Disjunct distribution of Szeptyckiella gen. nov. from New Caledonia and South China undermines the monophyly of Willowsiini (Collembola: Entomobryidae)

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Morphology of scales is an important taxonomical character at all levels of Entomobryidae taxonomy. A new scaled genus of Collembola, Szeptyckiella gen. nov., and three new species are described: Szeptyckiella boulouparica sp. nov. and Szeptyckiella sinelloides sp. nov. from New Caledonia, and Szeptyckiella lii sp. nov. from South China. The genus, assigned to Willowsiini, is characterized by pointed scales on the body, eyes and pigment absent, antennal apical bulb absent, dens lacking spines and scales, and bidentate mucro with a short basal spine. It is closest to Hawinella from Hawaii but the latter possesses a falcate mucro. However, its morphological characteristics and its disjunct distribution raise a number of problems. Its widely disjunct distribution is difficult to explain in terms of palaeobiogeographical or more recent dispersal events. The new genus is similar to Sinella without consideration of scales, although both genera are placed in different tribes following the current supra-generic classification of Entomobryidae. We discuss other cases of paired genera differing only by the presence or absence of scales, and placed in either Willowsiini or Entomobryini. On this basis, we assume that scale presence could independently occur in the former tribe, questioning the monophyly of the tribe Willowsiini.

Keywords: new genus; scales; chaetotaxy; Sinella

Introduction

Scales occur in most Tomoceroidea and Entomobryoidea species of Collembola, with their morphology (shape and surface sculpture) highly diversified among Entomobryidae. Classification of the subfamily Entomobryinae sensu Soto-Adames et al. (2008) relies on the distribution and morphology of scales and, at species level, scale morphology is important in the taxonomy of the genus Willowsia. Denis (1941) recognized two groups in scaled entomobryids, Siraeiformes and Lepidocyrtiformes respectively without and with dental scales. Yosii (1961) erected Seirinae (sensu Lepidocyrtiformes Denis) including the species with accessory chaetae around bothriotricha and retained Siraeiformes in Entomobryinae. In 1979, Szeptycki further divided Seirinae into Seirinae and Lepidocyrtinae based on tergal chaetotaxy and scale morphology. Yosii and
Suhardjono (1989) demoted the subfamilies Seirinae and Lepidocyrtinae into the tribes Seirini and Lepidocyrtini, while establishing a new tribe Willowsiini *sensu* Siraeformes Denis. Four tribes, Entomobryini, Willowsiini, Seirini and Lepidocyrtini, are now included in Entomobryinae, with only Entomobryini lacking scales (Soto-Adames et al. 2008). A new genus of Willowsiini from New Caledonia and South China is described here and species from the two areas are compared. The problems raised by the discovery of this new taxon and the use of scales in the taxonomy of the family Entomobryidae are discussed.

**Material and methods**

Specimens were mounted after clearing in lactic acid under a coverslip in Marc André II solution, and were studied using a Leica DMLB microscope. Photographs were taken with a ProgRes camera mounted on a Leica DMLB microscope and were enhanced with Photoshop CS2/PC (Adobe Inc.). The dorsal and ventral chaetotaxy of head and the Ant. III organ are described after Chen and Christiansen (1993). Dorsal body chaetae are designated following Szeptycki (1979) and Zhang et al. (2011b). The number of macrochaetae is given by half-tergite in the descriptions. Material is deposited in the collections of the Muséum national d’Histoire naturelle (MNHN), Paris, France and of the Department of Entomology, College of Plant Protection, Nanjing Agricultural University (NAU), Nanjing, China.

Abbreviations used in the text: Th., thoracic segment; Abd., abdominal segment; Ant., antennal segment; Tita, tibiotarsus; mac, macrochaeta(e); mes, mesochaeta(e); mic, microchaeta(e).

**Taxonomy**

*Genus Szeptyckiella* Zhang, Bedos and Deharveng gen. nov.

Type species. *Szeptyckiella boulouparica* sp. nov.

Type locality. Mont Do, Bouloupari, New Caledonia.

