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Differences in foraging ecology of Wood Sandpiper *Tringa glareola* and Ruff *Philomachus pugnax* during spring migration in Sajna River valley (northern Poland)

Skillnader i födosöksekologi hos grönbena Tringa glareola *och brushane* Philomachus pugnax *under vårflyttningen i Sajnaflodens dalgång (norra Polen)*

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Abstract

The research was conducted in 2002, in Sajna River valley (NE Poland). It was aimed at foraging ecology of two wader species not specialised in terms of feeding techniques. We found that while foraging on a stopover site during spring migration Ruffs used different ecological niche than Wood Sandpipers. Ruffs foraged significantly more often in medium and deep water and made also more medium and deep probes, what indicates preference in random probing. High intensity and proportionally low efficiency of foraging may confirm it. Contrary, Wood Sandpiper foraged less intensively but much more effectively; this, together with frequent changes of feeding places in terms of water level indicate that Wood Sandpiper to greater extent uses visual detection of prey than Ruff.

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Introduction

Foraging waders use in general two basic techniques: visual detection of prey items and random probing of a substrate. The first one is used mostly by short-billed species e.g. plovers (*Charadrius* sp. and *Pluvialis* sp.). Long-billed waders such as godwits *Limosa* sp., curlews *Numenius* sp., Greenshank *Tringa nebularia* or Curlew Sandpiper *Calidris ferruginea* prefer the second method (Pienkowski 1982, Schnieder 1983, Piersma 1994). According to Durell (2000) Ruff *Philomachus pugnax* and Wood Sandpiper *Tringa glareola*, having relatively small eyes and medium-long bills, are among the not specialised species. The feeding technique that they choose depends on age or sex and also on local conditions on a feeding ground, i.e. substrate type, prey composition and availability, time of the day, and weather conditions (Goss-Custard 1969, Dugan 1982, Esselnik & Zwarts 1989, Wiersma & Piersma 1994, Skakuj 1999). Studies on bill anatomy of waders have revealed that there is a slight difference; Wood Sandpiper is to greater extent than Ruff, but also than closely related species, e.g. Redshank *Tringa totanus*, adapted to catching free-living and mobile organisms and therefore they rely more on visual detection of prey. The bill of the Ruff is more omni-potential as the species forages on a wider spectrum of food including plant material, particularly seeds (Hoerschelmann 1968, Cramp & Simmons 1983).

Spring migration of Ruff in northern Poland is rapid and starts in third decade of April with a peak in first decade of May (Meissner & Sikora 1995, Meissner & Włodarczak 1998, Wójcik et al. 1999); more easterly it starts earlier and proceeds longer – from beginning of April to mid-May (Górski & Nowakowski 1999), similar to the passage in southern Poland (Wiehle 1999). Wood Sandpipers are common on spring passage either inland or at the coast (Tomiałojć & Stawarczyk 2003) and are observed from second decade of April to mid-May (Meissner & Sikora 1995, Wójcik et al. 1999, Tomiałojć & Stawarczyk 2003). Both Ruffs and Wood Sandpipers migrate through Europe in a broad front, appearing only scarcely on coasts of northwestern Europe (Glutz von Blotzheim et al. 1975). Their stopover sites are inland wetlands, i.e. river valleys, muddy lake shores and wet grasslands. Despite their abundance during spring migration,

inland-migrating waders were seldom a subject of foraging ecology research (van Roomen 2001).

The aim of this study is to characterise and compare foraging techniques of Ruff and Wood Sandpiper when stopping during spring migration in Sajna River valley in northeastern Poland (Varmia and Masuria District).

Materials and methods

The research was conducted from 29 April to 14 May 2002 near a field ringing station of Waterbird Research Group KULING. The study area covered Pleśno Reservoir and floodplains of Sajna River (N 54°04'; E 21°02', NE Poland) (Figure 1). Pleśno Reservoir (ca. 340 ha) was created by damming the floodplain between Sajna and Ryn rivers. Since 1998 it is protected by law as a land of ecological use (Nowicki & Cymes 2000). The lake is surrounded by dense vegetation, mainly reedbeds and rushes (*Phragmitetum comunis* and *Typhetum latifoliae* communities). Due to low water transparency, underwater vegetation is poorly developed and neophytes are dominants. The water level in the reservoir changes significantly during the course of the year, which makes it an attractive stopover site for migrating waders during spring and autumn (Meissner et al. 2002).

