



<http://dx.doi.org/10.11646/zootaxa.3856.3.2>

<http://zoobank.org/urn:lsid:zoobank.org:pub:060F9D25-F1BF-4DD2-BCF0-379779218E5E>

Nematodes from galls on Myrtaceae. VI. *Fergusobia* from galls on *Angophora* in Australia, with description of *F. colbrani* n. sp. and key

KERRIE A. DAVIES^{1,5}, GARY S. TAYLOR², LEIGH A. NELSON³, DAVID YEATES³
& ROBIN M. GIBLIN-DAVIS⁴

¹Australian Centre for Evolutionary Biology and Biodiversity, and School of Agriculture, Food and Wine, The University of Adelaide, Waite Campus, PMB 1, Glen Osmond, South Australia 5064, Australia. E-mail: kerrie.davies@adelaide.edu.au

²Australian Centre for Evolutionary Biology and Biodiversity, and School of Earth and Environmental Sciences, The University of Adelaide, North Terrace, Adelaide, South Australia 5005, Australia. E-mail: gary.taylor@adelaide.edu.au

³CSIRO Ecosystem Sciences, Clunies Ross Street, Acton, Australian Capital Territory 2601, Australia.
E-mail: nelson.leigh@gmail.com; David.Yeates@csiro.au

⁴Fort Lauderdale Research and Education Center, University of Florida, 3205 College Ave, Davie, Florida 33314–7799, USA.
E-mail: giblin@ufl.edu

⁵Corresponding author

Abstract

Collection data and biological information is presented on the *Fergusobia* (Nematoda: Neotylenchidae)/ *Fergusonina* (Diptera: Fergusoninidae) mutualism inducing galls on *Angophora* in Australia. Three species and two morphospecies have been recognised. *Fergusobia colbrani* Davies n. sp. is described from soft spheroid leaf galls on *Angophora floribunda*. It is characterised by a combination of morphological characters including a small C-shaped parthenogenetic female with a short broadly conoid tail, an arcuate infective female with an almost hemispherical tail tip, and an arcuate to barely J-shaped male with an angular spicule having a notched tip and mid-length leptoderan bursa. A key to the species and morphospecies of nematodes collected from *Angophora* is presented. Possible relationships of these organisms are discussed based on evidence from the nematode morphology, gall forms, and the morphology of the dorsal shield of the associated *Fergusonina* fly larvae.

Key words: Myrtaceae, galls, Neotylenchidae, *Fergusonina*, Diptera, morphology, morphospecies, collection data, key

Introduction

Nematodes of the genus *Fergusobia* Currie 1937 (Tylenchida: Neotylenchidae) and flies of the genus *Fergusonina* Malloch 1932 (Diptera: Fergusoninidae) have a mutualistic association (Giblin-Davis *et al.* 2004b, Ye *et al.* 2007) and together form galls on some Myrtaceae (Malloch 1932; Morgan 1933; Currie 1937; Giblin-Davis *et al.* 2004a, b; Taylor *et al.* 2005). It is hypothesized that the *Fergusobia*/*Fergusonina* mutualism radiated and speciated with the Myrtaceae as they radiated, largely within Australia. Hosts include *Corymbia* Hill & Johnson, 1995 (Currie 1937; Taylor *et al.* 2005), *Eucalyptus* L'Heritier 1788 (Tonnoir 1937), *Syzygium* R. Brown ex Gaertner 1828 (Harris 1982), *Melaleuca* Linnaeus 1767, nom. cons. (Goolsby *et al.* 2000; Taylor 2004; Davies & Giblin-Davis 2004), *Metrosideros* Banks ex Gaertner 1788 (Taylor *et al.* 2007), *Leptospermum* Forster & Forster 1776 (Robin Adair pers. com.; Kerrie Davies unpub. data), and *Angophora* Cavanilles 1797 (Colbran 1964; Taylor *et al.* 2005). Each unique *Fergusobia*/*Fergusonina* mutualism appears to induce formation of a specific gall form (Davies & Giblin-Davis 2004). It is therefore interesting to compare the gall forms induced by nematode/fly mutualisms thought to be genetically close, on genetically related host plants. The individual locules, in which a fly larva and associated nematodes develops, have lumens lined with hypertrophied cells (Giblin-Davis *et al.* 2004a). The flies and nematodes are thought to feed on these.

