Ectoparasites of Bats in Mongolia, Part 2 (Ischnopsyllidae, Nycteribiidae, Cimicidae and Acari)

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Ectoparasites of bats in Mongolia, Part 2 (Ischnopsyllidae, Nycteribiidae, Cimicidae and Acari)[1]

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Abstract

This study analyses ectoparasites found on Mongolian bats between 2008 and 2011. We examined 12 different bat species, with a total of 23 ectoparasite species present. Apart from reporting distributions, we also discuss specific host-parasite relationships. Owing to recent taxonomic changes splitting the *Myotis mystacinus*-group into several new taxa, their corresponding ectoparasite fauna could also be addressed in detail. Introducing ectoparasitic insects at length elsewhere (SCHEFFLER et al. 2010), this paper focuses on the analysis of parasitic Acari. Additional findings for Spinturnicidae (wing mites) and Macronyssidae broadened the spectrum of known parasites. Altogether, the knowledge of bat ectoparasites from Mongolia remains very sketchy. Based on different examples, we discuss current taxonomic problems regarding the species status of parasites, and suggest avenues for future research.

Key words: bats, ectoparasites, Acari, Spinturnicidae, Macronyssidae, Mongolia

1. Introduction

In bats, both fur and patagium harbour a highly specialized parasite fauna. In the course of host-parasite co-evolution, only those parasites able to adapt their physiology and behaviour sufficiently to cope with the host's torpor- and hibernation periods, high body temperature, frequent change of roost locations and little substrate contact, could survive. Bat ectoparasite research in Mongolia traditionally stems from bat-centered studies qualitatively reporting the parasitic bycatch. Mongolian-German biological expeditions and collections by local bat researchers (THEODOR 1966; DUSBÁBEK 1966; SMITH 1967, 1980; MINAR & HURKA 1980; KHERZHNER 1989) provided important information about single groups of ectoparasites, and led to the description of new species. SCHEFFLER et al. (2010) recently summarized previous and new findings of parasitic fleas, bat flies, bat bugs, and wing mites. Given the sporadic frequency of parasite studies, combined with the size of territory that is Mongolia, assessing its bat ectoparasite fauna is far from complete. Mongolian bat taxonomy is still subject to widely differing interpretations, which in turn causes difficulty with categorizing bat parasites. Based on the works of DOLCH et al. (2007), NAYAMBAR et al. (2010), and unpublished communication (T. DATZMANN, J. ARIUNBOLD), we assumme the following bat species:

Eptesicus gobiensis BOBRINSKOJ, 1926 (previously = *E. nilssonii*)
Eptesicus nilssonii KEYSERLING & BLASIUS, 1839
Eptesicus „serotinus“ SCHREBER, 1774 (still requires clarification, likely to become *E. turkomanus*)
Hypsugo alaschanicus BOBRINSKOJ, 1926 (previously = *Hypsugo savii*)
Murina leucogaster MILNE-EDWARDS, 1872
Myotis aurascens KUZYAKIN, 1935 (previously = *M. mystacinus, = M. „mystacinus“* F1/F2)

[1] Results of the Mongolian-German Biological expeditions since 1962, No. 315.

Myotis blythii TOMES, 1857
Myotis frater ALLEN, 1923
Myotis gracilis OGNEV, 1927 (previously = *M. brandtii*, = *M. brandtii gracilis*)
Myotis ikonnikovi OGNEV, 1912 (previously = *M. mystacinus* ?)
Myotis „nattereri“ (still requires clarification)
Myotis petax HOLLISTER, 1912 (previously = *M. daubentonii*)
Nyctalus noctula SCHREBER, 1774
Plecotus kozlovi BOBRINSKOJ, 1926 (previously = *P. austriacus*)
Plecotus ognevi KISHIDA, 1927 (previously = *P. auritus*)
Plecotus strelkovi SPITZENBERGER, 2006 (previously = *P. auritus ?*)
Plecotus turkmenicus STRELKOV, 1988 (previously = *P. austriacus ?*)
Vespertilio murinus LINNAEUS, 1758
Vespertilio sinensis PETERS, 1880 (previously = *V. superans*)

So far, ectoparasite information was limited to just nine out of the above 19 bat species, and only parasite occurrences on *M. aurascens*, *M. petax*, *P. ognevi* and *Vespertilio murinus* are confirmed by more than three independent reports (DOLCH et al. 2007, SCHEFFLER et al. 2010). The newly changed and extended taxonomy of bat species now allows for a more differentiated view of host – parasite relationships not yet accessible to the above works.

2. Materials and methods

A large part of ectoparasites discussed in this paper was collected by J. Ariunbold and colleagues between 2009 and 2011. Further specimens stem from excursions by the Landesfachausschuss Säugetierkunde Brandenburg (LFA) (the Regional Committee of Mammalogy Brandenburg) between 7–21 July 2011, from J. & J. Teubner and U. Zöphel (July 2008), and from A. and M. Stubbe (20 July–3 August 2011). Table 1 lists all collection data.

Bats were mostly caught with nets (as detailed in SCHEFFLER et al. 2010). The LFA excursion also assessed parasites quantitatively. Prior to analysis, bats were kept separate to avoid potential parasite transfers. Using forceps and brushes, specimens were picked off bat coat (fur) and wings and preserved in 70 % ethanol. In preparation for light microscopy fleas and mites were treated with 10 % KOH. For viewing at higher magnification, mites were transferred into distilled water and subsequently placed into 70 % ethanol. Fleas were embedded in Canada balsam.

Fig. 1: Examining bats caught during the 2011 expedition: J. Ariunbold, I. Bolorchimeg, K. Thiele, B. Gärtner and D. Dolch (from left). Photo: D. Steinhauser.

