Review of North American Verrucoentomon Species (Protura: Acerentomidae, Nipponentominae), with a Key to Species of the Related Genus Imadateiella Rusek

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Review of North American *Verrucoentomon* species (Protura: Acerentomidae, Nipponentominae), with a key to species of the related genus *Imadateiella* Rusek

*Julia Shrubovych*¹*, Josef Rusek*², Jerzy Smykla*³ and Ernest C. Bernard*⁴

**Abstract**

Type material of 3 North American *Verrucoentomon* (Protura: Acerentomidae, Nipponentominae) species was studied: *Verrucoentomon imadatei* Nosek, 1977 from Alaska, *Verrucoentomon mixtum* Nosek, 1981 from Alaska and *Verrucoentomon canadensis* (Tuxen, 1955) from northern Canada. Additional morphological characters for *V. imadatei* and *V. canadensis* are provided. *Verrucoentomon mixtum* is redescribed and transferred to the genus *Imadateiella* Rusek, 1974 due to the presence of 4 pairs of A-setae on the metanotum rather than 3 and the absence of teeth on the hind margins of segments IX–XI. *Imadateiella mixta* (Nosek, 1981) is characterized by the presence of *P1α* setae on tergite VIII and only 4 setae on sternite VIII. The species is unique within the Nipponentominae in having only one long terminal spine on the labial palp. *Imadateiella* is redefined and a key to its species is provided.

**Key Words:** redescription; chaetotaxy; porotaxy; Alaska; northern Canada

**Resumen**

Se estudió el material tipo de tres especies de *Verrucoentomon* de América del Norte: *V. imadatei* del estado de Alaska, *V. mixtum* de Alaska y *V. canadensis* del norte de Canadá. Se aportan caracteres morfológicos adicionales para *V. imadatei* y *V. canadensis*. Se re-describe *Verrucoentomon mixtum* y se transfiere al género *Imadateiella* debido a la presencia de cuatro pares de setas - A sobre el metanoto en lugar de tres y por la ausencia de dientes en los márgenes posteriores de los segmentos IX–XI. Se caracteriza *Imadateiella mixta* por la presencia de setas *P1α* en los tergitos I–VII, 4 setas - A en el tergito VIII y sólo 4 setas en el esternito VIII. La especie es única entre las *Nipponentominae* por tener una sola espinilla terminal larga en el palpo labial. Se re-definen el género *Imadateiella* y se aporta una clave de sus especies.

**Palabras Clave:** nueva descripción; chaetotaxy; porotaxy; Alaska; norte de Canadá

*Verrucoentomon* Rusek, 1974 currently contains 13 species (Szeptycki 2007; Shrubovych 2011; Shrubovych & Bernard 2012). The distribution of *Verrucoentomon* spp. and their taxonomic differentiation within the genus were discussed in a previous paper (Shrubovych & Bernard 2012). In that paper it was recognized that *V. mixtum* from Alaska bore some characters that differed from those of other *Verrucoentomon* spp. In the current paper we redescribe 2 poorly known *Verrucoentomon* spp. from Alaska and Northern Canada and transfer *V. mixtum* to *Imadateiella* Rusek, 1974.

**Materials and Methods**

The type material of *V. canadensis*, *V. imadatei* and *V. mixtum* was borrowed from the Zoological Museum, University of Copenhagen, Denmark (ZMUC) and the National Museum of Natural History (NMNH), Washington, D.C. The identification key to *Imadateiella* spp. is based on original descriptions and redescriptions of type material *(Imadaté 1961, 1964; Shrubovych 2014; Yin 1980, 1999).*

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equal setae, 5 pairs of A-setae on tergites II–VI (with except the members
of Alaskacentomon Nosek, 1977) and by posterior position of seta
P3 on abdominal tergites II–VI (with except of Alaskacentomon fijellbergi

**Verrucoentomon canadense** (Tuxen 1955) (Figs. 1-3, Table 1)


**Material Examined**

**HOLOTYPE** 1 female, CANADA: Yukon, Richardson Mountains, in dry
localities with *Dryas* sp., elev. 600 m, N 68°24’ E 135°37’, 25-VI-1948,
M. Hammer. **PARATYPES** 1 male, 1 female data same as HOLOTYPE.
Other material: 2 maturus juniors, 1 larva II, same data as holotype.
The type specimens are preserved in ZMUC.

