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Bat Ectoparasites of Mongolia, Part 3

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Bat Ectoparasites of Mongolia, Part 3 [1]

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Abstract

The fauna of Mongolian bats and their ectoparasites is not yet fully documented. This study analyzes ectoparasite samples of 15 bat species from diverse taiga, steppe, and desert locations. We recorded 27 parasite species in total and report their abundance, host preference, and occurrence herein. In describing a new bat fly species (*Basilia dolchii* n. spec.), reporting six parasite species never before recorded in Mongolia, and examining rare host species such as *Myotis frater* and *Murina hilgendorfi,* this work expands present knowledge in this research area. To assess respective individual and species-specific parasite loads comprised of different insects or mites, we introduce a parasite body size dependent model.

Key words: bats, ectoparasites, Nycteribiidae, Ischnopsyllidae, Cimicidae, Macronyssidae, Spinturnicidae, Mongolia

1. Introduction

This study relates to existing research into the fauna of Mongolian bats and their ectoparasites. The nocturnal nature of bats and their flying lifestyle complicate direct observation in natural habitats while foraging, and necessitates special equipment or acoustic techniques for their capture and determination. In recent years, research of species composition in both bat and parasite species has progressed (DOLCH et al. 2007; SCHEFFLER et al. 2010, 2012). However, the low number of studies overall requires considerably more investigation.

Bat ectoparasites must endure extreme living conditions. They inhabit a difficult to reach host that frequently changes sleeping spots or quarters and usually rests well above the ground. Bat body temperature varies considerably, and can fall from normal (35-40° C) to outside temperatures during torpor. In winter, bats hibernate several months at temperatures just above 0°C. Parasites inhabiting the coat or wing membrane must affix themselves thoroughly during flight and grooming, so as not to risk removal by either action. However, the relatively long host life span and regular aggregation of many host individuals in nursery quarters benefits parasites. Currently known ectoparasites of Mongolian bats either inhabit their coat (bat flies, bat fleas, coat mites = Macronyssidae), ears (ear mites = *Trombicula* species), wing membranes (Spinturnicidae), or resting quarters (true bugs). We expect a species-specific parasite composition for each of the 19 Mongolian bat species known to date. However, robust, more detailed data only exist for a few species that are more common: *Myotis aurascens, M. gracilis*, *M. petax*, *Plecotus ognevi* and *Vespertilio murinus.*

2. Materials and Methods

This study drew on parasite samples from the substantial collection of Jargalsaikhan Ariunbold and Idertsogt Bolorchimeg (2011-2014) and field excursions by the Regional Commitee of Mammalogy Brandenburg = LFA (16 August - 13 September 2014) and Beatrix Wuntke (14 July - 30 July 2014). Annegret & Michael Stubbe also provided samples collected in August 2010. Bats were caught with nets and kept separated by species until examination for ectoparasites. Using

[1] Results of the Mongolian-German Biological Expeditions since 1962, No. 341.

forceps, parasites were collected from each bat and preserved in vials with 70 % ethanol (see details in SCHEFFLER et al. 2010). Each vial contained all parasites from one animal and was labeled with the location, date, gender, and host species name. Sample processing followed in the laboratories of Potsdam University.

Bat flies were directly analyzed under a stereo microscope, mostly not requiring mounting. Where body or extremities showed strong deformation, submerging specimens into a hot KOH solution (5-10 % at 60-70 °C) for 30 minutes allowed for sufficient expansion and stretchability.

All other specimens were bleached in KOH: fleas and wing mites in a 10 % solution at 60° C and coat mites at room temperature, while frequently monitoring their state. Subsequent rinsing in distilled water to remove KOH and dehydration with alcohol preceded embedding in Canada balsam (fleas) or Hoyers's medium (Spinturnicidae, Macronyssidae).

With respect to assessing and comparing intra- and interspecific ectoparasite loads, we considered that various parasite species might inhabit the same host either singularly or in combination. The literature largely negates this problem and most parasitology studies only focus on a single parasite group or species. Simply summarizing all ectoparasites occurring on one bat does not adequately characterize that individual's parasite load. Very likely, diverse families or species of bloodsucking insects exert varied negative effects on host animals. For example, a large louse fly produces a larger amount of salivary secretion, a larger wound, and a larger volume of blood loss, when compared to a much smaller wing mite. Even though we cannot incorporate all influencing parameters (sucking frequency, sex differences, among others), using a body size dependent parasitization-factor aims at describing a host's parasite load more objectively. Calculating this factor for a given parasite species involves squaring the arithmetic mean of the average body lengths of both sexes. The resulting numerical value approximates respective parasite body volumes. Small mite species varying little in body size, and we applied a standardized value to each mite family.

Each parasite species is assigned a parasitization value, resulting from multiplying the number of parasites with the species-specific parasitization-factor described above. The sum of all parasitization values then yields the individual bat's specific parasite load.

(*parasite load: PL = ∑ number of parasites of a particular species x parasitization-factor*)

Example:

A bat carries 2 x *Basilia mongolensis* and 12 x *Spinturnix kolenati*. This individual's parasite load calculates: 2 x 4.0 + 12 x 0.81 = 17.72, where 4.0 and 0.81 represent calculated parasitization-factors from averaged male and female body lengths of each species (see table 1). Because of such calculation, the parasite load of individuals and host species can be quantitatively assessed and compared when various ectoparasite groups or species are present.