Observations of foraging birds were conducted from flood-dams by a telescope. Average distance was ca. 50 m, and this allowed us to avoid disturbance the birds' behaviour. Birds for observation were chosen randomly. From each bird 1-minute samples were collected. Maximally three samples were taken from each individual before switching to another bird. When 2 or 3 samples were taken from the same bird they were recalculated to one 1-minute sample. Large numbers of foraging birds and high turnover rate minimised the risk of double recordings of the same individual. The time spent by the birds on foraging, preening and alert activities was recorded with 1-second accuracy. Other activities were seen very seldom (e.g. aggressive behavior) or did not appear during observations at all (e.g. lekking (in Ruff) or flight). Number of attempts to catch a prey was recorded, distinguishing between whether or not it resulted in swallowing the prey. Observations were conducted only in daytime and they were split into 3.5-hour periods: 6:00–9:30 (morning), 9:30–13:00 (noon), 13:00–16:30 (afternoon) and 16:30–20:00 (evening).

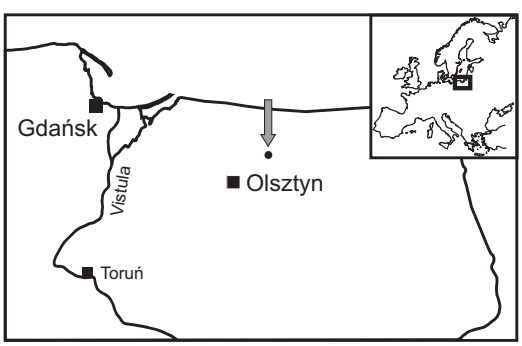

Figure 1. Location of the study area.
Platsen för undersökningsområdet.

The observed birds foraged on a muddy ground to various extent covered with water and plants. Three categories of water depth were distinguished: shallow (covering toes at most), medium (up to tarsus joint) and deep (over the tarsus joint). Also depth of bill submersion was classified into three categories: shallow (prey items collected from the ground or bill submerged up to its quarter length), medium (bill submerged up to nostrils) and deep (over the nostrils).

Intensity of foraging (I) was defined as the number of all probes in a minute, success of foraging (S) as the number of prey items caught in a minute, and efficiency of foraging (E) as the percentage of all probes that were successful (prey item caught) in a minute (E=S/I*100). Significance of differences between foraging in different levels of water and different depths of probes within species and sex was checked with Kruskal-Wallis test, while significance of differences between species and sexes was checked with Mann-Whitney test. Significance of differences between time budgets in succeeding day periods was tested using ANOVA test with Tukey post-hoc test (Zar 1996). All statistics were made in Statistica 6.0 software (StatSoft 2001).

Results

Comparison of feeding techniques of Ruff males and females

During the observations 424 samples for Ruff were recorded (27 for males and 397 for females). No differences between sexes were found in intensity, success and efficiency of foraging (Table 1).

Time budgets of males and females were compared (Table 2) and no significant differences were revealed in frequency of time spent on foraging and resting (Mann-Whitney test, $p<0.05$ in both cases). Males spent more time on alert than females (Mann-Whitney test, $Z=1.97$, $p<0.05$).

We analysed males' and females' frequency of probing in different water depths but neither here

Table 1. Median intensity, success and efficiency of foraging for males and females of Ruff. N=number of individuals studied.
Medianintensitet, framgång och effektivitet vid födosök hos hanar och honor av brushane, N=antal studerade individer.

Sex *Kön*	N	Intensity *Intensitet*	Success *Framgång*	Efficiency [%] *Effektivitet*
Females *Honor*	397	26	8	30,0
Males *Hanar*	27	25	7	29,4
U Test		Z=0.89, p=0.37	Z=1.15, p=0.25	Z=0.23, p=0.82

Table 2. Time budget of Ruff and Wood Sandpiper in Sajna river valley. N=number of individuals studied.
Tidsbudget för brushane och grönbena i Sajnaflodens dalgång. N=antal studerade indivier. F=hona, M=hane.

