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RESEARCH ARTICLE

A preliminary report with new records of feather mites (Acariformes: Astigmata) collected from birds ringed at Boğazkent Bird Ringing Station (Antalya, Türkiye)

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ASBTRACT: Feather mites (Astigmata: Analgoidea, Pterolichoidea) are arthropods that live parasitically or commensal on the wing, tail and body feathers of birds. These mites have high host specificity and diversity. Here we studied feather mites collected from birds subjected to ectoparasitic examination during ringing at the Boğazkent Bird Ringing Station (Antalya, Türkiye). Feather mite infestation was detected in 50 of 103 hosts representing 30 species during the study. As a result of microscopic examinations, 16 feather mites were identified, five of which are new records for Türkiye: *Dermonoton parallelus* (Mégnin and Trouessart, 1884), *Gymnolichus secundus* Černý and Schumilo, 1973, *Proctophyllodes anthi* (Vitzthum, 1922), *Pteronyssus robini* (Faccini and Atyeo, 1981), and *Pteroherpus africanus* Mironov and Kopij, 2000. Additionally, new host-parasite associations for the feather mite fauna of Türkiye were revealed in the species *Dolichodectes edwardsi* (Trouessart, 1885), *P. clavatus* Fritsch, 1961, *P. pinnatus* (Nitzsch, 1818), and *Trouessartia kratochvili* Černý, 1979.

Keywords: Acarofauna, avian parasite, bird parasite, first record, host-parasite association
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INTRODUCTION

Feather mites (Acariformes: Astigmata: Analgoidea, Pterolichoidea) are arthropods that commonly infest birds with over 2600 identified species in 36-38 families and over 500 genera (Gaud and Atyeo, 1996; Mironov, 2003a; OConnor, 2009; Schatz et al., 2011; Rodrigues et al., 2015). These mites are permanent arthropods that live as commensal or ectoparasites on birds and have extremely high host specificity (Gaud and Atyeo, 1996; Dabert and Mironov, 1999). Generally transmitted from parents to fledgeling vertically or by contact outside the nest, and rarely by phoresis, the nutritional content of these mites consists of fungi and bacteria found on feathers (Doña et al., 2017, 2019). Dependent on their hosts, feather mites have developed a number of morphological (e.g. flattened body to avoid falling from feathers, wide interlocked legs: ambulacra, hooked spines on body and legs) and behavioral (move away from feathers about to fall) adaptations to survive (Mironov, 1999; Proctor, 2003; Jovani and Serrano, 2004).

The aim of this study is to report the feather mites detected in birds at the Boğazkent Bird Ringing Station (Antalya, Türkiye).

MATERIALS AND METHODS

This study was conducted at Boğazkent Applied Environmental Education and Bird Ringing Station (Antalya, Türkiye) during the spring 2024 ringing studies. Sampling studies were carried out after obtaining legal permissions from the Republic of Türkiye Ministry of Agriculture and Forestry, General Directorate of Nature Conservation and National Parks (21264211-288.04-11857750). Before the ringing process, the hosts were subjected to ectoparasite examination under a stereo microscope (Leica EZ4, Wetzlar, Germany). Mite specimens were carefully collected from the hosts using blunt-ended forceps.

Afterwards, the specimens were stored in Eppendorf tubes containing 70% ethanol until microscopic identification. In the identification stages, first a representative number of mite specimens were cleaned with lactophenol for 48 hours and then slides were prepared using Hoyer's medium (Evans, 1992). Finally, feather mites were identified under the light microscope (MIC-B30/B Binocular 45 Economic Microscope-Led-Achromat, Soif Optical Instruments Factory, China) in the light of relevant literature (Atyeo and Braasch, 1966; Santana, 1976; Gaud, 1980; Mironov, 1985, 2002; Badek and Dabert, 2005; Mironov and Wauthy, 2008; Burdejnaja and Kivganov, 2009; Mironov et al., 2015).

Mite specimens were photographed using the integrated camera of the light microscope. All scale bars on the figures are given in micrometres (µm). In addition, a slide of each identified species is deposited both in Pamukkale University, Faculty of Science, Department of Biology, Acarology Laboratory (Denizli, Türkiye) and in G. Eren's personal collection.

RESULTS

During the ectoparasitic examination, feather mite infestation was detected in 50 hosts from 19 species belonging to five orders. While infestation of only one species was detected in 13 host species, infestation of at least two species was detected in six host species. On the other hand, *Dolichodectes edwardsi* (2 hosts) and *Proctophyllodes clavatus* (4 hosts) species were detected in more than one host.

