Recent changes in the abundance of Common Pochard *Aythya ferina* breeding in Europe

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Abstract

National accounts suggest that the Common Pochard *Aythya ferina* was an uncommon breeding bird throughout western Europe before 1850. Extensions to the breeding range in the late 19th century were potentially aided by the rapid development of managed fish-ponds in eastern Europe, which provided suitable novel habitat at that time. Expansion into western Europe followed in subsequent decades. Wetland and waterbody eutrophication throughout Europe, which likely provided food and cover for the birds, may have accelerated the rapid expansion from the 1950s until the early 1980s. Widespread declines in the last 30 years, especially in eastern Europe, where breeding numbers are highest, are possibly linked to intensification and/or abandonment of freshwater fish farming and changes in water quality. Studies show that Pochard gain fitness benefits from nesting in Black-headed Gull *Chroicocephalus ridibundus* colonies and hence has been affected by major losses of European gull colonies in the last 30 years. The spread of alien fish species such as the Carp *Cyprinus carpio*, which compete with Pochard for food resources, is a problem in the Mediterranean region. Changing predation pressures (in some cases linked to invasive alien mammals) are also implicated in some areas. Relatively modest numbers breeding in the UK, France and the Netherlands have remained stable or increased over the same recent span of years, confirming that different factors currently affect Pochard breeding abundance throughout its range. We urgently need better information relating to key factors affecting Pochard breeding success and abundance, which is currently showing an unfavourable conservation status throughout much of Europe.

Key words: *Aythya ferina*, breeding, Common Pochard, population declines, population stressors.

The Common Pochard (hereafter Pochard) *Aythya ferina* is a numerous and widespread diving duck, which breeds largely in freshwater to the south of the tundra region across the Palearctic from Iceland to the steppe lakes of Mongolia and the Daurian region (Kear 2005). It winters throughout Europe, in northern Africa along the Nile as far as Sudan, the Mediterranean, Black and Caspian Sea regions, and the Indian sub-continent, through to southern China, Korea and Japan (Kear 2005; Reeber 2015). Latest estimates put the global population at between 1.95 and 2.45 million individuals (Wetlands International 2016), which suggests it is as numerous as its ecological counterparts in North America combined (the Redhead *Aythya americana* at 1.35 million and the Canvasback *A. valisineria* with 0.69 million; Wetlands International 2016). Since the 1850s, the Pochard has expanded its breeding range north and westwards, colonising Fennoscandia, Scandinavia, Britain and the Netherlands, and since the 1950s has spread into Mediterranean countries including Greece, Italy, Spain and North Africa (Bezzel 1969; Hagemeijer & Blair 1997). For much of the last 150 years the species therefore appears to have expanded and consolidated its breeding range within Europe.

More recently, however, the assessment for the European Red List of Birds 2015 (BirdLife International 2015a), indicated that there were serious reductions in the distribution and abundance of breeding Pochard from the late 20th century onwards, resulting in the European population being upgraded from IUCN Least Concern status to Vulnerable on the basis of a 30–49% decline in breeding population size over the course of three generation spans (22.8 years; after BirdLife International 2015a). This reflects similar declines in numbers recorded on its wintering grounds, which after a long period of relative stability have decreased by 50%, to *c.* 150,000 birds in northern Europe between the late 1980s–2012, and to *c.* 600,000 in Central Europe, the Mediterranean and Black Sea region slightly later during the late 1990s–2012 (Nagy *et al.* 2014). The species therefore is now also designated as being globally Vulnerable (IUCN 2015).

How could a species that has consistently shown expansion of its breeding distribution and increases in winter abundance in, for instance the United Kingdom from the 1940s until the 1990s (Eltringham & Atkinson-Willes 1961; Holt *et al.* 2011), suddenly be in such unfavourable conservation status? Clearly, overall population size in relatively long-lived duck species can be affected by changes in survival rate, but in the case of the Eurasian Wigeon *Anas penelope* it has recently been shown that changes in annual reproductive output may also have a major impact on flyway population size (Fox *et al.* 2016). It is difficult to relate changes in Pochard abundance in specific breeding areas with changes in winter numbers and distribution because many of the birds wintering in Europe may originate from central Eurasia (*e.g.* Fox & Salmon 1988; Keller *et al.* 2009; A. Caizergues *et al.* in press). Nonetheless, in this review we have attempted to assess the relative abundance of the Pochard population breeding in European countries now and in the recent past, to determine the existing distribution of breeding birds across range states, to compare the colonisation history for Pochard in these countries and to assess recent population trends for different parts of the range. We also sought to compile published assessments of the factors considered responsible for the differing trends in breeding abundance, in an attempt to understand the underlying causes for the variation in trends, and to provide recommendations for sympathetic management of breeding habitat, to restore the former breeding abundance of Pochard wherever possible.

