Declining Ruff *Philomachus pugnax* populations: a response to global warming?

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Ruff breeding populations have declined widely and in all habitats across temperate Eurasia. Of an estimated population of 2.2–2.8 million birds, 98% are now confined to habitats in the Arctic tundra. Only 8,000–14,000 females still breed in wet grassland habitats in Europe. Although drainage and agricultural intensification have damaged or destroyed many grassland habitats, they do not explain why Ruffs have continued to decline even where habitats have been improved and in places where other wet grassland species are stable or increasing. The hypothesis that the problem is limited to one or a few flyways is not fully supported by the available data though there is some suggestion of a greater decline in W Europe/W Africa populations. For most regions, systematic monitoring data are lacking. Nevertheless the emerging picture is that the population has shifted northwards and eastwards and has retreated from the wet grassland habitats formerly occupied along the southern edges of its range. It is suggested that the causes are probably of a global nature and may be linked with climate change. It is unclear whether the total population has declined or only shifted north and east. More co-ordinated and systematic monitoring of breeding and wintering populations will be necessary before a full understanding of these changes can be reached.

INTRODUCTION AND METHODS

Despite recent declines, the Ruff *Philomachus pugnax* is still widespread and one of the commonest wader species of Eurasia. The breeding population has recently been estimated at 2.3–2.8 million birds (Zöckler in prep.). This roughly equates to the latest estimate for the wintering population in Africa of more than 2 million birds (Trolliet & Girard 2001, van Gils & Wiersma 1996). However, recent observations of declining numbers, particularly in wet grassland habitats, are alarming. This paper presents an overview of the current situation for breeding Ruff in Eurasia as a base line for future population monitoring.

Most data in this report come from two sources: recently published regional overviews for countries or regions within countries (for sources see Tables 1 & 2), and through direct personal communication with local and country experts in the International Wader Study Group. The figures differ substantially from those of Piersma (1986), and also from those of Heath *et al.* (2000). It is therefore important to provide an updated overview of current population status, including breeding areas outside Europe, wherever possible. The discussion section draws international, national and local attention to a species that is apparently declining all over Europe, and possibly also in many parts of Asia. It also focuses on possible reasons for the decline, particularly the likely impact of climate change.

RESULTS

In wet grassland sites and in natural habitats across Eurasia, the predominant trend in the breeding ruff population in recent years has been one of decline (Tables 1 & 2). Sites formerly occupied around the periphery of the range are now vacated with the remaining population now concentrated mainly in Central and Eastern Europe. It should be noted, however, that although information from European sites is fairly complete, few data are available for many regions of the tundra on either population size or trends. Nevertheless some observations from these regions are discussed below.

In Europe, the Ruff was formerly much more widespread than it is today, ranging as far south as Austria, Hungary, and Bavaria. Even in the 19th century, however, it was already in serious decline. First it retreated from its breeding sites in south-central Europe. Then, by the 1940s, the once coherent distribution became patchy and restricted to coastal areas and a few wet grassland sites inland (e.g. Glutz *et al.* 1975). The decline continued through the 1970s and 1980s with concentrations in fewer and fewer sites along the coast and even fewer sites inland (Melter 1995, van Dijk 2000, Hötker *et al.* 2001, Chylarecky pers. comm.). Nevertheless some coastal sites continued to support substantial populations; particularly newly reclaimed salt marshes and mudflats in the Waddensea. After a period of desalination, many of these polders were newly colonised and for some years held significant populations, but later these crashed as the habitat changed. Examples include the Lauwersmeer (van Dijk pers. comm.), the Hauke Haien Koog and other polders along the Schleswig-Holstein coastline (Hötker *et al.* 2001) (Figs 1–2).

The recent decline in the species was first noted among the small population on the southern edge of the breeding range. The decrease in Belgium, France and Britain led to its current extinction in these countries during the 1980s and 1990s. Also, further east along the southern boundary of the range in the steppe region of Bashkortostan, Tomkovich (1992) described the Ruff as extinct. The decline over the last 20 years in the Netherlands from 1,500 to a maximum of 150 females and in Germany from 450–600 to a maximum of 100 (Tables 1 & 2) is alarming and has resulted in a lot of attention in these countries which are on the edge of the species'

Table 1. Population size (females) and trends of the breeding Ruff population in countries and sub-national regions with mainly wet grassland habitats. Data for countries and sub-national region are in bold; data for Länder in Germany and specific sites in The Netherlands, Poland and Estonia are in regular font. Trends are based on either data in table or listed reference (DEC = decline; INC = increase; STA = stable; EXT = extinct).

