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Habitat selection and winter food resources of the Water Pipit *Anthus spinoletta* in south-western Poland

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Abstract. In winter 2004/2005, 1532 Water Pipits were recorded during 37 censuses carried out along an established route on a sewage farm flooded with wastewater (Wrocław, SW Poland). Single birds were seen in nearly 39% of all 299 encounters, while the largest concentrations, between 16–28 individuals, accounted for 9%. 78% of all birds were observed on meadows flooded with communal wastewater. The remaining ones stayed around irrigation ditches (n = 172, 11.5%), sedimentation basins (n = 88, 5.9%) and reedbeds (n = 72, 4.8%). The mean size of the Water Pipit concentration was largest on the meadows (mean ± SE = 6.54 ± 0.50 individuals) and smallest at the sedimentation basins (mean = 1.44 ± 0.14). In this winter season (December-first half of March), rainfall enlarged numbers of birds to forage on the meadows, and the thickness of the snow cover was positively correlated with bird abundance at the sedimentation basins. The dominant available prey items inhabiting the warm wastewater were Diptera larvae (96%), 88% of which belonged to the genus *Eristalis*. The mean (± SD) invertebrate biomass was highest in the basin sediments (1.03 ± 1.14 g/dm^3 of deposits), and lowest on the flooded meadows (0.20 ± 0.37 g/dm^3 of deposits). The results point to the significance of the artificial environmental conditions created by warm sewage water, which enable the birds to remain largely independent of the weather and thus to overwinter in a cold region of central Europe.

Key words: Water Pipit, *Anthus spinoletta*, sewage deposits, Dipteran larveae, *Eristalis* sp., flocking behaviour, weather conditions, winter

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INTRODUCTION

The Water Pipit migrates in winter from central European mountains to the north of the continent (Witt 1982, Cramp 1998). Our current knowledge of Water Pipit wintering in central Europe is limited to the lists of records and descriptions of habitats where the birds were spotted (Witt 1982). This is certainly caused by identification difficulties, resulting from the species' remarkable shyness, extensive dispersion and small flocking tendency throughout its wintering range, which make the birds elusive to the observers (Johnson 1970, Lewartowski et al. 1988, Cramp 1998). In western Europe the Water Pipit wintering grounds are concentrated around inland waters, including those highly contaminated with sewage, freezing in temperatures below 0°C (Witt 1982). Also in western Poland nearly 60% of the observations during the 1970s were made around sewage basins (Lewartowski et al. 1988). A small number of records east of Odra river (see Witt 1982, and data compiled in Tomiałojć & Stawarczyk 2003) is most probably a result of much lower winter temperatures in this part of Europe that cause freezing of waters and make it impossible for birds to feed in natural biotopes.

To my knowledge, no studies describing habitat selection and food composition of Water Pipit wintering in western Europe or dealing with the impact of weather conditions on its social behaviour and habitat use have been published so far. The breeding biology and ecology of the species have been much better recognized, as a result of detailed research carried out on the central European populations in Alps (e.g. Brodman & Reyer 1999 and references herein) and Sudete Mts. (Jeseniky, e.g. Bures 1994 and references herein). Among the best known aspects of Water Pipit wintering ecology in Europe is its daily activity, which was the subject of a study on a sewage farm near Berlin in 1974–1984 (Witt 1984).

The aim of the current study is to present the abundance dynamics of Water Pipits wintering in artificial habitats on a sewage farm supplied with warm wastewater in south-western Poland and to determine the food resources of the used biotopes as well as the relationships between weather conditions, flock sizes and habitat use.