**DIAGNOSIS**

**Verrucoentomon canadense** is characterized by 3 pairs of A-setae on the
mesonotum, metanotum and tergite VIII, presence of *P*1a setae on
tergites I–VI, absence of *M*2 on prosternum, 3 A-setae on sternites I–VII,
absence of *P*1a setae on sternites I and VIII, presence of *Pc* seta on sternite
VIII, and presence of additional *d*6 setae on head. Mesonotal accessory
seta *P*1a is twice the length of *P*2a. Foretarsal sensillum *b* and *c* are short,
equal in length, reaching the base of seta *P*3. The male squama genitalis has 6+6 setae and the female squama genitalis has bifurcated acrostyli.

**REMARKS**

The description and figures given by Tuxen (1955, 1964) were accu-
rate except that on tergite VII setae *P*1a were present. In the original
description and redescription the author reported 16 *P*1a setae on tergite
VII, but actually there are 14 on the holotype and 2 paratypes (Fig. 1).
Additional and corrected characters for *V. canadensis* follow: head with
additional *d*6 seta (length 19 μm), setae *I*3, *s*4d and *s*5 setiform and
equal in length (12 μm); hind marginal cephalic setae *d*7 and *s*7 nearly
equal in length (25 and 27 μm, respectively). Pronotal seta 1.1.6 times
longer than seta 2 (13 and 23 μm, respectively). Accessory setae *P*1a
and *P*2a on nota long and setiform, *P*1a more than twice length of seta *P*2a
(25 and 11 μm, respectively). Length ratio of mesonot al setae *P*1:1.6 times
longer than seta 2 (36 and 23 μm, respectively). Accessory setae *P*1a and
*P*2a on nota long and setiform, *P*1a more than twice length of seta *P*2a
(25 and 11 μm, respectively). Length ratio of mesonotal setae *P*1:1:1.8 (length of seta *P*1 32 μm, *P*2 46 μm). Foretarsal seta *B1* long and
setiform, seta *h*4 short, thickened and blunt. Mesonotum with *s*l and *a*l pores, metanotum with *s*l pore only. Prosternum without pores, mesosternum and
metasternum with *s*pc pores (Figs. 8, 9). Accessory setae *P*1a on tergites
I–VI longer than seta *P*2a (22 vs. 19 μm) (Fig. 7). Pores *psm* present on
tergites I–II between setae *P*1a and *P*2a, *a*l pores on tergites II–VII, *ps*l
pores on tergite VII. Accessory setae on sternites I–III shorter (11 μm)
than those of sternites IV–VII (13 μm). Sternite VII with *Pc*-seta
on the holotype, absent on a paratype.

Besides the variation in tergite I-A-setae mentioned above, the fol-
lowing setal variability was noted: tergite VI without seta *P*1a in holotype,
but this seta present symmetrically in 2 paratype specimens and
asymmetrically in 2 other paratype specimens. Sternite VII with *Pc*-seta
on the holotype, absent on a paratype.

*Imadateiella mixta* (Nosek 1981) **new combination** (Figs. 11-27, Table 3)

**Verrucoentomon mixtum** Nosek 1981: 160.

**Material Examined**

**HOLOTYPE** 1 male (No. 75792) and **PARATYPE** 1 female on slides,
ALASKA: Fairbanks, Chena Ridge, litter in forest with *Betula* sp. and
*Equisetum* sp., 12-VIII-1976, A. Fjellberg, deposited in NMNH.

**DIAGNOSIS**

The species is characterized by 3 pairs of *A*-setae on the meso-
notum and 4 pairs of *A*-setae on the metasternum, presence of *P*1a setae on
tergites I–VII, 4 *A*-setae on tergite VIII and 4 setae on sternite VIII,
presence of *M*2 on prosternum and 5 *P*-setae on sternite III. Accessory
seta *P*2a is more than 3 times the length of *P*2a on the mesonotum,
metanotum and tergites I–VII. Foretarsal sensillum *b* is shorter than *c*

**Verrucoentomon imadatei** is characterized by 3 pairs of *A*-setae on the
mesonotum, metanotum and tergite VIII, presence of *P*1a setae on
tergites I–V, absence of *M*2 on prosternum, 3 *A*-setae on sternites I–VII,
absence of *P*1a setae on sternites I and VIII, presence of *Pc* seta on sternite
VIII, presence of additional *d*6 setae on head. Mesonotal accessory
seta *P*1a is twice the length of *P*2a. Foretarsal sensillum *b* is shorter than *c*

**Material Examined**

**HOLOTYPE** 1 female (No. 75792), ALASKA: Meade River, in litter and
humus, 25-VIII-1976, A. Fjellberg. **PARATYPES** 2 males, 4 females data
same as HOLOTYPE. All specimens deposited in NMNH.
and does not reach the base of seta γ3. The male squama genitalis has 7+7 setae; female squama genitalis has blunt, triradiate acrostyli.

