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To cite this article: L. Rolbiecki, J. N. Izdebska, K. Cierocka, A. Ribas & S. Morand (2026) A search for a universal pattern of infestation of Demodecidae skin mites in murid hosts, exemplified by the description of a new species of the genus *Demodex* (Acariformes: Demodecidae) in the Polynesian rat *Rattus exulans*, The European Zoological Journal, 93:1, 375-389, DOI: [10.1080/24750263.2026.2621455](https://doi.org/10.1080/24750263.2026.2621455)

To link to this article: <https://doi.org/10.1080/24750263.2026.2621455>



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Published online: 02 Mar 2026.



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A search for a universal pattern of infestation of Demodecidae skin mites in murid hosts, exemplified by the description of a new species of the genus *Demodex* (Acariformes: Demodecidae) in the Polynesian rat *Rattus exulans*

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ABSTRACT

The Polynesian rat *Rattus exulans* is the third most common species of *Rattus*, after the cosmopolitan brown rat *R. norvegicus* and black rat *R. rattus*. However, despite its wide distribution and great natural and economic importance, its acarofauna is poorly known. It has been found to host a species of demodecid mite that is new to science, *Demodex exulantis* sp. nov. which occurred in various areas of the hairy skin of the body. Demodecidae occupying analogous locations and with similar morphological features are typical skin parasites in other Muridae of Eurasian origin, including host species of the genera *Apodemus*, *Mus* and *Bandicota*. However, no such mite has previously been identified in hosts of the genus *Rattus*. The present study confirms the universality of this pattern of skin colonization of this group of rodents, i.e. with the dominant mite species associated with the hairy skin of the entire body. The identified model of skin infestation by co-occurring/synhospital demodecid mites, with the dominant species inhabiting hair follicles, may be a universal pattern for Demodecidae colonizing all mammalian groups. The present discovery also constitutes the first record of Prostigmata skin mites in *R. exulans*, and we present a global checklist with an updated list of Demodecidae records in murids.

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<https://zoobank.org/NomenclaturalActs/2cf24b22-4566-453c-9d42-f755daa5778b>

ARTICLE HISTORY

Received 12 June 2025

Accepted 20 January 2026

KEYWORDS

Demodecid mites; host-parasite relationships; Muridae; rodents; topographic analysis

Introduction

The Demodecidae (Acariformes: Prostigmata) are among the most specialized parasitic mites; they are usually host-specific, and often demonstrate great medical and veterinary importance. Among the mammals, the rodents of the Muridae family appear to be the best model for studying their biodiversity, because about 20% of all known species of these mites have been described in them (Izdebska & Rolbiecki 2020; Cierocka et al. 2024). This applies to Eurasian and cosmopolitan rodents (including synanthropic ones), whose evolutionary lineage reaches the area of Eurasia (Michaux et al. 2001; Zeng et al. 2017). They are therefore the best model for parasitological analyses concerning *inter alia* the functioning of host–parasite relationships for individual host species.

Among this group of hosts, demodecid mites demonstrate similar models of colonization and host microhabitat use; typically, several specific (monoxenic) species co-occur in different host microhabitats, inhabiting the hair follicles of ordinary hair (occurring in the entire hairy skin of the body) and sensory hair (in the region of the head vibrissae), the region of the eyelid and eyeball, various regions of sparsely haired and hairless skin (e.g. auricles, nose, lips, feet, tail), the glands of the genital–anal region, auditory canals, and tissues of the oral cavity (gums, tongue) (Izdebska & Rolbiecki 2020). The highest numbers of co-occurring demodecid mites have been described so far in the house mouse (seven species of mites), the brown rat, the yellow-necked field mouse and

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the long-tailed field mouse (five species each) (Bukva et al. 1992; Bukva 1995; Izdebska & Rolbiecki 2014, 2015a, 2015b, 2016; Izdebska et al. 2014, 2016; Cierocka et al. 2024). Each individual mite species shows different infection parameters, depending on the extent of the occupied microhabitat and the possibility of transmission between hosts.

Undoubtedly, for an individual host, the dominant species with regard to numbers is that associated with the entire hairy skin of the body, e.g. *Demodex musculi* in the house mouse, *D. corniculatus* in the yellow-necked field mouse, *D. apodemi* sensu lato in the striped field mouse, or *D. bandicotae* in the greater bandicoot rat (Izdebska & Rolbiecki 2013, 2015b; Izdebska et al. 2017a, 2017b). These species exhibit substantial morphological similarity, which may result from adaptation to living in similar microhabitats. However, this also applies to features of taxonomic importance that have little or negligible adaptive significance and are likely plesiomorphic. The mites are usually characterized by very large, supracoxal spines with similar shapes and locations in individual species; they have a similar number and structure of spines on the palpi, or the structure and location of the opisthosomal organ (occurring only in males in this case) and the shape of the aedeagus in males (Izdebska 2012; Izdebska & Rolbiecki 2015b; Izdebska et al. 2017b). Representatives of these mite species usually occur in all, or almost all, members of the population, i.e. a prevalence often reaching 100%, with the highest infection intensity/density among co-occurring Demodecidae (Izdebska et al. 2017a; Cierocka et al. 2024). Hence, during the study of a new host, these species are usually discovered and described first (Izdebska 2012; Izdebska & Rolbiecki 2015b; Izdebska et al. 2017b). The detection of subsequent, rarer and less numerous taxa usually requires the study of a much larger sample of hosts from multiple locations (Cierocka et al. 2024).

Such a common model, i.e. of optimal colonization of different microhabitats within the host, has been noted in other studied species of the genus *Apodemus*. In such cases, a dominant species is always noted in the hairy skin, with rarer species found in the eye area, the region of the vibrissae, or the auditory canals (Izdebska & Rolbiecki 2013; Cierocka et al. 2024). A similar model of colonization by Demodecidae has been reported in the house mouse (Izdebska & Rolbiecki 2020).

It seems interesting whether the complete pattern of colonization of multiple microhabitats, with a dominant species occurring throughout the entire hairy skin of the body and several rarer species with narrow, restricted microhabitats, recorded in rodents of the genus *Apodemus* or *Mus*, is universal for Eurasian Muridae, and may also apply to hosts of demodecid mites of the genus *Rattus*.

Although the Demodecidae of the brown rat are relatively well understood, as noted in studies of individuals from different regions (Europe, North America), they did not demonstrate any species analogous to other demodecid mites of the Muridae occurring throughout the entire hairy skin of the body (Hirst 1918, 1919; Desch 1987; Bukva 1995; Izdebska & Rolbiecki 2012a, 2014). Of the five species described here, two occupy limited microhabitats in the head area (*D. ratti*, *D. ratticola*), two are located in the genital–anal region (*D. nanus*, *D. norvegicus*), and another is found in the thinly haired skin of the paws and tail (*D. ponderosus*) (Bukva 1995; Izdebska & Rolbiecki 2014). In addition, Demodecidae have also been found in the black rat and the Malaysian field rat. The former was inhabited by *D. nanus*, recorded in the genital region and also noted in *R. norvegicus* (Hirst 1918; Desch 1987; Bukva 1995), and the latter was occupied by *D. sabani*, found in the Meibomian glands of the eyelids in several Asian rodent species (Desch et al. 1984). Both of these species require systematic revision, based on broader criteria currently used in the taxonomy of Demodecidae and the related verification of the host range.

