

# Two New Species of *Demodex* (Acari: Demodecidae) with a Redescription of *Demodex musculi* and Data on Parasitism in *Mus musculus* (Rodentia: Muridae)

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**ABSTRACT** This article describes two new skin mite species found on the house mouse *Mus musculus* L., 1758. *Demodex marculus* sp. nov. is a very small demodecid mite (adult stages, on average, 99 µm in length) found in mouse skin in the abdomen, back, limbs, and anal area. It is characterized by relatively large bossing hammer-shaped supracoxal spines, embedded in the trapezoidal gnathosoma. *Demodex fusiformis* sp. nov., in turn, is a little larger (adult stages on average 111 µm in length), with a small oval gnathosoma equipped with fine, knob-like supracoxal spines. It was found in the skin of abdomen, back, and limbs. Moreover, *Demodex musculi* (Oudemans, 1897) was redescribed, which is small demodecid mite (adult stages on average 142 µm in length) and characterized by relatively large morphological variation and considerable sexual dimorphism. The characteristic feature of this species is the strongly elongated and rectangular gnathosoma equipped with very large wedge-shaped supracoxal spines. *D. musculi* was found in the skin of various, haired regions of the mice body (head, neck, abdomen, back, limbs, genital-anal region, and tail). Moreover, one more demodecid mite was found in the skin of the examined mice, it was *Demodex flagellurus* Bukva, 1985, which was found only in the genital area. Overall infection of *Mus musculus* L. by all species of *Demodex* was with the prevalence of 100%, mean intensity of 24.0, and range of intensity of 1–109. Despite high infection levels, no symptoms of parasitosis were observed in the hosts.

**KEY WORDS** *Demodex marculus*, *Demodex fusiformis*, *Demodex musculi*, *Demodex flagellurus*, *Mus musculus*

Demodecid mites (Acari: Demodecidae) are mammal host-specific parasitic mites, usually related to various skin structures or more rarely to internal organs. The highest number of species has been demonstrated so far in rodents (Izdebska 2012, Izdebska and Rolbiecki 2013a), and even a few specific demodecid mite species of various locations have been described in individual hosts (Izdebska and Rolbiecki 2013b). However, little is known about the occurrence of demodecid mites in the house mouse *Mus musculus* L., 1758. The house mouse is strongly connected with humans; be it synanthropic, cosmopolitan, or in its role as a laboratory animal, or bred for pets or as food for snakes, etc. *Demodex musculi* Oudemans, 1897 was one of the first described representatives of this group, but there is little information concerning its occurrence. The largest amount of data concerns laboratory mice (e.g., Hill et al. 1999, Liu et al. 2004, Gressler et al. 2010), while observations of wild mouse populations are sparse (Bregotova et al. 1955; Izdebska 2000, Izdebska and Rolbiecki 2006, 2013c), and the taxonomic status of this demodecid mite requires evaluation (Izdebska

2000). One more demodecid mite, *Demodex flagellurus* Bukva, 1985, has been described from the genital area of the house mouse, noted so far in the Czech Republic and Poland (Bukva 1985, 1990; Izdebska 2000; Izdebska and Rolbiecki 2006, 2013c), while there have been some indications that other Demodecidae representatives also occur in the house mouse (Hill et al. 1999, McKenna 2007). Host-specific synhospital *Demodex* mites have already been described in a few rodent species, including four species from the Palearctic mice *Apodemus agrarius* Pallas, 1771 and *Apodemus sylvaticus* L., 1758 (Hirst 1919, Lukoschus and Jongman 1974, Mertens et al. 1983, Bukva 1994, Izdebska and Rolbiecki 2013b, Izdebska et al. 2014), and five demodecid mite species have been demonstrated in cosmopolitan murids, i.e., in the brown rat *Rattus norvegicus* Berkenhout, 1769 (Hirst 1919, Desch 1987, Bukva 1995, Izdebska and Rolbiecki 2014a).

We have identified new Demodecidae mite species in *M. musculus*, originating from wild populations of this host from an area of Poland.

The description of these new demodecid mite species from the house mouse was related to the need for a redescription of *D. musculi*. This species was described by Oudemans (1897), first as *Demodex folliculorum* var. *musculi*, based on one female (specimen currently in

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Utrecht, The Netherlands). However, the description was limited to the information that the specimen was found in a sebaceous pimple in the mouse lip, and to four dimensions (total body length and width, and "head" and "torax" length). Then, in the next elaboration (Oudemans 1909), the same specimen was classified as *D. musculi*, which showed its distinctiveness from the other known representatives of genus *Demodex*; also its figure (dorsal and ventral) was made. Hirst (1919), in turn, briefly provided characteristics (concerning body shape and proportions), as well as male and female body dimensions (without the number of examined specimens), classifying them as *Demodex arvicolae* var. *musculi*. He completed this with the figures of the male (dorsal side) and two female morphotypes (ventral side); however, it is difficult to verify whether both females actually belong to the same species or not.

Thus, previous descriptions of *D. musculi* are insufficient, in practice limited to the selected metric features. They do not take into account the structure elements used currently in taxonomic characteristics of Demodecidae representatives. Also, the holotype was not determined formally; however, the single specimen of female obtained by Oudemans (1897) should be considered as typical material. In fact, *D. musculi* is a species characterized not only by considerable variability in metric features but also exhibits strong sexual dimorphism, thus precise characterization of male features is a significant issue. It seems essential that the description of *D. musculi* should fulfill the current taxonomic criteria accepted for Demodecidae.

