NOTES ON MIGRATION DYNAMICS AND BIOMETRY OF THE WOOD SANDPIPER (*Tringa glareola*) AT THE SEWAGE FARM OF MÜNSTER (NW GERMANY)*

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ABSTRACT

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This paper summarises results of almost daily counts of Wood Sandpiper and an extensive ringing and colour-marking scheme at the sewage farm of Münster from 1969 to 2000. In the course of this 32-year period, migration phenology tended to have advanced in spring, and delayed in autumn. While roosting numbers remained stable in spring, they decreased in autumn, which is partly attributed to changes of the local habitat quality. A total of 1432 Wood Sandpipers were ringed and measured. Analysis of biometric data revealed larger wing and tail length in juveniles due to feather wear in adults, whereas bill and nalospi were longer in adult birds. In spring, birds had longer wings and tails, but lower body mass than adults caught in autumn. While birds with active primary moult have so far hardly been reported from other sites in Central Europe, our data indicate that a low number of birds regularly start moult of remiges at an early stage of autumn migration. Recoveries indicate that birds passing through Münster take a more south-westerly route than generally assumed for Central European migrants. A bird ringed at Münster is to our knowledge the oldest known individual of the species (at least 11-years-old).

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INTRODUCTION

The Wood Sandpiper is one of the most numerous waders migrating through inland Central Europe, using a wide variety of wetland habitats for stop-over. As only low numbers of Wood Sandpipers forage in coastal mudflats, the species is hardly

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considered in the extensive studies on the migration of coastal waders (*e.g.* Boere 1976, Smit and Piersma 1989, Wymenga *et al.* 1990, Meltofte *et al.* 1994, Poot *et al.* 1996, Günther and Rösner 2000, Thyen *et al.* 2000). On the other hand, there are many studies at inland staging sites based on more or less regular counts, but most of them present summarising information only on migration phenologies (*e.g.* Bezzel and Wüst 1965, Fiala 1991, Andres and Reeber 1992, Pannach 1992, Matthes 1994, Oldekop *et al.* 2000, Sauvage 2000), few going beyond (*e.g.* Leuzinger and Jenni 1993). With the establishment of the project "Tringa glareola 2000" in 1997, the Waterbird Research Group KULING set the basis for a more profound analysis of the migration phenology, dynamics, energetics and strategies of Wood Sandpiper (Remisiewicz 1998).

The Biological Station 'Rieselfelder Münster' will contribute to this project with the analysis of data from an extensive colour-ringing and monitoring scheme at the sewage farm of Münster. The migration dynamics of waders roosting at Münster have been intensively studied since 1962 (Harengerd *et al.* 1973). While counts were the main objective during the first decade of research, a ringing program was established in 1969. By 1971, individual colour-ringing of many species of waders has been started. So far, analysis of monitoring and ringing data has been published on Dunlin – *Calidris alpina* (OAG Münster 1976), Curlew Sandpiper – *Calidris ferruginea* (OAG Münster 1983), Ruff – *Philomachus pugnax* (OAG Münster 1988b, 1989a, 1991, 1998), Black-tailed Godwit – *Limosa limosa* (Grüneberg and Melter 2001), Green Sandpiper – *Tringa ochropus* (Harengerd 1969, OAG Münster 1989b) and Snipe – *Gallinago gallinago* (OAG Münster 1975), whereas data on Wood Sandpiper have only been included in summarising papers (OAG Münster 1977, 1988a, 1994; Harengerd *et al.* 1995). This paper aims to review data available for further analysis and to present some preliminary results on migration phenology, migration dynamics, biometry and recoveries of the Wood Sandpiper at the sewage farm of Münster.

STUDY AREA

The sewage farm of Münster (52°02'N, 7°39'E) is located at the northern edge of Münster, in North-Rhine Westphalia (NW Germany). In the 1960s and 1970s, an area of up to 600 ha of sandy soil was used to purify sewage water. With benthic organisms available in high densities, the sewage farm soon supported significant numbers of breeding, roosting and moulting waders and waterbirds. In 1975, a modern sewage plant was built nearby, meaning that its purified water ran into the sewage ponds instead of hypertrophic sewage. Due to mud mineralisation, the nutrient load of the ponds, and in consequence prey availability, declined rapidly. As a second consequence more than 50% of the farm area was subsequently turned into arable land, leaving only 233 ha of wetlands. Nevertheless, the area is still one of the most important inland wader staging sites in Germany. Since 1976, the area has been primarily managed for the purpose of bird and especially wader conserva-

tion. In 1983, it was notified as a "wetland of international importance" under the RAMSAR convention, and in 1998 as a Special Protection Area (SPA) under the EU Bird Conservation Directive. During a EU-Life project the nature reserve was enlarged to 435 ha in 1998-2000, expanding the wetland almost to its original size. Detailed descriptions of the area and its history have been published by Biologische Station Rieselfelder Münster (1981) and Harengerd *et al.* (1995).

