

New records of the mealybug genus *Vryburgia* De Lotto in greenhouses in Germany

(Hemiptera: Coccothorax: Pseudococcidae)

Alejandro Caballero, Takumasa Kondo & Michael J. Raupach

Caballero, A., Kondo, T. & Raupach, M. J. 2026. New records of the mealybug genus *Vryburgia* De Lotto in greenhouses in Germany (Hemiptera: Coccothorax: Pseudococcidae). Spixiana 49(1): 35–51.

German Pseudococcidae diversity comprises about 57 species, grouped in 22 genera. One of those is *Vryburgia* De Lotto, which is represented solely by *Vryburgia amaryllidis* (Bouché). *Vryburgia* species in Europe are restricted to indoor environments, where they can be a phytosanitary problem. As part of a larger survey of scale insects conducted in botanical gardens in Germany, three species of *Vryburgia* were identified: *Vryburgia amaryllidis*, *Vryburgia brevicurvis* (McKenzie), and *Vryburgia succulentarum* Williams, with the first record of *V. brevicurvis* in Germany and *V. succulentarum* for Europe. Our study provides new host records and documents previously unreported intraspecific variation in adult females. In addition, we present a detailed morphological description of the adult male of *V. succulentarum* and discuss diagnostic characters useful for distinguishing the species treated here.

Alejandro Caballero (corresponding author), Faculty of Biology, Ludwig-Maximilians-Universität, München, Germany; and Section Hemiptera, SNSB – Zoologische Staatssammlung München, München, Germany; e-mail: l.caballero@campus.lmu.de

Takumasa Kondo, Corporación Colombiana de Investigación Agropecuaria – AGROSAVIA, Centro de Investigación Palmira, Valle del Cauca, Colombia; e-mail: tkondo@agrosavia.co

Michael J. Raupach, Section Hemiptera, SNSB – Zoologische Staatssammlung München, München, Germany; e-mail: raupach@snsb.de

Introduction

The genus *Vryburgia* De Lotto, 1967 (Hemiptera: Coccothorax: Pseudococcidae) currently comprises 10 described species (García Morales et al. 2016). It was established based on the presence of oral collar tubular ducts arranged in rows or clusters on the venter, dorsum, or both surfaces – features that distinguish it from closely related genera such as *Trionymus* Berg, 1899 or *Chorizococcus* McKenzie, 1960 (De Lotto 1967).

However, there is no consensus regarding the validity of *Vryburgia*. A review of Palaearctic Pseudococcidae proposed synonymising it with *Atrococcus*

Goux, 1941, arguing the character that separates the two genera, i.e. number of oral collar tubular ducts on the dorsum, is “... one of the most variable (within a species as well as between species) in all large genera of mealybugs” (Danzig & Gavrilov-Zimin 2014).

Nevertheless, molecular evidence does not support this proposed synonymy. In the most recent molecular phylogenetic analysis of Pseudococcidae (Choi & Lee 2022), *Vryburgia amaryllidis* (Bouché, 1837) was placed in a clade with *Dysmicoccus* Ferris, 1950 and *Pseudococcus* Westwood, 1840 (each genus with three species), *Erium globosum* (Maskell, 1892), *Palmicultor lumpurensis* (Takahashi, 1951), and *Trionymus perrisi*

(Signoret, 1875). In contrast, the genus *Atrococcus*, including *Atrococcus pacificus* (Borchsenius, 1949) formed a clade with species of *Amonostherium* Morrison & Morrison, 1922, *Antonina* Signoret, 1875, *Chorizococcus*, *Nipaecoccus* Šulc, 1945, *Paracoccus marginatus* Williams & Granara de Willink, 1992, *Saccharicoccus* Ferris, 1950, *Trionymus*, and related genera. Therefore, a comprehensive taxonomic revision is needed to clarify morphological boundaries within this group. Given the molecular data and the fact that the proposed synonymies are based solely on Palaearctic species so far, we treat *Vryburgia* as a valid genus.

The morphological delimitation of *Vryburgia* is challenging because several taxonomically important characters vary among species, including the presence or absence of oral rim tubular ducts and claw digitules, as well as the number and distribution of cerarii (De Lotto 1967, Williams 1985). Despite this variability, the currently accepted diagnosis of the genus is based on the following combination of characters: cerarii confined to the posterior abdominal segments, with no more than three pairs present; circulus absent or present; oral collar tubular ducts consistently present on both dorsum and venter; apical antennal segment at least partially divided; and claw denticles either present or absent (De Lotto 1958, McKenzie 1960, 1967, Williams 1985, 2004, Choi et al. 2021). As in most studies of Coccoomorpha, the generic diagnosis is based primarily on character states of adult females. Other life stages remain poorly known, and only the adult male of *V. amaryllidis* has been described to date (Beardsley 1960).

Despite several previous surveys on greenhouse insect pests, only *Vryburgia amaryllidis* has been recorded from Germany, surprisingly with no additional records since its initial report 189 years ago (Bouché 1837). As part of a broader effort to update the current knowledge of Coccoomorpha diversity in German botanical gardens, this study documents two additional species previously unrecorded in the country. It also reports new host-plant associations, provides novel information on intraspecific variation in adult females, and presents the first description of the adult male of *V. succulentarum*. Finally, we discuss morphological characters of the adult females and outline diagnostic features for identifying the three species of *Vryburgia* now known from Germany.

Material and methods

Sampling was conducted in the greenhouses of the botanical gardens in Berlin, Bonn, and Hamburg (Germany). Collected specimens were preserved in 96% ethanol for subsequent analysis. Permanent slide mounts were prepared according to the methodology of Kondo & Watson (2022) and are deposited in the

Bavarian State Collection for Zoology (Zoologische Staatssammlung München – SNSB-ZSM).

The morphological interpretation and terminology used in the description of the male adult follow primarily Afifi (1968) with adaptations from Giliomee (1961) and Hodgson (2020). The term “flagellate seta” is adopted in place of the more commonly used “hair-like seta”. Wing venation terminology follows Wu & Xu (2022). Terminology for female morphology follows McKenzie (1967) and Williams (1985). Cerarii are named according to a posteroanterior numbering system, with the anal lobe cerarii designated as C₁ and subsequent pairs numbered progressively anteriorly towards the head. Morphometric image analyses and measurements were obtained using a Leica DM6 B phase-contrast/differential interference contrast microscope in combination with LAS X Life Science Microscope software (v3.10). In females, measurements are presented as mean ± standard deviation, followed by the range in parentheses; the measurement of the labium includes the combined apical and medial segments. In both males and females, tibial width was measured at the apical portion near the articulation with the tarsus, and total leg length excludes the coxa. For adult males, measurements of body regions were taken along the midline.

Results

Three *Vryburgia* species were found feeding on greenhouse plants. *Vryburgia amaryllidis* was collected on leaves of *Euphorbia socotrana* Balf.f, 1883 (Euphorbiaceae) in Bonn, and from *Worsleya procera* (Lem.) Traub, 1944 (Amaryllidaceae) in Hamburg. This species of mealybug has been recorded from 26 plant species in eight families, most frequently from approximately 14 species of Amaryllidaceae (Ben-Dov 1994, García Morales et al. 2016). The present findings represent the first record of *V. amaryllidis* on a species of the genus *Worsleya* (Traub) Traub, 1944, and the first record from the family Euphorbiaceae.

Two additional species are recorded from Germany for the first time. *Vryburgia brevicruris* was found on the stems and flowers of *Stapelia divaricata* Masson, 1797 (Apocynaceae) in Hamburg, whereas *Vryburgia succulentarum* was collected from the stems of *Kleinia neriifolia* Haw. 1812 (Asteraceae) in Bonn and from stems and leaf bases of *Drosanthemum* sp. (Aizoaceae) in Hamburg.

Morphological intraspecific variation

Vryburgia amaryllidis (Bouché, 1837)

Adult female (Fig. 1)

The following morphological information provides information on intraspecific variation obtained from

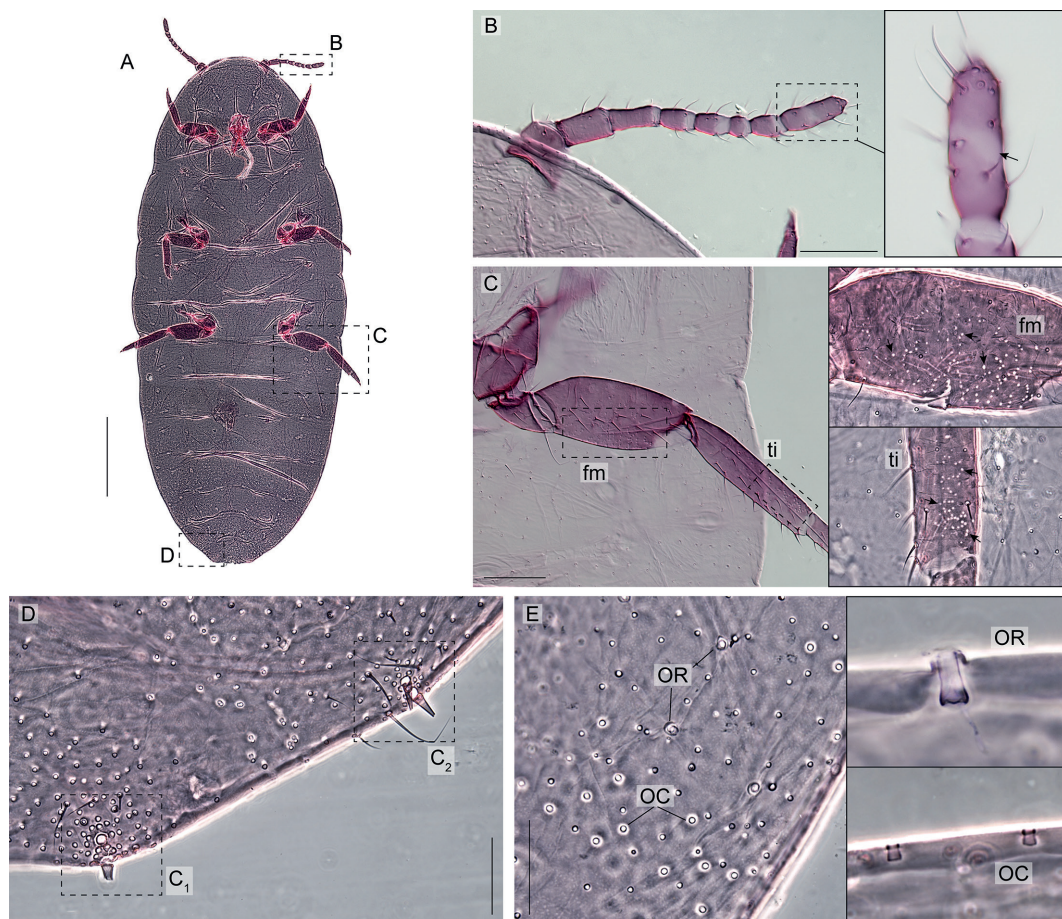


Fig. 1. Microphotographs of the adult female of *Vryburgia amaryllidis* (Bouché). **A.** Ventral view of body. **B.** Antenna, with enlargement of apical segment, indicating the pseudo division by an arrow. **C.** Hind leg with enlargements showing the translucent pores on femur (fm) and tibia (ti). **D.** Marginal cerarii 1 (C₁) and 2 (C₂). **E.** Tubular ducts with enlargements showing side view of oral rim ducts (OR) and oral collar ducts (OC). Scale bars: A = 500 μ m; B and C = 100 μ m; D and E = 50 μ m.

