The Lichenologist **39**(4): 361–369 (2007) © 2007 British Lichen Society
doi:10.1017/S0024282907006998 *Printed in the United Kingdom*

The genus *Chrysothrix* in Australia

John A. ELIX and Gintaras KANTVILAS

Abstract: *Chrysothrix occidentalis* Elix & Kantvilas, *C. palaeophila* Kantvilas & Elix and *C. tchupalensis* Elix & Kantvilas are described as new to science. In addition, the new combination *Chrysothrix sulphurella* (Räsänen) Kantvilas & Elix is proposed, *C. granulosa* G. Thor is reported for the first time from Australia (including Tasmania) and New Zealand, and *C. xanthina* (Vain.) Kalb for the first time from Tasmania, Norfolk Island and New Zealand. A key to the Australian species of *Chrysothrix* is presented. Chemical data on non-Australasian species of the genus are also provided.

Key words: Australia, *Chrysothricaceae*, lichenized Ascomycota, new species

Introduction

The lichen genus *Chrysothrix* Mont. is widely distributed in Australia, occurring on rocks, bark and dead wood, and is often prominent in habitats that are shaded or sheltered from direct rain. Species are characterized by a powdery to granular, bright yellow to lemon-yellow or yellow-green, leprose thallus in which ascomata are often very rare (Kalb 2001; Laundon 1981; Thor 1988). The thalli contain pulvinic acid derivatives that are responsible for their intense yellow colouration. The genus is included in the family *Chrysothricaceae* within the *Arthoniales* (see Grube 1998) and has distinctive, eight-spored, *Arthonia*-type asci and hyaline, usually 3-septate ascospores. Two species, *C. candelaris* (L.) J. R. Laundon and *C. xanthina* (Vain.) Kalb., have been recorded for Australia by McCarthy (2006). A further three new species are described here. In addition, the new combination *Chrysothrix sulphurella* (Räsänen) Kantvilas & Elix is proposed and *C. granulosa* G. Thor is reported for the first time from Australia and New Zealand. This brings the total number of *Chrysothrix* species for Australia to seven, a remarkable level of species-richness in a global context for a rather distinctive, albeit poorly studied group.

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Methods

Lichen morphology was examined using a Zeiss Stemi 2000C stereo microscope, and ascospores were examined using a Zeiss Axioskop compound microscope. Measurements of ascospores are based on at least 50 observations and are presented in the format: lowest value–*mean*–highest value. Chemical constituents were identified by thin layer chromatography (Culberson 1972; Elix & Ernst-Russell 1993), high performance liquid chromatography (Elix *et al.* 2003) and comparison with authentic samples.

New Species

Chrysothrix occidentalis Elix & Kantvilas sp. nov.

Chrysothrici xanthinae similis sed acidum leprapinicum continenti differt.

Typus: Australia, Western Australia, Brookton Highway Nature Reserve, Darling Plateau, 32°23′50″S, 116°44′03″E, 285 m, on sheltered laterite ledge in *Eucalyptus* woodland, 15 April 2006, *J. A. Elix* 36551 (PERTH—holotypus; CANB, HO—isotypi).

(Fig. 1A)

Thallus crustose-leprose, bright yellow to yellow-green or yellow-orange, ecorticate, unstratified, adnate, delimited or not, lacking well-defined lobes, up to 250 μm thick,

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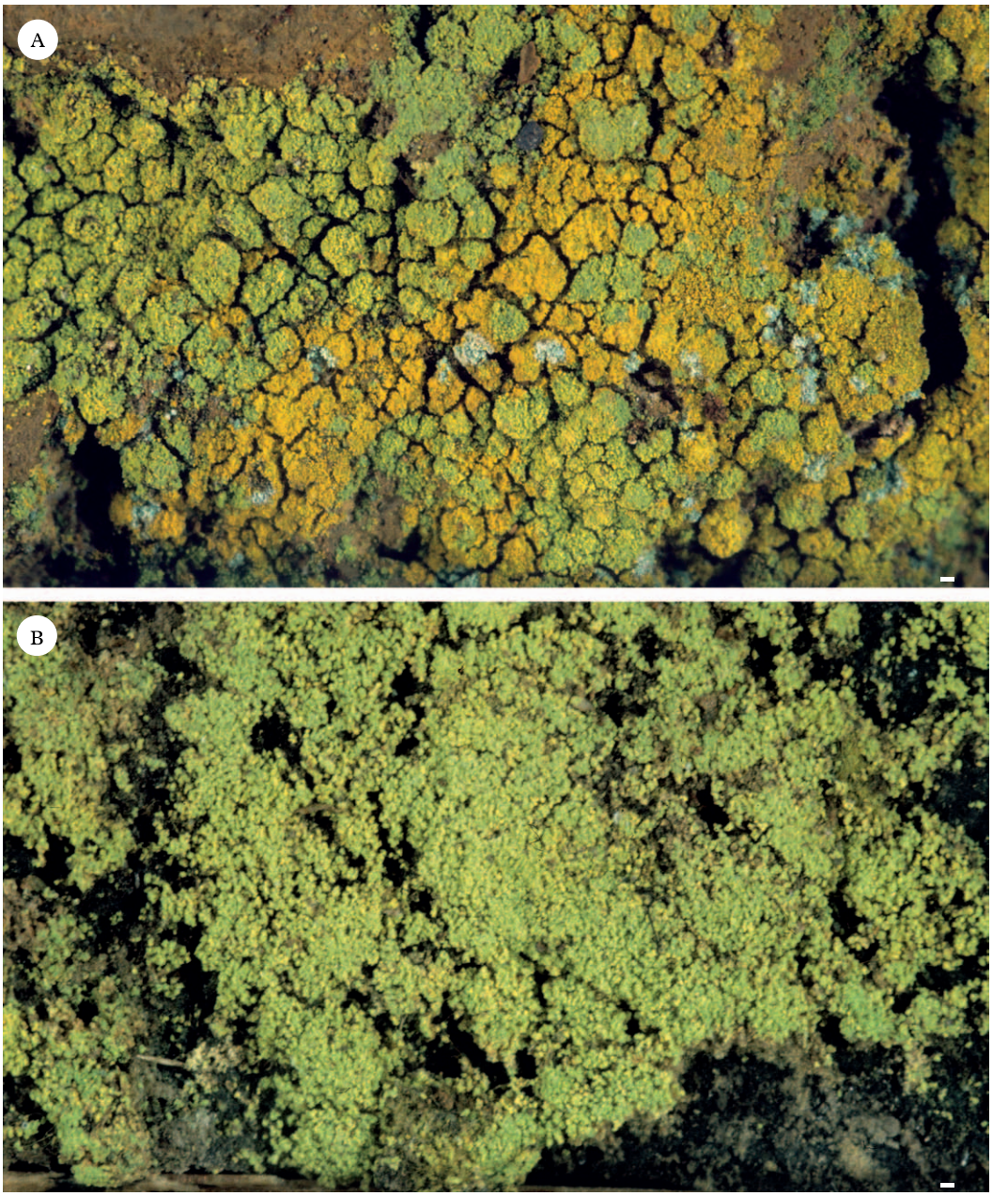


