New combinations of *Tetramelas* (Caliciaceae, Ascomycota) and a key to the species in Antarctica

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Abstract

The new combinations *Tetramelas anisomerus* (Nyl.) Elix, *T. cladocarpizus* (I.M.Lamb) Elix, *T. darbishirei* (I.M.Lamb) Elix, *T. grimmiae* (Filson) Elix, *T. inordinatus* (Hue) Elix, *T. nelsonii* (Darb.) Elix and *T. subpedicellatus* (Hue) Elix are proposed, and a key is provided to the eleven species of *Tetramelas* present in Antarctica.

Introduction

In their monograph of the *Lichens of Antarctica and South Georgia,* Øvstedal & Lewis-Smith (2001) recorded a total of 30 species of *Buellia sens. lat.* Four of those species have since been transferred to *Amandinea* (Søchting *et al.* 2004), and four to *Tetramelas* (Kalb 2004; Nordin 2004; Elix 2017). Phylogenetic studies have confirmed that *Tetramelas* Norman constitutes a well-founded segregate of *Buellia sens. lat.* (Helms *et al.* 2003; Nordin & Tibell 2005). Generic characters often include the presence of xanthones (arthothelin, 6-*O*-methylarthothelin, isoarthothelin or 2,5,7-trichloro-3-*O*-methylnorlichexanthone), commonly curved, 1–3-septate ascospores with pointed apices that show *Callispora*-type thickenings in early ontogeny (Giralt *et al.* 2009), and a predominantly Arctic-Antarctic or alpine-subalpine distribution (Kalb 2004). Careful study has shown that a further seven species among the remaining 22 buellioid taxa recorded from Antarctica by Øvstedal & Lewis-Smith (2001) belong to *Tetramelas*.

In this contribution, a key is provided to the species of *Tetramelas* present in Antarctica, and seven new combinations are proposed for the genus.

Methods

Observations and measurements of thallus and apothecium anatomy, asci, ascospores and conidia were made on hand-cut sections mounted in water and treated with 10% potassium hydroxide (K) and 50% nitric acid (N). Asci were also observed in Lugol's Iodine (I), with and without pretreatment in K. Chemical constituents were identified by thin-layer chromatography (TLC) (Elix 2014) and comparison with authentic samples.

The new combinations

1. Tetramelas anisomerus (Vain.) Elix, comb. nov.
MycoBank number: **MB 825485**
Basionym: *Buellia anisomera* Vain., Lichens. In *Expédition Antarctique Belgique. Résultats du Voyage du S.Y. Belgica en 1897–1898–1899 sous le commandement de A. Gerlache de Gomery. Rapports Scientifiques. Botanique*: 26 (1903).
Type: Antarctica, West Graham Land, Wiencke Island, 64°50'S, 63°25'W, on granodioritic rock, *E. Racovitza BAE 447 pr.p.*, 1897–1899 (BR – holotype; TUR – isotype not seen).
The synonymy, a detailed description and illustrations of this species can be found in Lamb (1968).
Chemistry: Thallus K– or K+ pale yellow, P–, C+ yellow-orange, UV+ orange; containing arthothelin (major), atranorin (minor or trace), thiophanic acid (minor or trace), 4,5-dichloronorlichexanthone (minor), 2,5-dichloronorlichexanthone (trace), 2,4-dichloronorlichexanthone (trace).

This widespread Antarctic species is known from the Antarctic Peninsula, South Georgia, Bouvetøya, South Sandwich Islands, South Orkney Islands and South Shetland Islands (Øvstedal & Lewis Smith 2001; Søchting *et al.* 2004). It is characterized by a yellow to pale yellow-grey, crustose thallus that contains arthothelin but lacks medullary calcium oxalate, an amyloid medulla, sessile, lecideine apothecia, 0.5–1.3 mm wide, a dark brown to olive-brown, N– epihymenium, often curved, *Callispora*- then *Buellia*-type ascospores, 16–[*19.6*]–24 × 6–[*8.2*]–10 µm, that become constricted at maturity and have a microrugulate outer spore-wall, and bacilliform conidia, 4–6 × 0.8–1 µm. The spores are usually 1-septate, but sometimes develop 1 or 2 additional septa. The species closely resembles *T. concinnus* (Th.Fr.) Giralt, which differs in having shorter ascospores, 13–[*17.1*]–22 µm long, a thinner hymenium, 60–80 µm thick (cf. 75–110 µm thick in *T. anisomerus*) and shorter conidia, 2–4 × 1–2 µm.