MATERIAL AND METHODS

Migration phenology and dynamics

Since 1969, waders have been counted almost daily (Fig. 1). Based on these counts we analysed migration phenology and trends of local roosting numbers. An overview of the seasonal migration pattern was gained by calculating mean daily counts for three decades – 1971-1980, 1981-1990 and 1991-2000. Furthermore, we analysed seasonal dynamics in migration phenology by calculating start, median and end of each migration period using the 5%-, 50%- and 95%-percentils, respectively. Spring migration (15 April – 5 June) and autumn migration (11 June – 31 October) were separated by the local minimum of mean daily counts.

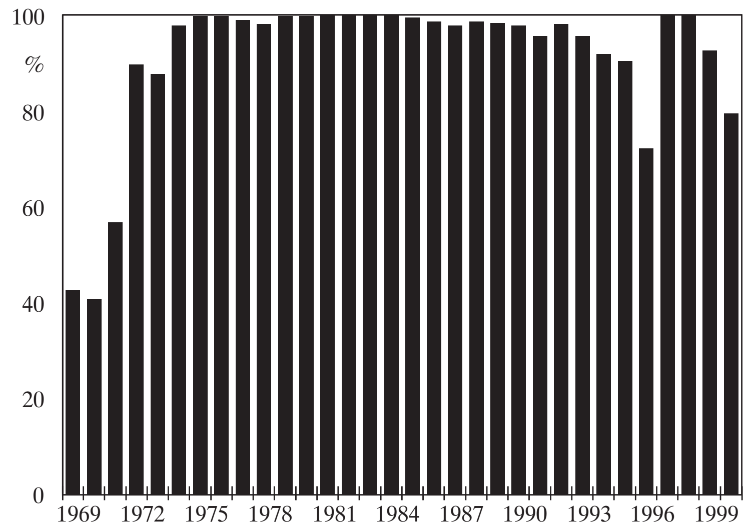

Fig. 1. Frequency of wader counts at the sewage farm of Münster in years 1969-2001. 100% equals 365 (366) counts per year.

Dynamics of the numbers of roosting birds per season were analysed using mean counts during the main migration period. The main migration period was defined as the period between the 16%- and 84%-quantile of the total count per migration period. This resembles the method described by Harengerd *et al.* (1973), who used the standard deviation of the mean migration date as a measure of the main migration

period. This also includes 2/3 of the counts assuming normal distribution of the data. As daily counts of Wood Sandpiper are not normally distributed, we decided to use quantiles.

Trends of migration phenology and roosting numbers were calculated by linear regression analysis. Data were tested for normal distribution of residuals before (Dytham 1999).

Ringing program

Until 1995, waders were caught at night using mist-nets. Since 1996, up to 20 (depending on personnel resources) frequently moved walk-in traps have been used instead, meaning that birds were trapped during daytime. A total of 1432 birds were measured and ringed between 1969 and 2000: in spring – 194 birds, in autumn – 1238 (813 *juv.*, 425 *ad.*). In total, 1232 of the birds were individually colour-ringed,

