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Review of the genus *Strumigenys* (Hymenoptera, Formicidae, Myrmicinae) in Hong Kong with the description of three new species and the addition of five native and four introduced species records

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Abstract

The species of the ant genus *Strumigenys* Smith, 1860 found in Hong Kong are reviewed based on new sampling efforts performed over the past five years (2014–2018). Prior to this, 12 *Strumigenys* species had been recorded from Hong Kong, all confirmed here. Moreover, we add to this list three newly described species: *S. hirsuta* **sp. n.**, *S. lantaui* **sp. n.**, and *S. nathistorisoc* **sp. n.**, and describe for the first time the worker caste of *S. formosa* Terayama, Lin & Wu, 1995. We report new records for nine additional species, bringing the total number of species to 24, including four newly recorded species (*S. hexamera* Brown, 1958, *S. membranifera* Emery, 1869, *S. nepalensis* Baroni Urbani and De Andrade, 1994, and *S. rogeri* Emery, 1890) which are considered to be introduced to Hong Kong. A global review of the introduced *Strumigenys* species is presented. The taxonomic validity of *S. feae* and *S. formosensis* is discussed in light of new specimen measurements. New ecological information on the swarming periods of 11 species is presented on the basis of year-long sampling of aerial insects. Finally, the importance of our results within Southeast Asia and the need for future sampling efforts in the region is discussed.

Keywords
Ant diversity, biogeography, China, exotic ants, Hong Kong, *Strumigenys*

Introduction

With 836 described extant species (Bolton 2018), *Strumigenys* is a hyperdiverse ant genus both taxonomically and morphologically. Though globally distributed, *Strumigenys* is primarily a tropical and subtropical ant genus, notably scarce within more temperate regions (antmaps.org, Janicki et al. 2016; Guénard et al. 2017). The Oriental, Neotropical and Afrotropical realms (sensu Holt et al. 2013) possess the highest species richness globally with 240, 154, and 135 species respectively (Guénard et al. 2017). Within Asia (Oriental, Sino-Japanese, and eastern Palearctic realms), 253 native species and eight introduced species have been recorded. New species discoveries and new species records extending the known distribution range of described species are expected with further sampling (e.g. Eguchi et al. 2011) and exploration of undersampled regions (Guénard et al. 2010; Jaitrong et al. 2016).

Strumigenys is typically collected from leaf-litter samples from forests floors, though several species are associated with the accumulated leaf litter in trees (Longino and Nadkarni 1990, Lattke et al. 2018). *Strumigenys* species tend to be associated with primary and secondary forest habitats, but a few species, including several tramp species (e.g. *S. emmae*, *S. membranifera*), are relatively common in open disturbed habitats (Kitahiro et al. 2014). In general, species of *Strumigenys* are specialized predators of Collembola but also often take non-preferred small arthropod prey such as Chilopoda, Diplura, Symphyla, and Acari (Wesson 1936; Wilson 1953; Masuko 1984, 2009a, b), with *Strumigenys* species within a similar community occupying different trophic positions (Mezger and Pfeiffer 2010).

Strumigenys is easily distinguishable from other ant genera by the combination of the following characters: small size (TL: ca 2–5 mm), elongate or triangular mandibles, and for many species the presence of spongiform tissues on the propodeal declivity, petiole and postpetiole, and first abdominal segment. In the field, these species can also be identified by their slow-motion, the occasional presence of thanatotic behaviour (Smith 1931; Brown 1949), and small colony sizes ranging from a few dozen to a maximum of 500 workers (Wilson 1959; Terayama et al. 2014). Traditionally, species of *Strumigenys* were included within the tribe Dacetini, but recent molecular phylogenetic work placed them within the tribe Attini as the sister taxon to the phalacromyrmecine ants (Ward et al. 2015).

Despite its small size (1100 km^2), Hong Kong has a relatively high level of biodiversity, due to its geographic position within continental Asia and subtropical climate. Prior to this study, 11 native and one introduced species of *Strumigenys* had been recorded. Here, we review the species of *Strumigenys* in Hong Kong based on new

material collected between 2014 and 2018, describe three new species, and report new records for nine additional species, including four species considered as introduced for the region. We also provide new information on the sociometry of several species collected including reproductive phenology and colony composition.

Methods and materials

The specimens examined were collected by members of the Insect Biodiversity and Biogeography Laboratory (IBBL) at the University of Hong Kong throughout Hong Kong between 2014 and 2018. A wide range of sampling methods were used, including Winkler extractors, pitfall traps, Malaise traps, and hand collection. Information on altitude, when not recorded in the field with the help of a GPS, was extracted from Google Earth Pro v. 7.1.8.3036 based on the recorded coordinates. Images were taken with a Leica DFC450 camera mounted on a Leica M205 C dissecting microscope. Image montages of the specimens were taken, stacked, enhanced and measured using the Leica Application Suite v. 4.5.

Female alate specimens of *Strumigenys* were collected from two projects using Malaise traps. The first project, led by Mr. Christophe Barthélémy, focuses on wasps and has been run since September 2014 at three main locations (Mai Po Nature Reserve, Pak Sha O, and Ping Chan Shai), with a single Malaise trap set at each location. The majority of traps (75%) are collected every two weeks, with occasional 3- or 4-week periods. While the overall period coverage includes the whole year, traps have been run discontinuously at some sites or during specific years (e.g. interruption from 22 November 2014 to 12 April 2015 in Pak Sha O). The second project focuses on mangrove insect diversity with sampling effort spread across 26 sites and seasonally clustered in two seasons from October to January and May to August. At each site one or two Malaise traps were operating for a period of 2 weeks in both seasons. Due to the peculiar habitat sampled in this study, specimens of *Strumigenys* collected most likely represent transient and not resident species.

Morphological measurements (Fig. 1) and indices are listed below and were used following the standard established for *Strumigenys* (Bolton 2000; Lattke et al. 2018), with the exception of the addition of Postpetiole Length (PPL) and Gaster Length (GL), change to Total Length (TL) with the addition of PPL and GL, and change to Petiolar Height (PH). All measurements are reported in millimetres to the nearest 0.01 mm. Sculpture definitions follow Harris (1979).

- Total Length (TL). The total length from the mandibular apex to the posterior margin of abdominal tergite IV. Sum of MandL + HL + ML + PL + PPL + GL.
- Head Length (HL). The length of the head capsule excluding the mandibles, measured in full-face view in a straight line from the midpoint of the anterior clypeal margin to the midpoint of the occipital margin. In species where one or both of

these margins is concave, the measurement is taken from the midpoint of a transverse line that spans the apices of the projecting portions.

- Head Width (HW). The maximum width of the head in full-face view, excluding the eyes.
- Mandible Length (MandL). The straight-line length of the mandible at full closure, measured in the same plane for which the HL measurement is taken (i.e. full-face view), from the mandibular apex to the anterior clypeal margin, or to the transverse line connecting the anteriormost points when the margin is concave medially.
- Scape Length (SL). The maximum straight-line length of the scape, excluding the basal constriction or neck that occurs just distal of the condylar bulb. (In species with a hypertrophied subbasal lobe on the scape, SL is measured from the tip of the subbasal lobe to the scape apex.)
- Eye Length (EL). The maximum diameter of the eye.
- Pronotal Width (PW). The maximum width of the pronotum in dorsal view. Projecting tubercles or other cuticular prominences at the pronotal humeral angles, if present, are ignored.
- Mesosoma Length (ML) (= Weber's Length). The diagonal length of the mesosoma in profile from the point at which the pronotum meets the cervical shield to the posterior basal angle of the metapleuron.
- Petiolar Length (PL). The maximum length of the petiole from the posterior petiolar margin to the point it is obscured by the posteroventral lobes of the propodeum in profile. Spongiform tissues, if present, are ignored.
- Petiolar Height (PH). The maximum distance measured between two parallel lines, one tangent with the node apex and the other tangent with the ventral-most point of the petiole in profile. When the ventral margin is concave upward, then the lower line tangent to the uppermost portion of the curve. Spongiform tissues, if present, are ignored.
- Dorsal Petiolar Width (DPW). The maximum width of the petiolar node in dorsal view.
- Postpetiole Length (PPL). The maximum length of the postpetiole, measured in the same plane for which the PL measurement is taken (i.e. profile view), from the anterior margin to the posterior margin. Spongiform tissues, if present, are ignored.
- Gaster Length (GL). The maximum length of the gaster, measured in the same plane for which the PL measurement is taken (i.e. profile view), from the anterior margin to the posterior margin. Spongiform tissues and sting, if present, are ignored.
- Cephalic Index (CI). HW / HL × 100
- Mandibular Index (MI). MandL / HL × 100
- Scape Index (SI). SL / HW × 100
- Ocular Index (OI). EL / HW × 100
- Lateral Petiolar Index (LPI). PH / PL × 100
- Dorsal Petiolar Index (DPI). DPW / PL × 100

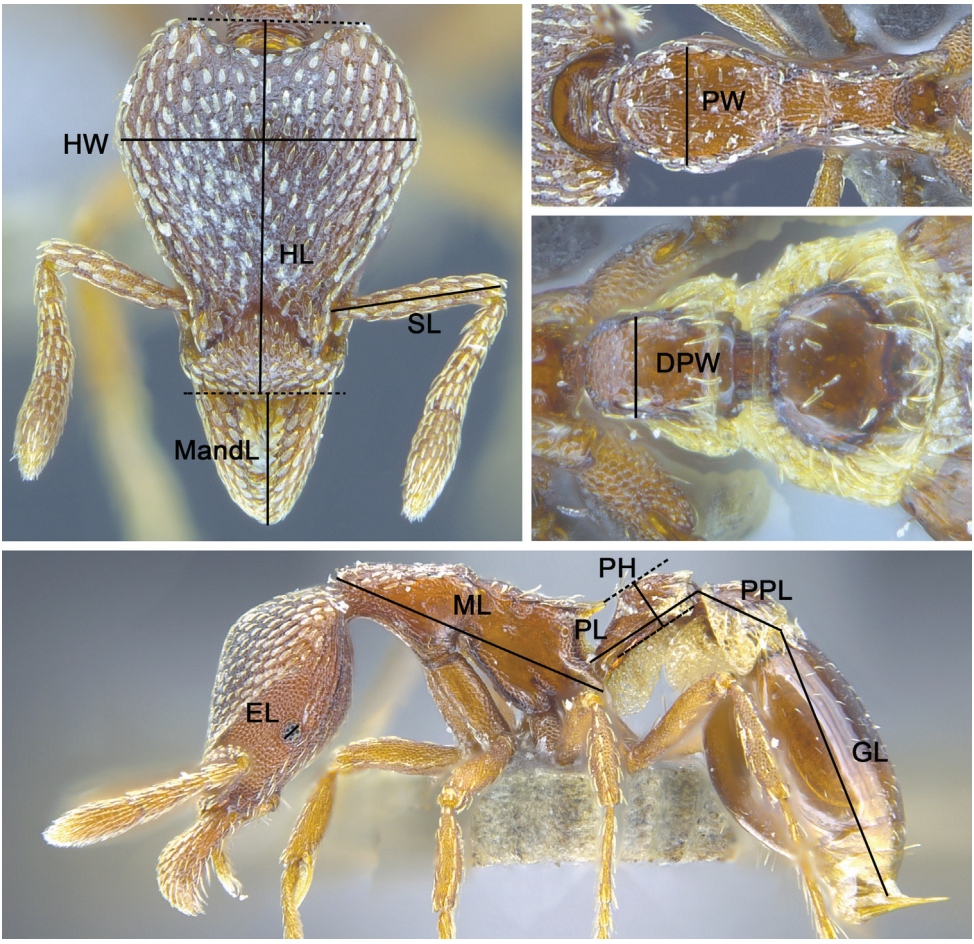

Figure 1. Morphological measurements used. For full definition of each abbreviation, refer to text under the methods and materials section.

Results

Strumigenys canina (Brown & Boisvert, 1979) – First recorded in Hong Kong in 1994 (Fellowes 1996)

Pentastruma canina Brown and Boisvert 1979: 203, figs 2–4 (w.q.m.) JAPAN. Palearctic.
Pyramica canina (Brown & Boisvert, 1979). Combination in *Pyramica*: Bolton 1999: 1673.
Strumigenys canina (Brown & Boisvert, 1979). Combination in *Strumigenys*: Baroni Urbani and De Andrade 2007: 116.

Material examined. HONG KONG: Central & Western District, LFS Plot 3D, 22.278318N, 114.137804E, 04.01.2016, G. Yong, Winkler, IBBL; Central & West-

ern District, Lung Fu Shan, 22.2783N, 114.138017E, 24.04.2015, R.H. Lee, pitfall trap, IBBL; Central & Western District, Lung Fu Shan, 22.278986N, 114.13717E, 18.11.2014, 211 m, M. Wong, Winkler, 4 Corners, IBBL; Central & Western District, Lung Fu Shan, 22.2790333N, 114.1366202E, 30.12.2015, G. Yong, Winkler, IBBL; Central & Western District, Lung Fu Shan, 22.279201N, 114.137209E, 12.09.2018, B. Guénard, hand collection, IBBL; Central & Western District, Lung Fu Shan, 22.28039N, 114.137830E, 25.11.2014, 295 m, M. Wong, Winkler, 12 Random, IBBL; Central & Western District, The Peak, 22.276038N, 114.141995E, 17.08.2015, R.H. Lee, Winkler, IBBL; Central & Western District, The Peak, 22.2767N, 114.1423E, 17.08.2015, R.H. Lee, Winkler, IBBL; North District, A Ma Wat, 22.5191N, 114.2441E, 19.12.2016, R.H. Lee, Winkler, IBBL; North District, H.W. Hang, 22.52819N, 114.2006E, 14.06.2015, 29 m, T. Tsang, Winkler, IBBL; North District, Lai Chi Wo, 22.527N, 114.258E, 08.05.2015, R.H. Lee, Winkler, IBBL; North District, Sheung Wo Hang, 22.522305N, 114.197237E, 16.06.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Kam Shan Country Park, 22.3562N, 114.15167E, 18.10.2017, R. Cheung, Winkler, IBBL; Sha Tin District, Kam Shan Country Park, 22.37089N, 114.14839E, 18.10.2017, R. Cheung, Winkler, IBBL; Sha Tin District, Lion Rock, 22.357002N, 114.175047E, 13.07.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Lion Rock, 22.357002N, 114.175047E, 15.08.2017, R.H. Lee, Winkler, IBBL; Sha Tin District, Lion Rock, 22.35805N, 114.176995E, 13.07.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Lion Rock, 22.360915N, 114.180028E, 13.07.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Mau Ping Wood, 22.3844N, 114.241E, 20.10.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Tai Po Kau Nature Reserve, 22.4281N, 114.1808E, 24.02.2016, B. Guénard, Winkler, IBBL; Sha Tin District, Tai Po Kau Nature Reserve, 22.4285N, 114.1808E, 22.02.2017, B. Guénard, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.41678N, 114.1878E, 03.07.2015, 317 m, T. Tsang, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.41841N, 114.1779E, 12.07.2015, 295 m, T. Tsang, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.422858N, 114.180827E, 14.07.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.42706N, 114.179996E, 14.07.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Kadoorie Centre, 22.4291N, 114.11491E, 08.09.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Kadoorie Centre, 22.4297N, 114.1143E, 08.09.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Kadoorie Farm and Botanic Garden, 22.43076N, 114.1215E, 04.07.2011, 335 m, P. Ward, sifted litter, IBBL; Tai Po District, KFBG, 22.4302N, 114.1192E, 14.09.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Pak Sha O, 22.44743N, 114.3082E, 17.10.2017, R. Cheung / M. Pierce, Winkler, IBBL; Tai Po District, Sha Lo Tong, 22.47708333N, 114.18195E, 28.05.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Sha Lo Tong, 22.4817666N, 114.182833E, 28.05.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Sha Shan, 22.449N, 114.145E, 03.11.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Tai Om, 22.44171N, 114.13518E, 28.02.2018, B. Guénard, Winkler, IBBL; Tai Po District, Tai Om, 22.44184N, 114.134571E, 28.02.2018, B. Guénard, Winkler, IBBL; Tai Po District, Tai Om, 22.4419N, 114.133533E, 05.10.2016, R.H. Lee, Winkler, IBBL; Tai Po District, Tai Om, 22.44214N, 114.13533E, 28.02.2018, B. Guénard, Winkler, IBBL; Tai Po District, Tai To Yan, 22.4538N, 114.11937E, 07.08.2015, R.H. Lee, Winkler,

IBBL; Tsuen Wan District, Lin Fa Shan, 22.3956N, 114.0885E, 15.07.2016, R.H. Lee, Winkler, IBBL; 41; Tsuen Wan District, Shing Mun, 22.397083N, 114.1539166E, 14.05.2015, R.H. Lee, Winkler, IBBL; Tsuen Wan District, Shing Mun, 22.39755N, 114.15385E, 14.05.2015, R.H. Lee, Winkler, IBBL; Tsuen Wan District, Shing Mun, 22.39845N, 114.1628E, 24.08.2015, 367 m, T. Tsang, Winkler, IBBL; Tuen Mun District, Castle Peak, 22.390117N, 113.955767E, 30.06.2015, R.H. Lee, pitfall trap, IBBL; Yuen Long District, Ng Tung Chai, 22.429589N, 114.131276405085E, 01.11.2016, R.H. Lee, pitfall trap, IBBL; Yuen Long District, Ng Tung Chai, 22.429589N, 114.131276405085E, 01.11.2016, R.H. Lee, Winkler, IBBL.

Ecology. One of the most common species of *Strumigenys* in Hong Kong (Fig. 2), collected in a variety of habitats including trees along roadsides, shrubland, tree plantation (*Lophostemon confertus* Wilson & Waterh.), bamboo forest, secondary forest and Feng Shui woods. Known elevation range in Hong Kong from 29 to 474 m. In a Winkler sample collected on October 8th, 2018, 149 workers, 3 queens, 1 larva of a gyne, 24 alate gynes, and 1 male were collected altogether, potentially belonging to the same colony.

Strumigenys elegantula (Terayama & Kubota, 1989) – First recorded in Hong Kong in 1993 (Fellowes 1996)

Smithistruma elegantula Terayama and Kubota 1989: 788, figs 23–27 (w.q.) TAIWAN. Indomalaya.

Pyramica elegantula (Terayama & Kubota, 1989). Combination in *Pyramica*: Bolton 1999: 1673.

Strumigenys elegantula (Terayama & Kubota, 1989). Combination in *Strumigenys*: Baroni Urbani and De Andrade 2007: 119.

Material examined. HONG KONG: Islands District, Shek Pik, 22.2309N, 113.8861E, 18.08.2015, R.H. Lee, Winkler, IBBL; Islands District, Shek Pik, 22.233N, 113.888E, 18.08.2015, R.H. Lee, pitfall trap, IBBL; North District, Lai Chi Wo, 22.527N, 114.258E, 08.05.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Sha Lo Tong, 22.47708N, 114.18195E, 28.05.2015, R.H. Lee, pitfall trap, IBBL; Tai Po District, Tung Ping Chau, 22.5382N, 114.4365E, 02.10.2017, R. Cheung / B. Morgan, Winkler, IBBL; Tai Po District, Wu Kau Tang, 22.49645N, 114.2441E, 25.10.2015, 29 m, T. Tsang, Winkler, IBBL; Tsuen Wan District, Tai Lam Country Park, 22.38091N, 114.05324E, 08.11.2017, R. Cheung / M. Pierce, Winkler, IBBL; Tsuen Wan District, Tai Lam Country Park, 22.38109N, 114.05511E, 08.11.2017, R. Cheung / M. Pierce, Winkler, IBBL; Yuen Long District, Lok Ma Chau, 22.51192N, 114.06064E, 29.05.2018, 1 m, M. Wong, pitfall trap, IBBL; Yuen Long District, Lok Ma Chau, 22.51378N, 114.06301E, 29.05.2018, 1 m, M. Wong, pitfall trap, IBBL.

Ecology. While this species is seldom collected in Hong Kong (Fig. 2), it was found across a wide range of areas and habitats including managed grasslands, trees along roadsides, shrubland, secondary forest, and Feng Shui woods. Known elevation range in Hong Kong is from 1 to 254 m.

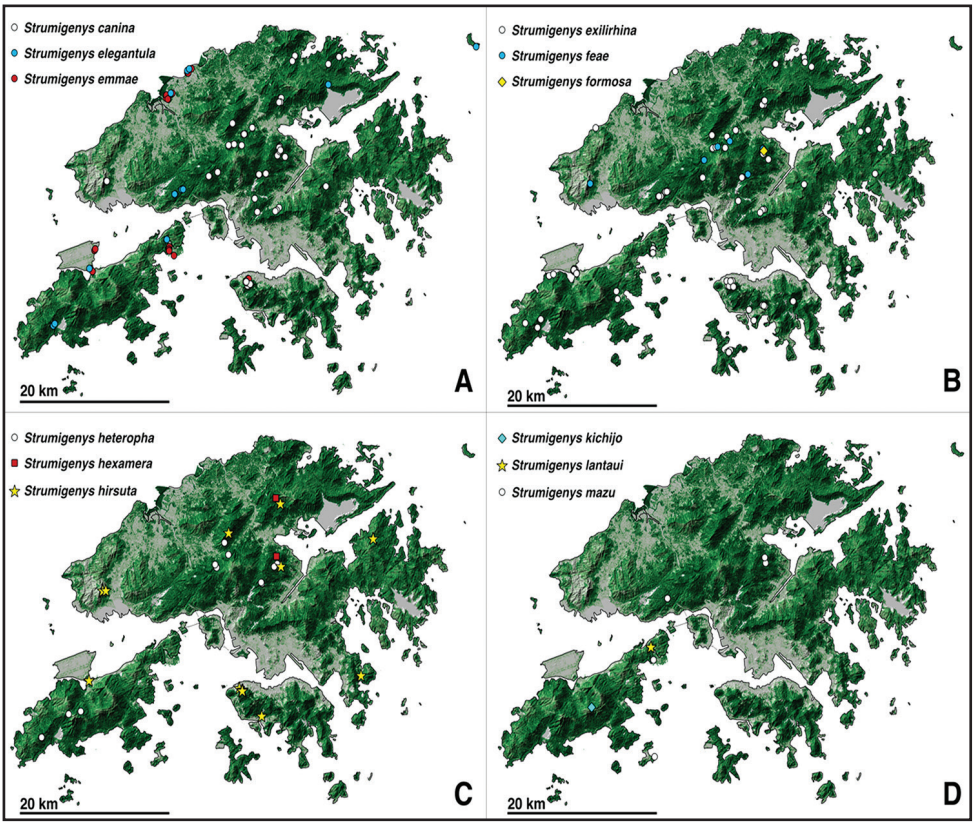

Figure 2. Distribution of *Strumigenys* species in Hong Kong **A** *S. canina*, *S. elegantula*, and *S. emmae* **B** *S. exilirhina*, *S. feae*, and *S. formosa* **C** *S. heteropha*, *S. hexamera*, and *S. hirsuta* sp. n. **D** *S. kichijo*, *S. lantaui* sp. n., and *S. mazu.* Circles represent species previously recorded from Hong Kong, diamonds represent newly recorded species, and stars represent new species. Newly recorded introduced species are shown with red squares, and previously recorded introduced species are shown with red circles. Green shaded portions of the map correspond with higher levels of tree cover, and grey with lower levels of tree cover.

Strumigenys emmae (Emery, 1890) – First recorded in Hong Kong in 1993 (Fellowes 1999)

Epitritus emmae Emery 1890: 70, pl. 8, fig. 6 (w.) ANTILLES. Neotropic.
Quadristruma emmae (Emery, 1890). Combination in *Quadristruma*: Brown 1949: 48.
Strumigenys emmae (Emery, 1890). Combination in *Strumigenys*: Bolton 1999: 1674.

Material examined. HONG KONG: Central & Western District, HKU campus, near Chemistry building, 22.28275N, 114.13981E, 29.05.2015, C. Wang, Winkler, IBBL; Central & Western District, HKU CYT, 22.28245N, 114.14042E, 07.01.2016, G. Yong, Winkler, IBBL; Central & Western District, The Peak, 22.27604N,

114.14199E, 17.08.2015, R.H. Lee, Winkler, IBBL; Islands District, Disneyland, 22.30812N, 114.04318E, 27.07.2016, B. Guénard, Gut content Water Dragon, IBBL; Yuen Long District, Lok Ma Chau, 22.50942N, 114.06076E, 19.06.2018, 0 m, M. Wong, pitfall trap, IBBL; Yuen Long District, Lok Ma Chau, 22.50963N, 114.06053E, 19.06.2018, 1 m, M. Wong, pitfall trap, IBBL; Yuen Long District, Mai Po, 22.48023N, 114.03576E, 30.07.2018, 10 m, M. Wong, pitfall trap, IBBL; Yuen Long District, Mai Po, 22.48048N, 114.03514E, 30.07.2018, 10 m, M. Wong, pitfall trap, IBBL; Yuen Long District, Mai Po, 22.48153N, 114.03289E, 30.07.2018, 10 m, M. Wong, pitfall trap, IBBL; Yuen Long District, Mai Po, 22.48482N, 114.03335E, 07.08.2018, 1 m, M. Wong, pitfall trap, IBBL; Yuen Long District, Mai Po, 22.4858N, 114.0391E, 26.10.2016, R.H. Lee, pitfall trap, IBBL; Yuen Long District, Mai Po, 22.4868N, 114.0409E, 26.10.2016, R.H. Lee, pitfall trap, IBBL.

Ecology. An introduced species, likely originating from the Australian realm (Bolton 2000), found mostly in disturbed habitats, including managed grasslands, isolated patches of urban trees, and with a single record from a secondary forest but located slightly over 100 m from urban habitations. Common in the Mai Po Nature Reserve (Fig. 2), a heavily disturbed landscape managed for bird populations. Known elevation range in Hong Kong is from 1 to 407 m. A single alate gyne was collected between June 27 and July 11 in a Malaise trap located within a mangrove area.

Strumigenys exilirhina **Bolton, 2000 – First recorded in Hong Kong in 2000 (Bolton 2000)**

Strumigenys exilirhina Bolton 2000: 881 (w.q.) NEPAL. Indomalaya.

Material examined. HONG KONG: Central & Western District, HKU Campus, 22.28216N, 114.13829E, 19.11.2014, 113 m, M. Wong, Winkler, 12 Random, IBBL; Central & Western District, HKU campus, near Robert Black, 22.282129N, 114.138105E, 01.05.2015, C. Wang, Winkler, IBBL; Central & Western District, HKU CYT, 22.2824528N, 114.140429E, 07.01.2016, G. Yong, Winkler, IBBL; Central & Western District, LFS Plot 1 B–C, 22.277134N, 114.134792E, 28.12.2015, G. Yong, Winkler, IBBL; Central & Western District, LFS Plot 1 C, 22.277134N, 114.134806E, 28.12.2015, G. Yong, Winkler, IBBL; Central & Western District, Lung Fu Shan Park, N, E, 03.05.2015, C. Wang, Winkler, IBBL; Central & Western District, Lung Fu Shan, 22.276729N, 114.136693E, 24.11.2014, 295 m, M. Wong, Winkler, 12 Random, IBBL; Central & Western District, Lung Fu Shan, 22.28039N, 114.137830E, 25.11.2014, 156 m, M. Wong, Winkler, 4 Corners, IBBL; Central & Western District, Lung Fu Shan, 22.28221N, 114.133476E, 13.11.2014, 115 m, M. Wong, Winkler, 12 Random, IBBL; Central & Western District, Plot 1 B–C, 22.27713N, 114.13479E, 08.01.2016, G. Yong, Winkler, IBBL; Central & Western District, The Peak, 22.276038N, 114.141995E, 17.08.2015, R.H. Lee, Winkler, IBBL; Eastern District, Tai Tam, 22.259933N, 114.22009E, 27.07.2015, R.H. Lee,

Winkler, IBBL; Islands District, Lamma Island, 22.20363N, 114.13599E, 14.09.2017, R.H. Lee, Winkler, IBBL; Islands District, Luk Tei Tong, 22.26233N, 113.99066E, 25.10.2016, R.H. Lee, pitfall trap, IBBL; Islands District, Pak Ngan Heung, 22.27099N, 113.98911E, 25.10.2016, R.H. Lee, pitfall trap, IBBL; Islands District, Shek Pik, 22.230898N, 113.88606E, 18.08.2015, R.H. Lee, Winkler, IBBL; Islands District, Shek Pik, 22.240075N, 113.89041E, 18.08.2015, R.H. Lee, Winkler, IBBL; North District, A Ma Wat, 22.5191N, 114.2441E, 19.12.2016, R.H. Lee, Winkler, IBBL; North District, Kuk Po Sam To, 22.523977N, 114.2355E, 15.11.2016, R.H. Lee, Winkler, IBBL; North District, Kuk Po San Uk, 22.529123N, 114.234675E, 15.11.2016, R.H. Lee, Winkler, IBBL; North District, Sheung Wo Hang, 22.52203N, 114.1962E, 12.06.2015, 71 m, T. Tsang, Winkler, IBBL; North District, Sheung Wo Hang, 22.52232N, 114.1972E, 16.06.2015, 99 m, T. Tsang, Winkler, IBBL; Sai Kung District, Pak Tam Chung, 22.400962N, 114.327163E, 05.06.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Lion Rock, 22.35805N, 114.176995E, 13.07.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Lion Rock, 22.360915N, 114.180028E, 13.07.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Lion Rock, 22.36121N, 114.181997E, 13.07.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Mui Tsz Lam wood, 22.389185N, 114.234462E, 04.10.2016, R.H. Lee, pitfall trap, IBBL; Sha Tin District, Tai Po Kau Nature Reserve, 22.4285N, 114.1808E, 22.02.2017, B. Guénard, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.41678N, 114.1878E, 03.07.2015, 317 m, T. Tsang, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.422858N, 114.180827E, 14.07.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.42402N, 114.18029E, 14.07.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.426138N, 114.181783E, 14.07.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.427285N, 114.181298E, 16.09.2015, B. Guénard, hand collection, IBBL; Southern District, Lam Long Shan, 22.23887N, 114.16864E, 20.09.2017, R.H. Lee, Winkler, IBBL; Southern District, Nam Fung Road, 22.2546N, 114.1833E, 20.08.2016, R.H. Lee, pitfall trap, IBBL; Southern District, Nam Fung Road, 22.25519N, 114.1818E, 28.09.2015, 120 m, T. Tsang, Winkler, IBBL; Southern District, Nam Fung Road, 22.25554N, 114.1802E, 01.10.2015, 110 m, T. Tsang, Winkler, IBBL; Tai Po District, Kadoorie Farm and Botanic Garden, 22.43076N, 114.1215E, 04.07.2011, 335 m, P. Ward, sifted litter, IBBL; Tai Po District, KFBG, 22.4302N, 114.1192E, 14.09.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Sha Lo Tong, 22.477083N, 114.18195E, 28.05.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Sha Lo Tong, 22.477N, 114.1797E, 28.05.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Sha Lo Tong, 22.481767N, 114.18283E, 28.05.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Sha Shan, 22.449N, 114.145E, 03.11.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Tai Om, 22.4419N, 114.133533E, 05.10.2016, R.H. Lee, Winkler, IBBL; Tai Po District, To Kwa Peng, 22.42901N, 114.3336E, 25.05.2018, 1 m, R. Cheung / C. Taylor, Malaise trap, IBBL; Tsuen Wan District, Ha Lin Fa Shan, 22.39664N, 114.1019E, 31.07.2015, 355 m, T. Tsang, Winkler, IBBL; Tsuen Wan District, Shing Mun, 22.396783N, 114.1531E, 14.05.2015, R.H. Lee, pitfall trap, IBBL; Tsuen Wan District, Shing Mun, 22.39678N, 114.1531E, 23.08.2015, 238 m,

T. Tsang, Winkler, IBBL; Tsuen Wan District, Shing Mun, 22.39693N, 114.153E, 17.05.2016, R.H. Lee, Winkler, IBBL; Tsuen Wan District, Shing Mun, 22.397083N, 114.1539166E, 14.05.2015, R.H. Lee, Winkler, IBBL; Yuen Long District, Kap Lung, 22.41596N, 114.1038E, 11.09.2015, 288 m, T. Tsang, Winkler, IBBL; Yuen Long District, Ng Tung Chai, 22.42959N, 114.13128E, 01.11.2016, R.H. Lee, Winkler, IBBL; Yuen Long District, Sheung Pak Nai, 22.45151N, 113.96213E, 28.05.2018, 1 m, R. Cheung / C. Taylor, Malaise trap, IBBL; Yuen Long District, Sheung Tin Liu Ha, 22.44348N, 114.114E, 03.08.2015, 106 m, T. Tsang, Winkler, IBBL.

Ecology. This is one of the most common species of *Strumigenys* in Hong Kong (Fig. 2). It has been collected in a variety of habitats including disturbed urban forests, tree plantations (*Lophostemon confertus* Wilson & Waterh.), shrubland, secondary forest, and Feng Shui woods. The known elevation range in Hong Kong for this species is from 1 to 407 m.

***Strumigenys feae* Emery, 1895 – First recorded in Hong Kong as *S. formosensis* in Bolton (2000); see comments below**

Fig. 3A–B

Strumigenys feae Emery 1895: 473 (w.q.) MYANMAR. Indomalaya.

Material examined. HONG KONG: Tai Po District, Tai Om, 22.43681N, 114.1373E, 07.08.2015, 138 m, T. Tsang, Winkler, IBBL; Tsuen Wan District, Shing Mun, 22.40027N, 114.161E, 04.09.2015, 366 m, T. Tsang, Winkler, IBBL; Tuen Mun District, Castle Peak, 22.389935N, 113.954937E, 30.06.2015, R.H. Lee, pitfall trap, IBBL; Yuen Long District, Kap Lung, 22.41596N, 114.1038E, 11.09.2015, 288 m, T. Tsang, Winkler, IBBL; Sha Tin District, Tai Po Kau Nature Reserve, 22.4285N, 114.1808E, 22.02.2017, B. Guénard, Winkler, IBBL; Tai Po District, Kadoorie Farm and Botanic Garden, 22.43076N, 114.1215E, 04.07.2011, 335 m, P. Ward, sifted litter, IBBL.

Measurements. Workers (n = 2): TL 3.1–3.3, HL 0.81–0.87, HW 0.52–0.55, MandL 0.39–0.41, SL 0.52–0.53, EL 0.061–0.062, PW 0.26–0.28, ML 0.82, PL 0.30, PH 0.15–0.16, DPW 0.11–0.12, PPL 0.19–0.20, GL 0.58–0.71, CI 63–64, MI 47–48, SI 96–100, OI 11–12, LPI 51–52, DPI 37–40.

Ecology. In Hong Kong, *S. feae* was collected within tree plantations of *Lophostemon confertus* Wilson & Waterh. and in secondary forests, with elevation ranging from 138 to 457 m.

Comments. While *S. formosensis* (Forel, 1912) has been recorded from Hong Kong (Bolton 2000), we consider these records as *S. feae*. *Strumigenys formosensis* was initially described as a subspecies of *S. feae*, and Brown (1949: 24) raised *S. formosensis* to the species level without strong justification and without examining specimens of *S. feae*, writing: "Although I have seen no specimens of Emery's Burmese species *feae*, I am arbitrarily raising the Taiwan form to species rank.", on the basis of Forel's description of *S. formosensis* having small propodeal teeth and a strongly concave posterior mesosomal dorsum, with this

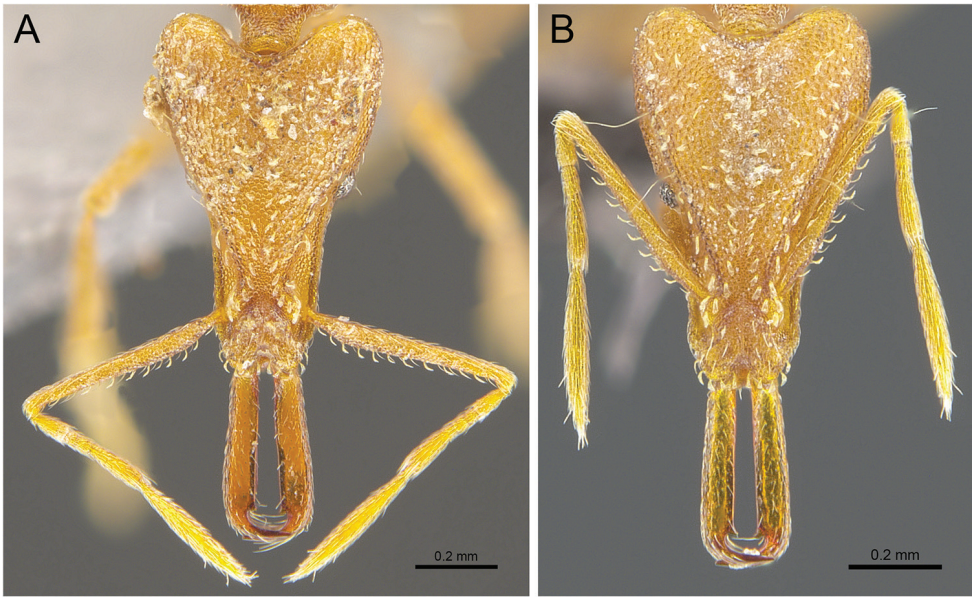

Figure 3. *Strumigenys feae/formosensis* **A** worker (ANTWEB1017082) full-face view **B** worker (RHL01266) full-face view.

latter information absent in Emery's description of *S. feae*. The examination of the pictures of the type specimen of *S. feae* available on AntWeb (CASENT0904951), however, show the presence of a concavity between the mesonotum and propodeum, and with propodeal spines of the type of *S. formosensis* (CASENT0909309) indistinctly smaller than *S. feae*.

The revised descriptions of *S. feae* and *S. formosensis* by Bolton (2000) also revealed no clear distinction between them except the difference in morphological measurements, the length and morphology of the preapical teeth ("not directed medially but instead so strongly inclined toward the apicodorsal tooth that its proximal margin forms a single continuous line with the inner mandibular margin" for *S. formosensis*), and brief mentioning of the maximum diameter of the eye compared to the width of the scape ("slightly greater" for *S. feae* and "equal to or slightly less" for *S. formosensis*), with the rest of the descriptions almost identical to one another.

Specimens collected in Hong Kong could not be assigned to either *S. feae* or *S. formosensis* without ambiguity under the current descriptions. Preapical teeth are neither fully directed medially as in *S. feae*, nor with a single continuous proximal margin as in *S. formosensis* (Fig. 3). Morphological measurements also give little additional information. Measurements of the specimen ANTWEB1017082 (Fig. 3A), which has more forward-inclined preapical teeth, fall within the norm of *S. formosensis* as expected, specimen RHL01266 (Fig. 3B) with more medially-directed preapical teeth has some of its measurements closer to *S. formosensis* than to *S. feae* (Table 1). Considering the fact that *S. formosensis* was raised to its current species level somewhat arbitrarily, the validity of *S. formosensis* as a species would require further investigation using specimens from a wider geographic range than is available for this study.

Table 1. Morphological measurements of *S. feae* and *S. formosensis* comparing information on specimens presented in Bolton (2000) and specimens collected in Hong Kong. For additional information, refer to text under *Strumigenys feae*.

Species/Specimens	HL	HW	SL	MandL	PW	ML	CI	SI	MI
Measurements (in mm) from Bolton (2000)									
S. feae	0.75–0.80	0.47–0.52	0.48–0.50	0.33–0.36	0.27–0.28	0.72–0.80	61–68	94–102	41–46
S. formosensis	0.84–0.87	0.54–0.56	0.52–0.54	0.39–0.40	0.25–0.28	0.75–0.78	63–65	93–98	46–47
Measurements (in mm) from two Hong Kong specimens									
ANTWEB1017082	0.87	0.55	0.53	0.41	0.28	0.82	63	96	47
RHL01266	0.81	0.52	0.52	0.39	0.26	0.82	64	100	48

Strumigenys formosa (Terayama, Lin & Wu, 1995) – new record

Fig. 4A–C

Epitritus formosus Terayama et al., 1995: 85, figs 1–4 (q.) TAIWAN. Indomalaya.
Pyramica formosus (Terayama et al., 1995). Combination in *Pyramica*: Bolton 1999: 1672.
Strumigenys formosa (Terayama et al., 1995). Combination in *Strumigenys*: Baroni Urbani and De Andrade 2007: 120.

Material examined. HONG KONG, Sha Tin District, Tai Po Kau Nature Reserve, 22.426138N 114.181783E, 162 m, 6.VII.2017, R.H. Lee, RHL03476, pitfall trap, IBBL.

Measurements. Worker (n = 1): TL 1.6, HL 0.35, HW 0.38, MandL 0.13, SL 0.18, EL 0.024, PW 0.24, ML 0.41, PL 0.18, PH 0.10, DPW 0.12, PPL 0.11, GL 0.41, CI 109, MI 37, SI 47, OI 6, LPI 57, DPI 68.

This species has been described from two queens collected in 1988 in Nantou County, Taiwan. To the best of our knowledge, no additional records have been reported in the following 30 years. A single worker was collected in Hong Kong which fits the morphological characteristics and size of *S. formosa*. In the absence of nest series, assigning this worker to this species might be uncertain, however, the extreme rarity of this species in Hong Kong and Taiwan limits the likelihood of collecting nest series. As a result, in the presence of several convergent characters, we assign the worker collected to *S. formosa*. Complete description and diagnosis are provided below.

Worker description. (Fig. 4) ***Head.*** In full-face view, head slightly longer than wide with its widest portion near its mid-length. Occipital margin deeply, evenly concave; occipital corners well developed and flattened on their apical portion, then forming a rounded angle with lateral margins. Posterolateral margins divergent on more than half of their length, then more abruptly converging towards the centre of head. Anteromedian clypeal margin slightly convex. Scapes with a well-developed subbasal lobe on their anterior portion. Mandibles elongate and curvilinear. Inner margin of mandibles without spoon-shaped hairs and with teeth clearly visible. In the mid-part of each mandible, a single denticle present, followed by a well-developed tooth and further three denticles all similar to the first. In profile view, apical portion of mandibles distinctly enlarged and with apicoventral tooth distinct (but not in full-face view) and longer than

Figure 4. *Strumigenys formosa* **A–C** worker (RHL003476) **A** profile view **B** dorsal view **C** full-face view.

other teeth. In anterior view of the mandibles, enlarged extremity of mandibles composed of a single apicodorsal tooth followed by a series of very fine, compact, baleen-like mandibular setae. Eyes present but reduced and indistinct, on lateroventral position.

Mesosoma. In profile view, dorsum of mesosoma continuous and slightly concave on its mesonotum portion. Pronotomesopleural suture visible and extending on about one-third on the height of the pronotum. Fine lamellae of spongiform tissues present on propodeal declivity, with its upper posterior portion slightly acute as in female holotype. Metapleural gland bulla well developed. In dorsal view, thorax trapezoidal with pronotum much wider than mesonotum and propodeum. Anterior margin of pronotum convex and forming rounded angles with lateral margins.

Waist segments. Petiolar peduncle long, its lateral margins slightly concave in shape when seen in dorsal view. In profile view, petiolar node low and rounded. In profile view, postpetiole lower than petiole. In dorsal view, postpetiole distinctly larger than petiole, bean shaped, and fully surrounded by spongiform tissues.

Pilosity. On posterior half of head, pilosity limited to a few short J-shaped hairs present on lateral margin of head and oriented apically when head observed in full-face view. More short J-shaped hairs visible in profile view, slightly denser on particular on the posterior margin of head. In full head view, as for the female reproductive caste, frontal lobes covered by about 15 appressed large orbicular hairs arranged longitudinally. Clypeus with sparse presence of small to medium-sized spoon-shaped hairs. Anterior clypeal margin with four spoon-shaped hairs pointing forward and directed towards the mid-point of the clypeus, with central hairs significantly larger than those present on lateral margins. Spoon-shaped hairs completely lacking on mandibles but with finer pubescence present. On scapes, spoon-shaped hairs present on lateral margins and arranged in a crescendo fashion from smaller hairs present from about two-third of the scape on its apical to larger hairs present on the subbasal lobes; all pointing anterodorsally towards the apex of subbasal antennal lobe. In profile view, a few short, acute and erected hairs visible on mesonotum and anterodorsal part of the propodeum. Legs with numerous suberected fine and long hairs present on femurs, with apical portion of femurs bearing a few spoon-shaped hairs. Petiolar node with a continuous collar of four large spoon-shaped hairs oriented backwards and extending from the lateral margin of the petiole at about its midpoint to its dorsal portion, with their size increasing posteriorly. Other thick hairs present on dorsal portion of the petiole and oriented backwards. Sparse erected spoon-shaped hairs present on gaster significantly longer with their basal portion elongated and thin. Fine elongated simple hairs present on sternites and arranged transversely.

Sculpture. Head finely aerolated in all visible portions, including scapes, but not on mandibles. Aerolate sculptures particularly well defined around the eyes, when specimen observed in profile view. In profile view, pronotum mostly reticulated at the exception of its most ventral region which is smooth. Mesopleuron and metapleuron almost entirely smooth and shiny. Posterodorsal part of the propodeum reticulated. In dorsal view, thorax with coarse reticulated sculpture. Coxa, femur and tibia aerolated. In profile view, petiole mainly reticulated at the exception of the anterior part of the petiolar peduncle smooth. In dorsal view, petiole clearly reticulated. Visible part of postpetiolar node smooth and shiny. Gaster entirely smooth and shiny, with only short longitudinal striae present on anterior portion of the dorsal part of the tergite of the fourth metasomal segment.

Colouration. Bright yellow for most of the body at the exception of the gaster which is slightly darker.

Comments. The specimen clearly shares all characters of the *S. murphyi*-group (Bolton 2000) for which five species occur within the Oriental realm. The absence of flattened hairs on the inner margin of the mandibles distinguishes it from *S. dyschima*, *S. hemisobek*, and *S. murphyi*. All hairs on the scape are curved toward the basis of the scape, in contrast to *S. nannosobek*, which has hairs that are pointing towards the apex. On the Hong Kong specimen, the posterior margin of the head is deeply concave, con-

trary to other species of the *S. murphyi*-group except for *S. formosa* (based on the queen description), which also lacks flattened hairs on the inner margin of the mandibles and has a similar disposition and orientation of spoon-shaped hairs on the scape.

Geographic range. Hong Kong, Taiwan. This record of *S. formosa* represents the second record for this species and the first outside of Taiwan. Therefore, this species should not be considered as endemic to Taiwan.

Ecology. The only worker known from Hong Kong (Fig. 2) was collected in a secondary forest at an elevation of 162 m.

Strumigenys heteropha Bolton, 2000 – First recorded in Hong Kong in 1996 (Bolton 2000)

Strumigenys heteropha Bolton 2000: 758 (w.) CHINA. Palearctic.

Material examined. HONG KONG: Islands District, Tei Tong Tsai, 22.25707N, 113.92628E, 29.11.2016, R.H. Lee, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.41698N, 114.1789E, 03.07.2015, 337 m, T. Tsang, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.42007N, 114.1829E, 02.07.2015, 291 m, T. Tsang, Winkler, IBBL; Tai Po District, KFBG, 22.4302N, 114.1192E, 14.09.2015, R.H. Lee, Winkler, IBBL; Tsuen Wan District, Shing Mun, 22.39845N, 114.1628E, 24.08.2015, 367 m, T. Tsang, Winkler, IBBL; Tsuen Wan District, Shing Mun, 22.39962N, 114.162E, 12.08.2015, 355 m, T. Tsang, Winkler, IBBL; Yuen Long District, Kap Lung, 22.41596N, 114.1038E, 11.09.2015, 288 m, T. Tsang, Winkler, IBBL; Yuen Long District, Kap Lung, 22.41931N, 114.1018E, 24.09.2015, 190 m, T. Tsang, Winkler, IBBL; Yuen Long District, Sheung Tin Liu Ha, 22.44348N, 114.114E, 03.08.2015, 106 m, T. Tsang, Winkler, IBBL.