Wet/Salt grassland populations	ca. 1980	ca. 1990	ca. 2000	Trend	Source
Russian oblasts					
Chuvashia Republic			**1–50**	DEC	Glushenkov *et al.* (1999)
Kaliningradskaya			**4 – 10**	DEC	Grishanov (1998)
Kirov region			**300–1,500**	INC?	Tomkovich 1992, V. Sotnikov – estimate
Kostroma region			**500–4,000**	?	Lebedeva – estimate,
Mordovia			**1–10**	DEC	Lebedeva – estimate
Moscow region	**150**	**50 –100**	**0–1**	DEC	Zubakin *et al.* (1998)
Novgorod region			**3,500–4,000**	?	Mischenko & Sukhanova (1998)
Ryazan' region			**100–200**	DEC	Ivanchev, Kotyukov (1999)
Smolensk region			**10–100**	DEC	Lebedeva – estimate
Vladimir region			**5–50**	DEC	Lebedeva – estimate
Belarus		**2,000 – 2,400**	**2,200**	STA?	Nikiforov & Mongin (1998), Kozulin (pers. comm.)
Estonia	**10,000?**	**2,000?**	**85–180**	DEC	Veromann 1980, Heath *et al.* (2000), Löhmus *et al.* (2001)
Matsalu	>150	50	20–30	DEC	Mägi & Kaisel (1999)
Latvia	**50**	**200**	**50**	DEC	Viksne (1983, 1997), Priedniks *et al.* (1989)
Lithuania			**100–200**	DEC	Tomkovich 1992, Heath *et al.* (2000)
Poland	**350–400**	**150–300**	**50–100**	DEC	Chylarecki P. & Winiecki (2001)
Biebrza		50	11	DEC	Witkowski, Dyrcz, Lontkowski & Stawarczyk (in prep.), Nawrocky (pers. comm.)
Ukraine			**10–15**	DEC	Lebed & Knysh (1999), Gorban & Shidlovski (1999)
South Sweden			**500**	DEC	Sörenssen (1999), Widemo (pers. comm.)
Denmark	**500**	**540**	**200–300**	DEC	Thorup (pers.comm.), Frikke (1991), Koskimies (1992), Grell (1998)
Germany	**500–600**	**300**	**75**	DEC	Zöckler (1998a), Hälterlein *et al.* 2000, Hötker *et al.*2001
Schleswig-Holstein	~200	200	50	DEC	Hälterlein *et al.* 2000
Mecklenburg-Vorpommern	50–80	30	10	DEC	Kube pers. comm., Hälterlein *et al.* 2000
Brandenburg	~10		1	DEC	Ryslavy 2001
Niedersachsen	~200	45	15	DEC	Hälterlein *et al.* 2000
Bremen	10	5–10	0	DEC	Seitz 2001
Nordrhein-Westfalen	0–2	0–2	0	EXT	Nehls *et al.* 2001
The Netherlands	**1,250 –1,500**	**600**	**100–150**	DEC	Osieck & Hustings 1994, Cramp *et al.* 1983 van Dijk pers. comm.
Lauwersmeer	350	200	6	DEC	van Dijk pers. comm.
UK	**3–21**	**1–7**	**0**	EXT	Sharrock *et al.* 1981, Ogilvie *et al.* 2001
France		**5–13**	**0**	EXT	Dubois *et al.* (1991), Trolliet (pers. comm.)
Total		**10,900–17,100**	**8,090–13,890**	**DEC**	

distribution. In 1991, Hötker estimated the Ruff population of the twelve countries that at the time formed the European Union at 1,900 breeding females. Now only a quarter of that number, 475, remain. Country populations listed as stable by Hötker (1991), such as those in Britain and France, in fact became extinct shortly afterwards, with no breeding records since 1996 and 1997 respectively.

Long-term monitoring in Finland has also shown a substantial decline over the past 20 years. However, with about 30,000 breeding females, that population is not endangered (Väisänen *et al.* 1998). No significant changes have been noted in other parts of Scandinavia or in most of European Russia, but these populations have not been intensively studied. Most wet grassland areas with time series information confirm the decreasing trend noticed in the rest of Europe (Tables 1 & 2). The drastic decline in almost all non-tundra sites is in contrast to the stable or even increasing situation in some northern Arctic populations (Table 3) and requires explanation.

The Russian tundra supports by far the majority of the total Ruff population, about 95%. Trend information is scarce and is often disguised by natural annual fluctuations resulting from cold weather and predation as well as spatial fluctuations due to the species' highly nomadic behaviour. However, at several sites Ruffs have declined when other waders have performed well and this suggests that some populations of Arctic Ruff may also be in decline. Declines are reported for most (10/14) of the few tundra sites that are regularly monitored (Table 3). These data give an indication of a widespread decline but this needs to be verified. A recent Russian initiative of the International Wader Study Group has addressed the issue of trend interpretation in Arctic breeding birds, such as Ruff. A co-ordinated Breeding Condition Survey with a circumpolar approach started in 1997 to monitor breeding performance in connection with weather conditions and lemming abundance (Soloviev *et al.* 1998) and it is hoped that this will lead to a better understanding of what is happening to tundra-breeding Ruffs.

DISCUSSION

Reasons for the decline

The widespread decline of almost all wet grassland waders in Europe and in many parts in Asia urgently needs to be

Table 2. Population size (females) and trends of the breeding Ruff population in countries and sub-national regions with mainly natural habitats. Trends are based on either data in table or listed reference (DEC = decline; INC = increase; STA = stable; EXT = extinct).

Tundra/peatland habitats	**ca. 1980**	**ca. 1990**	**ca. 2000**	**Trend**	**Source**
Norway	**15,000**	**15,000**	**15,000**	STA	Koskimies 1992, Kalas (1994)
Sweden	**80,000**	**57,000**	**50,000?**	DEC?	Koskimies (1992), Girard & Kirby (1997), Sörenssen (1999)
Finland	**196,000**	**39,000**	**30,000**	DEC	Girard & Kirby (1997), Väisänen *et al.* (1998)
Russian oblasts					
Murmansk region			**8,000–20,000**	DEC	Lebedeva, recalculated from Bianki *et al.* (1993), Tatarinkova (1998)
Karelia			**800–5000**		Mikhaleva, (1998), Lebedeva – estimate
Leningrad region			**500–5000**		Lebedeva – estimate
Tver region (peatlands)			**500–5000**		Nikolaev (1998), Lebedeva – estimate
Novgorod region			**3500–4000**		Mischenko & Sukhanova (1998)
Vologda region			**1,000–10,000**		Butiev, Shitikov, Lebedeva, (1998)
Arkhangelsk (exc. Nenetsk AO)			**1,500–10,000**	STA	Butiev, Shitikov (1998), Morozov (1998), Lebedeva – estimate
Nenetsky Autonomous Region			**1,600 –5,000**	STA	Morozov (1998) (Vaigach only) + Lebedeva – estimate
Komi Republic			**1,000–10,000**		Lebedeva – estimate
Pskov region (peatland?)			**3,000–4,000**		Lebedeva – estimate
Yamal				INC	Ryabitsev & Alekseeva (1998)
Gydan				?	
Taimyr				INC?	Soloviev *et al.* (2001b)
Yakutia				?	
Chukotka				STA	
Koryak Mountains				?	
Sachalin				?	
Steppe habitats					
Hungary	**8–10**		**0–1**	EXT?	Heath *et al.* (2000)
Kasakhstan		**1–5**	**0–1**	EXT?	Khrokov 1998
Bashkortostan			**0–1**	EXT?	Ilyichev & Fomin 1979, Tomkovich (pers.comm.)
Baikal area			**10–100?**		Sumja & Skryabin (1989)
Mongolia			**10?**		Skryabin & Toopitsyn (1998)

