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The status of the Nordic populations of the Mallard (*Anas platyrhynchos*) in a changing world

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Dabbling ducks (*Anas* spp.) are important migratory quarry species, protected as a shared resource under international legislation. However, there is a lack of sufficient high-quality data on vital demographic rates and long-term trends in numbers to judge the conservation status of many duck populations at the flyway level. In response to reported declines in the North-West European flyway population of the Mallard, we compiled available data on this species in the Nordic countries up to 2010. Generally, national breeding numbers showed increasing trends, wintering abundance showed variable trends, and productivity measures indicated stable or increasing trends. Major knowledge gaps were identified, namely the size of hunting bags, the influence of the released Mallards and the role of short-stopping in explaining changing patterns of wintering abundance across the North-West European flyway. Numerically the Nordic breeding population appears in "good condition", and the wintering numbers have been either stable or increasing in the last two decades. The annual number of releases needs to be determined in order to judge the sustainability of the current levels of exploitation. Overall, none of the indicators showed alarming signs for the Mallard population in the Nordic countries when considered in isolation. However, the widespread decline in wintering numbers elsewhere across North-western Europe requires urgent pan-European action.

1. Introduction

Dabbling ducks (*Anas* spp.) are a popular and important quarry species. As a group they are also an important component of wetland biodiversity and enjoy special protection under international conventions and legislation (AEWA 2008, EC 2009, Ramsar 2011). The Natura 2000 site networks have been designated to maintain the favourable conservation status of waterbirds throughout Europe, mindful of their legal quarry status (Stroud *et al.* 2001). Despite the long-established need for international actions to protect waterfowl stocks (e.g., Berry 1941), we lack detailed monitoring data and knowledge about the distribution, abundance and demographics of many dabbling duck species. Most European dabbling ducks breed in low densities over vast areas, so measuring "vital rates" (demographic rates of adult survival and annual reproductive output) represents a major challenge. Historically, ringing efforts have been concentrated on wintering or autumn-migrating birds, taking no account of breeding performance, while using catch or "bag" age ratios to estimate productivity. Duck ringing has also declined dramatically since the 1970s (Guillemain *et al.* 2011), so emphasising a lack of data relating to reproductive success, subsequent survival and post-breeding dispersal. However, high-quality data on population size and demographic parameters are prerequisites for sustainable management (Elmberg *et al.* 2006). This presents a challenge to conservation and harvest management.

The Mallard (*Anas platyrhynchos*) is the most numerous, widespread and familiar of European Anatidae (Scott & Rose 1996). There are an estimated 4.5 million individuals in North-Western Europe (Wetlands International 2012b), ranging from the Arctic Ocean to the Tropics (Kear 2005). Its importance as a quarry species is underlined by the fact that ca. 4.5 million individuals are shot annually within the European Union, Norway and Switzerland (Hirschfeld & Heyd 2005).

Current international legislation via the African Eurasian Migratory Waterbird Agreement AEWA 2008, and the EUs Birds Directive EC 2009, requires effective management of the European Mallard stocks in Europe. Present management and conservation decisions, however, are based largely on mid-January counts across Europe (International Waterbird Census, IWC; Gilissen *et al.* 2002). This census suggests long-term declines between 1983–2007 (Fig. 1; Wetlands International 2012a). Meanwhile, wintering numbers in the UK have steadily fallen since 1990 (Calbrade *et al.* 2010) and in the Netherlands since 2000 (Hornman *et al.* 2011), suggesting a general long-term decline in the North-West European flyway (*sensu* Atkinson-Willes 1976; see also Scott & Rose 1996).

Dabbling ducks may be affected by climate, as they respond strongly to winter severity by migrating further southwards in harsh winters (Ridgill & Fox 1990). Conversely, "short-stopping" – the redistribution of wintering dabbling ducks in response to climate warming – is likely to cause fewer wintering ducks to travel to the extreme South-West of the flyway, as increasing numbers remain in the North-East. Declining numbers of wintering Mallards in the UK (Calbrade *et al.* 2010) and the Netherlands (Hornman *et al.* 2011), and increasing numbers in Sweden (Nilsson & Månsson 2010, present study), suggest that this may be the case. However, Mallards occur in low numbers on a plethora of small wetlands, coasts, rivers and ditches, habitats not necessarily well covered by the IWC. The recent trend towards milder winters (Klein Tank *et al.* 2002) might cause a larger proportion of the Mallard population to winter at smaller wetlands and at sites further North-East in the Baltic region where IWC coverage has not traditionally been carried out (partly because of formerly frozen conditions). Therefore, the present coverage of waterbird counts in this area remains scanty (with the exception of Latvia and Estonia), making assessments of population trends difficult.