Ecology. This species was collected in several closed-canopy habitats including tree plantations of *Lophostemon confertus* Wilson & Waterh., secondary forests and Feng Shui woods (Fig. 2) with an elevation range from 106 to 367 m.

Strumigenys hexamera (Brown, 1958) – new record

Fig. 5A–C

Epitritus hexamerus Brown 1958: 70, figs 1–3 (w.q.) JAPAN. Palearctic.
Pyramica hexamerus (Brown, 1958). Combination in *Pyramica*: Bolton 1999: 1672.
Strumigenys hexamera (Brown, 1958). Combination in *Strumigenys*: Baroni Urbani and De Andrade 2007: 122.

Material examined. HONG KONG: Sha Tin District, Tai Po Kau, 22.42841N, 114.18197E, 22.02.2017, 160 m, R.H. Lee, Winkler, IBBL; Tai Po District, Ping Shan Chai, 22.486N, 114.187E, 25.03.2017, 142 m, C. Barthélémy, Malaise trap, IBBL.

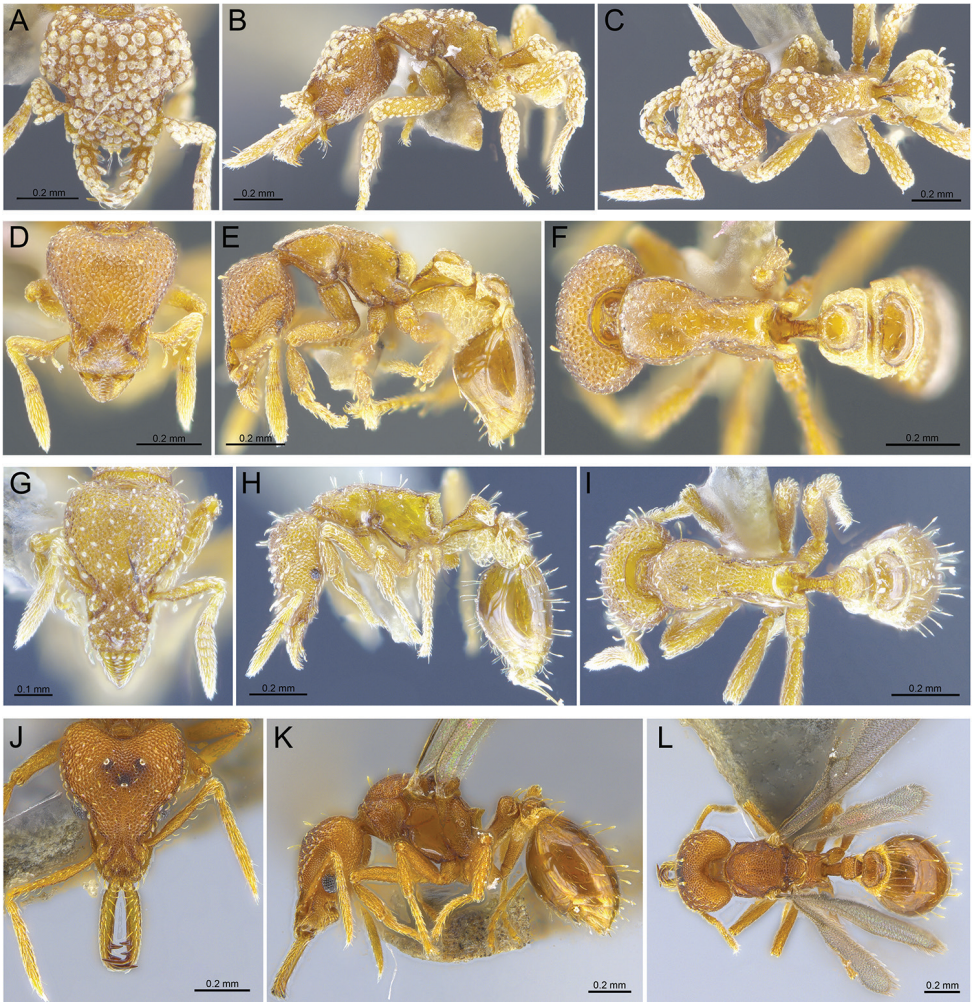

Figure 5. New introduced species records for Hong Kong, in full-face, profile, and dorsal view, respectively **A–C** worker of *S. hexamera* (RHL003477) **D–F** worker of *S. membranifera* (BMW02021) **G–I** worker of *S. nepalensis* (BMW02392) **J–L** queen of *S. rogeri* (ANTWEB1013909).

Measurements. Worker (*n* = 1): HL 0.47, HW 0.50, MandL 0.18, SL 0.22, EL 0.036, PW 0.27, ML 0.53, PL 0.23, PH 0.12, DPW 0.15, PPL 0.16, CI 106, MI 38, SI 44, OI 7, LPI 51, DPI 63. Queen (*n* = 1): TL 2.7, HL 0.54, HW 0.60, MandL 0.20, SL 0.25, EL 0.10, PW 0.37, ML 0.71, PL 0.34, PH 0.17, DPW 0.22, PPL 0.18, GL 0.78, CI 111, MI 37, SI 42, OI 17, LPI 48, DPI 65.

Geographic range. ***Native:*** Japan (mainland and Ryukyu Islands), South Korea, Taiwan.

Introduced: Hong Kong, Ogasawara Islands (Japan), United States.

Ecology. This is a rare species in Hong Kong with only two records, both from secondary forests at elevations of 142 and 160 m (Fig. 2). This species seems to have small monogynous colonies of about 35 individuals (Terayama et al. 2014).

Comments. The record of *S. hexamera* in Hong Kong represents the first record of this species for continental China. This species is known as an introduced species in Southeast USA (Alabama, Florida, Louisiana, and Mississippi), and was reported as introduced within the Ogasawara Islands (Shindo 1979). Here we tentatively classify this species as introduced to Hong Kong in light of its tramp characteristics, including its known thelytokous reproductive strategy (Masuko 2013), and the lack of previous collections in Hong Kong or other parts of mainland China. However, for this species, as for many tramp species across Asia, further study is needed to determine their exact origin and the extent of their native range.

Strumigenys hirsuta sp. n.

http://zoobank.org/CEDE445A-A4B3-4368-AA45-EBEFE44A7483
Figs 6A–C, 7A–C

Diagnosis. Dorsolateral margin of head in full-face view with at most 4 freely laterally projecting flagellate hairs: 1 on the upper scrobe margin posterior to the level of eye, 1 at apicoscrobal position, 0–2 posterior to this on the lateral margin of occipital lobe. Cephalic dorsum, dorsal mesosoma and side of pronotum densely and strongly reticulate-punctate; metapleuron and side of propodeum reticulate-punctate but weaker and fainter than on the dorsum; katepisternum mostly smooth and shining. Dorsal and ventral surfaces of femur with numerous fine erect to suberect hairs. SI 61–63.

Type material. Holotype worker: Hong Kong, Hong Kong Island, Lung Fu Shan, 22.27899N, 114.13717E, 211 m, 18 November 2014 (M. Wong) (collection code F2W-m[2]) [IBBL, ANTWEB1009855]. Paratype workers (n = 5): same data as holotype worker. Holotype queen: same data as holotype worker.

Non-type material examined. 1 queen and 17 workers. HONG KONG: Central & Western District, Lung Fu Shan, 22.279201N, 114.137209E, 12.09.2018, B. Guénard, hand collection, IBBL; Central & Western District, Lung Fu Shan, 22.28039N, 114.13783E, 25.11.2014, 156 m, M. Wong, Winkler, 12 Random, IBBL; Central & Western District, Lung Fu Shan, 22.28221N, 114.133476E, 13.11.2014, 115 m, M. Wong, Winkler, IBBL; Central & Western District, Lung Fu Shan, R.H. Lee, pitfall trap, IBBL; Islands District, Tung Chung, 22.2907N, 113.9371E, 1 m, B.M. Worthington, Winkler, 12 Random, IBBL; Islands District, Tung Chung, 22.2907N, 113.9371E, B.M. Worthington, Winkler, 4 Corners, IBBL; Sai Kung District, Clear Water Bay Country Park, 22.29618N, 114.29239E, 24.10.2017, 113 m, R. Cheung / M. Pierce, Winkler, 12 Random, IBBL; Sai Kung District, Pak Sha O, 22.44743N, 114.3082E, 17.11.2017, 135 m, R. Cheung / M. Pierce, Winkler, 4 Corners, IBBL; Sha Tin District, Tai Po Kau, 22.41678N, 114.1878E, 03.07.2015, 317 m, T. Tsang, Winkler, IBBL; Tai Po District, Ping Shan Chai, 22.486N, 114.187E, 04.06.2016, C. Barthélémy, Malaise

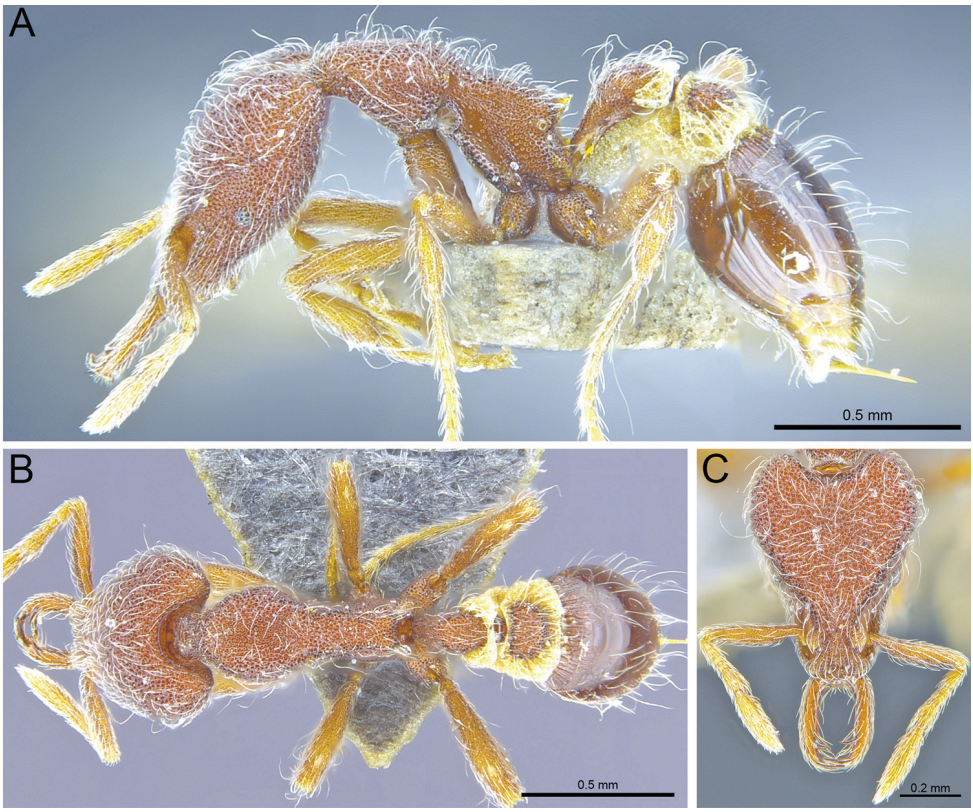

Figure 6. *Strumigenys hirsuta* sp. n. **A–C** Holotype worker (ANTWEB1009855) **A** Profile view **B** dorsal view **C** full-face view.

trap, IBBL; Tai Po District, Tai To Yan, 22.4538N, 114.11937E, 07.08.2015, 459 m, R.H. Lee, Winkler, IBBL; Tuen Mun District, Castle Peak, 22.389935N, 113.954937E, 30.06.2015, 457 m, R.H. Lee, pitfall trap, IBBL; Tuen Mun District, Castle Peak, 22.39012N, 113.958983E, 30.06.2015, 204 m, R.H. Lee, Winkler, IBBL

Measurements. Holotype worker: TL 3.1, HL 0.74, HW 0.55, MandL 0.30, SL 0.35, EL 0.054, PW 0.31, ML 0.79, PL 0.35, PH 0.15, DPW 0.14, PPL 0.22, GL 0.69, CI 75, MI 41, SI 63, OI 10, LPI 42, DPI 40. Paratype workers (n = 5): TL 2.9–3.1, HL 0.71–0.74, HW 0.53–0.55, MandL 0.29–0.30, SL 0.34–0.35, EL 0.050–0.057, PW 0.29–0.31, ML 0.74–0.78, PL 0.32–0.34, PH 0.13–0.15, DPW 0.14, PPL 0.20–0.21, GL 0.63–0.70, CI 73–75, MI 40–42, SI 63–65, OI 9–11, LPI 41–44, DPI 43–45. Holotype queen: TL 3.6, HL 0.78, HW 0.59, MandL 0.31, SL 0.37, EL 0.12, PW 0.38, ML 0.89, PL 0.44, PH 0.19, DPW 0.19, PPL 0.23, GL 0.90, CI 76, MI 40, SI 62, OI 21, LPI 43, DPI 44.

Worker description. (Fig. 6A–C). ***Head.*** In full-face view occipital margin evenly concave; occipital corners well developed and bluntly rounded; anterior clypeal margin transverse to very shallowly concave across its width. Scapes subcylindrical, marginated

but not converging anteriorly to form a thin lamella at the leading edge. Mandible in full-face view long, narrow and elongated, with an elongated preapical tooth located close to the apicodorsal tooth; at the basal third of their length diverging from one another and curving inward, then running straight and parallel at the middle third, and curving inward and converging at the apical third; width of mandible fairly constant from the basal portion to where the preapical tooth first arose; the preapical tooth about the same to slightly longer than the width of mandible at the point where the tooth arises; apicodorsal tooth is markedly longer than apicoventral tooth.

Mesosoma. In profile pronotal dorsum broadly convex, with the rest of the dorsum of the mesosoma more or less flat transversely; pronotum marginate dorsolaterally. In dorsal view, lateral margins of the pronotum evenly convex. Propodeal teeth short, triangular and acute, and not subtended by lamella.

Waist segments. Petiole in profile claviform, the node long and low; the peduncle grade evenly into the node without a marked change of slope; node in dorsal view longer than broad. Disc of the postpetiole in dorsal view very slightly broader than long, and slightly shorter than petiolar node. Spongiform tissues present on both petiole and postpetiole; ventral lobes of petiole and postpetiole extensive. In profile view, spongiform tissues present ventrally on the peduncle of the petiole notably larger than that under the petiolar node portion, and markedly thicker than the height of the peduncle. Lateral lobe of petiole restricted to posterior half of the node in profile; in dorsal view present along the posterior margin of the petiolar node and surrounding the disc of postpetiole.

Pilosity. Dorsolateral margin of head in full-face view with at most 4 pairs of freely laterally projecting flagellate hairs: 1 on the upper scrobe margin posterior to the level of eye, 1 at apicoscrobal position, 0–2 posterior to this on the lateral margin of occipital lobe. Cephalic dorsum, against ground pilosity of short, suberect to decumbent, simple hairs, with several erect flagellate hairs close to the occipital margin but without erect hairs anterior to this. Leading edge of scape with apically directed, decumbent simple hairs. Pronotal humeral hair long, flagellate or looped apically. Dorsum and side of mesosoma covered with ground pilosity of short, suberect hairs arising and curving in various directions. Dorsal and ventral surfaces of femur with numerous fine erect to suberect hairs against ground pilosity of appressed hairs; dorsal surface of tibia and basitarsus with 1–4 long filiform erect hairs on each segment. Petiolar node and postpetiole with numerous erect to suberect, flagellate hairs against ground pilosity of posteriorly directed, shorter decumbent hairs; first gastral tergite with numerous curved to subflagellate erect hairs.

Sculpture. Cephalic dorsum densely and strongly reticulate-punctate. Dorsal mesosoma and side of pronotum densely and strongly reticulate-punctate, occasionally with very weak and faint rugulose; metapleuron and side of propodeum also reticulate-punctate to punctate, with reticulation limited to the dorsal half of the propodeum, and weaker and fainter than on the dorsum or side of pronotum, sometimes even partially smooth and shining; katepisternum mostly smooth and shining, with some light punctation and vestiges of sculpture around the margins. Anterior coxae with weak transverse rugulae. Petiole and disc of postpetiole densely and strongly reticulate-punctate. Basigastral costulae arise across the entire width of tergite, short and limited to the basal third or fourth of tergite.

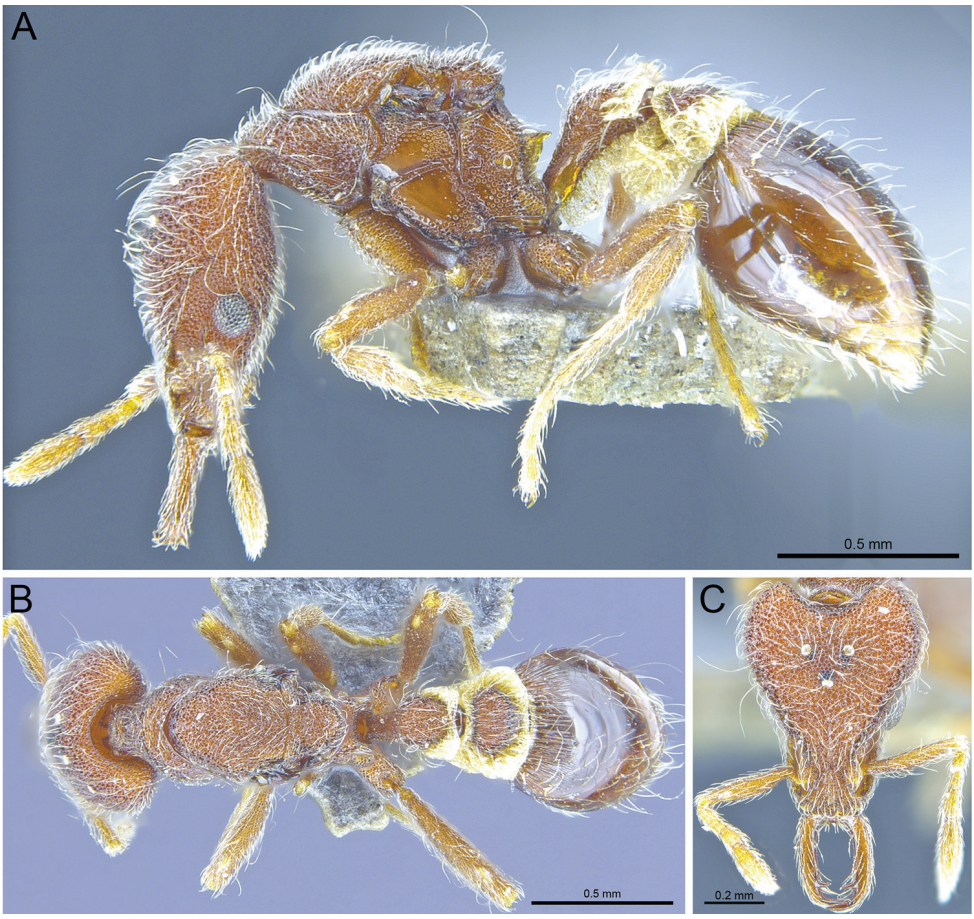

Figure 7. *Strumigenys hirsuta* sp. n. **A–C** holotype queen (ANTWEB1009854) **A** profile view **B** dorsal view **C** full-face view.

Gyne description. (Fig. 7A–C) Similar to all points to the worker caste except for the reproductive caste morphological characters (presence of 3 ocelli, enlarged eyes and thorax), and the following: in profile view, most of anepisternum and katepisternum distinctly smooth and shiny.

Comments. *Strumigenys hirsuta* is a member of the *caniophanes*-complex in the *S. caniophanes*-group and shares all the characters (Bolton 2000). There are six other species (*S. dipsas*, *S. paraposta*, *S. lacunosa*, *S. benulia*, *S. daithma*, and *S. pliocera*) from the species group that also have unsculptured (or at least not completely sculptured) katepisternum as in *S. hirsuta*. In comparison, *S. dipsas* and *S. paraposta* both have reticulate-rugulose sculpture with fine punctulate on the cephalic dorsum, and predominant longitudinal rugulose sculpture on the pronotal dorsum (instead of simply predominant reticulate-punctate on both cephalic and pronotal dorsum as in *S. hirsuta*); *S. lacunosa*, *S. benulia*, and *S. daithma* have their entire pleurae and side of pro-

podeum mostly smooth (instead of katepisternum only); *S. pliocera* has no erect hairs on the dorsal surface of its hind femur, unlike *S. hirsuta*.

Strumigenys hirsuta (HL 0.71–0.74, HW 0.53–0.55, ML 0.74–0.78) is a smaller species than *S. dipsas* (HL 0.80–0.86, ML 0.87–0.90) and *S. pliocera* (HL 0.89, ML 0.90); and a larger species than *S. benulia* (HL 0.56, HW 0.39, ML 0.56). *Strumigenys hirsuta* (SI 63–65) also has a markedly relatively shorter scape than those 6 species from the *caniophanes*-complex: *S. benulia* (SI 72), *S. dipsas* (SI 73–76), *S. paraposta* (SI 73–78), *S. lacunosa* (SI 75), *S. daithma* (SI 85), and *S. pliocera* (SI 84).

Etymology. The species is named for the multiple standing and convoluted hairs present on most of the body.

Geographic range. Hong Kong.

Ecology. *Strumigenys hirsuta* appears to be widespread in Hong Kong and has been collected from multiple locations in Hong Kong Island, the New Territories, and Lantau Island (Fig. 2). Considering the widespread distribution of this species in Hong Kong and its association with disturbed secondary forests or forest remnants, we hypothesize that the geographic range of this species might extend further. It seems likely that this species also occurs in Guangdong province (China). The known elevation range is from 1 to 459 m.

Strumigenys kichijo (Terayama, Lin & Wu, 1996) – new record

Fig. 8A–C

Smithistruma kichijo Terayama Lin and Wu 1996: 335, figs 23–25, 28, 29 (w.) TAIWAN. Indomalaya.

Pyramica kichijo (Terayama, Lin & Wu, 1996). Combination in *Pyramica*: Bolton 1999: 1673.

Strumigenys kichijo (Terayama, Lin & Wu, 1996). Combination in *Strumigenys*: Baroni Urbani and De Andrade 2007: 122.

Material examined. HONG KONG: Islands District, Sunset Peak, 22.26112N, 113.956332E, 572 m, 28.03.2016, R.H. Lee, Winkler, IBBL.

Measurement. Workers (n = 3): TL 2.5–2.6, HL 0.59, HW 0.46–0.47, MandL 0.14–0.16, SL 0.32–0.33, EL 0.045–0.049, PW 0.30, ML 0.61–0.66, PL 0.31–0.33, PH 0.14–0.15, DPW 0.17–0.18, PPL 0.23–0.24, GL 0.60–0.62, CI 78–80, MI 24–27, SI 70, OI 10, LPI 45–48, DPI 53–58.

Geographic range. Bhutan, China (Fujian, Hunan, Yunnan, Hong Kong), Japan, Taiwan, Thailand, Vietnam.

Ecology. This is a rare species for Hong Kong with a single worker collected (Fig. 2) in secondary forest at a relatively high elevation (572 m).

Comments. This is a widespread species in Asia, though rarely collected. The new record from Hong Kong fits within the known range of this species, which ranges in Asia from Hunan (north) to Thailand (south), and from Bhutan (west) to Okinawa (east).

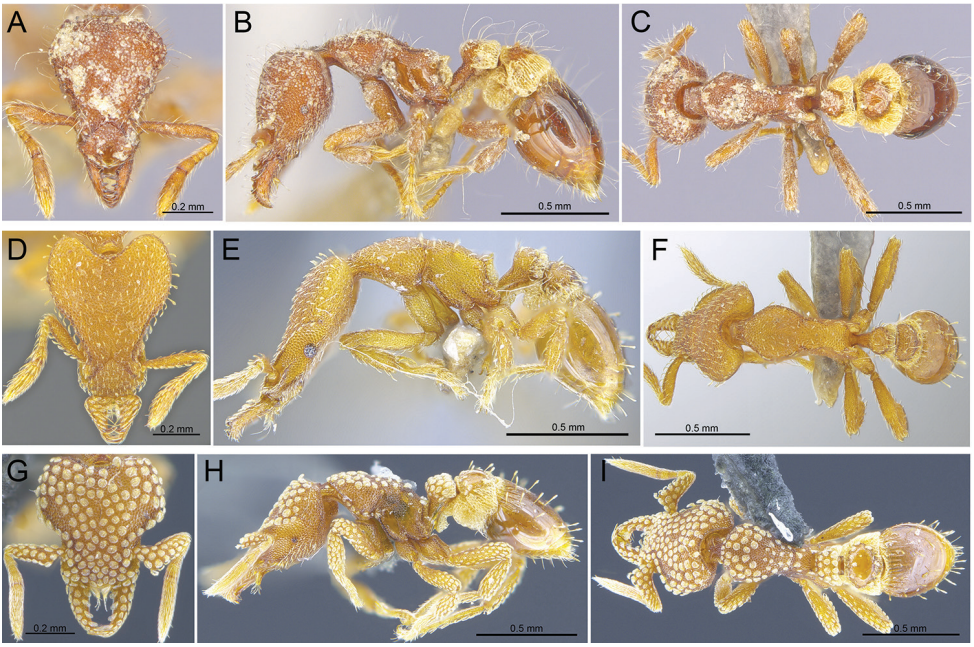

Figure 8. New species records for Hong Kong, in full-face, profile, and dorsal view, respectively **A–C** worker of *S. kichijo* (RHL003471) **D–F** worker of *S. sydorata* (RHL003404) **G–I** worker of *S. tisiphone* (RHL02818).

***Strumigenys lantaui* sp. n.**
http://zoobank.org/A577ADFF-6CCB-4E1B-A7FE-6F803A0C64EC
Fig. 9A–D

Diagnosis. Anterior clypeal margin medially shallowly convex with 6 anteriorly projecting strap-like hairs; lateral margin each with 3 anteriorly directed spatulate hairs that are smaller than those on the clypeal margin. Mandibles without preapical tooth. Antenna 4-segmented. Orbicular hairs present on dorsal surface of scapes, head, pronotum and mesonotum. Mesonotum in profile not forming a differentiated surface between pronotum and propodeum.

Type material. Holotype worker: Hong Kong, Lantau Island, Penny's Bay, 22.3271N, 114.0335E, 9 m, 25 October 2017 (M. Pierce) (collection code WC-PB-NON-06), Winkler [IBBL, ANTWEB1009620]. Paratype workers (n = 2): same data as holotype.

Measurements. Holotype worker: TL 1.6, HL 0.36, HW 0.31, MandL 0.10, SL 0.18, EL 0.026, PW 0.20, ML 0.39, PL 0.19, PH 0.09, DPW 0.11, PPL 0.13, GL 0.40, CI 86, MI 28, SI 58, OI 8, LPI 51, DPI 57. Paratype workers (n = 2): TL 1.6–1.7, HL 0.37, HW 0.32–0.33, MandL 0.10–0.11, SL 0.19, EL 0.019–0.022, PW 0.21, ML 0.41, PL 0.19, PH 0.10, DPW 0.11, PPL 0.13–0.14, GL 0.43–0.45, CI 86–89, MI 27–30, SI 58–59, OI 6–7, LPI 53, DPI 55–57.

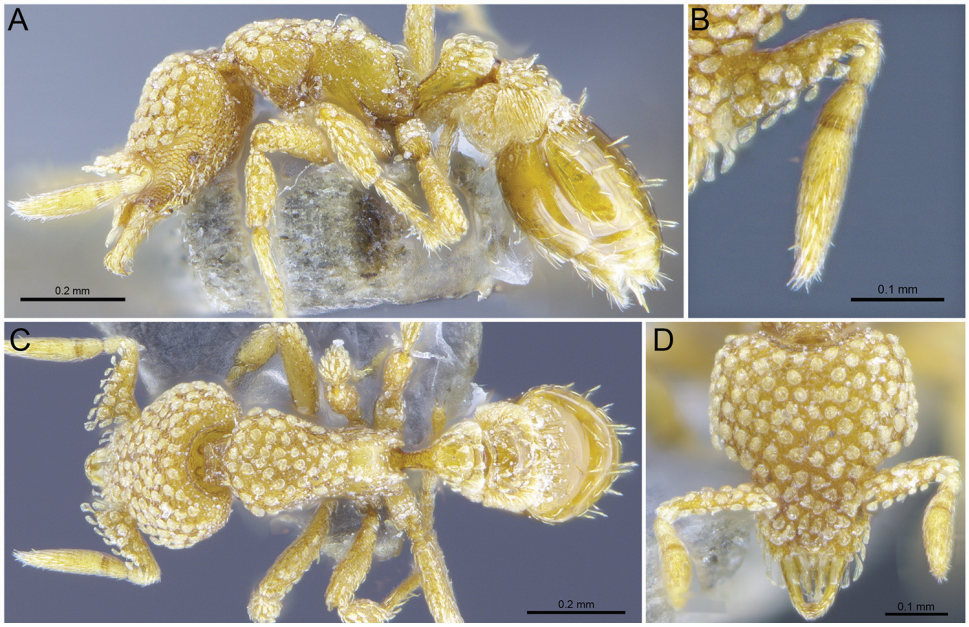

Figure 9. *Strumigenys lantaui* sp. n. **A–D** holotype worker (ANTWEB1009620) **A** profile view **B** close-up on the antenna **C** dorsal view **D** full-face view.

Worker description. ***Head.*** In full-face view occipital margin broadly concave; occipital corner evenly rounded; lateral margin broadly convex and slightly diverging from one another, then forming blunt angle with the strongly converging upper scrobe margin; anterior clypeal margin broadly concave across its width. In profile vertex at or near its highest point evenly curved and convex, without a raised transverse crest. Antenna 4-segmented; scape dorsoventrally flattened and board; subbasal angle expanded anteriorly into a large subbasal lobe. Mandible in full-face view narrow, elongate, curvilinear and without preapical tooth. Proximal to apices with a prominent diastema between the mandibles, through which the labral lobes are visible. Apex of mandible with a nearly vertical series of minute teeth or denticles; apicoventral teeth markedly enlarged.

Mesosoma. In profile view the dorsum of mesosoma broadly, shallowly convex; pronotum bluntly marginate laterally; mesonotum not forming a differentiated surface between pronotum and propodeum; in dorsal view lateral margin with a bluntly rounded angle on each side and meet anteriorly into a broadly convex anterior margin. Propodeum unarmed, declivity with a lamella running down each side.

Waist segments. Petiole in profile elongate and subclavate; peduncle does not grade evenly into the node; node in dorsal view long about the same as broad. Disc of postpetiole in dorsal view broader than long and slightly shorter or about the same as petiolar node. Spongiform tissues present on both petiole and postpetiole; ventral lobes of postpetiole in particular extensive; lateral lobe of petiole restricted to posterior

portion of the node in profile; in dorsal view present along the posterior margin of the petiolar node, and surrounding disc of postpetiole.

Pilosity. Anterior clypeal margin with 6 anteriorly projecting strap-like hairs; lateral margin each with 3 anteriorly directed spatulate hairs that are smaller than those on clypeal margin. Leading edge of scape with row of basally directed spatulate hairs. Orbicular hairs present on dorsal surface of scapes and all over the cephalic dorsum, including clypeal dorsum, and promesonotal dorsum; dorsal surface of mandibles with short appressed simple or spatulate hairs. Dorsal surfaces of tibiae with short appressed spatulate hairs. Petiolar node and disc of postpetiole with posteriorly directed spatulate hairs, and at most a few decumbent to suberect short simple hairs on the disc of postpetiole; first gastral tergite with numerous short, simple standing hairs.

Sculpture. Cephalic dorsum, including surface of antennal scrobe and antenna, areolate. Dorsum of mesosoma and side of pronotum areolate to densely reticulate-punctate, and with fine reticulopunctate; mesopleuron and side of propodeum mostly smooth and shining, while in some specimens those can appear opaquer but with undefined sculpture. Dorsum of petiolar node and disc of postpetiole generally smooth and shining; basigastral costulae short and arise across entire width of tergite.

Comments. *Strumigenys lantaui* is a member of the *argiola*-complex in the *S. argiola*-group and shares all the characters (Bolton 2000). *S. lantaui* is well distinguished from all other Oriental species in the species group by its 4-segmented antennae, and absence of any scale-like, orbicular, or spoon-shaped hairs on the surface of the mandibles. In addition, unlike *S. hirashimai* or *S. lachesis*, projecting strap-like hairs on the anterior clypeal margin are not directed nor curved towards the midline. It is unlike *S. hexamera* and *S. tisiphone*, in the absence of preapical teeth, and the mesonotum, in profile, not forming a differentiated surface between pronotum and propodeum.

Strumigenys lantaui (HL 0.36–0.37, HW 0.31–0.33, ML 0.39–0.41) is also a smaller species than all other Oriental species in the species group: *S. hirashimai* (HL 0.40–0.46, HW 0.36–0.40, ML 0.42–0.48), *S. lachesis* (HL 0.39, HW 0.39, ML 0.42), *S. hexamera* (HL 0.50–0.53, HW 0.53–0.55, ML 0.57–0.60), *S. tisiphone* (HL 0.50, HW 0.48, ML 0.53), and *S. sinensis* (HL 0.52, HW 0.46, ML 0.50).

Etymology. This species is named after Lantau Island, the type locality and currently only known location for the species.

Geographic range. Hong Kong.

Ecology. *Strumigenys lantaui* is currently only known from a single location (Fig. 2) where it was collected by leaf-litter extraction at the inner edge of a secondary forest.

Strumigenys mazu (Terayama, Lin & Wu, 1996) – First recorded in Hong Kong in 2000 (Bolton 2000).

Smithistruma mazu Terayama Lin and Wu 1996: 337, figs 26, 27, 30, 31 (w.) TAIWAN. Indomalaya.

Pyramica mazu (Terayama, Lin & Wu, 1996). Combination in *Pyramica*: Bolton 1999: 1673.

Strumigenys mazu (Terayama, Lin & Wu, 1996). Combination in *Strumigenys*: Baroni Urbani and De Andrade 2007: 123.

Material examined. HONG KONG: Sha Tin District, Tai Po Kau, 22.42007N, 114.1829E, 02.07.2015, 291 m, T. Tsang, Winkler, IBBL; Tsuen Wan District, Tai Lam Country Park, 22.38109N, 114.05511E, 8.XI.2017, 254 m, R. Cheung / M. Pierce, ANTWEB1016463, Winkler, IBBL.

Geographic range. China (Guangxi), Hong Kong, Japan, Taiwan.

Ecology. This is an uncommon species in Hong Kong where it is known only from a few locations (Fig. 10). This species occurs in secondary forests at elevations ranging from 262 to 291 m. It apparently forms small monogynous colonies of about 20 individuals (Masuko 2009b).

Strumigenys membranifera Emery, 1869 – new record

Fig. 5D–F

Strumigenys (Trichoscapa) membranifera Emery 1869: 24, fig. 11 (w.) ITALY. Palearctic.

Strumigenys (Cephaloxys) membranifera (Emery, 1869). Combination in *Strumigenys (Cephaloxys)*: Emery 1916: 205.

Trichoscapa membranifera (Emery, 1869). Combination in *Trichoscapa*: Brown 1948: 113.

Pyramica membranifera (Emery, 1869). Combination in *Pyramica*: Bolton 1999: 1673.

Strumigenys membranifera (Emery, 1869). Combination in *Strumigenys*: Baroni Urbani and De Andrade 2007: 123.

Senior synonym of *S. foochowensis*, *S. membranifera marioni*, *S. membranifera santschii*, *S. silvestriana*, *S. membranifera simillima*, *S. vitiensis*, *S. membranifera williamsi*: Brown 1948: 114.

Material examined. HONG KONG: Islands District, Chek Lap Kok, 22.2947N, 113.9336E, 21 m, B.M. Worthington, Winkler, 4 Corners, IBBL; Islands District, Chek Lap Kok, 22.2953N, 113.9354E, 28 m, B.M. Worthington, Winkler, 12 Random, IBBL; Islands District, Chek Lap Kok, 22.2953N, 113.9354E, B.M. Worthington, Winkler, 12 Random, IBBL; Islands District, Chek Lap Kok, 22.2957N, 113.9338E, 15 m, B.M. Worthington, Winkler, 12 Random, IBBL; Islands District, Chek Lap Kok, 22.2957N, 113.9338E, 15 m, B.M. Worthington, Winkler, 4 Corners, IBBL; Islands District, Chek Lap Kok, 22.2957N, 113.9338E, B.M. Worthington, Winkler, 12 Random, IBBL; Islands District, Chek Lap Kok, 22.3139N, 113.9398E, 2 m, B.M. Worthington, Winkler, 4 Corners, IBBL; Islands District, Chek Lap Kok, 22.3139N, 113.9398E, B.M. Worthington, Winkler, 12 Random, IBBL; Islands District, Chek Lap Kok, 22.3153N, 113.9407E, B.M. Worthington, Winkler, 12 Random, IBBL; Islands District, Chek Lap Kok, 22.3153N, 113.9407E, B.M. Worthington, Winkler, 4

Corners, IBBL; Islands District, Disneyland, 22.309433N, 114.04575E, 19.07.2016, B. Guénard, Gut content Water Dragon, IBBL; Tai Po District, Ping Shan Chai, 22.486N, 114.187E, 13.06.2015, C. Barthélémy, Malaise trap, IBBL; Tai Po District, To Kwa Peng, 22.42901N, 114.3336E, 25.05.2018, 1 m, R. Cheung / C. Taylor, Malaise trap, IBBL; Yuen Long District, Lok Ma Chau, 22.51031N, 114.06376E, 16.05.2018, 1 m, M. Wong, pitfall trap, IBBL; Yuen Long District, Lok Ma Chau, 22.51287N, 114.06463E, 17.07.2018, 1 m, M. Wong, pitfall trap, IBBL.

Measurements. Workers (n = 5): TL 1.9–2.1, HL 0.45–0.47, HW 0.40–0.41, MandL 0.08–0.09, SL 0.20–0.23, EL 0.029–0.037, PW 0.22–0.24, ML 0.49–0.53, PL 0.22–0.26, PH 0.13–0.15, DPW 0.14–0.15, PPL 0.15–0.18, GL 0.47–0.53, CI 87–91, MI 17–20, SI 49–56, OI 7–9, LPI 55–58, DPI 54–61.

Geographic range. *Native:* Ghana, Sierra Leone, South Africa

Introduced: a widespread species in multiple biogeographic realms. For a full global account, please refer to records presented under antmaps.org (Janicki et al. 2016, Guénard et al. 2017). Here, the Asian distribution is presented for the Oriental (China: Guangdong, Hong Kong, Yunnan; India; Taiwan) and Sino-Japanese realms (Bhutan, China: Fujian, Sichuan; Japan: Honshu, Kyushu, Ryukyu Islands, Shikoku; Nepal).

Ecology. This is a species restricted to habitats with frequent disturbance, particularly within lowland areas (Hong Kong Airport, Disneyland, and Mai Po Nature Reserve) covered with grasslands or remnants of forests within urbanized matrices (Fig. 10). One alate female was collected in a Malaise trap between the June 13–27, suggesting potential swarming during this period in Hong Kong. Elevation ranged from 1 to 29 m, with the exception of an alate gyne collected at an elevation of 142 m. This species forms relatively large colonies of about 250 individuals (up to 350 individuals; Ito et al. 2010).

Comments. The record of this tramp species in Hong Kong is not surprising considering its widespread range in the region and previous records in the nearby provinces of Guangdong and Fujian as well as from Macau for 90 years (Wheeler 1928), while extending further west in China to Yunnan. Considering the widespread range of this species in tropical and subtropical regions, it appears likely that this species is already present in two other provinces of China: Guangxi and Hainan. Future sampling efforts, in particular within urban habitats, could support this hypothesis.

Strumigenys minutula Terayama & Kubota, 1989 – First recorded in Hong Kong in 2000 (Bolton 2000)

Strumigenys minutula Terayama and Kubota 1989: 782, figs 13–17 (w.q.) TAIWAN. Indomalaya.

Material examined. HONG KONG: Central & Western District, Lung Fu Shan, 22.28221N, 114.133476E, 115 m, 13.11.2014, M. Wong, Winkler, 12 Random, IBBL; North District, H.W. Hang, 22.52819N, 114.2006E, 29 m, 14.06.2015, T. Tsang, Winkler, IBBL; North District, Lai Chi Wo, 22.527N, 114.258E, 08.05.2015, R.H. Lee, Winkler,

IBBL; Sai Kung District, Pak Tam Chung, 22.454795N, 114.118215E, 05.06.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.4198N, 114.1839E, 18.05.2016, B. Guénard, hand collection, IBBL; Southern District, Nam Fung Road, 22.25291N, 114.1877E, 70 m, 10.10.2015, T. Tsang, Winkler, IBBL; Southern District, Nam Fung Road, 22.25554N, 114.1802E, 01.10.2015, 110 m, T. Tsang, Winkler, IBBL; Tsuen Wan District, Lin Fa Shan, 22.3956N, 114.0885E, 15.07.2016, R.H. Lee, pitfall trap, IBBL.

Ecology. This is a rather uncommon species collected from tree plantation, secondary forest, and Feng Shui woods (Fig. 10). The known elevation range of this species in Hong Kong is from 29 to 475 m. A colony of *S. minutula* including three dealate queens, 47 workers, 97 pupae, and 80 larvae were collected in a log at Tai Po Kau on May 18, 2016. The presence of multiple queens and the high number of pupae and larvae retrieved indicate that functional polygyny and large colony size (300 individuals) as previously reported occur within this species (Terayama et al. 2014). A single alate gyne was collected between June 26 and July 10 in a Malaise trap located within a mangrove area.

Strumigenys mitis (Brown, 2000) – First recorded in Hong Kong in 1994 (Fellowes 1996)

Pyramica mitis Brown 2000: 442, figs 267, 290 (w.q.) PHILIPPINES. Indomalaya.
Strumigenys mitis (Brown, 2000). Combination in *Strumigenys*: Baroni Urbani and De Andrade 2007: 124.

Material examined. HONG KONG: Central & Western District, Lung Fu Shan, 22.27896N, 114.13601E, 244 m, 20.11.2014, M. Wong, Winkler, 4 Corners, IBBL; Islands District, Sunset Peak, 22.26084N, 113.95753E, 03.06.2015, R.H. Lee, Winkler, IBBL; Islands District, Sunset Peak, 22.26392N, 113.95376E, 03.06.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.42706N, 114.179996E, 06.06.2017, R.H. Lee, pitfall trap, IBBL; Southern District, Aberdeen Reservoir, 22.25964N, 114.16251E, 29.06.2015, R.H. Lee, Winkler, IBBL; Southern District, Aberdeen Reservoir, 22.26N, 114.162E, 26.06.2015, R.H. Lee, Winkler, IBBL; Southern District, Nam Fung Road, 22.25291N, 114.1877E, 10.10.2015, 70 m, T. Tsang, Winkler, IBBL; Tai Po District, Kadoorie Centre, 22.4291N, 114.11491E, 08.09.2015, R.H. Lee, Winkler, IBBL; Tsuen Wan District, Ha Lin Fa Shan, 22.39664N, 114.1019E, 30.07.2015, 355 m, T. Tsang, Winkler, IBBL; Tsuen Wan District, Ha Lin Fa Shan, 22.39854N, 114.0966E, 410 m, 18.07.2015, T. Tsang, Winkler, IBBL; Tsuen Wan District, Lin Fa Shan, 22.3956N, 114.0885E, 15.07.2016, R.H. Lee, Winkler, IBBL; Tsuen Wan District, Tai Mo Shan, 22.416073N, 114.125158E, 09.06.2015, R.H. Lee, pitfall trap, IBBL; Tsuen Wan District, Tai Mo Shan, 22.416073N, 114.125158E, 21.06.2016, R.H. Lee, pitfall trap, IBBL.

Ecology. Although this species is not among the most commonly collected, it was found in a wide range of habitats and elevation, including grasslands, shrublands, tree plantations (e.g. *L. confertus*), and secondary forest at elevation ranging from 70 to 809

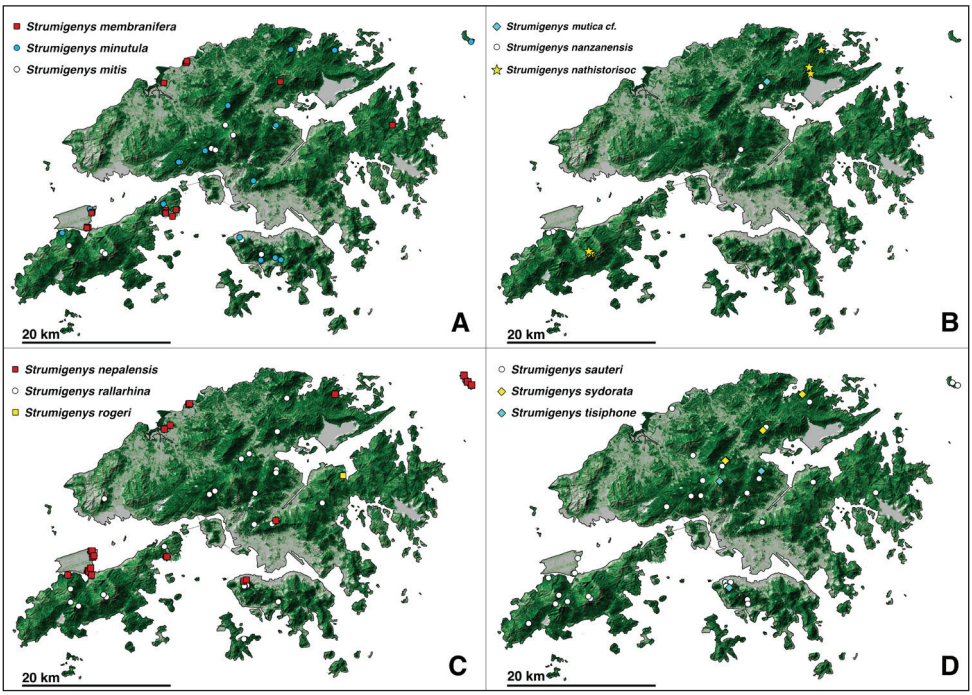

Figure 10. Distribution of *Strumigenys* species in Hong Kong **A** *S. membranifera*, *S. minutula*, and *S. mitis* **B** *S.* cf. *mutica*, *S. nanzanensis*, and *S. nathistorisoc* sp. n. **C** *S. nepalensis*, *S. rallarhina*, and *S. rogeri** **D** *S. sauteri*, *S. sydorata*, and *S. tisiphone*. Circles represent species previously recorded from Hong Kong, diamonds represent newly recorded species, and stars represent new species. Newly recorded introduced species are shown with red squares. Green shaded portions of the map correspond with higher levels of tree cover, and grey with lower levels of tree cover. *To avoid confusion, *S. rogeri* (a newly recorded introduced species) is represented by a yellow square instead of a red square.

m (Fig. 10). Colonies apparently can be relatively small in size with about 50 individuals (Mezger and Pfeiffer 2008).

Strumigenys cf. *mutica* (Brown, 1949) – New record

Fig. 11A–C

Material examined. HONG KONG: Tai Po District, Ping Shan Chai, 22.486N, 114.187E, 142 m, 3.VI.2017 to 30.VI.2017, C. Barthélémy, ANTWEB1016246, Malaise trap, IBBL.

Measurements. Alate females (n = 2): TL 2.2–2.5, HL 0.51–0.57, HW 0.39–0.41, MandL 0.13–0.14, SL 0.33–0.38, EL 0.14–0.16, PW 0.28–0.35, ML 0.58–0.68, PL 0.22–0.24, PH 0.19–0.20, DPW 0.13, PPL 0.11–0.13, GL 0.61–0.73, CI 72–76, MI 25, SI 85–92, OI 36–39, LPI 84–86, DPI 55–59.

