Pied Avocet conservation in Denmark – breeding conditions and proposed conservation measures

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(Med et dansk resumé: Beskyttelse af Klyden i Danmark – yngleforhold og forslag til beskyttelsestiltag)

Abstract Although numbers of breeding Pied Avocets in Denmark increased between the 1920s and the early 1990s, they are now declining significantly more rapidly than in almost all other NW European countries. There have been few studies of the causes of the declines in breeding colonies in Denmark, and here we analyse some case studies and overall trends in predation and weather patterns to try and assess the importance of selected potential factors affecting breeding numbers. Western Denmark lies on the very north-western edge of the Pied Avocet breeding distribution, and breeders here are therefore most likely to be more vulnerable to reductions in reproduction rates as a result of severe weather events, such as strong winds and heavy precipitation, especially during the chick rearing period. Increased risk of flooding of low-lying coasts and islands, a general increase in abundance of the most significant predators, such as red fox *Vulpes vulpes* and Peregrine Falcon *Falco peregrinus*, and disturbance by human visitors are other likely factors, which may contribute to declines in Pied Avocet breeding numbers in Denmark over the last 20 years. Finally, we provide some management recommendations, which could potentially reverse the present negative trend.

Introduction

Following 60-70 years of steady increases in the total number of Danish breeding Pied Avocets *Recurvirostra avosetta* (hereafter 'Avocets') from the 1920s until the early 1990s (Thorup 2005), the population has been declining over the last 25 years (Fig. 1; Bregnballe *et al.* 2015). Increasing numbers in Denmark during most of the 20th century followed trends elsewhere in NW Europe. Better protection of the species at breeding, staging and wintering sites is thought to be the primary cause of these increases in Denmark (Thorup 2005) and in NW Europe (Hötker & Dodman 2009). The creation

of artificial nesting structures by coastal engineering works and higher food densities as a consequence of eutrophication have most likely also improved the breeding conditions for Avocets markedly (Hötker & Dodman 2009). In an international perspective, the Avocet is one of the most important Danish breeding birds, as some 14% of the European biogeographic population and 2% of the world population occur in Denmark (Delany & Scott 2006, Thorup 2006).

In contrast, the 28% decline observed in Denmark between 1990 and 2009 and a further 32% decline from 2009 to 2014 (Bregnballe *et al.* 2015) is unique in a NW European context where breeding numbers have generally been stable or have shown only moderate declines during 1990 to 2009 (Hötker & Dodman 2009, Koffijberg *et al.* 2009). However, after 2006 marked declines also took place in the Netherlands (Koffijberg *et al.* 2015). This suggests that currently, the Danish Avocets face some unique and specific pressures, which are the cause of the population declines. As the Avocet is listed in Annex 1 of the EU Birds Directive, Denmark is responsible for providing good breeding conditions for the species, and in that context, also obliged to identify the causes of its less favourable conservation status in the country. Only with an understanding of the causes of poor breeding success will it be possible to recommend specific actions to improve the current situation.

Before we started analysing the data, we thought the following factors were the currently most likely factors limiting the long-term reproduction and survival in Avocets or contribute to emigration to new breeding sites abroad and thereby cause population declines in Denmark:

1) changes in predation that increase adult and/or chick and egg mortality and/or increase the perceived risk of predation, which may affect the choice of breeding sites and the decision on whether to breed or not;
2) climate change that increases the flooding risk to low lying predator-free breeding sites and/or increases the chill factor to a point where chick survival rate is affected;
3) changes in land use and vegetation management, as Avocets depend on breeding sites with very short or no vegetation;
4) changes in disturbance, because increases in early season disturbance may lead to abandonment of breeding sites, and high disturbance levels later in the season may be energetically costly for chicks which may impact on their survival;
5) increased competition with other species for space on the limited number of islets and other sites with no or difficult access for ground predators, where the presence of more aggressive species like gulls may ultimately prevent breeding by Avocets.

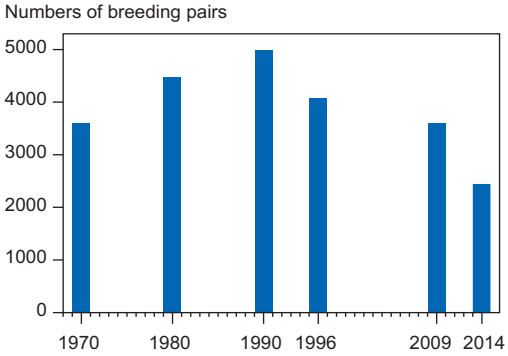

Fig. 1. Numbers of Avocet breeding pairs in Denmark in five nationwide surveys.
Antal ynglepar af Klyde i Danmark ved fem landsdækkende tællinger (Bregnballe *et al.* 2015).

Often more than one of these five factors are present and interacting at specific breeding sites, making it difficult to attribute observed declines to any one factor at any given site. For example, increased predation on saltmarshes and the sections of the beaches closest to land may force Avocets to select to nest on sand banks further away from the mainland, where they face an increased risk of flooding.

Very few detailed studies of the factors affecting Avocet breeding success have been performed in Denmark. Where information on breeding Avocets has been gathered for a site, it is usually limited to the results from one or two counts of the breeding birds present or of the incubating individuals or nests. Therefore it is rarely possible to relate declines at certain sites with any of the specific adverse factors listed above. One exception is at the Tipperne nature reserve, where factors affecting the breeding of Avocets and other waders (shorebirds) have been followed fairly closely during the last 30 years. Studies at Tipperne have included mapping of colony displacement due to predation during the entire breeding season, and the number of chicks has been counted regularly and systematically during late spring and summer (Thorup 1998, Thorup & Laursen 2013).