Species *Art*	Sex *Kön*	N	Foraging *Födosök*	Preening *Putsning*	Alert *Uppsikt*	Kruskal-Wallis test
Ruff *Brushane*	F	397	92.1%	7.7%	0.2%	H=914.97, p<0.001
Ruff *Brushane*	M	27	92.3%	6.8%	0.9%	H=69.19, p<0.001
Mann-Whitney test			Z=0.16, p=0.87	Z=0.79, p=0.43	Z=1.97, p=0.049	
Ruff *Brushane*	F+M	424	92.1%	7.6%	0.3%	H=982.50, p<0.001
Wood Sandpiper *Grönbena*		477	93.9%	5.8%	0.4%	H=1149.87, p<0.001
Mann-Whitney test			Z=3.73, p<0.05	Z=0.16, p<0.05	Z=0.39, p=0.70	

Table 3. Percentage distribution of probing of Ruff and Wood Sandpiper during foraging in different levels of water. N=number of probes. Mann-Whitney test in all cases: Z=0.00, p=1.00 and Kruskal-Wallis test in all cases: H=0.00, p=1.00.
Fördelningen av borrningar eller ytplock hos brushane och gröbena under födosök i olika vattendjup. N=totala antalet borrningar eller plock. F=hona. M=hane.

			Water depth *Vattendjup*		
Species *Art*	Sex *Kön*	N	Shallow *Grunt*	Medium *Medium*	Deep *Djupt*
Ruff *Brushane*	F	10167	3.7%	38.8%	57.5%
Ruff *Brushane*	M	632	0.0%	42.1%	57.9%
Ruff *Brushane*	F+M	10799	3.5%	39.0%	57.5%
Wood Sandpiper *Grönbena*	F+M	4674	7.9%	66.0%	26.1%

Table 4. Percentage distribution of probes of different depth in Ruff and Wood Sandpiper. N=number of probes. Mann-Whitney test in all cases: Z=0.00, p=1.00 and Kruskal-Wallis test in all cases: H=0.00, p=1.00.
Fördelningen av olika djupa nerstickningar av näbben hos brushane och grönbena. N=totala antalet nerstickningar av näbben. F=honor. M=hanar.

Species	Sex	N	Probing depth Nerstickningens djup		
Art	*Kön*		Shallow *Grunt*	Medium	Deep *Djupt*
Ruff *Brushane*	F	10167	4.5%	46.4%	49.0%
Ruff *Brushane*	M	632	0.0%	55.7%	44.3%
Ruff *Brushane*	F+M	10799	4.3%	47.0%	48.8%
Wood Sandpiper *Grönbena*	F+M	5136	62.2%	18.2%	19.6%

Table 5. Intensity and efficiency of foraging of Ruff and Wood Sandpiper during spring migration in Sajna river valley. Period of day (hours): 1 (6:00-9:30), 2 (9:30-13:00), 3 (13:00-16:30), 4 (16:30-20:00). N = number of individuals studied. Intensity – number of probes per 1 minute. Efficiency – percent of successful probes.
Intensitet och effektivitet i födosöket hos brushane och grönbena under vårflyttningen i Sajnafjodens dalgång under olika perioder av dagen: 1 (6:00–9:30), 2 (9:30–13:00), 3 (13:00–16:30), 4 (16:30–20:00).

Species *Art* Activity *Aktivitet*	Period	N	Mean *Medel*	SE	SD	Range *Intervall*	Differ from *Skilt från*
Ruff	1	98	22.9	0.8	7.5	0.0-52.0	2, 4
Intensity	2	132	26.3	0.8	8.6	0.0-45.0	1
Brushane	3	69	22.3	1.2	10.2	0.0-44.0	4
Intensitet	4	125	28.4	0.9	10.4	0.0-53.0	1, 3
Ruff	1	96	30.9	0.9	9.3	8.3-47.6	4
Efficiency (%)	2	129	32.8	0.7	7.9	0.0-52.4	4
Brushane	3	68	31.9	1.1	8.8	0.0-60.0	4
Effektivitet (%)	4	118	25.2	0.7	7.1	9.5-43.3	1, 2, 3
Wood Sandpiper	1	116	13.1	0.7	7.4	0.0-27.0	2
Intensity	2	175	8.2	0.5	6.2	0.0-31.0	1, 3, 4
Grönbena	3	104	11.1	0.6	5.9	0.0-24.0	2
Iintensitet	4	82	12.5	0.7	6.1	0.0-27.0	2
Wood Sandpiper	1	103	58.3	1.7	17.4	0.0-100.0	-
Efficiency (%)	2	155	62.1	1.7	21.5	0.0-100.0	-
Grönbena	3	100	65.2	1.9	18.8	0.0-100.0	-
Effektivitet (%)	4	79	61.7	2.0	17.6	33.3-100.0	-