MATERIALS AND METHODS

Study area and bird counts

The research was carried out on a sewage farm situated in northern, peripheral part of Wrocław city (640 000 inhabitants; 17°02′E, 51°07′N, SW Poland). Meadows in this area for over 100 years have been subject to regular communal wastewater flooding, via an extensive, many kilometer long network of irrigation canals. The Water Pipit survey was conducted within a study plot comprising a mixture of biotopes typical for the area. It constituted ca. 15% (190 ha) of the entire sewage farm (1422.5 ha). The research focused on four separate biotopes: extensively used meadows flooded periodically with wastewater (170 ha), ten sewage sedimentation basins (total area = 6 ha), irrigation ditches (total length = 1500 m) and parts of four reedbeds (ca. 15 ha). The counts (n = 37) were carried out every 4–5 days, between 14 December 2004 and 20 April 2005, always along the same route. The number of birds was established on the basis of a detailed observation of the area with a spotting scope (20–60x102 mm), followed by flushing the birds from the more sheltered places. The reedbeds were controlled along their edges, with birds taking flight even at over 50 m distance. Places where Water Pipits stayed during the census were noted and assigned to one of the four specified habitats (meadow, sedimentation basin, ditch, reedbed). Due to a very loose nature of the foraging flocks in this species (e.g. Johnson 1970, Cramp 1998) all birds taking flight simultaneously or feeding up to 50–100 m apart were treated as a single flock. In cases when birds from the same flock stayed in different biotopes (e.g. ditch and meadow) the flock size (the total number of all individuals) and the biotopes used were analysed separately (it mean that birds from one flock were attributed to one or more biotopes). This is why the number of flocks (n = 299, including cases where only single birds were seen) is smaller than the number of groups of birds which was used to assess the habitat preferences (n = 346). The separate category was formed by the birds just passing above the study area. The time between 14 December and 12 March (from the 1st to 26th census) was assumed to be the wintering period. The counts were made during calm, dry weather, between 10 a.m. and the sunset.

Weather conditions

In order to determine the relationship between the weather conditions, flock size and habitat preferences of Water Pipits, records from the meteorological station of Wrocław Agricultural University (Wrocław-Swojec, 10 km from the study area, 17°12′E, 51°12′N) were used. The following values were used in the analysis: mean daily air temperature (T_{mean}), minimum daily air temperature (T_{min}), minimum daily air temperature 5 cm above ground ($T_{min+5\ cm}$), maximum daily air temperature (T_{max}) as well as the occurrence (yes or not) and amount (mm) of precipitation (only rain) and snow cover.

Weather conditions during the Water Pipit wintering period were varied. The mean daily temperature in December was 1.74°C (min-max = -4.4–7.2°C), in January 2.05°C (min-max = -6.1–9.5°C) and in February -1.5°C (min-max = -7.8–4.4°C). There were no days with maximum temperature below 0°C in December, six such days were in January, and four in February. March, however, was surprisingly cold, the first half of this month being one of the coldest spells of the whole winter 2004/2005. As many as 7 days with maximum temperature below 0°C were recorded in the first decade of March, and the mean daily temperature for this period amounted to barely -4.4°C (min-max = -8.3–0.9°C). There were 44 days with snow cover between December and the end of March. The longest period of snow cover presence (up to 21 cm) occurred on the turn of February (31 days in total).

Analysis of sediment invertebrates

A total of 46 samples of sediments were collected to analyse the invertebrate composition of three types of habitats: 5 samples from each of three sedimentation basins, 5 from each of three irrigation ditches and 16 samples from three separate parts of the flooded meadows. The analysis did not involve reedbeds, where sediments were frozen at the time of collecting. The samples were gathered on 24 (with 10 cm snow cover and temperature ca. 0°C) and 28 February 2005 (with 10 cm snow cover and ca. -5°C), from the upper layer of deposits (1–2 cm). In the sedimentation basins and ditches they contained mainly communal waste, decaying plant matter and a thick muddy substance resulting from sewage sedimentation. The last two components dominated also in sediments collected on meadows. The total weight of all samples was 18 212 g (mean weight of sample ± SD = 395.9 ± 85.8 g). In order to isolate the invertebrates, the sediments were rinsed in the laboratory with running water on two sieves (15 cm diameter) with 5 and 2 mm mesh size. Once isolated, the invertebrates were weighed (with 0.001 g accuracy) on an electronic scales and conserved in ethanol for further identification. Due to the different mass of particular samples, resulting from diverse sediment composition (containing both communal waste and plant stalks) the invertebrate abundance was calculated per 100 g of deposits. The mean weight of 1 dm^3 of sediments amounted to 1410 g.

