Contrasting trends in two Black-tailed Godwit populations: a review of causes and recommendations

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In recent decades, the West European population of Black-tailed Godwits, *Limosa limosa limosa*, has declined in size at a quite alarming rate, while the Icelandic population, *L. l. islandica*, has undergone a rapid increase in population size. These two populations have been the subject of a great deal of research, much of which has been focused on understanding the causes and consequences of the contrasting population trends. In 2007, a workshop was held during the annual conference of the International Wader Study Group at La Rochelle, France, with the aims of identifying the likely causes of the population changes and providing recommendations for future actions to improve the conservation of both populations. The available evidence strongly suggests that changes in productivity as a consequence of agricultural intensification are the most likely driver of the decline in *L. l. limosa,* although the concentration of much of the population in just a few sites in winter and spring is likely to exacerbate their vulnerability to future habitat changes. Agricultural and climatic changes are implicated in the expansion of *L. l. islandica*, and the availability of both intertidal mudflats and wet grasslands as foraging habitats appears to be very important across much of the winter range of this population. A series of recommendations for actions to conserve both populations are provided, including improving agricultural land management and protecting key passage and winter sites and habitats.

The last three decades have seen widespread declines in the population size of many species of shorebird (International Wader Study Group 2003). While research has strongly implicated the loss and degradation of breeding habitats in these declines, largely through drainage of wetlands and conversion to intensive agriculture (Thorup 2006), efforts to reverse declining population trends have met with little success. The West European population of Black-tailed Godwits, *Limosa limosa limosa*, provides one of the clearest examples of this problem. The great majority of this population breed in the Netherlands where, after increasing in the first half of the 20th century (Bijlsma *et al.* 2001), it was a widespread and common meadow bird in the 1960s, numbering up to 250,000 individuals (Mulder 1972, Piersma 1986). However, since then this population has declined severely, and now numbers only around 50,000 breeding pairs (BirdLife International 2004).

Attempts to reverse this population decline (and similar declines in many other meadow-breeding bird species) have focused on implementing agri-environment schemes (AES) on farmland in breeding areas to improve breeding success (Beintema *et al.* 1997, Kleijn *et al.* 2001, van Brederode & Laporte 2006, Verhulst *et al.* 2007). Despite the area covered by AES aimed at conserving meadow birds increasing from *c.*20,000 ha to *c.*150,000 ha of farmland in the Netherlands by 2006, and schemes costing in excess of 30 million Euro per year, no discernible improvement in the population so far has been apparent (Kleijn *et al.* 2001). In fact, the national population trends of meadow birds in the period 2000–2004 have declined even more rapidly (by approximately 3.5%) than trends in the period 1990–2000 (Teunissen & Soldaat 2006). In addition to agri-environment initiatives, the creation and management of nature reserves for meadow birds has also occurred but on relatively small areas (*c.*18,000 ha, Schekkerman *et al.* subm. b). Although population declines are less steep in reserves than in the wider countryside, there is much variability between reserves (Teunissen & Soldaat 2006).

By contrast, the population of Black-tailed Godwits that breeds in Iceland, *Limosa limosa islandica*, has undergone a rapid increase over the same time period, from an estimated 2,000–3,000 individuals around 1900 to *c.*50,000–75,000 at present. This population has expanded from breeding locations in south-west Iceland and now occurs virtually throughout lowland Iceland (Gunnarsson *et al.* 2005a).

Both the *limosa* and *islandica* subspecies of Black-tailed Godwits have been the subject of extensive research studies in recent years, mostly focused on the causes and consequences of population changes (e.g. Beintema 2007, Both *et al.* 2006, Gill *et al.* 2001a, Groen & Hemerik 2002, Gunnarsson *et al.* 2005b, Roodbergen *et al.* subm., Schekkerman *et al.* 2005, subm. a,b, Schekkerman & Verhulst *et al.* 2007). In order to bring together the available information on both populations, a workshop was held at the International Wader Study Group conference at La Rochelle, France in 2007. This workshop aimed to:

- compare current knowledge of the Icelandic and West European *L. limosa* populations
- inform potential explanations for the divergent population trajectories
- highlight research gaps and potential future collaborations
- recommend conservation measures.

Here we report on the findings of this workshop, particularly focusing on identifying the likely drivers of changes in demography and distribution of both populations, highlighting the key issues influencing each population and providing a series of recommendations for future conservation and research efforts. The workshop attracted *c.*100 participants with a wide range of expertise and knowledge of these birds and their habitats. This meeting was therefore a unique and exciting opportunity to compare two subspecies with widely diverging population trajectories, and to discuss causes of changes and prioritise future actions.

The workshop comprised a series of comparative talks which detailed current knowledge of the key processes influencing breeding and non-breeding season distribution and demography, and patterns of connectivity between seasons and sites, for the two populations. During the workshop, information from each talk was used to complete a summary table of current status, drivers of change and potential impact for a series of demographic, distribution and habitat issues (Tables 1 & 2). The key issues arising from this summary are discussed below.