In this article, we present results of observations and case studies, to attempt to cast light on the processes that regulate breeding output by relating local breeding conditions to the numbers of young produced at some important Danish breeding sites. The case studies are geographically biased towards western Denmark, because good quality data were limited to the two nature reserves at Vejlerne and Tipperne and to colonies in the Danish part of the Wadden Sea. Finally, we conclude by recommending some conservation measures in response to some of these factors which could be applied in an attempt to improve breeding conditions for Avocets.

Material

In 2011-2012, a meadow bird database was developed as part of the EU Life BaltCoast project. It contains breeding records of Avocet, Baltic Dunlin *Calidris alpina schinzii*, Ruff *Calidris pugnax* and Black-tailed Godwit *Limosa limosa* from Denmark, Estonia and Sweden. All available Danish breeding data relating to these species, published as well as unpublished, have been collected, and the data gathering included a special effort to search for Avocet data from a large number of non-professional observers (further details in Bregnballe *et al.* 2015). One breeding population figure per site per year is stored, and in November 2013 there were 6107 Danish Avocet breeding records in the database.

Additionally, we have used information on distribution and breeding success collected at the Tipperne field station in W Denmark published in newsletters (the latest in Thorup & Laursen 2013), internal annual reports to Aarhus University and breeding data stored in various files together with information stored in a Wadden Sea breeding bird database maintained by Amphi Consult and Aarhus University, Department of Bioscience.

Observations and case studies – results and discussion

Unstable breeding conditions on major sites

The numbers of Avocets found at Danish colonies with many breeding pairs have varied greatly between years. Amongst the five nationwide Danish surveys undertaken during 1970-2009, between 17% (1970) and 47% (1990) of the Danish total were found at sites with more than 100 breeding pairs while in 2014 no sites had more than 100 pairs (Bregnballe *et al.* 2015). During the five counts between 1970 and 2009, 18 different sites held more than 100 pairs, but none of the sites sustained such high numbers of pairs during all of the counts: one site maintained more than 100 pairs during four of the five counts, three sites during three of the five counts, whereas the remaining sites only exceeded 100 pairs during one or two counts (Tab. 1). Another 15 sites supported more than 100 breeding pairs in at least one season outside the nationwide count years between 1958 and 2014.

Effects of poor reproduction on subsequent population size

Based on the data collected at Tipperne, we explored the relationship between breeding numbers and breeding success in previous years. Breeding success was defined as the maximum number of chicks counted per breeding pair during regular surveys each year in May-July during 1985-2013. Changes in overall breeding numbers were related to breeding success one, and especially two, years earlier (Fig. 2). This dataset covered the period 1985-2000 when larger numbers of Avocets were breeding (77-510 pairs, 258 pairs on average). Since most Avocets start breeding at two years of age and they show some natal philopatry (Cadbury & Olney 1978), the statistically significant correlation in Fig. 2b probably reflects the fact that local breeding success directly influenced the numbers of new individuals that were ready to recruit to their natal colony two years after hatching. The plot in Fig. 2b also shows that in the 10 seasons with 0.3 or less chicks produced per pair, the population declined, whereas in the four seasons with 0.4 or more chicks per pair the change in numbers was positive.

In 2001-2013 – when the population fluctuated at a much lower level (1-130 pairs; 57 pairs on average) – there was no such relationship between breeding success and annual population growth rate (regression analysis, one year later: $R^2 = 0.00$, $F_{1,10} = 0.02$, $P = 0.90$; two years later: $R^2 = 0.03$, $F_{1,9} = 0.26$, $P = 0.63$).

Two main factors affect hatching success on Tipperne: (i) predation (especially of eggs) and (ii) weather conditions – particularly the occurrence of flooding of low lying breeding islets (Salvig 1990, Thorup 1998). It is unknown exactly how important each of these factors has been for the observed breeding success (Thorup 1998). In a study in the German part of the Wadden Sea, hatching success had only a minor effect on breeding success, and here June temperature was the most important factor for chick survival and the best predictor of breeding success (Hötker & Segebade 2000).

Creation and losses of breeding islets

A large proportion of the Danish Avocets breeds on islands and islets where access by foxes *Vulpes vulpes* and other mammalian predators is restricted because of the surrounding water. In years with systematic counts in the Danish Wadden Sea (1991-2013), between 44% and 87% of the breeders were found on such islets.

Many islets were and continue to be created by natural dynamic processes due to currents and in northern Denmark isostatic uplift, but in addition, artificial islets have also been constructed for avian conservation purposes, particularly in the Danish Wadden Sea. Such islets were created in artificial wetlands during dike construction and establishment of storm-tide backwater reservoirs. In the years 1991-2013, between 22% and 64% of the Wadden Sea breeding Avocets were found at artificial wetlands, but the wetlands were generally only used temporarily (Fig. 3). The vegetation on these islets has not normally been managed by grazing or mowing and they generally became overgrown with high and dense vegetation some years after their construction, render-

Tab. 1. Sites where at least 100 pairs of Avocets were counted in one of the five Danish total counts performed in 1970, 1980, 1990, 1996 and 2009. There were no colonies with 100 or more pairs in 2014. Counts with 100 pairs or more are marked with green (klæggrav = clay pit).
Lokaliteter hvor der optaltes mindst 100 ynglepar af Klyde på en af de fem landsdækkende tællinger 1970-2009; ved tællingen i 2014 var der ingen lokaliteter med 100 eller flere par. Tællinger med mindst 100 par er markeret med grønt.

