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Low productivity of Curlews *Numenius arquata* on farmland in southern Finland: Causes and consequences

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We monitored population changes and breeding success of Curlews *Numenius arquata* in a 18 km^2 arable farmland area in southwestern Finland over a four-year period (1995–1998). During this time, the breeding population decreased from 30 to 23 pairs (23% decline). The majority of breeding failures took place during the incubation (57/84, 68%), and further losses occurred during chick rearing period as a result of which only 20% (17/84) of verified breeding attempts produced fledglings. There were 17 pairs (more than half of the breeding population) that failed in their breeding attempts every year. The overall reproductive success was 0.32 fledglings/pair, which was calculated to be too low to maintain a stable population. Nest predation (81%) and nest losses due to agricultural practices (16%) were the most important reasons for failed breeding attempts. We suggest that continual breeding failures (especially due to nest predation) may be the most important reason for the observed decline of Curlew populations in southern Finland.

1. Introduction

Populations of many farmland bird species have declined throughout Europe during the recent decades (Pain & Dixon 1997). Well-known examples of decreasing populations include Grey Partridge *Perdix perdix*, Lapwing *Vanellus vanellus*, Barn Owl *Tyto alba*, and Corncrake *Crex crex* (Baines 1990, de Bruijn 1994, Potts & Aebischer 1995, Green 1996). Intensive agricultural practices, e.g. mechanization, chemical pest control, subsurface drainage, and cultivation or loss of natural habitats (e.g. meadows) are likely to be important reasons for the observed population declines (Berg & Pärt 1994, Pain & Dixon 1997, Potter 1997). In addition, nest predation appears to be more common in intensively managed areas e.g. due to the lack of diverse vegetation which provide shelter for nests (Baines 1989, 1990, Berg & Pärt 1994).

Curlew *Numenius arquata* populations have declined in most of Europe (Berg 1994, Grant 1997, Bednorz & Grant 1997), although in parts of central Europe Curlew has increased in numbers (Slotta-Bachmayr 1992). Nest losses, especially due to agricultural practices, are often considered to be the most important reason for decreasing numbers (Berg 1992, 1994). Until recently, hunting during migration and witering has been intensive (*see* Saurola 1982, Meltofte 1986, Berg & Sjöberg 1990), and although hunting has ceased in most European countries, it still continues e.g. in France. There is increasing evidence that nest predation may also be a contributory factor in explaining population decline, e.g. in the UK (Grant 1997, M. Grant unpubl.).

The estimated size of the Finnish Curlew population varies from 55 000 pairs (Väisänen et al. 1998) to 70 000–90 000 pairs (Ylimaunu et al. 1987, Bednorz & Grant 1997), which represents 40–60% of the European breeding total (Bednorz & Grant 1997). Thus, the Finnish Curlew population is of international importance. In this paper, we examine population changes and breeding success of Curlews during a four-year period (1995–1998) on farmland in southwestern Finland. We investigate reasons for failed breeding attempts, and in case of nest predation, identify the most important predators. We also discuss whether the productivity of Curlews is sufficient to maintain a stable population.

2. Material and methods

Research was undertaken in an arable farmland site in Vammala region (61° 22′N, 22° 50′E) during a four-year period (1995–1998). The study area (18 km^2) consisted of five small agricultural areas (each less than 5 km^2) separated by forests, farms and small villages. Agricultural land-use was dominated by spring cereals (70%), the rest of the area being hay and fallow fields. The mean breeding density of Curlews was 1.6 pairs/km^2.

Curlews arrived from mid to late April, and egg-laying started during the first week of May. Nest searching was initiated after clutch completion. We marked most of the nests (80%) with sticks 1.0–1.5 m high to prevent them from being destroyed by spring farming practices. There was no indication that marking of nests increased predation risk (Valkama et al. 1999, *see* also Galbraith 1987).

During the first three weeks of incubation nests were checked every two to three days from a distance of 50–100 m with binoculars to minimise disturbance. Adults (or at least one of them) were caught at the nest during the last week of incubation and colour-ringed.

Due to dense and tall vegetation we were unable to count the exact number of chicks that survived to fledging in all territories (number of chicks was not counted in 10/17 broods). In those cases, pairs were classified as having chicks or not; parents with chicks were visible and started their alarming behaviour immediately when the brood was approached (*see* Cramp & Simmons 1983).