Hunting is an important recreational activity in the Nordic countries, with a total annual bag of several million animals. These are mostly wild stock but the release of certain bird species occurs on a large scale in some countries (e.g., Denmark and Sweden). Hand-reared Mallards have been released for hunting in many European countries at least since the 1950s (Boyd & Harrison 1962, Tamisier 1992, Noer *et al.* 2008). The exact number released annually in Europe is unknown but in Denmark alone up to 400,000 individuals are

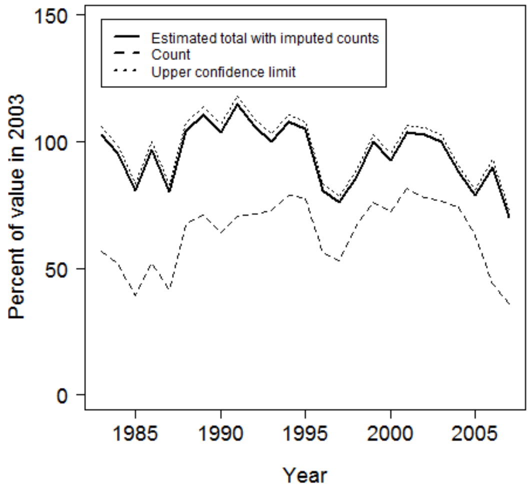

Fig. 1. Annual estimated index of total Mallard counted in North-western Europe from 1983 to 2007, based on counts from the International Waterbird Census (reproduced with permission; Wetlands International 2012a). Index values are expressed as percentage of the count in 2003. Missing counts were imputed using TRIM (Van Strien *et al.* 2004).

thought to be released each year (Noer *et al.* 2008). The consequences for wild populations and wetland ecosystems are not well understood. It is nevertheless well established that hybridization with native species or wild populations may threaten the genetic integrity of the native stock (e.g., New Zealand Grey Duck *Anas superciliosa* Williams & Basse 2006). Also, the abundance of birds released may contribute to the eutrophication of local wetlands (Callaghan & Kirby 1997, Noer *et al.* 2008). Lack of knowledge about long-term effects of releases adds uncertainty to population-size estimates.

Sustainable management of a migratory species under heavy anthropogenic influence (e.g., release, hunting and climate change) requires management and conservation efforts to be coordinated at a flyway scale (Elmberg *et al.* 2006), and an appreciation of variation in vital rates (Pöysä *et al.* 2004). However, with restricted knowledge of how Mallards respond to climate change and how the release of birds contributes to changes in overall population size, this remains a severe challenge.

Here we assess the current status of the Mallard in the Nordic countries by combining national count data (from both breeding and non-breeding seasons), bag statistics and data on vital rates. We compare these measures with those from Iceland which is similar to but geographically isolated from the Mallard population of North-Western Europe.

2. Material and methods

2.1. Breeding abundance

Estimates of national breeding abundance come from atlas projects and national monitoring schemes. BirdLife Denmark has coordinated annual surveys of Danish breeding birds since 1976 (Heldbjerg *et al.* 2011), based on counts at 10–20 voluntarily-selected points along more than 300 routes. The number of routes has been relatively constant since the late 1980s and spatially they cover the entire country, except for some smaller islands. In Sweden, a similar point-count survey has been run since 1975. Each route consists of 20 points, normally counted in May/June (Lindström *et al.* 2011). The number of routes has varied between 84 (in 1983) and 325 (in 2001; mean 219) with a geographic bias towards southern Sweden.

BirdLife Norway ran the Norwegian Breeding bird census during 1995–2008 based on voluntarily-selected routes (Husby & Stueflotten 2009). This approach was replaced by the Terrestrial Ecosystem Monitoring Programme (TOV) with a larger set of geographically representative census plots distributed over all regions except the far North-Eastern part of Finnmark (Framstad 2010). The present data combine both survey programs to produce an index of abundance.

The Finnish Game and Fisheries Research Institute and the Finnish Museum of Natural History have coordinated the monitoring of Finnish breeding waterfowl numbers at an average of 275 sites from 1986 onwards (Pöysä *et al.* 1993). In Finland, point counts done in May are the basic method for pair surveys, but route counts encircling wetlands are also used (see Koskimies & Väisänen 1991).

In all four countries, annual indices and trends were calculated using a log-linear Poisson regression model in the software TRIM (Van Strien *et al.* 2004). There was no national monitoring scheme for breeding dabbling ducks in Iceland, though adult male Mallards have been monitored at Lake Myvatn by breeding season counts since 1963 (Gardarsson *et al.* 2008).

2.2. Winter abundance

Annual winter counts of waterfowl in Denmark comprise aerial surveys combined with ground counts at 48 selected wintering sites. The counts have been co-ordinated since 1987 by the National Environmental Research Institute, now Aarhus University (Pihl 2000). An index was calculated following a method by Underhill and Prys-Jones (1994).