understood as a basis for conservation action. Several explanations have been proposed. Often, however, the most obvious site-specific factor has been identified as the prime cause and conservation action has been taken without considering what is known about whole populations. Possible reasons for the decline of Ruff are listed below and then discussed briefly.

Local, site-related factors:

- ❑ Drainage
- ❑ Agricultural intensification
- ❑ Abandonment of land-use practices and succession
- ❑ Predation (by foxes, weasels, crows and birds of prey)

Global factors:

- ❑ Changes along flyways
- ❑ Global change, including climate change

Drainage

The decline in wet grassland birds, particularly Ruff, has most frequently been connected with drainage and improvement of land for agriculture. Without doubt this was responsible for the large-scale decline over the past century in many areas of Western and Central Europe, and also in parts of Eastern Europe (e.g. Glutz *et al.* 1975, Beintema 1986, Melter 1995, van Dijk *et al.* 2000, Tomkovich & Lebedeva 1998, 1999). The breeding populations that remain, whether in natural habitats or in wet grasslands, rely entirely on wet or very wet conditions. All nests found throughout the entire range have been in such locations, usually in the immediate surroundings of small ponds, puddles or undrained surface water on permafrost or peat grounds (Zöckler in press). High water levels therefore appear to be essential, though probably not the only factor, for maintaining wet grassland bird communities, such as Ruff, Black-tailed Godwit *Limosa limosa* and other wet grassland birds at healthy population levels.

By itself, however, drainage no longer explains the continued decline of wet grassland waders for they have also declined in well-managed, wet and deliberately flooded reserves, such as the Wümmewiesen reserve near Bremen, Germany (Fig. 3), the Alte Sorgeschleife reserve in Schleswig-Holstein, Germany, and the Biebrza marshes in Poland. Ruffs have even declined at extremely wet coastal sites, such as the Matsalu reserve in Estonia (Fig. 4) where dunlin have been increasing (Mägi & Kaisel 1999). This demonstrates the need to look for other reasons. The decline of Ruff in Finnish peatland reserves is also not necessarily connected with drainage or wet conditions. Certainly the loss of peatland in the 1950s and 1960s (Järvinen & Sammalisto 1976) caused a huge loss of habitat for Ruff and other peatland species. This cannot, however, explain the continuation of the decline in the 1980s and 1990s, after large-scale peat destruction had ceased.

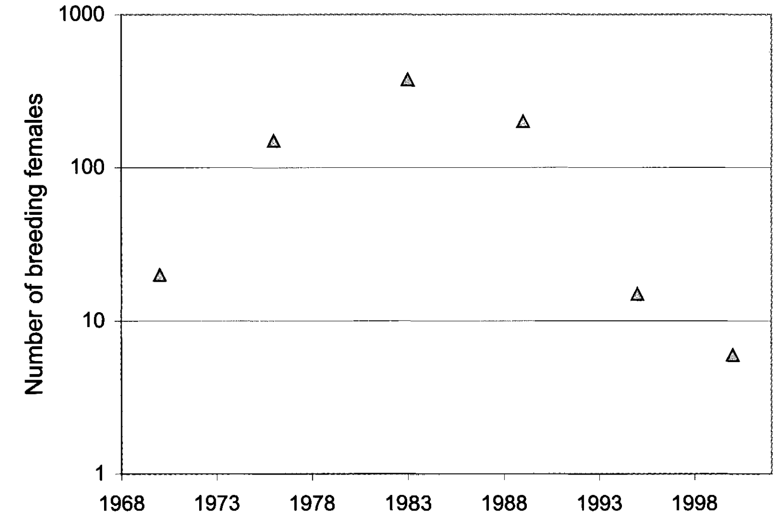

Fig. 1. Population trend of Ruffs at the Lauwersmeer polder nature reserve, the Netherlands (based on van Dijk *et al.* 2000 and pers. comm.).

Agricultural intensification

The use of land for agriculture has intensified for centuries and at an increasing rate during the last 50 years, especially in Western and Central Europe, with a generally adverse effect on birdlife (Donald *et al.* 2001). Grassland birds have declined as fertiliser use, grazing and the frequency of mechanical treatment have increased. Two observations, however, indicate that additional explanations are needed.

First, the reverse process, the extensification and de-nitrification by zero-application of fertilisers, has not always led to a re-colonisation by grassland bird communities (e.g. Nehls 2001). Moreover, the few sites that never faced the intensification process and remained mostly untouched experienced a decline in wet grassland birds, particularly Ruff (see examples in North Germany, the Netherlands and Poland (Table 1, Figs 1 & 2)). Secondly and more significantly, the decline of Ruff in Eastern Europe started before the large-scale intensification of agriculture began, as shown for example in Estonia and Poland (Table 1). For these reasons it is important to look for other explanations for the decline without denying the severe impact that intensive land use has had on wet grassland bird communities.