### Material and Methods

Sixteen specimens of the house mouse *M. musculus* collected from central and northern Poland (Pomeranian Lake District, 54° 15' N/18° 14' E; Wielkopolska-Kujawska Lowland, 52° 21' N/17° 32' E) on March–December 2009 were examined for demodicid mites. The host skin fragment digestion method was used to recover skin mites (Izdebska 2004). Skin fragments (~1 cm<sup>2</sup>) were collected from several body regions including head, neck, abdomen, back, limbs, genital and anal regions, and tail. Skin samples were preserved in 70% ethanol and digested in 10% KOH solution; samples obtained were decanted and examined using a phase contrast microscope. Specimens were placed in polyvinyl lactophenol solution and measured (µm). Measurements were taken as follows: gnathosomal width = width at base; podosomal and opisthosomal width = maximum width. The materials were deposited in the collection of the Department of Invertebrate Zoology and Parasitology, University of Gdańsk, Gdańsk, Poland (UG DIZP), and in the Museum and Institute of Zoology, Polish Academy of Sciences, Warszawa, Poland (MIZ).

The description of the species adopted the nomenclature commonly used for the family Demodecidae (Nutting 1976) and was completed with the nomenclature proposed by Bochkov (2008) for superfamily Cheyletoidea (Prostigmata). The Latin and common names of the hosts follow Wilson and Reeder (2005).

Basic parasitological parameters (prevalence (percentage of hosts infested), mean intensity (the average number of parasites per infested host), and intensity range (minimum and maximum number of parasite individuals per host), were measured in order to determine host infestation levels (Margolis et al. 1982).

## Results

### *Demodex musculi* (Oudemans, 1897)

Synonyms:

*Demodex folliculorum musculi* Oudemans, 1897

*Demodex musculi* Oudemans, 1909

*Demodex arvicolae musculi* Hirst, 1919

### Redescription

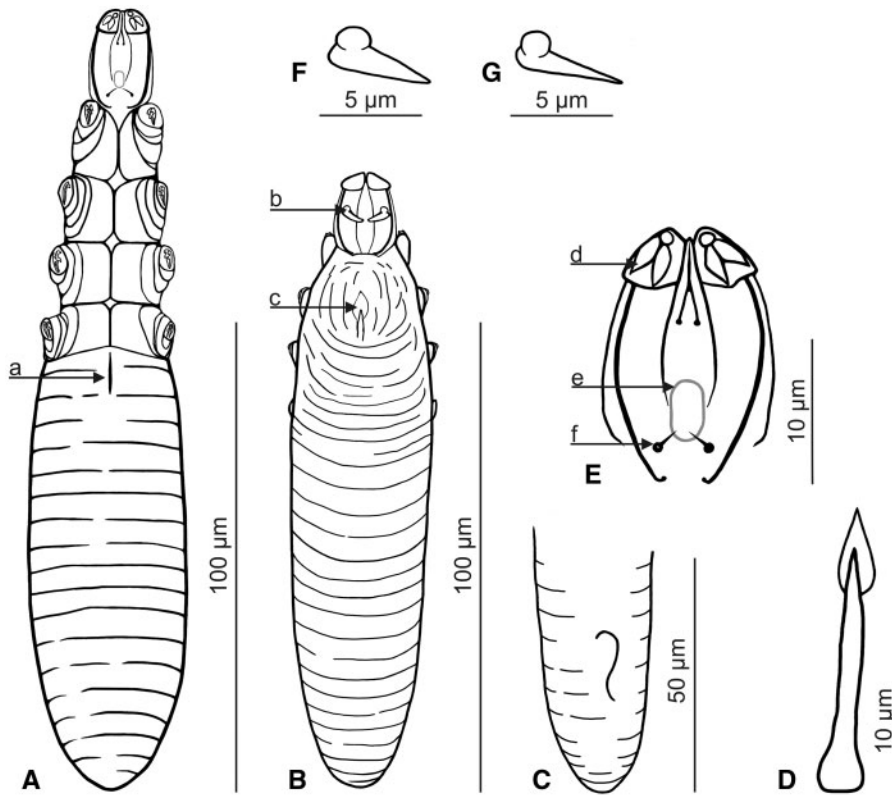
(Table 1 and 4; Figs. 1, 4A and 4B)

The redescription that follows was based on new material.

**Male.** Body length 132 µm, width 28 µm (Table 1). Gnathosoma strongly elongated, rectangular, or barrel-shaped (longer than base width; Fig. 1B and E). Pair of very large (~5–6 µm in length), wedge-shaped supra-coxal spines (setae elc.p), situated on dorsal side across whole gnathosoma, adjoined in central part (Fig. 1B and F); two larger and one smaller spines on terminal segments of three-segmented palpi, adjoined at base, forming triangular structure (Fig. 1E). On the ventral part of the gnathosoma, longitudinally oval pharyngeal bulb, with pair of large and long (>1 µm) subgnathosomal setae (setae n) below it (Fig. 1E). Podosoma rectangular, distinctly wider than gnathosoma, equipped with four pairs of short, six-segmented legs, three pairs slightly protruding beyond its edges, legs of pair IV usually within its area. Epimeral plates (coxal fields) of pair I–IV trapezoidal, narrow, with distinct sclerotized edges. Tarsi I–IV with two forked claws. Opisthosoma cylindrical, slightly tapered toward end, usually constitutes ~54% of body length, its width similar to podosoma width (Figs. 1B and 4A). Striping distinct over whole opisthosoma length, reaches dorsal podosoma side. Opisthosomal organ question mark-shaped, situated in posterior half of opisthosoma (Fig. 1C). An aedeagus (~20 µm in length), localized at level of II and half of IV pair of epimeral plates, with genital