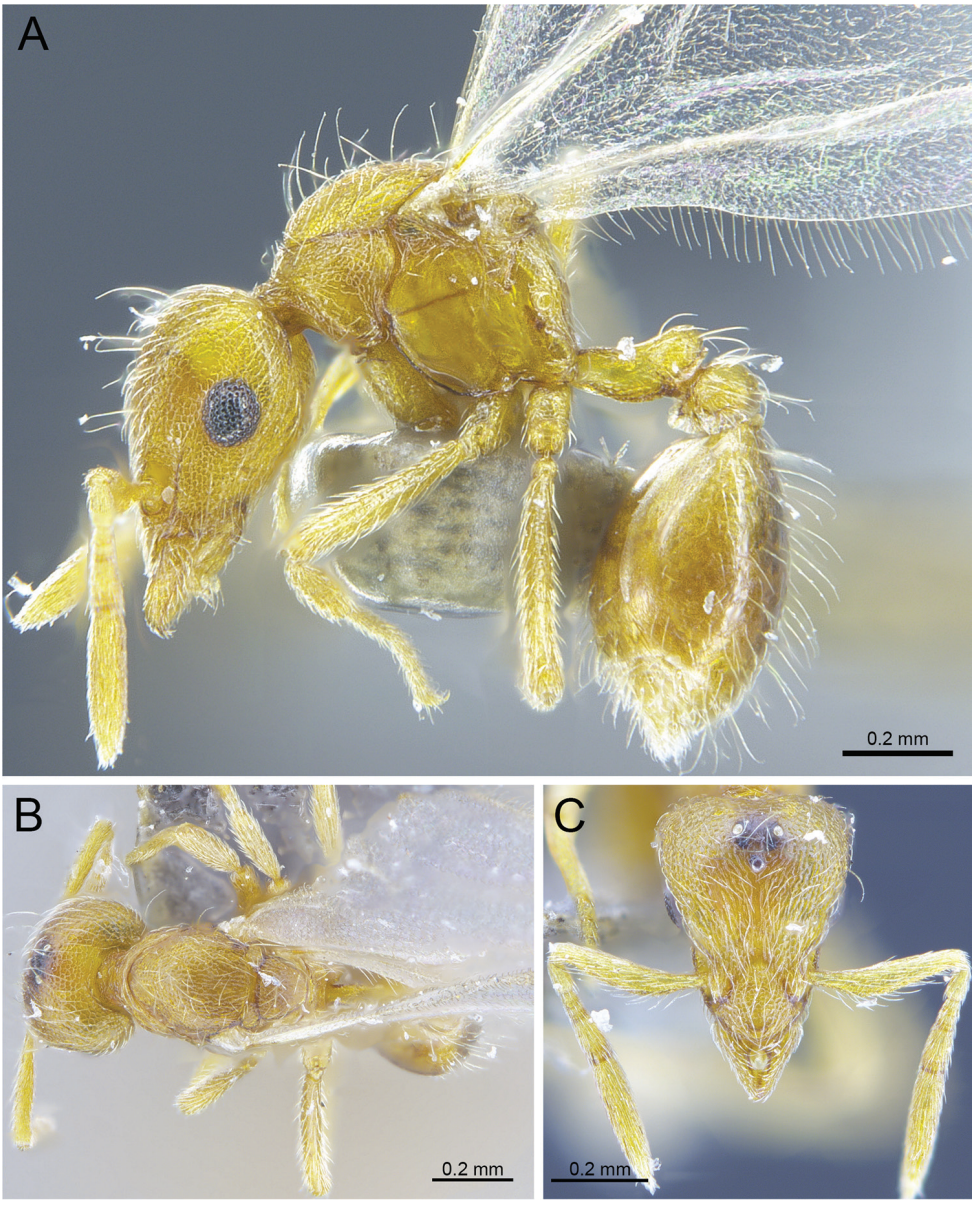

Figure 11. *Strumigenys* cf. *mutica* **A–C** queen (ANTWEB1016246(1)) **A** profile view **B** dorsal view **C** full-face view.

This species is known in Hong Kong from two alate females. The shape of the mandibles, including the conspicuous diastema and dentition suggests that this species belongs to the *S. mutica*-group as defined by Bolton (2000). However, this species differs from other Asian species in this group, defined on the basis of the worker caste, by the absence of spatulate or spoon-shaped hairs, instead having elongate fine hairs covering the body. However, the queen caste of *S. mutica* was originally described as

a separate species, *Kyidris nuda* (Brown 1949), but then synonymized with *S. mutica* on the basis of complete nest series reared in laboratory conditions (Brown 1952). The fine hairs on queens of *S. mutica* were described by Brown (1949) as short and pointed, which we confirmed after examination of photographs of the holotype of *K. nuda* (Japanese Ant Image Database 2006, pictures PCD2228–48, 49 & 50). This is contrary to our specimens, which possess long suberect and erect fine hairs (Fig. 11A–C). According to Brown (1949), queens of *S. mutica* also possess a densely punctulate-granulose mesonotal surface, while our specimens show a punctuate to finely strigate mesonotal surface, with shiny and smooth anepisternum and katepisternum. Unfortunately, we were not able to examine the queen specimen of *S. mutica* in great detail. While the specimens collected in Hong Kong might represent a new species within the *S. mutica*-group, we do not think that at this point enough evidence could be gathered to describe those as a new species. Future collection of workers or new available material of gynes collected in Taiwan or Japan might help solve this problem.

Ecology. Very little is known about the ecology of *S. mutica*, as only two alate individuals collected in a secondary forest by Malaise traps are known (Fig. 10).

Comments. Two species within the *S. mutica*-group have been recorded in nearby regions, *S. mutica* in mainland China (Guangxi, Hunan), Japan, South Korea, and Taiwan, and *S. takasago*, endemic to Taiwan. The latter species also differs from our specimens by its larger size (HL 0.70, HW 0.63), the conspicuous presence of erect spoon-shaped hairs on the body, and the acute propodeal declivity (Terayama et al. 1995).

Strumigenys nanzanensis Lin & Wu, 1996 – First recorded in Hong Kong in 1993 (Fellowes 1996; Bolton 2000)

Strumigenys nanzanensis Lin and Wu 1996: 148, figs 13, 30–34 (w.q.) TAIWAN. Indomalaya.

Material examined. HONG KONG: Tai Po District, Ping Shan Chai, 22.486N, 114.187E, 02.05.2015, C. Barthélémy, Malaise trap, IBBL; Tai Po District, Ping Shan Chai, 22.486N, 114.187E, 09.04.2016, C. Barthélémy, Malaise trap, IBBL; Tsuen Wan District, Shing Mun Reservoir, 22.39718N, 114.15273E, 230 m, 06.07.2011, P. Ward, sifted litter, IBBL.

Ecology. This is a relatively rare species in Hong Kong known only from secondary forests at elevations between 143 and 230 m (Fig. 10).

Strumigenys nathistorisoc sp. n.

http://zoobank.org/039F77DA-9AE1-4293-94B2-10D1332FFD77
Fig. 12A–D

Diagnosis. Dorsum of head, scape, and mandibles covered with appressed spatulate hairs, but no standing hairs. Side of mesosoma generally smooth and shining. Elon-

gated propodeal spines subtended by narrow concave lamellae. Masticatory margin of mandibles engaging only at the apical half (or slightly less than half) of their lengths, with a prominent diastema proximal to this and first 3 preapical teeth not reaching their counterpart from the opposing mandible. Dentition consisting of a small conical tooth, a series of alternating long conical teeth and low round teeth, a crowded series of minute denticles at the down curvature of the apex of mandible, and a small conical apical tooth.

Type material. Holotype worker: HONG KONG: Islands District, Lantau Island, Sunset Peak, 22.263923N, 113.953762E, 467 m, 3 June 2015 (R.H. Lee) (collection code RHL-HK-LSP-T3WM) [IBBL, ANTWEB1016948]. Paratype workers (n = 26): same data as holotype.

Non-type material examined. Islands District, Sunset Peak, 22.26112N, 113.956332E, 572 m, 03.06.2015, R.H. Lee, Winkler, IBBL; North District, Lai Chi Wo, 22.527N, 114.258E, 08.05.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Wu Kau Tang, 22.49645N, 114.2441E, 29 m, 25.10.2015, T. Tsang, Winkler, IBBL; Tai Po District, Wu Kau Tang, 22.5046N, 114.2422E, 115 m, 21.10.2015, T. Tsang, Winkler, IBBL.

Measurements. Holotype worker: TL 3.2, HL 0.72, HW 0.57, MandL 0.24, SL 0.33, EL 0.068, PW 0.27, ML 0.79, PL 0.37, PH 0.15, DPW 0.15, PPL 0.26, GL 0.81, CI 79, MI 33, SI 58, OI 12, LPI 41, DPI 40. Paratype workers (n = 26): TL 2.9–3.3, HL 0.67–0.75, HW 0.51–0.60, MandL 0.22–0.25, SL 0.30–0.35, EL 0.064–0.080, PW 0.25–0.30, ML 0.75–0.86, PL 0.34–0.40, PH,0.15–0.18 DPW 0.14–0.17, PPL 0.22–0.26, GL 0.72–0.87, CI 76–81, MI 30–34, SI 56–62, OI 11–15, LPI 42–45, DPI 39–44.

Worker description. (Fig. 12A–D) ***Head.*** In full-face view occipital margin deeply, evenly concave; occipital corners well developed and bluntly angular. Clypeus, with a broadly convex anterior margin, in full-face view roughly resembling an inverted diamond-shape, broader than long; with a clear colour differentiation from the rest of the cephalic dorsum. Scapes subcylindrical, marginated but not converging anteriorly to form a thin lamella at leading edge. Mandibles in full-face view elongate and narrow, linear and very slightly curved; basal lamellae low and broadly triangular, not fully visible at full closure of the mandibles; in profile view robust with the apical half enlarged, portion following midpoint distinctively raised then curving downwards apically. Masticatory margins engage only at apical half (or slightly less than half) of their lengths; proximal to this is a prominent diastema between the mandibles, through which the labral lobes are visible.

Dentition. Basal most preapical tooth small and conical, sometimes followed by a small denticle; the following tooth also conical, larger and longer; the third tooth low and rounded; in full-face view all first three teeth located on the basal half of the mandible and not reaching their counterpart from the opposing mandible when the mandibles are fully closed. Distal to these, the fourth tooth conical and slightly curved, being the longest of the preapical teeth; the fifth tooth low and rounded, sometimes almost squircle in shape, wider and longer than the third tooth; the sixth tooth conical, similar in length to second tooth; all these three teeth fully engaging with their counterparts from the opposing mandible and are visible in full-face view. Apex of mandible at the down curvature, in anterior view, with a crowded series of around 11 minute denticles, terminating with a small conical apical tooth.

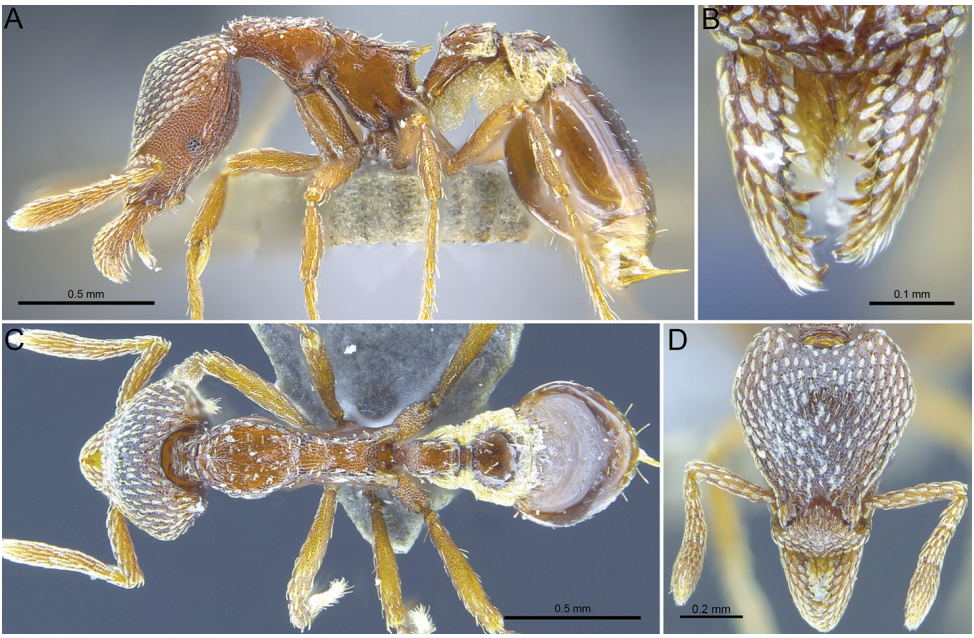

Figure 12. *Strumigenys nathistorisoc* sp. n. **A, C, D** Holotype worker (ANTWEB1016948), **B** paratype worker (ANTWEB1009636) **A** profile view **B** close-up on the mandibles in anterodorsal view **C** dorsal view **D** full-face view.

Mesosoma. In profile view the dorsum of mesosoma more or less flat transversely, except for a slight depression at the mesonotum immediately posterior to the pronotum; pronotum marginate dorsolaterally. In dorsal view, lateral margins of the pronotum evenly convex. Propodeum spines elongate acute triangular, subtended on each side by a very narrow concave lamella that broadens slightly basally into a small rounded convex propodeal lobe.

Waist segments. Petiole in profile elongate and subclavate; peduncle does not grade evenly into the node, and about as long as (or slightly shorter than) the node; node in dorsal view longer than broad. Disc of the postpetiole in dorsal view broader than long, and slightly shorter than petiolar node. Spongiform tissues present on both petiole and postpetiole; ventral lobes of petiole and postpetiole extensive; lateral lobe of petiole merely a small flap at the posterolateral angle of the node in profile; in dorsal view present along the posterior margin of the petiolar node, and surrounding the disc of postpetiole, thicker along the posterior margin than that on the anterior margin.

Pilosity. Cephalic dorsum in profile without standing hairs. In full-face view cephalic dorsum covered in rows of anteriorly directed appressed spatulate hairs that are slightly inclined toward the midline; no laterally projecting standing hair; cephalic dorsolateral margin, from the anterolateral margin of the occipital lobe to the frontal carina, with anteriorly directed appressed hairs; leading edge of scape with apically directed, appressed spatulate hairs, and an additional 2 or 3 rows of similar hairs on the

surface of the scape. In full-face view, dorsal masticatory margin of mandibles with a row of anteriorly directed spatulate hairs that slightly inclined toward the midline; rest of dorsal surface of mandibles also densely covered in rows of similar hairs. Pronotal dorsum covered sparsely with appressed spatulate hairs directed toward the midline; row of similar appressed hairs on the dorsolateral margins of the pronotum. Propodeal dorsum with a few posteriorly directed, suberect to decumbent short simple hairs; a few similar hairs on the dorsolateral margin of the petiolar node and postpetiole. First gastral tergite with sparse, very short suberect simple hairs; in dorsal view with 1 or 2 pairs of simple apical erect hairs positioned laterally.

Sculpture. Cephalic dorsum, excluding clypeal dorsum, sparsely reticulate-rugulose, with spaces between rugulae densely areolate-rugulose; clypeal dorsum densely reticulate-rugulose; surface of antennal scrobe, antenna and mandibles densely reticulate-punctate. Pronotal dorsum faintly reticulate-rugulose; mesonotal and propodeal dorsum densely reticulate-punctate; side of mesosoma generally smooth and shining, with vestiges of sculpture around margins. Dorsum of petiolar node faintly reticulate-punctate; dorsum of postpetiole smooth and shining. Basigastral costulae short and inconspicuous, rest of gaster smooth and shiny.

Comments. *Strumigenys nathistorisoc* is well distinguished from other *Strumigenys* species by a combination of the characteristics listed in the diagnosis. It does not fit the description of any existing *Strumigenys* species group, in particular due to its highly distinctive mandibles and dentition.

Comparing *S. nathistorisoc* with the most similar appearing *Strumigenys* species, such as *S. kichijo* and species from the *S. leptothrix*-group, these species, in contrast, are often either hairless or have simple or flagellate hairs on the cephalic and pronotal dorsum, or have sculpture on the sides of the mesosoma, or have propodeal spines subtended by medium to broad lamellae. *S. nathistorisoc* also lacks the laterally projecting hairs in full-face view or the distinct transverse striations on the pronotal dorsum and dorsum of the petiolar node that characterise *S. nankunshana*.

Focusing on the mandibles and dentition, in contrast to the description of *S. nathistorisoc*, *S. kichijo* has only conical teeth. *S. nankunshana* and species from the *S. leptothrix*-group have masticatory margins that engage throughout the entire length. *S. wilsoniana* has a much wider gap between the mandibles, the masticatory margins engage at the apical third (instead of around half as in *S. nathistorisoc*) of their length, with the basal 2 teeth (instead of 3) situated at around the mid-length of the mandible (instead of sparsely across the basal half of the mandible) and not reaching their counterparts from the opposing mandible when the mandibles are fully closed.

Etymology. This species is named after the Hong Kong Natural History Society whose members graciously supported our work on the ants of Hong Kong.

Geographic range. Hong Kong

Ecology. *Strumigenys nathistorisoc* was only recorded in secondary forests and Feng Shui woods, along a relatively large gradient of elevation ranging from 29 to 572 m (Fig. 10).

***Strumigenys nepalensis* Baroni Urbani & De Andrade, 1994 – new record**
Fig. 5G–I

Strumigenys nepalensis Baroni Urbani and De Andrade 1994: 57, figs 33, 34 (w.q.) NEPAL. Indomalaya.
Smithistruma nepalensis (Baroni Urbani & De Andrade, 1994). Combination in *Smithistruma*: Bolton 1995: 385.
Pyramica nepalensis (Baroni Urbani & De Andrade, 1994). Combination in *Pyramica*: Bolton 1999: 1673.
Strumigenys nepalensis Baroni Urbani & De Andrade, 1994. Combination in *Strumigenys*: Baroni Urbani and De Andrade 2007: 124.

Material examined. HONG KONG: Central & Western District, HKU Campus, 22.282164N, 114.138296E, 113 m, 19.11.2014, M. Wong, Winkler, 12 Random, IBBL; Central & Western District, HKU CYT, 22.2824528N, 114.14043E, 07.01.2016, G. Yong, Winkler, IBBL; Islands District, Chek Lap Kok, 22.2939N, 113.9331E, B.M. Worthington, Winkler, 12 Random, IBBL; Islands District, Chek Lap Kok, 22.2947N, 113.9336E, 21 m, B.M. Worthington, Winkler, 4 Corners, IBBL; Islands District, Chek Lap Kok, 22.2957N, 113.9338E, B.M. Worthington, Winkler, 4 Corners, IBBL; Islands District, Chek Lap Kok, 22.2964N, 113.9352E, 10 m, B.M. Worthington, Winkler, 4 Corners, IBBL; Islands District, Chek Lap Kok, 22.298N, 113.9359E, 5 m, B.M. Worthington, Winkler, 4 Corners, IBBL; Islands District, Chek Lap Kok, 22.298N, 113.9359E, B.M. Worthington, Winkler, 4 Corners, IBBL; Islands District, Chek Lap Kok, 22.3139N, 113.9398E, 2 m, B.M. Worthington, Winkler, 4 Corners, IBBL; Islands District, Chek Lap Kok, 22.3153N, 113.9407E, B.M. Worthington, Winkler, 12 Random, IBBL; Islands District, Chek Lap Kok, 22.3204N, 113.9376E, 6 m, B.M. Worthington, Winkler, 12 Random, IBBL; Islands District, Chek Lap Kok, 22.3193N, 113.9377E, B.M. Worthington, Winkler, 12 Random, IBBL; Islands District, Sha Lo Wan, 22.2898N, 113.9069E, 43 m, B.M. Worthington, Winkler, 4 Corners, IBBL; Islands District, Tung Chung, 22.2907N, 113.9371E, 1 m, B.M. Worthington, Winkler, 4 Corners, IBBL; North District, Lai Chi Wo, 22.527N, 114.258E, 08.05.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Lion Rock, 22.360915N, 114.180028E, 13.07.2015, R.H. Lee, Winkler, IBBL; Yuen Long District, Mai Po, 22.48121N, 114.03332E, 30.07.2018, 1 m, M. Wong, pitfall trap, IBBL; Yuen Long District, Mai Po, 22.48625N, 114.04097E, 03.08.2018, 1 m, M. Wong, pitfall trap, IBBL. MACAU: Hac Sa Reservoir, Coloane Island, 22.1344N, 113.5725E, 20.08.2016, 93 m, C.M. Leong, Winkler, IBBL.

Measurements. Workers (n = 8): TL 1.3–1.8, HL 0.42–0.46, HW 0.31–0.33, MandL 0.08–0.09, SL 0.18–0.20, EL 0.033–0.043, PW 0.19–0.21, ML 0.44–0.48, PL 0.20–0.22, PH 0.11–0.13, DPW 0.10–0.11, PPL 0.13–0.15, GL 0.43–0.47, CI 70–76, MI 17–21, SI 56–63, OI 11–13, LPI 52–58, DPI 48–54.

Geographic range. China (Yunnan), India, Malaysia, Nepal, Singapore, Thailand, Vietnam.

Introduced: Mauritius, Hong Kong.

Ecology. This is a common species in urban forest patches or disturbed grassland (e.g. Mai Po Nature Reserve), with only a few records collected within secondary forests and one record within Feng Shui woods (Fig. 10). Elevation records ranged from 1 to 135 m, suggesting that this species might prefer lowland habitats. The association of this species with relatively disturbed habitats suggests a potential tramp species, although other biological characteristics (e.g. polygyny, unicoloniality) are unknown at present.

Comments. New records of *Strumigenys nepalensis* in Hong Kong expand the current known native range of this species by 800 km eastward from Vietnam. A record from Mauritius (Casent0799280, Ile Aux Aigrettes, –20.419017, 57.730183, 5 m a.s.l., A. Suarez 2.VI.2005; Doug Booher pers. comm.) confirms the tramp character of this species. Specimens collected from Hong Kong, Macau and Mauritius are considered introduced.

Strumigenys rallarhina Bolton, 2000 – First record in Hong Kong in 1978 (Bolton 2000)

Strumigenys rallarhina Bolton 2000: 891 (w.) CHINA. Palearctic.

Material examined. HONG KONG: Central & Western District, Lung Fu Shan Park, 22.280693N, 114.137027E, 3 Oct. 2018, B. Guénard, hand collection, IBBL; Central & Western District, Lung Fu Shan, 22.2751778N, 114.138576E, 07.01.2016, G. Yong, Winkler, IBBL; Central & Western District, The Peak, 22.276038N, 114.141995E, 17.08.2015, R.H. Lee, Winkler, IBBL; Islands District, Lamma Island, 22.20575N, 114.13808E, 14.09.2017, R.H. Lee, Winkler, IBBL; Islands District, Lantau Peak, 22.249N, 113.921E, 15.09.2015, R.H. Lee, pitfall trap, IBBL; Islands District, Sunset Peak, 22.260842N, 113.957533E, 03.06.2015, R.H. Lee, Winkler, IBBL; Islands District, Sunset Peak, 22.263923N, 113.953762E, 03.06.2015, R.H. Lee, pitfall trap, IBBL; Islands District, Sunset Peak, 22.263923N, 113.953762E, 03.06.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Lion Rock, 22.357002N, 114.175047E, 13.07.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Lion Rock, 22.36121N, 114.181997E, 15.08.2017, R.H. Lee, Winkler, IBBL; Sha Tin District, Mau Ping Wood, 22.3844N, 114.241E, 20.10.2015, R.H. Lee, Winkler, IBBL; Sha Tin District, Tai Po Kau Nature Reserve, 22.4281N, 114.1808E, 24.02.2016, B. Guénard, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.42402N, 114.18029E, 14.07.2015, R.H. Lee, Winkler, IBBL; Southern District, Nam Fung Road, 22.2546N, 114.1833E, 20.08.2016, R.H. Lee, pitfall trap, IBBL; Tai Po District, Sha Lo Tong, 22.47708N, 114.18195E, 28.05.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Sha Lo Tong, 22.47808N, 114.18193E, 28.05.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Sha Shan, 22.449N, 114.145E, 03.11.2015, R.H. Lee, Winkler, IBBL; Tsuen Wan District, Shing Mun Reservoir, 22.39718N, 114.15273E, 230 m, 06.07.2011, P. Ward, sifted litter, IBBL; Tai Po

District, Tai Om, 22.442321N, 114.134738E, 28.02.2018, B. Guénard, Winkler, IBBL; Tsuen Wan District, Shing Mun, 22.39678N, 114.1531E, 238 m, 23.08.2015, T. Tsang, Winkler, IBBL; Tsuen Wan District, Shing Mun, 22.39693N, 114.153E, 14.05.2015, R.H. Lee, Winkler, IBBL; Tsuen Wan District, Tai Lam, 22.3956N, 114.0928E, 26.10.2015, R.H. Lee, Winkler, IBBL; Tuen Mun District, Castle Peak, 22.389935N, 113.954937E, 30.06.2015, R.H. Lee, Winkler, IBBL.

Ecology. This is a relatively widespread species collected in a wide range of habitats and elevation, including grassland, roadside trees, shrubland, bamboo forest, secondary forest and Feng Shui woods at elevation ranging from 56 to 589 m (Fig. 10).

Strumigenys rogeri **Emery, 1890 – new record**

Fig. 5J–L

Strumigenys rogeri Emery 1890: 68, pl. 7, fig. 6. SAINT THOMAS, U.S. VIRGIN ISLANDS. Neotropical.

Material examined. HONG KONG: Tai Po District, Sai Keng, 22.41998N 114.26824E, 1 m, 26.VI.2018–10.VII.2018, R. Cheung / C. Taylor, Malaise trap, IBBL. VIETNAM: Cat Tien National Park, 11.26.237N, 107.25.431E, 145 m, 3.VI.2018, B. Guénard, IBBL, hand collection.

Measurements. Alate (*n* = 1) TL 2.5, HL 0.58, HW 0.46., MandL 0.32, SL 0.35, EL 0.10, PW 0.32, ML 0.60, PL 0.28, PH 0.15, DPW 0.13, PPL 0.10, GL 0.62, CI 78, MI 54, SI 77, OI 21, LPI 54, DPI 48.

Geographic range. ***Native:*** Afrotropical region, known from Ivory Coast to Zanzibar Archipelago (Tanzania) and south to Angola.

Introduced: A widespread species in multiple biogeographic realms. For a full global account, see antmaps.org (Janicki et al. 2016; Guénard et al. 2017). Here, the Asian distribution is presented for the Oriental realm (Hong Kong; Kerala [India]; Java and Sumatra [Indonesia], Peninsular and East Malaysia [Malaysia], Philippines, and Taiwan). We can also confirm the presence of this species from Vietnam, which was previously reported by Zryanin (2011).

Comments. The record of this tramp species in Hong Kong is not surprising considering its widespread range in nearby countries (Philippines, Taiwan, and Vietnam), which have relatively similar climatic conditions. However, a single alate has been collected from a mangrove habitat, an unlikely habitat for this species, and no workers have been collected in Hong Kong. Nonetheless, the record from Hong Kong is the first observation of this species for mainland China.

Strumigenys sauteri **(Forel, 1912) – First record in Hong Kong in 1994 (Fellowes 1996)**

Pentastruma sauteri Forel 1912: 51 (w.) TAIWAN. Indomalaya.

Pyramica sauteri (Forel, 1912). Combination in *Pyramica*: Bolton 1999: 1673.
Strumigenys sauteri (Forel, 1912). Combination in *Strumigenys*: Baroni Urbani and De Andrade 2007: 127.

Material examined. HONG KONG: Central & Western District, HKU CYT, 22.2824528N, 114.140431E, 07.01.2016, G. Yong, Winkler, IBBL; Central & Western District, LFS Plot 1 B–C, 22.277134N, 114.134793E, 28.12.2015, G. Yong, Winkler, IBBL; Central & Western District, LFS Plot 1 C, 22.277134N, 114.134808E, 28.12.2015, G. Yong, Winkler, IBBL; Central & Western District, Lung Fu Shan, 22.276729N, 114.136693E, 295 m, 24.11.2014, M. Wong, Winkler, 4 Corners, IBBL; Central & Western District, Lung Fu Shan, 22.27896N, 114.13601E, 244 m,20.11.2014, M. Wong, Winkler, 12 Random, IBBL; Central & Western District, Lung Fu Shan, 22.28221N, 114.133476E, 115 m, 13.11.2014, M. Wong, Winkler, 12 Random, IBBL; Central & Western District, Plot 1 B–C, 22.277134N, 114.134794E, 08.01.2016, G. Yong, Winkler, IBBL; Islands District, Sunset Peak, 22.26112N, 113.956332E, 03.06.2015, R.H. Lee, Winkler, IBBL; Islands District, Tei Tong Tsai, 22.257066N, 113.926281747627E, 29.11.2016, R.H. Lee, Winkler, IBBL; North District, A Ma Wat, 22.5191N, 114.2441E, 19.12.2016, R.H. Lee, Winkler, IBBL; Sai Kung District, Pak Tam Chung, 22.400033N, 114.330997E, 05.06.2015, R.H. Lee, pitfall trap, IBBL; Sha Tin District, Lion Rock, 22.36121N, 114.181997E, 13.07.2015, R.H. Lee, pitfall trap, IBBL; Sha Tin District, Tai Po Kau Nature Reserve, 22.4288N, 114.1813E, 22.02.2017, B. Guénard, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.41841N, 114.1779E, 295 m, 12.07.2015, T. Tsang, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.427285N, 114.181298E, 16.09.2015, B. Guénard, hand collection, IBBL; Sha Tin District, Tai Po Kau, 22.42781N, 114.181462E, 08.10.2018, B. Guénard, hand collection, IBBL; Southern District, Aberdeen Reservoir, 22.259638N, 114.162508E, 29.06.2015, R.H. Lee, Winkler, IBBL; Southern District, Aberdeen Reservoir, 22.26N, 114.162E, 26.06.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Hunch Backs, 22.4139N, 114.2489E, 13.11.2015, R.H. Lee, pitfall trap, IBBL; Tai Po District, Ping Shan Chai, 22.486N, 114.187E, 19.03.2016, C. Barthélémy, Malaise trap, IBBL; Tai Po District, Tai Om, 22.44157N, 114.13513E, 28.02.2018, B. Guénard, Winkler, IBBL; Tai Po District, Tap Mun, 22.47N, 114.363E, 28.07.2015, R.H. Lee, pitfall trap, IBBL; Tsuen Wan District, Ha Lin Fa Shan, 22.39608N, 114.1014E, 28.07.2015, 344 m, T. Tsang, Winkler, IBBL; Tsuen Wan District, Lin Fa Shan, 22.3956N, 114.0885E, 15.07.2016, R.H. Lee, pitfall trap, IBBL; Tsuen Wan District, Lin Fa Shan, 22.3956N, 114.0885E, 15.07.2016, R.H. Lee, Winkler, IBBL; Tsuen Wan District, Shing Mun, 22.39845N, 114.1628E, 367 m, 24.08.2015, T. Tsang, Winkler, IBBL; Tsuen Wan District, Shing Mun, 22.39962N, 114.162E, 355 m, 12.08.2015, T. Tsang, Winkler, IBBL; Yuen Long District, Kap Lung, 22.41596N, 114.1038E, 288 m, 11.09.2015, T. Tsang, Winkler, IBBL; Yuen Long District, Ng Tung Chai 22.43492N, 114.12927E, 01.11.2016, R.H. Lee, Winkler, IBBL.

Ecology. This is a widespread species found in diverse habitats including grasslands, shrublands, plantations (e.g. *L. confertus*), urban forest remnants, secondary forest, and Feng Shui woods. Specimens were collected at elevation ranging from 19 to 630 m (Fig. 10).

***Strumigenys sydorata* Bolton, 2000 – new record**
Fig. 8D–F

Strumigenys sydorata Bolton 2000: 876 (w. q.) JAVA. Indomalaya.

Material examined. HONG KONG: North District, Kuk Po San Uk, 22.52912N, 114.23468E, 15.11.2016, R.H. Lee, Winkler, IBBL; Sha Tin District, Tai Po Kau, 22.42614N, 114.18178E, 162 m, 06.07.2017, R.H. Lee, pitfall trap, IBBL; Tai Po District, Sha Lo Tong, 22.481767N, 114.18283E, 28.05.2015, R.H. Lee, Winkler, IBBL; Tai Po District, Tai Om, 22.4419N, 114.1335E, 76 m, 05.10.2016, Winkler, IBBL; Tai Po District, Tai Om, 22.4423N, 114.1343E, 81 m, 07.08.2015, T. Tsang, Winkler, IBBL.

Measurements. Worker (n = 1): TL 2.5, HL 0.69, HW 0.53, MandL 0.19, SL 0.28, EL 0.059, PW 0.30, ML 0.66, PL 0.24, PH 0.17, DPW 0.15, PPL 0.16, GL 0.52, CI 77, MI 28, SI 53, OI 11, LPI 70, DPI 62.

Geographic range. China (Hong Kong), Indonesia (Java), Thailand, Vietnam.

Ecology. This is a rare species in Hong Kong collected only within secondary forests and Feng Shui woods (Fig. 10). Elevations of collection sites ranged from 15 to 170 m.

Comments. This new record from Hong Kong represents another important geographic extension of 900 km north-eastward in Mainland Asia, with the closest record known from Cúc Phương in Vietnam (Eguchi et al. 2011). *Strumigenys sydorata* belongs to the *lyroessa*-complex within the *S. lyroessa*-group. This species can be separated from others in this group by the presence of pronotal humeral hairs, a smooth first gastral tergite, a well-developed lamella along the propodeal declivity, and a larger preapical tooth when compared to the apicodorsal tooth on mandibles. The latter character separates it from *S. arrogantia*, which is slightly smaller than *S. sydorata*.

***Strumigenys tisiphone* Bolton, 2000 – new record**
Fig. 8G–I

Pyramica tisiphone Bolton 2000: 390 (w.) CHINA. Indomalaya.
Strumigenys tisiphone (Bolton, 2000). Combination in *Strumigenys*: Baroni Urbani and De Andrade 2007: 129.

Material examined. HONG KONG: Central & Western District, Lung Fu Shan, 22.27518N, 114.13858E, 07.01.2016, G. Wong, Winkler, IBBL; Sha Tin District, Tai Po Kau Nature Reserve, 22.4288N, 114.1813E, 22.02.2017, B. Guénard, Winkler, IBBL; Tsuen Wan District, Tai Mo Shan, 22.41496N, 114.12608E, 816 m, 24.06.2016, R.H. Lee, Winkler, IBBL.

Measurements. Worker (n = 1): TL 2.4, HL 0.54, HW 0.50, MandL 0.20, SL 0.24, EL 0.036, PW 0.29, ML 0.59, PL 0.29, PH 0.16, DPW 0.16, PPL 0.19, GL 0.55, CI 93, MI 37, SI 48, OI 7, LPI 56, DPI 56.

Geographic range. Hong Kong, Guangdong, Hubei, Hunan (China).

Ecology. This is a rare species in Hong Kong, collected only within secondary forest but through a wide elevational range extending from 141 to 816 m (Fig. 10).

Comments. The Hong Kong record confirms the distribution of *S. tisiphone* within China and represents the south-easternmost record for the species. The previous record in China is from Gutian, central Guangdong (24.2N, 116.6E) (Bolton 2000).

Discussion

The genus *Strumigenys* currently includes 839 valid species and ranks as the third most diverse ant genus, after *Camponotus* (1031 valid species + 457 subspecies) and *Pheidole* (1004 valid species + 134 subspecies) (Bolton 2018). However, despite its hyperdiverse status, our results suggest that even 70 years after its publication, the statement by William Brown Jr (1949: 1) that "…the dacetine ants presently known from eastern Asia undoubtedly represent only a fraction of the species which actually exist there…" might still apply. As Hong Kong is a small territory of 1100 km² with a history of extensive deforestation and disturbance over nearly all of its territory (Zhuang and Corlett 1997), the discovery of three new species and nine new records (Table 2) stresses the need for further sampling and taxonomic work on this genus within southeastern China. These results show that even within a region with high disturbance history, and thus usually perceived as of lower ecological quality, taxonomic knowledge on a particular group of insect is still highly fragmented. Undoubtedly, future myrmecological surveys in this region will lead to the discovery of new species and the collection of new records. For instance, species such as *S. minutula* and *S. sydorata*, for which the new records presented here represent a disjunction within south-east China, or other widely distributed species in Hong Kong such as *S. canina*, *S. feae*, *S. hirsuta*, *S. heteropha*, *S. nathistorisoc*, *S. rallarhina*, and *S. sauteri*, are expected to be found in the nearby provinces of Guangdong, Guangxi, and Hainan (Hainan is currently devoid of any *Strumigenys* records [antmaps.org, November 2018]). With the addition of the three newly described species here, the total number of *Strumigenys* species known only from Hong Kong is now four, including *S. heteropha*, described by Bolton (2000) and widespread in Hong Kong (Fig. 10). However, this apparent endemism is likely the result of a lack of sampling in south-eastern China rather than a true biogeographic pattern. However, as urban development and deforestation within south-east China is expanding, the populations of these species in Hong Kong might become increasingly isolated. As such, the evolution of these populations and their conservation, coupled with potential limited dispersal abilities, might represent a good study system to address questions related to large scale fragmentation, genetic drift, and species or population extinction.

The number of native *Strumigenys* species now recorded from continental China is 49 (Guénard et al. 2012, 2017), nearly half of which are found in Hong Kong (19 native species). With 24 species recorded (Table 1), the *Strumigenys* fauna of Hong Kong can be considered especially diverse for the region. In comparison, only 9, 13, and 17

Table 2. List of the twenty-four *Strumigenys* species recorded in Hong Kong, with reference of their first record, collection within recent years (IBBL = Insect Biodiversity and Biogeography Laboratory at HKU) and type of habitat collected presented.

***Strumigenys* species**	**First published record in HK**	**Specimen at IBBL**	**Type of habitat**
S. canina Brown & Boisvert, 1979	Fellowes 1996	Yes	Secondary forest; tree plantation; Feng Shui woods
S. elegantula Terayama & Kubota, 1989	Fellowes 1996	Yes	Reclaimed land; mixed woodland; semi-open forest
S. emmae Emery, 1890	Fellowes 1999	Yes	Reclaimed land; secondary forest
S. exilirhina Bolton, 2000	Bolton 2000	Yes	Semi-open forest; secondary forest; reclaimed land
S. feae Forel, 1912	Bolton 2000	Yes	Disturbed secondary forest
S. formosa Terayama. Ling & Wu, 1995	New record	Yes	Secondary forest
S. heteropha Bolton, 2000	Bolton 2000	Yes	Semi-open forest
S. hexamera Brown, 1958	New record	Yes	Secondary forest
S. hirsuta sp. n.	New species	Yes	Disturbed secondary forest; semi-open forest
S. kichijo Terayama, Lin & Wu, 1996	New record	Yes	Secondary forest
S. lantaui sp. n.	New species	Yes	Reclaimed land
S. mazu Terayama, Lin & Wu, 1996	Bolton 2000	Yes	Reclaimed land
S. membranifera Emery, 1869	New record	Yes	Secondary forest
S. minutula Terayama & Kubota, 1989	Bolton 2000	Yes	Semi-open forest; reclaimed land
S. mitis Brown, 2000	Fellowes 1996	Yes	Disturbed secondary forest; semi-open forest
S. cf. *mutica* (Brown, 1949)	New record	Yes	Mangrove (alates in Malaise trap)
S. nanzanensis Lin & Wu, 1996	Fellowes 1996	Yes	Secondary forest
S. nathistorisoc sp. n.	New species	Yes	Secondary forest
S. nepalensis Baroni Urbani & De Andrade, 1994	New record	Yes	Secondary forest
S. rallarhina Bolton, 2000	Bolton 2000	Yes	Secondary forest; semi-open forest; Feng Shui woods
S. rogeri Emery, 1890	New record	Yes	Mangrove (alate in Malaise trap)
S. sauteri Forel, 1912	Fellowes 1996	Yes	Semi-open forest; secondary forest
S. sydorata Bolton, 2000	New record	Yes	Feng Shui woods
S. tisiphone Bolton, 2000	New record	Yes	Secondary forest

native species have been recorded in the southern provinces of Guangdong, Guangxi, and Yunnan, respectively. Again, this suggests insufficient sampling. In contrast, 30 species are known from Taiwan, which has a much longer history of survey and taxonomic work (e.g. Terayama and Kubota 1989; Terayama 2009). While a multitude of sampling approaches have been deployed across Hong Kong over the past 5 years, the use of Winkler extractors in particular has allowed the collection of numerous *Strumigenys* specimens. As a result, the large increase in new species and records match those of a previous study conducted in Yunnan, which recorded six additional *Strumigenys* species for the province on the basis of a 3-week survey (Liu et al. 2015). Because the use of sampling methods specifically targeting leaf-litter ants has been seldom used in China and other Asian countries, we recommend a more systematic and generalized use of these methods to survey the local myrmecofauna.

In addition, the use of Malaise traps resulted in the discovery of new species records on the basis of alate gynes (*S.* cf. *mutica* and *S. rogeri*). This resulted in new information on the phenology of several *Strumigenys* species within Hong Kong. While many tropical ant species exhibit multiple swarming periods (Kaspari et al. 2001), our results, though preliminary, indicate that each individual species' nuptial flight is restricted to a period of a few days to a few weeks, with no instance of multiple distinct nuptial flight periods recorded. It is also interesting to note that 10 of the species collected were caught in a period ranging over only 4 months between late-March to early-July (Fig. 13). This might indicate that most species of *Strumigenys* in Hong Kong use a relatively short period of the year characterised by warmer temperature (21–28 °C) and heavier precipitation, with a peak of precipitation observed in June (Hong Kong Observatory 2018) corresponding to the period during which a maximum of species were observed swarming. The only exception to this was *S. canina*, whose alates, including 24 females, 1 female pupa, and 1 male, were collected in early October from leaf litter, potentially indicating swarming in the later part of the year characterised by drier weather conditions. Surprisingly, while *S. canina* was one of the most commonly encountered species in Hong Kong, we were unable to detect any alate females using Malaise traps. *Strumigenys* female alates were rather uncommon in Malaise traps, with only a handful of individuals collected from several hundred Malaise trap samples. This might indicate either that *Strumigenys* females are poor fliers or that Malaise traps installed above ground (about 1.8–2 m high) are not appropriate for capturing them. Finally, while male *Strumigenys* could be identified to the genus level and seemed more abundant than females, as observed in previous studies (Feitosa et al. 2016), we could not associate them with a particular species; this limited the information that we could retrieve. Thus, in order to understand the phenology of *Strumigenys* in the region, taxonomic classification of males should be a priority for future studies.

By its central position in Asia and its leading role in regional and global trade, Hong Kong presents numerous opportunities for the introduction, establishment, and spread of introduced species (Lu et al. 2018). Our results suggest that introduced *Strumigenys* species are particularly diverse and common in open and disturbed habitats. Prior to this study, only *S. emmae* had been recorded in the mid-1990s (Fellowes 1999) and more recently in multiple instances in urban environments of Hong Kong as well as in the neighbouring region of Macau (Leong et al. 2017). Future surveys within the Pearl River Delta Metropolitan Region will probably reveal a more widespread distribution of this species within urban habitats. More significantly, our results indicate an increase in introduced species since the survey performed 20 years ago (Fellowes 1996, 1999), with four species newly recorded from Hong Kong: *S. hexamera*, *S. membranifera*, *S. nepalensis*, and *S. rogeri*. These results, in combination with recent publications, confirm the spread of several introduced *Strumigenys* species throughout Southeast Asia. For instance, the introduced species *S. eggersi* has recently been recorded in the Philippines (General 2018) and Singapore (Wang and Yamane 2017). The establishment of this species in Hong Kong is plausible considering its presence as an introduced species within regions with similar climatic conditions as those observed in Hong Kong (e.g.

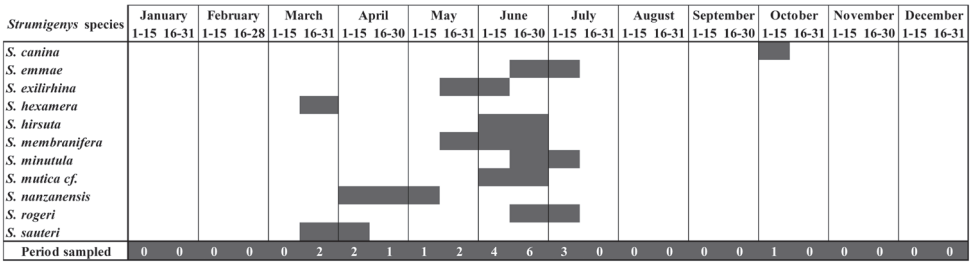

Figure 13. Phenology of 11 *Strumigenys* species collected in Hong Kong on the basis of alate female specimens collected within Malaise traps, with the exception of *S. canina* with females and males collected in leaf litter. Dark grey areas represent periods during which a given species was collected (in front of a species name) or the period in which sampling was conducted (Period sampled). Numbers in the last row of the table represent the number of species collected within a given period.

Florida). Moreover, two species recorded in our study, *S. emmae* and *S. membranifera*, were also recently recorded for the first time from Sri Lanka (Dias et al. 2018). While distinguishing the recent spread of these species from the effects of increased sampling effort targeting anthropogenic habitats is impossible with the data currently available, it nonetheless shows that introduced *Strumigenys* species are probably more widespread than previously described. On the other hand, records for another species, *S. silvestrii*, recorded from Macau (Hua 2006), would require confirmation, as the origin of this record is uncertain and recent myrmecological work conducted in Macau, although limited in scope, failed to collect this species (Leong et al. 2017). Hence, this record might either be a misinterpretation of a record of *Strumigenys silvestriana* (a synonym of *Strumigenys membranifera*) from Macau in Chapman and Capco (1951); or, given that *S. silvestrii* has been recorded from both Portugal and Madeira islands (MacGown et al. 2012), and Macau used to be a Portuguese territory, an indication that this species was introduced there through the intense trade during the colonial period.

Globally, 24 *Strumigenys* species have been recorded outside of their putative native range (Table 3), with two species without established populations but intercepted during quarantine process. The largest number of introduced *Strumigenys* species is recorded within the Nearctic realm (11), with Florida alone hosting 10 introduced species (Deyrup 2016), followed by the Malagasy (8), and the Oceanian and Panamanian (7) realms. If five *Strumigenys* species have been introduced to the Oriental realm, a similar number of species originating from this realm have been introduced to other parts of the world, while the Sino-Japanese realm acts more as an exporter of *Strumigenys* species (4 species) than as an importing realm (2 species). Several species with their native range in Japan or China (e.g. *S. hexamera*, *S. lewisi*) have been recorded in Europe (Schembri and Collingwood 1995) and in the U.S.A. (Deyrup and Cover 2009). However, for several species, these records represent non-established populations detected during quarantine inspections (e.g. *S. minutula* [Boer and Vierbergen 2008], *S. solifontis* [Brown 1949]). If none of the introduced *Strumigenys* species are suspected

Table 3. List of the 24 *Strumigenys* species with records outside their native range with a presentation by biogeographic realms of their putative native and introduced ranges (data from antmaps.org, Janicki et al. 2016). Definitions of biogeographic realms follow Holt et al. 2013.

