Evidence for the causes of the decline in Northern Wheatear *Oenanthe oenanthe* in NW Europe

Simon Wotton, Conservation Scientist, RSPB Conservation Science.

The northern wheatear is widely distributed throughout Western Europe, in a range of open-ground habitats, although generally avoiding heavily cultivated areas Hagemiejer & Blair 1997). It is an insectivorous, ground-foraging species mainly found in habitats consisting of bare ground or short field layers (Cramp 1988). It is thought to be declining across much of its range, and between 1980 and 2008 there has been a 54% decline in Europe (Klvaňová et al. 2010). In the UK, declines have been attributed to losses of suitable grasslands, such as the conversion of grazing land to cultivation, and, possibly due to declines in rabbit abundance (Baillie *et al*. 2010). In the Netherlands, the species has declined been lost from a number of areas since the 1970s, particularly on the heathlands in the south of the country (SOVON). The decline on the coastal dune systems appeared to start in the late 1980s (Verstrael & Van Dijk 1997).

Terrestrial eutrophication has resulted in an encroachment of nitrophilic grasses and shrubs in the Dutch coastal dunes and heathlands, with taller and denser vegetation cover replacing the original mix of low vegetation and bare ground (Kooijmann *et al*. 1998; Roelofs *et al*. 1996). Loss of natural ecosystem dynamics and decrease of rabbit populations have also contributed to these vegetation changes (Verstrael & Van Dijk 1997). Grass encroachment on heathland habitats may have led to a decrease in arthropod abundance and thus in food availability for insectivorous heathland species (Van Turnhout 2005).

In Sweden, it is suggested that the strong decline of northern wheatears is linked to the loss of high quality breeding habitat, such as grazed semi-natural grasslands (Arlt *et al*. 2008). Based on extensive long-term data on reproduction and survival, habitats characterised by tall field layers (spring- and autumn-sown crop fields, ungrazed grasslands) displayed negative stochastic population growth rates, that were markedly lower than growth rates of habitats characterised by permanently short field layers (pastures grazed by cattle or horses, and farmyards). Although habitats differed with respect to reproductive performance, differences in habitat-specific population growth were largely due to differences in adult and first-year survival rates (Artl *et al*. 2008). The results from this study also indicate that grazed grasslands and farmyards may act as source habitats, whereas crop fields and ungrazed grasslands with tall field layers may act as sink habitats.

During the same period of the decline in the northern wheatear, the area of semi-natural dry pastures (i.e. pastures with stones, boulders and bare rock, unsuitable for ploughing or mowing and with a continuous grazing regime for centuries and therefore permanently short field layers) has decreased by about 30% (Arlt *et al*. 2008). Most of the

grazed pastures (i.e. the potential source habitat) were of this semi-natural type with abundant nesting sites for wheatears. Furthermore, the number of farms, and farmyards, has decreased due to either amalgamation into larger units in intensively farmed regions, or extensification and abandonment of small-scale farming in forest-dominated regions. Such forest-dominated landscapes with small-scale farming had previously dense populations of wheatears.

Another study of wheatears in Sweden, by Low et al. (2010), showed that females had lower annual survival than males (0.42 ± 0.02 vs. 0.50 ± 0.02), with the difference largely resulting from low female survival in tall habitats because of higher nest-predation risk and the large proportion of adult females being killed on the nest (>20%) during nest predation events. Among successful breeders, both sexes displayed similar survival rates, but survival was lower for breeders in tall as compared to short habitats (0.43 ± 0.03 vs. 0.51 ± 0.02). Experimental manipulation of ground vegetation height, controlling for individual and territory quality, suggested the cost of rearing young to be higher in tall habitats (survival of successful breeders in TALL vs. SHORT; 0.43 ± 0.11 vs. 0.57 ± 0.05). Detailed observations of food provisioning behaviour during chick rearing revealed a habitat-related difference in parental workload corresponding to the observed habitat differences in adult survival for successful breeders. Adults breeding in tall habitats were forced to forage further from the nest relative to short-habitat breeders (mean ± SE; 69m ± 10 vs. 21m ± 2), which increased the estimated daily workload for adults in TALL vs. SHORT habitats by c. 20%.

Tye (1992) studied wheatears in Breckland, England, and found that prey densities during the breeding period (egg-laying to chick independence) were strongly correlated with prey densities at the same sites during the period of arrival and territory establishment. Prey densities were also related to vegetation structure, averaging highest on short turf. Male arrival date and territory size were not significantly related to prey density but were strongly related to vegetation structure, implying that birds used vegetation as an indirect clue to prey availability.

Northern wheatears winter in the Sahel region of West Africa. From modeling population changes of 170 breeding species in the Netherlands, between 1995 and 2005, Turnhout *et al*. (2010) found that species that winter in the Guinean zone tended to decrease, whereas birds that winter in the Sahel zone or other parts did not decline on average. However, there is some evidence that excessive woodland clearance may be having an adverse effect on northern wheatear densities in the Sahel (Wilson & Cresswell 2010).

As with whinchats, northern wheatears breed across a range of habitats, lowland and upland grasslands, heathland and moorland fringe that are very likely to be those with low insecticide burdens.

In summary, declines in wheatear populations can be directly linked to the loss of short vegetation and bare ground in semi-natural and low-intensity habitats, such as through agricultural intensification and eutrophication.

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