Abandonment of land-use practices and succession

When Ruff breed on farmland, outside primary natural habitat, moderate grazing or mowing is required for it to remain suitable. If this stops, it is destroyed as breeding habitat by successional changes that lead to a higher and denser vegetation structure. Several times the decline or disappearance of Ruff and other waders has been attributed to the abandonment

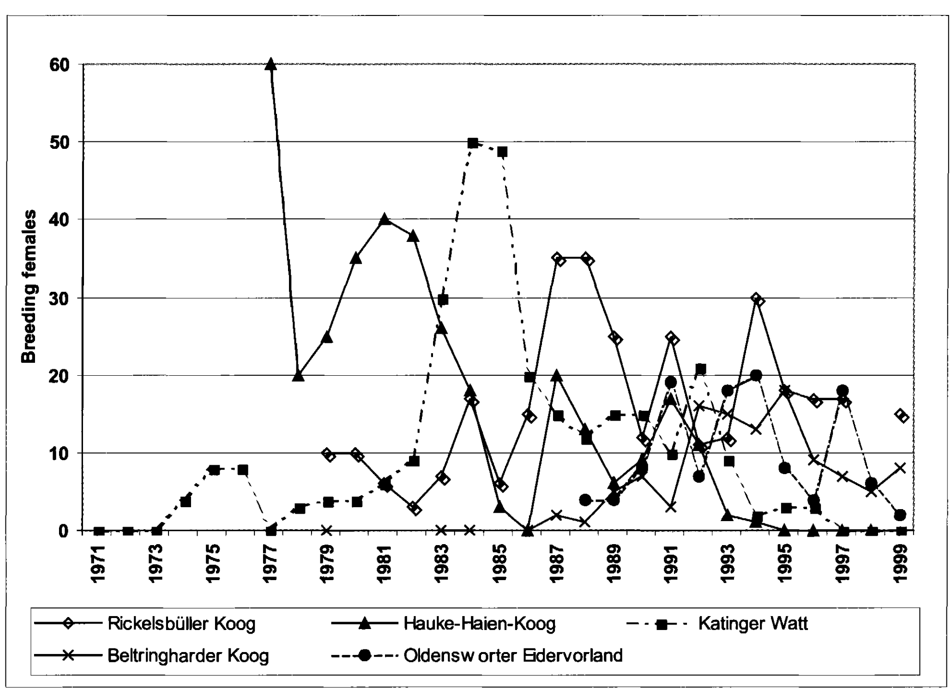

Fig. 2. Population changes of Ruff at selected breeding sites in recently enclosed polders (Köge) along the North Sea coast of Germany during the past 20–30 years (based on Hötker *et al.* 2001).

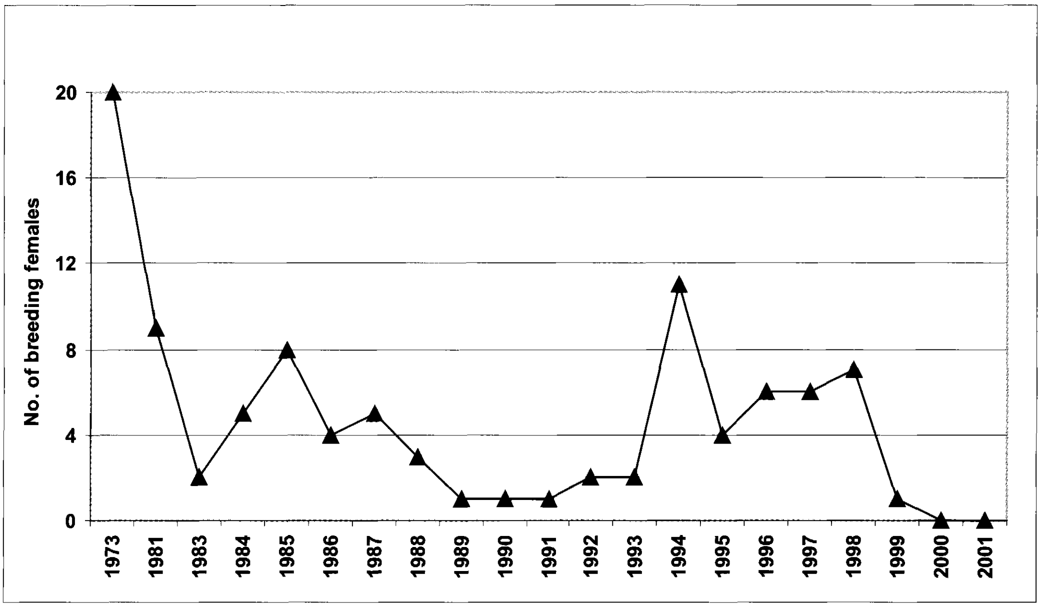

Fig. 3. Population changes of Ruff at an inland site: the nature reserve at Wümmewiesen, on a floodplain near Bremen, Germany (based on Eikhorst & Mauruschat 2000 and the author's own observations).

of land-use practices. Soikkeli & Salo (1979), for example, demonstrated that a decline in populations along the south coast of Finland was due to the abandonment of less productive farmland. Moreover, the decline in the Netherlands has been attributed largely to the succession of vegetation (van Eerden *et al.* 1979, Altenburg *et al.* 1985, van Dijk *et al.* 1999).

Predation

Predators play an important role in wet grassland bird communities (Lugert 1994, Schoppenhorst 1996, Hase & Ryslavy 1998 & Seitz 2001). Most commonly recorded in Europe are Red Fox *Vulpes vulpes*, Weasel *Mustela nivalis*, Mink *Lutreola lutreola* and domestic dog. Among avian predators are crows *Corvus* spp., Marsh Harriers *Circus aeruginosus* and Peregrines *Falco peregrinus*. However, it seems unlikely that conditions for predators have simultaneously changed in their favour all over the Ruff's breeding range, to the extent that that they have been the major cause of the decline. Moreover, the decline has also been observed on Dutch islands where most of these predators are absent (van Dijk pers. comm.). The well-being of some species at particular sites and the decline of others, as with the Dunlins and Ruffs at Matsalu (Fig. 4), suggests that predation is not an important reason for the large-scale decline in wet grassland birds.