5 specimens, and complements the descriptions of McKenzie (1967) [as *Chorizococcus lounsburyi*], Cox (1987) [as *Vryburgia lounsburyi*], and Longo (2012) [as *V. amaryllidis*].

Body 3792 ± 235.4 (3553–4081) μ m long and 1664 ± 160 (1531–1861) μ m wide. Antenna 446.1 ± 17.7 (425–464) μ m long; with eight segments, apical segment partially divided, length per segment as follows: I 63.1 ± 4.8 (58–69) μ m, II 71.2 ± 1.3 (69–72), III 68.8 ± 4.2 (65–74), IV 45.9 ± 1.6 (44–47), V 44.1 ± 4.7 (37–47), VI 32.3 ± 2.4 (30–36), VII 45.2 ± 2.7 (41–48), VIII 89.4 ± 2.2 (87–91). Eye 26.2 ± 2 (24–28) μ m wide. Labium 99.9 ± 8.2 (93–106) μ m long and 88.9 ± 9.1 (79–96) μ m wide; apical segment with 18 setae, medial segment with two setae and basal segment with

6 setae. Hind leg 724.4 ± 12.4 (709–736) μ m long, length per segments as follows: coxa 108.5 ± 2.2 (107–112) μ m long and 133.8 ± 7.9 (125–141) μ m wide; trochanter 78.1 ± 3.8 (75–84) μ m long; femur 267.3 ± 6.3 (258–273) μ m long and 114.8 ± 4.1 (110–120) μ m wide, with 132–147 translucent pores; trochanter–femur length 341.7 ± 8.5 (331–352) μ m; tibia 263.6 ± 3.5 (260–267) μ m long and 51.8 ± 0.7 (51–53) μ m wide, with 56–87 translucent pores; tarsus 103.1 ± 3 (100–107) μ m long; claw 31.6 ± 1.3 (30–33) μ m long with two digitules, each 30.9 ± 0.9 (30–32) μ m long, reaching the tip of claw. Anal ring with transversal diameter 77.9 ± 3 (74–80) μ m; six flagellate setae, each 106.3 ± 11.5 (90–123) μ m long. Cerarii restricted to abdominal segments VIII and VII, each

composed of 2 conical setae and 4–11 and 4–7 flagellate setae, respectively. Trilocular pores 4 µm wide.

Oral rim tubular ducts (OR) totalling 119±15 (102–141) on body; all similar in size, each 9.8±0.4 (9–11) µm long, diameter of rim 7.4±0.7 (6–9) µm wide, and diameter of tubule 3.9±0.4 (3–5) µm wide. Dorsal OR totalling 75±5.4 (67–78), distributed as follows: head with 5.3±1 (4–6), thorax 18.5±3.3 (14–22), abdominal segment I 9±1.8 (7–11), segment II 7±1.6 (5–9), segment III 6±1.2 (5–7), segment IV 8±1.4 (7–10), segment V 10.3±2.1 (8–13), segment VI 5.8±1.3 (4–7), segment VII 5.3±1 (4–6), and absent on segment VIII; each duct 9–11 µm long, diameters of rim 6–9 µm wide and ductule 4–5 µm wide. Ventral OR totalling 36.5±6.6 (31–46), distributed as follows: absent in area from head margin to anterior spiracles, rest of thorax with 10±1.8 (8–12), abdominal segment I with 3.5±1.9 (2–6), segment II 3.8±0.5 (3–4), segment III 4.5±0.6 (4–6), segment IV 4.3±1.3 (3–6), segment V 3.8±1 (3–5), segment VI 4.3±1.3 (3–6), segment VII 2.5±1.3 (1–4), absent on segment VIII, abdomen totalling 26.5±5.4 (22–34).

Oral collar tubular ducts (OC) abundant on dorsum and venter (not counted); dorsal OC of two sizes defined by their diameters: large ducts with diameter larger than a trilocular pore, each 6.2±1.7 (5–10) µm long and 4.1±0.2 (4–5) µm wide; small ducts with diameter smaller than a trilocular pore, each 5.3±1 (4–7) µm long and 2.7±0.3 (2–3) µm wide. Ventral OC, with two sizes, slightly smaller than those on dorsum: large ducts 5.2±0.3 (5–6) µm long and 3.9±0.3 (4–5) µm wide; small ducts 5.8±1.4 (4–8) µm long and 2.8±0.4 (2–3) µm wide.

Multilocular disc pores (MP) 5–7 µm wide, with 10 loculi, abundant on both venter and dorsum, totalling 583.2±88.5 (440–675) on whole body. Dorsal MP restricted to abdominal segments as follows: absent in segments I to III, IV 0.3±0.5 (0–1), V 3.3±0.5 (1–5), VI 0.8±1 (0–2), VII 0.3±0.5 (0–1), absent in VIII, totalling 4.5±2.5 (1–7), each pore 5–7 µm wide. Ventral MP totalling 239.3±19.1 (224–267) distributed as follows: absent on head, thorax with 10.3±6.1 (6–19), abdominal segment I 3±2.9 (0–6), absent in segment II, segment III 1±1.4 (0–3), segment IV 8±10.5 (0–22), segment V 23.3±12.6 (10–38), segment VI 50.5±10.7 (43–66), segment VII 80.8±7.4 (72–89), segment VIII 62.5±4.1 (58–68), abdomen with 229±2.6 (212–261); diameter of each pore similar to those on dorsum.

Material examined. GERMANY, Nordrhein-Westfalen, Bonn, Botanischer Garten, 50.725283°N 7.093614°E, 57 m, 2.vii.2024, ex leaf of *Euphorbia socotrana* (Euphorbiaceae), A. Caballero leg. (2 adult ♀♀); Hamburg, Hamburg, Loki Schmidt Botanical Garden of the University of Hamburg, 53.560800°N 9.860388°E, 23 m, 22.viii.2024, ex leaf of *Worsleya procera* (Amaryllidaceae), A. Caballero leg. (12 adult ♀♀).

Vryburgia brevicurvis (McKenzie, 1960)

Adult female (Fig. 2)

The following data were obtained from 7 specimens, and complement the descriptions in McKenzie (1960, 1967) [as *Chorizococcus brevicurvis*], Brookes (1976) [as *Chorizococcus radicalis*] and Williams (1985) [as *Vryburgia brevicurvis*].

Body 2551.3±322.1 (2040–2939) µm long and 2077.8±343.7 (1772–2667) µm wide. Antenna 334.7±17.7 (310–356) µm long, 8-segmented, with apical segment partially divided; length per segment as follows: I 50.7±6.1 (44–61) µm, II 43.7±3 (40–49), III 44.5±2.7 (42–47), IV 25.1±3 (22–29), V 30.1±2.3 (26–33), VI 28.7±5.6 (23–39), VII 34.1±3.3 (28–37), VIII 79.9±2.1 (77–83). Eye 28.2±3.7 (24–34) µm wide. Clypeolabral shield 158.9±11.7 (143–176) µm long and 135.5±8.2 (122–144) µm wide. Labium 107.9±6.4 (97–115) µm long and 88.5±6.9 (82–97) µm wide; apical segment with 18 setae, medial segment with two setae and basal segment with 6 setae. Posterior leg 461.1±7.3 (451–474) µm long, length per segments as follows: coxa 72.6±7.2 (66–86) µm long and 101.5±3.9 (97–106) µm wide; trochanter 55.6±2.5 (53–60) µm long; femur 168.5±5.6 (162–175) µm long and 80±3.3 (74–83) µm wide, with 67±11 (50–81) translucent pores; trochanter-femur length 222.5±7.6 (215–234) µm; tibia 135.5±3 (132–141) µm long and 35.6±2.3 (33–39) µm wide, with 25.5±1.6 (24–28) translucent pores; tarsus 78.8±2.3 (76–82) µm long; claw 29.2±0.8 (28–30) µm long. Anal ring with transversal diameter 68.5±2.7 (64–72) µm; six flagellated setae, each 97.3±5 (90–107) µm long. Cerarii restricted to abdominal segments VI to VIII, C₁ always with 2 conical setae and 3–8; C₂ with 2–4 conical setae and 3–4 flagellate setae, C₃ with 2 conical setae and no flagellate setae. Trilocular pores 3–4 µm wide.

Oral rim tubular ducts (OR) totalling 136±11.6 (123–147) on body. Dorsal OR of one size, 11.5±0.6 (10–12) µm long, diameter of rim 8.7±0.5 (8–10) µm, and diameter of tubule 4.8±0.4 (4–6) µm; most OR with 2–4 discoidal pores associated with the rim, each 2–4 µm wide; dorsum totalling 83.2±8.5 (74–96), distributed as follows: head 6.4±0.9 (5–7), thorax 32±6.3 (23–40), abdominal segment I 7.8±2.6 (4–11), II and III each with 6.6±1.5 (5–9), IV 6.6±1.1 (5–8), V 7.2±0.4 (7–8), VI 4±0.7 (3–5), VII 5.8±1.3 (5–8), and absent on segment VIII. Ventral OR of one size, diameter slightly shorter than dorsal OR, 11±1.4 (10–15) µm long, diameter of rim 7.6±1 (5–8) µm, and diameter of tubule 5.2±1.3 (4–8) µm; most OR with 0–3 discoidal pores associated with the rim, each 2–4 µm wide; venter totalling 53±10.7 (43–69), distributed as follows: head 0–2, thorax 19±4.7

