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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 *P1a* setae on tergites I–VII, 4 *A*-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 mixtum* por la presencia de setas *P1a* 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 sóla espina terminal larga en el palpo labial. Se re-define 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).

All synonymy and literature data up to 2006 are given in Szeptycki (2007). Head seta designations follow Rusek et al. (2012); terminology for body chaetotaxy and porotaxy follow Szeptycki (1988) and Shrubovych (2014). Abbreviations used in the redescriptions are as follows: Abd. – abdominal segments, Th. – thoracic segments, *psm* = posterosubmedial, *psl* = posterosublateral, *al* = anterolateral, *sal* = sternal anterolateral, *sc* = sternal central, *spm* = sternal posteromedial, *spsm* = sternal posterosubmedial cuticular pore.

Taxonomy

The genus *Verrucoentomon* is characterized by 3 pairs of *A*-setae on mesonotum and metanotum, foretarsal sensillum *t1* is filiform, sensillum *t3* is leaf-like, the position of sensillum *d* is close to base of *e,* and seta *ƀ1* is setiform*.* The position of sensillum *a'* is level with or distal to the base of *t2.* The genus is similar to all thirteen genera from subfamily Nipponentominae Yin, 1983 by possession of wide calyx of the maxillary gland with a racemose surface, abdominal legs with 2 nearly

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equal setae, 5 pairs of *A*-setae on tergites II–VI (with except the members of *Alaskaentomon* Nosek, 1977) and by posterior position of seta *P3* on abdominal tergites II–VI (with except of *Alaskaentomon fjellbergi* Nosek, 1977) (Bu et al. 2013; Shrubovych & Smykla 2012; Shrubovych et al. 2012; Shrubovych 2014; Shrubovych et al. 2014a,b,c).

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

Acerentulus canadensis Tuxen 1955: 113.
Acerella canadensis Tuxen 1964: 242.

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 *P1a* setae on tergites I–VI, absence of *M2* on prosternum, 3 *A*-setae on sternites I–VII, absence of *P1a* setae on sternites I and VIII, presence of *Pc* seta on sternite VII, and presence of additional *d6* setae on head. Mesonotal accessory seta *P1a* is twice the length of *P2a*. Foretarsal sensilla *b* and *c* are short, equal in length, reaching the base of seta *γ3*. 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 accurate except that on tergite VII setae *P1a* were present. In the original description and redescription the author reported 16 *P*-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 *d6* seta (length 19 µm), setae *l3, sd4* and *sd5* setiform and equal in length (12 µm); hind marginal cephalic setae *d7* and *sd7* nearly equal in length (25 and 27 µm, respectively). Pronotal seta *1* 1.6 times longer than seta *2* (36 and 23 µm, respectively). Accessory setae *P1a* and *P2a* on nota long and setiform, *P1a* more than twice length of seta *P2a* (25 and 11 µm, respectively). Length ratio of mesonotal setae *P1*:*P1a*:*P2* as 1.3:1:1.8 (length of seta *P1* 32 µm, *P2* 46 µm). Foretarsal seta *β1* long and setiform, seta *δ4* short, thickened and blunt (Fig. 2). Mesonotum and metanotum with pores *sl* and *al*, prosternum without pores, mesosternum and metasternum with pore *sc* (Fig. 3). Accessory setae *P1a* on tergites I–V longer than seta *P2a* (19 and 13 µm, respectively). Pores *psm* present on tergites I–VII, *al* on tergites II–VII, *psl* on tergites V–VII (Fig. 1). Accessory setae on sternites I–III shorter (15 µm) than those on sternites IV–VII (22 µm). Sternites II–VII with pore *spm*. Metasternum with asymmetric seta *A1* in all type specimens (Fig. 3). Seta *P1a* on tergite VI symmetrical on holotype, absent on paratype male. Sternite VII *Pc*-seta present on holotype, absent on paratype female.

Verrucoentomon imadatei Nosek 1977 (Figs. 4-10, Table 2)

Acerentulus imadatei Nosek 1977: p. 280.

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.

