

Paropeas achatinaceum (Pfeiffer, 1846) and other alien subulinine and opeatine land snails in European greenhouses (Gastropoda, Achatinidae)

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INTRODUCTION

Biological invasions are one of the greatest environmental and economic threats, often responsible for biodiversity loss and local extinctions (Canning-Clode, 2015). There are many pathways for alien species introductions, and these differ among taxonomic groups. Land snails are often introduced unintentionally, for instance in soil, with plant material, attached to vehicles, and shipped in containers. Due to the enormous diversity of land snails (> 35,000 species worldwide; Barker, 2001), local biologists cannot be expected to be familiar with land snail species from other parts of the world and there is often limited information on the indigenous local snail fauna. Thus many alien species may remain undetected and/or erroneously identified for a long time (e.g. Naggs, 2004; Naggs & Raheem, 2005), even though they may pose severe economic and environmental threats (Pimentel et al., 2000). Many alien land snail species have been reported from greenhouses (e.g. Flasar & Kroupová, 1976; Leiss & Reischütz, 1996; Albrecht & Meng, 1997; Horsák et al., 2004; Cameron, 2016). Species of the family Achatinidae, subfamilies Subulininae and Opeatinae (previously included in the Subulinidae), are commonly reported from European greenhouses where they often reach high densities. The groups have a primarily tropical cosmopolitan distribution with over 1300 described species (Naggs, 1994). Four of these species are commonly reported and illustrated from greenhouses across Europe (e.g. Kerney et al., 1983; Anderson, 2005; von Proschwitz, 2005; Kobiálka et al., 2006; Olenin & Didziulis, 2009; Horsák et al., 2013; Naggs et al., 2015; Horsák et al., 2019). These are: (i) *Opeas hannense* (Rang, 1831) [= *Opeas goodallii* (Miller, 1822) = *Opeas pumilum* (Pfeiffer, 1840)], (ii) *Allopeas clavulinum* (Potiez & Michaud, 1838) [see Kadolsky (2012) for the explanation to keep 1838, instead of 1835, as the publication year], (iii) *Subulina octona* (Bruguière, 1789), and (iv) *Subulina striatella* (Rang, 1831) [= *Striosubulina striatella* (Rang, 1831) as suggested by MolluscaBase, although Raheem et al. (2014: 117) point out that the reproductive anatomy of *S. octona* closely resembles that of *S. striatella*, thus implicitly questioning the genus level distinction between these two species]. A fifth species, *Allopeas gracile* (Hutton, 1834), has been reported from Europe, too, though only rarely and without any photographic documentation (but see Naggs et al., 2015).

We here report on a viable colony of another subulinine species, non-native in Europe, *Paropeas achatinaceum* (Pfeiffer, 1846) [= *Allopeas javanicum* (Reeve, 1849), also placed in

Prosopeas or *Lamellaxis*], that has been discovered in Austria. Because several species of Subulininae and Opeatinae have been recognized as successful invaders in many parts of the world (Pilsbry, 1946; Cowie, 1997; Robinson & Slapcinsky, 2005), it is important to report any introductions into a new continent, as recorded here. This information is also essential for updating and revising the “EASIN - European Alien Species Information Network” database (<https://easin.jrc.ec.europa.eu/easin>) (Katsanevakis et al., 2012) and its older relatives, “NOBANIS - North European and Baltic Network for Invasive species” (<https://www.nobanis.org/>) and “DAISIE – Delivering Alien Invasive Species Inventories for Europe” (Olenin & Didziulis, 2009). We provide notes on how to distinguish the above-mentioned six species that have been recorded recently from Europe, along with photographs of their shells. We also review published records of all other alien Subulininae hitherto reported from Europe. Because the taxonomy and nomenclature of the Subulininae remain a source of considerable confusion and disagreement, we provide nomenclatural comments when appropriate.

RESULTS AND DISCUSSION

Paropeas achatinaceum was recorded in Vienna zoo (Tiergarten Schönbrunn) on 27 February 2016 (M. Horsák leg.), 11 live specimens were collected from a large population in the rainforest pavilion (48°10'52.5"N, 16°18'21.7"E) along with *Subulina octona*. *Paropeas achatinaceum* has a high-turreted, yellowish to brownish shell (Fig. 1a, b), in general reaching up to 15 mm in height and 5 mm in width (Cowie et al., 2017). Adult shells have a soft silky or waxy lustre, hardly or not transparent, with a distinct vertical striation, which in fresh specimens appear as thread-like ribs. Full-grown shells have up to 8-9 whorls, the last whorl occupying about 1/3 of the shell length. While the native area of this species is unclear (even if its type locality is in Java), it is widely distributed and common in disturbed habitats around the Indo-Pacific region (Fig. 2; Naggs, 1994). It was established in the Hawaiian Islands prior to 1904 (Cowie, 1997); additional early Pacific records were provided by Brook (2010). It was first detected in Florida in 2001, where it probably arrived on plant material imported from tropical regions. Subsequently, in 2002-2003, several well-established populations were discovered, mostly associated with horticultural plants (Robinson & Slapcinsky, 2005), representing the first penetration inland on any major landmass. The species reproductive anatomy was described in detail by Naggs (1994).