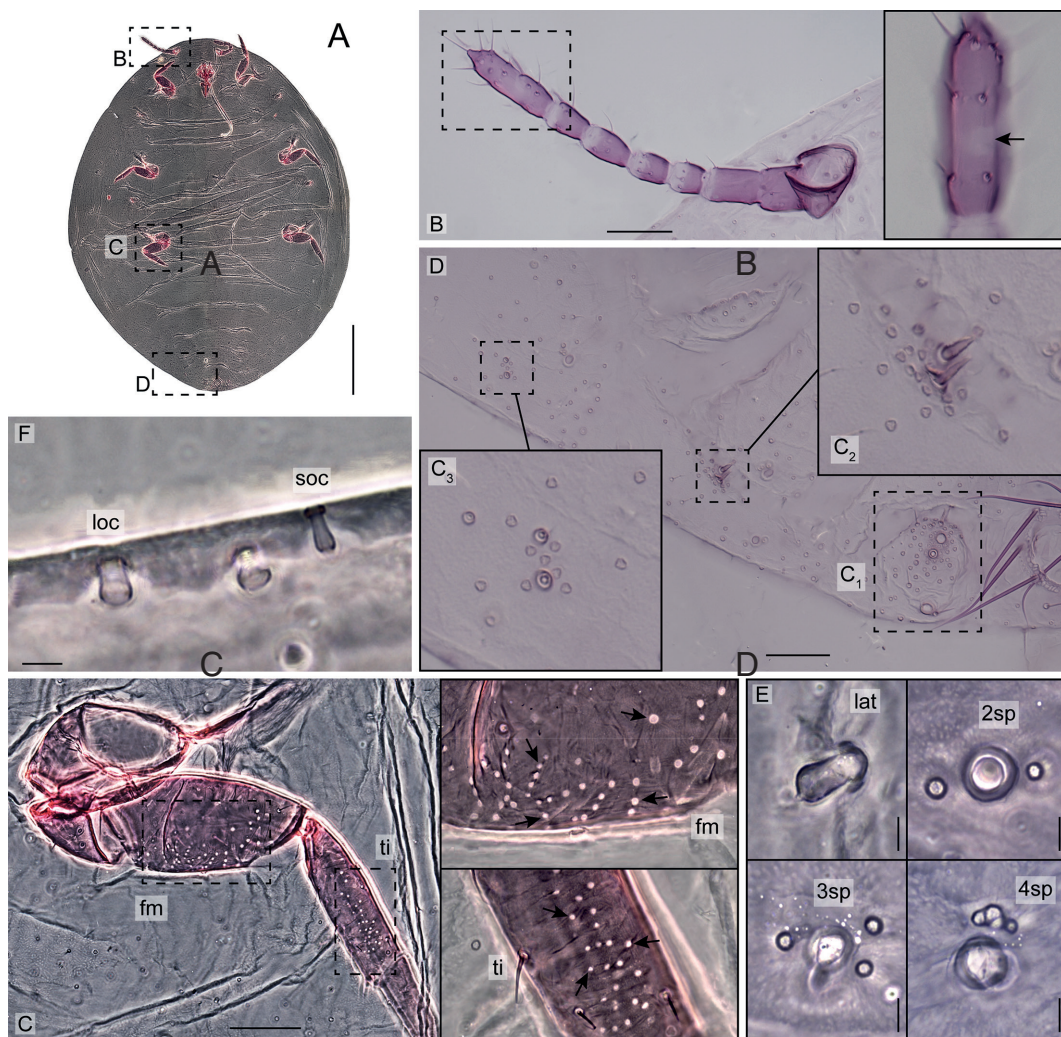


Fig. 2. Microphotographs of the adult female of *Vryburgia brevicurvis* (McKenzie). **A.** Ventral view of body. **B.** Antenna, with enlargement of apical segment showing partial division of the apical segment, indicated by arrow. **C.** Hind leg with enlargements of translucent pores on femur (fm) and tibia (ti). **D.** Margin of last three abdominal segments indicating cerarii 1 (C_1), 2 (C_2) and 3 (C_3). **E.** Oral rim tubular ducts in lateral view (lat), and top view with 2 (2sp), 3 (3sp) and 4 (4sp) simple pores associated with the rim. **F.** Oral rim collar tubular ducts of small (soc) and large (loc) diameter. Scale bars: A=500 μ m; B-D=50 μ m; E and F=5 μ m.

(15–25), abdominal segment I 4.8 ± 1.3 (4–7), II and III each with 3.8 ± 1.4 (2–5), IV 5.2 ± 2.4 (3–9), V 4.8 ± 0.8 (4–6), VI 5.6 ± 1.1 (4–7), VII 5.4 ± 2.1 (3–8), and absent on segment VIII.

Oral collar tubular ducts (OC) of two sizes: large OC 5.5 ± 0.2 (5–6) μ m long and 3.8 ± 0.2 (4) μ m wide; small OC with diameter smaller than a trilocular pore, each 5.6 ± 1.1 (4–8) μ m long and 2.5 ± 0.3 (2–3) μ m wide, abundant OC on both surfaces (not counted).

Multilocular disc pores (MP) of 5–7 μ m wide, with 10 loculi, abundant on both venter and dorsum, totalling 583.2 ± 88.5 (440–675) on whole body. Dorsal MP numbering 205 ± 40 (137–243), distributed as follows: absent on head, thorax 76 ± 19.5 (49–101), abdominal segment I 29 ± 7.8 (18–40), II 23.4 ± 11.3 (5–33), III 20.4 ± 6.2 (13–28), IV 25.4 ± 2.9 (21–28), V 15.8 ± 5.4 (9–23), VI 5.8 ± 2.2 (2–7), VII 9.2 ± 0.8 (8–10), and absent on segment VIII. Ventral MP numbering 378.2 ± 63 (303–458), distributed as follows:

head 15.8 ± 5.2 (8–20), thorax 103 ± 21.8 (82–137), abdominal segments I 14.2 ± 7.3 (6–25), II 27 ± 8.8 (14–38), III 29.8 ± 9.8 (18–40), IV 37.6 ± 8.6 (25–46), V 36 ± 11.3 (20–48), VI 43 ± 6.7 (35–50), VII 40.4 ± 5.5 (34–45), VIII 31.4 ± 4.3 (25–37).

Material examined. GERMANY, Hamburg, Hamburg, Old Botanical Garden, $53.5601181^\circ \text{N}$ 9.9857871°E , 23 m, 20.viii.2024, ex stem and flower of *Stapelia divaricata* (Apocynaceae), A. Caballero leg. (15 adult ♀♀).

Vryburgia succulentarum Williams, 1985

Adult female (Fig. 3)

The following data were obtained from 12 specimens, and complement the descriptions of Moghaddam (2015), Moghaddam & Watson (2022) and Williams (1985).

Body 2388.5 ± 493 (1477–3138) μm long and 1390.4 ± 295.2 (779–1778) μm wide. Antenna 374.3 ± 34.7 (301–413) μm long; 10 out of 12 specimens have 9 segments, but specimens with 8 segments have the apical segment partially divided, length per segment as follows: I 54.3 ± 5.9 (48–68) μm , II 54.5 ± 4.9 (44–59), III 53.7 ± 5.9 (45–64), IV 29.1 ± 3.2 (23–33), V 41.9 ± 6.1 (30–51), VI 31.4 ± 3.1 (28–37), VII 39.9 ± 4 (36–45), VIII 38.4 ± 3.9 (33–44) and IX 45.1 ± 2.8 (40–49). Eye 25.5 ± 1.8 (23–28). Clypeolabral shield 158.1 ± 8.8 (149–175) μm long and 134.1 ± 11.2 (116–150) μm wide. Labium 94.7 ± 4.9 (84–102) μm long and 94.8 ± 5.1 (89–102) μm wide; apical segment with 18 setae, medial segment with two setae and basal segment with 6 setae. Hind leg 530.8 ± 43.6 (463–591) μm long, length per segments as follow: coxa 68.4 ± 4.4 (61–74) μm long and 101.5 ± 17.5 (81–135) μm wide; trochanter 53.8 ± 4.5 (45–58) μm long; femur 184.1 ± 17.8 (155–209) μm long and 67.9 ± 5.4 (62–78) μm wide; trochanter-femur length 237.9 ± 21.2 (201–265) μm ; tibia 190.7 ± 23.4 (156–

219) μm long and 39.3 ± 2.9 (35–44) μm wide, with 50 ± 9.9 (34–68) translucent pores; tarsus 83.4 ± 2.6 (79–87) μm long, with tarsal digitules of two lengths, the shortest 27–32 μm long and the largest 33–39 μm long; claw 27.9 ± 1.2 (25–30) μm long with two capitate digitules 23.4 ± 2.4 (18–27) μm long, reaching the tip of claw, denticle present. Anal ring with transversal diameter 74.3 ± 4.8 (67–81) μm ; six flagellated setae, each 103.5 ± 9.5 (88–122) μm long. Cerarii restricted to abdominal segments VIII and VII, C_1 always with 2 conical setae and 4–7 flagellate setae; C_2 with 1–2 conical setae and 0–4 flagellate setae. Trilocular pores each 3–4 μm wide.

Oral collar tubular ducts (OC) of three sizes: large ducts 9.8 ± 0.8 (8–12) μm long and 5.2 ± 0.5 (4–6) μm wide, many of them with 1 or 2 simple pores near to the collar; medium ducts, each 5.6 ± 0.4 (4–7) μm long and 3.9 ± 0.3 (3–5) μm wide; small ducts with diameter smaller than a trilocular pore, each 5.2 ± 0.7 (4–7) μm long and 2.5 ± 0.3 (2–3) μm wide; small and medium OC abundant (not counted), distributed in transversal rows on each body segment; large OC totalling 100 ± 14.1 (81–122) on body. Dorsal large OC totalling 72.1 ± 10.4 (56–85), distributed as follows: head 6.6 ± 1.4 (4–9), thorax 25.3 ± 2.2 (22–28), abdominal segment I 6.3 ± 1.7 (4–9), II 7.3 ± 1.7 (4–9), III 7.3 ± 2 (5–11), IV 6.8 ± 1.9 (5–10), V 5.2 ± 1.5 (3–8), VI 3.6 ± 0.9 (2–5), VII 3.7 ± 0.8 (3–5), absent on segment VIII. Ventral large OC totalling 27.8 ± 5.3 (20–37), usually restricted to margin and submarginal areas, with almost no OC in the central area, distributed as follows: absent on head, thorax 9.8 ± 2.1 (6–13) restricted to meso- and metathorax, abdominal segment I 3.5 ± 1.8 (1–8), II 2.4 ± 0.8 (1–4), III 2 ± 1 (0–3), IV 2 ± 1 (0–4), V 3 ± 1.2 (1–5), VI 2.8 ± 0.8 (2–4), VII 2.3 ± 0.7 (2–4), absent on segment VIII.

Multilocular disc pores (MP) of 6–8 μm wide, with 10 loculi, abundant in venter and few in dorsum (3 out of 12 specimens without pores on dorsum), totalling 138.2 ± 26.5 (102–188) on whole body. Dorsal

Table 1. Morphological differences between adult females of the *Vryburgia amaryllidis*, *V. brevicurris* and *V. succulentarum* species recorded for Germany.

