First report of *Masseëlla capparidis* in Australia

J. R. Liberato · A. R. McTaggart · R. G. Shivas

Received: 15 April 2012 / Accepted: 18 December 2013 / Published online: 9 January 2014
© Australasian Plant Pathology Society Inc. 2014

Abstract The rust fungus *Masseëlla capparidis* is reported for the first time in Australia on *Flueggea virosa* (Phyllanthaceae). This is the first species of *Masseëlla* found in Australia. The rust is described and illustrated from Australian specimens. A discussion on species of *Masseëlla* is provided. A reconstructed phylogeny with the Large Subunit region of ribosomal DNA indicated that *Masseëlla* has an affinity with the Phakopsoraceae.

Keywords Phakopsoraceae · Phylogeny · Pucciniales · Northern Territory · Queensland

Flueggea virosa (Euphorbiaceae sensu lato or Phyllanthaceae) comprises two subspecies; subsp. *virosa*, which is widespread in the tropics from Africa to south east Asia, and subsp. *melanthesoides*, which occurs in New Guinea and northern Australia (Wheeler 1992, Barker and van Welzen 2010). Three specimens of rust fungi on *F. virosa* subsp. *melanthesoides* from the Northern Territory and Queensland were identified as *Masseëlla capparidis* based on morphology,

according to the descriptions given by Massee (1892), Dietel (1895), Mishra and Nema (1973) and Kumar et al. (1978). A detailed description of *M. capparidis* based on the Australian specimens follows.

Masseëlla capparidis (Hobson bis in Cooke) Dietel [as ‘*capparidis*’] (Figs. 1 and 2)

Berichte der Deutschen Botanischen Gesellschaft 13: 334 (1895)

≡ *Cronartium capparidis* Hobson bis in Cooke [as ‘*capparidis*’], *Grevillea* 14: 89 (1886). Holotype on *Capparis* sp. [probably *Flueggea virosa*, fide Mundkur and Thirumalachar (1946: 12)], India, Karnataka, Belgaum, coll. Major-General Hobson, K; fide Mundkur and Thirumalachar (1946: 11).

= *Masseëlla flueggeae* Syd. in Syd. & Petrak, *Annales Mycologici* 26: 424 (1928). Holotype on *Flueggea virosa*, Philippines; fide Mundkur and Thirumalachar (1946: 11).

Spermogonia, aecia and uredinia not seen. Telia amphigenous, mostly on the upper leaf surface, immersed, solitary or gregarious, extruding a smooth curled column, light to dark reddish brown, up to 2 cm long and 30–300 µm wide, composed of teliospores embedded in a dense hyaline matrix that becomes gelatinous when moist. Teliospores one-celled, rounded to pyriform, slightly angular, often conspicuously truncate at the base, sessile, non-catenulate, 21–37 ($\bar{x}$ = 29.1, SD=3.2, n =100) × 17–26 ($\bar{x}$ = 21.3, SD=1.9, n =100) µm, length/width ratio 1.0–2.3 ($\bar{x}$ = 1.4), golden brown, wall (2–) 3–5.5 µm thick, longitudinally striate, commonly rounded at the apex, with a prominent apical germ pore.

Specimens examined: on *Flueggea virosa* subsp. *melanthesoides* (F. Muell.) G.L. Webster: AUSTRALIA, NORTHERN TERRITORY: Mataranka, 24 June 2010, 14.92249° S, 133.13392° E, *H. Wallace* (DNAP 4605), III;

J. R. Liberato (✉)
Department of Primary Industry and Fisheries, Plant Pathology
Section, GPO Box 3000, Darwin, Northern Territory 0801, Australia
e-mail: jose.liberato@nt.gov.au

A. R. McTaggart
Queensland Alliance for Agriculture and Food Innovation,
The University of Queensland, Ecosciences Precinct, GPO Box 267,
Brisbane, Queensland 4001, Australia

R. G. Shivas
Plant Pathology Herbarium, Biosecurity Queensland, Department of
Agriculture, Fisheries and Forestry, GPO Box 267, Brisbane,
Queensland 4001, Australia

Fig. 1 Coiled hair-like extrusions of teliospores of *Masseëlla capparidis* on *Flueggea virosa* subsp. *melanthesoides* (dried specimens). **a** on the upper leaf surface (DNAP 4605). **b-d** on the lower leaf surface (seen under stereo microscope). Bar=0.5 mm. **b** DNAP 4627. **c-d** DNAP 4489

loc. cit., 19 July 2010, *H. Wallace* (DNAP 4489, BRIP 53724), III; 10 May 2011, 14.92173° S, 133.13588° E, *H. Wallace* (DNAP 4627, BRIP 57656), III; Victoria River, 20 April 2012, *V. Andjic, M. Butt, K. Ireland, C. Doungsa-ard, A.R. McTaggart, R. Berndt, V. Faust-Berndt, M.D.E. and R.G. Shivas* (BRIP 56845), III; Katherine, same date and coll., (BRIP 56844), III. QUEENSLAND: Musgrave, 14.8625° S, 143.09717° E, 15 July 1999, *R.G. Shivas and M. Gunther* (BRIP 26745), III. On *Flueggea virosa* (Roxb. ex Willd.) Royle subsp. *virosa*: ZAMBIA: Palm Island, Livingstone, 30 Apr. 1963, *K.A. Pirozynski* (IMI 112481, BRIP 18791), III; Chilanga, Lusaka, 15 July 1963, *K.A. Pirozynski* (IMI 115337, BRIP 18795), III.