Table 1: List of bat capture sites and dates

ID	site	geo.-ref.	date	collectors	host species
01	Tsakhir	48°'05'21,1" N 99°12'50,5" E	07.07.2011	LFA	*M. petax*
02	Telmen nuur, Bulnain nuruu	49°00'04,3" N 97°34'01,8" E	08.07.2011	LFA	*E. nilssonii*
03 04, 08 05 06	Tesiin gol	49°43'40,0" N 95°41'51,9" E	10.07.2011	LFA	*M. gracilis* *M. aurascens* *M. petax* *P. ognevi*
09 10	Braruun turuun gol	49°29'06,8" N 94°38'44,7" E	11.07.2011	LFA	*P. ognevi* *E. nilssonii*
11	Chono kharaih gol	48°19'07,1" N 92°54'11,5" E	16.07.2011	LFA	*M. aurascens*
12	Mankhan sum	47°26'31,7" N 92°13'31,7" E	17.07.2011	LFA	*H. alaschanicus*
13 14 15	Hoid tsenkheriin gol	47°20'55,9" N 91°57'04,6" E	18.7.2011	LFA	*H. alaschanicus* *P. (koslovi?)* *P. spec.*
18	Bulgan, Ulaistain gol	46°16'06,4" N 91°32'44,7" E	21.07.2011	LFA	*M. blythii*
S4	Ikh Nart	45°43'21,8" N 108°38'45,0" E	20.07.2011	A. & M. Stubbe	*M. (aurascens?)*
S15	Šutegiju Bajan-gol	43°54'19,5" N 107°43'45,5" E	24.7.2011	A. & M. Stubbe	*H. alaschanicus*
S19, 21, 23-32 20, 21	Bordzongijn-gobi	42°28'58,9" N 105°15'09,5" E	02.08.2011	A. & M. Stubbe	*M. (aurascens?)* *E. gobiensis*
A1	Tuv,Badsumber, Schatangiin gol	48°30'21,5" N 106°50'26,1" E	09.06.2011	Ariunbold	*M. gracilis*
A2 A9	UmnuGobi, Khanbogd	43°27'37,3 N 106°50'26,1" E	21.08.2009	Ariunbold	*E. gobiensis* *V. murinus*
A3	Dornod, Daschbalbar, Baga dalai nuur	47°98'17,8" N 114°40'38,0" E	28.07.2006	Ariunbold	*M. petax*
A4	Selenge, Bugant	49°28'24,5" N 107°12'23,0" E	23.06.2011	Ariunbold	*M. petax*
A5, A6	Khuvsgul, Tsagaan nuur, Khuit cave	51°11'04,2" N 99°20'35,8" E	24.09.2010	Ariunbold	*M. gracilis* *E. nilssonii*
A7	Khuvsgul Tsagaan nuur, Khavtgainzah	51°23'22,3" N 99°19'23,4" E	24.06.2010	Ariunbold	*M. petax*

continued table 1

ID	site	geo.-ref.	date	collectors	host species
A8 A15	Khuvsgul Tsagaan nuur, Usariinam	51°26'09,6'' N 99°12'03,7'' E	26.6.2010	Ariunbold	*M. petax* *M. gracilis*
A 10	Ikh Nart	45°43'21,8'' N 108°38'45,0'' E	18.05.2010	Ariunbold	*M. aurascens*
A11 A12	Selenge, Eroo river, Berelgiin tsagaan	49°06'28,1'' N 107°05'06,3'' E	21.06.2011	Ariunbold	*M. gracilis* *M. frater*
A13 A17	Zelter river, Kheregchin	50°13'57,9'' N 104°49'42,4'' E	27.6.2011	Ariunbold	*M. ikonnikovi* *P. ognevi*
A14	Khuvsgul, Rinchinlhumbe, Tengis river	51°29'05,9'' N 99°03'33,4'' E	27.06.2010	Ariunbold	*P. ognevi*
A16	Khentii, Dadal, Balj gol	49°04'58,9" N 111°28'21,5" E	19.08.2010	Ariunbold	*P. ognevi*
A18	Bayanhongor, Bayanlig, Tsagaan cave	44°42'43,3'' N 101°10'13,8'' E	14.07.2009	Ariunbold	*P. kozlovi*
A19	UmnuGobi, Sevrei, Duut Mankhan	43°48'22,5'' N 102°15'78,8'' E	05.07.2011	Ariunbold	*M. aurascens*
A20	Tuv Argalant, Hustai NP	47°41'40,6'' N 105°54'49,9'' E	24.08.2010	Ariunbold	*M. aurascens*
A21	UmnuGobi, Bulgan Sum, Tugrugiin shiree	44°14'02,1'' N 103°15'31,1'' E	06.07.2011	Ariunbold	*E. gobiensis*
A22	Tuv, Batsumber, Shatangiin gol	48°30'21,5" N 106°50'26,1" E	13.06.2010	Ariunbold	*E. nilssonii*
A23	Uvurhangai, Hairhanulaan, Arguutiin gol	45°39'65,7'' N 102°04'80,8'' E	15.07.2009	Ariunbold	*E. gobiensis*
A24 A25 A26 A27	GobiAltai, Shar-khuls oasis	43°18'46,5'' N 97°47'13,3'' E	08.05.2011	Ariunbold	*M. aurascens* *H. alaschanicus* *E. gobiensis* *M. aurascens*
T1	Uecherin	47°28'42,4'' N 101°46'31,9'' E	15.07.2008	Teubner	*V. murinus*
LFA = D. Dolch; K. Thiele; D. Steinhäuser; B. Gärtner, I. Richter; S = A. & M. Stubbe; Ariunbold = Jargalsaikhan Ariunbold and Collegues; Teubner = J. & J. Teubner; U. Zöphel					

Fig. 2: K. Thiele exploring quarters of *E. gobiensis* and *M. aurascens* in wall cracks at Har Buhyn algas ruins. Photo: D. Dolch, 2002.

Fig. 3: Netting bats at buidlings. The image documents catching *Vespertilio sinensis* at a maternity roost in Eastern Mongolia. Photo: A. Meinel, 2008.

3. Results and discussion

Identified bat flea species (Ischopsyllidae) and their distribution

Mydopsylla trisellis JORDAN, 1929
ex Myotis gracilis: ID A1 (1♀); ID A5 (3♂, 2♀); ID A7 (2♂, 6♀); ID A8 (2♀); ID A15 (8♂, 26♀);
ex Myotis petax: ID LFA1 (1♀)

Ischnopsyllus hexactenus (KOLENATI, 1856)
ex Myotis aurascens: ID LFA4 (1♂); ex *Myotis gracilis*: ID A5 (1♂, 5♀); *ex Eptesicus nilssonii:* ID A6 (1♂, 1♀); ID LFA10 (1♀) *; ex Plecotus spec.*: ID A16 (1♂)*; ex Plecotus ognevi*: ID LFA6 (1♀); ID LFA9 (1♂,1♀)

Ischnopsyllus obscurus (WAGNER, 1898)
ex *Eptesicus nilssonii*: ID LFA10 (2♀)

Identified bat fly species (Nycteribiidae) and their distribution

Basilia mongolensis mongolensis THEODOR, 1966
ex Myotis aurascens: ID A10 (7♂, 3♀); ID A19 (1♀); ID A27 (1♂, 1♀); ID LFA4 (7♂, 1♀); ID LFA8 (9♂, 11♀); ID S4 (2♂); ID S19 (1♂, 4♀); ID S 21 (1♀); ID S23-32 (11♂, 6♀); *ex Eptesicus gobiensis*: ID A21 (4♂, 7♀); ex *Myotis gracilis*: ID LFA3 (1♀); ex *Myotis petax*: ID LFA5 (2♀); ex *Hypsugo alaschanicus*: ID LFA12 (3♂, 5♀)