To assess productivity of Curlews, we collected data on brood size close to fledging (chick age 25–30 days), including 10 broods from the surrounding but agriculturally similar areas (up to 50 km from Vammala). The estimate of the reproductive success for the study area was obtained by multiplying the mean brood size by number of successful pairs in the study area and then dividing this by the total number of pairs. Due to small yearly sample sizes, data across the entire four-year period were combined.

2.1. Egg experiment

During 1995–1997 we were only able to identify the nest predator (either avian or mammalian) for 12/38 cases in which the majority were depredated by mammals (10/12; identified by tracks and egg remains as either fox *Vulpes vulpes* or raccoon dog *Nyctereutes procyonoides*; Valkama et al. 1999). To identify nest predators in more detail, we conducted an experiment in 1998 in which one Curlew egg was replaced with a wax-filled Curlew egg in 15 nests (the experiment was carried out with a permission of Pirkanmaa Regional Environment Centre; *see* also Grant 1997). The wax egg was tied to a peg (using a thick fisherman's line embedded in the wax) which was buried at a depth of 25–30 cm in the ground under the nest. We visited each nest once when replacing the egg. After that, we checked the nests from a distance, and when the bird was not seen incubating we approached the nest. Following predation of the nest, the tooth/beak marks on the wax egg allowed identification of the predator (either avian or mammalian, *see* Grant 1997). We also recorded whether there were any shell remains at all in or close to a predated nest (e.g. small fragments of shell and yolk remains; Grant 1997).

We also conducted an artificial nest experiment in the same study area during the incubation period of Curlews. This was carried out to examine whether predators of the same type (avian or mammalian) depredate both Curlew nests and artificial nests. There is some evidence that real and artificial nests are preyed upon by different predators (Valkama et al. 1999), which indicates that reliability of artificial nest experiments in agricultural landscape may be limited (see also Willebrand & Marcström 1988). We placed fifty artificial nests containing two brown hen eggs (the other egg was wax-filled and anchored to the ground in the same way as wax egg in Curlew nests) randomly in different habitats (tillage, hay, stubble and fallow) in relation to their proportion in Curlew nest habitats. Nests were visited after 2, 5, 9 and 18 days, and predators were identified (see above).

3. Results

3.1. Population changes

In the beginning of the study (1995), 30 Curlew pairs were recorded in the area, but only four years later seven of these pairs had disappeared from the study area (23% reduction from the start of the study; two unpaired males excluded, see Table 1). We did not observe any new established territories in the course of the study, and there was no indication that any of the colour-ringed birds on focal territories was replaced by new individuals.

3.2. Breeding success

During the study, we were able to verify 84 breeding attempts (nest or brood found; eight replacement clutches included). Out of these, 57 attempts (68%) failed during incubation, mainly due to nest predation (46/57; 81%, Table 1). Other nest losses during incubation were due to nest desertion (two, 3%) or spring farming practices (nine cases, 16%). Further losses occurred during the chick rearing period, as a result of which only 17/84 (20%) of the verified breeding attempts produced at least one fledgling (Table 1). However, this is likely to be an overestimate since we were unable to find all nests in the study area due to high rate of nest predation and intensive spring farming practices. Therefore, we also estimated fledging success per pair (thus assuming that each pair on their territory laid eggs). According to this, only 17/105 (16%) of these pairs succeeded in raising at least one fledgling. Moreover, 17 pairs (57% of all pairs) consistently failed to produce any offspring during the four-year study.

We detected 17 Curlew broods with mean ($\pm$ *S.E.*) brood size of 2.00 ± 0.19 in the study area and in its vicinity (study area: 2.14 ± 0.26, n = 7; surrounding area: 1.90 ± 0.28, n = 10; Mann-Whitney U-test, U = 29, n.s.). Assuming that each successful breeding attempt produced 2.0 chicks gives an overall reproductive success of 0.32 fledglings per pair.