Hosts: on Euphorbiaceae: *Flueggea* spp. and *Suregada multiflora* (Mishra and Nema 1973, as *Gelonium multiflorum*).

Distribution: Australia, India (Cooke 1886, Massee 1892, Dietel 1895, Singh and Singh 1967, Mishra and Nema 1973, Kumar et al. 1978), Pakistan (Khalid et al. 2010), South Africa (Doidge 1939), Philippines (Sydow and Petrak 1928, Arthur & Cummins 1936, Cummins 1937) and Zambia.

The aecial stage of *M. capparidis* is unknown. Aecia found on leaves of *F. virosa* in India (Singh and Singh 1967) and the Philippines (Cummins 1937, as *M. flueggeae*) were not connected with telia of *M. capparidis*. Doidge (1939) reported the uredinial stage of *M. capparidis* (as *M. flueggeae*) on *F. virosa* in South Africa as *Uredo brideliae* (Henn. & A. Evans) Doidge, which is an illegitimate name as it is a nomenclatural homonym of *Uredo brideliae* Koord. This specimen did not possess telia. Sydow and Petrak (1928) considered the urediniospores and teliospores described in the diagnosis of *M. flueggeae* belonged to the same fungus as both spore forms occurred together on some of their specimens.

There are six additional species of *Masseëlla* that have been described, including *M. flueggeae*, which is a synonym of *M. capparidis*. The remaining five species are (i) *M. breyniae* Thirum. on *Breynia vitis-idaea* (Phyllanthaceae) in India (Thirumalachar 1943a, as *Breynia rhamnoides*); (ii) *M. narasimhanii* Thirum. on *F. leucopyrus* and *F. virosa* in India (Thirumalachar 1943b, Singh and Singh 1967, Kalode and Patil 1978); (iii) *M. ciferrii* Ciccar. on *Berchemia yemensis* (Rhamnaceae) in Ethiopia (Ciccarone 1951); (iv) *M. putranjivae* T.S. Ramakr. on *Putranjiva roxburghii* (Putranjivaceae) in India (Ramakrishnan 1957) and (v) *M. terminaliae* (Henn.) Patw. on *Terminalia chebula* (Combretaceae) in India (Patwardhan 1964).

Spermogonia, aecia, uredinia and telia were described for *M. breyniae*, *M. narasimhanii* and *M. putranjivae*. The connection between spermogonia/aecia and uredinia/telia was demonstrated for *M. breyniae* through experimental inoculation, which showed this rust was a macrocyclic and autoecious (Thirumalachar 1943a). The teliospores of species of *Masseëlla* are morphologically similar. Arthur & Cummins (1936) reported *M. flueggeae* from Philippines as having teliospores finely and longitudinally striate as in *M. capparidis*. According to Ciccarone (1951), *M. ciferrii* does not differ morphologically from *M. capparidis* and was described as a new species on the basis that the host belonged to a different family (Rhamnaceae). Furthermore *M. narasimhanii* was described from *F. leucopyrus*, the same host genus as *M. capparidis*. Whereas *M. narasimhanii* has teliospores longitudinally striate and with similar size and colour to ones of *M. capparidis*, there is a possibility of synonymy among these *Masseëlla* species, which needs molecular phylogenetic analysis and pathogenicity experiments to be verified.

Fig. 2 Teliospores of *Masseëlla capparis* (DNAP 4489). **a-d** Spore tendrils. Bar=50 μ m; **e-h** Bar=20 μ m. **a-b** mounted in lactic acid and not heated. **c** mounted in water. **d-h** mounted in lactic acid and gently heated

The phylogenetic position of *Masseëlla* within the Pucciniales is uncertain (Cummins and Hiratsuka 2003) and there is no molecular data available for that genus. To establish the phylogenetic placement of *M. capparis*, DNA was extracted from one specimen (BRIP 56844) according to the protocol described by Aime (2006) using the UltraClean Plant DNA Isolation Kit (MoBio Laboratories, Solana Beach, CA, USA). The ITS2-LSU region was amplified with Rust2inv (Aime

2006)/LR7 (Vilgalys and Hester 1990). The novel sequence data was deposited in GenBank (accession number JX136798).