Basilia truncata THEODOR, 1966
ex Myotis aurascens: ID A20 (1♂)

Nycteribia quasiocellata THEODOR, 1966*:*
ex Myots petax: ID A3 (5♂, 4♀); ID A4 (1♀); ID A7 (1♀), ID A8 (8♂, 4♀); ID A15 (1♂, 1♀); ID LFA1 (1♂, 3♀); ex *Myotis blythii* ID LFA18 (2♂)

Penicillidia monoceros SPEISER, 1900
ex Myotis petax: ID A8 (1♂, 2♀); ID LFA1 (1♂); ex *Myotis gracilis*: ID A11(1♂, 1♀)

To date, Mongolian bat ectoparasites comprise six bat flea and 5 bat fly species (SCHEFFLER et al. 2010). For a number of these, this study contributes new data on the range of both host and parasite species. The more precise taxonomy of some bat species, especially the former "mystacinus-group'' with its recent division into the Mongolian species *Myotis gracilis* (= brandtii-type) and *Myotis aurascens* (= mystacinus-type), also enables a detailed analysis of host-specificity. In fact, we observed striking differences in ectoparasite composition between these two bat species: *Myotis aurascens* prevalently presented with bat flies (*Basilia mongolensis* especially), whereas bat fleas (*Mydopsylla trisellis, Ischnopsyllus hexactenus*) were most commonly caught on *Myotis gracilis.*

In Central Europe, bat fleas very rarely share the same host with bat flies. This could be due to an altered host immune response, triggered by the larger flies, which in turn could deteriorate living conditions for fleas. Other possible explanations for why some bat species (i.e. the entire genus *Plecotus*) harbour only fleas, and others mostly host flies (*Myotis daubentonii, Myotis petax*), lie in the respective parasite's biology, (life cycle requirements) and bat behavioural patterns (consistent roost location). However, it is unusual for the macro-ectoparasite composition of closely related bat species such as *M. aurascens* and *M. gracilis* to differ as drastically as found here. Future research should consider investigating this phenomenon further.

This is also a first record of *Basilia mongolensis* present on both *Hypsugo alaschanicus* and *Myotis petax,* and of *P. monoceros* occurring on *M. gracilis.*

Identified bat bugs (Cimicidae)

Cimex pipistrelli typ
ex *Myotis aurascens?* ID S23-32 (1♂); *ex Vespertilio murinus* ID T1 (2♀)
Cimex lectularius typ
ex *Myotis petax* ID A8 (2♀); ex *Myotis gracilis* A11 (1♀)

Little information exists on parasitic bat bugs of Mongolia. KERZHNER (1989) identified specimens derived from different Mongolian bat species (*Myotis daubentoni*, *Myotis mystacinus* and *Eptesicus gobiensis*) as *Cimex pipistrelli.* The original description of this species used single individuals from England (USINGER 1966) and Holland (PÉRICART 1972). Other bat bug species from continental Europe were also described and classified as *Cimex dissimilis* and *Cimex stadleri* (USINGER 1966). However, the separate classification of these latter two species found little recognition and was eventually reversed. Individuals representing this group were either combined as *Cimex dissimilis* or *Cimex stadleri.* Based on the analysis of ca.100 individuals from Russia, Kazakhstan and Central Asia, KERZHNER (1989) postulated a great variability among defining characteristics and suggested to regard all Palearctic parasitic bat bugs as one species

(*C. pipistrelli*). We identified our specimens from Mongolia (2005–2007 excursions) accordingly, with the exception of acknowledging the Central European *Cimex lectularius* as a second parasitic bat bug species.

Individuals examined in this study only partly corresponded with the original description of *Cimex pipistrelli* (USINGER 1966), which bases on measurements of head width, pronotum width & length, length of 3rd antennal segment, hind femur width and length, length of lateral bristles on pronotum, bristles surrounding the paragenital sinus in females, and several morphometric ratios (pronotum width/length, head width/ length of 3rd antennal segment, and hind femur length/width). Particularly the length of lateral bristles on the pronotum differed clearly between Mongolian individuals and all German specimens available to us, which were classified as *C. dissimilis* or *C. lectularius.* Other measurements vary greatly among individuals, thus only larger collections would yield reliable results. Both ratios of pronotum width to length and head width to 3rd antennal segment length proved inappropriate, as they failed to distinguish even the German species *C. dissimilis* and *C. lectularius*. Calculating the ratio of hind femur length to width is a more suitable measure to verify differences, even though eight out of nine times values derived from Mongolian specimens fell between those of their German counterparts *C. dissimilis* and *C. lectularius*. These two species differ markedly in their pronotum's attributes, specifically its width of lateral margin, angle of anterior corners (referred to as "pronotum angle" hereafter), and length of lateral bristles.

When applying these parameters to Mongolian specimens (fig. 4), resulting groups suggest the presence of different species.

Both pronotum angle and the width of its lateral margin measured similarly for Mongolian specimens (sites ID 18 (SCHEFFLER et al. 2010) and ID T1), and *Cimex dissimilis* individuals of German origin. However, the length of lateral bristles on the pronotum (= *Cimex pipistrelli*-type) differed. To date, the common identity of *Cimex pipistrelli* (Mongolia) and *Cimex dissimilis* (Central

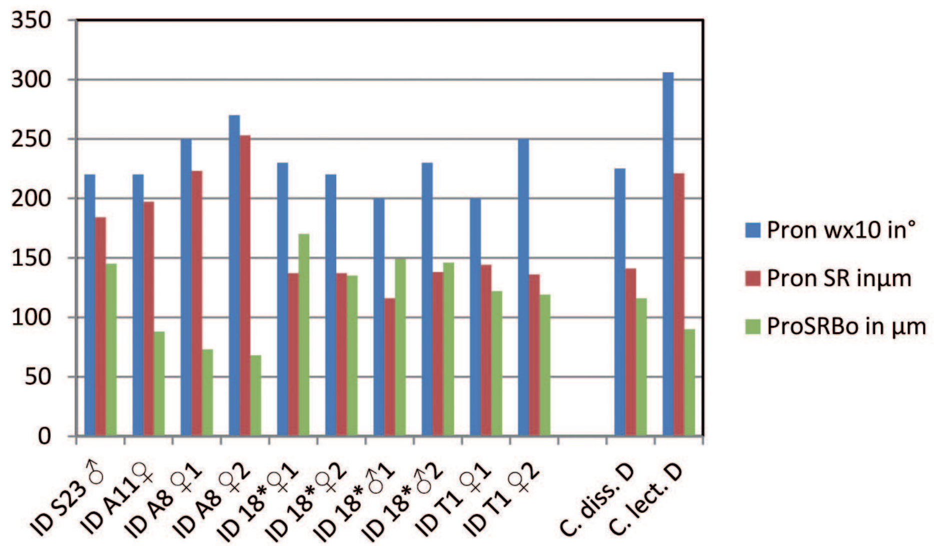

Fig. 4: Comparison of pronotum angle (Pron w), pronotum lateral margin width (Pron SR), and pronotum lateral bristle length (ProSRBo) of Mongolian specimens with mean values from two German species, *Cimex dissimilis* (C. diss.) and *Cimex lectulatrius* (C. lect.).
* = Sites given in SCHEFFLER et al. (2010).