	1970	1980	1990	1996	2009
Rønnerne Læsø (Færøn, Langerøn, Kringelrøn, Hornfiskrøn and Alsdyb Holme)	265	93	380	342	11
Treskelbakkeholm	23	30	125	119	120
Stenholm ved Gjøl and Dynen	160	68	0	0	0
Ulvedybet	21	35	25	14	210
Bygholm, Selbjerg and Glombak Vejler	83	162	120	94	71
Fjordholmene	20	21	5	154	0
Harboøre Tange	50	130	270	86	71
Agger Tange	200	170	20	20	162
Fjandø	50	50	110	320	0
Tipperne	35	330	416	83	87
Keldsand-Trinden	33	33	180	18	3
Sneum klæggrav (Engsø)	0	0	0	187	0
Sdr. Farup klæggrav	25	25	250	1	13
Mandø Forland	5	0	18	21	103
Ballum Forland	70	234	24	0	0
Frederikskog Forland/Margrethe Kog	70	425	302	268	13
Selsø, Okseholme and Selsø Hage	5	3	1	0	123
Saltholm	18	117	182	185	200

ing them unsuitable for nesting Avocets. Moreover, when individual predators establish themselves near or return repeatedly to such islets, it often forces colonial breeders like Avocets to move (cf. Hötker & Segebade 2000).

Reaction of Avocets to mammalian predators

Favourable management to encourage breeding meadow birds was re-established at Tipperne in the early and mid-1970s, and by the end of the decade, short-grazed meadows had been achieved in most of the reserve (Thorup 1998). This was also the case on the former island 'Fuglepold' which had been connected to the mainland by a manmade land bridge. In 1980, Fuglepold was re-established as an island by digging a deep, *c.* 30 m wide channel across the land bridge, and Avocets reacted promptly by settling on the island to breed (Fig. 4). In the next 15 years, between 50 and 353 pairs bred here, and large numbers of other breeding shorebirds also colonized the island. In the peak years of 1988 and 1989, some 300-350 pairs of 'territorial' shorebirds were found on this 35 ha island in addition to the Avocets, some of the densest populations recorded (Thorup 1991). From 1986 onwards, the nest survival of the territorial shore-

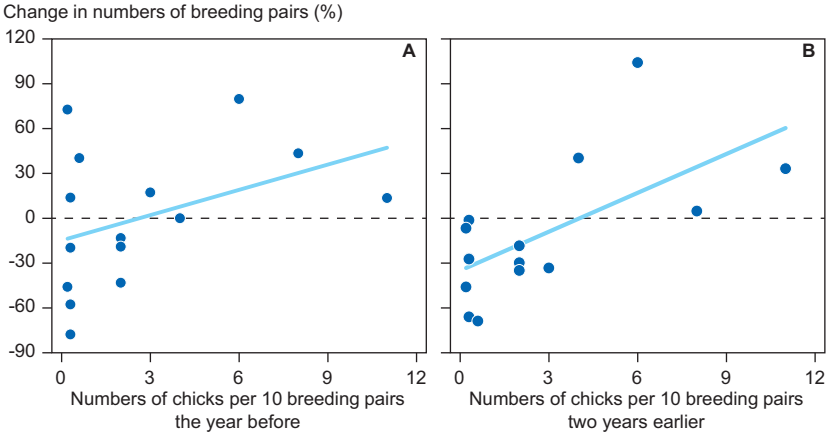

Fig. 2. The relationship between the percentage change in local breeding abundance between year t and t+1 and the observed breeding success at Tipperne (no. of observed chicks per 10 breeding pairs) in years t and t-1 during 1985-2000. A: Breeding success and population change the year after (year t); $y = 5.64x - 14.84$, $R^2 = 0.16$, regression analysis: $F_{1,13} = 2.47$, $P = 0.14$. B: Breeding success and population change two years later (year t-1); $y = 8.67x - 35.01$, $R^2 = 0.41$, regression analysis: $F_{1,13} = 8.97$, $P = 0.01$.
Sammenhængen mellem den observerede ynglesucces på Tipperne (antal observerede unger pr. 10 par) og bestandsændringen et og to år efter 1985-2000. A: Bestandsændring et år efter. B: bestandsændring to år efter.

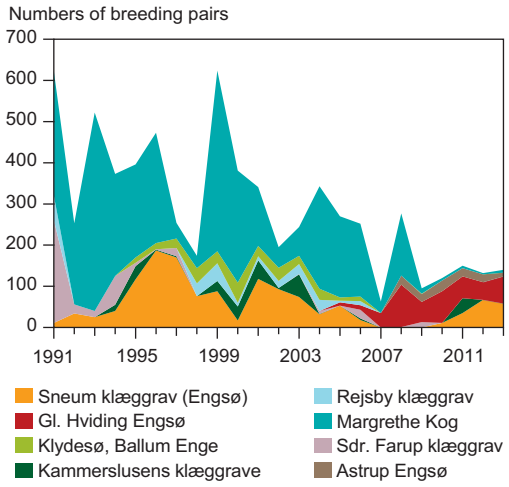

Fig. 3. Numbers of pairs of Avocets breeding at eight man-made wetlands in the Danish Wadden Sea 1991-2013, mostly the result of nesting on constructed islets in water bodies. Klæggrav = clay pit.
Antal ynglepar af Klyde i otte menneskeskabte vådområder i det danske Vadehav 1991-2013, hvor Klyderne især ynglede på kunstige øer.