DIAGNOSIS

Verrucoentomon imadatei is characterized by 3 pairs of *A*-setae on the mesonotum, metanotum and tergite VIII, presence of *P1a* setae on tergites I–V, absence of *M2* on prosternum, 3 *A*-setae on sternites I–VII, absence of *P1a* setae on sternites I and VIII, presence of *Pc* seta on sternite VII, presence of additional *d6* setae on head. Mesonotal accessory seta *P1a* is twice the length of *P2a*. Foretarsal sensillum *b* is longer than *c* and clearly surpasses the base of seta *γ3*. The male squama genitalis bears 7+7 setae and female squama genitalis has blunt, bifurcated acrostyli.

REMARKS

The original description and figures (Nosek 1977) are generally accurate except for the chaetotaxy of tergite I. In the original description the author identified 6 *A*-setae on tergite I, but the holotype and 2 paratypes have 4 *A*-setae (*A1*, *A2*), with seta *A5* absent (Fig. 7). The other 4 paratypes have 6 *A*-setae (*A1*, *A2*, *A5*). Therefore, the number of *A*-setae on tergite I is a variable character and cannot be used in the diagnosis of the species. Some corrected and additional characters are given: head with additional *d6* seta (length 20 µm), setae *l3, sd4* and *sd5* setiform, seta *l3* slightly shorter than other 2 (9 and 12 µm, respectively) (Figs. 4, 5). Hind marginal cephalic setae *d7* and *sd7* lengths nearly equal (20 and 23 µm) (Fig. 4). Pronotal seta *1* 1.6 times length of seta *2* (32 and 20 µm) (Fig. 6). Accessory setae *P1a* and *P2a* on nota long and setiform, *P1a* twice the length of *P2a* (23 and 12 µm) (Fig. 6). Length ratio of mesonotal setae *P1*:*P1a*:*P2* as 1.2:1:1.7 (length of seta *P1* 27 µm, *P2* 39 µm). Foretarsal seta *β1* setiform and long, seta *δ4* short, thickened, blunt. Mesonotum with *sl* and *al* pores, metanotum with *sl* pore only. Prosternum without pores, mesosternum and metasternum with *sc* pore (Figs. 8, 9). Accessory seta *P1a* on tergites I–VI longer than seta *P2a* (22 vs. 19 µm) (Fig. 7). Pores *psm* present on tergites I–VII between setae *P1* and *P2*, *al* pores on tergites II–VII, *psl* pores on tergite VII. Accessory setae on sternites I–III shorter (11 µm) than those of sternites IV–VII (13 µm). Sternites II–VII with pore *spm* (Fig. 10).

Besides the variation in tergite I *A*-setae mentioned above, the following setal variability was noted: tergite VI without seta *P1a* 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.