Europe) cannot be conclusively inferred from our morphometric measurements. Furthermore, genetic exchange between British and Mongolian *Cimex pipistrelli*- types seems unlikely. Therefore, the Mongolian *Cimex pipistrelli*- type could well be a separate species.

Pronotum features such as lateral margin width and lateral bristles length set females from sites ID A8 and ID A11 apart from the Mongolian *Cimex pipistrelli* and the German *C. dissimilis.* The pronotum angle also distinguishes them from *Cimex lectularius*. These individuals' bristled paragenital sinus marks them as members of the *C. lectularius*-group, after USINGER (1966), and also clearly distinguishes them from other Mongolian specimens. The distinct paragenital sinus, lesser pronotum angle and smaller body size suggest a discrete morphotype, and thus species. However, current evidence comes from two individuals only. The Bordseng (ID S23) male combines traits of both types, *Cimex pipistrelli* (body size & shape, lateral bristle length of pronotum), and *C. lectularius* (pronotum width of lateral margin). For this single specimen, classification is uncertain. Owing to traumatic insemination, all true bug species (incl. any sub-groups) can potentially interbreed. Thus, bastards of different species are always possible.

In summary, at least two bat bug species exist in Mongolia. Based on our current morphometric data, it is uncertain whether these are identical with the Central European *Cimex pipistrelli* and *Cimex lectularius*, so that further research seems essential.

Identified spinturnicid mites (Spinturnicidae)

Spinturnix mystacinus (KOLENATI, 1857)
ex *Myotis gracilis*: ID A1 (1♂, 2♀, 2♀g) ; ID A5 (2♂); ID A11 (9♂, 14♀g, 7N); ID A15 (5♂, 13 ♀g, 15N); ID LFA3 (1♂, 2♀); ex *Myotis aurascens*: ID A10 (1♀); ID LFA11 (2♂); ID S4 (1♂, 1♀); ID S19 (2M♂, 5N); ID S 23-32 (3♂, 2♀); ex *Myotis ikonnikovi*: ID A13 (3♀); ex *Eptesicus gobiensis*: ID A21 (2♂, 2♀g); ex *Hypsugo alaschanicus*: ID LFA12 (2♂, 1♀)

Spinturnix mystacinus is a medium-sized spinturnicid, found on five bat species in this study. Morphometric measurements were obtained from pregnant females and males (tab. 2). Comparing measurements with Central European individuals of the same species, no significant variations were found. Given its abundance in our samples, *Myotis gracilis* and *M. aurascens* most likely serve as main hosts of *S. mystacinus* in Mongolia. This corresponds with *S. mystacinus* also existing on the similar Central European bat species *Myotis mystacinus* and *M. brandtii*. The majority of our specimens was found in June & July, where spinturnicid abundance usually peaks, possibly reflecting the gathering of many host individuals at maternity roosts. The high proportion of pregnant spinturnicid females (ca. 72 %) and presence of nymphs support this view. Here, as in an earlier study (SCHEFFLER et al. 2010), *S. mystacinus* was the only spinturnicid species found, and just one single record of it exists from *Myotis ikonnikovi* to date. The unusual occurrence on *Eptesicus gobiensis* and *Hypsugo alaschanicus* likely originated from direct body contact between these species and the above main hosts, allowing mites to cross over and populate bats that typically harbour other spinturnicids.

Table 2: Morphometrics of *Spinturnix mystacinus*, Mongolia

µm (STABW) ex M. gracilis	body length	body width	length of dorsal shield	width of dorsal shield	length of sternal shield	width of sternal shield
♂ *mystacinus*	821 (29)	663 (27)	641 (17)	506 (16)	297 (9)	211 (6)
♀g *mystacinus*	1182 (30)	880 (30)	699 (22)	557 (16)	173 (16)	161 (9)
Source: 8 ♂, 12 ♀g, (g = gravid)						

Spinturnix kolenati OUDEMANS, 1910
ex Eptesicus nilsonii: ID A 22 (1♀g); ID LFA2 (1♀g, 1N); ID LFA10 (2N); ex Eptesicus gobiensis: ID S 20-21 (2♂, 3♀, 3N)

Spinturnix myoti- complex
ex Myotis petax: ID A 4 (2♂); ID A7 (2♂, 1♀); ID A8 (8♂, 10♀g, 15N); ID LFA1(3♂, 4♀g, 4N); ID LFA5 (2♂, 2♀); ex Myotis blythii ID LFA18 (1♀g)

Classifying the Central European *Spinturnix andegavinus* and the often oligoxenous *Spinturnix myoti* involves a number of morphometric and ecological parameters each of which by themselves fail to unambiguously identify the species. Therefore, we address both species as *Spinturnix myoti*-complex. One distinguishing criterion is their differing host choice, which restricts mutual exchange. However, at least in German hibernating quarters, we occasionally found both species in close proximity, so that host transfers should not be generally ruled out. Both species exhibit a largely identical structure and spacing of bristles on the dorsal opistosoma. *Spinturnix andegavinus* often possesses a higher number of larger bristles on its ventral opistosoma. Contrary to other spinturnicids with a differently shaped male sternogenital shield, this feature does not allow to distinguish *S. andegavinus* and *S. myoti.* According to DEUNFF (1977), female *S. myotis* exhibit a wider distance between coxae of leg pairs I-II and III-IV, and possess a more rounded sternal shield. Indeed, non-gravid females feature a wider gap between coxae, although it diminishes during pregnancy due to swelling of the opistosoma. One of the most reliable identifiers is the pointed sternal shield in *S. andegavinus*, which only rarely occurs in female *S. myoti.* Also, a significant size difference exists between both species, where morphometrics for *S. myoti* typically return larger values. Table 3 summarizes morphometrics for *S. myoti* and *S. andegavinus* individuals from Germany, compared with their Mongolian counterparts of the same species complex (herein referred to as *Spinturnix petax*, after its most common host species). Males and females (including pregnant individuals) of *Spinturnix myoti* and *Spinturnix andegavinus* differ significantly in body length & width, and the width of both ventral and dorsal shields. Previous analyses of Mongolian spinturnicids (SCHEFFLER et al. 2010) further categorized representatives

