wood Warbler (*Phylloscopus sibilatrix*)

General data on frequency of trapping, number fluctuations and population dynamics of Wood Warbler is presented in Table 3. Numbers of Wood Warblers caught are the smallest out of more common Leaf Warblers - the average is only 14.4 individuals per season at station. The most numerous were at Ottenby (47.9 ind.) and Rybatchy (45.0 ind.), where, surprisingly, they were more common than Chiffchaffs. Relatively good numbers were at Falsterbo and Sörve, moderate - at Pape and Illmitz. At other stations Wood Warblers were really rare and their numbers do not exceed 7 individuals per season. For this reason the indices characterising migration and population dynamics should be treated more cautiously than in other discussed species.

The level of yearly fluctuations was high (mean *CF* calculated for six main stations equals 60.22), what is not surprising, because of low numbers causing high level of accidental deviations. However, it is interesting that *CF* value for Ottenby (9.63) is three times lower than for Rybatchy (26.99), despite the stations have the same numbers of birds caught. Surprisingly low *CF* values were found at Illmitz (4.86), where this value is at the level of *CF* value for Willow Warbler and Chiffchaff and at Falsterbo (5.46), where this value is even lower than those for other species of Warblers. Both these stations have moderate numbers of Wood Warblers caught. The other surprise can be met when *CF* value is calculated for pooled data set from six main stations - the value is over six times lower than average of stations values, while this relation in Willow Warbler and Chiffchaff is at a level of three fold. The low *CF* value for pooled data suggests that general regression coefficient *R* for these data can be accepted as a measure of the population welfare of the species in the northern Europe. The negative

Table 3

General data on Wood Warbler number dynamics at different bird stations

Station	Period	Ind. per season	*CF*	*R*			
	No of years			1961-86	1974-83	1980-88	Max.
Mierzeja Wiślana	1961-90	6.8	71.97	–13.06**	–26.52*	—	
	30			–13.00**	–21.29**	14.63**	–8.47**
Hel	1961-86	1.3	108.76	—	—	—	—
	26			–18.36**	–7.96~	—	–18.36**
Bukowo	1961-90	2.6	71.65	–9.82~	21.62*	—	
	30			–2.51~	17.20**	–7.72~	–0.49~
Helgoland	1961-88	1.9	72.35	0.64~	–20.07~	—	—
	28			0.57~	–19.01**	–5.18**	–0.04~
Ottenby	1961-88	47.9	9.63	2.62*	5.56~	—	—
	28			2.97**	7.23**	7.50**	3.44**
Rybatchy	1961-86	45.0	26.99	3.93*	4.65~	—	—
	26			3.86*	4.53**	—	3.86~
POOLED N = 2 699			9.58	–4.42**	–3.52~	—	—
				–4.73**	–2.92~		–3.21**
Pape	1971-89	11.4	59.49	—	13.00~	—	—
	19			—	8.05**	2.78~	2.76*
Tankar	1972-88	—	—	—	—	—	
	17			—	—	—	—
Reit	1974-83	0.6	—	—	—	—	
	10			—	—	—	—
Mettnau	1974-83	4.3	28.48	—	–7.44~	—	
	10			—	–8.04**	—	–8.04**
IIlmitz	1974-83	14.5	4.86	—	10.22*	—	
	10			—	9.50**	—	9.50**
Falsterbo	1980-88	24.0	5.46	—	—	—	
	9			—	—	–1.13~	–1.13~
Sörve	1981-88	26.75	6.92	—	—	—	—
	8			—	—	—	—

Explanations: *CF* – coefficient of fluctuations;

R – coefficient of regression, calculated from raw (above) and smoothed data;

statistical significance: ** – $p < 0.01$, * – $0.05 > p > 0.01$, ~ – $p > 0.05$.

trend (R = -3.21) is statistically significant and it is a little bit larger than for other discussed species. The long-term trends are significantly positive at the stations with the highest number of Wood Warblers migrating (Ottenby and Rybatchy), significantly negative at Mierzeja Wiślana and Hel and not significantly negative at Helgoland and Bukowo. Taking under consideration all stations, the trends are positive at stations with