**Table 1. Body size (mean, range, and SD; measurements in µm) of *D. musculi***

Morphologic features	♂ (n = 52)	♀ (n = 60)
Length of gnathosoma	16 (15–20), SD 1	18 (15–25), SD 2
Width of gnathosoma	12 (10–15), SD 1	11 (10–18), SD 1
Length of podosoma	44 (38–50), SD 3	51 (48–63), SD 3
Width of podosoma	27 (20–35), SD 3	22 (18–25), SD 2
Length of opisthosoma	71 (55–83), SD 7	83 (58–118), SD 9
Width of opisthosoma	28 (23–38), SD 4	30 (23–38), SD 3
Aedeagus	20 (15–28), SD 2	–
Vulva	–	8 (5–13), SD 2
Total length of body	132 (111–148), SD 9	152 (123–195), SD 12



**Fig. 1.** *D. musculi*. (A) ♀, ventral view, (a) vulva. (B) ♂, dorsal view, (b) supracoxal spine and (c) aedeagus. (C) Posterior part of opisthosoma with visible opisthosomal organ, ♂. (D) Aedeagus. (E) Gnathosoma, ♂, ventral view, (d) spines on palps, (e) pharyngeal bulb, and (f) subgnathosomal seta. (F) Supracoxal spine, ♂. (G) Supracoxal spine, ♀.

opening on dorsal side, at level of posterior edge of I pair of epimeral plates (Fig. 1B and D).

**Female.** Body length 152 µm, width 30 µm (Table 1). Prosoma distinctly narrower than opisthosoma. Gnathosoma strongly elongated, rectangular, or rotund (longer than base width). Pair of wedge-shaped supracoxal spines on dorsal side, finer, and more delicate than in male (~3–5 µm in length; Fig. 1G); two larger and one smaller spines on terminal segments of three-segmented palpi, slightly smaller than in male but of similar shape and arrangement. On the ventral part of the gnathosoma, longitudinally oval pharyngeal bulb, with pair of large and long (>1 µm) subgnathosomal setae below it (Fig. 1A). Podosoma oblong, very narrow (usually slightly wider than gnathosoma base width), equipped with four pairs of short, six-segmented legs slightly protruding beyond its edges. Epimeral plates of pair I–IV trapezoidal, with distinct sclerotized edges; posterior edges of pair IV indented archwise; vulva under the incision (Fig. 1A). Tarsi I–IV with two forked claws. Opisthosoma usually constitutes ~54% body length; considerably wider than podosoma, more or less longitudinally oval.

Opisthosomal organ absent. Opisthosoma distinctly striped, also reaches dorsal podosoma side; stripes are distinct, with large intervals between particular stripes (Figs. 1A and 4B).

**Type Materials.** **VOUCHER SPECIMENS:** 50 ♂♂ (registration numbers MMmDDmu01m, MMmDDmu02m, MMmDDmu04m, MMmDDmu05m, and MMmDDmu07m–MMmDDmu52m) and 58 ♀♀ (registration numbers MMmDDmu01f–MMmDDmu07f, MMmDDmu09f, MMmDDmu10f, and MMmDDmu12f–MMmDDmu60f), Poland, Pomeranian Lake District, 54° 15' N/18° 14' E and Wielkopolska-Kujawska Lowland, 52° 21' N/17° 32' E, III, IV, IX, XI, XII–2009, host *M. musculus* (registration numbers MRMMm01/2009–MRMMm08/2009, MRMMm10/2009, MRMMm12/2009–MRMMm14/2009, MRMMm16/2009), col. J.N. Izdebska and L. Rolbiecki, deposited at UG DIZP. 2 ♂♂ (9/2014/1–9/2014/2) and 2 ♀♀ (9/2014/3–9/2014/4), Poland, Pomeranian Lake District, 54° 15' N/18° 14' E, III, XI, XII–2009, host *M. musculus* (registration numbers MRMMm01/2009–MRMMm03/2009), same collectors, deposited at MIZ.

**Distribution.** In different region of the world (Europe, Asia, Africa, North and South America, and Australia), both in laboratory and wild mice populations.

**Infestation and Location in the Host.** *D. musculi* was noted in 81.3% of the 16 examined house mouse, with a mean intensity of 7.0 and an intensity range of 1–25 individuals per host; 112 individuals (52 males

and 60 females) were found. Mites were found in the skin of various, haired regions of the mice body (head, neck, abdomen, back, limbs genital and anal regions, and tail). Infestations were not associated with skin lesions or other disease symptoms.

**Differential Diagnosis of *D. musculi* and *Demodex corniculatus*.** In terms of morphological features, *D. musculi* is the most similar to *Demodex corniculatus* Izdebska, 2012 observed in hairy skin of the head of yellow-necked mouse *Apodemus flavicollis* Melchior, 1834. It is, however, characterized by a considerably more distinct sexual dimorphism – *D. corniculatus* females have body proportions similar to males, and also have a similar opisthosomal organ. Structures related to the gnathosoma are very similar in both sexes, slightly smaller in females. *D. musculi* females, in turn, have a more slender gnathosoma and podosoma compared with males, an oval opisthosoma, without an opisthosomal organ. Structures related to the gnathosoma (supracoxal spines and spines on palpi) are more delicate and smaller in females (Fig. 1A, E, F and G).

Moreover, the two species differ in terms of the shape, size and proportions of the gnathosoma – in *D. musculi* the gnathosoma is usually longer and narrower; subgnathosomal setae in *D. musculi* are considerably more massive and longer, situated below with respect to the pharyngeal bulb than in *D. corniculatus*. Moreover, the opisthosomal organ in *D. musculi* is only observed in males and is question mark-shaped, while in *D. corniculatus*, it is observed in both sexes and has an arc-shaped form (more or less curved).

