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Variation in ectoparasite load in the Mehely's horseshoe bat, *Rhinolophus mehelyi* (Chiroptera: Rhinolophidae) in a nursery colony in western Iran

***Mozafar Sharifi, Najmeh Taghinezhad, Fatema Mozafari and Somaye Vaissi**

Razi University Center for Environmental Studies, Department of Biology, Baghabrisham 67149, Kermanshah, Iran

Abstract

We studied variation of ectoparasite load in a free ranging populations of Mehely's horseshoe bat (*Rhinolophus mehelyi*) on five successive occasions in a nursery roost in western Iran. In total, 87 *Rhinolophus mehelyi* were captured. The patterns of abundance differed greatly among parasite species but total parasite load was markedly higher in pregnant females in spring and early summer and lower in solitary males. On average, 90% of bats were infested by *Eyndhovenia* sp. with a mean intensity of 13.79 individuals per bat. *Penicillidia* sp. and one species from Streblidae were found in 66.7% and 11.49% of bats with parasite load of 2.31 and 1.8 parasite per bat, respectively. Using ratio of forearm length to body mass as an indication of bat health the correlation coefficient between parasite load and the health indicator was 0.002 for males and 0.06 for females indicating that parasite load has no apparent impact on bat's health.

Keywords

Ectoparasite, *R. mehelyi*, parasite load, prevalence, mean intensity, relative density

Introduction

A parasite is an organism that feeds at the expense of another species, but normally does not kill its host (Fitze *et al*. 2004). Ectoparasites live on the surface of a host and are dependent on the host to complete their own life-cycle (Guerrero 1998, Kutsch and Jones 2000). Ectoparasites normally use blood as the main food. Studies on various groups of vertebrates have shown that ectoparasite influence the host life (Kutsch and Jones 2000) as they can cause mortality, morbidity, reduce fecundity or regulate host population size and demographic characteristics. Parasites can even have an impact on host sexual selection and can select against inbreeding by hosts so that parasite resistance is increased (Luean 2006). However, exposure to parasites is responsible for the natural selection of very diverse behavioural adaptations and the immune system characteristics together with other physiological forms of resistance which finally enable the animals to survive and reproduce while interacting with their parasites (Fitze *et al*. 2004). Patterns of parasite abundance and prevalence are thought to be influenced by several host characteristics such as size, sex, developmental stage and environmental factors such as seasonality and climatic conditions (Moura *et al*. 2003).

Bats are one of the most diverse groups of mammals and they harbor many ectoparasites species (Moura *et al*. 2003). The arthropod ectoparasites of bats belong to a diverse group but they are not necessarily restricted to bats. So far 687 bat ectoparasite have been identified (Dick *et al*. 2003). These species belong to the Dermaptera, Hemiptera, Diptera and Siphonaptera orders from which six families are restricted to bats (Dick *et al*. 2003). Some authors have observed that there is a synchrony between host and parasite reproductive events and have concluded that this may be due to an increasing number of hosts suddenly available when birth takes place. There are also studies that have documented the relationship between the number of parasites and the condition of bat health (e.g., Glover 1962; Christe *et al*. 2000). Sharifi *et al*. (2008) showed that ectoparasite load in *Myotis blythii* reflects the life history traits in this species and the amount of parasite load has no apparent effect on the bat health. Other factors such as roosting habits, sexual dimorphism, social contact and activity pat-

*Corresponding author: sharifimozafar2012@gmail.com

tern of the host species may lead to differences in the abundance of ectoparasites.

There is limited information available about ectoparasite of bats from Iran. While the ectoparasites of some bat species may have been identified in Iran (Vatandoost *et al*. 2010) studies on quantitative relationships between ectoparasite and bat hosts are scarce. Therefore, our specific objectives in present study are to (i) identify ectoparasites of bats in the study area, (ii) quantitatively characterize parasite load, prevalence (percentage of infested bats) and relative density and (iii) identify relationship between parasite load and ratio of body mass to forearm length. In the present study, we also aim to explore the role of life history traits in hosts and the abundance of their parasites during a growing season.