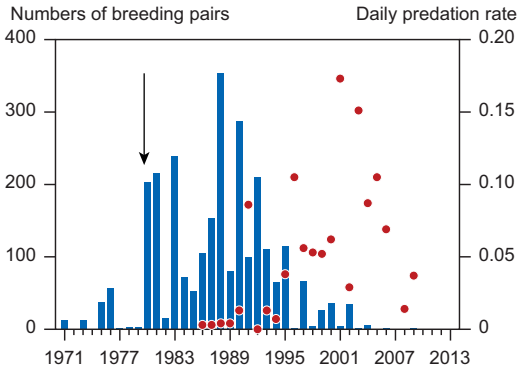

Fig. 4. Numbers of breeding pairs of Avocets on the islet of Fuglepold, Tipperne 1971-2013 (blue bars) compared with known daily predation rates on nests of Redshanks (red dots) on Fuglepold 1986-2006 and 2008-2009 (2007 and 2010-2013 not enough Redshank nests were controlled to provide a predation value). The arrow denotes the year when Fuglepold was re-established as an islet by digging a deep, *c.* 30 m wide channel across the artificial land bridge.
Antal ynglepar af Klyde på øen Fuglepold, Tipperne 1971-2013 (blå søjler) og daglige prædationsrater for Rødben (røde prikker) på øen 1986-2006 og 2008-09. Pilen angiver året, hvor Fuglepold blev genskabt som en ø.

birds was monitored systematically, and in Fig. 4 the daily predation rates in nests of Common Redshanks *Tringa totanus* – the most abundant territorial shorebird on the island – are depicted in order to illustrate the overall predation level on Fuglepold. Similar nest success data for Avocets are not available, but during 1986-1994 (except 1991), the Redshank predation level was negligible with daily predation rates of 0.3 to 1.3% (mean 0.6%). After 1995, the annual daily predation rates increased considerably (14-fold), almost certainly because ground predators found their way to the island more regularly, and the daily predation rate on Redshank was above 2.9% in every season 1995-2006 (mean 8.2%). Avocets suddenly almost entirely ceased to breed on Fuglepold after the increase in Redshank predation level, strongly suggesting some parallel cause (Fig. 4).

Increased populations of mammalian predators in the Wadden Sea, in particular foxes, are thought to force an increasing number of Avocets to breed on low-lying breeding sites in the outer parts of the saltmarshes and on off-shore sand banks much more exposed to flooding (K. Fischer in Skriver 2007). Increased levels of disturbance by human visitors along the Wadden Sea coasts in the last 20-30 years may further have enhanced such a displacement. The change in Avocet distribution patterns on the islands along the south coast of Fanø support this idea (Fig. 5): The breeders on the relatively high sand banks at Keldsand-Trinden situated between 0.2 and 2.8 km from Fanø have gradually disappeared, during which time, more and more pairs have started breeding on the low-lying islets known as Peter Meyers Sand situated 3.5 km from Fanø over open sand flats.

Climate change and flooding

The frequency of occurrence of floods hitting low-lying sand banks and outer saltmarshes in the international Wadden Sea has increased significantly in the last 40 years (Pol *et al.* 2010). The modelled risk to an Avocet pair that their nest would be flooded at least once during a breeding season increased from 41% in the period 1971-1989 to 52% during 1990-2008, and according to the prognoses, this risk will increase further to almost 60% in 2009-2027 (Pol *et al.* 2010).

Breeding success of Danish Wadden Sea Avocet colonies is not monitored systematically. However, it is observed that in most years, sand banks like Peter Meyers Sand are flooded at least once in the Avocet nest or chick rearing period (May-early July), and in many years all the breeders on such sand banks are unsuccessful.

Abandonment of a colony due to Peregrine Falcons

Colonial breeders like Avocets are very vulnerable to visiting mammalian predators, and destruction of all nests and abandonment of colonies after such visits are frequent and well documented (Thorup 1998, Hötker & Segebade 2000). However, the presence of hunting avian predators can also have serious impacts on a colony. Two examples were recorded on Tipperne. On 24 April

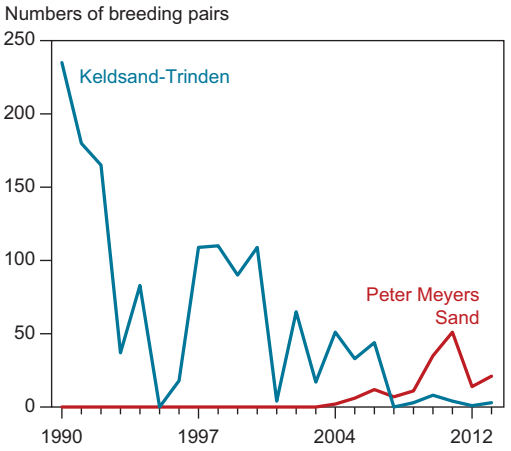

Fig. 5. Numbers of breeding Avocet pairs on an inner sand (Keldsand-Trinden) and an outer sand (Peter Meyers Sand) immediately south of Fanø in the Danish Wadden Sea 1990-2013.
Antal ynglepar af Klyde på Keldsand-Trinden lige syd for Fanø og Peter Meyers Sand længere ude syd for Fanø 1990-2013.