Character	<i>V. amaryllidis</i>	<i>V. brevicurris</i>	<i>V. succulentarum</i>
Number of oral rim tubular ducts (OR)	102–140	123–147	Absent
Number of pores associated with each OR	Absent	1–4	Not applicable
Distribution and number of multilocular disc pores on dorsum	0–8, only on abdomen	>100, on thorax and abdomen	0–9, only on abdomen
Number of multilocular disc pores on the venter of thorax	6–23	82–137	0–2
Number of multilocular disc pores on venter of head	Absent	8–20	Absent
No. of sizes of oral collar tubular ducts	Two	Two	Three
Distribution of translucent pores of hind leg	Femur and tibia	Femur and tibia	Tibia

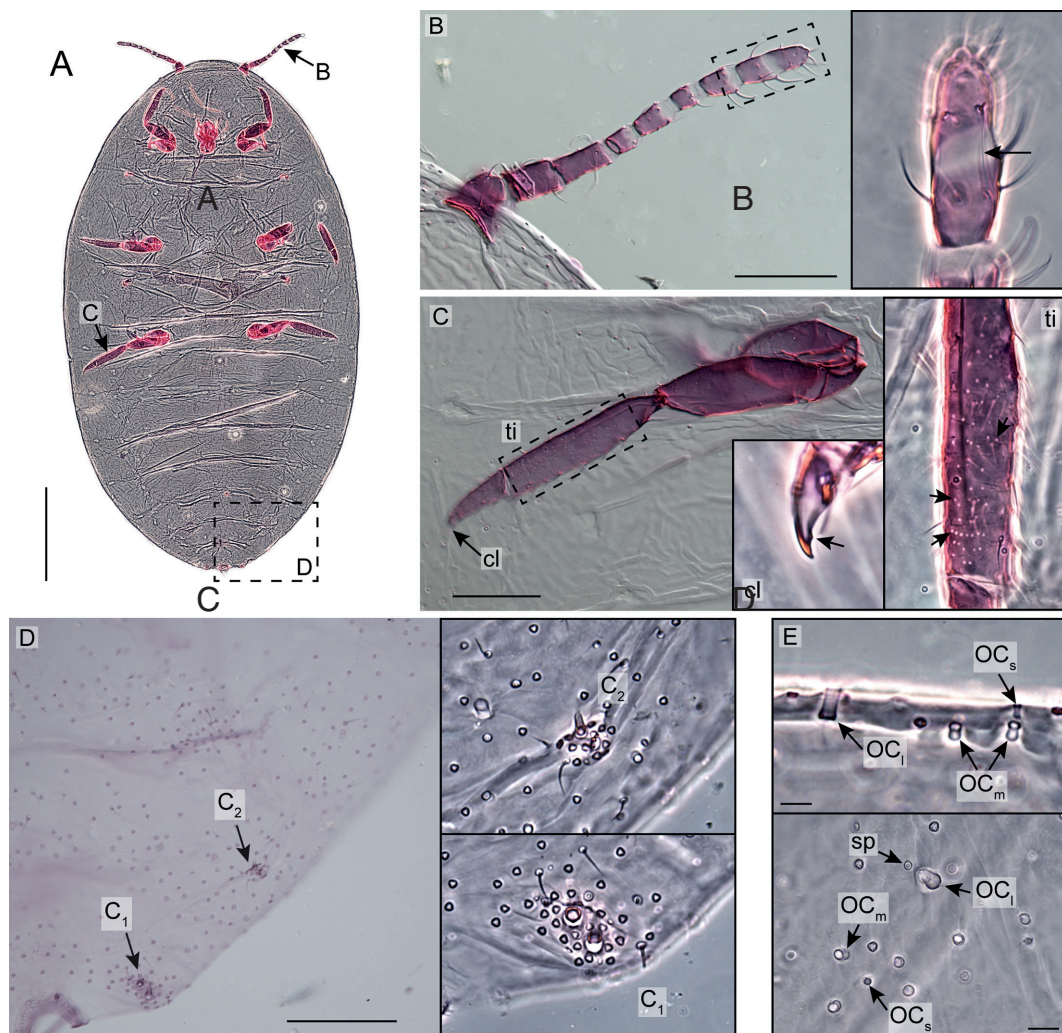


Fig. 3. Microphotographs of the adult female of *Vryburgia succulentarum* Williams. **A.** Ventral view of body. **B.** Antenna with enlargement of apical segment showing division of the apical segment indicated by an arrow. **C.** Hind leg with enlargements of the tibia (ti) showing translucent pores indicated by arrows, and of the claw showing small denticle. **D.** Section of abdomen with close-up of marginal cerarii 1 (C₁) and 2 (C₂). **E.** Oral collar tubular ducts in lateral view (upper box), and vertical view (lower box) of large (OC_l), medium (OC_m) and small (OC_s) size; large OC with discoidal pore (sp) associated to the collar. Scale bars: A = 500 µm; B–D = 100 µm; E = 10 µm.

MP totalling 1.9 ± 2.6 (0–9), distributed as follows: absent on head, thorax, abdominal segment II and VIII, abdominal segment I, III, and VI 0–1, segment IV and V 0–3. Ventral MP totalling 136.3 ± 25.2 (102–179), distributed as follows: absent in head, 0–2 on thorax (pro- or metathorax) and abdominal segments I to III, segment IV 6 ± 3.8 (0–14), V 16.3 ± 6.5 (6–29), VI 33.8 ± 6.2 (25–46), VII 42.7 ± 8.1 (34–57), VIII 36 ± 5.8 (26–45).

Material examined. GERMANY, Hamburg, Hamburg, Loki Schmidt Botanical Garden of the University of Hamburg, $53.560800^\circ \text{N } 9.860388^\circ \text{E}$, 23 m, 21.viii.2024, ex stem and base leaf of *Drosanthemum* sp. (Aizoaceae), A. Caballero leg. (16 adult ♀♀).

Although *V. succulentarum* lacks oral rim tubular ducts, it possesses large oral collar tubular ducts comparable in length and diameter to the oral rim tubular ducts of *V. amaryllis* and *V. brevicurvis*. *Vry-*

burgia amaryllidis exhibits intermediate complexity in ducts and pores: it has fewer multilocular disc pores, similar to *V. succulentarum*, but features two types of ducts, numerous oral rim and oral collar tubular ducts, and translucent pores on both femur and tibia, resembling *V. brevicurvis*. These detailed comparisons for *V. amaryllidis*, *V. brevicurvis*, and *V. succulentarum* are summarised in Table 1 above. The taxonomic key provided by Williams (1985, pp. 386–387) includes all three species and is applicable to German specimens, except for differences in the number of antennal segments.

Morphology of the adult male of *Vryburgia succulentarum* Figs 4–6

Note. The description is based on a single specimen.

Description

Macropterous, total body length 880 μm (Figs 4 and 6); wings about equal to total body length and about a third as wide as long.

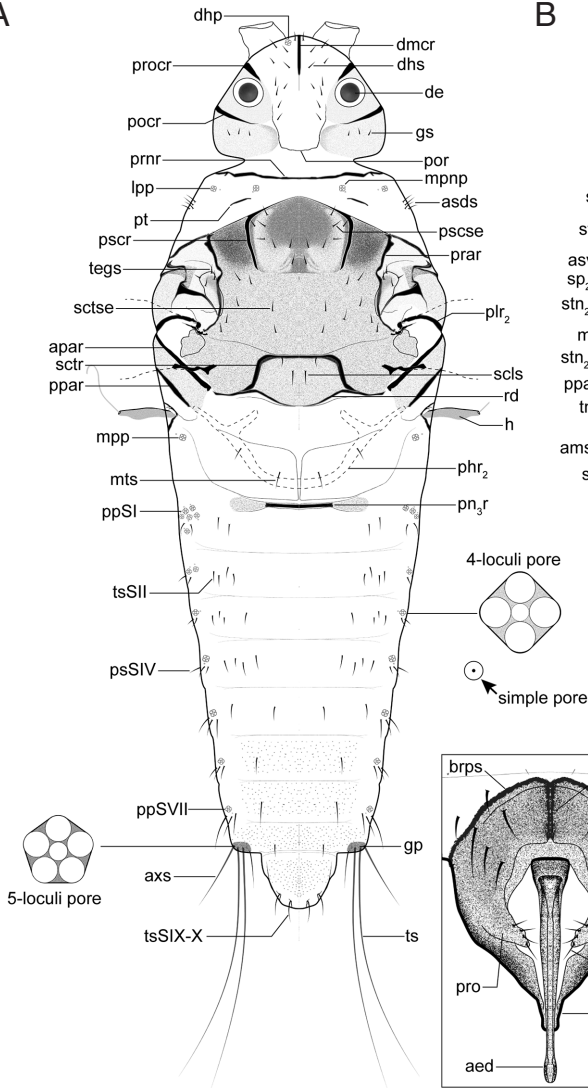
Head. Cephalic capsule rounded, length from anterior margin to postoccipital ridge (por) 109 μm , width between postocular ridges (pocr) 172 μm . Epicraneum without reticulation. Dorsal mid-cranial ridge (dmcr) slightly sclerotised, 43 μm long, extending posteriorly to level with preocular ridges (procr); ventral mid-cranial ridge (vmcr) more sclerotised than the dorsal section, length 56 μm ; lateral arms of mid-cranial ridge (lmcr) 34 μm long between extreme points. Each preocular ridge (procr) sclerotised, projecting medially on venter beyond the interocular ridge. Each postocular ridge sclerotised (pocr), with ventral section extending posteromedial and connecting with the propisternum + cervical sclerite (pepcv), and dorsal section extending transversally until the level of medial margin of dorsal eye (de). Two pairs of simple eyes present, round, each 24–25 μm wide; dorsal pair (de) located on the lateral area of head on reticulated part of ocular sclerite; ventral pair round, each 26–27 μm wide, on ventral part (ve) of ocular sclerite. Postoccipital ridge (por) poorly developed, barely visible, uninterrupted, U-shaped. Ocelli (o) situated laterally, each 17–18 μm wide, completely encircled by extensions from postoccipital ridge (por) and by interocular ridges. Genae membranous, with a punctured texture in

ventral section. Ocular sclerite membranous, with reticulations, extending as a single sclerite from the epicranium around behind the ventral eyes. Preoral ridge (pror) unsclerotised, poorly developed. Cranial apophysis narrow, extending longitudinally between preocular and postocular ridges. Chaetotaxy: Dorsal setae (dhs) numbering ten pairs, each seta 8–15 μm long, distributed as five pairs anterior to the dorsal eyes and five pairs in the interocular area along margins of epicranium. Three flagellate setae present on each gena, each 9–11 μm long. Ventral surface with 14 pairs of flagellate setae, each seta 9–25 μm long, distributed as follows: one pair anterior on the lateral mid-cranial ridge; four on each side of the ventral mid-cranial ridge; three on each preocular ridge, and eight pairs along the anterior margin of ocular sclerite. Pores: A single pore (dhp), 5 μm wide with four loculi, present near the anterior margin of the head between antennae.