Materials and methods

This study was conducted at Mahidasht Cave in Kermnashah Province, western Iran. Mahidasht cave (33°23´N and 47°30´E) has a small nursery colony situated at outskirt of the city of Kermanshah at a distance of some 10 km from the city centre. Mahidasht Cave has a winter temperature of 24±1ºC and relative humidity of more than 90% (Sharifi 2004). This cave is not used as a hibernaculum presumably because of its high temperature in winter. In several emerge counts performed in this cave it was seen that a population of approximately 700 bat of at least four species including *Myotis blythii*, *Rhinolophus mehelyi*, *Miniopterus schreibersii*, and *Myotis cappachinii*, roost in this cave. Kermanshah is amongst the medium-size cities in Iran which still support a diverse bat populations and most bats emerging from Mahidasht Cave were observed to heading toward the city (Sharifi and Hemmati 2004).

On 5 occasions (6th May, 3rd June, 1st July, 19th August and 15th September 2005) a total of 87 *Rhinolophus mehelyi* (64 males and 23 females) were captured using hand net as they roosted. In these studies upon capture, each bat was held in a separate, clean cloth bag and hanged at the entrance of the cave. The following data were recorded: date and locality, sex, weight, forearm length, reproductive stage for females (pregnant, non-pregnant) and developmental stage as juvenile and adult based on the presence or absence of an epiphyseal gap (Sharifi *et al*. 2008). During each bat inspection, the presence or absence of ectoparasites on pelage, ears, wings and tail membrane was recorded. In addition about 20 seconds was spent searching each bat for various ectoparasites by blowing the fur of bats. Bats were released after examination. Metrics to evaluate parasite impacts included relative density or parasite load (mean number of ectoparasites per bat), prevalence (percentage of infested bats) and mean intensity (mean number of ectoparasites per infested bat). Ratio of body mass to forearm length (W/F) was used as an indication of well being of the Mehely's horseshoe bat and effects of ectoparasite load was assessed by correlation coefficient between parasite load and the health indicator.

Results

On 87 *R. mehelyi* captured, 1227 ectoparasites were observed including 1075 *Eyndhovenia* sp., 132 *Penicillidia* sp. and 20 Strelidae. *Eyndhovenia* sp. was the most abundant ectoparasite and was often seen on the wing and tail membrane. *Penicillidia* sp. was found mainly on fur and Streblidae were distributed on all part of the body. Total number of infested bats with different ectoparasites species, ratio of male to female bats, relative prevalence as percentage of infested bats to total sampled bats, mean intensity of ectoparasite as mean number of ectoparasites per infested bat, and relative density or parasite load as mean number of ectoparasites per bat are shown in Table I.

In present study mean parasite load of three ectoparasite species for Mehely's horseshoe bat for two sexes was 17.12. Average difference between parasite load for male and female Mehely's horseshoe bat was not significantly different ($P<0.05$). Table II demonstrates percent prevalence, relative density and mean intensity of three species of ectoparasites occurring on adult males, adult females and juvenile Mehely's horseshoe bat sampled from Mahidasht caves in five occasions during spring and summer. Figure 1 demonstrates total parasite load of Mehely's horseshoe bat in different dates in Mahidasht cave. Relationships between the ratio of body mass (g) to forearm length (mm) against number of parasites on male and female Mehely's horseshoe bat is shown in Fig. 2. A rapid increase in parasite load was observed during summer months, with a peak occurring during the lactation period in May and June (Fig. 1). Average prevalence of total ectoparasite infection on *R.mehelyi* was 96% in males, 90% in females, and 100% in juvenile bats. Relative density male, female and juveniles are 15.14, 9.61 and 23.66, respectively. Mean intensity of parasites for these three

Table I. The percent of infected bats (prevalence %), number of ectoparasites per infected bats (mean intensity), and number of ectoparasites per bats (relative density or parasite load) for three species of ectoparasites found on *R. mehelyi*