Most mature *Fergusonina* fly larvae (third instar) have a characteristic cuticular structure on the dorsum. This varies in form, and may be apparently absent, comprise a few transverse rows of raised spicules, transverse rows of

References

- Bell, S.A.J. (2004) Distribution and habitat of the vulnerable tree species, *Angophora inopina* (Myrtaceae), on the Central Coast of New South Wales. *Cunninghamia*, 8, 477–484.
- Boland, D.J., Brooker, M.I.H., Chippendale, G.M., Hall, N., Hyland, B.P.M., Johnston, R.D., Kleinig, D.A., McDonald, M.W. & Turner, J.D. (2006) *Forest Trees of Australia*, CSIRO Publishing, Melbourne, pp. 212–217.
- Chippendale, G.M. (1988) Myrtaceae – *Eucalyptus*, *Angophora*. In: *Flora of Australia*. Australian Government Publishing Service, Canberra, pp. 448–494.
- Christie, J.R. (1941) Life history (Zooparasitica): Parasites of invertebrates. In: Chitwood, B.C. & Chitwood, M.B. (Eds.), *An Introduction to Nematology*. Babylon, New York, pp. 246–266.
- Colbran, R.C. (1964) Studies of plant and soil nematodes. 7. Queensland records of the order Tylenchida and the genera *Trichodorus* and *Xiphinema*. *Queensland Journal of Agricultural Sciences*, 21, 77–123.
- Currie, G.A. (1937) Galls on *Eucalyptus* trees. A new type of association between flies and nematodes. *Proceedings Linnaean Society of New South Wales*, 62, 147–174.
- Davies, K.A. & Giblin-Davis, R.M. (2004) The biology and associations of *Fergusobia* (Nematoda) from the *Melaleuca leucadendra*-complex in eastern Australia. *Invertebrate Systematics*, 18, 291–319.
<http://dx.doi.org/10.1071/is02034>
- Davies, K.A. & Lloyd, J. (1996) Nematodes associated with Diptera in South Australia: a new species of *Fergusobia* Currie and a new record of *Syrphonema* Laumond & Lyon. *Transactions of the Royal Society of South Australia*, 120, 13–20.
- Davies, K.A., Ye, W., Giblin-Davis, R., Taylor, G.S., Scheffer, S. & Thomas, W.K. (2010a) The genus *Fergusobia* (Nematoda: Neotylenchida): molecular phylogeny, descriptions of clades and associated gall, host plants and *Fergusonina* fly larvae. *Zootaxa*, 2633, 1–66.
- Davies, K.A., Ye, W., Giblin-Davis, R., Taylor, G.S. & Thomas, W.K. (2010b) Nematodes from galls on Myrtaceae. I. *Fergusobia/Fergusonina* galls on *Corymbia* spp., with re-description of *F. magna* and notes on its phylogenetic relationships. *Zootaxa*, 2634, 25–40.
- Davies, K.A., Ye, W., Giblin-Davis, R., Taylor, G.S. & Thomas, W.K. (2012a) Nematodes from galls on Myrtaceae. II. *Fergusobia/Fergusonina* from small axillary bud ('stem') and leaf ('pea') galls in Australia, with descriptions of two new species. *Zootaxa*, 3415, 1–22.
- Davies, K.A., Ye, W., Giblin-Davis, R., Taylor, G.S. & Thomas, W.K. (2012b) Nematodes from galls on Myrtaceae. III. *Fergusobia* from flower bud and stigma galls on *Eucalyptus*, with descriptions of four new species. *Zootaxa*, 3532, 1–36.