***Strumigenys* species**	**Native range**	**Introduced range**
S. eggersi Emery, 1890	Neotropical, Panamanian	Nearctic, Oriental, Panamanian (Galapagos Islands)
S. emmae (Emery, 1890)	Australian	Afrotropical, Madagascan, Nearctic, Neotropical, Oceanian, Oriental, Panamanian, Saharo-Arabian
S. epinotalis Weber, 1934	Neotropical, Panamanian	Nearctic
S. godeffroyi Mayr, 1866	Australian, Oceanian (West part), Oriental	Madagascan, Oceanian (East part),
S. gundlachi (Roger, 1862)	Neotropical, Panamanian	Nearctic
S. hexamera (Brown, 1958)	Oriental, Sino-Japanese	Nearctic, Oceanian
S. lanuginosa Wheeler, 1905	Neotropical, Panamanian	Nearctic
S. lewisi Cameron, 1886	Oriental, Sino-Japanese	Oceanian, Palearctic (West)
S. louisianae Roger, 1863	Nearctic, Neotropical, Panamanian	Panamanian (Cocos Island, Galapagos Islands)
S. ludovici Forel, 1904	Afrotropical	Madagascan
S. lujae Forel, 1902	Afrotropical	Oceanian (not established)
S. mandibularis Smith, 1860	Neotropical	Afrotropical, Madagascan
S. margaritae Forel, 1893	Nearctic (south), Neotropical, Panamanian	Nearctic (north)
S. maxillaris Baroni Urbani, 2007	Afrotropical	Madagascan
S. membranifera Emery, 1869	Afrotropical	Australian, Madagascan, Nearctic, Neotropical, Oceanian, Oriental, Palearctic, Panamanian, Saharo-Arabian, Sino-Japanese
S. minutula Terayama & Kubota, 1989	Oriental, Sino-Japanese	Palearctic (not established)
S. nepalensis Baroni Urbani & De Andrade, 1994	Oriental	Madagascan (Mauritius), Sino-Japanese (Hong Kong, Macau)
S. nigrescens Wheeler, 1911	Panamanian	Panamanian (Cocos Island)
S. perplexa (Smith, 1876)	Australian	Australian (New Zealand)
S. rogeri Emery, 1890	Afrotropical	Madagascan, Nearctic, Neotropical, Oceanian, Oriental, Palearctic (not established), Panamanian
S. silvestrii Emery, 1906	Neotropical	Nearctic, Oriental?, Palearctic, Panamanian
S. simoni Emery, 1895	Afrotropical	Madagascan
S. solifontis Brown, 1949	Oriental, Sino-Japanese	Nearctic (not established)
S. xenos Brown, 1955	Australian	Australian (Lord Howe Island, New Zealand)

to reach an invasive level, the ecological traits of these species (specialized predators found within leaf litter) challenge the general paradigm of many generalist introduced ant species. As a result, the genus represents an interesting study system to understand introduction mechanisms that favour the establishment of particular species within new regions, and to study their potential impacts or roles in their introduced range. Finally, local myrmecologists, particularly within Asia, are encouraged to conduct inventory within urban areas (parks, university campus, around airports, or ports) to detect potential new records of introduced *Strumigenys* species, as the introduced species detected in this study are likely to have widespread distributions within the region.

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RESEARCH ARTICLE

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Integrative taxonomy of root aphid parasitoids from the genus *Paralipsis* (Hymenoptera, Braconidae, Aphidiinae) with description of new species

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Abstract

Species from the genus *Paralipsis* are obligatory endoparasitoids of root aphids in the Palaearctic. It is known that these species are broadly distributed, parasitizing various aphid hosts and showing great biological and ecological diversity. On the other hand, this group of endoparasitoids is understudied and was thought to be represented by a single species in Europe, viz., *Paralipsis enervis* (Nees). However, recent description of two new species indicated the possibility of cryptic speciation and recognition of additional *Paralipsis* species in Europe. In this research, *Paralipsis* specimens collected during the last 60 years from eight European countries, as well as one sample from Morocco, were subjected to molecular and morphological characterization. Newly designed genus-specific degenerative primers successfully targeted short overlapping fragments of COI of the mitochondrial DNA. Molecular analyses showed clear separation of four independent lineages, two of which are the known species *P. enervis* and *P. tibiator*, while two new species are described here, viz., *P. brachycaudi* Tomanović & Starý, **sp. n.** and *P. rugosa* Tomanović & Starý, **sp. n.** No clear specialization of the taxa to a strict root aphid host has been determined. The recognized mitochondrial lineages were distinct one from another, but with a substantial within-lineage divergence rate, clearly indicating the complexity of this group of parasitoids, on which further research is required

in order to clarify the factors triggering their genetic differentiation. We reviewed literature data and new records of *Paralipsis enervis* aphid host associations and distributions. A key for the identification of all known *Paralipsis* species is provided and illustrated.

Keywords
Cryptic speciation, molecular phylogeny, *Paralipsis*, *Paralipsis brachycaudi* sp. n., *Paralipsis rugosa* sp. n.

Introduction

Parasitoid wasps from the subfamily Aphidiinae (Hymenoptera, Braconidae) attack various aphid phylogenetic lineages, exhibiting several specialized associations with their hosts (Gagić et al. 2016). Few parasitoid wasps are specialized to parasitize only root aphid species (Starý 1961). However, there is no substantial biological knowledge about these obligatory parasitoid species of root aphids, probably as a consequence of them being of little economic importance and difficult to access for sampling. Moreover, it is well known that the parasitoids of root aphids developed obligatory relationships with ants (Starý 1966, Takada and Shiga 1974, Völkl 1992, Völkl et al. 1996). Although, there are many examples of relationships between ants that collected honeydew from aphids and protected the aphid colony and parasitoid wasps, it seems that chemical mimicry plays a more important role in some parasitoids [e.g., *Lysiphlebus cardui* (Marshall 1896)] than behavioural mimicry (Liepert and Dettner 1993). However, parasitoid wasps from the genus *Paralipsis* Foerster, 1863 have developed species-specific relationships with ants attending root aphids (Starý 1966, Takada and Shiga 1974, van Achterberg and Ortiz de Zugasti Carrón 2016). The genus *Paralipsis* is a good example as case of specific obligatory parasitoids of root aphids in Europe and the Palaearctic (Figure 1). Until recently, *Paralipsis enervis* (Nees) was considered to be the only European species, while *P. eikoae* (Yasumatsu) was known as a Far Eastern species (Starý and Schlinger 1967). However, after examining two samples of *Paralipsis* from Spain and the Netherlands, van Achterberg & Ortiz de Zugasti Carrón (2016) described two new species on the basis of morphological characters, viz., *P. planus* van Achterberg and *P. tibiator* van Achterberg and Ortiz de Zugasti Carrón. It is known that the genus *Paralipsis* shows great biological and ecological complexity and diversity in view of their acceptance of various aphid hosts and also having a broad geographical distribution.

Bearing in mind it was thought that the genus *Paralipsis* was represented by a single species in Europe, until additional two species were newly described recently, we started this research to address the possibility of cryptic speciation and recognition of additional *Paralipsis* species in Europe. Since rarely encountered, there is almost a complete lack of knowledge about morphology and reliable characters for diagnostics of these root aphid parasitoids.

A set of wasps collected during the last 60 years from eight European countries and Morocco were initially subjected to morphological characterization. In addition,

Figure 1. *Forda* sp. aphids colony on root *Dactylis* sp. with mummy of *P. enervis*.

DNA was extracted from available *Paralipsis* specimens to perform the amplification and sequencing of the mitochondrial DNA barcoding region of cytochrome c oxidase subunit I (COI). We developed DNA amplification protocol and designed new internal genus-specific degenerative primers in order to retrieve short overlapping COI fragments for molecular characterization of the wasps. Subsequently, we used an integrative approach analyzing the morphological and molecular results to recognize phylogenetic lineages and cryptic species within the analyzed *Paralipsis* specimens. Two new species in Europe were described. In addition, we reviewed the host aphids and distribution of associations for *Paralipsis enervis.* A new determination key including all previously known and two newly described species is provided and illustrated.

Materials and methods

Insect material

We were provided with *Paralipsis* specimens collected during the last 60 years from eight European countries (Czech Republic, France, Germany, Lithuania, Moldova, Serbia, Slovakia, and Spain), in addition to one non-European sample from Morocco (Figure 2). Material was obtained by rearing from 17 different plant/aphid trophic associations, which included specimens emerging from 13 different aphid hosts (Table 1). Additionally, the paratype of *P. planus* was provided by the Naturalis Biodiversity Center, Leiden, the Netherlands.

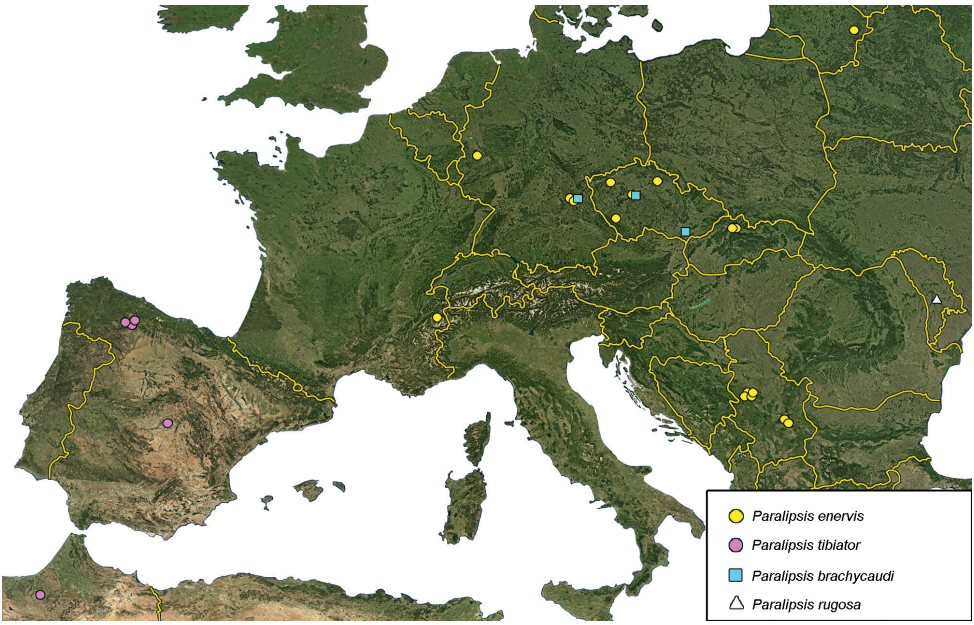


Figure 2. Distribution of analyzed *Paralipsis* specimens in Europe including Morocco.

Our examination of *Paralipsis* specimens took into account reliable morphological characters used in aphidiinae taxonomy (number of flagellomeres, shape of flagellomere 1 and 2, number of labial and maxillary palpomeres, size and shape of fore tarsus, shape of hind tibia and femur, wing venation pattern, pterostigma shape, ratio between the pterostigma and radial vein 1, petiole shape, propodeal areolation, and ovipositor shape) (Kavallieratos et al. 2005, van Achterberg and Ortiz de Zugasti Carrón 2016, Tomanović et al. 2018). The morphological terminology used in this article for diagnostic characters of aphidiines is based on Sharkey and Wharton (1997).

DNA extraction, PCR, and sequencing

The barcoding region of the mitochondrial cytochrome oxidase c subunit I gene (COI) was chosen for phylogenetic study as a proven informative marker in species delineation for numerous aphidiines (Derocles et al. 2012, Tomanović et al. 2018). Most of the samples subjected to molecular analyses were dry and stored in entomological collections (Biology Center, Institute of Entomology, České Budějovice, Czech Republic [abbreviation IECR] – specimens from Czech Republic, Germany, Slovakia, Moldova, France, Morocco, Lithuania; Faculty of Biology, Institute of Zoology, Belgrade, Serbia [abbreviation FBS] - specimens from Serbia and Czech Republic) prior to DNA extraction, except for several samples that were kept in 96% alcohol (Table 1).

Table 1. The list of available *Paralipsis* specimens subjected to molecular analyses.

Code*	Aphid host	Plant	Sampling year /age of sample at the time of DNA extraction	Sampling locality, collector	Country
Pr1Rd*	*Forda* sp.	*Dactylis glomerata* L.	2016 / 2	Niš, Sićevačka klisura, lgt. V Žikić	Serbia
PA1	*Anoecia* sp.	*Agropyrum* sp.	1960 / 58	Hořenec, BM 60/706, lgt. P Starý	Czech Republic
PA2	*Anuraphis farfarae* (Koch)	*Tussilago farfara* L.	1969 / 49	Leverkusen, Rheinland, lgt. M Boness	Germany
PA3	*Brachycaudus ballotae* (Passerini)	*Ballota nigra* L.	1960 / 58	Praha, lgt. J Holman	Czech Republic
PA4	*Anuraphis farfarae*	*Tussilago farfara*	1974 / 44	Stankovany, Choc pohorie, lgt. P Starý	Slovakia
PA5	*Dysaphis crataegi* (Kaltenbach)	*Daucus carota* L.	1959 / 59	Praha, lgt. Pintera	Czech Republic
PA6	*Forda marginata* Koch	*Agropyron repens* L.	No data	Erlangen, Nordbayern, lgt. H Zwolfer	Germany
PA7	*Aphis lambersi* (Börner)	*Daucus carota* L.	1974 / 44	Stankovany, Choc pohorie, lgt. P Starý	Slovakia
PA8	*Aphis* sp.	*Potentilla anserina* (L.)	1963 / 55	Sušice, B m, lgt. J Holman	Czech Republic
PA9	Unknown	*Pastinaca sativa* L.	1959 / 59	Jičín, Bor, lgt. J Holman	Czech Republic
PA10	*Forda formicaria* von Heyden	*Poa pratensis* L.	No data	Erlangen, Nordbayern, lgt. H Zwolfer	Germany
PA11	*Brachycaudus mordvilkoi* Hille Ris Lambers	*Echium vulgare* L.	No data	Čejč, Mm, lgt. J Holman	Czech Republic
PA12	Unknown	Unknown	1960 / 58	Kisinev, lgt. Adaškevič	Moldova
PA13	*Tetraneura ulmi* (L.)	*Avena sativa* L.	No data	Erlangen, Nordbayern, lgt. H Zwolfer	Germany
PA14	*Dysaphis reaumuri* (Mordvilko)	*Ranunculus* sp.	No data	Le Combe, Passy, Ht Savoie, lgt. G Remaudiere	France
PA15	*Aphis rumicis* L.	*Rumex* sp.	1987 / 31	Immezeur, lgt. Sekkar	Morocco
PA16	*Forda marginata*	*Poa annua* L.	No data	Molety, raj, lgt. Zickai	Lithuania
PA17	*Forda formicaria*	Poaceae	2013 / 5	Morales del Arcediano, Leon, lgt.N Pérez Hidalgo	Spain
PA18	*Forda formicaria*	Poaceae	2013 / 5	Morales del Arcediano, Leon, lgt. N Pérez Hidalgo	Spain
PA19	*Forda formicaria*	Poaceae	2013 / 5	Morales del Arcediano, Leon, lgt. N Pérez Hidalgo	Spain
PA20*	*Forda formicaria*	*Setaria viridis* L.	1996 / 22	Sićevačka klisura, lgt. V Žikić	Serbia
PA21	*Forda formicaria*	*Bromus sterilis* L.	1998 / 20	Petnica, lgt. Ž Tomanović	Serbia
PA22	*Forda formicaria*	*Bromus sterilis*	1998 / 20	Petnica, lgt. Ž Tomanović	Serbia
PA23	*Forda formicaria*	*Bromus sterilis*	1998 / 20	Petnica, lgt. Ž Tomanović	Serbia
PA24	*Forda formicaria*	*Bromus sterilis*	1998 / 20	Petnica, lgt. Ž Tomanović	Serbia
PA26*	*Forda formicaria*	Unknown	2015 / 3	Madrid	Spain

*specimens preserved in 96% ethanol prior to DNA extraction, while the others were stored dry in the collections.

DNA extraction was conducted using a commercial DNeasy Blood and Tissue Kit (Qiagen Inc., Valencia, California, USA) following the manufacturer's instructions. Initially, we attempted to amplify the barcoding region of the COI gene from dry material using the standard primer pair LCO1490/HCO2198 (Folmer et al. 1994). Each reaction was carried out in a volume of 20 µl, according to the following protocol: i) initial denaturation 95 °C/5 min; ii) 35 cycles including three steps, viz., 1 min/94 °C, 1 min/54 °C, and 30 sec/72 °C; and iii) final extension at 72 °C for 7 min.

Since the standard primer pair failed to successfully amplify the barcoding region in more than three specimens, the next step was to test the suitability of the internal degenerative primers designed by Mitrović and Tomanović (2018) for dry museum specimens of other Aphidiinae genera. Partial success was achieved in such trials amplifying random fragments, but predominantly in the first 200–350 base pairs (bp) of the barcoding region, imposing the need to design new *Paralipsis*-specific primers with the aim to target the middle and last portions of mitochondrial DNA fragments. In the absence of reference COI sequences of *Paralipsis* parasitoids in the available public databases, we used our own sequences to design internal primers for dry material. These primers were positioned to amplify the missing fragments of COI, which could later be concatenated to longer barcoding sequences (Figure 3). Trials of retrieving the COI barcodes included PCR reactions combining the standard primers LCO1490 and HCO2198, ones designed by Mitrović and Tomanović (2018), and newly designed *Paralipsis*-specific primers, targeting overlapping fragments of different lengths and positions (Table 2, Figure 3).

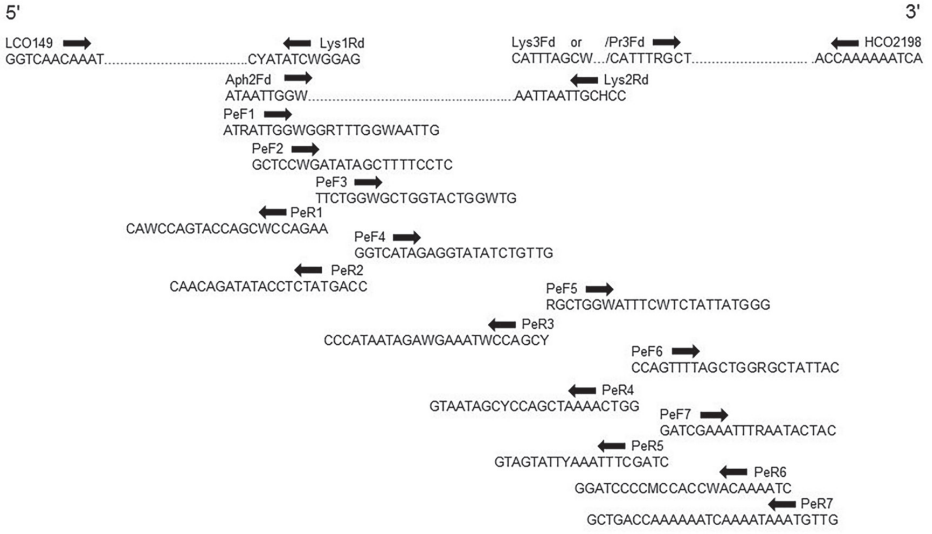


Figure 3. Distribution of the primers used in retrieving short overlapping barcode fragments of COI from dry *Paralipsis* specimens.

Table 2. The list of primers used for retrieval of COI sequences from dry *Paralipsis* specimens.

primer name	5 ' 3' primer sequence	primer direction	Reference
LCO1490	GGTCAACAAATCATAAAGATATTGG	Forward	Folmer et al. (1994)
HCO2198	TAAACTTCAGGCTGACCAAAAAATCA	Reverse	
Aph2Fd	ATAATTGGWGGATTTGGWAATTG	Forward	Mitrović and Tomanović (2018)
Lys1Rd	GAGGAAAAGCYATATCWGGAG	Reverse	
Lys2Rd	GTWCTAATAAAATTAATTGCHCC	Reverse	
Lys3Fd	CATTTAGCWGGDATTTCWTC	Forward	
Pr3Fd	CATTTRGCTGGWATTTCYTC	Forward	
PeF1	ATRATTGGWGGRTTTGGWAATTG	Forward	*Paralipsis*-specific newly designed primers
PeF2	GCTCCWGATATAGCTTTTCCTC	Forward	
PeF3	TTCTGGWGCTGGTACTGGWTG	Forward	
PeR1	CAWCCAGTACCAGCWCCAGAA	Reverse	
PeF4	GGTCATAGAGGTATATCTGTTG	Forward	
PeR2	CAACAGATATACCTCTATGACC	Reverse	
PeF5	RGCTGGWATTTCWTCTATTATGGG	Forward	
PeR3	CCCATAATAGAWGAAATWCCAGCY	Reverse	
PeF6	CCAGTTTTAGCTGGRGCTATTAC	Forward	
PeR4	GTAATAGCYCCAGCTAAAACTGG	Reverse	
PeF7	GATCGAAATTTRAATACTAC	Forward	
PeR5	GTAGTATTYAAATTTCGATC	Reverse	
PeR6	GGATCCCCMCCACCWACAAAATC	Reverse	
PeR7	GCTGACCAAAAAATCAAAATAAATGTTG	Reverse	

Products of PCR were obtained in 40 µl following the protocol described by Mitrović and Tomanović (2018). All barcoding products were sequenced with forward and reverse primers for each part of the barcoding region using automated sequencing equipment (Macrogen Inc, Seoul, South Korea). Short barcode fragments were manually edited in FinchTV ver. 1.4.0 (www.geospiza.com), aligned and concatenated using the Clustal*W* program integrated in MEGA5 (Tamura et al. 2011). Sequenced mitochondrial barcodes were subjected to maximum likelihood best fit model analysis using the MEGA5 program. According to the obtained Akaike information criterion scores, the best fit model to calculate evolutionary distances was the Tamura-Nei model (Tamura and Nei 1993).

Maximum likelihood (ML) and maximum parsimony (MP) trees were constructed using the MEGA5 software, with 500 bootstrap replicates performed to assess the branch support (Felsenstein 1985). Another parasitoid belonging to the same subfamily (Aphidiinae), *Aphidius sussi* Pennachio and Tremblay, 1989, was used as an outgroup. A median-joining network (Bandelt et al. 1999) using maximum parsimony calculation was constructed with the NETWORK ver. 4.6.1.2 (http://www.fluxus-engineering.com).

Results

Barcoding fragments of COI were successfully recovered from 18 specimens. The material subjected to molecular analyses was of different ages in terms of the time passing between sampling until DNA extraction; several of the oldest had been preserved in collections for nearly 60 years. This probably caused DNA disintegration, which resulted in failed attempts to recover the barcoding region with the LCO1490/HCO2198 standard primer pair. The newly designed *Paralipsis*-specific primers made it possible through diverse combinations to retrieve short subsequences of different length and position from disintegrated DNA of archival specimens. Prior to molecular analyses, all the barcoding sequences were aligned and trimmed to the same length of 568 bp. Comparison of COI barcodes identified 14 haplotypes (PH1-PH14) distinguished by a total of 83 variable sites, of which 51 were parsimony-informative (Table 3). The phylogenetic relationship was inferred using the MP and ML methods, which resulted in trees sharing identical topology with no substantial differences in bootstrap support (Figure 4).

Phylogenetic analysis showed molecular differentiation on the basis of COI barcoding fragments, with recognition of four distinct lineages. The first group includes seven haplotypes: PH1, PH2, PH4, PH5, PH9, PH11, and PH13, which morphologically correspond to the first known species in this genus and in Europe, *P. enervis*. The specimens were sampled from different aphid hosts (*Forda*, *Aphis*, *Anuraphis*, *Dysaphis*) in association with different plants originating from Serbia, Germany, France, Lithuania, and the Czech Republic. The average overall divergence rate between the haplotypes within this group was 1%, with distances ranging from 0.4 to 2.5% (Table 4).

The second lineage, a "Mediterranean" clade, includes haplotypes PH12 and PH14 from Spain, and haplotype PH10 from Morocco. The overall divergence rate within this group was 2.8%. Genetic distances show that the haplotype PH12 associated with *Forda formicaria* is intermediary, diverging from the haplotype PH10 from *Aphis rumicis* (2.4%) and from the haplotype PH14 associated with *Forda formicaria* (2%), while the genetic distance between the other two was 4% (Table 4). Haplotype PH14 belongs to the paratype specimen of the newly described species *P. tibiator*. On the basis of morphological examination, it can be concluded that the haplotypes PH12 and PH10 belong to *P. tibiator*, although with evident high intraspecific genetic diversity. These three specimens clearly differ from the other congeners in having an elongated flagellomere 1 (F_1) (the ratio between F_1 and F_2 is 1.3–1.4) and a large number of longitudinal placodes on F_1 and F_2 in males (5–6 in *P. tibiator* versus 0–2 in other *Paralipsis*).

The third distinct lineage on the phylogenetic tree consists solely of the haplotype PH7, with unknown host data. The single specimen available from Moldova is characterized by having a very rugose and irregularly carinated propodeum. It is described as the new species *P. rugosa* sp. n., clearly separated genetically, with average distance from the first, second, and fourth lineage of 7.3, 7.7, and 9.6%, respectively.

Table 3. The list of identified barcoding COI haplotypes in the analyzed *Paralipsis* specimens.

Haplotype	Specimens sharing the haplotype	Accession number of haplotype in GenBank
PH1	Pr1	MH475319
PH2	PA2	MH475320
PH3	PA3	MH475321
PH4	PA6	MH475322
PH5	PA9	MH475323
PH6	PA11	MH475324
PH7	PA12	MH475325
PH8	PA13	MH475326
PH9	PA4	MH475327
PH10	PA15	MH475328
PH11	PA16	MH475329
PH12	PA17, PA18, PA19	MH475330
PH13	PA21, PA23, PA24	MH475331
PH14	PA26	MH475332

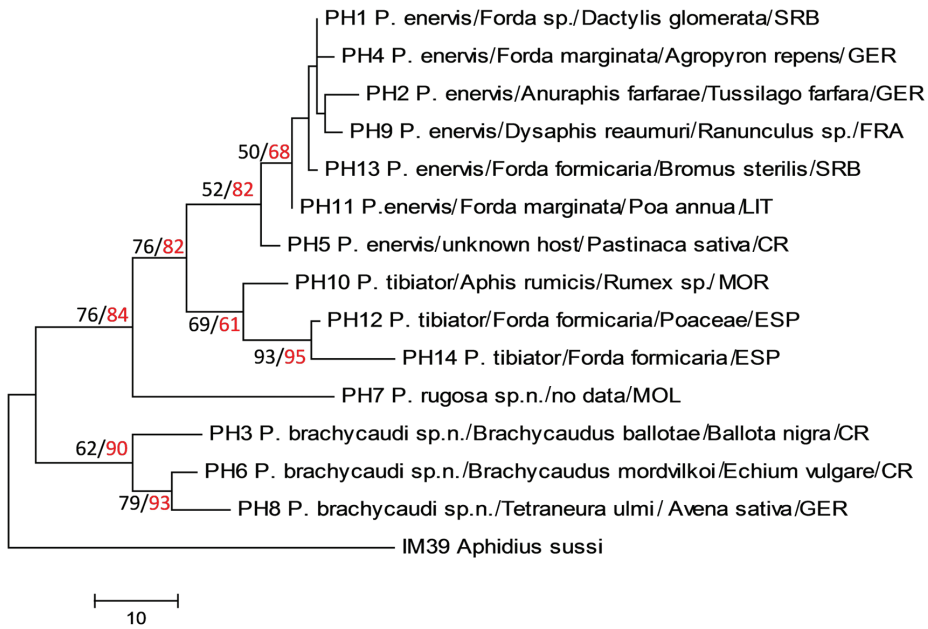


Figure 4. Phylogenetic relationship inferred using the maximum parsimony (MP) method. The consistency index is (0.533333), the retention index is (0.681818), and the composite index is 0.476540 (0.363636) for all sites and parsimony-informative sites. The MP tree was obtained using the subtree-pruning-regrafting (SPR) algorithm with search level 1, in which the initial trees were obtained by the random addition of sequences (10 replicates). The percentage of replicate trees in which >50% of the associated taxa clustered together in the bootstrap test (500 replicates) is shown next to the branches (in red color). Since the topology is identical, the bootstrap support of branches obtained by the maximum likelihood method is presented in black color as well. Barcoding haplotypes of the analyzed archival *Paralipsis* specimens are designated with codes from PH1 to PH14, species name, host aphid and host plant. Abbreviations for the countries of origin are as follows: **GER** – Germany; **FRA** – France; **SRB** – Serbia; **LIT** – Lithuania; **CR** – Czech Republic; **MOL** – Moldova; **MOR** – Morocco; and **ESP** – Spain.

Table 4. Genetic distances between the COI barcoding haplotypes of *Paralipsis* calculated using the Tamura-Nei method.

Group	Haplotype	Tamura-Nei evolutionary distances												
	PH1													
	PH2	0.009												
	PH4	0.004	0.013											
1	PH5	0.016	0.025	0.016										
	PH9	0.005	0.011	0.009	0.022									
	PH11	0.005	0.014	0.005	0.011	0.011								
	PH13	0.004	0.013	0.007	0.016	0.009	0.005							
	PH10	0.044	0.046	0.044	0.036	0.050	0.042	0.048						
2	PH12	0.050	0.056	0.050	0.037	0.056	0.048	0.054	0.024					
	PH14	0.063	0.070	0.059	0.050	0.069	0.061	0.067	0.040	0.020				
3	PH7	0.071	0.073	0.071	0.073	0.077	0.069	0.075	0.063	0.077	0.091			
	PH3	0.048	0.046	0.048	0.051	0.050	0.046	0.048	0.074	0.084	0.098	0.095		
4	PH6	0.068	0.066	0.068	0.076	0.069	0.070	0.072	0.070	0.063	0.081	0.093	0.029	
	PH8	0.056	0.062	0.056	0.066	0.058	0.062	0.060	0.070	0.061	0.075	0.100	0.036	0.018

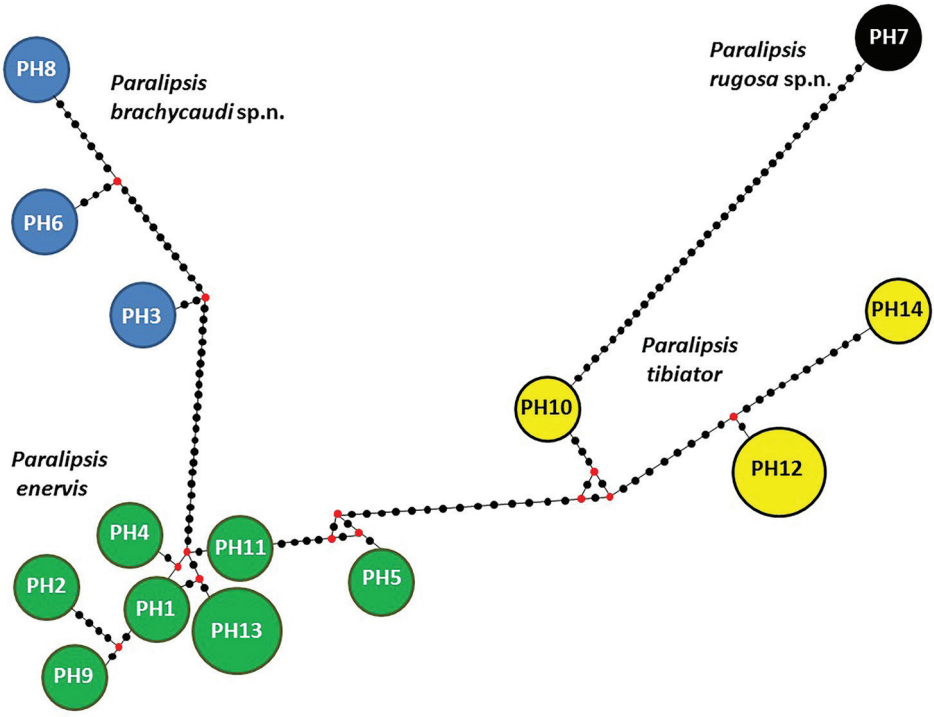


Figure 5. Median-joining network obtained for 14 *Paralipsis* COI barcoding haplotypes. Green circles represent group 1 (*P. enervis*), with haplotypes PH1, PH2, PH4, PH5, PH9, PH11, and PH13; yellow circles represent group 2 (*P. tibiator*), with haplotypes PH10, PH12, and PH14; the black circle represents the single haplotype PH7 from Moldova within group 3 (*P. rugosa* sp. n.); blue circles represent group 4 (*P. brachycaudi* sp. n.), consisting of haplotypes PH3, PH6, and PH8. Circle size reflects the number of individuals with that haplotype (not to scale). Red dots are median vectors. Black dots are mutational steps.

Three haplotypes (PH3, PH6, and PH8) originating from *Brachycaudus* sp. and *Tetraneura ulmi* aphid hosts from Central Europe (Czech Republic and Germany) are grouped within the fourth distinct lineage. The barcoding haplotypes differ in the range of 1.8 to 3.6%, with an average overall interlineage divergence rate of 2.8% (Table 4). Specimens of *Paralipsis* within this lineage are characterized by having a more elongated petiole and ovipositor sheath in comparison with other congeners, and are described as the new species *P. brachycaudi* sp. n.

The median-joining network recognized the same four distinct groups of mitochondrial haplotypes with a confidence limit of 95%: group 1 (*P. enervis*) – haplotypes PH1, PH2, PH4, PH5, PH9, PH11, and PH13; group 2 (*P. tibiator*) – haplotypes PH10, PH12, and PH14; group 3 (*P. rugosa* sp. n.) – the single haplotype PH7 from Moldova; and group 4 (*P. brachycaudi* sp. n.) - haplotypes PH3, PH6, and PH8 (Figure 5). Using maximum parsimony calculation, we determined that all haplotypes are connected with no ambiguities, and the median vectors representing either unsampled or extinct haplotypes. A significant number of mutational steps (up to 40) connecting the groups confirms clear separation of the lineages, which corresponds with high divergence rates between the groups (group 1 and group 2 – 5.2%; group 1 and group 3 – 7.3%; group 1 and group 4 – 5.9%; group 2 and group 3 – 7.7%; group 2 and group 4 – 7.5%; and group 3 and group 4 – 9.6%).

Paralipsis enervis – a review of host aphids and distribution of associations

The presented review includes evidence obtained for the most part from consulted published references about the species. The material was often re-visited, which was possible due to its preservation in available collections (IECR and FBS). The review also includes some new supplementary records (*).

Eriosomatinae

Pemphigini:

Pemphigus sp.: Czech Republic (Starý 2006).

Eriosomatini:

Tetraneura ulmi (L.): Czech Republic (Starý 1972, 2006), England (Pontin 1960), Germany (Starý 1961), Sweden (Hincks 1949).

Fordini:

Forda formicaria von Heyden: England (Hincks 1958, Pontin 1960), Germany (Starý 1961), Serbia (Kavallieratos et al. 2004, Žikić et al. 2012), *Spain (Leon, 13.06.2013, leg. N Pérez Hidalgo).

Forda marginata Koch: Lithuania - Molety, distr. Žičkai, 1-VIII-2012, on *Poa annua* roots, sample 12HAO4563 I male (J Havelka)

*Spain (Arcos de las Salinas, Teruel, 24/05/2017).

Geoica utricularia (Passerini): Serbia (Kavallieratos et al. 2004, Žikić et al. 2012).

Anoeciinae

Anoecia corni (Fabricius): Germany (Völkl et al. 1996).
Anoecia sp.: England (Pontin 1960), Czech Republic (Starý 1961), France (Noury 1962).

Aphidinae

Anuraphis catonii Hille Ris Lambers: Czech Republic (Starý 2006).
Anuraphis farfarae (Koch): Czech Republic (Starý 2006), Slovakia (Starý and Lukáš 2009).
Anuraphis subterranea (Walker): England (Pontin 1960), Czech Republic (Starý 1961).
Dysaphis crataegi (Kaltenbach): Czech Republic (Starý 1961, 2006).
Dysaphis apiifolia petroselini (Börner): Spain (Suay Cano and Michelena Saval 1998).
Dysaphis reaumuri (Mordvilko): *France (La Combe, Hte. Savoie, 12.07.1989, *Ranunculus* sp., leg. G Remaudière).
Brachycaudus ballotae (Passerini): Czech Republic (Starý 1961, 2006).
Brachycaudus cardui (L.): Czech Republic (Starý 1961, 2006).
Brachycaudus jakobi Stroyan: Netherlands (van Achterberg and Ortiz de Zugasti Carrón 2016)
Brachycaudus mordvilkoi Hille Ris Lambers: Czech Republic (Starý 2006).
Brachycaudus sp.: Czech Republic (Starý 1961, 2006).
Aphis lambersi (Börner): Slovakia (Starý and Lukáš 2009).
Aphis roepkei (Hille Ris Lambers): Czech Republic (Starý 2006).
Aphis rumicis L.: *Morocco (Immouzer, 28.04.1985, leg. A Sekkat).
Protaphis terricola Rondani: Russia-Western Siberia (Davidian and Gavrilyuk 2014).

This integrated review contains broad information and also allows a cross-comparison of all the known host aphid-parasitoid locations of *P. enervis* in the Western Palaearctic. The true distribution range of *P. enervis* is somewhat more extensive than that derivable from the above review, since in most of the countries the parasitoid wasp was determined from individually sampled specimens with no data on the associated host aphids. Similarly, the distribution data reflect strength of the respective field research efforts. It seems that the northern distribution limits are the Scandinavian countries. The vertical distribution also manifests some peculiarities. *Paralipsis enervis* was also reared from the root aphid *Dysaphis reaumuri* sampled in the Alps (France) at approximately 2200 meters (see the review).

Descriptions of new species in Europe

On the basis of morphological examination of our available material from across Europe and the Mediterranean and using the COI mitochondrial barcoding marker, we confirmed the existence of the recently described *Paralipsis* species *P. tibiator*. In addition, two new *Paralipsis* species are described below.

***Paralipsis brachycaudi* Tomanović & Starý, sp. n.**
http://zoobank.org/E2918E28-9DA3-41C1-8ABA-3546CF423793
Figures 6–14

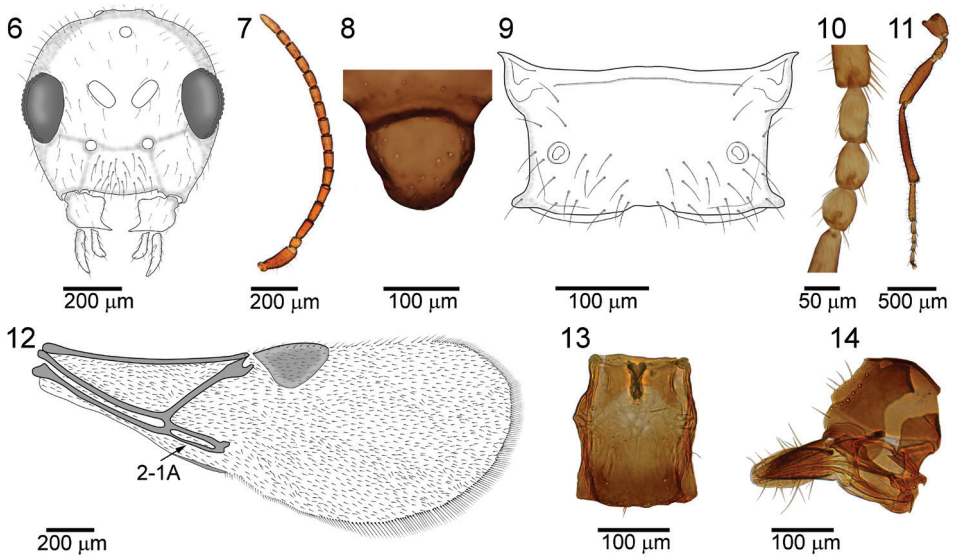
Material. Holotype ♀, Czech Republic, Čejč, 28.V.1963, reared from *Brachycaudus mordvilkoi* Hille Ris Lambers on *Echium vulgare* L., leg. J Holman; deposited in the IECR collection, slide mounted.

Paratypes 2♀♀, Czech Republic, Prague, 26.IX.1960, reared from *Brachycaudus ballotae* (Passerini) on *Ballota nigra* L., leg. J Holman; deposited in the FBS collection, slide mounted. Germany, Erlangen, Nordbayern, reared from *Tetraneura ulmi* (L.) on *Avena sativa* L., leg. H. Zwölfer; deposited in the IECR collection, slide mounted.

Diagnosis. The new species morphologically resembles *P. enervis* in petiole shape, absence of longitudinal placodes from flagellomeres 1 (F_1) and 2 (F_2), and fore wing venation pattern. *Paralipsis brachycaudi* sp. n. differs from *P. enervis* in having a longer petiole (Figure 13), the ratio between petiole length and width at the spiracle level is 1.50-1.60 in *P. brachycaudi* sp. n., while in *P. enervis* it is 1.30–1.40; somewhat shorter F_1 and F_2 (Figure 7) (the ratio between length and width of F_1 and F_2 is approximately 2.00 in *P. brachycaudi* sp. n., as opposed to 2.20–2.30 in *P. enervis*); and a propodeum that is smooth with just a few rugosities at the side (Figure 9), while the propodeum in *P. enervis* sometimes possess rugosities in the central parts which indicate for the presence of a central areola. Additionally, F_1 and F_2 are light-brown to yellow in *P. brachycaudi* sp. n., while in *P. enervis* only half of flagellomere 1 is yellow and the remaining parts of the flagellomeres are brown. The ovipositor sheath in *P. brachycaudi* sp. n. (Figure 14) is more elongated than in *P. enervis*.

Description. ***Female***: *Head* (Figure 6) rounded, narrower than mesosoma at tegulae, bearing sparse setae (Figure 6). Head 1.1 times wider than long medially. Eyes oval, small with scarse and long setae. Tentorial index approximately 0.95. Clypeus with 15–20 long setae. Maxillary and labial palpi with one palpomere each. Ocular-ocelar line: diameter of posterior ocellus: Postocelar line=12:4:14. Malar space: height of eye =20:26. Antenna 16-segmented, filiform (Figure 7). Scapus widened at the tip, vase shaped at lateral view. Pedicel subspherical. F_1 equal to F_2 and F_3 and 2.0–2.1 times as long as its maximum width at the middle. Penultimate flagellomera 1.6 times as long as wide. F_1, F_2 and F_3 without and F_4 with one short longitudinal placode (Figure 7). Flagellomeres covered uniformly with short appressed and semi-erect setae.

Mesosoma: Mesoscutum smooth, and only moderately sculptured within small central area, usually with four rows of setae along its dorsolateral part. Mesoscutum 1.4 times as long as wide. Scutellum (Figure 8) smooth elongated, bearing 20–30 long setae in the central part. Propodeum (Figure 9) smooth, sometimes with rugosities laterally. Upper and lower parts of propodeum with 3–5 and 15–20 long setae on each side (Figure 9). Fore wing (Figure 12) densely pubescent, with long marginal setae, longer than those on fore wing surface. Vein 2-1A sclerotized (Figure 12). Pterostigma triangular, 1.7–1.9 times as long as its width (Figure 12). Second-fourth segments of fore tarsus in dorsal view (Figure 10) almost as long as wide (1.1–1.2 times as long as wide) and medium sized of apical bristles. Hind tibia medially and femur subbasally parallel-sided (Figure 11).



Figures 6–14. *Paralipsis brachycaudi* sp. n., female **6** head, anterior view **7** antennae, lateral view **8** scutellum, dorsal view **9** propodeum, dorsal view **10** second-fourth segments of fore tarsus, dorsal view **11** hind leg, lateral view **12** fore wing **13** petiole, dorsal view **14** ovipositor sheath, lateral view.

Metasoma: Petiole (Figure 13) smooth, with prominent spiracular tubercles, its length 1.50–1.60 times its width at spiracles and maximum width at level of spiracles 0.7 times distance between spiracle and apex of tergite 1; 10–15 setae positioned on posterior dorsolateral margin on each side. Ovipositor sheath (Figure 14) elongated, dorsally straight, narrowed toward tip, bearing 2–6 long setae on the ventral and dorsal surface. Length of ovipositor sheath 2.25–2.87 times its maximum width.

Length: body 1.5–2.0 mm; fore wing 1.3–1.7 mm.

Coloration: General body color light-brown to brown. Head brown with light-brown mouthparts. Scape and pedicel yellow to light-brown. Flagellomere 1 and 2 yellow, remaining parts of antennae brown. Mesosoma brown. Legs yellow to light-brown. Propodeum yellow. Metasoma brown. Petiole yellow. Ovipositor sheath dark-brown.

Male: unknown.

Etymology. The name of the new species is derived from that of its aphid host.

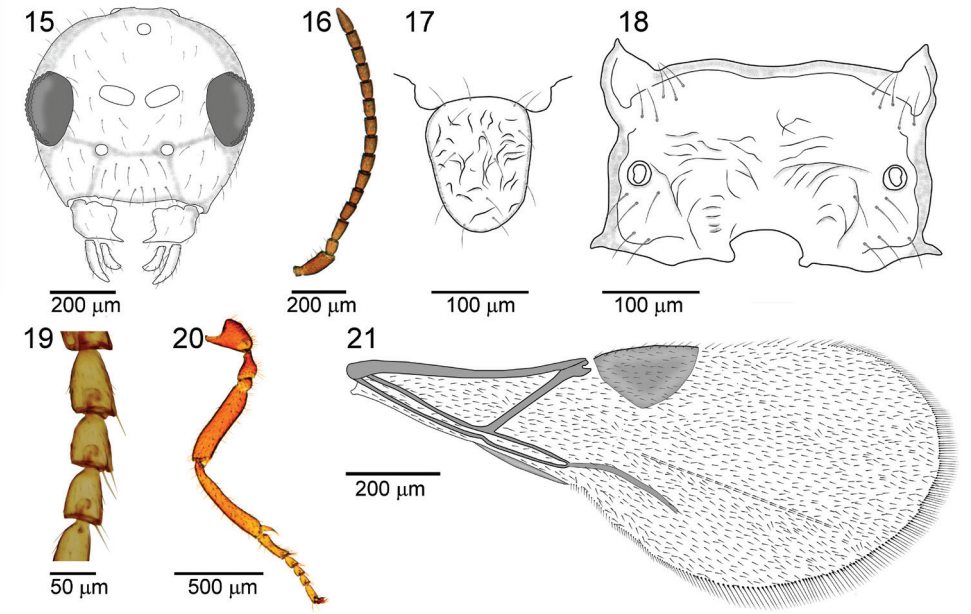
Distribution. Czech Republic, Germany.

Paralipsis rugosa Tomanović & Starý, sp. n.

http://zoobank.org/8BA5B5C2-F16E-4006-AAC6-001662AC26B3

Figures 15–21

Material. Holotype female, Moldova, Kišinev, 26.VI.1960, unknown aphid host and host plant, leg. Adaškevič; deposited in the IECR collection, slide mounted.



Figures 15–21. *Paralipsis rugosa* sp. n., female **15** head, anterior view **16** antennae, lateral view **17** scutellum, dorsal view **18** propodeum, dorsal view **19** second-fourth segments of fore tarsus, dorsal view **20** hind leg, lateral view **21** fore wing.

Diagnosis. The new species differs clearly from all known *Paralipsis* species in having a strongly rugose propodeum (Figure 18) and scutellum (Figure 17) that are irregularly deep carinated, while other *Paralipsis* species are characterized by a smooth propodeum, sometimes with moderately expressed rugosities. Also, *P. rugosa* sp. n. is with F_1 longer than F_2 (the ratio between F_1 and F_2 is approximately 1.15) (Figure 16), while *P. enervis*, *P. brachycaudi* sp. n., and *P. planus* have F_1 equal or subequal to F_2. An exception is *P. tibiator*, which has much longer F_1 than F_2 (the ratio of F_1 and F_2 is about 1.4). Further, F_1 and F_2 are very short (proportion of length and width of F_1 and F_2 are 1.76 and 1.50, respectively) (Figure 16).

