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# A new genus and species of the family Microdispidae (Acari: Prostigmata) associated with *Oryctes nasicornis* (Coleoptera: Scarabaeidae) and redescription of the monotypic genus *Vietodispus* Mahunka, 1975

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## Abstract

**Background:** Mites of the family Microdispidae (Acari: Prostigmata: Heterostigmata) are fungivorous, usually living in soil, litter, decaying plant materials, and similar substrates, and adult females have phoretic associations with arthropods, particularly insects. The family Microdispidae is poorly studied, and because of the vague descriptions of most of the genera and species, the taxonomy of this family is in a state of confusion. Previous to this study, more than 109 microdispid species in 17 genera have been described worldwide.

**Results:** In this study, a new genus, *Neomicrodispus* gen. nov. (Acari: Microdispidae) (type species *Neomicrodispus iranicus* sp. nov.) is described and illustrated based on phoretic females recovered from *Oryctes nasicornis* (Coleoptera: Scarabaeidae), which were collected from the forests in northern Iran. Also, the monotypic genus *Vietodispus* Mahunka, 1975 (type species *Vietodispus calcaratus*) is redescribed based on its holotype lent from the Hungarian Natural History Museum. The representatives of the family Microdispidae associated with arthropods are reviewed.

**Conclusions:** There are now 18 genera of this family worldwide that are primarily defined by reductions in their morphology. Because of poor description of some genera and species, synonymies or decreasing in systematic ranks may be expected. A review of arthropod associations, provided in this paper, showed that these mites are primarily associated with ants and beetles, where a rich source of various kinds of fungi particles is easily obtained.

**Keywords:** Heterostigmata; Mite; *Neomicrodispus* gen. nov.; Beetle; Phoretic relationship; Iran

## Background

The cohort Heterostigmata, one of the two cohorts placed in the supercohort Eleutherengonides (Acari: Prostigmata) (Walter et al. 2009), mostly includes small mites associated with various arthropods. They are fungivores, parasites, parasitoids, and sometimes phytophages. Heterostigmata includes eight superfamilies and more than 2,000 described species. Based on Khaustov (2008), the family Microdispidae (Acari: Heterostigmata) is a member of the superfamily Pygmephoroidae. These mites inhabit soil, litter, decaying plant materials, and

similar substrates, and adult females have phoretic associations with arthropods (Rack 1979; Kaliszewski et al. 1995; Khaustov 2006, 2009a; Walter et al. 2009; Hajiqanbar et al. 2012). About 109 species of 17 microdispid genera have been described; however, the taxonomy of this family is highly problematic and perplexed by vague generic and species descriptions, particularly over the last decades of the twentieth century. Here, we describe the 18th genus of this family that is associated with scarab beetles (Coleoptera: Scarabaeidae), collected from forests of Golestan Province, northern Iran, and redescribe the monotypic genus *Vietodispus* Mahunka, 1975 because of its similarity to the new genus and incomplete original description. In addition, the representatives of the

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family Microdispidae associated with arthropods are reviewed.

## Methods

### Materials

Mites were collected from scarabaeid beetles (Coleoptera: Scarabaeidae), which were captured directly in their habitat by forceps. The mite specimens were cleared in lactophenol and mounted in Hoyer's medium. The morphology of the specimens was studied with a phase contrast microscope (Olympus BX51, Olympus Corporation, Tokyo, Japan). All measurements in this description are given in micrometers for the holotype and three paratypes (in parentheses). The terminology and setal notation follow Lindquist (1986). The holotype of the new species is deposited in the Acarological Collection, Department of Entomology, Faculty of Agriculture, Tarbiat Modares University, Tehran, Iran. One paratype is deposited in the US National Museum of Natural History, Washington, D.C., USA. Other paratypes as well as the beetle host are retained with the holotype. The holotype of *Vietodispus calcaratus* was lent from the Hungarian Natural History Museum (HNHM).

### Systematics

Family: Microdispidae Cross, 1965

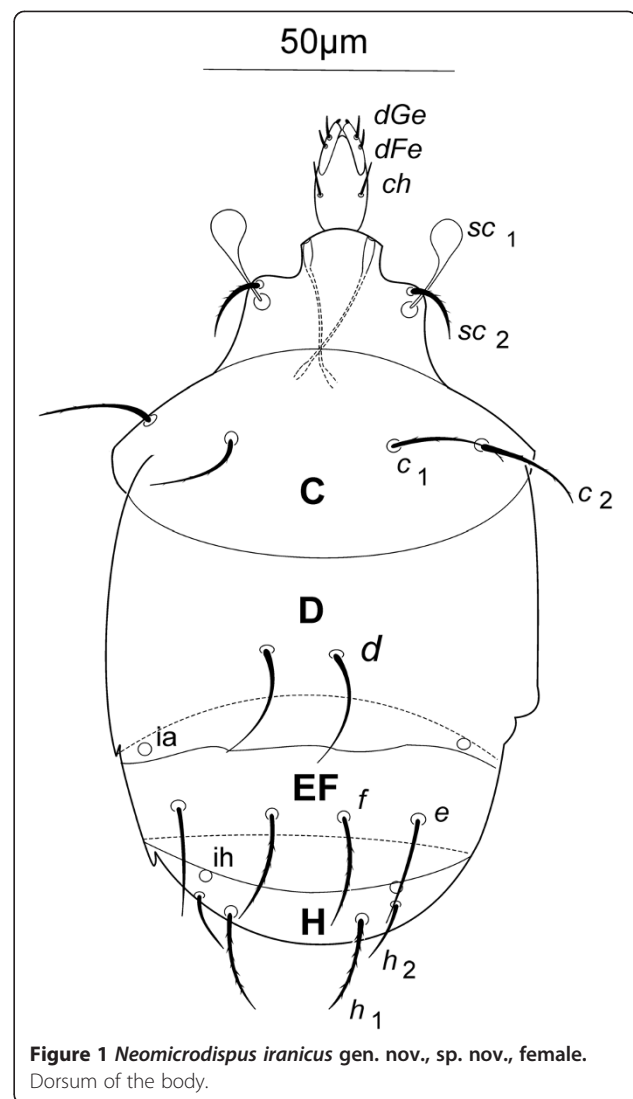
Genus: *Neomicrodispus* Hajiqanbar and Hosseinaveh gen. nov.

**Type of species:** *Neomicrodispus iranicus* Hajiqanbar and Hosseinaveh sp. nov.

**Diagnosis** Gnathosomal capsule about two times longer than wide, dorsally with one pair of cheliceral setae ( $ch_1$ ) and ventrally with one pair of subcapitular setae ( $su$ ); pharyngeal pump system includes three pumps, second pharyngeal pump large, transversely striated, pharyngeal pumps 1 and 3 reduced; stigmata elongated with a distinct tracheal system; cupuli  $ia$  and  $ih$  rounded; setal formula of coxal fields: 2-2-3-2 (setae  $4a$  absent); posterior margin of poststernal plate entire; with three pairs of pseudanal setae ( $ps_1$ ,  $ps_2$ , and  $ps_3$ ); leg I with no ambulacrum; leg setal formula: leg I: 1-3-4-14(+1 $\omega$  + 2 $\phi$ ), leg II: 1-3-3-4(1 $\phi$ )-6 (1 $\omega$ ), leg III: 1-2-2-4(1 $\phi$ )-6, leg IV: 1-2-1-3(1 $\phi$ )-6, tibial IV seta  $v$  absent.

**Description of adult female** The description of adult female is shown in Figures 1, 2, 3, 4, and 5.

**Gnathosoma.** Gnathosomal capsule about two times longer than wide, dorsally with one pair of cheliceral setae ( $ch_1$ ); ventrally with one pair of subcapitular setae ( $su$ ). Palps short and compressed to gnathosomal capsule, with two pairs of setae,  $dFe$  and  $dGe$  and with small terminal claw.