Global factors

Global factors are those that impact on a species at the global or flyway level and flyway factors are those that impact along an entire migration route. Global factors include climate change and pollution and also the assemblage of multiple human activities that impact the Earth at a global scale. Several recent studies have indicated the importance of such matters in explaining distribution changes and population trends in a variety of taxa (e.g. butterflies (Parmesan 1996)). These factors may be working together. For example, wader

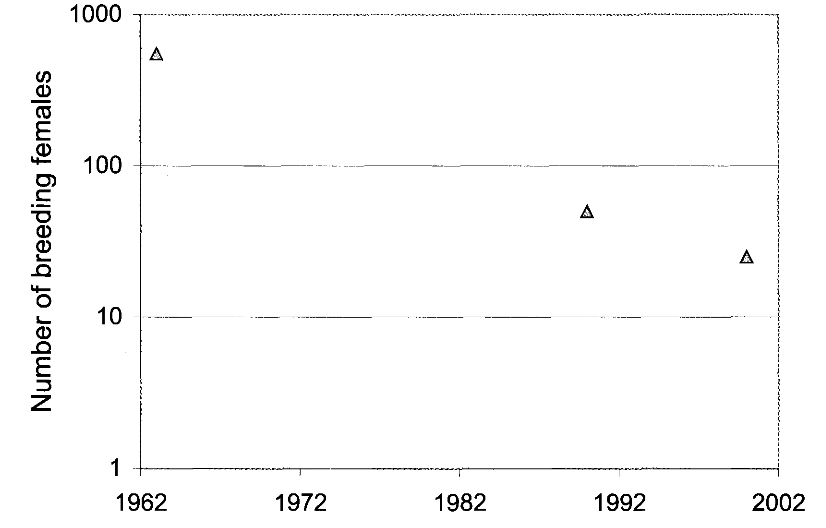

Fig. 4. Population trend of Ruff in the Matsalu nature reserve, Estonia (based on E. Mägi pers. comm.).

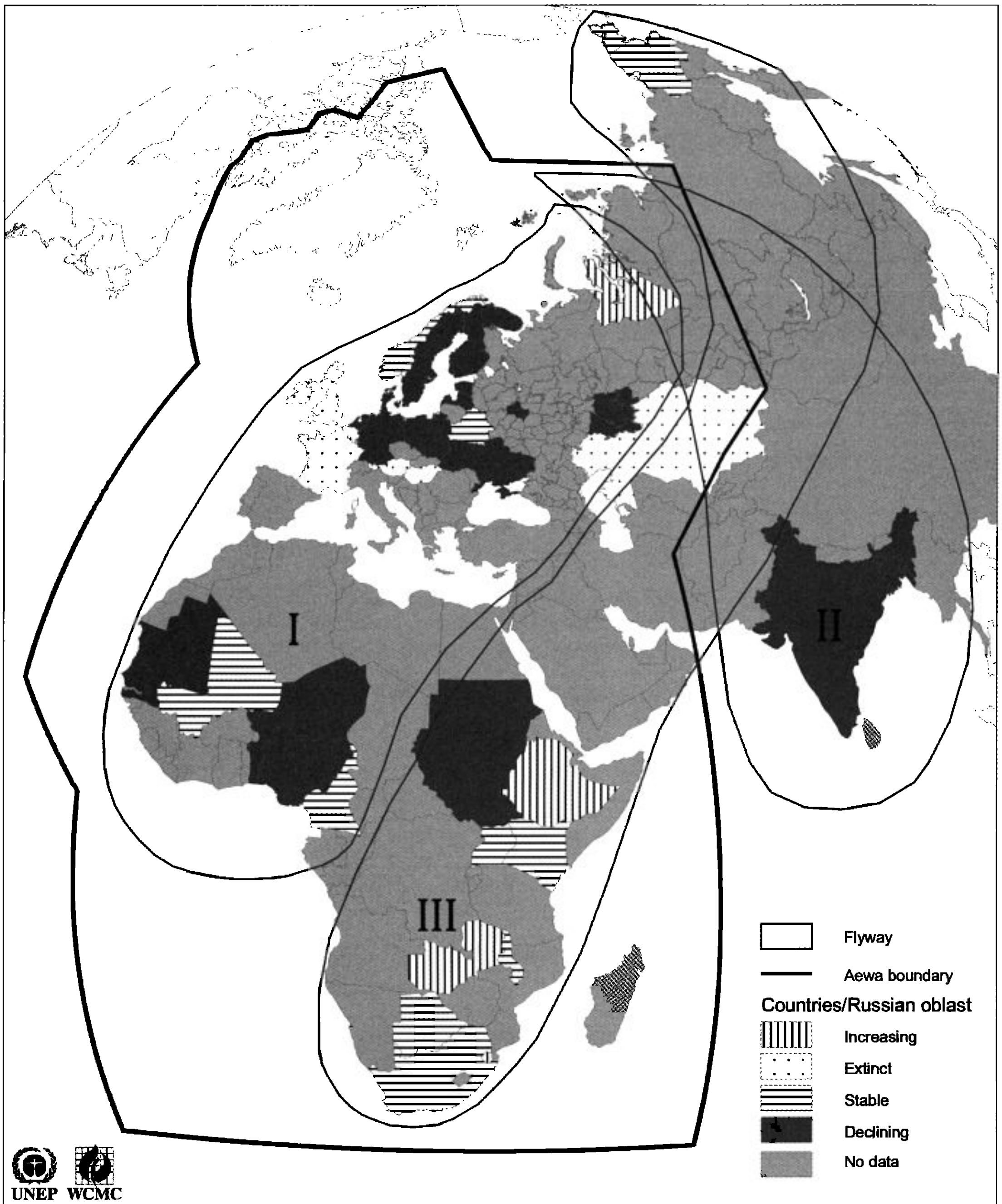

Fig. 5. Trends in the Ruff population on the breeding and wintering grounds in the context of three recognised flyways I-III; based on Boere (1991), Syroechkovski & Rogacheva (1996), Rogacheva (1992), Underhill *et al.* (1999) (sources of trend data: Tables 1 & 2, Triplet & Yesou (1998) and unpublished data from the IWC for Africa, courtesy Wetlands International).

habitats are likely to be changing not only because carbon dioxide and other greenhouse gases are leading to global climate change, but also because of the impact of increasing amounts of air- and waterborne nutrients.