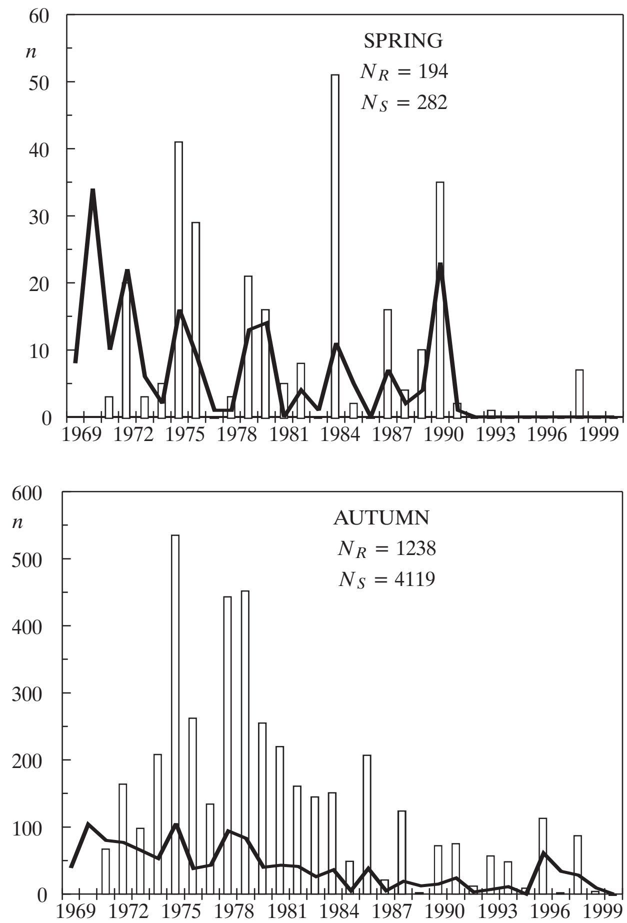

Fig. 2. Total number of individuals ringed (line, R) and re-sightings (bars, S) at the sewage farm of Münster during spring and autumn migration. Note a difference in *n*-scale.

173 individuals were re-trapped up to three times. The numbers of trapped individuals per year are shown at Figure 2.

For comparison of biometric data (juvenile and adult birds in autumn, seasonal comparison of adults) we used the non-parametric Mann-Whitney *U*-test, as measurements of wing, tail, and in some cases body mass were not normally distributed (1-sample Kolmogorov-Smirnov test – Dytham 1999). Additionally, datasets were characterised by range, mean, and standard deviation for each measurement. The use of the mean instead of the median did not cause problems as all data distributions were symmetric, and it enabled comparison with published data. For body mass we analysed only the measurements of birds caught at night (1969-1996) excluding subsequent measurements of the same individuals. In most birds, the following standard measurements were taken with the same methods since 1969: maximum wing cord, bill length and tarsus were measured according to Baker (1993), nalospi according to Prater and Marchant (1997), and primary length according to Svensson (1992). Wing tip was measured since 1973 as the distance between the first secondary and the longest primary using wing ruler with the wing in the same position as for measurement of wing length. To measure tail length, we gently slided standard butted wing ruler (2 mm thick) towards the body between the two central tail feathers until it reached the root and measured the longest tail feather. Body mass of birds caught at night was measured twice: first – when the bird was ringed, second – just before the bird was released in the morning. For analysis, the body mass was standardised to 10.00 *p.m.* by calculating the mean body mass decline. It was -0.75% per hour in spring, -0.69% per hour in adults in autumn (*cf.* Fig. 3: the correlation coefficient – r = -0.73 is highly significant – $p < 0.001$, $N = 172$, the regression line – y = 99.9 – 0.69x) and -0.64% per hour in juveniles (Harengerd 1982, OAG Münster 1983). Moult was recorded individually for all primaries, secondaries and tail feathers using scores with 10% intervals. Categorical moult scores were recorded separately for lesser, median and greater upper- and underwing coverts,

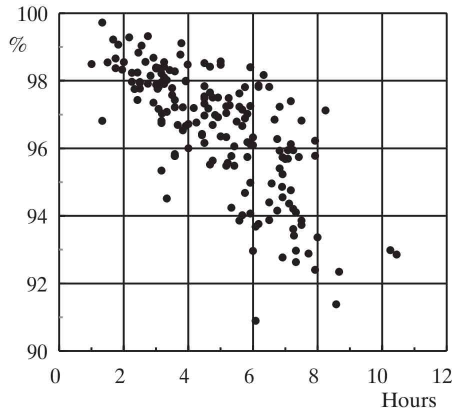

Fig. 3. Nocturnal decrease of body mass of adult Wood Sandpipers in autumn. Relative body mass at release is given in relation to number of hours in captivity.

alula, humerals, scapulars, head, upper- and underparts of body. Feather and tail length were not included in this analysis due to small sample size.

PRELIMINARY RESULTS

Migration phenology and dynamics

In general, migration of Wood Sandpiper at the sewage farm of Münster started by the end of April, peaked during the first days of May (with most of the birds passing through within just a few days) and quickly declined towards the end of May. Autumn migration of adults started by mid-June and peaked at the beginning of July. Usually, the migration of juveniles was much stronger with a peak in mid-August, a constant decline in numbers during September, and with the last individuals staying until mid-October (Fig. 4). The separation of adult and juvenile migration peaks is supported by seasonal distribution of ringed birds (Fig. 5, compare median dates with Table 1). It was not significantly different from the relative distribution of mean maximum counts per pentade (2-sample Kolmogorov-Smirnov test: spring – $Z = 0.84$, $p = 0.47$; autumn – $Z = 0.69$, $p = 0.72$).