FIG. 1. A, *Chrysothrix occidentalis* (part of isotype CANB); B, *Chrysothrix tchupalensis* (part of isotype CANB). Scales: A & B=5 mm.

forming small, irregularly roundish colonies 0·5–1 cm wide that eventually coalesce into extensive, irregularly spreading patches to 10 cm wide; *soredia* farinose, with individual granules minutely convex to spherical, 20–80 µm wide; *photobiont* chlorococcoid, ± spherical, 15–18 µm wide; *hyphae* 1·6–3 µm thick. *Hypothallus* not apparent.

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Apothecia and *pycnidia* not seen.

Chemistry. Thallus K+ orange, C−, KC−, PD+ orange; containing leprapinic acid (major), calycin (minor), vulpinic acid (minor or trace), pulvinic dilactone (minor or trace).

Etymology. The specific epithet refers to the common occurrence of this species in Western (Latin, *occidentalis*) Australia.

Notes. *Chrysothrix occidentalis* is distinguished by the small thallus granules and the presence of leprapinic acid as the major secondary metabolite. Leprapinic acid has been reported from *Chrysothrix candelaris* on one occasion in material collected in India (Mittal & Seshadri 1955), but this substance was not detected in subsequent investigations of this species by Laundon (1981). Morphologically *C. occidentalis* most closely resembles *C. xanthina* as both species have small thallus granules 20–80 µm wide (Kalb 2001). However, *C. xanthina* contains pinastric acid as the major metabolite (sometimes together with calycin in trace amounts) whereas *C. occidentalis* contains leprapinic acid as the major lichen substance. Pinastric and leprapinic acids can readily be differentiated by thin layer chromatography using a hexane: ethyl acetate (3:1) solvent system (with Rf values of 0·22 and 0·35 respectively). *Chrysothrix candelaris* differs from the new species by having larger thallus granules (75–200 µm wide) and containing calycin (major), very rarely with traces of additional parietin.

This new species is known from a number of localities in south-west Western Australia where it occurs on sheltered granite or laterite ledges in open *Eucalyptus* forests from 100 m to 650 m. Common associated species include *Buellia substellulans* Zahlbr., *Lecanora farinacea* Fée, *Ramboldia petraeoides* (C. Bab. & Mitt.) Kantvilas & Elix, *Xanthoparmelia antleriformis* (Elix) Elix & J. Johnst. and *X. tasmanica* (Hook. f. & Taylor) Hale. *Chrysothrix occidentalis* is less common in eastern Australia and Norfolk Island where it occurs on bark and dead wood in moist temperate and tropical forests. Common associated species in these habitats include *Flavoparmelia rutidota* (Hook. f. & Taylor) Hale, *Lepraria coriensis* (Hue) Sipman, *Parmotrema reticulatum* (Taylor) M. Choisy, *P. tinctorum* (Nyl.) Hale and *Pseudocyphellaria poculifera* (Müll. Arg.) D. Galloway & P. James. A collection of this species from Nepal has also been examined.