Table 1: Calculated parasitization-factors for Mongolian bat ectoparasites

Ectoparasite species	**Length (L) in mm**	**P-factor (L^2)**	**Ectoparasite species**	**Length (L) in mm**	**P-factor (L^2)**
Cimex lectularius/pipistrelli	4,80	23,04	*Mydopsylla trisellis*	2,25	5,06
Penicillidia monoceros	4,00	16,00	*Ischnopsyllus hexactenus*	2,30	5,29
Basilia mongolensis	2,00	4,00	*Ischnopsyllus obscurus*	3,00	9,00
Basilia dolchi	2,35	5,52	*Ischnopsyllus elongatus*	3,15	9.92
Basilia truncata	2,35	5,52	Macronyssidae (all species)	0,65	0,42
Nycteribia quasiocellata	2,10	4,41	Spinturnicidae (all species)	0,90	0,81
			Trombicula	0,46	0,21

Measurements our own and after RUDNIK (1960), THEODOR & ROTHSCHILD (1967), and STANYUKOVICH (1997).

Table 2: List of sampling sites

ID	Site	Date	Host species
01	Batschireet-Barchiin bridge 48°36.972' N; 110°11.743' E	19./20.8.2014	*E. nilssonii, M. gracilis, P. ognevi*
02	Buural cave 48°48.636' N; 111°05.254' E	21.8.2014	*P. ognevi*
03	Balj-gol, Dadal 49°03.416' N; 111°34.356' E	23.8.2014	*E. nilssonii, M. hilgendorfi, M. gracilis, M. ikonnikovi, M. petax, P. ognevi*
04	Balj-gol, NW Dadal 49°05.001' N; 111°28.195' E	24.8.2014	*E. nilssonii, M. leucogaster, M. frater, M. gracilis, M. ikonnikovi*
05	Onon-gol 48°50.879' N; 111°39.868'E	25.-26.8.2014	*M. gracilis, M. ikonnikovi, M. petax, P. ognevi*
06	Saynshand 45°13.899' N; 110°10.309' E	28.8.2014	*E. gobiensis, V. murinus*
07	Khövsgol 44°15.523' N; 109°44.722' E	29.8.2014	*E. gobiensis*
08	Hatnii Bulag spring 43°00.222' N; 108°54.528' E	30.8.2014	*E. gobiensis, V. murinus*
09	Khanbogd SW 43°09.099' N; 107°08.165' E	02.09.2014	*V. murinus*
10	Mandakh E 44°22.052' N; 108°19.697' E	05.09.2014	*E. gobiensis, V. murinus*
11	Herlenbayan-Ulaan/Kherlen-gol 47°13.768' N; 108°36.614'E	09.09.2014	*M. aurascens, P. ognevi*
A1	Tuv aimag, Batsumber sum, Ulgii gol 48°32'02.8" N; 106°51'14.0" E	10.06.2014	*M. bombinus*
A2-3	Selenge aimag, Mandal sum, Eruu gol, Berlegiin tsagaan tohoi 49°06'28.1" N; 107°05'06.3" E	18./19.06.2014	*M. ikonnikovi, M. gracilis*
A4	Selenge aimag, Khuder sum, Khuder gol 49°49'10.44" N; 107°28'13.56" E	21.06.2014	*M. brandtii (gracilis)*
A5	Selenge aimag, Baruunburen sum 49°29'36.5" N; 105°02'00.7" E	07.2014	*M. frater*
A6	Selenge aimag, Khuder sum, Tshu gol 50°02'34.8" N; 107°06'22.50" E	23.06.2014	*M. petax*
A7	Darkhan uul aimag, Shariin gol 49°45'26.10" N; 106°10'00.30" E	26.06.2014	*M. petax*
A8	Tuv aimag, Batsumber sum, Kharaa and Ulgii gol 48°32'02.8" N; 106°49'29.5" E	05.06.2013	*P. ognevi*
A9	Umnogovi aimag, Gurvantes sum, Khurshuut bulag 43°00.951" N; 100°59.692" E	27.07.2014	*P. kozlovi*
A10	Selenge aimag, Mandal sum, Eruu gol, Berlegiin tsagaan tohoi 49°06'28.1" N; 107°05'06.3" E	19.06.2014	*E. nilssonii*
A11-12	Umnogovi aimag, Gurvantes sum, Deliin us 42°58'492" N; 100°40'008" E	30.07.2014	*E. gobiensis, E. turcomanus*