#### ***Demodex marculus* sp. nov.**

(Table 2 and 4; Figs. 2, 4C and 4D)

**Male (Holotype).** Body length 97 µm, width 25 µm (Table 2). Gnathosoma trapezoidal (usually length lower than base width). Pair of supracoxal spines at dorsal side, bossing hammer-shaped, size 3–4 µm, situated in middle gnathosoma part (Fig. 2B and F); three small spines at terminal segments of three-segmented palpi (Fig. 2E). On the ventral part of the gnathosoma, oval pharyngeal bulb, with pair of very small subgnathosomal setae below it (Fig. 2E). Podosoma rectangular, with four pairs of short six-segmented legs slightly protruding beyond its edges. Epimeral plates of pair I–III trapezoidal, with distinct sclerotized edges; posterior edges of pair IV weakly sclerotized. Tarsi I–IV with two forked claws. Opisthosoma similar to podosoma in term of width, cylindrical in shape and rounded at end; constitutes ~52% body length. Striping regular, dense, clear over whole opisthosoma length, reaches dorsal podosoma side (Figs. 2B and 4C). Opisthosomal organ S-shaped, reaches the posterior end of opisthosoma (Fig. 2C). An aedeagus (~13 µm in length), situated between half of II and IV pair of epimeral plates, with genital opening on dorsal side, below the anterior edge of II epimeres pair (Fig. 2B and D).

**Female.** Body length 101 µm, width 28 µm (Table 2). Gnathosoma trapezoidal, and its proportions and related structures similar to the male (Fig. 2A).

**Table 2. Body size (µm) of *D. marculus* sp. nov.**

Morphologic features	♂ (n = 28)	♀ (n = 22)
Length of gnathosoma	11 (10–13), SD 1	11 (9–13), SD 1
Width of gnathosoma	12 (11–13), SD 1	13 (11–15), SD 1
Length of podosoma	35 (31–39), SD 2	38 (35–43), SD 2
Width of podosoma	25 (23–33), SD 2	28 (23–33), SD 2
Length of opisthosoma	50 (41–58), SD 5	52 (43–63), SD 5
Width of opisthosoma	25 (23–31), SD 2	28 (24–33), SD 3
Aedeagus	13 (11–16), SD 1	–
Vulva	–	6 (5–8), SD 1
Total length of body	97 (86–104), SD 4	101 (90–112), SD 6

Podosoma rectangular like in male, with four pairs of short six-segmented legs slightly protruding beyond its edges. Epimeral plates of pairs I–III trapezoidal, with distinct sclerotized edges, posterior edges of pair IV weakly sclerotized, form V-shaped incision with vulva below it. Tarsi I–IV with two forked claws (Fig. 2A). Opisthosoma similar to podosoma in width, cylindrical in shape, and slightly rounded at end; constitutes ~51% body length. Opisthosomal organ absent. Opisthosoma distinctly striped, striping regular, dense, reaches dorsal podosoma side (Figs. 2A and 4D).

**Type Materials.** HOLOTYPE: ♂ (registration number MMmDDma12m), Poland, Pomeranian Lake District, 54° 15' N/18° 14' E, XI–2009, host *M. musculus* (registration number MRMMm01/2009), col. J.N. Izdebska and L. Rolbiecki, deposited at UG DIZP. PARATYPES: 26 ♂♂ (registration numbers MMmDDma01m–MMmDDma04m, MMmDDma06m–MMmDDma11m, MMmDDma13m–MMmDDma28m) and 21 ♀♀ (registration numbers MMmDDma01f, MMmDDma03f–MMmDDma22f), Poland, Pomeranian Lake District, 54° 15' N/18° 14' E and Wielkopolska-Kujawska Lowland, 52° 21' N/17° 32' E, III, IV, IX, XI, XII–2009, host *M. musculus* (registration numbers MRMMm01/2009–MRMMm05/2009, MRMMm07/2009, MRMMm16/2009), same collectors and deposition. 1 ♂ (9/2014/5) and 1 ♀ (9/2014/6), Poland, Pomeranian Lake District, 52° 21' N/17° 32' E, XI–2009, host *M. musculus* (♀; registration number MRMMm01/2009), same collectors, deposited at MIZ.

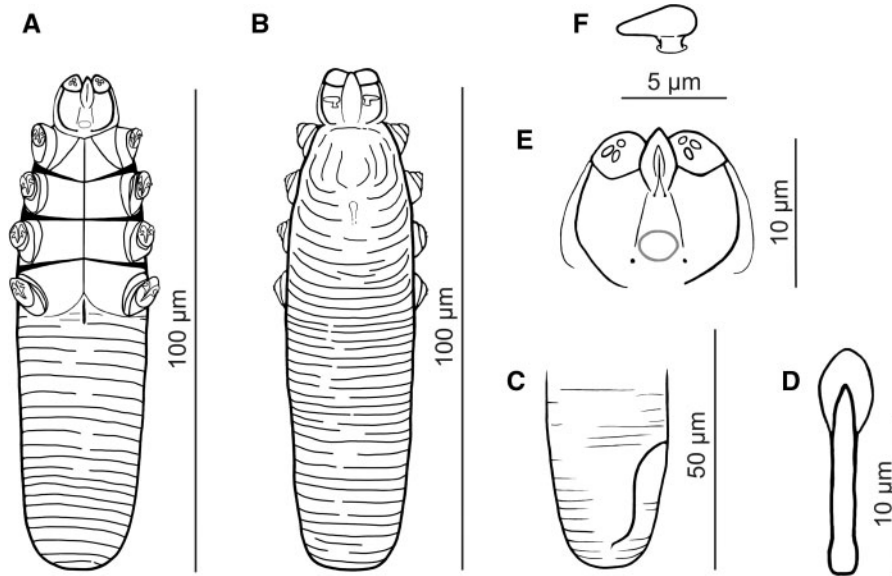
**Etymology.** The specific epithet *marculus* (hammer-shaped) refers to the shape of the supracoxal spines.