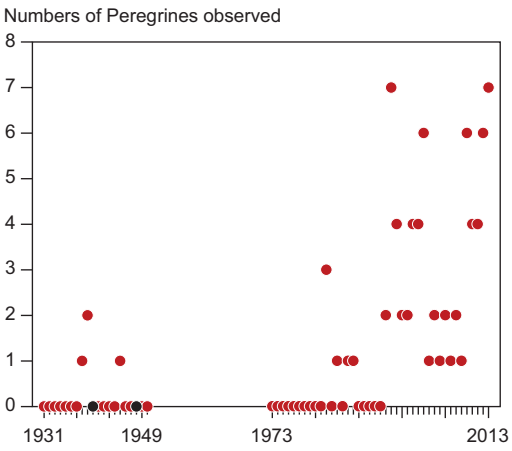

Fig. 6. Observations of Peregrine Falcons on Tipperne (bird-days) between 26 April and 31 July (breeding season of Avocets) during 1931-1950 and 1973-2013. Data from 1940 and 1948 are incomplete, because observations only started early May these years.
Antal Vandrefalke (fugledage) på Tipperne mellem 26. april og 31. juli (Klydens ynglesæson) i perioderne 1931-50 og 1973-2013. Data fra 1940 og 1948 er mangelfulde, fordi Tipperne først blev bemandet et stykke inde i maj disse år.

2010, a newly established Avocet colony with 46 pairs was abandoned immediately after a Peregrine Falcon *Falco peregrinus* had hunted Avocets for several hours above the colony. And in 2012, a stationary Peregrine Falcon in a colony in late April and early May caused the colony – holding 50-70 pairs on 18 April – to be abandoned within a few days. Only after the Peregrine Falcon had left the area in mid-May, did a small colony of Avocets re-establish.

It is unknown to what degree the Peregrine Falcons had hunting success during the abovementioned events at Tipperne. There is growing evidence, however, that the mortality itself is only a small part of the effects of the presence of a prominent predator like the Peregrine Falcon. The perceived risk of mortality is most likely much more important in directing the behaviour of the potential prey (Cresswell 2008, Hout 2009, 2010). This phenomenon has so far primarily been studied at staging sites for waders, but an increase in predation risk with the population recovery of in particular Peregrine Falcons has been shown to influence migration and feeding strategies of waders markedly, e.g. by preventing European Golden Plovers *Pluvialis apricaria* from fattening maximally as an insurance against starvation during cold spells (Piersma *et al.* 2003), or by altering the migration tactics of Western Sandpipers *Calidris mauri* and force the birds to leave staging sites when Peregrine Falcons arrive (Ydenberg *et al.* 2004).

Effects on behaviour and distribution caused by predation and predation risk have mainly been found in situations when staging and wintering waders are most vulnerable: when they are loading and carrying extra fat for moulting, migration or to prevent winter starvation. Although the phenomenon is not yet studied concerning breeding birds, waders are most likely also very vulnerable to the risk of predation by Peregrine Falcons when they are laying eggs or incubating in the open. With the recent population recovery, the presence of Peregrine Falcons on Avocet breeding sites during the breeding season April-July must have increased markedly during the last decades. At Tipperne, Peregrines have been registered quite systematically since 1973 (Fig. 6), and ornithologists also noted Peregrines in the area (though less systematically) in the period 1931-1972 (Meltofte & Amstrup 2013). There are no Peregrine Falcon breeding sites in the neighbourhood of Tipperne, but the frequency of Peregrine Falcon observations in the breeding season of Avocets during the last two decades (Fig. 6) was much higher than at any other time since 1931. There are not only much more frequent observations today than during the period with population depression mainly caused by negative effects by DDT and other organochlorines in the 1950s-1970s, but also a much higher frequency of observations than in the pre-DDT years in the 1930s and 1940s. The 1930s and 1940s is the period with the largest known natural breeding population of Peregrines in Denmark, at minimum since the first ornithological reviews were worked

Fourteen percent of Europe's Pied Avocets breed in Denmark, but several management improvements are needed, if the current decrease should be halted. Photo: Jens Kristian Kjærgård.
Fjorten procent af Europas Klyder yngler i Danmark, men der skal en række tiltag til, hvis den nuværende nedgang skal stoppes.

out in the 1700s, so the present level of Peregrine numbers is higher than has been the case for many centuries (Løppenthin 1967, Andreasen 2008). There are no similar data from elsewhere in Denmark, but as most of the good Avocet breeding sites are at extensive mudflats bordering low water areas, and such sites mostly also are good waterbird sites, which attract Peregrine Falcons in the same way as Tipperne, the patterns of relative abundance in Peregrine Falcons seen at Tipperne is probably typical for a large portion of the Avocet colonies in Denmark. Nowadays, the Danish population of Peregrine Falcons – also during migration and winter – is probably well above former levels for at least 300-500 years thanks to large scale breeding programmes and installation of nest boxes in otherwise unsuitable breeding habitat for Peregrine Falcons in Denmark as well as in our neighbouring countries of Sweden and Germany (Andreasen 2008) combined with a different human attitude towards birds of prey and a better protection in the breeding season.

Wetter meadows attract more breeding Avocets

Many embanked polder areas are important breeding sites for meadow birds in Denmark, and locally also for Avocets. During the last 40 years, most polder areas have been subject to intensification of their use for agriculture. In order to stimulate earlier grass growth and for various veterinarian reasons, there has been large scale lowering of water tables in Danish polders, which has had a dramatic adverse effect on breeding shorebirds like Ruff and Black-tailed Godwit (Thorup 2004, Thorup & Laursen 2008, Laursen & Thorup 2009).