Our present findings concern the Polynesian rat: the third most widespread rat species in the world, after the cosmopolitan brown and black rats. Although it comes from Southeast Asia, it is a very plastic species with a tendency to synanthropization; it has spread to various regions of Asia, the Malay Archipelago, the Philippines, Oceania, including New Guinea and New Zealand, and Polynesia, including Hawaii (Wilson & Reeder 2005). Despite its wide distribution and great natural and economic significance, as both an invasive species and a pest of agricultural crops and food storage, the acarofauna of this rat is poorly known. So far, from the group of so-called skin mites, only the sarcoptic mite *Notoedres pahangi* Klompen, Lukoschus, Fain et Nadchatram, 1983, recorded in various representatives of the genus *Rattus*, has been found in Polynesian rats, and only once (Bochkov 2010). However, no data exists on the occurrence of skin mites of Prostigmata (Giesen 1990; Izdebska & Rolbiecki 2020). Our present findings reveal the presence of a new species, *Demodex exulantis* sp. nov., in various areas of the hairy skin of the host. It also bears a set of specific features that match those of mite species that occupy analogous locations in rodents of the genera *Apodemus*, *Mus* and *Bandicota*.

Material and methods

Four specimens of *R. exulans* from Laos (Vientiane Province, village Phonepheng, 18°17'0"N, 102°30'45"E, 3 rats; village Thulakom, 18°16'57"N, 102°32'6"E, 1 rat) collected in May 2015 were examined for demodecid mites. Morphological characteristics and morphometry of rats were assigned for species identification in distinct specimens following Marshall (1988) and Aplin et al. (2003).

The rodent species of this study is not on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) list or the International Union for Conservation of Nature (IUCN) Red List. Animals were treated in accordance with the guidelines of the American Society of Mammalogists, and within the European Union legislation guidelines (Directive 86/609/EEC). The trapping campaign was validated by the national health authorities as included in a rodent-borne disease survey. Approval notices for trapping and investigation of rodents were provided by the Ministry of Health Council of Medical Sciences, National Ethics Committee for Health Research (NHCHR) Lao PDR, number 51/NECHR.

Skin fragments ($\approx 1 \text{ cm}^2$) were taken from several body regions including head, back, abdomen, front limb, hind limb, genital–anal area, and tail. The skin samples were preserved in 70% ethanol. For the recovery of demodecid mites, skin fragments were digested in 10% potassium hydroxide solution as described previously (Izdebska 2004). The digest material was decanted (examination of 1 cm^2 of the skin equal to the analysis of approximately 100 wet preparations), and examined using phase-contrast microscopy (Nikon Eclipse 50i). The mites were placed in polyvinyl-lactophenol solution. The following measurements were taken: total body length = length of gnathosoma, podosoma and opisthosoma; gnathosomal width (at base); podosomal and opisthosomal width = maximum width. All measurements are given in micrometres.

The specimen depositories are cited using the following abbreviation: UGDIZP, University of Gdańsk, Department of Invertebrate Zoology and Parasitology, Gdańsk, Poland (Zhang 2018). For the description of the species we adopted the nomenclature commonly used for the family Demodecidae (Nutting 1976), complemented with the nomenclature proposed by Bochkov (Bochkov 2008) for the superfamily Cheyletoidea (Acariformes: Prostigmata) and by Izdebska and Rolbiecki (2016). The scientific and common names of the hosts follow Wilson and Reeder (2005) and the Integrated Taxonomic Information System (2025).

To define the level of host infection, the following main parasitological parameters were measured: prevalence (percentage of hosts infected), mean intensity (mean number of parasites in infected hosts), intensity range (minimum and maximum number of parasite individuals per host), and density (number of parasites per unit area) (Bush et al. 1997).

The checklist of demodecid mites has been compiled based on manuscripts published during the period 1897–2025. It also contains a new record, marked as the present study. The list includes all formally described demodecid mite species known to date and other functioning specific names. The study also includes information on the host species, as well as the occurrence and microhabitats of mites. Host records related to unidentified *Demodex* spp. have not been included.

Results

Taxonomy

Demodex exulantis Izdebska, Rolbiecki, Cierocka, Ribas et Morand (Table 1, Figures 1, 2)

Table 1. Body size (μm) for adults of *Demodex exulantis* sp. nov.

Morphologic features	Males ($n = 201$): Mean (range) \pm SD	Females ($n = 66$): Mean (range) \pm SD
Length of gnathosoma	25 (22–27) \pm 1	24 (22–25) \pm 1
Width of gnathosoma (at base)	15 (14–19) \pm 1	15 (13–17) \pm 1
Length of podosoma	62 (55–67) \pm 2	62 (57–67) \pm 2
Width of podosoma	35 (30–40) \pm 2	27 (23–31) \pm 2
Length of opisthosoma	126 (105–150) \pm 9	131 (100–158) \pm 13
Width of opisthosoma	39 (30–45) \pm 3	30 (23–36) \pm 3
Aedeagus	23 (18–28) \pm 2	–
Vulva	–	8 (5–10) \pm 1
Total length of body	212 (186–238) \pm 10	217 (183–248) \pm 13

SD - standard deviation.

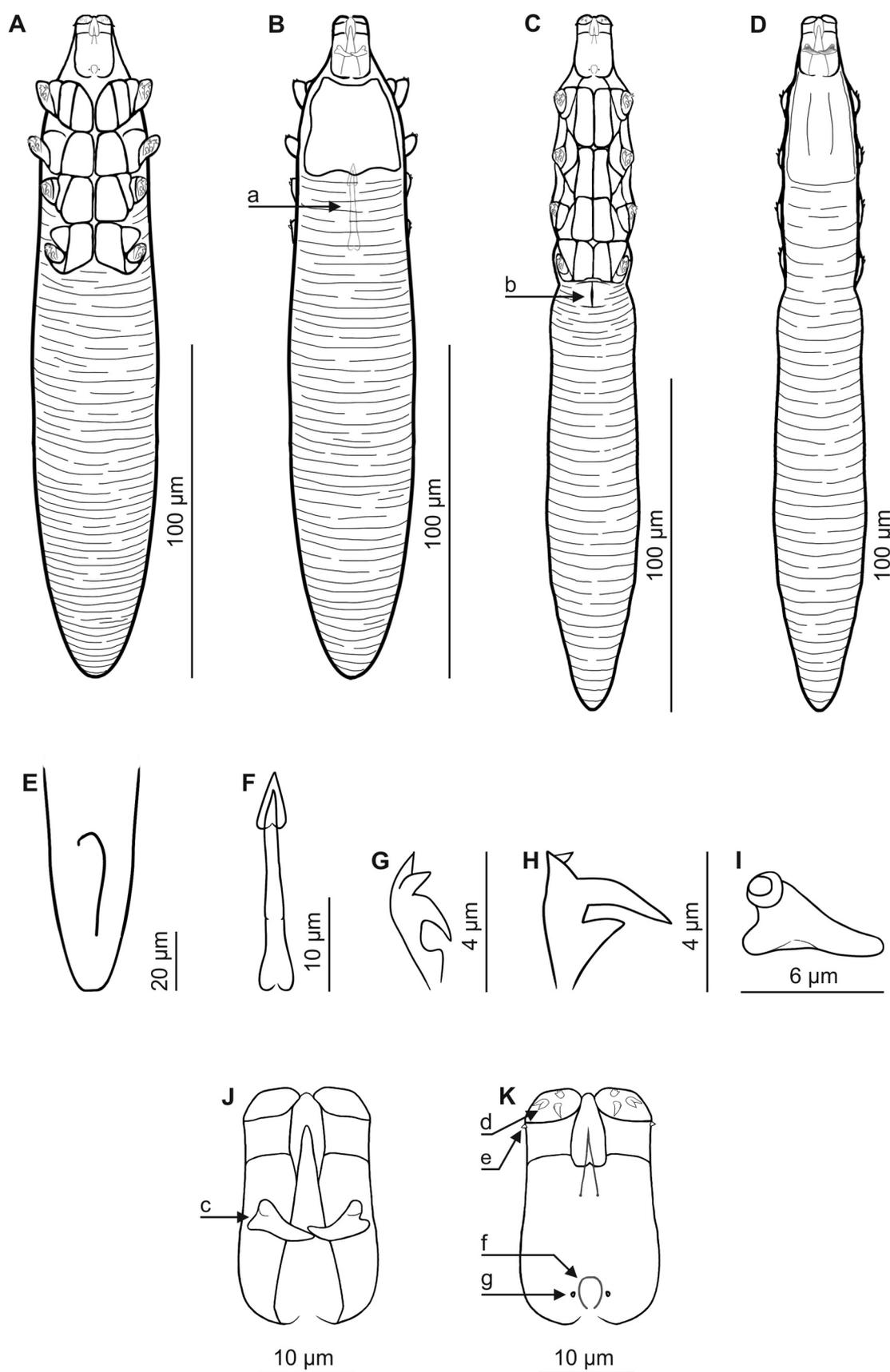


Figure 1. *Demodex exulantis* sp. nov.: (A) male, ventral view; (B) male, dorsal view, a – aedeagus; (C) female, ventral view, b – vulva; (D) female, dorsal view; (E) posterior part of opisthosoma with visible opisthosomal organ; (F) aedeagus; (G, H) claw on the leg, various views; (I) supracoxal spine (seta *elc.p*); (J) gnathosoma, male, dorsal view, c – supracoxal spine (seta *elc.p*); (K) gnathosoma, male, ventral view, d – spines on palps, e – seta *v'F*, f – pharyngeal bulb, g – subgnathosomal seta (seta *n*).



