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Willemia anophthalma-group (Collembola: Hypogastruridae): Systematics, new species, distribution and habitats

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Collembola, Hypogastruridae, *Willemia*, systematics, new species, redescriptions, synonymy, key, habitats, Holarctic region

Abstract. Two new species belonging to the genus *Willemia* are described: *W. bedosae* sp. n. and *W. christianseni* sp. n. Redescriptions of *Willemia dubia* Christiansen & Bellinger, 1980 and *W. similis* Mills, 1934 are provided. *Willemia vashtia* Wray, 1950 is a new synonym of *W. similis*. These four species and four other of the genus constitute the *Willemia anophthalma*-group. This group is characterized by one feature not shared by the other species of the genus: the presence of setae *a*1 on abdominal sternum IV. A comparative table and an identification key are given for these eight species, as well as some remarks on their habitats.

INTRODUCTION

In 1994, Potapov established the *Willemia anophthalma*-group with three species: *W. anophthalma,* type species of the genus, described by Börner in 1901 from Marburg, Germany, *W. scandinavica* Stach, 1949 from Finland and *W. similis* Mills, 1934 from Kansas, USA. This group was characterized by the following characters: anal spines normally developed; sensilla on antennal segment IV subcylindrical and not enlarged; postantennal organ with 5 or more simple vesicles; labrum with 2–4/454 setae; setae *a*4, *m*4 and *p*5 (*a*6, *m*6 and *p*6 in Potapov's nomenclature) present on abdominal tergum IV; setae *p*2 present on abdominal tergum V (i.e. setae *s* in *p*3 position); setae *a*1 present on abdominal sternum IV.

In this work, two new species *Willemia bedosae* sp. n. and *W. christianseni* sp. n. are described and added to the *W. anophthalma*-group with the following species: *W. dubia* Christiansen & Bellinger, 1980 described from Wyoming, USA; *W. koreana* Thibaud & Lee, 1994 described from Byunsanbando National Park, South Korea; and *W. virae* Kapruś, 1997 from Eastern Carpathians, Ukraine. *W. dubia* and *W. similis* (= *W. vashtia* Wray, 1950, syn. nov.) are redescribed. Type specimens, as well as other material from the type locality of *W. dubia* were studied and shown to be two different species: *W. dubia* sensu stricto and *W. christianseni* sp. n. A comparative table and an identification key are given for the eight species of *Willemia anophthalma*-group.

ABBREVIATIONS: INHS – Illinois Natural History Survey, Champaign; MCZC – Museum of Comparative Zoology, Harvard University, Cambridge; MNHN – Laboratoire d'Entomologie, Muséum national d'Histoire naturelle, Paris; NCSU – North Carolina State University, Raleigh.

DIAGNOSIS OF *WILLEMIA ANOPHTHALMA*-GROUP

The eight species of *W. anophthalma*-group are clearly characterized by setae *a*1 present on abdominal sternum IV. They share with *W. namibiae* Thibaud & Massoud, 1988 and *W. trilobata* Barra, 1995, which do not belong to this group, a labral chaetotaxy with 2–4/454 setae.

Species of this group also share other characteristics: antennal segment IV with subcylindrical sensilla (neither globular, nor in cavity); antennal segment I and II with 7 and 12 setae respectively; setae *a*0 and *c*1 present on head; postantennal organ with 5 to 9 simple vesicles (8 to 12 in *Willemia similis* according to Mills, 1934); setae *a*2 and *m*3 present on thoracic terga II and III; tibiotarsi I, II and III with 17, 17 and 16 setae respectively; setae *p*5 present on abdominal tergum IV; *p*2 present or absent on abdominal tergum V (i.e. setae *s* in *p*3 or *p*2 position). Anal spines present.

Potapov (1994) considered that the *W. anophthalma*-group lacks the *m*-row of setae on abdominal sternum IV. However, species of this group have 4 rows of setae on abdominal sternum IV as well as species of the *W. denisi*-group. Since Potapov considered *m*-row to be present in the latter group and absent in the *W. anophthalma*-group, a new row would have to appear under *p*-row and *p'*-row that does not appear in the *W. denisi*-group. In fact, primary homology criterion (De Pinna, 1991) leads to consider that the 4 rows of setae in the *W. anophthalma*-group are homologous to those in the *W. denisi*-group.

Willemia bedosae sp. n.

DESCRIPTION. Holotype (♀) length 0.89 mm, paratype (♀) lenght 0.82 mm. Color in alcohol slightly pink, not hypodermic. Tegumental granulation fine and regular.

Antennae somewhat shorter than head's diagonal. Antennal segment III and IV only slightly separated. Antennal segment I with 7 setae, antennal segment II with 12 setae. Sensory organ of antennal segment III consisting of two internal microsensilla hidden by a tegumental fold, two guard sensilla, and one ventrolateral microsensillum. Guard setae longer than or subequal to guard sensilla. Antennal segment IV with 4 subcylindrical and thick sensilla (*e*1, *e*2, *e*3 and *i*2) and 2 subcylindrical and thiner sensilla (*d* and *i*1). Microsensillum and subapical organite present. Apical vesicle globular (Fig. 3).

