Journal of Arid Environments 126 (2016) 68–75

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

Patterns in arthropod abundance and biomass in the semiarid thorn scrub of Bosque Fray Jorge National Park, north-central Chile: A preliminary assessment

Peter L. Meserve [a, *], Hernán Vásquez [b], Douglas A. Kelt [c], Julio R. Gutiérrez [b, d, e], W. Bryan Milstead [f]

[a] *Department of Biological Sciences, Northern Illinois University, DeKalb, IL 60115, USA*
[b] *Departamento de Biología, Universidad de La Serena, Casilla 599, La Serena, Chile*
[c] *Department of Wildlife, Fish, and Conservation Biology, University of California, Davis, CA 95616, USA*
[d] *Universidad de La Serena & Centro de Estudios Avanzados en Zonas Áridas (CEAZA), Casilla 599, La Serena, Chile*
[e] *Instituto de Ecología y Biodiversidad (IEB), Casilla 653, Santiago, Chile*
[f] *U.S. Environmental Protection Agency, National Health and Environmental Effects Laboratory, Atlantic Ecology Division, Narragansett, RI 02882, USA*

ARTICLE INFO

Article history:
Received 5 May 2015
Received in revised form
2 November 2015
Accepted 10 November 2015
Available online 27 November 2015

Keywords:
Long-term studies
Climate change
Arthropods
Semiarid systems
Chile

ABSTRACT

In 2003, we initiated a sampling protocol for arthropods as part of long-term field experiment in a semiarid thorn scrub community in north-central Chile. We utilized pitfall and Malaise traps to sample terrestrial and volant arthropods, respectively. Inventories were conducted for 4 days and nights monthly. We posited that arthropod abundance and biomass would track environmental changes such as high rainfall often due to El Niño Southern Oscillations (ENSOs). Peaks in both abundance and biomass for terrestrial and volant arthropods were in similar months (spring–early summer; August–November); arthropods also tracked high rainfall years in 2004, 2006, and 2011, due mostly to increases in a few dominant groups, i.e., tenebrionid beetles (Coleoptera) in terrestrial sampling, and moths (Lepidoptera: Noctuidae, microlepidoptera) in aerial sampling. However, the same groups increased dramatically in 2008 which was a below-average rainfall year. Numerical decreases in late summer-fall months (January–April) were more abrupt for terrestrial arthropods than for volant ones. Both terrestrial and volant arthropods reached their lowest levels in winter months (June–July). Some evidence suggests long-term shifts in the composition of volant taxa. Arthropods likely are important prey items for insectivorous reptiles (i.e., lizards), birds, and an insectivorous small mammal, the elegant mouse opossum (*Thylamys elegans*), and future efforts are being directed towards examining the evidence for correlated changes in those consumers with arthropod abundance and biomass.

1. Introduction

Arthropods are an important faunal group in virtually every non-polar terrestrial ecosystem. They fill important niches as herbivores, predators, parasites, pollinators, and symbionts, and they provide food for insectivorous vertebrate groups including lizards, birds, and some small mammals. However, relatively little is known about long-term patterns in their abundance, especially from semiarid systems; semiarid Chile is no exception. Since 1989 we have maintained a multi-factorial field experiment as described in this volume and recent reviews (e.g., Meserve et al., 1996, 1999, 2011). In 2003 we established a sampling protocol to monitor arthropod populations using both pitfall and Malaise traps (terrestrial and volant arthropods, respectively). The initial goals of this effort were modest; to determine if: 1) changes in abundance and biomass of arthropods track environmental changes relating to aperiodic high rainfall events such as those due to El Niño Southern Oscillations (henceforth "ENSOs"); and: 2) if specific consumer groups such as birds and insectivorous small mammals (most notably, the elegant mouse opossum [*Thylamys elegans*]) respond similarly to changes in their prey abundance and biomass. This report focuses on the first goal, but provides some preliminary data for eventually examining the second.