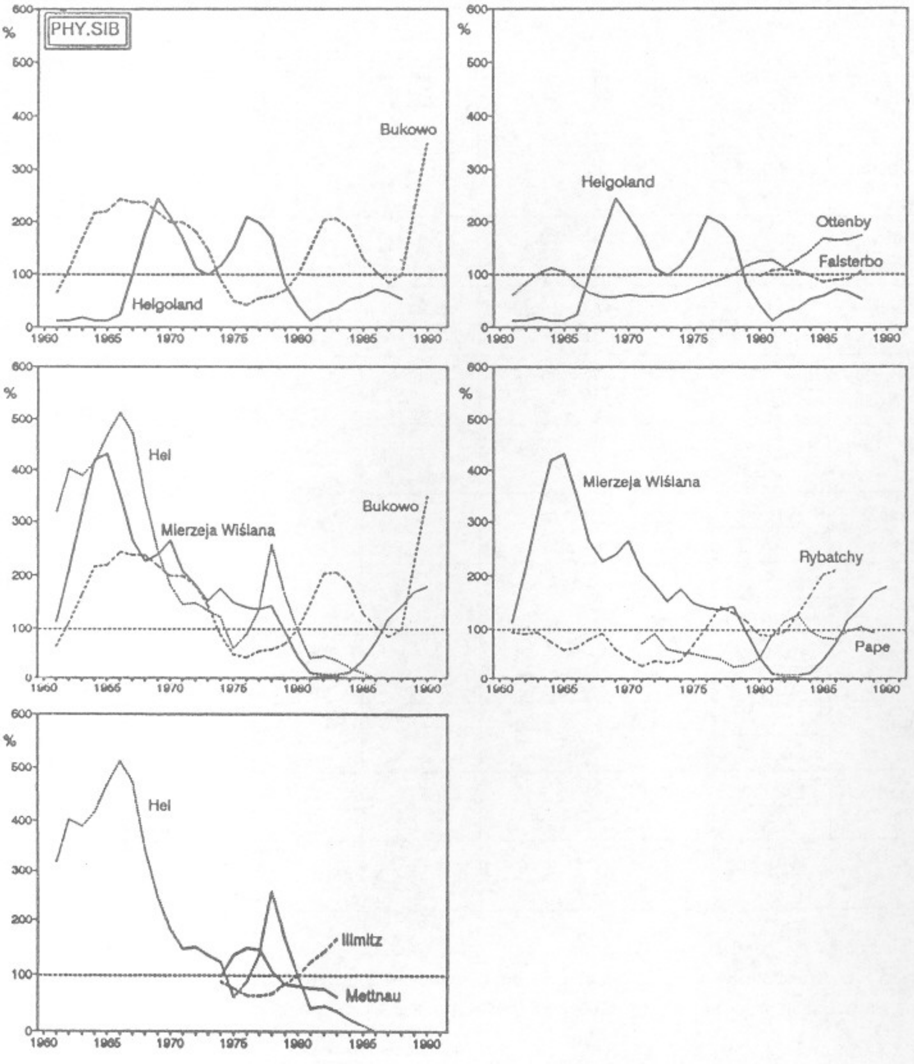

Fig. 6. Population dynamics of Wood Warbler at different stations (smoothed data)

higher numbers of migrating Wood Warblers and negative at stations with low number of migrants. The causes of this rule cannot be explained at the moment.

The shapes of population dynamics curves (Fig. 6) cannot be clearly grouped as they are extremely differentiated. Only the curves for Mierzeja Wiślana, Hel and Bukowo are similar in the 60-ies and beginning of the 70-ies, but then they are very different. Even the curves for Ottenby and Rybatchy, the stations having the same positive trend, are dissimilar.