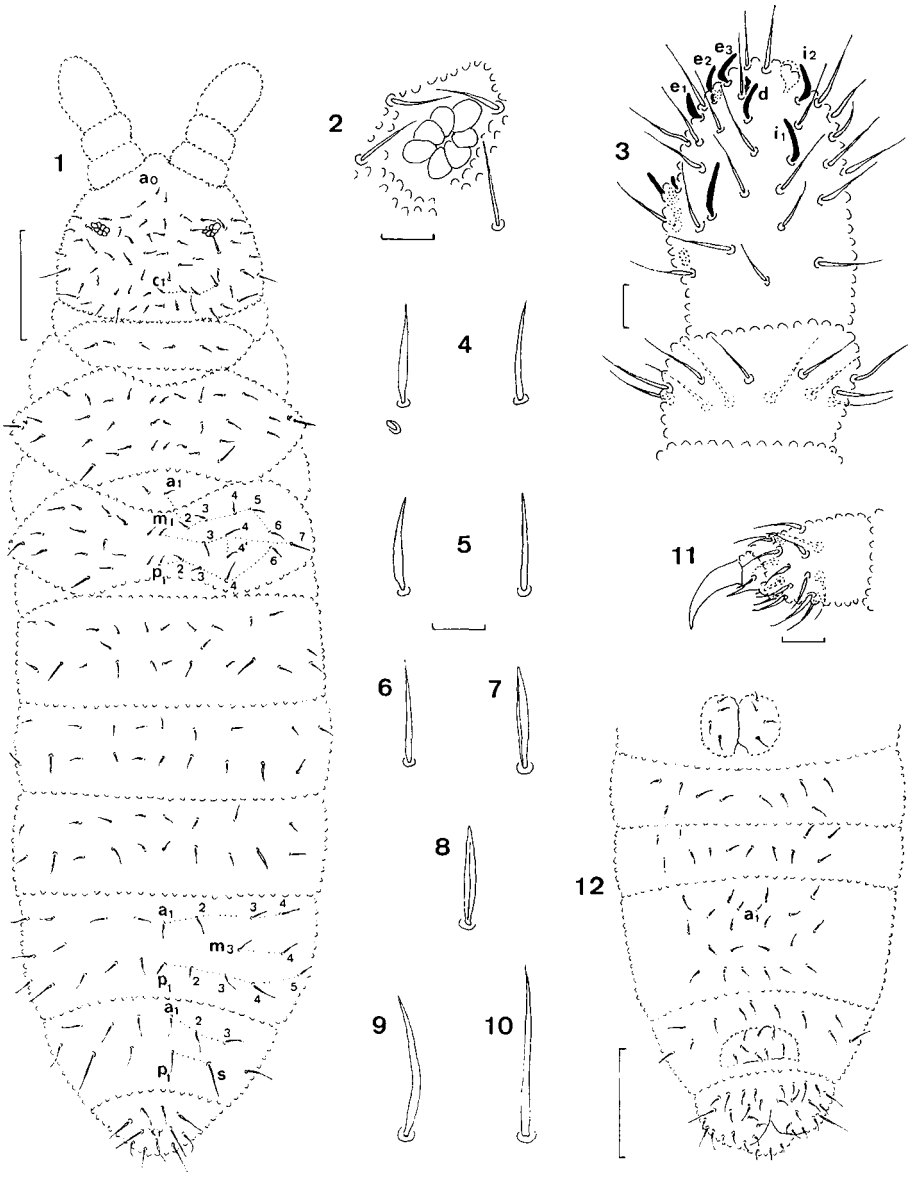
Postantennal organ with 7 vesicles (Fig. 2). Setae *a*0 and *c*1 present on head. Labrum with 4/454 setae.

Dorsal chaetotaxy presented in Fig. 1. Setae straight and elongate. Setae *s* per half tergum formula is 22/11111 in *m*7 and *p*4 position on thoracic terga II and III, in *p*4 position on abdominal terga I to IV, and in *p*2 position on abdominal tergum V (i.e. setae *p*2 absent, so the seta *s* which is *p*3 is in *p*2 position). Setae *s* slightly lanceolate on second and third abdominal terga (Figs 4–10). Setae *m*1 absent on abdominal tergum IV. Ventral chaetotaxy as in Fig. 12. Ventral tube with 4+4 distal setae.

Tibiotarsi I, II and III with 17, 17 and 16 setae respectively, without tenent hair. Claw curved, toothless. Empodial appendage distally setaceous (Fig. 11).

Small anal spines, ratio claw III : anal spines = 1 : 0.40.

VARIATION. Paratype with asymmetries on thoracic tergum III on *m*-row (*m*3 setae absent on one side). Holotype with *m*2 seta on one side, on abdominal tergum I only, *m*2 absent on other abdominal terga.