Methods

Following a workshop convened at the Pan-European Duck Symposium in Hanko in Finland on 9 April 2015, national experts were approached and asked to compile information on Pochard from national count databases and reports, for as many European countries as possible, in order to develop a profile of the past breeding status, current breeding status and an estimated trend in the abundance of breeding pairs over the last 10–12 years for short-term trends and since the 1980s for longer term trends. Although we attempted to assess changes in annual breeding success and survival, these were rarely available because the Pochard is generally neither a well-studied nor effectively monitored species, except at the classic study sites at Lake Engure in Latvia (*e.g.* Nichols *et al.* 1997; Opermanis *et al.* 2001) and Lac de Grand-Lieu in France (*e.g.* Gourlay-Larour *et al.* 2014). We were especially interested to learn about any information relating to factors that might have specifically affected female survival and reproductive output (*e.g.* predation pressure), as well as any changes in habitat quality that might influence the food supply, nesting cover and its overall attractiveness to the species for breeding. This resulted in the expression of much opinion, but relatively few studies were available to relate such changes directly to reductions in nesting abundance and/or breeding success.

Results

Contrasting recent national trends in breeding Pochard abundance throughout Europe

Country-specific data and interpretation of trends can be found in the detailed country accounts which are available in Supporting Materials (http://wildfowl.wwt.org.uk/index.php/wildfowl/rt/suppFiles/2638/0).

The full list of national population estimates and recent trends for those countries thought to support <1% of the total European breeding population are shown in Table 1, while Table 2 shows the data for the 15 countries thought to support ≥ 1% of Pochard breeding in Europe (data from BirdLife International 2015b, modified in accordance with the results of the review presented here). Trends in national breeding abundance over the last 20–30 years are shown in Fig. 1, where it is evident that, amongst the countries supporting > 100 breeding pairs, 48% of 29 counties showed declines,

Table 1. Reported national European breeding population sizes of Pochard for countries supporting <1,500 breeding pairs (*i.e.* <1% of the total European breeding population). Data from BirdLife International (2015b), with modifications by the authors. Percentage change is not indicated for countries with <*c.* 100 breeding pairs.

Country	Current population estimate				Short term population trend			Long term population trend		
	Pairs	% Europe	Period	Quality	% Change	Period	Quality	% Change	Period	Quality
Luxembourg	1	<1	2008–2012	good						
Albania	0–5	<1	2002–2012	good						
Kosovo	<10	<1	2009–2014	medium						
Montenegro	<10	<1	2002–2012	poor						
Switzerland	<11	<1	2008–2012	medium						
Norway	<15	<1	2000–2013	good						
FYRO Macedonia	<20	<1	2001–2012	poor						
Georgia	Present	<1	?	?						
Portugal	<50	<1	2008–2012	poor						
Greece	30–80	<1	2008–2012	medium						
Slovenia	50–100	<1	2007–2012	medium						
Moldova	100–120	<1	2000–2010	medium	–30 to –40	2000–2010	medium	–20 to –40	1980–2010	medium
Austria	130–200	<1	2001–2012	medium	0	2001–2012	medium	0	1980–2012	poor
Bosnia HG	100–200	<1	2010–2014	poor	?					
Italy	150–200	<1	2012	medium	–50	2000–2012	medium	–25 to –40	1980–2012	medium
Bulgaria	80–250	<1	2005–2012	medium	fluctuating	2000–2012	good	+5 to +20	1980–2012	medium
Denmark	280	<1	2011	medium	–20 to –33	1999–2011	good	–50 to –100	1980–2011	good
Armenia	100–350	<1	2002–2012	medium	?					
Slovakia	300–500	<1	2012	medium	–30 to –50	2000–2012	medium	+10 to +25	1980–2012	medium
United Kingdom	350–630	<1	2006–2010	medium	+36	1996–2008	good	+216	1971–2008	good
Belgium	500–1,000	<1	2008–2012	medium	0	2000–2012	poor	+178 to +567	1973–2012	poor
Estonia	500–1,000	<1	2008–2012	medium	–20 to –50	2001–2012	medium	+20 to +50	1980–2012	medium
Turkey	500–1,000	<1	2013	medium	–70 to –89	2000–2012	good	0	1990–2013	poor
Serbia	870–1,250	<1	2008–2012	medium	+1 to +9	2000–2012	medium	0	1980–2012	medium
Sweden	700–1,500	<1	2008–2012	medium	0	2001–2012	medium	–35 to –91	1980–2012	medium