CURRENT DISTRIBUTION AND HABITAT USE OF *L. L. LIMOSA*

The West European breeding population of Black-tailed Godwits breeds throughout the Netherlands, with smaller numbers in Germany, Belgium, Denmark, France and the UK, and migrates via France and Iberia to winter grounds in Senegal, Guinea-Bissau and Guinea in sub-Saharan West Africa (Beintema & Drost 1986, Kuijper *et al.* 2006).

Key breeding season issues

This population depends on grasslands with high groundwater levels as breeding sites, and on wetlands as passage and winter foraging sites (Wymenga *et al.* 2006). Over the last 50 years, both of these habitats have undergone extensive modification. The core of the recent breeding range of this population is on clay-on-peat and peat soils, but the historical distribution also included blanket bogs and wet moorland, which were abandoned as the population expanded into agricultural habitats in the first half of the 20th century (Bijlsma *et al.* 2001). Since then, drainage, urbanisation and conversion of grasslands to arable crops have created drier and highly fragmented breeding habitats (SOVON 2002). The remaining grasslands are generally farmed very intensively, with mowing dates having advanced by one month over the last century, most grasslands now being mown more than twice per year, and livestock number per unit grassland area being the highest of all European countries (Statistics Netherlands, Statline). In addition, there is evidence that changes in predator control and environmental contamination, and landscape changes such as road-building and tree-planting, have altered predator abundance and distribution, and consequently increased nest and chick predation rates (Schekkerman *et al.* subm. a, Teunissen *et al.* 2006, Teunissen & Willems 2004).

When the population size was higher, godwits bred on grasslands in areas of peat, clay and sandy soils. The population decline has been characterised by a contraction into largely peat areas, although levels of degradation now appear similar across all soil types. AES initiatives to reverse the population decline have focused on delaying mowing dates and improving nest protection. However, there is no strong evidence that these schemes have improved breeding densities (Kleijn *et al.* 2001, Kleijn & van Zuijlen 2004, Verhulst *et al.* 2007, Willems *et al.* 2004), despite evidence that delayed mowing saves nests and improves chick survival (Schekkerman & Müskens 2000, Schekkerman *et al.* 2005, subm b). Godwits preferentially choose areas with high groundwater levels as breeding sites (Kleijn & van Zuijlen

2004, Verhulst *et al.* 2007); although clay soils with relatively low ground water levels can also be used. Current AES do not, however, include management of groundwater levels, as this is a contentious issue for farmers. Successful management is also likely to require fields with tall, open and structurally diverse swards within the matrix of more intensively farmed fields throughout the breeding season. This provides chicks hatched throughout an area with access to high quality foraging sites as well as shelter from predators (Schekkerman *et al.* subm. b).

Key non-breeding season issues

On passage and at wintering sites in Iberia and West Africa, wetlands have been extensively drained and dammed since the 1960s, to facilitate energy production, water storage and agriculture (Kuijper *et al.* 2006). Rice production is now widespread, and rice fields provide an alternative habitat which, when flooded, is wet enough to allow birds such as godwits to forage. Godwits have been reported foraging on rice fields in winter since at least the 1970s (Altenburg *et al.* 1985, Tréca 1984, van der Kamp *et al.* 2007), and recent studies of godwits in Iberia and Africa have shown that the birds primarily consume rice seeds (along with smaller amounts of invertebrate food) during the months in which rice fields are used (Tréca 1994). Godwits typically forage on molluscs, worms and other invertebrates, and the consequences of this largely plant-based diet through much of the winter and spring are currently unknown.

Godwits begin to arrive in West Africa in July, and they use rice fields extensively, particularly during planting (Jul–Aug) and harvest (Nov–Dec) (Kuijper *et al.* 2006, van der Kamp *et al.* 2007). When the African rice fields are dried out and harvested during December, the birds begin to migrate north to use rice fields in Spain and Portugal (Sanchez-Guzman *et al.* 2007, Zwarts *et al.* in press). At this time they can be highly concentrated, with up to 50,000 birds in the Doňana National and Natural Park, SW Spain, in December, up to 25,000 in Extremadura, W Spain, by early February and up to 45,000 around the Tagus and Sado estuaries, W Portugal, by late February. Passage sites in Morocco were formerly used in autumn and spring but few birds use these sites now. Drainage of Moroccan wetlands may have influenced this shift in passage site use, as may recent increases in rice production in Spain. Similarly, use of French sites on spring migration may have declined in recent years, although overlap

Table 1. Summary of the current status of the demography, distribution and habitat use of the West European Black-tailed Godwit population, *Limosa limosa limosa*, together with likely drivers of changes and estimates of the proportion of the population experiencing these conditions.