SPECIMENS EXAMINED
Antarctica: ● South Shetland Islands, Livingston Island, Punta Polaca, 62°40'S, 60°23'W, on bird perching stone near the shore, *U. Søchting 7593*, 12–28.ii.1998 (C).
Australia: *Macquarie Island*: ● Gadgets Gully, *c.* 2.4 km S of ANARE Station, 54°30'S, 158°55'E, 60 m alt., on rock with E aspect, *R.B. Filson 6358B & P. Atkinson*, 18.iii.1964 (MEL); ● Hasselborough Bay, 54°30'S, 158°57'E, 10 m alt., on stones in scree outwash at base of plateau slope, upper raised beach terrace, *R.D. Seppelt 19524 pr.p.*, 5.ii.1995 (HO) [these specimens were previously misidentified as *T. concinnus*].
South Georgia: ● Royal Bay, above Köppen Point, 54°30'S, 36°02'W, 30 m alt., on dry, S-facing bird perching stone, *D.C. Lindsay s.n.*, 25.i.1972 (MEL).

2. Tetramelas cladocarpizus (I.M.Lamb) Elix, comb. nov.
MycoBank number: **MB 825486**
Basionym: *Buellia cladocarpiza* I.M.Lamb, *British Antarctic Survey Scientific Reports* **61**, 24 (1968).
Type: Antarctica, West Graham Land, Wiencke Island, Noble Peak, 64°48'S, 63°25'W, 135 m alt., on S-facing, slightly overhanging face of granodioritic rock in an outcrop, *I.M. Lamb FIDS A1782*, 19.xi.1944 (BM – holotype not seen).

A detailed description and illustrations of this species can be found in Lamb (1968).
Chemistry: Thallus K+ yellow, P+ pale yellow, C–, UV–; containing atranorin (major).

This Antarctic endemic is known from the Antarctic Peninsula and South Shetland Islands (Øvstedal & Lewis Smith 2001; Søchting *et al.* 2004). It is characterized by a thick, grey to grey-white, crustose thallus that forms granular cushions to 15 mm thick, and contains atranorin but lacks medullary calcium oxalate. It has an amyloid medulla, broadly adnate to sessile, lecideine apothecia, 0.5–2 mm wide, a dark brown to olive-brown, N– epihymenium, a finely inspersed hymenium, often curved, *Callispora*- then *Buellia*-type ascospores, 17–[*19.8*]–24 × 7–[*9.5*]–11 µm, which become constricted at maturity and have a microrugulate outer spore-wall, and bacilliform conidia, 5–7 × 1 µm. The spores are usually 1-septate, but sometimes develop 1 or 2 additional septa. It is chemically identical to *T. papillatus* (Sommerf.) Kalb, but the latter differs in growing on moribund bryophytes, in having a non-inspersed hymenium and a non-amyloid medulla (Nordin 2005).

SPECIMEN EXAMINED
Antarctica: ● South Shetland Islands, King George Island, E side of Esther Harbour, 61°55'S, 57°59'W, 0–1 m alt., on rock, Discovery Expedition 1936–37, *collector unknown 1949–3*, 6.i.1937 (BM).

3. Tetramelas darbishirei (I.M.Lamb) Elix, comb. nov.
MycoBank number: **MB 825487**
Basionym: *Buellia darbishirei* I.M.Lamb, *British Antarctic Survey Scientific Reports* **61**, 23 (1968).
Type: Antarctica, East Graham Land, Hope Bay, 63°24'S, 57°00'W, on rocks, *C. Skottsberg SAE 170,* 11.xi.1903 (S – holotype!).

