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Effects of traditional clam harvesting on the foraging ecology of migrating curlews (*Numenius arquata*)

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Abstract

One of the main conservation priorities in many geographical regions for intertidal estuaries is to protect and maintain internationally important numbers of migratory shorebirds (Charadrii). Traditional harvesting practices at low tide cause alterations to the surface of the intertidal habitat by trampling and digging the substrate to obtain benthic resources, which may have negative effects on shorebirds. Here, we conducted a BACI (Before–After Control-Impact) experiment to monitor changes in foraging ecology of Eurasian curlews *Numenius arquata*, before and after an experimental disturbance of the intertidal mud in a key stopover area for migratory shorebirds. Mean density of curlews, foraging activity, feeding rate, percentage of crabs in the diet, size of crabs, and foraging speed differed neither between treatment and control plots, nor between before and after mud disturbance. The feeding technique was similar between treatment and control plots, but differed significantly between periods. These findings suggest that mud disturbance by harvesters working by hand did not affect curlew fitness by altering the energy deposition necessary for long-distance migration. Although conclusions must be extrapolated with caution to other sites and/or species, the Santoña Marshes Natural Park may provide a potentially good example of compatibility between shorebird conservation and traditional low tide harvesting practices.

Keywords: BACI; Disturbance; Foraging; Mud-digging; Shellfishing; Shorebirds

1. Introduction

Many long-distance migratory shorebird (Charadrii) populations are declining worldwide (International Wader Study Group, 2003; Stroud et al., 2004; Bart et al., 2007). Most of these populations rely on a few estuarine intertidal areas for food during their annual migrations (Pennycuick and Battley, 2003; Battley et al., 2005; Gill et al., 2005; Piersma et al., 2005), so one of the main conservation priorities in north-western Europe and other geographical regions for intertidal estuaries is to protect and maintain internationally important numbers of migratory shorebirds (Hickey et al., 2003; Durell et al., 2006).

Harvesters (mainly shellfishers and worm-diggers) working by hand at low tide in the intertidal areas may have negative effects on migratory shorebirds feeding in these areas (Davidson and Rothwell, 1993; Shepherd and Boates, 1999; Goss-Custard et al., 2000; Navedo and Masero, 2007). In addition to effects on shorebird distribution or bird density in the intertidal areas, traditional harvesting practices cause alterations to the surface of the intertidal habitat by trampling and digging the substrate to obtain benthic resources (Olive, 1993; Ambrose et al., 1998; Shepherd and Boates, 1999; Navedo and Romero, 2003; Cunha et al., 2005; Masero et al., 2005; Skilleter et al., 2006). These alterations may have negative effects on shorebirds due to the potential loss of benthic prey removed by harvesters, as well as benthic prey that were covered by sediment and would remain unavailable to foraging birds (Skilleter et al., 2006). Additionally, substrate turn-over can lead to changes in habitat microstructure and a resulting reduction in shorebirds' feeding efficiency in dug areas that may last for several days, since these changes make these birds less likely to find the prey (Shepherd and Boates, 1999; Masero et al., 2005). Mud-digging by traditional harvesters, therefore, may reduce the density (Shepherd and Boates, 1999; Skilleter et al., 2006), detectability (Shepherd and Boates, 1999), and/or availability of prey for shorebirds (Masero et al., 2005). As the food supply must be available during a fairly narrow time window in order to satisfy

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the high energy demands for time-stressed migrating shorebirds (Skagen and Knopf, 1993), all these effects on the harvestable (available and profitable) food supply for shorebirds may be especially severe in areas with high densities of both harvesters and shorebirds during migratory periods (Shepherd and Boates, 1999). Nevertheless, the effects of mud-digging by traditional harvesters on shorebird's feeding ecology are still poorly understood due to the lack of available experimental studies.

In the East Atlantic Flyway (EAF), Eurasian curlews (*Numenius arquata*), as well as other *Numenius spp.*, are one of the most sensitive to harvesting disturbance in estuarine areas (Smit and Visser, 1993; De Boer and Longamane, 1996; Blumstein, 2006). The present study was the first experimental determination of whether mud disturbance by traditional shellfishers working by hand at low tide had negative effects on Eurasian curlew foraging ecology. We conducted a BACI (Before–After Control-Impact) experiment to monitor changes in all these variables before and after an experimental disturbance of the intertidal mud in a key stopover area for migratory shorebirds using the EAF.