As a result of microscopic examination, seven species from the Proctophyllodidae family, three species from the Trouessartiidae family, two species from the Pteronyssidae family, one species each from the Analgidae, Avenzoariidae, Kramerellidae and Pterolichidae families were identified. Among these species, *Dermonoton parallelus* (Mégnin and Trouessart, 1884), *Gymnolichus secundus* Černý and Schumilo, 1973, *Proctophyllodes anthi* (Vitzthum, 1922), *Pteronyssus robini* (Faccini and Atyeo, 1981), and *Pteroherpus africanus* Mironov and Kopij, 2000 are new records for the feather mite fauna of Türkiye.

DISCUSSION

Feather mites are generally overlooked by the Turkish parasitology studies compared to other ectoparasites of birds (ticks and chewing lice). More than 10 studies have been conducted in Türkiye so far, but since these studies were mostly conducted on birds in narrow scopes and limited regions, the feather mite fauna of Turkish birds has not been sufficiently revealed. The first comprehensive study was conducted by Gürler et al. (2013) at the Cernek Ringing Station (Kızılırmak delta, Samsun), in which 196 individual hosts from 42 bird species were examined and 30 feather mite species were identified. All species of feather mites detected in this study were presented as new records for Türkiye. The second comprehensive study was conducted at the same station by Per and Aktaş (2018). In this study, 591 individual hosts from 10 warbler (Sylviidae) species were examined and 10 feather mite species were identified. Only one of these mites was reported as a new record for Türkiye. Finally, in the study conducted by Eren et al. (2023), 59 individual hosts from 28 bird species were examined and 18 feather mite species were identified. 11 of these mites were presented as new records for Türkiye. Except from these studies, together with other small-scale studies (Özkan et al., 2017; Eren and Açıcı, 2022; Eren et al., 2022), more than 50 feather mite species in 15 families (Alloptidae, Analgidae, Avenzoariidae, Dermoglyphidae, Eustathiidae, Falculiferidae, Freyanidae, Gabuciniidae, Kramerellidae, Proctophyllodidae, Pterolichidae, Pteronyssidae, Ptiloxenidae, Psoroptoididae, Trouessartiidae) have been reported in Türkiye so far.

The family Analgidae Trouessart and Mégnin, 1884 includes over 200 species in 34 genera that cause infestation in many bird orders (e.g. Apterygiformes, Coliiformes, Columbiformes, Coraciiformes, Cuculiformes, Gruiformes, Piciformes, Galliformes, Strigiformes, Passeriformes, Tinamiformes) (Gaud and Atyeo, 1996; Chang et al., 2018; Mironov, 2019; Schatz et al., 2011; Pedroso and Hernandes, 2018; Mironov, 2021; Waki et al., 2024). *Analges* Nitzsch, 1818 is the first identified feather mite genus among feather mites and contains over 60 identified species associated with the order Passeriformes (Mironov, 2019). As a result of studies conducted in Türkiye, the following four species were reported from this genus: *Analges mucronatus*, *A. passerinus*, *A. spiniger* and *A. turdinus* (Eren and Açıcı, 2022).

The family Avenzoariidae Oudemans, 1905 comprises 3 subfamilies in the common taxonomic classification with 37 genera and approximately 170 species (Faccini and Atyeo, 1981; Mironov, 1991). Feather mites in the subfamilies Avenzoariinae and Bonnetellinae are associated with aquatic bird orders such as Charadriiformes, Procellariiformes, Pelecaniformes and Ciconiiformes, while species in the subfamily Pteronyssinae are associated with terrestrial bird orders such as Passeriformes, Piciformes and Coraciiformes (Gaud and Atyeo, 1996). However, Mironov and Dabert (1999) consider the subfamily Pteronyssinae as a separate family. The genus *Avenzoaria* Oudemans, 1905 includes 15 species identified to be associated with birds in the order Charadriiformes (Badek and Dabert, 2005). *Avenzoaria totani* (Canestrini, 1878), which was also identified in this study, has been reported in many bird species from the Anatidae and Scolopacidae families in previous studies in Africa (Cameroon, Congo) (Gaud and Mouchet, 1959; Gaud, 1972), Asia (Korea, Russia) (Dubinin, 1951; 1956; Vasjukova and Mironov, 1991; Han and Min, 2019), and Europe (Italy, Poland, Türkiye) (Canestrini, 1878; Dubinin, 1956; Dabert, 1992, 2000; Badek and Dabert, 2006; Gürler et al., 2013).

