RESEARCH NOTE

ARGASID AND SPINTURNICID MITE LOAD ON SWARMING BATS IN THE TATRA MOUNTAINS, POLAND

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Abstract: Altogether 445 bats, representing nine species, caught during swarming in the Lodowa Cave in Mount Ciemniak, Western Tatra Mountains, southern Poland, were examined for ectoparasitic mites. In total, 259 spinturnicid (*Spinturnix mystacina*, *S. andegavinus*, *S. kolenatii*, *S. plecotinus* and *S. myotis*) and 95 argasid (*Carios vespertilionis*) mites were collected from seven bat species, *Myotis myotis*, *M. mystacinus*, *M. brandtii*, *M. daubentonii*, *Eptesicus nilssonii*, *Plecotus auritus*, and *Vespertilio murinus*. There were sex-based differences in the prevalence of mites in some hosts but no differences in their mean intensity and there was no observed relationship between the number of mites and the condition of the bats. The prevalence of mites differed significantly between years in *E. nilssonii*. The results suggested a very low mite load on swarming bats that had no impact on the body condition of bats.

During summer and early autumn in the temperate zone of Europe and North America, a great number of bats visit caves, mines and other underground spaces. Bats pursue each other during this activity; other frequently observed phenomena are in-flights and out-flights through the entrances, social vocalisation and mating behaviour (Davis and Hitchcock 1965, Thomas et al. 1979, Parsons et al. 2003). Due to its mass nature, this activity is called swarming (Davis 1964).

Swarming is the sum of many processes and is connected with different functions. A few basic and not mutually exclusive hypotheses have been proposed to explain its role. One of them points to the function of swarming in mating (Thomas et al. 1979). Another stresses information transfer, whereby adult females show their young the location of winter quarters (Humphrey and Cope 1976). A third suggests that swarming sites serve as signposts and stopover places on the routes between summer and winter quarters (Whitaker 1998).

Many aspects of swarming have been described: for example, bat species richness and abundance, their night and seasonal activity (Horáček and Zima 1978, Parsons et al. 2003), the effect of climatic variables, altitude, moon phases and characteristics of cave structure (Karlsson et al. 2002, Glover and Altringham 2008, Berková and Zúkal 2009, Piksa et al. 2011), and the roles and functions of swarming (Davis and Hitchcock 1965, Thomas et al. 1979, Whitaker 1998). Given the mass nature of swarming and the high intensity of physical contacts among bats during swarming, one might expect it to play an important role in ectoparasite transmission, but little is known about the occurrence and load of ectoparasites on bats during this period.

Mites of the families Spinturnicidae and Argasidae are among the most frequently recorded ectoparasites of bats (Haitlinger 1978, Deunff and Beaucournu 1981, Zahn and Rupp 2004, Lučan 2006, Laurenço and Palmeirim 2007). Spinturnicid mites are permanent, obligatory and host-specific (i.e., mono- or oligoxenous) ectoparasites of bats (Rudnick 1960, Bruyndonckx et al. 2009). In Poland this family is represented by eight species (Ferenc and Skoracki 2000, Ferenc and Mysłajek 2003). Argasid (soft) ticks are non-permanent obligatory blood-sucking ectoparasites of vertebrates (Siuda 1991). Of the three species of this family recorded in Poland (Siuda 1993), only *Carios vespertilionis* was found parasitizing bats (Siuda et al. 2009). As very little is known about the occurrence of ectoparasites on bats during swarming, in this study we (1) identified spinturnicid and argasid mites parasitizing bats during swarming; (2) analysed basic infestation parameters as related to the species, sex and age of bat hosts; and (3) assessed whether the occurrence of these parasites affects the bats' body condition during swarming.

The Lodowa Cave in Mount Ciemniak located in the Western Tatra Mountains in southern Poland (49°14'N, 19°53'W) was chosen as the study site. The entrance to this ice cave is on the northwest slope of Mt. Ciemniak at 1715 m a.s.l. The length of known corridors is 390 m with 42 m of denivelation. It is the largest ice cave in Poland.

The study was carried out from July to October of 2008, 2009 and 2010. Bats were captured with a mist net (7 m or 6 m length; Ecotone, Poland) and identified to the species and sex. The age of bats was determined to as adults or juveniles (born that summer) by examination of the epiphyseal joints in the finger bones (Antony 1988). To ascertain the rate of re-captured bats, the animals were marked with non-toxic, alcohol-based colour marks. Quotient of body weight to forearm length was calculated as a Body Condition Index (BCI) (Speakman and Racey 1986). Spinturnicid mites and argasid ticks were collected using forceps and preserved in 70% ethanol. The research was carried out under permits from the Polish Ministry of Environment and the Tatra National Park.