Two broad hypotheses are proposed as the explanation for the widespread decline of the Ruff and many other wet grassland waders:

1) The flyway hypothesis: Something has happened to the birds along the flyways of the population in their wintering or staging grounds
2) The global change hypothesis: The gradual alteration of wet grassland habitats, due to direct and indirect human activities, has caused the decline.

The flyway hypothesis

This assumes that the decline is particularly prominent in one flyway population compared with others having different migrating routes, suggesting that the cause lies somewhere along that particular flyway. There appears to be some evidence for different flyway trends in the case of the Ruff (Fig. 5), but winter count data are too sparse for any firm conclusion. In particular, data for Africa are insufficient to determine long-term trends (Trolliet & Girard 2001). However, the fact that there is also a declining trend in the rather separate South Asian population suggests a more general decline over all flyways. Similarly the decline of most wader populations in the Americas (Morrison *et al.* 2001) not only indicates that the problem is more global than local, but also suggests that it is larger than something that has occurred in just one or two flyways. However, a variety of local changes have developed a global character, which include:

- Desertification, droughts and the loss of wetlands,
- Eutrophication of staging and wintering wetlands,
- General changes in land-use and application of chemicals and nutrients on wintering grounds, leading to changes in vegetation and changes in growth rate and biomass.

The impact of habitat loss and desertification on wintering waders has been particularly noticed in West Africa where Ruff and Black-tailed Godwit are highly nomadic and often change their wintering site from year to year (Altenburg & van der Kamp 1986, Yesou & Triplet 1996, Triplet & Yesou 1998). These two species have become more and more dependant on inundated rice fields after the loss of many natural wetlands (Altenburg & van der Kamp 1986). Depending largely on rainfall, rice production varies from year to year, so bird counts from one area might not reveal the full picture. Only aerial surveys covering several regions reveal a picture that is close to reality (Trolliet & Girard 2001). Even so, counts from different regions often derive from different years, so trends cannot readily be identified. In some regions, however, numbers seemed to have declined considerably, particularly in Senegal and Northern Nigeria (Glutz *et al.* 1975, OAG Münster 1991, Triplett & Yesou 1998, Trolliet & Girard 2001).

The nominate subspecies of the Black-tailed Godwit in Europe, *L. l. limosa*, more or less shares the same flyway and wintering grounds as the Ruff (Glutz *et al.* 1975, Cramp *et al.* 1983) and most likely faces the same threats. Both are declining strongly and persistently all over Europe, whereas other species with different flyways, such as Common Redshank *Tringa totanus* and Common Snipe *Gallinago gallinago*, have only declined in those areas where there have been habitat losses. Similarly, the Icelandic subspecies of the Black-tailed Godwit, *L. l. islandica*, which winters in the British Isles and southwest Europe, has an increasing population (Gill *et al.* 2001).

When each Ruff flyway is considered separately, it appears that western populations have declined most and those breeding and wintering further east have remained more stable. Therefore the decline in Europe, including the western parts of Russia, is matched by similar falls in the main wintering grounds of the same populations in West Africa (Fig. 5). In Siberia, Tomkovich (1992) considered that the Ruff had extended its range into Chukotka, Kamtchatka and other parts of Central Yakutia. However, it is quite possible that the species had previously been overlooked in those areas. Indeed, in Chukotka, ancient Ruff skeletons have been found in Chukchi settlements indicating the species' presence there in historical times (P. Tomkovich pers. comm.). Stable or increasing wintering populations in East Africa may reflect more healthy populations in Eastern Russia (Fig. 5). The Central Asian flyway may be similar, though there are not enough data from the breeding grounds to prove this conclusively. Broadly therefore it seems that there is some evidence to support the flyway hypothesis, but there are too many gaps in the data for confidence.

In Southern Asia, the Ruff is the seventh most numerous wintering wader species. The highest count in 1995 was 11,400 with a declining trend compared to several increasing species, such as Curlew Sandpiper *Calidris ferruginea*, Temminck's Stint *C. temminickii*, Little Ringed Plover *Charadrius dubius*, Lesser Sand Plover *Ch. mongolus*, Pacific Golden Plover *Pluvialis fulva*, Grey Plover *Pluvialis squatarola*, Black-tailed Godwit, Bar-tailed Godwit *Limosa lapponica*, Whimbrel *Numenius phaeopus*, Eurasian Curlew *N. arquata*, Common Redshank, Common Sandpiper *Actitis hypoleucos*, Terek Sandpiper *Xenus cinereus* and Black-winged Stilt *Himantopus himantopus* (Lopez & Mundkur 1997). The Ruff is declining, whereas Common Snipe, Pintail Snipe *Gallinago stenura* and Wood Sandpiper *Tringa glareola*, recognised widely over Siberia as frequent co-breeders with Ruff (Zöckler in prep.), show a stable or only slightly declining trend. Only Little Stint *C. minuta*, the species with the second largest wader population in the region, also shows a clear declining trend similar to the Ruff. There is little information available either on the use of fertilisers or on land-use changes or the impact of hunting in the wintering areas.