3.3. Egg experiments

In 1998, a total of 17 Curlew nests were found, out of which 10 were depredated, two were destroyed during spring farming activities and only five survived until hatching. Ten (of 15) wax egg treated nests were depredated, two were destroyed during spring farming practices and three survived

Table 1. Numbers of Curlew pairs, verified breeding attempts, failed breeding attempts, and depredated nests in Vammala 1995–1998. Daily failure rates of nests are also shown (calculated after Mayfield 1961, 1975; number of nests is given in parentheses). Verified breeding attempts refer to cases where either a nest or a brood was detected, while the number of depredated nests and daily failure rate were calculated for detected clutches only.

	Pairs	Verified breeding attempts	Failed breeding attempts	Depredated nests	Daily failure rate $\pm$ *S.E.*
1995	30	24	18	11	0.0700 $\pm$ 0.0180 (22)
1996	28	20	14	8	0.0389 $\pm$ 0.0121 (17)
1997	24*	21	18	17	0.0804 $\pm$ 0.0182 (21)
1998	23*	19	17	10	0.0494 $\pm$ 0.0138 (17)
Total		84	67	46	0.0584 $\pm$ 0.0077 (77)

* two unpaired males excluded

until hatching. We were unable to precisely identify the nest predators because all eggs were either eaten at the nest or removed (peg into ground was always absent). However, wax eggs were so hard and firmly anchored to the ground that avian predators were not likely to be able to break them or carry them away.

All artificial nests (n = 50) were depredated by birds (as indicated by beak marks in wax-filled hen eggs) within two days, but none of the wax eggs were broken or removed as observed for Curlew nests. This finding further suggests that wax-treated Curlew eggs were not depredated by birds.

4. Discussion

During the four-year study, the Curlew population decreased from 30 to 23 pairs (23% decline), but any new established territories were not observed. Instead, new 'free areas' were rapidly incorporated into previously existing territories. Territory disappearances may be due to mortality during migration or in wintering areas (*see* e.g. Meltofte 1986), but continual nest losses in the breeding area may also be a reason for moving elsewhere (*see* Wilcove 1985, Berg 1994). In this study, each territory disappearance was preceded by at least one unsuccessful breeding attempt on that territory.

We found that 17 pairs (more than 50% of the breeding population) failed in their breeding attempts every spring during the four-year study either as a result of nest predation or spring farming practices. The ultimate reason for repeated failures of certain pairs is unknown, but there did not seem to be any association between nest-site characteristics (e.g. nest habitat or distance from the nest to the nearest forest edge) and nest predation rate (Valkama et al. 1999). Instead, there may have been some differences between "successful" and "unsuccessful" pairs in their nest defence behaviour or, alternatively, territories of unsuccessful pairs were for an unknown reason more susceptible to predator activities. There was, however, no evidence that unsuccessful pairs were either younger or more inexperienced than successful pairs.

The egg experiment confirmed that virtually all predators of Curlew nests were mammals (red fox, raccoon dog or badger *Meles meles*), but we were unable to distinguish between the species. Densities of both foxes and raccoon dogs are high in southern Finland (Lindén et al. 1997) and foxes, in particular, were frequently observed in the study area. The relative density of these mammalian predators is clearly lower in south Ostrobothnia (appr. 200 km north from Vammala; Kurki et al. 1997, Lindén et al. 1997) where also reproductive success of Curlews is much higher (Currie & Valkama 1998, Valkama et al. 1999). Contrary to Curlew nests, artificial nests were most likely preyed upon by birds. Therefore, it appears that artificial nest experiments may not give a realistic picture of nest predation patterns on farmland.

Nest predation was an important reason for breeding failure (Table 1; also Valkama et al. 1999) although, by marking most nests, we may have artificially reduced the effect of spring farming activities on nest losses. Spring farming practices mainly affect nests on tillage, which covers ca. 70% of agricultural land in the study area. However, tillage is not preferred by breeding Curlews as in this study only 36% of nests were on that habitat (*see* also Valkama et al. 1998). Thus, nest destruction due to farming practices is likely to affect approx. 35–40% of all Curlew nests, i.e. the effects of farming on reproductive success may be more negative than suggested by this study.

Replacement clutches were uncommon in this study, as only 11% (9/84) of breeding attempts were re-lays (in Sweden the proportion of re-lays has been higher, approx. 43%; Berg 1992). Failed breeding attempts led to replacement clutches only when failure had occurred during egg-laying or early incubation (Cramp & Simmons 1983, pers. obs.). Furthermore, replacement clutches appeared to be less productive than first clutches (11% vs. 21% produced fledglings, respectively), which stresses the importance of first broods for reproductive success.