Chi-square and Fisher's exact tests were used to check the significance of differences in the prevalence of mites between bats and between groups, and the Mann-Whitney U-test to compare the mean intensities of mites between sex and age categories. Spearman's rank-order correlation coefficient (Spearman's Rho) was used to examine the relationship between the BCI of bats and their mite load. Statistical analyses were conducted us-

Table 1. Spinturnicid and argasid mite load (prevalence and mean intensity) in the examined bat species. Mite and bat sample sizes (n) are given in parentheses. Recaptured bats were excluded from the analysis. Mean intensity calculations ignore zero values.

Bat species	Mite species	Prevalence %			Mean intensity		
		Bat males	Bat females	Test	Bat males	Bat females	Test
<i>Myotis mystacinus</i> (Kuhl) Adults	<i>Spinturnix mystacina</i> (Kolenati, 1857) (18)	9.8 (41)	36.8 (19)	$P < 0.05$	1.8	1.6	$Z = -0.472$ $P = 0.637$
<i>M. mystacinus</i> Juveniles	<i>S. mystacina</i> (20)	40.0 (10)	38.4 (13)	$P = 0.662$	1.8	2.6	$Z = 0.98$ $P = 0.327$
<i>M. mystacinus</i>	<i>Carios vespertilionis</i> Latreille, 1802 (82)	– (51)	3.1 (32)	–	–	82.0	–
<i>Myotis daubentonii</i> (Kuhl)	<i>Spinturnix andegavinus</i> Deunff, 1977 (24)	40.0 (10)	80.0 (5)	$P = 0.18$	3.0	3.0	$Z = 0.00$ $P = 1.00$
<i>Eptesicus nilssonii</i> (Keyserling et Blasius)	<i>Spinturnix kolenatii</i> Oudemans, 1910 (148)	20.4 (152)	55.9 (34)	$\chi^2 = 17.80$ $P < 0.001$	2.6	3.6	$Z = 0.720$ $P = 0.472$
<i>Plecotus auritus</i> (Linnaeus)	<i>C. vespertilionis</i> (1)	–	2.9	–	–	1.0	–
	<i>Spinturnix plecotinus</i> (Koch, 1839) (25)	17.6 (34)	45.5 (11)	$P < 0.05$	2.0	2.6	$Z = 0.822$ $P = 0.411$
	<i>Spinturnix myotis</i> (Kolenati, 1856) (1)	2.9 (34)	– (11)	–	1.0	–	–
<i>Myotis myotis</i> (Borkhausen)	<i>S. myotis</i> (21)	50.0 (2)	50.0 (4)	–	12.0	4.5	–
<i>Myotis brandtii</i> (Eversmann)	<i>S. mystacina</i> (2)	11.1 (9)	– (1)	–	2.0	–	–
<i>Vespertilio murinus</i> Linnaeus	<i>C. vespertilionis</i> (12)	– (3)	100 (1)	–	–	12.0	–

ing STATISTICA for Windows v. 9.0 package (Statsoft®, Inc., Tulsa, USA). Only bat species that were represented by both sufficient number of sex- and age- classes and mites collected were statistically analysed. Terminology of infestation parameters was based on Margolis et al. (1982) modified by Bush et al. (1997).

Altogether, 445 bats representing nine species, *Myotis myotis* (8 individuals), *M. nattereri* (4), *M. mystacinus* (87), *M. brandtii* (10), *M. alcahoie* (1), *M. daubentonii* (17), *Eptesicus nilssonii* (261), *Plecotus auritus* (53), and *Vespertilio murinus* (4), captured on 18 nights between 2008 and 2010 were examined.

A total of 259 spinturnicid and 95 argasid mites were collected from seven bat species; no mites were found on *M. nattereri* and *M. alcahoie*. The mite load varied considerably depending on bat species and their sex (Table 1).

In juvenile and adult *E. nilssonii* and *P. auritus*, and in adult *M. mystacinus*, there were significant differences in mite prevalence between males and females (Table 1). There were no sex-based differences in mite prevalence in *M. daubentonii* and in juveniles of *M. mystacinus*. In the latter species, mite prevalence was higher in juvenile males than in adult males (Fisher's exact test: $P = 1.00$ for juvenile females vs. adult females; $P < 0.05$ for juvenile males vs. adult males). Mean mite intensity did not differ significantly between the sexes (Table 1). In *E. nilssonii* there were significant between-year differences in mite prevalence (Chi-square test; $\chi^2 = 6.82$, $df = 2$, $P < 0.05$).

Spearman's correlation coefficient did not show any significant relationship between the number of mites and bat BCI (Spearman's Rho for *M. mystacinus* females: $r_s = -0.004$, $n = 34$, $P = 0.982$; for males: $r_s = -0.164$, $n = 41$, $P = 0.306$; for *E. nilssonii* females: $r_s = -0.308$, $n = 30$, $P = 0.098$; for males: $r_s = -0.094$, $n = 149$, $P = 0.254$).

Carios vespertilionis was recorded three times from three bat species (Table 1), with a notable intensity of 82 larvae on a young *M. mystacinus* female (19 September 2008). The body weight and BCI of this bat were the lowest of all the *M. mystacinus* females (weight = 3.7 g, BCI = 0.11 vs. other females weight_{mean} = 5.52 g, BCI_{mean} = 0.16).