Figure 2. *Demodex exulantis* sp. nov.: (A) male; (B) female; (C) female with visible remains of nymphal exuviae (arrows).

Male ($n = 200$ and 1 holotype). Body elongated, cylindrical, with long, distinctly separated gnathosoma, $212 \mu\text{m}$ ($186\text{--}238 \mu\text{m}$) long and 39 ($30\text{--}45 \mu\text{m}$) wide (holotype, $212 \times 43 \mu\text{m}$). Gnathosoma trapezoidal, distinctly longer than width at base; on dorsal side in the central part of basal segment, pair of wedge-shaped supracoxal spines (setae *elc.p*) present, ca. 6–7 long (holotype, 4.0), directed medially, overlapping each other. Palps 3-segmented, terminating in three spines: one small, denticled and two large (one single and one bifurcated) on tibio-tarsus; also setae *v*^{*F*} present on middle segment (trochanter-femur-tarsus). On ventral surface of gnathosoma, horseshoe-shaped pharyngeal bulb, with pair of very small subgnathosomal setae (setae *n*), situated halfway along pharyngeal bulb on both sides. Podosoma rectangular; four pairs of short legs with coxa integrated into ventral idiosomal wall and five free, overlapping segments (trochanter-tarsus); two bifurcated claws, ca. $4 \mu\text{m}$ long (holotype, $4.0 \mu\text{m}$), with sharp, slightly downwardly curved subterminal spur, with proximal pointed projection on each tarsus; additionally two tubercles at base of each claw. Two solenidia on each leg genu. Epimeral plates (coxal fields) connect medially, distinctly sclerotized, I

pair trapezoidal, II–IV pairs rectangular. On dorsal side of podosoma distinct sclerotized podosomal shield, reaches anterior level of legs III. Opisthosoma constitutes 59% (56–63%) of body length (holotype, 59%); elongated, cylindrical or slightly fusiform, slightly tapered towards end, rounded at the end. Whole opisthosoma densely annulated, delicate annuli wide at ca. 2 µm. Opisthosomal organ tubular, elongated, cane-shaped, ca. 30–40 µm long (holotype, 35 µm), posterior margin located at 30 µm (holotype, 30 µm) from end of opisthosoma. Aedeagus elongated, 23 µm (18–28 µm) long (holotype, 24 µm), on dorsal surface, located at level of epimeral plates II–IV; genital opening located in posterior part of epimeral plate II.

Female ($n = 60$). Cylindrical, more slender than male, 217 µm (183–248 µm) long, 30 µm (23–36 µm) wide. Gnathosoma shape similar to male, trapezoidal, longer than width at base. Pharyngeal bulb and morphological details of gnathosoma similar to those in female, often more delicate (e.g. slightly smaller supracoxal spines, ca. 5–6 µm). Shape of podosoma and legs similar to those in male: connected medially, distinctly sclerotized, I pair trapezoidal, II–IV pairs rectangular, but unlike those in the male posterior edges of pair IV form slight incision. On dorsal side of podosoma podosomal shield present, reaches level of legs III. Opisthosoma constitutes 60% (55–64%) of body length; narrow, cylindrical, slightly tapered towards end, rounded at the end. Whole opisthosoma distinctly annulated, annuli relatively wide at ca. 3–4 µm. Opisthosomal organ missing. Vulva 8 µm (5–10 µm) long, located below posterior level of epimeral plates IV.

Immature stages. Only adults were found in the remains of nymphal exuviae; a few larvae (two individuals) and nymphs (five individuals) were noted, but without visible features enabling stage identification.

Egg. No eggs were found.

Material deposition

Holotype male (reg. no. UGDIZPRReDDe142m), 200 male paratypes (reg. no. UGDIZPRReDDe01m–141 m, UGDIZPRReDDe143m–201m) and 66 female paratypes (reg. no. UGDIZPRReDDe01f–66f); hairy skin of the body (head, back, abdomen, limbs, genital–anal area, root of the tail); host *Rattus exulans* (reg. no. MRMR510/♂/2015, MRMR511/♀/2015, MRMR520/♀/2015); Vientiane Province, village Phonepheng, village Thulakom, Laos; May 2015; parasite coll. J.N. Izdebska, L. Rolbiecki, K. Cierocka; host coll. A. Ribas, S. Morand; the whole-type material (mounted microscope slides with the demodecid mites) deposited within the framework of the Collection of Extant Invertebrates in the Department of Invertebrate Zoology and Parasitology, University of Gdańsk, Poland.

Etymology

The specific epithet *exulantis* refers to the specific name of the host.

Infestation and location in the host

Demodex exulantis sp. nov. was noted in three out of four examined rats (prevalence 75%), with a mean intensity of 91.3, range of intensity of 8–251, and density of 18.3; 274 (201 males, 66 females, two larvae, five nymphs) individuals were noted (Table 2). The demodecid mites were found in various areas of the hairy skin of the body (head ×78, back ×15, abdomen ×11, front limbs ×26, hind limbs ×50, genital–anal area ×83, root of the tail ×11) (Figure 3). Infected rats were from Phonepheng (2 infected rats and 266 mites) and from

Table 2. Density of *Demodex exulantis* sp. nov. found in the skin of the *Rattus exulans*.

Body regions ($n = 4$ rats*)	<i>Demodex exulantis</i> sp. nov.		
	Number of parasites	Number of infected host/skin samples	Density
Head	78	3	26.0
Back	15	2	7.5
Abdomen	11	2	5.5
Front limbs	26	3	8.7
Hind limbs	50	2	25.0
Genital–anal area	83	2	41.5
Tail (root)	11	2	11.0
Total	274	15*	18.3

*A skin fragment of $\approx 1\text{cm}^2$ was examined from any body region in the individual rats.

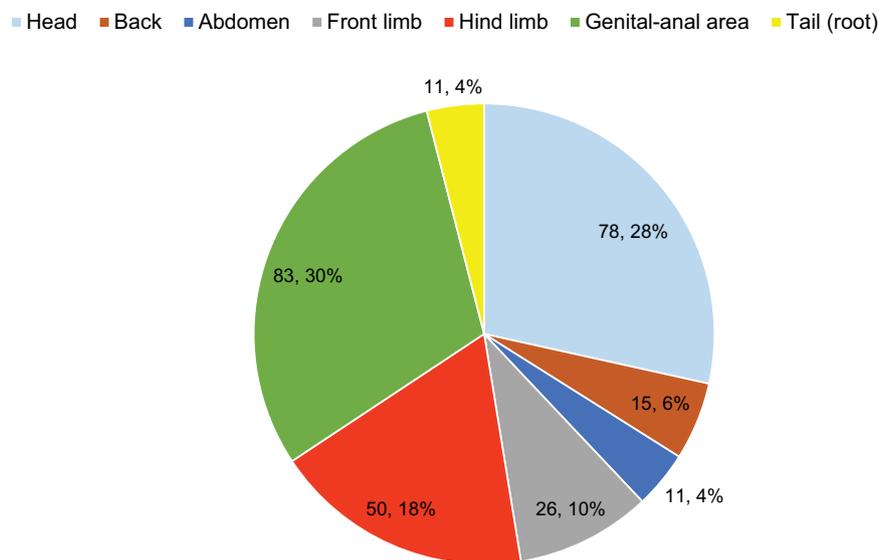


Figure 3. Location (number, %) of *Demodex exulantis* sp. nov. in *Rattus exulans*.