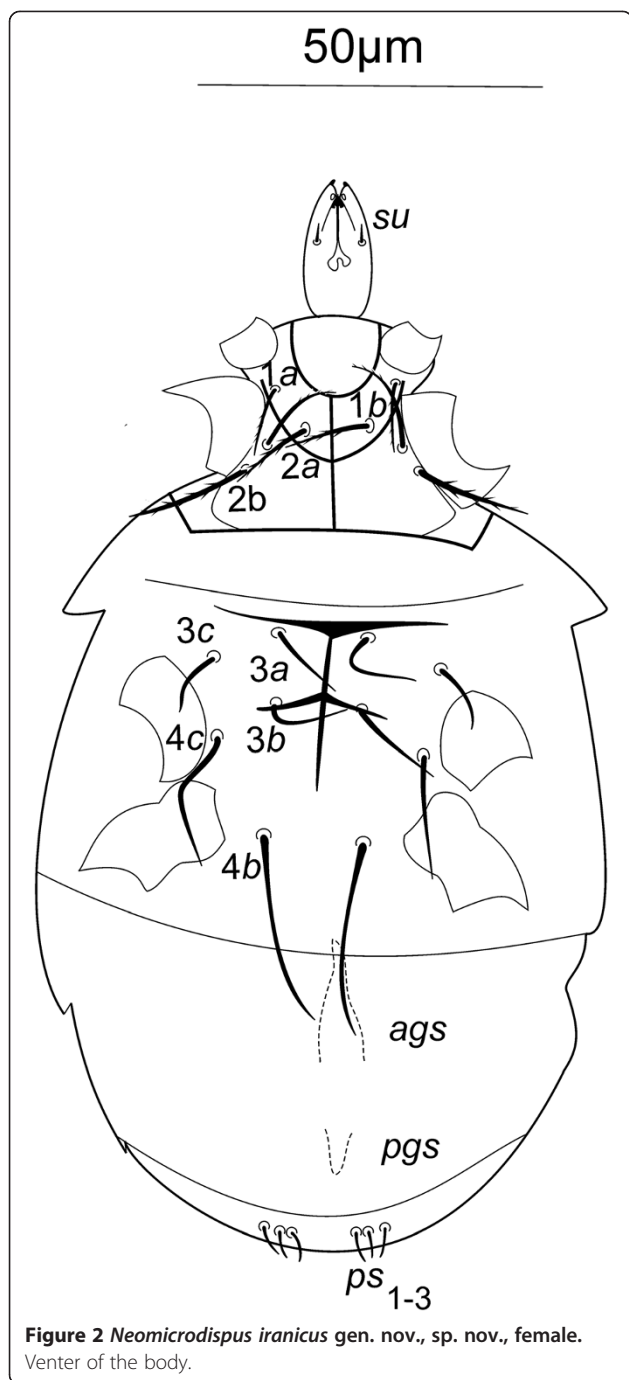


**Figure 1** *Neomicrodispus iranicus* gen. nov., sp. nov., female. Dorsum of the body.

**Pharynx.** Pharyngeal pump system including three pumps, second pharyngeal pump large, transversely striated, pharyngeal pumps 1 and 3 reduced.

**Dorsal idiosoma.** Prodorsal shield with one pair of setae ( $sc_2$ ), one pair of capitate trichobothridia ( $sc_1$ ), and one pair of elongate stigmata with a distinct tracheal system. Hysterosoma with four visible tergites: tergite C with two pairs of setae ( $c_1$  and  $c_2$ ); tergite D widest tergite, with one pair of setae ( $d$ ) and one pair of round cupuli; tergite EF with two pairs of setae ( $e$  and  $f$ ); tergite H with two pairs of setae ( $h_1$  and  $h_2$ ) and one pair of round cupuli.

**Ventral idiosoma.** Apodemes (ap1 to ap4, appr, apsej, appo) well-developed, ap5 absent. Setal formula of coxal fields: 2-2-3-2. Setae  $4a$  absent. Anterior genital sclerite (ags) subtriangular. Pseudanal plate with three pairs of setae ( $ps_1$ ,  $ps_2$ , and  $ps_3$ ).



**Figure 2** *Neomicrodispus iranicus* gen. nov., sp. nov., female. Venter of the body.

**Legs.** All legs five-segmented except leg I (four-segmented). Leg I: slightly thinner than other legs, with no ambulacrum, setal formula (with number of solenidia in parentheses): Tr 1;  $v'$  - Fe 3;  $v''$ ,  $l'$ ,  $d$  - Ge 4;  $l'$ ,  $v'$ ,  $v''$ ,  $l''$  - TiTa 14(+1 $\omega$  + 2 $\phi$ );  $tc'$ ,  $tc''$ ,  $ft'$ ,  $ft''$ ,  $pv'$ ,  $pv''$ ,  $l'$ ,  $l''$ ,  $v'$ ,  $v''$ ,  $pl'$ ,  $pl''$ ,  $d$ ,  $k$ . Leg II: with pair of claws and empodium, setal formula: Tr 1;  $v'$  - Fe 3;  $v''$ ,  $l'$ ,  $d$  - Ge 3;  $l'$ ,  $v'$ ,  $l''$  - Ti 4(+1 $\phi$ );  $l'$ ,  $v'$ ,  $v''$ ,  $d$  - Ta 6(+1 $\omega$ );  $tc'$ ,  $tc''$ ,  $pv'$ ,  $pv''$ ,  $pl''$ ,  $u'$ . Leg III: with pair of claws and empodium, setal formula: Tr 1;  $v'$  - Fe 2;  $v'$ ,  $d$  - Ge 2;  $l'$ ,  $v'$  - Ti 4(+1 $\phi$ );  $v'$ ,  $v''$ ,  $l'$ ,  $d$  - Ta 6;  $tc'$ ,  $tc''$ ,  $pv'$ ,

$pv''$ ,  $pl''$ ,  $u'$ . Leg IV: with pair of claws and empodium, setal formula: Tr 1;  $v'$  - Fe 2;  $v'$ ,  $d$  - Ge 1;  $v'$  - Ti 3(+1 $\phi$ );  $v'$ ,  $l'$ ,  $d$  - Ta 6;  $tc'$ ,  $tc''$ ,  $pv'$ ,  $pv''$ ,  $pl''$ ,  $u'$ .

*Male and larva.* Unknown.

**Differential diagnosis** The new genus is most similar to the genera *Microdispus* Paoli, 1911, *Punicodoxa* Mahunka, 1978, and *Paramicrodispus* Khaustov, 2009 because of the following characters: stigmata elongate, cupuli rounded, and tibiotarsus I with three solenidia. The *Neomicrodispus* gen. nov. differs from *Microdispus* by the absence of setae 4a (present in *Microdispus*) and 14 setae on tibiotarsus I (13 setae in *Microdispus*,  $pv''$  absent). The new genus differs from *Punicodoxa* by the absence of setae 4a (present in *Punicodoxa*) and three pairs of pseudoanal setae (two pairs in *Punicodoxa*). The *Neomicrodispus* gen. nov. differs from *Paramicrodispus* by the absence of setae 4a (present in *Paramicrodispus*) and three pairs of pseudoanal setae (two pairs in *Paramicrodispus*,  $ps_2$  vestigial). The new genus could also be similar to *Vietodispus* Mahunka, 1975, due to absence of setae 4a, cupuli rounded, three pairs of pseudoanal setae, and tibiotarsus I with three solenidia. *Neomicrodispus* gen. nov. differs from *Vietodispus* by its elongate stigmata (stigmata small and rounded in *Vietodispus*), entire posterior margin of the poststernal plate (posterior margin of poststernal plate tripartite in *Vietodispus*), and 14 setae on tibiotarsus I (15 setae in *Vietodispus*). The new genus also differs from all mentioned genera by the absence of setae  $v''$  on tibia IV. The key characters of six microdispid genera are summarized in Table 1.