Statistical analysis

Due to the fact that most analysed variables did not have the normal distribution, the non-parametrical statistical methods were applied in the analysis. The differences in the average mass and number of invertebrates in sediments and the average size of Water Pipit flocks in the studied biotopes were examined with Kruskal-Wallis and Mann-Whitney test. In order to determine the Water Pipit abundance in winter (December-half of March) and during the whole study period, the simple regression analysis was used. The relationships between the flock size and the weather conditions were tested with Spearman rank correlation coefficient. The Water Pipit numbers in the four studied biotopes in consecutive months were compared with χ^2 test. The probability $p \leq 0.05$ was assumed as the significance level. Excel and Statistica 5 software were used for the statistical analysis.

RESULTS

Flock size and used habitat

Water Pipits were recorded in all but one of 37 censuses, with the last two individuals seen on 17 April. There were no more birds around during the last visit to the area (20 April). A total of 1532 individuals were recorded; 1497 out of that number were assigned to one of the four specified biotopes. The remaining birds (n = 35) only passed over the study area. The Water Pipit abundance from December to the first half of March, despite the big differences in consecutive censuses remained at roughly the same level (lack of trend significance for 26 counts in this period, $r^2 = 0.06$, $p = 0.23$). A clear drop of

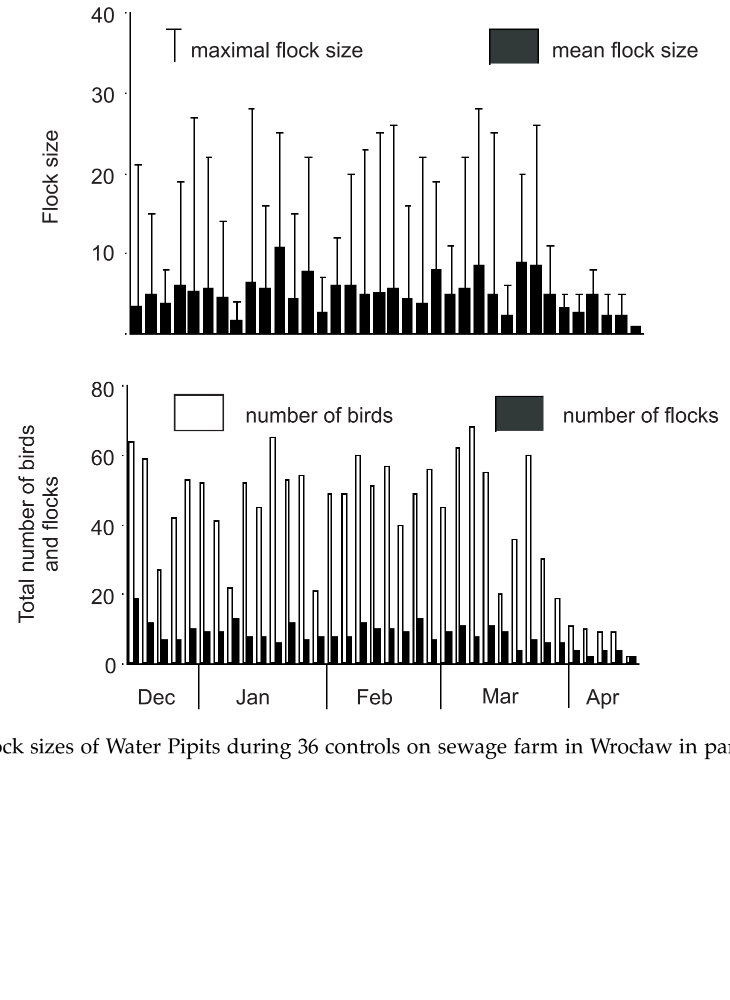

Fig. 1. Abundance and flock sizes of Water Pipits during 36 controls on sewage farm in Wrocław in particular months of winter 2004/2005.

abundance became visible from the second half of March (trend for 37 counts during the whole study period, $y = -1.96x + 65.93$, $r^2 = -0.51$, $p < 0.0001$, Fig. 1).