Description. *Female*: Head rounded, smooth, narrower than mesosoma at tegulae, bearing dense setae (Figure 15). Head 1.1 times wider than long medially. Eyes oval, small, with scarse and long setae. Tentorial index 0.67. Clypeus with ten long setae (Figure 15). Maxillary and labial palpi with one palpomere each. Ocular-ocelar line: diameter of posterior ocellus: Postocelar line =12:4:14. Malar space: height of eye =11:13. Antenna 15-segmented, slightly thickened at apex (Figure 16). Scapus subapically with subparallel side at lateral view. Pedicel subspherical. F_1 (Figure 16) longer than F_2 and about 1.76 times as long as its maximum width at the middle, and F_2 and F_3 about 1.50 times as long as its maximum width at the middle. F_1 and F_2 without longitudinal placodes. Penultimate flagellomera 1.6 times as long as wide. F_1, F_2 and F_3 without, and F_4 with one short longitudinal placode. Flagellomeres covered uniformly with short appressed and semi-erect setae (Figure 16).

Mesosoma: Mesoscutum smooth, sculptured laterally, with very dense setae laterally. Mesoscutum 1.4 times as long as wide. Scutellum subspherical, strongly rugose with about 15 setae (Figure 17). Propodeum (Figure 18) extremely rugose. Upper and lower parts of propodeum with 5–6 long setae on each side. Fore wing (Figure 21) densely pubescent, with long lower marginal setae, longer than those on fore wing surface. Pterostigma triangular, 1.62 times as long as its width. Vein 2-1A sclerotized. Metacarpus absent. Second-fourth segments (Figure 19) of fore tarsus in dorsal view distinctly longer than wide (1.4–1.8 times as long as wide) and medium sized of apical bristles. Hind tibia medially and femur subbasally parallel-sided (Figure 20).

Metasoma: damaged.

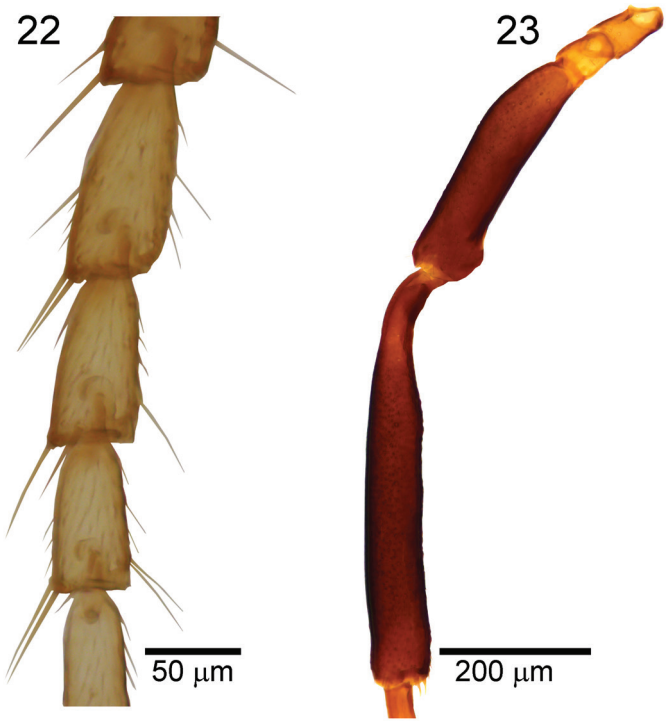
Length: head and mesosoma combined about 1 mm; fore wing about 1.7 mm.

Coloration: General body color brown. Head brown. Mouthparts light-brown. Scape and pedicel brown with small yellow terminal part. F_1 and F_2 yellow, remaining parts of antennae brown. Mesosoma brown to light-brown. Legs yellow to light-brown.

Male: unknown.

Etymology. The name of the new species refers to the very rugose propodeum and scutellum.

Distribution. Moldova.



Figures 22, 23. *Paralipsis tibiator*, female **22** second-fourth segments of fore tarsus, dorsal view **23** hind tibia and femur, lateral view.

Key to the species of the genus *Paralipsis* Foerster on the basis of females

1 Propodeum and scutellum with strong and deep rugosities (Figs 17, 18); F_1 and F_2 stout, 1.7 and 1.5 times as long as wide, respectively (Fig. 16); pterostigma triangular, about 1.6 times as long as wide (Fig. 21).....***P. rugosa* sp. n.**

– Propodeum and scutellum smooth or with moderate expressed rugosities (Figs 8, 9); F_1 and F_2 elongate, 2.0–2.2 and 1.8–2.1 times as long as wide, respectively (Fig. 7); pterostigma 1.8–2.0 times as long as wide (Fig. 12) **2**

2 Second-fourth segments of fore tarsus distinctly longer than wide in dorsal view (Fig. 22); hind tibia medially and femur subbasally widened (Fig. 23); flagellar segments narrowed basally **3**

– Second-fourth segments of fore tarsus approximately as long as wide in dorsal view (Fig. 19); hind tibia medially and femur subbasally almost parallel sided (Fig. 20); flagellar segments parallel-sided **4**

3 Mesoscutum and scutellum smooth and densely setous; flagellomere 1 distinctly longer than F_2 (1.3–1.4 times as long as wide); pterostigma triangular, approx. 1.8 times as long as wide.....***P. tibiator***

– Mesoscutum and scutellum moderate rugose and setous; F_1 subequal to F_2 (about 1.1 times as long as wide); pterostigma twice as long as wide .....***P. planus***

4 Forewing 2-1A vein absent; Japan and Far East .....***P. eikoae***

– Forewing 2-1A vein present, partly or completely sclerotized; Europe.....**5**

5 Petiole 1.50-1.60 times as long as wide at spiracles level; F_1 about 2.0 times as long as wide; F_1 and F_2 yellow..... ***P. brachycaudi* sp. n.**

– Petiole 1.30–1.40 times as long as wide at spiracles level; flagellomere 1, 2.0–2.2 times as long as wide; basal third of F_1 yellow till light brown and remaining part F_1 and whole F_2 brown.....***P. enervis***

Discussion

We have demonstrated here a progress in methodology of DNA amplification by designing *Paralipsis*-specific degenerative primers to retrieve disintegrated DNA fragments from archived museum specimen collections of which can be considered as biobanks and used to discover new species (Yeates et al. 2016). Sequencing of the COI barcoding region of 18 specimens collected across the Western Palaearctic over a long period of time did not determine any clear specialization of taxa to a strict root aphid host. There is no geographical structuring of genetic variation between specimens associated with the same aphid host within the lineages *P. enervis*, *P. tibiator*, nor *P. brachycaudi* sp. n. However, it confirmed the existence of *Paralipsis tibiator*, a species recently described by van Achterberg and Ortiz de Zugasti Carrón (2016). Although a second recently described species, viz., *P. planus* (van Achterberg and Ortiz de Zugasti Carrón 2016), was not available for molecular analysis, the general morphological description (petiole shape, wing venation pattern, antennae) indicates that it is close to *P. enervis*, so we sup-

pose it belongs to the *P. enervis* lineage. However, since *P. planus* was described on the basis of a single specimen, it is necessary to further explore the morphological and genetic variability of this species in order to finally confirm its taxonomic status. In addition, the present study revealed two new *Paralipsis* species, *P. rugosa* sp. n. and *P. brachycaudi* sp. n. Four separate phylogenetic lineages showed clear distinction, but with significant intralineage genetic variation between the haplotypes associated with different aphid/host associations. All phyletic lineages share aphid hosts from the subfamilies Aphidinae and Eriosomatinae. Many Eriosomatinae are specialized gall-producing aphids, but only on primary host plants, while this is not the case on secondary host plants (grasses), where they are parasitized by *Paralipsis* wasps and other specialized root aphid parasitoids.

It is necessary to examine in detail all known records of *P. enervis* in the light of the diagnosis given for the new *Paralipsis* species described in the present paper. Probably, *P. enervis* represents a complex of cryptic species, which is a common case among aphid parasitoids (Mitrovski-Bogdanović et al. 2013, Derocles et al. 2016). Although our molecular analyses were restricted to only 18 COI barcoding sequences retrieved from dry *Paralipsis* specimens, we recognized four phyletic lineages on the phylogenetic tree with a sister position of *P. brachycaudi* sp. n. in relation to *P. enervis* + *P. rugosa* sp. n. + *P. tibiator* lineages. The strong rugosities of the propodeum and scutellum in *P. rugosa* sp. n. represent an autapomorphic character state, while its possession of very short flagellomeres is a plesiomorphic character state. We recognize the elongated ovipositor sheath and petiole in *P. brachycaudi* sp. n. as apomorphic characters. We did not find any strong support for the existence of *Paralipsis* host-specific lineages. *Brachycaudus* aphid hosts were found only in the *P. brachycaudi* sp. n. lineage, while other aphid hosts are mainly shared between *P. enervis* and *P. tibiator*. Although *Forda* root aphids are distributed throughout the whole of Europe, *P. tibiator* attacked them only in Mediterranean-type habitats. It is known that the distribution of parasitoids is usually narrower than that of their aphid hosts, due to the more specific habitat and microhabitat of parasitoids (Starý 1970). The records of *P. enervis* associated with *Brachycaudus* aphid hosts should be carefully examined, as they may be referable to *P. brachycaudi* sp. n. All findings of *P. tibiator* are from Mediterranean areas.

Although most of our samples originated from central and southern Europe, *Paralipsis* species are distributed in several European countries, including ones in the northern part of the continent (van Achterberg 2012, Staverløkk and Ødegaard 2016). However, no *Paralipsis* species have been recorded in more than half of the countries of Europe (van Achterberg 2012). In the present study, we have not explored the relationships between ants and *Paralipsis* wasps. However, future research should reveal existing relationships of the two newly described species with ants and result in new knowledge about the biology and ecology of these *Paralipsis* wasps.

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Four notable additions to the South African echinoid fauna (Echinodermata, Echinoidea)

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Abstract

Although a comprehensive guide to the South African echinoid fauna was published as recently as 2017, four notable additions to the fauna have emerged since that time and are reported on here. The first South African records for *Histocidaris purpurata* (Thomson, 1872), *Echinothrix diadema* (Linnaeus, 1758), *Microcyphus rousseaui* L. Agassiz, in Agassiz and Desor 1846, and *Pseudoboletia maculata* Troschel, 1869 are presented. All four species have previously been recorded from the Atlantic and/or Indian Oceans and their ranges are thus extended southwards here. These additions increase the total number of echinoid species known from South Africa to 74.

Keywords

Biodiversity, new records, taxonomy

Introduction

The echinoid fauna of South Africa has recently been revised by Filander and Griffiths (2014), who added 19 species to the regional fauna, and by Filander and Griffiths (2017), who provided an identification key and a guide to each of the 70 species then known from the region. Since the publication of that review, four more remarkable

additions to the echinoid fauna have been identified and are reported on here. These additions thus increase the number of recorded South African echinoids to 74 species, spread across 29 families.

Materials and methods

Morphological analysis of the specimens followed the invasive method, which included removal of the primary and secondary spines to expose features of the test. This was done by soaking specimens in a solution of domestic bleach for various time intervals, depending on their size. For the single available specimen of *H. purpurata* the spines were removed from only one half of the test.

Taxa are listed systematically according to Kroh and Smith (2010), which is in line with the classification presented in the World Register of Marine Species (2018), and the scientific name is presented with the author and date of publication. Synonyms are listed in historical order, together with selected literature records under that name. A brief paragraph on the identification features of each species, its previously reported distributional range, and data on the new regional records are also included.

Studied specimens are derived from the following museums:

SAMC Iziko South African Museum, Cape Town, South Africa
RBINS Royal Belgian Institute of Natural Sciences
RMCA Royal Museum for Central Africa, Tervuren, Belgium

Taxonomic part

Class Echinoidea Leske, 1778
Order Cidaroida Claus, 1880
Family Histocidaroidea Lambert, 1900
Genus *Histocidaris* Mortensen, 1903

***Histocidaris purpurata* (Thomson, 1872)**
Fig. 1A, B

Poriocidaris purpurata: Mortensen 1928: 104–107, pl. I, fig. 6, pl. III, figs 3–5 [distribution and synonymy].
Histocidaris purpurata: Clark 1925: 38; Schultz 2011: 872–973, figs.1465–1468; Atkinson et al. 2018: 441.

Identification. Test medium sized (test diameter = 28 mm); round and robust. Marginal series with regular and small tubercles. Interambulacra with distinctively large, crenulate primary tubercles. Areoles slightly deepened. Apical system covered with tubercles, ocular plates exsert. Periproct raised, with plates decreasing in size inwards. Primary spines

cylindrical, tapering gently. Oral spines broad, flattened, slightly curved, with serrated edges. Secondary spines flattened, narrowing towards blunt point. Primary spines brown to purplish violet, with white shaft. Secondary spines light brown. Denuded test white.

Material examined. SAMC.A090123: one specimen collected by an otter trawl through the South African Observation and Environmental Network/Department of Agriculture and Fisheries long-term offshore invertebrate programme in May 2016 on board the Compass Challenger, depth 570 m. Whole specimen preserved in 70 % ethanol.

Habitat. Muddy habitat.

Global distribution. Previously known only from the Atlantic, Ireland to Canary Islands, and the Caribbean, at 750–1084 m depth (Mortensen 1928; Schultz 2011).

South African distribution. South-east coast of South Africa, off Mossel Bay (35.079°S, 23.603°E).

Remarks. Although Döderlein (1906) previously reported this species in the Indian Ocean (at the Sombrero Channel, Nicobar Islands, at 805 m), Mortensen (1932) disregarded this record on the basis that the specimen was too small and that no adults of this species had been previously collected in the region. The current record therefore represents the first reliable report of this species from the Indian Ocean.

Only one other species, *Histocidaris elegans* (A. Agassiz, 1879), belonging to this genus has previously been reported in South African waters and this remains a dubious record, as it lacks locality data (Mortensen 1932; Filander and Griffiths 2017). Nonetheless, *H. purpurata* differs from *H. elegans* both in its distinctive coloration and shape of the primary spines. *Histocidaris purpurata* has a distinctively purple and brown coloration, with thick, cylindrical, and pointed primary spines; whereas *H. elegans* is light brown in colour, with thinner and blunt primary spines.

Order Diadematoida Duncan, 1889
Family Diadematidae Gray, 1855
Genus *Echinothrix* Peters, 1853

***Echinothrix diadema* (Linnaeus, 1758)**
Fig. 1C, D

Garelia cincta: Agassiz 1863: 18–19.
Echinothrix diadema: Mortensen 1940: 290–295, pl. XLIII, figs 1–2, pl. XLV, figs 1–8, pl. XLVI, figs 2–4, pl. XLVII, figs 4, 6–7, pl. XLVIII, fig. 4, pl. LXXI, figs 1, 3 [synonym and description]; Clark and Rowe 1971: 153, fig. 64a [description and distribution]; Samyn and Vanden Berghe 2000: 11 [distribution].

Identification. Test large sized (test diameter = 120 mm). Ambulacra not bulging, with one primary tubercle per three pore-pairs. Interambulacra with distinctively large, perforated, and crenulated primary tubercles, where each plate is surrounded by six smaller tubercles. Areoles slightly deepened. Apical system with insert plates, where gonopores are positioned distally on genital plates. Spines banded, long, and needle-like,

with a ridged surface. Denuded test creamy white and reported by Samyn and Vanden Berghe (2000) to be sometimes reddish.

Material examined. RMCA.2561: one specimen collected from the intertidal zone of Isipingo Beach in August 1999; RMCA.2568: one specimen collected by SCUBA diving off 2-Mile Reef in August 1999, at 15 m. All were complete specimens which were fixed and originally preserved in 90–70% ethanol. At present they are preserved dry.

Habitat. Littoral and reef habitats.

Global distribution. Indo-Pacific: Paumotu, Tahiti, Hawaii to Japan, north Australia; to Madagascar, East Africa to Red Sea (Mortensen 1940; Clark and Rowe 1971; Samyn and Vanden Berghe 2000).

South African distribution. East coast of South Africa, south of Durban off Isipingo Beach (30.0036°S, 30.9425°E: approximate co-ordinates), and off 2-Mile Reef, Sodwana Bay (27.5129°S, 32.6862°E: approximate co-ordinates).

Remarks. *Echinothrix diadema* closely resembles *E. calamaris* (Pallas, 1774), but differs in coloration, patterns of ambulacra, interambulacra, and apical plates. *Echinothrix diadema* is not reported to have a greenish denuded test, lacks a conspicuous naked interambulacral space, and the ambulacral tubercles increase in size at the ambitus; the apical plates have numerous tubercles (Mortensen 1940).

The current record was not included in previous South African reviews (Filander and Griffiths 2014; Filander and Griffiths 2017) because these publications were based on Iziko South African Museum samples and online accessible samples. Presented here is new material from the Royal Museum for Central Africa, which was not known by the authors at the time (Filander and Griffiths 2014; Filander and Griffiths 2017).

Order Camarodonta Jackson, 1912
Family Temnopleuridae A. Agassiz, 1872
Genus *Microcyphus* L. Agassiz in L. Agassiz & Desor, 1846

Microcyphus rousseaui L. Agassiz in L. Agassiz & Desor, 1846

Fig. 1E, F

Microcyphus rousseaui L. Agassiz & Desor, 1846: 358, pl. 15.10; Mortensen 1904: 98; Mortensen 1943: 155–159, pl. XIII, figs 18–25, pl. XLVII, figs 18–20, 23–24 [description and synonymy]; Clark and Rowe 1971: 140, 156; Samyn and Vanden Berghe 2000: 6, 13, pl. 1E [distribution]; Schultz 2010: 148, fig. 273 [distribution].

Identification. Test small sized (test diameter = 20 mm), low, hemispherical. Ambulacral pore-pairs arranged in double series, outer series formed by pore-pair of median component, and the inner series by pore-pairs of the upper and lower component of each compound ambulacra plate. Interambulacra partially tuberculated, with sparsely and irregularly arranged same-sized tubercles. Naked part of interambulacra broad and conspicuous. Apical system with apical plates densely covered by tubercles, ocular

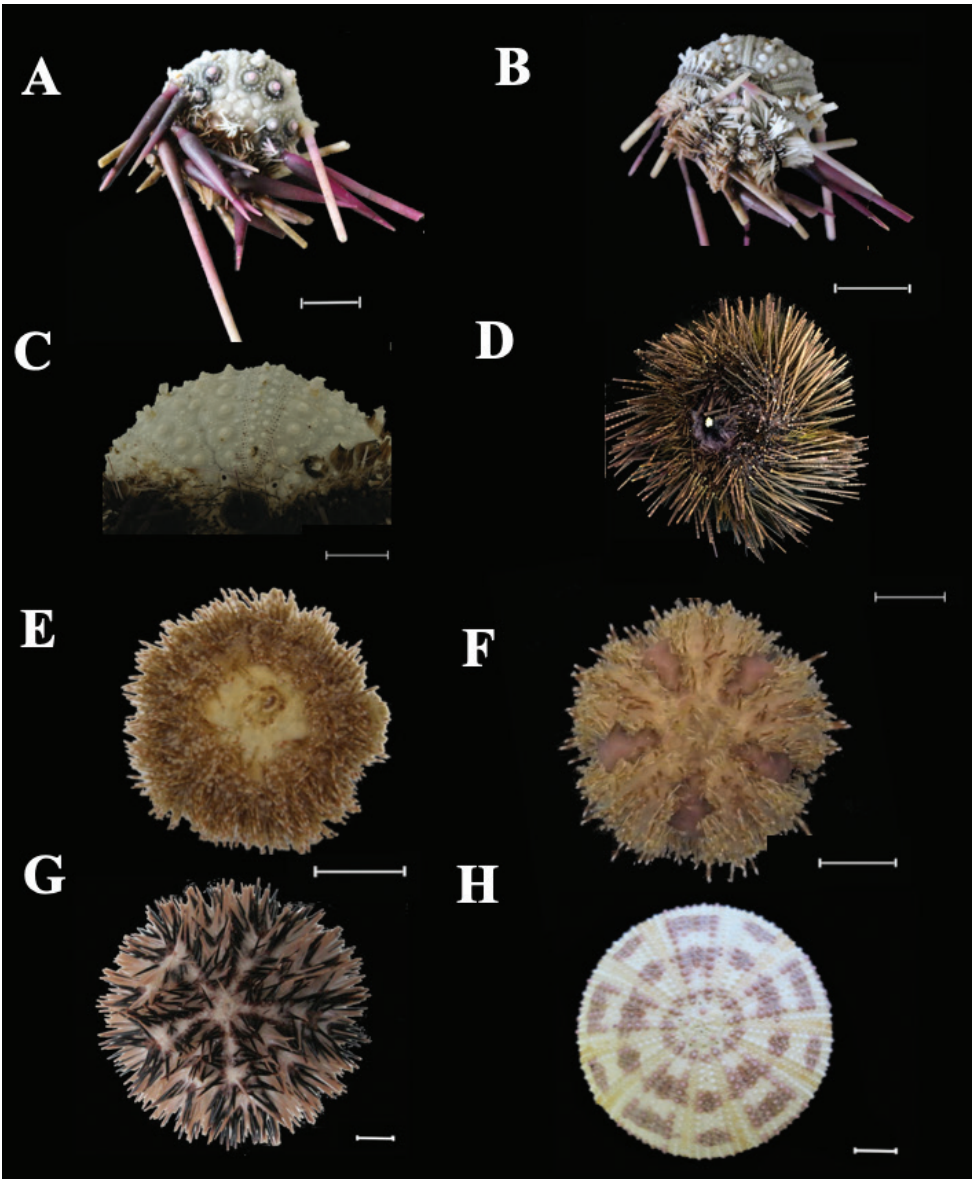

Figure 1. A–B (SAMC.A090123, off Mossel Bay): *Histocidaris purpurata*. **A** Aboral view of preserved specimen with partially removed spines **B** Oral view of preserved specimen with partially removed spines **C–D** *Echinothrix diadema* **C** (RMCA.2561, Ispingo). Aboral view of partially denuded test **D** (RMCA.2568, Sodwana Bay). Oral view of preserved specimen with spines **E–F** (SAMC.A090124, Sowdana Bay): *Microcyphus rousseaui* **E** Oral view of preserved specimen with spines **F** Aboral view of preserved specimen with spines **G–H** (SAMC.A090126, Park Rynie): *Pseudoboletia maculata* **G** Aboral view of preserved specimen with spines **H** Aboral view of preserved denuded test. Scale bars: 2 cm (**A, B, G, H**); 1 cm (**C–F**)**.** All images were edited in GIMP 2.8.22 by Dr Carl Palmer and plate created by Zoleka Filander.

plates exsert. Periproct covered with numerous plates. Spines of uniform size, reddish-brown with white tips; naked median areas brownish-red, becoming lighter to centre. Denuded test light brown, with darker tuber-covered parts.

Material examined. SAMC.A090124: two specimens collected by SCUBA diving off Leadsman Shoal, Sodwana Bay; SAMC.A090125: one specimen collected by SCUBA diving off Redsands Reef, Sodwana Bay; RBINS I.G. 33199/Ech.132: one specimen collected by SCUBA diving off the 7-Mile Reef, Sodwana Bay. All samples were collected through the Belgian Global Taxonomy Initiative in January 2016, at a 10–23.9 m depth range. All specimens, except for those belonging to sample SAMC. A090124, are complete with spines and preserved in 70 % ethanol.

Habitat. Reef habitat.

Global distribution. Western Indian Ocean: Red Sea, East African coast southwards to Mozambique (Mortensen 1943; Clark and Rowe 1971; Samyn and Vanden Berghe 2001; Schultz 2010)

South African distribution. East coast of South Africa, off Sodwana Bay; off Leadsman Shoal (27.8737°S, 32.6036°E), Redsands Reef (27.7384°S, 32.6298°E), and 7-Mile Reef (27.4515°S, 32.7118°E).

Remarks. Closely resembles *Microcyphus maculatus* L. Agassiz in L. Agassiz and Desor 1846 from which it differs in the coloration and apical system. *Microcyphus rousseaui* has reddish brown spines and apical plates bearing more than three tubercles, whereas *M. maculata* has light green spines and an apical system bearing fewer than three tubercles per plate (Mortensen 1943).

Microcyphus rousseaui differs from *M. rousseaui purpuratus* Mortensen, 1942 in coloration of the spines, the sub-species having purple spines with distinctive white bands (Mortensen 1942).

This is the first South African record of this species and represents a range extension southwards from Mozambique, the southernmost-recorded location. It is also the first record of the genus in the region.

Family Toxopneustidae Troschel, 1872
Genus *Pseudoboletia* Troschel, 1869

Pseudoboletia maculata Troschel, 1869
Fig. 1G, H

Pseudoboletia maculata Troschel, 1869: 96; Bell 1884: 110, pl. XIII; de Meijere 1904: 286–289, pl. XVII; Clark 1925: 131; Mortensen 1943: 532–534, pl. XLII, figs 4–5, pl. LV, figs 2, 5–6, 16–17, 21 [synonyms and distribution]; Clark and Rowe 1971: 142, 156 [distribution]; Schultz 2010: 264, figs 506–508; Conand et al. 2018: 115.

Identification. Test large sized (70 mm) and low, hemispherical in shape. Ambulacra with pore-pairs arranged in a double series per compound plate, with one larger second-

ary non-crenulated tubercle outside the pore-pair. Interambulacra with sparsely and irregularly arranged same-sized tubercles, which increase in size towards ambitus. Apical system with smooth apical plates encircled by tubercles, ocular plates I and V appear to be insert. Periproct covered with numerous plates. Spines of uniform size, reddish brown and pinkish white. Denuded test white, with dark brown patches on interambulacra.

Material examined. SAMC.A090126: two specimens collected by Roy Jackson from University of KwaZulu-Natal on an intertidal field trip in August 2015. One specimen is preserved as a naked corona and the other is complete with spines. Both specimens are preserved in 70 % ethanol.

Habitat. Rocky shore.

Global distribution. Indo-West Pacific: Ceylon to Australia, 10–100 m depth (Mortensen 1943; Schultz 2010; Arachchige et al. 2017).

South African distribution. East coast of South Africa, off Park Rynie (30.3187°S, 30.7425°E: approximate co-ordinates).

Remarks. According to our present material, the ocular plates I and V appeared to be insert, which would be consistent with what is observed in other specimens of this species. This is the first South African record, representing a range extension southwards of this species from Madagascar (Clark and Rowe 1971).

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Supplementary material 1

Further additions to the South African echinoid (Echinodermata, Echinoidea) fauna (COL)

Authors: Zoleka Filander, Yves Samyn, Charles Griffiths

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RESEARCH ARTICLE

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New record of an estuarine polychaete, *Neanthes glandicincta* (Annelida, Nereididae) on the eastern coast of Peninsular Malaysia

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Abstract

An estuarine species of Nereididae (Annelida), *Neanthes glandicincta* (Southern, 1921) has been newly recorded on the eastern coast of Peninsular Malaysia located in the South China Sea based on 23 specimens collected from three estuaries (Tumpat, Kelantan Delta, Kelantan; Setiu Lagoon, Terengganu; Kuala Ibai, Terengganu). The morphological characteristics of the Malaysian specimens agree well with those of the previous original description and the redescription of *N. glandicincta* based on Indian, Myanmar and Singapore specimens. The number of paragnaths in all groups on the proboscis of our Malaysian specimens is within the range of the intraspecific variation of *N. glandicincta* as shown in the previous descriptions. An identification key to species of the *Neanthes glandicincta* species complex, which includes two morphologically similar species, is provided.

Keywords

Kuala Ibai, paragnath, polychaete, Setiu Lagoon, South China Sea, taxonomy, Tumpat

Introduction

Estuaries are ecologically important habitats which serve as critical transition zones between freshwater and marine habitats (Levin et al. 2001). In general, nereidid polychaetes often occur as major components of the macrobenthic fauna in estuaries and play important roles in the nutrient cycling of an estuary ecosystem (Sato 2017). However, taxonomic knowledge of nereidid fauna in tropical Asia seems to be insufficient although the area has the greatest diversity of coastal species in the world (Tittensor et al. 2010). In Malaysia, only six nereidid species belonging to three genera (*Namalycastis rhodochorde*, *N.* cf. *abiuma*, *Namalycastis* sp., *Dendronereides* sp., *Perinereis* cf. *nuntia* and *P. aibuhitensis*) have been recorded with a published taxonomic account (Idris et al. 2012, Ibrahim et al. 2017), while approximately 700 species belonging to 45 genera have been recorded worldwide (Santos et al. 2005, Read and Glasby 2015).

In Asian tropical estuaries, two nereidid species, *Neanthes glandicincta* (Southern, 1921) and *Composetia burmensis* (Monro, 1937), have been most commonly reported (Lee and Glasby 2015). Lee and Glasby (2015) demonstrated that *C. burmensis* is a junior synonym of *N. glandicincta,* and newly found a cryptic species from eastern Singapore, which is morphologically very similar to but distinct from *N. glandicincta,* and described as *Neanthes wilsonchani.*

During our survey of the nereidid fauna in estuaries located on the eastern coast of Peninsular Malaysia, we found *N. glandicincta,* which commonly occurs in all of the three sites surveyed, without any occurrence of *N. wilsonchani* in spite of geographical proximity between our sampling sites and the type locality of *N. wilsonchani*. In the present paper, we describe *N. glandicincta* as a new record from the eastern coast of Peninsular Malaysia.

Materials and methods

Field sampling for nereidid specimens was carried out at three estuaries located on the eastern coast of Peninsular Malaysia (Fig. 1): Tumpat, Kelantan Delta, Kelantan (Fig. 2A) in August 2009 (three sites); Setiu Lagoon, Terengganu (Fig. 2B, C) in August 2009 (two sites) and 2015 (one site); and Sungai Ibai, Kuala Ibai, Terengganu (Fig. 2D) in August 2009 (one site).

Specimens were collected from sediment samples dug out from intertidal bottoms using shovels, fixed in 80% ethanol, and transferred to fresh 80% ethanol for preservation. The salinity of the surface or interstitial water (water kept in a hole dug in the sediment surface at low tide) was measured using a SCT meter (Quanta Multi-Parameter Probe).

For preserved specimens, the anterior maximum body width, excluding parapodia (BW) was measured at a scale of 1-mm units; for complete specimens, its body length from the anterior end of the prostomium to the posterior end of the pygidium, excluding the anal cirri (BL) was measured, and the number of total chaetigers was also counted. The paragnaths in each group on the proboscis were counted under

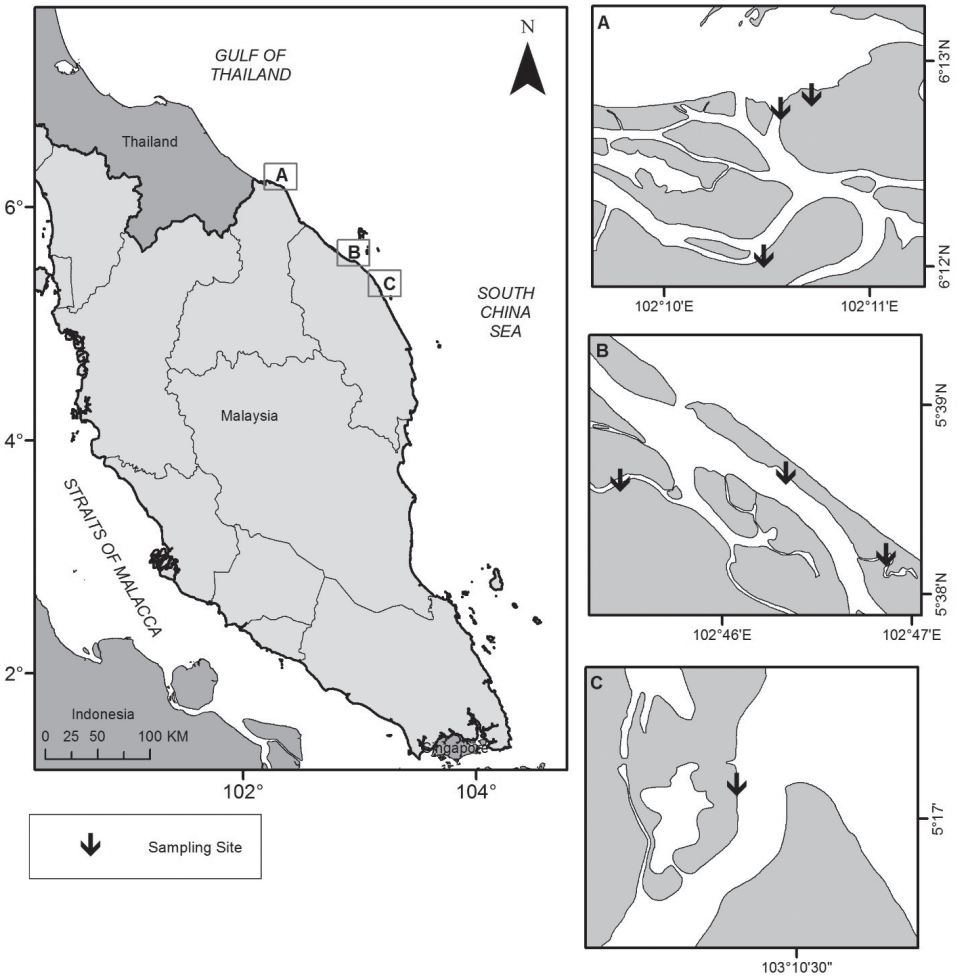

Figure 1. Map showing three estuaries in the eastern coast of Peninsular Malaysia. **A** Tumpat, Kelantan Delta, Kelantan **B** Setiu Lagoon, Terengganu **C** Kuala Ibai, Terengganu.

a stereoscopic microscope both the right and left sides of Groups II and IV were counted but only the larger count was reported. Photographs of the specimens were taken using a digital camera (AM4023X Dino Eye) attached to stereoscopic (Olympus SZX7) and compound (Leica DM300) microscopes. Drawings were prepared using a camera lucida attached to the microscopes. A map drawing was prepared using the ArcGIS 10.3 software.

The usage of terminology of paragnath groups on the proboscis, and parapodial and chaetal morphology is according to Bakken and Wilson (2005).

Specimens were deposited in the South China Sea Repository and Reference Center of Universiti Malaysia Terengganu (**UMT**) and the National Museum of Nature and Science, Tsukuba, Japan (**NSMT**).

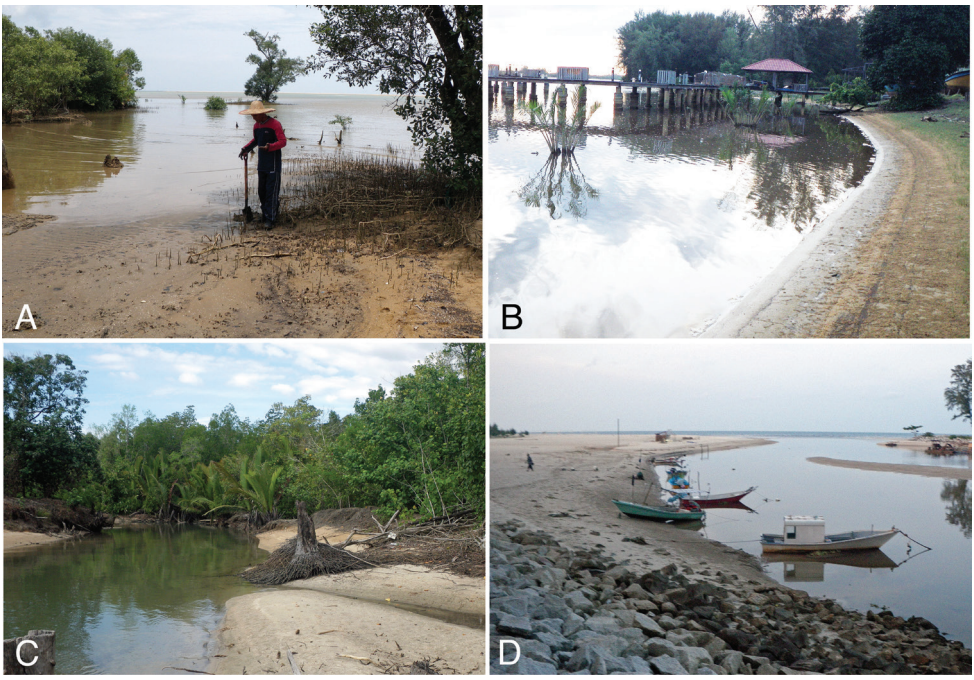

Figure 2. Sampling sites in three estuaries in the eastern coast of Peninsular Malaysia. **A** around river mouth of Sungai Mak Neralang in Tumpat, Kelantan Delta, Kelantan (photographed on 13 August 2009) **B** site 102 at the eastern coast of Setiu Lagoon, Terengganu (photographed on 10 August 2009) **C** muara Kuala Setiu at the western coast of Setiu Lagoon, Terengganu (photographed on 6 August 2015) **D** around river mouth of Sungai Ibai (photographed on 12 August 2009).

Systematics

Family Nereididae Blainville, 1818

Genus *Neanthes* Kinberg, 1865

Neanthes Kinberg, 1865: 171–172; Imajima 1972: 102; Fauchald 1977: 89; Wu et al. 1985: 143; Khlebovich 1996: 102; Bakken 2002: 328; Bakken and Wilson 2005: 527; Glasby et al. 2011: 363; Sato 2013: 35; Bakken et al. 2018: 29.

Type species. *Neanthes vaalii* Kinberg, 1865.

Diagnosis. Prostomium with entire anterior margin, one pair of antennae, one pair of palps. Eyes present or absent. Eversible proboscis usually with conical paragnaths on both maxillary and oral rings; paragnaths on oral ring occasionally degenerating to minute ones or completely lost; paragnaths occasionally emerging from plate-like basement; smooth bar-like paragnaths present or absent on group IV of maxillary ring. Four pairs of tentacular cirri. Parapodia biramous, except first two pairs; notoaciculae present or absent on chaetigers 1 and 2. Dorsal cirrus lacking basal cirrophore. Notochaetae homogomph spinigers. Upper neurochaetae including homo-

gomph spinigers and heterogomph falcigers; heterogomph spinigers present or absent. Lower neurochaetae including heterogomph falcigers; homogomph and heterogomph spinigers present or absent. Neuropodial heterogomph falcigers occasionally with varying degrees of fusion of chaetal shaft and blade in posterior body.

Remarks. *Neanthes* is a large genus, considered to be polyphyletic (Bakken and Wilson 2005; Glasby et al. 2011). The generic diagnosis is modified here from Sato (2013) to allow for the occasional absence of paragnaths on the oral ring of the proboscis of the *Neanthes glandicincta* species complex (see below).

Neanthes glandicincta species complex

Diagnosis. Conical paragnaths present in all of groups I, II, III, and IV on maxillary ring of proboscis. Only few minute rudimentary paragnaths or none present in groups VI and VII–VIII on oral ring of proboscis; paragnaths absent in group V; single round papilla usually present in group VI, with single minute paragnath, or no paragnaths, seated on tip of papilla. Uniramous parapodia of first two chaetigers without notoacicula. In following biramous parapodia, notopodia, consisting of dorsal cirrus and three ligules/lobe (dorsal ligule, prechaetal lobe and ventral ligule) throughout. Neuropodia, consisting of four ligules/lobes (superior lobe, inferior lobe, postchaetal lobe, ventral ligule) and ventral cirrus present in anterior and middle body; superior lobe absent in posterior body. Upper neurochaetae includes homogomph spinigers with long blades and heterogomph spinigers with short blades throughout; some or most of heterogomph spinigers replaced by heterogomph falcigers in middle body. Lower neurochaetae include heterogomph spinigers with long blades and heterogomph spinigers with short blades throughout; some or most of heterogomph spinigers with short blades replaced by heterogomph falcigers in middle body. Heterogomph falcigers first appear around chaetiger 20. Conspicuous dark glandular patches present in notopodial dorsal ligules.

Geographical distribution. The coast of Indian Ocean (Iran, India, Bangladesh, Myanmar), Singapore, the coast of South China Sea (Peninsular Malaysia, Thailand, Vietnam, China, Taiwan), and eastern Australia. Based on Southern (1921), Monro (1937), Fauvel (1932, 1939, 1953), Khlebovich (1963), Rullier (1965), Wu (1967), Wu et al. (1985), Muir and Maruf Hossain (2014), Lee and Glasby (2015), Bonyadi-Naeini et al. (2017), and the present study.

Remarks. Two species, *Neanthes glandicincta* (Southern, 1921) and *N. wilsonchani* (Lee & Glasby, 2015), are included in this species complex at present. The two species are distinguishable only by the numbers of paragnaths (Lee and Glasby 2015; see the key below).

Key to species of the *Neanthes glandicincta* species complex

1 Paragnaths more than 30 in group III, more than 70 in total ..... ***N. glandicincta***
– Paragnaths fewer than 30 in group III, fewer than 50 in total..... ***N. wilsonchani***

***Neanthes glandicincta* Southern, 1921**
Figs 3, 4

Nereis (*Nereis*) *glandicincta* Southern, 1921: 589–593, pl. 23, fig. 9A–L, text fig. 5a–c.
Nereis glandicincta: Fauvel 1932: 92–93; Fauvel 1953: 181–182, fig. 91f–h.
Neanthes glandicincta: Lee and Glasby 2015: 80–85, figs 7–9.
Ceratonereis burmensis Monro, 1937: 532–536, fig. 1a–f; Ng et al. 2011, in part.
Nereis (*Ceratonereis*) *burmensis*: Fauvel 1953: 196–197, fig. 97d–f.
Ceratonereis (*Composetia*) *burmensis*: Hartmann-Schröder 1985: 49 (list); Chan 2009: 165–167, fig. 5a–r, in part.

Type locality. Brackish lakes or pools at four localities in Barantolla, Dhappa and Garia, near Calcutta in India (26 syntypes) (Southern 1921).

Material examined. Tumpat, Kelantan Delta, Kelantan, Malaysia: a specimen (BW, 1.3 mm; UMTAnn 428), around the jetty (6°12'03"N, 102°10'29"E), coll. M. Sato, 13 August 2009; 5 (BW, 1.6–2.0 mm; NSMT 113250), around the river mouth of Sungai Mak Neralang (6°12'46"N, 102°10'34"E), coll. M Sato, 13 August 2009; 2 (BW, 1.5–2.0 mm; UMTAnn 429), natural mangrove forest (6°12'50"N, 102°10'43"E), coll. M Sato, 13 August 2009. Setiu Lagoon, Terengganu, Malaysia: 3 (BW, 1.6–1.8 mm; UMTAnn 430), site 102, northwest of Terrapuri Heritage Village, Penarik (05°38'12.5"N, 102°46'52"E), coll. M Sato et al., 10 August 2009; 8 (BW, 1.5 mm –2.0 mm; NSMT 113251), site 103, northwest of site 102 (05°38'38.4"N, 102°46'20.2"E), coll. M Sato et al., 10 August 2009; 2 (BW, 1.2–1.7 mm; UMTAnn 431), Muara Kuala Setiu (05°40'26.3"N, 102°43'17.4"E), coll. YS Ibrahim et al., 6 August 2015; Kuala Ibai, Terengganu, Malaysia: 2 (BW, 0.7 mm –1.1 mm; UMTAnn 432), around the river mouth of Sungai Ibai (5°17'04"N, 103°10'23"E), coll. M Sato et al., 12 August 2009.

Diagnosis. Based on Southern (1921), Lee and Glasby (2015), and the present study. Maxillary ring of proboscis with conical paragnaths (0–17, usually approx. 10, scattered and unequal in group I; 10–23, large and curved in group II; 30–63, in 4 rows of transversely elongated bands in group III; 10–22, large in group IV). Oral ring of proboscis with only few minute rudimentary paragnaths, often with none (0 in group V; 0 or 1, seated on tip of round papilla in group VI; up to approx. 8 in a single row in Group VII-Group VIII). Total paragnaths more than 70.

Description. Largest complete specimen 70 mm BL, 2.0 mm BW, with 132 chaetigers. Colour in preserved specimens is whitish cream with brownish pigmentation on prostomium, anterior part of palps, and dorsum of anterior chaetigers. Sub-pentagonal prostomium with a pair of smooth tapered antennae situated at anterior end (Figs 3, 4A). A pair of palps with massive palpophores and short conical palpostyles. Two pairs of eyes arranged trapezoidally (anterior pair with space wider than that of posterior pair); anterior pair reniform and slightly larger; posterior pair round and smaller. Mid-longitudinal white slit present on dorsal anterior surface of prostomium. Peristomium with four pairs of tentacular cirri of unequal length; posterodorsal tentacular cirri longest, reaching back to chaetigers 6–12 (Figs 3, 4A).

Proboscis with a pair of light brown jaws, each with approx. ten teeth. Typical conical paragnaths present on maxillary ring (Figs 3, 4A); number of paragnaths on each group are as follows (Table 1): group I: 3–13, scattered and unequal; group II: 13–20 in two arched rows, marked large paragnaths with sharply tapering and curved tip present in middle position; group III: 39–58, in three or four rows of transversely elongated bands; group IV: 11–17 in a triangular patch with markedly large paragnaths present in posterior position. Oral ring sometimes expanded into a trapezoidal shape at full-everted proboscis, with only a few or no rudimentary paragnaths; number of paragnaths on each group are as follows (Table 1): group V: none; group VI: 0 or 1 minute paragnath seated on tip of small round papilla, sometimes only papilla present; groups VII–VIII: 0 or 1 minute paragnath present. Total number of paragnaths 94–137.

Parapodia of first two chaetigers uniramous, all following parapodia biramous. Uniramous parapodia of first two chaetigers are without notoacicula. In subsequent biramous parapodia, notopodia consists of dorsal cirrus, dorsal ligule, prechaetal lobe and ventral ligule throughout (Fig. 4B–D); all ligules/lobes are conical with tapering tip throughout; ventral ligule subequal to or slightly smaller than dorsal ligule; prechaetal lobe much shorter than two ligules. Dorsal cirri tapering, shorter than notopodial dorsal ligule throughout (about half length). Glandular patches present along dorsal edge of dorsal and ventral ligules.

Neuropodia consisting of superior lobe, inferior (acicular) lobe, postchaetal lobe, ventral ligule and ventral cirrus present in anterior and middle body, but lack superior lobe in posterior body (Fig. 4C, D); postchaetal lobe present throughout; all ligules/lobes are conical with tapering tip throughout. Ventral cirrus is slender with tapering tip. Glandular patches present along ventral edge of neuropodial ligule/lobes.

Notochaetae all homogomph spinigers having long blades with finely serrated edges (Fig. 4E). Upper neurochaetae include homogomph spinigers with long blades (posteriorly) and heterogomph spinigers with short blades (anteriorly, Fig. 4F) throughout; some or most of heterogomph spinigers are replaced by heterogomph falcigers with slender blades (Fig. 4G) in middle body. Lower neurochaetae include heterogomph spinigers with long blades (posteriorly) and heterogomph spinigers with short blades (anteriorly) throughout; some or most of heterogomph spinigers with short blades are replaced by heterogomph falcigers in middle body. Heterogomph falcigers first appear around chaetiger 20 in both upper and lower neurochaetae.

Reproduction. The coelom of a female specimen collected from Tumpat, Kelantan Delta on 13 August 2009 (BW 1.7 mm) was filled with oocytes (probably immature eggs) 100–140 μm in diameter.

Habitat. Intertidal sandy or muddy flats in estuaries. Salinity in habitats highly varied; the salinity of surface water at Muara Kuala Setiu in Setiu Lagoon varied in a range from 22.4 to 28.3 psu (Nicholas 2018), while the salinity of interstitial water at the other sites, Setiu Lagoon, Kuala Ibai, and Tumpat, was in the range from 3.0 (Site 103 in Setiu Lagoon) to 16.5 psu (Tumpat).

Geographical distribution. India, Myanmar, western Singapore, the eastern coast of Peninsular Malaysia. Based on synonymy with *C. burmensis*, and Southern (1921), Lee and Glasby (2015) and the present study.

Figure 3. Photographs of a preserved specimen of *Neanthes glandicincta* (Southern, 1921) collected from Setiu Lagoon, Terengganu, Malaysia (UMTAnn 431). **A** dorsal view of the anterior body with everted proboscis **B** ventral view of the anterior body with everted proboscis. Scale bar: 1 mm.