	Status of *limosa* population	Drivers of changes	Potential population impact
Population size	*c.*60,000 breeding pairs		
Population trend	Severe decline at *c.*5%p.a.	Primarily due to declining productivity	Population-wide
Nest survival	Intermediate to low and variable.	Earlier mowing and increased predation	Population-wide
Chick survival	Low. Declines since 1980s	Earlier mowing, reduced habitat heterogeneity and increased predation	Population-wide
Productivity trend	Decline since 1980s from *c.*0.7 to 0.2 fledged young /pair	Loss of grasslands with high water tables, intensification of remaining grasslands	Population-wide
Juvenile survival	Estimates from 40% to 68%	Hunting of juveniles on migration could be significant	Higher estimate from one site only (Workumerwaard)
Adult survival	Annual estimates = 81–96%	Unknown	Probably population-wide
Breeding habitat	Grasslands with high ground water levels in open landscapes	26% loss to urbanisation and arable conversion since 1960s. Severe decline in quality through drainage and intensification	Population-wide
Breeding locations	Grassland in Netherlands, Germany, Belgium and Denmark	Unknown as degradation of all soil types appears similar	Population wide
Breeding trend	Declining and contracting in range	Declining habitat quality, fragmentation	Population-wide
Autumn habitat	Wetlands, mudflats, saltpans, rice fields	Unknown	Unknown
Autumn locations	France (Jun–Nov), Iberia (Jun–Nov) and W Africa (Jul–Nov)	Reduced wetland area in Morocco and S Europe and/or changes in site quality	Most adults fly direct to Africa. Juveniles may use European sites
Autumn trend	Earlier departure and reduced use of Morocco	Early departure correlated with poor breeding success and deferral of breeding	Unknown
Winter habitat	Rice fields and wetlands	Increased use of rice following widespread conversion of wetlands	Population-wide
Winter locations	Senegal and Guinea Bissau (Nov–Dec), Iberia (Dec–Feb)	Large-scale damming, drainage, water storage and agriculture in Senegal delta	Population-wide
Winter trend	Possible earlier departure from Africa for Iberia	Departure follows drying of rice fields – changing rainfall patterns may be involved	Population-wide
Spring habitat	Rice fields, saltpans and wetlands	Conversion of wetlands to rice fields	Population-wide
Spring locations	Iberia (Dec–Feb), France (Feb–Mar) and Netherlands (Mar–Apr), reduced use of Morocco and France	Reduced wetland area in Morocco and France and/or changes in site quality Switch to rice-seed diet	Population-wide
Spring trend	Possible earlier departure from Iberia but arrival in Netherlands unchanged	Unknown	Unknown

between the two subspecies at this time of year makes this difficult to assess.

POSSIBLE CAUSES OF THE POPULATION DECLINE IN *L. L. LIMOSA*

These extensive habitat changes throughout the range of *L. l. limosa* allow several plausible causes of the severe population decline to be identified:

- declining habitat quality and availability in the breeding season may have resulted in reductions in productivity;
- changes in winter and spring diet may have altered the body condition or survival probability of fully-grown birds;
- habitat and climatic changes in the Sahel region may have altered habitat availability, and consequently body condition or survival of fully-grown birds.

The demographic evidence presented at this workshop strongly suggests that reductions in productivity are the most likely driver of the population decline. Changes in productivity through the period of breeding habitat change have been severe, declining from *c.*0.7 chicks per pair (range: 0.5–1) in the 1980s to *c.*0.2 chicks per pair (range: 0.1–0.7) at present (Schekkerman *et al.* 2005, subm b). Changes in the timing and frequency of mowing, affecting both direct nest and chick losses and the foraging conditions for chicks (Schekkerman & Beintema 2007), are strongly implicated in driving these declines. In addition, the abundance of nest and chick predators and their impact on an increasingly fragmented and exposed (through loss of cover by early mowing) population appears to be growing. In recent years, there has also been evidence from one site for deferral of breeding by up to half of the adults returning to the breeding grounds.

The widespread use of rice as food in winter and spring may affect adult body condition but there is currently no evidence for any declines in adult survival rates, in fact adult survival appears to have increased in recent decades (Zwarts *et al.* in press). Recent colour-ring studies suggest high adult annual survival rates of *c.*81–96% (Both *et al.* 2006, Roodbergen *et al.* subm., J. Schröder in prep.), though national estimates from ring-recoveries suggest annual survival rates of *c.*80% (van Noordwijk & Thomson subm.). Recent reductions in the length of the hunting season in France are likely to have reduced hunting pressure, and numbers of hunting recoveries of ringed birds have declined in recent years (Zwarts *et al.* in press). Mortality of juveniles on autumn migration may

Table 2. Summary of the current status of the demography, distribution and habitat use of the Icelandic Black-tailed Godwit population, *Limosa limosa islandica*, together with likely drivers of changes and estimates of the proportion of the population experiencing these conditions.