The family Kramerellidae Gaud and Mouchet, 1961 includes the genera *Dermonoton* Gaud and Mouchet, 1959, *Kramerella* Trouessart, 1916 and *Petitota* Gaud and Mouchet, 1959, which infest owls (Strigiformes) (Gaud, 1980; Philips, 2000). Of these genera, *Dermonoton* includes six described species (Mégnin and Trouessart, 1884; Gaud and Mouchet, 1959; Gaud, 1980). *Dermonoton parallelus* (Mégnin and Trouessart, 1884), found on the scops owl (*Otus scops*) in the present study, is a new record for Türkiye. This species was previously reported from *Asio capensis* (Smith, 1834) (Cameroon), *Asio otus* (Linnaeus, 1758) (North Africa), *Bubo africanus* (Temminck, 1821) (Democratic Republic of Congo, Mozambique, Rwanda and Zimbabwe) and *Bubo lacteus* (Temminck, 1820) (Republic of Botswana) hosts (Philips, 2000).

The family Proctophyllodidae Trouessart and Mégnin, 1884 is the richest family among feather mites with 50 genera and over 500 species (Proctophyllodinae and Pterodectinae) (Mironov, 2009; Hernandes and Valim, 2014). The genus *Proctophyllodes* Robin, 1877 is the most specious genus both in this family and among all feather mites (Atyeo and Braasch, 1966; Mironov, 2012; Sun et al., 2023). It is also the genus with the highest number of feather mites reported in Türkiye (Gürler et al., 2013; Per and Aktaş, 2018; Eren and Açıcı, 2022; Eren et al., 2023). In the present study, *Proctophyllodes anthi* (Vitzthum, 1922) found on the neck-turning bird (*Jynx torquilla*) and the red-throated pipit (*Anthus cervinus*) is a new record for Türkiye. The genus *Dolichodectes* Park and Atyeo, 1971 contains ten species associated with birds from the order

Passeriformes (Acrocephalidae, Monarchidae, Phylloscopidae, Platysteiridae, Muscicapidae, Turdidae and Ploceidae) (Mironov and Fain, 2003, Mironov et al., 2010, 2012, 2015).

The family Pterolichidae Trouessart and Mégnin, 1884 is one of the largest families of mites that infest species in 120 genera with over 400 species in 12 non-passeriform bird orders (Gaud and Atyeo, 1996). The genus *Gymnolichus* Gaud and Mouchet, 1961 is also one of the smallest genera in this family and includes two species described in the nightjars (Caprimulgiformes: Caprimulgidae): *Gymnolichus anadorus* Gaud and Mouchet, 1961 and *Gymnolichus secundus* Černý and Schumilo, 1973 (Gaud and Mouchet, 1961; Černý and Schumilo, 1973; Gaud, 1980*). Gymnolichus secundus*, identified in this study from the nightjar (*Caprimulgus europaeus*), is a new record for Türkiye.

The family Pteronyssidae Oudemans, 1941 includes approximately 150 species described in 23 genera associated with birds classified in the orders Passeriformes, Piciformes and Coraciiformes (Mironov, 2003b; Mironov and Wauthy, 2005, 2008). Of these genera, *Pteronyssus* includes five species that infest species in the woodpeckers (Picidae) genera *Dendrocopos*, *Melanerpes*, *Picus* and *Picoides*: *Pteronyssus brevipes* Berlese, 1885, *P. centurus* McDaniel and Price, 1963, *P. dubinini* Černý and Schumilo, 1973, *P. picoides* Černý and Schumilo, 1973 and *P. robini* (Faccini and Atyeo, 1981). Among these species, *P. robini* was firstly reported from Türkiye in this study on the lesser woodpecker (*Dryobates minor*), and in previous studies it was identified in the woodpeckers *Picus viridis* (Switzerland, Moldova and Russia), *Picus canus* (Russia), *Dendrocopos major* (Russia), *Dendrocopos medius* (Moldova) and *Dryobates minor* (Russia) (Mironov, 2002). The genus *Pteroherpus* Gaud, 1981, one of the richest genera in its family, contains over 20 species identified so far related to birds in the Passeriformes order (Cisticolidae, Pycnonotidae, Sylviidae, Timaliidae, Zosteropidae, Muscicapidae, Monarchidae and Paradisaeidae) (Faccini and Atyeo, 1981; Mironov and Wauthy, 2008; Mironov, 2011; Mironov and Proctor, 2011; Constantinescu et al., 2014, 2019). With this study, *Pteroherpus africanus* Mironov and Kopij, 2000 was detected on the Arabian nightingale (*Pycnonotus xanthopygos*) for the first time in Türkiye and in the world. Previously, it was reported from *Pycnonotus barbatus* (Morocco and South Africa) and *Pycnonotus nigricans* (South Africa) hosts (Mironov and Wauthy, 2008).