A13 A16	Bulgan aimag, Teshig sum, Erengiin gol 50°11'34.76" N; 102°53'31.41" E	20./19.06.2013	*M. hilgendorfi, M. petax*
A14	Bulgan aimag, Teshig sum, Zalman, Erengiin gol 49°58.627" N; 102°42.533" E	18.06.2014	*E. nilssonii,*
A15	Tuv aimag, Batsumber sum, Ulgii gol 48°32'02.8" N; 106°51'14.0" E	10.06.2013	*M. bombinus*
A17 A20	Tuv aimag, Batsumber sum, Kharaa gol 48°31'57.4" N; 106°49'29.5" E	04./05.06.2014	*M. petax, M. brandtii (gracilis)*
A18-19	Khuvsgul aimag, Ulaan uul sum, Khug gol 50°59'47.22" N; 99°10'24.67" E	12.07.2013	*M. petax, M. brandtii (gracilis)*
A21	Bulgan aimag, Teshig sum, Erengiin gol 50°11'34.76" N; 102°53'31.41" E	19.06.2014	*M. brandtii (gracilis)*
A22	Ulaanbaatar 47°55'27.44" N; 106°48'36.79" E	02.08.2013	*V. murinus*
A23	Ulaanbaatar, Hujirbulan 47°55'15.2" N; 107°04'25.0" E	21.07.2012	*V. sinensis*
A24-25	Tuv aimag, Erdene sum, Tereljiin guur 047°49.305" N; 107°19.563" E	01.07.2012	*E. nilssonii, M. aurascens*
A26	Umnugovi, Bulgan sum, Bayanzag 44°10.119' N; 103°42.120' E	23.06.2012	*E. gobiensis*
A27	Bulgan aimag, Bayan-Agt sum, Hanui river, Tsagaan gol 49°10'05.90" N; 102°20'58.10" E	12.07.2012	*M. ikonnikovi*
A28-30	Tuv aimag, Altanbulag sum, Hustai National Park 47°41'406" N; 105°54'499" E	2011-2012	*M. aurascens, P. ognevi, M.petax*
T1-2	Khakhorin 47°09.246'N; 102°47.507'E	14./15.07.2014	*P. ognevi, M. gracilis*
T3	Khanui 48°58.096'N; 102°08.628'E	17.07.2014	*M. aurascens*
T4-5	Frontier area to Russia 50°09.676'N; 102°44.436E	20.07.2014	*M. petax*
T6-7	Hutag ondör 49°23.266'N; 102°52.234'E	22.07.2014	*M. petax*
T8	Terelj 47°49.771'N; 107°19.132'E	30.7.2014	*M. petax*
S1	Uenč-gol 45°59'1,3''N; 91°57'46,6''E	09.08.2010	*N. noctula*
S2	Bodončijn-gol 45°46'09,1''N; 92°10'57,7''E	10.08.2010	*Plecotus* spec., *Myotis (aurascens?)*
S3	Taacijn-gol 45°55'33,1''N; 101°26'54,2''E	15.08.2010	*E. gobiensis*

1-11: collection of LFA-expedition 2014; A1-30: collection of J. Ariunbold;
T1-8: collection of A. Wuntke; S 1-3: collection of A. &. M. Stubbe.

3. Results

3.1. Ectoparasite hosts and their distribution

Identified bat flea species

Ischnopsyllus elongatus (CURTIS, 1832)
ex *Nyctalus noctula* ID: S1 (1♀)

Ischnopsyllus hexactenus (KOLENATI, 1856)
ex *Plecotus spec*. ID: S2 (1♀) ; ex *Plecotus ognevi* ID: 05 (1♀); A29 (1♀); T1 (2♀); ex *Murina hilgendorfi* ID: A13 (2♂, 3♀); *ex Eptesicus nilssonii* ID: A14 (1♀); A24 (1♀); ex *Myotis ikonnikovi* ID: 02 (1♀)

Ischnopsyllus obscurus (WAGNER, 1898)
ex *Vespertilio murinus* ID: 10 (4♀); A22 (2♂, 2♀)*; ex Eptesicus nilssonii* ID: A24 (1♂, 1♀)

Mydopsylla trisellis JORDAN, 1929
ex *Myotis gracilis* ID: A3 (2♂, 6♀); A4 (1♀); A21 (2♂, 2♀); A20 (3♂, 2♀)**;** ex *Myotis petax* ID: 05 (6♂, 9♀), A17 (1♂, 2♀); A18 (1♀); A30 (2♂, 3♀); T8 (1x); ex *Myotis aurascens* ID: A28 (2♀)

Known Mongolian bat fleas include six species to date. Here, we report new evidence for three species: *Ischnopsyllus hexactenus*, *I. obscurus* and *Mydopsylla trisellis.* As per their host specificity, Mongolian species of *Ischnopsyllus hexactenus* were most often encountered on *Plecotus ognevi.* Additional hosts included *Myotis aurascens*, *M. bombinus*, *M. gracilis*, *M. ikonnikovi*, *M. petax* and *Eptesicus nilssonii* (SCHEFFLER et al. 2010, 2012). Our finding of *I. hexactenus* on *Murina hilgendorfi* represents a new record for this host species. *Ischnopsyllus obscurus* uses *Vespertilio murinus* as main host*,* with occasional occurence on *Eptesicus nilssonii,* as now confirmed by several independent records. From previous studies, *Mydopsylla trisellis* seems to prefer *Myotis gracilis.* As shown by several independent results, further hosts include *Myotis petax* and *M. aurascens*. New for Mongolia is the finding of *Ischnopsyllus elongatus*. This flea is an ectoparasite exclusive to the Common noctule, whose range includes large regions of Eurasia. Hence, encountering this ectoparasite species was not surprising, probably only reflecting a lack of records and parasitological studies on this bat in Mongolia.

Identified bat fly species (Nycteribiidae)

Basilia mongolensis mongolensis THEODOR, 1966
ex *M. aurascens* ID: S2 (1♂, 4♀)

Basilia dolchii n. spec.
ex *Myotis aurascens* ID: 11 (2♂, 1♀); ex *Myotis bombinus* ID: A1 (2♀); ex *Myotis petax* ID:T6 (1♂, 2♀)

Basilia truncata THEODOR, 1966
ex *Myotis aurascens* ID: A25 (1♂); A28 (6♂, 10♀); T3 (1♀); ex *Myotis bombinus* ID: A15 (2♂); ex *Myotis petax* ID: 05 (2♂); A 17 (1♂)

Nycteribia quasiocellata THEODOR, 1966
ex *Myotis petax* ID: 05 (5♂, 9♀); A6 (1♂, 2♀); A7 (5♂, 4♀); A17 (13♂, 19♀); A18 (4♂, 6♀); A30 (7♂, 12♀); T6 (6♂, 4♀); T8 (1♀); ex *Myotis aurascens* ID: A28 (3♂, 1♀); ex *Myotis ikonnikovi* ID: 03 (3♂, 2♀)