we found any differences (Mann-Whitney test, Z=0.96, p=0.34). Both sexes made most of their probes in deep water (Table 3).

No significant difference between Ruff sexes was recorded while analysing bill immersion depths (Mann-Whitney test, Z=1.06, p=0.29). Preferences in bill immersion depths differed slightly between the sexes. Most often males made deep probes, but no shallow ones at all (Table 4).

Comparison of feeding techniques of Ruffs and Wood Sandpipers

During the observations 477 samples for Wood Sandpiper were obtained. Since we found no differences between sexes in the Ruff, the data for males and females were pooled. The median intensity of foraging of Ruffs was 26 probes/min and this was significantly higher than in Wood Sandpiper with only 11 probes/min (Mann-Whitney test, Z=20.75, p<0.001). Also median success of foraging of Ruffs (8 prey items/min) was significantly higher than of Wood Sandpipers (6 prey items/min) (Mann-Whitney test, Z=4.84, p<0.001), but mean efficiency of foraging was significantly lower in Ruff than in Wood Sandpiper (30.0% and 62.5%, respectively, (Mann-Whitney test, Z=-22.21, p<0.001). Both species spent most of the time on foraging – over 90% of a day (Table 2). Time budgets did not differ significantly between species (Mann-Whitney test, p>0.05 in all cases).

Time budget in succeeding day periods was compared. Because alert activity was not always recorded or it gained very low values, only distributions of two activities (foraging and preening) were checked. No significant changes in time budget were recorded, neither for Ruff nor for Wood Sandpiper (Mann-Whitney test, in all cases p>0.05). No differences were either found in comparison of particular day periods between species (Mann-Whitney test, in all cases p>0.05).

Intensity (ANOVA, $F_{3,424}$=9.71, p<0,001), success (ANOVA, $F_{3,424}$=7.31, p<0,001) and efficiency (ANOVA, $F_{3,411}$=19.85, p<0,001) of foraging differed between day periods in Ruff. Intensity of foraging of this species was lowest in the morning and in the afternoon, and highest in the evening, but success of foraging reached highest values at noon. The Ruffs' efficiency of foraging was lowest in the evening (Table 5). In Wood Sandpipers there were significant differences in the intensity (ANOVA, $F_{3,477}$=40.95, p<0,001) and success (ANOVA, $F_{3,477}$=17.10, p<0,001) of foraging between day periods, as well. Wood Sandpipers foraged less intensively at noon and they had then the lowest success. Efficiency of foraging of Wood Sandpipers did not

differ between day periods (ANOVA, $F_{3,437}$=2.14, p=0,09) (Table 5).

Due to the foraging technique of the Wood Sandpiper, it was not possible to compare objectively time budgets of birds foraging in different water levels. During 56.5% of the one-minute observations (N=437) Wood Sandpipers changed the depth of water and foraged in at least two water levels. Some of the changes were so rapid that it was not possible to record the time birds foraged in water of a given depth. Therefore frequencies of probing of Ruffs and Wood Sandpipers in different water levels were compared and significant differences were revealed (Mann-Whitney test, Z=35.95, p<0.001). Ruffs made most probes in deep water while Wood Sandpipers made them in water of medium depth (Table 3). Significant differences were found also in depth of probes (Mann-Whitney test, Z=106.35, p<0.001). Ruffs made mostly medium and deep probes, but Wood Sandpipers made mainly shallow ones (62.2%, N=5136) (Table 4). Moreover, 40.3% of the Wood Sandpipers' shallow probes were actually surface pecks, i.e. collecting prey items from water surface and floating leaves.

