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Simple tools for the evaluation of protected areas for the conservation of grasshoppers

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ABSTRACT

Spatial conservation prioritization needs a strong informational background on the conservation value of sites. However, standard diversity indices do not distinguish between less valuable (e.g. invasive species) and highly valuable species (e.g. threatened endemics). Furthermore, park managers often lack the taxonomic capacity to study species-rich insect groups. Therefore, there is a need for indices that consider the conservation value of species and simple indicators for the conservation value of sites. The aim of our study was to develop such indices and test them in a biodiversity hotspot. We studied grasshopper diversity in the UNESCO World Heritage "Cape Floral Region Protected Areas" (South Africa). We used endemism, mobility and rarity to calculate a grasshopper conservation index (GCI) for each species and site and a standardized index (GCIn) to evaluate the mean conservation value of species per site. We analyzed the indicator value (IndVal) of environmental factors for identifying sites of high conservation value or high biodiversity. Unlike plant species richness, we found the highest species richness in the Eastern Cape. The main factors determining grasshopper diversity were vegetation heterogeneity, altitude and cover of bare ground. The abundance of wingless grasshopper species and the ratio of wingless to winged species were suitable indicators of conservation value (regarding the diversity of rare or endemic species) of sites. These factors might function as conservation indicators in other regions as well, as they are generally associated with the occurrence of endemic species. GCI/GCIn are globally applicable tools for the evaluation of grasshopper communities.

1. Introduction

The global loss of biodiversity is one of the major challenges of the Anthropocene. Although invertebrates are the most species-rich taxa, conservation prioritization is often based on vertebrate species such as birds, mammals and amphibians (Ceballos and Ehrlich, 2006), because they are both well-described and easy to identify, and information on their conservation status is available, whereas information on invertebrate species is scarce and many species are still undescribed. Therefore, there is a need for data on invertebrate diversity in protected areas (Hochkirch, 2014). However, as reserve managers and rangers often lack taxonomic capacity to identify insects, there is also a need for simple guidelines on the conservation value of sites. This should be based upon the conservation value of species rather than on simple alpha diversity indices, which may also be driven by invasive or common species.

Protected areas are generally believed to be the most effective tool for sustainable conservation of biodiversity (Watson et al., 2014). Protected areas are particularly necessary in species-rich regions, i.e. biodiversity hotspots (Myers et al., 2000). One biodiversity hotspot is the Cape Floral Region in South Africa (Mittermeier et al., 1998; Mittermeier et al., 2004; Grant and Samways, 2011). Due to its enormous plant diversity and high rate of endemism in a comparatively small area, eight reserves situated in this fynbos biome were inscribed as UNESCO world heritage site ("Cape Floral Region Protected Areas") in 2004 (UNESCO, 2014; see Fig. 1). The Cape region is rich in red-listed plant species (i.e. 1406 species: Raimondo et al. 2009), it maintains many endemic vertebrate species and is also recognized as an Endemic Bird Area (Stattersfield, 1998). However, information on species richness, biogeography, ecology, biology and evolution of most endemic invertebrate taxa is missing. Such data are essential for developing effective conservation strategies and management plans in order to prevent the loss of biodiversity (Olson et al., 2001). The Cape Floral Region is highly threatened due to climate change, invasive species, changed fire regimes and other anthropogenic influences (UNESCO, 2014). The delineation of the UNESCO World Heritage sites is biased towards mountain areas, whereas other parts suffer from a lack of protection, especially lowland areas (Rouget et al., 2003). A total of 90% of

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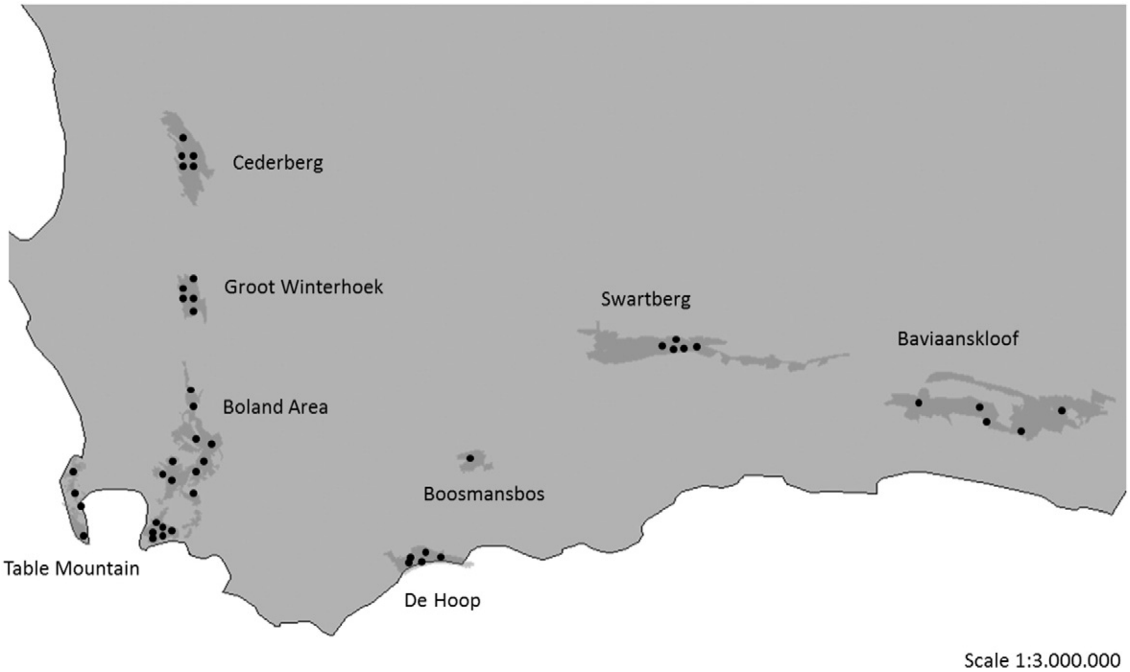