Table 3: Comparing German and Mongolian specimens within the *Spinturnix myoti*-complex

µm (STABW)	body length	body width	length of dorsal shield	width of dorsal shield	length of sternal shield	width of sternal shield
♂ *S. myoti*	948 (47)	716 (21)	709 (21)	508 (25)	394 (16)	258 (8)
♂ *S. andeg.*	849 (38)	676 (22)	676 (22)	501 (26)	358 (11)	242 (17)
♂ *„S. petax“*	859 (29)	719 (22)	670 (17)	526 (14)	370 (9)	253 (10)
♀ *S. myoti*	1283 (71)	934 (46)	795 (47)	590 (5)	216 (12)	217 (26)
♀ *S. andeg.*	993 (27)	772 (16)	744 (20)	565 (15)	222 (9)	186 (8)
♀ *„S. petax“*	1079 (64)	844 (51)	756 (46)	588 (26)	207 (11)	176 (8)
♀g *S. myoti*	1511 (65)	1061 (43)	819 (33)	591 (19)	215 (14)	223 (15)
♀g *S. andeg.*	1248 (46)	946 (33)	750 (26)	582 (17)	211 (8)	184 (15)
♀g *„S. petax”*	1328 (46)	1016 (45)	789 (23)	605 (16)	216 (7)	196 (14)
S. myoti (Germany): 17♂, 5♀, 15♀g; *S. andegavinus* (Germany): 14♂, 19♀, 5♀g; *S. petax* (Mongolia): 11♂ 11, 13♀g, 4♀; g = gravid						

of the *Spinturnix myoti*-complex into either *S. myoti* or *S. andegavinus*, according to individual characteristics (i.e. body size, sternal shield). Owing to the newly collected specimens and a new form of analysis (immersion-microscopy), more individuals could be exactly measured. In most cases, the body size of specimens representing the Mongolian *Spinturnix myoti*-complex (fig. 5) fell between that of *S. myoti* and *S. andegavinus.*

As was previously common, when not splitting the *S. myoti*-complex into further categories (STANYUKOVICH 1997), all individuals class as *Spinturnix myoti.* The often ambiguous identification of individuals within the complex supports this view. Following the argument that *S. andegavinus,* despite negligible deviations in morphology, constitutes a separate species based on its body size and choice of different host species, one could similarly postulate the existence of a separate species in Mongolia („*Spinturnix petax"*). Thus, present taxonomy within the Mongolian *Spinturnix myoti*-complex remains open to verification.

Spinturnix kolenati OUDEMANS, 1910
ex *Eptesicus nilsonii*: ID A 22 (1♀g); ID LFA2 (1♀g, 1N); ID LFA10 (2N); ex *Eptesicus gobiensis*: ID S 20-21 (2♂, 3♀, 3N)

The topography of all bristles and the shape of both sternal (♀) and sternogenital shields (♂) unambiguously identify *Spinturnix kolenati*. Based on our analysis of only a few individuals, we found no evidence for morphological differences between Central European and Central Asian specimens. DUSBÁBEK (1966) mentioned a smaller dorsal shield size in males, but derived this from only five specimens. Morphometric analysis of larger samples could prove beneficial here. As shown here and in earlier research from Mongolia, *Eptesicus* species most commonly hosted this spinturnicid. Additionally, single records exist from *Plecotus spec.* and *Vespertilio murinus* (DUSBÁBEK 1966, SCHEFFLER et al. 2010).

Spinturnix plecotinus (KOCH, 1839) = *(Spinturnix plecoinus ognevi n.subspec.)*
ex *Plecotus ognevi*: ID A17 (3♂); ID LFA6 (1♀); ID LFA9 (1♂, 2♀); ex *Plecotus koslovi ?*: ID LFA14 (1♂,3♀, 1N)

Spinturnix plecotinus differs from all other Palearctic spinturnicids with its lanceolate terminal bristles on leg pairs II-IV. The pattern of dorsal opistosoma bristles (♂ one pair, ♀ six to seven pairs also defines this species. In these and most other parameters measured, no significant differences existed between German and Mongolian specimens. However, Mongolian specimens differ considerably from German counterparts in the structure of male sternogenital shields (fig. 6), and the form and size of female sternal shields. Variation in size and shape of ventral shields in specimens from both countries is distinctly higher for *S. plecotinus*-types than in any other spinturnicid species. Currently known morphological differences are insufficient to confer species status. However, owing to their clearly distinct origin, Mongolian representatives could be viewed as a sub-species: *Spinturnix plecotinus ognevi.* Table 4 also includes spinturnicid sampling results from previous excursions (SCHEFFLER et al. 2010). Individuals caught on what is presumably *Plecotus koslovi,* did not differ from animals found on *Plecotus ognevi.*

Spinturnix bregetovae STANYUKOVICH, 1995
ex *Myotis gracilis*: ID A11 (21.6.2011), 1 ♂

A single individual of *Spinturnix bregetovae* occurred unexpectedly among a larger assembly of *Spinturnix mystacinus.* According to present knowledge, *Myotis gracilis* does not appear to be the main host of this species, and too little information exists to date. STANYUKOVICH (1997) merely offers this remark: ''Hosts: Bats, Distribution: Russia (the Far East)''.

Fig. 5: *Spinturnix „petax“ (S. myoti*-complex) ♂, ventral view. – Photo: I. Scheffler.

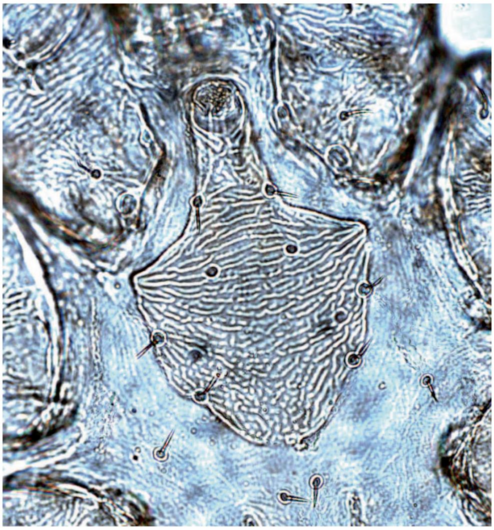

Fig. 6: *Spinturnix plecotinus ognevi* ♂, sterno-genital shield. – Photo: I. Scheffler.