Paropeas achatinaceum has been confused with *A. clavulinum*, but the shell of the latter is far more glossy and, when fresh, far more transparent (Fig. 1b, d; see also Naggs, 1994). Moreover, *A. clavulinum* has almost no shell sculpture, whereas *P. achatinaceum* shows distinct vertical striations. *Paropeas achatinaceum* can also be confused with *A. gracile* but differs in having a less lanceolate, i.e. more turreted, shell shape with a notably higher body whorl and a more distinct striation (Fig. 1b, c). *Paropeas achatinaceum* grows much larger than *O. hannense* and has a less regular striation. In fact, *O. hannense* can be easily distinguished from the other species dealt with here by the backward curve of the edge of the aperture where it joins the suture (indicated at Fig. 1e by an arrow; compare with Fig. 1c). Both *S. octona* and *S. striatella* grow much larger, and their apices are much larger and more bulbous than in the other species (Fig. 1f, g). However, this size difference can be deceiving as both reach sexual maturity, and start reproducing before reaching two thirds or less of their full shell length (Pilsbry, 1946; D'ávila et al., 2018).

Given the great species diversity of the Subulininae and the ease by which many of these species are transported via commerce, more species may be expected to reach Europe. In fact, at least five other nominal species, additional to the six mentioned above, have been reported from greenhouses in Europe. These are briefly discussed in the next paragraphs. We also summarize all European records of *A. gracile* because in Europe this species is known from only a few records. This

is in contrast to the remaining five subulinines and opeatines that are well established and common in European greenhouses.

Allopeas gracile (Hutton, 1834) was described from India, but Neck (1976) and Auffenberg & Stange (1988) suggested that its origin is South America. However, later archaeological and palaeontological evidence suggested its origin in the Old World tropics (Christensen & Weisler, 2013). It has been introduced widely across tropical and subtropical areas of Asia, Australia, Polynesia, Central and South America, including many islands in the Caribbean region, and much of southeastern USA (e.g. Dundee, 1971; Cowie, 1997; Neubert, 1998; Robinson, 1999; Boyko & Cordeiro, 2001; Capinera, 2017). However, surprisingly, only a few records have been published from Europe. It seems that the first record ever made in Europe was by L. Dawes in 1917 in England (Headington Hill gardens, Oxford). Eleven empty shells are deposited in the NHM J. W. Taylor Collection (Accession number 2130). Originally identified as *Opeas goodallii* (Miller) they were subsequently identified as *A. gracile* by Naggs (1990a). The first published record was made in Germany (Botanischen Garten Berlin-Dahlem) by Jaeckel & Plate (1967). This record was also cited by Kerney et al. (1983) and probably was the basis for including *A. gracile* (as *Lamellaxis gracilis*) in the DAISIE list of alien species in Europe (Olenin & Didziulis, 2009). Subsequently, more records were published in the early 2010s from several places in Austria (Reischütz, 2012; Reischütz et al., 2012; 2018) and England (Preece & White, 2012). Da Sois (2015) reported in his undergraduate thesis a record of *Lamellaxis* cf. *gracilis* (Hutton, 1834) from one of the greenhouses of the *Hortus botanicus* in Leiden (the Netherlands). Two European records of *A. gracile* reported on the Discover Life map (Discover Life, 2019a) were wrongly attributed as they were from overseas territories, i.e. Bermuda for England, and the Loyalty Islands of New Caledonia for France (confirmed by John Slapcinsky in litt. 18 October 2019). It appears that the species is spreading in Europe, although the extent to which it may have been overlooked and/or misidentified in the past is unknown. In addition, *A. gracile* (Hutton, 1834) may be a species complex (e.g. Gittenberger & Van Bruggen, 2013), whose taxonomy may be further complicated by the fact that some subulinines can reproduce uniparentally (e.g. Schmidt, 1959; Marcus & Marcus, 1968; de Almeida Bessa & de Barros Araújo, 1995; de Almeida & de Almeida Bessa, 2001; Pilate et al., 2013), including *A. gracile* (e.g. Biswas et al., 1976; Subba Rao et al., 1980; Capinera, 2017). Therefore some populations may consist of clones or homozygous strains, for which the biological species concept may be difficult to apply (e.g. Prévot et al., 2013).