Figs 1–12: *Willemia bedosae* sp. n. 1 – dorsal chaetotaxy; 2 – postantennal organ; 3 – antennal segment II, III and IV; 4 – setae *s* and microsensillum *ms* of mesothorax; 5 – setae *s* of metathorax; 6 – seta *s* of abdominal segment I; 7 – seta *s* of abdominal segment II; 8 – seta *s* of abdominal segment III; 9 – seta *s* of abdominal segment IV; 10 – seta *s* of abdominal segment V; 11 – tibiotarsus III; 12 – ventral abdominal chaetotaxy. Scale bars: 1, 12 – 0.1 mm; 2–11 – 0.01 mm.

TYPE MATERIAL: Holotype (♀), Spain, Gerona province, near Beuda, deep stony soil under oaks, 340 m, 26.xii.1996, L. Deharveng and A. Bedos (MNHN); paratype (♀), same data as holotype (MNHN).

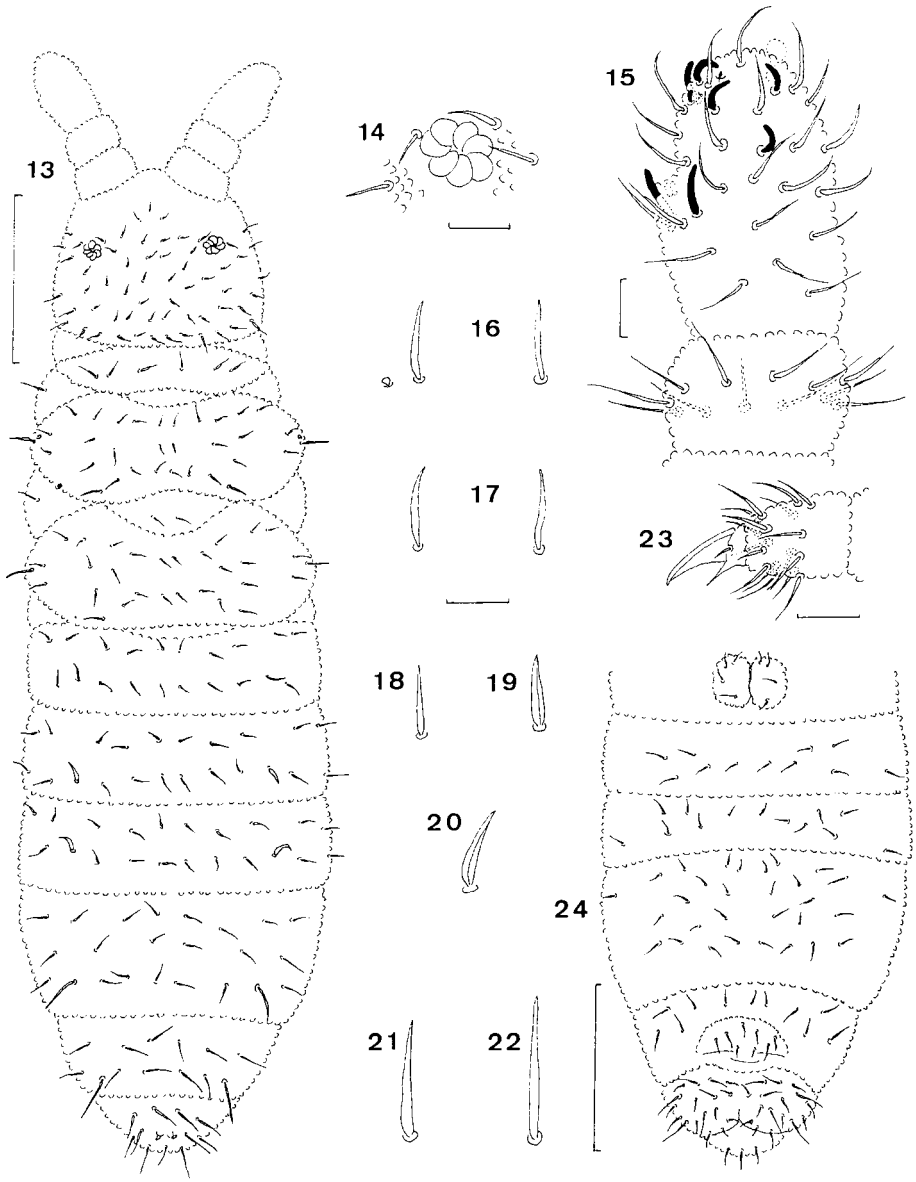
ETYMOLOGY. This new species is cordially dedicated to the French collembologist Anne Bedos.

DISCUSSION. The new species is close to *Willemia virae* Kapruś, 1997, they do not have setae *m*2 and *m*3 on abdominal terga II and III and setae *m*1 on abdominal tergum IV. Both species differ from the other species of the group by setae *p*2 absent on fifth abdominal tergum, i.e. setae *s* are in *p*2 position (*p*2 present in the other species of the group, i.e. setae *s* are in *p*3 position). *W. bedosae* differs from *W. virae* by having setae in *m*-row on abdominal tergum IV and having *a*4 setae on thoracic terga II and III (these setae absent in *W. virae*).