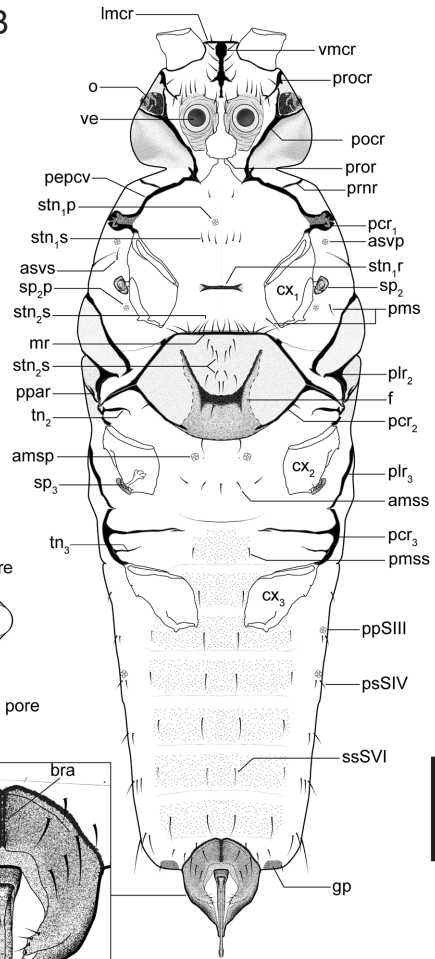
Antennae (Fig. 5A–B): Filiform, with 10 segments. Total length 633–649 μm , ratio body:antenna length 1:0.7. Scape (scp) 37–41 μm long; with 5 or 6 flagellate setae, each 17–21 μm long. Pedicel (pdc) 60–61 μm long, each 14–16 μm wide; with 17–19 flagellate setae, each 15–23 μm long plus 13 or 14 fleshy setae, each 13–15 μm long, and 1 campaniform sensilla, 5 μm wide, located at the distal apex. Antennomere III 97–101 μm long; with 9–15 flagellate setae, each 13–18 μm long plus 18–21 fleshy setae, each 12–16 μm long. Antennomere IV 65–73 μm long; 2–4 flagellate setae, each 19–25 μm long and 24–29 fleshy setae, each 14–17 μm long. Antennomere V 64–66 μm long; 1 or 2 flagellate setae, each 21–22 μm long plus 21 or 22 fleshy setae, each 15–16 μm long. Antennomere VI 66–67 μm long; 2 flagellate setae, each 17–25 μm long plus 22 or 23 fleshy setae, each 15–17 μm long. Antennomere VII 56–60 μm long; 1 flagellate setae 29 μm long; 2 capitate sensory setae (set.ca), each 37–40 μm long; 17 or 18 fleshy setae, each 13–17 μm long plus 1 antennal bristle (ab) 22 μm long, only differentiable by a slightly larger basal socket (about 0.5 μm wider) than other sockets. Antennomere VIII 60–64 μm long; 4 capitate sensory setae, each 29–35 μm long and 23 fleshy setae, each 16–21 μm long. Antennomere IX 54–60 μm long; 4 capitate sensory setae, each 30–39 μm long, 2 flagellate setae, each 14–15 μm long, 14–17 fleshy setae, each 14–17 μm long and one antennal bristle 22 μm long. Antennomere X 67–70 μm long; 2 flagellate setae, each 14 μm long; 5 capitate sensory setae, each

Fig. 4. Taxonomic illustration of the adult male of *Vryburgia succulentarum* Williams. **A.** Dorsal view; **B.** ventral view with enlargement of penial sheath. Scale bar: 100 μm ; pores and setae are intentionally out of scale (enlarged) for easier visualisation. Abbreviations: Aedeagus (aed), anterior metasternal disc pores (amsp), anterior metasternal setae (amss), anterior postalar ridge (apar), antespircular ventral pore (asvp), antespircular dorsal setae

A



B



(asds), antespирacular ventral setae (asvs), auxiliary seta of glandular pouch (axs), basal rod of aedeagus (bra), basal ridge of penial sheath (brps), procoxa (cx₁), mesocoxa (cx₂), metacoxa (cx₃), dorsal head pore (dhp), dorsal eyes (de), dorsal head setae (dhs), dorsal midcranial ridge (dmcr), glandular pouch (gp), genal seta (gs), hamulohalteres (h), lateral arms of midcranial ridge (lmcr), lateral pronotal pores (lpp), mesopronotal pore (mpnp), metapleural disc pore (mpp), marginal ridge (mr), metatergal setae (mts), ocellus (o), precoxal ridge of prothorax (pcr₁), precoxal ridge of mesothorax (pcr₂), precoxal ridge of metathorax (pcr₃), proepisternum + cervical sclerite (pepcv), mesopostphragma (phr₂), mesopleural ridge (plr₂), metapleural ridge (plr₃), posterior mesospiracular seta (pms), posterior metasternal setae (pmss), metapostnotal ridge (pn₃r), postocular ridge (pocr), postoccipital ridge (por), posterior postalar ridge (ppar), pleural pores of abdominal segment I, III and VII (ppSI, ppSIII, ppSVII), prealar ridge (prar), prescutal setae (pscse), pleural setae of abdominal segment IV (psSIV), pronotal ridge (prnr), process of penial sheath (pro), preocular ridge (procr), preoral ridge (pror), prescutal ridge (pscr), post-tergite (pt), posterior marginal fold of notum (rd), scutellar setae (scls), scutoscuteellar ridge (sctr), scutal setae (sctse), mesothoracic spiracle (sp₂), mesospiracular pore (sp₂p), metathoracic spiracle (sp₃), sternal setae of abdominal segment VI (ssSVI), style (st), prosternal pore (stn₁p), prosternal ridge (stn₁r), prosternal setae (stn₁s), basisternal setae (stn₂s), mesotrochantin (tn₂), metatrochantin (tn₃), tail setae (ts), tergal seta of abdominal segment II and IX + X (tsSII, ts SIX + X), ventral eyes (ve), ventral midcranial ridge (vmcr).

31–36 μm long; 19–22 fleshy setae, each 14–17 μm long; 2 or 3 antennal bristles, each 14–26 μm long.

Thorax. Prothorax: pronotal ridge (prnr) extending transversally across the dorsum and extending ventrally to the proepisternum + cervical sclerite, with its lateral pronotal sclerite quite reduced. Posttergite (pt) sclerotised and slightly curved, 30–40 μm long. Proepisternum + cervical sclerite connected at its anterior end with preoral ridge and post-ocular sclerite, and around the mid-point with the pronotal ridge; precoxal ridge of prothorax (pcr₁) with apophysis well-developed at the anterior end, connecting with the proepisternum + cervical sclerite. Prosternum membranous. Prosternal ridge distinct, extending transversely on medial area. Chaetotaxy: All setae flagellate. Dorsal antespирacular setae (asds) 3 or 4 on each cluster, each seta 9–13 μm long. One ventral antespирacular seta (asvs) visible only on one side, 10 μm long. Prosternal setae (stn₁s) arranged in two groups: one pair immediately posterior to proepisternum + cervical sclerite, the second group as a transverse row anterior to prosternal ridge, numbering 6 setae, each 12–19 μm long. Pores: each 4–6 μm in diameter, with 4 or 5 loculi, with an associated small simple pore 2–3 μm wide, distributed as follows: 2 medial pronotal pores (mpnp), 1 pair of lateral pronotal pores (lpp), one on each side, a single prosternal pore (stn₁p) and 2 antespирacular ventral pores (asvp).

Mesothorax: Prescutum 72 μm long and 104 μm wide, sclerotised, pentagonal shaped, enclosed by prescutal ridges (pscr) only laterally. Scutum 50 μm long in the midline, more sclerotised in the anterolateral areas. Tegula protruded, oval-shaped. Prealar visible, bound by a prealar ridge (prar). Scutellum bound anterolaterally with scutoscutellar ridge (sctr) and posteriorly with marginal fold of notum. Anterior and posterior notal wing processes not visible. Postalare developed, delimited by anterior and posterior ridges (apar, ppar). Mesopostphragma (phr₂) well developed and sclerotised. Mesopleural ridge (plr₂) connecting with the posterior end of precoxal ridge of mesothorax (pcr₂) and extending dorsally toward the pleural wing process. Mesepisternum large and protruded, without reticulations. Lateropleurite triangular, delimited posterolaterally by the marginal ridge (mr) and the subepisternal ridge. Mesothoracic spiracle (sp₂) 29–30 μm long, with peritreme 17–19 μm wide. Mesotrochantin (tn₂) about 28 μm long. Mesosternum 108 μm long, bound anterolaterally by a marginal ridge and posterolaterally by the mesoprecoxal ridge. Furca (f) well developed, with arms extending about $\frac{4}{5}$ to marginal ridge anteriorly. Chaetotaxy: all setae flagellate, arranged as follows: 14 prescutal setae (pscse), 15 scutal setae (sctse), and 4 scutellar setae (scls), each

seta 8–12 μm long; 4 or 5 tegular setae on each teg, each 7–9 μm long; 2 posterior mesospiracular seta (without its corresponding opposite seta) (pms), one seta immediately posterior to the spiracle, 8 μm long, the other setae immediately anterolateral to marginal ridge, 20 μm long; 32 basisternal setae (stn₂s), each 14–23 μm long, distributed as 16 setae along the edge of the marginal ridge, 13 setae in the central area, 2 setae on the sternal suture and one on the precoxal ridge. Pores: 1 pair of mesospiracular disc pore (sp₂p) of 4 loculi, each 5 μm wide.

Metathorax: Metanotum 56 μm long, membranous. Metapostnotal sclerite poorly developed, each one connected by a ridge (pn₃r) 89 μm long. Metapleural ridge (plr₃) connected anteriorly with a suspensorial sclerite and posteriorly with a precoxal ridge (pcr₃). Epimeron membranous, without a clear division from metanotum. Metepisternum membranous, protruded, separated from epimeron by metapleural ridge. Metathoracic spiracle (sp₃) 28–35 μm long, with peritreme 20–19 μm wide. Metatrochantin (tn₃) 27–30 μm long. Metasternum 74 μm long. Chaetotaxy: All setae flagellate, each 8–14 μm long, arranged as: 5 metatergal setae (mts), 5 anterior metasternal setae (amss), and 2 posterior metasternal setae (pmss). Pores each 5–6 μm wide, with 4 loculi, distributed 1 pair of metapleural disc pore (mpp) and 2 anterior metasternal disc pores (amsp).

Legs: Fore leg of 540–574 μm length; coxa (cx₁) 81–86 μm long and 64–68 μm wide, with 20 flagellate setae (hs); trochanter 62 μm long, with 6–8 flagellate setae and six placoid sensilla, each 4–5 μm wide; femur 158–160 μm long, with 25–28 flagellate setae and 12 or 13 fleshy setae (fs); tibia 189–195 μm long, with 33–35 flagellate setae, 12–14 fleshy setae, two long spur-like setae (sps), each 17 μm long and five short spur-like setae, each 11–12 μm long; tarsus 78–79 μm long, with 28 flagellate setae, 8 fleshy setae, 2 capitata digitule (td), each 30–34, and one placoid sensillum 4 μm wide; claw 24–25 μm long, with 2 setose digitules (cd), each 6–8 μm long. Middle leg total length 494–544 μm ; coxa 72 μm long and 53 μm wide, with 20 flagellate setae; trochanter 59–60 μm long, with 7–9 flagellate setae and six placoid sensilla, each 5 μm wide; femur 143–144 μm long, with 25 or 26 flagellate setae and 8–10 fleshy setae; tibia 190 μm long, with 35 flagellate setae, 6 fleshy setae, 2 long spur-like setae, each 17 μm long and 4 short spur-like setae, each 11–13 μm long; tarsus 77 μm long, with 30 flagellate setae and 4 fleshy setae, two capitata digitules, each 29–30 μm long and one placoid sensillum 4 μm wide; claw of 24 μm long, with two setose cd, each 8–10 μm long. Hind leg (Fig. 5C–D) total length 591–605 μm ; coxa (cx₃) 82–85 μm long and 59–60 μm wide, with 18–20 flagellate setae and 1 fleshy setae; trochanter 58–62 μm long,