*Diagnosis*

Medium size (up to 1.42 mm) entomobryid. Eyes and pigment absent. Scales present on the body, coarsely striate with striations very short, and leaf-like with tip pointed; scales on ventral side of manubrium present but narrower than those on body. Polymacrochaetotic chaetotaxy. Prelabral and labral chaetae 4/5, 5, 4, all smooth. Labrum margin with inverted median U-form intrusion. Chaetae mel1,l2 of labium smooth. Five papillae of labial palp with 0, 5, 0, 4, 3 guard chaetae. Subapical chaeta of maxillary outer lobe slightly stronger than apical one; three smooth hairs on sublobal plate. Four antennal segments (I and II not subdivided, IV not annulated). No apical bulb. Fourth abdominal tergite 2.33 to 3.62 times longer than the third. Trochanteral organ of leg III always present, with 7 to 17 spines. Inner differentiated tibiotarsal chaetae ciliated with ciliations not closely appressed to axis. Ungual basal paired teeth unequal, outer one large. Tenent hair of tibiotarsus pointed and subequal
to unguiculus. Tenaculum with 4 + 4 teeth and one large striate chaeta. Manubrium without smooth chaetae. Dens without spines and scales. Bidentate mucro with a short basal spine. Male genital plate of the papillate type.

**Distribution**
New Caledonia, China (Guangdong).

**Etymology**
The genus is named after the famous Polish collembologist Andrzej Szeptycki, for his outstanding work on Entomobryomorpha chaetotaxy.

**Remarks**
*Szeptyckiella* gen. nov. belongs to Willowsiini due to the absence of dental scales. It is closest to *Hawinella* in body habitus, scale morphology and distribution, and in having smooth prelabral and labral chaetae and no antennal apical bulb or eyes. It differs from *Hawinella* in having bidentate mucro. *Szeptyckiella* gen. nov. also resembles *Sinella*, from which it differs only in having scales.

**Key to Willowsiini genera**

| Step | Decision | Key
|------|----------|------|
| 1 | Dental spines present | *Sinhomidia* Zhang et al. 2009b
|  | Dental spines absent | 2
| 2 | Eyes absent | 3
|   | Eyes present | 5
| 3 | Mucro bidentate | *Szeptyckiella* gen. nov.
|   | Mucro falcate | 4
| 4 | Macrochaetotaxy well developed | *Hawinella* Bellinger and Christiansen, 1974
|   | Macrochaetotaxy strongly reduced | *Lepidosinella* Handschin, 1920
| 5 | Mucro falcate | 6
|   | Mucro bidentate | 7
| 6 | Mucronal basal spine absent | *Desertia* Chelnokov, 1979
|   | Mucronal basal spine present | *Drepanosira* Bonet, 1942
| 7 | Unguis without unpaired inner tooth | *Lepidobrya* Womersley, 1937
|   | Unguis with unpaired inner tooth | 8
| 8 | Scales chaeta-like, narrow, finely sculpted with all ribs short, and elongate and narrower in the posterior row of tergites | *Janetschekbrya* Yosii, 1971
|   | Scales variously sculpted, not chaeta-like and not much longer in the posterior row of tergites | 9
| 9 | Scales narrow, with two uninterrupted lateral ribs; macrochaetotaxy reduced | *Americabrya* Mari Mutt and Palacios-Vargas, 1987
Key to the world species of *Szeptyckiella* gen. nov.

1. Abd. I with 4 + 4 central mac; Abd. II with 4 + 4 mac .......... *S. lli* sp. nov.
   Abd. I with no more than 2 + 2 central mac; Abd. II with 2 + 2 mac ..... 2

2. Antennae less than 1.5 times as long as cephalic diagonal; Abd. I with 1 + 1 central mac .......................................................... *S. boulouparica* sp. nov.
   Antennae more than twice as long as cephalic diagonal; Abd. I with 2 + 2 central mac .......................................................... *S. sinelloides* sp. nov.

*Szeptyckiella boulouparica* sp. nov.

**Types**

Holotype. Female on slide: New Caledonia: Province Sud: Bouloupari: Mont Do, soil under Araucaria, Berlese extraction, 12 December 1995, L. Deharveng and A. Bedos leg. (NC95-206). Paratypes. Two probably females on slide, same data as holotype (NC95-206); two females on slide, ibid, Araucaria litter (NC95-205). Holotype and two paratypes in MNHN (NC95-205 and NC95-206), two paratypes in NAU (NC95-205 and NC95-206).

**Description**

Body length up to 1.00 mm, male smaller than female. Ground colour pale yellow in alcohol (Figure 1A). No eyes. Body scales coarsely striate, leaf-like with tip pointed (Figures 1D, 2P); present on Ant. I, head, tergites and ventral side of manubrium; scales of manubrium narrower (Figures 1F, 2Q).