Two studies have shown that maintaining higher water tables in polders may also attract breeding Avocets. At the important Avocet breeding site Bygholmengen in NW Denmark, there was a statistically significant positive relationship between water table and breeding numbers in the period 1988-2003, when between 50 and 685 pairs bred at the site (Kjeldsen 2008). In the NW polders of Mandø, a project raised the spring water table significantly in 2012-2014, and Avocet breeding numbers increased from an average of 10 pairs in 2006-2011 (0 to 34 pairs) to 65 pairs in 2012-2014 (45 to 78 pairs).

Nothing is known of the breeding success at the two sites, however, and on Mandø there have been problems in retaining the water throughout the breeding season. So the effect on the reproductive output of the Avocets is unknown.

Other factors likely to limit survival and reproductive performance

Energetic constraints

Western Denmark is at the north-western margin of the Avocet breeding range, and Avocets do not breed in Scotland and only irregularly in Norway (Hagemeijer & Blair 1997, Kålås *et al.* 2010) west and northwest of Denmark. Avocet chicks feed on exposed mudflats, and studies in northern Germany have shown that cold and severe weather caused slower growth among young chicks, and that chicks with slow growth had a much reduced survival (Hötker 1998). In the Wadden Sea, the rate of storm flooding has increased significantly recently (Pol *et al.* 2010) indicating that severe weather situations have become more regular.

The majority of the Danish decline between the peak year 1990 and 2009 took place in the westernmost regions of Denmark (Bregnballe *et al.* 2015), which is the part of Denmark most affected by Atlantic low pressure weather. Although this represents only indirect evidence for causation, a change in weather patterns may quite likely have influenced Avocet reproduction in western Denmark adversely by effectively pushing the energetic NW border southeast of the major breeding sites in some years.

Population increases in foxes

In southernmost Jutland, populations of red foxes are known to be much larger today than 20-40 years ago, when foxes were systematically eradicated in several campaigns in this border zone in order to prevent rabies from entering Denmark from Germany (Clausen & Kahlert 2010). In most other parts of Denmark it is a common and widespread assumption that fox populations have also increased significantly, at any rate along the coasts, although good data are rarely available. A possible major reason for increased fox numbers could be a declining interest or time among hunters living in rural Denmark for 'controlling' fox numbers.

In Vejlerne in NW Denmark, a peak in the number of breeding Avocets in 2000-2002 coincided with a breakout of sarcoptic mange among foxes and subsequent unusually low numbers of this predator (Kjeldsen 2008).

If many more foxes are present nowadays in coastal meadows, and they access islets more regularly, this could cause a lower breeding success among Avocets, and also that more coastal meadows and islets would be abandoned as breeding sites. Inevitably, this will result in lower Avocet breeding numbers with time.

However, the number of foxes also increased in the last decades in e.g. Germany (Langgemach & Bellebaum 2005) and the Netherlands (Beintema *et al.* 1995), where Avocet breeding numbers did not decline accordingly. For this reason, we should be prudent about concluding that a general increase in foxes automatically causes wide-scale unfavourable breeding conditions for Avocets.

Kestrels can specialize in predation of Avocet chicks

After a population low in the 1950s and 1960s, the Danish population of Kestrels *Falco tinnunculus* recovered in the period from the 1970s to the 1990s (Dybbro 1976, Noer & Secher 1983, Grell 1998). Hence, between the two breeding bird atlas periods in 1971-1974 and 1993-1996 undertaken by the Danish Ornithological Society, the species expanded its distribution by 20% (Grell 1998). Furthermore, it has become popular to establish nest boxes for the species, including in habitats without natural nest sites, so that Kestrels now breed closer to many good Avocet breeding sites than was previously the case. Kestrel food choice in salt marshes has never been studied in Denmark, but locally this change has likely increased the predation of Avocet chicks considerably. Studies in France and England have shown systematic predation of Avocet chicks by Kestrels (Watier & Fournier 1980, Hill 1988), and the French study revealed that such predation might potentially be important. In their study site in SW France, Watier and Fournier (1980) found that one specialized Kestrel killed about 12% of the chicks in one year in a colony with some 200 pairs, equivalent to 26% of the chick mortality that year.

Avocet conservation in Denmark

Avocets are very widely distributed in Denmark, being found breeding at 492 different sites between 1958 and 2014, and 245 sites had breeding Avocets at the latest countrywide survey in 2014 (Bregnballe *et al.* 2015, BaltCoast meadow bird database unpubl.). For this reason, it is difficult to introduce measures that will benefit Avocets at all breeding sites, but several actions can be taken at a more local scale, directed at potentially important breeding sites that could contribute to a more effective conservation of breeding Avocets.

- *Creation of islets in artificial and natural wetlands near good feeding sites for Avocets in order to increase the availability of suitable safe nesting habitat.* We infer from the availability of good feeding areas, but the more restricted distribution of colonies, that Avocets continue to be limited by suitable nesting sites. In order to provide new breeding sites that are safe from regular visits by specialized predators, an array of potential breeding islets/islands with low levels of disturbance can be provided.
- *Continuous vegetation management on islets and other predator restricted breeding sites.* Because Avocets

abandon otherwise favourable breeding sites if the sites become overgrown with high vegetation, continuous vegetation management on such sites may be an important part of Avocet conservation. This may be by grazing when this is possible to arrange, but often annual or biennial mowing of the vegetation during winter is the only practicable way to keep the vegetation sufficiently low to be attractive to the species. Such vegetation removal also gives Avocets a competitive advantage over more aggressive gull species, which would otherwise take over such breeding habitats.