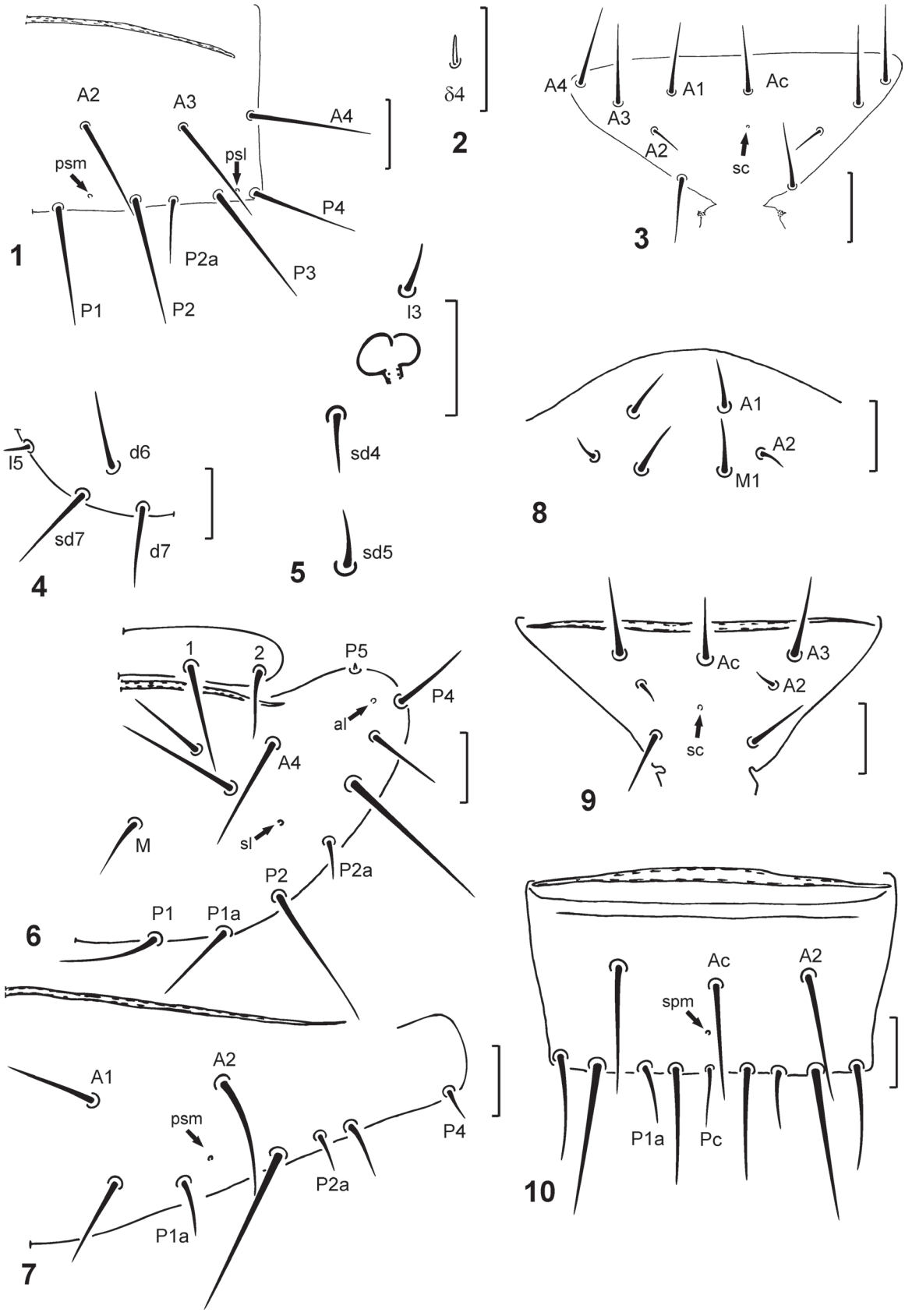
Material Examined

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 mesonotum and 4 pairs of *A*-setae on the metanotum, presence of *P1a* setae on tergites I–VII, 4 *A*-setae on tergite VIII and 4 setae on sternite VIII, presence of *M2* on prosternum and 5 *P*-setae on sternite III. Accessory seta *P1a* is more than 3 times the length of *P2a* on the mesonotum, metanotum and tergites I–VII. Foretarsal sensillum *b* is shorter than *c*

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Figs. 1–10. *Verrucoentomon* species. **1-3.** *V. canadense* (Tuxen, 1955). Holotype. 1. Tergite VII, right part; 2. Foretarsal seta *δ4*; 3. Anterior part of metasternum. Arrows indicate pores (psm = tergal posterosubmedial, psl = tergal posterosublateral pore, sc = sternal central). Scale bar: 20 μm. **4–10.** *Verrucoentomon imadatei* (Nosek, 1977). 4. Hind margin of head; 5. Pseudoculus with cephalic setae *l3, sd4* and *sd5*; 6. Pronotum and mesonotum, right side; 7. Tergite I, right side; 8. Anterior part of prosternum; 9. Anterior part of mesosternum; 10. Sternite VII. Arrows indicate pores (sl = tergal sublateral, al = tergal anterolateral, psm = tergal posterosubmedial, sc = sternal central, spm = sternal posteromedial). Scale bars: 20 μm.

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Table 1. Body chaetotaxy of *Verrucoentomon canadense* (Tuxen 1955).