During the whole study period single birds were most frequently observed (38.5% of all encounters, Fig. 2), and the largest concentrations had 28 individuals (Fig. 1). The mean size (± SE) of Water Pipit concentration (n = 299, including observations of single birds) during 37 censuses amounted to 5.01 (± 0.35) individuals. The largest average Water Pipit concentrations were recorded in February (mean = 5.56 ± 0.80, n = 71), and the smallest in March (mean = 2.56 ± 0.52, n = 16). However, the differences in average flock sizes from December to April were not statistically significant (Kruskal-Wallis test, $H_4 = 2.95$, $p = 0.57$, n = 299).

Seventy eight percent of all birds were seen around the flooded meadow fragments (n = 1165), 11.5% (n = 172) in ditches, 5.9% (n = 88) in sediment basins and 4.8% (n = 72) in reedbeds (Fig. 3). No pipits were spotted on dry meadows, not flooded with wastewater. The share of birds in the four biotopes from December to March was similar (χ^2-test, $\chi^2 = 11.27$, $p < 0.30$, df = 9).

The average Water Pipit abundance was highest on meadows (mean ± SE = 6.54 ± 0.50), and lowest around the sedimentation basins (mean = 1.44 ± 0.14; Fig. 3). The differences in the average number of birds between the four studied biotopes were statistically significant (Kruskal-Wallis test, $H_3 = 87.47$, $p < 0.0001$, n = 346). Sixty three (4.2%) out of 1497 watched foraging individuals (some of them flushed during the census) perched on nearby trees.

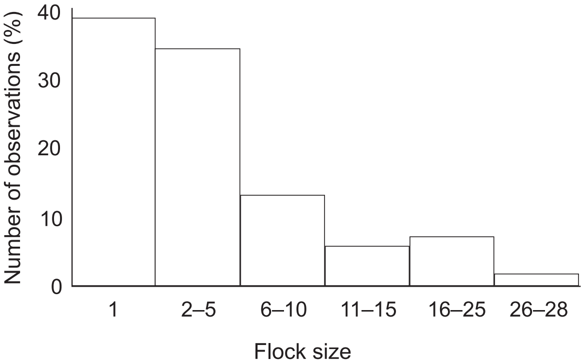

Fig. 2. Percentage distribution of 299 Water Pipit flock sizes (1497 individuals) recorded on Wrocław sewage farm between December 2004 and April 2005.

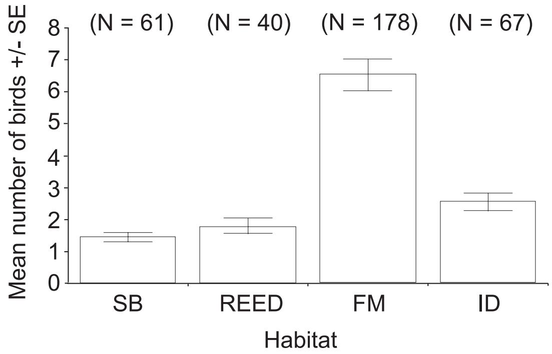

Fig. 3. The average number (± SE) of the Water Pipits recorded in four surveyed habitats. Habitat abbreviations,: SB — sediment basins, REED — reedbeds, FM —flooded meadows, ID — irrigation ditches. The numbers above the bars indicate the total number of birds recorded in the given habitat.

Influence of weather conditions

Spearman rank correlation coefficients between flock size and the analysed weather conditions were statistically significant only for the entire study period, which is undoubtedly the result of birds leaving the wintering sites, in March-April; the effect of spring departure or time effect, and rising temperatures around that time, and in one case ($T_{+5\ cm}$ vs flock size) for winter period (Table 1). No statistically significant differences were found between days with (mean ± SD = 4.9 ± 6.1, n = 189) or without snow cover (mean ± SD = 5.2 ± 6.1, n = 110) (Mann-Whitney test, U = 9606.0, p = 0.27), nor between days with temperature below or above 0°C (average flock size on days with $T_{max} \leq 0$°C: 5.0 ± 6.2, n = 264 vs days with $T_{max} > 0$°C: 5.2 ± 5.8, n = 35, U = 4181.5, p = 0.36).