Table 2. Reported national European breeding population sizes of Pochard for countries supporting ≥1,500 breeding pairs (*i.e.* ≥ 1% of the total European breeding population). Data from BirdLife International (2015b), with modifications by the authors.

Country	Current population estimate				Short-term population trend			Long-term population trend		
	Pairs	% Europe	Period	Quality	% Change	Period	Quality	% Change	Period	Quality
Latvia	1,500–2,000	1	2004	medium	?			–20 to –50	1994–2004	medium
Netherlands	1,307–2,621	1	2008–2011	medium	0	2002–2011	good	0	1984–2011	good
Hungary	2,000–3,000	1	2000–2012	poor	–60 to –70	2000–2012	poor	–60 to –70	1980–2012	poor
Lithuania	2,000–2,500	1	2008–2012	medium	–30 to –40	2001–2012	medium	–30 to –40	1980–2012	medium
Belarus	3,000–4,000	1	2009–2010	medium	–50	2001–2012	medium	–50	1980–2012	medium
Croatia	1,000–5,000	1	2013	poor	?					
France	3,000–5,000	2	2009–2012	medium	?			–20 to –40	1985–2012	poor
Germany	4,000–5,500	2	2005–2009	good	–31 to –100	1998–2009	medium	–21 to –50	1985–2009	medium
Poland	2,000–11,000	3	2008–2012	medium	?			–20 to –100	1980–2012	good
Ukraine	7,000–12,000	4	2015	medium	declining	2010–2015	medium	declining	1980–2012	medium
Spain	8,300	4	2007	medium	fluctuating	1998–2009	medium	fluctuating	1980–2009	medium
Finland	10,000–16,000	5	2006–2012	good	–69 to –82	2001–2012	good	–51 to –67	1986–2012	good
Czech Rep	9,000–17,000	5	2001–2003	medium	+90 to +110	2001–2013	good	–40 to –50	1981–2013	good
Romania	20,698–28,762	10	2008–2013	medium	?					
Russia	90,000–120,000	44	2008–2011	poor	–1 to –10	2000–2010	poor			