	Dorsal		Ventral	
Segment	Formula	Setal composition	Formula	Setal composition
Th. I	4	1, 2	4+2 6	A1, 2, M P1, 2, 3
Th. II	8 16	A2, 3, 4, M P1, 1a, 2, 2a, 3, 3a, 4, 5	5+2 4	Ac, 2, 3, M P1, 3
Th. III	8 16	A2, 3, 4, M P1, 1a, 2, 2a, 3, 3a, 4, 5	7 (9)+2 4	Ac, (1), 2, 3, 4, M P1, 3
Abd. I	4 12	A1, 2 P1, 1a, 2, 2a, 3, 4	3 2	Ac, 2 P1
Abd. II	10 16	A1, 2, 3, 4, 5 P1, 1a, 2, 2a, 3, 4, 4a, 5	3 5	Ac, 2 Pc, 1a, 2
Abd. III	10 16	A1, 2, 3, 4, 5 P1, 1a, 2, 2a, 3, 4, 4a, 5	3 6	Ac, 2 P1, 1a, 2
Abd. IV-VI	10 16	A1, 2, 3, 4, 5 P1, 1a, 2, 2a, 3, 4, 4a, 5	3 8	Ac, 2 P1, 1a, 2, 3
Abd. VII	8 14	A2, 3, 4, 5 P1, 2, 2a, 3, 4, 4a, 5	3 9	Ac, 2 Pc, P1, 1a, 2, 3
Abd. VIII	6 15	A1, 4, 5 Pc, 1, 1a, 2, 2a, 3, 3a, 5	4	1, 2
Abd. IX	12	1, 1a, 2, 2a, 3, 4	4	1, 2
Abd. X	10	1, 2, 2a, 3, 4	4	1, 2
Abd. XI	6	1, 3, 4	6	
Abd. XII	9		6	

and does not reach the base of seta *γ3*. The male squama genitalis has 7+7 setae; female squama genitalis has blunt, trifurcate acrostyli.

Redescription

Labium not protruded, additional cephalic setae *d6* present, length ratio of posterior cephalic setae *d7*:*sd7*:*l5* as 2.8:3.6:1 (Fig. 11). Setae *l3*, *sd4* and *sd5* setiform, setae *l3* 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 dilatation. Foretarsal seta *β1* long and setiform; setae *δ4* and *δ5* blunt, half the length of *β1* (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 *aI* and *sI*. 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 *P4a* 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, *aI* on tergites II–VII. Sternite I with a pair of pores *sal* (Fig. 21). Sternites II–VII with *spm* pore. Sternites VI and VII additionally 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 basiperiphallar setae present (Fig. 26). Female squama genitalis with short, blunt, trifurcated acrostyli (Fig. 27).

Body measurements and setal lengths (2 adults, in µm): body length 1120, head 130–135, pseudoculus 7–8, distal part of maxillary gland 20–21, pronotal seta *1* 30–32, pronotal seta *2* 15–17, mesonotal *P1* 28–30, mesonotal *P1*a 16–18, mesonotal *P2* 36–38, mesonotal *P2*a 5; foretarsus 80–82, claw 32–34, empodial appendage 5–6.

REMARKS

Verrucoentomon mixtum is similar to other members of the genus, with the exception of the metanotal chaetotaxy 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* Imadaté & Yosii, 1959 and *Vesiculentomon* Rusek, 1974 within Nipponentominae. *Vesiculentomon* 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 *a'* 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-

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Table 2. Body chaetotaxy of *Verrucoentomon imadatei* Nosek 1977**.**

