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Landscape and a political border determine desert arthropods distribution

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ABSTRACT

We studied the distribution of arthropods in the Arava desert on both sides of the Israeli-Jordanian border, to assess the impact of different anthropogenic pressures on the local fauna. We examined how different landscape units, proximity to agricultural fields, and human societies, might affect the diversity of ground dwelling beetles, and spiders, using ordination and diversity estimation methods. Our results suggest that although both countries contain similar habitats, each has its own unique characteristics, probably due to different cultural practices. The immediate repercussion is that loss of a habitat on one side of the border cannot be compensated with preservation of the same habitat across the border, due to fauna dissimilarity. For example, beetle species can be assembled according to landscape units, but within each landscape unit they show dissimilarities that are based on the geopolitical location. Spiders fail to assemble according to landscape units but cluster as a unique group within Israel. Both landscape unit type and the border, were found to be important for the overall species diversity of this ecosystem and therefore “redundancy” should be carefully applied, especially across geopolitical borders.

1. Introduction

The reduction in biodiversity due to habitat loss and ecosystem degradation has made it vital to prioritize land usage for conservation (Wilson et al., 2006). Land-use prioritization has been suggested on a range of geographic scales: global [in which primarily worldwide hot spots of diversity or endemism are identified for preservation (Orme et al., 2005; Brooks et al., 2006; Lamoreux et al., 2006; Araujo and Rahbek, 2007)], continental (Williams et al., 2000; Moore et al., 2003; Larsen and Rahbek, 2005; Tognelli, 2005), regional (Gering et al., 2003), and national or state (Kati et al., 2004; Warman et al., 2004; Bonn and Gaston, 2005; Bani et al., 2006). However, to date, most of the land-use prioritization decisions are made on a national level rather than across international boundaries. Consequently, and unfortunately, the world's land is managed by multiple, independent bodies (i.e., countries), each having different and often conflicting agendas concerning their own land use. The potential shortcomings of this situation are readily seen when countries share a single, continuous, biome, yet treat their natural resources in different ways (e.g., the Serengeti-Mara region shared by Kenya and Tanzania, Homewood et al., 2001). Therefore better collaboration and coordination are often sought between countries sharing a mutual priority region (Medail and Quezel, 1999).

In this study, we aimed to examine how a political border affects the diversity of two well established indicative taxonomic groups, beetles and spiders (Bromham et al., 2002; Pearce and Venier, 2006), and what consequences this has on the mutual management of biodiversity in an important desert system, the Arava valley. We chose to concentrate on epigeal arthropod communities by constructing pitfall traps, an unbiased method to relate species diversity to a specific sampling plot. In addition to the border effect, we examined the effects of proximity to agricultural fields and how different landscape units affect diversity levels. We also wished to compare the suitability of various surrogate species, from different taxonomic groups and at different levels of analysis, for prioritization decision-making.

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The Arava valley is a desert ecosystem, part of the great rift valley, shared by Israel and Jordan. It is one of the major migratory routes for old world birds, as approximately half a billion birds of more than 260 species pass through this valley twice a year on their spring and autumn migrations between Africa and Eurasia (Yosef, 1996). It is also an important biogeographical corridor, located at the junction of three continents. Nevertheless, the ecology of this region is under increasing threat that has escalated as a result of the peace treaty signed by Israel and Jordan in 1994. Immediate concerns include the proposed Red Sea – Dead Sea water canal (World Bank publications, 2007), the construction of a new international airport, and increased agricultural use of land. Therefore, land-use prioritization with special emphasis on biodiversity conservation and management should be sought for this region. For example, the main stakeholders on the Israeli side of this region, namely, the local regional council, the Israel Land Administration, and the Israel Nature and Park Authority, are in constant dispute on land use, often unsupported by empirical data.

The valley has been disproportionately developed on the Israeli side of the border, with vast areas settled and transformed into irrigated agricultural fields by ten collective communities (Kibbutzim: Efrat, 1993). The land on the Jordanian side has remained relatively intact and only sparsely populated mainly by traditional and pastoral societies, with few villages that started in recent years to develop irrigated farming (Khoury and Al-Shamlih, 2006). This has resulted in different faunal representation across the political border (Shanas et al., 2006). Hence, in this study, we aimed to examine how the different patterns of land use affect biodiversity patterns across this political border. To date, this study is the most comprehensive biodiversity study along the Israel-Jordan border.