Additional specimens examined. **Australia:** *Queensland*: Forrest Beach, 18 km ESE of Ingham, 18°43′02″S, 146°17′50″E, 2 m, on dead tree, 2006, *J. A. Elix* 36793 (CANB); Whitehaven Beach, Whitsunday Island, 20°15′S, 149°00′E, on bark, 1974, *J. M. Gilbert* s.n. (HO). *New South Wales*: Dural, on base of *Eucalyptus*, 1964, *B. Briggs* s.n. (HO); Sydney, Lane Cove River Park, on bark of *Banksia*, 20 m, 1975, *J. A. Elix* 714 (CANB); Forster, 32°11′S, 152°31′E, 12 m, on dead wood, 1977, *J. A. Elix* 3361 (CANB). *Western Australia*: Boyagin Rock, Boyagin Nature Reserve, 20 km NW of Pingelly, 32°28′S, 116°53′E, 350 m, on sheltered granite ledge, 1994, *J. A. Elix* 40971, *H. T. Lumbsch & H. Streimann* (CANB); near summit of Mt. Observation, Mt. Observation National Park, 20 km W of York, 31°53′45″S, 116°33′26″E, 365 m, on sheltered laterite ledge, 2004, *J. A. Elix* 31732 (PERTH), 2006, *J. A. Elix* 36536 (CANB); near summit of Mt Brown, 3 km SE of York, 31°53′16″S, 116°47′07″E, 295 m, on sheltered granite ledge, 2006, *J. A. Elix* 36544 (CANB); Caernarvon Hills, Dryandra Woodland, 17 km NW of Narrogin, 32°48′21″S, 117°03′21″E, 325 m, on sheltered laterite ledge, 2006, *J. A. Elix* 36551 (CANB).—**Norfolk Island:** Rocky Point Reserve, 29°03′S, 167°55′E, 60 m, on *Quercus suber*, 1984, *J. A. Elix* 18193 *& H. Streimann* (CANB); Norfolk Island National Park, West Palm Glen Track, 29°01′06″S, 167°56′33″E, 140 m, on base of *Cyathea*, 1992, *J. A. Elix* 29046 (CANB); Norfolk Island National Park, King Fern Valley 29°00′54″S, 167°56′10″E, 240 m, on palm, 1992, *J. A. Elix* 29315 (CANB).—**Nepal:** *Langtang Himal*: trekking route from Dunche to Kyangjing, between Borbal and Barkhu, 1860–2270 m, on bark, 1991, *W. A. Weber* L-87604 (COLO, HO).

Chrysothrix palaeophila Kantvilas & Elix sp. nov.

Chrysothrici chrysophthalmae affinis et item apotheciis minutis, 0·1–0·3 mm latis, citrinis pruinosis et ascosporis triseptatis, 10–15 µm longis, 2·5–4 µm latis, sed apotheciis plusminusve subpedicellatis et acidum vulpinicum invicem acidum diffractaicum et acidum rhizocarpicum continenti differt.

Typus: Australia, Tasmania, Weindorfers Forest, 41°38′S 145°56′E, on rotting *Athrotaxis selaginoides* wood in rainforest, 920 m altitude, 6 March 1988, *G. Kantvilas 38/88* (HO—holotypus; BM—isotypus).

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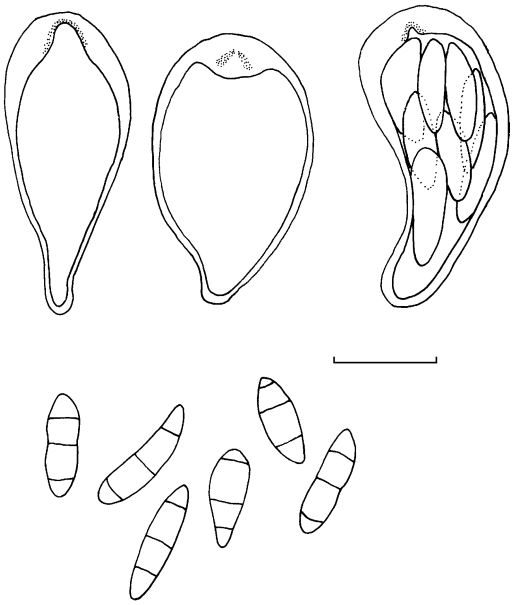


FIG. 2. *Chrysothrix palaeophila* (*Kantvilas* s.n. HO), asci (with amyloid structures stippled) and ascospores. Scale = 10 μm.

(Fig. 2)

Thallus endophloeodal, visible at best only as bleaching of the substratum; *photobiont* a unicellular green alga with individual cells globose, 4–8 μm diam., dispersed or aggregated in chains. Soredia absent.

Apothecia scattered, 0·1–0·3 mm wide, convex to subglobose, immarginate, superficial, basally constricted to subpedicellate, pale yellow-grey to grey-black, typically densely yellow to yellow-green pruinose. *Excipulum* in section to *c.* 10 μm thick, poorly differentiated, soon ± excluded, yellow-brown, intensifying yellowish in KOH, composed of loosely interwoven, branched and anastomosing hyphae. *Hypothecium* 60–100 μm thick, yellow-brown, intensifying yellowish in KOH. *Hymenium* 35–45 μm thick, pale yellow-brown, K/I+ pale blue, inspersed in the upper part with minute, angular crystals that fluoresce pale yellow in polarized light, mostly dissolving in KOH; asci eight-spored, of the *Arthonia*-type, broadly clavate, with a well-developed, very weakly amyloid tholus and, when young, with a beak-like ocular chamber, 25–40 × 9–14 μm; paraphyses very numerous, richly branched and anastomosing, 0·75–1 μm thick, forming a tightly interwoven weft extending to *c.* 10 μm above the level of the asci. *Ascospores* fusiform to ellipsoid, straight or slightly curved, 3-septate, 10–*12·6*–15 × 2·5–*3·2*–4 μm.

Pycnidia not found.

Chemistry. Thallus K−, C−, KC−, PD−; containing vulpinic acid (major), pulvinic dilactone (minor or trace).

Etymology. The specific epithet describes the prediliction (Greek, *-philos*) of the new species for ancient (Greek, *palaeos*) trees.