The slightly pink colour of the specimens is exceptional in this genus. However, it is not a hypodermic pigmentation, and is probably caused by feeding on red algae.

TABLE 1. Characters differentiating species of *Willemia anophthalma*-group (* = possible asymmetries, see text for further explanation; sensilla absent on antennal segment IV means they are not differentiated from ordinary setae).

	anophthalma	*bedosae*	*dubia*	*christianseni*	*koreana*	*scandinavica*	*similis*	*virae*
Sensilla *e*1 on antennal segment IV	present	present	present	absent	present	present	present	present
Sensilla *d* on antennal segment IV	present	present	present	present	absent	absent	present	present
Sensilla *i*1 on antennal segment IV	present	present	present	present	absent	absent	present	present
Number of prelabral setae	4	4	4	4	4	4	2	4
Vesicles number in PAO	5 (4–6)	7	7	7	6–8	5–9	7–12	5–6
*a*4 setae on thoracic terga II and III	present	present	present	present	present	present	present	absent
*m*2 setae on abdominal terga II and III	absent	absent	absent	absent	absent	absent	present*	absent
*m*3 setae on abdominal terga II and III	present	absent	absent	absent	absent	absent	absent	absent
*m*1 setae on abdominal tergum IV	present	absent	absent	present	absent	absent	present	absent
*m*4 setae on abdominal tergum IV	present	present	present	present	present	present	present	absent
*p*2 setae on abdominal tergum V	present	absent	present	present	present	present	present	absent
Empodial appendage	present	present	present	present	absent	present	present	present
Number of *hr* setae on anal valves	2	3	3	3	3	3	3	3
Ratio Claw III : Anal spines	1 : 0.40	1 : 0.40	1 : 0.40	1 : 0.40	1 : 0.40	1 : 0.40	1 : 0.35	1 : 0.25



Figs 13–24: *Willemia christianseni* sp. n. 13 – dorsal chaetotaxy; 14 – postantennal organ; 15 – antennal segment II, III and IV; 16 – setae *s* and microsensillum *ms* of mesothorax; 17 – setae *s* of metathorax; 18 – seta *s* of abdominal segment I; 19 – seta *s* of abdominal segment II; 20 – seta *s* of abdominal segment III; 21 – seta *s* of abdominal segment IV; 22 – seta *s* of abdominal segment V; 23 – tibiotarsus III; 24 – ventral abdominal chaetotaxy. Scale bars: 13, 24 – 0.1 mm; 14–23 – 0.01 mm.

Willemia christianseni sp. n.

DESCRIPTION. Holotype (♀) length 0.59 mm, paratype (♂) 0.61 and paratype (♀) 0.63 mm. Color in alcohol white, tegumental granulation fine and regular.

Antennae somewhat shorter than head's diagonal. Antennal segment III and IV only slightly separated. Antennal segment I with 7 setae, antennal segment II with 12 setae. Sensory organ of antennal segment III consisting of two internal microsensilla hidden by a tegumental fold, two guard sensilla, and one ventrolateral microsensillum. Guard setae longer than or subequal to guard sensilla. Antennal segment IV with 5 subcylindrical and thick sensilla, sensillum *e*1 is lacking (in fact, not differentiated from ordinary setae), sensilla *d* and *i*1 slightly thiner than *e*2, *e*3 and *i*2, *e*2 and *e*3 strongly curved. Microsensillum and subapical organite present. Apical vesicle globular (Fig. 15).

Postantennal organ with 7 vesicles (Fig. 14). Setae *a*0 and *c*1 present on head. Labrum with 4/454 setae.

Dorsal chaetotaxy presented in Fig. 13. Setae *s* per half tergum formula is 22/11111 in *m*7 and *p*4 position on thoracic terga II and III, in *p*4 position on abdominal terga I to IV, and in *p*3 position on abdominal tergum V. Setae *s* on second and third abdominal terga slightly lanceolate (Figs 16–22). Setae *m*1 on abdominal tergum IV present. Ventral chaetotaxy as in Fig. 24. Ventral tube with 4+4 distal setae.

Tibiotarsi I, II and III with 17, 17 and 16 setae respectively, without tenent hair. Claw curved, toothless. Empodial appendage distally setaceous (Fig. 23).

Small anal spines, ratio claw III : anal spines = 1 : 0.40.

TYPE MATERIAL: Holotype (♀), USA, Wyoming, Teton National forest, about 48 km SE of Jackson, coniferous forest, under boards, 2,569 m, 15.vii.1950, K. Christiansen; 2 paratypes (♂ and ♀), same data as holotype (MNHN); USA, Wyoming, Teton pass, Teton Co., spruce and pine duff, 2,569 m, 15.vii.1950, K. Christiansen, 1 specimen (♀) (MCZC).