**Distribution.** Northern and central Poland. It is probable that the distribution of *D. marculus* corresponds directly to that of its host, *M. musculus*.

**Infestation and Location in the Host.** *D. marculus* n. sp. was noted in 43.8% of the 16 examined house mice, with a mean intensity of 3.1 and an intensity range of 3–14 individuals per host; 50 individuals (28 males and 22 females) were found. Mites were found in the skin of various regions of the mice body (abdomen, back, limbs, and anal area). Infestations were not associated with skin lesions or other disease symptoms.

**Differential Diagnosis of *D. marculus* and *D. musculi*.** *D. marculus* sp. nov. is most congruent to *D. musculi*. Compared with *D. musculi*, *D. marculus* sp. nov. is usually smaller and does not exhibit a clear





**Fig. 2.** *D. marculus* sp. nov. (A) ♀, ventral view. (B), ♂, dorsal view. (C) Posterior part of opisthosoma with visible opisthosomal organ, ♂. (D) Aedeagus. (E) Gnathosoma, ♂, ventral view. (F) Supracoxal spine.

sexual dimorphism (Table 4, Figs. 4A, B, C and D). The body of *D. marculus* sp. nov. (both sexes) is proportional, cylindrical, with opisthosoma slightly rounded at the end. Its gnathosoma is shorter and wider, trapezoidal, while in *D. musculi*, this is strongly elongated and rectangular. Supracoxal spines have different shapes in these species: in *D. musculi* they are larger (especially in males), wedge-shaped, while in *D. marculus* sp. nov. they are slightly smaller and bossing hammer-shaped (Figs. 1F, G, and 2F). In turn, the spines on terminal palpi segments have similar forms and arrangements in both species, but in *D. musculi* they are distinctly larger (especially in males; Figs. 1E and 2E). Subgnathosomal setae in *D. musculi* are very large, and in *D. marculus* sp. nov., they are very small. Epimeral plates of IV pair of legs in *D. musculi* are distinctly sclerotized, while the epimeres of IV pair in *D. marculus* sp. nov. are poorly marked. The *D. musculi* male opisthosoma is usually more narrowed at the end, while in females the anterior body part is considerably narrower than the opisthosoma, which is wide and oval. The opisthosomal organ observed in males of *D. musculi* is question mark-shaped, while in *D. marculus* sp. nov. it is longer and S-shaped (Figs. 1C and 2C). Males of these species also differ in terms of aedeagus shape (Figs. 1D and 2D).

***Demodex fusiformis* sp. nov.**  
(Table 3 and 4; Figs. 3, 4E and 4F)

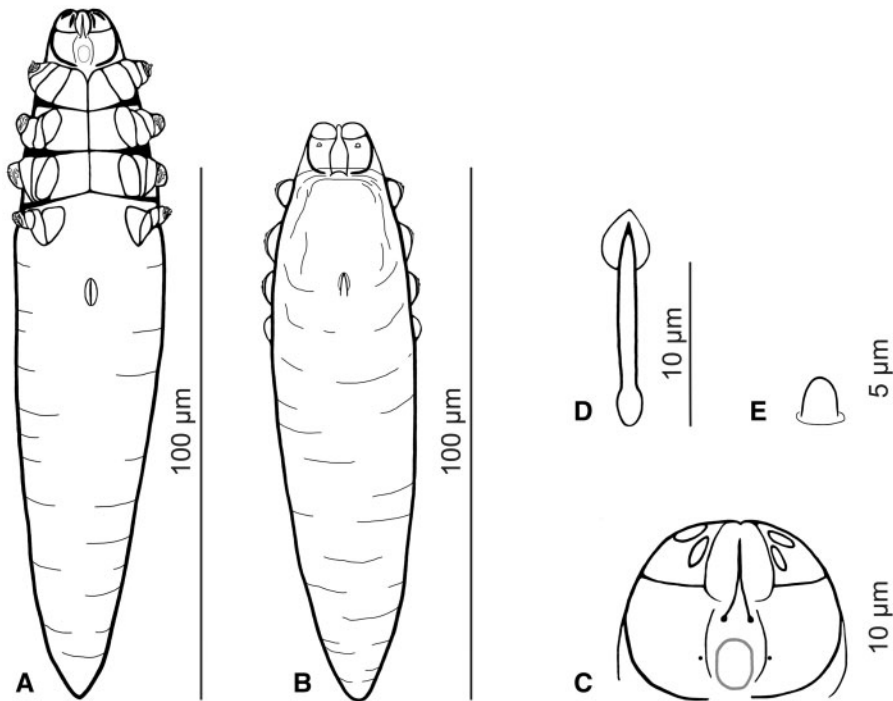
**Male (Holotype).** Body length 94 µm, width 25 µm (Table 3). Gnathosoma small, oval, partially covered by podosoma at dorsal side (usually length lower than base width). Pair of small, knob-like supracoxal spines (~2 µm) at dorsal side, situated at gnathosoma edges (Figs. 3B and E); two obovate spines at terminal