For all 36 counts from the entire study period, the Water Pipit abundance on meadows, irrigation ditches and basins was negatively correlated with air temperature (proved only for T_{max}). The precipitation affected positively the abundance of Water Pipits feeding on meadows, while the thickness of snow cover was positively correlated with the number of birds staying at the sedimentation basins (Table 2). However, just as the above mentioned relationship between flock size and weather conditions, these relations are largely distorted by the wintering grounds departure effect (March–April) and the spring rise of temperature. The analogical results from the wintering period, when the similar number of birds stayed in the study plot, seem to be much more reliable (Fig. 1). In the case of 26 censuses

Table 1. Spearman rank correlation coefficients between the Water Pipit flock sizes and weather conditions. Total — for 299 flocks (incl. single birds), Flocks — for 260 flocks, MF — mean flock size during one control, TF — total number of flocks during one control. Significance level: * — p ≤ 0.05, ** — p < 0.01.

Weather factor	All controls (Dec.–April, N = 36)			Winter controls (Dec.–first half of March, N = 26)		
	Total	MF	TF	Flocks	MF	TF
T_{mean}	-0.14*	-0.36*	-0.41*	-0.11	-0.08	0.13
T_{min}	-0.11*	-0.34*	-0.31	-0.11	-0.09	0.15
T_{max}	-0.09	-0.26	-0.45**	-0.10	-0.004	0.14
$T_{+5\ cm}$	-0.15*	-0.29	-0.24	-0.13*	-0.16	0.28
Rainfall	0.06	0.29	0.29	0.05	0.07	0.15
Snow cover	0.08	0.12	0.25	0.09	0.14	-0.07

from this period, statistically significant, positive correlations were found between the rainfall and the bird abundance on meadows as well as between the thickness of snow cover and abundance at the sedimentation basins and in all controlled area (Table 2). The average number of Water Pipits recorded on meadows during rainy days (n = 9, mean ± SD = 45.1 ± 6.7 individuals) was significantly higher than on days without rainfall (n = 13, mean ± SD = 32.5 ± 11.4 ind.) (Mann-Whitney test, U = 22.50, Z = -2.40, p =0.016).

Invertebrates in sediments of different habitats

A total of 83 invertebrates, the overall mass of 8.538 g (mean weight of individual ± SE = 0.103 ± 0.006 g), were found in 46 sediment samples. Eighty (96%) of them were dipteran larvae: *Eristalis* sp. (family Syrphidae, n = 73, 88%), Muscidae (n = 5, 6%) and Dolichopodidae (n = 2, 2.5%). The rest were unidentified invertebrate eggs (n = 2, 2.5%) and an earthworm *Lumbricus* sp. (n =1, 1%). In sediments from irrigation ditches and meadows only *Eristalis* larvae were recorded. Other invertebrates were found only in sedimentation basins.

The mean number and biomass of invertebrates per 100 g of sediments in samples from one biotope were similar (Kruskal-Wallis test, appropriately for number and biomass of invertebrates: sediment basins: H_2 = 5.50 and 5.49, p = 0.08 and 0.06, n = 15; irrigation ditches: H2 = 3.57 and 4.73, p = 0.17 and 0.09, n = 15; flooded meadows: H_2 = 0.84 and 0.64, p = 0.66 and 0.72, n = 16).

Comparison of three different biotopes shows that the mean number and biomass of invertebrates per 100 g was highest in sediment basins and lowest (5 times lower) in flooded meadows (Table 3). The differences in the mean invertebrate density and biomass among the habitats were statistically significant (Kruskal-Wallis test, for number of invertebrates: H_2 = 9.28, n = 46, p < 0.01; for biomass of invertebrates: H_2 = 8.67, n = 46, p = 0.01). In the analysis of particular biotopes the statistically significant differences were found between sediment basins and meadows (Table 3).

Table 2. Spearman rank correlation coefficients between the number of the Water Pipits recorded in four surveyed habitats and weather conditions. Significance level: * — p < 0.05, ** — p < 0.01, *** — p < 0.001.