Figure 7 shows that yearly values of pooled data do not deviate from the smoothed curve especially more than in Willow Warbler and Chiffchaff. The low value in 1961 can be an artefact caused by later than in other years beginning of the work at three Polish stations - Wood Warbler migrates so early that it cannot be correctly represented in the period covered by this year work. As 1961 is the border year of the series the influence of this deviation on the shape of smoothed curve is well pronounced. Elimination of this year value would give higher negative trend for the species. The negative deviation in 1968 does not influenc the shape of the smoothed curve. It was the combined result of low catches at three Polish stations and high ones at Helgoland and Rybatchy. Very high value for 1978 was caused by very good catches at three

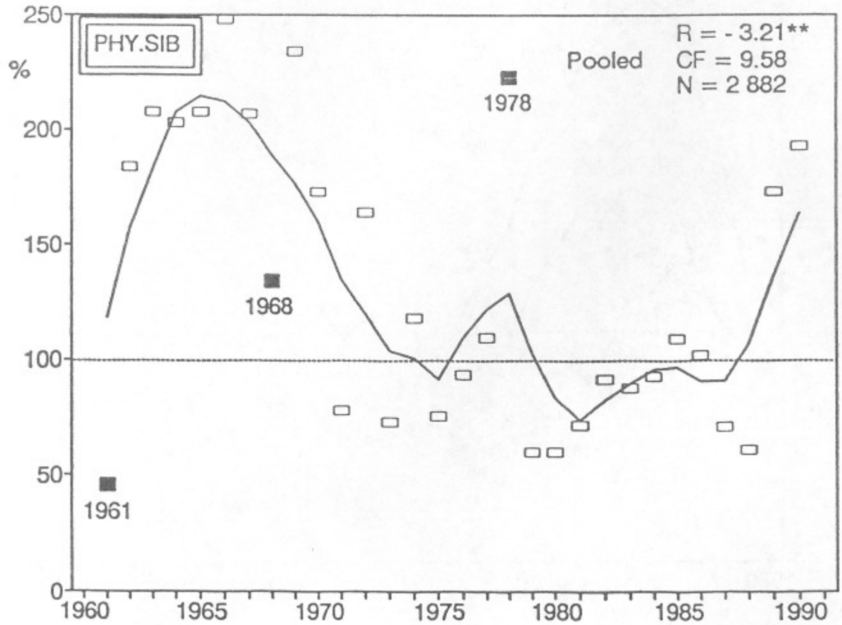

Fig. 7. Population dynamics of Wood Warbler – data pooled for six main stations. Explanations as Fig. 3.

stations - Helgoland, Hel and Mierzeja Wiślana. These are the stations with usually weak migration of the species, so the local peak of the pooled curve is rather of small importance in evaluation of general population dynamics.

Comparison of population dynamics of three species

The correlations between fluctuations (raw data) and trends (smoothed population dynamics curves - Fig. 5) of three discussed species calculated from data pooled for six main stations are presented in Table 4. There are statistically significant positive correlations between population dynamics of Willow Warbler and Chiffchaff as well as Willow Warbler and Wood Warbler. There is, however, no significant correlation between Chiffchaff and Wood Warbler. This simple statement became to be doubtful when these relations are studied at the stations separately (Table 5). In all interspecific relations the correlation coefficients are differentiated very much – from null (e.g. 0.01 – *Ph. collybita – Ph. trochilus*, Ottenby, fluctuations) to nearly one (0.96 – *Ph. trochilus – Ph. sibilatrix*, Mierzeja Wiślana, smoothed data). Many of *r* values are statistically highly significant. The example comparison of population dynamics patterns at two stations is given at Figure 9. Extreme differentiations