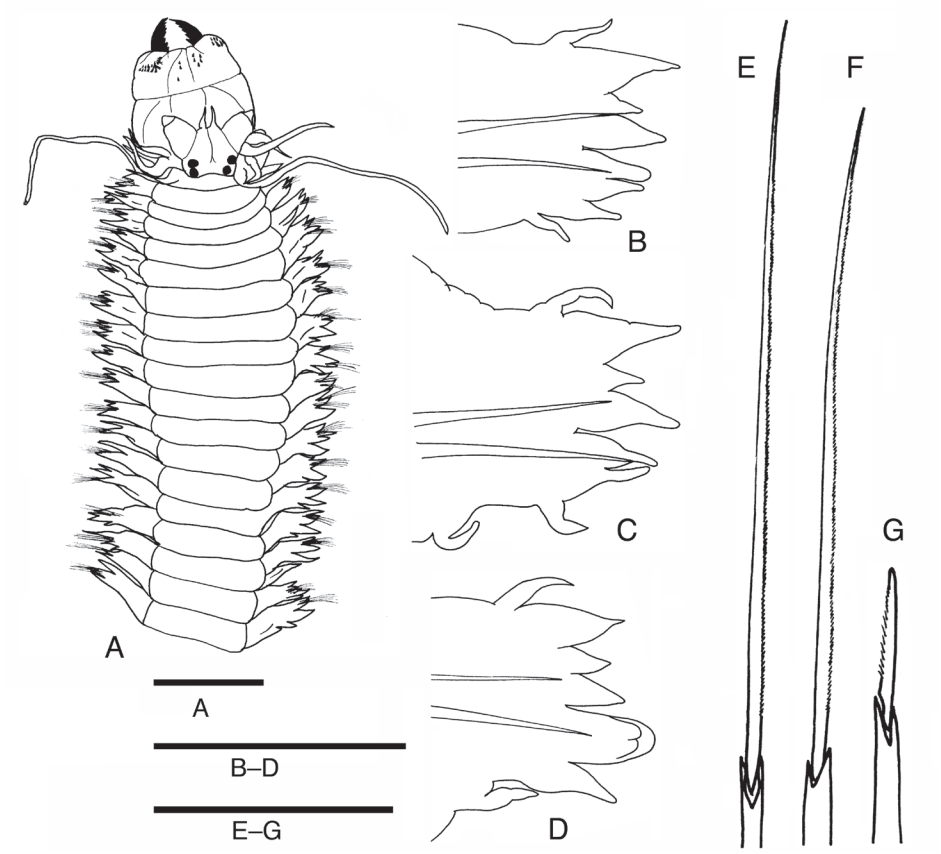

Figure 4. Drawings of a specimen of *Neanthes glandicincta* (Southern, 1921) collected from Setiu Lagoon, Terengganu, Malaysia (UMTAnn 431). **A** dorsal view of the anterior body with everted proboscis **B–D** anterior view of parapodia **B** parapodium 10 **C** parapodium 18 **D** parapodium 35 **E** homogomph spiniger from notochaetae **F** heterogomph spiniger from lower neurochaetae **G** heterogomph falciger from neurochaetae. Scale bars: 1 mm (**A, B–D**); 0.1 mm (**E–G**).

Discussion and conclusion

In the present study, an estuarine nereidid species, *Neanthes glandicincta* (Southern, 1921) is newly recorded at the eastern coast of Peninsular Malaysia in the South China Sea. The morphological characteristics of the present specimens which were collected from three estuaries in Malaysia well agreed with those of *N. glandicincta* originally described by Southern (1921) based on Indian specimens, and also those redescribed by Lee and Glasby (2015) based on Indian, Myanmar and Singapore specimens. The number of paragnaths in all groups on proboscis of our Malaysian specimens was within the range of the variation of *N. glandicincta* shown in the original description and redescription (Table 1). Therefore, our specimens can be clearly identified as *N. glandicincta*.

Table 1. Variation of morphological characteristics of *Neanthes glandicincta* collected from three estuaries in the east coast of Peninsular Malaysia in the present study, in comparison with data from previous studies in other countries.

Locality	Number of specimen(s) examined	Body width[2]	Body length[2, 3]	Number of total	Number of paragnaths[4]							Total[6]
(site no. in the present study)[1]		(mm)	(mm)	chaetigers[2, 3]	I	II[5]	III	IV[5]	V	VI[5]	VII–VIII	
Eastern coast of Peninsular												
Malaysia												
Tumpat, Kelantan Delta	8	1.3–2.0	45–60	114	11.1 ± 1.8	17.8 ± 1.7	49.1 ± 5.4	13.6 ± 1.6	0	0.3 ± 0.5	0.1 ± 0.4	121.8 ± 11.0
(1)		(8)	(2)	(1)	(9–13, 8)	(15–20, 8)	(40–57, 8)	(11–16, 8)	(0–0, 8)	(0–1, 8)	(0–1, 8)	(107–137, 8)
Setiu Lagoon, Terengganu	13	1.2–2.0	54–70	121–132	7.8 ± 3.0	16.1 ± 1.7	51.3 ± 5.9	13.7 ± 2.0	0	0.2 ± 0.4	0 ± 0	116.1 ± 11.4
(2)		(13)	(4)	(4)	(3–13, 13)	(13–18, 13)	(39–58, 13)	(11–17, 13)	(0–0, 13)	(0–1, 13)	(0–0, 13)	(94–136, 13)
Kuala Ibai, Terengganu	2	0.7–1.1	15		6.0	17.0	42	12	0	0	0	106
(3)		(2)	(1)		(6–6, 2)	(16–18, 2)	(42–42, 1)	(12–12, 2)	(0–0, 2)	(0–0, 2)	(0–0, 2)	(106–106, 1)
Pooled data from all of 3 sites		0.7–2.0	15–70	114–132	8.8 ± 3.0	16.7 ± 1.8	50.1 ± 5.8	13.5 ± 1.8	0	0.2 ± 0.4	0.04 ± 0.2	117.7 ± 11.4
		(23)	(7)	(5)	(3–13, 23)	(13–20, 23)	(39–58, 22)	(11–17, 23)	(0–0, 23)	(0–1, 23)	(0–1, 23)	(94–137, 22)
Singapore												
Nine sites in northern and southern coasts (Lee and Glasby 2015)[7]	54				9.0 ± 3.4	17.3 ± 2.5	49.2 ± 7.2	14.1 ± 2.5	0	0.1 ± 0.3	1.2 ± 2.1	120.1 ± 13.9
					(0–17, 54)	(11–23, 54)	(35–63, 54)	(10–22, 54)	(0–0, 53)	(0–1, 53)	(0–8, 51)	(93–148, 50)
Myanmar (Burma)												
Maungmagan (Lee and Glasby 2015)[7, 8]	8				5.8 ± 3.9	13.1 ± 2.0	41.3 ± 9.7	14.0 ± 2.9	0	0	0	101.3 ± 19.9
					(2–14, 8)	(11–17, 8)	(30–60, 8)	(11–20, 8)	(0–0, 8)	(0–0, 8)	(0–0, 8)	(80–138, 8)
India												
Water Lakes, St. 2, Calcutta (Lee and Glasby 2015)[7, 9]	1				10	12	38	7	0	1	2	90
					(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Near Calcutta (original description by Southern (1921)	1		88	123	10	(10–13)	50	(10–12)	0	(0–1)	up to 7	
			(1)	(1)								

Note: 1) Corresponding to site numbers in Fig. 1.; 2) Range and (number of available data); 3) Data from complete specimens; 4) Mean ± SD (range, and number of available data); 5) Larger value at a left or right side; 6) All total with numbers from both sides of groups II, IV, and VI; 7) Calculated based on the individual data shown in Table 3 in Lee and Glasby (2015); 8) A part of syntypes of *Ceratonereis burmensis* Monro, 1937; 9) One of probable syntypes of *Nereis* (*Nereis*) *glandicincta* Southern, 1921.

According to Atlas of Living Australia (2017), this species was previously recorded from Blue Lagoon which is situated near Port Dickson on the western coast of Peninsular Malaysia, based on specimen(s) deposited in the Northern Territory Museum and Art Gallery, Darwin, Australia (NTM W19065) (Chris Glasby, pers. comm.), though its taxonomic description has not yet been published. This record should be re-examined to clarify whether *N. wilsonchani* or other morphologically similar species are included or not.

Lee and Glasby (2015) showed that *Ceratonereis burmensis* Monro, 1937 (type locality: Maungmagan in Myanmar and off Bombay in India) is a junior synonym of *Neanthes glandicincta* (Southern, 1921), and that *N. glandicincta* was distributed in western Singapore, whereas the closely similar species, *N. wilsonchani* Lee & Glasby, 2015 was distributed in eastern Singapore. In the present study on three estuaries in eastern Malaysia, we could not find *N. wilsonchani* in spite of geographical proximity between our sampling sites and the type locality of *N. wilsonchani* (eastern Singapore). The record of *C. burmensis* from Jeram, Selangor, western peninsular Malaysia by Polgar et al. (2015), is likely to represent one of these two species, but this needs to be verified.

Lee and Glasby (2015) described the epitokous metamorphosis of both *N. glandicincta* and *N. wilsonchani* based on sexually mature males and females collected from Singapore in a period from December to April. However, we were not able to collect any epitokous specimens of *N. glandicincta* probably because our sampling period was limited to August.

Previous records of "*N. glandicincta*" and "*Ceratonereis burmensis*" on the coasts of South China Sea (Khlebovich 1963, Wu 1967, Wu et al. 1985) and Australia (Rullier 1965) should be re-examined because some morphologically similar but distinct species (*N. wilsonchani* or other cryptic species) may have been confused with *N. glandicincta* or *C. burmensis*. Lee and Glasby (2015) and Sato (2017) suggested that another cryptic species similar to *N. glandicincta* and *N. wilsonchani* may be distributed on the coasts of South China Sea and East China Sea.

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RESEARCH ARTICLE

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Checklist of the Sarcophagidae (Diptera) of Croatia, with new records from Croatia and other Mediterranean countries

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Abstract

An updated checklist of Croatian flesh flies is presented based on the literature, on material collected from 2004 to 2017, and on specimens in museum collections. The checklist comprises 22 genera and 148 species (two left unnamed), 105 of which are represented by new Croatian records. Twenty-five species are recorded from Croatia with certainty for the first time: *Amobia pelopei* (Rondani, 1859), *Apodacra seriemaculata* Macquart, 1854, *Craticulina tabaniformis* (Fabricius, 1805), *Macronychia striginervis* (Zetterstedt, 1838), *Metopia campestris* (Fallén, 1810), *Miltogramma brevipila* Villeneuve, 1911, *Miltogramma iberica* Villeneuve, 1912, *Miltogramma oestracea* (Fallén, 1820), *Miltogramma punctata* Meigen, 1824, *Oebalia cylindrica* (Fallén, 1810), *Phylloteles pictipennis* Loew, 1844, *Senotainia conica* (Fallén, 1810), *Taxigramma hilarella* (Zetterstedt, 1844), *Taxigramma stictica* (Meigen, 1830), *Agria monachae* (Kramer, 1908), *Nyctia lugubris* (Macquart, 1843), *Blaesoxipha* (*Blaesoxipha*) *aurulenta* Rohdendorf, 1937, *Blaesoxipha* (*Blaesoxipha*) *batilligera* Séguy, 1941, *Blaesoxipha* (*Blaesoxipha*) *plumicornis* (Zetterstedt, 1859), *Sarcophaga* (*Helicophagella*) *okaliana* (Lehrer, 1975), *Sarcophaga* (*Heteronychia*) *amita* Rondani, 1860, *Sarcophaga* (*Heteronychia*) *ancilla* Rondani, 1865, *Sarcophaga* (*Heteronychia*) *pseudobenaci* (Baranov, 1942), *Sarcophaga* (*Myorhina*) *lunigera* Böttcher, 1914 and *Sarcophaga* (*Stackelbergeola*) *mehadiensis* Böttcher, 1912. *Taxigramma hilarella*, *Nyctia lugubris*, *Agria monachae*, *Blaesoxipha* (*Blaesoxipha*) *aurulenta* and

Sarcophaga (*Heteronychia*) *amita* are recorded from Southeast Europe with certainty for the first time. The species *Sarcophaga* (*Sarcophaga*) *hennigi* Lehrer, 1978 is omitted from the list, as previous records from Croatia are shown to be based on an erroneous synonymy with *Sarcophaga novaki* Baranov, 1941 (= *Sarcophaga* (*Sarcophaga*) *croatica* Baranov, 1941). *Blaesoxipha* (*Blaesoxipha*) *rufipes* (Macquart, 1839) could not be confirmed from Croatia and is not included in the checklist. Three new synonymies are proposed: *Golania* Lehrer, 2000 = *Thyrsocnema* Enderlein, 1928, **syn. nov.**, *Parasarcophaga* (*Liosarcophaga*) *kovatschevitchi* Strukan, 1970 = *Sarcophaga* (*Liosarcophaga*) *marshalli* Parker, 1923, **syn. nov.**, and *Sarcophaga subvicina* ssp. *novaki* Baranov, 1941 = *Sarcophaga* (*Sarcophaga*) *croatica* Baranov, 1941, **syn. nov.** As part of an effort to update the European distributions of all Croatian species, the following new national and regional records are also provided: *Miltogramma brevipila*, *Miltogramma taeniata* Meigen, 1824 and *Sarcophaga* (*Heteronychia*) *pandellei* (Rohdendorf, 1937) new to Greece; *Sarcophaga* (*Liosarcophaga*) *harpax* Pandellé, 1896 and *Sarcophaga* (*Sarcophaga*) *croatica* new to Italy (respectively mainland and mainland and Sicily); *Miltogramma iberica* new to Bulgaria and Sardinia; *Pterella convergens* (Pandellé, 1895) new to mainland Italy and Sicily; *Nyctia lugubris* new to mainland Italy and Sardinia; *Blaesoxipha* (*Blaesoxipha*) *litoralis* (Villeneuve, 1911) new to Sardinia and thus confirmed for Italy; *Apodacra seriemaculata*, *Macronychia striginervis*, *Protomiltogramma fasciata* (Meigen, 1824) and *Blaesoxipha* (*Blaesoxipha*) *ungulata* (Pandellé, 1896) new to Sardinia and Sicily; *Macronychia dolini* Verves & Khrokalo, 2006, *Macronychia polyodon* (Meigen, 1824), *Metopia argyrocephala* (Meigen, 1824), *Senotainia albifrons* (Rondani, 1859), *Taxigramma multipunctata* (Rondani, 1859), *Taxigramma stictica*, *Blaesoxipha* (*Blaesoxipha*) *unicolor* (Villeneuve, 1912) and *Sarcophaga* (*Helicophagella*) *agnata* Rondani, 1860 new to Sardinia; *Metopodia pilicornis* (Pandellé, 1895), *Miltogramma oestracea*, *Miltogramma rutilans* Meigen, 1824, *Nyctia halterata* (Panzer, 1798), *Blaesoxipha* (*Blaesoxipha*) *lapidosa* Pape, 1994 and *Blaesoxipha* (*Blaesoxipha*) *plumicornis* new to Sicily.

Keywords

Balkans, Bulgaria, flesh flies, Greece, Italy, new synonyms, Sardinia, Sicily, Southeast Europe

Introduction

Sarcophagidae, commonly known as flesh flies because many species feed on the soft tissues of animals (Povolný and Verves 1997), comprise ca 2800 species worldwide (Pape 1996 and unpublished) and are currently divided into three subfamilies: Miltogramminae, Paramacronychiinae and Sarcophaginae (Pape 1996). The flesh fly fauna of Croatia has been poorly studied. The earliest data were published between the mid-19th century and the beginning of the 20th century (Schiner 1862; Brauer and Bergenstamm 1891; Strobl 1893, 1900, 1904; Böttcher 1912, 1913; Langhoffer 1920; Rohdendorf 1937), whereas the first studies more specifically focused on Croatian flesh flies were undertaken before and during World War II by Baranov (1928, 1929, 1930, 1931, 1938, 1939, 1940, 1941a, 1941b, 1942, 1943), who provided information on the general morphology and taxonomy of Croatian Sarcophaginae as well as descriptions and identification keys. Baranov's work was continued by Strukan (1964, 1967, 1968, 1970), and further data were added after the breakup of Yugoslavia by Povolný and Znojil (1994), Rucner (1994), Pape (1996), Povolný and Znojil (1998, 1999), Pape (2004), Whitmore (2011) and Whitmore et al. (2013). The primary aim of this paper is to summarize all available data on the flesh fly fauna of Croatia, based on a critical review of literature records, on data obtained from recent collecting (2004–2017),

and on older specimens in the collections of the Natural History Museum of Denmark (Copenhagen), the National Museum of Natural History, Smithsonian Institution (Washington, D.C.), the Natural History Museum (London) and Museum für Naturkunde (Berlin). We also report 33 new national and regional species records for Bulgaria, Greece, Italy, Sardinia and Sicily.

Materials and methods

Study area

Croatia has an area of 56,542 square kilometers and borders with Slovenia, Hungary, Bosnia and Herzegovina, Serbia, Montenegro and Italy. The country is divided into three biogeographical regions: Pannonian-Peripannonian, Alpine, and Mediterranean (Bertić et al. 2001). The Pannonian-Peripannonian region extends between the rivers Drava, Sava and Danube, the Alpine region covers the area of the Dinaric Alps, Gorski Kotar and Lika, whereas the Mediterranean region extends along the Adriatic coast and includes a multitude of islands, cliffs and ridges. The study area includes 38 localities belonging to the Mediterranean, Alpine and Pannonian-Peripannonian regions of Croatia (Figs 1–6, Table 1).

Specimen sampling and identification

The recent sampling effort was carried out between 2004 and 2017. Most flies were collected with hand nets, with additional specimens collected by Malaise traps, plastic bottle traps and multipurpose traps used to collect biting flies. Specimens were preserved in 96% ethanol or killed in ethyl acetate and pinned shortly after sampling. Male terminalia were extended *in loco* when specimens were still fresh, or male and female terminalia were dissected at a later stage following the method described by Richet et al. (2011). Male abdomens were removed and soaked in a 10% KOH solution for 72 hours, immersed in 10% acetic acid for one minute and rinsed in water for another minute before being dehydrated in beech-wood creosote for four hours; the phallus, pre- and postgonites, sternite 5, cerci and surstyli were separated from the rest of the abdomen, placed in a drop of Canada balsam on a microscope slide and covered with a coverslip. Female abdomens were detached, washed in an ethanol solution and left to macerate in a 10% KOH solution for one hour; abdomen tips were then separated by cutting the membrane between the last two tergites, and rinsed in acetic acid and water before being left between slide and coverslip in beech-wood creosote for a period of four hours; they were then mounted in Canada balsam between two coverslips. Identifications were carried out using current keys for Sarcophagidae (Pape 1987; Povolný and Verves 1997; Richet et al. 2011) and descriptions and illustrations in Whitmore (2010, 2011), Whitmore et al. (2013) and Whitmore and Perry (2018).

Figure 1. Croatia, Alpine region, Primorsko-goranska Co., 11 km SE Begovo Razdolje, nr Bijele Stijene, 45°13'11"N, 14°58'29"E (photo: E. Buenaventura).

Figure 2. Croatia, Alpine region, Primorsko-goranska Co., Sunger, 45°19'22"N, 14°49'12"E (photo: S. Krčmar).

Figure 3. Croatia, Mediterranean region, Ličko-senjska Co., nr Sušanj Cesarički, 44°31'51"N, 15°07'37"E (photo: E. Buenaventura).

Figure 4. Croatia, Mediterranean region, Dubrovačko-neretvanska Co., nr Vid, 43°04'46"N, 17°37'33"E (photo: S. Krčmar).

Figure 5. Croatia, Pannonian-Peripannonian region, Osječko-baranjska Co., Zmajevac, 45°48'03"N, 18°48'29"E (photo: S. Krčmar).

Format of checklist

The nomenclature and classification follow the Fauna Europaea database (Pape 2004). For newly collected and museum material, the following information is provided for each record: locality and date of collection, collector(s), number and sex of specimens, and depository; for previously published records, literature sources are listed in chronological order together with locality information, if available. In both sections, main localities (e.g., city, village, island, mountain) are separated by semicolons (viz., Zmajevac; Zagreb; Pag Is.; Medvednica). When two locality names are separated by a comma, the second locality is the exact sampling site and is subordinate to the main locality (e.g., Brač Is., Bol; Medvednica, Medvedgrad; Otočac, Metla; Ston, Broce). Species marked with a black triangle (▲) are recorded for Croatia with certainty for the first time. Species marked with an asterisk (*) are recorded for Croatia based on unverified literature records only. European distributions are derived from Séguy (1941), Pape et al. (1995), Pape (1996), Povolný (1997, 1999), Panu et al. (2000), Pape (2004), Whitmore (2009a, 2009b, 2010), Gaglio et al. (2011), Richet et al. (2011), Whitmore (2011), Richet et al. (2013), Verves and Khrokalo (2014), Whitmore (2016) and Whitmore and Perry (2018), and listed according to the Fauna Europaea format for countries and regions (Pape et al. 2015). Geographic coordinates of recent Croatian sampling localities are given in Table 1. All specimens examined for this study are de-

Figure 6. Croatia, Pannonian-Peripannonian region, Sisačko-moslavačka Co., nr Čigoč, 45°24'55"N, 16°37'50"E (photo: S. Krčmar).

posited in the collections of the Natural History Museum of Denmark, Copenhagen, Denmark (NHMD), the National Museum of Natural History, Smithsonian Institution, Washington, D.C., U.S.A. (NMNH), the Department of Biology, Josip Juraj Strossmayer University, Osijek, Croatia (DBUO), the Natural History Museum, London, U.K. (NHMUK), the Museum für Naturkunde, Berlin, Germany (ZMHB), and

Table 1. List of sites sampled for flesh flies (Sarcophagidae) in Croatia between 2004 and 2017.

	Biogeographical region	Locality	Geographic coordinates
1	Pannonian-Peripannonian	Čigoč	45°24'55"N, 16°37'50"E
2		Kamenac	45°45'37"N, 18°42'38"E
3		Orahovica	45°31'44"N, 17°52'49"E
4		Slatinski Drenovac	45°33'01"N, 17°42'27"E
5		Zmajevac	45°48'03"N, 18°48'29"E
6	Alpine	Baške Oštarije	44°31'35"N, 15°10'28"E
7		Begovo Razdolje, nr Bijele Stijene	45°13'11"N, 14°58'29"E
8		Bjelolasica	45°16'24"N, 14°57'40"E
9		Brušane	44°30'05"N, 15°16'08"E
10		Lokve	45°21'30"N, 14°45'03"E
11		Plitvička jezera National Park, Turčić	44°51'55"N, 15°34'55"E
12		Podoštra	44°31'37"N, 15°19'58"E
13		Sertić Poljana	44°55'30"N, 15°34'02"E
14		Skrad	45°25'49"N, 14°54'29"E
15		Sunger	45°19'22"N, 14°49'12"E
16	Mediterranean	Badžula	42°57'53"N, 17°36'41"E
17		Banja	43°03'09"N, 17°30'11"E
18		Biograd	43°55'41"N, 15°24'42"E
19		Blace	43°00'06"N, 17°28'49"E
20		Brač Is., Bol	43°15'44"N, 16°39'15"E
21		Crikvenica	45°10'25"N, 14°41'29"E
22		Desne	43°03'33"N, 17°32'13"E
23		Drivenik	45°14'26"N, 14°38'59"E
24		Hvar Is., Dubovica	43°08'46"N, 16°32'06"E
25		Komin	43°02'30"N, 17°32'09"E
26		Krk Is., Krk	45°01'40"N, 14°34'31"E
27		Krk Is., Punat	45°01'15"N, 14°37'54"E
28		Modro Oko	43°03'25"N, 17°31'05"E
29		Oštrovica	45°22'52"N, 14°51'40"E
30		Pakleni Is., Sveti Klement	43°09'53"N, 16°22'27"E
31		Podrujnica	43°03'34"N, 17°35'31"E
32		Rudelić Draga	44°26'13"N, 15°11'33"E
33		Sušanj Cesarički	44°31'51"N, 15°07'37"E
34		Sveti Juraj	44°55'42"N, 14°55'13"E
35		Tribanj-Kruščica	44°20'59"N, 15°18'59"E
36		Učka Nature Park, Vela Učka	45°18'08"N, 14°11'32"E
37		Vid	43°04'46"N, 17°37'33"E
38		Vriještica	43°04'41"N, 17°35'38"E

in the second author's private collection (DW; currently Stuttgart, Germany). Croatian records published by Strobl (1893, 1900, 1904), Langhoffer (1920), Baranov (1928, 1929, 1930, 1931, 1938, 1939, 1940, 1941a, 1941b, 1942, 1943), Mikačić (1938), Strukan (1964, 1967, 1968, 1970), Povolný (1987), Sisojević et al. (1989), Rucner (1994), Pape (1996), Szpila (2010), Whitmore (2011) and Whitmore et al. (2013) are mostly based on specimens deposited in the following collections: NMNH; NHMD;

NHMUK; DW; Moravské Muzeum, Brno, Czech Republic; Naturhistoriska Riksmuseet, Stockholm, Sweden; Centro Nazionale per lo Studio e la Conservazione della Biodiversità Forestale "Bosco Fontana", Verona, Italy; Department of Ecology and Biogeography, Nicolaus Copernicus University, Toruń, Poland; Croatian Natural History Museum, Zagreb, Croatia; Institute for Biological Research "Siniša Stanković", Belgrade, Serbia; National Museum of Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina; Natural History Museum, Admont, Austria.

Results

Altogether, 1534 specimens were examined from Croatia and other Mediterranean countries. New locality records are provided for 132 species, including new Croatian records for 105 species. In Croatia, the highest number of species (72) was recorded in the Mediterranean region, followed by the Pannonian-Peripannonian region with 48 species and the Alpine region with 39 species. The most common species in this study was *Sarcophaga* (*Sarcophaga*) *croatica* Baranov, 1941 with 233 specimens from 12 localities. The next most common species were *S.* (*Sarcophaga*) *lehmanni* Müller, 1922 with 172 specimens from 14 localities, *S.* (*Parasarcophaga*) *albiceps* Meigen, 1826 with 70 specimens from 7 localities, and *S.* (*Bellieriomima*) *subulata* Pandellé, 1896 with 40 specimens from 5 localities. The updated checklist of Croatian Sarcophagidae consists of 148 species (two left unnamed): 104 in the subfamily Sarcophaginae, 35 in the subfamily Miltogramminae and 9 in the subfamily Paramacronychiinae. The majority of species belong to the genus *Sarcophaga* Meigen (88), followed by *Blaesoxipha* Loew (15), *Miltogramma* Meigen (11), and *Macronychia* Rondani, *Pterella* Robineau-Desvoidy, *Sphenometopa* Townsend and *Taxigramma* Perris (3 each). The remaining 15 genera are represented by one or two species each. Two species previously recorded from Croatia are omitted from the checklist. *Blaesoxipha rufipes* (Macquart, 1839) was listed from Croatia (Pape 1994, 1996; Verves and Khrokalo 2014) based on a misreading of Baranov (1942). Records of *Sarcophaga* (*Sarcophaga*) *hennigi* Lehrer, 1978 are based on an erroneous synonymy, as discussed below under *S.* (*S.*) *croatica*. As part of an effort to update the distributions of all Croatian species, we here firstly report the occurrences of one species for Bulgaria, three species for Greece (Corfu), two species for Italy, 15 species for Sardinia and 12 species for Sicily (for details, see Abstract and Remarks under individual species).

Checklist
Subfamily Miltogramminae Lioy, 1864

1. *Amobia pelopei* (Rondani, 1859) (▲)

Records: Gračac, 6.X.1929, N. Baranov leg. (1♂) (NMNH); same locality, 7.X.1929, N. Baranov leg. (1♂) (NMNH); same locality, 10.X.1929, N. Baranov leg. (1♂) (NMNH);

Mraclin, 22.VI.1930, N. Baranov leg. (1♂) (NMNH); Pag Is., VIII.1933, N. Baranov leg. (1♂) (NMNH); same locality, VIII.1935, N. Baranov leg. (2♂) (NMNH).

European distribution: Austria, Croatia, Czech Republic, France (mainland), Germany, Hungary, Italy (mainland), Poland, Russia (South European Territory), Switzerland, Ukraine.

2. *Amobia signata* (Meigen, 1824)

New records: Mraclin, 19.VIII.1928, N. Baranov leg. (1♂) (NMNH); Brač Is., Bol, 5.VIII.2004, D. Whitmore leg. (1♀) (DW); Gornje Igrane, 18.V.2012, C. Lange, J. Ziegler leg. (1♂) (ZMHB).

Literature records: Split (Strobl 1900); Pape (2004); Slano, nr Dubrovnik (Szpila 2010).

European distribution: Albania, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark (mainland), France (mainland, Corsica), Germany, Greece (mainland), Hungary, Italy (mainland, Sardinia, Sicily), Lithuania, Malta, Moldova, Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Slovenia, Spain (mainland, Canary Is.), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

3. *Apodacra seriemaculata* Macquart, 1854 (▲)

Records: Đurđenovac, 20.VII.1901, N. Baranov leg. (1♂) (NMNH).

European distribution: Austria, Croatia, France (mainland, Corsica), Italy (mainland, Sardinia, Sicily), Romania, Russia (South European Territory), Spain (mainland), Ukraine.

Remarks: We here record this species from Sardinia (Sassari, Stintino, 9.VII.2004, D. Birtele leg., 1♀, DW; Arbus, Piscinas, 39°32'25.62"N, 8°27'7.88"E, 25.V.2006, D. Whitmore leg., 1♀, DW; same as previous except 14.VII.2006, 2♀, 3♂, DW; Domusnovas, Valle Oridda, 39°24'32.16"N, 8°36'58.94"E, 592 m, 11.VII.2006, D. Whitmore leg., 1♂, DW) and Sicily (Agrigento, Torre Salsa, 22.V.2004, D. Whitmore leg., 1♀, 2♂, DW) for the first time.

4. *Craticulina tabaniformis* (Fabricius, 1805) (▲)

Records: Pag Is., VIII.1934, N. Baranov leg. (2♂) (NMNH).

European distribution: Austria, Croatia, France (mainland, Corsica), Hungary, Italy (mainland, Sardinia, Sicily), Malta, Romania, Russia (South European Territory), Spain (mainland), Ukraine.

5. *Macronychia dolini* Verves & Khrokalo, 2006

New records: Baške Oštarije, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD).

Literature records: Verves and Khrokalo (2006).

European distribution: Croatia, Czech Republic, France (mainland), Italy (mainland, Sardinia), Poland, Russia (South European Territory), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

Remarks: We here record this species from Sardinia for the first time (Domusnovas, Valle Oridda, 39°24'32.16"N, 8°36'58.94"E, 592 m, 11.VII.2006, D. Whitmore leg., 1♂, DW; Domusnovas, Bega d'Aleni, 39°24'1.76"N, 8°37'33.66"E, 621 m, 17.VII.2006, D. Birtele leg., 1♀, DW).

6. *Macronychia polyodon* (Meigen, 1824)

New records: Krapina, VIII.1927, N. Baranov leg. (1♀) (NMNH); Samobor, 25.VI.1930, N. Baranov leg. (1♂) (NMNH); Baške Oštarije, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Rudelić Draga, 14.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Krapina; Mraclin; Pag Is.; Samobor (Baranov 1938); Verves and Khrokalo (2006).

European distribution: Andorra, Austria, Belgium, Bulgaria, Croatia, Czech Republic, Estonia, Finland, France (mainland), Germany, Hungary, Italy (mainland, Sardinia), Malta, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

Remarks: We here record this species from Sardinia for the first time (Iglesias, Monti Marganai, 480 m, 7–11.VI.2004, P. Cerretti et al. leg., 1♀, 4♂, DW).

7. *Macronychia striginervis* (Zetterstedt, 1838) (▲)

Records: Mraclin, 9.VIII.1928, N. Baranov leg. (3♀) (NMNH); same locality, 6.VII.1929, N. Baranov leg. (1♀) (NMNH); same locality, 26.VI.1930, N. Baranov leg. (1♀) (NMNH).

European distribution: Austria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland), Germany, Hungary, Italy (mainland, Sardinia, Sicily), Portugal (Madeira Is.), Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

Remarks: We here record this species from Sardinia (Domusnovas, Bega d'Aleni, 621 m, 39°24'1.76"N, 8°37'33.66"E, 15–17.VII.2006, D. Whitmore leg., 2♀, 1♂, DW; Iglesias, Conca Margiani, 39°21'40.76"N, 8°33'44.05"E, 750 m, D. Whitmore leg., 2♀, DW) and Sicily (Palermo, Bosco della Ficuzza, 27.VI.2005, P. Cerretti leg., 1♀, DW; Palermo, Corleone, nr Bivio Ponte Casale, 37°50'55.27"N, 13°20'9.35"E, 476 m, 27–30.VI.2005, D. Whitmore leg., 2♂, DW; Palermo, Parco delle Madonie, Petralia, Gorgo Nero, 1157 m, 29.VI.2005, D. Whitmore leg., 1♀, DW) for the first time.

8. *Metopia argyrocephala* (Meigen, 1824)

New records: Krapina, 28.VII.1929, N. Baranov leg. (1♀) (NMNH); Mraclin, 9.VII.1928, N. Baranov leg. (1♂) (NMNH); Zagreb, Podsused, 3.V.1931, N. Baranov leg. (1♀) (NMNH); Samobor, 22.IX.1929, N. Baranov leg. (1♀) (NMNH); Zagreb, 2.VII.1928, N. Baranov leg. (1♂) (NMNH); same locality, 16.VIII.1929, N. Baranov leg. (1♂) (NMNH); Vis Is., Komiža, 24.VI.1973, M. Chvála leg. (1♀) (NHMUK); Sveti Juraj, 12.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Delnice; Lokve; Plitvice (Langhoffer 1920, as *leucocephala* Rossi); Baranov (1928, as *leucocephala*).

European distribution: Andorra, Austria, Belarus, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland, Corsica), Germany, Greece (mainland), Hungary, Italy (mainland, Sardinia, Sicily), Latvia, Lithuania, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, North European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

Remarks: We here record this species from Sardinia for the first time (Buggerru, Portixeddu, 14.VI.2004, P. Cerretti et al. leg., 1♀, DW; Villacidro, Canale Monincu, 39°25'10.01"N, 8°37'40.61"E, 450 m, 21.V.2006, D. Whitmore leg., 3♂, DW; Domusnovas, Valle Oridda, 39°24'32.16"N, 8°36'58.94"E, 592 m, 24.V.2006, D. Whitmore leg., 3♂, DW; Villacidro, S'Acqua Frischedda, 39°24'51.74"N, 8°37'58.13"E, 390 m, D. Whitmore leg., 1♀, DW; Arbus, Piscinas, 39°32'25.62"N, 8°27'7.88"E, 25.V.2006, D. Whitmore leg., 1♂, DW; Villacidro, Lago di Montimannu, 39°25'5.85"N, 8°41'58.18"E, 256 m, 10.VII.2006, D. Whitmore leg., 2♂, DW; Domusnovas, Punta Planotzara, 39°21'16.71"N, 8°35'59.09"E, 360 m, 13.VII.2006, D. Whitmore leg., 1♂, DW; Siniscola, Santa Lucia, 26.VII.2009, D. Birtele leg., 1♀, DW).

9. *Metopia campestris* (Fallén, 1810) (▲)

Records: Krapina, 2.VIII.1929, N. Baranov leg. (1♂) (NMNH).

European distribution: Albania, Andorra, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland),

Germany, Hungary, Ireland, Italy (mainland), Latvia, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, North European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

10. *Metopodia pilicornis* (Pandellé, 1895)

Literature records: Pape (1996, 2004); Slano, nr Dubrovnik (Szpila 2010).

European distribution: Croatia, Cyprus, Czech Republic, France (mainland), Germany, Hungary, Italy (mainland, Sardinia, Sicily), Russia (South European Territory), Spain (mainland).

Remarks: We here record this species from Sicily for the first time (Palermo, Bosco della Ficuzza, Cima Cucco, 37°52'11.41"N, 13°24'34.56"E, 995 m, D. Whitmore leg., 5♂, DW).

11. *Miltogramma brevipila* Villeneuve, 1911 (▲)

Records: Pag Is., 30.IX.1932, N. Baranov leg. (1♀) (NMNH).

European distribution: Austria, Croatia, Czech Republic, France (mainland, Corsica), Greece (mainland), Italy (mainland, Sicily), Norway (mainland), Romania, Slovakia, Russia (South European Territory), Spain (mainland), Sweden, Switzerland, Ukraine.

Remarks: We here record this species from Greece for the first time (Corfu, Agios Gordios, 39°33'2.39"N, 19°50'51.06"E, 7.IX.2016, D. Whitmore leg., 2♂, DW).

12. *Miltogramma contarinii* Rondani, 1859 (*)

Literature records: Senj (Langhoffer 1920).

Distribution: Croatia, France (mainland), Italy (mainland).

Remarks: Unverified record. Langhoffer (1920) published a list of 1323 species in 50 Diptera families from Croatia, but these data are partly outdated (Britvec 2000) and many species may have been misidentified. *Miltogramma contarinii* is a rare species so far recorded with certainty only from Italy and France.

13. *Miltogramma germari* Meigen, 1824

New records: Krapina, 10.VII.1923, N. Baranov leg. (1♀, 1♂) (NMNH); Mraclin, 2.VII.1928, N. Baranov leg. (1♂) (NMNH); same locality, 9.VIII.1928, N. Baranov leg. (1♀) (NMNH).

Literature records: Đurđevac (Langhoffer 1920); Baranov (1928).

European distribution: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Finland, France (mainland), Germany, Hungary, Italy (mainland), Latvia, Moldova, Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

14. *Miltogramma iberica* Villeneuve, 1912 (▲)

Records: Krapina, 29.VIII.1910, N. Baranov leg. (1♂) (NMNH); same locality, 4.IX.1912, N. Baranov leg. (1♂) (NMNH); Mraclin, 19.VII.1933, N. Baranov leg. (1♀) (NMNH).

European distribution: Austria, Bulgaria, Croatia, Finland, Hungary, Italy (mainland, Sardinia), Russia (Central European Territory, South European Territory), Spain (mainland), Ukraine.

Remarks: We here record this species from Bulgaria (Burgas, Tsarevo, nr Sinemorets, 42°3'1.68"N, 27°59'3.32"E, 28.V.2018, D. Whitmore leg., 1♀, DW) and Sardinia (Palau, Porto Rafael, 1–15.IX.1997, P. Cerretti leg., 1♀, 2♂, DW; Iglesias, Monti Marganai, 500 m, 2.IX.2003, P. Cerretti leg., 1♂, DW; Domusnovas, Grotta San Giovanni, 12.VI.2004, D. Birtele et al. leg., 1♂, DW; Iglesias, Monti Marganai, 480 m, 22.IX.2004, D. Birtele et al. leg., 1♀, DW; Domusnovas, Sa Duchessa, 308 m, 25.IX.2004, P. Cerretti et al. leg., 2♀, DW; Domusnovas, Bega d'Aleni, 39°24'1.76"N, 8°37'33.66"E, 621 m, 17.VII.2006, D. Whitmore leg., 3♀, 1♂, DW; same as previous except P. Cerretti leg., 1♂, DW; same as previous except D. Birtele leg., 2♂, DW; Iglesias, Vecchia Cantoniera Marganai, 39°20'26.52"N, 8°33'43.90"E, 491 m, 23.V.2006, D. Whitmore leg., 1♂, DW; Domusnovas, Rio Sa Duchessa, 39°21'41.85"N, 8°36'48.46"E, 270 m, 12.VII.2006, D. Whitmore leg., 2♂, DW; Domusnovas, Sa Duchessa, 39°22'27.18"N, 8°35'36.74"E, 371 m, 12.VI.2006, P. Cerretti leg., 1♀, DW; Domusnovas, Valle Oridda, 39°24'32.16"N, 8°36'58.94"E, 592 m, 15.VII.2006, D. Whitmore leg., 1♂, DW; Tortolì, Lido di Orri, 2.VIII.2009. D. Birtele leg., 1♀, DW) for the first time.

15. *Miltogramma murina* Meigen, 1824

New records: Brač Is., Bol, 4.VIII.2004, D. Whitmore leg. (1♀) (DW); Hvar Is., Dubovica, 12.VIII.2004, D. Whitmore leg. (1♀) (DW).

Literature records: Bakar (Langhoffer 1920); Baranov (1928); Slano, nr Dubrovnik (Szpila 2010).

European distribution: Belgium, Croatia, Czech Republic, Germany, Greece (mainland), Hungary, Italy (mainland, Sardinia, Sicily), Malta, Poland, Romania, Slovakia, Ukraine.

16. *Miltogramma oestracea* (Fallén, 1820) (▲)

Records: Srijem, 8.VII.1930, N. Baranov leg. (1♂) (NMNH).

European distribution: Albania, Austria, Belarus, Belgium, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland), Germany, Hungary, Italy (mainland, Sicily), Latvia, Moldova, Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Ukraine.

Remarks: We here record this species from Sicily for the first time (Trapani, Oasi dello Zingaro, 9.V.2004, D. Whitmore leg., 3♂, DW; Palermo, Corleone, 476 m, 27.VI.2005, D. Whitmore leg., 1♂, DW).

17. *Miltogramma punctata* Meigen, 1824 (▲)

Records: Krapina, 13.VIII.1912, N. Baranov leg. (1♂) (NMNH); Orebić, VI.1927, Ziegenhagen leg. (2♂) (ZMHB).

European distribution: Austria, Belarus, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland, Corsica), Germany, Greece (mainland), Hungary, Ireland, Italy (mainland, Sardinia, Sicily), Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland, Canary Is.), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

18. *Miltogramma ruficornis* Meigen, 1824 (*)

Literature records: Rijeka; Hvar (Strobl 1893); Krka Falls (Strobl 1900); Hvar (Strobl 1904).

European distribution: Albania, Austria, Belgium, Croatia, France (mainland, Corsica), Germany, Hungary, Italy (mainland), Poland, Spain (mainland).

Remarks: Unverified records. Species of *Miltogramma* can easily be misidentified, and misidentifications in older publications cannot be excluded.

19. *Miltogramma rutilans* Meigen, 1824

New records: Pag Is., VIII.1933, N. Baranov leg. (4♂) (NMNH); same locality, 26.VIII.1933, N. Baranov leg. (1♂) (NMNH); same locality, VIII.1935, N. Baranov leg. (3♂) (NMNH).

Literature records: Pag Is., Kolansko Blato (Baranov 1938).

European distribution: Austria, Croatia, Czech Republic, France (mainland, Corsica), Germany, Hungary, Italy (mainland, Sardinia, Sicily), Malta, Poland, Russia (Central European Territory, South European Territory), Slovakia, Ukraine.

Remarks: We here record this species from Sicily for the first time (Sicily, Corleone, nr Bivio Ponte Casale, 37°50'55.27"N, 13°20'9.35"E, 476 m, 30.VI.2005, D. Whitmore leg., 2♀, DW).

20. *Miltogramma taeniata* Meigen, 1824

New records: Brač Is., Bol, 5.VIII.2004, D. Whitmore leg. (1♀) (DW); Tučepi, 16.V.2012, C. Lange, J. Ziegler leg. (1♂) (ZMHB); Sveti Juraj, 12.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Rijeka (Strobl 1893, as *pilimana* Rondani); Krka Falls (Strobl 1900, as *pilimana*); Plešce; Selce; Senj (Langhoffer 1920); Baranov (1928); Jakišnica; Krapina; Samobor (Baranov 1938); Paklenica, Velebit Mts; Brač Is., Milna; Vozilići (Sisojević et al. 1989); Slano, nr Dubrovnik (Szpila 2010).

European distribution: Albania, Bulgaria, Croatia, Czech Republic, France (mainland, Corsica), Germany, Greece (mainland), Hungary, Italy (mainland), Poland, Serbia, Slovakia, Spain (mainland), Switzerland, Ukraine.

Remarks: We here record this species from Greece for the first time (Corfu, Agios Gordios, 39°33'2.39"N, 19°50'51.06"E, 7.IX.2016, D. Whitmore leg., 3♂, DW).

21. *Miltogramma testaceifrons* (von Roser, 1840)

New records: Krapina, 13.VII.1910, N. Baranov leg. (1♂) (NMNH); same locality, 3.VI.1923, N. Baranov leg. (2♂) (NMNH); same locality, 6.VII.1930, N. Baranov leg. (2♂) (NMNH); Zagreb, 4.VII.1929, N. Baranov leg. (1♂) (NMNH).

Literature records: Starigrad (Langhoffer 1920, as *pilitarsis* Rondani).

European distribution: Austria, Croatia, Belarus, Czech Republic, France (mainland), Germany, Hungary, Italy (mainland), Lithuania, Moldova, Poland, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine.

22. *Oebalia cylindrica* (Fallén, 1810) (▲)

Records: Krapina, N. Baranov leg. (1♂) (NMNH).

European distribution: Andorra, Austria, Belgium, Croatia, Czech Republic, Denmark (mainland), Finland, France (mainland), Germany, Hungary, Italy (mainland), Norway (mainland), Poland, Russia (Central European Territory, South European Territory), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

23. *Phylloteles pictipennis* Loew, 1844 (▲)

Records: Susedgrad, 11.VII.1931, N. Baranov leg. (1♂) (NMNH); same locality, 28.VII.1931, N. Baranov leg. (2♂) (NMNH).

European distribution: Albania, Austria, Bulgaria, Croatia, Cyprus, Czech Republic, France (mainland, Corsica), Germany, Greece (mainland), Hungary, Italy

(mainland, Sicily), Macedonia, Poland, Russia (Central European Territory, North European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Switzerland, Ukraine.

24. *Protomiltogramma fasciata* (Meigen, 1824)

Literature records: Senj (Langhoffer 1920); Baranov (1928); Pape (2004).

European distribution: Austria, Croatia, Czech Republic, France (mainland, Corsica), Germany, Hungary, Italy (mainland, Sardinia, Sicily), Poland, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland, Canary Is.), Ukraine.

Remarks: We here record this species from Sardinia (Palau, Porto Rafael, 1–15. IX.1997, P. Cerretti leg., 1♀, 2♂, DW; Stintino, Cala Coscia di Donna, 9.VII.2004, D. Birtele leg., 1♂, DW) and Sicily (Palermo, Bosco della Ficuzza, 30.VII.2003, P. Cerretti leg., 4♀, DW) for the first time.

25. *Pterella convergens* (Pandellé, 1895)

Literature records: Pag Is.; Samobor (Baranov 1938).

European distribution: Croatia, France (mainland, Corsica), Germany, Greece (mainland), Italy (mainland, Sardinia, Sicily), Poland, Ukraine.

Remarks: We here record this species from mainland Italy (Latium, Rome, Tivoli, Colle Vescovo, 448 m, 18.IX.1999, M. Mei leg., 2♂, M. Mei collection) and Sicily (Palermo, nr Corleone, 27.VI.2005, D. Whitmore leg., 1♀, DW) for the first time. It had previously been recorded from Sardinia by Venturi (1966).

26. *Pterella grisea* (Meigen, 1824)

New records: Pag Is., 27.VIII.1933, N. Baranov leg. (1♂) (NMNH); same locality, II.1935, N. Baranov leg. (1♂) (NMNH); same locality, VIII.1935, N. Baranov leg. (4♂) (NMNH); same locality, 19.VIII.1935, N. Baranov leg. (2♀) (NMNH); Zagreb, 28.VII.1929, N. Baranov leg. (1♀) (NMNH).

Literature records: Rijeka; Hvar (Strobl 1893, as *intricata* Meigen); Hvar (Strobl 1900, as *intricata*).