Penicillidia monoceros SPEISER, 1900
ex *Myotis petax* ID: 05 (4♂, 8♀); A17 (2♂, 3♀); A18 (1♀); A30 (1♂); T6 (1♀)

This study provides records of all known Mongolian bat flies. The three smaller species described by THEODOR (1966) (c. 2mm body length) showed clear host preferences: *Basilia m. mongolensis* and *Basilia truncata* most frequently occured on *Myotis aurascens.* Yet, both bat flies never simultaneously inhabited the same host individual. Previous range data (SCHEFFLER et al. 2010) suggest a geographical separation into western (*B. m. mongolensis*) and eastern distributions (*B. truncata*). *Nycteribia quasiocellata* prefers *Myotis petax* as main host. This bat often concurrently harbors Mongolia's largest bat fly species: *Penicillidia monoceros,* measuring 4-5 mm in length.

Both *Myotis bombinus* and *Myotis petax* presented with several specimens of a bat fly formerly undescribed for Mongolia. At 2-2.5mm in length, its body size hardly exceeds that of the three species described by THEODOR (1966), but is significantly smaller than *Penicillidia monoceros.* Presence of eyes place it in the genus *Basilia*. Female tergal plate chaetotaxy (Fig. 1) differs from that of *B. mongolensis* and *Basilia truncata* (THEODOR 1966: fig. 9 & fig. 1), where claspers and spiny protuberances of the 5th sternite in males also provide further clearly distinguishable features characteristic of both above species (THEODOR 1966: fig. 7 & fig. 12). Neither the works of THEODOR (1967) nor those of HŮRKA (1984) mention this fly, which we recognized as a new species. The species was named after the bat researcher Dietrich Dolch. At first glance, *Basilia dolchii* resembles some features of the Middle European *Basilia nana.* However, morphological differences in the male clasper tip and female 2nd tergite chaetotaxy clearly mark them as separate species. Furthermore, *Basilia nana* is a parasite specific to *Myotis bechsteinii*, a bat species absent from Asia.

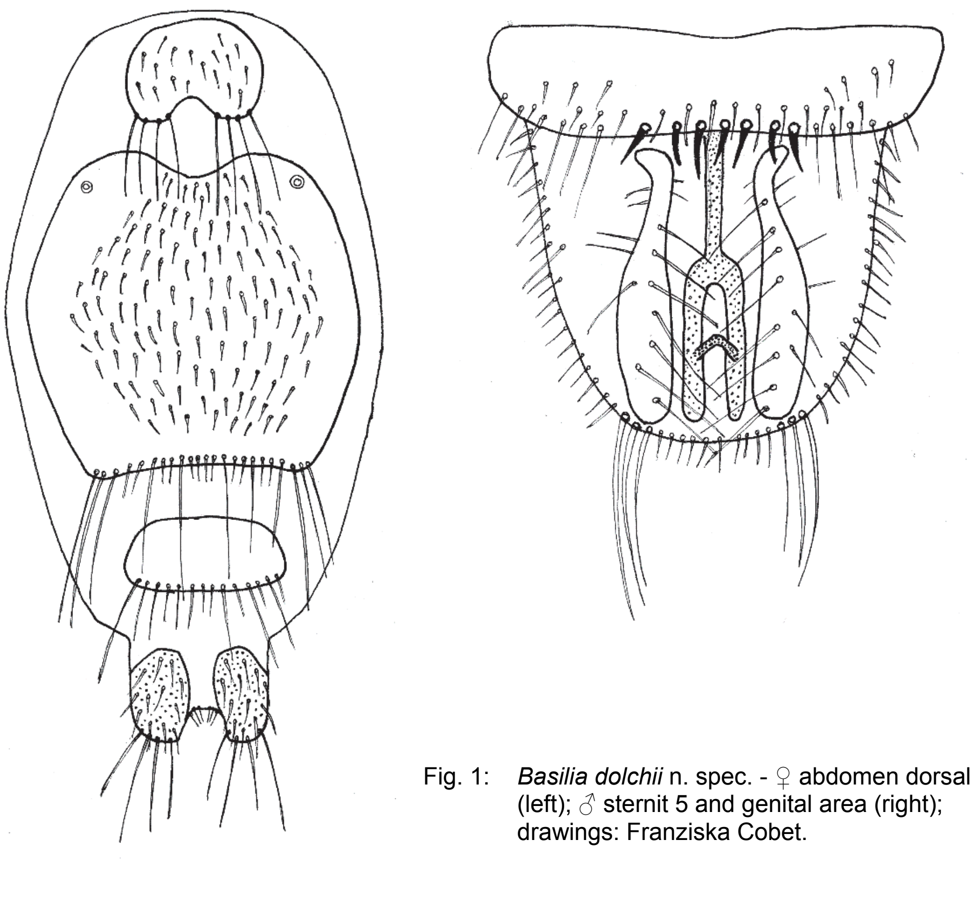

Fig. 1: *Basilia dolchii* n. spec. - ♀ abdomen dorsal (left); ♂ sternit 5 and genital area (right); drawings: Franziska Cobet.