	Status of *islandica* population	Drivers of changes	Potential population impact
Population size	*c.*50,000–75,000 individuals		
Population trend	Rapid increase, from *c.*2600 around 1900	Warmer temperatures and agricultural expansion in Iceland	Population-wide
Nest survival	50–75% of nests hatch	Unknown	Unknown
Chick survival	20–80% pairs fledge at least one chick. Productivity likely to be *c.*0.5–0.8 chicks/pair	Population expansion may have reduced average productivity	Unknown
Productivity trend	Unknown	Unknown	Population-wide
Juvenile survival	*c.*60% from ringing to fledging and *c.*50% post-fledging to first autumn	Unknown	Population-wide
Adult survival	Annual estimates = 87–99%, highest in winter and lowest during spring migration	Survival increased in late 1990s. Some evidence of recent declines	Probable regional variation in survival trends
Breeding habitat	Lowland marshes and dwarf-birch bogs	Suitability of dwarf-birch bogs as breeding sites may have increased	Population-wide
Breeding locations	Expansion from SW to NE Iceland	Expansion into colder parts of Iceland with more dwarf-birch bog	Population-wide
Breeding trend	Increasing and expanding distribution	Average productivity likely declined but number of pairs increased	Population-wide
Autumn habitat	Estuarine mudflats, occasional use of river valleys and gravel pits	None	Most use of freshwater habitats by juveniles
Autumn locations	Most in UK, Ireland and France (Jul–Sep).	None	Population-wide
Autumn trend	Expansion into E and NW England moulting sites	Population size increase	*c.*30% of population in new sites
Winter habitat	Estuarine mudflats and grasslands. Saltpans in Iberia	Grassland use more extensive in recently occupied sites	*c.*80% on mudflats and *c.*20% on grasslands
Winter locations	UK, Ireland, France and Iberia (Oct–Feb)	Population size increase	Population-wide
Winter trend	Recent expansion into E and NW England	Population size increase	*c.*10% of population in new sites
Spring habitat	Estuarine mudflats and grasslands. Some use of saltpans (France & Iberia) and rice fields (Iberia)	Grassland use more extensive in recently occupied sites	*c.*30% on mudflats and *c.*70% on grasslands
Spring locations	Netherlands (Iberian and French birds), Ireland (Irish birds), UK (UK and Irish birds) (Mar–Apr)	Increase in use of Netherlands and E England grasslands	*c.*50–60% of the population uses Netherlands and E England sites
Spring trend	Increasing use of grasslands on spring passage. Earlier arrival in Iceland	Changing rainfall. Population increase and/or warmer springs	Earlier arrival trend may be more apparent in the earliest birds

be higher as they appear to use European passage sites more than adults, and may thus be exposed to hunting pressures in France. The available national ringing recovery data, together with a recent colour-ringing study from one site, suggest that juvenile survival is not particularly low, but these estimates may not be representative of the whole population.

Habitat structure and composition in Iberia and West Africa have clearly changed dramatically since the 1950–1960s, especially in the Senegal delta, but again there is little evidence for negative impacts on survival rates, at least in recent years. Mortality rates do appear to be a little higher in years with low rainfall in the Sahel, possibly as a consequence of birds occurring at high densities in the remaining wet areas, especially during the post-breeding arrival period when conflict with rice farmers can make the godwits vulnerable to hunting pressure (Zwarts *et al.* in press). However, although there is no strong evidence for climatic or habitat changes in the non-breeding season driving the population declines, there is clear concern that these processes could exacerbate the declines, as such a high proportion of the population is dependent upon relatively small areas of rice fields at key times of year.

CURRENT DISTRIBUTION AND HABITAT USE OF *L. L. ISLANDICA*

The Icelandic population of Black-tailed Godwits breeds primarily in Iceland, with small numbers in the Faeroes, Lofoten and Shetland Islands. In Iceland they breed in lowland areas, primarily on coastal marshes and dwarf-birch bogs (Gunnarsson *et al.* 2006a).

Key breeding season issues

In both marshes and dwarf-birch bogs, Icelandic Black-tailed Godwits are strongly associated with shallow pools, often surrounded by sedges, which support foraging adults. Chicks feed mostly on invertebrates gleaned from vegetation, and seek out tracts of grassland which are rarer in the dwarf-birch bog habitats. The expansion from SW Iceland (around 1900) to the major basins in the north and west (1920s–1940s) and then the east and north-east of Iceland (1970s–1980s) was characterised by an increase in the proportion of dwarf-birch bog sites occupied (Gunnarsson *et al.* 2005a). The most recently occupied sites are also colder than the traditionally occupied southerly sites (Gunnarsson *et al.* 2006b). The lowland areas of Iceland have seen widespread drainage of wetlands and increases in numbers of hayfields since the 1960s, and godwits are now frequently recorded feeding on hayfields during the breeding season.

Key non-breeding season issues

After the breeding season, Icelandic godwits migrate south to the UK, Ireland and France. Small numbers of birds also appear to migrate directly to Portugal from Iceland. The moulting sites in the north-west and east of England have seen particularly large increases in use in recent decades, especially the Wash, Humber and Dee estuaries. The vast majority of Icelandic godwits use estuarine mudflats during the autumn months. By winter many birds have moved south to estuaries in France and Portugal and, in Ireland and England, they start to forage on grasslands. The number of Icelandic godwits wintering in the UK, Ireland and France is well reported, but the number wintering in Iberia is difficult to assess because the subspecies overlap there, particularly during January and February when both wintering and migratory continental godwits are present.

