# The effects of grazing and mowing on large marsh grasshopper, *Stethophyma grossum* (Orthoptera: Acrididae), populations in Western Europe: a review

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## Abstract

The large marsh grasshopper, *Stethophyma grossum* L. (Orthoptera: Acrididae), has undergone a significant range contraction in the UK and is now restricted to the bogs and mires of the New Forest and Dorset Heaths. In other parts of Western Europe, the species makes use of a wider range of wetland habitat types. Traditionally, many of these habitats would be managed through low intensity grazing, mowing, or both, and these measures are now often employed in the conservation management of wet grassland habitats. This paper reviews the effects of mowing and grazing on *S. grossum* populations, through looking at the potential impacts (both positive and negative) on different life stages of the grasshopper. Both techniques are valuable in the maintenance of an open and varied vegetation structure which is known to benefit *S. grossum* in all its life stages. However, grazing on very wet sites or at high intensity can result in trampling of vegetation and *S. grossum* eggs, and mowing which is too frequent may negatively affect populations through repeated losses of nymphs. Recommendations are given regarding the suitability of mowing and grazing for different habitats and intensity of management to generate the required vegetation structure. Measures are also outlined, such as the provision of unmown or ungrazed refuge areas, which can help reduce negative effects.

## Key words

adults, biodiversity conservation, bog, eggs, grassland, management, mire, nymphs, vegetation structure, wetland

## Introduction

Grazing and mowing exert important influences on vegetation structure and are therefore key factors affecting grasshopper populations (Clarke 1948, Gardiner et al. 2002, Humbert et al. 2009, Kenyeres and Szentirmai 2017). Rare and localized species, such as the large marsh grasshopper, *Stethophyma grossum* L. (Orthoptera: Acrididae), have very specific micro-habitat requirements which can be influenced by grazing and mowing. In the UK *S. grossum* is a priority species under the NERC Act 2006 and has a GB IUCN status of Near Threatened (Sutton 2015). It has undergone the largest range contraction of all the UK Orthoptera between the 1980s and 2000s (Beckmann et al. 2015), and is currently confined to the Dorset Heaths and New Forest. In Europe, it is locally distributed with an IUCN status of Least Concern (Hochkirch et al. 2016), however, in Switzerland and Austria it is listed as Vulnerable (Berg et al. 2005, Monnerat et al. 2007) and in Denmark it is considered Near Threatened (Wind and Pihl 2010). It is the aim of this paper to describe what is known about the links between the life cycle and habitat requirements of *S. grossum* and provide a discussion of the benefits and disadvantages of mowing and grazing for the management of this species in Western Europe.

## *Stethophyma grossum* distribution and life history

*Stethophyma grossum* (Figs 1, 2) is locally distributed across Europe and found from Ireland in the west, northern Spain and Italy in the south, east to Siberia and north as far as parts of Scandinavia (JNCC 2010, Benton 2012). In the UK, its former distribution was in suitable habitat south of a line from the Bristol Channel to the Wash, although it has experienced a sharp contraction in its range and is now confined to the *Sphagnum*-dominated bogs and mires of east Dorset and the New Forest (Benton 2012). Populations are thought to have been relatively stable in the New Forest over the last 20 years, and there is potential for the species to benefit from mire restoration projects underway in the Forest (Harvey and Brock 2017). In Ireland, the species is found primarily in bogs and mires, with some records from more grassy habitats, and it is locally distributed across the west, south-west and central parts of the country (Sutton 2017).

*S. grossum* is herbivorous, feeding on the stems and seed heads of grasses, rushes and sedges (Benton 2012). Adults can be seen from late July through to October or even early November (Haes and Harding 1997, Benton 2012). They lay up to 14 eggs in the late summer in an elongated pod at the base of grass stems (Benton 2012). The nymphs usually emerge in late May and early June the following year and pass through four or five instars before reaching the adult stage in late summer (Evans and Edmondson 2007, Benton 2012).