Allopeas mauritianum (Pfeiffer, 1853), a species described from the island of Mauritius, was reported from several greenhouses in the Netherlands (Meeuse & Hubert, 1949), the botanical gardens in Belfast, UK (Meeuse & Hubert, 1949), the “pálmház” (palmhouse) in the zoo of Budapest, Hungary (Pintér & Suara, 2004), and the greenhouses of both the Botanischer Garten in Rostock and the Palmengarten in Frankfurt am Main, Germany (Plate & Frömmling, 1953a, b; Schmidt, 1959). Although, the taxonomic status of *A. mauritianum* is very confused, some authors have treated it, or at least listed it, as a separate species (e.g. Baker, 1945; Cowie, 1997; Burke 2013). Others suggest placing it in the synonymy of *A. clavulinum* (e.g. Griffiths & Florens, 2006) or actually do so either for *A. mauritianum* overall (e.g. von Proschwitz, 1994; using the erroneous spellings “*mauritanum*” and “*mauritanus*”) or for *A. mauritianum* auct. non Pfeiffer, 1853 more specifically (e.g. Kerney et al., 1983; Waldén, 1985; Leiss & Reischütz, 1996) [but see Gittenberger & Van Bruggen (2013) regarding this synonymy]. Even the publication year of the original description of Pfeiffer’s *Bulimus mauritianus* is a source of confusion since the literature mentions 1847 (e.g. Griffiths & Florens, 2006), 1852 (e.g. Burke, 2013), 1853 (e.g. MolluscaBase), and 1854 (e.g. Cowie, 1997). We follow MolluscaBase in using 1853 as publication year since Pfeiffer’s “original” description of *B. mauritianus* in the Proceedings of the Zoological Society of London, 1852, Part XX, p. 150, was effectively only published in 1854 (Waterhouse in Duncan, 1937), i.e. one year after Pfeiffer’s “subsequent” description of this species in the Systematisches Conchylien-Cabinet von Martini und Chemnitz, 1(13) p. 86 no. 99, in

1853 (Coan & Kabat, 2015). We also follow MolluscaBase in regarding *A. mauritanum* (Pfeiffer, 1853) as a junior synonym of *A. clavulinum* (Potiez & Michaud, 1838), since the three syntypes of *Bulimus mauritanus* Pfeiffer, 1853 are identical to *A. clavulinum* (Budha et al., 2015; but with erroneous reference to one, instead of three syntypes, see Naggs, 1990b).

Leptinaria unilamellata (d'Orbigny, 1838), native to tropical South America, was recently observed in the rainforest house of the science center Universeum, Göteborg, Sweden, where it is now extinct after having survived from 2004 to 2014 (von Proschwitz, 2016). The name *Helix unilamellata* d'Orbigny, 1838 is here used, because the older *Helix unilamellata* d'Orbigny, 1835 is a nomen nudum (Delannoye et al., 2015; von Proschwitz, 2017). Von Proschwitz (2017) suggested that this species should be referred to as *Leptinaria lamellata* (Potiez & Michaud, 1835). However, as it is not clear if *Achatina lamellata* Potiez & Michaud, 1835 is conspecific with *Helix unilamellata* d'Orbigny, 1838, and as the exact publication year of Potiez & Michaud's *A. lamellata* is still debated (see Falkner et al., 2002; Kadolsky, 2012), we use the name *L. unilamellata* (d'Orbigny, 1838).

Leptinaria urichi (Smith, 1896), a species described from Trinidad, was reported from Kew Gardens in London (Tomlin, 1916), the Cambridge Botanic Garden (Brindley, 1904), and the Royal Botanical Garden, Edinburgh (Baker, 1945). However, the status of this taxon is still unclear; it has been treated as a separate species (e.g. Robinson et al., 2011; Rutherford, 2014), whereas Baker (1945) suspected it to be synonymous with *A. clavulinum*. Some authors accepted this latter synonymy without further comments (Kerney et al., 1983; Waldén, 1985; both with the erroneous generic spelling *Leptiniaria*).

South American *Allopeas micra* (d'Orbigny, 1835) was reported and illustrated from the greenhouses of the Jardin des Plantes in Paris, France [as *Stenogyra octonoides* (Adams, 1845)] (Dautzenberg, 1896; Dollfus et al., 1896) and without any reference or locality information, but with doubt by Eichler (1952). Boettger (in Eichler, 1952) commented that reports of *A. micra* probably refer to *A. clavulinum*, though 20 years before, Boettger (1932) had referred to Dautzenberg (1896) and Dollfus et al. (1896) for the records of *A. micra* and *O. pumilum* [now *O. hannense*] in the greenhouses of the Jardin des Plantes in Paris. Nevertheless, based on Eichler (1952), Geiter et al. (2002) included *A. micra* among the neozoa of Germany, though with doubtful status. The species was also listed among alien species in Europe in the DAISIE project (Olenin & Didziulis, 2009). As far as we know, there are no other records of *A. micra* in Europe.

Beckianum beckianum (Pfeiffer, 1846), is probably native to the Caribbean Basin and was reported from the port of Hamburg, Germany (Kraepelin, 1901; as *Stenogyra caracasensis* Reeve) and from a greenhouse in York, UK (Jackson, 1926).

Finally, Dautzenberg (1896) and Dollfus et al. (1896) also published a record of another subulinine, under the name "*Stenogyra (Spiraxis) venusta* Morelet", from the greenhouses of the Jardin des Plantes in Paris. However, C. R. Boettger considered it unidentifiable with certainty, "probably a species belonging to *Opeas* or *Lamellaxis*" (Eichler, 1952).