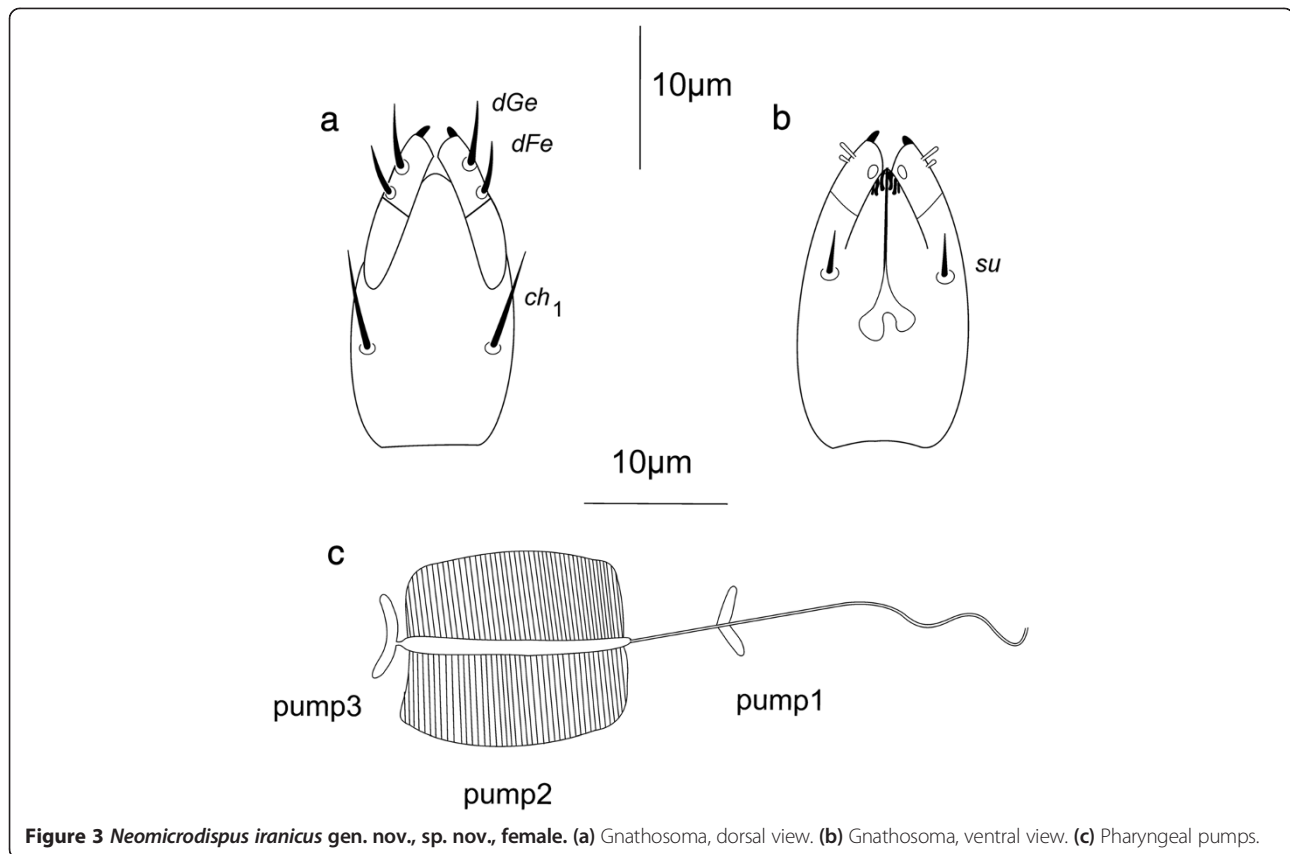
**Etymology** The generic name is derived from 'Neo' (Greek, *neos* which means new) and 'microdispus' (the root name of Microdispidae).

***Neomicrodispus iranicus* Hajiqanbar and Hosseinaveh sp. nov.**

**Description of adult female** The description of adult female is shown in Figures 1, 2, 3, 4, and 5.

**Gnathosoma** (Figure 3a,b). Length of gnathosoma 20 (16 to 24), width 13 (10 to 15). Cheliceral setae  $ch_1$  7 (7 to 8). Subcapitular setae  $su$  2 (2 to 3). Palp setae  $dFe$  3 (3 to 4) and  $dGe$  4 (4 to 5), all gnathosomal setae smooth.

**Idiosomal dorsum** (Figure 1). Idiosomal length 165 (150 to 165), maximum width 99 (82 to 100). All tergites smooth. All dorsal setae pointed. Setae  $sc_2$  barbed, setae  $c_1$  and  $c_2$  indistinctly barbed and subequal, setae  $d$  smooth, setae  $f$  barbed, setae  $e$  smooth, setae  $f$  longer than setae  $e$ , setae  $h_1$  barbed, setae  $h_2$  smooth, setae  $h_1$  distinctly longer than  $h_2$ . Length of dorsal setae:  $sc_2$  15 (13 to 16),  $c_1$  23 (21 to 23),  $c_2$  24 (23 to 26),  $d$  30 (27 to 30),  $e$  25 (21 to 25),  $f$  32 (28 to 32),  $h_1$  23 (22 to 24),  $h_2$  15 (14 to 16). Distances between dorsal setae:  $sc_2$ - $sc_2$  32 (31 to 32),  $c_1$ - $c_1$  37 (36 to



**Figure 3** *Neomicrodipus iranicus* gen. nov., sp. nov., female. (a) Gnathosoma, dorsal view. (b) Gnathosoma, ventral view. (c) Pharyngeal pumps.

38),  $c_1$ - $c_2$  19 (17 to 19),  $d$ - $d$  15 (14 to 17),  $e$ - $f$  18 (16 to 18),  $f$ - $f$  21 (18 to 22),  $h_1$ - $h_1$  26 (25 to 28),  $h_1$ - $h_2$  8 (8 to 10).

**Idiosomal venter** (Figure 2). All ventral plates smooth. Apodemes 1 and 2 reaching to presternal apodeme (appr), appr reaching to sejugal apodeme (apsej), apodemes 3 extending beyond setae 3a and apodemes 4 reaching to setae 3b. Anterior border of poststernal plate faintly concave and posterior border of poststernal plate entire. Setae 1b and 2b with several large barbs, setae 2a and 1a indistinctly barbed, other ventral setae smooth, seta 1b longer than 1a, seta 2b the longest on anterior sternal plate, 3a and 3b subequal, 3c shorter than them, setae 4a absent, setae 4b the longest on posterior sternal plate. Anterior genital sclerite (ags) rhombus. Setae  $ps_1$ ,  $ps_2$ , and  $ps_3$  subequal. Length of ventral setae: 1a 10 (10 to 12), 1b 18 (15 to 18), 2a 21 (18 to 22), 2b 24 (24 to 25), 3a 19 (19 to 22), 3b 21 (21 to 23), 3c 14 (13 to 15), 4b 41 (39 to 42), 4c 29 (25 to 29),  $ps_1$  6 (5 to 7),  $ps_2$  5 (4 to 6),  $ps_3$  5 (5 to 7).

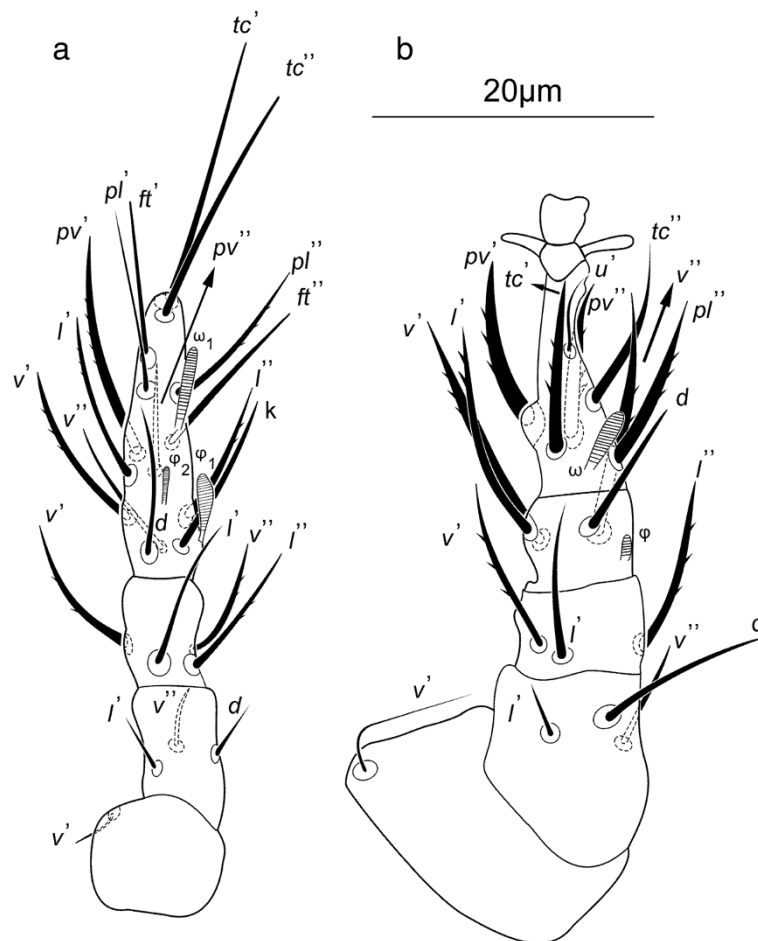
**Legs** (Figures 4 and 5). Leg I (Figure 4a): tibiotarsus: with four eupathidial setae  $tc'$ ,  $tc''$ ,  $ft'$ , and  $ft''$ , setae  $tc'$  and  $tc''$  subequal and longer than other eupathidial setae, setae  $pv'$ ,  $v'$ ,  $l'$ ,  $l''$ , and  $pl''$  barbed, the rest of the setae of the segment smooth, solenidia  $\omega_1$  7 (7 to 8) >  $\phi_1$  6 (5 to 6) >  $\phi_2$  4 (3 to 4), solenidium  $\omega_1$  baculiform, longer than other solenidia, solenidium  $\phi_1$  clubbed, solenidium  $\phi_2$

baculiform, thinner than  $\omega_1$ . Genu: seta  $l'$  smooth,  $v'$ ,  $v''$ ,  $l''$  barbed,  $v''$  the shortest setae of the segment,  $l''$  and  $v''$  subequal and shorter than  $l'$ . Femur: setae  $v''$ ,  $d$ , and  $l'$  subequal. Trochanter: seta  $v'$  the shortest setae of the leg.