The global change hypothesis

Global change comprises all natural and human-driven changes on our planet, including climate change by the accumulation of greenhouse gases, and also eutrophication through fertilisers and nutrient release through fossil burning. The impact of these changes is complex and few factors are traceable and identifiable as responsible for what we observe in wet grassland and its birds. The main features of global change relevant to wet grassland and tundra birds can be summarised as:

- Changes in climate,
  - generally more rain in temperate regions, warmer annual mean temperature
  - drier and hotter climate in wintering areas with losses of wetlands
- Extended growing season and early start of vegetation growth
- Increase of biomass
- Change of vegetation height and density
- Impoverishment of vegetation in structure and diversity
- Increase of natural forestation in the main breeding area in the tundra region.

Climate change is a complex process that may affect wet grassland birds, and Ruff in particular, in three different areas. First, they may be affected in their prime Arctic breeding range. Habitat conditions will change due to warming. Most of the open tundra habitats currently occupied by Ruff, for example, will change into forest tundra and forest tundra may become densely forested, a process that has already started, as observed in Alaska (Scott *et al.* 1996, see also Zöckler & Lysenko 2000).

Second, climate change also affects the temperate region, though not so fundamentally as in the Arctic, and its effects are already evident in the growing season of European trees (Menzel & Fabian 1999). The combination of global warming and eutrophication from both airborne nutrients and fertiliser run-off has been identified as responsible for boosting vegetation growth in most parts of Europe. It is estimated that about 50 kg of nitrogen per hectare is applied annually by rainfall alone. In addition nutrients arrive via floodwater on wet grassland. In combination with global warming, this

Table 3. Population trends of Ruff at various breeding locations in the Arctic (DEC = declining or low numbers compared to year before, INC= increasing, S = southern tundra, N = Northern tundra).

Location	Trend	Years, comments	Sources
Fenno-Scandinavia **S**	DEC	Last 20 years	Väisänen *et al.* (1998)
Northern Murmansk coast **S**	DEC	1989, 1990, 1994, 1998, 1999, 2000	Tatarinkova (1998) and in Tomkovich & Lebedeva (1996), Soloviev & Tomkovich (1999, 2000, 2001)
Malazemelskaya Tundra **S**	DEC	1998	Mineev cit. in Soloviev & Tomkovich (1999)
Kanin Peninsula **S**	DEC	1996	Filchagov in Tomkovich & Zharikov 1997
Russki Zavarot, Pechora **S**	DEC	1997, 1998, 1999	Shchadlikov & Belousova in Tomkovich & Zharikov (1998), Soloviev & Tomkovich (1999, 2000)
Russki Zavarot, Pechora **S**	INC	1994	Shchadlikov & Belousova in Tomkovich & Lebedeva (1996),
Central Yamal **N**	DEC	1993	Shtro in Tomkovich (1998b)
Southern Yamal **S**	INC	1982–1991	Ryabitsev & Alekseeva (1998)
Southern Yamal **S**	DEC	1993	Paskhalny cit. in Tomkovich (1998b)
Southern Yamal **S**	DEC	1998	Morozov in Soloviev & Tomkovich (1999)
Lower Ob valley **S**	DEC	1999	Paskhalny in Soloviev & Tomkovich (2000)
Eastern Taimyr **N**	INC	1995–2001	Soloviev *et al.* (2001)
Yana Delta **N**	INC	1998	Keremyasov & Turakhov in Soloviev & Tomkovich (1999)
Western Taimyr, Lower Kolyma **N**	DEC	1988 compared to year before	Tomkovich (1998a)

has resulted in the growing season starting four weeks earlier, and in an increase of biomass with a more lush and dense vegetation compared to the 1950s in northwest Europe (Beintema *et al.* 1995). Of all the wet grassland birds of central Europe, the Ruff has been recognised as the species that is the most sensitive to these changes and one of the first to react to drainage and eutrophication (Beintema & Müskens 1987). The Ruff, however, is not the only one affected. Others like Common Snipe, Common Redshank and Black-tailed Godwit are following.

Vegetation samples taken at one site without any fertiliser application in the Wümmewiesen reserve, Germany, between the early 1980s and 1995 showed an increase in biomass after a short period of decrease (Warnken 1994, Rosenthal in prep). Another indication of earlier growth with more biomass is the date on which the first cut of harvested grass is taken. In all areas without conservation restrictions, this has been taken earlier and earlier every year and it has now moved to early May (Nehls *et al.* 2001). In 2000, the first cut in the vicinity of Wümmewiesen was as early as 1st May (Warnken, pers. comm.) compared with the end of May in the early 1980s. Drainage tends to enhance biomass even further because drained meadows warm up faster and warmth increases growth.

Third, the warming climate will also change conditions in the wintering areas. Wetlands will decrease as a direct result of the increasing dryness of the climate. Moreover, secondary processes, such as the increasing demand for water to irrigate previously rain-fed crops, will reinforce this effect. According to a study by University of Wisconsin-Madison researchers using satellite images, Lake Chad is now only a twentieth of the size it was 35 years ago. The region has suffered from an increasingly dry climate, with a significant decline in rainfall since the early 1960s (Coe & Foley 2001). In addition, the lake has become the source of water for massive irrigation projects. In the winter of 1999/2000, 339,000 Ruff were counted in the Lake Chad area (Trolliet & Girard 2001). However, because of changes in survey methods and the area covered, it is not possible to determine any population trend.

In the Arctic, plenty of suitable breeding habitat can still be found in the tundra and peatbogs where future changes in vegetation are unlikely to affect Ruff. In fact, there, changes are more likely to be beneficial to Ruff than most other species (Zöckler & Lysenko 2000) because Ruff can be found at moderately high densities in forest tundra. It has also been observed that Ruff will tolerate a certain amount of change in the vegetation structure, including bushes and scattered trees, as long as the base vegetation layer does not get too dense and the water conditions remain unchanged and suitable to provide enough food resources (Zöckler in prep.).