Obviously, if the invasion biology of these subulinine species is to be better understood and monitored, then there is a need for a more comprehensive taxonomic framework integrating not only shell morphology but internal anatomy, especially of the reproductive tract, and molecular data.

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LITERATURE CITED

- ALBRECHT, C. H. & S. MENG, 1997, Die Schnecken der Gewächshausanlagen des Erfurter Erwerbsgartenbaus (Mollusca: Gastropoda). *Thüringer Faunistische Abhandlungen*, 4: 33–43.
- ANDERSON, R., 2005, An annotated list of the non-marine Mollusca of Britain and Ireland. *Journal of Conchology*, 38: 607–638.
- AUFFENBERG, K. & L. A. STANGE, 1988, The Subulinidae of Florida. *Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Entomology Circular*, 305.
- BAKER, H. B., 1945, Some American Achatinidae. *The Nautilus*, 58: 84–92.
- BARKER, G. M., 2001, Gastropods on Land: Phylogeny, Diversity and Adaptive Morphology. Pp. 1–146, in: G. M. BARKER, ed., *The Biology of Terrestrial Molluscs*. CABI Publishing, United Kingdom, 558 pp.
- BISWAS, S. K., R. RAHMNA & T. R. MITRA, 1976, Observations on the breeding habits of *Opeas gracile* (Hutton) (Gastropoda: Subulinidae). *Journal of Conchology*, 29: 69–70.
- BOETTGER, C. R., 1932, Die Besiedlung neu angelegter Warmhäuser durch Tiere. Ein Beitrag zur Frage der Bildung von Gewächshausfaunen. *Zeitschrift für Morphologie und Ökologie der Tiere*, 24: 394–407.
- BOYKO, C. B. & J. R. CORDEIRO, 2001, The terrestrial Mollusca of Easter Island (Gastropoda, Pulmonata). *Basteria*, 65: 17–25.
- BRINDLEY, H. H., 1904, The Mollusca of Cambridgeshire. Pp. 114–138 in: MARR, J. E. & A. E. SHIPLEY (Eds) *Handbook to the Natural History of Cambridgeshire*. Cambridge: University Press, VIII + 260 pp.
- BROOK, F. J., 2010, Coastal landsnail fauna of Rarotonga, Cook Islands: systematics, diversity, biogeography, faunal history, and environmental influences. *Tuhinga*, 21: 161–252.
- BUDHA, P. B., F. NAGGS & T. BACKELJAU, 2015, Annotated checklist of the terrestrial gastropods of Nepal. *ZooKeys*, 492: 1–48.
- BURKE, T. E., 2013, *Land Snails and Slugs of the Pacific Northwest*. Corvallis: Oregon State University Press, 344 pp.
- CAMERON, R., 2016, *Slugs and Snails* (Collins New Naturalist Library, Book 133). HarperCollins, UK, 508 pp.
- CANNING-CLODE, J. (Ed.), 2015, *Biological invasions in changing ecosystems: vectors, ecological impacts, management and predictions*. Walter de Gruyter GmbH & Co KG, China, 488 pp.
- CAPINERA, J. L., 2017, Biology and food habits of the invasive snail *Allopeas gracile* (Gastropoda: Subulinidae). *Florida Entomologist*, 100: 116–123.
- CHRISTENSEN, C. C. & M. I. WEISLER, 2013, Land snails from archaeological sites in the Marshall Islands, with remarks on prehistoric translocations in tropical Oceania. *Pacific Science*, 67: 81–104.
- COAN, E. V. & A. R. KABAT, 2015 (2020). *2,400 Years of malacology, 17th edition - Annex 2: Collation of the Systematisches Conchylien-Cabinet (1837-1920)*, American Malacological Society, 63 pp. <https://ams.wildapricot.org/2400-Years-of-Malacology>
- COWIE, R. H., 1997, Catalog and bibliography of the nonindigenous nonmarine snails and slugs of the Hawaiian Islands. *Bishop Museum Occasional Papers*, 50: 1–66.
- COWIE, R. H., R. J. RUNDELL & N. W. YEUNG, 2017, *Samoan Land Snails and Slugs – An Identification Guide*. Department of Marine and Wildlife Resources, American Samoa Government, USA, viii + 71 pp.
- DA SOIS, L., 2015, Greenhouse Gastropods of the *Hortus botanicus* Leiden (Distribution) and other experiences in the Botanical Garden. Bachelor thesis, Università degli studi di Padova, 47 pp.