The Swedish Winter Bird Counts (SWBC, running since the winter 1975/1976) use the same methods as the Swedish Breeding Bird Survey and are carried out between 19 December and 8 January. Annual winter waterfowl counts have been undertaken in Sweden every January since 1967. These counts are mainly site-based and ground-based, but include more or less complete aerial surveys of coastal areas in 1971–1973, 1987 and 2004 (Nilsson 2008). Since 1987, the counts have been standardized with 500–700 annually-covered count units, generating an index calculated using the chain method (Crawford 1991).

Winter-bird abundances in Finland have been monitored since the winter of 1956/57. Here, only data from 1970 to 2010 are presented, based on annual mid-winter (25 December–7 January) counts at 300–500 fixed routes with an average length of ca. 10 km (see Koskimies & Väisänen 1991). Most routes are in Southern and Central Finland where also most Mallards winter. Annual sample size has been relatively stable during the study period. The population index was calculated using TRIM (Van Strien *et al.* 2004).

The Norwegian index for wintering Mallards was based on annual counts within 10 regions (covering ca. 200 sites) distributed along the coast from Østfold county in Southern Norway to Varangerfjorden, Finnmark county in North-Eastern Norway (Lorentsen & Nygård 2001). No inland water bodies were covered. These counts were done between late January (Southern Norway) and early March (Northern Norway). The index was calculated using TRIM (Van Strien *et al.* 2004).

In Iceland, wintering Mallards were counted at ca. 200 standardised sites as part of the Icelandic Christmas bird count, initiated in 1952. Only data collected during 2002–2010 were available for this study (Icelandic Institute of Natural History 2012).

2.3. Hunting bag

Numbers of Mallards shot in Denmark were available since 1959 (Noer *et al.* 2009). From 2002–03 a new method of correction for missing bag reports from hunters was implemented, which led to a slight decrease in the estimated total bag (Asferg & Lindhart 2003).

In Norway, the size of the hunting bag has been monitored since 1971/72. From 1984/1985 to 1992/1993, numbers were calculated based on a survey of a representative selection of hunters. Since 1993/1994, a reporting form had been sent to all hunting-license holders, and from 1994/1995 to 1999/2000 an extra questionnaire had been sent to hunters not reporting their bags. Since 2000/2001, hunters failing to report have had to pay a fee, and from this season onwards no correction for missing reports has been applied.

The Swedish hunting-bag scheme is run by the Swedish Association for Hunting and Wildlife Management. Hunters usually team up in specific areas for which they obtain exclusive hunting rights from land owners. The bag data are reported voluntarily to hunting-management units. Data from these defined geographical areas are in turn extrapolated to the county level, based on the percentage of area covered (Carlsson *et al.* 2010, Elmhagen *et al.* 2011). The data in the present study covered the period from 1939/40 to 2008/2009. In 1997, a new method of reporting was introduced, leading to more between-year variation in the numbers in recent years.

The Finnish Game and Fisheries Research Institute has compiled annual small-game-bag statistics since 1971 (Finnish Game and Fisheries Research Institute 2011). The information has been collected by means of a sampling survey via a questionnaire sent to hunters. There have been changes in the sampling and calculation procedures over the years so only data since 1996 are reported here, during which period data have been collected using the same method.

Since 1995, Icelandic hunters have reported their bags when renewing their licence for the next hunting season, under a scheme organized by the Environment Agency.

There is no bag limit in any of the Nordic countries. Released Mallards may contribute to the bag, especially in Denmark.

2.4. Wing surveys

In Denmark, hunters have voluntarily submitted wings of shot birds under the Danish wing survey since 1982 (Clausager 2004). The wings allow individual ageing, sexing and species identification. Mallards shot in Denmark are likely to be a mixture of Danish breeding birds, released birds, and birds from further north along the flyway, so the data do not solely monitor the Danish population. In Iceland, a wing survey of geese and ducks similar to that in Denmark was conducted from 1993–2000 (Frederiksen & Sigfusson 2004).

2.5. Productivity

Annual monitoring of the productivity of the most important game species was initiated in Finland in 1989 (Pöysä 1998). Annual brood counts are coordinated by the Finnish Game and Fisheries Research Institute between late June and mid-July at 250–450 fixed census sites throughout Finland. The resulting productivity index is based on the number of broods and ducklings in age classes IIa or older (i.e., ducklings of at least three weeks old; Gollop & Marshall 1954, Pirkola & Högmander 1974). When studying between-year variation in productivity, only data from sites surveyed in two consecutive years were used, and the productivity index for the whole time series was calculated using the chain method (e.g., Crawford 1991).

