THE ACARINIA AND NYCTERIBIDIA ZONES OF MINIOPTERUS SCHREIBERSI KUHL (MAMMALIA: CHIROPTERA) IN THE NORTHEAST OF SPAIN

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Abstract. Acarinia and nycteribidia zones of the bat species *Miniopterus schreibersi* Kuhl are studied in an area of northeast of Spain, where captures over a period of five years have been carried out. The species that characterize the mite-tick spectrum are *Ixodes (Pomerantzevella) simplex, Macronyssus longimanus, Macronyssus granulosus* and *Spinturnix psi;* nycteribidium is determined mainly by the presence of *Nycteribia schmidlii.* The life cycle, prevalence, curves of parasitation, and other notes on these most abundant ectoparasites are provided, as well as observations on other ticks, mites, and nycteribiid species found on this bat.

Spinturnicidae, Macronyssidae, and Nycteribiidae are specialized mite and insect ectoparasites of bats, which together with some other species of Ixodoidea and Siphonaptera conform the acarinia+insectaria zones of bats all over the world. With a few exceptions, field observations of the biology, life cycle and ecology of these parasites have been cursory and incidental to collecting activities. Previous studies on the acarinia zone of bats have been conducted by Dusbábek (1964a, 1971, 1972) in Central Europe. The first extensive study of the biology of spinturnicid activities based on field observations is by Deunff and Beaucournu (1981); these authors, studying several species on their respective hosts, were able to compare parasite life-cycles as well as adaptations and interactions between different spinturnicid mites.

During an in-depth study of the ectoparasitic spectrum of *Miniopterus schreibersi* Kuhl in Spain conducted over five years, we have followed-up several colonies of this bat species, mainly for migratory and biological purposes. A high number of mites, ticks, and insects (up to 5,000) were collected in this time. This paper deals with the life cycle, location on hosts, incidence and prevalence of the most common ectoparasite species on *Miniopterus schreibersi* in Cataluña (northeast of Spain). Data for accidental parasites and the probable causes of adventitious parasitism, are also outlined here.

MATERIALS AND METHODS

The collecting sites of *Miniopterus schreibersi* are located along the Northeast of Spain (Cataluña) in about 32 colonies, some of them used as hibernation refuges and others as breeding colonies. The colonies were visited every month through 1985–1989.

Bats were hand collected, properly manipulated to ensure no stress and carried alive to a mobile laboratory. The bats were anesthetized and the ectoparasites removed by trained laboratory staff.

Special attention was paid to collect all the mites, ticks, fleas, and nycteribiids; parasites were stored separately for each host and body area (patagium, uropatagium, head, body, etc.). Bats were also weighted and measured and, after recovery, released. Because the parasites were removed from the living hosts, some groups of mites of small size such as Myobiidae and Chirodiscidae were only collected irregularly. Although the bats were also observed under a stereomicroscope with low magnification, it is possible that not all specimens of these mites were found. In this way, data for these species are not included here.

Other bat species were also collected when found together with *M. schreibersi*, and, in the same way, ectoparasites removed and properly stored. This procedure allows us to know the acarinia and nycteribidia zones in the complex of bat species living in the northeast of Spain.

RESULTS

1) Parasites collected on *Miniopterus schreibersi*

In the five years of study, 1,534 *M. schreibersi* were collected, of which ectoparasites were removed in the 77.78 %; the 22.22 % were negative to the presence of external parasites. The collected mites, ticks, and nycteribiids were *Eyndhovenia euryalis euryalis* and *Spinturnix psi* (Spinturnicidae), *Macronyssus cyclaspis, M. granulosus, M. longimanus, M. rhinolophi, M. diversipilis,* and *M. ellipticus* (Macronyssidae), *Ixodes (Eschatocephalus) vespertilionis* and *I. (Pomerantzevella) simplex simplex* (Ixodidae), *Penicillidia dufouri* and *Nycteribia schmidlii* (Nycteribiidae).