Redescription

Labium not protruded, additional cephalic setae d6 present, length ratio of posterior cephalic setae d7:d7:5 as 2:8.3:6.1 (Fig. 11). Setae i3, sd4 and sd5 setiform, setae i3 and sd4 slightly shorter than seta sd5, 8 μm and 10 μm long, respectively (Figs. 12, 13). Maxillary palp sensilla slender (Fig. 14). Labial palp with terminal spine, 3 setae and broad sensillum (Fig. 15). Maxillary gland with large, densely granulated calyx and posterior filament with simple dilation. Foretarsal seta B1 long and setiform; setae B4 and B5 blunt, half the length of B1 (Figs. 16, 17).

Length ratio of pronotal setae 1: 2 as 2:1. Mesonotum with 3 pairs of A-setae, metanotum with 4 pairs of A-setae. Length ratio of P1:P1a:P2 on mesonotum as 1.7–1.8:1.2:0–2.4. Seta M on mesonotum short and slender, on metanotum longer, 15 and 25 μm, respectively. Accessory seta P1a setiform and long (17 μm), seta P2a modified, stumpy and short (5 μm) (Fig. 18); P3a and P4 on mesonotum and metanotum subequal in length and shape, short, setiform; P5 a small sensillum. Mesonotum and metanotum with pores al and sl. Prosternum with seta M2, mesosternum and metasternum lacking A1 setae (Fig. 19). Setae A2 and M2 on prosternum and A2 on mesosternum and metasternum setiform (Fig. 20). Prosternum lacking pores; mesosternum and metasternum with pore sc (Fig. 19). Tergite I with 3 pairs of A-setae: A1, A2 and A5 (Fig. 21), and sternite I with 2 pairs of P-setae (P1 and P1a (Fig. 22) rather than one pair. Accessory seta P1a on tergites I–VII long and setiform, setae P2a and P4o short, sensilliform, stumpy as on mesonotum (Fig. 18). Accessory setae on sternites setiform, shorter than on tergites, length about 10 μm (Figs. 23, 24). Pores psm present on tergites I–VII, psl on tergite VII, al on tergites II–VII. Sternite I with a pair of pores sal (Fig. 21). Sternites II–VII with spm pore. Stermites VI and VII along with a pair of pores spsm, situated near bases of P2 setae (Fig. 23). Hind margin of segments VIII–XII smooth, except tergite XI with weak ciliation. Seta 2a on tergites IX and X shorter than remaining setae. Comb with 10 distinct teeth (Fig. 25). Male squama genitalis with 7+7 setae, lateral basiperothisetal seta present (Fig. 26). Female squama genitalis with short, blunt, triradiate acrostyli (Fig. 27).


REMARKS

Verrucoentomon mixtum is similar to other members of the genus, with the exception of the metamorpho-chitosy and form of the terminal tuft on the labial palp. Common to all other Verrucoentomon spp. is the presence of 3 pairs of A-setae on the mesonotum and metanotum and a 4-branched terminal tuft on labial palp. Verrucoentomon mixtum bears 4 pairs of A-setae on metasternum and only a terminal spine on labial palp. The presence of seta A1 on the metanotum (absent in other Verrucoentomon spp.) is a generic character shared only with Imadateiella, Nipponentomon Imadate & Yosii, 1959 and Vesculentomon Rusek, 1974 within Nipponentominae. Vesculentomon differs from the other 3 genera in the presence of a large vesicle near the calyx of maxillary gland and in the baculiform sensillum t1 on foretarsus. Verrucoentomon, Nipponentomon and Imadateiella are very similar in morphological characters, as previously discussed by Shrubovych (2014). These genera have a wide, racemose calyx on the maxillary gland without vesicles, 2 nearly equal setae on the legs of Abd. II and III, P3 in posterior position on the abdominal tergites, well-developed striate band with distinct parallel striae, filiform foretarsal sensillum t1 and leaf-like sensillum t3, foretarsal sensillum d close to base of e, and sensillum α level with t2 base. Verrucoentomon differs from the other 2 in having only 3 pairs of A-setae on the metanotum. The presence or absence of teeth on segments IX–XI separates Nipponentomon and Imadateiella (Rusek 1974). Therefore, Verrucoentomon mixtum is transferred to Imadateiella Rusek, 1974 (Acerentomidae, Nipponento-
minae), because it has 8 A-setae on metanotum (6 in Verrucoentomon) and does not possess teeth on hind margins of segments IX–XI (present in most Nipponentomon spp.).