**Leg II** (Figure 4b). Tarsus: setae  $tc''$  and  $u'$  smooth, other setae of the segment barbed, solenidium  $\omega$  6 (6 to 7) finger-shaped. Tibia: all setae barbed except  $d$ , setae  $l'$ ,  $v''$ , and  $v'$  subequal and longer than  $d$ , solenidium  $\phi$  3 (2 to 3) finger-shaped. Genu: setae  $v'$  and  $l''$  barbed, longer than seta  $l'$ . Femur: all setae smooth,  $d$  distinctly longer than other setae,  $l'$  the shortest setae of the leg. Trochanter: seta  $v'$  subequal to  $v'$  of genu.

**Leg III** (Figure 5a). Tarsus: setae  $tc'$  and  $tc''$  subequal and longer than other setae of the segment, setae  $pv'$  barbed. Tibia: setae  $d$  and  $v'$  subequal and longer than other setae of the segment, setae  $l'$  and  $v'$  barbed, solenidium  $\phi$  3 (3 to 4) small. Genu: setae  $v'$  and  $l'$  subequal, setae  $v'$  barbed. Femur: seta  $d$  barbed and distinctly longer than  $v'$ . Trochanter: seta  $v'$  smooth.

**Leg IV** (Figure 5b). Longer than other legs. Tarsus: all setae barbed except  $u'$  and  $pl''$ ,  $u'$  the shortest and  $tc''$  the longest seta of the segment. Tibia: all setae barbed except  $l'$ ,  $v'$  and  $l'$  subequal and shorter than setae  $d$ , solenidium  $\phi$  2 (1 to 2) tiny. Genu: seta  $v'$  barbed. Femur: seta  $d$  barbed and more than two times longer than  $v'$ . Trochanter: seta  $v'$  subequal to femoral seta  $v'$ .



**Figure 4** *Neomicrodispus iranicus* gen. nov., sp. nov., female. (a) Leg I. (b) Leg II.

**Etymology** The name of the new species refers to its country of origin, Iran.

**Type of material** Holotype phoretic female (VR20100715) and three paratypes found in a vial containing the beetle *Oryctes nasicornis* (Coleoptera: Scarabaeidae) and ethyl alcohol 75%. The host beetle was collected in Naharkhoran forest, Golestan Province, northern Iran, 36.46°N, 54.27°E, altitude 450 m., coll. V. Rahiminejad, 15 July 2010.

**Genus *Vietodispus* Mahunka, 1975**

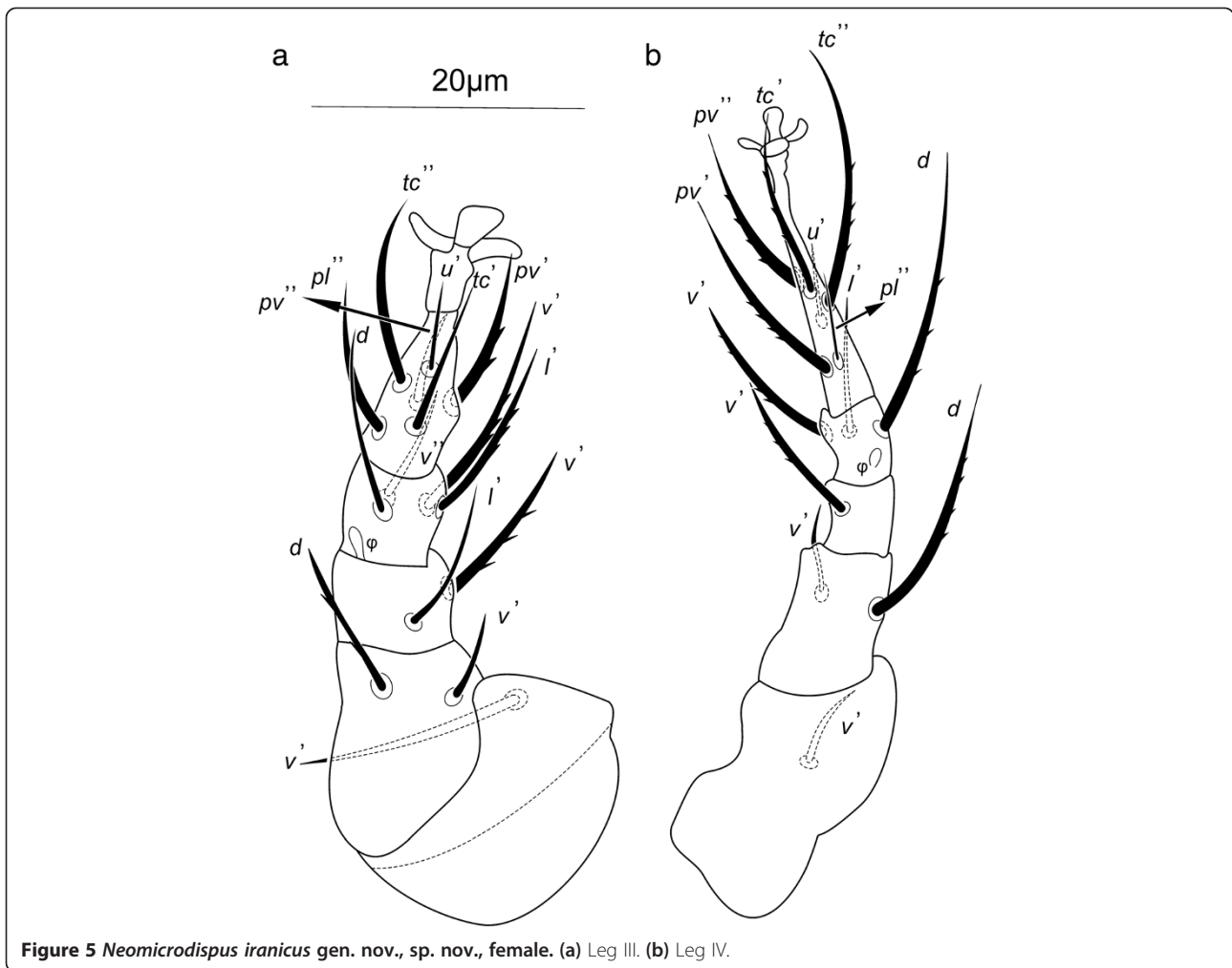
**Diagnosis** Gnathosomal capsule about three times longer than its width, dorsal and ventral sides each with only one pair of setae; first pharyngeal pump reduced, second pump enlarged, third pump rounded; stigmata small and rounded; cupuli *ia* and *ih* rounded; setal formula of coxal fields: 2-2-3-2 (setae *4a* absent); posterior margin of poststernal plate tripartite; three pairs of pseudanal setae (*ps*<sub>1</sub>, *ps*<sub>2</sub>, and *ps*<sub>3</sub>); leg I with no ambulacrum; leg setal formula: leg I: 1-3-4-15(3), leg II: 1-3-3-4(1)-6(1), leg III: 1-2-2-4(1)-6, leg IV: 1-2-1-4(1)-6.

**Redescription of adult female *Gnathosoma*.** Gnathosomal capsule about three times longer than its width, dorsally with only one pair of cheliceral setae (*ch*), ventrally with one pair of subcapitular setae (*su*). Palps short and compressed to gnathosomal capsule, with two pairs of setae, *dFe* and *dGe*.

**Pharynx.** Pharyngeal system including three pumps, weakly sclerotized, first pharyngeal pump reduced, second pump enlarged, third pump rounded.

**Dorsal idiosoma.** Prodorsal shield with one pair of setae *sc*<sub>2</sub>, one pair of capitate trichobothridia (*sc*<sub>1</sub>), and one pair of small and round stigmata. Hysterosoma with four visible tergites: tergite C with two pairs of setae (*c*<sub>1</sub> and *c*<sub>2</sub>), tergite D widest on hysterosoma with one pair of setae (*d*) and one pair of rounded cupuli (*ia*), tergite EF with two pairs of setae (*e* and *f*), tergite H with two pairs of setae (*h*<sub>1</sub> and *h*<sub>2</sub>) and one pair of rounded cupuli (*ih*).

**Ventral idiosoma.** Apodemes well-developed, ap5 present. Setal formula of coxal fields: 2-2-3-2. Setae *4a* absent. Anterior genital sclerite (*ags*) subtriangular. Pseudanal plate with three pairs of setae (*ps*<sub>1</sub>, *ps*<sub>2</sub>, and *ps*<sub>3</sub>).