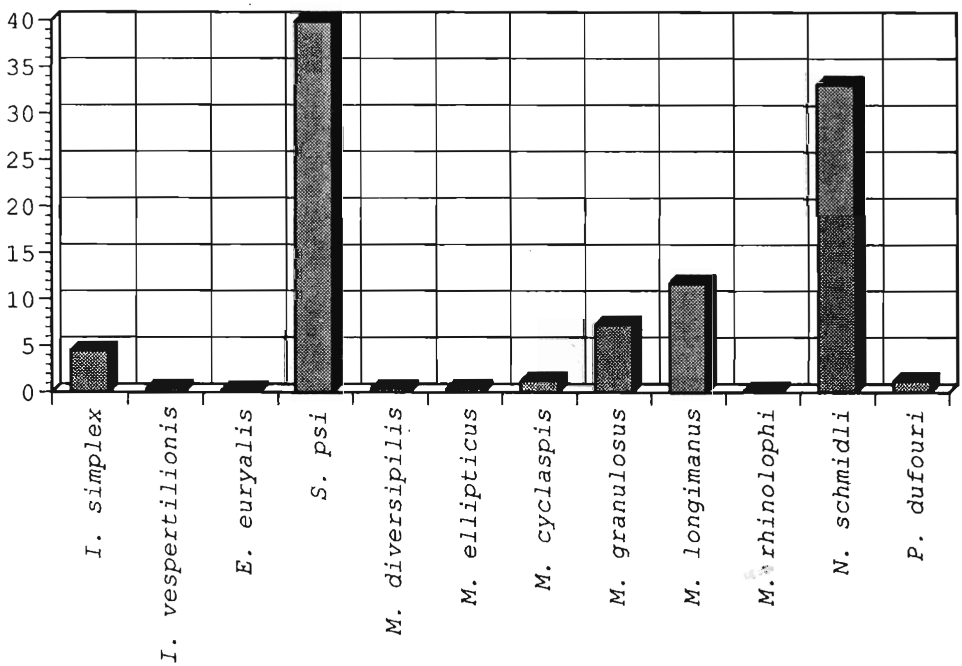


Fig. 1. Percentage of hosts infested with each species of parasite, of the total of positive hosts.

The percentage of hosts infested with each species, on the total of positive hosts, is shown in Fig. 1. The high prevalence of both *S. psi* and *N. schmidlii* must be noted, as well as the relatively low prevalence of *Macronyssus* species, even *M. longimanus* and *M. granulosus*.

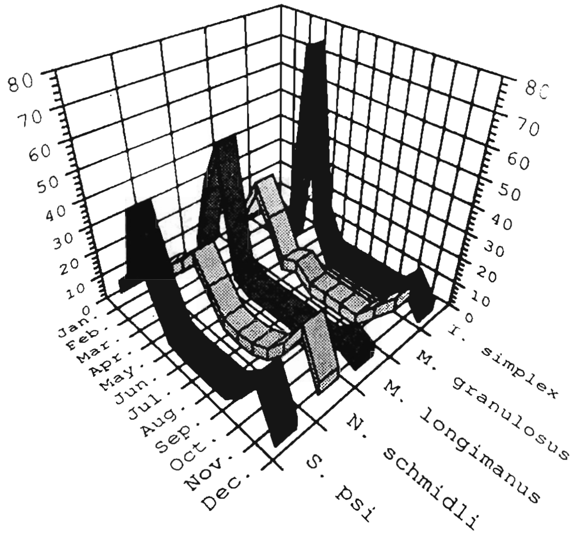
The different ectoparasites recorded here must be determined as "specific" or "adventitious" for *M. schreibersi*. In the first group, *S. psi, I. simplex*, and *N. schmidlii* are included. The second category is that of those species commonly removed from other bat species, as *Rhinolophus ferrumequinum, R. euryale, R. hipposideros, Myotis emarginatus*, and *M. myotis*, scarcely collected on *M. schreibersi*. As mentioned above, these adventitious parasites, commonly removed from other cave dwelling bats, are not longer included in the main body of this paper. A third category of mites is that of some cave dwelling mites; both *Macronyssus granulosus* and *M. longimanus* were collected in great numbers on *M. schreibersi* with no records on other bat species. In such a way, both species are included in the main body of this paper.

Spinturnix psi was always collected on the patagium, although a low number of specimens (1.12 %) were removed from the hair in the lateral areas of the body. These captures were not related with cases of high parasitation nor other host-derived causes (age, sex, etc.). No *S. psi* specimens were observed on the uropatagium. Macronyssid mites (*M. longimanus* and *M. granulosus*) were collected mainly on the patagium (60.02 %), with specimens on tail membrane (32.55 %) and some captures on the hairs of the body (7.43 %). *I. simplex* was always collected under the lower lip, without specimens in other body areas commonly parasitized with ixodid ticks, as the ear. Finally, *N. schmidlii* was primarily removed from between hairs of the body (100 %).