European distribution: Austria, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland), Germany, Hungary, Italy (mainland, Sicily), Latvia, Lithuania, Moldova, Poland, Russia (Central European Territory, South European Territory), Slovakia, Serbia, Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

27. *Pterella melanura* (Meigen, 1824)

New records: Sušanj Cesarički, 13.VI.2012, E. Buenaventura, D. Whitmore, T. Pape leg. (1♀) (NHMD); Tribanj-Kruščica, Ljubotić, 14.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♀) (NHMD).

Literature records: Zadar (Strobl 1904); Pape (2004).

European distribution: Albania, Austria, Croatia, Czech Republic, Estonia, France (mainland, Corsica), Germany, Hungary, Italy (mainland, Sardinia, Sicily), Macedonia, Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Slovenia, Spain (mainland), Ukraine.

28. *Senotainia albifrons* (Rondani, 1859)

New records: Hvar Is., Dubovica, 12.VIII.2004, D. Whitmore leg. (3♀, 2♂) (DW); Krk Is., Glavotok, 12–15.VII.2003, T. Pape leg. (1♂) (NHMD).

Literature records: Hvar; Split (Strobl 1900); Zadar (Strobl 1904); Pape (2004).

European distribution: Austria, Bulgaria, Croatia, Cyprus, Czech Republic, France (mainland, Corsica), Germany, Greece (mainland), Hungary, Italy (mainland, Sardinia, Sicily), Lithuania, Moldova, Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland), Switzerland, The Netherlands, Ukraine.

Remarks: We here record this species from Sardinia for the first time (Iglesias, Monti Marganai, 500 m, 1–2.IX.2003, P. Cerretti leg., 2♂, DW; Domusnovas, Sa Duchessa, 308 m, 25.IX.2004, P. Cerretti et al. leg., 1♀, DW; Villacidro, Rio Cannisoni, 39°25'2.26"N, 8°38'1.09"E, 463 m, 21.V.2006, D. Whitmore leg., 1♀, DW; same as previous except 11.VII.2006, 1♂, DW; Arbus, Piscinas, 39°32'25.62"N, 8°27'7.88"E, 25.V.2006, D. Whitmore leg., 2♀, 3♂, DW; same as previous except 14.VII.2006, 7♂, DW; Villacidro, Lago di Montimannu, 39°25'5.85"N, 8°41'58.18"E, 256 m, 10.VII.2006, D. Whitmore leg., 2♀, 3♂, DW; Domusnovas, Valle Oridda, 39°24'32.16"N, 8°36'58.94"E, 592 m, 11–17.VII.2006, D. Whitmore leg., 3♀, 6♂, DW; Domusnovas, Rio Sa Duchessa, 39°21'41.85"N, 8°36'48.46"E, 270 m, 12–18.VII.2006, D. Whitmore leg., 5♀, 11♂, DW; Iglesias, ex Colonia Beneck, 39°20'51.32"N, 8°33'48.71"E, 636 m, 13.VII.2006, D. Whitmore leg., 1♂, DW; Domusnovas, Bega d'Aleni, 39°24'1.76"N, 8°37'33.66"E, 621 m, 17.VII.2006, D. Whitmore leg., 1♀, 1♂, DW; Domusnovas, Sa Duchessa, 39°22'27.18"N, 8°35'36.74"E, 371 m, 7.IX.2006, D. Birtele leg., 1♂, DW).

29. *Senotainia conica* (Fallén, 1810) (▲)

Records: Zagreb, 21.VII.1930, N. Baranov leg. (1♂) (NMNH).

European distribution: Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland), Germany, Hunga-

ry, Italy (mainland), Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

30. *Sphenometopa mannii* (Brauer & Bergenstamm, 1891)

Literature records: Rijeka (Brauer and Bergenstamm 1891); Pape (2004).

European distribution: Croatia.

31. *Sphenometopa steinii* (Schiner, 1862)

Literature records: Dubrovnik (Schiner 1862; Strobl 1900); Pape (1996, 2004).

European distribution: Croatia, Cyprus, Greece (mainland).

32. *Sphenometopa variegata* (Stein, 1924)

New records: Hvar Is., nr Jelsa, 5–8.VII.2003, T. Pape leg. (2♂, 2♀) (NHMD); Rudelić Draga, 14.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂, 1♀) (NHMD).

Literature records: Dalmatia (Verves 1986); Pape (1996, 2004).

Distribution: Croatia, France (mainland).

Remarks: This species was probably described from Croatia (Dalmatia), even though the type locality was originally given by Stein (1924) as "Europe" (see Pape 1996). Pape (2004) listed it for Croatia but considered its presence in France as doubtful.

33. *Taxigramma hilarella* (Zetterstedt, 1844) (▲)

Records: Samobor, 21.VII.1929, N. Baranov leg. (1♂) (NMNH); Zagreb, 17.VIII.1930, N. Baranov leg. (2♂) (NMNH); Sveti Juraj, 12.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Sušanj Cesarički, 13.VI.2012, E. Buenaventura, D. Whitmore, T. Pape leg. (1♀) (NHMD); Baške Oštarije, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂, 1♀) (NHMD); Rudelić Draga, 14.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Brušane, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

European distribution: Austria, Belgium, Canary Is., Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland), Germany, Hungary,

Italy (mainland), Lithuania, Moldova, Poland, Russia (Central European Territory, South European Territory), Slovakia, Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

34. *Taxigramma multipunctata* (Rondani, 1859)

Literature records: Pape (2004).

European distribution: Austria, Bulgaria, Belarus, Croatia, Cyprus, France (mainland, Corsica), Germany, Greece (mainland), Hungary, Italy (mainland, Sardinia, Sicily), Macedonia, Malta, Russia (South European Territory), Serbia, Spain (mainland, Canary Is.), Ukraine.

Remarks: We here record this species from Sardinia for the first time (Iglesias, Monti Marganai, 500 m, 2.IX.2003, P. Cerretti leg., 2♂, DW; Domusnovas, nr Agriturismo Perda Niedda, 350 m, 8.VI.2004, P. Cerretti et al. leg., 1♂, DW; nr Iglesias, 550 m, 26.IX.2004, D. Birtele leg., 1♂, DW; Villacidro, Rio Cannisoni, 39°24'51.10"N, 8°38'0.98"E, 401 m, 19.V.2006, D. Whitmore leg., 2♂, DW; Villacidro, Canale Monincu, 39°25'10.01"N, 8°37'40.61"E, 450 m, 21.V.2006, D. Whitmore leg., 1♂, DW; Villacidro, Lago di Montimannu, 39°25'5.85"N, 8°41'58.18"E, 256 m, 10.VII.2006, D. Whitmore leg., 1♂, DW; 39°24'37.47"N, 8°38'27.65"E, 390 m, 11.VII.2006, D. Whitmore leg., 1♂, DW; Domusnovas, Sa Duchessa, 39°22'27.18"N, 8°35'36.74"E, 371 m, 12.VI.2006, D. Whitmore leg., 1♂, DW; Iglesias, ex Colonia Beneck, 39°20'51.32"N, 8°33'48.71"E, 636 m, 13.VII.2006, D. Whitmore leg., 1♂, DW; Villacidro, Cuccuruneddu, 39°22'8.68"N, 8°40'45.65"E, 708 m, 13.VII.2006, D. Whitmore leg., 1♀, DW; Buggerru, Rio Mannu, 14.VII.2006, D. Whitmore leg., 2♀, DW; Domusnovas, Valle Oridda, 39°24'32.16"N, 8°36'58.94"E, 592 m, 11.VII.2006, D. Whitmore leg., 1♀, 3♂, DW).

NB: These Sardinian specimens do not all fall within the range of variation of *T. multipunctata* defined by Richet et al. (2013), particularly with regard to setation of the parafacialia. Further studies are required to determine whether *T. multipunctata sensu auct.* is a morphologically variable species or a species complex.

35. *Taxigramma stictica* (Meigen, 1830) (▲)

Records: Otočac, VIII.1931, N. Baranov leg. (1♂) (NMNH).

European distribution: Andorra, Austria, Bulgaria, Croatia, Czech Republic, Denmark (mainland), France (mainland), Germany, Hungary, Italy (mainland, Sardinia), Poland, Russia (Central European Territory, South European Territory), Serbia, Sweden, Switzerland, The Netherlands, Ukraine.

Remarks: We here record this species from Sardinia for the first time (Domusnovas, Rio Sa Duchessa, 39°21'41.85"N, 8°36'48.46"E, 270 m, 12.VII.2006, D. Whitmore leg., 1♂, DW).

Subfamily Paramacronychiinae Brauer & Bergenstamm, 1889

36. *Agria affinis* (Fallén, 1817)

Literature records: Sisojević et al. (1989, as *punctata* Robineau-Desvoidy); Pape (2004).

European distribution: Andorra, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland), Germany, Hungary, Italy (mainland, Sardinia), Moldova, Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

37. *Agria monachae* (Kramer, 1908) (▲)

Records: Baške Oštarije, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

European distribution: Belarus, Croatia, Czech Republic, Germany, Poland, Russia (Central European Territory), Slovakia, Switzerland, Ukraine.

38. *Brachicoma devia* (Fallén, 1820)

New records: Učka Nature Park, nr Vela Učka, 19.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♀) (NHMD).

Literature records: Orehovica (Langhoffer 1920); Baranov (1928); Zagreb (Sisojević et al. 1989).

European distribution: Andorra, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland), Germany, Greece (mainland), Hungary, Ireland, Italy (mainland, Sicily), Lithuania, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, North European Territory, South European Territory), Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

39. *Nyctia halterata* (Panzer, 1798)

New records: Dubrovnik, Ombla, 27.V.1934, D. Aubertin leg. (1♂) (NHMUK); Brač Is., Bol, 4.VIII.2004, D. Whitmore leg. (1♂) (DW); Igrane, 19.V.2012, C. Lange, J. Ziegler leg. (1♂) (ZMHB); Učka Nature Park, nr Vela Učka, 19.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (12♂) (NHMD).

Literature records: Zagreb; Sljeme; Osijek; Bregi; Petrinja; Bakar; Orehovica; Riječina (Langhoffer 1920); Baranov (1928); Trnovec; Kaštel Stari; Komiža; Lopud; Makarska; Paklenica, Velebit Mts; Solin; Split; Trogir; Žrnovnica; Vozilići (Sisojević et al.1989).

European distribution: Albania, Austria, Belarus, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark (mainland), Estonia, France (mainland, Corsica), Germany, Greece (mainland), Hungary, Italy (mainland, Sicily), Latvia, Malta, Moldova, Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland), The Netherlands, Ukraine, United Kingdom.

Remarks: We here record this species from Sicily for the first time (Palermo, Corleone, Rocca Busambra, 37°50'42.89"N, 13°23'10.37"E, 950 m, 30.VI.2005, P. Cerretti leg., 1♀, DW).

40. *Nyctia lugubris* (Macquart, 1843) (▲)

Records: Brač Is., Bol, 5.VIII.2004, D. Whitmore leg. (1♀) (DW).

European distribution: Croatia, Cyprus, France (mainland), Italy (mainland, Sardinia, Sicily); Malta, Portugal (mainland), Sicily, Spain (mainland).

Remarks: We here record this species from mainland Italy (Abruzzo; Calabria; Emilia-Romagna; Latium; 6♂, 3♀, DW and M. Mei collection) and Sardinia (Iglesias [outskirts of town], 23.V.2006, D. Whitmore leg., 1♂, DW; Iglesias, Mamenga, 610 m, 39°21'29.47"N, 8°33'39.24"E, 18.VII.2006, P. Cerretti, D. Whitmore leg., 3♀, 1♂, DW; Iglesias, Conca Margiani, 39°21'39.83"N, 8°33'50.46"E, 725 m, 7.IX.2006, D. Avesani et al. leg., 1♀, DW; San Vero Milis, Sa Marigosa, 40°2'24.99"N, 8°24'17.00"E, 13.IX.2006, D. Avesani et al. leg., 1♀, DW) for the first time.

41. *Sarcophila latifrons* (Fallén, 1817)

New records: Tribanj-Kruščica, Ljubotić, 14.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♀, 6♂) (NHMD).

Literature records: Rijeka; Hvar (Strobl 1893); Dubrovnik; Hvar; Krka Falls; Split (Strobl 1900); Zadar (Strobl 1904); Senj (Langhoffer 1920); Baranov (1928, 1938).

European distribution: Albania, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland), Lithuania, Luxemburg, Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland, Canary Is.), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

42. *Sarcophila* sp.

Records: Brač Is., Bol, 4.VIII.2004, D. Whitmore leg. (1♀) (DW); same locality, 5.VIII.2004, D. Whitmore leg. (4♀, 1♂) (DW); Hvar Is., Dubovica, 12.VIII.2004, D. Whitmore leg. (1♀, 1♂) (DW); Pakleni Is., Sveti Klement, 8.VIII.2004, D. Whitmore leg. (1♀) (DW).

Remarks: The above-listed specimens belong to a common and widespread Mediterranean species or species complex, of which we have examined numerous specimens also from Corsica, Greece (incl. Corfu), and southern and insular Italy. Pending the examination of type material in the framework of a full revision of the genus *Sarcophila* Rondani, we prefer to leave these specimens unnamed for the time being.

43. *Wohlfahrtia magnifica* (Schiner, 1862)

Literature records: Baranov (1928); Dubrovnik, nr Loznica; Osijek (Baranov 1943).

European distribution: Albania, Austria, Belarus, Bulgaria, Croatia, Cyprus, Czech Republic, France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland, Sardinia, Sicily), Lithuania, Moldova, Poland, Portugal (mainland), Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Ukraine.

Remarks: Larvae recorded on sheep by Mikačić (1938) were identified as belonging to *W. magnifica*. However, these records should be treated with caution because the larvae of *Wohlfahrtia* Brauer & Bergenstamm are difficult to identify to species level.

44. *Wohlfahrtia meigenii* (Schiner, 1862) (*)

Literature records: Langhoffer (1920); Baranov (1928).

European distribution: Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), France (mainland), Germany, Hungary, Italy (mainland), Latvia, Lithuania, Moldova, Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland), Switzerland, Ukraine.

Remarks: Unverified record. Although male and female terminalia provide important characters for distinguishing *W. meigenii* from other closely related species of *Wohlfahrtia*, misidentifications in older generalist publications cannot be ruled out. The taxonomy of the nominal taxa *W. meigenii* (Schiner) and *W. vigil* (Walker) is unsettled, as discussed by Hall et al. (2009) and Ge et al. (2018). We are here using *W. meigenii* due to its Palaearctic type locality and because this was the name used by Langhoffer (1920) and Baranov (1928).

Subfamily Sarcophaginae Macquart, 1834

45. *Blaesoxipha* (*Blaesoxipha*) *arenicola* Rohdendorf, 1928

Literature records: Baranov (1931); Pag Is. (Baranov 1942); Pape (1996, 2004).

European distribution: Croatia, France (mainland), Switzerland.

46. *Blaesoxipha* (*Blaesoxipha*) *aurulenta* Rohdendorf, 1937 (▲)

Records: Pag Is., 21.VI.1931, N. Baranov leg. (1♂) (NMNH); same locality, VII.1933 N. Baranov leg. (2♂) (NMNH); same locality, 19.VII.1934, N. Baranov leg. (1♂) (NMNH).

European distribution: Croatia, France (mainland).

47. *Blaesoxipha* (*Blaesoxipha*) *batilligera* Séguy, 1941 (▲)

New records: Pag Is., 26.VII.1933, N. Baranov leg. (2♀, 1♂) (NMNH); Sljeme, 2.VIII.1929, N. Baranov leg. (2♂) (NMNH); same locality, 13.IX.1933, N. Baranov leg. (1♀) (NMNH).

Distribution: Croatia, France (mainland), Greece (mainland), Russia (Central European Territory), Switzerland.

48. *Blaesoxipha* (*Blaesoxipha*) *cochlearis* (Pandellé, 1896)

Literature records: Otočac; Pag Is.; Sljeme (Baranov 1942).

European distribution: Bulgaria, Croatia, Czech Republic, France (mainland), Germany, Hungary, Italy (mainland), Poland, Russia (Central European Territory, South European Territory), Romania, Slovakia, Spain (mainland), Switzerland, Ukraine.

49. *Blaesoxipha* (*Blaesoxipha*) *lapidosa* Pape, 1994

Literature records: Baranov (1938); Delnice; Krapina; Otočac; Požega; Sljeme; Zagreb (Baranov 1942, as *lineata* Fallén); Pape (1994, 1996, 2004).

European distribution: Albania, Austria, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Finland, France (mainland, Corsica), Germany, Hungary, Italy (mainland, Sardinia, Sicily), Lithuania, Malta, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Slovenia, Spain (mainland, Canary Is.), Switzerland, The Netherlands, Ukraine.

Remarks: We here record this species from Sicily for the first time (Agrigento, 25.VI.1941, A. Giordani-Soika leg., 1♂, Museo di Zoologia, Sapienza Università di Roma, Rome).

50. *Blaesoxipha* (*Blaesoxipha*) *laticornis* (Meigen, 1826)

Literature records: Koprivnica; Krapina; Požega; Samobor; Zagreb (Baranov 1942).

European distribution: Austria, Bulgaria, Croatia, Denmark (mainland), France (mainland), Germany, Italy (mainland), Liechtenstein, Poland, Serbia, Russia (Central European Territory, South European Territory), Switzerland, Ukraine.

51. *Blaesoxipha* (*Blaesoxipha*) *litoralis* (Villeneuve, 1911)

Literature records: Pag Is. (Baranov 1942).

European distribution: Bulgaria, Croatia, France (mainland), Hungary, Italy (Sardinia), Russia (South European Territory), Serbia, Spain (mainland), Switzerland, Ukraine.

Remarks: We here record this species from Sardinia for the first time (Domusnovas, Valle Oridda, 4.IX.2003, P. Cerretti et al. leg., 2♂, DW; same as previous except 23.IX.2004, 1♂, DW; Villacidro, Canale Monincu, 39°25'10.01"N, 8°37'40.61"E, 450 m, 21.V.2006, D. Whitmore leg., 2♂, DW; Gonnosfanàdiga, Monte Idda, 39°28'11.72"N, 8°36'56.60"E, 474 m, 22.V.2006, D. Whitmore leg., 1♂, DW; Domusnovas, Valle Oridda, 39°24'32.16"N, 8°36'58.94"E, 592 m, 24.V.2006, D. Whitmore leg., 1♂, DW; same as previous except 15–17.VII.2006, 12♂, DW; Domusnovas, Rio Sa Duchessa, 39°21'41.85"N, 8°36'48.46"E, 270 m, 12.VII.2006, D. Whitmore leg., 1♂, DW), thus confirming it for Italy (see Pape et al. 1995).

52. *Blaesoxipha* (*Blaesoxipha*) *plumicornis* (Zetterstedt, 1859) (▲)

Records: Krapina, 11.VII.1929, N. Baranov leg. (1♂) (NMNH); Samobor, 22.IX.1930, N. Baranov leg. (1♂) (NMNH); Zagreb, 30.VIII.1929, N. Baranov leg. (1♂) (NMNH); same locality, 1.IX.1929, N. Baranov leg. (1♂) (NMNH); same locality, 25.VII.1931, N. Baranov leg. (1♂) (NMNH).

European distribution: Albania, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland, Corsica), Germany, Hungary, Italy (mainland, Sicily), Latvia, Norway (mainland), Poland, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

Remarks: We here record this species from Sicily for the first time (Palermo, Parco delle Madonie, 29.VI.2005, D. Whitmore leg., 2♂, DW; Palermo, Corleone, Rocca Busambra, 37°50'42.89"N, 13°23'10.37"E, 950 m, 30.VI.2005, D. Whitmore leg., 1♂, DW).

53. *Blaesoxipha* (*Blaesoxipha*) *pygmaea* (Zetterstedt, 1844)

Literature records: Pape (1994, 1996, 2004).

European distribution: Croatia, Denmark (mainland), France (mainland), Germany, Italy (mainland), Poland, Switzerland.

54. *Blaesoxipha* (*Blaesoxipha*) *ungulata* (Pandellé, 1896)

Literature records: Krapina; Zagreb (Baranov 1942).

European distribution: Andorra, Bulgaria, Croatia, Czech Republic, France (mainland), Hungary, Italy (mainland, Sardinia, Sicily), Poland, Serbia, Russia (Central European Territory, South European Territory), Spain (mainland), Switzerland, Ukraine.

Remarks: We here record this species from Sardinia (Domusnovas, Bega d'Aleni, 39°24'1.76"N, 8°37'33.66"E, 621 m, 17.VII.2006, D. Whitmore leg., 1♀, 1♂, DW) and Sicily (Palermo, Bosco della Ficuzza, 24.VI.2005, D. Whitmore leg., 1♀, DW) for the first time.

55. *Blaesoxipha* (*Blaesoxipha*) *unicolor* (Villeneuve, 1912)

Literature records: Zagreb (Baranov 1942, as *intermedia* Baranov); Pape (1996, 2004).

European distribution: Andorra, Bulgaria, Croatia, France (mainland), Hungary, Italy (mainland, Sardinia), Russia (Central European Territory, South European Territory), Serbia, Spain (mainland), Switzerland, Ukraine.

Remarks: We here record this species from Sardinia for the first time (Domusnovas, nr Agriturismo Perda Niedda, 350 m, 8.VI.2004, P. Cerretti et al. leg., 1♂, DW; Domusnovas, Sa Duchessa, 39°22'27.18"N, 8°35'36.74"E, 371 m, 12.VI.2006, D. Whitmore leg., 1♂, DW).

56. *Blaesoxipha* (*Servaisia*) *croatica* Baranov, 1942

Literature records: Zagreb (Baranov 1942, as *silantjevi* ssp. *croatica*); Pape (1996, 2004).

Distribution: Croatia.

57. *Blaesoxipha* (*Servaisia*) *erythrura* (Meigen, 1826)

New records: Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Baške Oštarije, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂, 1♀) (NHMD); Sušanj Cesarički, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Zadar (Strobl 1904); Mraclin; Samobor; Zagreb (Baranov 1942).

European distribution: Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Estonia, Finland, France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland), Lithuania, Poland, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Switzerland, Ukraine, United Kingdom.

58. *Blaesoxipha* (*Servaisia*) *rossica* Villeneuve, 1912

New records: Vrhovine, 3.VII.1955, R.L. Coe leg. (2♂) (NHMUK); Zmajevac, 15.VII.2015, S. Krčmar leg. (1♂) (DBUO); same locality, 25.VIII.2017, S. Krčmar leg. (2♂) (DBUO).

Literature records: Delnice; Mraclin; Mrzla Vodica; Požega; Samobor; Zagreb (Baranov 1942).

European distribution: Albania, Austria, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, France (mainland), Germany, Hungary, Italy (mainland), Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Switzerland, Ukraine, United Kingdom.

59. *Blaesoxipha* (*Tephromyia*) *grisea* (Meigen, 1826)

New records: Pag Is., VIII.1934, N. Baranov leg. (1♂) (NMNH); same locality, VII.1935, N. Baranov leg. (4♀) (NMNH); Samobor, 19.VI.1931, N. Baranov leg. (2♂) (NMNH); Sljeme, 23.VI.1931, N. Baranov leg. (2♂) (NMNH).

Literature records: Baranov (1931); Krapina; Zagreb (Baranov 1942).

European distribution: Albania, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, France (mainland), Germany, Hungary, Italy (mainland), Moldova, Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Slovenia, Spain (mainland), Switzerland, Ukraine.

60. *Ravinia pernix* (Harris, 1780)

New records: Dalmatia, 18–19.V.1927, T. Becker leg. (2♂) (ZMHB); Korčula, 22–27.V.1955, R.L. Coe leg. (1♂, 4♀) (NHMUK).

Literature records: Dubrovnik; Hvar; Krka Falls; Solin; Šibenik (Strobl 1900, as *haematodes* Meigen); Zadar (Strobl 1904, as *haematodes*); Bakar; Klana; Samobor; Senj; Zagreb (Langhoffer 1920, as *haematodes*); Baranov (1928, as *haematodes*); Krapina (Baranov 1929, as *striata* Fabricius); Baranov (1938, as *striata*); Pag Is., Metajna (Baranov 1940, 1941a, as *striata*); Gruž; Krapina; Pag Is.; Zagreb (Baranov 1942, as *striata*); Trogir (Strukan 1964, as *striata*); Gotalovo (Sisojević et al. 1989); Podgora (Povolný and Znojil 1998, 1999).

European distribution: Albania, Andorra, Austria, Belarus, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland, Corsica), Germany, Greece (mainland), Hungary, Italy (mainland, Sardinia, Sicily), Latvia, Lithuania, Malta, Moldova, Norway (mainland), Poland, Portugal (mainland), Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland, Canary Is.), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

61. *Sarcophaga* (*Bellieriomima*) *subulata* Pandellé, 1896

New records: Baške Oštarije, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Čigoč, 10.VI.2016, S. Krčmar leg. (1♂) (DBUO); same locality, 5.VI.2017, S. Krčmar leg. (3♂) (DBUO); Skrad, 11.VI.2016, S. Krčmar leg. (3♂) (DBUO); same locality, 31.V.2017, S. Krčmar leg. (6♂) (DBUO); same locality, 8.VI.2017, S. Krčmar leg. (14♂) (DBUO); Zmajevac, 15.VII.2015, S. Krčmar leg. (1♂) (DBUO); same locality, 9.VIII.2016, S. Krčmar leg. (1♂) (DBUO); same locality, 30.IV.2017, S. Krčmar leg. (2♂) (DBUO); same locality, 14.V.2017, S. Krčmar leg. (3♂) (DBUO); same locality, 11.IX.2017, S. Krčmar leg. (4♂) (DBUO).

Literature records: Zagreb; Mraclin; Samobor (Baranov 1942, as *laciniata* Pandellé); Otočac, Veliki Kuk (Rucner 1994); Pape (2004).

European distribution: Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland), Germany, Hungary, Italy (mainland), Norway (mainland), Poland, Romania, Russia (Central European Territory, North European Territory, South European Territory), Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

62. *Sarcophaga* (*Bercaea*) *africa* (Wiedemann, 1824)

New records: Korčula, 22–27.V.1955, R.L. Coe leg. (5♂, 10♀) (NHMUK); Hvar Is., Dubovica, 12.VIII.2004, D. Whitmore leg. (1♀) (DW); Sveti Juraj, 12.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Drivenik, 5.VI.2014, S. Krčmar leg. (1♂) (DBUO); Komin, 16.VII.2014, S. Krčmar leg. (3♂) (DBUO); Badžula, 18.VII.2014, S. Krčmar leg. (1♂) (DBUO); Biograd, 18.VIII.2014, S. Krčmar leg. (1♂) (DBUO); same locality, 19.VIII.2014, S. Krčmar leg. (4♂) (DBUO); same locality, 20.VIII.2014, S. Krčmar leg. (2♂) (DBUO); Krk Is., Punat, 13.VI.2016, S. Krčmar leg. (1♂) (DBUO); Zmajevac, 11.IX.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Dubrovnik; Šibenik; Zadar (Strobl 1900, as *nurus* Rondani); Solin; Split (Strobl 1900, as *nurus*); Dalmatia (Böttcher 1913, as *haemorrhoidalis* Meigen); Baranov (1928, as *haemorrhoidalis*); Pag Is., Metajna (Baranov 1940, as *haemorrhoidalis*); Gruž; Korčula; Pag Is.; Zagreb; Samobor; Krapina (Baranov 1942, as *haemorrhoidalis*); Donja Stubica; Trogir; Velika Paklenica (Strukan 1970, as *haemorrhoidalis*); Oprić (Sisojević et al. 1989, as *cruentata* Meigen); Pelješac, Potomje; Ston, Česvinica; Ston, Broce (Rucner 1994, as *haemorrhoidalis*); Biokovo Mts; Podgora (Povolný and Znojil 1994, 1998, 1999, as *cruentata*); Krk Is. (Povolný and Znojil 1998, as *cruentata*); Pape (2004).

European distribution: Albania, Austria, Belarus, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark (mainland), France (mainland, Corsica), Germany, Greece (mainland), Hungary, Ireland, Italy (mainland, Sardinia, Sicily), Latvia, Lithuania, Luxemburg, Moldova, Norway (mainland), Poland, Portugal (mainland, Ma-

deira Is.), Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland, Canary Is.), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

63. *Sarcophaga* (*Helicophagella*) *agnata* Rondani, 1860

New records: Baške Oštarije, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Sušanj Cesarički, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Plitvička jezera National Park, Turčić, 16.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Zagreb; Našice (Baranov 1942); Pape (2004).

Distribution: Albania, Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), France (mainland, Corsica), Germany, Hungary, Italy (mainland, Sardinia, Sicily), Norway (mainland), Poland, Romania, Russia (Central European Territory), Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

Remarks: We here record this species from Sardinia for the first time (Domusnovas, Conca Margiani, 39°21'37.59"N, 8°33'58.62"E, 700 m, 16–17.VII.2006, D. Whitmore leg., 5♂, DW; same as previous except 39°21'40.76"N, 8°33'44.05"E, 750 m, 2♂, DW).

64. *Sarcophaga* (*Helicophagella*) *crassimargo* Pandellé, 1896

New records: Zmajevac, 11.IX.2017, S. Krčmar leg. (2♂) (DBUO).

Literature records: Zagreb; Krapina; Požega (Baranov 1942); Pape (2004).

European distribution: Albania, Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Finland, France (mainland), Germany, Greece (mainland), Hungary, Ireland, Italy (mainland), Lithuania, Macedonia, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

65. *Sarcophaga* (*Helicophagella*) *hirticrus* Pandellé, 1896

New records: Brač Is., Bol, 4.VIII.2004, D. Whitmore leg. (1♂) (DW); Sveti Juraj, 12.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Zmajevac, 2.VII.2014, S. Krčmar leg. (1♂) (DBUO); same locality, 4.VII.2014, S. Krčmar leg. (1♂) (DBUO).

Literature records: Baranov (1928); Gruž; Otočac; Pag Is.; Zagreb (Baranov 1942); Biokovo Mts; Podgora (Povolný and Znojil 1998, 1999); Pape (2004).

European distribution: Albania, Andorra, Austria, Belgium, Bulgaria, Croatia, Czech Republic, France (mainland, Corsica), Germany, Hungary, Italy (mainland, Sardinia, Sicily), Malta, Norway (mainland), Poland, Romania, Russia (South European Territory), Slovakia, Spain (mainland, Canary Is.), Sweden, Switzerland, Ukraine, United Kingdom.

Remarks: This species was not listed for Sardinia by Pape (2004), but has been known from the island at least since Povolný (1997).

66. *Sarcophaga* (*Helicophagella*) *melanura* Meigen, 1826

New records: Novi Varoš, 27.VII.1969, W.G. Tremewan leg. (1♀) (NHMUK); Modro Oko, 18.VII.2014, S. Krčmar leg. (1♂) (DBUO); Zmajevac, 14.V.2017, S. Krčmar leg. (1♂) (DBUO); same locality, 10.VIII.2017, S. Krčmar leg. (2♂) (DBUO); same locality, 11.IX.2017, S. Krčmar leg. (3♂) (DBUO).

Literature records: Hvar; Split (Strobl 1900); Zadar (Strobl 1904); Bakar; Bjelovar; Delnice; Osijek; Pleskovac; Prezid; Senj; Zagreb (Langhoffer 1920); Baranov (1928); Krapina; Pag Is.; Zagreb; Mraclin; Samobor (Baranov 1942); Oprić (Sisojević et al. 1989); Podgora (Povolný and Znojil 1994, 1998, 1999); Pape (2004).

European distribution: Albania, Austria, Belarus, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark (mainland), Finland, France (mainland, Corsica), Germany, Greece (mainland), Hungary, Ireland, Italy (mainland, Sardinia, Sicily), Latvia, Lithuania, Luxemburg, Macedonia, Malta, Moldova, Norway (mainland), Poland, Portugal (mainland), Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland, Canary Is.), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

67. *Sarcophaga* (*Helicophagella*) *novella* Baranov, 1929

Literature records: Biokovo Mts (Povolný and Verves 1997).

Distribution: Croatia, France (Corsica), Hungary, Italy (mainland, Sardinia), Macedonia, Romania, Serbia.

Remarks: A junior synonym of this species, *Helicophagella reicostae* Povolný, 1999, was described from Sardinia. It has since been confirmed as locally abundant on the island (Whitmore, unpubl. data).

68. *Sarcophaga* (*Helicophagella*) *noverca* Rondani, 1860

New records: Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (3♂) (NHMD); Sušanj Cesarički, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Kamenac, 23.VII.2016, S. Krčmar leg. (1♂) (DBUO); Zmajevac, 27.VI.2014, S. Krčmar leg. (2♂) (DBUO); same locality, 2.VII.2014, S. Krčmar leg. (1♂) (DBUO);

same locality, 4.VII.2014, S. Krčmar leg. (4♂) (DBUO); same locality, 30.IV.2017, S. Krčmar leg. (2♂) (DBUO); Skrad, 8.VI.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Dubrovnik; Šibenik (Strobl 1900); Zadar (Strobl 1904); Gruž; Krapina; Mraclin; Sljeme; Zagreb (Baranov 1942); Medvednica, Sv. Jakob; Medevednica, Medvedgrad; Otočac, Metla; Otočac, Veliki Kuk; Baške Oštarije, Filipov Kuk (Rucner 1994); Podgora (Povolný and Znojil 1998, 1999); Pape (2004).

European distribution: Albania, Austria, Belgium, Bulgaria, Croatia, Czech Republic, France (mainland, Corsica), Germany, Hungary, Italy (mainland), Macedonia, Malta, Norway (mainland), Poland, Romania, Russia (South European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine.

69. *Sarcophaga* (*Helicophagella*) *novercoides* Böttcher, 1913

New records: Sveti Juraj, 12.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Biokovo Mts (Povolný and Znojil 1998, 1999); Podgora (Povolný and Znojil 1994, 1998, 1999); Pape (2004).

European distribution: Albania, Austria, Bulgaria, Croatia, Cyprus, France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland, Sardinia, Sicily), Malta, Russia (South European Territory), Serbia, Slovakia, Spain (mainland), Switzerland, Ukraine.

70. *Sarcophaga* (*Helicophagella*) *okaliana* (Lehrer, 1975) (▲)

Records: Begovo Razdolje, nr Bijele Stijene, 18.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Bjelolasica Mts, 2.VI.2015, S. Krčmar leg. (1♂) (DBUO).

Distribution: Albania, Austria, Croatia, France (mainland), Italy (mainland), Slovakia, Spain (mainland), Switzerland.

71. *Sarcophaga* (*Helicophagella*) *rosellei* Böttcher, 1912

New records: Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Plitvička jezera National Park, Turčić, 16.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Begovo Razdolje, nr Bijele Stijene, 18.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Oštrovica, 13.VI.2016, S. Krčmar leg. (1♂) (DBUO); Skrad, 31.V.2017, S. Krčmar leg. (1♂) (DBUO); same locality, 8.VI.2017, S. Krčmar leg. (1♂) (DBUO); Lokve, 8.VI.2017, S. Krčmar leg. (2♂) (DBUO).

Literature records: Delnice; Mrzla Vodica; Samobor; Sljeme; Zagreb (Baranov 1942); Pape (2004).

European distribution: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), France (mainland), Germany, Hungary, Italy (mainland, Sicily), Norway (mainland), Poland, Romania, Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

72. *Sarcophaga* (*Heteronychia*) *amita* Rondani, 1860 (▲)

Records: Krk Is., Punat, 7.VI.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Dubrovnik; Krka Falls; Šibenik (Strobl 1900, as *haemorrhoa* var. *amita*). NB: These records could not be assigned to this species with certainty.

Distribution: Croatia, France (mainland, Corsica), Germany, Hungary, Italy (mainland), Spain (mainland), Switzerland.

73. *Sarcophaga* (*Heteronychia*) *ancilla* Rondani, 1865 (▲)

Records: Sušanj Cesarički, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

European distribution: Austria, Bulgaria, Croatia, Czech Republic, France (mainland), Greece (mainland), Hungary, Italy (mainland), Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Switzerland, Ukraine. NB: Some of these country-level records require verification (see Whitmore 2010).

74. *Sarcophaga* (*Heteronychia*) *arcipes* Pandellé, 1896

New records: Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Krapina; Otočac (Baranov 1942); Bosut (Strukan 1967); Pape (2004).

Distribution: Austria, Belgium, Bulgaria, Croatia, Czech Republic, France (mainland), Germany, Hungary, Italy (mainland), Poland, Romania, Serbia, Slovakia, Spain (mainland), Switzerland, The Netherlands, Ukraine, United Kingdom.

75. *Sarcophaga* (*Heteronychia*) *belanovskyi* (Verves, 1973)

Literature records: Krapina (Baranov 1942, as *ancilla* Rondani); Whitmore (2010).

European distribution: Croatia, Hungary, Italy (mainland), Romania, Serbia, Ukraine.

76. *Sarcophaga* (*Heteronychia*) *benaci* Böttcher, 1913

New records: Sušanj Cesarički, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Učka Nature Park, Vela Učka, 19.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Banja, 30.VI.2015, S. Krčmar leg. (1♂) (DBUO); Desne, 1.VII.2015, S. Krčmar leg. (1♂) (DBUO); Vriještica, 3.VII.2015, S. Krčmar leg. (1♂) (DBUO); Zmajevac, 15.VII.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Pag Is. (Baranov 1942); Biokovo Mts, Čerešnik nr Makarska (Povolný 1987, as *vachai* Povolný); Biokovo Mts; Podgora (Povolný and Znojil 1994, as *bezziana* Böttcher, misidentification); Pape (1996, as *vachai*); Povolný and Verves (1997, as *bezziana*); Biokovo Mts; Podgora (Povolný and Znojil 1998, 1999); Pape (2004, as *vachai*); Biokovo Mts, nr Podgora; Hvar Is., Jelsa; Krk Is., Veli Vrh (Whitmore 2011).

Distribution: Bulgaria, Croatia, Czech Republic, Germany, Greece (mainland), Italy (mainland), Serbia, Slovakia, Spain (mainland).

77. *Sarcophaga* (*Heteronychia*) *boettcheri* Villeneuve, 1912

Literature records: Zagreb, Stenjevac; Pag Is. (Baranov 1942); Pape (2004); Pag Is.; Stinica (Whitmore 2011).

Distribution: Austria, Croatia, Cyprus, Greece (mainland, Cyclades Is.), Hungary, Romania, Serbia, Ukraine.

78. *Sarcophaga* (*Heteronychia*) *bulgarica* (Enderlein, 1936)

New records: Baške Oštarije, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Plitvička jezera National Park, Turčić, 16.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Pape (2004).

European distribution: Austria, Belarus, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, France (mainland, Corsica), Germany, Hungary, Italy (mainland, Sardinia, Sicily), Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland), Sweden, Switzerland, Ukraine.

79. *Sarcophaga* (*Heteronychia*) *consanguinea* Rondani, 1860

Literature records: Zadar (Strobl 1904); Zagreb (Baranov 1942, as *rondanii* Böttcher); Verves and Khrokalo (2014).

European distribution: Bulgaria, Croatia, France (mainland), Greece (mainland), Hungary (doubtful), Italy (mainland, Sicily), Russia (South European Territory), Serbia, Ukraine.

80. *Sarcophaga* (*Heteronychia*) *croca* Pape, 1996

New records: Sušanj Cesarički, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Biokovo Mts, nr Podgora; Hvar Is., nr Jelsa (Whitmore 2011).

Distribution: Croatia, Greece (mainland).

81. *Sarcophaga* (*Heteronychia*) *cucullans* Pandellé, 1896

New records: Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Otočac; Pag Is.; Zagreb (Baranov 1942); Metković, Šibanica (Rucner 1994); Pape (2004); Krk Is., Veli Vrh; Zadar, Borik; Zagreb (Whitmore et al. 2013).

European distribution: Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland, Sicily), Russia (South European Territory), Serbia, Slovakia, Spain (mainland), Switzerland, Ukraine.

82. *Sarcophaga* (*Heteronychia*) *depressifrons* Zetterstedt, 1845

New records: Sveti Juraj, 12.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Skrad, 8.VI.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Dubrovnik; Solin; Split (Strobl 1900); Samobor; Zagreb (Baranov 1942, as *offuscata* Meigen); Pape (2004); Krk Is., Glavotok; Labin; Sljeme; Zagreb (Whitmore 2011).

European distribution: Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland), Macedonia, Malta, Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

83. *Sarcophaga* (*Heteronychia*) *dissimilis* Meigen, 1826

Literature records: Krapina (Baranov 1942); Virovitica (Sisojević et al. 1989); Pape (2004).

European distribution: Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Estonia, France (mainland), Germany, Hungary, Italy (mainland), Latvia, Macedonia, Moldova, Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Switzerland, The Netherlands, Ukraine, United Kingdom.

84. *Sarcophaga* (*Heteronychia*) *filia* Rondani, 1860

New records: Novi Grad, 27–31.V.1958, R.L. Coe leg. (1♀) (NHMUK); Brušane, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Krk Is., Punat, 1.VI.2017, S. Krčmar leg. (7♂) (DBUO); same locality, 7.VI.2017, S. Krčmar leg. (3♂) (DBUO).

Literature records: Baranov (1928); Krapina; Mraclin; Pag Is.; Susedgrad (Baranov 1938); Krapina; Pag Is.; Zagreb (Baranov 1942); Premuda; Bačinci (Strukan 1964); Oprić (Sisojević et al. 1989); Podgora (Povolný and Znojil 1994, 1998, 1999); Biokovo Mts; Pag Is.; Podgora; Zagreb (Whitmore 2011).

European distribution: Albania, Austria, Belgium, Bulgaria, Croatia, Czech Republic, France (mainland, Corsica), Germany, Greece (mainland, Crete), Hungary, Italy (mainland, Sardinia), Macedonia, Malta, Moldova, Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Switzerland, The Netherlands, Ukraine, United Kingdom.

85. *Sarcophaga* (*Heteronychia*) *giganta* Pape, 1996

New records: Sveti Juraj, 12.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); same locality, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Biokovo Mts, Čerešnik nr Makarska (Povolný 1987, as *gigas* Povolný); Biokovo Mts; Podgora (Povolný and Znojil 1994, 1998, 1999, as *gigas*); Pape (1996); Dalmatia (Povolný 1996, as *gigas*); Pape (2004, as *gigas*); Biokovo Mts, nr Podgora (Whitmore 2011).

Distribution: Croatia.

86. *Sarcophaga* (*Heteronychia*) *haemorrhoa* Meigen, 1826

New records: Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Zmajevac, 15.VII.2015, S. Krčmar leg. (1♂) (DBUO); same locality, 30.IV.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Dalmatia (Böttcher 1913); Zagreb (Langhoffer 1920); Dubrovnik; Krapina; Mraclin; Pag Is.; Zagreb, Podsused; Samobor (Baranov 1942); Podgora (Povolný and Znojil 1998, 1999); Krapina; Zagreb (Whitmore 2011).

European distribution: Albania, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland, Corsica), Germany, Greece (mainland), Hungary, Ireland, Italy (mainland, Sicily), Latvia, Norway (mainland), Poland, Romania, Russia (Central European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

87. *Sarcophaga* (*Heteronychia*) *haemorrhoides* Böttcher, 1913

New records: Novi Grad, 27–31.V.1958, R.L. Coe leg. (2♂, 1♀) (NHMUK); Baške Oštarije, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Tribanj-Krušćica, 14.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Biograd, 20.VIII.2014, S. Krčmar leg. (1♂) (DBUO); Banja, 30.VI.2015, S. Krčmar leg. (1♂) (DBUO).

Literature records: Crikvenica; Fužine; Osijek; Senj; Zagreb (Langhoffer 1920); Bačinci (Strukan 1964); Podgora (Povolný and Znojil 1998, 1999); Pape (2004); Gračac; Krapina; Krk Is., Glavotok; Pakleni Is., Sveti Klement; Pag Is. (Whitmore et al. 2013).

European distribution: Albania, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Estonia, France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland), Macedonia, Malta, Moldova, Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Switzerland, Ukraine.

88. *Sarcophaga* (*Heteronychia*) *infantilis* Böttcher, 1913

New records: Sušanj Cesarički, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Sljeme (Whitmore et al. 2013).

European distribution: Austria, Bulgaria, Croatia, Czech Republic, France (mainland), Greece (mainland), Germany, Italy (mainland), Norway (mainland), Poland, Romania, Serbia, Slovakia, Spain (mainland), Sweden, Switzerland.

89. *Sarcophaga* (*Heteronychia*) *mediterranea* Whitmore, 2011

Literature records: Pag Is. (Baranov 1942, as *penicillata* Villeneuve); Brač Is., Bol; Pag Is. (Whitmore 2011).

Distribution: Croatia, Italy (mainland, Sicily).

90. *Sarcophaga* (*Heteronychia*) *minima* Rondani, 1862

New records: Rudelić Draga, 14.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Pape (2004).

European distribution: Bulgaria, Croatia, Czech Republic, France (mainland, Corsica), Greece (mainland), Hungary, Italy (mainland, Sardinia, Sicily), Malta, Slovakia, Spain (mainland).

91. *Sarcophaga* (*Heteronychia*) *mutila* Villeneuve, 1912

New records: Korčula, 22–27.V.1955, R.L. Coe leg. (10♂, 2♀) (NHMUK).

Literature records: Dalmatia (Böttcher 1913, as *setinervis* var. *mutila*); Gruž; Pag Is. (Baranov 1942, as "*mutilla*"); Biokovo Mts (Povolný and Znojil 1998, 1999); Premuda (Strukan 1964); Pape (2004); Krk Is., Glavotok; Pag Is. (Whitmore 2011).

European distribution: Bulgaria, Croatia, Cyprus, Greece (mainland), Hungary, Italy (mainland), Romania, Russia (South European Territory), Serbia, Slovakia, Ukraine.

92. *Sarcophaga* (*Heteronychia*) *pandellei* (Rohdendorf, 1937)

Literature records: Dalmatia (Baranov 1942, as *consanguinea* Pandellé); Pape (2004); Brač Is., Bol; Hvar Is., Jelsa (Whitmore et al. 2013).

European distribution: Andorra, Croatia, France (mainland, Corsica), Greece (mainland), Italy (mainland, Sardinia, Sicily), Portugal (mainland), Spain (mainland).

Remarks: We here record this species from Greece for the first time (Corfu, Corfu city, 39°37'24.82"N, 19°55'19.76"E, 9.IX.2016, D. Whitmore leg., 1♂, DW).

93. *Sarcophaga* (*Heteronychia*) *pauciseta* Pandellé, 1896

Literature records: Povolný and Verves (1997)

European distribution: Bulgaria, Croatia, Estonia, Germany, Hungary (doubtful), Poland, Russia (Central European Territory), Slovakia, Switzerland, Ukraine.

94. *Sarcophaga* (*Heteronychia*) *porrecta* Böttcher, 1913

New records: Begovo Razdolje, nr Bijele Stijene, 18.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Krapina; Medvedgrad; Samobor; Zagreb (Baranov 1942); Pape (2004); Krapina; Zagreb (Whitmore 2011); Zagreb, Samobor (Whitmore et al. 2013).

Distribution: Bulgaria, Croatia, Greece (mainland), Italy (mainland), Romania, Serbia, Slovakia.

95. *Sarcophaga* (*Heteronychia*) *proxima* Rondani, 1860

New records: Učka Nature Park, Vela Učka, 19.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (3♂) (NHMD); Zmajevac, 9.VIII.2016, S. Krčmar leg. (1♂) (DBUO).

Literature records: Baranov (1928); Sljeme (Whitmore 2011).

European distribution: Albania, Andorra, Austria, Belarus, Bulgaria, Croatia, Czech Republic, Estonia, Finland, France (mainland), Germany, Hungary, Italy (mainland, Sicily), Latvia, Moldova, Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Switzerland, Ukraine.

96. *Sarcophaga* (*Heteronychia*) *pseudobenaci* (Baranov, 1942) (▲)

Records: Zmajevac, 25.VIII.2017, S. Krčmar leg. (2♂) (DBUO); same locality, 11.IX.2017, S. Krčmar leg. (1♂) (DBUO).