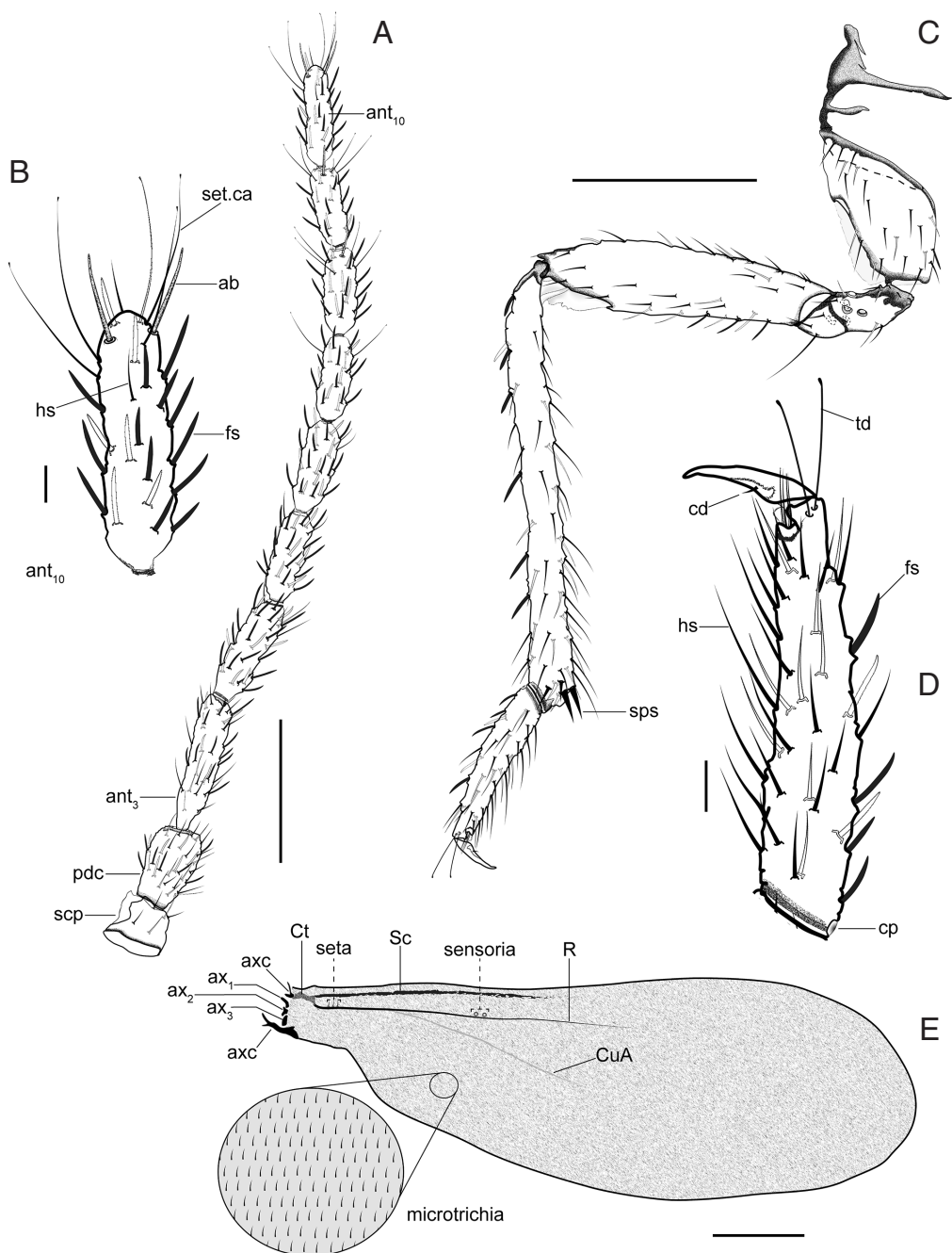


Fig. 5. Taxonomic illustrations appendages of the adult male of *Vryburgia succulentarum* Williams. **A.** Antenna. **B.** Antennomere X. **C.** Hind leg. **D.** Metatarsus and claw. **E.** Wing. Scale bars: A, C, E = 100 μ m; B, D = 10 μ m. Abbreviations: Antennal bristle (ab), Antennomere III (ant₃), Antennomere X (ant₁₀), first axillary sclerite (ax₁), second axillary sclerite (ax₂), third axillary sclerite (ax₃), axillary cord (axc), claw digitule (cd), campaniform pore (cp), costal thickening (Ct), cubitus anterior vein (CuA), fleshy setae (fs), flagellate setae (so-called hair-like setae) (hs), pedicel (pdc), Radius vein (R), subcostal vein (Sc), scape (scp), capitate sensory setae (set.ca), spur-like setae (sps), tarsal digitule (td).

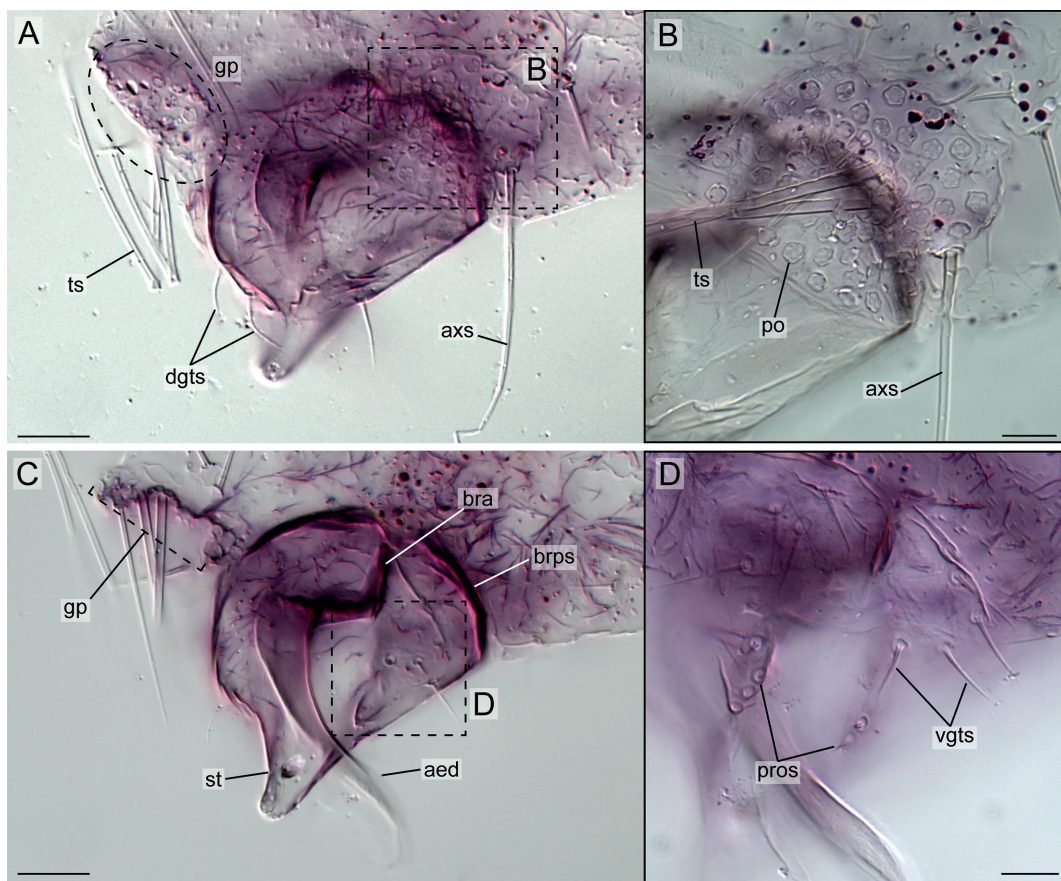


Fig. 6. Microphotographs of abdominal segment VIII and genital capsule for adult male of *Vryburgia succulentarum* Williams. **A.** Dorsal view with **B.** close-up of glandular pouch. **C.** Ventral view with **D.** close-up of penial sheath processes. Scale bars: A, C = 20 μ m; B, D = 10 μ m. Abbreviations: Aedeagus (aed), auxiliary seta of glandular pouch (axs), basal rod of aedeagus (bra), basal ridge of penial sheath (brps), tergal setae of genital capsule (dgts), glandular pouch (gp), pores of glandular pouch (po), setal sensillae of penial sheath processes (pros), style (st), tail setae (ts), ventral setae at base of penial sheath (vgts).

with 10 flagellate setae and 6 placoid sensilla, each 4–5 μ m wide; femur 153–154 μ m long, with 30 or 31 flagellate setae and 5 fleshy setae; tibia 214–218 μ m long, with 35–41 flagellate setae, 8–10 fleshy setae, and apex with 2 long spur-like setae, each 17–19 μ m long and 4 short spur-like setae, each 11–13 μ m long; tarsus 83–89 μ m long, with 29–31 flagellate setae, 6 or 7 fleshy setae, 2–4 thin setae in the internal apex, two capitate digitule 30–32 μ m long and one campaniform pore (cp) 4 μ m wide; claw 22–26 μ m long and two setose digitule, each 8–9 μ m long.

Wings: Fore wing (Fig. 5E) approximately 740 μ m long and 300 μ m in the widest section, surface covered by microtrichia, each 1–3 μ m long. The anterior and posterior axillary cords (axc), plus three axillary sclerites (ax₁, ax₂, ax₃) well developed.

The Costal thickening (Ct) short and reduced to a sclerotised plate, about 25 μ m long. Subcostal vein (Sc) 316 μ m long, diffused with no distinct cavity, arising from Costal thickening and fully separated from Radius vein. Radius vein (R) about 390 μ m long, with a distinct cavity; with three short flagellate alar setae, each 11–14 μ m long and two circular sensoria, each 4 μ m wide. Cubitus Anterior vein (CuA) 218 μ m long, poorly developed. Hamulohalteres (h) 65–71 μ m long, 18–19 μ m wide, each with a single hooked hamulus 68 μ m long and an anterior ridge 32 μ m long.

Abdomen. Pregenital segments I to VII (SI to SVII): membranous, with anterior segments about 245 μ m wide, decreasing posteriorly on SVII to about 170 μ m. Ostioles not distinguishable. Chaetotaxy SI

to SVII: all setae, except for those on glandular pouch flagellate; each seta 8–28 µm long, with shortest setae (<19 µm) on SI, becoming progressively longer toward SVII, and large setae (>20 µm long), present on medial area of sternum of SII to SVII and tergum of SVII; a thicker and longer seta on each pleura of SVII, each 39–42 µm long. Distribution of setae as follows: SI with 2 tergal setae on each submedian area, and 2 setae on each pleura; SII with 8 tergal setae (4 on each submedian area), 2 or 3 setae on each pleura, and 2 sternal setae; SIII with 8 tergal setae (4 on each submedian area), 4 setae on each pleura, and 4 sternal setae; SIV with 8 tergal setae (4 on each submedian area), 5 or 6 setae on each pleura, and 4 sternal setae; SV with 4 tergal setae, 5 or 6 setae on each pleura, and 4 sternal setae; SVI with 2 tergal setae, 5 or 6 setae on each pleura, and 4 sternal setae; SVII with 2 tergal setae, each pleura with 4 setae plus 2 thicker setae, and 4 sternal setae; SVIII with 2 tergal setae, and 6 sternal setae (3 on each submedian area). Pores SI to SVII: restricted to pleura, each 5–6 µm wide, with four loculi plus and one associated simple pore, distributed as follows: 3 or 6 pores on SI, 1 or 2 on each SII and SIII, 2 on SIV, and 1 on each SV to SVII. Segment VIII: 130 µm wide, with tergite slightly sclerotised, and sternite strongly reduced; glandular pouch (gp) present on either side of SVIII, composed of 66–74 pores, each 3–5 µm wide and 4 and 5 loculi; two main fleshy tail setae (ts), each 221–258 µm long, and two auxiliary setae (axs), each 63–90 µm long.