Habitat	Weather factor					
	T_{mean}	T_{min}	T_{max}	$T_{+5\ cm}$	Rainfall	Snow cover
Data set for the whole survey (36 controls)						
Meadows	-0.41*	-0.41*	-0.36*	-0.35*	+0.52**	+0.12
Sediment basins	-0.28	-0.16	-0.39*	-0.16	-0.04	+0.47**
Irrigation ditches	-0.56***	-0.47**	-0.55***	-0.44**	+0.31	+0.17
Reedbeds	-0.12	+0.01	-0.20	+0.02	-0.10	+0.22
Whole controlled area	-0.57***	-0.51**	-0.52**	-0.44**	+0.47**	+0.25
Data set for December-first half of March (26 controls)						
Meadows	+0.12	+0.05	+0.16	+0.04	+0.49*	-0.05
Sediment basins	-0.21	-0.13	-0.31	-0.11	-0.24	+0.44*
Irrigation ditches	-0.36	-0.25	-0.26	-0.19	+0.16	-0.03
Reedbeds	+0.05	+0.15	-0.03	+0.14	-0.23	+0.19
Whole controlled area	-0.18	-0.15	-0.12	-0.10	+0.48*	+0.13

Table 3. Comparison of the number and biomass of invertebrates in deposits from the three surveyed habitats on sewage farm in south-western Poland.

Habitat (abbreviation)	Mean ± SD (min-max) invertebrates number in 100 g of sediments (g)	Mean ± SD invertebrate biomass in 100 g of sediments (g)
Sediment basins (SB)	0.75 ± 0.73 (0; 0.25-2.36)	0.073 ± 0.081
Irrigation ditches (ID)	0.38 ± 0.37 (0; 0.25-1.07)	0.039 ± 0.043
Flooded meadows (FM)	0.14 ± 0.26 (0; 0.29-0.76)	0.014 ± 0.026
All habitats	0.42 ± 0.54 (0; 0.25-2.36)	0.041 ± 0.059
p-value of post-hoc contrasting comparison (Mann-Whitney test) between different habitats	SB vs FM (p = 0.004) ID vs FM (p = 0.053) SB vs ID (p = 0.28)	SB vs FM (p = 0.006) ID vs FM (p = 0.063) SB vs ID (p = 0.36)

DISCUSSION

Results of the present study show that at least 70 Water Pipits wintered on the area of the Wrocław sewage farm in winter 2004/2005. Probably during all counts (especially in winter) the same birds were observed. Bearing in mind an observation from the previous winter, when on 26th December 2003 (at ca. -10°C air temperature and 15 cm snow cover) a total of 76 Water Pipits were recorded, including a compact flock of 70 individuals feeding on the frozen wastewaters (own observ.), it can be assumed that ca. 80 individuals winter near Wrocław. This value seems to be very high in the light of the current knowledge about Water Pipit wintering in Poland (Tomiałojć & Stawarczyk 2003). So far the wintering Water Pipits were most often seen in Wielkopolska, where in 1970–1998 in total 218 observations, mainly in winter, were made, with the largest flock containing 7 individuals, and the whole wintering population estimated at about 50–80 birds (Lewartowski et al. 1988, Winiecki 2000). According to Winiecki (2000) a drop of winter abundance after 1980 in Wielkopolska was noted, and in the light of the present study results it cannot be ruled out that a shift in the wintering range of some of these birds towards Silesia has taken place. It is worth mentioning that before 1995 Water Pipit was recorded only 6 times on Wrocław sewage farm (Lontkowski 1989, Słychan 1996), which could also be however the result of the observers lacking both an adequate observation methodology and the good quality optical gear allowing the species' identification.

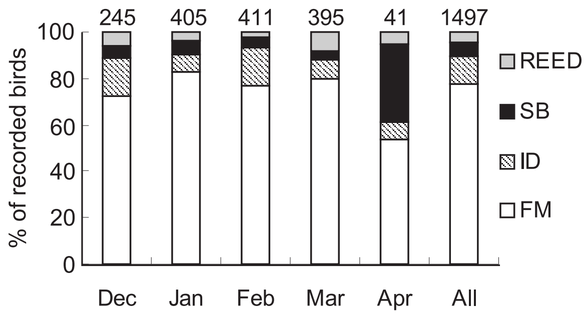

Fig. 4. The share of wintering Water Pipits recorded in four habitat types on Wrocław sewage farm in the consecutive months. The total numbers of birds in each month are given above the bars. Habitat abbreviations as in Fig. 3.

