Dorsipes diplocheilae sp. nov. and Dorsipes zeelandicae sp. nov. (Acari: Podapolipidae), subelytral parasites of Diplocheila zeelandica (Redtenbacher) (Coleoptera: Carabidae) in Japan

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Dorsipes diplocheilae sp. nov. and Dorsipes zeelandicae sp. nov. (Acari: Podapolipidae), subelytral parasites of Diplocheila zeelandica (Redtenbacher) (Coleoptera: Carabidae) in Japan

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Abstract

Two of three new species of Podapolipidae (Acari: Tarsonemoida) discovered under the elytra of Diplocheila zeelandica (Coleoptera: Carabidae) are described under the names Dorsipes diplocheilae sp. nov. and D. zeelandicae sp. nov. This is the first record of species in the dorsipes group of the genus Dorsipes from the genus Diplocheila. Adult females of species in the dorsipes group share the plesiomorphic character of two pairs of setae on plate EF. The vagina is not broad and the opening is terminal. The male genital capsule is not broader at its base than at its apex. Putative apomorphies for adult females of the dorsipes group are: coxal setae 3a not present, setae v1 reduced, ambulacra I claws small and tarsi II solenidia omega absent. Dorsipes diplocheilae and D. zeelandicae are compared with five species from Europe, Asia and western North America in the dorsipes group, parasites of carabid beetles in the genus Carabus. Revised keys to species of the group dorsipes are provided.

Key words: Taxonomy, Podapolipidae, new species, Japan, insect parasites

Introduction

Mites in the family Podapolipidae (Acari: Tarsonemina) are highly specialized ecto- and endoparasites of insects in the orders Blattodea, Orthoptera, and especially Coleoptera. One podapolipid mite species each occurs on insects in the orders Hemiptera and Hymenoptera. Eighty two species of Podapolipidae in four genera occur on fifty one genera of beetles in the family Carabidae. A majority of the 34,175 species of Carabidae (Lorenz 2005) have not been examined thoroughly for podapolipid parasites. Regenfuss (1968) examined nearly 7,000 carabid beetles in 78 genera and found podapolipids on 839 hosts. He described the genus Dorsipes and placed seven species of Dorsipes from a relatively small area of Central Germany in three groups: dorsipes, inflatus and platysmae (Regenfuss 1968). Eidelberg (1994) noted Dorsipes from Ukraine and eastern Russia. Japanese species of Dorsipes are: D. curtonoti Kurosa and Husband, 2002, D. limnocarabi Husband and Kurosa, 2002, D. yezoensis Husband and Kurosa, 2002 and the species described herein. The expansion of literature involving Dorsipes after 1968 includes the following contributions: Husband and Rack (1991), Eidelberg (1994), Husband (2000), Husband and Dastych (2000), Husband and Kurosa (2002), Kurosa and Husband (2002), Husband and Husband (2005), Husband and Weatherby (2005), Husband and Husband (2007), Hajiqanbar et al. (2008) and Husband and Husband (2010). The purposes of this paper are to describe the first record of species in the dorsipes group from a host genus other than Carabus, the genus Diplocheila, compare them with five species in the dorsipes group from Japan, Europe and Western North America and present a revised key to species in the dorsipes group.
Materials and methods

Fourteen specimens of *Diplocheila zeelandica* (Redtenbacher) (Coleoptera: Carabidae) from Yamagata, Chiba, Ehime, Fukuoka and Okinawa Prefectures, Japan, four specimens of *D. elongata* (Bates) from Chiba and Ibaraki Prefectures, Japan, and three specimens of *D. macromandibularis* (Habu and Tanaka) from Yamagata Prefecture, Japan, were examined for mites by the senior author. Podapolipid mites were discovered on eleven specimens of *D. zeelandica*. Mites were cleared with Keifer’s clearing agent (Keifer 1953) and mounted in Andre’s fluid (modified Hoyer’s medium). Taxonomic research was made on two of the three species involved.