The family Trouessartiidae Gaud, 1957 includes approximately 170 species, mainly associated with birds in the order Passeriformes, but also with birds belonging to the orders Piciformes, Coraciiformes and Caprimulgiformes (Orwig, 1968; Santana, 1976; Hernandes, 2014; Mironov et al., 2023). Members of the genus *Trouessartia* Canestrini, 1899 include approximately 150 species identified as related to birds belonging to the orders Piciformes, Charadriiformes, Gruiformes and Psittaciformes, predominantly Passeriformes (Mironov, 2022). *Trouessartia* is the second genus with the highest number of reported species in Türkiye, after *Proctophyllodes*, with seven species (Gürler et al., 2013, Per and Aktaş, 2018).

As a result, this study reports new species records and new host-parasite associations for the feather mite fauna of Türkiye. The current study is also the first comprehensive research conducted on the southern coasts of the country (Boğazkent, Antalya). Other comprehensive studies were conducted in the provinces located on the northern coasts of Türkiye. The multidisciplinary studies conducted at ringing stations are crucial for uncovering the diversity of feather mites and the host-parasite relationships across various bird species. These studies are particularly valuable as they allow for the examination of a substantial number of host ectoparasites within a relatively short time frame, typically during the spring or autumn ringing periods.

Authors' contributions

Gökhan Eren: Conception/design of study, methodology (equal), data acquisition, data analysis/interpretation, identification, preservation (equal), drafting manuscript (lead), final approval and accountability (equal). **Esat Kızılkaya:** Methodology (equal), collection of specimens (lead), preservation (equal), final approval and accountability (equal). **Hakan Karaardıç:** Project administration/supervision, methodology (equal), collection of specimens (supporting), preservation (equal), critical revision of manuscript (supporting), final approval and accountability (equal). **Mehmet Karaca:** Methodology (equal), drafting manuscript (supporting), critical revision of manuscript (lead), final approval and accountability (equal).

Statement of ethics approval

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Conflict of interest

Authors declared no conflict of interest.

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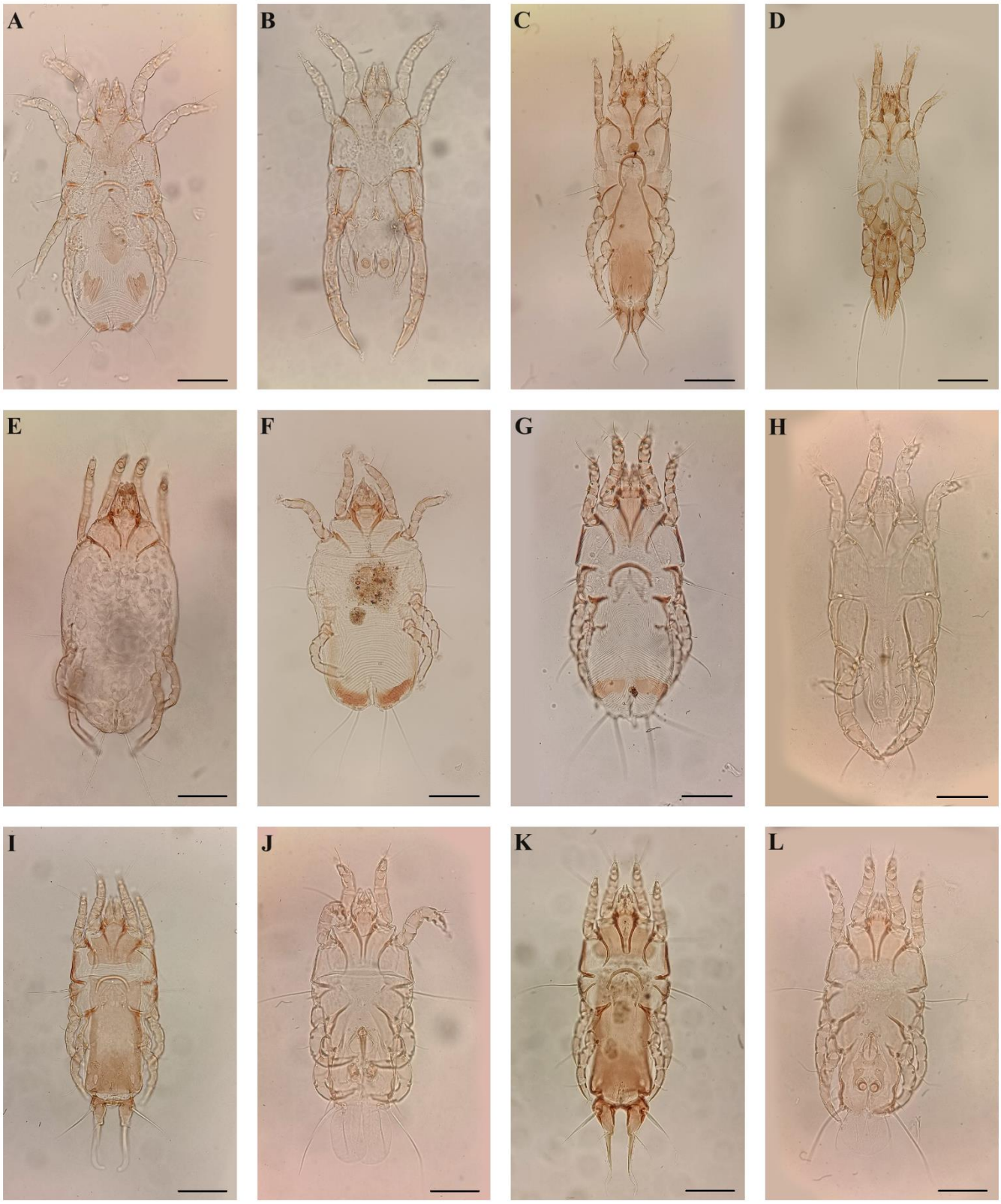