- DAUTZENBERG, P., 1896, Mollusques testacés terrestres recueillis dans les serres du Muséum. *Bulletin du Muséum National d'Histoire Naturelle*, 2: 28–29.
- D'ÁVILA, S., C. MEDEIROS, T. VARGAS & C. L. FURTADO MENDONÇA, 2018, Life history of *Subulina octona* (Bruguière) (Gastropoda: Pulmonata: Subulinidae) based on four-year laboratory observations and a comparative histological analysis of egg-retaining and ovoviviparous subulinids. *Journal of Natural History*, 52: 1551–1569.
- DE ALMEIDA, M. N. & E. C. DE ALMEIDA BESSA, 2001, Growth and reproduction of *Leptinaria unilamellata* (d'Orbigny) (Mollusca, Subulinidae) in laboratory conditions. *Revista Brasileira de Zoologia*, 18: 1107–1113.
- DE ALMEIDA BESSA, E. C. & J. L. DE BARROS ARAÚJO, 1995, Occurrence of self-fertilization in *Subulina octona* (Bruguière) (Pulmonata, Subulinidae) under laboratorial conditions [in Portuguese]. *Revista Brasileira de Zoologia*, 12: 719–723.
- DELANNOYE, R., L. CHARLES, J.-P. POINTIER & D. MASSEMIN, 2015. *Mollusques continentaux de la Martinique / Non-marine Molluscs of Martinique, Lesser Antilles*. Biotope, Mèze & Publications scientifiques du Muséum national d'Histoire naturelle, Paris, 328 pp.
- DISCOVER LIFE, 2019a, *Lamellaxis gracilis* (Hutton, 1834). Available online at: <https://www.discoverlife.org/mp/20m?kind=Lamellaxis+gracilis> (accessed 24 December 2019).
- DISCOVER LIFE, 2019b, *Paropeas achatinaceum* (Pfeiffer, 1846). Available online at: <https://www.discoverlife.org/mp/20m?kind=Paropeas+achatinaceum> (accessed 24 December 2019).
- DOLLFUS, A., E. ANDRE, E. SIMON, E. CHEVREUX & P. DAUTZENBERG, 1896, Recherches zoologiques dans les serres du muséum de Paris (Suite). *La Feuille des Jeunes Naturalistes*, 11e Série, 26(306): 112–114.
- DUNCAN, F. M., 1937, On the Dates of Publication of the Society's 'Proceedings,' 1859-1926. With an Appendix containing the dates of Publication of 'Proceedings,' 1830-1858, compiled by the late F. H. WATERHOUSE, and of the 'Transactions,' 1833-1869, by the late HENRY PEAVOT, originally published in P. Z. S. 1893, 1913. *Proceedings of the Zoological Society of London*, 107A: 71–84.
- DUNDEE, D. S., 1971, Subulinids and veronicellids in the United States. *The Biologist*, 53: 128–132.
- EICHLER, W., 1952, *Die Tierwelt der Gewächshäuser*. Akademische Verlagsgesellschaft, Leipzig, Germany, IV + 93 pp.
- FALKNER, G., TH. E. I. RIPKEN & M. FALKNER, 2002. Mollusques continentaux de France. Liste de Référence annotée et Bibliographie. *Patrimoines naturels*, 52: 1-350.
- FLASAR, I. & V. KROUPOVÁ, 1976, Die Malakofauna der Gewächshäuser in Bratislava (Tschechoslowakei). *Malakologische Abhandlungen Staatliches Museum für Tierkunde Dresden*, 5: 139–154.
- GBIF, 2019. *Paropeas achatinaceum* (Pfeiffer, 1846). Available online at: <https://www.gbif.org/species/8398927> (accessed 24 December 2019).
- GEITER, O., S., HOMMA & R. KINZELBACH, 2002, Bestandsaufnahme und Bewertung von Neozoen in Deutschland. Texte 25/02, Umweltbundesamt, Berlin, 52 pp.
- GITTENBERGER, E. & A. C. VAN BRUGGEN, 2013, Land snails of the islet of Misali, off Pemba Island, Zanzibar, Tanzania. *Zoologische Mededelingen, Leiden*, 87: 235–273.
- GRIFFITHS, O. L. & V. F. B. FLORENS, 2006, *A Field Guide to the Non-Marine Molluscs of the Mascarene Islands (Mauritius, Rodrigues and Reunion) and the Northern Dependencies of Mauritius*. Bioculture Press, Mauritius, XV + 185 pp.
- HORSÁK, M., L. DVOŘÁK & L. JUŘIČKOVÁ, 2004, Greenhouse gastropods of the Czech Republic: current stage of research. *Malacological Newsletter*, 22: 141–147.
- HORSÁK, M., L. JUŘIČKOVÁ & J. Pícka, 2013, *Měkkýši České a Slovenské republiky* [Molluscs of the Czech and Slovak Republics]. Kabourek, Zlín, LXVIII + 264 pp. [in Czech and English].
- HORSÁK, M., T., ČEJKA, L., JUŘIČKOVÁ, L., BERAN, J., HORÁČKOVÁ, J.Č., HLAVÁČ, L., DVOŘÁK, O., HÁJEK, J., DIVÍŠEK, M., MAÑAS & V. LOŽEK, 2019, Check-list and distribution maps of the