Measurements were taken with the aid of a Zeiss compound phase contrast microscope with an ocular micrometer. All measurements are in micrometers. Setae no longer than the diameter of setal acetabulae are listed as microsetae (m). Setae represented by acetabulae without setal remnants are listed as vestigials (v). Terminology follows Lindquist (1986). Long setae are often bent, obscured, broken or at an angle that makes measurement difficult. Setae are at least as long as indicated.


Taxonomy

Podapolipidae Ewing 1922

*Dorsipes diplocheilae* Kurosa and Husband sp. nov. (Figs. 1–2)

**Differential diagnosis.** Setae e (13) of adult female *D. diplocheilae* shorter than the length of setae e (24) of *D. yezoensis* and longer than the length of setae e (3) of *D. limnocarabi*. Setae f (29–35) longer than the length of setae f (20–26) of *D. limnocarabi* and shorter than the length of setae f (76–100) of *D. yezoensis*. Prodorsal setae v₁ (23–35) longer than setae v₁ of any of the other nineteen species of *Dorsipes* (m-18). Setae d and f of larval female *D. diplocheilae* (20–29, 22–29) longer than species of *Dorsipes* from the genus *Carabus* (5–15, 7–18). Species in *inflatus* and *platysmae* groups without setae e. Setae h₁–h₁ adjacent in larval female *D. diplocheilae* in contrast to separated by 5–20 in related *Dorsipes* with *Carabus* hosts. Tarsi II solenidia ω present in all instars of *D. diplocheilae* but not present in the five related species of *Dorsipes* in the *dorsipes* group with *Carabus* hosts. *D. diplocheilae* and African *Dorsipes tefflii* (*platysmae* group) with genua I, II, III setae of all instars 4-3-3, respectively.

**Description**

**Female** (Fig. 1, n=6): Gnathosoma length 50–62, width 49–54. Cheliceral stylets length 75–92, pharynx width 13–19, dorsal gnathosomal setae 30–35, ventral gnathosomal setae 15–23, distance between ventral setae 11–21.

**Idiosoma.** Stigmata evident anterolateral to setae v₁, tracheae narrow throughout. Idiosoma length 310–580, width 237–460 (Table 1). Prodorsal setae v₁ 23–35, v₂ v, s₁ m, s₂ 50–57. Distance between setae v₁ 50–57. Plate C, setae c₁ 27–37, setae c₂ 27–35, plate D setae d 30, foramen ia anteromedial to setae d, plate EF, lateral setae e 5–13, setae f 29–35, foramen im slightly anterior to setae e and f, plate H setae h₁ 15–17, distance between h₁ setae 46–57. Venter with apodemes conspicuous, coxal setae thin, 1a 10–11, 2a 10, 3a 0–m, 3b 9–11.
FIGURE 1. Dorsipes diplocheilae Kurosa and Husband, sp. nov., adult female.

Larval female (Fig. 2, n=7): Gnathosoma length 40–45, width 35–40. Cheliceral stylet length 50–53. Pharynx width 8–10, dorsal gnathosomal setae 42–60, ventral setae 15–24, distance between ventral setae 14–18.

**FIGURE 2.** Dorsipes diplocheilae Kurosa and Husband, sp. nov., larval female.


Egg (n=1): Length 220, width 145.

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**Male** unknown.

**Host.** All the specimens examined were found on the hind wings (mostly basal portion), metanotum or abdominal dorsum under the elytra of *Diplocheila (Isorembus) zeelandica* (Redtenbacher, 1867) (Coleoptera: Carabidae: Licinini) collected in four localities of Japan.