**Figure 5** *Neomicrodispus iranicus* gen. nov., sp. nov., female. (a) Leg III. (b) Leg IV.

**Legs.** All legs five-segmented except leg I (four-segmented). Leg I: with no ambulacrum, setal formula: Tr 1;  $v' - Fe\ 3; v'', l', d - Ge\ 4; l', v', v'', l'' - TiTa\ 15(+2\omega + 1\phi); p'', tc', tc'', ft', ft'', pv', pv'', l', l'', v', v'', pl', pl'', d, k$ . Leg II: with pair of claws and empodium, setal formula:

Tr 1;  $v' - Fe\ 3; v'', l', d - Ge\ 3; l', v', l'' - Ti\ 4(+1\phi); l', v', v'', d - Ta\ 6(+1\omega); tc', tc'', pv', pv'', pl'', u'$ . Leg III: with pair of claws and empodium, setal formula: Tr 1;  $v' - Fe\ 2; v', d - Ge\ 2; l', v' - Ti\ 4(+1\phi); v', v'', l', d - Ta\ 6; tc', tc'', pv', pv'', pl'', u'$ . Leg IV: with pair of claws and

**Table 1** Comparison of some characters of the *Neomicrodispus* gen. nov. with five genera

|   | <i>Microdispus</i> | <i>Paramicrodispus</i>      | <i>Premicrodispus</i>                               | <i>Punicodoxa</i> | <i>Vietodispus</i> | <i>Neomicrodispus</i> gen. nov. |
|---|--------------------|-----------------------------|---|-------------------|--------------------|---------------------------------|
| Setae $4a$                                      | +                  | +                           | ±   | +                 | –                  | –                               |
| Stigma  | Elongate           | Elongate                    | Elongate (the length 4 times longer than the width) | Elongate          | Small and rounded  | Elongate                        |
| Cupuli  | Rounded            | Rounded                     | Rhombic   | ?                 | Rounded            | Rounded                         |
| Posterior margin of the posterior sternal plate | Entire             | Entire                      | Tripartite  | Entire            | Tripartite         | Entire                          |
| $Ps$ setae                                      | 3 pairs            | 3 pairs ( $ps_2$ vestigial) | 2 pairs, rarely 3 pairs                             | 2 pairs           | 3 pairs            | 3 pairs                         |
| Number of setae on tibiotarsus I                | 13                 | 14                          | 15  | ?                 | 15                 | 14                              |
| Number of solenidia on tibiotarsus I            | 3                  | 3                           | 3 to 4  | 3                 | 3                  | 3                               |
| Number of setae on tibia IV                     | 4                  | 4                           | 4   | 4                 | 4                  | 3                               |

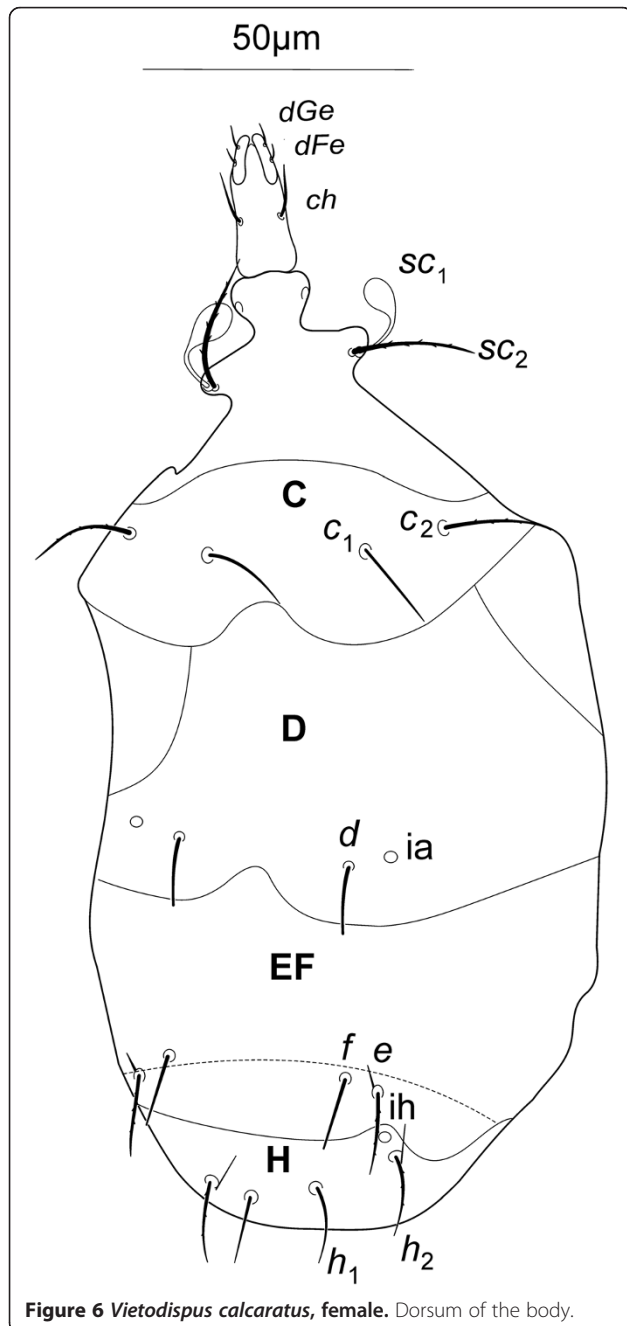
empodium, setal formula: Tr 1;  $v'$  - Fe 2;  $v'$ ,  $d$  - Ge 1;  $v'$  - Ti 4(+1 $\phi$ );  $v'$ ,  $v''$ ,  $l'$ ,  $d$  - Ta 6;  $tc'$ ,  $tc''$ ,  $pv'$ ,  $pv''$ ,  $pl''$ ,  $u'$ .

*Male and larva.* Unknown.

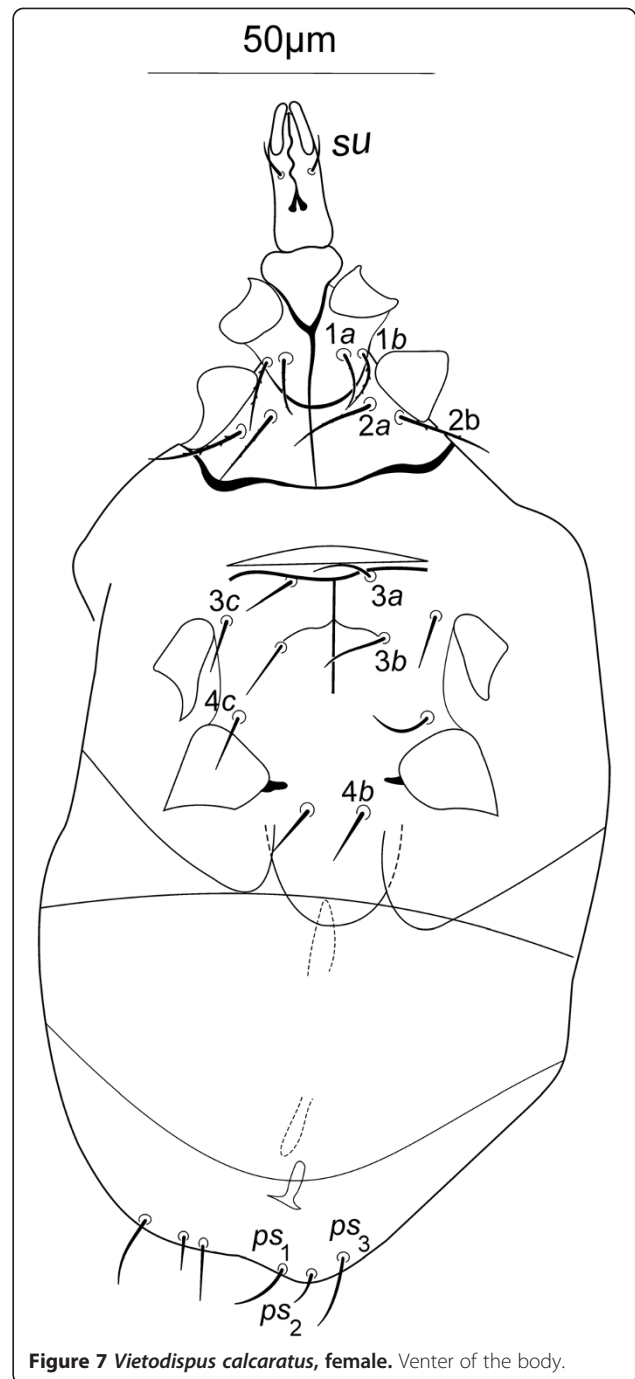
***Vietodispus calcaratus* Mahunka, 1975**

**Redescription of adult female** The redescription of adult female is shown in Figures 6, 7, 8, 9, and 10.

*Gnathosoma* (Figure 8a,b). Cheliceral setae (*ch*) 12, subcapitular setae (*su*) 9. Palp setae *dFe* 3 and *dGe* 4. All gnathosomal setae smooth.