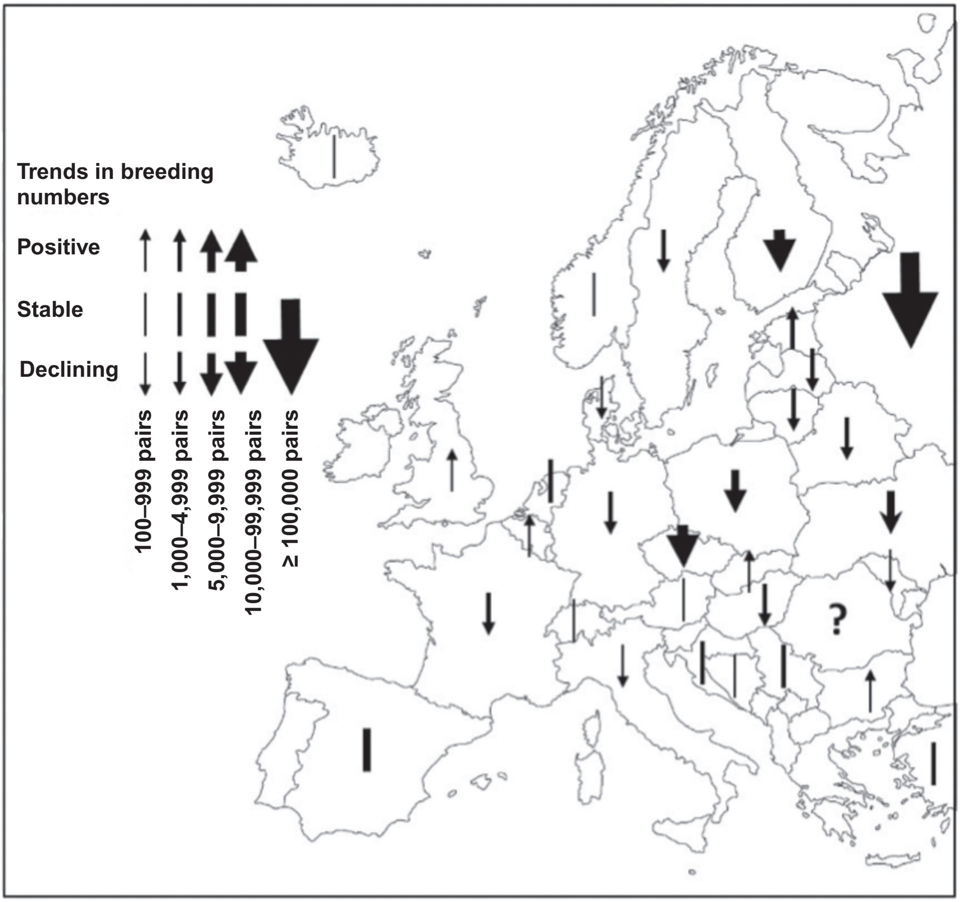

Figure 1. Map showing the relative abundance of breeding Pochard *Aythya ferina* in each European country, as indicated by relative arrow/bar size. Abundance is measured in terms of the maximum number of breeding pairs recorded in the last 20–30 years (see Tables 1 and 2 for details). Countries supporting <100 breeding pairs in this period are omitted. Arrows indicate countries with increasing (upward) and declining trends (downward), bars indicate no trends.

including European Russia, Czech Republic, Poland and Finland, which currently constitute the four most important states numerically for breeding Pochard. Only five (17%) countries (Belgium, Bulgaria, Estonia, Slovakia and United Kingdom) showed long-term increases. Since all of these countries supported < 1,000 breeding pairs, they contributed relatively little to the overall totals. There were no discernible geographical trends, suggesting that contrasting trends reflect different pressures on breeding abundance in different countries.

Longer term trends in breeding abundance and causes of change

In attempting to synthesise the "colonisation" by breeding Pochard throughout Europe, it was extremely difficult to determine precisely when the species first bred in each country. It was quite impossible to determine whether Pochard recorded as breeding "for the first time" had merely returned after a period of extirpation, had genuinely reproduced in a previously unoccupied country, or indeed had been present and undetected for many years. Hence, while many countries cite a specific year for the first "recorded" case of proven breeding, it is rarely possible to determine if this did indeed represent the year in which the country was first colonised. There were some glaring anomalies; for instance, while it was clear that European Russia, Ukraine and the Baltic States had all hosted breeding Pochard from before the mid 1800s, Belarus (which is totally surrounded by these states) first recorded breeding in 1926. What does seem evident is that Pochard were recorded as first breeding in Finland, Sweden and Denmark during the period 1849–1867 (see Supporting Materials), so this does seem to represent a northwestern extension of range during the second half of the 19th century. Pochard are also thought to have reached Iceland and the United Kingdom at around the same time. Numbers in these countries do not seem to have consolidated until much later in the 20th century, however, and Norway did not experience its first breeding record until 1972. Nevertheless, it seems likely from the combined accounts that there was also a major extension of the range west into Germany (where the species was more confined to the east in former years), the Netherlands and the UK in the late 1880s, which was consolidated by Pochard colonising Belgium in the first half of the 20th century, a period during which there was apparent expansion and increasing breeding abundance in France and Spain. What does seem reasonably consistent was the more evident increase in breeding abundance across much of the range that seemed to simultaneously occur from the 1950s until the mid to late 1980s (see Supporting Materials). This period of increase and expansion of the breeding population of Europe was also characterised by increases in the wintering population in Western Europe (Atkinson-Willes 1967; Fox & Salmon 1988; Nagy *et al.* 2014).

Potential causes of changes in breeding abundance

In hindsight, we cannot understand the factors affecting the expansion of range and the increase in breeding numbers that occurred within Europe starting in the early 1800s, but more recent increases in nesting range and abundance in the 1950s–1980s were linked in several countries to the creation of artificial waterbodies (*e.g.* reservoirs constructed for drinking water, flood relief or hydro-electric power, or the flooding of mineral extraction sites such as sand and gravel quarries), especially in areas with nutrient-rich waters (see the summary of reported factors contributing to Pochard breeding increases in Table 3). This may reflect a successful niche shift or merely opportunism on the part of species whose

Table 3. Summarised suggested causes of changes in abundance amongst breeding Pochard, as provided by the authors of this paper. Red boxes indicate adverse effects and green boxes positive effects on breeding Pochard. Countries are listed according to population trends (see Fig. 1 and Tables 1 and 2).