Thulakom (1 infected rat and 8 mites). The observed mites did not cause any skin lesions in the examined rats.

Differential diagnosis of *Demodex exulantis* sp. nov.

Demodex exulantis sp. nov. from *R. exulans* is morphologically similar to *D. bandicotae* from *B. indica* (Izdebska et al. 2017b).

Demodex exulantis sp. nov. females are similar in size to *D. bandicotae* females, while the males are distinctly larger, with a longer opisthosoma (Table 3). Both species exhibit distinct sexual dimorphism, but in *D. exulantis* sp. nov., the female is similar in length to the male, albeit with different body proportions (narrower, more slender) and different opisthosoma striations: dense, delicate in the male, but distinct; while in the female, with annuli twice as wide. In *D. bandicotae*, the male is distinctly smaller than the female. The differences between these species concern also important structures of the gnathosoma. The supracoxal spines of both species are large and wedge-shaped, but in *D. exulantis* sp. nov. they are slightly larger, more massive, and have a rounded thickening in the anterior part; additionally, they are located in the middle part of the gnathosoma, directed towards the centre, where they slightly overlap. The supracoxal of *D. bandicotae* are also wedge-shaped, but narrower, located similarly, but not overlapping in the middle part of the gnathosoma. In both species, the terminal segments of the palpi present three spines (one small and two larger), but in *D. exulantis* sp. nov. the small spine is denticled, and in *D. bandicotae* it is bifurcated. The subgnathosomal setae in *D. exulantis*

Table 3. Morphometric comparison between *Demodex exulantis* sp. nov. and *Demodex bandicotae*.

Feature	<i>Demodex exulantis</i> sp. nov.		<i>Demodex bandicotae</i>	
	Present study		Izdebska et al. (2017b)	
	Males (<i>n</i> = 201) Mean (range) ± SD	Females (<i>n</i> = 66) Mean (range) ± SD	Males (<i>n</i> = 4) Mean (range) ± SD	Females (<i>n</i> = 24) Mean (range) ± SD
Body total length	212 (186–238) ± 10	217 (183–248) ± 13	167 (143–180) ± 17	231 (190–253) ± 15
Body total width	39 (30–45) ± 3	30 (23–36) ± 3	34 (33–38) ± 3	33 (28–38) ± 2
Body length to width ratio	5.5:1 (4.7–6.9:1) ± 0.4:1	7.2:1 (5.7–9.0:1) ± 0.8:1	5.0:1 (3.8–5.5:1) ± 0.8:1	6.9:1 (5.6–8.2:1) ± 0.6:1
Opisthosoma length to body length ratio (%)	59 (56–63) ± 2	60 (55–64) ± 2	53 (51–58) ± 3	61 (54–66) ± 2
Aedeagus length	23 (18–28) ± 2	–	26 (23–30) ± 3	–
Vulva length	–	8 (5–10) ± 1	–	9 (7–18) ± 2

SD - standard deviation.

sp. nov. are located on both sides in the middle part of the pharyngeal bulb, while they are below the pharyngeal bulb in *D. bandicotae*. The tubular opisthosomal organ occurs in males of both species: it is longer, usually bent in the shape of a cane, in *D. exulantis* sp. nov., while it is L-shaped in *D. bandicotae*. Parasitological data also confirm the distinctness of this species: *D. exulantis* sp. nov. occurs in *R. exulans*, while *D. bandicotae* is found in *B. indica*.

Biodiversity of Demodecidae in Muridae

Of the 15 murid species (representing seven genera) studied so far, 28 Demodecidae species have been documented. The highest species richness (seven species) was found in the house mouse (Table 4).

Discussion

The studied mites demonstrated a similar pattern of colonization of skin microhabitats as previously examined Demodecidae in murid rodents (*Apodemus* spp., *M. musculus*). The mites optimally use the host body as a living environment for co-occurring species (Table 4). In each case, the dominant parasite was always the species associated with the entire hairy skin of the body, and this was accompanied by rarer species associated with limited microhabitats and lower infestation rates; they were hence discovered later (Izdebska et al. 2023; Cierocka et al. 2024). Similar demodecid mites were also discovered in the hairy skin of the Asian murid – *B. indica* (Izdebska et al. 2017b). So far, no analogous method of skin colonization by demodecid mites has been confirmed in the genus *Rattus*, where the model host was *R. norvegicus*: one of the two most common and most widely distributed species of rats. In the rat specimens examined earlier, which came from Europe (Great Britain, Czech Republic and various locations in Poland) and the USA, five species of Demodecidae were described. All were recorded in Europe, and two species have been recorded so far in the USA. The most data had been obtained from Poland, where a fifth species associated with the hairless skin of the paws and tail was recently discovered (Izdebska & Rolbiecki 2014). Of this set of species, only *D. ratti* demonstrates the model of skin colonization observed in other Muridae by various synhospital demodecid mites. It is located in the eyelid region, similarly to *D. huttereri* from *A. agrarius*, *D. lacrimalis* from *A. sylvaticus*, *D. mollis* from *A. flavicollis*, or *D. sabani* from various Asian murids. The brown rat originates from Southeast Asia and only in the Middle Ages did it begin to spread to other regions, becoming a cosmopolitan species (Cierocka et al. 2024). Perhaps the composition of the Demodecidae fauna in different regions of its occurrence is not complete, and this may result, for example, from the founder effect. To clarify this issue, it would be necessary to examine rats from the original regions of occurrence.

Our present data derives from the third most widespread species of rat in the world, the Polynesian rat, and represents the first such data on the presence of Demodecidae. Our analysis of four rat specimens has already allowed the discovery of a new species, inhabiting different areas of hairy skin. The level of *D. exulantis* sp. nov. infection in the examined rats was high, being recorded in three out of four examined rats, with a relatively high intensity and density of infection, with a mean number of 18 and 90 and specimens in the examined host/skin fragments, respectively. However, the infection varied between individual hosts: a dozen mites were found in each of two rats, while 251 (185 males, 59 females, two larvae, five nymphs) were noted in the third. However, similarly to the case of infection with other wild Muridae, no disease symptoms have been observed at present. Skin lesions associated with the presence of demodecid mites have so far been reported only in farm/laboratory mice (Nashat et al. 2017).

The distribution of *D. exulantis* sp. nov. in the skin was uneven – most specimens were found in the head region and posterior parts of the body (genital–anal region, hind legs). This may be related to the transmission mechanism of these parasites, i.e. in inter-individual contacts, including sexual contacts. The population structure was also interesting, in which males dominated over females (proportion 3:1). As a rule, in the Demodecidae, the population structure is dominated by females or demonstrated similar proportions of females and males; this also applies to other species from *Rattus*, as well as other Muridae (Izdebska & Rolbiecki 2012b). In the current analysis, however, almost exclusively adults were found, with only a few larvae and adults being noted in the remains of the nymphal exuviae, so perhaps only one stage of the population functioning/development was observed.

Table 4. Murid host associations and geographical distribution of the valid demodecid mites of the world.