2) **Seasonal dynamics**

Here, data for *S. psi, M. longimanus, M. granulosus, I. simplex*, and *N. schmidlii* will be included. The evolution of effectives of these parasites throughout the year is displayed in the Fig. 2, as the percentage of population of each species collected in every month.

Although evident differences are observed between these ectoparasites, a main pattern can be deduced from this figure. The great proportion of effectives is concentrated in the winter months (from January to March) with a second peak at the autumn (October–November). In July, all the species included here are absent on *M. schreibersi*. Variations to this pattern are noticed both in the absolute population peak and in the number of months without parasites on the hosts. The two macronyssid species display their population maxima in March, although *M. granulosus* is absent between July and October, and *M. longimanus* did not appear between May and October. *N. schmidlii* is absent only in July, with two periods of high prevalence, between late February to April, and in October to November. *I. simplex* concentrates the effectives in the late spring, with a second small peak in the autumn. In the same way, *S. psi* shows a two-peak population.



Month	N. of collected hosts
Jan.	271
Feb.	184
Mar.	161
Apr.	130
May.	64
Jun.	44
Jul.	41
Aug.	50
Sep.	80
Oct.	184
Nov.	144
Dec.	181

Fig. 2. Comparative life-cycle of the five more prevalent parasite species on *Miniopterus schreibersi.* Data are included as the percentage of parasites population of each species (on the total of parasites) collected in every month. Number of hosts collected each month are in the table.

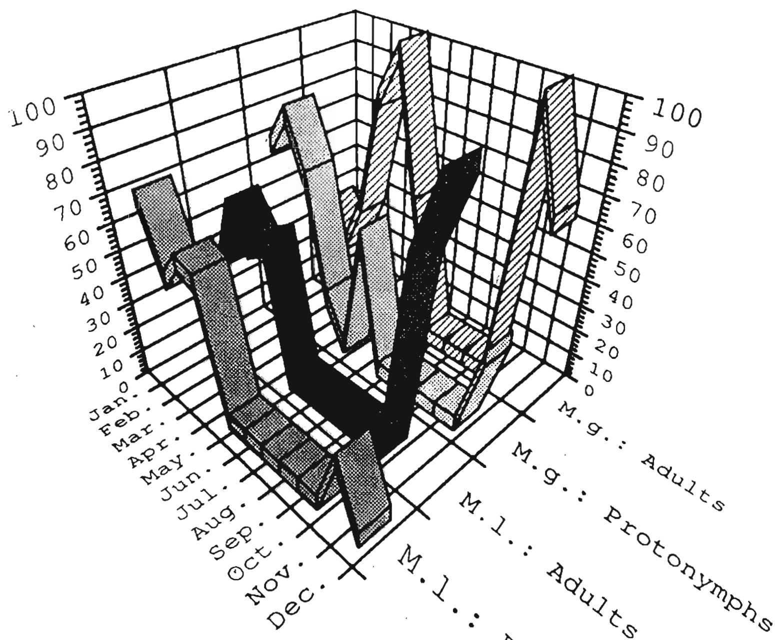


Fig. 3. The life-cycle of *Macronyssus granulosus* (M. g.) and *Macronyssus longimanus* (M. l.) all over one year. Data are included as the percentage of specimens of one stage (protonymphs or adults) on the entire population of each species, collected in one month.

Fig. 3 includes the variations in the percentage of adults and protonymphs on the total population of *M. longimanus* and *M. granulosus,* collected each month. Both species show a similar pattern, although, as mentioned above, effectives of *M. granulosus* can be collected through May and June, while *M. longimanus* did not appear on the hosts as soon as in April. From the winter to mid spring, number of adult stages of *M. granulosus* increases, while that of protonymphs clearly decreases to April, with a small increment just before the summer. Likely, non-feeding deutonymphs are the remnant stage in the summer, because no parasitic stages were detected in the warm season, and only adults have been collected at the start of the new activity season. The sex ratio (male-female) of *M. granulosus* for the entire year is 0.33.

In the same way, an interchange protonymph-adult-protonymph is observed for *M. longimanus* between January and April; however, this transition between the parasitic stages is much faster than that observed for *M. granulosus*. The nonmotile deutonymph seems to be the stage present in the summer, because captures of parasitic stages on the hosts stopped soon after April, and started again in November. In this species, the sex ratio for the entire year is 0.66.

The life cycle of *S. psi* through an entire year is included in the Fig. 4; for this species, data for pregnant females and molting immatures are also considered.