In our study area the mean annual mortality of adult Curlews was 15.6% during 1995–1996 (both sexes combined; J. Valkama unpubl.), which is similar to that observed in Sweden (17.9%, Berg 1994). Thus, each adult should be replaced with 0.156 first breeders every year to maintain the population. Providing that (1) Curlews start to breed at the age of two years, (2) the survival of young Curlews from fledging to one year is 47% (Bainbridge & Minton 1978) and (3) survival during the second year is similar to that of adults, we obtained a productivity value of 0.063 first breeders per adult per year (0.5 * 0.32 * 0.47 * 0.84 = 0.063) which is clearly less than the required 0.156. The required number would be achieved when the reproductive success is at least 0.79 fledglings per breeding pair.

According to Finnish bird censuses (e.g. von Haartman 1975, Yrjölä et al. 1986, Väisänen et al. 1998) and an inquiry targeted to local birdwatchers (Hildén & Koskimies 1984), Curlew populations have declined all over the southern Finland during the last few decades. On the other hand, populations have been stable in Ostrobothnia over the last 15–30 years (Kauhava 63°N 23°E from 1983 to 1998:Ylimaunu et al. 1987, O. Hemminki pers. comm.; Liminka 65°N 25°E from 1957 to 1984: Ylimaunu & Siira 1985; and Tornio 66°N 25°E from 1982 to 1998: Ylimaunu et al. 1987, O. Ylimaunu pers. comm., H. Sankila pers. comm.). There are possibly two main explanations for the opposite population trends between southern and more northern Finland: First, both relative density of mammalian predators (especially red fox and raccoon dog) and intensity of nest predation have been consistently higher in southern Finland, which has markedly reduced the reproductive success of Curlews. Second, the agricultural landscape is more diverse in Ostrobothnia than in southern Finland, since there are more open ditches and also the proportion of grassland is higher (up to 70%, pers. obs.). The higher proportion of grassland in Ostrobothnia may indicate that Curlews in that area suffer less from spring farming practices than their conspecifics in southern Finland. Putting these together, it may be that poor productivity over a long period of time is the most important reason for the observed decline of Curlew populations in southern Finland.

We suggest that more research should be undertaken to investigate the overall importance of nest predation in agroecosystems, since it is likely to affect reproductive success of most farmland bird species and their population trends. Direct effects of agricultural practices on reproductive success have already been identified (e.g. Shrubb 1990, Berg *et al.* 1992), but indirect effects — such as disturbance — have received less attention. For example, during cultivation practices birds are frequently forced to leave from and return to their nest thereby revealing it to predators (*see* also Hegyi & Sasvári 1998).

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Selostus: **Miksi isokuovi on taantunut Etelä-Suomessa?**

Tutkimme isokuovin pesimistulosta ja populaatiokoon vaihtelua Vammalan seudulla Lounais-Suomessa v. 1995–1998. Tutkimusjakson aikana pesivien parien määrä väheni 30:sta 23:een. Kaikista pesintäyrityksistä tuhoutui vuosittain 70–90%, suurin osa jo haudonnan aikana (68%). Suurten pesä- ja poikastappioiden seurauksena vain 20% kaikista pesintäyrityksistä tuotti vähintään yhden lentopoikasen. Tutkimusalueella oli 17 sellaista kuoviparia, jotka epäonnistuivat pesinnässään joka vuosi. Pesäpredaation (81%) ja maataloustöiden (16%) aiheuttamat pesätappiot olivat tärkeimmät syyt pesintöjen epäonnistumiseen. Epäonnistuneiden pesintäyritysten vuoksi kuovien poikastuotto oli vain 0.32 lentopoikasta/pari, mikä on alle puolet populaation ylläpitoon vaadittavasta poikastuotosta (0.79). Isokuovin taantuminen Etelä-Suomessa johtunee suureksi osaksi vuosittain toistuvista pesimätappioista, joiden tärkein yksittäinen syy tämän tutkimuksen mukaan on munapesiin kohdistuva predaatio. Predaatio saattaa ainakin osittain selittää muidenkin pelloilla pesivien lintulajien taantumista.

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