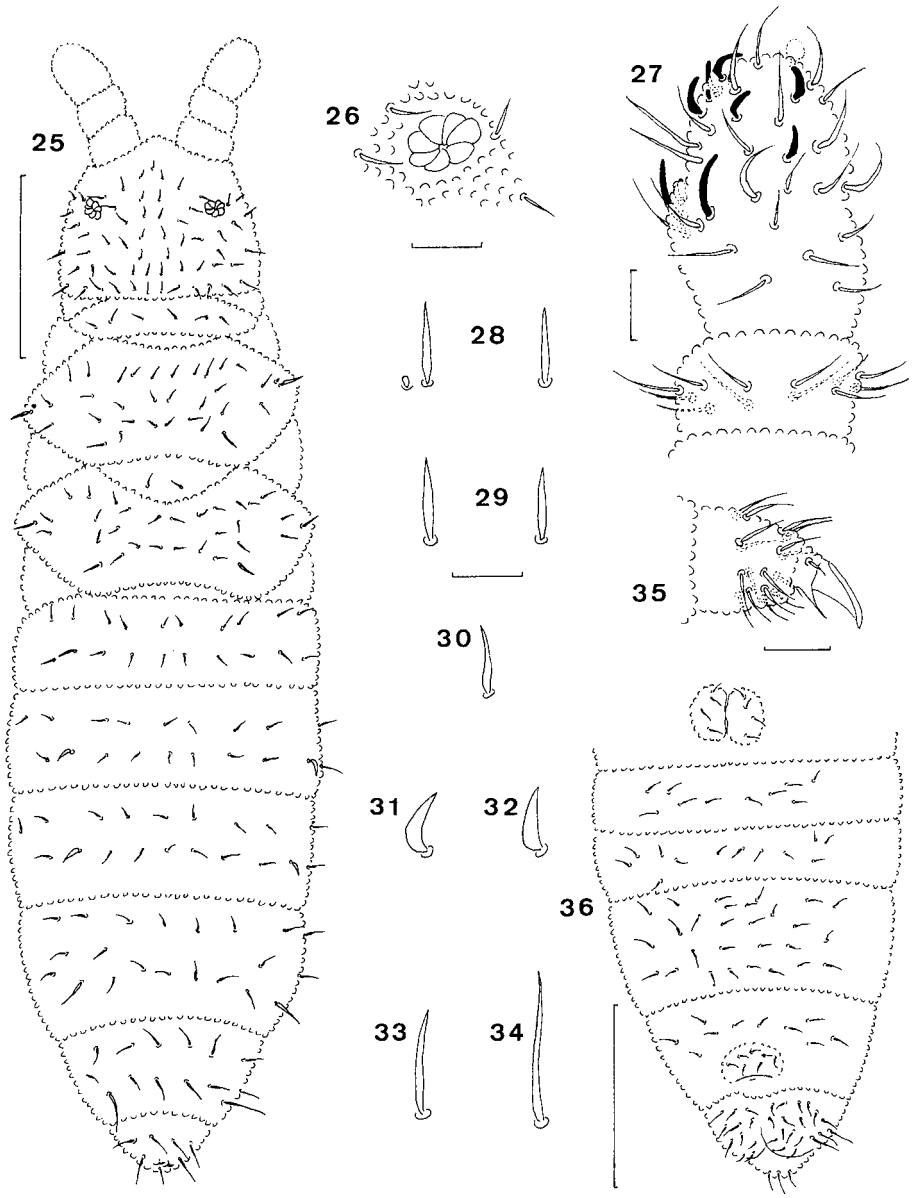
ETYMOLOGY. This new species is cordially dedicated to the North American collembologist Kenneth Christiansen.

DISCUSSION. *Willemia christianseni* sp. n. was found with *W. dubia* Christiansen & Bellinger, 1980 in the same locality. They can be distinguished by the presence of setae *m*1 on abdominal tergum IV and absence of sensilla *e*1 on antennal segment IV in the new species (they are respectively absent and present in *W. dubia*). *W. christianseni* differs from all the other species of the *Willemia anophthalma*-group by absence of sensilla *e*1 (i.e. *e*1 is not differentiated from ordinary setae) on antennal segment IV.

Willemia dubia Christiansen & Bellinger, 1980

REDESCRIPTION. Holotype (♀) length 0.56 mm, other specimens (♀) length 0.56 to 0.63 mm. Color in alcohol white, tegumental granulation fine and regular.

Antennae somewhat shorter than head's diagonal. Antennal segment III and IV only slightly separated. Antennal segment I with 7 setae, antennal segment II with 12 setae. Sensory organ of antennal segment III consisting of two internal microsensilla hidden by a tegumental fold, two guard sensilla, and one ventrolateral microsensillum. Guard setae longer than or subequal to guard sensilla. Antennal segment IV with 6 subcylindrical and thick sensilla (sensilla *d* and *i*1 slightly thiner than *e*1, *e*2, *e*3 and *i*2). Microsensillum and subapical organite present. Apical vesicle globular (Fig. 27).



Figs 25–36: *Willemia dubia* Christiansen & Bellinger, 1980. 25 – dorsal chaetotaxy; 26 – postantennal organ; 27 – antennal segment II, III and IV; 28 – setae *s* and microsensillum *ms* of mesothorax; 29 – setae *s* of metathorax; 30 – seta *s* of abdominal segment I; 31 – seta *s* of abdominal segment II; 32 – seta *s* of abdominal segment III; 33 – seta *s* of abdominal segment IV; 34 – seta *s* of abdominal segment V; 35 – tibiotarsus II; 36 – ventral abdominal chaetotaxy. Scale bars: 25, 36 – 0.1 mm; 26–35 – 0.01 mm.