- *Management to create easy access to food rich mudflats.* Breeding Avocets are dependent on both the presence of a favourable nest site with limited access for ground predators and food rich mudflats or shorelines in the neighbourhood, where chicks can find sufficient food after hatching. Safeguarding of unrestricted passage from nest sites to chick feeding areas may demand vegetation management. Passage through dense vegetation on the way may cause extensive chick mortality due to starvation or predation (Bie & Zijlstra 1979).
- *Regulation of the provision of falcon nest boxes.* Provision of nest boxes for predators known to be particularly susceptible to specialize on hunting of breeding adults or chicks of Avocets should not take place around sites designated as priority breeding sites for Avocet (together with sites for similarly vulnerable meadow birds like Black-tailed Godwit, Baltic Dunlin and Ruff). Peregrine Falcons (hunting adults, juveniles and large chicks) and Kestrels (hunting chicks) are the most important aerial predators for Avocets (and other vulnerable meadow birds), and in wide open landscapes both species are dependent on manmade constructions in order to be able to breed there. The exact hunting distances of breeding Peregrine Falcons and Kestrels are not yet well studied, but there is one case where a colour ringed Northern Lapwing *Vanellus vanellus* chick was found in a Peregrine Falcon nest box 15-20 km from the birth site of the chick (Olsson *et al.* 2013). In an Avocet conservation context, Peregrine Falcons are by far the most important of the two predator species, because they hunt adults, the loss of which is much more 'costly' in terms of population development than of young. This conservation conflict was analysed by an expert group in BirdLife Denmark (DOF) and resulted in an unanimous recommendation that nest boxes for Peregrine Falcons should not be placed too close (<15 km) to important breeding sites for Avocets, Dunlins, Ruffs and Black-tailed Godwits (Thomsen *et al.* 2012). In order to improve breeding conditions for Avocet (and Baltic Dunlin) on designated breeding sites, we recommend that Kestrel nest boxes should be avoided within 5 km from such sites.
- *Restrictions on public access to uninhabited islets with avocet breeding potential.* Where uninhabited islands and islets are found in the neighbourhood of good Avocet chick feeding sites, public access should be restricted in the breeding season (15 April – 25 July). Limiting such disturbance could be effective in allowing Avocets to increase their productivity and to possibly expanding their breeding distribution.
- *Avocet conservation demands knowledge of both present and historical breeding sites.* Results from the five nationwide surveys during 1970-2009 showed no consistency in the geographical distribution and location of big colonies (>100 pairs). This implies that sympathetic conservation management has to be targeted at a range of potentially good breeding sites as well as sites which have been good breeding sites in the past. Focussing on a few presently good sites may not necessarily be the optimal investment to safeguard the best conservation status for Avocets in the years to come.
- *Improvement of breeding conditions by increasing the water level*. In polder areas and other grasslands subject to hydrological management, increases in the water level can be highly effective in creating suitable complexes of nesting islets with limited accessibility for mammalian predators. At the same time, temporarily flooded grassland supports fewer rodents (Kempf 2005), which makes an area less attractive for mammalian predators, reducing the risk of nest predation by 'accidental bycatch'.

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Resumé

Beskyttelse af Klyden i Danmark – yngleforhold og forslag til beskyttelsestiltag

De seneste to landsdækkende opgørelser over antal ynglende Klyder er fra 2009 og 2014. De viste, at antallet af ynglepar i Danmark var gået tilbage med 28 % fra 1990 til 2009 og med yderligere 32 % fra 2009 til 2014 (Fig. 1; Bregnballe *et al.* 2015). Danmark er det eneste land i Nordeuropa, hvor antallet er gået

markant tilbage fra 1990 til 2009; i enkelte lande er yngleantallet gået en smule tilbage, men de fleste steder har ynglebestanden været stabil eller i fremgang i den samme periode (Hötker & Dodman 2009, Koffijberg *et al.* 2009). De seneste 10 år er antallet i det hollandske Vadehav dog også gået markant tilbage (Koffijberg *et al.* 2015). I et internationalt perspektiv udgør Danmark et vigtigt yngleområde for Klyde, idet 14 % af den europæiske biogeografiske bestand og 2 % af verdensbestanden blev registreret ynglende i Danmark sidst en sådan opgørelse blev lavet (Delany & Scott 2006, Thorup 2006).

Der er ingen større undersøgelser i Danmark af Klydernes yngleforhold. I denne artikel fremlægger vi noget af den information, vi trods alt har om, hvordan lokale og eksterne faktorer tilsyneladende kan påvirke artens yngleforekomst. Beskrivelsen baseres primært på data indsamlet på et mindre antal lokaliteter, der i kortere eller længere tid har været vigtige ynglelokaliteter for Klyder. Vi inddrager bl.a. et materiale fra reservatet Tipperne, som er det eneste mere detaljerede for ynglende Klyder i Danmark.

Data herfra tyder på, at Klydernes ynglesucces i ét år har stor indflydelse på bestandsudviklingen to år efter, hvor ungerne når en alder, hvor de er klar til at yngle første gang. Denne effekt sås dog kun de år, hvor der var mange ynglepar i området (Fig. 2).

