

Effects of seawater flooding on Orthoptera and the yellow meadow ant *Lasius flavus* during New Zealand pygmy weed *Crassula helmsii* eradication at Old Hall Marshes, Essex, England

Tim Gardiner^{1*} & Paul Charlton²

¹ Environment Agency, Icen House, Cobham Road, Ipswich, Suffolk IP3 9JD, UK

² Royal Society for the Protection of Birds, The Lodge, Sandy, Bedfordshire SG19 2DL, UK

* Corresponding author e-mail: tim.gardiner@environment-agency.gov.uk

SUMMARY

Coastal grazing marsh was flooded with seawater in a successful attempt to eradicate New Zealand pygmy weed *Crassula helmsii* at Old Hall Marshes in 2006. The abundance of Orthoptera and the presence of yellow meadow ants *Lasius flavus* were broadly similar between the flooded grazing marsh and unflooded ground in 2011 indicating that inundation did not have a deleterious impact on these non-target terrestrial insects. Ant hills in areas of lower ground within the flooded area, which were fully inundated in 2006, had a lower occupancy rate (44%) than those on higher ground (94% occupied), suggesting that unflooded refuges may be important.

INTRODUCTION

A recent paper described the eradication of the invasive plant species, New Zealand pygmy weed *Crassula helmsii*, from coastal grazing marsh at the RSPB's Old Hall Marshes nature reserve in Essex, England (Charlton *et al.* 2010). Flooding of the grazing marsh with seawater effectively eradicated the invasive plant species from the site. However, the impact of the inundation on non-target terrestrial insects such as grasshoppers and bush-crickets (Orthoptera) and yellow meadow ants *Lasius flavus* was not known. Grasshoppers are likely to benefit from the bare earth exposed on ant hills of the yellow meadow ant, because this provides basking and oviposition sites for species such as the meadow grasshopper *Chorthippus parallelus*. Ant hills at Old Hall Marshes are

also important for a range of disturbance-dependent annual plant species such as common whitlow-grass *Erophila verna* and sticky mouse-ear *Cerastium glomeratum* (Tarpey 2003). The estimated number of ant hills on the site is more than 500,000 (Tarpey 2001). This paper describes the impact that the seawater flooding of grazing marsh at Old Hall Marshes had on non-target terrestrial insect species such as grasshoppers, bush-crickets and yellow meadow ants.

ACTION

Description of the field-scale New Zealand pygmy weed eradication programme: Old Hall Marshes nature reserve is situated on

the Blackwater Estuary in Essex, southeast England. An 8 ha area of freshwater grazing marsh (Irongate Field in Charlton *et al.* 2010; Fig. 1) was flooded with seawater from April 2006 to January 2007 in a successful field-scale attempt to eradicate New Zealand pygmy weed (Charlton *et al.* 2010). The grazing marsh in Irongate Field was flooded to a depth of 5 cm above the usual peak winter flood level. The scheme did allow some areas of the grazing marsh in Irongate Field to remain unflooded as they were above the seawater flood level. However, all the ditches and low-ways (i.e. lowest parts of a grazing marsh) were completely covered by the seawater.

Sampling of non-target terrestrial insects:

In summer 2011, we sampled the grasshopper and bush-cricket populations and the occupancy of ant hills by yellow meadow ants in flooded (Irongate Field) and unflooded control areas of grazing marsh directly to the north of Irongate Field. For grasshoppers and bush-crickets, populations were also sampled on a length of sea wall directly to the north of Irongate Field which was completely unaffected by the seawater flooding. These insects may have been the source of recolonising individuals after seawater had been drained. Very few ant hills were present on the sea wall so it was not possible to sample effectively for yellow meadow ants in this habitat.

Grasshopper open quadrat abundance estimates: Open quadrats were used to measure abundance and species richness of grasshoppers and bush-crickets. The technique used for the open quadrat study has been reported in detail previously by Gardiner *et al.* (2002) and Gardiner & Hill (2006). The observer counted grasshoppers and bush-crickets in each 2 × 2 m quadrat. The insects were flushed by brushing the vegetation with a pole (1 m long). Flushing proceeded from one edge of the quadrat to the other, sweeping the vegetation in an arc of 180°. Only grasshoppers within the quadrat at the start of the sweep were recorded, with those leaping in from outside discounted. All quadrats were randomly located. On each survey occasion, 20 quadrats were located and surveyed in grazing marsh previously flooded by seawater, as well as 20 quadrats in adjacent

unflooded grazing marsh (controls), and another 20 quadrats in nearby sea wall grassland (60 quadrats in total for each survey occasion). The sea wall grassland quadrats were surveyed on the landward slope of the flood defence which was south-facing and included in this study as a likely source of recolonising grasshoppers for the flooded grazing marsh. All 60 quadrats were surveyed on two occasions in 2011: 1 July and 2 August.