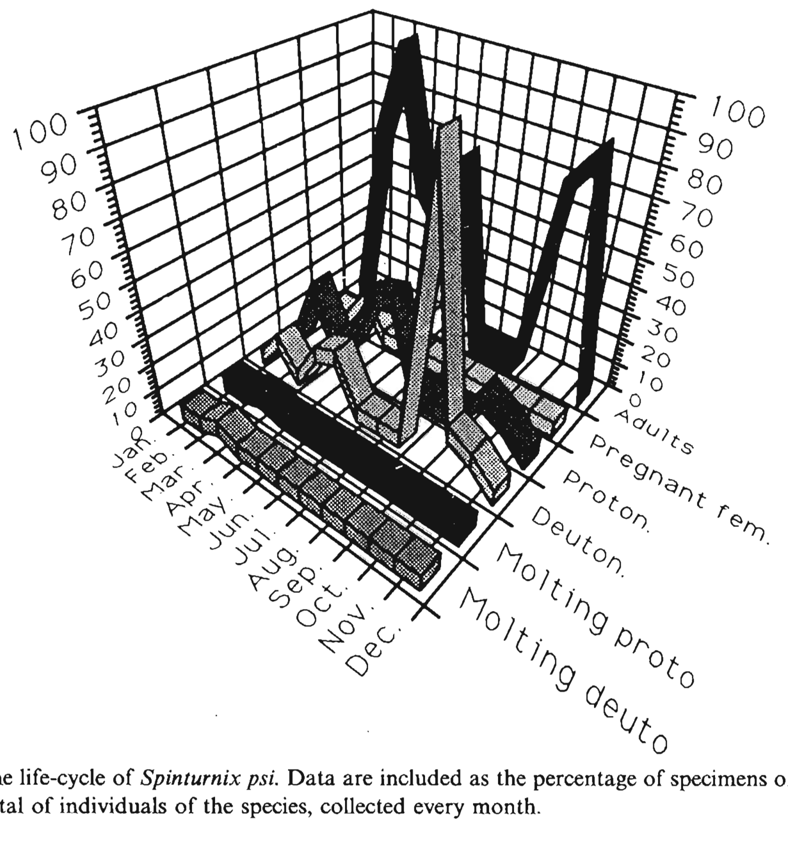


Fig. 4. The life-cycle of *Spinturnix psi.* Data are included as the percentage of specimens of each stage on the total of individuals of the species, collected every month.

There are two main periods of activity of the adult stage, between February and June, and in October–November. The highest values for protonymphal stage are observed also in February and in June. On the other hand, deutonymphs are observed in appreciable numbers only in early autumn (September). The low number of pregnant females as well as molting immatures collected on the hosts is a striking feature. Only small percentages from the total spinturnicid population, corresponding to these stages, have been picked off the hosts in April. Almost the same number of males and females of this species have been collected in the study period, the sex ratio being of 0.99.

3) Distribution of parasites among the hosts

Data of the distribution of *I. simplex*, *M. granulosus*, *M. longimanus*, *S. psi*, and *N. schmidlii* among hosts are presented in Fig. 5; these histograms display the values as the percentage of hosts with 1, 2, ..., n parasites.

Two types of parasitic distributions can be noted. In the first, recorded for *I. simplex* and *M. granulosus*, parasites are overdispersed on their hosts, a high number of bats having a low number of parasites with no intense parasitations. In the second, reported here for *M. longimanus*, *N. schmidlii*, and *S. psi*, a high number of parasites concentrate on a low number of hosts.

DISCUSSION

An acarinium is a group of mesostigmatid mites that are parasites of a certain terrestrial vertebrate and live in its nest (Rosický 1959). The determination of