Table 4: Comparing German and Mongolian specimens of *Spinturnix plecotinus*

µm (STABW)	body length	body width	length of dorsal shield	width of dorsal shield	lenght of sternal shield	width of sternal shield
♂ex *P. ognevi*	792 (21)	641 (17)	670 (35)	494 (24)	294 (13)	202 (9)
♂ex *P. aurtius*	802 (21)	633 (23)	696 (23)	488 (25)	293 (12)	192 (11)
♀g ex *P. ognevi*	1214 (45)	878 (21)	673 (27)	499 (19)	147 (10)	148 (6)*
♀g ex *P. auritus*	1248 (48)	860 (55)	661 (39)	476 (24)	143 (11)	130 (10)*
Spinturnix plecotinus (Mongolia) ex *P. ognevi* 8♂, 6♀; ex *P. aurtius* (Germany): 7♂, 7♀; * = largest difference						

Spinturnix spec. (*Spinturnix frater* n. spec.)
ex *Myotis frater* ID A12: 1♂

So far, no records of *Myotis frater* exist from Mongolia. Rather, this bat species is known from Russia's Far East, Middle Siberia, Tadzikistan, Uzbekistan, SE China, and Japan (TSYTSULINA & STRELKOV 2001). The individual bat inspected by J. Ariunbold carried a male spinturnicid that cannot be assigned to any species known from Mongolia to date. UCHIKAWA et al. (1994) published an image (fig. 22, p. 292: ‘’Sternogenital shield *Spinturnix ssp.* from Japan ex *M. frater”*) that seemingly matches this specimen. They ascribed it to the ‘’myoti species-group’’, but did not provide further details. The most marked difference to *Spinturnix myoti* (or representatives of this group in Mongolia) is the structure of the sternogenital shield (fig. 7). Owing to a distinct host species and a clearly distinguishable morphological trait, this likely constitutes a separate species. Failing the existence of a current designation, we suggest calling it *Spinturnix frater*, after its host.

Spinturnix nobleti DEUNFF, VOLLETH, KELLER & AELLEN*,* 1990
ex *Hypsugo alaschanicus*: ID LFA13 (2♂); ID S15 (1♀)

The only host known to date is Savis`s pipistrelle (*Hypsugo savii).* The presence of *Spinturnix nobleti* on *H. alaschanicus* in our samples may be due to the high degree of kinship between both bat species. To our knowledge, this is a first record of *S. nobleti* from Mongolia. Fig. 8 shows the spade shaped sternogenital shield in males, with its characteristic reticulate pattern.

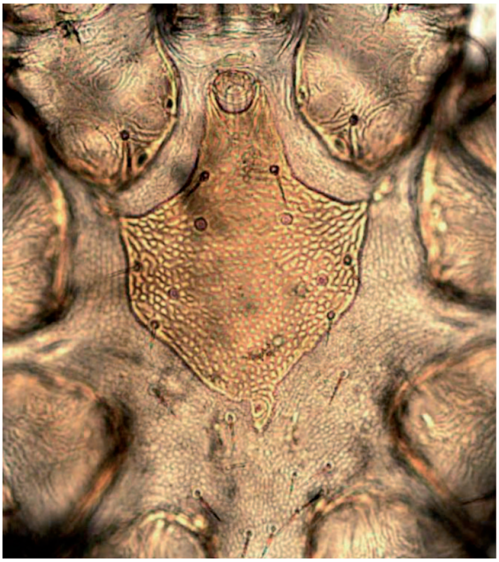

Fig. 7: *Spinturnix frater* n. spec. ♂ sternogenital shield. – Photo: I. Scheffler.

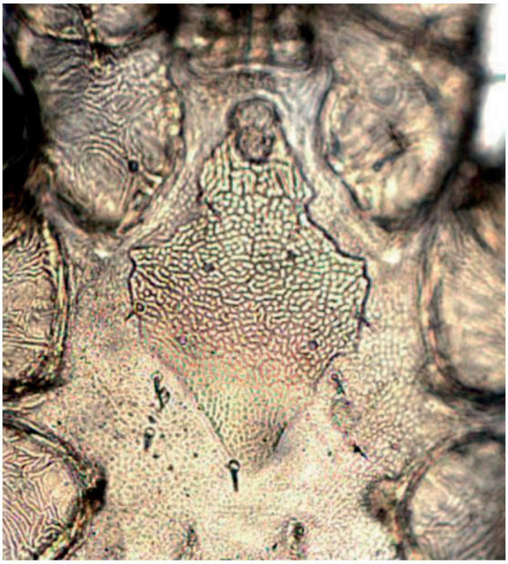

Fig. 8: *Spinturnix nobleti* ♂, sternogenital shield. – Photo: I. Scheffler.

Quite specific ectoparasites, spinturnicids occupy their host permanently. Separated from it, they remain stationary, or move seemingly without orientation (SCHEFFLER 2008). The likelihood of acquiring a new host in this manner is rather slim, and host-deprived animals survive for just a few hours. Only direct body contact between bats allows these parasites to transfer from one host to another. The frequency of transfers is largely unknown. Since healthy host individuals react to parasite presence with an immune response, crossing over to a less infested host could prove advantageous. This corresponds to similar annual population fluxes, where spinturnicids reach their greatest density in maternity roosts, when pregnant females decrease their immune response. Later, mites transfer to the offspring in large numbers, until the immune system of the young animals is fully developed (CHRISTE et al. 2000, LUCAN 2006).

Due to known Palearctic host-parasite relationships, certain combinations of spinturnicid species could be expected for Mongolian bats: *Spinturnix mystacinus* on *Myotis gracilis*, *M. aurascens* & *M. ikonnikovi*; *Spinturnix myoti*-complex on *M. petax; Spinturnix kolenati* on *Eptesicus* species; *Spinturnix plecotinus* on *Plecotus* species, and *Spinturnix nobleti* on *Hypsugo alaschanicus*. The occurrence of *Spinturnix frater* on *Myotis frater* can be viewed accordingly. The distribution of Mongolian spinturnicids corresponds with this expectation. Only 4.62 % were outliers unexpectedly found on the ''wrong'' host species.

The composition of the "expected" spinturnicids (180 individuals) involved 33.33 % males / 10.55 % non-pregnant females/ 26.11 % pregnant females and 30 % nymphs. Results for spinturnicids found on unexpected hosts (11 individuals) followed a different pattern: a higher number of males (45.45 %) and non-pregnant females (36.3 %), fewer pregnant females (18.18 %), and no nymphs. These findings may reflect co-evolutionary adaptations between host and parasite, and the higher mobility of spinturnicid males. However, the low number of outliers must be considered here. Morphometrics (body length & width, dorsal and ventral shield dimensions) turned out similar for females, and differed between males: individuals found on unexpected hosts scored notably lower across all parameters compared to animals encountered on expected hosts.