	Increasing nutrient levels	Creation of reservoirs, fish-ponds and/or gravel pits	Hyper-eutrophication associated with agricultural runoff	Changes in water chemistry	Reductions in benthos biomass	Increased competition from fish	Excessive growth of emergent macrophytes	Abandonment of fish-ponds	Falling water levels (abstraction, climate change)	Loss of grazing to maintain short grass vegetation for nesting	Loss of submerged macrophytes	Intensification of fish pond management	Wetland destruction	Cutting of wetland vegetation	Reed-bed destruction	Fishing and hunting disturbance	Loss of Black-headed Gull colonies	Interactions with other alien species	Raccoon Dog predation	Raccoon predation	Red Fox predation	American Mink predation	Increased native predator pressure	No. of adverse factors identified
Belgium	green	green																			red			1
Austria												red												1
Bosnia and Herzegovina													red	red	red	red								4
Spain		green	red	red		red			red		red							red						6
Ukraine		green						red	red			red	red											4
Norway																	red					red ?		2
Finland			red			red											red		red ?			red		5
Denmark																	red							1
Germany								red									red			red				3
France			red															red				red	red	4
Lithuania		green	red	red						red	red						red		red			red	red	8
Latvia	green	green															red					red	red	3
Czech Republic	green		red		red	red					red	red					red							6
Hungary									red	red		red						red					red	5
Poland			red								red	red					red					red	red	6
Belarus		green	red	red	red		red	red											red		red	red		8
Russia		green	red	red			red	red	red	red	red					red	red							9
Total number of reports for each factor from different countries	3	7	8	4	2	3	2	4	4	3	5	5	2	1	1	2	9	3	3	1	2	7	5	

former rarity merely reflected the scarcity of its habitat. Either way, the expansion in the area and number of suitable open waterbodies through the creation and management of artificial fish-ponds for aquaculture also had a major effect, especially in eastern Europe, where such management created optimal conditions with high levels of fertilisation and regular water table drawn down (Table 3). As it expanded its breeding range westwards, the species seemingly took advantage of long-established extensive areas of fish-ponds, as in France for example, which had been previously unoccupied. In more recent times, both the reduction in intensity and abandonment of such aquaculture practices on the one hand, and increasing intensification of fish management on the other (in the sense that more feed, nutrients and medication treatments are being applied to the same bodies of water), have been shown to affect breeding Pochard in France (Broyer *et al.* in press) and cited as the causes of declines in breeding Pochard in Austria, Czech Republic, Hungary, Poland and Ukraine, as well as potentially elsewhere. Changes in water chemistry (especially due to hyper-eutrophication of waterbodies caused by agricultural runoff) are also cited in several countries as potentially being responsible for declining Pochard breeding numbers, as are the knock-on effects of these on reductions in benthos biomass, excessive growth of emergent macrophytes and loss of submerged macrophytes (Table 3). Direct competition between Common Carp *Cyprinus carpio* and adult and duckling Pochard was found in some studies (Pykal & Janda 1994; Musil *et al.* 1997; Musil 2006). Increased predation rates are often cited as a cause of declines in Pochard nesting abundance, particularly those involving introduced alien species, such as Raccoons *Procyon lotor*, Raccoon Dogs *Nyctereutes procyonoides* and American Mink *Mustela vison*, but predation by Red Fox *Vulpes vulpes* and other native predators (including Wild Boar *Sus scrofa*) were also cited.

Some of these effects may involve complex interactions with other species, such as the Black-headed Gull *Chroicocephalus ridibundus* with which nesting Pochard frequently associate. Pochard breeding in association with gull colonies apparently benefit from elevated breeding success and female survival in comparison with occasions where they do not do so (*e.g.* Väänänen 2000; Väänänen *et al.* 2016). Since the Black-headed Gull is declining across much of the Pochard's breeding range, authors from several countries proposed that this trend has contributed to the local decline of Pochard in their region. Despite the association between gull colonies and Pochard breeding success, however, we cannot reject the alternative explanation that a common factor is involved in the decline of both Black-headed Gull and Pochard where they co-occur. Abandonment of grazing of wetland vegetation on the one hand and excessive cutting of wetland vegetation and loss of reedbeds on the other have also been implicated in the loss of suitable nesting cover, together with falling water levels and habitat destruction and degradation (Table 3).