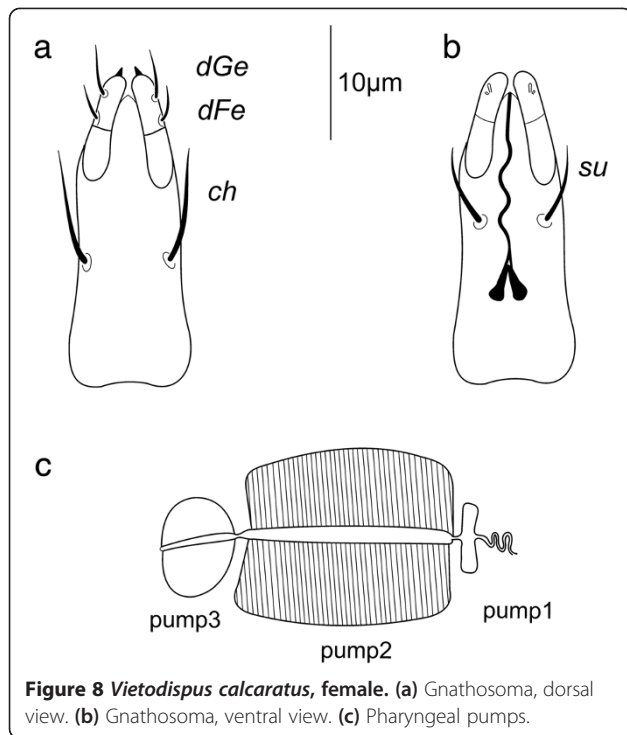


**Figure 6** *Vietodispus calcaratus*, female. Dorsum of the body.



**Figure 7** *Vietodispus calcaratus*, female. Venter of the body.

*Idiosomal dorsum* (Figure 6). Idiosomal length 192, width 97. All tergites smooth. Dorsal setae smooth or barbed, all dorsal setae pointed except setae *d* which is blunt-ended, setae *sc*<sub>2</sub> distinctly barbed, setae *c*<sub>2</sub> barbed and longer than setae *c*<sub>1</sub>, posterior border of tergite C with excision, setae *d* smooth, posterior border of tergite D with excision, setae *e* barbed, setae *f* smooth, setae *e* longer than setae *f*, bases of setae *e* associated with weakly developed apodemes directed anteromedially,

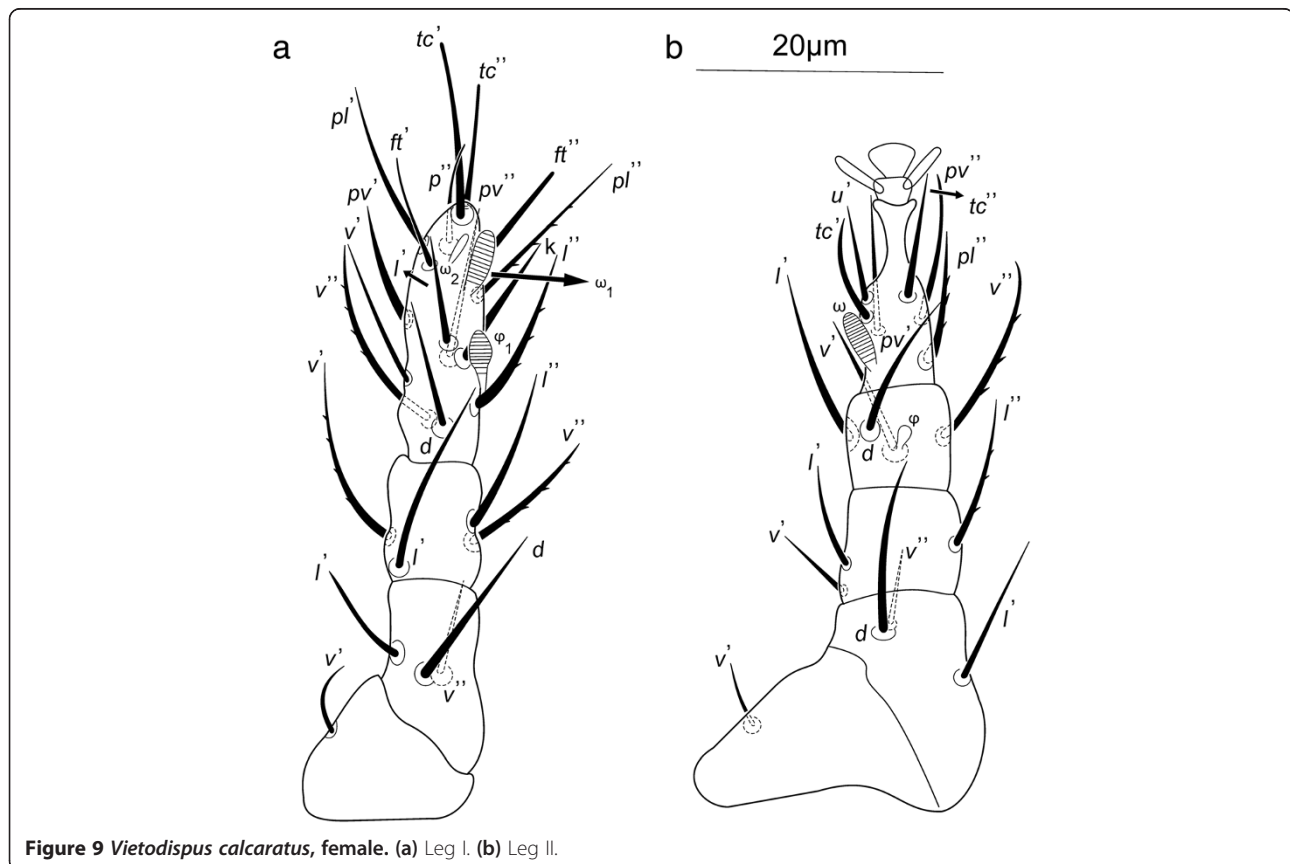


**Figure 8** *Vietodispus calcaratus*, female. (a) Gnathosoma, dorsal view. (b) Gnathosoma, ventral view. (c) Pharyngeal pumps.

posterior border of tergite EF with excision, setae  $h_2$  barbed and associated to one thin apodemes, setae  $h_1$  smooth, both subequal. Length of dorsal setae:  $sc_2$  22,  $c_1$  15,  $c_2$  21,  $d$  14,  $e$  17,  $f$  15,  $h_1$  16,  $h_2$  17. Distances between dorsal setae:  $sc_2-sc_2$  26,  $c_1-c_1$  31,  $c_2-c_2$  62,  $d-d$  34,  $e-e$  47,  $e-f$  7,  $f-f$  35,  $h_1-h_1$  14,  $h_1-h_2$  17,  $h_2-h_2$  37.

