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Ecology

Seasonal variation of gastro-intestinal helminths of three bat species in the dry forest of western Mexico

Variación estacional de helmintos gastrointestinales en tres especies de murciélagos en el bosque tropical caducifolio del occidente de México

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Abstract

Studies on helminths of chiropterans are relatively uncommon compared to those of other animals, and seasonal changes in helminth load have been rarely examined. We characterized the gastro-intestinal helminth load of 3 bats species to test for the existence of seasonal changes in response to known seasonal environmental and bat prey fluctuations. We did not find seasonal variation in most of the cases. However, the prevalence of 4 endoparasite species was significantly higher during one of the seasons. The highest richness was registered in *Pteronotus parnellii* during the wet season. The effective number of species was higher during the dry season in the 3 species of *Pteronotus*. Diet seems to be an important driver of helminth infracommunity structure, but we found heterogeneous patterns in the relationship between diversity and load of helminths and seasonal patterns of bat's diets and abundance of potential intermediate hosts.

Keywords: Bat; Endoparasites; Interactions; *Pteronotus*; Seasonality

Resumen

Las investigaciones sobre los helmintos de quirópteros son relativamente escasas en comparación con las de otros vertebrados y los cambios estacionales en su carga han sido poco estudiados. En este estudio se caracterizó la carga de helmintos gastrointestinales de 3 especies de murciélagos para probar la existencia de cambios estacionales en respuesta a las fluctuaciones ambientales y de presas. No se encontró variación estacional en la mayoría de los casos. Sin embargo, la prevalencia de 4 especies de endoparásitos fue significativamente mayor durante una de las épocas. La mayor riqueza de especies se registró en *P. parnellii* durante la época de lluvias. El número efectivo de especies fue mayor durante estaciones secas en las 3 especies de *Pteronotus*. La dieta parece dirigir la estructura de las infracomunidades de helmintos, aunque se encontraron patrones heterogéneos en la relación entre la diversidad y la carga de helmintos y los patrones estacionales de la dieta y la abundancia de los posibles huéspedes intermediarios.

Palabras clave: Murciélago; Endoparásitos; Interacciones; *Pteronotus*; Estacionalidad

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Introduction

All organisms, including parasites, are influenced directly or indirectly by environmental variations (Marcogliese, 2001; Pilosof, Dick, Korine, Patterson, & Krasnov, 2012). The transmission, development and distribution of parasites can be regulated by abiotic factors (Brooks & Hoberg, 2007; Gotz, Harf, Sommer, & Matthee, 2010). In particular, dynamics of helminths are regulated by environmental conditions such as ambient temperature, humidity and precipitation (Appleton & Gouws, 1996; Doi & Yurlova, 2011; Hudson, Cattadori, Boag, & Dobson, 2006; Mouritsen & Poulin, 2002; Moyer, Drown, & Clayton, 2002; Tinsley et al., 2011). A few studies have also suggested that seasonal variation in parasite communities is influenced by biotic factors such as abundance, diet, reproductive behavior, and immunocompetence of hosts (Carvalho & Luque, 2011; Esch & Fernández, 1993; Felis & Esch, 2004; Šimková, Jarkovsky, Koubková, Barus, & Prokes, 2005).

Bats are one of the most diverse and widespread of mammal orders (Altringham, 1996; Wilson & Reeder, 2005). Studies of helminths in chiropteran populations are relatively uncommon compared to those of other animals (Kirschbaum, Perkins, & Gannon, 2009; Lord, Parker, Parker, & Brooks, 2012). Chiropterans harbor a great variety of helminths, including trematodes, cestodes, and nematodes (Cuartas-Calles & Muñoz-Arango, 1999; Lord et al., 2012) and most studies consist of checklists of species and new descriptions of host or localities (Guzmán-Cornejo, García-Prieto, Pérez-Ponce de León, & Morales-Malacara, 2003; McAllister, Bursey, & Dowler, 2007; Muñoz et al., 2011; Nahhas, Yang, & Uch, 2005; Nogueira, de Fabio, & Peracchi, 2004; Shimalov, Demyanchik, & Demyanchik, 2002). Nevertheless, a few studies have explored the effect of seasonal variation in intensity and prevalence of bat endoparasites (Blankespoor & Ulmer, 1970; Coggins, Tedesco, & Rupprecht, 1982; Lord et al., 2012; Nickel & Hansen, 1967). For example, studies with insectivorous bats have reported that prevalence and intensity of helminths are low during the spring, increase in the summer and reach a peak in the autumn (Blankespoor & Ulmer, 1970; Nickel & Hansen, 1967). Among other factors intrinsic to host biology, seasonal changes in endoparasite abundance might be related to increased abundance of arthropods that act as intermediate hosts and that are then ingested by bats (Lord et al., 2012).