Identified mites of the family Macronyssidae and Trombiculidae

Macronyssus "gracilis" n. spec. (Abb. 10)
ex *Myotis gracilis*: ID A1 (1♀); ID A15 (1♀)

Macronyssus charunurensis DUSBÁBEK, 1962 (Abb. 9)
ex *Myots petax*: ID A3 (2♀); ID A7 (1♀); ID A8 (1♀); ex *Vespertilio murinus*: ID A9 (1♀); ex *Myotis gracilis*: ID A11 (1♀); ex *Myotis frater*: ID A12 (1♀)

Macronyssus" ikonnikowi" n. spec.
ex *Myotis ikonnikowi*: ID A13 (1♀)

Macronyssus "nilssoni" n. spec.
ex *Eptesicus nilssonii*: ID A22 (1♀)

Macronyssus "petax" n. spec.
ex *Myotis petax*: ID LFA1 (10x)

Steatonyssus mongolicus DUSBÁBEK, 1966
ex *Vespertilio murinus* (1♀): Bradajiin gol 30.07.2008 (Koordinaten in SCHEFFLER 2010)

Trombicula spec.
ex *Eptesicus gobiensis*: ID A26 (6 L3); *Eptesicus nilssonii*: ID LFA2 (20 L3)

To our knowledge, only few papers exist about parasitic Acari from Mongolian bats. DUSBÁBEK (1966) described four sepcies: *Ichronyssus flavus* (KOLENATI 1856), *Steatonyssus murinus* (LUCAS 1840), *Steatonyssus mongolicus* (as a new species), all ex *Myotis mystacinus* and *Ichronyssus charusnurensis* (as a new species) on *Myotis daubentoni*. STANYUKOVICH (1997) ascribes two of these species to a different genus: *Macronyssus charusnurensis* (DUSBÁBEK 1962) and *Macronyssus flavus* (KOLENATI 1856). This author also cites *Steatonyssus mongolicus* and *Steatonyssus periblepharus (*KOLENATI 1856) for Mongolia. Here, we could confirm the occurrence of *Macronyssus charunurensis* on four host species. Furthermore, reviewing records from 2008 revealed an instance of *Steatonyssus mongolicus.* Lacking any descriptions (for prac-

Fig. 9: *Macronyssus charunurescens* ♀. Photo: I. Scheffler.

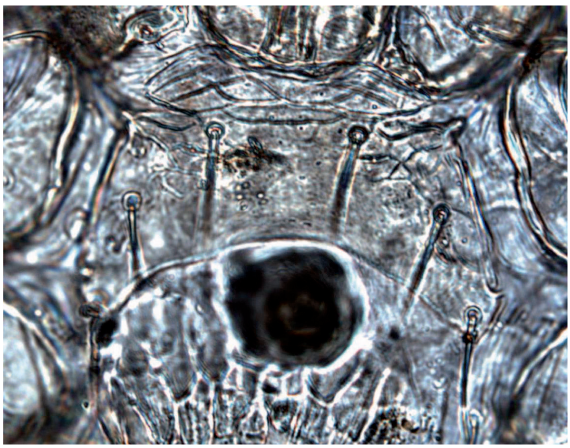

Fig. 10: Ventral shield of *Macronyssus gracilis* n. spec. ♀. – Photo: I. Scheffler.

tical purpose) we called four mite species after their respective host. Leading identifier was the sternal shield in females (fig. 11). Males and nymphs could not be allocated unambiguously. Our collection does not yet allow a description to the degree required for documenting a new species. Thus, further examination of these tiny parasites seems worthwhile.

Coloring and location on their host (ears) readily signal the third larval stage of *Trombicula*-species (fig. 12). Common in Central Europe, they especially occur on hibernating Barbastelle Bats. Identifying these Acari reliably to species level is still impossible.

Ectoparasite species composition of Mongolian bats

Table 5 summarizes ectoparasites from all examined bat species in this study. Despite no survey of exact abundance and prevalence, typical host-parasite combinations emerged. Most bat species exhibit a specific ectoparasite community, even when closely related. *Eptesicus nilssonii* and *Eptesicus gobiensis* both harbour the same spinturnicid, but differ in their bat flies and fleas. This also applies to *Myotis aurascens* and *Myotis gracilis.* Both degree of infestation and parasite diversity differed widely among bats. *Myotis gracilis*, *M. petax* and *M. aurascens* presented with high parasite levels, whereas *Plecotus ognevi* and *Vespertilio murinus* showed lower densities and diversity. Similar differences in ectoparasite patterns exist between Central European sister species, suggesting ecological preferences as possible causes. Building on our first study (SCHEFFLER et al. 2010), we also included ectoparasites of *Hypsugo alaschanicus*, *Myotis blythii* and *Myotis frater* here. The currently low numbers of bat studies from Mongolia make their ectoparasite fauna an exciting field for future research.

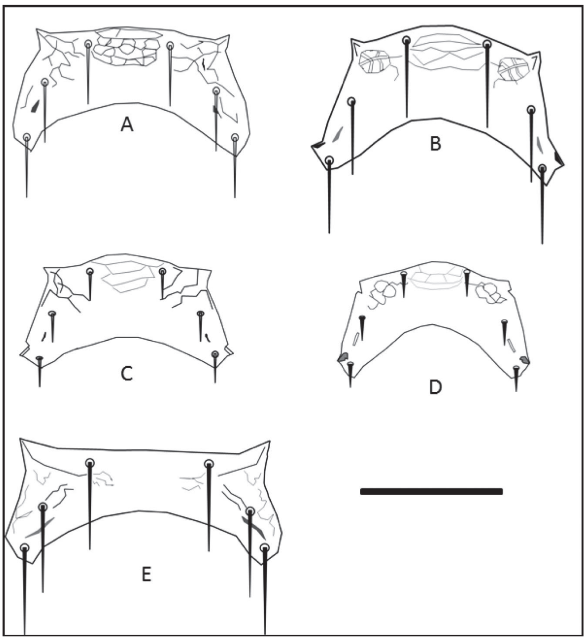

Fig. 11: Sternal shields of A= *Macronyssus gracilis*; B = *M. charunurensis*; C = *M. nilssoni*; D = *M. petax*; E = *M. ikonnikowi*; bar = 100 µm. Drawings: I. Scheffler.

Fig. 12: *Plecotus ognevi* with ear mites (Trombiculidae), Western Mongolia, 2011. Photo: D. Steinhauser.