**Fig. 1.** Female *Stethophyma grossum* purple form; credit P. Brock.

**Fig. 2.** Male *Stethophyma grossum*; credit P. Brock.

**Fig. 3.** *Sphagnum*-dominated mire in the New Forest, UK; habitat for *Stethophyma grossum*; credit T. Gardiner.

**Fig. 4.** *Metrioptera brachyptera*; credit T. Gardiner.

### Habitat types used by *S. grossum*

In the UK, *S. grossum* is typically found on quaking acid bogs with purple moor-grass, *Molinia caerulea* (L.) Moench, bog myrtle, *Myrica gale* L., cross-leaved heath, *Erica tetralix* L., broad-leaved cotton grass, *Eriophorum latifolium* Hoppe, and white beak-sedge, *Rhynchospora alba* (L.) Vahl (Haes and Harding 1997, Edwards 2002, Benton 2012). In the New Forest in southern England (Fig. 3), it shows a preference for *Sphagnum*-dominated mires with open water and wet areas indicated by cotton grass, and often coexists with the bog bush-cricket, *Metrioptera brachyptera* L. (Orthoptera: Tettigoniidae; Fig. 4) (Benton 2012, Harvey and Brock 2017). Similarly, Cheesman and Brown (1998) report that *S. grossum* occurrence shows a positive correlation with area of surface water, cover of *Sphagnum* and white beak-sedge and a negative correlation with ericoids and sub-shrubs. The species typically inhabits the wettest parts of such habitats (Ragge 1965), and has even been observed swimming across bog pools in the New Forest (Gardiner 2013).

Its former distribution in the UK and current distribution in the rest of Western Europe shows a wider habitat usage, including areas of fenland, moorland, wet meadow and riverside (Benton 2012). Lucas (1920) noted a record of the species from Norfolk in 1892 occurring in tall rank grass close to a river bank and Marshall and Haes (1988) suggested that the few remaining fenland populations in England at that time were found in very wet conditions among sedge and grass tussocks.

Malkus (1997) noted that vegetation structure appeared to be particularly important in determining distribution of *S. grossum*, with nymphs being predominantly found in areas with patchy and medium-high vegetation. An open habitat structure (determined by vegetation height and density) is thought to be beneficial in allowing sufficient warming of the ground and the base of the vegetation to promote egg development and hatching (Malkus 1997, Marzelli 1997, Maas et al. 2002). A study by Krause (1996) in Germany found that tufted hair grass, *Deschampsia cespitosa* (L.) P. Beauv., held high densities of early instar nymphs and postulated that the growth form of this plant was favorable at the time of hatching, being lower and less dense than other vegetation in the study area. Decleer et al. (2000) and Thorens and Nadig (1997) also recognize a link between periodic/winter flooding and *S. grossum* occurrence, which may be due to the high humidity requirements of *S. grossum* eggs and their sensitivity to dehydration (Detzel 1998, Maas et al. 2002).

Table 1 summarizes the general habitat types currently used by *S. grossum* in Western Europe. A wide variety of wet habitats are used, some of which will provide the required vegetation structure through management by mowing and/or grazing.

## Effects of mowing and grazing on life stages of *S. grossum*

The traditional management of wet hay meadows and floodplain grasslands in Western and Central Europe centered on hay cutting and the grazing of livestock. Many wet areas were grazed by livestock at low intensities. This was sometimes combined with cutting for hay, with one early cut followed by grazing of the remnant sward. Alternatively, on some sites, hay cutting was carried out once or twice a year, typically in May-June and/or August-September (Grootjans and Verbeek 2002, Kenyeres and Szentirmai 2017).

The wet heath, mire and bog habitats of *S. grossum* in the UK and Ireland typically have a naturally open and patchy vegetation structure with areas of open water. The wettest parts of these habitats are not suitable for management by mowing or grazing, either in terms of the potential impacts on the habitat, or safety and accessibility for animals and machinery. Around the drier margins of these habitats, low intensity grazing by ponies or cattle during the summer may be used to help reduce the dominance of purple moor grass and reduce encroachment of scrub (Symes and Day 2003, Lake and Underhill-Day 2004, Groome and Shaw 2015). However, grazing of the wettest areas (mires or bogs) can be detrimental through trampling damage, particularly to bog mosses, and the creation of a more homogeneous vegetation structure (Symes and Day 2003, Groome and Shaw 2015). In the New Forest, Pinchen and Ward (2010) attribute a general decline in Orthoptera to increased grazing pressure since the 1960s, with trampling and changes to vegetation structure likely to negatively affect many invertebrate species. While mires and bogs are less likely to be affected by overgrazing due to inaccessibility of the habitat, the effects of heavy grazing pressure were observed at two *S. grossum* sites in the New Forest during a recent survey (Harvey and Brock 2017).