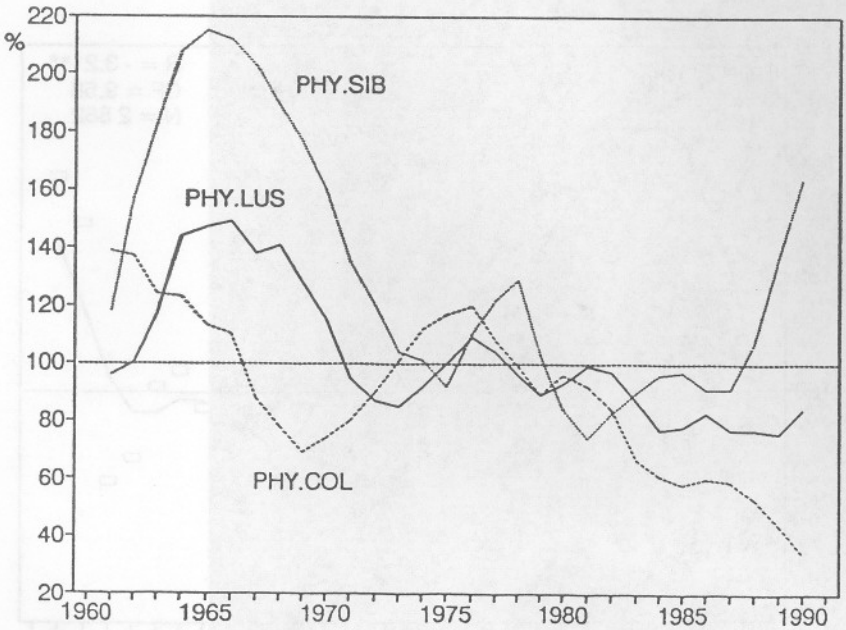

Fig. 8. Population dynamics of Willow Warbler (PHY. LUS), Chiffchaff (PHY.COL) and Wood Warbler (PHY.SIB) – pooled data.

can be found even in one pair of species (Fig. 10). It seems that at the background of this surprising picture lies complicated situation resulting from differentiated migration patterns of studied species. This is the next problem for further studies.

SUMMARY

1. Yearly fluctuations around smoothed (by five year moving average) number dynamics curves are much differentiated (*CF* values examined) at separate stations.

Table 4

Comparison between pooled number dynamics data of three studied species.
As "correlations" – Pearson's r values are given.

	R	*CF*	Correlations: fluctuations (raw data)		Correlations: trends (smoothed data)	
Ph.collybita	–2.45**	5.09	X 0.36*	X	X 0.51**	X
Ph.trochilus	–1.90**	5.12	X 0.40*	0.03~	X 0.83**	0.21~
Ph.sibilatrix	–3.21**	9.58	X	X	X	X

Explanations: *CF* – coefficient of fluctuations;
R – coefficient of regression;
statistical significance: ** – $p < 0.01$, * – $0.05 > p > 0.01$, ~ – $p > 0.05$.

Table 5

Correlations between population dynamics of Willow Warbler, Chiffchaff and Wood Warbler at six stations.

Correlation coefficients (Pearson's *r*) and level of confidence are given
PHY.COL – *Ph. collybita*, PHY.LUS – *Ph. trochilus*, PHY.SIB – *Ph. sibilatrix*

Raw data	HD	BU	HL	OT	MW	RB	Pooled
PHY.LUS – PHY.COL	0.09~	0.50**	0.58**	0.01~	0.33~	0.19~	0.36*
PHY.LUS – PHY.SIB	0.14~	0.39*	0.23~	0.53**	0.75**	0.42*	0.40*
PHY.COL – PHY.SIB	0.10~	0.39*	0.31~	0.01~	0.21~	0.21~	0.03~
Smoothed data	HD	BU	HL	OT	MW	RB	Pooled
PHY.LUS – PHY.SIB	0.06~	0.52**	0.31~	0.31~	0.28~	0.03~	0.51**
PHY.LUS – PHY.SIB	0.39*	0.77**	0.58**	0.58**	0.96**	0.41*	0.83**
PHY.COL – PHY.SIB	0.64**	0.83**	0.38*	0.38*	0.31~	0.17~	0.21~

HD – Helgoland, BU – Bukowo, HL – Hel, OT – Ottenby, MW – Mierzeja Wiślana, RB – Rybatchy
Statistical significance: ** – $p < 0.01$, * – $0.05 > p > 0.01$, ~ – $p > 0.5$.