	Dorsal		Ventral	
Segment	Formula	Setal composition	Formula	Setal composition
Th. I	4	1, 2	4+2	A1, 2, M
			6	P1, 2, 3
Th. II	8	A2, 3, 4, M	5+2	Ac, 2, 3, M
	16	P1, 1a, 2, 2a, 3, 3a, 4, 5	4	P1, 3
Th. III	8	A2, 3, 4, M	7+2	Ac, 2, 3, 4, M
	16	P1, 1a, 2, 2a, 3, 3a, 4, 5	4	P1, 3
Abd. I	4+(6)	A1, 2, (5)	3	Ac, 2
	12	P1, 1a, 2, 2a, 3, 4	2	P1
Abd. II	10	A1, 2, 3, 4, 5	3	Ac, 2
	16	P1, 1a, 2, 2a, 3, 4, 4a, 5	5	Pc, 1a, 2
Abd. III	10	A1, 2, 3, 4, 5	3	Ac, 2
	16	P1, 1a, 2, 2a, 3, 4, 4a, 5	6	P1, 1a, 2
Abd. IV-V	10	A1, 2, 3, 4, 5	3	Ac, 2
	16	P1, 1a, 2, 2a, 3, 4, 4a, 5	8	P1, 1a, 2, 3
Abd. VI	10	A1, 2, 3, 4, 5	3	Ac, 2
	14	P1, 2, 2a, 3, 4, 4a, 5	8	P1, 1a, 2, 3
Abd. VII	8	A2, 3, 4, 5	3	Ac, 2
	14	P1, 2, 2a, 3, 4, 4a, 5	9	Pc, P1, 1a, 2, 3
Abd. VIII	6	A1, 4, 5	4	1, 2
	15	Pc, 1, 1a, 2, 2a, 3, 3a, 5		
Abd. IX	12	1, 1a, 2, 2a, 3, 4	4	1, 2
Abd. X	10	1, 2, 2a, 3, 4	4	1, 2
Abd. XI	6	1, 3, 4	6	
Abd. XII	9		6	

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 VIII (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 (long setiform seta *P1a* and very short sensilliform setae *P2a* and *P4a*). *Verrucoentomon mixtum* is more similar to *I. shideiana eos* in the absence of *P3a* setae on tergites II–VII and *Pc* seta 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 without *Pc* seta ..... *I. shiria* (Imadaté) – Japan.

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

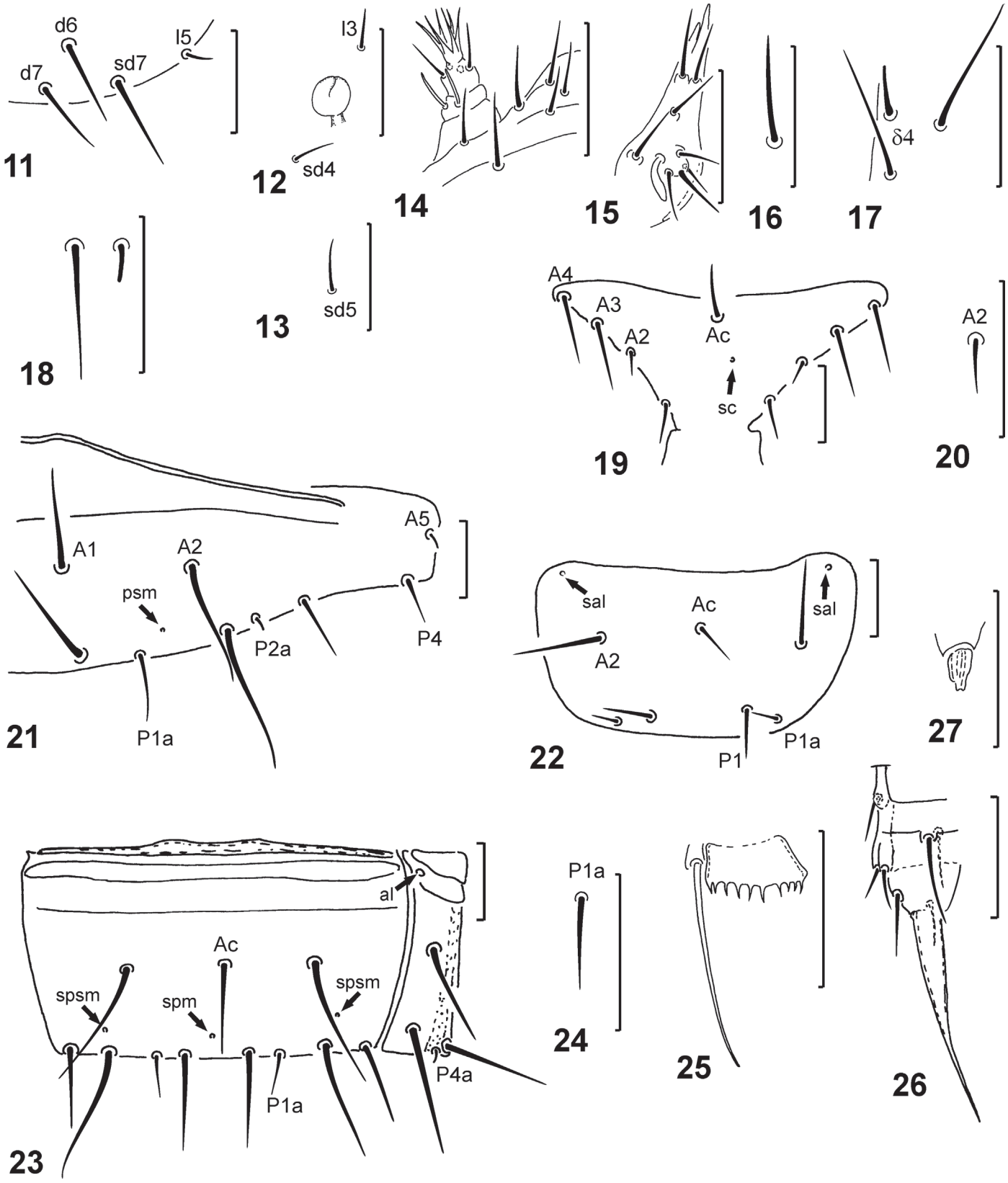
5′.— Foretarsal empodium smooth ..... *I. saucrosi* Yin – China.