- molluscs of the Czech and Slovak Republics. Available online at:
<http://molluscasav.sk/malacology/checklist.htm> (accessed 26 December 2019).
- JACKSON, J. W., 1926, in: Proceedings of the Conchological Society of Great Britain & Ireland – 542nd Meeting, held at the Manchester Museum, December 2nd 1925. *Journal of Conchology*, 18: 31.
- JAECKEL, S. H. & H. P. PLATE, 1967, Land-und Süßwasserschnecken aus den Gewächshäusern des Botanischen Gartens Berlin-Dahlem. *Zeitschrift für Angewandte Zoologie*, 54: 361–371.
- KADOLSKY, D., 2012, Nomenclatural comments on non-marine molluscs occurring in the British Isles. *Journal of Conchology*, 41: 65–90.
- KATSANEVAKIS, S., K. BOGUCARSKIS, F. GATTO, J. VANDERKERKHOVE, I. DERIU & A. S. CARDOSO, 2012, Building the European Alien Species Information Network (EASIN): a novel approach for the exploration of distributed alien species data. *BioInvasions Records*, 1: 235–245.
- KERNEY, M. P., R. A. D., CAMERON & J. H. JUNGBLUTH, 1983, *Die Landschnecken Nord- und Mitteleuropas*. Hamburg/Berlin: Parey Verlag, XXIV + 384 pp.
- KOBIALKA, H., K.-H., BECKMANN & E. SCHRÖDER, 2006, Arbeitscheckliste Mollusken NRW 6. aktualisierte Ausgabe (Stand 15.01.2006). Höxter, Ascheberg-Herbern und Bonn, 11 pp.
<http://www.mollusken-nrw.de/forschung/checkliste.htm>
- KRAEPELIN, K., 1901. Ueber die durch den Schiffsverkehr in Hamburg eingeschleppten Tiere. *Mitteilungen aus dem Naturhistorischen Museum in Hamburg*, 18: 183–209.
- LEISS, A. & P. L. REISCHÜTZ, 1996, Ein Beitrag zur Kenntnis der Molluskenfauna der Gewächshäuser in Wien und Niederösterreich. *Wissenschaftliche Mitteilungen Niederösterreichisches Landesmuseum*, 9: 173–184.
- MARCUS, E. & E. MARCUS, 1968, Über einige Subulinidae (Pulmonata von Sao Paulo). *Beiträge zur Neotropischen Fauna*, 5: 186–208.
- MEEUSE, A. D. J. & B. HUBERT, 1949, The mollusc fauna of glasshouses in the Netherlands. *Basteria*, 13: 1–44.
- NAGGS, F., 1990a, *A catalogue of the family Subulinidae (Pulmonata, Mollusca) in the general collection of the Natural History Museum London*. Natural History Museum, London, UK, 85 pp.
- NAGGS, F., 1990b, *A catalogue of types in the family Subulinidae (Pulmonata, Mollusca) held in the Natural History Museum London*. Natural History Museum, London, UK, 64 pp.
- NAGGS, F., 1994, The reproductive anatomy of *Paropeas achatinaceum* and a new concept of *Paropeas* (Pulmonata: Achatinoidea: Subulinidae). *Journal of Molluscan Studies*, 60: 175–191.
- NAGGS, F., 2004, Case Study 30: Lack of information allows invasion of slug and snail pests in Sri Lanka. In: Davies, H., N. King & R. Smith (eds), *Taxonomy: Targeting Invasives*. BioNET-INTERNATIONAL. Publication downloadable at: <https://docplayer.net/158781239-Taxonomytargetinginvasives.html>
- NAGGS, F. & D. RAHEEM, 2005, Sri Lankan snail diversity: faunal origins and future prospects. *Records of the Western Australian Museum, Supplement* 68: 11–29.
- NAGGS, F., R. C., PREECE, R., ANDERSON, A., PEIRIS, H., TAYLOR & T. S. WHITE, 2015, *An illustrated guide to the land snails of the British isles*. Second edition. Joint Conchological Society / Malacological Society Publication, SRP Ltd, Exeter, 12 pp.
- NECK, R. W., 1976, Adventive land snails in the Brownsville, Texas area. *The Southwestern Naturalist*, 21: 133–135.
- NEUBERT, E., 1998, Annotated checklist of the terrestrial and freshwater mollusks of the Arabian Peninsula with descriptions of new species. *Fauna of Arabia*, 17: 333–461.
- OLENIN, S. & V. DIDZIULIS, 2009, Introduction to the list of alien taxa. Pp. 129–263, in: DAISIE (Delivering Alien Invasive Species Inventories for Europe), *Handbook of alien species in Europe*. Springer, The Netherlands, XXVIII + 399 pp.
- PILATE, V. J., L. C. SILVA & E. C. A. BESSA, 2013, Life cycle of *Dysopeas muibum* (Mollusca, Subulinidae) in laboratory: effect of isolation on biological and conchological patterns [in Portuguese]. *Iheringia, Série Zoologia*, 103: 350–356.