Discussion

Efficiency of foraging of the Ruff in Sajna river valley reached 30% and was only half of the value found in Wood Sandpiper, while intensity of foraging showed the converse pattern – Ruffs foraged twice as intensively as Wood Sandpipers. The foraging behaviour of the Ruff was typical for species using random probing. They foraged mostly in deep water making predominantly deep probes, often submerging the whole head which surely makes visual detection of prey impossible. Wood Sandpipers, on the other hand, foraged in medium water with mainly shallow and surface probes. Low intensity of foraging linked with its high efficiency indicates visual detection of prey. Another confirmation is that Wood Sandpipers sometimes changed their foraging technique – they stopped probing in shallow or medium water and ran up directly to prey items seen up to one meter away. Such habits has been previously found in Greenshank (van Roomen 1998, Ntiaoma-Baidu et al. 1998).

High frequencies of deep probes in Ruff and shallow probes in Wood Sandpiper suggest partial segregation of foraging niches, at least in places where they occur together. Ruffs, thanks to longer legs and bill could also choose foraging in deeper water, inaccessible for Wood Sandpipers. Whereas the latter ones often fed on floating platforms of neophytes, which was also found in this species at Akyatan Gölü lake, Turkey (Dijksen & Kivit 1994), those floating plants were not accessible for the heavier Ruffs.

Foraging was the major activity in the time budget of the Sajna river birds. Similar results were found for Ruffs stopping in Cukurova seashore in Turkey where they spent 99% of daytime on foraging in April and 93% in May (Hannewijk 1994). Such predominance of foraging in spring migration reflects the necessity of gaining sufficient energy reserves in short time, which allows the birds to reach breeding grounds as fast as possible. In Münster (Germany) on the turn of April Ruff males spent most time on foraging before noon, while females did so in the afternoon. In both sexes a decrease of time spent on foraging was found in the evening (Melter 1995). A similar pattern was recorded in our study. However, in this part of the day Ruffs foraged with highest intensity but with lowest efficiency. This may be linked with changes in vertical distribution of invertebrates. Together with fall of temperature potential prey may move down in the substrate, which makes catching more difficult (Kalejta 1992). The significance of temperature drop on prey accessibility – and its consequence on feeding ecology – was proven for Redshanks wintering in Great Britain. In colder days the birds were forced to forage in deeper water, which was caused by lower accessibility of prey in shallower water (Goss-Custard 1969).

The Ruffs reached high efficiency of foraging around noon (9:30–13:00), when also intensity was very high – close to the level recorded in the evening. This suggests that the noon hours is the most important period of a day for gaining energy reserves during stopover in Sajna river valley. In Wood Sandpipers foraging efficiency in the evening was at the same level as in the rest of the day. At the same time birds foraged least intensively so they most probably used visual detection of prey.

During our study nocturnal observations were not practised although morning intensification of foraging together with the fact that birds did not enter walk-in traps nor mist nets during nights may prove that Wood Sandpipers did not forage at night or made it very seldom. In a closely related species – Green Sandpiper *Tringa ochropus* – nocturnal foraging was not recorded (Smith et al. 1999). On the other hand, Ntiaoma-Baidu et al. (1998) observed a few Wood Sandpipers (as well as other *Tringa* species) foraging at night at tropical wintering sites. Also Redshanks wintering in the temperate zone

were found undertaking nocturnal foraging in bad weather conditions and with low accessibility of prey (Goss-Custard 1969). Low morning foraging intensity of the Ruff in our study may indicate that this species forages at night as was the case in the Lapwing *Vanellus vanellus* (Milsom et al. 1990).