**Table 3.** Body size (µm) of *D. fusiformis* sp. nov.

Morphologic features	♂ (n = 7)	♀ (n = 30)
Length of gnathosoma	10 (8–12), SD 1	11 (8–13), SD 1
Width of gnathosoma	11 (10–13), SD 1	13 (10–15), SD 1
Length of podosoma	29 (28–33), SD 2	35 (30–38), SD 2
Width of podosoma	25 (25–28), SD 1	27 (24–34), SD 3
Length of opisthosoma	56 (50–65), SD 6	81 (70–95), SD 5
Width of opisthosoma	24 (23–26), SD 2	29 (25–35), SD 3
Aedeagus	13 (12–15), SD 1	–
Vulva	–	7 (5–9), SD 1
Total length of body	94 (88–106), SD 7	127 (118–140), SD 6

segments of three-segmented palpi (Fig. 3C). On the ventral part of the gnathosoma, a pair of very small subgnathosomal setae, one placed on each side of the oval pharyngeal bulb. Podosoma rectangular, equipped with four pairs of short six-segmented legs, three pairs slightly protruding beyond its edges, legs of pair IV usually not protruding beyond podosoma edges. Epimeral plates of pair I–III trapezoidal, with distinct sclerotized edges; epimeres of pair IV weakly sclerotized; all epimeral plates not meeting at midline. Tarsi I–IV with two forked claws. Opisthosoma at basal part is similar in terms of width and shape to podosoma, conical, distinctly narrowed at end, sharply ended; constitutes ~59% of body length. Striping is unclear, poorly marked (Figs. 3B and 4E). Opisthosomal organ absent. An aedeagus situated at level of posterior part of II and half of IV pair of epimeral plates, with genital opening on dorsal side, at level of II pair of epimeres (Fig. 3B and 3D).

**Female.** Body length 127 µm, width 29 µm (Table 3). Gnathosoma small, oval, its proportions and related structures similar to the male (Fig. 3A). Podosoma as in



**Fig. 3.** *D. fusiformis* sp. nov. (A) ♀, ventral view. (B) ♂, dorsal view. (C) Gnathosoma, ♂, ventral view. (D) Aedeagus. (E) Supracoxal spine.

male rectangular, equipped with four pairs of short six-segmented legs, three pairs slightly protruding beyond its edges, legs of pair IV usually not protruding beyond podosoma edges. Epimeral plates of pair I–III trapezoidal, with distinctly sclerotized edges, epimeres of pair IV weakly sclerotized; vulva situated distinctly below IV pair of epimeres. Tarsi I–IV with two forked claws (Figs. 3A and 4F). Opisthosoma usually constitutes ~64% of body length, like in male, with poorly marked striping, often longer and more narrowed toward the end (Fig. 3A). Opisthosomal organ absent.

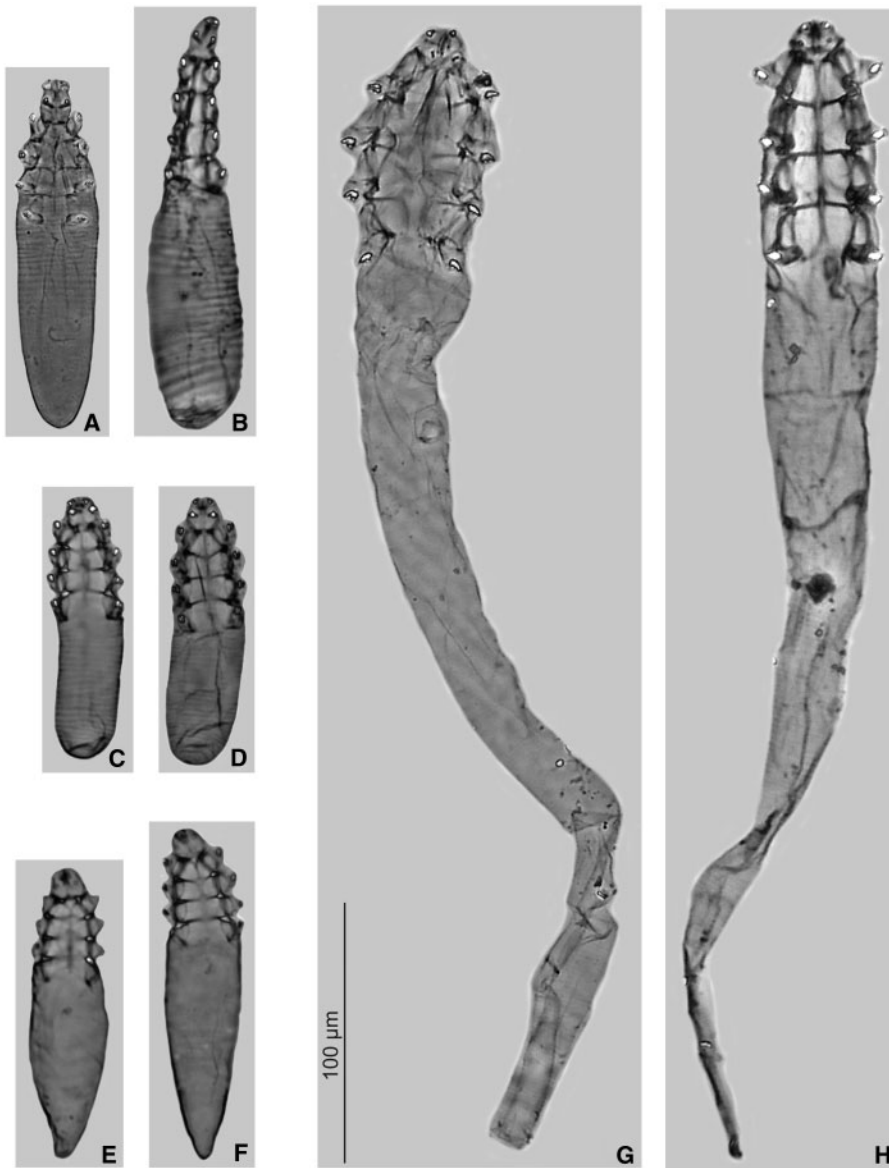
**Type Materials.** HOLOTYPE: ♂ (registration number MMmDDfu07m), Poland, Pomeranian Lake District, 54°15'N/18°14'E, XI–2009, host *M. musculus* (registration number MRMMm01/2009), col. J.N. Izdebska and L. Rolbiecki, deposited at UG DIZP. PARATYPES: 5♂♂ (registration number MMmDDfu01m–MMmDDfu04m, MMmDDfu06m) and 29♀♀ (registration number MMmDDfu02f–MMmDDfu30f), Poland, Pomeranian Lake District, 54°15'N/18°14'E and Wielkopolska-Kujawska Lowland, 52°21'N/17°32'E, III, IV, IX, XI, XII–2009, host *M. musculus* (registration number MRMMm01/2009–MRMMm07/2009, MRMMm14/2009), collectors and deposition same as holotype. 1♂ (9/2014/5) and 1♀ (9/2014/6), Poland, Pomeranian Lake District, 54°15'N/18°14'E, IX, XI–2009, host *M. musculus* (registration number MRMMm07/2009), same collectors, deposited at MIZ.