Table 1
Mean migration dates and mean counts of Wood Sandpiper at the sewage farm of Münster, averaged for the whole period (*Total*), and splitted into three periods between 1969 and 2000

Parameter	*Spring (15 Apr. – 5 Jun.)*				*Autumn (11 Jun. – 31 Oct.)*			
	Total spring	1969-1980	1981-1990	1991-2000	**Total autumn**	1969-1980	1981-1990	1991-2000
Arrival date	**20 Apr.**	23 Apr.	18 Apr.	19 Apr.	–	–	–	–
Start of migration	**30 Apr.**	1 May	28 Apr.	29 Apr.	**4 Jul.**	3 Jul.	4 Jul.	6 Jul.
Median	**9 May**	11 May	8 May	8 May	**6 Aug.**	4 Aug.	7 Aug.	9 Aug.
End of migration	**20 May**	22 May	20 May	18 May	**7 Sept.**	6 Sept.	3 Sept.	13 Sept.
Departure date	–	–	–	–	**12 Oct.**	9 Oct.	13 Oct.	16 Oct.
Count number	**57**	65	62	53	**68**	101	70	28

Migration pattern, in particular the beginning and the end of the migration period, varied strongly in subsequent seasons (Fig. 6, Table 1). Furthermore, spring migration tended to take place earlier in the season, while autumn migration showed a significant delay during the last three decades. The mean number of roosting individuals on the spring passage remained stable over the last 32 years, although the numbers strongly fluctuated from year to year (Fig. 7). However, negative trend was shown for the autumn passage, with mean roosting numbers decreasing to a very low level.

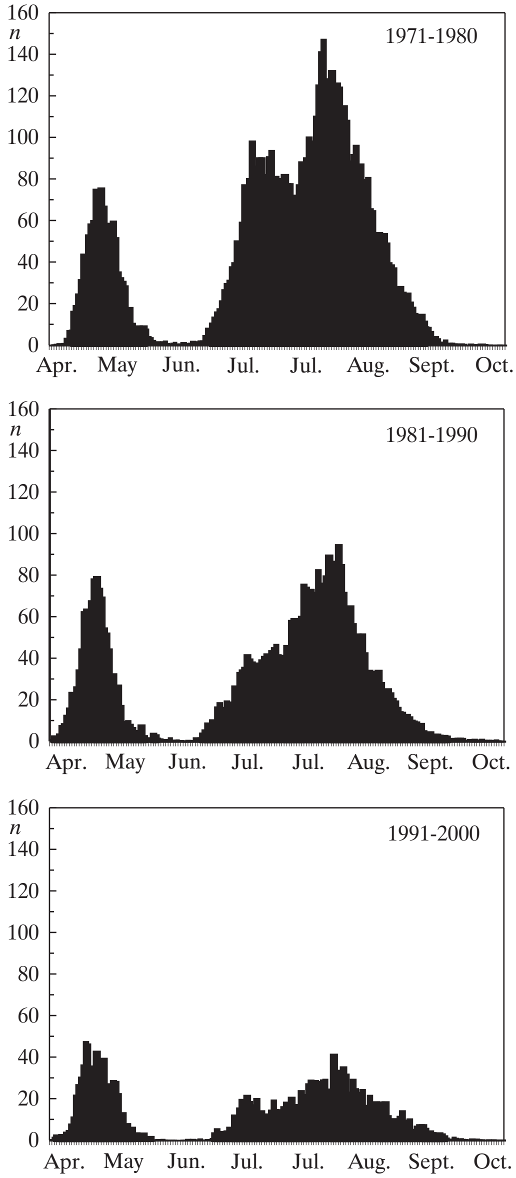

Fig. 4. Seasonal phenology of Wood Sandpiper at the sewage farm of Münster. The graph shows mean daily counts during the three decades 1971-1980, 1981-1990 and 1991-2000.

Biometric data and moult

In autumn, juveniles had longer wings and tail feathers, but shorter bills and nalospi compared to adults (Table 2). Tarsus length did not differ significantly. Adults were generally heavier than juveniles. In spring, birds had longer wings and tails, but lower body mass than adults caught in autumn (Table 3).

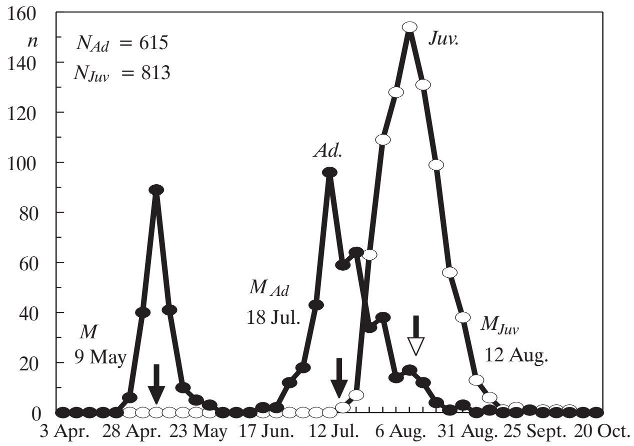

Fig. 5. Seasonal pattern of trapped Wood Sandpipers at the sewage farm of Münster, giving the sum of ringed birds per pentade. Arrow, M_x = median date. Note separate median in autumn for adults and juveniles.