Table 3 indicates that some universal factors may be behind the decline of Pochard across Europe, specifically hyper-eutrophication of waters, loss of gull colonies and predation by American Mink. It is clear, however, that both the abandonment and conversely the intensification of fish-farm management (which is largely restricted in practice to eastern European countries) have also been cited as major causes of change in Pochard nesting numbers in the very parts of the range where the species was formerly most common, and is now showing the greatest declines.

Discussion

Differences in trends between countries

The results of this survey support the hypothesis that the Pochard breeding population has recently experienced significant declines across many countries. Amongst the countries supporting 100–1,000 pairs, the long-term trends are mixed. Most are stable or increasing, with the notable exceptions of Moldova, Italy, Denmark and Sweden, but in the shorter term, many more countries show declines, including Turkey in the south of the breeding range (Table 1).

In contrast, the majority of the short and long-term trends for the countries supporting > 1,000 breeding pairs of Pochard are showing consistent declines (Table 2), several of major magnitude, which gives considerable cause for concern given the disproportionate contributions (> 90%) these states make to the European breeding population. The numbers of Pochard breeding in European Russia, for example, are considered to have declined by up to 10% during 2000–2010 alone and the upper estimate of population size has fallen by 50% (although there remains considerable imprecision about the estimates compared to those in smaller countries further west). Furthermore, we know relatively little about how the breeding numbers further east in Russia (*i.e.* outside of Europe and beyond the scope of this review) have fared in the same period, because many of the breeding birds from these areas also contribute to European wintering numbers, which have fallen dramatically in recent years (Nagy *et al.* 2014). Hence, whilst trends in breeding abundance in some of the countries with relatively low numbers in the west of the range and those which have been recently colonised seem to be reasonably favourable, those in areas with greatest numbers and especially those in the north and east of the range seem to be experiencing the greatest rates of decline. Despite evidence of recent increases in Mediterranean areas, longer term prospects are poor given climate change, increased water abstraction and invasive species, which will lead to loss of habitat, increased salinity and hypertrophy in remaining wetlands (Moss *et al.* 2009).

Management options to address declines throughout the European breeding range

Although it is important to stress that for many of the factors we lack hard evidence for the ultimate causes of the decline in European breeding Pochard, the congruence of factors reported from many different countries supports the hypothesis that there may be some common causes (see Table 3). Regionally, macro-environment conditions (such as poor weather during laying and incubation or drought) could contribute a common cause to explain regional declines. Pochard do seem to select to nest on eutrophic (and in many cases ephemeral) wetlands (Kear 2005), which makes them susceptible to nutrient and hydrological change given the relative rarity and unstable nature of such wetland types. Several authors noted the benefit of the provision of new waterbodies in the form or reservoirs, gravel pits and fish-ponds as habitat for breeding Pochard, which likely fuelled the expansion of its range and population size during the middle part of the last century. The eutrophication of such waters as a result of the increasing use of inorganic fertilisers in agriculture from the 1950s onwards was also cited as providing enhancement of suitable breeding habitat for Pochard during their period of range extension and consolidation. Continuation of nutrient enrichment however typically elevates primary production, leading to overgrowth of reed-beds and willow scrub at cost to open water in such wetlands. Increased phytoplankton and water turbidity in remaining open water also restricts benthos and submerged macrophyte communities (Ekholm & Mitikka 2006) and ultimately the attractiveness to breeding duck species, including Pochard (Lehikoinen *et al.* 2016). The European Water Framework Directive (WFD) adopted in 2000 aims to restore good ecological status to all surface waters by 2027, including the mediation of such eutrophication effects, although there is wide agreement that such a timescale for delivery is overly optimistic (*e.g.* Hering *et al.* 2010). Hence, to restore breeding Pochard populations at sites of particular significance to the species in the short term (especially in protected areas where water quality issues are associated with catchment processes outside the jurisdiction of the protected area), specific site-based remedial action plans are required to tackle problems associated with local water quality. There also remain considerable challenges associated with remediation and reinstatement of hyper-eutrophicated waters (*e.g.* Jarvie *et al.* 2013), so recreating suitable conditions for Pochard and other breeding waterbirds may present longer term conservation management targets in such situations. Meanwhile, successful wetland restoration projects at some key breeding sites for Pochard, as, for example, recently implemented in the Baltic States, have resulted in immediate increases in numbers of breeding as well as staging Pochard (Viksne *et al.* 2010), which gives hope that targeted wetland creation and restoration can contribute to local increases in nesting abundance.