Ectoparasite	Bat sex ratio M:F	Prevalence (%)	Mean intensity	Relative density
Eyndhovenia sp.	1:0.35	89.65	13.79	12.36
Penicillidia sp.	1:0.35	66.66	2.31	1.54
Streblidae	1:0.35	11.49	1.80	0.20

Table II. Percent prevalence, relative density and mean intensity of three species of ectoparasite occurring on Mehely's horseshoe bat from Mahidasht cave

Host		No. of ectoparasite	Prevalence (%)			Relative density			Mean intensity		
Parasite	Date		Male	Female	Juvenile	Male	Female	Juvenile	Male	Female	Juvenile
Eyndhovenia sp.	6/5/05	8	100	100		4.00	4.00	–	4.00	4.00	–
	3/6/05	4	–	100	–	–	4.00	–	–	4.00	–
	1/7/05	68	–	100	100	–	–	28.00	–	8.00	28.00
	19/8/05	184	100	–	–	12.26	–	–	12.26	–	–
	15/9/05	667	97.22	100	–	17.38	8	–	17.88	9.40	–
Penicillidia sp.	6/5/05	4	100	100	–	2.00	2.00	–	2.00	2.00	–
	3/6/05	–	–	–	–	–	–	–	–	–	–
	1/7/05	7	–	100	–	–	7.00	–	–	7.00	–
	19/8/05	19	66.66	–	–	1.26	–	–	1.90	–	–
	15/9/05	75	69.44	80.00	–	1.86	1.60	–	2.68	2.00	–
Streblidae	6/5/05	–	–	–	–	–	–	–	–	–	–
	3/6/05	–	–	–	–	–	–	–	–	–	–
	1/7/05	–	–	–	–	–	–	–	–	–	–
	19/8/05	2	6.66	–	–	0.13	–	–	2.00	–	–
	15/9/05	17	25.00	20.00	–	0.47	0.20	–	1.88	1.00	–

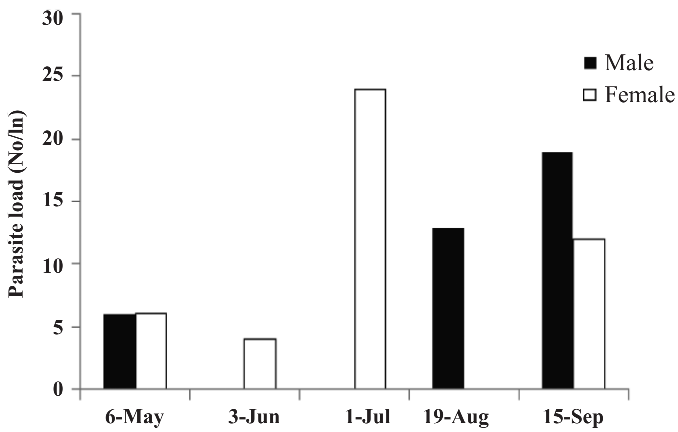

Fig. 1. Variation in parasite load for males and females *R. mehelyi* bat sampled from Mahidasht cave

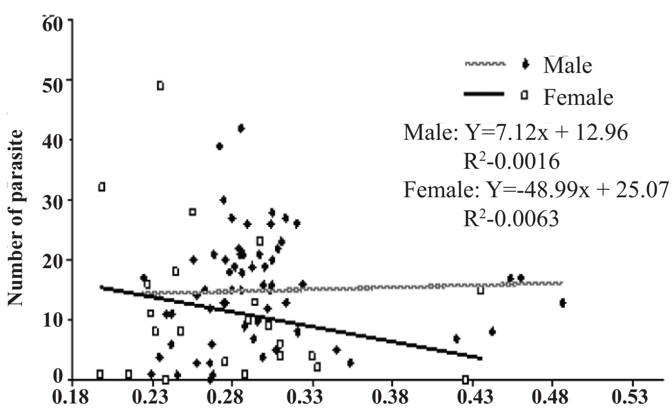

Fig. 2. Relationship between ratio of mass to forearm (W/F) and number of parasites in male and female *R. mehelyi*

groups are 15.63, 10.63 and 23.66. We found that the well being of the Mehely's horseshoe bat as reflected by the ratio of body mass to forearm length is independent of ectoparasite load. Using forearm ratio to body mass as an indication of bat health the correlation coefficient between parasite load and the health indicator was 0.0016 for males Mehely's horseshoe bat, 0.063 for females.