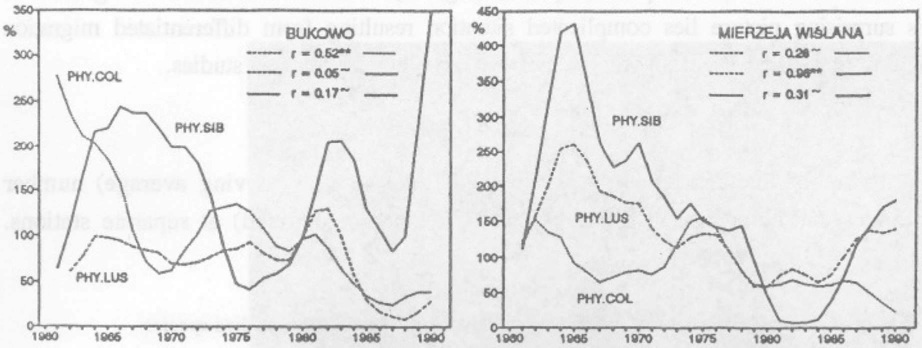

Fig. 9. Population dynamics of Willow Warbler (PHY. LUS), Chiffchaff (PHY.COL) and Wood Warbler (PHY.SIB) – at Bukowo and Mierzeja Wiślana. Pearson's *r* coefficients are given with significance signs (see - Fig. 3)

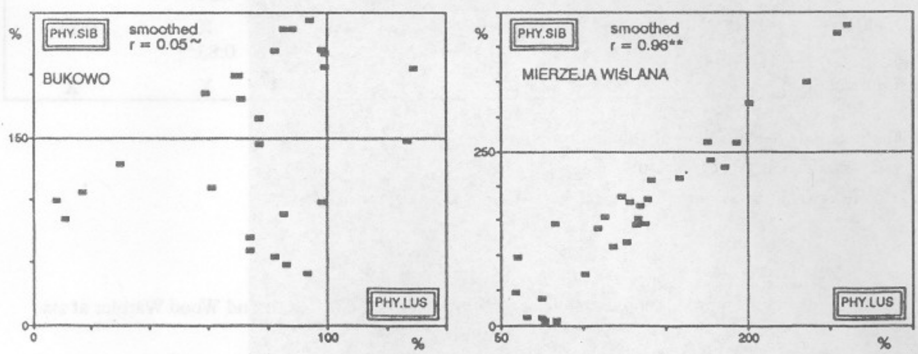

Fig. 10. Correlation of Willow Warbler (PHY.LUS) and Wood Warbler (PHY.SIB) smoothed curves at Bukowo and Mierzeja Wiślana. Pearson's *r* coefficients are given with significance signs (see – Fig. 3)

When data pooled for species at six main stations were studied Willow Warbler and Chiffchaff show lower values of *CF* (5.12 and 5.09 respectively) than Wood Warbler (9.58); these values are much lower than averages for stations.

2. The population trends at the stations were differentiated with examples of both decrease and increase of numbers. However, regression coefficient values for long-term series of pooled data were all negative (Willow Warbler – $R = -1.90$, Chiffchaff – –2.45, Wood Warbler – –3.21) and they all were statistically highly significant.

3. Population dynamics curves for pooled data were positively correlated between Willow Warbler and Chiffchaff as well as between Willow Warbler and Wood Warbler (highly significant), but correlation between Chiffchaff and Wood Warbler was low and not significant. At the level of separate stations values of correlation coefficient were differentiated so much that further studies of the problem are necessary.

4. Evaluation of migration monitoring data from number of stations covering larger territory and few species simultaneously points at number of new problems connected with interpretation of the results. These are interpretation

- of differences in numbers of birds caught at the stations,
- of the level of yearly fluctuations at the stations and the pooled data,
- of correlation of number dynamics of the species between stations, and
- of correlations between species population dynamics.

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