Postantennal organ with 7 vesicles (Fig. 26). Setae *a*0 and *c*1 present on head. Labrum with 4/454 setae.

Dorsal chaetotaxy presented in Fig. 25. Setae *s* per half tergum formula is 22/11111 in *m*7 and *p*4 position on thoracic terga II and III, in *p*4 position on abdominal terga I to IV, and in *p*3 position on abdominal tergum V. Setae *s* on second and third abdominal terga shorter and slightly thiner than other setae *s* but not lanceolate (Figs 28–34). Setae *m*1 absent on abdominal tergum IV. Ventral chaetotaxy as in Fig. 36. Ventral tube with 4+4 distal setae.

Tibiotarsi I, II and III with 17, 17 and 16 setae respectively, without tenent hair. Claw curved, toothless. Empodial appendage distally setaceous (Fig. 35).

Small anal spines, ratio claw III : anal spines = 1 : 0.40.

MATERIAL EXAMINED. USA, Wyoming, Teton pass, Teton Co., spruce and pine duff, 2,569 m, 15.vii.1950, K. Christiansen, holotype (♀) and 3 paratypes (♀) (MCZC); USA, Wyoming, Teton National forest, about 48 km south east of Jackson, coniferous forest, under boards, 2,569 m, 15.vii.1950, K. Christiansen, 4 specimens (♀) (MNHN).

DISCUSSION. *W. dubia* Christiansen & Bellinger, 1980 is close to *W. koreana* Thibaud & Lee, 1994 and *W. scandinavica* Stach, 1949. They share the presence of setae *p*2 on abdominal tergum V (setae *s* on *p*3 position), absence of setae *m*2 and *m*3 on abdominal terga II and III and absence of setae *m*1 on abdominal tergum IV. *W. dubia* can be distinguished from them by having sensilla *d* and *i*1 on antennal segment IV more strongly developed (not differentiated from ordinary setae in *W. koreana* and *W. scandinavica*). However, Potapov (1994) observed specimens with an intermediate development of *d* and *i*1 and considers that *W. scandinavica* sensu lato may be a group of species including *W. dubia*. Nevertheless, as Potapov did not put them into synonymy, *W. scandinavica* and *W. dubia* are maintained as separate species pending further study. Christiansen & Bellinger (1998) separated *W. scandinavica* and *W. dubia* according to the shape of setae *s* on abdominal tergum IV (normal in the first species, flame like in the second one). However, after seeing a lot of specimens in both species, it appeared that neither *W. dubia* nor *W. scandinavica* have flame like setae s on abdominal tergum IV.

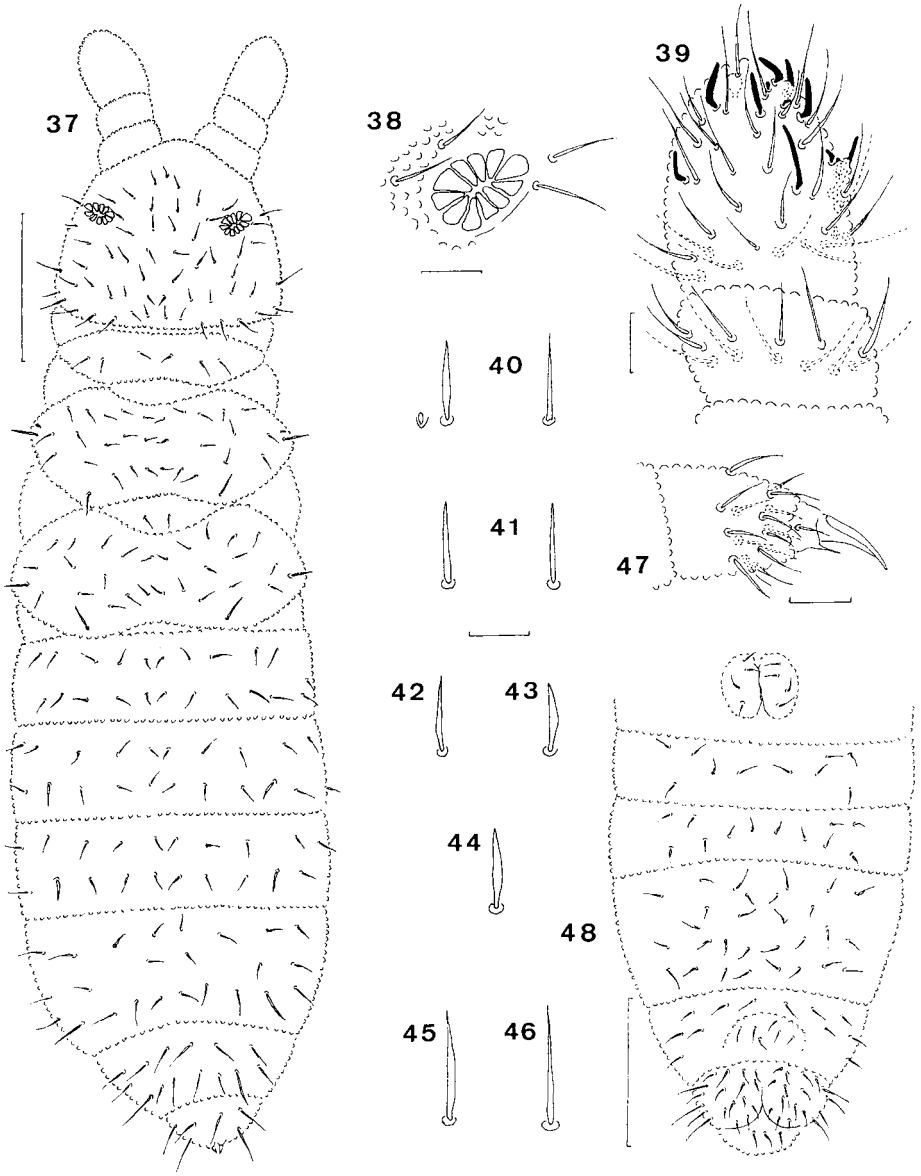
These species are also close to *W. bedosae* sp. n. and *W. virae* Kapruś, 1997 by the absence of setae *m*2 and *m*3 on abdominal terga II and III and absence of setae *m*1 on abdominal tergum IV. They mainly differ from *W. bedosae* and *W. virae* by the presence of setae *p*2 on abdominal tergum V (*p*2 present in *W. dubia*, *W. koreana* and *W. scandinavica*, *p*2 absent in *W. bedosae* and *W. virae*).