**Etymology.** The specific epithet *fusiformis* (fusiform) refers to the shape of the body.

**Distribution.** Northern and central Poland. It is probable that the distribution of *D. fusiformis* sp. nov. corresponds directly to that of its host, *M. musculus*.

**Infestation and Location in the Host.** *D. fusiformis* sp. nov. was noted in 43.8% of the 16 examined house mice, with a mean intensity of 2.3 and an intensity range of 1–18 individuals per host; 37 individuals (7 males and 30 females) were found. Mites were found in the skin of abdomen, back, and limbs. Infestations were not associated with skin lesions or other disease symptoms.

**Differential Diagnosis of *D. fusiformis* and *Demodex ponderosus*.** Among the known demodecid mites, *D. fusiformis* sp. nov. is most similar to *Demodex ponderosus* Izdebska et Rolbiecki, 2014 from *R. norvegicus*. *D. fusiformis* sp. nov. is smaller, a little more slender, with a less distinct sexual dimorphism. *D. ponderosus* males are distinctly smaller than females, and are oval; females have a longer opisthosoma narrowing at the end. While males and females of *D. fusiformis* sp. nov. have a similar body shape (Figs. 3A, B, 4E, and F). The gnathosoma of *D. fusiformis* sp. nov. is smaller than that of *D. ponderosus*. The supracoxal spines of both species are small; however, in *D. fusiformis* sp. nov., these are knob-like, whereas in *D. ponderosus*, they are conical. The terminal segments of the palpi in *D. fusiformis* sp. nov. are equipped with two, small spines; in *D. ponderosus* – single, archwise-bent claws. The aedeagus of *D. ponderosus* males is longer, situated between half of II and IV pair of epimeral plates, whereas in *D. fusiformis* sp. nov., it is situated at the level of posterior part of II and half of IV pair of epimeral plates.



**Fig. 4.** Demodecid mites (scaled) from *M. musculus*. (A and B) *D. musculi*, ♂, ♀. (C and D) *D. marculus* sp. nov., ♂, ♀. (E and F) *D. fusiformis* sp. nov., ♂, ♀. (G and H) *D. flagellurus*, ♂, ♀.

Except described species, i.e., *D. musculi*, *D. marculus* sp. nov., and *D. fusiformis* sp. nov., another demodecid mite was found – *D. flagellurus* (Fig. 4G and H). It was found in the skin of the genital area (Table 4) in 25.0% of mice at a mean intensity of 11.6 and intensity range of 2–103.

Overall, infection of *M. musculus* by all four species of demodecid mites was at 100% prevalence, with a mean intensity of 24.0, and range of intensity of 1–109.

### Discussion

A host body creates numerous microhabitats for demodecid mites; thus, mites from this group are

usually characterized not only by host but also by topical and topographical specificity (Izdebska and Rolbiecki 2013b). Currently, three species of house mouse demodecid mites have been characterized, and they exhibit not only morphological distinctions but also differentiated locations (Table 4). *D. musculi* inhabits haired skin over the whole body. This is a demodecid mite of morphological features (especially gnathosoma elements) similar to other representatives of this genus related to the hair follicles of murids, e.g., *D. corniculatus* from *A. flavicollis* and *D. apodemi* s. lato from *A. agrarius* and *A. sylvaticus* (Izdebska 2012, Izdebska et al. 2014). *D. musculi* is currently noted in most examined house mice; however, the level of infection