**Type material:** Holotype, adult female (Kurosa No. 4889-1), from *Diplocheila zeelandica* (Redtenbacher) (Coleoptera: Carabidae), Funaura, Iriomote Is., Okinawa Prefecture, Japan, 24 April 1979, Y. Kurosa leg., deposited in the National Museum of Nature and Science, Tokyo, Japan (NSMT). Paratypes, four adult females and five larval females with the same data as the holotype; one adult female, one egg, Mt. Tomisan, Minami-Bôsô-shi, Chiba Pref., Japan, 5 March 1978, T. Okumura leg.; one larval female, Oda-chô, Ehime Pref., Japan, 23 July 1957, E. Yamamoto leg.; one larval female, Sonai, Iriomote Is., Okinawa Pref., Japan, 27 April 1979, Y. Kurosa leg. One adult female paratype and one larval female paratype are deposited in each of the following museums: NMNH, UMMZ and BGZM. The remaining paratypes are deposited in NSMT.

**Etymology.** The specific name *diplocheilae* refers to the generic name of the host beetle, *Diplocheila zeelandica*.

*Dorsipes zeelandicae* Kurosa and Husband sp. nov. (Figs. 3–5)

**Differential diagnosis.** Setae e (5) of adult female *D. zeelandicae* shorter than the length of setae e (13–24) of *D. yezoensis* and *D. diplocheilae* and longer than length of setae e (3) of *D. limnocarabi*. Setae f (48–65) longer than the length of setae f (20–35) of *D. limnocarabi* and *D. diplocheilae*, shorter than the length of setae f (76–100) of *D. yezoensis*. Prodorsal setae v₁ (22–37) longer than setae v₁ of any of the other nineteen species of *Dorsipes* (m-18) except *D. diplocheilae* (23–35). Setae d and f of larval female *D. zeelandicae* (29–35) longer than all other species of *Dorsipes* (5–15, 7–18). Species in *inflatus* and *platysmae* groups without setae e. Tarsi II solenidia ω present in all instars of *D. zeelandicae* and *D. diplocheilae* but not present in the five related species of *Dorsipes* in the *dorsipes* group. *D. zeelandicae*, *D. diplocheilae* and African *Dorsipes tefflii* (*platysmae* group) with genua I, II, III setae of all instars 4–3–3, respectively.

**Description**

**Female** (Fig. 3, n=5): *Gnathosoma* length 52–70, width 55–68. Cheliceral stylets length 84–100, pharynx width 12–15, dorsal gnathosomal setae 30–35, ventral gnathosomal setae 11–20, distance between ventral setae 20.

**Idiosoma.** Stigmata evident anterolateral to setae v₁, tracheae narrow throughout. Idiosoma length 332–430, width 240–318 (Table 1). Prodorsal setae v₁ 22–37, v₂ v, sc₁ m, sc₂ 89–89. Distance between setae v₁ 60. Plate C, setae c₁ 58–68, setae c₂ 37–72, plate D setae d 50–65, plate EF lateral setae e 5, setae f 48–65; plate H setae h₁ 14–17, distance between h₁ setae 51–57. Venter with apodemes 2 not extending to sternal apodeme, coxal setae thin, 1a, 10–15, 2a 10–14, 3a absent, 3b 8–10.

Male (Fig. 4, n=1): Gnathosoma length 33, width 35. Cheliceral stylet length 18, pharynx width 7. Dorsal gnathosomal length 24, ventral gnathosomal length 10, distance between ventral gnathosomal setae 17.

Idiosoma. Length 195, width 137 (Table 1). Prodorsal plate setae v₁, v₂ and sc₁ m, sc₂ 60, distance between setae v₁ 42. Aedeagus middorsal between fused plates C, D and EF, length 20, maximum width 19. Venter with apodemes I and II moderately developed, apodemes II not extending to sternal apodeme. Coxal setae 1a 6, 2a 10, 3a 0, 3b 8.

Legs. Setation as in female. Ambulacrum I with a single small claw (5), ambulacra II, III each with two strong claws (15). Tibia I solenidion ϕ 10, seta k 4, tarsus I solenidion ω 10. Femur II setae

FIGURE 3. Dorsipes zeelandicae Kurosa and Husband, sp. nov., adult female.
**Larval female** (Fig. 5, n=1): *Gnathosoma* length 48, width 45. Cheliceral stylet length 61. Pharynx width 8, dorsal gnathosomal setae 44, ventral setae 11, distance between ventral setae 15.