Fig. 1. Study sites in the UNESCO world heritage site "Cape Floral Region Protected Areas". Dots represent study sites.

these lowland areas have been transformed anthropogenically and they are likely to disappear completely if no suitable extension of the reserves is performed. However, it is worth noting that the world heritage site has recently been extended from eight to now 13 reserves including an important lowland reserve (Agulhas Complex, UNESCO, 2015).

Orthoptera are important herbivores in many open ecosystems (e.g. Sinclair, 1975). They show high levels of endemism (Hochkirch, 1998) and are known to be sensitive to changes in climate and vegetation structure (Weiss et al., 2013). Therefore, they have become an important group for environmental impact assessments in Europe (Henle et al., 1999). Even though many endemic Orthoptera species occur in the Cape region, there is still very little known on their ecology (Matenaar et al., 2014). This is mainly caused by the lack of field guides or other comprehensive taxonomic literature, hampering managers and rangers in collecting data about distributions and ecology of Orthoptera. While information on the occurrence of rare grasshopper species might help to identify sites of particular importance for conservation, this can currently be obtained only by taxonomic experts. Increased taxonomic efforts might be one solution to this problem, but it is also important to identify potential surrogate indicators as a proxy for biodiversity and conservation value (Crous et al., 2013).

The aim of our study was to develop an index for the assessment of conservation value of grasshopper assemblages based upon their endemism, dispersal capacity and rarity as a tool for prioritization of conservation measures. Furthermore, we wanted to test the indicator function of simple environmental parameters for grasshopper species richness and conservation value. Therefore we studied grasshopper diversity on 46 plots in eight reserves of the Cape Floral Region and examined the major factors influencing species richness.

2. Material & methods

2.1. Study sites

The Cape Floral Region Protected Areas cover eight reserves: Table Mountain National Park, Boland Mountain Complex, Groot Winterhoek Wilderness Area, Cederberg Wilderness Area, Boosmansbos Wilderness Area, Swartberg Nature Reserve, De Hoop Nature Reserve and Baviaanskloof Nature Reserve (Fig. 1). The Boland Mountain Complex consists of four nature reserves: Limietberg, Hottentots Holland and Kogelberg and the water catchment area of Jonkershoek. The CFRPA reserves cover an area of 553,000 ha and contain a buffer zone with approximately. 1,315,000 ha (UNESCO, 2014). Elevations range from sea level in De Hoop to 2077 m in Groot Winterhoek and soil types vary from nutrient poor, acid soils to marine alkaline sands and alluvials. Mountain fynbos is the common vegetation type in the reserves, whereas lowland fynbos is associated with flat areas, being typically found in De Hoop. The threatened vegetation type Renosterveld occurs in patches on nutrient rich soils in Table Mountain NP and Swartberg. Kogelberg features other rare fynbos types, such as western strandveld and seashore vegetation (Mucina and Rutherford, 2006; Grab and Knight, 2015).

In each reserve we selected four to six study sites together with the park managers according to the following criteria: veld age (i.e. time since last fire), accessibility, vegetation type (aiming at a high variety of vegetation types per reserve) and range of elevation (Fig. 1, for details see Table A1 in Supplemental Material). In Boosmansbos only one study site could be studied as the wilderness area is difficult to access. Therefore this reserve was excluded for most statistical analyses.

2.2. Data collection

The 46 study sites were surveyed during three field trips, one in spring (October to December 2012) and two in summer (February to April 2012 and 2013). During each field trip the study sites were inspected by two persons for one hour and all detected grasshoppers were recorded (timed counts; for information on species abundances see Table A2 in Supplemental Material). One observer focused on searching for species in dense bushes and trees, while the other observer focused on more open vegetation. The size of the sites was 1–2 ha and the distance between them was minimally 1 km (a distance, which is usually not crossed by grasshoppers, e.g. Hochkirch and Adorf, 2007). This method has successfully been used in several invertebrate studies before (Pryke and Samways, 2009). It is particularly useful in habitats, which are difficult to sample with other quantitative methods due to their dense and thorny vegetation (Gardiner et al., 2005). Specimens which could not be identified in the field were collected and identified