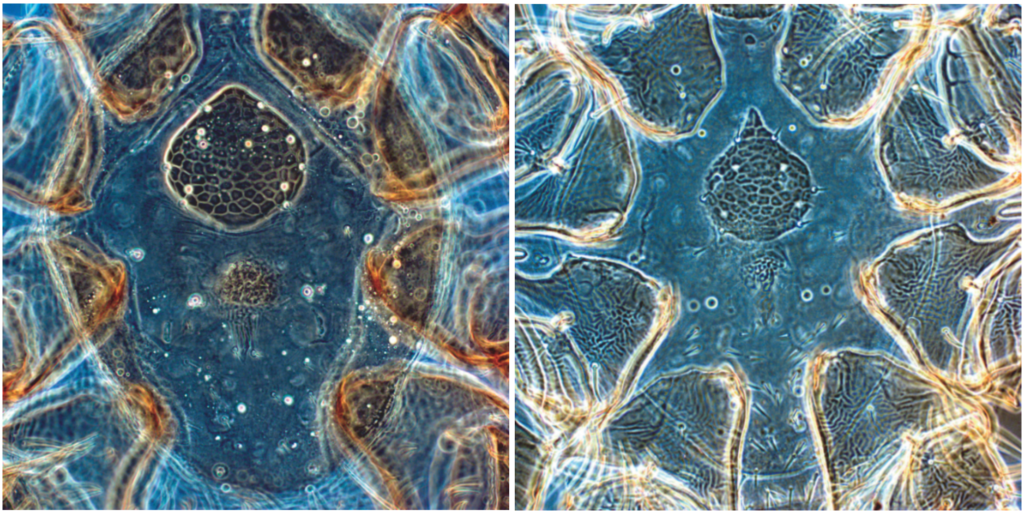

Fig. 2: ♀ ventral site, with sternal shield of *Myotis bombinus* (left) and *Myotis frater* (right); photos: I. Scheffler.

Identified true bug species

Cimex lectularius-typ
ex *Eptesicus nilssonii* ID: A10 (2♂)

SCHEFFLER et al. 2012 reported the present state of information on Mongolian bat bugs. Records to date include occurrences on *Myotis aurascens, M. daubentonii, M. gracilis, Eptesicus gobiensis* and *Vespertilio murinus*. Here, we document *Eptesicus nilssonii* as another additional host species.

Identified species of mites (Spinturnicidae)

Spinturnuix “frater”
ex *Myotis frater* ID: 04 (1♂, 1♀); A5 (1♂)

Spinturnix kolenati OUDEMANS, 1910
ex *Eptesicus nilssonii* ID: 04 (2♂, 2♀); A10 (5♀, 3N); A14 (2N); A24 (16♂, 14♀, 21N); ex *Eptesicus gobiensis* ID: 06 (2♂, 2♀); 08 (15♂, 16♀, 4N); 10 (13 ♂, 10♀, 3N); A11 (2♂, 1♀); A26 (1♀); ex *Eptesicus turcomanus* ID: A12 (9N)

Spinturnix myoti-Group

a) “petax–typ”
ex *Myotis petax* ID: 04 (2♂, 2♀); 05 (18♂, 33♀, 8N); A6 (2♂, 1♀, 1N); A17 (2♀, 2N); A18 (6♂, 9♀, 10N); A30 (5♂, 6♀, 13N); T6 (4♂, 5N); T8 (2♂, 1♀, 12N); ex *Myotis ikonnikovi*: ID: 03 (4♀, 1 N)

b) “bombinus-typ”*:* ex *Myotis bombinus* ID: A1 (1♂, 2♀, 3 N)

Spinturnix mystacinus (KOLENATI, 1857)
ex *Myotis ikonnikovi* ID: 05 (1N); A2 (1♂, 1♀, 9L); A27 (1♂); ex *Myotis gracilis* ID: 03 (3♂, 1♀); 04 (5♂, 8♀, 1N); 05 (1♂, 4♀); A3 (9♂, 17♀, 13N); A4 (2♂, 4♀, 12N); A21 (9♀) ; A20 (4♀, 1N); T1 (1♂); ex *Myotis aurascens* ID: 11 (2♂, 3♀); A28 (7♂, 12♀, 27N)

Spinturnix plecotinus (KOCH, 1839) (= *Spinturnix plecotinus ognevi*, Scheffler et al. 2012)
ex *Plecotus spec.* ID: S2 (3♂, 13♀s, 3N); *ex Plecotus ognevi* ID: 02 (1♀, 1N); 05 (4♂,5♀); 11 (1♂, 1♀, 1N); A8 (2♂); A29 (4♂, 1♀); ex *Plecotus kozlovi* ID: A9 (2♂, 1L)

Spinturnix maedai UCHIKAWA & WADA, 1979
ex *Murina hilgendorfi* ID 04 (2 N)

Fig. 3: *Macronyssus spec*. ex *Murina hilgendorfi* (left); sternal plate (right).

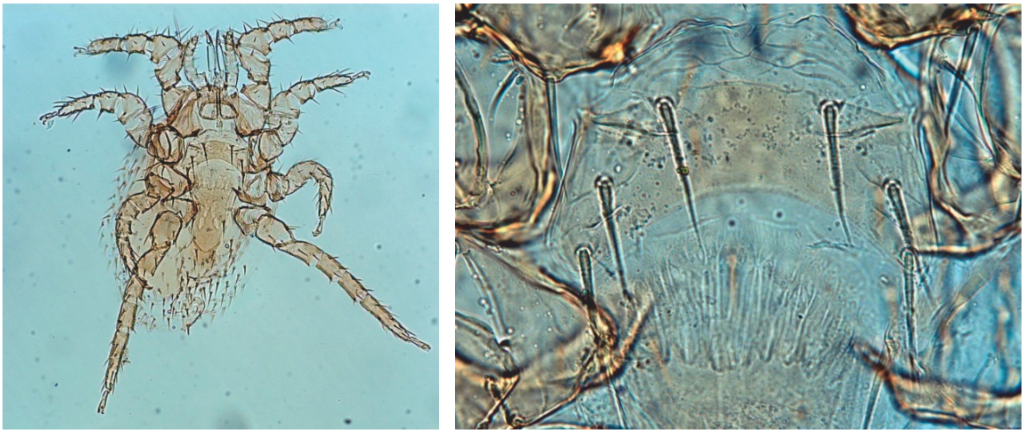

Fig. 4: *Macronyssus hosonoi* (left), Sternal plate of the female (right).

