Orthoptera response to grazing: an introduction to the special issue

Corinna S. Bazelet[1], Tim Gardiner[2]

1 Integrated Pest Management Initiative, Department of Conservation Ecology and Entomology, Stellenbosch University, Stellenbosch 7602, South Africa. **2** Environment Agency, Iceni House, Cobham Road, Ipswich, Suffolk IP3 9JD, UK.

Corresponding author: *Corinna S. Bazelet* (cbazelet@sun.ac.za)

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Grazing is a global driver of vegetation dynamics and exerts far-reaching effects on plant traits such as promoting the growth of annual over perennial plants, short plants over tall plants, and procumbent plant architectures (Díaz et al. 2007). Since approximately one quarter (26%) of Earth's non-ice surface is utilized as wildland or pastures for grazing of livestock and wild ungulates (FAO 2006), grazing is responsible for shaping much of the world around us, both directly and indirectly. Orthoptera, which largely co-occur with mammalian grazers in pasturelands and meadows worldwide, are more vulnerable to the effects of trampling and grazing than most.

The order Orthoptera includes many herbivorous species which are specifically adapted to play an important nutrient cycling role in grassland environments and compete with ungulates for the same forage. All Orthoptera, herbivores and non-herbivores alike, are sensitive to meso- and micro-climatic conditions (Gardiner and Dover 2008) brought about, at least in part, by structural aspects of their grazed habitats. With few exceptions (but see Gardiner et al. 2002), the diversity and abundance of grassland orthopterans correlate with vegetation structure rather than species composition of the plant community (Hochkirch and Adorf 2007, Gardiner and Hassall 2009, Bazelet and Samways 2011a), making Orthoptera particularly vulnerable to habitat changes caused by grazing.

The effects of grazing on Orthoptera are multi-faceted and depend on many biotic and abiotic factors relating to both the grazing animal, the orthopteran, their surrounding environment, and its management. In this issue, co-editor Gardiner (2018) provides a detailed review of these factors which include, among others, grazing intensity, type of grazing animal, and season of grazing; as well as life stage of the orthopteran, its movement capability, and resource requirements. Furthermore, in many environments grazing is used as a defoliation technique in combination with fire and/or mowing, all of which can have synergistic, complementary, neutral, or opposing effects on local Orthoptera (Joern 2005, Bazelet and Samways 2011b, Kati et al. 2012, Joubert et al. 2016). For these reasons, the effect of grazing on Orthoptera can be either positive, negative or neutral. For instance, heavy livestock grazing led indirectly to increased abundance of locusts in China (*Oedaleus asiaticus*: Cease et al. 2012) and pest grasshoppers in American rangelands (*Aulocara elliotti*: O'Neill et al. 2003). On the other hand, in multi-species studies, total grasshopper density decreased in heavily grazed plots in Mediterranean pastures (Fonderflick et al. 2014), and for most species in the American rangeland community (O'Neill et al. 2003).

The idea for this special issue originated from an International Union of Nature Conservation (IUCN) Grasshopper Specialist Group (GSG) email discussion in 2015, as the group discussed possible monitoring targets and their implementation. As members of the GSG described the monitoring needs for their particular regions, and for species of conservation interest in their areas, the impacts of grazing arose several times. Participants debated whether grazing impacts were net positive or negative for Orthoptera, as well as logistical, political, and biological differences which were particular to their region. It became clear that the impacts of grazing are localized and specific to individual habitats and species.

In this special issue, we address the diversity of grazing impacts on Orthoptera in two principal sections. First, we present four papers from South Africa, North America, and Europe which describe the effects of grazing at the habitat-scale and on Orthoptera communities. Joubert-van der Merwe and Pryke (2018) investigate the interaction of burning and grazing practices on a South African grasshopper community, as well as on the subset of the community which is endemic and rare. Kenyeres (2018), working in a Hungarian grassland, investigates the effects of grazing intensity, including the abandonment of grazing, on his local Orthoptera community. Lightfoot (2018) conducts a long-term study in a North American semi-arid grassland to assess the interaction of grazing and climate variation on the plant and Orthoptera communities. Finally, Fargeaud and Gardiner (2018) review the effects of grazing sea walls (i.e. dikes) throughout Europe on the resident orthopteran communities and suggest measures to improve these practices.

In the second group of articles, each study focuses on the effects of grazing on an individual Orthoptera species which is of conservation concern. All four of these species are found in Europe and were included in the recently published Red List of European species (Hochkirch et al. 2016). Two of the species, the Criti-

cally Endangered Crau Plain grasshopper, *Prionotropis rhodanica* (Pamphagidae), and the Near Threatened saltmarsh band-winged grasshopper, *Mioscirtus wagneri* (Acrididae: Oedipodinae), are found in Mediterranean regions of Europe, in France and Spain, respectively. Both the Crau Plain grasshopper and the saltmarsh band-winged grasshopper are rare habitat specialists which are confined to very narrow niches. Piry et al. (2018) investigate whether the population density and gene flow of the Crau Plain grasshopper correlates with habitat quality as an indication of sheep grazing. Aguirre et al. (2018) relate the presence and abundance of the saltmarsh band-winged grasshopper to the presence and abundance of goat and sheep droppings.

The two final articles discuss the British populations of species which were assessed as Least Concern globally (Hochkirch et al. 2016), but which have experienced significant range reductions in Britain in recent years. Selman and Cherrill (2018) investigate the effects of grazing on the lesser mottled grasshopper, *Stenobothrus stigmaticus* (Acrididae: Gomphocerinae), at its last remaining site in Britain. Miller and Gardiner (2018) review the interactive effects of mowing and grazing on the large marsh grasshopper, *Stethophyma grossum* (Acrididae: Oedipodinae), which is confined to wet habitats in two regions of Britain. Both studies make recommendations for mitigating measures to help conserve their species.

The articles presented here contribute significant evidence to the growing body of work investigating the effects of ungulate grazing on Orthoptera. This relationship is not straight-forward, and our hope is that this synthesis will assist in identifying general, common principles that can be used to improve management decision-making for the benefit of healthy ecosystems and the survival of threatened Orthoptera species.

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