Large differences in the overall number of Water Pipits in consecutive counts (Fig. 1) may result from their movements around the entire area of the sewage farm, which is most probably associated with flooding of uncontrolled parts of meadows. In addition, Water Pipits can move during the day to the feeding grounds up to several km away and use reedbeds as overnight roosting places (van der Berg 1975, Witt 1984). The relationships between temperature and Water Pipit abundance in the four biotopes throughout the whole study period (Table 2) are largely distorted by the spring rise of temperatures and departure of birds from wintering grounds at that time (spring departure effect or time effect). This effect does not exist, however, in the case of precipitation and snow cover. The positive influence of precipitation on Water Pipit abundance on meadows (statistically significant correlations were also proved for winter period; Table 2) was clearly associated with the increased soil moisture, that facilitated prey detection and encouraged the development of Diptera larvae. The positive relationship between bird abundance at the sedimentation basins and snow cover thickness in winter points to the better food availability in this biotope during the snowy period (Table 2).

Although the Water Pipit wintering on sewage farms in central Europe is known for several decades (e.g. the largest concentrations in Berlin reached 150 and in Münster 200 individuals; data compiled by Witt 1982), no assessments of the food resources in this habitat have been made so far. The analysis of wastewater sediments from 3 biotopes (meadows, sediment basins and ditches) of the Wrocław sewage farm showed that the dominant group of invertebrates in winter were dipteran larvae, with 88% share of *Eristalis* sp. Their occurrence in warm wastewater is widespread in sewage treatment plants and sedimentation basins (e.g. Learner 2000), with the elevated water temperature allowing all year round development of invertebrates (Learner & Chawner 1998). *Eristalis* larvae abound in waters highly contaminated with sewage, occurring also in vast numbers in heaps of manure. The observed differences in invertebrate biomass and density between the studied biotopes result most probably from the varying regime of wastewater supplies. It seems, however, that in spite of all these differences, all the biotopes are equally attractive for Water Pipit, as the lowest invertebrate densities on meadows (Table 3) are compensated by the much larger area of this habitat, where many more birds can feed at the same time. Meanwhile, the area suitable for foraging around ditches and sediment basins is restricted to a narrow (up to 0.5 m) belt of sediments along their edges. The foraging association with water-filled ditches was also observed in the closely related Rock Pipit *Anthus petrosus* wintering on Wadden Sea salt marshes (Dierschke & Bairlein 2004). On Wrocław sewage farm Water Pipits were absent from dry parts of meadows, not subject to flooding. Both pipits show therefore a strong association with water edges in winter, which was previously emphasized by many authors (Johnson 1970, van der Berg 1975, Witt 1982, Cramp 1998).

The invertebrate densities in sediments of the Wrocław sewage farm are relatively low compared to other biotopes used by insectivorous birds wintering on meadows and fields of western Europe. Extrapolation of the obtained mean per 1 dm^3 densities by multiplying $\times 100$ every mean value in order to get densities per 1 m^{-2}, yielded the following results: 75 (sediment basins), 38 (ditches) and 14 (meadows) individuals per 1 m^{-2}. These data, however, may be largely biased, due to the different consistency and humidity of sediments, and also because of various sample sizes. For example mean densities of invertebrates in different kinds of arable fields and meadows in central England ranged from 60 (ploughed fields) to 280 (permanent grass) individuals per 1 m^{-2} (Tucker 1992). In Brittany (NW France) in several surveyed biotopes (different forest cultures, stubble fields and meadows with various humidity levels) the invertebrate density was very varied and ranged ($\pm$ SD) from 283 ($\pm$ 199) individuals per 1 m^{-2} in forest to 737 ($\pm$ 390) individuals per 1 m^{-2} on arable fields (Duriez et al. 2005).