Notes. With its endophloeodal thallus, tiny, yellow-pruinose apothecia and 3-septate, fusiform-ellipsoid ascospores, *Chrysothrix palaeophila* is clearly closely related to *C. chrysophthalma* of the temperate Northern Hemisphere. The two taxa differ primarily by their chemical composition: vulpinic acid in the former and diffractaic and rhizocarpic acids in the latter. In addition, *C. palaeophila* tends to have rather pedicellate apothecia.

The new species is known from only three Tasmanian collections, all from very old trees in cool temperate rainforest or wet eucalypt forest: the conifers, *Lagarostrobos franklinii* (Hook.f.) Quinn [aged *c.* 1300 years (Jarman & Kantvilas 1995)] and *Athrotaxis selaginiodes* D. Don, and *Eucalyptus obliqua* L'Hérit. The related *C. chrysophthalma* has a similar ecology, occurring on conifers in the British Isles (Purvis 1992). The habitat of *C. palaeophila*, in fissures on dry, cracked wood and on dry, fibrous bark, is generally devoid of other lichens and hence it is likely that this highly inconspicuous, cryptic species has been overlooked elsewhere.

Additional specimens examined. **Australia:** *Tasmania*: *c.* 3 km S of Teepookana, 42°13′S, 145°26′E, 220 m, 1990, *G. Kantvilas* s.n. (HO); Warra LTER site, W of Tomalah Creek, 43°05′S 146°39′E, 270 m, 1999, *G. Kantvilas* 416/99 (HO).

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Chrysothrix tchupalensis Elix & Kantvilas sp. nov.

Chrysothrici granulari similis sed thallo lanato, laxe adnato, granulis maioribus et acidum leprapinicum continenti differt.

Typus: Australia, Queensland, Wooroonooran National Park, Tchupala Falls, 34 km W of Innisfail, 17°36′25″S, 145°46′44″E, 360 m, on sheltered rocks below falls, in tropical rainforest, 29 July 2006, *P. M. McCarthy & J. A. Elix* 36691 (BRI—holotypus; CANB, HO—isotypi).

(Fig. 1B)

Thallus crustose-leprose, bright lemon yellow, very loosely adnate, delimited or not, lacking well-defined lobes, ecorticate, stratified, yellow in the upper part but almost white within, to 1·5 mm thick, forming small, irregularly roundish, convex cushions 0·5–1 cm wide that eventually coalesce into irregularly spreading patches to 5 cm wide; *soredia* granular, with scattered to pulverulent, rounded to spherical, sorediate granules 60–160 µm wide; *photobiont* chlorococcoid, ± spherical, 10–18 µm wide; *hyphae* 1·8–3 µm thick. *Hypothallus* pale grey-white to black.

Apothecia and *pycnidia* not seen.

Chemistry. Thallus K−, C−, KC−, PD−; containing leprapinic acid (major), 4,5-dichlorolichexanthone (minor).

Etymology. The specific epithet refers to the type locality, Tchupala Falls.

Notes. *Chrysothrix tchupalensis* is distinguished by the very loosely adnate, convex, lemon-yellow cushions composed of coarse thallus granules 60–160 µm wide, the pale grey-white to black hypothallus, and by the presence of leprapinic acid and 4,5-dichlorolichexanthone as secondary metabolites. This is the first report of a xanthone in the genus. Morphologically *C. tchupalensis* resembles *C. granularis* Thor as both species have ± stratified thalli of thick, rounded, convex, sometimes almost placodioid cushions. However, *C. granularis* lacks a hypothallus, and its thallus is tightly adnate, has smaller granules 25–42 µm wide and contains calycin and diffractaic acid (Thor 1998; Tønsberg 2004). *Chrysothrix occidentalis* is chemically similar to *C. tchupalensis* but lacks a hypothallus, is more tightly adnate, has smaller granules and contains leprapinic acid and calycin. Futhermore, these two species occupy very different ecological niches: *C. tchupalensis* is found on sheltered, humid rocks in tropical rainforest whereas *C. occidentalis* occurs on dry, sheltered acid rocks in temperate south-western Western Australia and on wood and bark in moist, open forests in eastern Australia.

At present this new species in known only from the type locality in north Queensland where it co-occurs with *Porina crassa* P. M. McCarthy and an unidentified *Cryptothecia* species.

New Combination

Chrysothrix sulphurella (Räsänen) Kantvilas & Elix comb. nov.

Lepraria sulphurella Räsänen, *Suom. Eläin-ja Kasvit. Seuran Van. Tiedon. Pöytäkirjat* **3:** 188 (1949); type: [Australia] Victoria, Black Spur, ad corticem arboris, 1888, *F. R. M. Wilson* (H—holotype!).

Previously this species was known only from the type collection. As Räsänen (1949) offered only a brief diagnosis of this species, a full description is presented here.

Thallus crustose, effuse, very thin, mostly 20–40 µm thick, whitish to pale glaucous to dull olive-grey, not delimited, ecorticate, in small irregular colonies that coalesce to form wide-spreading patches to 5(–10) cm wide, sorediate, eventually becoming ± entirely leprose; *soredia* vivid lemon yellow to yellow-orange, initially in punctiform soralia but soon becoming diffuse and forming thick cushions to 0·5 mm thick, composed of ± spherical granules 8–30 µm wide; *photobiont* a unicellular green alga with cells ± globose, 5–8 µm wide, mostly aggregated in clumps; *hyphae* short-celled, 1·5–2·5 µm wide.

Apothecia and *pycnidia* not seen.