A detailed description and illustrations of this species can be found in Lamb (1968).
Chemistry: Thallus K+ pale yellow or K–, P+ pale yellow or P–, C+ pale orange, UV+ pale orange; containing atranorin (major or minor), 6-*O*-methylarthothelin (major or minor), 4,5-dichloro-6-*O*-methylnorlichexanthone (minor or trace).

This species is known from the Antarctic Peninsula and continental Antarctica (Øvstedal & Lewis Smith 2001). It is characterized by a verruculose, off-white to grey-brown thallus in which the verrucae can form small cushion-like clumps to 3 mm thick, and it contains 6-*O*-methylarthothelin but lacks medullary calcium oxalate. It has an amyloid medulla, immersed then adnate to sessile, lecideine apothecia, 0.3–0.8 mm wide, a dark brown to olive-brown, N– epihymenium, often curved, *Callispora*- then *Buellia*-type ascospores, 14–[*17.4*]–21 × 6–[*7.3*]–9 µm, which become constricted at maturity and have a microrugulate outer spore-wall, and bacilliform conidia, 4–6 × 0.7–1 µm. The spores are mostly 1-septate, but rarely develop 1 or 2 additional septa. It is morphologically similar to *T. inordinata* (below), but the latter differs in having an aeruginose, N+ red-violet to purple-brown epihymenium.

SPECIMEN EXAMINED
Antarctica: ● Marie Bryd Land, Edward VII Peninsula, Rockefeller Mountains, Paterson Ridge, 78°03'S, 155°00'W, on rock, *P.A. Broady 48,* 1.i.1988 (HO).

4. Tetramelas grimmiae (Filson) Elix, comb. nov.
MycoBank number: **MB 825488**
Basionym: *Buellia grimmiae* Filson, *Lichens and Mosses of MacRobertson Land* (Melbourne) 34 (1966).
Type: Antarctica, MacRobertson Land, Field Rock, 1.6 km E of Mawson, 67°36'S, 62°54'E, growing over patches of *Grimmia lawiana*, *R. Filson 4456*, 9.xii.1962 (MEL– holotype!).

A detailed description and illustrations of this species can be found in Filson (1966).
Chemistry: Thallus K–, P–, C–, UV–; no lichen substances detected by TLC.

This species is known from continental Antarctica, the Antarctic Peninsula and the South Shetland Islands (Filson 1966; Øvstedal & Lewis Smith 2001; Søchting *et al.* 2004). It is characterized by a thick, verruculose, white to grey-white, compacted granular to areolate or verrucose thallus that lacks lichen substances and medullary calcium oxalate. It has a strongly amyloid medulla, sessile, lecideine apothecia, 0.5–1 mm wide, a dark olive-brown to aeruginose-black, N+ red-violet to purple-brown epihymenium, sometimes curved, *Callispora*- then *Buellia*-type ascospores, 15–[*17.1*]–25 × 7–[*8.4*]–13 µm, which become constricted at maturity and have a microrugulate to rugulate outer spore-wall, and bacilliform conidia, 3–5 × 0.7–1 µm. The spores are invariably 1-septate.

SELECTED SPECIMENS EXAMINED
Antarctica: ● Wilkes Land, Windmill Islands, Bailey Peninsula, SSSI 60 m N of melt lake, 66°17'S, 110°32'E, *c.* 45 m alt., on sand and dead *Ceratodon purpureus* in moraine debris, *R.D. Seppelt 13121*, 14.xii.1982 (HO); ● *loc. id., R.D. Seppelt 13237*, 20.xii.1982 (HO); ● *loc. id., R.D. Seppelt 16761*, 5.xii.1986 (HO).

5. Tetramelas inordinatus (Hue) Elix, comb. nov.
MycoBank number: **MB 825489**
Basionym: *Lecidea inordinata* Hue, Lichens. In *Deux Expéditions Antarctiques Française (1908–10), sciences naturelles*: 122 (1915).
Buellia inordinata (Hue) Darb., *British Antarctic Terra Nova Expedition 1910, Natural History Reports*, Botany, **1**(3), 63 (1923).
Type: Antarctica, West Graham Land, Booth Island, Jeanne Hill, 65°04'S, 64°02'W, 30–100 m alt., on diorite rocks, *unknown collector FAE 1908-10/115 pr.p.*, 30.xii.1908 (PC – lectotype *fide* I.M. Lamb *British Antarctic Survey Scientific Reports* **61**, 23, 1968; not seen).