An essential factor influencing density and abundance of soil-dwelling invertebrates on arable fields and meadows are weather conditions, including air temperature (e.g. Duriez et al. 2005). It seems however, that under artificial habitat conditions of sewage farms, the weather has only slight impact on soil megafauna, thanks to warm wastewater flooding, that makes the development of invertebrates largely independent of the meteorological conditions (e.g. Learner & Chawner 1998). Food availability, even under unfavourable weather conditions (snow cover, long-lasting below zero temperatures) is the reason why social behaviour and habitat use by Water Pipits are only to a small extent dictated by the climatic factors.

In recent years the organic fertilization of meadows (e.g. with manure or slurry) is becoming increasingly popular. This practice boosts the biomass of soil-dwelling invertebrates, that form the base of diet of many insectivorous birds (e.g. Tucker 1992, review in Vickery et al. 2001, Atkinson et al. 2005). An analogical conclusion can be drawn in relation to the warm wastewater fertilization of sewage farms, which enables the dipteran development in the harsh winter period, unfavourable for most soil invertebrates. Apart from Water Pipits, other bird species were regularly seen feeding on sediments of the Wrocław sewage farm in winter, such as Fieldfares *Turdus pilaris*, Starlings *Sturnus vulgaris*, Corn Buntings *Miliaria calandra*, even exceptionally wintering in Poland Common Snipes *Gallinago gallinago*, Jack Snipes *Lymnocryptes minimus* and Lapwings *Vanellus vanellus* (Orłowski 2005).

Low winter temperatures in central Europe, causing freezing of soil and water surface, are most probably the main obstacle for wintering of many birds relying on soil invertebrates such as some waders (e.g. Lapwing, Golden Plover *Pluvialis apricaria*, Common Snipe) or Starlings (Orłowski 2006), as well as Water Pipit. The artificial habitat conditions created by warm wastewater make the wintering Water Pipits largely independent from meteorological conditions, allowing them to spend winter in cold climate of central Europe.

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STRESZCZENIE

[Wybiórczość środowiskowa i zasoby pokarmowe zimowisk siwerniaka w południowo-zachodniej Polsce]

Zimą 2004/2005 na polach irygacyjnych zasilanych ciepłymi wodami ściekowymi położonych na peryferiach Wrocławia, podczas 37 kontroli prowadzonych na stałej trasie liczeń zarejestrowano 1532 siwerniaki (Fig. 1). Wśród 299 dokonanych obserwacji blisko 39% stanowiły pojedyncze osobniki, a największe koncentracje liczące 16–28 ptaków stanowiły 9% (Fig. 2). Średnia wielkość skupisk siwerniaka była największa na łąkach (średnia ± SE = 6.54 ± 0.50 osobników), najmniejsza zaś przy odstojnikach ścieków (1.44 ± 0.14) (Fig. 3). Siedemdziesiąt osiem procent wszystkich ptaków (n = 1165) odnotowano na łąkach zalewanych ściekami komunalnymi. Pozostałe ptaki przebywały przy rowach nawadniających (n = 172, 11.5%), odstojnikach ścieków (n = 88, 5.9%) i trzcinowiskach (n = 72; 4.8%) (Fig. 4). W okresie zimowym (grudzień-pierwsza połowa marca) opad wpływał pozytywnie na liczebność siwerniaków żerujących na łąkach, a pokrywa śnieżna zwiększała liczbę ptaków żerujących na odstojnikach ścieków (Tab. 2). Dominującą, dostępną zdobyczą bytującą w ciepłych osadach ściekowych były larwy Diptera (96%), a wśród nich osiemdziesiąt osiem procent stanowił *Eristalis* sp. Średnia (± SD) biomasa bezkręgowców była największa w osadach pochodzących z odstojników (1.03 ± 1.14 g/dm^3 osadów), najniższa zaś na zalanych łąkach (0.20 ± 0.37 g/dm^3 osadów) (Tab. 3). Liczebność siwerniaków zimujących na polach irygacyjnych we Wrocławiu można ocenić na 70–80 osobników. Uzyskane wyniki wskazują, że sztuczne warunki środowiskowe wytworzone przez ciepłe wody ściekowe w dużym stopniu uniezależniają zimujące siwerniaki od warunków meteorologicznych, umożliwiając tym samym zimowanie w chłodnym rejonie Europy środkowej.