Indications that Ruff have declined in southern regions of the tundra and increased in the north and east (Table 3, Tomkovich & Sorokin 1983, Tulp *et al.* 1997) support the idea that the distribution has shifted because of the warming climate. Similarly, in Europe the decline started first in the south, in Austria and Bavaria, early in the 20th century, then in France and Belgium in the 1980s and in the UK, southern Russia and Kaskhstan in the 1990s (Glutz *et al.* 1975, Ogilvie *et al.* 2001, Morozov pers. comm.). Recently, it has continued in west Europe and in north-central Europe, as far north as Arctic Finland. Today, the decline may even extend to the southern parts of the Russian tundra.

The emerging picture is therefore that the Ruff is being forced to retreat to its core northern habitats through global climate change and the effect of that on the quality of its wet grassland habitats. The decline is steepest in the south of the breeding range, particularly in Finland (Väisänen *et al.* 1998), but also over the last ten years in Denmark (50%), Germany (75%) and The Netherlands (80%) (Table 1). As the decline has occurred all over Europe, including European Russia and in all habitats, including some tundra areas (but not strongly if at all in Siberia), it can be concluded that the impact of global change on Ruff breeding in wet grassland habitats is greater than on those breeding in tundra habitats.

This pattern would seem to be consistent with changes apparent from the fossil record which shows sequences of colonisation, disappearance and re-colonisation in cooling and warming periods between the ice ages. Evidence from Pleistocene fossil Ruffs in Denmark, Finland, Azerbaijan and Hungary (van Rhijn 1991) might indicate breeding further south during colder periods, but it is equally possible that the fossils are from migrants. The tundra biome during recent glaciations was much further south than it is today and could well have enabled Ruff to breed in those areas. Undoubtedly Ruffs must have accompanied the cyclic shift of the tundra and its adjacent biomes through the ice-ages and it is quite possible that this process continues to this day with the current retreat northwards as the globe warms.

This coincides with the recent northern expansion of other wet grassland waders, such as Common Snipe in the Bolshemelzkaya tundra (Morozov 1998), Black-tailed Godwit and Northern Lapwing *Vanellus vanellus* in Northern Russia concomitant with a northward expansion of agriculture including sown meadows (Morozov 1987, Lebedeva 1998). Several other bird species have recently recorded in more northern locations in the Arctic (Zöckler *et al.* 1997) and this confirms a general trend of species shifting their distributions in response to changing climate.

There seem to be a variety of factors responsible for the increase of vegetation biomass. The most obvious are linked with the general intensification of land use. But even in those nature reserves where no fertilisers have been applied and water quality protected, the Ruff and several other species have declined. In these places, subtle changes associated with global climate change, particularly earlier and warmer springs, have boosted vegetation biomass, often aided by drainage as well as by airborne and waterborne nutrients.

CONCLUSIONS

The Ruff is still a common species in the Eurasian tundra nor is it globally threatened. The recent decline in wet grassland habitats, however, has been so widespread that it should be considered in a global context. Most other wet grassland waders have declining populations. Sometimes this is the result of local changes in land-use or the impact of predators, but for certain species, especially Ruff and Black-tailed Godwit, it seems that the causes must be of a nature that is global. Unlike species that are largely confined to wet grassland, Ruff differ in that they maintain a strong population in tundra habitats. Available data show a shift in distribution, but it is not possible to determine to what extent losses in southern parts of the range are compensated by gains in the north and east. Similar changes may apply in the Icelandic and Norwegian populations of the Black-tailed Godwit. It is therefore important that these be monitored closely (which is currently not being done).

The Ruff appears to be very sensitive to changing climate as well as to changing water tables and faster vegetation growth. Therefore it might be an ideal indicator-species for monitoring global change. In wet grassland areas, however, it may be already too scarce to provide adequate data. Climate seems to be the overriding factor with similar, though not everywhere pronounced changes occurring all over the temperate parts of the Palearctic. Together with eutrophication, it is probably the main reason for the changes documented here. It is a factor that might drive a cold-temperate species further north.

It is unfortunate that trend data are scarce and scattered randomly. Particularly in the Arctic there is lack of well-organised long-term monitoring. This is vitally important for understanding the major outstanding questions: the retreat from southern breeding sites, the northward extension and the decline in natural habitats. An increase in monitoring sites in the Arctic will also help to disentangle such trends from the background "noise" of natural variation. The observed trends along the flyways (Fig. 5) are not based on systematic monitoring. This needs to be remedied as a matter of urgency. Future monitoring should take account of all these factors and be designed to cover all flyways from the breeding grounds to the wintering grounds as well as all stopover sites in between.

The plight of the Ruff in Europe is alarming. Although it is only understandable in the context of changes that are of global application, other factors have undoubtedly exacerbated the situation. These include large-scale land-use changes, drainage and the general increase of nutrients. These add to the eutrophication of the landscape and global warming with a synergetic effect on the species. Similarly, although the impact of predators is usually quite local, this may be quite devastating where it causes the final extinction of a vulnerable population at a degraded site.

This study demonstrates that the decline of the Ruff needs to be considered in the context of entire flyways and the global situation. All conservation action should take this into account. However, despite the well-documented decline of the breeding population across temperate Eurasia, even now we cannot be sure exactly what has happened. Has the population merely shifted or has it declined globally? To answer this question, more systematic monitoring in the wintering grounds of Africa and southern Asia is vital. Also, although we may have confidence in the connection between the decline of the Ruff and global change, we have yet to come to grips with a real understanding of the proximate factors involved. For example, vegetation biomass in the breeding habitats may have increased, but how does this impact on the ability of Ruffs to survive and/or reproduce?

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