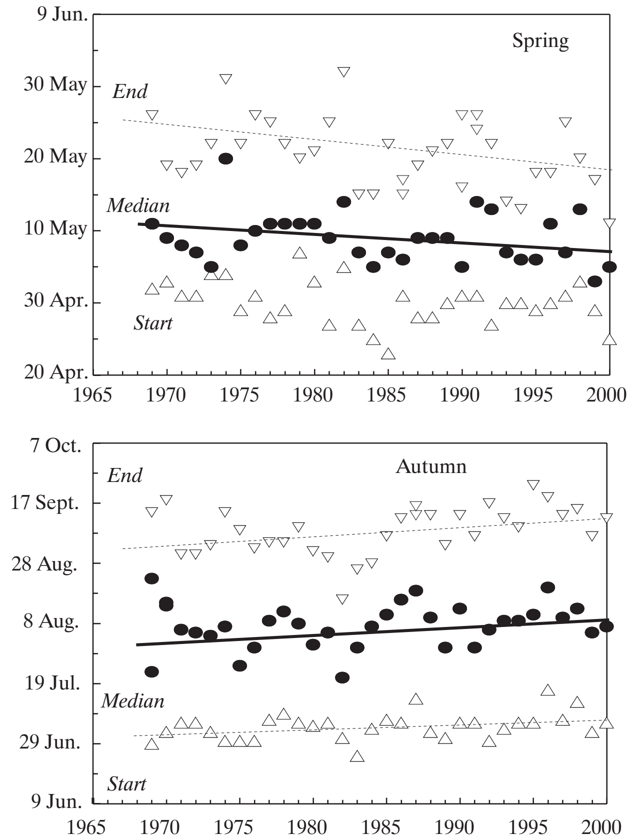

Fig. 6. Changes of Wood Sandpiper migration phenology at the sewage farm of Münster 1969-2000. Start, median and end of the migration period (open triangles, filled circles and open triangles) are shown respectively. Significant trends ($p < 0.05$) are indicated by regression lines.

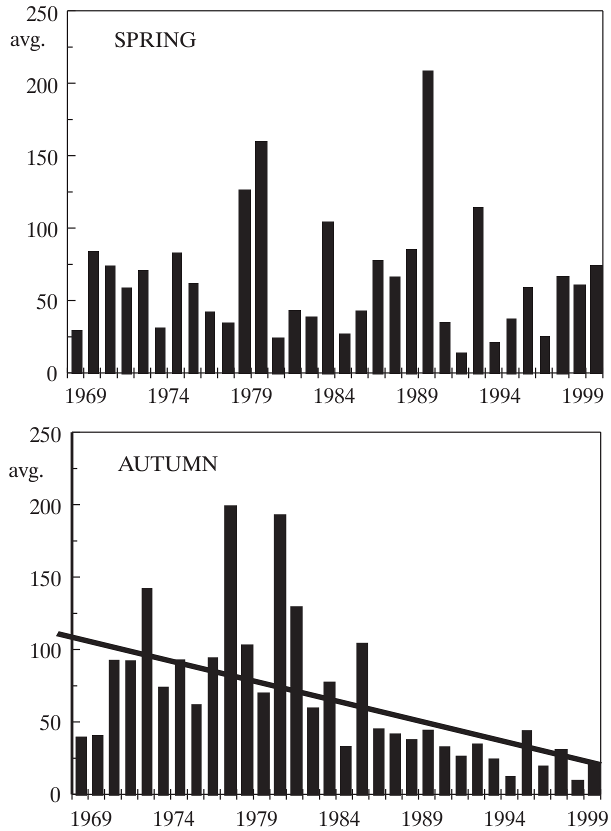

Fig. 7. Dynamics of mean numbers of roosting Wood Sandpipers at the sewage farm of Münster 1969-2000. The regression line indicates a significant trend in autumn ($p < 0.01$).

Table 2

Biometric data of Wood Sandpipers ringed at Münster sewage farm 1969-1999 in autumn. Mann-Whitney *U*-test was used to compare measurements of juvenile and adult birds.