Trematodes are the most diverse group of helminths found in bats (Coggins, 1988; Ubelaker, 1970). They are found mainly within the gastrointestinal tract and in other body cavities (Coggins, 1988; Ricci, 1995; Shimalov et al., 2002), and their incidence and prevalence are affected by the host's feeding habits (Coggins, 1988; Marshall & Miller, 1979). For example, most digenean species (trematodes) have been collected in insectivorous bats since they are more prone to ingest infected insects (intermediate hosts) than nectar or fruit feeding bats (Coggins, 1988; García-Vargas, Osorio, & Pérez-Ponce de León, 1996; Lord et al., 2012; Ubelaker, 1970). Studies with other vertebrates (e.g., fishes) have reported that the diet of the host determines the abundance and richness of helminths (Bell & Burt, 1991; Poulin & Morand, 2004; Šimková et al., 2005).

In this study, we investigated the seasonal variation of the endoparasitic load in 3 insectivorous [*Pteronotus davyi* (Gray), *P. parnellii* (Gray), and *P. personatus* (Wagner)] bat species. Previous studies have reported the helminthological record of these bats species in Mexico (Caballero-Caballero & Zerecero, 1942; Espericueta-Viera, 2012; García-Vargas et al., 1996; Guzmán-Cornejo et al., 2003; Peralta-Rodríguez, Caspeta-Mandujano, & Guerrero, 2012; Pérez-Ponce de León, León-Régagnon, & García-Vargas, 1996), but few have examined seasonal variations of infection patterns. For example, Clarke (2008) found no seasonal variation in endoparasite species composition of *P. davyi* and *P. personatus* and no seasonal difference in prevalence and abundance in a related species (*Mormoops megalophylla*) in a tropical deciduous forest in southern Mexico.

The study was conducted in a highly seasonal dry forest. Tropical dry forests have extreme changes in the physiognomy and availability of food resources during the wet and dry seasons, affecting the composition and diversity of fauna (Castaño-Meneses, 2014). For instance, the abundance of arthropods in tropical dry forests experiences considerable seasonal fluctuations, reaching its highest level during the wet season (Andresen, 2005; Castaño-Meneses, 2014; Güizado & Casas-Andreu, 2011; Leavings & Windsor, 1984), a pattern that has been previously reported for the study region (Pescador-Rubio, Rodríguez-Palafox, & Noguera, 2002).

A previous study using DNA barcodes showed that the diet of the 3 species of *Pteronotus* considered in our study is more diverse during the dry season (Salinas-Ramos, Montalvo, León-Regagnon, Arrizabalaga-Escudero, & Clare, 2015). For completing their transmission, some species of helminths use arthropods as intermediate hosts (Bush, Fernández, Esch, & Seed, 2001; Clarke, 2008) and insectivorous bats as definite host (Chitwood, 1938; García-Vargas, 1995). Accordingly, we predicted that the endoparasite load in insectivorous bats would exhibit seasonal changes, having the highest richness during the dry season (spring), when their diet is more diverse (Salinas-Ramos et al., 2015). In contrast, we expected that the prevalence, abundance and intensity of helminths would be higher in the rainy season, when the abundance of intermediate hosts peaks (Lord et al., 2012).

Material and methods

The 3 focal bat species roost in a cave in San Panchito Island, off the Pacific coast in Jalisco, Mexico (19°32′6″ N, 105°5′17.9″ W). The adjacent continental region is composed of tropical deciduous and tropical semideciduous forest (Rzedowski, 1981), with most of the rainfall occurring from July to November (Bullock, 1995; Méndez-Alonzo, Pineda-García, Paz, Rosell, & Olson, 2013; Pringle, Dirzo, & Gordon, 2012). We carried out 3 collecting trips during the dry season (spring: June 2012, April 2013, May 2014) and 4 in the wet season (summer: July 2013; autumn: November 2012, November 2013 and September 2014). Bats were collected with mist nests at sunset and with sweep nets inside the cave during the morning. All the specimens captured were adults and we held each individual in

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