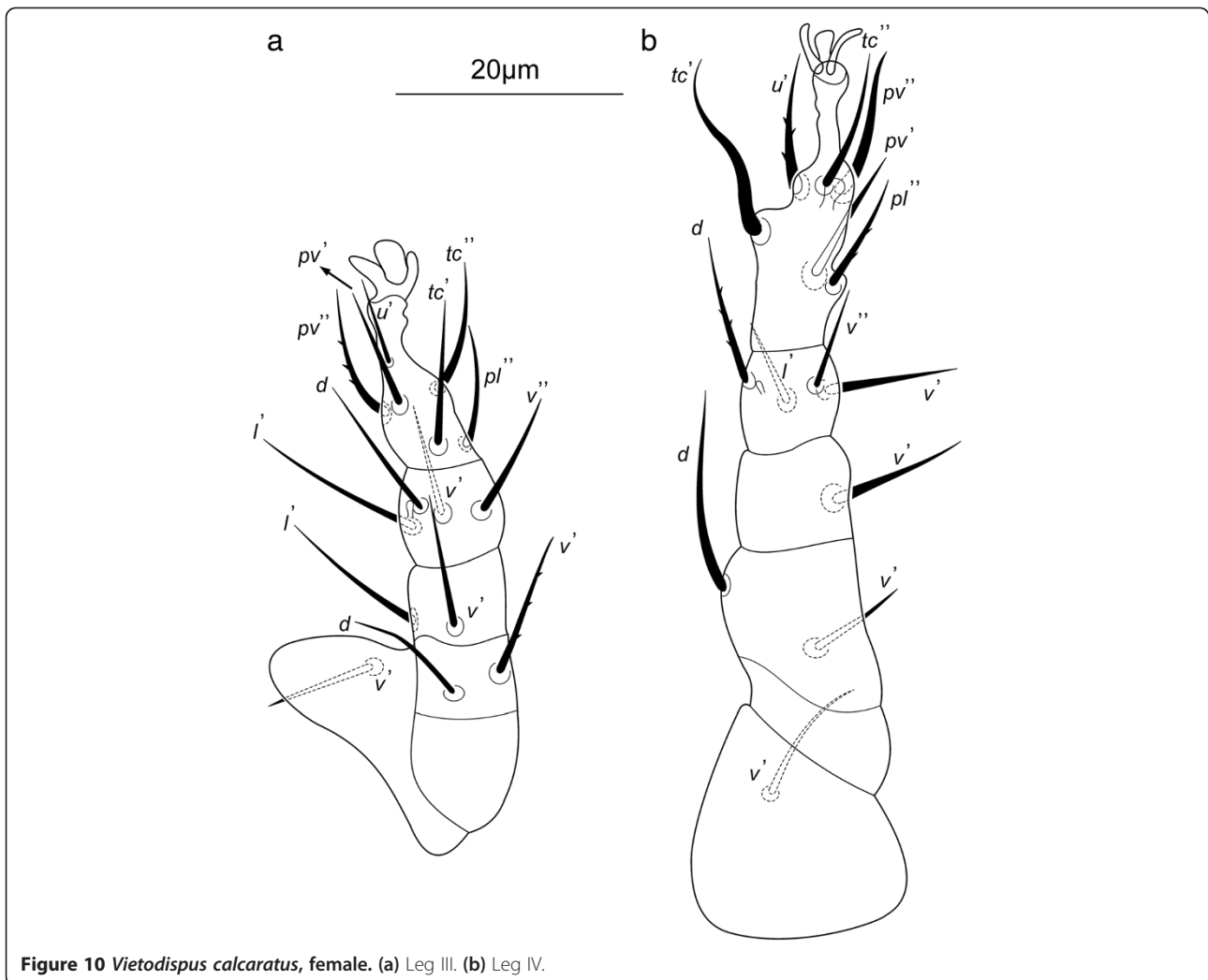
*Idiosomal venter* (Figure 7). All ventral plates smooth. Apodemes 1 and 2 reaching to presternal apodeme, apodeme 3 extending beyond setae  $3a$ , and apodemes 4 reaching to setae  $3b$ , apodeme 5 short. Anterior border of poststernal plate faintly concave and posterior border of poststernal plate tripartite. Setae  $1a$  and  $2a$  indistinctly barbed, setae  $1b$  and  $2b$  with distinct barbs, other ventral setae smooth, seta  $1a$  and  $1b$  subequal, seta  $2a$  and  $2b$  subequal, seta  $3a$  and  $3b$  subequal, seta  $3c$  smaller than them, setae  $4a$  absent, setae  $4b$  and  $4c$  subequal. Anterior genital sclerite rhomboid. Setae  $ps_3$  longer than  $ps_1$ , setae  $ps_1$  longer than  $ps_2$ . Length of ventral setae:  $1a$  11,  $1b$  10,  $2a$  17,  $2b$  16,  $3a$  12,  $3b$  13,  $3c$  10,  $4b$  12,  $4c$  11,  $ps_1$  10,  $ps_2$  6,  $ps_3$  13.

*Legs* (Figures 9 and 10). Leg I (Figure 9a): Tibiotarsus: with five eupathidial setae  $p''$ ,  $ft'$ ,  $ft''$ ,  $tc'$ ,  $tc''$ , setae  $tc'$  longer than  $tc''$ , setae  $pv''$  longer than  $pv'$ , setae  $d$  and  $k$  subequal, setae  $v'$  shorter than  $v''$ , setae  $l''$  longer than  $l'$ , setae  $pl''$ ,  $l''$  and  $v''$  barbed, solenidia  $\omega_1$  5 and  $\phi_1$  5 >  $\omega_2$  2, solenidion  $\omega_2$  uniformly thin, solenidion  $\omega_1$  finger-shaped, solenidion



**Figure 9** *Vietodispus calcaratus*, female. (a) Leg I. (b) Leg II.





**Figure 10** *Vietodispus calcaratus*, female. (a) Leg III. (b) Leg IV.

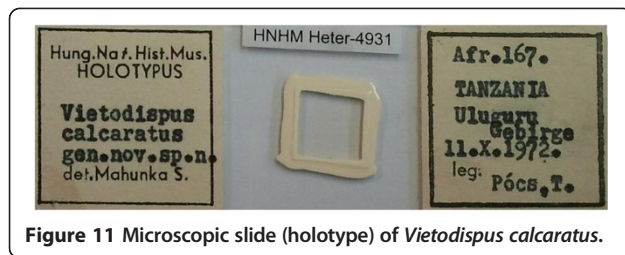
$\phi_1$  clubbed. Genu: with setae  $l'$  and  $v'$  subequal and longer than  $l''$  and  $v''$ , setae  $v'$  and  $v''$  barbed. Femur: with setae  $d$  longer than other setae of the segment. Trochanter: with seta  $v'$ .

**Leg II** (Figure 9b). Tarsus: with seta  $pv''$ ,  $pv'$ , and  $pl''$  subequal, setae  $u'$  the shortest on the segment, setae  $pl''$  barbed, solenidion  $\omega$  4 finger-shaped. Tibia: with setae  $v''$  longer than  $l'$ , setae  $d$  and  $v'$  subequal and shorter than  $l'$ , setae  $v''$  barbed, solenidion  $\phi$  2 finger-shaped. Genu: setae  $l''$  longer than  $l'$  and setae  $l'$  longer than  $v'$ , setae  $l''$  barbed. Femur: with seta  $d$  longer than  $l'$  and setae  $l'$  longer than  $v''$ . Trochanter: with seta  $v'$ .

**Leg III** (Figure 10a). Tarsus: with setae  $pv''$ ,  $tc'$ , and  $tc''$  subequal and longer than setae  $pl''$  and  $pv'$ , setae  $u'$  the shortest on the segment, setae  $pv'$  barbed. Tibia: setae  $l'$  longer than  $d$  and setae  $d$  longer than  $v'$  and  $v''$ , solenidion  $\phi$  1 small. Genu: with seta  $l'$  and  $v'$  subequal. Femur: divided into basifemur and telofemur, setae  $d$  and  $v'$  inserted on telofemur, setae  $v'$  barbed and longer than  $d$ . Trochanter: with seta  $v'$ .

**Leg IV** (Figure 10b). Tarsus: seta  $tc'$  thick and longer than other setae of this segment, setae  $u'$  and  $pl''$  barbed. Tibia: setae  $d$  barbed and longer than  $v'$ , setae  $l'$  and  $v''$  subequal and shorter than  $v'$ , solenidion  $\phi$  1 small. Genu: seta  $v'$  as long as tibial seta  $v''$ . Femur: divided into basifemur and telofemur, setae  $d$  and  $v'$  inserted on telofemur, setae  $d$  longer than  $v'$ . Trochanter with seta  $v'$ .

**Remarks** Two of the closest genera to the *Neomicrodispus* are *Punicodoxa* Mahunka and *Vietodispus* Mahunka; however, original descriptions of these genera are incomplete, particularly their leg chaetotaxy. We tried to access the holotypes for redescription, but unfortunately, the holotype of *Punicodoxa* was not available in the Hungarian Natural History Museum. Redescription of *Vietodispus* based on its holotype, only one microscopic slide (Figure 11), is provided above. Redescription of the genus *Vietodispus* revealed that this genus is very close to the genus *Premicrodispus* Cross. Significant similarities are as follows: one pair of cheliceral setae, same pharyngeal



**Figure 11** Microscopic slide (holotype) of *Vietodispus calcaratus*.

structure, absence of setae *4a*, tibiotarsus I with 15 setae (seta *s* absent), and posterior margin of poststernal plate tripartite. Some mentioned or other traits are variable in *Premicrodispus*. They are the presence or absence of the second pair of cheliceral setae, presence or absence of setae *4a*, having two or three pairs of *ps* setae, and having three or four solenidia on tibiotarsus I. The only distinct differences between these two genera are shapes of stigmata and cupuli (see Table 1). Therefore, it appears that *Vietodispus* could be considered as another subgenus of *Premicrodispus*.

## Results and discussion

*Neomicrodispus* gen. nov. has some apomorphic character states which are as follows (see Table 1): tibiotarsus I with 14 setae and three solenidia, no seta *4a*, one pair of cheliceral setae, posterior margin of posterior sternal plate entire, reduced pharyngeal pumps I and III, and three setae on tibia IV. In contrast, the new genus has the following plesiomorphies: three pairs of pseudoanal setae and rounded cupuli. It should be noted that the presence of three setae on tibia IV (*d*, *l*, and *v*) may be a reduction and could be as a result of homoplasy, as it is also found in *Reductodispus* Mahunka, 1977, but it is otherwise unique in Microdispidae. However, the loss of a tibial seta (*v*" absent) is found in several scutacarid genera and in the pygmephorid *Elattoma* (*l*' absent), one of the most derivative genera of the family Pygmephoridae (Khaustov 2006; Rahiminejad et al. 2011a).