In spring, most godwits from Portugal and France migrate to the Netherlands or eastern England, where they forage primarily on grasslands. At the same time, many birds from coastal sites around the UK move inland to forage on flooded grasslands. Studies of energetic intake rates on mudflats and grasslands suggest that godwits move to grasslands when estuarine food supplies are no longer sufficient to support them, and that they frequently use both mudflats and grasslands throughout winter and spring. This seems to be particularly common in the northern part of their range, where estuarine prey are often subject to strong seasonal depletion (e.g. Gill *et al.* 2001b) and where grassland foraging appears to be a necessary addition to compensate for insufficient estuarine food supplies.

POSSIBLE CAUSES OF THE POPULATION INCREASE IN *L. L. ISLANDICA*

The drivers of the population increase in Icelandic godwits are not fully identified, but there are several plausible candidates:

- climatic amelioration in Iceland may have improved breeding conditions and increased the area available for breeding godwits;
- changes in habitat structure in Iceland may have improved breeding conditions;
- climatic and habitat changes in the non-breeding range may have improved survival and condition for breeding;
- changes in hunting pressures may have improved survival rates.

The initial increase in godwit numbers around the 1920s coincided with a period of rapid warming in Iceland, suggesting that climatic amelioration may have been involved, at least in the early stages of population growth. From the 1930s to the 1980s, the rate of colonisation of Iceland is correlated with the number of drainage ditches installed, indicating that large-scale habitat changes may have positively influenced godwit breeding distribution. The common observation of godwits foraging in hayfields, especially those close to dwarf-birch bogs, suggests that the presence of hayfields as foraging habitats may have improved the quality of dwarf-birch bogs as breeding sites.

In recent decades, the primary habitat change in lowland Iceland has been the development of afforestation schemes, many of which are focused on marsh habitats, in addition to house-building in lowland areas. Since the 1980s, there has been a strong positive correlation between Iceland spring temperatures and the index of Icelandic godwits wintering in the UK (as recorded by the Wetland Bird Survey, Banks *et al.* 2006). Colour-ring information has shown that the majority of the UK population increase has involved birds from the recently occupied east and north-east of Iceland (Gunnarsson *et al.* 2005b); strongly suggesting that recent climatic amelioration has allowed these coldest parts of the country to be occupied.

In the non-breeding range, there are few indications of improvements to habitat quality, but changing rainfall patterns may be altering the timing of availability of grassland foraging sites. This may be particularly true of sites in eastern England and the Netherlands, use of which has increased substantially in recent years (Gerritsen & Tijsen 2003, Gill *et al.* 2001). The reduced frequency of cold winters in NW Europe also may be influencing survival rates.

The role of hunting pressure in driving population changes in Icelandic godwits is difficult to assess. Historically, there are records of godwits being considered a delicacy, having been described as "highly esteemed for the table" and "both shot and taken by snares" (Morris 1897). It is possible that reductions in hunting pressure, and the associated disturbance levels, may have influenced the population changes, but there are currently no data with which to explore this issue. At present, the only country in which Icelandic godwits are shot is France, and the lack of accurate bag statistics precludes calculation of the impact of this hunting pressure. Although the Icelandic population is increasing, it is still small and restricted in range, and the impact of hunting is therefore difficult to predict should conditions change.

CONTRASTING *LIMOSA* AND *ISLANDICA* POPULATIONS

Despite the current contrast in the fortunes of these two populations, comparison of their demography and distribution has revealed intriguing similarities, which we hope will help to focus current and future conservation and research efforts. In both Iceland and the Netherlands, it seems evident that agricultural intensification has played a role in driving population expansions and contractions over the last century. Wetlands and heathlands have been converted into agricultural habitats in which productivity has increased through fertilisation and reduction of flooding intensity, while frequent cutting and mowing maintains an open sward structure. This seems to have benefited several large, ground-nesting shorebird species, probably through higher abundances of soil macrofauna and improved access to these resources (Beintema 1986, Beintema *et al.* 1987). Throughout Europe this process began in the first half of the twentieth century, but so far the area converted and the level of intensification have been much greater in the more populated countries of NW Europe than in Iceland. In both Iceland and the Netherlands, there is evidence that populations of Black-tailed Godwit, along with other similar species, may have been able initially to increase and expand their distribution in response to this habitat conversion and increase in productivity.

In the Netherlands, the agricultural landscape is now so intensively managed that the area suitable for breeding godwits has declined dramatically, such that the population is now probably lower than it was prior to the 1950s. By contrast, the Icelandic population appears to be still benefiting from changes in agricultural practice that have created a landscape in which grass production and moderate levels of horse grazing have given rise to the complex sward structure necessary for breeding, alongside areas suitable for foraging. The extent to which these habitat changes have driven the population increase in Iceland is not currently clear, and there may yet be scope for further population expansion in Iceland. However, the Netherlands experience would strongly suggest that further intensification, such as increasing grazing intensities, are likely to be very detrimental to godwits and other ground-nesting birds. In addition, land-use changes in Iceland, such as the current widespread afforestation programmes, are a major threat to the internationally important shorebird populations of lowland habitats.