Chemistry. Thallus K+ orange-red, C+ orange, PD− or PD+ yellow; containing

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atranorin (major, minor or trace), xantholepinone A (major), xantholepinone X (minor), unknown eumitrin derivative (minor).

Notes. *Chrysothrix sulphurella* is distinguished by its corticolous, vivid lemon-yellow to yellow-orange sorediate thallus comprising very fine granules, and by the presence of xantholepinone A as the major secondary metabolite. Morphologically it most closely resembles *C. xanthina* as both species have bright yellow thalli with relatively fine thallus granules. However, whereas the former is leprose-sorediate from the outset, *C. sulphurella* is initially crustose and only becomes sorediate at maturity. Furthermore, the granules of *C. sulphurella* are finer than those of *C. xanthina* (8–30 µm cf. 20–80 µm wide) and these two species also differ chemically. Whereas *C. xanthina* is a rather opportunistic species, commonly found on saxicolous substrata and exotic, wayside trees, *C. sulphurella* is exclusively corticolous in wet native forests.

This species is known from south-eastern Australia and Tasmania where it occurs on trees in wet *Eucalyptus* forests or temperate rainforests from 80 m to 1000 m altitude. Smooth-barked phorophytes such as *Atherosperma moschatum* Labill. and *Pomaderris apetala* Labill. are especially favoured. Common associated species include *Hypogymnia subphysodes* (Kremp.) Filson, *Lepraria lobificans* Nyl., *Pannaria elixii* P. M. Jørg. & D. J. Galloway, *P. microphyllizans* (Nyl.) P. M. Jørg., *Parmotrema reticulatum* (Taylor) M. Choisy and *Thelotrema lepadinum* (Ach.) Ach.

Additional specimens examined. **Australia:** *New South Wales*: Monga State Forest, along the Mongarlowe River, 3·5 km S of Monga, 35°37′S, 149°55′E, 665 m, on tree trunk, 1984, *J. A. Elix* 11740 *& P. W. James* (CANB); Misty Mountain Road, Currowan State Forest, 23 km NW of Batemans Bay, 35°34′S, 149°59′E, 400 m, on dead wood, 1989, *J. A. Elix* 22037 (CANB); Monga National Park, Penance Grove, 28 km SE of Braidwood, 35°35′58″S, 149°54′51″E, 655 m, on base of *Acacia*, 2005, *J. A. Elix* 36642 (CANB, HO). *Tasmania*: Edwards Road, Arve Valley, 80 m, on *Pomaderris apetala*, *G. Kantvilas* 327/80, 1980 (HO); Adamsons Road, near Strathblane, 1000 m, on *Atherosperma moschatum*, 1981, *G. Kantvilas* 1063/81 (HO); Weldborough, 41°12′S, 147°54′E, 770 m, on *Atherosperma moschatum*, 1981, *G. Kantvilas* 1125/81 (HO); S of Meunna, on *Atherosperma moschatum*, 1982, *G. Kantvilas* s.n. (HO); SE slopes of McGregor Peak, 42°59′S, 147°57′E, 400 m, on trunks of *Atherosperma moschatum*, 1989, *G. Kantvilas* 366/89 (HO); Bun Hill, Forestier Peninsula, 41°58′S, 147°56′E, 320 m, on *Atherosperma moschatum*, 1989, *G. Kantvilas* 377/89 (HO); Rebecca Road, *c.* 4 km W of Nelson Bay River, 41°12′S, 144°47′E, 120 m, on *Pomaderris apetala*, 1990, *G. Kantvilas* 211/90 (HO); en route to Cape Surville, 42°57′S, 147°59′E, 130 m, on *Beyeria vicosa*, 2000, *G. Kantvilas* 346/00 (HO); Buckland Military Training Area, S of Bluestone Tier, 42°30′S, 147°48′E, 300 m, on *Olearia argophylla*, 2003, *G. Kantvilas* 322/03 (HO); Arve Road, Zig Zag Track, 43°06′S, 146°44′E, 170 m, on *Pomaderris apetala*, 2006, *G. Kantvilas* 281/06 (HO).

New records of *Chrysothrix* for Australia and New Zealand

Chrysothrix granulosa G. Thor

Bryologist **91:** 361 (1988).

Chrysothrix granulosa is characterized by a lemon-yellow, leprose-sorediate thallus that often forms rounded, convex, placodioid cushions, a well developed medulla that is yellow in the upper half and may be almost white in the lower part, and by the presence of diffractaic acid (major) and calycin (minor). Apothecia were not observed in the Australian material. This species was known previously from South and North America (Thor 1988; Tønsberg 2004). A detailed description is given in both references. This species usually occurs in dry, sheltered overhangs on rock, wood or bark.