2. Methods

2.1. Study site

The southern Arava Valley, a part of the Great Rift Valley, located between Nahal Shita in Israel and Wadi Arandal in Jordan (030°07′10″ N) in the north; the Red Sea (029°32′57″ N) in the south; the mountains of the Israeli Negev in the west; and the Sharrah Mountains of Jordan in the east. Temperatures in this region vary from 23 to 45 °C during the summer and 0 to 23 °C during the winter. Average annual precipitation is 28.7 mm (1971–2000 mean, Israel Central Bureau of Statistics). During the two-year period of our study, precipitation levels were 12.0 mm and 22.5 mm for 2002–2003 and 2003–2004, respectively. The valley is comprised of different habitats, of which the major ones are alluvial fans, sand dunes, semi-stable sands, salt marshes, and wadi beds. Although the border politically divides Israel and Jordan, the physical division is only a loose wire mesh fence along the border.

2.2. Landscape units, proximity to agriculture and “border effect”

Based on literature and preliminary data, we selected four habitat types to represent landscape units in which we expected to find most of the region’s biomass: **HD** – High Density, alluvial fans with a relatively high density of acacia trees (*Acacia tortilis* and *Acacia. raddiana*) and shrubs (10–20 acacia trees per hectare, *Salsola tetrandra* and *Lycium shawii* as major shrubs); **SM** – Salt Marsh, salt marsh edges typified by silty soil, where the most common shrub was *Nitraria retusa* (18–160 individuals per hectare), in some places joined by *Alhagi graecorumi* and *Zygophyllum* spp. shrubs; **SD** - Sand Dunes, typified by shifting sands with approximately 30 *Haloxylon persicum* shrubs per hectare; and **MX** – Mix, semi-stable sands occasionally mixed with gravel, with approximately 25 *Haloxylon persicum* shrubs per hectare and sporadic occurrence of *Calligonum comosum* shrubs (see also Shanas et al., 2006). Within each landscape unit, we established three “close” plots close to (50–200 m) and three plots “far” (>2 km) from the agricultural fields (hereafter, close and far, respectively). Due to the imbalance in agricultural activity on the two sides of the border, we could not find enough “close” and “far” sites for all habitat types. Therefore, most of the “close” sites were on the Israeli side and most of the “far” sites were on the Jordanian side of the border. Because we also suspected that the border itself, dividing two societies with distinct and different impacts on the land, would affect biodiversity, we chose three additional plots in each country to enable an exclusive cross-comparison of the effect of agricultural fields as well as an exclusive cross-comparison of the “border effect” (for complete details of the study sites see Appendix A and Shanas et al., 2006). In this way, we were able to compare the four landscape units within each country; then use the SM plots close and far from agricultural fields within Israel, and the SD plots close and far from agricultural fields within Jordan to perform separate comparisons of the effect of agriculture proximity. The SM far plots and the SD close plots were used to compare the “border effect”, as these landscape unit types were monitored on both sides of the border. Each of the 30 plots (15 on each side of the border) was 150 × 150 m (2.25 ha). The agricultural fields were comprised mainly of irrigated date palms, seasonal onions, melons, and tomatoes.

2.3. Timeframe and replications

Each of the 30 plots was sampled four times a year; winter, spring, summer, and autumn. The precise timing of sampling sessions was chosen based on temperature, with mid-winter (January–February) and mid-summer (July–August) sampling sessions taking place during the extreme cold and hot seasons, respectively. Sampling dates within a given season were chosen according to lunar phase. All sites were sampled either immediately before or after the new moon. In each season, plots were sampled for three consecutive nights and days. Every night, four plots were sampled in parallel (two in Israel and two in Jordan) in a fixed order to ensure that the same landscape units were sampled at the same time on both sides of the border (i.e., to avoid temporal bias). Thus, sampling started in four plots six nights before the new moon and progressively moved to the next plots until sampling was completed in the last plots on the sixth night after the new moon.

2.4. Sampling method

We constructed 20 pitfalls (five sets of four pitfalls) in each plot. Each pitfall was an18 L bucket, equipped with a movable double bottom. A set was comprised of four pitfalls with a central bucket from which three drift fences (18 m each) proected to three peripheral buckets (see Appendix B and Shanas et al., 2006). Between trapping sessions, we sealed the buckets with lids and lowered the drift fences. Drift fences were reset and pitfalls were opened before sunset of the first night in each trapping session. Buckets were emptied the next three mornings before sunrise and the two following afternoons. All invertebrates that fell into the pitfalls were lifted out of the bucket using the double bottom, and the entire sample was funneled into jars containing alcohol. These invertebrates were later separated from the sand with entomological tweezers under magnifying glasses and then sorted into three major taxonomic groups: Coleoptera, Araneae and others. We assembled Coleoptera species and Araneae family abundance data for each of the 30 sites. The data included all the specimens collected during the yearlong sampling and specimens collected during each season. Some specimens were identified only to the