Species of host	Species of demodecids	Microhabitat	Occurrence
<i>Apodemus agrarius</i> (Pallas, 1771)	<i>Demodex agrarii</i> Bukva, 1994	Glands in external auditory meatus	Poland (Izdebska & Cydzik 2010; Izdebska & Rolbiecki 2013), Slovak Republic (Bukva 1994)
	<i>Demodex apodemii</i> Hirst, 1918	Hairy skin of the body, especially skin of head	Poland (Izdebska & Cydzik 2010), Russia (Bregetova et al. 1955). Described by Hirst (1918), considered a subspecies <i>D. arvicolae</i> var. <i>apodemii</i> (Hirst 1919). Verified as <i>D. apodemii</i> (Izdebska 2012); species inquirenda (specimens from <i>A. agrarius</i> may be a separate species) Poland (Izdebska & Rolbiecki 2013)
<i>Apodemus flavicollis</i> (Melchior, 1834)	<i>Demodex gracilentus</i> Izdebska et Rolbiecki, 2013	Vibrissae area	Germany (Mertens et al. 1983), Poland (Izdebska et al. 2011)
	<i>Demodex huttereri</i> Mertens, Lukoschus et Nutting, 1983	Eyelid area, Meibomian glands	Poland (Izdebska 2012; Izdebska et al. 2017a)
	<i>Demodex corniculatus</i> Izdebska, 2012	Hairy skin of the head (eyelids, cheeks, ears, chin), skin of the genital–anal region	
	<i>Demodex mediacris</i> Izdebska, Cierocka et Rolbiecki, 2024	Chin	Poland (Cierocka et al. 2024)
	<i>Demodex mollis</i> Izdebska, Rolbiecki, Fryderyk et Mierzynski, 2017a	Eyelid area	Poland (Izdebska et al. 2017a)
	<i>Demodex rosus</i> Bukva, Vitovec et Viček, 1985	Oral cavity, esophagus	Czech Republic (Bukva et al. 1985), Poland (Izdebska & Fryderyk 2011)
	<i>Demodex tenuis</i> Izdebska, Cierocka et Rolbiecki, 2024	Lips	Poland (Cierocka et al. 2024)
<i>Apodemus sylvaticus</i> (Linnaeus, 1758)	<i>Demodex apodemii</i>	Hairy skin of the body	Great Britain (Hirst 1918, 1919), Poland (Izdebska et al. 2014), Russia (Bregetova et al. 1955). See also comment at <i>Demodex apodemii</i>
	<i>Demodex auricularis</i> Izdebska, Rolbiecki et Fryderyk, 2014	Ear canal	Poland (Izdebska et al. 2014)
	<i>Demodex lacrimalis</i> Lukoschus et Jongman, 1974	Meibomian glands	Netherlands; Italy (Lukoschus & Jongman 1974), Poland (Izdebska & Fryderyk 2012)
	<i>Demodex longior</i> Hirst, 1918	Sensory hair follicles within the nose region	Great Britain (Hirst 1918, 1919), Russia (Bregetova et al. 1955), Poland (Izdebska & Rolbiecki 2013)
	<i>Ophthalmodex apodemii</i> Bukva, Nutting et Desch, 1992	Ocular area	Czech Republic (Bukva et al. 1992)
<i>Bandicota indica</i> (Beschstein, 1800)	<i>Demodex bandicotae</i> Izdebska, Rolbiecki, Morand et Ribas, 2017	Hairy skin of the body	Laos (Izdebska et al. 2017)
<i>Leopoldamys edwardsi</i> (Thomas, 1882)	<i>Demodex sabani</i> Desch, Lukoschus et Nachatram, 1984	Meibomian glands	Malaysia (Desch et al. 1984)
<i>Leopoldamys sabanus</i> (Thomas, 1887)	<i>Demodex sabani</i>	Meibomian glands	Malaysia (Desch et al. 1984)
<i>Mus musculus</i> Linnaeus, 1758	<i>Demodex conicus</i> Izdebska et Rolbiecki, 2015	Ear canal	Poland (Izdebska & Rolbiecki 2015a)
	<i>Demodex flagellurus</i> Bukva, 1985	Genital region	Czech Republic (Bukva 1985), Poland (Izdebska 2000; Izdebska & Rolbiecki 2006, 2015c)
	<i>Demodex fusiformis</i> Izdebska et Rolbiecki, 2015	Abdomen, back, and limbs	Poland (Izdebska & Rolbiecki 2015b)
	<i>Demodex marculus</i> Izdebska et Rolbiecki, 2015	Abdomen, back, limbs, and anal region	Poland (Izdebska & Rolbiecki 2015b)
	<i>Demodex musculi</i> Oudemans, 1897 (redescription, Izdebska et Rolbiecki, 2015)	Skin of various, haired regions of the body	Europe (Oudemans 1897; Hirst 1919), Poland (Izdebska 2000; Izdebska & Rolbiecki 2015b), Russia (Bregetova et al. 1955), Spain (Ventura et al. 2020); laboratory animals (e.g. Nashat et al. 2017)
	<i>Demodex vibrissae</i> Izdebska, Rolbiecki et Fryderyk, 2016	Vibrissae area	Poland (Izdebska et al. 2016)
	<i>Glossicodex musculli</i> Izdebska et Rolbiecki, 2016	Tissue of tongue	Poland (Izdebska & Rolbiecki 2016)

(Continued)

Table 4. (Continued).

Species of host	Species of demodecids	Microhabitat	Occurrence
<i>Niviventer cremoriventer</i> (Miller, 1900)	<i>Demodex sabani</i>	Meibomian glands	Malaysia (Desch et al. 1984)
<i>Niviventer rapit</i> (Bonhote, 1903)	<i>Demodex sabani</i>	Meibomian glands	Malaysia (Desch et al. 1984)
<i>Rattus annandalei</i> (Bonhote, 1903)	<i>Demodex sabani</i>	Meibomian glands	Malaysia (Desch et al. 1984)
<i>Rattus exulans</i> (Peale, 1848)	<i>Demodex exulantis</i> Izdebska, Rolbiecki, Cierocka, Ribas et Morand, 2026	Hairy skin of the body	Laos (present study)
<i>Rattus norvegicus</i> (Berkenhout, 1769)	<i>Demodex nanus</i> Hirst, 1918 (redescription, Desch, 1987)	Sebaceous glands, skin of genital–anal region	Great Britain (Hirst 1918), Poland (Izdebska 2004, Izdebska & Rolbiecki 2012a, 2012b, 2014), Russia (Bregetova et al. 1955); laboratory animals (Desch 1987)
	<i>Demodex norvegicus</i> Bukva, 1995	Genital–anal region	Czech Republic (Bukva 1995), Poland (Izdebska 2004, Izdebska & Rolbiecki 2012a, 2012b, 2014)
	<i>Demodex ponderosus</i> Izdebska & Rolbiecki, 2014	Thinly haired regions (tail and paws)	Poland (Izdebska & Rolbiecki 2014)
	<i>Demodex ratti</i> Hirst, 1917 (redescription, Bukva, 1995)	Head	Europe (Hirst 1917, 1919), Czech Republic (Bukva 1995), Poland (Izdebska 2004; Izdebska & Rolbiecki 2012a, 2012b, 2014), Russia (Bregetova et al. 1955)
	<i>Demodex ratticola</i> Bukva, 1995	Skin of head (nose, lips, chin)	Czech Republic (Bukva 1995), Poland (Izdebska & Rolbiecki 2012a, 2012b, 2014)
<i>Rattus rattus</i> (Linnaeus, 1758)	<i>Demodex nanus</i>	Sebaceous glands	Great Britain (Hirst 1918), New Zealand (Desch 1987), Russia (Bregetova et al. 1955)
<i>Rattus tiomanicus</i> (Miller, 1900)	<i>Demodex sabani</i>	Meibomian glands	Malaysia (Desch et al. 1984)
<i>Sundamys muelleri</i> (Jentink, 1879)	<i>Demodex sabani</i>	Meibomian glands	Malaysia (Desch et al. 1984)