While habitat changes may be the primary driver of population changes over the last century, climatic changes have the potential to be an equally important issue in the near future. Temperature increases and changing precipitation patterns are both implicated in the *islandica* population increase, and there is some recent evidence for deferral of breeding in *limosa* in particularly dry years, although warm conditions are also likely to improve chick growth and survival. The timing of spring rainfall and the magnitude of temperature changes in the future are therefore likely to be very important in determining the impact of climate change on breeding success. The dependence of most of the *limosa* population on relatively small areas of flooded rice fields in Africa and Iberia is also likely to make them highly vulnerable to changing rainfall patterns. The recent drought in the Sahel region (Dai *et al.* 2004) is of particular concern for the maintenance of suitable foraging areas for these birds. Rice production is also dependent upon global markets and, in Iberia, on European Union agricultural support mechanisms, further increasing concern over the persistence of these key habitats.

A more immediate threat to the godwits that depend on rice fields and mudflats in Portugal is the proposed development of a new airport near Lisbon. One potential location for this airport is in the vicinity of the Tagus Estuary Nature Reserve, with approach routes that are likely to cross the main rice field areas in the Tagus and Sado estuaries, which are used by tens of thousands of godwits during January and February, and the corridor linking the Tagus and Sado mudflats which are used by godwits throughout the non-breeding season. Such a development could seriously impact on a very large proportion of the godwit population at a critical time of year, and would therefore be very likely to exacerbate already severe population declines.

The historical context of the population changes, and concern about future conditions for godwits and other similar bird species, led the workshop participants to identify the key recommendations that we believe it will be necessary to implement in order to conserve Black-tailed Godwits effectively in Iceland and W Europe.

CONSERVATION RECOMMENDATIONS FOR *L. L. LIMOSA*

1. Improve prescriptions and targeting of AES in the breeding range, focusing efforts in areas with high groundwater levels and open landscapes to attract godwits and avoid high predator densities, in order to have the potential to improve overall productivity. Include raising groundwater levels in the Netherlands AES prescriptions (as is the case in the UK, Denmark and Germany)
2. Incorporate the creation of small-scale habitat mosaics into management prescriptions, to provide both foraging and predator avoidance options throughout the season.
3. Improve conservation of key wetland habitats in Iberia and Africa, either through maintenance of support for rice production or restoration of wetlands, as well as designation of more sites under relevant national legislation and international treaties (EU Birds and Habitats Directives, Ramsar Convention etc.).
4. In view of the severe continuing declines of this population, take a precautionary approach and ban hunting of godwits, at least temporarily, where there is any risk that birds from

this population could be involved (especially late migrating juveniles in autumn), until productivity is increased to a level that can sustain a certain amount of additional mortality of adults and immatures.

CONSERVATION RECOMMENDATIONS FOR *L.L. ISLANDICA*

1. Improve conservation of winter habitat mosaics, particularly in areas, such as Ireland, England and France, where grasslands, coastal lagoons and salinas may be necessary to maintain populations when estuarine food supplies are depleted.
2. Reduce impact of afforestation and building developments in Iceland on godwits and other shorebird species, by conserving key breeding areas.
3. Improve protection of coastal habitats in areas where development and associated disturbance levels are high (especially in Ireland).

KEY RESEARCH GAPS FOR *L. L. LIMOSA*

1. Improve estimates of juvenile survival, causes of mortality and distribution prior to recruitment.
2. Improve survey information on the distribution and abundance of Black-tailed Godwits in the West African wintering grounds.
3. Improve understanding of the importance of the Doñana National and Natural Park area for protecting *L. l. limosa* during spring migration.
4. Explore the potential impact of hunting on the *limosa* population, and work with hunting organizations to develop better methods of recording accurate bag statistics in France.
5. Explore the impact of the increasing time-lag between godwit arrival in the Netherlands and the commencement of breeding, and the frequency of deferral of breeding attempts.
6. Improve understanding of the location, timing and duration of use of passage sites in Europe and Africa, and habitat use and diet within these sites.

KEY RESEARCH GAPS FOR *L. L. ISLANDICA*

1. Improve understanding of the role of agricultural intensification in Iceland.
2. Identify the key drivers of productivity in different habitats in Iceland.
3. Improve survey data for Iberia and France during the passage period of January to March, when there is the greatest overlap between the subspecies.
4. Explore the factors influencing the quality and availability of grassland habitats.
5. Explore the consequences of seasonal matching (individual use of similar quality habitat in both breeding and wintering areas) for population processes and identification of key areas for conservation.
6. Explore the potential impact of hunting on the *islandica* population.

FINAL COMMENT

The workshop provided an exciting and hopefully very valuable means of exploring the causes of population change in two closely related subspecies. The large group of experts provided an ideal forum for both highlighting key issues and using expert opinion to identify and prioritise the conservation recommendations. This process would undoubtedly have been helped were information available on the eastern population of *L. l. limosa* and the eastern subspecies, *L. l. melanuroides*. Our final recommendation is therefore to encourage the collation and presentation of information on these two populations.