Mites of the familiy Spinturnicidae belong to the most frequent bat parasites, easily visible on glabrous wing membranes. Closely related bat species often carry the same wing mites. Examples include *Eptesicus* bats caught in this study harboring *Spinturnix kolenati, Plecotus* species carrying *Spinturnix plecotinus* and "moustache bats" (*Myotis aurascens*, *M. gracilis,* and *M. ikonnikovi*) with *Spinturnix mystacinus*. We also frequently observed specimen of the *Spinturnix myoti-group* (*S. "petax*" SCHEFFLER et al. 2012) on *Myotis petax*. This wing mite is smaller than the European *Spinturnix myoti,* and females exhibit fewer dorsal (n = 70-77) and ventral (n = 41-64) abdominal setae, compared to the ancestral form. We view finding a few females of this wing mite on *Myotis ikonnikovi* as rather conincidental, probably resulting from switching host animals during body contact between two different bat species. Of the six wing mite specimens found on *Myotis bombinus,* only one qualified for mounting. It turned out a female showing typical traits of the *Spinturnix myoti–group*: genital shield without setae, and dorsal abdomen with numerous setae (here n = 82) decreasing in length going inward. However, ventral chaetotaxy differed clearly (fig. 2). Whereas *S. "petax"*-types such as the European *S. myoti* usually carry 70+ setae of various lengths (25-45 µm) on their ventral abdomen, the *Myotis bombinus* specimen only exhibited

34 setae of equal length (25 µm). Confirming these differences requires further parasite samples from this host species. We collected three spinturnicids (two males, one female) from *Myotis frater,* a bat species rarely caught so far. The sternogenital shield structure in male mites represents a clearly distinct trait, and we identified them as *Spinturnix frater* (SCHEFFLER et al. 2012).

However, with 82 setae of varying size on the dorsal abdomen, and 34 short ventral setae of equal length, and absent genital shield setae, female chaetotaxy more closely resembles that of the spinturnicid specimen from *Myotis bombinus.* Yet, the genital shield is clearly more pointed and shows a finer mesh structure (fig. 2). Lastly, we caught two spinturnicid nymphs on *Murina hilgendorfi,* most likely classifiable as *Spinturnix maedai.*

Identified mites, family Trombiculidae

Trombicula spec.
ex *Plecotus spec*. ID: S2 (5N); ex *Plecotus ognevi* ID: 05 (3N); ex *Vespertilio murinus* ID: 08 (2N);ex *Eptesicus gobiensis* ID 10:(2N)

Identified mites, family Macronyssidae

Macronyssus hosonoi UCHIKAWA, 1979 (= *Ichronychus hosonoi*?)
ex *Myotis gracilis* ID: 04 (1♀); ex *Myotis ikonnikovi* ID: A2 (2♀), A13 (1♀)
*Macronyssus charusnurens*is DUSBABEK, 1966
ex *Myotis petax* ID: A8 (3♀); A17 (1♂, 2♀, 2N); A18 (3♀); ex *Vespertilio murinus* ID: A9 (1♀); ex *Myotis bombinus* ID: A1 (1♀)

Macronyssus “gracilis” SCHEFFLER et al., 2012
ex *Myotis gracilis* ID: A1 (5♀); A15 (1♂, 1♀)

Macronyssus “frater”?
ex *Myotis frater* ID: A12 (1♂, 2♀)

Macronyssus heteromorphus DUSBABEK & RADOVSKY, 1972
ex *Myotis aurascens* ID: A28 (1♀)

Macronyssus murini UCHIKAWA, 1979
ex *Murina hilgendorfi* ID: A13 (2♀)

Macronyssus “nilssoni” SCHEFFLER et al., 2012
ex *Eptesicus nilssonii* ID: A24 (1♀); A10 (2♀); ex *Myotis gracilis* ID: A3 (1♀)

Steatonyssus spinosus WILLMANN, 1936
ex *Vespertilio murinus* ID: A22 (15x, mounted 5♀); ex *Vespertilio sinensis* ID: A23 (2♀);
ex *Eptesicus nilssonii* (3♀)

Steatonyssus superans ZEMSKAJA, 1951
ex *Vespertilio murinus* ID: A22 (1♀); ex *Vespertilio superans* ID: A23 (8x, mounted 3 ♀)

Individuals of smaller mite species usually pose the greatest difficulty for mounting and identification. Four bat parasitizing mite species have been described for Mongolia: *Macronyssus charunurensis*, *M. flavus, Steatonyssus mongolicus* and *S. periblepharus* (DUSBÁBEK 1966, STANYUKOVICH 1997). Analyzing samples from the last Mongolia excursion in 2011, we could identify *Macronyssus charunurensis* and *Steatonyssus mongolicus* (SCHEFFLER et al. 2012). There was also evidence of additional species, which we called *Macronyssus “gracilis”, M. “ikonnikovi”, M. “nilssonii”,* and *M.“petax”,* after their respective host species. The results reported herein and an extended literature search to include studies from China and Japan allowed us to determine and confirm further mite species for Mongolia: *Macronyssus murini*, *Steatonyssus spinosus, S. superans,* and *Macronyssus heteromorphus.* In females, *Macronyssus heteromorphus* shows similarity to what we identified as *Macronyssus “gracilis”* (SCHEFFLER et al. 2012). However, males clearly differ, requiring further clarification. Three mite specimens collected off *Myotis frater* resembled the common species *Macronyssus charunurensis,* but deviated in their sternal shield morphology (oval impressions) (fig. 3).