Drought, especially in the south and southeast of Europe, has reduced the reliability of ephemeral wetlands appearing during spring and summer, to which breeding Pochard are attracted. Although management of hydrological abstraction from rivers and waterbodies can moderate such effects, in the face of changing patterns of precipitation and increasing temperatures associated with climate change, there is little beyond enhancing water management that can be done to safeguard important breeding sites for Pochard under such circumstances. Climate change acts in tandem with water abstraction, resulting in salinity increases at wetlands, rendering them unsuitable for Pochard (Jeppesen *et al.* 2015).

Changes in management of fish-ponds, either as a result of intensification (which results in the negative effects reported for eutrophication, or direct feeding competition between Carp and Pochard adults and young), or abandonment has reduced the potential carrying capacity of this very important anthropogenic habitat to support breeding Pochard (*e.g.* Broyer *et al.* in press). Although we lack firm scientific confirmation that expert opinion has identified the key drivers of changes in Pochard abundance correctly, it does seem that changes in east European aquaculture have played a disproportionate role in the decline in numbers of Pochard breeding in that part of the range. Nevertheless, the future appropriate management of these sites does provide some options for restoring nesting Pochard populations. For instance, agri-environmental and food security support mechanisms may be available to support sustainable and ecologically friendly aquaculture production in rural areas otherwise suffering poor employment opportunities.

Predation on nests and incubating females must also have an effect on the reproductive potential of the Pochard population to reproduce successfully, even where nesting conditions are perfect, and many countries reported adverse changes in predation levels due to several, often interacting processes. In France, the Wild Boar constitutes a problem and with increases in their abundance and distribution could become a source of greater predation pressure in the future (*e.g.* Elmberg *et al.* 2009). However, most evident in some other states were the presence of non-native predator species, such as Raccoon Dog, Raccoon and American Mink, all of which are able to access nests on islands, in reed-beds and on floating vegetation. However, while the evidence for the magnitude of the specific impacts of these three predator species on nesting duck species remains equivocal (*e.g.* Nordström *et al.* 2003; Kauhala 2004; Nordström & Korpimäki 2004; Väänänen *et al.* 2007; Kauhala & Kowalczyk 2011), there is good evidence for the ecological impacts of American Mink and potential to prevent and mitigate the effects of this species (*e.g.* Bonesi & Palazon 2007). A rich literature from North America shows that local predator control in areas of high duck nesting densities increases nesting success (*e.g.* the pioneering work of Duebbert & Lokemoen 1980), but the intervention tends to be financially costly, requires consistent sustained investment over much larger areas than a single duck breeding site and is not likely to have effects at the population level (Côté & Sutherland 1997). Other exotic species that may have potential influence on breeding Pochard in France include the Coypu *Myocastor coypus*, Muskrat *Ondatra zibethicus*, Red Swamp Crayfish *Procambarus clarkii* and Catfish *Silurus* sp. as well as some non-native exotic plants (*e.g.* Water Primrose *Ludwigia* sp.) which are all thought to exert an adverse effect on natural vegetation (A. Caizergues, unpubl. data). Bonesi & Palazon (2007) stressed the requirement for strategic solutions and in particular for sensitising public and government agencies to the need to respond nationally and internationally to invasive alien species. As of January 2015, the EU has implemented a new Regulation on Invasive Alien Species 2015 (European Commission 2014) with the major objective (under the EU's Biodiversity Strategy Target 5 for 2020) to coordinate EU-wide actions to prevent, minimise and mitigate the adverse impacts of invasive alien species (IAS) on biodiversity and ecosystem services, the economy and public health. The Regulation seeks to establish three types of measures, namely: (i) prevention, (ii) early warning and rapid response and (iii) management of already established IAS. Within EU member states, therefore, there is now a vital imperative on statutory bodies to manage IAS (including through international coordination), which provides a much needed imperative to tackle some of the species considered here to be a challenge to the effective maintenance of breeding Pochard numbers.