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REFERENCES

Altenburg, W., van der Kamp, J. & Beintema, A. 1985. The wintering grounds of the black-tailed godwit in West Africa. *Wader Study Group Bull.* 44: 18–20.

Banks, A.N., Collier, M.P., Austin, G.E., Hearn, R.D. & Musgrove, A.J. 2006. Waterbirds in the UK 2004/05. The Wetland Bird Survey. BTO/WWT/RSPB/JNCC, Thetford.

Beintema A.J. 1986. Man-made polders in the Netherlands: a traditional habitat for shorebirds. *Colonial Waterbirds* 9: 196–202.

Beintema, A.J. & Drost, N. 1986. Migration of the Black-tailed Godwit. *Gerfaut* 76: 37–62.

Beintema A.J., Dunn, E. & Stroud, D. 1997. Birds and wet grasslands. In. D.J. Pain & M.W. Pienkowski (eds.). *Farming and birds in Europe: the Common Agricultural Policy and its implications for bird conservation*. Academic Press, San Diego.

Beintema, A.J. & Müskens, G.J.D.M. 1987. Nesting success of birds breeding in Dutch agricultural grasslands. *J. Appl. Ecol.* 24: 743–758.

Bijlsma R., Hustings, F. & Camphuysen, C.J. 2001. *Common and scarce birds of the Netherlands*. Avifauna of the Netherlands 2. GMB / KNNV, Haarlem.

BirdLife International. 2004. *Birds in Europe: population estimates, trends and conservation status*. BirdLife Conservation Series. Cambridge, BirdLife International.

Both, C., Schroeder, J., Hooijmeijer, J., Groen, N. & Piersma, T. 2006. The balance between reproduction and death of Black-tailed Godwits. *De Levende Natuur* 107: 126–129.

Dai, A.G., Lamb, P.J., Trenberth, K.E., Hulme, M., Jones, P.D & Xie, P.P. 2004. The recent Sahel drought is real. *Int. J. Climatology* 24: 1323–1331.

Gerritsen, G.J. & Tijsen, W. 2003. De betekenis van Nederland als pleisterplaats voor IJslandse Grutto's *Limosa limosa islandica* tijdens de voorjaarstrek in 2001 en 2002. *Limosa* 76: 103–108.

Gill, J.A., Norris, K., Potts, P.M., Gunnarsson, T.G., Atkinson, P.W. & Sutherland, W.J. 2001a. The buffer effect and large-scale population regulation in migratory birds. *Nature* 412: 436–438.

Gill, J.A., Sutherland, W.J. & Norris, K. 2001b. Depletion models can predict shorebird distribution at different spatial scales. *Proc. Royal Soc. Lond. B*. 268: 369–376.

Groen, N.M. & Hemerik, L. 2002. Reproductive success and survival of black-tailed godwits *Limosa limosa* in a declining local population in the Netherlands. *Ardea* 90: 239–248.

Gunnarsson, T.G., Gill, J.A., Petersen, A., Appleton, G.F. & Sutherland, W.J. 2005a. A double buffer effect in a migratory population. *J. Anim. Ecol.* 74: 965–971.

Gunnarsson, T.G., Gill, J.A, Newton, J., Potts, P.M. & Sutherland, W.J. 2005b. Seasonal matching of habitat quality and fitness in migratory birds. *Proc. Royal Soc. Lond. B.* 272: 2319–2323.

Gunnarsson, T.G., Gill, J.A., Appleton G.F., Gíslason H., Gardarsson, A., Watkinson, A.R. & Sutherland, W.J. 2006a. Large-scale habitat associations of birds in lowland Iceland: implications for conservation. *Biol. Conserv.* 128: 265–275.

Gunnarsson, T.G., Gill, J.A., Atkinson, P.W., Gélinaud, G., Potts, P.M., Croger, R.E., Gudmundsson, G.A., Appleton, G.F. & Sutherland, W.J. 2006b. Population-scale drivers of individual arrival times in migratory birds. *J. Anim. Ecol.* 75: 1119–1127.

International Wader Study Group. 2003. Waders are declining worldwide. *Wader Study Group Bull.* 101/102: 8–12.

Kleijn, D. & van Zuijlen, G.J.C. 2004. The conservation effects of meadow bird agreements on farmland in Zeeland, the Netherlands, in the period 1989–1995. *Biol. Conserv.* 117: 443–451.

Kleijn, D., Berendse, F., Smit, R. & Gilissen, N. 2001. Agri-environment schemes do not effectively protect biodiversity in Dutch agricultural landscapes. *Nature* 413: 723–725.

Kuijper, D.P.J, Wymenga, E., van der Kamp, J. & Tanger, D. 2006. Wintering areas and spring migration of the Black-tailed Godwit: bottlenecks and protection along the migration route. Altenburg & Wymenga ecological consultants, A & W report 820, Veenwouden, the Netherlands (*www.altwym.nl*)

Morris, Rev. F.O. 1897. *A History of British Birds*, 4th edition. John C. Nimmo, London.

Mulder, T. 1972. *De grutto in Nederland*. Wetenschappelijke Mededelingen KNNV 90, Hoogwoud.