In wet grassland habitats, sensitive management by mowing and/or grazing is considered beneficial overall to *S. grossum*. The following section discusses considerations relating to mowing and grazing of wet grassland habitats and the requirements and characteristics of *S. grossum* eggs, nymphs and adults.

*Eggs.*—*S. grossum* eggs require high humidity levels for successful development and are very sensitive to dehydration (Detzel 1998, Maas et al. 2002). Because of this, soils which are saturated or flooded during the winter are preferred (Malkus 1997). While *S. grossum* has relatively low temperature requirements compared to other Orthoptera (Marzelli 1997), a sufficiently open habitat structure will promote egg development and hatching (Malkus 1997, Marzelli 1997, Maas et al. 2002).

Grazing while *S. grossum* is at the egg stage may result in the direct destruction of eggs by trampling, particularly on the wettest sites (Malkus 1997), but grazing or mowing of less wet sites can help provide the necessary open vegetation structure if carried out at low intensity and avoiding very wet areas.

*Nymphs.*—The distribution of early instar nymphs is thought to be a product of the female choice of habitat for oviposition, as

**Table 1.** Habitats of *S. grossum* in Western Europe.

| Country | Habitat types | References |
|---|---|---|
| Netherlands | Wet grasslands and meadows, floodplains, ditches and margins of waterbodies, fens, swamp, wet heath. | Kleukers et al. (2004), Bakker et al. (2015) |
| Belgium | Wet grasslands and meadows, swamp, bogs, ditches, wet heath. Land that is wet in winter. | Decleer et al. (2000), Sardet et al. (2015) |
| France | Wetlands: marshes, reedbeds, flooded meadows, peat bogs, ditches. In the Alps, up to 2400-2700 m in altitude. | Voisin (2003), Sardet et al. (2015) |
| Luxembourg | Wet meadows, marshes, peat bogs, ditches. | Sardet et al. (2015) |
| Switzerland | Near open water or periodically flooded vegetation, wet meadows and pasture, peat bogs, ditches. Up to 2450-2700 m in altitude. | Thorens and Nadig (1997), Sardet et al. (2015) |
| Austria | Peat bogs, fens, floodplains, ridges of raised bogs. | Ortner and Lechner (2015) |
| Germany | Marshes, edges of lakes, streams and ditches, wet meadows. Up to 1300 m in altitude. | Detzel (1998), Maas et al. (2002), Fischer et al. (2016) |
| Northern Italy | Lake margins, swamps, alpine fens, wet meadows. | Galvagni (2001), Fontana and Kleukers (2002), Kranebitter (2008) |
| Northern Spain | Wet peaty meadows, peat bog, wet mown meadows, margins of ponds and rivers. | Lüders (2009) |
| England, UK | Bogs and mires in the Dorset and New Forest heaths. | Haes and Harding (1997), Benton (2012) |
| Ireland | Mire, wet heath, blanket and raised bogs, *Molinia*-dominated grassland. By rivers and lakes. | Benton (2012), Sutton et al. (2017) |
| Denmark | Raised bogs, wet meadows, nutrient-poor fen. | Hansen and Jørgensen (2010) |
| Fennoscandia | Bogs, meadows, by lakes and streams. | Holst (1986) |

young nymphs have limited mobility and therefore do not tend to disperse from their hatching location (Marzelli 1997). Malkus (1997) found that patchy vegetation with a heterogeneous structure was preferred by nymphs. As above, low intensity grazing may provide the necessary diversity in sward structure.

Mowing can have a significant effect on the density of nymphs. If mowing takes place during the early summer, the density of early instar nymphs is likely to drop significantly afterwards (Krause 1996, Malkus 1997, Marzelli 1997, Detzel 1998). Due to the limited mobility of young nymphs, they are not able to take evasive action, and may either be directly killed, removed with the hay crop or made more vulnerable to dehydration and predation (Krause 1996, Malkus 1997). Malkus (1997) observed a collapse in nymph numbers after mowing in mid-June, however, after 1-2 weeks, numbers recovered as further hatching occurred, possibly promoted by the increased levels of solar radiation reaching the ground. Krause (1996) noted detrimental effects on populations affected by mowing at an early stage in nymph development. Later instar nymphs may be more able to escape mowed areas – Krause (1996) noted an increase in late instar nymph densities around ditch edges following mowing.