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 ..... *I. yosiiana* (Imadaté) – Japan.

7. (6) Tergite VIII with 6 setae 8

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Figs. 11–27. *Imadateiella mixta* (Nosek, 1977). 11. Hind margin of head; 12. Pseudoculus with setae *l3* and *sd4*; 13. Cephalic seta *sd5*; 14. Maxillary palp; 15. Labial palp; 16. Foretarsal seta *β1*; 17. Foretarsal setae *δ4* and *δ5*; 18. Setae *P1a* and *P2a* on mesonotum; 19. Anterior part of mesosternum; 20. Seta *A2* on mesosternum; 21. Tergite I, right side; 22. Sternite I; 23. Sternite VII; 24. Seta *P1a* on sternite VII; 25. Comb; 26. Part of male squama genitalis; 27. Acrostylus of female squama genitalis. Arrows indicate pores (al = tergal anterolateral, psm = tergal posterosubmedial, sc = sternal central, sal = sternal anterolateral, spm = sternal posteromedial, spsm = sternal posterosubmedial). Scale bars: 20 µm.

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Table 3. Body chaetotaxy of *Imadateiella mixta* (Nosek 1981).

	Dorsal		Ventral	
Segment	Formula	Setal composition	Formula	Setal composition
Th. I	4	1, 2	4+4 6	A1, 2, M1, 2 P1, 2, 3
Th. II	8 16	A2, 3, 4, M P1, 1a, 2, 2a, 3, 3a, 4, 5	5+2 4	Ac, 2, 3, M P1, 3
Th. III	10 16	A1, 2, 3, 4, M P1, 1a, 2, 2a, 3, 3a, 4, 5	7+2 4	Ac, 2, 3, 4, M P1, 3
Abd. I	6 12	A1, 2, 5 P1, 1a, 2, 2a, 3, 4	3 4	Ac, 2 P1, 1a
Abd. II-III	10 16	A1, 2, 3, 4, 5 P1, 1a, 2, 2a, 3, 4, 4a, 5	3 5	Ac, 2 Pc, 1a, 2
Abd. IV-VI	10 16	A1, 2, 3, 4, 5 P1, 1a, 2, 2a, 3, 4, 4a, 5	3 8	Ac, 2 P1, 1a, 2, 3
Abd. VII	8 14	A2, 3, 4, 5 P1, 2, 2a, 3, 4, 4a, 5	3 8	Ac, 2 P1, 1a, 2, 3
Abd. VIII	4 15	A4, 5 Pc, 1, 1a, 2, 2a, 3, 3a, 5	4	1, 2
Abd. IX	12	1, 1a, 2, 2a, 3, 4	4	1, 2
Abd. X	10	1, 2, 2a, 3, 4	4	1, 2
Abd. XI	6	1, 3, 4	6	
Abd. XII	9		6	

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 *P1a* 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 traegardhi* Ionescu, 1937 and *Acerentulus collaris* 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 *Fjellbergella* 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.*

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