3. Results

Most obtained estimates suggest that 400,000–605,000 pairs of Mallard breed in the Nordic countries (references given in Table 1). Stable or in-

Table 1. Summary of all available data on abundance and vital rates for Mallard *Anas platyrhynchos* from the Nordic countries. Fitted trends showing % rate of change per annum (p.a.) based on TRIM models, if not otherwise stated, show level of statistical significance as ns for not significant, * for $P < 0.05$, ** for $P < 0.01$, and *** for $P < 0.001$.

Variable	Denmark	Sweden	Iceland	Finland	Norway
Breeding population (pairs)	20,000–50,000[1]	160,000–240,000[9]	10,000–15,000[1]	170,000–230,000[16]	40,000–70,000[23]
– trend (% change p. a.)	1.63** (1976–2010)[2]	1.0*** (1975–2010)[10] 3.1*** (1998–2010)[10]	0.1^{ns} [29]	0.83** (1986–2010)[17]	7.5** (1996–2010)[17]
Wintering numbers (individuals)	135,893[3]	150,000[11]	13,206[14]	10,000–20,000[18]	60,000–90,000[24,25]
– trend (% change p. a.)	–0.42^{ns} † (1987–2010)[4]	1.2 ‡ (1967–2010)[4] 3.0*** (1976–2010)[10]	9.0 § (2003–2010)[4]	–0.44** (1970–2010)[4] 4.4** (1995–2010)[4]	Stable^{ns} (1980–2010)[4]
Production (% change p. a.)	No data	No data	No data	2.14*** †† (1989–2010)[19]	No data
Survival (wild birds)	No data	0.52[12] 0.69–0.71[28]	No data	0.73 (0.52–0.87) ad females[20] 0.9 (0.37–0.99) ad males[20] 0.46 (0.24–0.69) juv. females[20] 0.75 (0.61–0.86) juv. males[20]	No data
– trend	No data	No data	No data	No data	No data
Bag statistics	500,000[5]	91,500[13]	14,859[15]	265,400[21]	14,750[26]
– trend (% change p. a.)	–2.0% *** ‡‡ (1991–2010)[5]	0.4 § (1939–2008)[6]	stable[6]	–0.36^{ns} (1996–2010)[6]	–3.8 § (1973–2010)[6]
Release (individuals)	400,000[7]	No data	0[27]	No data	No data
Annual survival (released birds)	First year: 0.26[8] After first year: 0.41[8]	0.25[12]	No data	First year: No data After first year: 0.1[22]	No data

† Underhill index, (Underhill & Prys-Jones 1994). ‡ Chain index, (Crawford 1991). § Rate of increase based on annual totals. ‡‡ GLM on log-transformed annual bag sizes. †† GLM on annual chain index values. [1] BirdLife International (2004). [2] Heldbjerg *et al.* (2011). [3] Petersen *et al.* (2010). [4] This study, Fig. 2b. [5] Christensen *et al.* in prep. [6] This study, Fig. 2c. [7] Noer *et al.* (2008). [8] Fog (1964). [9] Ottosson *et al.* (2012). [10] Lindström *et al.* (2011). [11] Nilsson (2008). [12] Fransson & Pettersson (2001). [13] Kindberg *et al.* (2009). [14] Icelandic Institute of Natural History (2012). [15] The Environment Agency of Iceland (2012). [16] Valkama *et al.* (2011). [17] This study, Fig. 2a. [18] Koskimies (1993). [19] This study, Fig. 5. [20] Gunnarsson *et al.* (2008). [21] Finnish Game and Fisheries Research Institute (2011). [22] Söderquist *et al.* 2012. [23] Gjershaug (1994). [24] Størkersen (2006). [25] Nygård (1994). [26] Statistics Norway (2012). [27] A. Th. Sigfusson, pers. comm. [28] Birds ringed between 2002 and 2008; Gunnarsson *et al.* (2012). [29] Lake Myvatn; Gardarsson *et al.* (2008).

creasing trends ranged from 0.83% in Finland to 7.5% in Norway (Fig. 2, Table 1). In Iceland, annual numbers of males at Lake Myvatn remained stable since the early 1980s (Fig. 3).

Between 369,000 and 409,000 Mallards were counted in the Nordic countries in winter. Variation between years (Fig. 2, Table 1) and countries was considerable, ranging from a 0.44% annual decline in Finland between 1970 and 2010 (though a rapid 4.4% annual increase since 1995), to a 3.0% annual increase in Sweden (1975/76–2009/10; Lindström *et al.* 2011).