2. Methods

2.1. Study area

Santoña Marshes Natural Park (43°30′N 3°30′W; Fig. 1) is an estuarine area located in the eastern part of the Cantabrian region (N Spain), with semidiurnal tides exposing the intertidal zone for 5.5–6.5 h. During the non-breeding season, large numbers of curlews (mean counts from July to September

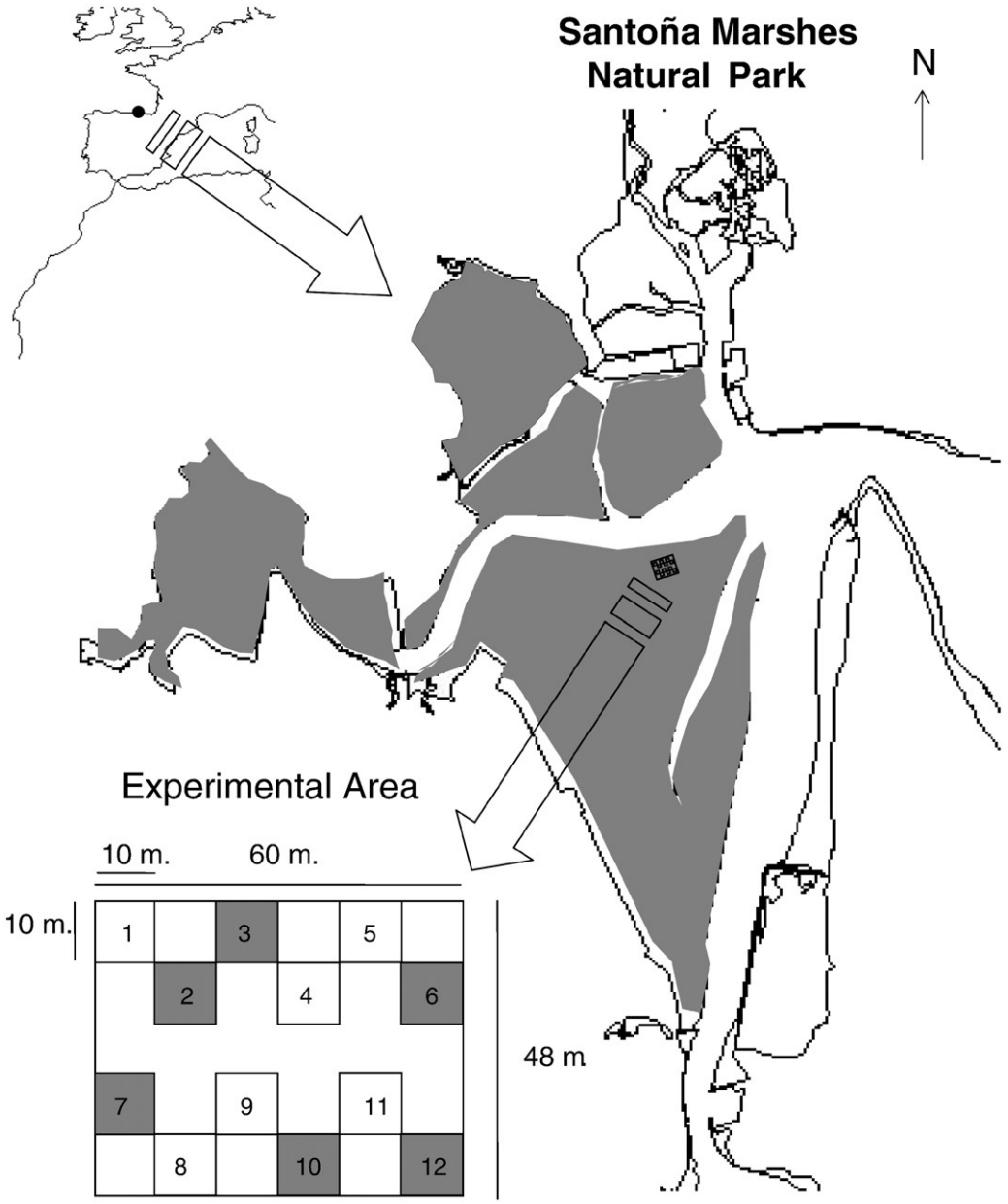

Fig. 1. Location of the Santoña Marshes Natural Park and design of experimental area (see text for more details).