*Idiosoma.* Length 190, width 132 (Table 1). Prodorsal plate setae \( v_1 \) 26, \( v_2 \) 0, \( sc_1 \) m, \( sc_2 \) 79, \( v_1 - v_1 \) distance 34. Plate C, setae \( c_1 \) 24, \( c_2 \) 22. Plate D, setae \( d \) 25, plate EF setae \( e \) 7, setae \( f \) 27. Plate H, setae \( h_1 \) 70, \( h_2 \) 7, \( h_1 - h_1 \) setae adjacent. Venter with apodemes 1, 2 moderately developed, extending to sternal apodeme medially. Coxal setae \( 1a \) 9, \( 2a \) 13, \( 3a \) 0, \( 3b \) 8.

*Legs.* Setation as in adult female. Ambulacra I each with two small claws (4), ambulacra II, III each with two larger claws (15). Femur I setae \( v' \) 20, Tibia I solenidion \( \phi \) 10, setae \( k \) 6, tarsus I solenidion \( \omega \) 9, tarsus \( f' \) 0. Femora II, III setae \( d \) 7, 6. Tarsi II, III setae \( pl' \) 30 and 33, and \( pl' \) 44 and 47, respectively.
Host. All of the mites from the host specimens examined were found on the basal portion of hind wings or abdominal dorsum under the elytra of two specimens of *Diplocheila (Isorembus) zeelandica* (Redtenbacher, 1867) (Coleoptera: Carabidae: Licinini) collected in two localities in Japan. In no case were *Dorsipes diplocheilae* and *D. zeelandicae* found in coexistence on a single host beetle.

Type material: Holotype, adult female (Kurosa No. 21740-2), from *Diplocheila zeelandica* (Redtenbacher) (Coleoptera: Carabidae), Yoshii-machi, Fukuoka Prefecture, Japan, 3 August 1957, N. Gyôtoku, leg., deposited in the National Museum of Nature and Science, Tokyo, Japan (NSMT). Paratypes, four adult females, one male and one larval female with the same data as the holotype; two adult females, Mt. Tomisan, Minami-Bōsô-shi, Chiba Pref., Japan, 31 December 1973, T. Okumura, leg. One adult female paratype is deposited in each of the following museums: NMNH, BGZM and UMMZ. The remaining paratypes are deposited in NSMT.

Etymology. The specific name *zeelandicae* refers to the specific name of the host beetle, *Diplocheila zeelandica*.
TABLE 1. Comparison of selected maximum measurements for species of the dorsipes group of the genus *Dorsipes*: *D. diplocheilae* (Ddi), *D. zeelandicae* (Dz), *D. dorsipes* (Ddo), *D. carabi* (Dc), *D. limnocarabi* (Dl), *D. yezoensis* (Dy), *D. balli* (Db). All measurements are in micrometers.

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<td>Tarsus II solenidion $\omega$</td>
<td>-</td>
<td>10</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tibia II setae $v''$</td>
<td>-</td>
<td>23</td>
<td>30</td>
<td>-</td>
<td>42</td>
<td>32</td>
<td>16</td>
</tr>
<tr>
<td>Tarsus III setae $p''$</td>
<td>-</td>
<td>40</td>
<td>45</td>
<td>-</td>
<td>85</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>Aedeagus width</td>
<td>-</td>
<td>19</td>
<td>31</td>
<td>-</td>
<td>26</td>
<td>35</td>
<td>40</td>
</tr>
</tbody>
</table>