---

[*] Corresponding author. Current address: Department of Biological Sciences, University of Idaho, Moscow, ID 83844, USA.
E-mail address: pmeserve@uidaho.edu (P.L. Meserve).

http://dx.doi.org/10.1016/j.jaridenv.2015.11.002
0140-1963/

2. Materials and methods

Fray Jorge (71°40′ W, 30°38′ S) is a ca. 9000 ha World Biosphere Reserve about 380 km N of Santiago, Chile and 150 km S of the southern edge of the hyperarid Atacama Desert (see Fig. 1 in Armas et al., this issue). The park is dominated by semiarid thorn scrub vegetation, and coastal hills support remnant fog forests, all of which has been protected from grazing and disturbance since 1941. The thorn scrub includes spiny drought-deciduous and evergreen shrubs and understory herbs on a primarily sandy substrate (Muñoz and Pisano, 1947; Muñoz, 1985). The climate is semiarid Mediterranean with 90% of the mean annual 125 mm (1989–2013) precipitation falling in winter months (May–Sept.), and warm, dry summers (Dec–Feb.). Since 1989, there have been 6 El Niño/high rainfall events in this region: 1991–92 (233–229 mm), 1997 (330 mm), 2000–2002 (236–339 mm), 2004 (168 mm), 2006 (147 mm), and 2011 (160 mm); intervening years have been dry (11–95 mm).

The experimental array of 20 small mammal trapping grids lies in thorn scrub habitat in an interior valley of the park ("Quebrada de las Vacas," 240 m elev.; see "Central grid complex" in Fig. 1 of Meserve et al., this issue). In late 2003, we installed 40 pitfall traps in two pairs of parallel lines running N–S along the axis of the valley. Each line has 10 traps 100 m apart, and paired traplines are 50 m apart; total area covered is 13.5 ha. Traps consist of plastic 1000 cc jars placed within PVC tubes (25 cm l × 110 mm d) buried flush with the ground. Funnels 110 mm d with 30 mm d holes cover the traps and limit escape. Traps are covered with boards when not in use. Although a few traps start or end inside of experimental grids, neither birds, lizards, or insectivorous small mammals were selectively excluded from these treatments. In March 2004 we initiated complementary sampling with 4 Malaise traps (BioQuip model DGT, 6′ h X 8′ w X 6′ deep with 8″ X 4″ acrylic collecting tubes and 70% ETOH; www.bioquip.com) arranged in a roughly diagonal line running SW to NE and spanning the pitfall lines. All traps are monitored for 4 consecutive days and nights during monthly small mammal trapping sessions. Pitfall traps are uncovered and captured terrestrial arthropods are collected each morning and evening; captured arthropods are euthanized with ethyl acetate, and placed in labeled flasks. Malaise traps are visited twice daily and captured arthropods euthanized and placed in labeled flasks. All specimens are transported to the laboratory for separation, identification, and counting using a Nikon SMZ-10 stereoscope. Beginning May 2005 we dried specimens in a forest air Memmert furnace and weighed taxa to the nearest mg with a Sartoruis B 310 P balance. Identification was facilitated with published guides and keys for Chilean arthropods (McAlpine, 1981; Borror et al., 1989; Saiz et al., 1989; Chiappa et al., 1990; Artigas, 1994; Cepeda, 1997; Peña and Ugarte, 1997; Peña, 2001).