Antenna about 1.7–1.9 times as long as cephalic diagonal. Antennal segments ratio as I : II : III : IV = 1 : 1.73–1.83 : 1.40–1.67 : 2.91–3.40. Antennal chaetae with seven main types: (1) ciliate, long or short; apically pointed (Figure 2, A1) or blunt (few on Ant. II, Figure 2, A2); (2) smooth straight mic at base of antennal segments (Figure 2, A3), three dorsal, three ventral and one external on Ant. I and one internal, one external and one ventral on Ant. II; (3) numerous short smooth straight chaetae present on Ant. IV laterally (Figure 2, A4); (4) curved, subcylindrical, thin (on Ant. II–IV, Figure 2, A5) or thick (on Ant. IV, Figure 2, A6), blunt S-chaetae (Figure 1B); (5) short, ordinary or thin S-chaetae on Ant. I–IV (Figure 2, A7); (6) swollen S-chaetae (Figure 2, A8) absent on Ant. I, and 1 dorsodistal on Ant. II; (7) short dagger-shaped chaetae ventrally on Ant. II–IV (Figure 2, A9). Ant. III organ with chaetae 2 and 3 swollen, chaeta 5 shorter than chaeta 4; chaeta 6 absent (Figures 1C, 2B). Labral margin with two strong conical papillae. Prelabral and labral chaetae 4/5, 5, 4, all smooth (Figure 2C). Lateral process of labial palp as thick as normal chaetae, with tip just reaching apex of closest labial papilla (Figure 2D). Maxillary outer lobe shown
Figure 1. *Szeptyckiella boulouparica* sp. nov. (A) Habitus; (B) chaetae on Ant. IV; (C) Ant. III organ; (D) scales on Abd. III; (E) lateral bothriotrichum of Abd. III; (F) scales on manubrium. Scale bar: 0.5 mm, A; 10 µm, B–F.
Figure 2. *Szeptyckiella boulouparica* sp. nov. (A) Antennal chaetae; (B) Ant. III organ; (C) labrum; (D) labial palp; (E) maxillary outer lobe; (F) chaetae on the ventral side of head; (G) dorsal cephalic chaetotaxy; (H) trochanteral organ; (I) inner outstanding mac on Tita; (J) hind claw; (K–M) ventral tube: anterior face (K), posterior face (L), lateral flap (M); (N) manubrial plaque; (O) mucro; (P) scales on tergites; (Q) scales on manubrium; (R) thoracic chaetotaxy. Scale bar: 10 µm, A–E, H–Q; 50 µm, F, G, R.
in Figure 2E. Labial base as mrel₁₁₂, all smooth; r 0.6 as long as chaeta m; chaetae X₂ and X₃ absent, X₄ ciliate; smooth chaeta X rarely present (Figure 2F). Cephalic dorsal chaetotaxy with four sutural mac and one mac in Gr. II (Figure 2G). Clypeal chaetae smooth.

Abd. IV 2.3–3.5 times as long as Abd. III along dorsal midline. Trochanteral organ with eight or nine smooth spiny chaetae (Figure 2H). Inner outstanding mac located at about 0.4 distance from base, ciliate, thick and tapered (Figure 2I). Ungual unpaired inner tooth extremely tiny. Unguiculus with a large outer tooth (Figure 2J). Ventral tube anteriorly with one small and one large ciliate chaeta on each side (Figure 2K); posteriorly with four apical smooth and two weakly ciliate proximal chaetae (Figure 2L); each lateral flap with four smooth chaetae (Figure 2M). Manubrial plaque with one pseudopore and two ciliate chaetae (Figure 2N). Distal smooth part of dens 1.7 times as long as mucro (Figure 2O). Male genital plate papillate and details not seen clearly.

Chaetotaxy. Th. II with two medio-medial (m₁, m₁i), one medio-lateral (m₄), 10 posterior mac and three lateral S-chaetae. Th. III with 10 mac and two lateral S-chaetae; a₆, m₆, m₆e as mac (Figure 2R). Abd. I with one mac (m₄) and one lateral S-chaeta. Abd. II with two central (m₃, m₃e), one lateral (m₅) mac and two S-chaetae. Abd. III with one central (m₃), two lateral (pm₆, p₆) mac and three S-chaetae (Figure 3A). Abd. IV with four central, five lateral (F₁a, F₁, E₂, E₃, D₃) mac, six short and at least 10 long S-chaetae (Figure 3B). Abd. V with four S-chaetae (as, acc.p₃, 4, 5); m₂, m₃ and m₅ mac always much larger than others (Figure 3C). Accessory mic of bothriotricha on Abd. II–III strongly modified; those on Abd. IV nearly as normal chaetae (Figure 1E).