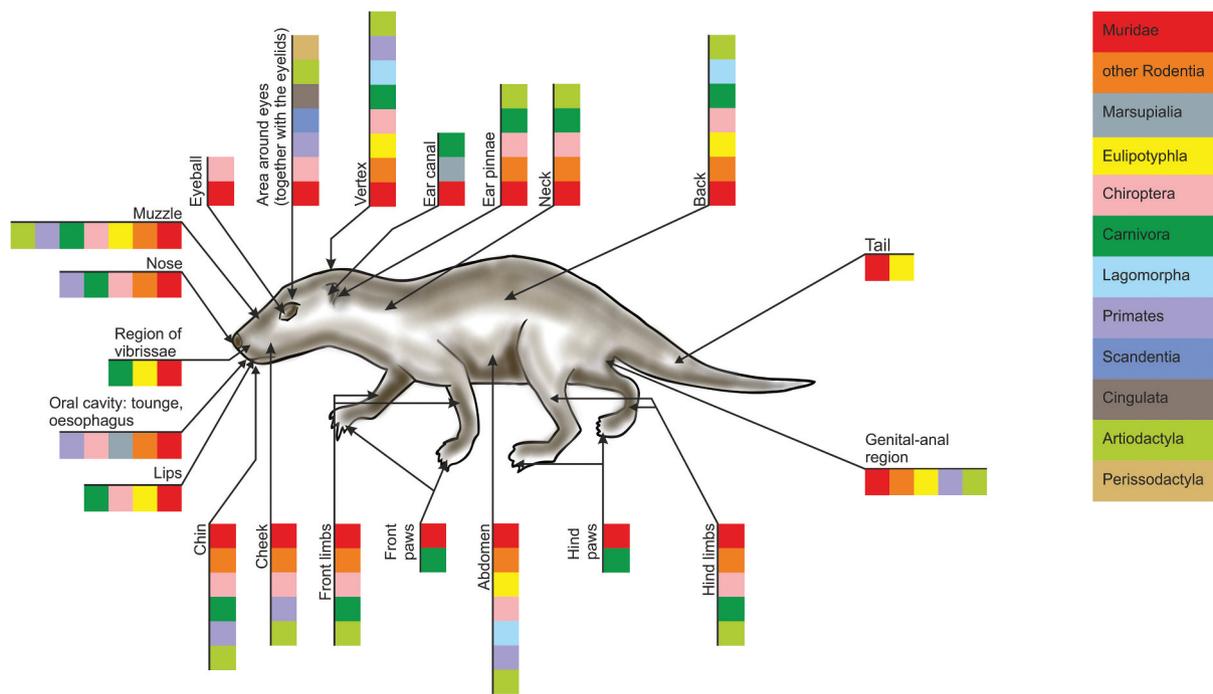


Figure 4. Model of skin infestation by demodecid mites in mammals.

Methodical studies of Demodecidae are very laborious – detecting asymptomatic infestation in the skin of mammals requires the analysis of thousands of wet slides (see the section on Material and methods). The asymptomatic course of infestation, microscopic size and hidden lifestyle of these mites, with limited location within the host and, as a rule, low levels of infection, make their detection difficult. As such, rodents seem to be a convenient model for studying the distribution of co-occurring species of demodecid mites in the skin, due to their small size (smaller skin surface area) and common occurrence, which determines greater availability of materials/parasites.

It is not known to what extent the patterns of Demodecidae infestation correspond to the location of these mites in the skin of other groups of mammals. However, a number of analogies can be identified. In other rodents (e.g. cricetids), soricomorphs, bats, carnivorans, ungulates, or primates, the dominant species is also associated with the hairy skin of the body (Raszeja-Kotelba et al. 2004; Izdebska et al. 2013; Izdebska & Rolbiecki 2018; Cierocka et al. 2021, 2022, 2024). The second universal location seems to be the eyelid area (Meibomian glands of the eyelids), because in addition to the species of Muridae mentioned above, other species are also identified in this area in bats and ungulates (Kadulski & Izdebska 1996; Cierocka et al. 2022). In the Muridae, another frequently chosen location is the area of the vibrissae or lips, the colonization of which has also been reported in carnivorans or soricomorphs (Cierocka et al. 2021; Izdebska et al. 2023). In turn, species analogous to those inhabiting the nose in the murids have been recorded in ungulates, and in the auditory canals in carnivorans (Morita et al. 2018; Izdebska et al. 2022). Also, the other microhabitats identified in murids are confirmed by the fact that similar locations are selected by demodecid mites in other groups of mammals. It can therefore be assumed that the model of settlement of various microhabitats observed in this common group of Muridae (Figure 4) may be a universal pattern, shaped in the course of evolution of Demodecidae, and the formation of subsequent host–parasite relationships in different hosts.

In summary, understanding the full model of skin colonization of rodents of the genus *Rattus* requires further, extensive studies based on larger material collections and specimens from different geographical regions. However, current studies indicate a universal mechanism of the formation or evolution of host–parasite relationships, in which related hosts (in this case Eurasian Muridae) present morphologically similar species inhabiting analogous microhabitats.

Acknowledgments

Special thanks to Dr. Ivo Elliott and Dr. Paul Newton.

Authors' contributions

Conceptualization: LR, JNI. Methodology: JNI, LR, AR, SM. Data collection: JNI, LR, KC, AR, SM. Parasitological analysis: LR, JNI, KC. Original draft: JNI, LR. Review and editing: JNI, LR, KC, AR, SM.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The data collection was financially and logistically supported by the Faculty of Biology, University of Gdańsk, Poland and the French [ANR CP&ES, grant ANR 11 CPEL 002] BiodivHealthSEA project.

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Compliance with ethical standards

All applicable international, national and/or institutional guidelines for the care and use of animals were followed.

Data availability statement

The data analyses in this study are available from the corresponding author upon reasonable request.

Ethics approval consent to participate

All the fieldwork was done according to the ethical standards recommended by the relevant institutions.

References

- Aplin KP, Brown PR, Jacob J, Krebs C, Singleton GR. 2003. Field methods for rodent studies in Asia and the Indo-Pacific. In: ACIAR monograph series No. 100. Canberra: Australian Centre for International Agricultural Research.
- Bochkov AV 2008. New observations on phylogeny of cheyletoid mites (Acari: Prostigmata: Cheyletoidea). Proceedings of the Zoological Institute RAS 312:54–73.
- Bochkov AV. 2010. A review of mammal-associated Psoroptidia (Acariformes: Astigmata). *Acarina* 18:99–260.
- Bregetova NG, Bulanova-Zahvatkina EM, Volgin VI, Dubinin VB, Zahvatkin AA, Zemskaa AA, Lange AB, Pavlovskij EN, Serdûkova GV, Šluger EG. 1955. Mites of rodents of the USSR fauna. Moskva, Leningrad: Izdatel'stvo Akademii Nauk SSSR.
- Bukva V. 1985. *Demodex flagellurus* sp. n. (Acari: Demodicidae) from the preputial and clitoral glands of the house mouse. *Mus musculus* L. *Folia Parasitologica* 32:73–81.
- Bukva V. 1994. *Demodex agrarii* sp. n. (Acari: Demodicidae) from cerumen and the sebaceous glands in the ears of the striped field mouse. *Apodemus agrarius* (Rodentia). *Folia Parasitologica* 41:305–311.
- Bukva V. 1995. *Demodex* species (Acari: Demodicidae) parasitizing the brown rat, *Rattus norvegicus* (Rodentia): Redescription of *Demodex ratti* and description of *D. norvegicus* sp. n. and *D. ratticola* sp. n. *Folia Parasitologica* 42:149–160.