Selected specimens examined. **Australia:** *Tasmania*: Weldborough, 41°12′S, 147°54′E, on tree, 1963, *G. C. & M. H. Bratt* 823 (HO); 7 km S of Bracknell Gorge near Cross Roads, 41°43′S, 146°57′E, on sandstone, 1967, *G. C. Bratt & J. A. Cashin* 67/31a (HO); De Witt Island, 43°35′S, 146°20′E, on dead wood, 1977, *J. A. Elix* 3325 (CANB), 1977, *A. M. Gray* s.n. (HO); Newdegate Creek, near Granville Harbour, 90 m, on *Nothofagus cunninghamii*, 1982, *G. Kantvilas* 136/82 (HO); Weldborough Pass, 41°13′S, 147°57′E, 560 m, on dry old *Nothofagus cunninghamii*, 1995, *G. Kantvilas* 59/95 (HO); Alum Cliffs, 41°32′S, 146°26′E, 350 m, on rocks in dry, sheltered overhang, 2005, *G. Kantvilas* 358/05 (HO); Île du Golfe, 43°34′S, 146°31′E, on bark, 1987, *S. Smith* s.n. (HO). *Western Australia*: Gairdner River, South Coast Highway, 5 km ENE of Jerramungup, 33°15′S, 118°58′E, 260 m, on *Hakea*

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twigs, 1994, *J. A. Elix* 41556 (CANB).—**New Zealand:** *North Island*: Gisbourne, Hawkes Bay, 10 km N of Tiniroto, 38°40′S, 177°34′E, on totara in open woodland, 1982, *J. A. Elix* 10104 (CANB). *South Island*: Canterbury, Port Hills, Lyttelton, SW slopes of Mt. Pleasant, 42°59′S, 173°07′E, 485 m, on moist rock overhang, 1980, *J. A. Elix* 6697 (CANB).

Chrysothrix xanthina (Vain.) Kalb

Biblioth. Lichenol. **78:** 144 (2001).

This species was previously known from Africa, Asia, Macaronesia, Madagascar, North America, South America and in Australia from New South Wales (Kalb 2001; McCarthy 2006). It occurs on trees and rocks in open eucalypt forests, rainforest and on exotic trees in parks and along roadsides. It contains pinastric acid (major), vulpinic acid (minor or trace) and pulvinic dilactone (minor or trace).

Selected specimens examined. **Australia:** *Northern Territory*: Umbrawarra Gorge, 22 km SW of Pine Creek, 13°59′S, 131°41′E, 220 m, on tree, 1988, *J. A. Elix* 22510 *& H. Streimann* (CANB); Murrenja Hills, 26 km NNE of mouth of Daly River, 13°07′S, 130°14′E, 20 m, on rocks, 1991, *J. A. Elix* 27738, *H. T. Lumbsch & H. Streimann* (CANB); Howard Springs National Park, 12°28′03″S, 131°02′54″E, 15 m, on dead tree, 2005, *J. A. Elix* 36737 (CANB). *Queensland*: Moreton District, Burleigh Heads National Park, 28°06′S, 153°26′E, 7 m, on bark, 1975, *J. A. Elix* 1158 (CANB); Mt. Whitfield, Cairns, 16°53′S, 145°44′E, 120 m, on dead wood, 1976, *J. A. Elix* 2562 (CANB); Marcus Beach, 5 km S of Noosa Heads, 26°26′S, 153°06′E, 1 m, on *Casuarina*, 1982, *J. A. Elix* 10396 (CANB); Black Gap, Black Trevethan Range, 21 km SSW of Cooktown, 15°39′S, 145°13′E, 100 m, on sheltered granite ledge, 1984, *J. A. Elix* 17342 *& H. Streimann* (CANB); Three Mile Creek, 5 km N of Townsville, 19°16′S, 146°49′E, 1 m, on dead mangrove, 1986, *J. A. Elix* 20059 *& H. Streimann* (CANB); Carnarvon Highway, 8 km S of Bullaroo River Bridge, 68 km N of Injune, 25°14′S, 148°36′E, 380 m, on dead branch, 1993, *J. A. Elix* 34082 (CANB); Callide Range, Dawson Highway, 19 km ENE of Biloela, 24°14′S, 150°34′E, 350 m, on dead *Acacia*, 1993, *J. A. Elix* 34830 (CANB); Bauhinia Downs-Duaringa road, 34 km SW of Duaringa, 23°59′S, 149°31′E, 150 m, on *Callitris*, 1993, *J. A. Elix* 34956 (CANB); Razorback Range, 3 km NW of Mount Morgan, 23°28′S, 150°22′E, 280 m, on metamorphic rocks, 1993, *J. A. Elix* 34641 (CANB); Ka Ka Mundie National Park, 0·8 km from Bunbuncundoo Spring camping area, 24°51′S, 147°26′E, 200 m, on bark, 1993, *R. W. Purdie* 4345 (CANB); Red Rock, 2 km SE of Einasleigh, 18°31′S, 144°06′E, 560 m, on shrub, 1990, *H. Streimann* 46803 (CANB); Leichhardt Highway, 12 km NNW of Taroom, 25°32′S, 149°46′E, 200 m, on base of tree, 1993, *H. Streimann* 52582 (CANB). *Australian Capital Territory*: Molonglo Gorge Reserve, 35°16′S, 149°16′E, on dead *Callitris*, 1971, *J. A. Elix* 5 (CANB); S of Paddys River near Murrays Corner, 35°22′S, 148°57′E, 620 m, on bark of *Leptospermum*, 1975, *J. A. Elix* 654 (CANB); Gudgenby River Gorge, 4·5 km S of Tharwa, 35°44′S, 149°04′E, 650 m, on dead wood, 1979, *J. A. Elix* 6058 (CANB); Black Mountain, 5 km NW of Canberra, 35°16′S, 149°06′E, 780 m, on rock, 1980, *H. Streimann* 10262 (CANB). *Victoria*: Along Bemm River, 21 km W of Cann River, 37°40′S, 148°54′E, 100 m, on tree trunk, 1978, *J. A. Elix* 5269 (CANB); near Bright, 36°43′S, 146°57′E, on dead wood, 1972, *P. Holbeach* 72/685 (HO); Sassafras Road, E of Melbourne, on *Eucalyptus regnans*, 1992, *G. Kantvilas* s.n. (HO); Kilmore-Lancefield Road, 37°19′S, 145°48′E, 530 m, on *Eucalyptus* trunk, 1981, *H. Streimann* 15487 (CANB); Acheron Way, 3 km N of Warburton, 37°44′S, 145°43′E, 480 m, on *Eucalyptus* trunk, 1993, *H. Streimann* 50810 (CANB). *Tasmania*: Ulverstone, 41°10′S 146°11′E, 2 m, on tree trunk, 1993, *J. A. Elix* 40299 *& G. Kantvilas* (CANB); Stanley Peninsula, 0·5 km W of Stanley Highway, 40°47′S, 145°16′E, 10 m, on bark of *Melaleuca*, 1998, *A. Gray* s.n. (HO); Styx River Valley, 370 m, on *Nothofagus cunninghamii*, 1981, *G. Kantvilas* 1051/81 (HO); *c.* 0·5 km N of Woolnorth, 40°41′S, 144°43′E, on bark of *Eucalyptus nitens*, 1999, *D. I. Morris* 86669 (HO); Evandale, 41°34′S 147°14′E, 170 m, 2002, *G. Kantvilas* 263/02 (HO); Launceston Royal Park, 41°26′S 147°08′E, 5 m, on *Quercus robur*, 2006, *G. Kantvilas* 366/06 (HO); Cascade Gardens, 42°54′S 147°18′E, 90 m, on shaded sandstone, 2006, *G. Kantvilas* 378/06 (HO). *South Australia*: near Kybybolite, on bark, 1974, *M. Beck* 244 (HO). *Western Australia*: Darling District, Ludlow Tuart Reserve, 8 km E of Busselton, 33°39′S, 115°50′E, on dead wood, 1982, *J. A. Elix* 10741 *& L. H. Elix* (CANB); 3 km E of Kununurra, 15°47′S, 128°45′E, 70 m, on sandstone rocks, 1988, *J. A. Elix* 22093 *& H. Streimann* (CANB); King Leopold Range, 22 km NE of the Lennard River along the Gibb River Road, 17°15′S, 124°54′E, 150 m, on metamorphic rocks, 1988, *J. A. Elix* 22164, *H. Streimann & D. J. Galloway* (CANB); Mt. Nyulasy, Great Northern Highway, 5 km N of Wilson River Crossing between Turkey Creek and Wyndham, 16°45′S, 128°17′E, 200 m, on sheltered granite crevices, 1988, *J. A. Elix* 22405 *& H. Streimann* (CANB); Lake Argyle Road, 35 km SE of Kununurra, 16°01′S, 128°59′E, 140 m, on shaded rocks, 1988, *J. A. Elix* 22480 *& H. Streimann* (CANB); Lake Argyle Road, 31 km SE of Kununurra, 15°59′S, 128°56′E, 160 m, on sandstone rocks, 1991, *J. A. Elix* 27799, *H. T. Lumbsch & H. Streimann* (CANB); Gibb River Road, 54 km NNE of Karunjie Station, 15°51′S, 127°25′E, 270 m, on sandstone rocks, 1991, *J. A. Elix* 27867, *H. T. Lumbsch & H. Streimann* (CANB).—**Norfolk Island:** Rocky Point Reserve, 29°03′S, 167°55′E, 60 m, on charred stump, 1984, *J. A. Elix* 18205 *& H. Streimann* (CANB); New Farm Road,