Imadateiella spp. are united in having 4 pairs of A-setae on metanotum, 5 pairs of A-setae on tergites II–VI, 4 pairs of A-setae on tergite VII, 5 A-setae on the mesosternum, 7 setae on the metasternum, 2 pairs of P-setae on sternite I (except I. yosiiana), and 3 A-setae on sternites I–VII. Verrucoentomon mixtum is similar to other Imadateiella spp. in these characters, but has only 2 pairs of A-setae on tergite VII (3 pairs in other members of Imadateiella) and in the shape of the labial palp. The species is similar to I. shideiana shideiana and I. shideiana eos in the presence of P1a setae on tergite VII, 5 P-setae on sternite III, 4 setae on sternite VIII and in the shape of accessory setae on tergites I–VII. Verrucoentomon mixtum is more similar to I. shideiana eos in the absence of P3a setae on tergites II–VII and Pc setae on sternite VII. Besides the presence of only 2 pairs of A-setae on tergite VIII V. mixtum possesses a long foretarsal sensillum a that reaches the base of sensillum t2 (in I. shideiana eos sensillum a shorter, apex not reaching t2 insertion).

Key to Imadateiella Species

1.— Mesonotum and metanotum with P2a’ setae ................................................................. I. murka Szeptycki – Russia, Siberia.

1’.— Mesonotum and metanotum without P2a’ setae .................................................... 2

2. (1’) Sternite VIII with P1a setae ................................................................. 3

2’.— Sternite VIII without P1a setae ................................................................. 6

3. (2) Tergite VII with P1a setae ................................................................. 4

3’.— Tergite VII without P1a setae ................................................................. 5

4. (3) Sternite VI with Pc seta ................................................................. I. sharovi (Martynova) – Russian Far East.

4’.— Sternite VI with Pc seta ................................................................. I. shiria (Imadaté) – Japan.

5. (3’) Foretarsal empodium with globule apically ................................................ I. sphaerempodia Yin – China.

5’.— Foretarsal empodium smooth ................................................................. I. saurosi Yin – China.

6. (2’) Tergites II–VI with P1a setae, sternite I with 4 P-setae, sternite III with 5 P-setae ................................................ 7

6’.— Tergites II–VI without P1a setae, sternite I with 2 P-setae, sternite III with 6 P-setae ................................................ 8

7. (6) Tergite VIII with 6 setae .................................................................

<table>
<thead>
<tr>
<th>Segment</th>
<th>Formula</th>
<th>Setal composition</th>
<th>Formula</th>
<th>Setal composition</th>
</tr>
</thead>
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<tr>
<td>Th. I</td>
<td>4</td>
<td>1, 2</td>
<td>4±4</td>
<td>A1, 2, M1, 2</td>
</tr>
<tr>
<td>Th. II</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>P1, 2, 3</td>
</tr>
<tr>
<td>Th. III</td>
<td>10</td>
<td>1, 2, 3, 4</td>
<td>5±2</td>
<td>A2, 3, 4, M</td>
</tr>
<tr>
<td>Abd. I</td>
<td>6</td>
<td>2</td>
<td>5 ± 2</td>
<td>P1, 1a, 2, 2a, 3a, 3a, 4, 5</td>
</tr>
<tr>
<td>Abd. II-III</td>
<td>10</td>
<td>1, 2, 3, 4</td>
<td>7 ± 2</td>
<td>P1, 1a, 2, 2a, 3a, 3a, 4, 5</td>
</tr>
<tr>
<td>Abd. IV-VI</td>
<td>10</td>
<td>1, 2, 3, 4</td>
<td>3</td>
<td>P1, 1a, 2, 2a, 3a, 3a, 4, 5</td>
</tr>
<tr>
<td>Abd. VII</td>
<td>10</td>
<td>1, 2, 3, 4</td>
<td>4</td>
<td>P1, 1a, 2, 2a, 3a, 3a, 4, 5</td>
</tr>
<tr>
<td>Abd. VIII</td>
<td>16</td>
<td>1, 2, 3, 4</td>
<td>3</td>
<td>P1, 1a, 2, 2a, 3a, 3a, 4, 5</td>
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<tr>
<td>Abd. IX</td>
<td>12</td>
<td>1, 2, 3, 4</td>
<td>8</td>
<td>P1, 1a, 2, 2a, 3a, 3a, 4, 5</td>
</tr>
<tr>
<td>Abd. X</td>
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<td>4</td>
<td>P1, 1a, 2, 2a, 3a, 3a, 4, 5</td>
</tr>
<tr>
<td>Abd. XI</td>
<td>6</td>
<td>1, 3, 4</td>
<td>6</td>
<td>P1, 1a, 2, 2a, 3a, 3a, 4, 5</td>
</tr>
<tr>
<td>Abd. XII</td>
<td>9</td>
<td>1, 3, 4</td>
<td>6</td>
<td>P1, 1a, 2, 2a, 3a, 3a, 4, 5</td>
</tr>
</tbody>
</table>