- PILSBRY, H. A., 1946, Land Mollusca of North America (North of Mexico). Volume II. Part 1. *Academy of Natural Sciences of Philadelphia Monographs*, 3: frontispiece + I–VI + 1–520.
- PIMENTEL, D., L., LACH, R., ZUNIGA & D. MORRISON, 2000, Environmental and economic costs of nonindigenous species in the United States. *BioScience*, 50: 53–66.
- PINTÉR, L. & R. SUARA, 2004, *Magyarországi Puhatestűek Katalógusa* [Catalogue of Hungarian Mollusca]. Budapest: Hungarian Natural History Museum, 547 pp. [in Hungarian].
- PLATE, H.-P. & E. FRÖMMING, 1953a, *Die tierische Schädlinge unsere Gewächshauspflanzen, ihre Lebensweise und Bekämpfung*. Duncker & Humblot, Berlin, Germany, 288 pp.
- PLATE, H.-P. & E. FRÖMMING, 1953b, Die Gastropoden der Berliner Gewächshäuser, ihre Biologie und Schadenswirkung. *Mitteilungen der Berliner Malakologen*, 1: 5–36.
- PREECE, R. C. & T. S. WHITE, 2012, Land and freshwater molluscs in Cambridge Botanic Garden. *Nature in Cambridgeshire*, 54: 53–56.
- PRÉVOT, V., K. JORDAENS, G. SONET & T. BACKELJAU, 2013, Exploring species level taxonomy and species delimitation methods in the facultatively self-fertilizing land snail genus *Rumina* (Gastropoda: Pulmonata). *PLoS ONE*, 8(4): e60736. doi:10.1371/journal.pone.0060736.
- RAHEEM, D. C., H. TAYLOR, J. ABLETT, R. C. PREECE, N. A. ARAVIND & F. NAGGS, 2014, A systematic revision of the land snails of the Western Ghats of India. *Tropical Natural History, Supplement*, 4: 1–294.
- REISCHÜTZ, P. L., 2012, *Veronicella* sp. (Veronicellidae: Pulmonata). Ein weiterer „unexpected inhabitant“ des Tropenhauses im Tiergarten Schönbrunn. *Nachrichtenblatt der Ersten Vorarlberger Malakologischen Gesellschaft*, 19: 15–16.
- REISCHÜTZ, A., P. L., REISCHÜTZ & W. FISCHER, 2012, Beiträge zur Kenntnis der Molluskenfauna Niederösterreichs, XXVII. Nochmals zur Verbreitung von *Hygromia cinctella* (Draparnaud 1901) (Hygromiidae: Pulmonata: Gastropoda) in Niederösterreich und Wien. *Nachrichtenblatt der Ersten Vorarlberger Malakologischen Gesellschaft*, 19: 11–12.
- REISCHÜTZ, A., P. L., REISCHÜTZ, I., RICHLING & C. GILLI, 2017, Die Molluskenfauna des Botanischen Gartens der Universität Wien. *Nachrichtenblatt der Ersten Vorarlberger Malakologischen Gesellschaft*, 25: 31–41.
- ROBINSON, D. G., 1999, Alien invasions: the effects of the global economy on non-marine gastropod introductions into the United States. *Malacologia*, 41: 413–438.
- ROBINSON, D. G. & J. SLAPCINSKY, 2005, Recent introductions of alien land snails into North America. *American Malacological Bulletin*, 20: 89–93.
- ROBINSON, D. G., A. FIELDS & F. J. ZIMMERMAN, 2011, The terrestrial malacofauna of Trinidad and Tobago. Unpublished interim report USDA – APHIS, Philadelphia, USA, 21 pp.
- RUTHERFORD, M. G., 2014, Tracking down the endemic land snails of Trinidad & Tobago. Poster presented at the VIII Caribbean Biodiversity Congress, Santo Domingo, Dominican Republic, January 29 – February 1, 2014. Poster downloadable at: https://www.researchgate.net/publication/306291557_Tracking_down_the_endemic_land_snails_of_Trinidad_Tobago_A_la_búsqueda_de_los_caracoles_terrestres_endemicos_de_Trinidad_Tobago
- SCHMIDT, H., 1959, Zur Biologie, insbesondere der Fortpflanzung, von *Opeas mauritianum* (Pfeiffer). *Archiv für Molluskenkunde*, 88: 55–67.
- SUBBA RAO, N. V., S. K. RAUT & S. C. MITRA, 1980, Observations on the fecundity of the garden snail, *Opeas gracile* (Hutton) (Pulmonata: Subulinidae). *Journal of the Zoological Society of India*, 32: 107–110.
- TOMLIN, J. R. LE B., 1916, Pp. 21 in: Proceedings of the Conchological Society of Great Britain & Ireland – 445th Meeting (Annual Meeting) held at the Manchester Museum, Oct. 16th 1915. *Journal of Conchology*, 15: 19–21.
- VON PROSCHWITZ, T., 1994, *Lamellaxis clavulinus* (Potiez & Michaud) as a greenhouse species in Sweden. *Journal of Conchology*, 35: 184–185.
- VON PROSCHWITZ, T., 2005, Faunistiskt nytt 2004 – snäckor, sniglar och musslor inklusive något om kinesisk skivsnäcka *Gyraulus chinensis* (Dunker) och amerikansk tropiksnäcka *Subulina*