Genital segment and external genitalia: Genital capsule conical, tergum membranous without invagination, 92 µm long and 80 µm wide, with two pairs of flagellate setae in the posterior margin, each 17–20 µm long. Anal opening not detected. Penial sheath slightly more sclerotised than tergum, cordate; the anterior margin with a basal ridge (brps) 103 µm long; basal rod (bra) 45 µm long. Two apical processes (pro), each with four flagellate setae (vgts) on base, each 12–17 µm long, plus 3 or 4 setal sensillae (pros) on the apical internal margin, each 6–13 µm long. Style (st) long, broad and sinuate, about 32 µm long and 10 µm wide in the apical section. Aedeagus (aed) broad and sinuate, 87 µm long and 16 µm wide at the base, progressively becoming smaller to 5 µm at the apex.

Material examined. GERMANY, Hamburg, Hamburg, Loki Schmidt Botanical Garden of the University of Hamburg, 53.560800°N, 9.860388°E, 23 m, 21.viii.2024, ex stem and leaf base of *Drosanthemum* sp. (Aizoaceae), A. Caballero leg, 1 adult male.

So far, only the adult male of *V. amaryllidis* has been described for the genus (Beardsley 1960). The main differences between the adult males of *V. succulentarum* and *V. amaryllidis* lie in the distribution and

number of loculate pores. In *V. succulentarum*, most loculate pores are associated with simple pores. There is a single lateral pronotal pore on each side, a single pore between the antennae, and nearly all loculate pores are paired with a simple pore. Each glandular pouch contains more than 60 pores. In contrast, *V. amaryllidis* has a cluster of 5 or 6 lateral pronotal pores, four pores between the antennae, and each glandular pouch comprises 35–45 pores. Additionally, Beardsley (1960) did not report any simple pores associated with the loculate pores in *V. amaryllidis*.

The shape of the genital sheath is generally similar between the two species, but the chaetotaxy of each process differs slightly. According to Beardsley's illustration, *V. amaryllidis* has three setae at the base of each process and three setae along each apical margin. In contrast, *V. succulentarum* has four setae at the base of each process and three to four setae per apical margin (see pros in Figs 4 and 6). Comparison of overall body chaetotaxy and thoracic areas and ridges was not possible due to the lack of detailed information for *V. amaryllidis*.

The following modification is proposed to the Beardsley's (1960) key to adult males

- 20 Fleshy (=digitiform) setae of antennae very short, 10 µm long or less; antennae about 0.43 mm long and hind femora about 115 µm long *Chorizococcus rostellum* (Lobdell, 1930)
- 20' Fleshy (=digitiform) setae of antennae longer than 15 µm long; antennae larger than 0.55 mm long and hind femora larger 150 µm long 20A
- 20A Each lateral pronotal pores forming a cluster of 5 or 6 pores; 4 pores present on interantennal space; each glandular pouch with fewer than 50 pores *V. amaryllidis*
- 20A' Each lateral pronotal pore present singly; a single pore in the interantennal space; each glandular pouch with more than 60 pores *V. succulentarum*

Discussion

According to the scale insect database ScaleNet (García Morales et al. 2016) (March, 2026), Germany has approximately 57 species of Pseudococcidae recorded to date, distributed across 22 genera. Prior to this study, the genus *Vryburgia* was represented by a single species, *Vryburgia amaryllidis*. During sam-

plings conducted at the botanical gardens of Hamburg and Bonn, *V. amaryllidis* plus two unrecorded species, namely, *V. brevicruris* and *V. succulentarum*, were detected.

The most significant finding is the presence of *V. succulentarum*, recorded here for the first time in Europe. This species has previously been reported only from Australia and Iran, where it has been associated with *Carpobrotus aequilaterus* (Haw.) N.E.Br. (Aizoaceae), *Echinopsis chamaecereus* H. Friedrich & Glaetzel (Cactaceae), and species of *Crassula* and *Sedum* (Crassulaceae) (Williams 1985, Moghaddam & Watson 2022). The considerable geographic gap between these previously known occurrences suggests that the introduction of this species into Germany likely resulted from the direct importation of plant material rather than from regional trade, such as plant exchanges among botanical gardens.

The host plant associations observed in this study may have potential phytosanitary implications. The specimens were collected feeding on *Kleinia neriifolia* and a species of *Drosanthemum*. Although the latter could not be identified to species level, no previous associations between *V. succulentarum* and these genera have been documented. *Kleinia neriifolia* and several species of *Drosanthemum* are commercially available in Germany and other European countries; therefore, the presence of *V. succulentarum* on these hosts suggests a potential pathway for its spread to indoor environments beyond botanical gardens.

Vryburgia brevicruris has been recorded in several European countries, including neighbouring nations such as Belgium, the Czech Republic, and Denmark (Kozarzhevskaya & Reitzel 1975, Ronse & Matile-Ferrero 1991, Ben-Dov 1994). At least two of these records – those from Belgium and Denmark – originate from greenhouses in botanical gardens, suggesting a plausible pathway for the species' introduction into Germany. This hypothesis is further supported by the host plant range of *V. brevicruris*, which is polyphagous and has been documented on *Stapelia grandiflora* Masson, 1797 and *Stapelia hirsuta* L., 1753 (McKenzie 1967), among other species. The specimens examined in this study were collected from *Stapelia divaricata*, thereby extending the known host range within the genus *Stapelia*.

Lastly, *Vryburgia amaryllidis* has not been recorded in Germany since its mention in 1837, despite the several published checklists. It could be related to the fact that many of those surveys were focused on outdoor environments (e.g. Schmutterer (1955, 1980, 2000), Hoffmann & Schmutterer (1999, 2003), Schmutterer & Hoffmann (2003, 2016), and Schönfeld (2015)). The next record after Germany took more than a century, in Bulgaria in 1968 (Trencheva & Tomov 2014), and progressively extended to Spain, Italy, Greece,

and France in recent years (Ben-Dov 1994, Kozár & Franco 1995, Longo et al. 1995, Foldi 2001, Longo 2012, Pellizzari et al. 2015). Most of these records are from the Mediterranean region, where abiotic factors may favour the establishment of populations in outdoor environments. Although Germany does not offer comparable conditions, the fact that specimens in France were recorded outdoors raises the possibility that *V. amaryllidis* could colonise environments in Germany beyond botanical gardens, too (Foldi 2001).

This study provides evidence of a larger, previously unexplored diversity of scale insects inhabiting botanical gardens across the country. These findings are particularly relevant, as botanical gardens can function as adaptive environments that facilitate the transition of introduced insects into natural spaces, with the potential of a phytosanitary threat to agriculture (Wondafraash et al. 2021).

The specimens analysed provide not only new geographical and ecological information but also intraspecific variation that deserves further analysis. Among the examined adult female specimens of *Vryburgia*, the most variable feature is the degree of partial division (or pseudoarticulation) of the apical antennal segment. This character shows a considerable variability, both in the extent of the division and in the proportion of specimens in which it occurs, and its anatomical basis remains unclear. When the segment appears fully divided, the separation does not constitute a true articulation but instead corresponds to an unsclerotised region within the segment. In *V. brevicruris*, the literature reports 8 antennal segments without pseudodivision in the apical segment (McKenzie 1960), whereas *V. succulentarum* is described with 9 antennal segments (Williams 1985, Moghaddam & Watson 2022). Several studied specimens of *V. succulentarum* have the apical segment fully rounded by a pseudodivision, resembling a ninth segment; however, the separation does not constitute a true articulation but instead corresponds to an unsclerotised region within the segment. This variation is relevant because the number of antennal segments is used as a character state for discriminating species of *Vryburgia* (Williams 1985, Moghaddam & Watson 2022).

The presence or absence of claw denticle is taxonomically important in some Pseudococcidae genera related with *Vryburgia*, such as *Chorizococcus* and *Phenacoccus* Cockerell, 1893 (McKenzie 1967, Williams & Granara de Willink 1992, Danzig & Gavrillov-Zimin 2014, 2015). All the studied specimens of *V. amaryllidis* and *V. brevicruris* were consistent with published information (i.e., absence of claw denticle). However, it has been reported in specimens of *V. succulentarum* collected from greenhouses in Iran (Moghaddam & Watson 2022), but not in specimens from Australia (Williams 1985). It is not clear whether this character

varies with environmental factors, as occurs in the cuticular structures of other species of Pseudococcidae, such as the distribution and number of ducts in *Planococcus citri*, which are affected by temperature (Cox 1983). Although the presence of claw denticle is not discriminant at the interspecific level in *Vryburgia*, understanding the nature of its variations may allow for refining its use taxonomically and contribute to the delimitation of the genus.

The adult females of the species of *Vryburgia* examined differ primarily in the type, number and distribution of pores and ducts. These characters exhibit a gradient of complexity among species. Here, *Vryburgia brevicruris* is morphologically the most complex species, with translucent pores on two leg segments, two types of ducts, oral rim ducts accompanied by numerous simple pores distributed throughout the body, and the presence of multilocular disc pores. By contrast, *V. succulentarum* is the least complex, with translucent pores restricted to the tibia, only oral collar tubular ducts, and a markedly reduced number of multilocular disc pores. The modified male key, combined with female characters, provides a practical tool for identification of German *Vryburgia* species. Differences in antennal segment number and male chaetotaxy should be considered when applying older keys (Beardsley 1960, Williams 1985).

Finally, information on the male morphology of the genus remains limited, with descriptions available for only about 6% of Palaearctic species (Danzig & Gavrilov-Zimin 2014). Here, we present the second description of an adult male for the genus *Vryburgia*. The first, *V. amaryllidis*, was based on specimens from Hawaii (Beardsley 1960). The German female specimens showed no significant variation, suggesting that minor variation is expected in male specimens from Germany. The main differences between the two were observed in cuticular structures, although features such as ridges and sclerites may also provide valuable taxonomic information. We encourage taxonomists to include such characters in future descriptions.

Conclusions

The diversity of *Vryburgia* in Germany has now increased to three species, including the first record of *V. succulentarum* in Europe and of *V. brevicruris* in Germany. All newly recorded species are polyphagous and, at least within the surveyed greenhouses, may pose a potential threat to other plants. It is also possible that one or more species could establish populations in outdoor plants because of climate change; therefore, extended studies are needed to assess both their current and potential impact. During our sampling, none of the species was present in

densities high enough to cause plant death, although localised chlorosis and necrosis were observed on leaves where specimens were feeding.