Discussion

The timing of ectoparasites intensity as related to their reproductive events showed that at four out of five sampling occasions (Fig. 1) significant difference exist between parasite loading in male and female *R. mehelyi*. A general similarity between ectoparasite load in male and female have also been observer in batfly parasites on some phyllostomid bats in Southeastern Brazil (Komeno and Linhares 1992). However, results of Dick *et al*. (2003) showed that relative density of ectoparasite load in several female bats from Central Pennsylvania is more than males. In an study on grooming behaviour and parasite load in the Greater horseshoe bat (*Rhinolophus ferrumequinum)* a significant difference between parasite load of male and female have been reported (Bertola *et al*. 2005).

There are contrasting reports on the relationships of ectoparasite load and host condition. Several studies have documented the negative relationship between the number of ectoparasites and the condition of the bats health (e.g., Dietz and Walter 1995, Kulzer 1998 and Christe *et al*. 2000). Parasites may affect host in different ways but generally health condition and parasite load of hosts may generate a feedback loop in which poor condition leading to increased parasitism leading to poorer condition (Whiteman and Parker 2004). Calvete *et al*. (2003) found that the relationship between body condition of host and the abundances of two species of lice were significantly inversely related. The patterns of distribution, assembly, and abundance of ectoparasite species has been broadly investigated and remains a focus of ongoing research (Czenze *et al*. 2011). However, there are other reports that have documented that ectoparasite load has no effect on health condition of host (Sharifi *et al*. 2008).

Major life history traits and annual activity for various species of bats occurring in the Mahidasht Cave have been studied. In early March a maternity colony of Mehely's horseshoe bat suddenly appears in this cave presumably by a rapid emergence from its winter hibernacula. Parturition occurs in early May, and young bats are suckled by their mothers for approximately 6 weeks (Sharifi 2004). Observations made at several caves in western Iran indicate that, similar to other temperate regions, a sudden increase in the numbers of cave-dwelling bats, including Mehely's horseshoe bat, occurs in early autumn. Following this autumn swarming period, bats seek refuge in caves to hibernate. At this time spermatogenesis is completed in late summer, and spermatozoa are stored in the cauda epididymides in males until copulation. Once mating occurs and females enter hibernation, sperm is stored during the winter months in the reproductive tract of females (Sharifi 2004). This typical activity patter of Mehely's horseshoe bat *R.mehelyi* as a cave dwelling bat provides uneven social contacts among bats which eventually can be reflected in the amount of ectoparasite load (Fig. 1). Such a relationship has been shown in other species of bat and also for the Lesser eared-mouse bat *Myotis blythii* in Mahidasht Cave (Sharifi *et al*. 2008).

There are other parameters that may have significant effect on the number of ectoparasites in a roost. Age of the colony, colony size and micro-climate in the cave might have an influence on levels of infestation of bats in a colony (Marshall 1982). According to Moura *et al*. (2003) patterns of parasite abundance and prevalence are thought to be influenced by several host characteristics such as size, sex, developmental stage and seasonality besides interactions between species (Moura *et al*. 2003). Dick *et al*. in 2003 have suggested that richness and diversity of bat ectoparasite assemblages may be related to many factors, including home range, behavior, size and roost type of the host. These factors may also result in differences in ectoparasite associations among host species, as well as between age or sex groups within a host species. Although it has been shown that host-grooming activities may reduce ectoparasite loads (Bertola *et al*. 2005), little is understood concerning the manner in which differences in other host characteristics affect population densities of ectoparasites, or the composition of species assemblages (e.g., species, age, and sex) on individual hosts (Dick *et al*. 2003).

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