Although Black-headed Gull colonies did not improve Pochard reproductive success significantly at Grand-Lieu in France (B. Folliot, unpubl. data), loss of gull colonies elsewhere (which provide protection from predators of eggs and hatchlings as a result of the gulls' communal mobbing behaviour, and have been shown to elevate Pochard reproductive success and female survival; Väänänen 2000; Blums *et al.* 2003) is frequently cited as being the cause of lost or reduced breeding Pochard numbers. Although the Black-headed Gull population is declining across much of Europe, local declines have been ascribed to different causes, *e.g.* in Latvia to a reduction in fishing-related activities and mink farms, where gulls could feed (Viksne 1997) and in Denmark to reduction in food availability at mink farms, changes in stock grazing intensity on grassland and the switch from spring-sown to autumn-sown cereals (Bregnballe *et al.* 2015). For such reasons associated with large-scale land use and changes in husbandry and aquaculture, there is little short-term likelihood of restoring food sources for nesting gull colonies. However, where changes in grazing pressure and cutting or loss of reed-beds are concerned, local management to restore such features and enhance the attraction of local wetland nesting habitat are clearly high priorities for the feasible sympathetic management for breeding Pochard.

Finally, it should not be forgotten that Pochard are huntable in several east European states from 1 August, which selects for breeding females and naive juveniles prior to their departure to winter quarters. This, together with drowning in fishing nets at the same stage in the annual cycle, also represents a source of avoidable mortality that could be mitigated that may otherwise increasingly contribute to local population decline.

Overall, therefore, it would seem that the expansion in the range and size of the Pochard population breeding in Europe was supported in the middle of the last century by habitat creation and nutrient enrichment, which was not possible to sustain in contemporary landscapes. Continued eutrophication of some waters and loss of other wetlands (especially amongst fish-ponds that seem to have supported particularly high numbers) has contributed to the subsequent decline over the last 2–3 decades, potentially exacerbated by elevated predation rates from a suite of predatory species that include some invasive alien species. There seems little doubt that local sympathetic site management can mitigate some of these impacts where there is good evidence for the local cause of declines in breeding abundance, but given the magnitude of the problem and the likely diversity of local factors involved, it would seem that in the short term at least, we need to accept that the breeding population of Pochard in Europe in the coming few decades will be lower than in the recent past. In this respect, it is clear that appropriate management is needed to stabilise the current population trend, while research and monitoring is concurrently implemented to understand the critical causes behind the declines and better track population change. There is a clear incentive to ensure that those sites that currently contribute the most important breeding concentrations of this declining species are effectively protected and subject to optimal management to maintain and enhance numbers of breeding Pochard present. However, we must also face the reality that this is a species that breeds in small numbers on large numbers of waterbodies and restoration of the quality of those waters remains a priority if we are to restore breeding numbers to former levels of abundance. In this respect, the Pochard presents us with a series of new nature conservation challenges, being a red-listed species which remains relatively common and widespread, but nevertheless with a relatively narrow ecological niche. As a result, it may not attract attention from conservation NGOs and agencies in the first instance, yet it could decline to relatively low population levels relatively quickly without clear management prescriptions for its rescue. Moreover, the Pochard may be experiencing additional negative demographic changes, which lay outside of the scope of this review, such as enhanced mortality outside of the breeding season (*e.g.* through changes in hunting mortality, drowning in fishing nets and suffering lead poisoning from lead shot in the environment), which may be contributing to current rapid declines in its overall abundance.

The species therefore deserves an integrated flyway-wide approach to its population management, taking into account of all the interacting processes which limit and regulate its abundance, preferably under an internationally agreed flyway management plan. Such an approach is vital for understanding the effects on population size of the factors discussed above in relation to the breeding season, relative to those that operate at other critical points through the remainder of the annual cycle (*e.g.* staging, moulting, wintering, *etc.*). Such knowledge is vital to balance and prioritise cost-effective conservation actions to restore the species to more favourable conservation status. In this respect, it may be a useful case study for other wetland species in similar situations, where it is clear that we require improved systems for the collection of key baseline data (*e.g.* objective measurement of annual national nesting abundance and breeding female survival in all countries, and of local factors that may be affecting these measures), in order to support evidence-based conservation management actions needed to maintain and ultimately restore local breeding abundance to previously higher levels. It is important that such coordinated research and monitoring be instigated across its range before the species approaches levels that are considered critically rare.

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Photograph: Common Pochard male, with female in the background, at Jeziorsko, Poland, by Adam Mańka.