Ecology
In litter and soil of a stand of Araucaria, in a thalweg.

Figure 3. Szeptyckiella boulouparica sp. nov., abdominal chaetotaxy: (A) Abd. I–III; (B) Abd. IV; (C) Abd. V. Scale bar: 50 µm.
Etymology
Named after the type locality.

Remarks
This species is characterized by relatively short antennae (less than twice as long as head), absence of X₂ on ventral side of head, four cephalic sutural mac, modified accessory mic of bothriotricha, reduced number of mac on Th. II, one mac (m4) and one S-chaeta on Abd. I, six short S-chaetae on Abd. IV, and four S-chaetae on Abd. V. Differences with other species of the genus are summarized in Table 1.

*Szeptyckiella sinelloides* sp. nov.

Types
Holotype. Female on slide, New Caledonia: Province Sud: Rivière Bleue, 10 December 1995, lowland forest, litter, Berlese extraction, L. Deharveng and A. Bedos leg. (NC95-194). Paratypes. Three females on slide and eight in alcohol, same data as holotype. Holotype and eight paratypes (two on slide and six in alcohol) in MNHN, three paratypes (one on slide and two in alcohol) in NAU.

Description
Body length 1.42 mm. Ground colour pale yellow in alcohol (Figure 4A). No eyes. Most scales coarsely striate and leaf-like with tip pointed; present on Ant. I, head (Figure 4D), tergites and ventral side of manubrium; scales of manubrium narrower.

Antenna 2.1–2.3 times as long as cephalic diagonal. Antennal segments ratio as I : II : III : IV = 1 : 2.44 : 2.22 : 3.00. Antennal chaetae mainly with seven types similar to *S. boulouparica*, sp. nov.; smooth straight mic at base of antennal segments, three dorsal (Figure 4B), three ventral and one external on Ant. I and one internal, one external and one ventral on Ant. II; swollen S-chaetae absent on Ant. I, and two dorsal present on Ant. II; dagger-shaped chaetae three, four and at least six ventrally on Ant. II, III and IV respectively. Ant. III organ with chaetae 2 and 3 rod-like and feebly swollen, chaeta 5 shorter than chaeta 4 (Figure 5A). Distal labral papillae absent. Lateral process of labial palp slightly thicker than normal chaetae, with tip reaching beyond apex of closest labial papilla (Figure 5B). Labial base as mrel1l₂, all smooth; r 0.65 as long as chaeta m; chaetae X₂ and X₃ absent, X and X₄ ciliate (Figure 5C). Dorsal cephalic chaetotaxy same as *S. boulouparica*, sp. nov.

Abd. IV 3.6 times as long as Abd. III along dorsal midline. Trochanteral organ with 17 smooth spiny chaetae (Figure 5D). Ungual unpaired inner tooth absent. Unguiculus with a large outer tooth (Figure 5E). Ventral tube anteriorly with two or three small and one large ciliate chaeta on each side (Figure 5F); posteriorly with four distal and four proximal smooth chaetae (Figure 5G); each lateral flap with five smooth chaetae. Manubrial plaque with one or two pseudopores and three ciliate chaetae. Distal smooth part of dens 0.7–1.0 times as long as mucro (Figure 4C).

Chaetotaxy. Th. II with two media-medial (m1, m1i), one medio-lateral (m4), 15 posterior mac and three lateral S-chaetae; p4–6 not mac. Th. III with 17 mac and two
lateral S-chaetae; a6, a6i, p6, m6, m6e and m6ai2 as mac (Figure 5H). Abd. I with two mac (m4, m4p) and two lateral S-chaetae. Abd. II with two central (m3, m3e), one lateral (m5) mac and two S-chaetae. Abd. III with one central (m3), two lateral (pm6, p6) mac and three S-chaetae (Figure 6A). Abd. IV with four central, five lateral (F1, E2–3, E2p, D3) mac, four short and about nine long S-chaetae (Figure 6B). Abd.