Further morphological studies of *Vryburgia*, including both males and females, could yield additional taxonomically relevant information. Characters such as the partial division of the apical antennal segment and the presence or absence of the claw denticle are frequently noted in *Vryburgia* descriptions, yet the extent of their intra- and interspecific variation and their potential significance for genus-level taxonomy remain unclear.

Acknowledgements

We thank Dr Penny J. Gullan (The Australian National University, Australia) and Dr Mehmet Bora Kaydan (Çukurova University, Turkey) for providing some of the literature cites, and to Dr Chris Hodgson for his comments and suggestions on the manuscript. This work was funded by the Deutscher Akademischer Austauschdienst (German Academic Exchange Service) – DAAD under Grant No. 91790444, and Zoologische Staatssammlung München.

References

- Afifi, S. A. 1968. Morphology and taxonomy of the adult males of the families Pseudococcidae and Eriococcidae (Homoptera: Coccoidea). *Bulletin of the British Museum (Natural History)*, Suppl. 13: 1–210.
- Beardsley, J. W. 1960. A preliminary study of the males of some Hawaiian mealybugs (Homoptera: Pseudococcidae). *Proceedings of the Hawaiian Entomological Society* 17: 199–243.
- Ben-Dov, Y. 1994. A systematic catalogue of the mealybugs of the world (Insecta, Homoptera, Coccoidea, Pseudococcidae and Putoidae): with data on geographical distribution, host plants, biology, and economic importance. 686 pp., Andover, UK (Intercept Limited).
- Bouché, P. F. 1837. Beschreibung einer neuen Art Schildlaus *Coccus amaryllidis* Bouché nebst Mittheilungen zur Vertilgung dieser und anderer Schildläuse .Allgemeine Gartenzeitung – Eine Zeitschrift für Gärtnerei und alle damit in Beziehung stehende Wissenschaften 5: 99–101.
- Brookes, H. M. 1976. New species and records of *Chorizococcus* McKenzie in Australia (Homoptera: Pseudococcidae). *Australian Journal of Entomology* 15: 421–432. <https://doi.org/10.1111/j.1440-6055.1976.tb01725.x>
- Choi, J. & Lee, S. 2022. Higher classification of mealybugs (Hemiptera: Coccoomorpha) inferred from molecular phylogeny and their endosymbionts. *Systematic Entomology* 47(2): 354–370. <https://doi.org/10.1111/syen.12534>

- Choi, J., Lee, Y.-S., Lee, H.-A. & Lee, S. 2021. Two new records of mealybugs (Coccoomorpha: Pseudococcidae) on succulent plants (Crassulaceae) from Korea. *Journal of Asia-Pacific Biodiversity* 14: 645–650. <https://doi.org/10.1016/j.japb.2021.06.008>
- Cox, J. M. 1983. An experimental study of morphological variation in mealybugs (Homoptera: Coccoidea: Pseudococcidae). *Systematic Entomology* 8(4): 361–382. <https://doi.org/10.1111/j.1365-3113.1983.tb00489.x>
- Cox, J. M. 1987. Pseudococcidae (Insecta: Hemiptera). *Fauna of New Zealand* No. 11. 230 pp., Wellington (Science information Publishing Center, DSIR).
- Danzig, E. M. & Gavrilov-Zimin, I. A. 2014. Palaearctic mealybugs (Homoptera: Coccinea: Pseudococcidae). Part 1. Subfamily Phenacoccinae. *Fauna of Russia and Neighbouring Countries, N.S., No. 148*. 678 pp., St. Petersburg (ZIN RAS).
- Danzig, E. M. & Gavrilov-Zimin, I. A. 2015. Palaearctic mealybugs (Homoptera: Coccinea: Pseudococcidae). Part 2. Subfamily Pseudococcinae. *Fauna of Russia and Neighbouring Countries, N.S., No. 149*. 619 pp., St. Petersburg (ZIN RAS).
- De Lotto, G. 1958. The Pseudococcidae (Homoptera: Coccoidea) described by C. K. Brain from South Africa. *Bulletin of the British Museum (Natural History), Entomology* 7: 77–120.
- De Lotto, G. 1967. The mealybugs of South Africa (Homoptera: Pseudococcidae). I. *Entomology Memoirs, Department of Agricultural Technical Services, Republic of South Africa, Pretoria* 12: 1–28.
- Foldi, I. 2001. Liste des Cochenilles de France (Hemiptera, Coccoidea). *Bulletin de la Société Entomologique de France* 106: 303–308. <https://doi.org/10.3406/bsef.2001.16768>
- García Morales, M., Denno, B. D., Miller, D. R., Miller, G. L., Ben-Dov, Y. & Hardy, N. B. 2016. ScaleNet: A literature-based model of scale insect biology and systematics. *Database* 2016: 1–5. <https://doi.org/10.1093/database/bav118>
- Giliomee, J. H. 1961. Morphological and taxonomic studies on the males of three species of the genus *Pseudococcus* (Hemiptera: Coccoidea). *Annals of the University of Stellenbosch A* 36: 241–296.
- Hodgson, C. 2020. A review of neococcid scale insects (Hemiptera: Sternorrhyncha: Cocomorpha) based on the morphology of the adult males. *Zootaxa* 4765: 1–264. <https://doi.org/10.11646/zootaxa.4765.1.1>
- Hoffmann, C. & Schmutterer, H. 1999. Die Pfirsichschildlaus *Parthenolecanium persicae* (F.) in Südbaden – ein für Deutschland neuer Schädling der Weinrebe *Vitis vinifera* L. *Anzeiger für Schädlingskunde* 72: 52–54. <https://doi.org/10.1007/BF02771097>
- Hoffmann, C. & Schmutterer, H. 2003. Beitrag zur Kenntnis der deutschen Fauna von Schildlausantagonisten mit Schwerpunkt Süddeutschland (Coccina). *Entomologische Nachrichten und Berichte* 47: 157–164.
- Kondo, T. & Watson, G. W. 2022. Collection, preservation, slide-mounting, labelling and vouchering of scale insects. Pp. 548–558 in: Kondo, T. & Watson, G. W. (eds). *Encyclopedia of scale insect pests*. Boston, MA, USA (CAB International). <https://doi.org/10.1079/9781800620643.0005>
- Kozár, F. & Franco, J. C. 1995. Some new data to the scale insect fauna (Homoptera: Coccoidea) from Continental Portugal. *Folia Entomologica Hungarica* 56: 69–74.
- Kozarzhevskaya, E. & Reitzel, J. 1975. The scale insects (Homoptera: Coccoidea) of Denmark. *Journal of Plant Breeding* 79: 1–40.
- Longo, S. 2012. First report of *Vryburgia amaryllidis* (Bouché) (Homoptera, Pseudococcidae) on *Agapanthus* sp. in Sicily, Italy. *Journal of Entomological and Acarological Research* 44: e3. <https://doi.org/10.4081/jeur.2012.e3>
- Longo, S., Marotta, S., Pellizzari, G., Russo, A. & Tranfaglia, A. 1995. An annotated list of the scale insects (Homoptera: Coccoidea) of Italy. *Israel Journal of Entomology* 29: 113–130.
- McKenzie, H. L. 1960. Taxonomic study of California mealybugs with descriptions of new species (Homoptera: Coccoidea: Pseudococcidae). *Hilgardia* 29: 681–770.
- McKenzie, H. L. 1967. Mealybugs of California with taxonomy, biology and control of North American species (Homoptera: Coccoidea: Pseudococcidae). 525 pp., Berkeley and Los Angeles (University of California Press).
- Moghaddam, M. 2015. New records of mealybug species in Iran with discussions on morphological variations (Hemiptera, Coccoidea: Pseudococcidae). *Entomologica Fennica* 26: 122–131. <https://doi.org/10.33338/ef.84641>
- Moghaddam, M. & Watson, G. W. 2022. The scale insect of Iran (Hemiptera: Cocomorpha). Part 2. The mealybugs (Pseudococcidae and Rhizoecidae) and Putoidae. *Zootaxa* 5126: 1–169. <https://doi.org/10.11646/zootaxa.5126.1.1>
- Ronse, A. & Matile-Ferrero, D. 1991. Première observation en Belgique de *Vryburgia brevicurvis* (McKenzie), cochenille nuisible aux plantes succulentes cultivées en serre (Homoptera, Pseudococcidae). *Revue Française d'Entomologie (N.S.)* 13: 33–34.
- Schmutterer, H. 1955. Bemerkenswerte Schildlausfunde in Süd- und Südwestdeutschland (Homopt., Coccoidea). *Nachrichtenblatt der Bayerischen Entomologen* 4: 98–102.
- Schmutterer, H. 1980. Zum Stand der Erforschung der Schildläuse (Homoptera, Coccoidea) in der Bundesrepublik Deutschland. [On the status of the scale insect (Homoptera, Coccoidea) in the Federal Republic of Germany.]. *Mitteilungen der Deutschen Gesellschaft für Allgemeine und Angewandte Entomologie* 2: 49–56.
- Schmutterer, H. 2000. Bemerkungen über in Deutschland erstmalig nachgewiesene und einige weitere, wenig bekannte Schildlausarten (Coccina). *Entomologische Nachrichten und Berichte* 44: 165–170.
- Schmutterer, H. & Hoffmann, C. 2003. Zur Schildlausfauna von Baden-Württemberg und benachbarten Gebieten (Coccina). *Entomologische Nachrichten und Berichte* 47: 13–17.

- Schmutterer, H. & Hoffmann, C. 2016. Die wild lebenden Schildläuse Deutschlands (Sternorrhyncha, Coccinea). *Entomofauna Germanica* 7. Entomologische Nachrichten und Berichte, Beiheft 20: 1–104.
- Schönfeld, U. 2015. Cocciden-Arten in Brandenburg. *Journal für Kulturpflanzen* 67(10): 337–341. <https://doi.org/10.5073/JFK.2015.10.02>
- Trencheva, K. & Tomov, R. 2014. Checklist of scale insects in Bulgaria (Hemiptera, Coccoidea). *Acta Zoologica Bulgarica Suppl.* 6: 65–72.
- Williams, D. J. 1985. Australian mealybugs. 431 pp., London (British Museum (Natural History)).
- Williams, D. J. 2004. Mealybugs of southern Asia. 896 pp., London, UK (The Natural History Museum) and Kuala Lumpur, Malaysia (Southdene SDN, BHD).
- Williams, D. J. & Granara de Willink, M. C. 1992. Mealybugs of Central and South America. 1st ed., 635 pp., Wallingford, UK (CAB International).
- Wondafrash, M., Wingfield, M. J., Wilson, J. R. U., Hurley, B. P., Slippers, B. & Paap, T. 2021. Botanical gardens as key resources and hazards for biosecurity. *Biodiversity and Conservation* 30: 1929–1946. <https://doi.org/10.1007/s10531-021-02180-0>
- Wu, S. & Xu, H. 2022. Nomenclature of the veins of the fore wings of male scale insects (Hemiptera, Cocomorpha). *ZooKeys* 1136: 163–174. <https://doi.org/10.3897/zookeys.1136.89528>