Approximately 890,000 Mallard are shot annually in the Nordic Countries, with recent harvest trends being stable or slightly declining (Fig. 2, Table 1). The Danish bag size remained stable until the mid-1970s, after which increased releases elevated the bag (Bregnballe *et al.* 2003). Since 1990/91 the Danish bag has slightly but significantly decreased (Noer *et al.* 2009, Christensen *et al.* in prep,). The Finnish Mallard bag remained stable between 1996 and 2010. The Icelandic hunting bag was stable until 2009/10, after which it increased in parallel with the numbers of issued licenses. The Norwegian Mallard hunting bag increased from 1973 to 1988, after which it declined. The estimated Swedish hunting bag peaked in 1945, declined until 1978, and increased again to the present day.

There are no available data on the release of hand-reared Mallard in the Nordic countries. Noer *et al.* (2008) estimated that 400,000 Mallard were reared and released in Denmark in 2008, compared to nearly 500,000 in the 1990s. More than 200,000 Mallards may be released in Sweden annually (Wiberg & Gunnarsson 2007; but see Laikre *et al.* 2006).

The ratio of juveniles-to-adults in the Danish wing survey remained stable from 1982 to 2010 except for peaks in 2008 and 2010 (Fig. 4). The proportion of young in the Icelandic wing survey from 1993–2000 fluctuated widely, with no appar-

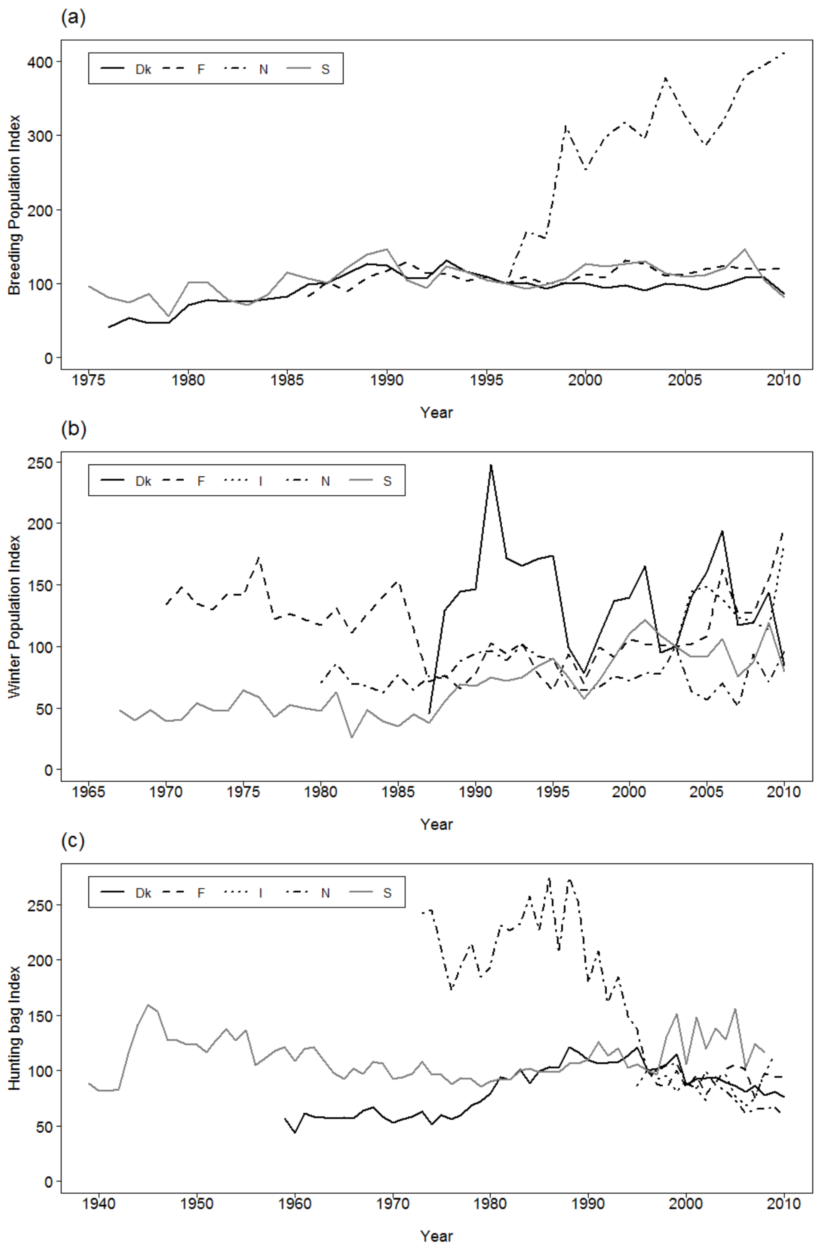

Fig. 2. (a) National breeding Mallard population indices based on the Danish, Finnish, Norwegian and Swedish count surveys. In all cases the indices are calculated by a log-linear Poisson regression using TRIM (Van Strien *et al.* 2004), set to 100 in 1995 (earliest common year). (b) Winter Mallard population indices from the International Waterbird Census from Denmark, Norway and Sweden, data from Finland are from separate Finnish winter bird censuses. Norwegian and Finnish indices are calculated using TRIM (Van Strien *et al.* 2004). Index from Iceland is based on the Icelandic Christmas bird counts. Index set to 100 in 2003 (earliest common year). (c) Mallard hunting bag statistics from Denmark, Finland, Norway, Sweden and Iceland. Index set to 100 in 1996 (earliest common year). See text for details; note different scales on x axes.

ent trend. Breeding productivity has only been systematically monitored in Finland, where an annual increase of 2.14% was reported from 1989–2010 ($p < 0.001$; Fig. 5).