| Characters | S. boulouparica sp. nov. | S. sinelloides sp. nov. | S. lii sp. nov. |
|-----------|-------------------------|------------------------|----------------|
| Distribution | New Caledonia | New Caledonia | South China |
| Ant./head ratio | 1.7–1.9 | 2.1–2.3 | 1.35–1.54 |
| Labial chaeta R | Smooth | Smooth | Ciliate |
| Ventral chaetae of head X | Ciliate or absent | Ciliate | Ciliate |
| H4 | Smooth | Smooth | Ciliate |
| Dorsal cephalic chaetotaxy | | | |
| Sutural chaetae | 4 | 4 | 5 |
| Gr. II | 1 | 1 | 3 |
| Clypeal chaetae | Smooth | Smooth | Ciliate |
| Spiny chaetae on trochanteral organ | 8–9 | 17 | 10–12 |
| Ungual unpaired inner tooth | Tiny | Absent | Present |
| Outer large tooth on unguiculus | Present | Present | Absent |
| Ventral tube | | | |
| Anterior face | 2 | 3 | 7–8 |
| Posterior face | 6 | 8 | 8 |
| Lateral flap | 4 | 5 | 7 |
| Manubrial plaque | | | |
| Pseudopores | 1 | 1-2act | 2 |
| Ciliate chaetae | 2 | 3 | 3 |
| Distal smooth part of dens/mucro | 1.7 | 0.7–1.0 | 2.4 |
| Tergal S-chaetotaxic pattern | | | |
| Th. II–Abd. III | 32/123 | 32/223 | 32/223 |
| Abd. IV | 6 short, ≥ 10 long | 4 short, ≥ 9 long | ? |
| Abd. V | 4 | 4 | 3 |
| Th. II | | | |
| m1+ | 2 | 2 | 3 |
| m4+ | 1 | 1 | 4 |
| posterior mac | 10 | 15 | 23–24 |
| Th. III | | | |
| mac a1–3, p1 | Absent | Present | Present |
| mac m5 | Absent | Absent | Present |
| mac a6i | Absent | Present | Present |
| mac p6 | Absent | Present | Present |
| Abd. I mac | 1 + 1 | 2 + 2 | 4 + 4 |
| Abd. II central mac | 2 + 2 | 2 + 2 | 4 + 4 |
| Abd. III lateral mac | | | |
| am6 as mac | Absent | Absent | Present |
| p6 | Mac | Mac | Not mac |
V with four S-chaetae (as, acc.p3, 4, 5, Figure 6C). Accessory mic of bothriotricha on Abd. II–III strongly modified, some scaly; those on Abd. IV nearly as normal mic.

Ecology
In litter of lowland forest on ultramafic rocks.

Etymology
Named after the similarity to species of Sinella.

Remarks
This species differs from S. boulouparica sp. nov. in having longer antennae, no labral papillae, longer lateral process of labial palp, ciliate X on ventral side of head, mac present on a1–3, p1, a6i and p6 on Th. III, m4p and a second S-chaeta on Abd. I, more chaetae on ventral tube and shorter distal smooth part of dens (Table 1).
Figure 5. *Szeptyckiella sinelloides* sp. nov. (A) Ant. III organ; (B) lateral process of labial palp; (C) chaetae on the ventral side of head; (D) trochanteral organ; (E) hind claw; (F) anterior face of ventral tube; (G) posterior face of ventral tube; (H) thoracic chaetotaxy. Scale bar: 10 µm, A, B, E; 50 µm, C, D, F–H.
Szeptyckiella lii sp. nov.

Types
Holotype. Female on slide, China: Guangdong Province: Nanling National Natural Reserve (altitude 1026 m, 24°55′42.6″ N, 113°0′58.3″ E, ), 22 July 2010, F. Zhang and Z.-H. Li leg. (C9640). Paratypes. Two females on slide and two in alcohol, same data as holotype. Holotype and three paratypes (one on slide, two in alcohol) in NAU, one paratype (on slide) in MNHN.

Description
Body length: up to 1.00 mm. Ground colour pale yellow in alcohol (Figure 7A). No eyes. Most scales coarsely striate, and leaf-like with tip pointed (Figure 7C); present
on head, tergites and ventral side of manubrium, absent on Ant. I; scales on manubrium narrower (Figure 7D).