A reconstructed phylogeny of the *Pucciniales* based on the Large Subunit (LSU) dataset of Minnis et al. (2012) placed *Masseëlla* as sister to *Phakopsora*, within the *Phakopsoraceae* with strong phylogenetic support (0.98 aRLT, 95 % bootstrap) (Aime 2006) (Fig. 3). Further analyses

Fig. 3 Phylogram of main families in the Pucciniales obtained from a maximum likelihood search in PhyML with the LSU region of rDNA (dataset of Minnis et al. 2012). aRLT support values (>0.90) from an SPR search in PhyML above nodes, bootstrap values (>70 %) from a

maximum likelihood bootstrap search with 1,000 replicates in RAxML shown below nodes. GTRGAMMA was specified as the model of evolution in both programs

including the Small Subunit region of rDNA may help to confirm the familial position of *Masseella*.

Acknowledgments The authors thank the Northern Territory Herbarium for identification of the plant species and Dr Reinhard Berndt (ETH Zürich, Switzerland) for translation of some of Sydow's comments. The junior authors would like to thank Dr Glynn Maynard (Commonwealth Department of Agriculture, Fisheries and Forestry) for making funds available through the Advanced Diagnostic Development framework (ADDf) program that facilitated part of this study. This work was partly

funded by the Australian Biological Resources Study grant number RFL212-33.

References

Aime MC (2006) Toward resolving family-level relationships in rust fungi (Uredinales). *Mycoscience* 47(3):112–122

- Arthur JC, Cummins JB (1936) Philippine rusts in the Clemens collection 1923–1926, II. Philippine Journal of Science, Section C Botany 61(4):463–488
- Barker C, van Welzen PC (2010) *Flueggea* (Euphorbiaceae s.l. or Phyllanthaceae) in Malesia. Syst Bot 35:541–551
- Ciccarone A (1951) Primo contributo alla conoscenza dei Micromiceti dell'Africa orientale. Mycopathol Mycol Appl 5:208–235
- Cooke MC (1886) Some exotic fungi. Grevillea 14(71):89–90
- Cummins GB (1937) Studies in the Uredinales of the Philippines. Annales Mycologici 35:98–105
- Cummins GB, Hiratsuka Y (2003) Illustrated Genera of Rust Fungi. 3 edn. American Phytopathological Society, St. Paul
- Dietel P (1895) Drei neue Uridineengattungen: *Masseella*, *Phakopsora* und *Schizospora*. Ber dtsch bot ges 13:332–335
- Doidge EM (1939) South African rust fungi, III. Bothalia 3(4):487–512
- Kalode MB, Patil BV (1978) Critical notes on some plant rusts from India. Sydowia 31:81–86
- Khalid AN, Afshan NS, Elahi H (2010) *Masseella flueggeae* on *Flueggea virosa*, a new record for Pakistan. Mycotaxon 114: 453–457
- Kumar A, Bhansali RR, Soni SR (1978) *Securinea leucopyrus* (Willd.) Muell. a new host of *Masseella* in Indian arid zone. Transactions of Indian Society of Desert Technology and University Centre of Desert Studies 3(1):41–42
- Massee G (1892) Notes on fungi in the royal herbarium Kew. Grevillea 21:33–35
- Minnis D, McTaggart AR, Rossman A, Aime MC (2012) Taxonomy of mayapple rust: the genus *Allodus* resurrected. Mycologia 104(4):942–950
- Mishra RP, Nema KG (1973) *Gelonium multiflorum* A. Juss a new host for *Masseella capparidis* (Hobson) Diet. JNKVV Res J Jarwaharlal Nehru Krishi Vishwa Vidyalaya 7(4):285–286
- Mundkur BB, Thirumalachar MJ (1946) Revisions of and additions to Indian fungi. Mycological Papers 16. IMI, Kew, 27pp
- Patwardhan PG (1964) The perfect stage of *Uredo terminaliae* P. Henn. Mycopathol Mycol Appl 24:172–174
- Ramakrishnan TS (1957) Notes in some fungi. Proceedings of the Indian Academy of Sciences, Section B 45(4):176–180
- Singh H, Singh BV (1967) On some Indian species of *Masseella*. Mycopathologia 33(2):193–199
- Sydow H, Petrak F (1928) Micromycetes Philippinenses. Annales Mycologici 26:414–446
- Thirumalachar MJ (1943a) *Masseella breyniae*, a new species of rust. New Phytol 42(1):45–48
- Thirumalachar MJ (1943b) *Masseella narasimhanii*, a new species of rust on *Flueggea leucopyrus* Willd. Proceedings of the Indian Academy of Sciences, Section B 18(2):36–40
- Vilgalys R, Hester M (1990) Rapid genetic identification and mapping of enzymatically amplified ribosomal DNA from several *Cryptococcus* species. J Bacteriol 172(8):4238–4246
- Wheeler JR (1992) Euphorbiaceae in Wheeler JR (ed.) Flora of the Kimberley region. Department of Conservation and Land Management, Perth, pp 589–629