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Sammanfattning

Födosökande vadare använder två olika metoder för att upptäcka bytena. Synen används främst av kortnäbbade arter såsom pipare. Långnäbbade arter, exempelvis spovar, gluttsnäppa och spovsnäppa, söker hellre föda genom att slumpvis borra med näbben i substratet. Brushane och grönbena, som har ganska små ögon och medellånga näbbar, är inte särskilt specialiserade och vilken teknik de väljer beror på ålder, kön och lokala förhållanden (substratet, typ av byten och deras tillgänglighet, tid på dygnet, väder). Under den snabba vårflyttningen rastar brushane och grönbena på inlandslokaler, där de söker föda på dyiga stränder och blöta gräsmarker. Denna studie syftar till att jämföra födosökstekniken hos grönbena och brushane, och studien utfördes i Sajnaflodens dalgång i nordöstra Polen mellan 29 april och 14 maj 2002. Varierande vattenstånd och ringa vegetation innebär att platsen är attraktiv för rastande vadare både vår och höst.

Slumpvis valda individer studerades med tubkikare på ungefär 50 m avstånd. Varje vald individ studerades under portioner om en minut, maximalt tre minuter. I de fall som en individ observerades under mer än en minut, räknades värdena om till en minut och varje sådan minut utgör således ett stickprov. Tre typer av aktiviteter registrerades med en sekunds noggrannhet: födosök, fjädervård och vakthållning (i praktiken dock bara de två förstnämnda eftersom vakthållning noterades sällan). Antalet födosöksförsök registrerades och vi skiljde på lyckade (byte togs) och misslyckade. Observationerna gjordes endast under dagtid och vi delade upp dagen i fyra 3,5-timmarsperioder mellan klockan 06.00 och 20.00.

Fåglarna sökte föda på gyttja och låg vegetation som delvis var täckt av vatten av varierande djup. Vi registrerade om födosöket skedde på grunt (vattnet högst över tårna), medeldjupt (upp till tarsleden) och djupt vatten. Hur djupt näbben fördes ner registrerades också i tre klasser: grunt (plockade på marken eller förde ner näbben till högst en fjärdedel), medel (upp till näsborrarna) och djupt. Födosöksintensiteten definierades som antalet försök per minut, framgången som antalet byten tagna per minut och effektiviteten som procenten lyckade försök av samtliga.

Totalt insamlades 424 stickprov för brushane (27 från hanar och 397 från honor). Inga skillnader fanns mellan könen (Tabell 1–4), varför könen slogs ihop vid jämförelsen med grönbena. För grönbena registrerades 477 stickprov. Brushanarna födosökte med signifikant högre intensitet än grönbenorna (26 resp. 11 försök per minut). Framgången, antalet byten per minut, var också signifikant högre, 8 för brushane mot 6 för grönbena. Däremot var effektiviteten lägre hos brushanen (30%) än hos grönbenan (62,5%). Fördelningen mellan olika aktiviteter var densamma hos båda arterna och mer än 90% av tiden ägnades åt födosök. Hos brushanen fanns det skillnader i intensitet, framgång och effektivitet i födosöket mellan olika perioder av dagen medan det hos grönbenan var skillnader enbart för intensitet och framgång. Brushanen födosökte mestadels i djupt, medan grönbenan föredrädesvis födosökte i medeldjupt vatten (Tabell 3). Brushanen förde oftast ner näbben medeldjupt eller djupt, medan grönbenan till stor del plockade från ytan eller från flytande blad.

Våra observationer visar att brushanens födosök var typiskt för arter som slumpvis söker föda genom att borra ner näbben i substratet, ofta i kombination med att huvudet sänktes ner i vattnet, något som utesluter att de använde synen. Grönbenorna plockade ytligt och deras låga sökintensitet i kombination med hög framgång indikerar att de använde synen. Skillnaderna visar att de två arterna exploaterar olika födonischer.

Att födosök är den huvudsakliga aktiviteten när brushanar och grönbenor rastar under vårflyttningen tycks vara regel, och har noterats i andra studier också. Förklaringen till detta är naturligtvis att de måste samla energi snabbt så att de kan nå häckningsområdet så fort som möjligt. Vi gjorde inga observationer nattetid. Men frånvaron av fångade grönbenor i vadarburar och slöjnät under natten indikerar att de inte sökte föda då, vilket är väntat om de främst använder synen. Hur det var med brushanen vet vi inte, men den låga fördosöksintensitet som vi noterade på morgonen kan vara en indikation på att de sökte föda nattetid, vilket bör vara möjligt för en art som söker med näbben nere i substratet.