I Vadehavet er der gennem årene blevet skabt mange nye yngleøer for kolonifuglene i forbindelse med forskellige kystsikringsprojekter. Ofte tager et større antal ynglende Klyder sådanne øer i besiddelse umiddelbart efter konstruktionen, men det er karakteristisk, at disse ynglesteder bliver forladt igen efter nogle år (Fig. 3). Hyppigt er der ikke nogen græsning eller anden vegetationspleje, så de kunstige øer efter nogle år bliver så tilgroede, at de ikke længere er attraktive for Klyde. Fuglekolonier tiltrækker ofte også specialiserede prædatorer efter nogle år, og tilstedeværelse af en effektiv prædator kan ligeledes betyde, at en ynglelokalitet opgives, i hvert fald for en periode. At Klyderne ret hurtigt reagerer og forsvinder ved tilstedeværelsen af en effektiv prædator illustreres ved udviklingen på øen Fuglepold på Tipperne (Fig. 4). I nogle år efter at en forbindelsesdæmning til fastlandet blev fjernet i 1980, var der stort set ingen prædation på vadefuglerederne, og der ynglede et stort antal Klyder. I anden halvdel af 1990erne steg prædationstrykket markant, og Klyderne opgav at yngle i løbet af nogle få år (Fig. 4).

Der har været seks landsdækkende tællinger af Klyder mellem 1970 og 2014, og disse har afsløret, at arten er afhængig af et stort antal lokaliteter med favorable ynglebetingelser. De vigtigste lokaliteter skifter mellem årene. Fx fandtes der mere end 100 ynglepar på 18 forskellige lokaliteter på de fem tællinger inden for årene 1970-2009, men ingen af disse 18 lokaliteter havde over 100 par ved alle tællingerne (Tab. 1).

Klyder kan ligesom andre kolonifugle på strandene være fanget i et dilemma mellem en større risiko for prædation på den ene side og en større risiko for oversvømmelse af rederne på den anden: Jo længere væk fra 'fastlandet' (eller hovedøen såsom Fanø eller Rømø) Klyderne etablerer sig, jo mindre er risikoen for besøg af rovpattedyr som ræv, men de ydre strande og sandøer ligger lavere, og dermed øges risikoen for oversvømmelse. Data fra sandene syd for Fanø synes at underbygge dette: Gennem de senere år har færre og færre Klyder ynglet på Keldsand-Trinden, der ligger i kort afstand fra Sydfanø med mange ræve, mens flere Klyder yngler på Peter Meyers Sand, der ligger meget længere væk fra ræve, men samtidigt ligger lavere og med større risiko for oversvømmelse (Fig. 5).

Ikke kun pattedyrprædatorer har betydning for, hvor Klyder kan etablere kolonier. På Tipperne er det set, hvordan en Vandrefalks intensive jagt på Klyder i nogle få timer kan opløse en koloni fuldstændigt. Udsætning af fugle og opsætning af redekasser på habitater, der ikke tidligere har været mulige yngleområder for Vandrefalke i Danmark og vore nabolande har betydet, at der har været langt flere Vandrefalke i Klydernes yngletid, end det har været tilfældet i hvert fald i 300-500 år. Det gælder også i områder som Tipperne – beliggende langt fra det nærmeste ynglested for Vandrefalke – hvor der de seneste 15-20 år er langt flere observationer af Vandrefalke i Klydernes yngletid, end der fx var i 1930erne og 1940erne (Fig. 6), som vurderes at være den periode siden 1700-tallet, hvor Danmark havde den største naturligt ynglende vandrefalkebestand (Løppenthin 1967, Andreasen 2008).

Meget tyder på, at den generelle afvanding af kystnære enge, der har haft store negative konsekvenser for engfugle som Stor Kobbersneppe og Brushane, også har påvirket antallet af ynglende Klyder negativt. Således er de største antal ynglende Klyder på Bygholmengen og i Mandøs Koge fundet i år med særlig høj vandstand (fx Kjeldsen 2008). Et så højt vandniveau som muligt på enge skaber gode fødeforhold og begrænser også prædationsniveauet fra rovpattedyr.

Tilbagegangen i Danmark kan også skyldes det faktum, at især Vestkysten ligger på artens nordvestlige udbredelsesgrænse. Denne grænse kunne godt være bestemt af, at vind og kulde forhindrer succesfuld ynglen længere mod vest og nord, og måske også i det vestlige Jylland i år med mange lavtrykspassager i ungetiden. Herudover er der generelt blevet flere ræve i Danmark de seneste årtier, i hvert fald i Sønderjylland, men det er der også i Tyskland og Holland, hvor der ikke er set tilsvarende tilbagegange i antallet af Klyder.

Vi finder det relevant at udvikle en strategi for opsætning af redekasser for fremmede prædatorer i nærheden af vigtige klydelokaliteter. Vi vurderer, at en sådan opsætning af redekasser ikke bør finde sted indenfor 15 km's afstand (for Vandrefalk). DOF har addresseret denne problematik og har udgivet et oplæg til foreslåede områder, hvor redekasser ikke bør opsættes (Thomsen *et al.* 2012). Der er også blevet flere Tårnfalke i Danmark de seneste 20-30 år bl. a. på grund af opsætning af redekasser; også i nærheden af ynglesteder for Klyder. Tårnfalk er en art, der i udlandet er set specialisere sig i fangst af Klydeunger.

Nogle af de nævnte negative faktorer kan modvirkes med målrettet forvaltning. Da Klydens ynglestrategi involverer muligheden for at flytte og vælge nye ynglesteder med mindre prædationsrisiko, er det vigtigt at sikre et netværk af favorable ynglesteder såsom øer nær vadeflader, hvor vegetationen holdes nede ved græsning eller slåning, og forstyrrelse fra mennesker begrænses i yngletiden, dvs. fra 15. april til 25. juli. Også mellem de gode redesteder og fødesøgningsområderne bør der sikres let passage for ungerne ved forvaltning af vegetationen.

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