**Table 4. Characteristic features of *Demodex* species from *M. musculus* (measurements in  $\mu\text{m}$ )**

Morphologic features	<i>D. musculti</i>		<i>D. narculus</i> sp. nov.		<i>D. fusiformis</i> sp. nov.		<i>D. flagellatus</i> (Bukva 1985) <sup>a</sup>	
	$\delta$ (n = 52)	$\text{♀}$ (n = 60)	$\delta$ (n = 28)	$\text{♀}$ (n = 22)	$\delta$ (n = 7)	$\text{♀}$ (n = 30)	$\delta$ (n = 20)	$\text{♀}$ (n = 20)
Length of body	132	152	97	101	94	127	689	476
Width of body	28	30	25	28	25	29	62	56
Ratio of body length to body width	4.8	5.1	3.8	3.6	3.7	4.4	11.2	8.5
Ratio of opisthosoma length to body length [%]	54	54	52	51	59	64	83	76
Gnathosoma	Strongly elongated, rectangular or barrel-shaped	Very large (~3-5), delicate, wedge-shaped	Trapezoidal, transverse	Average (~3-4), bossing hammer-shaped	Small, oval, partially covered by podosoma at dorsal side	Small (~2), knob-like	Trapezoidal	Small for the size of gnathosoma (~3)
Supracoxal spines	Very large (~5-6), massive, wedge-shaped	Two larger and one smaller spines, greater in males	Three small spines	Very small	Two obovate spines	Very small	Two small 2-tined and one small simple spines	Very small
Spines on terminal segment of palp	Short, I-III pairs slightly protruding beyond	Short, all legs slightly protruding beyond	Short, all legs slightly protruding beyond	Short, all legs slightly protruding beyond	Short, conical, I-III pairs slightly protruding beyond	Short, conical, I-III pairs slightly protruding beyond	Massive, all legs distinctly protruding beyond	Massive, all legs distinctly protruding beyond
Subgnathosomal setae	IV pair usually does not protrude beyond	IV pair usually does not protrude beyond	IV pair usually does not protrude beyond	IV pair usually does not protrude beyond	IV pair usually does not protrude beyond	IV pair usually does not protrude beyond	IV pair usually does not protrude beyond	IV pair usually does not protrude beyond
Legs	Cylindrical, slightly tapered toward end	Longitudinally oval	Cylindrical	Cylindrical	Conical, sharp at end	Conical, sharp at end	Extremely long and slender, tapering to whip-like apex	Extremely long and slender, tapering to whip-like apex
Shape of opisthosoma	Distinctly striped, sparse striae	Question mark-shaped; located in the posterior half of opisthosoma	Distinctly striped, reaches the posterior end of opisthosoma	Distinctly striped, dense striae	Poorly striped	Poorly striped	Distinctly striped, dense striae	Distinctly striped, dense striae
Vulva	Located directly below edge of the fourth epimeral plates; posterior edge of pair IV epimeral plates distinctly sclerotized, indented archwise	Located directly below edge of the fourth epimeral plates; posterior edge of pair IV epimeral plates weakly sclerotized, deeply indented V-shaped	Reaches incision of the fourth epimeral plates; posterior edge of pair IV epimeral plates weakly sclerotized, deeply indented V-shaped	Reaches incision of the fourth epimeral plates; posterior edge of pair IV epimeral plates weakly sclerotized, deeply indented V-shaped	Located distinctly below edge of the fourth epimeral plates; pair IV epimeral plates weakly sclerotized	Located distinctly below edge of the fourth epimeral plates; pair IV epimeral plates weakly sclerotized	Located directly below posterior edges of the fourth epimeral plates; posterior edge of pair IV epimeral plates weakly sclerotized	Located directly below posterior edges of the fourth epimeral plates; posterior edge of pair IV epimeral plates weakly sclerotized
Stration on opisthosoma	Distinctly striped, sparse striae	Question mark-shaped; located in the posterior half of opisthosoma	Distinctly striped, reaches the posterior end of opisthosoma	Distinctly striped, dense striae	Poorly striped	Poorly striped	Distinctly striped, dense striae	Distinctly striped, dense striae
Opisthosomal organ	Question mark-shaped; located in the posterior half of opisthosoma	Absent	S-shaped, reaches the posterior end of opisthosoma	Absent	Absent	Absent	Absent	Absent
Location/topography	Hairy skin of the whole body	Hairy skin of the whole body	Skin of the abdomen, back, limbs, and anal region	Skin of the abdomen, back, limbs, and anal region	Skin of the abdomen, back, and limbs	Skin of the abdomen, back, and limbs	Exclusively skin of genital region	Exclusively skin of genital region

<sup>a</sup> Measurements were rounded to the nearest micrometer with respect to the original results.



(intensity) is low and no parasitosis symptoms are observed. Such a course of infection is characteristic for demodecid mites in wild mammals, and the high prevalence of such infections is typical for demodecid mites inhabiting the haired skin of most body areas. Such arrangements favor parasite transmission between host individuals (Izdebska et al. 2014, Izdebska and Rolbiecki 2014a). Presumably, it was simply the high frequency of occurrence in hosts that led to this being the first demodecid mite to be described in the house mouse. It was also found in wild mouse populations, both related to rural and urban regions. It was usually characterized by high prevalence infection (Izdebska and Rolbiecki 2006, 2013c). In turn, the intensity of infection is low, and typically only adult individuals are noted, which has prevented a description of juvenile stages. These stages, depending on the research period, or the state of particular demodecid mite species populations, are sometimes noted abundantly (Izdebska and Rolbiecki 2013a, 2014b); however, they have not been recognized in the case of numerous species (Izdebska and Rolbiecki 2013b, Izdebska et al. 2014).

In turn, *D. fusiformis* sp. nov., noted in the skin of mouse abdomen, back, and limbs, has its equivalent in the morphologically similar *D. ponderosus*, described recently from the brown rat. This latter mite also exhibits low infection parameters (Izdebska and Rolbiecki 2014a). Miniature *D. marculus* sp. nov. is, in turn, found on the skin of the abdomen, back, limbs, and genital region, and similar to *D. flagellurus*, known previously from the house mouse, does not have its equivalent in other Muridae demodecid mite groups. Presumably, the small dimensions, low infestation parameters, and lack of parasitosis symptoms of this mite are the reasons for the absence of any previous data on the occurrence in the house mouse of the demodecid mites species described in this article.

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