- Davies, K.A., Ye, W., Giblin-Davis, R., Taylor, G.S. & Thomas, W.K. (2013a) Nematodes from galls on Myrtaceae. IV. *Fergusobia* from flat leaf galls on *Eucalyptus* and *Corymbia*, with descriptions of two new species. *Zootaxa*, 3741 (1), 151–171.
<http://dx.doi.org/10.11646/zootaxa.3741.1.5>
- Davies, K.A., Ye, W., Giblin-Davis, R., Taylor, G.S. & Thomas, W.K. (2013b) Nematodes from galls on Myrtaceae. V. *Fergusobia* from large multilocular shoot bud galls from *Angophora* and *Eucalyptus* in Australia, with descriptions of five new species. *Zootaxa*, 3741 (1), 101–140.
<http://dx.doi.org/10.11646/zootaxa.3741.1.3>
- Fisher, J.M. & Nickle, W.R. (1968) On the classification and life history of *Fergusobia curriei* (Sphaerulariidae: Nematoda). *Proceedings of the Helminthological Society of Washington*, 35, 40–46.
- Giblin-Davis, R.M., Davies, K.A., Taylor, G.S. & Thomas, W.K. (2004b) Entomophilic nematode models for studying biodiversity and cospeciation. In: Chen, Z.X. Chen, S.Y. & Dickson, D.W. (Eds.), *Nematology, Advances and Perspectives*. Tsing-Hua University Press/CABI, New York, pp. 493–540.
- Giblin-Davis, R.M., Center, B.J., Davies, K.A., Purcell, M.F., Scheffer, S.J., Taylor, G.S., Goolsby, J. & Center, T.D. (2004a) Histological comparisons of *Fergusobia/Fergusonina*-induced galls on different myrtaceous hosts. *Journal of Nematology*, 36, 249–262.
- Goolsby, J.A., Makinson, J. & Purcell, M. (2000) Seasonal phenology of the gall-making fly *Fergusonina* sp. (Diptera: Fergusoninidae) and its implications for biological control of *Melaleuca quinquenervia*. *Australian Journal of Entomology*, 39, 336–343.
<http://dx.doi.org/10.1046/j.1440-6055.2000.00193.x>
- Harris K.M. (1982) First record of Fergusoninidae (Diptera: Schizophora) outside Australia: a new species of *Fergusonina* on *Syzygium* in India. *Systematic Entomology*, 7, 211–216.
<http://dx.doi.org/10.1111/j.1365-3113.1982.tb00132.x>
- Hill, K.D. & Johnson, L.A.S. (1995) Systematic studies in the eucalypts 7. A revision of the bloodwoods, genus *Corymbia* (Myrtaceae). *Telopea*, 6, 185–504.
- Hill, K.D. (1996) New species in *Angophora* and *Eucalyptus* (Myrtaceae) from New South Wales. *Telopea*, 7, 97–109.
- Jairajpuri, M.S. (1962) On a new nematode *Boleodorus indicus* n. sp. (Neotylenchidae: Tylenchida) from soil about the roots of onions, *Allium cepa* L. *Zeitschrift für Parasitenkunde*, 22, 214–216.
<http://dx.doi.org/10.1007/bf00260007>
- Ladiges, P., Parra-O, C., Gibbs, A., Udovicic, F., Nelson, G. & Bayly, M. (2011) Historical biogeographical patterns in continental Australia: congruence among areas of endemism of two major clades of eucalypts. *Cladistics*, 27, 29–41.
<http://dx.doi.org/10.1111/j.1096-0031.2010.00315.x>
- Ladiges, P.Y., Udovicic, F. & Drinnan, A.N. (1995) Eucalypt phylogeny - molecules and morphology. *Australian Systematic*