Distribution: Bulgaria, Croatia, Greece (mainland), Serbia.

97. *Sarcophaga* (*Heteronychia*) *pumila* Meigen, 1826

Literature records: Krka Falls (Strobl 1900); Zagreb; Novi Marof (Baranov 1942; Whitmore et al. 2013); Pape (2004).

Distribution: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland), Germany, Hungary, Italy (mainland), Latvia, Lithuania, Norway (mainland), Poland, Romania, Russia (Central European Territory), Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

98. *Sarcophaga* (*Heteronychia*) *rondaniana* (Rohdendorf, 1937)

Literature records: Dalmatia (Böttcher 1913, as *arvorum* Rondani); Krapina; Mraclin; Pag Is.; Zagreb (Baranov 1942, as *arvorum*); Povolný and Verves (1997); Pape (2004); Labin (Whitmore et al. 2013).

European distribution: Austria, Bulgaria, Croatia, Czech Republic, France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland), Macedonia, Romania, Serbia, Slovakia, Spain (mainland), The Netherlands, Ukraine.

99. *Sarcophaga* (*Heteronychia*) *schineri* Bezzi, 1891

New records: Baške Oštarije, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Sertić Poljana, 17.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Zmajevac, 26.VII.2017, S. Krčmar leg. (1♂) (DBUO); Slatinski Drenovac, 17.VIII.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Zagreb, Podsused; Medvednica, Sljeme (Baranov 1942); Zagreb (Strukan 1964); Pape (2004); Zagreb, Podsused; Velika Kapela Mts, Vrh Kapele (Whitmore et al. 2013).

European distribution: Albania, Austria, Bulgaria, Croatia, Czech Republic, France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland, Sicily), Poland, Romania, Russia (South European Territory), Serbia, Slovakia, Switzerland, Ukraine.

100. *Sarcophaga* (*Heteronychia*) *vagans* Meigen, 1826

New records: Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD).

Literature records: Dubrovnik (Strobl 1900); Mraclin; Pag Is. (Baranov 1938, as *cruenta* Pandellé); Mraclin; Pag Is.; Samobor; Zagreb (Baranov 1942, as *frenata* Pandellé, *cruentata* Pandellé and *anastrenua* Baranov); Zagreb (Whitmore 2011).

European distribution: Andorra, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland), Germany, Hungary, Ireland, Italy (mainland), Latvia, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, North European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

101. *Sarcophaga* (*Heteronychia*) *vicina* Macquart, 1835

New records: Sušanj Cesarički, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Plitvička jezera National Park, Turčić, 16.VI.2012, T. Pape et al. leg. (1♂) (NHMD); Begovo Razdolje, nr Bijele Stijene, 18.VI.2012, T. Pape et al. leg. (1♀, 1♂) (NHMD).

Literature records: Zagreb (Baranov 1942, as *ebrachiata* Pandellé); Whitmore (2010).

European distribution: Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Finland, France (mainland, Corsica), Germany, Greece (mainland), Hungary, Ireland, Italy (mainland), Norway (mainland), Poland, Russia (South European Territory), Slovakia, Spain (mainland), Sweden, Switzerland, Ukraine, United Kingdom.

102. *Sarcophaga* (*Heteronychia*) sp.

Records: Skrad, 31.V.2017, S. Krčmar leg. (2♂) (DBUO).

Remarks: These two males belong to an undescribed species, probably ascribable to the *ancilla*-group, characterised by lateral styli conspicuously enlarged apically. They may be conspecific with specimens misidentified as *ancilla* by Povolný (1996, fig. 19) and Povolný and Verves (1997, fig. 177).

103. *Sarcophaga* (*Kramerea*) *schuetzei* Kramer, 1909

Literature records: Zagreb (Baranov 1942); Oprić (Sisojević et al. 1989); Xue et al. (2011).

European distribution: Austria, Belarus, Bulgaria, Croatia, Czech Republic, France (mainland), Germany, Hungary, Italy (mainland), Poland, Russia (Central European Territory, North European Territory, South European Territory), Slovakia, Switzerland, Ukraine.

104. *Sarcophaga* (*Krameromyia*) *anaces* Walker, 1849

New records: Novi Grad, 27–31.V.1958, R.L. Coe leg. (3♂) (NHMUK); Zmajevac, 30.IV.2017, S. Krčmar leg. (1♂) (DBUO); same locality, 11.09.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Hvar; Solin; Šibenik (Strobl 1900, as *setipennis* Rondani); Krapina; Pag Is.; Zagreb, Podsused (Baranov 1942, as *setipennis*); Omiš, Zakučac (Sisojević et al. 1989); Pape (2004).

European distribution: Austria, Belgium, Bulgaria, Croatia, Czech Republic, France (mainland), Germany, Hungary, Italy (mainland), Poland, Slovakia, Spain (mainland), Switzerland, The Netherlands, United Kingdom.

105. *Sarcophaga* (*Latistyla*) *czernyi* Böttcher, 1912

Literature records: Dubrovnik (Böttcher 1912); Dubrovnik; Otočac (Baranov 1942); Velika Paklenica (Strukan 1970); Pape (1996, 2004).

European distribution: Croatia, Greece (mainland).

106. *Sarcophaga* (*Liopygia*) *argyrostoma* (Robineau-Desvoidy, 1830)

New records: Zmajevac, 25.VIII.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Dalmatia (Böttcher 1913, as *falculata* Pandellé); Pag Is., Metajna (Baranov 1940, as *barbata* Thomson); Zagreb; Samobor; Krapina; Pag Is.; Krk Is.;

Split; Dubrovnik (Baranov 1942, as *falculata*); Velika Paklenica; Premuda (Strukan 1964); Biokovo Mts (Povolný and Znojil 1998, 1999); Krk Is. (Povolný and Znojil 1998); Podgora (Povolný and Znojil 1994, 1998, 1999); Pape (2004).

European distribution: Albania, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark (mainland), France (mainland, Corsica), Germany, Greece (mainland), Hungary, Italy (mainland, Sardinia, Sicily), Macedonia, Moldova, Poland, Portugal (mainland, Madeira Is.), Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland, Canary Is.), Switzerland, The Netherlands, Ukraine, United Kingdom.

107. *Sarcophaga* (*Liopygia*) *crassipalpis* Macquart, 1839

New records: Hvar Is., Dubovica, 12.VII.2004, D. Whitmore leg. (4♂) (DW); Tribanj-Krušćica, 14.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Zmajevac, 4.VII.2014, S. Krčmar leg. (1♂) (DBUO); Modro Oko, 18.VII.2014, S. Krčmar leg. (3♂) (DBUO); Biograd, 18.VIII.2014, S. Krčmar leg. (1♂) (DBUO); same locality, 19.VIII.2014, S. Krčmar leg. (3♂) (DBUO); same locality, 20.VIII.2014, S. Krčmar leg. (1♂) (DBUO).

Literature records: Dalmatia (Schiner 1862, as *dalmatina* Schiner; Böttcher 1913, as *securifera* Villeneuve); Samobor (Baranov 1942, as *securifera*); Trogir (Strukan 1964, 1970); Biokovo Mts; Podgora (Povolný and Znojil 1994, 1998, 1999); Pape (1996); Krk Is. (Povolný and Znojil 1998); Pape (2004).

European distribution: Albania, Bulgaria, Croatia, Cyprus, Czech Republic, France (mainland, Corsica), Germany, Greece (mainland), Hungary, Italy (mainland, Sardinia, Sicily), Malta, Moldova, Portugal (mainland, Madeira Is.), Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland, Canary Is.).

108. *Sarcophaga* (*Liosarcophaga*) *aegyptica* Salem, 1935

New records: Zmajevac, 11.IX.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Oprić (Sisojević et al. 1989).

European distribution: Albania, Bulgaria, Croatia, Czech Republic, France (mainland), Hungary, Italy (mainland), Moldova, Romania, Russia (Central European Territory, South European Territory), Slovakia, Ukraine.

109. *Sarcophaga* (*Liosarcophaga*) *dux* Thomson, 1869

New records: Korčula, 22–27.V.1955, R.L. Coe leg. (2♂) (NHMUK); Novi Grad, 27–31.V.1958, R.L. Coe leg. (1♂) (NHMUK); Rudelić Draga, 14.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Baranov (1928, 1929, as *exuberans* Pandellé); Dalmatia (Baranov 1929, as *exuberans* var. *setosa* Baranov); Pag Is., Metajna (Baranov 1940, as *exuberans*); Dubrovnik (Baranov 1942, as *exuberans*); Premuda; Velika Paklenica (Strukan 1964, 1970, as *exuberans*); Podgora (Povolný and Znojil 1994, 1998, 1999); Pape (1996, 2004).

European distribution: Albania, Bulgaria, Croatia, Cyprus, France (mainland, Corsica), Greece (mainland), Italy (mainland, Sardinia, Sicily), Malta, Romania, Serbia, Spain (mainland, Canary Is.), Ukraine.

110. *Sarcophaga* (*Liosarcophaga*) *emdeni* (Rohdendorf, 1969)

New records: Učka Nature Park, Vela Učka, 19.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Skrad, 11.VI.2016, S. Krčmar leg. (1♂) (DBUO); Zmajevac, 29.V.2016, S. Krčmar leg. (2♂) (DBUO); same locality, 14.V.2017, S. Krčmar leg. (4♂) (DBUO); same locality, 26.VII.2017, S. Krčmar leg. (2♂) (DBUO); same locality, 10.VIII.2017, S. Krčmar leg. (1♂) (DBUO); same locality, 11.IX.2017, S. Krčmar leg. (2♂) (DBUO); Slatinski Drenovac, 17.VIII.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Baranov (1928, 1929, as *teretirostris* Pandellé); Zagreb; Dalmatia (Baranov 1942, as *teretirostris*); Zagreb (Strukan 1970, as *teretirostris*); Oprić (Sisojević et al. 1989); Podgora (Povolný and Znojil 1998, 1999); Pape (2004).

European distribution: Austria, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, Germany, Greece (mainland), Hungary, Italy (mainland), Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Sweden, Switzerland, Ukraine.

111. *Sarcophaga* (*Liosarcophaga*) *harpax* Pandellé, 1896

Literature records: Zagreb (Baranov 1929, 1942); Velika Paklenica (Strukan 1970); Sisojević et al. (1989); Podgora (Povolný and Znojil 1998, 1999); Pape (2004).

European distribution: Austria, Belarus, Bulgaria, Croatia, Czech Republic, France (mainland), Germany, Hungary, Italy (mainland), Moldova, Poland, Romania, Russia (Central European Territory, North European Territory, South European Territory), Serbia, Slovakia, The Netherlands, Ukraine.

Remarks: We here record this species from Italy for the first time (Perugia, Gubbio, Scritto, 43°14'42.98"N, 12°32'48.82"E, 475 m, 15.VIII.2007, D. Whitmore leg., 1♂, DW).

112. *Sarcophaga* (*Liosarcophaga*) *jacobsoni* (Rohdendorf, 1937)

New records: Novi Grad, 27–31.V.1958, R.L. Coe leg. (1♂) (NHMUK).

Literature records: Pag Is. (Baranov 1942); Bačinci; Premuda; Pula; Trogir (Strukan 1964, 1970); Metković, Šibanica (Rucner 1994); Podgora (Povolný and Znojil 1998, 1999); Pape (2004).

European distribution: Albania, Bulgaria, Croatia, Cyprus, Denmark (mainland), France (mainland, Corsica), Germany, Greece (mainland), Hungary, Ireland, Italy (mainland, Sardinia), Moldova, Romania, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland, Canary Is.), Ukraine, United Kingdom.

Remarks: This species was not listed for Sardinia by Pape (2004), but has been known from the island at least since Povolný (1997).

113. *Sarcophaga* (*Liosarcophaga*) *marshalli* Parker, 1923

New records: Novi Grad, 27–31.V.1958, R.L. Coe leg. (3♂) (NHMUK); Brač Is., Bol, 4.VIII.2004, D. Whitmore leg. (1♂) (DW).

Literature records: Premuda; Trogir (Strukan 1970, as *kovatschevitchi* Strukan); Pag Is. (Povolný 1999); Pape (2004).

European distribution: Croatia, France (mainland), Italy (mainland, Sicily), Malta, Spain (mainland).

Remarks: *Parasarcophaga kovatschevitchi* Strukan, 1970 was described from one male collected in Trogir (15.VIII.1960) and fifteen males collected on the island of Premuda [18–19.VIII.1961 (4♂); 8–19.VIII.1963 (11♂)]. Based on the description and original drawings of the male terminalia of the new species, we propose *Parasarcophaga kovatschevitchi* Strukan, 1970 as a junior synonym of *Sarcophaga* (*Liosarcophaga*) *marshalli* Parker, 1923, syn. nov.

114. *Sarcophaga* (*Liosarcophaga*) *portschinskyi* (Rohdendorf, 1937)

New records: Sveti Juraj, 12.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Modro Oko, 18.VII.2014, S. Krčmar leg. (1♂) (DBUO); Podrujnica, 18.VII.2014, S. Krčmar leg. (1♂) (DBUO); Vriještica, 3.VII.2015, S. Krčmar leg. (9♂) (DBUO); Zmajevac, 20.VII.2014, S. Krčmar leg. (1♀) (DBUO).

Literature records: Trogir; Premuda; Velika Paklenica (Strukan 1964, 1970); Podgora (Povolný and Znojil 1994, 1998, 1999); Pape (2004).

European distribution: Albania, Andorra, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland, Corsica), Germany, Greece (mainland), Hungary, Ireland, Italy (mainland, Sardinia, Sicily), Malta, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Sweden, Switzerland, The Netherlands, Ukraine.

115. *Sarcophaga* (*Liosarcophaga*) *tibialis* Macquart, 1851

New records: Tribanj-Krušćica, 14.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Crikvenica, 5.VI.2014, S. Krčmar leg. (2♂) (DBUO); Desne, 17.VII.2014, S. Krčmar leg. (1♂) (DBUO); Modro Oko, 18.VII.2014, S. Krčmar leg. (2♂) (DBUO); Podrujnica, 18.VII.2014, S. Krčmar leg. (2♂) (DBUO); Biograd, 20.VIII.2014, S. Krčmar leg. (2♂) (DBUO); Krk Is., Punat, 1.VI.2017, S. Krčmar leg. (6♂) (DBUO); same locality, 7.VI.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Pag Is., Metajna (Baranov 1940, as *beckeri* Villeneuve); Pag Is.; Krk Is. (Baranov 1942, as *beckeri*); Premuda; Velika Paklenica; Zadar (Strukan 1964, 1970); Podgora (Povolný and Znojil 1994, 1998, 1999); Pape (2004).

European distribution: Bulgaria, Croatia, Czech Republic, France (mainland, Corsica), Greece (mainland), Italy (mainland, Sardinia, Sicily), Portugal (Madeira Is.), Malta, Spain (mainland, Canary Is.).

Remarks: This species was not listed for Bulgaria by Pape (2004), but has been known from the country at least since Drenski (1957).

116. *Sarcophaga* (*Liosarcophaga*) *tuberosa* Pandellé, 1896

New records: Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Vriještica, 3.VII.2015, S. Krčmar leg. (1♂) (DBUO).

Literature records: Kostrena (Langhoffer 1920); Baranov (1928); Krapina; Zagreb (Baranov 1942); Otočac, Metla (Rucner 1994).

European distribution: Austria, Belgium, Bulgaria, Croatia, Czech Republic, France (mainland, Corsica), Germany, Greece (mainland), Hungary, Italy (mainland, Sardinia), Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Switzerland, The Netherlands, Ukraine.

117. *Sarcophaga* (*Mehria*) *nemoralis* Kramer, 1908

New records: Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Plitvička jezera National Park, Turčić, 16.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD).

Literature records: Zagreb (Baranov 1942); Pape (2004).

European distribution: Austria, Bulgaria, Croatia, Czech Republic, Finland, Germany, Hungary, Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Sweden, Switzerland, The Netherlands, Ukraine.

118. *Sarcophaga* (*Mehria*) *sexpunctata* (Fabricius, 1805)

New records: Baške Oštarije, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD).

Literature records: Samobor; Stubičke Toplice; Zagreb (Baranov 1942, as *clathrata* Meigen); Pape (2004).

European distribution: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Finland, France (mainland), Germany, Greece (mainland), Hungary, Ireland, Italy (mainland), Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland, Canary Is.), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

119. *Sarcophaga* (*Mimarhopocnemis*) *granulata* Kramer, 1908

Literature records: Zagreb; Požega; Krapina (Baranov 1942); Bačinci (Strukan 1964); Pape (2004).

Distribution: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Finland, France (mainland), Germany, Hungary, Italy (mainland), Poland, Russia (Central European Territory), Slovakia, Spain (mainland), Ukraine.

120. *Sarcophaga* (*Myorhina*) *lunigera* Böttcher, 1914 (▲)

Records: Plitvička jezera National Park, Turčić, 16.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (3♂) (NHMD); Begovo Razdolje, nr Bijele Stijene, 18.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Učka Nature Park, Vela Učka, 19.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

European distribution: Austria, Bosnia and Herzegovina, Croatia, Czech Republic, France (mainland), Germany, Poland, Romania, Russia (South European Territory), Serbia, Slovakia, Switzerland, Ukraine.

121. *Sarcophaga* (*Myorhina*) *nigriventris* Meigen, 1826

New records: Sušanj Cesarički, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Plitvička jezera National Park, Turčić, 16.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (12♂) (NHMD); Zmajevac, 14.V.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Zadar (Strobl 1904); Bakar; Senj; Zagreb (Langhoffer 1920); Baranov (1928); Delnice; Otočac; Pag Is.; Samobor; Zagreb (Baranov 1942); Biokovo Mts (Povolný and Znojil 1998, 1999); Pape (2004).

European distribution: Albania, Andorra, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark (mainland), France (mainland, Corsica), Germany, Greece (mainland), Hungary, Ireland, Italy (mainland, Sardinia, Sicily), Malta, Poland, Romania, Russia (South European Territory), Serbia, Slovakia, Spain (mainland), Switzerland, The Netherlands, Ukraine, United Kingdom.

122. *Sarcophaga* (*Myorhina*) *pandifera* Blackith & Pape, 1999

Literature records: Sljeme (Baranov 1942, as *discifera* Pandellé); Pape (2004).

Distribution: Austria, Croatia, Czech Republic, France (mainland), Germany, Italy (mainland), Poland, Romania, Slovakia, Switzerland, Ukraine.

123. *Sarcophaga* (*Myorhina*) *socrus* Rondani, 1860

New records: Sveti Juraj, 12.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Sušanj Cesarički, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Krapina; Mrzla Vodica (Baranov 1942, as *rostrata* Pandellé); Otočac, Metla (Rucner 1994, as *rostrata*); Biokovo Mts; Podgora (Povolný and Znojil 1998, 1999); Pape (2004).

Distribution: Albania, Andorra, Austria, Bulgaria, Croatia, Czech Republic, Estonia, Finland, France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland, Sicily), Poland, Russia (Central European Territory, South European Territory), Slovakia, Switzerland, Ukraine.

124. *Sarcophaga* (*Myorhina*) *soror* Rondani, 1860

New records: Sušanj Cesarički, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Zmajevac, 30.IV.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Dubrovnik (Strobl 1900); Krapina; Otočac; Samobor; Zagreb; Sljeme (Baranov 1942); Biokovo Mts; Podgora (Povolný and Znojil 1998, 1999); Pape (2004).

European distribution: Austria, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, France (mainland), Germany, Hungary, Ireland, Italy (mainland, Sicily), Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland, Canary Is.), Sweden, Switzerland, Ukraine, United Kingdom.

125. *Sarcophaga* (*Pandelleana*) *protuberans* Pandellé, 1896

New records: Korčula, 22–27.V.1955, R.L. Coe leg. (3♂) (NHMUK); Sveti Juraj, 12.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Sušanj Cesarički, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD).

Literature records: Pag Is.; Sljeme; Zagreb (Baranov 1942); Biokovo Mts; Podgora (Povolný and Znojil 1998, 1999); Pape (2004).

European distribution: Austria, Bulgaria, Croatia, Czech Republic, France (mainland, Corsica), Germany, Hungary, Italy (mainland, Sicily), Moldova, Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Switzerland, The Netherlands, Ukraine.

126. *Sarcophaga* (*Pandelleisca*) *similis* Meade, 1876

New records: Komin, 16.VII.2014, S. Krčmar leg. (4♂) (DBUO); Badžula, 18.VII.2014, S. Krčmar leg. (2♂) (DBUO); Vid 17.VII.2014, S. Krčmar leg. (1♂) (DBUO); Desne, 17.VII.2014, S. Krčmar leg. (1♂) (DBUO); Modro Oko, 18.VII.2014, S. Krčmar leg. (1♂) (DBUO); Skrad, 11.VI.2016, S. Krčmar leg. (1♂) (DBUO); same locality, 31.V.2017, S. Krčmar leg. (4♂) (DBUO); Zmajevac, 25.VIII.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Klana (Langhoffer 1920); Baranov (1928); Zagreb (Baranov 1942); Zagreb, Maksimir (Strukan 1964, 1970); Oprić (Sisojević et al. 1989); Pape (2004).

European distribution: Albania, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Estonia, Finland, France (mainland, Corsica), Germany, Hungary, Italy (mainland), Latvia, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

127. *Sarcophaga* (*Parasarcophaga*) *albiceps* Meigen, 1826

New records: Novi Grad, 27–31.V.1958, R.L. Coe leg. (3♂) (NHMUK); Crikvenica, 5.VI.2014, S. Krčmar leg. (1♂) (DBUO); Zmajevac, 27.VI.2014, S. Krčmar leg. (2♂) (DBUO); same locality, 29.VI.2014, S. Krčmar leg. (4♂) (DBUO); same locality, 2.VII.2014, S. Krčmar leg. (2♂) (DBUO); same locality, 3.VII.2014, S. Krčmar leg. (3♂) (DBUO); same locality, 4.VII.2014, S. Krčmar leg. (16♂) (DBUO); same locality, 26.VIII.2014, S. Krčmar leg. (1♂) (DBUO); same locality, 15.VII.2015, S. Krčmar leg. (9♂) (DBUO); same locality, 9.VIII.2016, S. Krčmar leg. (2♂) (DBUO); same locality, 18.VII.2017, S. Krčmar leg. (1♂) (DBUO); same locality, 26.VII.2017, S. Krčmar leg. (1♂) (DBUO); same locality, 10.VIII.2017, S. Krčmar leg. (2♂) (DBUO); same locality, 25.VIII.2017, S. Krčmar leg. (3♂) (DBUO); same locality,

11.IX.2017, S. Krčmar leg. (6♂) (DBUO); Desne, 17.VII.2014, S. Krčmar leg. (6♂) (DBUO); same locality, 17.VII.2015, S. Krčmar leg. (1♂) (DBUO); Modro Oko, 18.VII.2014, S. Krčmar leg. (2♂) (DBUO); Biograd, 19.VIII.2014, S. Krčmar leg. (4♂) (DBUO); Skrad, 8.VI.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Rijeka (Strobl 1893); Dubrovnik (Strobl 1900, as *privigna* Rondani); Delnice; Lokve (Langhoffer 1920); Baranov (1928); Delnice; Krapina; Zagreb (Baranov 1942); Trogir; Premuda; Velika Paklenica; Zadar (Strukan 1970); Oprić; Vozilići (Sisojević et al. 1989); Našice, Prkos; Samoborsko gorje, Čudomerščak; Ston, Česvinica (Rucner 1994); Podgora (Povolný and Znojil 1994, 1998, 1999); Pape (2004).

European distribution: Albania, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Finland, France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland, Sicily), Latvia, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, North European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

128. *Sarcophaga* (*Phytosarcophaga*) *destructor* Malloch, 1929

Literature records: Trogir (Strukan 1964, 1968, as *destructrix* Malloch).

European distribution: Croatia, Cyprus, France (mainland), Greece (mainland), Italy (mainland), Spain (mainland).

129. *Sarcophaga* (*Robineauella*) *caerulescens* Zetterstedt, 1838

New records: Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Sunger, 6.VI.2014, S. Krčmar leg. (1♂) (DBUO); Zmajevac, 4.VII.2014, S. Krčmar leg. (1♂) (DBUO).

Literature records: Samobor; Skrad; Stubičke Toplice; Zagreb (Baranov 1942, as *scoparia* Pandellé); Samoborsko gorje, Čudomerščak (Rucner 1994, as *scoparia*); Pape (2004).

European distribution: Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland), Germany, Hungary, Italy (mainland, Sicily), Latvia, Norway (mainland), Poland, Romania, Russia (Central European Territory, North European Territory, South European Territory), Slovakia, Spain (mainland), Sweden, Switzerland, Ukraine, United Kingdom.

130. *Sarcophaga* (*Rosellea*) *aratrix* Pandellé, 1896

New records: Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Sunger, 6.VI.2014, S. Krčmar leg. (2♂) (DBUO); same locality, 14.VI.2016, S. Krčmar leg. (1♂) (DBUO); Zmajevac, 27.VI.2014, S. Krčmar leg. (1♂) (DBUO);

same locality, 2.VII.2014, S. Krčmar leg. (1♂) (DBUO); same locality, 4.VII.2014, S. Krčmar leg. (1♂) (DBUO); same locality, 30.IV.2017, S. Krčmar leg. (1♂) (DBUO); same locality, 14.V.2017, S. Krčmar leg. (2♂) (DBUO); Modro oko, 18.VII.2014, S. Krčmar leg. (2♂) (DBUO); Skrad, 11.VI.2016, S. Krčmar leg. (3♂) (DBUO); same locality, 31.V.2017, S. Krčmar, leg. (3♂) (DBUO); Kamenac, 23.VII.2016, S. Krčmar leg. (1♂) (DBUO); Krk Is., Punat, 1.VI.2017, S. Krčmar leg. (5♂) (DBUO).

Literature records: Crikvenica; Zagreb (Langhoffer 1920); Baranov (1928); Krapina; Mraclin; Zagreb (Baranov 1942); Kuzmin (Strukan 1964, 1970); Oprić; Vozilići (Sisojević et al. 1989); Vinica; Petrova gora, Brđani; Livade; Otočac, Šumečica; Otočac, Metla (Rucner 1994); Pape (2004).

European distribution: Albania, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland, Corsica), Germany, Hungary, Ireland, Italy (mainland, Sicily), Latvia, Lithuania, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

131. *Sarcophaga* (*Sarcophaga*) *adriatica* Böttcher, 1913

New records: Sveti Juraj, 12.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (5♂) (NHMD); Tribanj-Kruščica, 14.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (3♂) (NHMD).

Literature records: Dalmatia; Istria (Böttcher 1913, as *vicina* var. *adriatica*); Pag Is. (Baranov 1942); Premuda (Strukan 1964, 1967); Pape (1996); Krk Is. (Povolný and Znojil 1998); Pape (2004).

Distribution: Croatia, Serbia.

132. *Sarcophaga* (*Sarcophaga*) *baranoffi* Rohdendorf, 1937

New records: Samobor, 25.V.1930, N. Baranov leg. (2♂) (ZMHB); Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Krk Is., Punat, 4.VI.2014, S. Krčmar leg. (1♂) (DBUO); Drivenik, 5.VI.2014, S. Krčmar leg. (1♂) (DBUO); Bjelolasica Mts, 2.VI.2015, S. Krčmar leg. (3♂) (DBUO); Kamenac, 23.VII.2016, S. Krčmar leg. (1♂) (DBUO); Zmajevac, 9.VIII.2016, S. Krčmar leg. (1♂) (DBUO); same locality, 28.VIII.2016, S. Krčmar leg. (2♂) (DBUO); same locality, 30.IX.2016, S. Krčmar leg. (1♂) (DBUO); same locality, 30.IV.2017, S. Krčmar leg. (2♂) (DBUO); same locality, 14.V.2017, S. Krčmar leg. (2♂) (DBUO); same locality, 18.VII.2017, S. Krčmar leg. (1♂) (DBUO); same locality, 24.VII.2017, S. Krčmar leg. (2♂) (DBUO); same locality, 25.VIII.2017, S. Krčmar leg. (1♂) (DBUO); same locality, 11.IX.2017, S. Krčmar leg. (1♂) (DBUO); Skrad, 8.VI.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Zagreb, Samobor (Rohdendorf 1937, as *subvicina* ssp. *baranoffi*); Delnice; Klek; Zagreb, Podsused; Požega; Samobor; Zagreb (Baranov 1942); Oprić (Sisojević et al. 1989); Pape (1996, 2004).

Distribution: Bulgaria, Croatia, Italy (mainland), Serbia, Slovenia.

133. *Sarcophaga* (*Sarcophaga*) cf. *bergi* Rohdendorf, 1937

New records: Plitvička jezera National Park, Turčić, 16.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

European distribution: Bulgaria, Croatia, Ukraine.

Remarks: The single male of this species examined from Croatia is morphologically very similar to *S. bergi*, but differs in certain features of the distiphallus and in the shape of the cercus in lateral view. It may belong to a different species, but more material and more detailed studies are needed to confirm this.

134. *Sarcophaga* (*Sarcophaga*) *carnaria* (Linnaeus, 1758)

Literature records: Dubrovnik (Strobl 1900); Hvar; Zadar (Strobl 1904); Baranov (1928); Samobor (Baranov 1941b, 1942, as *subvicina* ssp. *vulgaris* Rohdendorf); Premuda; Zagreb, Maksimir (Strukan 1964); Pape (2004).

European distribution: Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland), Germany, Hungary, Ireland, Italy (mainland), Luxemburg, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, North European Territory, South European Territory), Slovakia, Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

135. *Sarcophaga* (*Sarcophaga*) *croatica* Baranov, 1941

New records: Novi Grad, 27–31.V.1958, R.L. Coe leg. (1♂) (NHMUK); Rudelić Draga, 14.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Sunger, 4.VI.2014, S. Krčmar leg. (2♂) (DBUO); same locality, 6.VI.2014, S. Krčmar leg. (5♂) (DBUO); same locality, 10.VI.2016, S. Krčmar leg. (1♂) (DBUO); same locality, 14.VI.2016, S. Krčmar leg. (2♂) (DBUO); Skrad, 1.VI.2015, S. Krčmar leg. (1♂) (DBUO); same locality, 31.V.2017, S. Krčmar leg. (10♂) (DBUO); same locality, 8.VI.2017, S. Krčmar leg. (6♂) (DBUO); Krk Is., 3.VI.2015, S. Krčmar leg. (1♂) (DBUO); Lokve, 2.VI.2017, S. Krčmar leg. (1♂) (DBUO); Zmajevac, 15.VII.2015, S. Krčmar leg. (1♂) (DBUO); same locality, 29.V.2016, S. Krčmar leg. (5♂) (DBUO); same locality, 9.VI.2016, S. Krčmar leg. (1♂) (DBUO); same locality, 9.VIII.2016, S. Krčmar leg. (11♂) (DBUO); same locality, 28.VIII.2016, S. Krčmar leg. (4♂)

(DBUO); same locality, 30.IX.2016, S. Krčmar leg. (8♂) (DBUO); same locality, 30.IV.2017, S. Krčmar leg. (6♂) (DBUO); same locality, 14.V.2017, S. Krčmar leg. (14♂) (DBUO); same locality, 18.VII.2017, S. Krčmar leg. (24♂) (DBUO); same locality, 24.VII.2017, S. Krčmar leg. (18♂) (DBUO); same locality, 26.VII.2017, S. Krčmar leg. (17♂) (DBUO); same locality, 10.VIII.2017, S. Krčmar leg. (33♂) (DBUO); same locality, 11.IX.2017, S. Krčmar leg. (21♂) (DBUO); Krk Is., Punat, 13.VI.2016, S. Krčmar leg. (1♂) (DBUO); same locality, 1.VI.2017, S. Krčmar leg. (2♂) (DBUO); Kamenac, 23.VII.2016, S. Krčmar leg. (1♂) (DBUO); Čigoč, 5.VI.2017, S. Krčmar leg. (15♂) (DBUO); Orahovica, 4.VII.2017, S. Krčmar leg. (15♂) (DBUO); Slatinski Drenovac, 17.VIII.2017, S. Krčmar leg. (4♂) (DBUO).

Literature records: Zagreb; Samobor; Kaštel Sućurac; Pag Is. (Baranov 1941b, 1942, as *subvicina* ssp. *croatica* and *subvicina* ssp. *novaki* Baranov); Pape (2004).

Distribution: Croatia, Italy (mainland, Sicily).

Remarks: This species, which was the most abundant flesh fly in recent Croatian samples, is common and widespread also in Italy where it had previously been confused with the closely related *S. variegata* (Scopoli, 1763) (Whitmore et al., unpubl. data). We here formally record this species from Italy for the first time (238♂ from Liguria, Lombardy, Umbria, Lazio, Abruzzo, Campania, Basilicata, Calabria and Sicily, 1995–2015, DW and Museo di Zoologia, Sapienza Università di Roma). Records of *Sarcophaga variegata* from Sardinia (see Whitmore 2009a) may possibly also refer to *S. croatica*. Literature records of "*S. croatica*" from Corsica (e.g., Jordaens et al. 2013) refer to the Corsican endemic *S. matilei* Blackith, Richet, Pape and Andrei-Ruiz, 2001. Based on our recent examination of the holotype male of *Sarcophaga subvicina* ssp. *croatica* Baranov, 1941 (NMNH) and of photographs of the holotype male of *Sarcophaga subvicina* ssp. *novaki* Baranov, 1941 (NMNH), we propose *Sarcophaga subvicina* ssp. *novaki* Baranov, 1941 as a junior synonym of *Sarcophaga* (*Sarcophaga*) *croatica* Baranov, 1941, syn. nov. This synonymy means that *S.* (*S.*) *hennigi* Lehrer, 1978 has not been recorded from Croatia. The previous listings of "*hennigi*" or "*novaki*" from Croatia by Verves (1986), Povolný (1996), Povolný and Verves (1997), Pape (1996, 2004) and Verves and Khrokalo (2014) were based on the erroneous synonymy with *S. novaki* proposed by Povolný and Verves (1987).

136. *Sarcophaga* (*Sarcophaga*) *lehmanni* Müller, 1922

New records: Zmajevac, 2.VII.2014, S. Krčmar leg. (3♂) (DBUO); same locality, 4.VII.2014, S. Krčmar leg. (7♂) (DBUO); same locality, 26.VIII.2014, S. Krčmar leg. (1♂) (DBUO); same locality, 15.VII.2015, S. Krčmar leg. (4♂) (DBUO); same locality, 29.V.2016, S. Krčmar leg. (3♂) (DBUO); same locality, 9.VIII.2016, S. Krčmar leg. (5♂) (DBUO); same locality, 28.VIII.2016, S. Krčmar leg. (5♂) (DBUO); same locality, 30.IX.2016, S. Krčmar leg. (3♂) (DBUO); same locality, 30.IV.2017, S. Krčmar leg. (2♂) (DBUO); same locality, 14.V.2017, S. Krčmar leg. (13♂) (DBUO); same locality, 18.VII.2017, S. Krčmar leg. (1♂) (DBUO); same locality, 24.VII.2017,

S. Krčmar leg. (7♂) (DBUO); same locality, 26.VII.2017, S. Krčmar leg. (24♂) (DBUO); same locality, 10.VIII.2017, S. Krčmar leg. (7♂) (DBUO); same locality, 25.VIII.2017, S. Krčmar leg. (4♂) (DBUO); same locality, 11.IX.2017, S. Krčmar leg. (1♂) (DBUO); Komin, 16.VII.2014, S. Krčmar leg. (3♂) (DBUO); same locality, 16.VII.2015, S. Krčmar leg. (1♂) (DBUO); Blace, 17.VII.2014, S. Krčmar leg. (1♂) (DBUO); Desne, 17.VII.2014, S. Krčmar leg. (2♂) (DBUO); Badžula, 18.VII.2014, S. Krčmar leg. (2♂) (DBUO); Modro Oko, 17.VII.2014, S. Krčmar leg. (1♂) (DBUO); same locality, 18.VII.2014, S. Krčmar leg. (2♂) (DBUO); Vid, 17.VII.2014, S. Krčmar leg. (1♂) (DBUO); Čigoč, 10.VI.2016, S. Krčmar leg. (9♂) (DBUO); same locality, 5.VI.2017, S. Krčmar leg. (15♂) (DBUO); Sunger, 6.VI.2014, S. Krčmar leg. (2♂) (DBUO); same locality, 10.VI.2016, S. Krčmar leg. (1♂) (DBUO); same locality, 14.VI.2016, S. Krčmar leg. (2♂) (DBUO); Krk Is., Punat, 13.VI.2016, S. Krčmar leg. (1♂) (DBUO); same locality, 1.VI.2017, S. Krčmar leg. (17♂) (DBUO); same locality, 7.VI.2017, S. Krčmar leg. (6♂) (DBUO); Kamenac, 23.VII.2016, S. Krčmar leg. (7♂) (DBUO); Skrad, 8.VI.2017, S. Krčmar leg. (1♂) (DBUO); Orahovica, 4.VII.2017, S. Krčmar leg. (6♂) (DBUO); Slatinski Drenovac, 17.VIII.2017, S. Krčmar leg. (2♂) (DBUO).

Literature records: Baranov (1942, as *carnaria* ssp. *meridionalis* Rohdendorf); Bačinci; Premuda; Zagreb, Maksimir (Strukan 1964, as *carnaria* ssp. *meridionalis*); Vozilići (Sisojević et al. 1989); Biokovo Mts (Povolný and Znojil 1998, as *lasiostyla* Macquart, misidentification).

European distribution: Albania, Andorra, Austria, Belarus, Belgium, Bulgaria, Cyprus, Croatia, Czech Republic, Denmark (mainland), Estonia, France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland, Sardinia, Sicily), Latvia, Lithuania, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine.

137. *Sarcophaga* (*Sarcophaga*) *moldavica* Rohdendorf, 1937

Literature records: Pape (1996); Povolný and Verves (1997); Pape (2004).

Distribution: Croatia, Czech Republic, Hungary, Moldova, Poland, Romania, Slovakia, Ukraine.

138. *Sarcophaga* (*Sarcophaga*) *pagensis* Baranov, 1939

New records: Sveti Juraj, 12.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD); Rudelić Draga, 14.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (1♂) (NHMD).

Literature records: Pag Is. (Baranov 1939, 1942); Podgora (Povolný and Znojil 1994, 1998, 1999); Pape (1996); Biokovo Mts (Povolný and Znojil 1999); Pape (2004).

Distribution: Croatia, France (mainland), Greece (mainland).

139. *Sarcophaga* (*Sarcophaga*) *serbica* Baranov, 1929

Literature records: Povolný and Verves (1997).

Distribution: Bulgaria, Croatia, Hungary, Romania, Russia (Central European Territory), Serbia, Slovakia, Ukraine.

140. *Sarcophaga* (*Sarcophaga*) *subvicina* Rohdendorf, 1937

Literature records: Baranov (1930, as *vicina* Villeneuve); Krapina (Baranov 1942); Krndija, Londžica; Učka, Planik (Rucner 1994).

European distribution: Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland, Corsica), Germany, Hungary, Ireland, Italy (mainland, Sicily), Latvia, Moldova, Poland, Romania, Russia (Central European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

141. *Sarcophaga* (*Sarcophaga*) *ukrainica* Rohdendorf, 1937

Literature records: Verves and Khrokalo (2014).

Distribution: Croatia, Hungary, Romania, Slovakia, Ukraine.

142. *Sarcophaga* (*Sarcophaga*) *variegata* (Scopoli, 1763)

New records: Brušane, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Plitvička jezera National Park, Turčić, 16.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Sušanj Cesarički, 13.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (3♂) (NHMD); Podoštra, 15.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (3♂) (NHMD).

Literature records: Pape (1996); Vozilići (Sisojević et al. 1989); Pape (2004).

European distribution: Albania, Andorra, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland), Latvia, Lithuania, Luxemburg, Moldova, Norway (mainland), Poland, Portugal (mainland), Romania, Russia (Central European Territory, North European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

143. *Sarcophaga* (*Sarcophaga*) *zumptiana* Lehrer, 1959

Literature records: Krapina (Baranov 1942, as *subvicina* ssp. *rohdendorfi* Baranov); Pape (1996, 2004).

Distribution: Austria, Bosnia and Herzegovina, Croatia, Czech Republic, France (mainland), Hungary, Romania, Serbia, Slovakia, Ukraine.

144. *Sarcophaga* (*Sarcotachinella*) *sinuata* Meigen, 1826

New Records: Čigoč, 10.VI.2016, S. Krčmar leg. (2♂) (DBUO); Zmajevac, 15.VII.2015, S. Krčmar leg. (2♂) (DBUO); same locality, 25.VIII.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Zagreb (Langhoffer 1920); Baranov (1928); Krapina; Mraclin; Zagreb (Baranov 1942).

European distribution: Albania, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, France (mainland), Germany, Hungary, Ireland, Italy (mainland), Latvia, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, North European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Sweden, The Netherlands, Ukraine, United Kingdom.

145. *Sarcophaga* (*Stackelbergeola*) *mehadiensis* Böttcher, 1912 (▲)

Records: Rudelić Draga, 14.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD).

European distribution: Croatia, Czech Republic, France (mainland), Greece (mainland), Romania.

146. *Sarcophaga* (*Thyrsocnema*) *incisilobata* Pandellé, 1896

New records: Korčula, 22–27.V.1955, R.L. Coe leg. (3♂) (NHMUK); Plitvice, 4–10.VII.1955, R.L. Coe leg. (1♂) (NHMUK); Sveti Juraj, 12.VI.2012, E. Buenaventura, T. Pape, D. Whitmore leg. (2♂) (NHMD); Zmajevac, 4.VII.2014, S. Krčmar leg. (2♂) (DBUO); same locality, 15.VII.2015, S. Krčmar leg. (4♂) (DBUO); same locality, 14.V.2017, S. Krčmar leg. (1♂) (DBUO); same locality, 24.VII.2017, S. Krčmar leg. (1♂) (DBUO); Podrujnica, 18.VII.2014, S. Krčmar leg. (2♂) (DBUO); Biograd, 18.VIII.2014, S. Krčmar leg. (2♂) (DBUO); Krk Is., Punat, 1.VI.2017, S. Krčmar leg. (3♂) (DBUO); Skrad, 8.VI.2017, S. Krčmar leg. (1♂) (DBUO).

Literature records: Pag Is.; Samobor; Zagreb (Baranov 1942); Oprić (Sisojević et al. 1989); Metković, Šibanica; Samoborsko gorje, Palačnik; Otočac, Metla; Baške Oštarije, Velika Basača; Baške Oštarije, Filipov Kuk; Posedarje (Rucner 1994); Podgora (Povolný and Znojil 1994, 1998, 1999); Pape (2004).

European distribution: Albania, Andorra, Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (mainland), Estonia, Finland, France (mainland),

Germany, Greece (mainland), Hungary, Ireland, Italy (mainland), Lithuania, Moldova, Norway (mainland), Poland, Romania, Russia (Central European Territory, South European Territory), Serbia, Slovakia, Spain (mainland), Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom.

Remarks: Records of the occurrence of *Sarcophaga incisilobata* in Sicily (e.g., Pape et al. 1995; Povolný 1999) refer to an undescribed species that also occurs in southern mainland Italy (Whitmore et al., unpubl. data).

147. *Sarcophaga* (*Thyrsocnema*) *platariae* (Povolný, 1992)

New records: Komin, 16.VII.2014, S. Krčmar leg. (1♂) (DBUO).

Literature records: Pape (2004).

European distribution: Croatia, Greece (mainland).

Remarks: Povolný (1992) described *Thyrsocnema platariae* from a single male collected in Greece. He tentatively placed it in *Thyrsocnema* Enderlein based on the shape of the cercus and sternite 5, whereas Pape (1996: 418) later listed it as *incertae sedis* within *Sarcophaga*. A new genus was created by Lehrer (2000) for *Golania israeliana* Lehrer, 2000. This species was synonymised with *Thyrsocnema platariae* by Pape (2004), who placed it in *Sarcophaga*, subgenus *Golania* Lehrer. Based on our study of recent material from Croatia (above) and Greece, we agree with Povolný's original placement in *Thyrsocnema* and propose *Golania* Lehrer, 2000 as a junior synonym of *Thyrsocnema* Enderlein, 1928, syn. nov., at the subgeneric rank.

148. *Sarcophaga* (*Varirosellea*) *uliginosa* Kramer, 1908

Literature records: Oprić (Sisojević et al. 1989); Pape (2004).

European distribution: Albania, Austria, Belarus, Bulgaria, Croatia, Czech Republic, Denmark (mainland), France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland, Sardinia), Moldova, Poland, Romania, Russia (Central European Territory, South European Territory), Slovakia, Spain (mainland), United Kingdom.

Discussion

Twenty-five species of Sarcophagidae are newly recorded from Croatia as part of this study. Most of these are widely distributed in Europe, which shows that the flesh fly fauna of Croatia is still superficially known. Twenty of them were collected from single localities only. *Sarcophaga* (*Sarcophaga*) *croatica* was the most abundant species in this study and was most common in the Pannonian-Peripannonian region. It was collected in a variety of habitats, from forest edges and grassland to river and lake banks

and the seashore in the Mediterranean region. *Sarcophaga* (*Sarcophaga*) *lehmanni* was the second most abundant species and was mainly collected in wet grasslands, forest edges and open habitats (grasslands, agricultural land), showing broad habitat preferences. Similar habitat preferences were observed for *S.* (*S.*) *lehmanni* in Poland (Draber-Mońko 1998; Szpila 1999; Szpila et al. 2015). *Sarcophaga* (*Parasarcophaga*) *albiceps* was the third most numerous species and was mostly collected in grasslands around ponds in the locality of Zmajevac in the Pannonian-Peripannonian region and near freshwater lakes in the Mediterranean region. This confirms a preference for open habitats, as this species was also one of the most abundant species in grasslands in Poland (Szpila et al. 2015). Sixteen of the newly-recorded species, *Amobia pelopei*, *Craticulina tabaniformis*, *Macronychia striginervis*, *Metopia campestris*, *Miltogramma iberica*, *M. punctata*, *Oebalia cylindrica*, *Phylloteles pictipennis*, *Senotainia conica*, *Taxigramma hilarella*, *T. stictica*, *Blaesoxipha* (*Blaesoxipha*) *plumicornis*, *S.* (*Heteronychia*) *amita*, *S.* (*H.*) *ancilla*, *S.* (*H.*) *pseudobenaci*, and *S.* (*Myorhina*) *lunigera*, were already known from the neighbouring Bosnia and Herzegovina, Hungary or Serbia (Pape 1996, 2004). Besides being a new country record, that of *S.* (*Helicophagella*) *okaliana* is also just the second record from Southeast Europe. Of the 105 species examined during this study, the following have a limited area of distribution: *Sphenometopa variegata*, *B.* (*Blaesoxipha*) *aurulenta*, *S.* (*H.*) *croca*, *S.* (*H.*) *giganta*, *S.* (*S.*) *adriatica*, *S.* (*S.*) *croatica*, *S.* (*S.*) *pagensis* and *S.* (*Thyrsocnema*) *platariae.* Until now, these eight species have been recorded in one to three European countries only, and four of them were described based on specimens collected in Croatia (Baranov 1939, 1941b; Povolný 1987; Pape 1996). The other species recorded in this study are widely distributed throughout Europe and beyond (Pape 1996, 2004). The 57 species recorded by Baranov (1928, 1929, 1930, 1931, 1938, 1939, 1940, 1941a, 1941b, 1942, 1943) and the 18 species recorded by Strukan (1964, 1967, 1968, 1970) were confirmed in this study. Our recent identifications and examination of the literature have enabled us to update the checklist of Croatian flesh flies to 148 species (including two left unnamed). The several new country records indicate that further studies of the flesh fly fauna of Croatia are necessary.

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