Ant hill occupancy survey: A survey of ant hill occupancy was undertaken on 2 August 2011. Occupancy of an ant hill was determined if ants could be flushed out of the hill during a 30 second search. A 1 m long pole was inserted into the top of each hill and moved around in a circular motion to disturb the ants within. If ants were flushed from within the hill by the action of the pole and were observed on the surface within the 30 second search period then this was counted as an occupied ant hill. If no ants were seen within 30 seconds then the ant hill was considered to be unoccupied. A total of 40 ant hills were searched using this method in both flooded grazing marsh and unflooded areas (80 hills in total).

CONSEQUENCES

Grasshoppers and bush-crickets: The most abundant species of grasshopper and bush-cricket in all survey areas was the lesser marsh grasshopper *Chorthippus albomarginatus* (Table 1). The overall mean number of grasshoppers and bush-crickets counted per quadrat was slightly higher in unflooded grazing marsh than in adjacent flooded areas. The overall mean numbers of grasshoppers and bush-crickets were much higher in the sea wall grassland quadrats. Four species of grasshopper and bush-cricket were observed in the unflooded grazing marsh which compared favourably with the total of three species in the adjacent ground which was flooded by seawater. Short-winged conehead *Conocephalus dorsalis* was absent from the flooded grazing marsh but present in the unflooded controls (Table 1). Its apparent absence from the grazing marsh flooded with seawater suggests that it may have been adversely affected by the inundation. However,

coneheads (*Conocephalus* spp.) are often under-recorded during quadrat surveying due to their cryptic behaviour (Gardiner & Hill 2006). Therefore, the absence of the short-winged conehead from the flooded grazing marsh may be due to it being overlooked during sampling rather than a genuine scarcity.

Grasshoppers and bush-crickets would probably have benefited from parts of the grazing marsh being higher than the seawater level (e.g. ant hills on higher ground would not have been covered by the water levels). It is possible that breeding and egg-laying could have occurred for grasshoppers such as the lesser marsh grasshopper on these isolated patches of unflooded habitat during inundation in summer 2006. Nymphs and adults on the unflooded higher ground could then have dispersed back onto the rest of the marsh in summer 2007 after it had been drained.

On the lowest areas of the flooded marsh it is likely that egg pods of later hatching species (nymphs emerging in May) such as *C. albomarginatus*, which were deposited at the base of grass stems in late summer 2005, would have been destroyed by the inundation of seawater during April 2006 due to waterlogging of the oviposition environment. However, this was probably not too much of a concern because there were large numbers of grasshoppers on the adjacent sea wall slopes. It is likely that these grasshoppers were the main source of recolonising individuals on the grazing marsh in 2007 (first season after seawater drained).

Ant hill occupancy: In the flooded grazing marsh, ant hill occupancy was 83% (33 out of 40 hills had ants observed), which was only slightly lower than the unflooded control area (85% or 34 out of 40 hills occupied). This indicates that yellow meadow ants were largely unaffected by the tidal inundation of the grazing marsh, an important consideration during New Zealand pygmy weed eradication because of the value of exposed soil on occupied ant hills for a range of vascular plants and egg-laying grasshoppers.

Within the flooded area, ant hill occupancy was noticeably lower in the low-ways and ditch banks, which would have been completely covered by seawater during 2006 (44% or 4 out of 9 hills occupied) than on the unflooded higher ground of the seawater treatment (94%, or 29 out of 31 ant hills occupied). This difference was recorded five years after flooding. It indicates that it is important to ensure that areas are left unflooded as refuges for yellow meadow ants during flooding treatment, because the ant colonies may be eradicated due to submergence by seawater for an entire season.

In summary, surveys in 2011 showed that inundation of the grazing marsh with seawater in 2006 to eradicate New Zealand pygmy weed had no significant detrimental long-term impact on grasshoppers and bush-crickets or yellow meadow ants.

This small-scale survey of terrestrial insects should be viewed alongside the results of the ditch sampling which suggested that aquatic

Table 1. Mean number of grasshoppers and bush-crickets (Orthoptera) and species richness per quadrat in grazing marsh flooded with seawater, an unflooded control area, and in sea wall grassland (\pm standard error).

Species	Flooded marsh	Unflooded marsh	Sea wall
<i>Chorthippus albomarginatus</i>	1.15 \pm 0.22	1.03 \pm 0.18	6.93 \pm 0.94
<i>Chorthippus brunneus</i>	0.00 \pm 0.00	0.00 \pm 0.00	0.03 \pm 0.03
<i>Chorthippus parallelus</i>	0.03 \pm 0.03	0.13 \pm 0.08	0.03 \pm 0.03
<i>Conocephalus dorsalis</i>	0.00 \pm 0.00	0.08 \pm 0.04	0.00 \pm 0.00
<i>Metrioptera roeselii</i>	0.08 \pm 0.04	0.05 \pm 0.04	0.13 \pm 0.05
Overall mean/quadrat	1.25 \pm 0.24	1.28 \pm 0.21	7.10 \pm 0.91
Mean no. species/quadrat	0.73 \pm 0.09	0.83 \pm 0.11	0.98 \pm 0.07

invertebrates were largely unaffected by inundation in Irongate Field, and observations of Nationally Scarce plant species such as sea barley *Hordeum marinum* which may have benefited from larger-scale flooding in 2009 (Charlton *et al.* 2010).

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