Measurement	**Age**	***n***	**Range**	**Mean ± *SD***	***U***	***p***
Wing length (mm)	*Juv.*	812	117-140	128.9 ± 3.6	118966	**< 0.001**
	Ad.	419	112-136	127.0 ± 3.6		
Wing tip (mm)	*Juv.*	647	51-77	63.5 ± 3.4	58736	**< 0.001**
	Ad.	274	53-73	61.6 ± 3.1		
Tail feather length (mm)	*Juv.*	806	41-58	49.1 ± 2.6	128907	**< 0.001**
	Ad.	413	40-59	48.1 ± 2.9		
Bill length (mm)	*Juv.*	804	23.0-33.0	27.7 ± 1.3	132443	**< 0.001**
	Ad.	418	24.5-32.0	28.3 ± 1.3		
Nalospi (mm)	*Juv.*	803	18.8-26.8	22.3 ± 1.1	135117	**< 0.001**
	Ad.	415	19.7-26.1	22.6 ± 1.1		
Tarsus length (mm)	*Juv.*	639	31.1-43.0	37.7 ± 1.6	83830	*ns*
	Ad.	274	33.9-42.9	37.9 ± 1.7		
Body mass (g)	*Juv.*	686	44.6-105.2	77.6 ± 11.8	105397	**< 0.001**
	Ad.	389	53.2-108.9	81.8 ± 10.9		

Table 3
Biometric data of Wood Sandpipers ringed at the sewage farm of Münster 1969-2000 in spring. Mann-Whitney *U*-test was used to compare the measurements with data from adults in autumn (*cf.* Table 2).

Measurement	*n*	Range	Mean ± *SD*	*U*	*p*
Wing length (mm)	192	120-138	128.5 ± 3.6	30806	**< 0.001**
Wing tip (mm)	118	52-75	62.3 ± 3.1	14132	**< 0.05**
Tail feather length (mm)	193	43-55	49.1 ± 2.5	30542	**< 0.001**
Bill length (mm)	193	24.6-33.2	28.1 ± 1.5	38786	*ns*
Nalospi (mm)	190	19.5-25.5	22.5 ± 1.2	37423	*ns*
Tarsus length (mm)	119	34.1-41.0	37.9 ± 1.6	15868	*ns*
Body mass (g)	191	56.1-99.8	74.5 ± 8.2	21398	**< 0.001**

Moult was only noted in some adult birds in autumn. 47 birds (11%) were actively moulting remiges or tail feathers, with three additional birds (0.7%) having moult suspended. Numbers of individuals moulting or suspending moult were as follows: 29 and 8 for primaries, 31 and 6 for secondaries, 30 and 5 for tail feathers.

Re-sightings and recoveries

Only four birds ringed at other locations were recovered at the sewage farm of Münster. One of them originated from the nearby sewage farm of Braunschweig (Lower Saxony, Germany), the other three from two sites in Sweden. 24 birds ringed in Münster were recovered elsewhere (Fig. 8). All the recoveries occurred along the western European flyway, with maximum distances being 1350 km to NE (Pori, southern Finland) and *ca* 2000 km to SW (the Moulouya mouth, Morocco). The Moroccan bird was recovered on 12 February 1971, indicating that it was wintering in this area. A bird ringed as an adult in Münster on 30 June 1973 lived at least eleven years. It was found dead (probably due to botulism) near Braunschweig on 24 July 1983. High migration speed was recorded in two birds: a juvenile ringed in Münster on 18 August 1976 was shot only three days later in the Basin d'Arcachon (France), 1000 km to SW. An adult bird was recorded in Münster on 17 August 1978 and shot the following day at Bouches du Rhone (S France), covering a distance of *ca* 1000 km within a single day.

DISCUSSION

Migration patterns of Wood Sandpiper in Münster

The strong decline of numbers of Wood Sandpipers roosting at the sewage farm of Münster in autumn, that has also been apparent in other species of waders (Harengerd *et al.* 1995), can be attributed at least partly to changes in habitat structure and prey availability. Over the last three decades, the ponds have become smaller and the vegetation structure more uniform. Nowadays, hardly any vegetation grows