A detailed description of this species can be found in Lamb (1968) and an illustration of the ascospores in Hue (1915, as *Lecidea inordinata*).
Chemistry: Thallus K+ pale yellow or K–, P+ pale yellow or P–, C+ pale orange, UV+ pale orange; containing ± atranorin (major or minor), 6-*O*-methylarthothelin (major or minor), 4,5-dichloro-6-*O*-methylnorlichexanthone (minor or trace).

This species is known from the Antarctic Peninsula and the South Orkney Islands (Lamb 1968). It is characterized by a thick, straw-yellow to cream, granular-verruculose, crustose thallus that contains atranorin and 6-*O*-methylarthothelin. It has an amyloid medulla, broadly adnate to sessile, lecideine apothecia, 0.4–1 mm wide, an aeruginose to brown-black, N+ red-purple to purple-brown epihymenium, often curved, *Callispora*- then *Buellia*-type ascospores, 14–[*17.5*]–23 × 6–[*7.3*]–10 µm, which become constricted at maturity and have a microrugulate outer spore-wall, and bacilliform conidia, 4–6 × 0.7–1 µm. The spores are mostly 1-septate, but very rarely develop 1 or 2 additional septa. It is morphologically similar to *T. anisomerus* (above), but differs mainly in having an aeruginose, N+ epihymenium (Lamb 1968) and different chemistry.

SPECIMEN EXAMINED
Antarctica: ● West Graham Land, Wiencke Island, Goudier Island, 64°50'S, 63°31'W, 7.5 m alt., on basalt dyke, *I.M. Lamb FIDS A2232j*, 14.i.1945 (BM).

6. Tetramelas nelsonii (Darb.) Elix, comb. nov.
MycoBank number: **MB 825490**
Basionym: *Buellia nelsonii* Darb., *Wissenschaftliche Ergebnisse der Schwedischen Südpolar-Expedition 1901–1903*, **4**(11), 15 (1912).
Type: Nelson Island, South Shetland Islands, 62°17'S, 59°02'W, on rock, *C. Skottsberg SAE 35/37 pr.p.*, 11.i.1902 (S – holotype!).

A detailed description and illustrations of this species can be found in Lamb (1968).
Chemistry: Thallus K+ pale yellow or K–, P–, C+ yellow, UV+ yellow-orange; containing ± atranorin (major or minor), 6-*O*-methylarthothelin (major or minor), 4,5-dichloro-6-*O*-methylnorlichexanthone (minor or trace).

This species is known from the South Shetland Islands (Lamb 1968) and continental Antarctica. It is characterized by a dirty yellow, rimose-areolate thallus containing atranorin and 6-*O*-methyl-arthothelin, with a marginal, black prothallus. It has a non-amyloid medulla, crowded, broadly adnate to sessile, lecideine apothecia, 0.3–0.5 mm wide, an aeruginose-black, N+ red-purple to purple-brown epihymenium, often curved, *Callispora*- then *Buellia*-type ascospores, 14–[*16.6*]–20 × 6–[*7.1*]–9 µm, which become constricted at maturity and have a microrugulate outer spore-wall, and bacilliform conidia, 4–6 × 0.7–1 µm. The spores are mostly 1-septate, but very rarely develop 1 or 2 additional septa. It is similar to *T. inordinatus* (above), but differs in having a well-developed black prothallus, a much thinner thallus, a non-amyloid or very weakly amyloid medulla and slightly smaller ascospores (Lamb 1968).

SPECIMEN EXAMINED
Antarctica: ● Wilkes Land, Bunger Hills, Obruchev Hills, NE end, 66°35'S, 99°45'E, on stones in talus, *D. Adamson & R.D. Seppelt 17064*, 4.ii.1986 (HO).