Identifying female macronyssids found on *Myotis gracilis* and *Myotis ikonnikovi* turned out very complicated. Because of leg morphology, using the key of STANYUKOVICH (1997), we first assigned them to the genus *Ichronychus* (fig. 4, left). However, the sternal shield of female mites (fig. 4, right) showed conspicuously close resemblance to the drawing of *Macronyssus hosonoi* (STANYUKOVICH 1997: fig. 52). The original monograph on this mite (UCHIKAWA 1979, fig. 4) depicts it with a different sternal shield. However, dorsal shield chaetotaxy again accords with *M. hosonoi,* as described in UCHIKAWA (1979, fig. 1) and STANYUKOVICH (1997). Embedding and re-examination of specimens we previously identified as *Macronyssus "ikonnikovi"* (SCHEFFLER et al. 2012) showed identical traits with the mite specimen from *Myotis gracilis.* Despite some obscurities remaining, we interpret our specimens as *Macronyssus hosonoi.* Citation of *Myotis mystacinus* and *M. ikonnikovi* as host species for this mite (UCHIKAWA 1979) lends another argument in support of this classification.

We could not identify any Trombiculidae at this time. In these mites, only the third larval stage lives parasitic. Rows of mites usually form yellowish or reddish crusts around their host's ears, or, less common, on wing membranes. Most individuals are lost when trying to collect them, as they firmly attach themselves with proteinaceous cement and are thus difficult to remove.

3.2. Parasite community and abundance of ectoparasites

Table 3: Abundance and parasite load of different bat species

			Parasite family abundance (Number of parasites/number of hosts)				
Host species / # of individuals		P-load ± SD	Ischnopsyllidae	Nycteribiidae	Spinturnicidae	Macronyssidae	Trombiculidae
Eptesicus gobiensis	18	1,96 ± 2,25	0	0	2,55	0	0,67
Eptesicus nilssonii	7	12,81 ± 19,72	0,57	0	6,12	1,14	0
Myotis aurascens	26	10,10 ± 8,67	0,08	0,96	2,56	0	0
Myotis gracilis	26	7,31 ± 7,81	0,65	0,04	3,42	1,00	0
Myotis ikonnikovi	7	4,66 ± 6,47	0,43	0	2,14	1,00	0
Myotis petax	36	22,42 ± 30,91	0,53	1,88	2,02	1,00	0
Plecotus ognevi	14	4,45 ± 6,24	0,36	0,14	1,07	0,71	0
Vespertilio murinus	7	7,96 ± 13,12	1,14	0	0	2,86	0,42

The harsh climatic conditions in Mongolia seem to promote good physical fitness in bats. Despite temperatures below 5° C und strong winds net captures documented flight activity of various species. Table 3 lists parasite load and parasite family abundance in eight bat species during the swarming period in autumn. We only report data where five or more bats were examined. For most bat species listed, spinturnicid mites constituted the major ectoparasite group. Only *Vespertilio murinus* showed no sign of spinturnicids, and fleas (*Ischnopsyllus obscurus*) and coat mites

(*Steatonyssus spinosus*) dominated here. Bat flies frequently occurred on *Myotis petax* and *M. aurascens,* whereas coat mites typically appeared as part of the parasite composition in the other bat species, with the exception of *Eptesicus gobiensis* and *Myotis aurascens.* Ear mites (*Trombicula spec.*) occurred on *Eptesicus gobiensis* and *Vespertilio murinus.* Thanks to recurring sampling over several months, we could also analyze temporal variations. Analysis of 155 samples gathered from bats showed a clear trend toward a decline in parasitization across all bat species between the summer and autumn months (parasite loads: June 14.85 ± 16.83; July 13.87 ± 23.95; August 6.81 ± 13.30; September 4.06 ± 7.04). Our data showed an overall higher parasitization in females (parasite load 7.35 ±14.28) compared to males (4.60 ± 8.15).

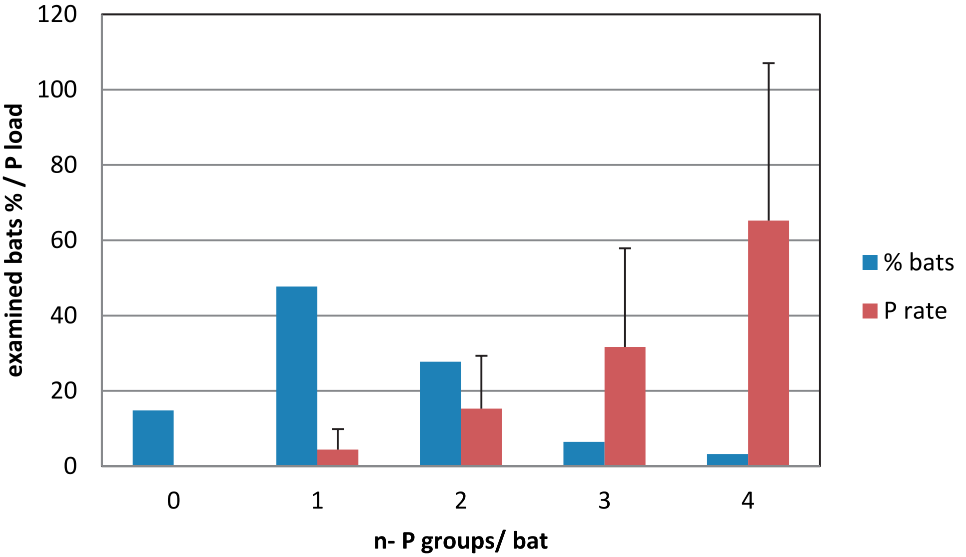

Fig. 5: Presence of different parasite groups (fleas, flies, wing mites, coat mites, ear mites, and true bugs) on bats, in percent. Average parasite loads (absolute values) for individual bats carrying none, one, or more simultaneously occurring parasite group(s).