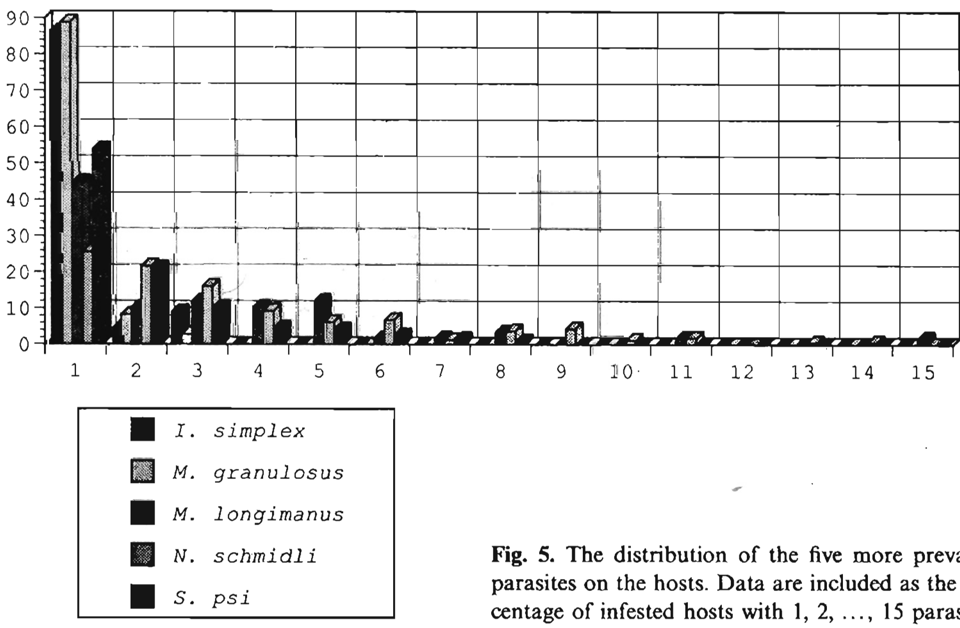


Fig. 5. The distribution of the five more prevalent parasites on the hosts. Data are included as the percentage of infested hosts with 1, 2, ..., 15 parasites.

such as natural synecological unit seems to be very useful in the characterization of acarinia zones (Rosický and Mrciak 1967). Such a characterization is poorly known for the bat ectoparasites today. Nycteribiids also seem to play an important role in the characterization of bat parasites; only one flea specimen was collected in this study, and no further discussion will be included here on Siphonaptera.

In the study area, the cave bat roosts together with *Rhinolophus euryale, R. ferrumequinum, R. hipposideros, Myotis emarginatus* and *M. myotis*. In this way, several species, as *Eyndhovenia euryalis euryalis, Ixodes vespertilionis, Macronyssus ellipticus,* and *M. rhinolophi* have been collected commonly on rhinolophids which live in colonies close together with *M. schreibersi*. On the other hand, *Macronyssus diversipilis* and *Penicillidia dufouri* are common parasites of *Myotis* spp. *M. cyclaspis* has been recorded in Spain and some other European countries (Dusbábek 1962, 1964b, Estrada-Peña et al. 1989) on several genera of bats, as *Barbastella, Eptesicus, Myotis, Pipistrellus,* and *Plecotus,* being a much less specific species. Far more important is the question whether an exchange takes place of some parasitic mites and insects between hosts of different species belonging to a certain ecological group of hosts which are either related from a taxonomic viewpoint or leading the same way of life from an ecological viewpoint.

As already mentioned, behavioural components of rhinolophids seem to play an important role in some kinds of aberrant parasitism. *Rhinolophus euryale* breeds in colonies, in opposition to the "hermit" behaviour of other *Rhinolophus* species. Sometimes, we have collected specimens of *R. euryale* touching with their wings other specimen of *M. schreibersi*. Under these conditions, passing of the parasites from the main host to the aberrant one may be easy. *Spinturnix* mites are very specific parasites, *S. myoti* and *S. emarginatus* being collected only from their main hosts in the study area; a few specimens of *S. myoti* have been already reported on *M. schreibersi* at Balearic Islands (Estrada-Peña et al. 1989). The presence in our samples of typical parasites of *Myotis* spp. may be due only to sharing the same biotope, because colonies of these species are not physically related in the cave habitat. The relatively high prevalence of *Penicillidia dufouri* must be noticed. Both *Macronyssus longimanus* and *M. granulosus* must be regarded as polyxenic-troglophilic species, associated with a certain type of microbiotope, which infest practically all bat species inhabiting caves (Dusbábek 1964a, b). In our collections, these two macronyssids were not observed on *Myotis myotis,* commonly found together with the cave bat.

The presence of other parasites through the European range of *M. schreibersi* has been noted for species as *Argas vespertilionis* (Aellen 1949, Dusbábek 1963) and *S. myoti* (Juvara 1967); to the date, *E. euryalis* has not been recorded on this bat species. This group of mites, in contrast with the specific main mites, are determined as secondary mites or secondary members of the acarinium.