- Bukva V, Nutting WB, Desch CE. 1992. Description of *Ophthalmodes apodemi* sp. n. (Acari: Demodecidae) from the ocular area of *Apodemus sylvaticus* (Rodentia: Muridae) with notes on pathogenicity. *International Journal of Acarology* 18 (4):269–276. DOI: [10.1080/01647959208683959](https://doi.org/10.1080/01647959208683959)
- Bukva V, Vítovec J, Vlček M. 1985. *Demodex rosus* sp. n. and *D. buccalis* sp. n. (Acari: Demodecidae) parasitizing the upper digestive tract of rodents. *Folia Parasitologica* 32:151–162.
- Bush AO, Lafferty KD, Lotz JM, Shostak AW. 1997. Parasitology meets ecology on its own terms: Margolis et al. revisited. *Journal of Parasitology* 68:131–133.
- Cierocka K, Izdebska JN, Rolbiecki L. 2021. *Demodex crocidurae*, a new demodecid mite (Acariformes: Prostigmata) parasitizing the lesser white-toothed shrew and a redescription of *Demodex talpae* from European mole with data on parasitism in Soricomorpha. *Animals* 11(9):2712. DOI: [10.3390/ani11092712](https://doi.org/10.3390/ani11092712)
- Cierocka K, Izdebska JN, Rolbiecki L. 2024. The co-occurrence of Demodecidae and Psorergatidae (Acariformes: Prostigmata) in the yellow-necked field mouse *Apodemus flavicollis* (Rodentia: Muridae) with a description of two new species and a new host record. *Diversity* 16(9):550. DOI: [10.3390/d16090550](https://doi.org/10.3390/d16090550)
- Cierocka K, Izdebska JN, Rolbiecki L, Ciechanowski M. 2022. The occurrence of skin mites from the Demodecidae and Psorergatidae (Acariformes: Prostigmata) families in bats, with a description of a new species and new records. *Animals* 12(7):875. DOI: [10.3390/ani12070875](https://doi.org/10.3390/ani12070875)
- Desch CE. 1987. Redescription of *Demodex nanus* (Acari: Demodecidae) from *Rattus norvegicus* and *R. rattus* (Rodentia). *Journal of Medical Entomology* 24(1):19–23. DOI: [10.1093/jmedent/24.1.19](https://doi.org/10.1093/jmedent/24.1.19)
- Desch CE, Lukoschus FS, Nadchatram M. 1984. A new demodecid (Acari: Demodecidae) from the meibomian glands of Southeast Asian rats (Rodentia: Muridae). *Tropical Biomedicine* 1:55–62.
- Giesen KMT. 1990. A review of the parasitic mite family Psorergatidae (Cheyletoidea: Prostigmata: Acari) with hypotheses on the phylogenetic relationships of species and species groups. *Zoologische Verhandelingen* 259:1–69.
- Hirst S. 1917. Remarks on certain species of the genus *Demodex*, Owen (the *Demodex* of man, the horse, dog, rat, and mouse). *Annals and Magazine of Natural History, Series* 8(20):232–235.
- Hirst S. 1918. XI.—on four new species of the genus *Demodex*, Owen. *Annals and Magazine of Natural History, Series* 9 (2):145–146.
- Hirst S. 1919. Studies on Acari. No. 1. The genus *Demodex*, Owen. United Kingdom: British Museum (Natural History). Integrated Taxonomic Information System (ITIS). 2025. <http://www.itis.gov/>.
- Izdebska JN. 2000. Nowe gatunki *Demodex* spp. (Acari, Demodecidae) u *Mus musculus* w Polsce. *Wiadomości Parazytologiczne* 46:277–280.
- Izdebska JN. 2004. *Demodex* spp. (Acari: Demodecidae) in brown rat (Rodentia: Muridae) in Poland. *Wiadomości Parazytologiczne* 50:333–335.
- Izdebska JN. 2012. A new Demodecidae species (Acari) from the yellow-necked mouse *Apodemus flavicollis* (Rodentia: Muridae)—description with data on parasitism. *Journal of Parasitology* 98(6):1101–1104. DOI: [10.1645/GE-3018.1](https://doi.org/10.1645/GE-3018.1)
- Izdebska JN, Cydzik K. 2010. Occurrence of *Demodex* spp. (Acari, Demodecidae) in the striped field mouse *Apodemus agrarius* (Rodentia, Muridae) in Poland. *Wiadomości Parazytologiczne* 56:59–61.
- Izdebska JN, Fryderyk S. 2011. Recent data on *Demodex rosus* Bukva, Vítovec et Vlček, 1985 (Acari, Demodecidae) from oral cavity of yellow-necked field mouse, *Apodemus flavicollis* (Rodentia, Muridae). *Wiadomości Parazytologiczne* 57:257–260.
- Izdebska JN, Fryderyk S. 2012. New data on the occurrence of *Demodex lacrimalis* (Acari, Demodecidae) of the wood mouse *Apodemus sylvaticus* (Rodentia, Muridae). *Annales Universitatis Mariae Curie-Skłodowska, Sectio C* 67(1):7–11. DOI: [10.2478/v10067-012-0008-x](https://doi.org/10.2478/v10067-012-0008-x)
- Izdebska JN, Kozina P, Fryderyk S. 2013. The occurrence of *Demodex kutzeri* Bukva, 1987 (Acari, Demodecidae) in red deer (*Cervus elaphus* L.) in Poland. *Annals of Parasitology* 59(2):85–88.
- Izdebska JN, Rolbiecki L. 2006. Correlation between the occurrence of mites (*Demodex* spp.) and nematodes in the house mice (*Mus musculus* Linnaeus, 1758) in the Gdańsk urban agglomeration. *Biological Letters* 43:175–178.
- Izdebska JN, Rolbiecki L. 2012a. Demodectic mites of the brown rat *Rattus norvegicus* (Berkenhout, 1769) (Rodentia, Muridae) with a new finding of *Demodex ratticola* Bukva, 1995 (Acari, Demodecidae). *Annals of Parasitology* 58:71–74.
- Izdebska JN, Rolbiecki L. 2012b. Topical structure and topography of *Demodex* spp. (Acari Demodecidae), in brown rat *Rattus norvegicus* (Rodentia, Muridae). In: Buczek A, Błaszak C, editors. *Arthropods - the medical and economic importance*. Lublin: Akapit. pp. 133–141.
- Izdebska JN, Rolbiecki L. 2013. A new species of *Demodex* (Acari: Demodecidae) with data on topical specificity and topography of demodectic mites in the striped field mouse *Apodemus agrarius* (Rodentia: Muridae). *Journal of Medical Entomology* 50(6):1202–1207. DOI: [10.1603/ME13044](https://doi.org/10.1603/ME13044)
- Izdebska JN, Rolbiecki L. 2014. New species of *Demodex* (Acari: Demodecidae) with data on parasitism and occurrence of other demodecids of *Rattus norvegicus* (Rodentia, Muridae). *Annals of the Entomological Society of America* 107 (4):740–747. DOI: [10.1603/AN13123](https://doi.org/10.1603/AN13123)
- Izdebska JN, Rolbiecki L. 2015a. A new species of the genus *Demodex* Owen, 1843 (Acari: Demodecidae) from the ear canals of the house mouse *Mus musculus* L. (Rodentia: Muridae). *Systematic Parasitology* 91(2):167–173. DOI: [10.1007/s11230-015-9561-4](https://doi.org/10.1007/s11230-015-9561-4)