7. Tetramelas subpedicellatus (Hue) Elix, comb. nov.
MycoBank number: **MB 825491**
Basionym: *Lecidea subpedicellata* Hue, Lichens. In *Deux Expéditions Antarctiques Française* (*1908–10*)*, sciences naturelles* 140 (1915).
Type: Antarctica, West Graham Land, Wiencke Island, Goudier Island, near Port Lockroy, 64°50'S, 63°31'W, on diorite rock, *unknown collector FAE 1908–10/84*, 28.xii.1908 (PC – holotype, not seen).

A detailed description and illustrations of this species can be found in Lamb (1968).
Chemistry: Thallus K+ pale yellow, P+ pale yellow or P–, C+ pale orange, UV+ pale orange; containing ± atranorin (major or minor), 6-*O*-methylarthothelin (major or minor), 4,5-dichloro-6-*O*-methylnorlichexanthone (minor or trace).

This species occurs on the Antarctic Peninsula, the South Orkney Islands (Øvstedal & Lewis Smith 2001), the South Shetland Islands (Søchting *et al.* 2004) and Tasmania. It is characterized by a yellow to off-white, crustose to subeffigurate, verrucose thallus in which the verrucae become conglutinated in the centre and sometimes form finger-like extensions. It contains atranorin and 6-*O*-methylarthothelin, has an amyloid medulla, broadly adnate to sessile, lecideine apothecia, 0.4–1 mm wide, a dark brown, N– epihymenium, often curved, *Callispora*-then *Buellia*-type ascospores, 16–[*21.8*]–30 × 8–[*9.3*]–12 µm, which become constricted at maturity and have a microrugulate outer spore-wall, and bacilliform conidia, 3–5 × 0.7–1 µm. The spores are mostly 1-septate, but very rarely develop 1 or 2 additional septa. It is similar to *T. darbishirei* (above), but differs in having larger ascospores (Lamb 1968).

SPECIMENS EXAMINED
Antarctica: ● West Graham Land, Wiencke Island, Goudier Island, 64°50'S, 63°31'W, 8 m alt., on granodioritic rocks, *I.M. Lamb FIDS A1169,* 17.iii.1944 (BM).
Australia: ●Tasmania, Harz Peak summit, 43°15'S, 146°46'E, 1250 m alt., on the sheltered eastern face of an alpine dolerite tor, *G. Kantvilas 500/14*, 14.xii.2014 (HO) [this specimen was previously misidentified as *Tetramelas allisoniae* Elix, H.Mayrhofer & Glenny].

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Key to species

1 Thallus growing on soil, moss or bryophytes 2
1: Thallus growing on rocks 5

2 Thallus sorediate ..... **T. graminicola**
2: Thallus not sorediate 3

3 Epihymenium aeruginose-black, N+ red-violet to purple-brown ..... **T. grimmiae**
3: Epihymenium dark brown or dark olive-brown, N– 4

4 Thallus containing 6-*O*-methylarthothelin and norstictic acid .... **T. austropapillatus**
4: Thallus containing only atranorin ..... **T. papillatus**

5 Epihymenium aeruginose-black, N+ red-violet to purple-brown 6
5: Epihymenium dark brown or dark olive-brown, N– 7

6 Thallus verrucose, to 2 mm thick; medulla strongly I+ blue-violet; prothallus absent or poorly developed ..... **T. inordinatus**
6: Thallus rimose-areolate, to only 0.2 mm thick; medulla I– or weakly I+ purple; prothallus well-developed, black ..... **T. nelsonii**

7 Thallus composed of small, cushion-like clumps, 5–15 mm high .... **T. cladocarpizus**
7: Thallus forming a crust up to 3 mm thick 8

8 Ascospores commonly 3-septate or becoming submuriform ..... **T. granulosus**
8: Ascospores mainly 1-septate, ± with additional endosepta 9

9 Arthothelin present; ascospores 16–24 × 6–10 µm ..... **T. anisomerus**
9: 6-*O*-Methylarthothelin present 10

10 Ascospores 16–30 × 8–12 µm ..... **T. subpedicellatus**
10: Ascospores 14–21 × 6–9 µm ..... **T. darbishirei**

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