Figure 1. The original photographs of the feather mites detected as new records or new host-parasite associations. *Pteroherpus africanus* female (**A**) and male (**B**); *Dolichodectes edwardsi* female (**C**) and male (**D**); *Gymnolichus secundus* tritonymph (**E**); *Dermonoton parallelus* female (**F**); *Pteronyssus robini* female (**G**) and male (**H**); *Proctophyllodes pinnatus* female (**I**) and male (**J**); *Proctophyllodes anthi* female (**K**) and male (**L**) (scale bars: 100).

Table 1. Feather mites detected on the avian hosts (*new records for the Turkish fauna, **new host-parasite associations).

Bird species (number of infected birds)	Bird order	Bird family	Mite species
Caprimulgus europaeus (1/1)	Caprimulgiformes	Caprimulgidae	*Gymnolichus secundus**
Tringa glareola (3/2)	Charadriiformes	Scolopacidae	*Avenzoaria totani*
Otus scops (1/1)	Strigiformes	Strigidae	*Dermonoton parallelus**
Acrocephalus arundinaceus (4/4)	Passeriformes	Acrocephalidae	*Dolichodectes edwardsi* *Trouessartia trouessarti*
Acrocephalus schoenobaenus (6/5)			*Dolichodectes edwardsi*** *Proctophyllodes clavatus*
Carduelis spinus (2/1)		Fringillidae	*Analges passerinus* *Proctophyllodes pinnatus***
Locustella luscinioides (1/1)		Locustellidae	*Proctophyllodes clavatus* *Trouessartia kratochvili*
Locustella fluviatilis (1/1)			*Trouessartia kratochvili*
Anthus cervinus (5/5)		Motacillidae	*Proctophyllodes anthi**
Erithacus rubecula (4/2)		Muscicapidae	*Proctophyllodes rubeculinus* *Trouessartia rubecula*
Ficedula semitorquata (1/1)			*Proctophyllodes doleophyes***
Luscinia luscinia (2/1)			*Proctophyllodes lusciniae*
Pycnonotus xanthopygos (7/7)		Pycnonotidae	*Pteroherpus africanus**
Curruca hortensis (5/1)		Sylviidae	*Proctophyllodes clavatus***
Curruca nisoria (7/5)			*Proctophyllodes clavatus***
Sylvia atricapilla (9/9)			*Proctophyllodes sylvia* *Trouessartia bifurcata*
Turdus merula (3/1)		Turdidae	*Proctophyllodes musicus*
Dryobates minor (1/1)	Piciformes	Picidae	*Pteronyssus robini**
Jynx torquilla (1/1)			*Proctophyllodes anthi**

The number (n) of infected birds: *Acrocephalus scirpaceus* (12), *Anthus trivialis* (1), *Cettia cetti* (1), *Chloris chloris* (3), *Curruca communis* (5), *Curruca curruca* (6), *Ficedula albicollis* (1), *Ficedula hypoleuca* (1), *Garullus glandarius* (1), *Lanius nubicus* (4), and *Phylloscopus collybita* (4) from the order Passeriformes.

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