The only field study on the life cycle of spinturnicid mites is that of Deunff and Beaucournu (1981), and for nycteribiids, those reviewed by Marshall

(1970, 1982). Observations on ecology and activity of *I. simplex* were mainly done by Beaucournu (1967). All the considered parasitic species concentrate their effectives in the colder months, with no population on the hosts in July. This fact is in direct opposition to other field studies mentioned above, in which *S. psi* reaches the maximum in the summer. Also, although the biology of *I. simplex* is not yet well know, some effectives were collected in summer months, as mentioned in the recopilatory paragraph of Arthur (1955), and the work of Beaucournu (1967). On the other hand, a variation of this pattern is currently observed at Castanya mines (Barcelona province, Spain), a summer refuge of *M. schreibersi.* As already mentioned (Estrada-Peña et al. 1991), *S. psi* reaches its maximum in the summer in this cave, but this feature is not observed for the remaining caves included in our study. We do not know at present time the reasons for the differences in the life cycle. Truly, a lower number of bats were collected in the summer months. Also, migratory habits of the species are marked by the very different use of biotopes depending on the seasonal requirements of the biological cycle; on the other hand, the different winter and summer caves are clearly separated one from each other. As a summary, *S. psi* reaches the maximum at the end of the hibernation period of the hosts, in our study area.

The two *Macronyssus* species have a very similar life cycle. For both species, a non-motile, non-feeding deutonymph is the resistance stage found in the summer, which explained the absence of parasitic stages collected during these months. However, Radovsky (1985) mentioned that deutonymph is a relatively brief stage and, because preimaginal feeding is concentrated in a single period of contact with the host, protonymphs have a prolonged feeding stage. According to Dusbábek (1972), intensive reproduction of both *Macronyssus ellipticus* and *M. cyclaspis* takes place in winter shelters; on the basis of a three-peak curve of maximum occurrence of protonymphs on hosts, Dusbábek (1972) presumed the existence of three generations during the winter season. *M. longimanus* concentrates the parasitic stages between November–April, with only one population peak and protonymphs occurring mainly in the middle of the cycle. The feeding of *M. longimanus* in winter refuges in Spain and the colder climatic conditions, reflect the paucity of its life cycle, with only one generation per year. On the other hand, *M. granulosus* is a summer species, as also mentioned by Dusbábek (1972). In our study area, *M. granulosus* is characterized by a two-peak cycle, with adults in April–May and November–December, and protonymphs mainly in January–February and May–June. The structure of macronyssid acarinium seems to be affected by the seasonal migrations of *M. schreibersi.* However, the types of shelters have little influence, because this bat has only been collected in cave refuges.

The parasites studied here display the typical distribution of other mites on their hosts (Randolph 1975, Lanciani and Boyett 1980). The differences observed between species can be attributed to the relative prevalence of each parasite. In this way, *I. simplex* and *M. granulosus* have very "short" distributions with only 1–3 specimens on one host. However, *M. longimanus, S. psi,* and *N. schmidlii* are very abundant species, and "long" distributions are observed, with high parasites numbers on one host. The data of *M. longimanus* merit special attention. Although *M. longimanus* is only slightly more prevalent than *M. granulosus*, effectives of the first species can be collected in a greater number of hosts. This observation seems to be directly correlated with the type of cycle of both species. As already mentioned, *M. longimanus* reaches the maximum in the winter, when larger colonies of bats are observed; on the other hand, *M. schreibersi* is dispersed at summer refuges, and *M. granulosus* displays a short distribution because the small size of the colony. Such observations agree with the ecological assessment of colonies of Central–European populations of bats made by Gaisler (1966) and included in the characterization of the acarinia zone of bats in Central Europe by Dusbábek (1972).

The data included here are the first for the dispersion of a nycteribiid on its natural host. As well as the high prevalence of this species on *M. schreibersi*, a long distribution must be noticed, which denote the specific behaviour of this parasite toward its host. As already mentioned, the nycteribiid is present almost all the year, with independence of the kind of activity of the host (breeding, hibernation, etc.). *S. psi* is more prevalent than *N. schmidlii* and smaller numbers of mite specimens are observed on each host; bats with one spinturnicid are more abundant than those carrying one nycteribiid. Hosts with as high as 14 nycteribiids have been collected, while the highest category for the distribution of *S. psi* is 8.

Clearly, the elucidation of the exact nature of host associations is not easy. Furthermore, past discussions have often been based on inaccurate data obtained from museum collections. It is believed that the comparison of acarinia zones through the range of a bat species, may lead to a great knowledge of the host-parasite relationships.

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