Willemia similis Mills, 1934

Willemia vashtia Wray, 1950 syn. n.

REDESCRIPTION. Lectotype (♀, presently designated), length 0.67 mm, paralectotypes (♀), length 0.51 mm to 0.65 mm, other specimens 0.45 mm to 0.73 mm. Tegumental granulation fine and regular.

Antennae somewhat shorter than head's diagonal. Antennal segment III and IV only slightly separated. Antennal segment I with 7 setae, antennal segment II with 12 setae. Sensory organ of antennal segment III consisting of two internal microsensilla hidden by a tegumental fold, two guard sensilla, and one ventrolateral microsensillum. Guard setae



Figs 37–48: *Willemia similis* Mills, 1934. 37 – dorsal chaetotaxy; 38 – postantennal organ; 39 – antennal segment II, III and IV; 40 – setae *s* and microsensillum *ms* of mesothorax; 41 – setae *s* of metathorax; 42 – seta *s* of abdominal segment I; 43 – seta *s* of abdominal segment II; 44 – seta *s* of abdominal segment III; 45 – seta *s* of abdominal segment IV; 46 – seta *s* of abdominal segment V; 47 – tibiotarsus III; 48 – ventral abdominal chaetotaxy. Scale bars: 37, 48 – 0.1 mm; 38–47 – 0.01 mm.

longer or subequal to guard sensilla. Antennal segment IV with 6 subcylindrical sensilla (*e*1, *e*2, *e*3, *d*, *i*1 and *i*2). Microsensillum and subapical organite present. Apical vesicle small and globular (Fig. 39).

Postantennal organ with 7–12 vesicles (Fig. 38). Setae *a*0 and *c*1 present on head. Labrum with 2/454 setae.

Dorsal chaetotaxy presented in Fig. 37. Setae straight and elongate. Setae *s* per half tergum formula is 22/11111 in *m*7 and *p*4 position on thoracic terga II and III, in *p*4 position on abdominal terga I to IV, and in *p*3 position on abdominal tergum V. Setae *s* on second and third abdominal terga shorter and thicker than other setae (Figs 40–46). Setae *m*1 present on abdominal tergum IV. Ventral chaetotaxy as in Fig. 48. Ventral tube with 4+4 distal setae.

Tibiotarsi I, II and III with 17, 17 and 16 setae respectively, without tenent hair. Claw curved, toothless. Empodial appendage distally setaceous (Fig. 47).

Small anal spines, ratio claw III : anal spines = 1 : 0.35.

VARIATION. Setae *m*2 usually present on abdominal terga I, II and III but in almost all the checked specimens there are asymmetries and setae *m*2 may be absent on one side or on some of the three abdominal terga, or even totally absent as in the lectotype.

MATERIAL EXAMINED. Lectotype (♀, presently designated), USA, Leon, Iowa, 31.x.1932, B.V. Travis (INHS); 2 paralectotypes (♀), same data as lectotype (INHS); 1 paralectotype (♀), USA, Ames, Iowa, humus, 28.iii.1932, H.B. Mills (INHS); USA, California, Mt. St. Helena (Napa Co.), 3.ii.1959, Roschuster, 1 specimen (♀); USA, California, Amador Co., 4.8 km west Fiddletown, oak leaf mould, 31.xii.1960, T. Rhaig and A.G. Forbes, 1 specimen (♀). Mexico, Tecolutla, Veracruz, in sand under rotten wood, 4.iii.1989, I. Vázquez, 1 specimen (♀); USA, Logan Canyon, Utah, in moss, 26.iv.1957, G.F. Knowlton, 3 specimens = *W. vashtia* type species not designed by Wray (♀) (NCSU); USA, Blacksmith Zork Canyon, Utah, in moss, 25.iv.1951, G.F. Knowlton, 3 specimens = *W. vashtia* type species not designed by Wray (♀ and ♂) (NCSU).