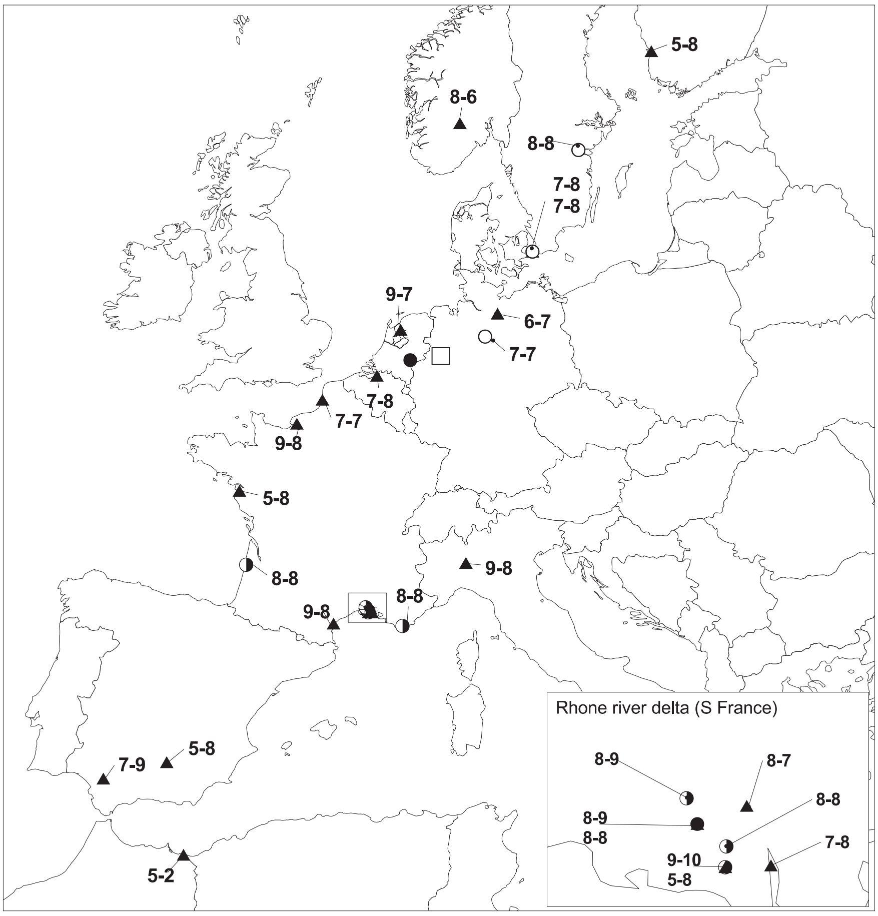

Fig. 8. Location of the sewage farm of Münster (square) and recoveries of Wood Sandpipers. Recovery sites of birds ringed at Münster are indicated by solid symbols, origin of birds recovered at Münster by open symbols. Birds recovered within the same migration period after ringing are indicated by circles (half of circle filled: juveniles, circle filled: adults), those recovered in subsequent years by triangles. Numbers indicate the month of ringing and recovery, respectively.

within the shallow water ponds, that are surrounded by monotonous reedbeds (OAG Münster 1977, Harengerd *et al.* 1995). On the contrary, Wood Sandpiper generally prefers widely open areas of shallow water with sedges and other grasses that provide hiding opportunities. However, the large areas of wet meadows and pastures created in the course of the recently finished EU-Life project should improve substantially the habitat quality for the species. Besides, after the sewage input had been stopped in 1975, the mud providing high prey densities subsequently became mineralised. As waders depend on high prey density to achieve economic food intake rates (Goss-Custard 1980, Gill *et al.* 2001), the birds might react to reduced prey availability with shorter staging times.

As declining numbers of Wood Sandpipers are also known from other inland sites (Fiala 1991, Leuzinger and Jenni 1993, Heine *et al.* 1999, Oldekop *et al.* 2000)

with no available evidence for a shift in migration routes, the trend at Münster might also reflect a population decline. However, population trends of the Fennoscandian Wood Sandpiper breeding population, being the majority of birds passing through western Europe (Glutz von Blotzheim and Bauer 1985), are largely unknown (Hagemeijer and Blair 1997).

The migration pattern of Wood Sandpiper seems to be very similar in most parts of Central and Western Europe, with only a slight and not significant latitudinal shift in median spring migration dates (OAG Münster 1988a, 1994). Also the autumn median dates published for other sites are very similar (*e.g.* Fiala 1991, Leuzinger and Jenni 1993, Meissner 1997, Boschert 2001), whereas autumn migration in western Ukraine seems to take place later in the season (Szydlowski and Lysaczuk 1998). However, differences might become obvious when data from many sites within the flyway are compared for separate seasons, as median dates calculated for many-year data cover up the considerable seasonal variation in migration timing (Leuzinger and Jenni 1993, Meissner 1997; Fig. 6). Provided equal median dates in central Europe, the lack of a latitudinal shift in migration timing indicates that Wood Sandpipers might use only very few stop-over sites on their journey between breeding and non-breeding grounds. This would correspond to the "skip" travel scheme defined by Piersma (1987), which is also supported by recoveries of two birds in France within one and three days (see also Glutz von Blotzheim and Bauer 1985). As shown by Persson (1998), the fat load of birds captured in the Öresund area (Sweden) should be sufficient to travel more than 1000 km in non-stop-flight. On the other hand, based on fat-load data of birds in the Gulf of Gdansk, Meissner (1997) assumed a mixed strategy, with some birds migrating short distances with generally low energetic reserves, and others accumulating large fat reserves to allow for long-distance flights. Accordingly, our data also includes short-distance recoveries: an adult ringed at Münster found two weeks later in the Netherlands (113 km to W), and an adult ringed at Braunschweig caught seven days later at Münster (210 km to WSW) (*cf.* Fig. 8).