Piersma, T. (ed.) 1986. Breeding waders in Europe. *Wader Study Group Bull.* 48 Suppl. 1–116.

Roodbergen, M., Klok, C. & Schekkerman, H. (submitted). Adult survival of Black-tailed Godwits (*Limosal l. limosa*) in the Netherlands 2002–2005 does not explain the ongoing decline of the breeding population. *Ardea.*

Sanchez-Guzman, J.M., Moran, R., Masero, J.A., Corbacho, C., Costillo, E., Villegas, A. & Santiago-Quesada, F. 2007. Identifying new buffer areas for conserving waterbirds in the Mediterranean basin: the importance of the rice fields in Extremadura, Spain. *Biodiv. & Conserv.* 16: 3333–3344.

Schekkerman, H. & Beintema, A.J. 2007. Abundance of invertebrates and foraging success of Black-tailed Godwit *Limosa limosa* chicks in relation to agricultural grassland management. *Ardea* 95: 39–54.

Schekkerman, H. & Müskens, G. 2000. Do black-tailed godwits *Limosa limosa* produce sufficient young to sustain populations in agricultural grasslands? *Limosa* 73: 121–134 [in Dutch with English summary].

Schekkerman, H., Teunissen, W. & Oosterveld, E. 2005. Breeding productivity of Black-tailed Godwits under 'mosaic management' a new agri-environment scheme. Alterra-report 1291, Alterra, Wageningen [in Dutch with English summary].

Schekkerman, H., Teunissen, W. & Oosterveld, E. (submitted a). Mortality of shorebird chicks in lowland wet grasslands: influences of predation and agricultural practice. *J. Ornithol.*

Schekkerman, H., Teunissen, W. & Oosterveld, E. (submitted b). Can 'mosaic management' improve breeding success and halt the population decline of Black-tailed godwits *Limosa limosa* in agricultural grasslands? *J. Appl. Ecol.*

SOVON. 2002. *Atlas van de Nederlandse broedvogels 1998–2000*. Nationaal Natuurhistorisch Museum Naturalis, Leiden.

Teunissen, W.A. & Soldaat, L.L. 2006. Recent population development of meadow birds in the Netherlands. *De Levende Natuur* 107: 70–74. [in Dutch]

Teunissen, W.A. & Willems, F. 2004. *Bescherming van weidevogels*. SOVON-onderzoeksrapport 04/06. SOVON, Beek-Ubbergen.

Teunissen, W., Schekkerman, H. & Willems, F. 2006. Predation on meadowbirds in the Netherlands – results of a four-year study. In: *Ökologie und Schutz von Wiesenvögeln in Mitteleuropa* (eds H. Düttman, R. Ehrnsberger & R. Akkermann), Osnabrücker Naturwissenschaftlige Mitteilungen, 32: 137–143.

Thorup, O. 2005. *Breeding Waders in Europe 2000*, International Wader Studies 14. International Wader Study Group, UK.

Tréca, B. 1984. La barge à queue noire (*Limosa limosa*) dans le Delta du Sénégal: regime alimentaire, donées biométriques, importance économique. *L'Oiseax et R.F.O.* 54: 247–262.

Tréca, B. 1994. The diet of ruffs and black-tailed godwits in Senegal. *Ostrich* 65: 256–263.

van Brederode, L. & Laporte, H.M. 2006. Weidevogelverbond werkt aan actieplan. *De Levende Natuur* 107: 146–147.

van der Kamp, J. & Ndiaye, I. 2006. Post-breeding exploitation of rice habitat in the Senegal delta by migrating Black-tailed Godwit *Limosa limosa*. Altenburg & Wymenga ecological consultants, A & W report in prep., Veenwouden, the Netherlands.

van Noordwijk, A.J. & Thomson, D.L. (submitted). Survival rates of Black-tailed Godwits breeding in the Netherlands estimated from ring recoveries. *Ardea.*

Verhulst, J., Kleijn, D. & Berendse, F. 2007. Direct and indirect effects of the most widely implemented Dutch agri-environment schemes on breeding waders. *J. Appl. Ecol.* 44: 70–80.

Willems, F., Breeuwer, A., Foppen, R., Teunissen, W., Schekkerman, H., Goedhart, P., Kleijn D. & Berendse, F. 2004. Evaluation of agri-environment schemes: effects on meadow bird breeding densities. Sovon-onderzoeksrapport 2004/02. Sovon/WUR/Alterra, Beek-Ubbergen. [In Dutch]

Wymenga, E., Oosterveld, E. & Bruinzeel, L. 2006. Management of meadow bird communities in Fryslân: bottlenecks and solutions in the core areas of the Black-tailed Godwit. Altenburg & Wymenga ecological consultants, A & W report 911, Veenwouden, the Netherlands (*www.altwym.nl*)

Zwarts, L., Bijlsma, R.G., van der Kamp, J. & Wymenga, E. (in press) *Living on the edge: Wetlands and birds in a changing Sahel.* KNNV publishers, Utrecht.