DISCUSSION. Christiansen & Bellinger (1980, 1998) pointed out that *W. vashtia* may be a geographical variant of *W. similis*. These species were mainly separated on the basis of the postantennal organ: in a pit in *W. vashtia*, not in a pit in *W. similis*. Postantennal organs are also in a pit in lectotype and paralectotypes of *W. similis* as well as in some specimens of *W. anophthalma* and *W. scandinavica*. Therefore, there is no reason to maintain *W. vashtia* as a seperate species.

Prelabral chaetotaxy with two setae distinguishes *Willemia similis* from the other species of the *Willemia anophthalma*-group.

Key to species of *Willemia anophthalma*-group

1 Setae *p*2 absent on abdominal tergum V (i.e. setae *s* in *p*2 position) (Fig. 1) 2
– Setae *p*2 present on abdominal tergum V (i.e. setae *s* in *p*3 position) (Figs 13, 25, 37) 3
2 Setae *a*4 present on thoracic terga II and III, setae *m*4 present on abdominal tergum IV ..... *W. bedosae* sp. n.
– Setae *a*4 absent on thoracic terga II and III, *m*-row absent on abdominal tergum IV ..... *W. virae* Kapruś, 1997
3 Setae *m*1 present on abdominal tergum IV (Figs 13, 37) 4
– Setae *m*1 absent on abdominal tergum IV (Figs 1, 25) 6
4 Setae *m*3 absent on abdominal terga II and III, 3 *hr* setae on anal lobes 5
– Setae *m*3 present on abdominal terga II and III, 2 *hr* setae on anal lobes, postantennal organ usually with 5 vesicles (4–6) ..... *W. anophthalma* Börner, 1901

5 Sensilla *e*1 present on antennal segment IV (Fig. 39), 2 prelabral setae ..... *W similis* Mills, 1934
– Sensilla *e*1 absent (i.e. *e*1 not differentiated from ordinary setae) on antennal segment IV (Fig. 15), 4 prelabral setae ..... *W. christianseni* sp. n.
6 Sensilla *d* and *i*1 absent (i.e. *d* and *i*1 not differentiated from ordinary setae) on antennal segment IV 7
– Sensilla *d* and *i*1 present on antennal segment IV (Fig. 27) . *W. dubia* Christiansen & Bellinger, 1980
7 Empodial appendage present ..... *W. scandinavica* Stach, 1949
– Empodial appendage absent ..... *W. koreana* Thibaud & Lee, 1994

DISTRIBUTION AND HABITATS

The *Willemia anophthalma*-group has a Holarctic distribution: *W. anophthalma*, *W. similis* and *W. scandinavica* have a Holarctic distribution (Arbea & Jordana, 1986, 1991; Fjellberg, 1985; Hüther, 1962; Jordana et al., 1997; Martynova et al., 1973; Potapov, 1994); *W. christianseni* and *W. dubia* present a Nearctic distribution (Christiansen & Bellinger, 1980, 1998); *W. koreana, W. virae,* and *W. bedosae* are known from the Palearctic region, the first one from South Korea only (Thibaud & Lee, 1994), the second one from the Ukraine only (Kapruś, 1997), and the third one from Spain.

This group presents wide ecological adaptations: some species live in the slightly humid zone of the soil, such as *W. anophthalma* (Hågvar, 1982, 1983; Ponge, 1980, 1983; Ponge & Prat, 1982); others were recorded from rather dry habitats, such as *W. bedosae*. Some species live in the upper part of the soil and the litter, such as *W. christianseni* and *W. dubia* (Christiansen & Bellinger, 1980, 1998). *W. koreana* lives in the interstitial sand dunes (Thibaud & Lee, 1994). *W. scandinavica* was collected in dry beach meadows, in moss in a dry river bed (Fjellberg, 1980, 1985), in a littoral salt meadow (material collected by A. Fjellberg), in sandy loam (Kovác, 1994) and in the deep layer of a sand dune (Sterzynska & Ehrnsberger, 1997), all habitats associated with sand. Kapruś (1997) described *W. virae* from a cave in the Ukraine. However, since the 7 known specimens of this species were found near the entrance of the cave, in litter deposited from the forest, it may not be a real troglobiont species. Fjellberg (1985) reported many specimens of *W. similis* in a wide variety of habitats, both wet and dry, even from one sampling, in a dry sandy flood plain. One of the presently studied specimens of *W. similis* was found in sand under rotten wood. Such ecological diversity probably tells us about the great ability of adaptation in this monophyletic group.

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