*Adults.*—Adult *S. grossum* also tend to be found in locations with relatively high soil moisture levels, perhaps due to their need to oviposit in wetter areas. Sonneck et al. (2008) propose that adults also benefit from a heterogeneous vegetation structure as this allows the adults to withstand fluctuating temperatures. Similarly, a variety of soil moisture levels within a site may allow adults to cope with varying weather conditions (Detzel 1998, Kleukers et al. 2004).

Malkus (1997) reports that mowing later in the summer (mid-July onwards) tends to displace adult *S. grossum* to neighboring areas until the vegetation regrows, when repopulation will occur. Grazing during this period has similar effects. Population effects as a result of mowing are unlikely unless the mowing is too frequent, takes place in cool weather when the grasshoppers are less active and therefore less able to take evading action, or where unmown refuge areas are not available (Malkus 1997). Malkus (1997) also observed adults flying up in front of a mower and moving to the as yet unmown center of the field. It is therefore possible that *S. grossum* could benefit from mowing that works from the inside of the field outwards (as is sometimes employed for certain bird species, e.g. corncrake *Crex crex* L.), as animals may then be more likely to reach safe habitat outside the mown area.

## Recommendations relating to mowing and grazing for *S. grossum* conservation

The following recommendations are derived from the studies of *S. grossum* populations in Western Europe and are relevant to the management of wet grasslands including wet meadows and pasture, floodplain grassland and fens. As discussed above, *S. grossum* is currently only found in valley mires and bogs in the UK (and predominantly so in Ireland), therefore many of these recommendations will not be directly applicable to UK and most Irish populations. In mire and bog habitats, management should focus on protecting sites from activities likely to cause drying, although removal of encroaching scrub and/or management of dominant grasses or bog myrtle may occasionally be required on the drier margins of such sites.

*Mowing.*—A sensitive mowing regime can be beneficial for the management of wet meadows for *S. grossum* (Krause 1996, Sörens 1996, Marzelli 1997, Malkus 1997, Detzel 1998). While it may cause short-term reductions in the numbers of grasshoppers (particularly early stage nymphs), if carried out with regard to their lifecycle, careful mowing can have positive effects on egg and nymph development by maintaining a more open vegetation structure, thus raising ground temperatures. Insufficient, irregular, or mowing only in the late summer may have negative effects through matting of the turf (Malkus 1997, Detzel 1998). However, there are some differences of opinion as to the optimum time for mowing. Krause (1996) recommends one late cut in August, by which point most individuals should be adults and able to move to an adjacent area. Marzelli (1997) recommends two cuts – one at the beginning of June before the eggs hatch and one in mid-September after oviposition. She also notes that mowing in July was particularly damaging to populations. Malkus (1997) recommends that mowing should take place once and, at most, twice a year. He points out that the timing may also need to take other grassland species into account – if amphibians or ground-nesting birds are present, early cuts should not take place before mid/end June and the late cut should be after mid-September.

It would therefore appear that wet grasslands managed for *S. grossum* should be cut at least once (though no more than twice) a year, depending on site-specific habitat needs, and with the aim of avoiding the vulnerable early nymph stage. If an early cut is required, ideally this should be before *S. grossum* has hatched, but the needs of other species present should also be considered. If a late summer cut is required, this should be after mid-September when most of the egg-laying is complete. In order to minimize mortality of grasshoppers (and other invertebrates), the use of a bar mower (rather than a rotary or flail mower) set to a minimum height of 10 cm is recommended (Humbert et al. 2009, Kenyeres and Szentirmai 2017). Malkus (1997) also makes further recommendations to reduce mortality of *S. grossum* during mowing: mowing should only take place in warm, sunny weather, to allow grasshoppers to escape; retain the hay on the surface for a few days following the cut, again to allow grasshoppers to escape; and unmown areas should be retained close to the mown area, to provide a refuge.