Botany, 8, 483–497.

<http://dx.doi.org/10.1071/sb9950483>

- Leach, G.J. (1986) A revision of the genus *Angophora* (Myrtaceae). *Telopea*, 2, 749–779.
- Malloch J.R. (1932) Notes on Australian Diptera, No. xxxii. *Proceedings of the Linnaean Society of New South Wales*, 57, 213–217.
- Morgan, W.L. (1933) Flies and nematodes associated with flower bud galls of Spotted Gum. *Agricultural Gazette of New South Wales*, 44, 125–127.
- Ochieng, J.W., Henry, R.J., Baverstock, P.R., Steane, D.A. & Shepherd, M. (2007) Nuclear ribosomal pseudogenes resolve a corroborated monophyly of the eucalypt genus *Corymbia* despite misleading hypotheses at functional ITS paralogs. *Molecular Phylogenetics and Evolution*, 44, 752–764.
<http://dx.doi.org/10.1016/j.ympev.2007.04.017>
- Parra-O, C., Bayly, M.J., Udovicic, F. & Ladiges, P.Y. (2006) ETS sequences support the monophyly of the eucalypt genus *Corymbia* (Myrtaceae). *Taxon*, 55, 653–663.
<http://dx.doi.org/10.2307/25065641>
- Sale, M.M., Potts, B.M., West, A.K. & Reid, J.B. (1993) Relationships within *Eucalyptus* using chloroplast DNA. *Australian Systematic Botany*, 6, 127–138.
<http://dx.doi.org/10.1071/sb9930127>
- Scheffer, S.J., Giblin-Davis, R.M., Taylor, G.S., Davies, K.A., Purcell, M., Lewis, M.L., Goolsby, J. & Center, T.D. (2004) Phylogenetic relationships, species limits, and host specificity of gall-forming *Fergusonina* flies (Diptera:Fergusoninidae) feeding on *Melaleuca* (Myrtaceae). *Annals of the Entomological Society of America*, 97, 1216–1221.
[http://dx.doi.org/10.1603/0013-8746\(2004\)097\[1216:prslah\]2.0.co;2](http://dx.doi.org/10.1603/0013-8746(2004)097[1216:prslah]2.0.co;2)
- Siddiqi, M.R. (1986) A review of the genus *Fergusobia* Currie (Hexatyliina) with descriptions of *F. jambophila* n. sp. and *F. magna* n. sp. In: Swarup, G. & Dasgupta, D.R. (Eds.), *Plant Parasitic Nematodes of India, Problems and Progress*. New Delhi, India, pp. 264–278.
- Siddiqi, M.R. (1994) *Fergusobia brevicauda* sp. n. and *F. philippinensis* sp. n. (Nematodea: Hexatyliina) from *Eucalyptus deglupta*. *Proceedings of the Second Afro-Asian Nematology Symposium*, 96–100.
- Slee, A.V., Brooker, M.I.H., Duffy, S.M. & West, J.G. (2006) EUCLID - Eucalypts of Australia. 3rd Edition. CSIRO Publishing. CD ROM.
- Steane, D.A., Nicolle, D., McKinnon, G.E., Vaillancourt, R.E. & Potts, B.M. (2002) Higher-level relationships among the eucalypts are resolved by ITS-sequence data. *Australian Systematic Botany*, 15, 49–62.
- Steane, D.A., McKinnon, G.E., Vaillancourt, R.E. & Potts, B.M. (1999) ITS sequence data resolve higher level relationships among the eucalypts. *Molecular Phylogenetics and Evolution*, 12, 215–223.
- Taylor, G.S. (2004) Revision of *Fergusonina* Malloch gall flies (Diptera: Fergusoninidae) from *Melaleuca* (Myrtaceae). *Invertebrate Systematics*, 18, 251–290.
<http://dx.doi.org/10.1071/is02033>
- Taylor, G.S., Head, E. & Davies, K.A. (2005) Gall flies (Diptera: Fergusoninidae) on Myrtaceae: a mutualistic association between flies and nematodes. In: A. Rahman, Schaefer, C.W. & Withers, T.M. (Eds.), *Biology, Ecology and Evolution of Gall-Inducing Arthropods. Vol. 2*. Science Publishers, New Hampshire, pp. 643–671.
- Taylor, G., Davies, K., Martin, N. & Crosby, T. (2007) First record of *Fergusonina* (Diptera: Fergusoninidae) and associated *Fergusobia* (Tylenchida: Neotylenchidae) forming galls on *Metrosideros* (Myrtaceae) from New Zealand. *Systematic Entomology*, 32, 548–557.
<http://dx.doi.org/10.1111/j.1365-3113.2007.00383.x>
- Taylor, G.S. & Davies, K.A. (2008) New species of gall fly (Diptera: Fergusoninidae) and an associated nematode (Tylenchida: Neotylenchidae) from flower bud galls on *Corymbia* (Myrtaceae). *Australian Journal of Entomology*, 47, 336–349.
<http://dx.doi.org/10.1111/j.1440-6055.2008.00665.x>
- Taylor, G.S. & Davies, K.A. (2010) The gall fly, *Fergusonina lockharti* Tonnoir (Diptera: Fergusoninidae) and description of its associated nematode, *Fergusobia brittenae* n. sp. (Tylenchida: Neotylenchidae). *Journal of Natural History*, 44, 927–957.
<http://dx.doi.org/10.1080/00222930903383545>
- Thiele, K. & Ladiges, P.Y. (1988) A cladistic analysis of *Angophora* Cav. (Myrtaceae). *Cladistics*, 4, 23–42.
<http://dx.doi.org/10.1111/j.1096-0031.1988.tb00466.x>
- Udovicic, F. & Ladiges, P.Y. (2000) Informativeness of nuclear and chloroplast DNA regions and the phylogeny of the eucalypts and related genera (Myrtaceae). *Kew Bulletin*, 55, 633–645.
<http://dx.doi.org/10.2307/4118780>
- Udovicic, F., McFadden, G.I. & Ladiges, P.Y. (1995) Phylogeny of *Eucalyptus* and *Angophora* based on 5S rDNA spacer sequence data. *Molecular Phylogenetics and Evolution*, 4, 247–256.
<http://dx.doi.org/10.1006/mpev.1995.1023>
- Williams, J.E. & Woinarski, J. (1997) *Eucalypt ecology: individuals to ecosystems*. Cambridge University Press, Cambridge, UK, pp. 430.
- Ye, W., Giblin-Davis, R.M., Davies, K.A., Purcell, M., Scheffer, S.J., Taylor, G.S., Center, T.D., Morris, K. & Thomas, W.K. (2007) Molecular phylogenetics and the evolution of host plant associations in the nematode genus *Fergusobia* (Tylenchida: Fergusobiinae). *Molecular Phylogenetics and Evolution*, 45, 123–141.
<http://dx.doi.org/10.1016/j.ympev.2007.02.027>