The observed trends in migration timing of Wood Sandpiper at the sewage farm of Münster could be explained by changes in local roosting behaviour and population structure, but also by shifts in the species' migration timing. Possible explanations and implications will be discussed separately (Anthes unpubl.).

Biometry of Wood Sandpiper passing through the sewage farm of Münster

Longer wing and tail of juvenile waders are generally known to be a result of the less worn juvenile feathers (*e.g.* Mitrus *et al.* 1998). On the contrary, bill and nalospi are smaller in juveniles as described by Glutz von Blotzheim and Bauer (1985) and Mitrus *et al.* (1998). The observed body mass differences between adults and juveniles fit the data in Glutz von Blotzheim and Bauer (1985) and Persson (1998), but were not found at other places (*e.g.* Mitrus *et al.* 1998). Our standardised body mass measurements are not directly comparable to published measurements obtained by different methods, but the much lower values of birds caught in the Gulf of Gdansk

region (Meissner 1997), the Bug valley (Mitrus *et al.* 1998), and southern Sweden (Persson 1998) are striking. This supports the assumption of Meissner (1997), that Wood Sandpipers reach the Polish coast with low energy load, and start accumulating fat reserves at Central European staging sites.

Most Wood Sandpipers start to moult their remiges in the northern Mediterranean, especially in the large floodplains of the Po and Ebro deltas and the Camargue (Glutz von Blotzheim and Bauer 1985), and reach wintering grounds in Africa with at least 1-4 inner primaries already renewed (Pearson 1974). Only very few birds with initial primary moult have been reported from staging sites in northern Germany (ponds near Nörten, Lower Saxony – Glutz von Blotzheim and Bauer 1985) and southern Sweden (Persson pers. comm.), single birds were caught at the central Polish Jeziorsko reservoir (Włodarczyk *fide* Meissner pers. comm.) but none at other sites in Poland (Meissner 1997, Mitrus *et al.* 1998, Meissner pers. comm.). Data obtained in Münster, however, indicate that a considerable proportion of birds already start moulting remiges prior to, or during the very first stages of migration.

Migration routes of Wood Sandpipers roosting in Münster

All recoveries occurred in south-western or north-eastern directions from Münster, including sites at the Channel and French Atlantic coast, that are supposed not to be a part of the main migration routes (Glutz von Blotzheim and Bauer 1985, but *cf.* single recoveries from Belgium and the Netherlands in eastern Germany in Lambert 1984). Although the picture might be biased by the high proportion of birds shot in France due to high hunting activity in this country, the low number of recoveries from southern directions, especially from moulting sites in northern Italy, is very striking. In comparison, birds ringed in Lower Saxonia, NW Germany (Zang *et al.* 1995), eastern Germany (Lambert 1984), southern Germany (Boschert 2001), and Switzerland (Leuzinger and Jenni 1993) were recovered in a much higher proportion in southern and also south-eastern directions. Similarly, Swedish birds generally migrate in southerly rather than in south-westerly directions (Glutz von Blotzheim and Bauer 1985, Holmgren and Pettersson 1998, Diadicheva and Matsievskaya 2000). There is also a high proportion of Wood Sandpipers moving south-eastwards from Sweden (Lebedeva *et al.* 1985), as do birds from the Gulf of Gdansk region in Poland (Meissner 1997). Although a higher number of recoveries might reveal a different view, available data indicate that the route taken by birds migrating through Europe shifts longitudinally from a south-western to a south-eastern direction comparing western and eastern European migrants, respectively. Having passed the Alps and the Mediterranean, at least some birds from both migration routes might converge to neighbouring wintering grounds in western Africa, as it is indicated by recoveries in Chad and Nigeria from birds ringed in southern Ukraine (Diadicheva and Matsievskaya 2000).

To our knowledge, the bird recovered at Braunschweig is the oldest Wood Sandpiper known. Hitherto, the oldest recovered individual survived for nine years and

two months (Rydzewski 1978, Cramp and Simmons 1983, Glutz von Blotzheim and Bauer 1985, Piersma 1996; Bezzel 1985 mentions an 11-years-old bird without any reference).

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