Few studies on survival rates of the Mallard have been conducted (Table 1). There was a general increasing trend in the sizes of national breeding populations, but the wintering numbers and bag statistics showed more inconsistencies. Moreover, the survival rates varied considerably between countries, but productivity measures suggested stable or increasing trends.

4. Discussion

The present study is the first assessment of the conservation status of a keystone freshwater duck spe-

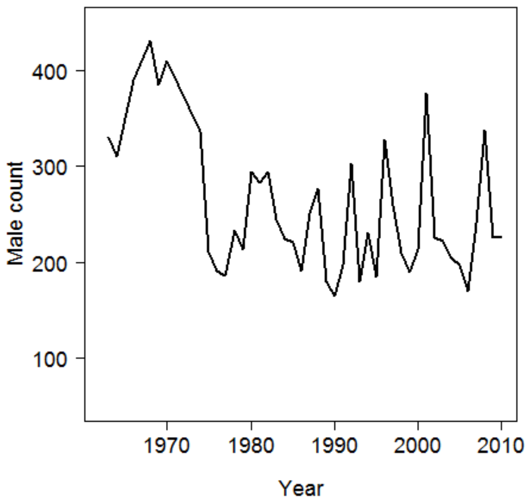

Fig. 3. Spring counts of male Mallard from Lake Myvatn, Iceland.

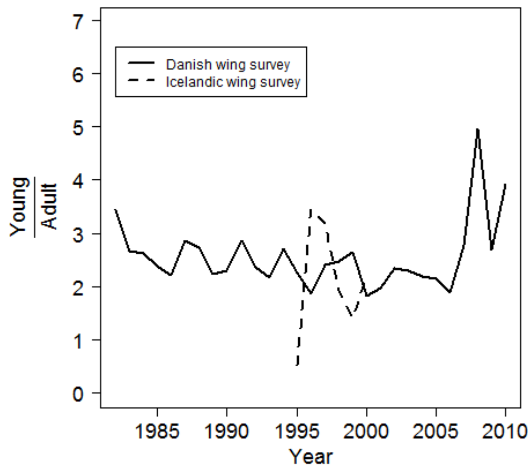

Fig. 4. Ratio between young and adult Mallard in the Danish (Clausager 2004) and Icelandic wing surveys (Frederiksen & Sigfusson 2004). Icelandic data before 1995 were excluded due to small sample size (*n* < 10).

cies in the Nordic countries. These countries altogether support 12% of the European breeding numbers (BirdLife International 2004) and 8–9% of the North-West European wintering numbers of the Mallard (Wetlands International 2012b). Reductions in wintering numbers in North-Western Europe suggest that this population may be suffering a long-term decline (Wetlands International 2012a), although the European breeding population has remained stable since the beginning of the 1990s (European Bird Census Council 2011). In contrast, breeding numbers increased in all Nordic countries, and the productivity was increasing in Finland. The remarkable increase in Norwegian breeding numbers may be due to the low number of survey routes compared to the other studied countries, and may thus be influenced by observer biases and site stochasticity. However, the increase coincided with a decrease in the Norwegian hunting bag, and considering that a large proportion of the Norwegian breeding Mallards stay in the country all year round (Gjershaug 1994), it is possible that hunting mortality has been additive. This hypothesis merits further investigation.

The observed large inter-annual fluctuations in winter indices in all Nordic countries may be due to variation in winter conditions. The Swedish index showed a long-term increase whereas that of Finland suggested a long-term decline. However, the latter has been rapidly increasing since the mid-1990s. The Danish index showed no statistically significant trend, possibly due to pronounced fluctuations, and the Norwegian index suggested no significant trends. However, long-term trends in some other parts of the Western Palaearctic region show 0.3–4.7% p.a. declines (Wetlands International 2012a).