Due to the apparently shared apomorphies (synapomorphies) of the following characters, the new genus is presumably closely related to the genera *Microdispus*-*Paramicrodispus*-*Punicodoxa*: posterior margin of posterior

**Table 2** List of microdispid mites associated with arthropods

| Mite species   | Arthropod host  | Reference(s)   |
|--|---|--|
| <i>Glyphidomastax rettenmeyer</i> Cross 1965                                   | <i>Neivamyrmex opacithorax</i> (Emery), <i>N. nigrescens</i> (Cresson) (Hymenoptera: Formicidae)                                    | Cross (1965)   |
| <i>Myrmecodispus</i> spp.  | Ants (Hymenoptera: Formicidae)  | Cross (1965)   |
| <i>Peponocara cathistes</i> Cross, 1965  | <i>Arenivaga apacha</i> (Saussure) (Blattodea: Corydiidae)  | Cross (1965)   |
| <i>Perperipes ornithocephala</i> Cross, 1965                                   | <i>Eciton burchelli</i> (Westwood), <i>E. hamatum</i> (Fabricius), <i>Nomamyrmex esenbecki</i> (Westwood) (Hymenoptera: Formicidae) | Cross (1965)   |
| <i>Premicrodispus chandleri</i> (Cross, 1965)                                  | <i>Nomamyrmex hartigi</i> (Westwood) (Hymenoptera: Formicidae)  | Cross (1965)   |
| <i>Premicrodispus silvestris</i> (Jacot, 1936)                                 | <i>Reticulitermes flavipes</i> (Kollar) (Isoptera: Rhinotermitidae)   | Cross (1965)   |
| <i>Unguidispus</i> spp.  | Ants (Hymenoptera: Formicidae) or their nests   | Mahunka (1970); Kurosa (1979)                              |
| <i>Reductodispus rettenmeyerorum</i> Mahunka, 1977                             | <i>Labidus praedator</i> (Smith, 1858) (Hymenoptera: Formicidae)  | Mahunka (1977a)  |
| <i>Caesarodispus</i> spp.  | Ants (Hymenoptera: Formicidae)  | Mahunka (1977b); Khaustov (2009b); Loghmani et al. (2014a) |
| <i>Premicrodispus scolopendrae</i> Rack, 1979                                  | <i>Scolopendra morsitans</i> L. (Chilopoda: Scolopendridae)   | Rack (1979)  |
| <i>Microdispus hastatus</i> Mahunka, 1981                                      | Ant nest  | Mahunka (1981)   |
| <i>Paramicrodispus crenulatus</i> (Sevastianov, 1978)                          | <i>Pterostichus niger</i> (Schaller) (Coleoptera: Carabidae);<br><i>Lucanus ibericus</i> Motschulsky (Coleoptera: Lucanidae)        | Khaustov (2009a); Hajiqanbar et al. (2012)                 |
| <i>Premicrodispus brevisetus</i> Khaustov, 2006                                | <i>Oxythyrea cinctella</i> (Schaum) (Coleoptera: Scarabaeidae)  | Rahiminejad et al. (2010)                                  |
| <i>Paramicrodispus scarabidophilus</i> Hajiqanbar and Rahiminejad, 2012        | <i>Oryctes nasicornis</i> L. (Coleoptera: Scarabaeidae)   | Hajiqanbar et al. (2012)                                   |
| <i>Premicrodispus akermanae</i> (Sevastianov and Chydyrov, 1988)               | <i>Oryctes nasicornis</i> L. (Coleoptera: Scarabaeidae)   | Hosseinaveh et al. (2013)                                  |
| <i>Premicrodispus krczali</i> Khaustov, 2006                                   | <i>Oxythyrea cinctella</i> (Schaum) (Coleoptera: Scarabaeidae)  | Loghmani et al. (2014b)                                    |
| <i>Premicrodispus paramaevi</i> Hosseinaveh and Hajiqanbar, 2014               | <i>Lucanus ibericus</i> Motschulsky (Coleoptera: Lucanidae)   | Hosseinaveh et al. (2014)                                  |
| <i>Premicrodispus spinosus</i> Hosseinaveh and Hajiqanbar, 2014                | <i>Corticeus unicolor</i> Piller and Mitterpacher (Coleoptera: Tenebrionidae)   | Hosseinaveh et al. (2014)                                  |
| <i>Neomicrodispus iranicus</i> Hajiqanbar and Hosseinaveh, gen. nov., sp. nov. | <i>Oryctes nasicornis</i> L. (Coleoptera: Scarabaeidae)   | This study   |

sternal plate entire and three solenidia on tibiotarsus I. However, the new genus differs from the above genera by apomorphies absence of setae 4a and three setae on tibia IV (setae 4a present and tibia IV with four setae in the genera *Microdispus*, *Paramicrodispus*, and *Punicodoxa*). The provisional synapomorphic character states absence of setae 4a and three solenidia on tibiotarsus I could imply that the new genus is close to the genus *Vietodispus* but it differs from *Vietodispus* by apomorphies posterior margin of posterior sternal plate entire, 14 setae on tibiotarsus I, and 3 setae in tibia IV (posterior margin of posterior sternal plate tripartite, tibiotarsus I with 15 setae and tibia IV with 4 setae in the genus *Vietodispus*). Totally, it seems the new genus probably places near the genus *Paramicrodispus* based on these potential synapomorphies: gnathosomal capsule two times longer than wide, one pair of cheliceral setae, reduced pharyngeal pumps I, posterior margin of posterior sternal plate entire, tibiotarsus I with 14 setae and three solenidia. Nevertheless, the new genus differs from the genus *Paramicrodispus* by the apomorphies no seta 4a, three setae on tibia IV, and reduced pharyngeal pumps III (seta 4a present, four setae on tibia IV, and larger pharyngeal pumps III in the genus *Paramicrodispus*).

According to Table 2, about 35% of described taxa of the family Microdispidae have some kind of relationship with arthropods. Except for *Premicrodispus scolopendrae* Rack, 1979 which has been found on a centipede, other arthropod-associated microdispids are associated with insects, mostly ants (Hymenoptera: Formicidae) and beetles (Coleoptera). It appears these mites feed on fungi particles available in habitats of their hosts (see Navarro et al. 2010). Many ant nests are suitable and rich sources of various kinds of fungi (Hölldobler and Wilson 1990). Regarding the coleopterans hosts, they usually utilize woody debris, rotten wood, and decaying stumps in the forests. Such habitats include a vast variety of fungi (Grove 2002) that microdispids could exploit in a similar way to that observed in many adult female fungivorous heterostigmatic mites, e.g., Dolichocybidae (Rahiminejad et al. 2011a; Katlav et al. 2014), Scutacaridae (Jagersbacher-Baumann and Ebermann 2013), Neopygmephoridae (Hajiqanbar and Khaustov 2013), and Pygmephoridae (Rahiminejad et al. 2011b; Hofstetter and Moser 2014).

## Conclusions

Taking into account the new genus described in this paper, the Microdispidae now comprises 18 genera. Further examination of the nests of social insects and insects dwelling in decaying woods, where fungi are abundant, should reveal more undescribed microdispid mites. A review of arthropod associations showed that these mites are primarily associated with ants and beetles, where a rich source of various kinds of fungi particles is easily obtained.

## Competing interests

The authors declare that they have no competing interests.

## Authors' contributions

FH prepared the line drawings, performed the measurements, and prepared the early version of the descriptive parts of the manuscript. HH conceived the study, examined the type series of the new genus and species and lent material, discussed the taxonomic parts, and completed the manuscript. Both authors read and approved the final manuscript.

## Acknowledgements

We express our sincere thanks to Vahid Rahiminejad for collecting the material. We also appreciate Dr. László Dányi of the Hungarian Natural History Museum for the loan of the holotype of *Vietodispus calcaratus* Mahunka, 1975 and Dr. Alexandr Khaustov (Tyumen State University, Russia) for the critical review of the manuscript. This research was financially supported by Tarbiat Modares University, which is greatly appreciated.

Received: 19 May 2014 Accepted: 22 August 2014

Published: 6 September 2014

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doi:10.1186/s40555-014-0058-7

**Cite this article as:** Hajiqanbar and Hosseinaveh: A new genus and species of the family Microdispidae (Acari: Prostigmata) associated with *Oryctes nasicornis* (Coleoptera: Scarabaeidae) and redescription of the monotypic genus *Vietodispus* Mahunka, 1975. *Zoological Studies* 2014 **53**:58.

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