*Grazing.*—Low intensity grazing is a useful method for managing vegetation height and density and tends to create a more varied vegetation structure than mowing alone (Lake and Underhill-Day 2004). Grazing can also help prevent scrub encroachment and reduce cover of dominant species (Symes and Day 2003, Lake and Underhill-Day 2004, Groome and Shaw 2015), thus helping to maintain the open vegetation structure required by *S. grossum*. As well as having similar displacement effects to mowing, grazing has the potential to cause damage to habitats and destruction of *S. grossum* eggs through trampling (Malkus 1997, Groome and Shaw 2015). It is therefore important to select an appropriate livestock type and stocking rate for the habitat type; ponies will tend to create a more homogeneous sward than cattle (particularly if grazed at high stocking rates), although cattle may be more likely to cause trampling damage (English Nature 2005). Malkus (1997) recommended that grazing in general should be carried out at a low stocking density and on a temporary basis and avoided completely on very wet habitats due to the risk of trampling damage. The potential negative effects of displacement of grasshoppers can be reduced by the retention of ungrazed refuge areas.

A summary of the advantages and disadvantages of mowing and grazing are presented in Table 2.

**Table 2.** Advantages and disadvantages of mowing and grazing for *S. grossum*.

| | Mowing | Grazing |
|---|---|---|
| Advantages | Creates an open sward structure.<br>Restricts scrub encroachment. | Creates a varied sward structure.<br>Reduces cover of dominant grasses.<br>Restricts scrub encroachment. |
| Disadvantages | Mortality of nymphs.<br>Displacement of adults.<br>Potential effects on other species (e.g. ground-nesting birds). | Poaching of wet habitats.<br>Displacement of adults.<br>Trampling of eggs.<br>Overgrazing possible.<br>Potential effects on other species (e.g. ground-nesting birds). |

## Conclusions

The following recommendations for mowing and grazing as part of the management of wet grassland habitats occupied by *S. grossum* can be derived from this review:

- Grazing and/or mowing (dependent on habitat type) are valuable management techniques for the maintenance of the open and varied vegetation structure required by *S. grossum*.
- Grazing should be at a low stocking density (and, where necessary, for a limited time-period), and nearby ungrazed refuge areas should be maintained.
- Grazing of very wet areas should be avoided.
- Wet grasslands should be cut once a year, or twice at the most, depending on the vegetation type.
- If early mowing is used, this should be before the main hatching period from mid-June onwards where possible (depending on the needs of other species) and late mowing should be after the main oviposition period from mid-September onwards.
- Use a bar mower set to a minimum height of 10 cm to minimize mortality.
- Grasshoppers should be allowed to escape mowing by carrying out operations only on warm, sunny days when grasshoppers are active, retaining unmown refuge areas nearby and leaving the hay crop on the surface for a few days before removal.

The following recommendations relate to the management of wet heath, mire and bog habitats, such as those used by *S. grossum* in the UK and Ireland:

- Protect sites from activities likely to cause drying of habitats.
- Grazing (and mowing) should be avoided in the wettest areas, particularly in mires and bogs.
- If necessary, low intensity grazing could be used on the drier margins of such sites during the summer months to reduce dominance by grasses or encroachment of scrub.

Recommended management measures for habitat types used by *S. grossum* in the UK and Western Europe are summarized in Table 3.

**Table 3.** Appropriate management options for *S. grossum* in Western Europe.

| Habitat | Management | Frequency | Additional measures |
|---|---|---|---|
| Alpine pasture | Light grazing[1] | 2-3 months/year | Livestock moved to valleys in winter. |
| Ditch banks | Mowing | 1-2 cuts/year | Unmown refuges (exclosures). |
| Fen | Sedge cutting | 1 cut/year | Uncut refuges (exclosures). |
| Mire/bog* | Avoid grazing | n/a | Protect from drying.<br>May need to manage scrub encroachment. |
| Reedbed | Reed cutting | 1 cut/year | Uncut refuges (exclosures). |
| Wet heath* | Light grazing | Summer/all year | Ungrazed refuges (exclosures).<br>Avoid grazing of very wet areas. |
| Wet grassland | Mowing | 1-2 cuts/year | Unmown refuges (exclosures). |

[1]Typical stocking density: 0.1 cows/ha (Homburger et al. 2015).
*Only habitats left for *S. grossum* in the UK (Dorset, New Forest).

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