7’. — Tergite VIII with 4 setae ................................. ................................. *I. mixta* (Nosek) — Alaska.

8. (7) Tergites II–VII with *P3a* setae, sternite VII with *Pc* seta ................................. ................................. *I. shideiana shideiana* (Imadaté) — Japan.

8’. — Tergites II–VII without *P3a* setae, sternite VII without *Pc* seta ................................. ................................. *I. shideiana eos* (Imadaté) — Japan.

**Discussion**

*Verrucoentomon canadense* and *V. imadatei* differ from nearly all other *Verrucoentomon* spp. in the presence of 4 setae on sternite VIII (*P1a* absent). They are also similar in the absence of seta M2 on the pronotum and *P1a* on sternite I, presence of *Pc* on sternites III and VII, and in porotaxic pattern. They differ in the presence of seta *P1a* on tergite VI (absent in *V. imadatei*) and in length of foretarsal sensillum *b* (in *V. canadense* *b* and *c* of equal length, *b* longer than *c* in *V. imadatei*). Only one other species, *V. rafalskii* Szeptycki, 1997 from Central Europe, has 4 setae on sternite VIII. It is similar to *V. canadense* and *V. imadatei* in the absence of seta M2 on the prosternum and *P2a* seta on sternite I, and in the presence of 5 *P*-setae on sternite III. It differs in having fewer setae on tergites VIII, IX and X (4 *A*-setae, 8, 10 setae vs. 6 *A*-setae, 10, 12 setae in both American species) and lacking seta *Pc* on sternite VII.

*Verrucoentomon mixtum* is similar to both American *Verrucoentomon* spp. in the presence of 4 setae on sternite VIII. Half of the known *Imadateiella* taxa (*I. murka*, *I. yosiiana*, *I. shideiana shideiana* and *I. shideiana eos*) also have just 4 setae on sternite VIII, whereas the other 4 *Imadateiella* spp. and 17 *Nipponentomon* spp. have 6 setae on sternite VIII (*Nipponentomon bifidum* Rusek, 1974 from Canada is the only exception). This difference as well as the absence of teeth on the terminal abdominal segments is additional justification for transferring *V. mixtum* to *Imadateiella* rather than to *Nipponentomon*. Also, the porotaxy of *I. murka* and *I. sharovi* is similar to *I. mixta* in possession of pores *sal* on sternite I. These pores are absent in *Nipponentomon* spp. (Bu et al. 2013; Nakamura 2004; Shrubovych 2009).

Reduction of the apical tuft of setae on the labial palp to 2-branched or only one terminal spine is rare among acerentomids, and appears to have arisen independently several times. The apical tuft consists of 2 branches in *Acerentulus traegardhii* Ionescu, 1937 and *Acerentulus colloi* Szeptycki, 1991, and in *Acerentulus ruseki* Nosek, 1967 consists of just a single terminal spine (Szeptycki 1991). Members of *Yihunentulus* have one terminal spine on the labial palp (Bu et al. 2014; Yin 1980). Species of *Efjellergelia* Nosek, 1978 have 2- or 3-branched apical tufts on their labial palps (Bu et al. 2014; Nosek 1978; Shrubovych & Bernard 2013). This character is very interesting to study, but at this time we cannot confirm the different steps of reduction as good generic characters. Moreover, Bu et al. (2014) noted 2 populations of *Imadateiella sharovi* that differed in having 4-branched and 2-branched setal tufts on the labial palps. Therefore, this character is not useful for generic placement of *I. mixta*.

**Acknowledgments**

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