- Izdebska JN, Rolbiecki L. 2015b. Two new species of *Demodex* (Acari: Demodicidae) with a redescription of *Demodex musculi* and data on parasitism in *Mus musculus* (Rodentia: Muridae). *Journal of Medical Entomology* 52(4):604–613. DOI: [10.1093/jme/tjv046](https://doi.org/10.1093/jme/tjv046)
- Izdebska JN, Rolbiecki L. 2015c. New data on occurrence of *Demodex flagellurus* (Acari, Demodicidae) – rarely recorded parasite from the house mouse *Mus musculus* (Rodentia, Muridae). *Annals of Parasitology* 61:37–41.
- Izdebska JN, Rolbiecki L. 2016. A new genus and species of demodecid mites from the tongue of a house mouse *Mus musculus*: Description of adult and immature stages with data on parasitism. *Medical and Veterinary Entomology* 30(2):135–143. DOI: [10.1111/mve.12167](https://doi.org/10.1111/mve.12167)
- Izdebska JN, Rolbiecki L. 2018. The status of *Demodex cornei*: Description of the species and developmental stages, and data on demodecid mites in the domestic dog *Canis lupus familiaris*. *Medical and Veterinary Entomology* 32(3):346–357. DOI: [10.1111/mve.12304](https://doi.org/10.1111/mve.12304)
- Izdebska JN, Rolbiecki L. 2020. The biodiversity of demodecid mites (Acariformes: Prostigmata), specific parasites of mammals with a global checklist and a new finding for *Demodex sciurinus*. *Diversity* 12(7):261. DOI: [10.3390/d12070261](https://doi.org/10.3390/d12070261)
- Izdebska JN, Rolbiecki L, Bielecki W. 2022. *Demodex bialoviensis* sp. nov. (Acariformes, Demodicidae) a new, specific parasite of the European bison *Bison bonasus* (Artiodactyla, Bovidae). *International Journal for Parasitology: Parasites and Wildlife* 17:138–143. DOI: [10.1016/j.ijppaw.2022.01.003](https://doi.org/10.1016/j.ijppaw.2022.01.003)
- Izdebska JN, Rolbiecki L, Fryderyk S. 2011. New data on distribution of *Demodex huttereri* Mertens, Lukoschus et Nutting, 1983 and topical specificity and topography of demodectic mites in striped field mouse *Apodemus agrarius*. *Wiadomości Parazytologiczne* 57:261–264.
- Izdebska JN, Rolbiecki L, Fryderyk S. 2014. *Demodex auricularis* sp. nov. (Acari: Demodicidae) from the ear canal of the European wood mouse *Apodemus sylvaticus* (Rodentia: Muridae). *International Journal of Acarology* 40(3):214–219. DOI: [10.1080/01647954.2014.912677](https://doi.org/10.1080/01647954.2014.912677)
- Izdebska JN, Rolbiecki L, Fryderyk S. 2016. A new species of *Demodex* (Acari: Demodicidae) from the skin of the vibrissal area of the house mouse *Mus musculus* (Rodentia: Muridae), with data on parasitism. *Systematic and Applied Acarology* 21(8):1031–1039. DOI: [10.11158/saa.21.8.4](https://doi.org/10.11158/saa.21.8.4)
- Izdebska JN, Rolbiecki L, Fryderyk S. 2023. *Demodex murilegi* and *Demodex obliquus*, two new specific skin mites from domestic cat *Felis catus*, with notes on parasitism. *Medical and Veterinary Entomology* 37(2):263–274. DOI: [10.1111/mve.12628](https://doi.org/10.1111/mve.12628)
- Izdebska JN, Rolbiecki L, Fryderyk S, Mierzyński L. 2017a. Adult and immature stages of the new species of the genus *Demodex* (Acariformes: Demodicidae) with data on parasitism, topography, and topical specificity of demodecid mites in the yellow-necked mouse, *Apodemus flavicollis* (Rodentia: Muridae). *Journal of Parasitology* 103(4):320–329. DOI: [10.1645/17-31](https://doi.org/10.1645/17-31)
- Izdebska JN, Rolbiecki L, Morand S, Ribas A. 2017b. A new species and new host record of Demodicidae (Acariformes: Prostigmata) associated with the bandicoot rat (Rodentia: Muridae) from Lao PDR with data on parasitism and a checklist of the demodecid mites of rodents. *Systematic and Applied Acarology* 22(11):1910–1923. DOI: [10.11158/saa.22.11.10](https://doi.org/10.11158/saa.22.11.10)
- Kadulski S, Izdebska JN. 1996. *Demodex bisonianus* sp. nov. (Acari, Demodicidae) a new parasite of the bison (*Bison bonasus* L.). *Wiadomości Parazytologiczne* 42:103–110.
- Lukoschus FS, Jongman RGH. 1974. *Demodex lacrimalis* spec. nov. (Demodicidae: Trombidiformes) from the Meibomian glands of the European wood mouse *Apodemus sylvaticus*. *Acarologia* 16(2):274–281.
- Marshall JT. 1988. Family Muridae: Rats and mice. In: Lekagul B, McNeely JA, editors. *Mammals of Thailand*. Bangkok: Association for the Conservation of Wildlife. pp. 397–487.
- Mertens LAJM, Lukoschus FS, Nutting WB. 1983. *Demodex huttereri* spec. nov. (Acarina: Prostigmata: Demodicidae) from the meibomian glands of *Apodemus agrarius* (Rodentia: Muridae). *Bonner Zoologische Beiträge* 34:489–498.
- Michaux J, Reyes A, Catzeflis F. 2001. Evolutionary history of the most speciose mammals: Molecular phylogeny of muroid rodents. *Molecular Biology and Evolution* 18(11):2017–2031. DOI: [10.1093/oxfordjournals.molbev.a003743](https://doi.org/10.1093/oxfordjournals.molbev.a003743)
- Morita T, Ohmi A, Kiwaki A, Ike K, Nagata K. 2018. A new stubby species of demodectic mite (Acari: Demodicidae) from the domestic dog (canidae). *Journal of Medical Entomology* 55(2):323–328. DOI: [10.1093/jme/tjx226](https://doi.org/10.1093/jme/tjx226)
- Nashat MA, Luchins KR, Lephherd ML, Riedel ER, Izdebska JN, Lipman NS. 2017. Characterization of *Demodex musculi* infestation, associated co-morbidities, and its topographical distribution in a mouse strain with defective adaptive immunity. *Comparative Medicine* 67:315–329.
- Nutting WB. 1976. Hair follicle mites (*Demodex* spp.) of medical and veterinary concern. *Cornell Veterinarian* 66:214–231.
- Oudemans AC. 1897. List of Dutch Acari. 7th part: Acarididae latr. 1806, and Phytoptidae Pagenst. 1861, with synonymical remarks and description of new species etc. *Tijdschrift voor Entomologie* 40:250–269.
- Raszeja-Kotelba B, Jenerowicz D, Izdebska JN, Bowszyc-Dmochowska M, Tomczak M, Dembińska M. 2004. Some aspects of the skin infestation by *Demodex folliculorum*. *Wiadomości Parazytologiczne* 50:41–54.
- Ventura J, Feliu C, Foronda P, Francino O, Sastre N. 2020. First record of the presence of skin mites (*Demodex musculi*) in wild house mice from the Canary Islands (Spain). *International Journal of Acarology* 46(4):1–4. DOI: [10.1080/01647954.2020.1765866](https://doi.org/10.1080/01647954.2020.1765866)

- Wilson DE, Reeder DM. 2005. Mammals species of the world. A taxonomic and geographic reference. Baltimore and Maryland: The Johns Hopkins University Press. editors <http://www.departments.bucknell.edu/biology/resources/msw3/>.
- Zeng L, Ming C, Li Y, Su L-Y, Su Y-H, Otecko NO, Dalecky A, Donnellan S, Aplin K, Liu X-H, Song Y, Zhang Z-B, Esmailizadeh A, Sohrabi SS, Nanaei HA, Liu H-Q, Wang M-S, Atteynine SA, Rocamora G, Brescia F, Morand S, Irwin DM, Peng M-S, Yao Y-G, Li H-P, Wu D-D, Zhang Y-P. 2017. Out of Southern East Asia of the brown rat revealed by large-scale genome sequencing. *Molecular Biology and Evolution* 35(1):149–158. DOI: [10.1093/molbev/msx276](https://doi.org/10.1093/molbev/msx276)
- Zhang ZQ. 2018. Repositories for mite and tick specimens: Acronyms and their nomenclature. *Systematic and Applied Acarology* 23(12):2432–2446. DOI: [10.11158/saa.23.12.12](https://doi.org/10.11158/saa.23.12.12)