Ringing data showed that Mallards tend to migrate shorter distances in milder winters. Migration distances in Western Europe have decreased during the 1950s and 1960s, and have remained stable since then (Sauter *et al.* 2010). However, others have found shorter migration distances in recent years (Svazas *et al.* 2001, Gunnarsson *et al.* 2012). Although the direct effect of temperature may not dictate the winter distribution of European dabbling ducks (Dalby *et al.* 2013), it remains possible that the projected increase in midwinter temperatures in Europe (Klein Tank *et al.* 2002) will continue the trend for shorter migration distance via indirect effects on the availability of food and habitat. However, it is not clear to what extent short-stopping can account for the declines in the UK and the Netherlands. Increases in breeding success and abundance in Nordic countries offer no demographic explanations for declines in winter numbers in the South-West of the flyway, though reported declines in breeding Mallard in

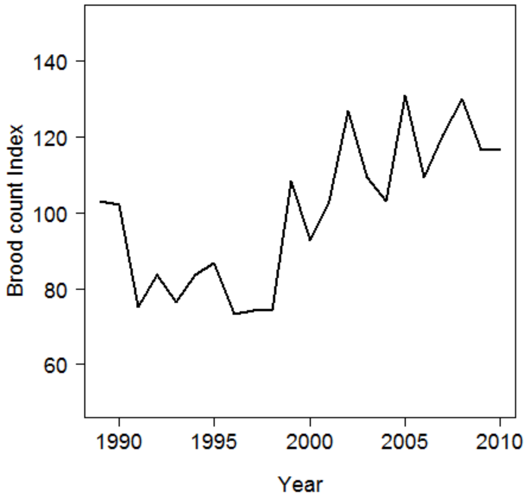

Fig. 5. Annual Finnish Mallard brood-survey indices (Pöysä *et al.* 1993, Pöysä 1998). The index is based on the number of broods seen in brood surveys and on the number of ducklings in broods of ca. three weeks or older. Index 100 is the mean of the time series.

Latvia, Lithuania, Belarus and Russia may be more relevent (Viksne *et al.* 2010)

If short-stopping is indeed a major factor in explaining winter-season Mallard trends further South and West, the lack of a clearer tendency for increasing winter numbers throughout the Nordic countries is of concern. One would thus expect Mallards to over-winter in increasing numbers in this region too. However, if the wintering distribution of Mallards has shifted closer to the breeding grounds, a larger proportion of the population may have started to overwinter in areas with poorer coverage in the IWC. Thus, an increasing proportion of the population might be missed by the census and yet trends would suggest declines. A detailed flyway analysis would be required to determine whether changes in wintering numbers are the result of changing population size and/or distributional changes in response to climate change.

Since 1990 hunting bags have declined in Denmark, Iceland and Norway, but have remained stable in Sweden and Finland. Breeding and wintering numbers have increased in Norway, so the decline in the kill may not be linked to abundance. Relatively few Mallards are shot annually in Norway (15,000, compared to 500,000 in Denmark), so a limited number of hunters changing their behaviour can markedly affect bag size. Bag statistics are difficult to interpret, more so because of differences in management of national schemes, hunting effort, and changes in hunting seasons. Hunting-bag numbers are likely to be maintained at a high level by release especially in Denmark, where a quarter of all Mallards in a season are shot in the first half of September (Madsen *et al.* 1996). Ring recoveries indicate that Danish breeding birds and their offspring move very little before mid-winter (Bønløkke *et al.* 2006), and autumn migration further north and east in the flyway usually peaks in the latter half of September (Lehikoinen & Vähätalo 2000). This pattern indicates that the early-season kill must derive almost exclusively from the breeding population, combined with locally reared and released birds. However, to what extent the later-season kill contains migratory Mallards from further north and east remains unknown, as the proportion of wild birds among those shot remains unknown. Hence, the sustainability of the current hunting pressure cannot be judged, but given the general tendency towards declining wintering numbers in the West Palaearctic region (Wetlands International 2012a), this merits further investigation.

We reported no signs of declining reproductive success among Mallards, despite remarkable interannual fluctuation. Ducks shot by Danish hunters later in the season originate from the Baltic region and Russia (Bønløkke *et al.* 2006) so the fluctuation might be caused by factors acting on breeding Mallard outside the Nordic countries. However, as released birds are almost exclusively shot during their first year (Fog 1964), releases have a large potential to affect age ratios in the shot sample.

Overall, the explored indicators suggest that the conservation status of the Mallard is favourable in the Nordic countries. However, most measures assessed here may be influenced by unknown numbers of released Mallards. Hunting-bag statistics and wing surveys are more prone to biases from such releases than are breeding numbers, but winter indices could also be affected. The number and survival of hand-reared Mallard released to supplement the wild population remains a major knowledge gap in all countries where hand-rearing is practised. Released Mallards are likely to locally make up a large proportion of the bag, complicating the interpretation of bag statistics. The few studies on released Mallards show short dispersal from release sites and much lower survival than individuals of wild populations (Fog 1964, Fransson & Pettersson 2001, Champagnon *et al.* 2012). Released birds presumably present more ducks to hunters than under natural conditions, perhaps buffering wild populations against greater mortality. However, interbreeding between released and wild Mallards may have led to morphological changes in wild French Mallard stock (Champagnon *et al.* 2010). Generally, the consequences of interbreeding across Europe are poorly understood (but see Callaghan & Kirby 1997 and references therein).