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Discussion

Regenfuss (1968) described the genus Dorsipes and placed seven species into three groups: dorsipes, inflatus and platysmae. With the addition of 12 species since 1968 and reexamination of characters of the original seven species, some of the eight apo- and plesiomorphic characters chosen by Regenfuss are no longer valid for all species in the three groups. Kurosa and Husband (2002) redescribed D. inflatus and D. notopus and noted that male D. inflatus and D. notopus have tarsus I solenidia co and tibiae I solenidion φ. Femur III setae are not present in most species in the inflatus group (one exception) and are also not present in four of the seven species in the platysma group. Setae e (setae lumbales externae) are consistently present in species in the dorsipes group and absent in all species of the inflatus and platysmae groups (Regenfuss 1968). Ambulacral claw I is “very small” (3–6) in all species in the platysma group (Regenfuss 1968). Coxal setae 3a (setae preternales internae) are not present in all species in the inflatus group and D. dorsipes and D. carabi, in the dorsipes group (Regenfuss 1968). Setae 3a are present in D. limocarabi Husband and Kurosa 2002, D. balli Husband and Husband 2010 and in D. diplocheilae herein of the dorsipes group. The presence of tarsus II solenidion ω in D. diplocheilae and D. zeelandicae is in contrast to the pattern of no tarsus II solenidion in the inflatus group and dorsipes groups as described by Regenfuss (1968).

The most consistent characters for females of species in the dorsipes group are: presence of setae e on plate EF, elongate setae f (20–100) in contrast to shorter setae f (7–18) for all Dorsipes except D. tefflii Husband from Africa, presence of femora II, III setae, long setae c1 (20–90) and d (25–78) (one exception) in contrast to setae c1 short (6–19), except D. tefflii and D. nigeri in the platysma group. Adult females of D. diplocheilae and D. zeelandicae have longer setae v1 (23–37) in contrast to shorter setae v1 (m-18) for all other female Dorsipes. Female D. diplocheilae have shorter setae c1, c2, d and f setae (27–37, mean value 31) and longer setae e (mean value 9.3) in contrast to lengths of setae c1, c2, d and f (37–72, mean value 57.2) and shorter setae e (5) in female D. zeelandicae. Larval females mimic adult females in respect to lengths of setae e.

Key to groups of the genus Dorsipes, adult females

1. Plate EF with setae f (7–18, except D. tefflii, 30), setae e absent. ................................................................. 2
   - Plate EF with setae f (15–100) and e (3–24), hosts Carabus and Diplocheila. .......... dorsipes group
2. Tarsus II solenidion ω absent, host genus Amura ................................................................. inflatus group
   - With tarsus II solenidion ω, host genera: Agonum, Cyclotrachelus, Poecilus, Pterostichus, Tefflus .... platysmae group

Key to species in the dorsipes group, adult females

1. Prodorsal setae v1 (22–37), as long as width of base of tarsus I (16–25), tarsus II solenidion ω present (9), host Diplocheila ................................................................. 2
   - Prodorsal setae v1 (m-10) shorter than width of base of tarsus I (15–28), tarsus II solenidion ω absent, host Carabus ................................................................. 3
2. Setae c1 and d 50–72, setae e shorter (5) .................................. Dorsipes zeelandicae sp. nov.
   - Setae c1 and d 27–37, setae e longer (5–13) .................. Dorsipes diplocheilae sp. nov.
3. Setae v1 shorter (m-3) ................................................................. 4
   - Setae v1 longer (5–10) ................................................................. 5
4. Cheliceral styles (60–62) shorter than width of gnathosoma (79) ........ Dorsipes carabi
   - Cheliceral styles (77–96) nearly equal to width of gnathosoma (72–110) .... Dorsipes balli

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5. Setae \( c_1 \) and \( d \) (45–70) longer than ventral gnathosomal setae (27–38) .......................... 6
6. Cheliceral styles (73–80) equal to or longer than width of gnathosoma (75–82), claw I larger (25) .............................................................. Dorsipes dorsipes
- Cheliceral styles (65–68) shorter than width of gnathosoma (72–76), claw I not as large (17) .......................... Dorsipes yezoensis

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