Table 5: Ectoparasite species composition of Mongolian bats
(+ = Species determinated qualitatively)

bat species/ ectoparasite species	*Eptesicus gobiensis*	*Eptesicus nilssonii*	*Hypsugo alaschanicus*	*Myotis aurascens*	*Myotis frater*	*Myotis gracilis*	*Myotis ikonnikovi*	*Myotis petax*	*Plecotus ognivi*	*Vespertilio murinus*
Ischnopsyllidae										
Ischnopsyllus hexactenus		3		1		6			3	
Ischnopsyllus obscurus		2								
Mydopsylla trisellis						48		1		
Nycteribiidae										
Basilia mongolensis	11		8	66		1		2		
Basilia truncata				1						
Nycteribia quasiocellata								29		
Penicillidia monoceros						2		4		
Cimicidae										
Cimex pipstrellus-typ				1						
Cimex lectularius-typ						1		2		
Spinturnicidae										
Spinturnix bregetovae						1				
Spinturnix frater n. spec.					1					
Spinturnix kolenati	8	5								
Spinturnix „myoti“								54		
Spinturnix mystacinus	4		3	17		73	3			
Spinturnix nobleti			3							
Spinturnix plecotinus									7	
Macronyssidae										
Macronyssus charunurensis					+	+		+		+
Macronyssus gracilis n spec.						+				
Macronyssus ikonnikovi n. spec.							+			
Macronyssus nilssonii n. spec.		+								
Macronyssus petax n. spec.								+		
Steatonyssus mongolicus										+
Trombiculidae										
Trombicula spec.		+								

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5. References

Christe, P.; Arlettaz, A. & Vogel, P. (2000): Variation of intensity of parasitic mite (Spinturnix myoti) in relation to reproductive cycle and immunocompetence of its host bat (Myotis myotis). – Ecol. Lett. **3**: 207–212.

DEUNFF, J. (1977): Observations sur les Spinturnicidae de la région paléarctique occidentale (Acarina, Mesostigmata) spécificité répartition et morphologie. – Acarologia **18**: 602–617.

DOLCH, D.; BATSAIKHAN, N.; THIELE, K.; BURGER, F.; SCHEFFLER, I.; KIEFER, A.; MAYER, F.; SAMJAA, R.; STUBBE, A.; STUBBE, M.; KRALL, L. & STEINHAUSER, D. (2007): Contributions to the chiroptera of Mongolia with first evidences on species communities and ecological niches. – Erforsch. biol. Ress. Mongolei (Halle/Saale) **10**: 407–458.

DUSBÁBEK, F. (1966): A contribution to the knowledge of parasitic mites from Mongolia (Acarina: Gamasides). – Mitt. Zool. Mus. Berlin **42**: 43–59.

KERZHNER, I. (1989): *Cimex pipistrelli* JENYNS (Heteroptera, Cimicidae) aus der Mongolei. – Mitt. Zool. Mus. Berl. **65**: 341–342.

LUČAN, R. (2006): Relationships between the parasitic mite *Spinturnix andegavinus* (Acari: Spinturnicidae) and its bat host, *Myotis daubentoniii* (Chiroptera: Vespertilionidae): seasonal, sex- and age-related variation in infestation and possible impact of the parasite on the host condition and roosting behaviour. – Folia Parasitologica **53**: 147–152.

MINAR, J. & HŮRKA, K. (1980): Parasitäre Dipteren (Insecta, Diptera: Hypodermatidae, Hippoboscidae, Nycteribiidae) aus der Mongolei. Ergebnisse der Mongolisch-Deutschen Biologischen Expeditionen seit 1962, Nr. 94. – Mitt. Zool. Mus. Berlin **56**: 187–189.

NYAMBAYAR, B; ARIUNBOLD, J. & SUKHCHULUUN, G. (2010): A contribution to the bats inhabiting arid steppe habitats in central Mongolia. – Erforsch. Biol. Ress. Mongolei (Halle/Saale) **11**: 329–340.

PÉRICART, J. (1972): Hémiptères Anthocoridae, Cimicidae et Microphysidae de l`Quest-Palèarctique. – In: Faune de l`Europe et du basin mediteranèen **7**, Paris, 402 pp.

SCHEFFLER, I. (2008): Zur Fähigkeit von Ektoparasiten der Fledermäuse ihre Wirte aktiv aufzusuchen. – Nyctalus (N.F.) **13** (2/3): 177–186.

SCHEFFLER, I.; DOLCH, D.; ARIUNBOLD, J.; BATSAIKHAN, N.; ABRAHAM, A. & THIELE, K. (2010): Ectoparasites of bats in Mongolia (Ischnopsyllidae, Nycteribbdae, Cimicidae and Spinturnicidae). – Erforsch. Biol. Ress. Mongolei (Halle/Saale) **11**: 367–381.

SMITH, F. (1967): Siphonaptera of Mongolia. Results of the Mongolian-German biological expeditions since 1962, No. 23. – Mitt. Zool. Mus. Berlin, Bd **43**: 77–115.

SMITH, F. (1980): Some recent collections of Siphonaptera from Mongolia. – Mitt. Zool. Mus. Berlin **56**: 71–84.

STANYUKOVICH, M. (1997): Keys to the gamasid mites (Acari, Parasitiformes, Mesostigmata, Macronyssoidea et Laelaptoidea) parasiting bats (Mammalia, Chiroptera) from Russia and adjacent countries. – Rudolstädter nat. hist. Schr. **7**: 13–46.

THEODOR, O. (1966): Über neue Nycteribiiden-Arten aus der Mongolei. – Mitt. Zool. Mus. Berlin **42**: 197–210.

TSYTSULINA, K. & STRELKOV, P. (2001): Taxonomy of the Myotis frater species group (Vespertilionidae, Chiroptera). – Bonn. Zool. Beitr. **50** (1–2): 15–26.

UCHIKAWA, K.; ZHANG, M.-Y.; O`CONNOR, B. & KLOMPEN, H. (1994): Contribution to the taxonomy of the genus *Spinturnix* (Acari: Spinturnicidae), with the erection of a new genus, *Emballonuria*. – Folia Parsitol. **41**: 287–304.

USINGER, R. (1966): Monograph of Cimicidae (Hemiptera-Heteroptera). – The Tomas Say Foundation, Vol. **7**. Baltimore, XI+585 pp.

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Participants of the international symposium in Halle/Saale, March 2012. From left the parasitologists Dr. Matthias Kiefer (München) and Dr. Ingo Scheffler (University Potsdam).

From left: Dr. Gundrun Wibbelt (Leibniz Institute for Zoo and Wildlife Reasearch Berlin), Dr. Andreas Kurth (Robert-Koch Institute Berlin), Dr. Sebastian Günther (Free University Berlin).