Most host individuals showed infestation with only one parasite group (fleas, flies, wing mites, coat mites, ear mites, true bugs) (fig. 5), and average parasite load remained low PL= 4.4). Bats harbouring two, three, or four different parasite groups appeared less frequently. However, the parasite load dramatically increased in those bats carrying the most diverse parasite fauna, returning the highest average values (with four parasite groups present: PL = 65.23). Data varied considerably between individual bats, however.

Table 4 summarizes our results. Combined with the findings of proceeding studies (SCHEFFLER et al. 2010, 2012), we can fairly reliably assert the parasite composition of five Mongolian bat species: *Eptesicus gobiensis*, *Myotis aurascens*, *M. gracilis*, *M. petax,* and *Vespertilio murinus*.

4. Discussion

Data concerning the parasitization of individual bat species are useful for ecological analysis. Establishing the typical parasite presence for a given host species allows inference about kinship status or distinguishing factors between bat species, among other things. Furthermore, comparing parasite loads of different bat species usually reveals distinct variations, leading to numerous exciting questions as to the cause. Data acquisition is very complex. Completely assessing the parasite composition of a given bat species requires a large enough sample size of caught bats (and parasites).

Table 4: Ectoparasite species composition of Mongolian bats

Bat species / Ectoparasite species	*Eptesicus gobiensis*	*Eptesicus nilssonii*	*Eptesicus turcomanus*	*Murina hilgendorfi*	*Myotis aurascens*	*Myotis bombinus*	*Myotis frater*	*Myotis gracilis*	*Myotis ikonnikovi*	*Myotis petax*	*Nyctalus noctula*	*Plecotus ognivi*	*Plecotus kozlovi*	*Vespertilio murinus*	*Vespertilio sinensis*
Taxa	22x	7x	1x	4x	27x	2x	2x	26x	6x	60x	1x	13x	1x	9x	1x
Ischnopsyllidae															
Ischnopsyllus elongatus											1				
Ischnopsyllus hexactenus		2		5					1			4			
Ischnopsyllus obscurus		2												8	
Mydopsylla trisellis					2			18		25					
Nycteribiidae															
Basilia dolchi n. spec.					3	2				3					
Basilia mongolensis					5										
Basilia truncata					18	2		1		3					
Nycteribia quasiocellata					4				5	98					
Penicillidia monoceros										20					
Cimicidae															
Cimex lectularius-typ		2													
Spinturnicidae															
Spinturnix frater n. spec.							3								
Spinturnix kolenati	69	65	9												
Spinturnix madedai				2											
Spinturnix myoti „bombinus“						6									
Spinturnix myoti „petax“									5	144					
Spinturnix mystacinus					51			95	13						
Spinturnix plecotinus												21	3		
Macronyssidae															
Macronyssus charunurensis						1				11				1	
Macronyssus „frater“							3								
Macronyssus „gracilis“								7							
Macronyssus hosonoi								1	3						
Macronyssus heteromorphus					1										
Macronyssus murini				2											
Macronyssus „nilssonii“		3						1							
Steatonyssus spinosus		3												15	2
Steatonyssus superans														1	8
Trombiculidae															
Trombicula spec.	2											3		2	

For bats with a wider geographical range, possible regional differences must be considered. Parasite abundance and combination may change considerably with seasonal variations throughout the year. Hence, specimens are ideally collected in spring, during the nursing period, the autumn swarming period, and from winter quarters. Our previous data from Mongolia only marginally consider such qualitative aspects. Thus, results provide evidence, yet should be verified by further research. Declining parasite loads associated with seasonal variations are also known from Europe (e.g. ZAHN & RUPP 2004, LUĆAN 2006). Nursery roosts house large numbers of female bats showing decreased immunocompetence during the lactation period (CHRISTE et al. 2000), benefiting parasites. McLEAN & SPEAKMANN (1997) also observed less self-grooming behavior in nursing females.

Lastly, presence of juveniles with still naive immune systems strongly boosts parasite numbers. During this period, spinturnicid mites dominate as parasites of most bat species. Male bats, usually absent from nursery roosts, produce their sperm during the summer months. This initially involves a strong increase of testosterone levels with simultaneously reduced immunocompetence, fostering parasite growth (HUGES & RANDOLPH 2001, ROBERTS & PETERS 2009, ENCARNACAO et al. 2012). Circumstances change towards the end of the nursing period, where the immunocompetence of all bats increases and animal aggregations disperse. A proportion of parasites likely also perish with the deaths of weakened host animals, which may accumulate large parasite numbers.

The parasite loads we found for Mongolian bats during the swarming period in autumn show similarity to those obtained from other bat species in Germany and Bulgaria (SCHEFFLER et al. 2011). The high standard deviation values present in almost all host parasite relations reflect strong fluctuations between parasite loads of individual bats.

Our data offer a sound basis for inferring the parasite compositions of Mongolia's five most common bat species, and present evidence for a further ten bat species and their respective parasite fauna. Overall, all bat species and groups of insects and mites referred to herein require a fair bit more investigation.

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