Antenna 1.35–1.54 times as long as cephalic diagonal. Antennal segments ratio as I : II : III : IV = 1 : 2.11 : 1.89 : 3.67. Antennal chaetae mainly with seven types similar to above two species; smooth straight mic at base of antennal segments (three dorsal and three ventral on Ant. I, and one internal, one external and one ventral on Ant. II); curved, thin or moderately thick (on Ant. II–IV), blunt S-chaetae (two internal and three external on Ant. II, not clear on Ant. III–IV); swollen S-chaetae absent on Ant. I, and one dorso-distal present on distal Ant. II; dagger-shaped
chaetae present on ventral Ant. II–IV, one external on Ant. II and three ventral on Ant. III. Ant. III organ with chaetae 2 and 3 swollen (Figure 8A). Labral margin without papillae. Lateral process of labial palp as thick as normal chaetae, with tip just reaching apex of closest labial papilla (Figure 8B). Labial base as mRel1, R ciliate and 0.6 as long as chaeta m; chaetae X2 and X3 absent, X and X4 ciliate; G1–4 and H3 smooth (Figure 8C). Cephalic dorsal chaetotaxy with five sutural mac and three mac in Gr. II. Clypeal chaetae ciliate (Figure 8D).

Abd. IV 3.1–3.6 times as long as Abd. III along dorsal midline. Trochanteral organ with 10–12 smooth spiny chaetae (Figure 8E). Ungual unpaired inner tooth present. Unguiculus outer edge smooth (Figure 8F). Ventral tube anteriorly with five or six small and two large ciliate chaetae on each side; posteriorly with four distal smooth and four proximal chaetae; each lateral flap with six smooth chaetae, and one smooth or weakly ciliate (Figure 8G). Manubrial plaque with two pseudopores and three ciliate chaetae (Figure 8H). Distal smooth part of dens 2.4 times as long as mucro (Figure 7B).

Chaetotaxy. Th. II with three medio-medial (m1, m2, m2i), three medio-lateral (m4, m4i, m4p), 23–24 posterior mac and three lateral S-chaetae (Figure 7E); mac p4i rarely present. Th. III with 25 macrochaetae and two lateral S-chaetae (Figure 9A). Abd. I with four mac (m2–4, m4p) and two lateral S-chaetae. Abd. II with four central (a2, m3, m3e, m3ep), one lateral (m5) mac and two S-chaetae. Abd. III with one central (m3), two lateral (am6, pm6) mac and three S-chaetae (Figure 9B). Abd. IV with four central and five lateral (F1, E2–4, E2p) mac (Figure 9C); S-chaetae not clearly seen. Abd. V with three S-chaetae (as, acc.p4, 5, Figure 9D). Accessory mic of bothriotricha on Abd. II–IV scaly.

Ecology
In litter of forest.

Etymology
Named after the collector Zhao-Hui Li.

Remarks
This new species differs from other species of *Szeptyckiella* in having ciliate R and H1, 2 and 4 on ventral side of head, smooth outer unguiculus edge and abundant tergal chaetotaxy (Table 1). The arrangement of S-chaetae on Abd. V is similar to that of most entomobryids.

Discussion
Problems raised by the new genus
The discovery of the new genus *Szeptyckiella* raises a number of problems. First, its species have a widely disjunct distribution. It is present in South China and New Caledonia but unknown in the areas between. No other collembolan exhibits such a disjunct distribution and it cannot readily be accounted for by any known palaeobiogeographical scenario.
Figure 8. *Szeptyckiella lii* sp. nov. (A) Ant. III organ; (B) lateral process of labial palp; (C) chaetae on the ventral side of head; (D) dorsal cephalic chaetotaxy; (E) trochanteral organ; (F) hind claw; (G) ventral tube; (H) manubrial plaque. Scale bar: 10 µm, A, B, E, F, H; 50 µm, C, D, G.
Three explanations can be envisaged: introduction by humans into China, convergent morphological evolution from a different stock of Entomobryidae, or a gap in our knowledge of distribution. The first hypothesis is weakly supported: the Chinese species (*S. lii*) is rare, quite different from the New Caledonian species and human exchange between China and New Caledonia has been, and is, extremely limited. There are very few introduced species shared between these regions that live outside human settlements, and all specimens of *Szeptyckiella* were collected in areas that were not strongly anthropized. The second hypothesis is that of evolutionary convergence. The similarity between *Szeptyckiella* species concerns scale shape and sculpture, but their chaetotaxic patterns recall those of the large, widespread genus *Sinella*, which is frequent and diversified in both regions and found in similar soil habitats. However, the same basic patterns are observed in other genera (e.g. *Coecobrya*; see Zhang et al. 2009a, 2011b) and may instead be plesiomorphic. In the absence of phylogeny, it is impossible to confirm the convergence hypothesis. The third possibility, that of a sampling gap, remains conceivable. Entomobryidae have been described from many areas between China and New Caledonia, but mostly from atmobiotic habitats. However, our own collections of soil fauna across the whole of