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Rocky Point Reserve, 29°03′S, 167°55′30″E, 65 m, on *Hibiscus* stem, 1984, *H. Streimann* 31845 (CANB).—**New Zealand**: North Island, Auckland Ecological Region, Awhitu Ecological District, Hamilton Road, Taitua Reserve, 37°06′S, 174°35′E, 70 m, on manuka, 1996, *D. B. Rogan* 26 *& A. R. Jameison* (HO).

Additional Species Studied

Chrysothrix candelaris (L.) J. R. Laundon

Lichenologist **13:** 110 (1981).

The name *C. candelaris* has been very widely applied in the literature and in herbaria to several species. In the Australasian region, most records appear to refer to *C. xanthina*, which Laundon (1981) regarded as a synonym. *Chrysothrix candelaris* is a widespread species characterized by the presence of calycin only; by contrast, *C. xanthina* contains pinastric acid. A full description is provided by Laundon (1981). This species appears to be most closely related to *C. granulosa* and, in the case of most Tasmanian specimens seen, chemical analysis to check for the presence of diffractaic acid (diagnostic for *C. granulosa*) is essential for reliable identification. In Tasmania, the two species have somewhat different ecologies: *C. candelaris* is saxicolous in dry sheltered overhangs on cliffs and bluffs whereas *C. granulosa* is mostly corticolous in wet forests.