Current measures of annual reproductive success in Mallard are restricted to Finland. Elsewhere across the Nordic region, low breeding densities make breeding success generally difficult to monitor, except at Lake Myvatn, Iceland, where densities of Mallard are sufficiently high for detecting density-dependent effects (Gardarsson *et al.* 2008). Rönkä *et al.* (2011) suggested that post-breeding population monitoring would provide a proxy for breeding success in Mallard. Similarly, Hill (1984) used differences between spring and autumn counts as a proxy for net productivity. In areas with no direct measurements, these less labour-intensive methods could provide proxies of annual reproductive success, especially if the methods withstand closer evaluation at larger spatial scales. Such information is essential for effective conservation management of the population, and is a high future priority. Wing surveys and ringing can contribute to monitoring breeding success and also provide information about dispersal and survival. However, large-scale duck ringing has largely ceased throughout Europe (with notable exceptions, e.g., Camargue, France and Ottenby, Sweden).

There is a need for a review of the factors affecting the entire North-West European Mallard flyway population, particularly the role of short-stopping in explaining apparent changes in abundance along the flyway. Effective management of the European Mallard population requires monitoring programmes that continuously assess the adequacy of the spatial and demographic coverage. The programme should account for changing environmental conditions while simultaneously maintaining the integrity of existing long-term monitoring programmes (Pöysä *et al.* 2004, Elmberg *et al.* 2006). Also, the potential effects of released individuals throughout the flyway require research, and numbers released should be reported at a national level at least once a year. Ringing of released birds would be required to estimate the magnitude of their contribution to the hunting bags. The Mallard remains such an important quarry species in Europe that it is important to harmonise the total kill by European hunters with trends in the flyway population size. Lack of information on bag sizes in parts of the North-West European flyway renders this a distant goal.

Wintering numbers of Mallards in the Nordic countries have been stable or increasing during the last two decades. It is uncertain, however, to what extent this trend compensates declining trends further south along the flyway, which require urgent concerted research and analysis.

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Sinisorsakantojen tila Pohjoismaissa

Puolisukeltajasorsat ovat tärkeitä riistalajeja, jotka muuttokäyttäytymisensä ansiosta toimivat yhteisenä resurssina useissa eri maissa, ja joiden kantojen turvaamiseksi on kansainvälisiä sopimuksia. Tästä huolimatta useimpien sorsakantojen elinvoimaisuus ja kannankehitys tunnetaan niin puutteellisesti, ettei niiden suojelutasoa voida luotettavasti arvioida. Koska sinisorsan (*Anas platyrhynchos*) talvikannat ovat taantuneet monin paikoin Luoteis-Euroopassa, selvitimme lajin kannan tilan Pohjoismaissa vuoteen 2010 asti.

Kansalliset laskennat osoittivat pesimäkantojen kasvaneen, mutta talvikantojen trendit vaihtelivat maiden välillä. Lisääntymismenestysmittarit osoittivat vakaata tai parantunutta poikastuottoa. Suurimmiksi ongelmiksi tunnistimme saalistilastojen sekä metsästystä varten kasvatettujen ja istutettujen sinisorsien lukumäärätietojen puuttumisen.

Kokonaiskannan selvittämiseksi tulisi tarkastella yksityiskohtaisemmin, ovatko sinisorsat lyhentäneet muuttomatkaansa ilmastonmuutoksen takia, jonka seurauksena talviaikaisen levinneisyyden painopiste on voinut siirtyä kohti koillista. Tällainen levinneisyysalueen muutos voi johtaa siihen, että yhä suurempi osa sinisorsakannasta talvehtii alueilla, jossa niitä ei ole laskettu aikaisemmin tai laskentaverkosto ei ole edustava. Pohjoismaiden pesimäkannan tila vaikuttaa hyvältä, ja talvimäärät ovat viimeisen kahden vuosikymmenen ajan olleet joko vakaita tai kasvussa. Istutettujen sinisorsien määrät tulisi selvittää pikimmiten, jotta voitaisiin tarkastella luotettavasti kannan verotuksen kestävyyttä. Pohjoismaiden sinisorsakannoissa ei näy huolestuttavia merkkejä tarkastelluilla mittareilla. Muualla Luoteis-Euroopassa talvikanta on kuitenkin vähentynyt huomattavasti, ja koko talvikannan tila tulisi selvittää laaja-alaisilla tutkimuksilla.

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