Figure 9. *Szeptyckiella lii* sp. nov. (A) Thoracic chaetotaxy; (B–D) abdominal chaetotaxy: (B) Abd. I–III; (C) Abd. IV; (D) Abd. V. Scale bar: 50 μm.
Southeast Asia have not provided anything that approaches *Szeptyckiella* morphologically.

The presence of scales in a genus otherwise very similar to *Sinella* is also problematic. Based on the current supra-generic classification of Entomobryidae (Soto-Adames et al. 2008), this character alone (scales on body but not on dens) places *Szeptyckiella* in a different tribe to that of *Sinella*. But the species of the new genus share many features with indigenous *Sinella* species except for the presence of scales.

In New Caledonia, the two species of *Szeptyckiella* have the same distinctive characters as indigenous species of *Sinella* (unpublished data): ungual unpaired inner tooth absent or extremely tiny; outer large tooth on unguiculus always present; tibiotarsal tenent hair pointed; two medio-medial (m1, m1i) and one medio-lateral (m4) mac on Th. II half-tergite; no more than four mac on Abd. I half-tergite; two (m3, m3e) mac in set m3+ on Abd. II half-tergite; one central (m2) and two lateral mac (pm6, p6) on Abd. III half-tergite (am6 as mic); four or more short S-chaetae on Abd. IV half-tergite; and 4 + 4 S-chaetae on Abd. V. The characters cited for Abd. III and Abd. V that are shared by both *Szeptyckiella* and *Sinella* species from New Caledonia can be considered the most characteristic features separating them from other entomobryid species.

Similarly, *Szeptyckiella lii* from South China is similar to several Chinese species of *Sinella* in having smooth outer edge of unguiculus, a more abundant tergal chaetotaxy, and 3 + 3 S-chaetae on Abd. V.

All of these similarities suggest that scales may have appeared to be independent between the *Szeptyckiella* of China and those of New Caledonia, and the new genus distribution favours this hypothesis. The discovery of *Szeptyckiella* tends to undermine the validity of Entomobryini and Willowsiini.

**Scales in the classification of Entomobryinae**

Among the three scaled tribes of the subfamily, Seirini and Lepidocyrtini have relatively conserved scale morphology and their monophyly is widely accepted. Willowsiini is well defined by the absence of dental scales, although it possesses diverse scale types (Zhang et al. 2011a). The monophyly of Willowsiini, to which the new genus formally belongs, has never been verified, but evidence that some of its species may be more related to those of other tribes brings into question its validity and limits (Yoshii and Suhardjono 1989; Zhang et al. 2011a). Similarities between *Szeptyckiella* (Willowsiini) and *Sinella* (Entomobryini) imply possible convergence. A broader review provides several pairs of genera consisting of scaled (Willowsiini) and unscaled (Entomobryini) genera that are very similar, except in scale morphology (Table 2). For example, *Homidia* and *Sinhomidia* share an “eye-brow” mac on anterior Abd. IV, the subapical mucronal tooth larger than the apical one, a bilobed bulb on antennal apex, and smooth labial chaetae e and l1. Similarly, *Coecobrya* and *Hawinella* have no or reduced eyes, a falcate mucro and no antennal apical bulb. The first-instar larval chaetotaxy of both tribes was shown to be almost identical by Szeptycki (1979), who did not formally isolate “Willowsiini” from other Entomobryinae, writing: “For practical reason in the subfamily Orchesellinae and Entomobryinae I combined the species without scales (chaetosae) and those with scales (lepidosae) into separate though not formal groups”. The placement of
Szeptyckiella within Willowsiini should be therefore considered as provisional. We expect that a phylogenetic analysis of Entomobryinae will solve this important taxonomic and evolutionary problem.

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