Selected specimens examined. **Australia:** *Queensland*: Pine Mountain State Forest, near Flutter Creek, 24 km SSW of Calliope, 24°12′S, 151°05′E, 100 m, on vine in dry monsoon scrub, 1993, *J. A. Elix* 34822 (CANB). *Victoria*: Great Dividing Range, Hanging Rock, 37°20′S, 144°36′E, on rock, 1976, *N. N. Donner* 5539 (AD, CANB). *Tasmania*: Coal River Gorge, between Colebrook and Tunnack, 41°29′S, 147°24′E, 160 m, on sheltered sandstone rocks, 1974, *J. M. Gilbert* 74/592 (HO); Elderslie area, *c.* 200 m, on dolerite outcrops in dry overhangs, 1981, *G. Kantvilas* 456/81 (HO); Coal River Gorge, above the western tip just outside the Nature Reserve, 41°29′S, 147°24′E, 360 m, on rocks in dry overhangs, 2002, *G. Kantvilas* 120/02 (HO); Northern slopes of Byatts Razorback, 41°34′S, 147°49′E, 850 m, on sheltered dolerite underhang, 2002, *G. Kantvilas* 203/02 (HO); Bluff River Gorge, 42°31′S, 147°40′E, 200–250 m, on dry sandstone underhangs, 2005, *G. Kantvilas* 128/05 (HO).—**Norway:** Hordaland, Kvinnherad, between Gjermundshavn and Ølve, the NW-facing slope E of Lakelet Kvitebergsvatnet, 60°01′N, 5°52′E, 100 m, on dead trunk of *Alnus incana*, 1998, *T. Tønsberg* 26172 *& J. Berge* (*Lichenes Isidiosi et Sorediosi Crustacei Exsiccati*, no. 29, CANB); Hordaland, Voss, S of Vinje, just E of River Strandelvi, farm Kvarme, 60°45′N, 6°30′E, 170 m, on wooden N wall of a small barn, 1998, *T. Tønsberg* 26176 (*Lichenes Isidiosi et Sorediosi Crustacei Exsiccati*, no. 30, CANB).

Chrysothrix chlorina (Ach.) J. R. Laundon

Lichenologist **13:** 106 (1981).

Chemistry. Calycin (minor), vulpinic acid (major), lobaric acid (trace).

Specimens examined. **Austria:** *Steiermark*: Schladminger Tauern, Riesachsee, SE of Schladming, 47°20′N, 13°46′E, 1250–1330 m, saxicolous in very shaded overhang, 1990, *H. Mayrhofer & G. Kantvilas* 381/90 (HO).—**Norway:** Hordaland, Odda, the W facing slope of Lake Sandvinvatnet, Midskreda, 60°03′N, 6°34′E, 180–200 m, saxicolous in dry, sheltered cavities, 1998, *T. Tønsberg* 26188 (*Lichenes Isidiosi et Sorediosi Crustacei Exsiccati*, no. 32, CANB).

Chrysothrix flavovirens Tønsberg

Graphis Scripta **6:** 31 (1994).

Chemistry. Rhizocarpic acid (major), diffractaic acid (major), barbatic acid (minor), epanorin (minor), and conrhizocarpic acid (trace)

Specimens examined. **Great Britain:** *Scotland*: Isle of Mull, Sput Dubh, N Aros Park, Mull, sheltered, E-facing woodland near coast, 1994, *G. Kantvilas*, *B. J. Coppins & A. M. O'Dare* (HO).—**Sweden:** *Södermanland Province*: Utö par., NE part of island Utö, at the shore opposite the small island of Svartkobb, 1·9 km ESE of Utö kvarn, 58°57′N, 19°21′E, 100 m, on decorticated *Pinus sylvestris*, 1988, *G. Thor 7508* (*Lichenes Selecti Exsiccati Upsalienses* no. 55, as *Chrysothrix chrysophthalma* (P. James) P. James & J. R. Laundon, CANB).

Chrysothrix pavonii (Fr.) J. R. Laundon

Lichenologist **13:** 117 (1981).

Chemistry. Calycin

Specimen examined. **Chile:** *Antofagasta Province*: Paposo, fog zone in coastal hills, 720 m, on branches of spiny shrubs, 1972, *P. W. Rundel* 7118 (as *Chrysothrix noli-tangere* (Mont.) Mont., HO).

https://doi.org/10.1017/S0024282907006998 Published online by Cambridge University Press

Key to the species of *Chrysothrix* in Australia

1 Thallus immersed; apothecia spherical immarginate, subpedicellate; disc yellow pruinose . . . . . **C. palaeophila**
Thallus superficial; leprose, apothecia usually absent 2

2(1) Thallus C+ orange; xantholepinone A present . . . . . **C. sulphurella**
Thallus C − ; calycin, pinastric acid or leprapinic acid present 3

3(2) Calycin present (acetone extract forming an orange-red spot on silica gel plate) 4
Calycin absent (acetone extract forming a yellow spot on silica gel plate) . . . 6

4(3) Granules coarse (75–200 μm wide); calycin only present . . . . **C. candelaris**
Granules finer (20–80 μm wide); calycin and leprapinic or diffractaic acid present 5

5(4) Thallus distinctly to weakly stratified; granules compact, very fine (20–45 μm wide); calycin and diffractaic acid present . . . . . **C. granulosa**
Thallus not stratified; granules loose, larger (20–80 μm wide); calycin and leprapinic acid present . . . . . **C. occidentalis**

6(3) Thallus distinctly to weakly stratified, fluffy, forming loosely adnate, convex cushions; granules coarse (60–160 μm wide); leprapinic acid present . . . . . **C. tchupalensis**
Thallus not stratified, adnate; granules finer (20–80 μm wide); pinastric acid ± vulpinic acid present . . . . . **C. xanthina**

We thank Neal McCracken of ANU photography for preparing the photographs and the Director of the Finnish Museum of Natural History (H), for a loan of the type specimen of *Lepraria sulphurella* Räsänen.

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Accepted for publication 14 *May* 2007

https://doi.org/10.1017/S0024282907006998 Published online by Cambridge University Press