Despite many years of research on a variety of aspects related to bat swarming, little is known about ectoparasite loads and the effect of ectoparasites on the body condition of swarming bats (e.g., Poissant and Broders 2008). In this three-year study at a single swarming site we gathered and analysed data on mite loads and their possible effects on bats' body condition. Overall, the most prevalent ectoparasites were spinturnicid mites. The load (intensity) of these mites fluctuates seasonally through the bats' annual cycle (Deunff and Beaucomurnu 1981, Lučan 2006, Lourenço and Palmeirim 2007). Their prevalence is lowest during bat hibernation; then it increases and peaks during the nursing season, then decreases during the period of autumn movements and mating (= swarming) (Zahn and Rupp 2004, Lučan 2006, Lourenço and Palmeirim 2007). In line with that scenario, our study demonstrated that for most bat species the mite loads were very low during swarming.

In this study, we recorded considerably lower numbers of mites on bat males than on females. This pattern is consistent with other findings: the intensity and prevalence of ectoparasite infestation were usually higher in females and juveniles than in males (Haitlinger 1978, Zahn and Rupp 2004, Lučan 2006, Christe et al. 2007). Such a discrepancy seems attributable to two factors. The crucial one may be the difference in lifestyle between females and males during the period of activity. Males of most bat species live solitarily or in small groups and often switch shelters, while females usually stay in one or a few shelters where they form breeding colonies, give birth and live in close proximity to their juveniles (Dietz et al. 2007). Consequently, females and juveniles are more prone to vertical and horizontal transmission of ectoparasites (Christe et al. 2000). The lower intensity of male infestation with ectoparasites may also be related to the nature of swarming. This activity takes place at cave entrances and other swarming sites in late summer and autumn. The participants are primarily males. They often travel long distances to swarming sites; during swarming they usually do not forage but chase each other, displaying mating behaviour (i.e., copulation and social vocalisation) (Davis and Hitchcock 1965, Thomas et al. 1979, Whitaker 1998). This ac-

tivity is therefore costly in terms of energy expenditure. Late summer and autumn is also the period of intense foraging of bats in order to accumulate fat reserves before the forthcoming winter (Ewing et al. 1970). Presumably, males in poorer body condition (e.g., with more ectoparasites) are forced to devote more time to foraging, while individuals in good body condition and with large energy reserves can afford to swarm; hence the high numbers of such bats in swarms.

Our analysis of the influence of ectoparasite load on the body condition of swarming bats did not confirm a negative impact. Other work done during comparable periods – during autumn movements and the mating season – also showed no such relationship in most groups of bats (Zahn and Rupp 2004, Lourenço and Palmeirim 2007). Only Lučan (2006) reported a negative impact of *Spinturnix andegavinus* on body condition in juvenile females of *Myotis daubentonii* during the post-lactation period, that is, a time corresponding to the swarming period. The lack of effect of mite infestation on the body condition of bats in our study can be explained by its low intensity. To observe an adverse effect, the intensity of infestation presumably must be considerably higher, on the order of tens of ectoparasites (Giorgi et al. 2001, Zahn and Rupp 2004, Lourenço and Palmeirim 2007). It cannot be ruled out that in bats the presence of ectoparasites may be only an indicator rather than the cause of poor physical condition (Marshall 1982, Zahn and Rupp 2004). Note, however, that Giorgi et al. (2001) demonstrated in laboratory experiments that bats with high numbers of mites lose more energy and weigh less than bats without mites, and suggested that the impact of mites may be even more pronounced in natural conditions.

Carios vespertilionis is distributed throughout Poland, with most localities recorded in the south (Siuda et al. 2009), but we rarely recorded it in the present study. Unlike *Spinturnix* mites, it is a periodic burrow-nest-dwelling parasite. It appears briefly on the host for between a few and ten days during bat feeding (Belashova 1966, Filippova 1966). Its annual activity peaks during spring and summer (Belashova 1966), when its highest infestations have been observed (Zahn and Rupp 2004). The short duration of its residence on bats, and time differences between the bat swarming period and the peak of *C. vespertilionis* activity explain the low incidence of this ectoparasite. Given high infestation by this species, its presence might be expected to be particularly detrimental to the body condition of the parasitized bats.

In summary, the present study demonstrated that the ectoparasitic infestation of bats during swarming was very low and had no impact on the body condition of parasitized bats. This appears to be due to several reasons: (1) a general annual pattern of the ectoparasite load which is low in the late summer and autumn; (2) the lower ectoparasite prevalence and intensity on males that may result from their lifestyle; and (3) maybe also nature of the swarming activity itself. Due to the high energetic costs of swarming, bat swarming can be afforded predominantly by individuals in good body condition, thus predisposing individuals without ectoparasites, or parasitized at low levels.

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