- octona* (Bruguière) – två för Sverige nya, människospridda snäckarter [In Swedish, with extended English summary]. *Göteborgs Naturhistoriska Museum Årstryck*, 2005: 35–61.
- VON PROSCHWITZ, T., 2016, Faunistical news from the Göteborg Natural History Museum 2015 – snails, slugs and mussels – with some notes on *Leptinaria unilamellata* (d’Orbigny) – a land snail species new to Sweden. *Göteborgs Naturhistoriska Museum Årstryck*, 2016: 33–51.
- VON PROSCHWITZ, T., 2017, Faunistical news from the Göteborg Natural History Museum 2016 – snails, slugs and mussels – with some notes on *Rangia cuneata* (G. B. Sowerby I) and *Mytilopsis leucophaeata* (Conrad) – two invasive brackish water mussel species new to Sweden. *Göteborgs Naturhistoriska Museum Årstryck*, 2017: 33–52.
- WALDÉN, H. W., 1985, *Kodlista LM Landmollusker i Norden Version 85291-EÖ*. Stockholm: Swedish Museum of Natural History, 47 pp.

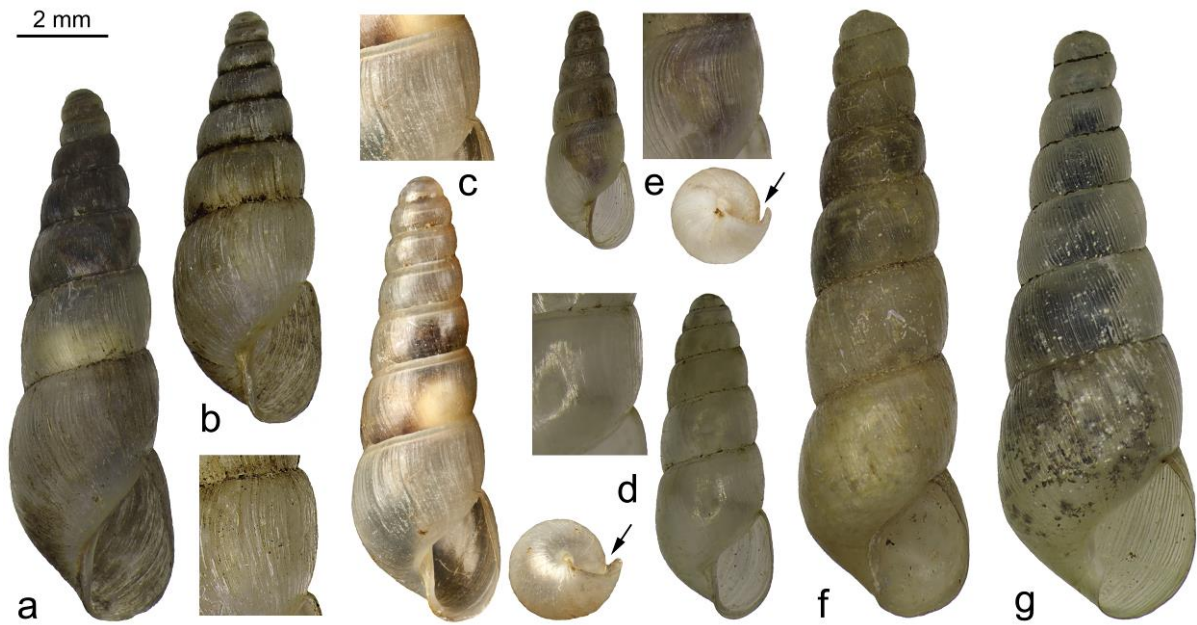


FIG. 1. Subulinine and Opeatine (Achatinidae: Subulininae, Opeatinae) species repeatedly recorded in European greenhouses along with *Paropeas achatinaceum* recorded for the first time: a-b, *P. achatinaceum* (Vienna, Austria) - a, 11.5 mm x 3.5 mm; b, 8.9 x 3.2; c, *Allopeas gracile* (London, United Kindom; copyright NHMUK, used with permission) - 10.2 x 3.3; d, *Allopeas clavulinum* (Brno, Czech Republic) - 6.9 x 2.4; e, *Opeas hannense* (Olomouc, Czech Republic) - 5.1 x 1.9; f, *Subulina octona* (Prague, Czech Republic) - 13.1 x 3.6; g, *Subulina striatella* (Prague, Czech Republic) - 12.5 x 4.1. The shells of *Subulina octona* and *Subulina striatella* are immature to illustrate the size and shape differences better as adult shells reach heights of 18-25 mm.



FIG. 2. The current distribution of *Paropeas achatinaceum* adapted from the Global Biodiversity Information Facility (GBIF, 2019) and the on-line database of the Museum of Florida (Discover Life 2019b). The white cross shows European record mentioned in the text.