In analyzing the results, we have concentrated on family-level classifications although some arthropods were identified to genus and/or species and some of these became exceptionally abundant during some years (e.g., *Gyriosomus* spp., *Nycterinus* spp., Tenebrionidae in pitfall traps in 2008). To visualize temporal patterns in arthropod assemblage structure (both seasonal and interannual) and to test for differences across seasons, we employed non-metric multidimensional scaling (NMS) in PC-Ord (v. 6.19 - McCune and Mefford, 2011) on family-level data. NMS uses the rank order of inter-group distances and not the variables themselves (James and McCullock, 1990), and differs from most ordinations in that sequential axes do not necessarily explain monotonically declining proportions of variance. We used Sorenson's distance metric and applied Varimax rotation to the resulting ordination. NMS operates by iteratively seeking the best positions of *n* entities (e.g., sites, time periods, etc.) on *k* dimensions (e.g., ordination axes) such that the stress of this *k*-dimensional relationship is minimized (Prentice, 1977; McCune et al., 2002). Stress is a metric that reflects departure from monotonicity in a graph of inter-sample distances in ordination space versus that in original multivariate space (for details, see McCune et al., 2002).

Within ordination space we applied multi-response permutation procedures (MRPP) in PC-Ord to test the hypothesis that arthropod community composition was similar in different seasons. We defined four seasons as Summer (December–February), Autumn (March–May), Winter (June–August), and Spring (September–November). MRPP is a nonparametric procedure and as such has limited assumptions concerning the distribution of data (McCune et al., 2002). MRPP applies a test statistic (T) to a weighted mean within-group distance (δ, calculated with Sørenson's distance metric), and provides an effect size ($A = 1 - (\delta_{obs}/\delta_{exp})$, where δ_{obs} is the observed value of this metric, and δ_{exp} is the mean δ calculated over all possible partitions of the data). The test statistic describes variation within groups relative to random expectation; in our case a value of $A = 1$ indicates that arthropod assemblage composition is identical within groups (e.g., seasons), and as the composition of groups differs the value of A declines; if heterogeneity within groups equals that between groups then $A = 0$ (for further detail see McCune et al., 2002). For analyses using Malaise trap results we used data for 123 arthropod taxa over 44 seasons, and for pitfall trap results we used 99 taxa over 46 seasons (see Table 1).

Finally, we applied indicator species analysis (ISA) to evaluate which, if any, higher arthropod groups were good indicators of seasonal assemblage composition. Good indicator species occur predictably in a given grouping (Dufrêne and Legendre, 1997), which here refers to taxa that are found in only one season at our study site. ISA determines an "indicator value" of a species as $IV_{kj} = 100(RA_{kj} * RF_{kj})$ where RA_{kj} and RF_{kj} are the relative abundance and relative frequency of species i in season j (for analytic details see McCune et al., 2002). The significance of IV_{kj} is calculated with a Monte Carlo approach in which sample units are randomly reassigned and IV re-calculated; the proportion of such randomized IV values that are as large or larger than the observed IV value is the probability of such an observed value occurring by chance. We ran 1000 such iterations in PC-Ord (McCune and Mefford, 2011).

3. Results

Over 11 years of monitoring we documented 5 classes, 26 orders, and 85 families of arthropods in pitfall traps, and 2 arthropod classes, 17 orders, and 111 families with Malaise traps (Table 1). Collections exhibit pronounced seasonality; terrestrial arthropods typically started to increase in early spring (August–September), peaking about November (Fig. 1A). Both numbers and biomass declined through summer and fall (December–April) reaching their minimum levels in May–June (Fig. 1A, C). Although volant arthropods showed similar periods of increase, there was more heterogeneity in the months in which they reached both maximum (September–December) and minimum (June–July) numbers and biomass (Fig. 1B, D).

Across years, abundance and biomass of arthropods in pitfall traps reached high levels in late 2004 (abundance only), 2006, 2008, and 2011 (Fig. 2A, C). This coincided roughly with periods of high abundance and biomass in volant collections (Fig. 2B, D). Three of these years (2004, 2006, and 2011) were above-average rainfall years, suggesting that peaks in terrestrial and volant arthropods occur with about a 2–4 month time lag after the winter rainfall period. However, increases in years without high rainfall (e.g., terrestrial and volant insects in 2008) suggest that their abundance does not always track rainfall closely; a similar situation exists for soil seed densities (e.g., Meserve et al., 2011).