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A revision of *Chara* sect. *Protochara, comb. et stat. nov.* (Characeae: Charophyceae)

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Abstract. A revision of a group of ecorticate species of *Chara* is presented, on the basis of fresh, pressed and spirit-preserved material. The following seven species are recognised, characterised by a very simple morphology, with few or inconspicuous accessory cells (cortication, stipulodes, bract cells, bracteoles) and large gametangia: *Chara australis* R.Br., *C. lucida* (A.Braun) Casanova & Karol *comb et. stat. nov.*, *C. porteri* Casanova, *sp. nov.*, *C. protocharoides* Casanova & Karol, *nom. nov.* (=*Protochara australis* Womersley & Ophel) and *C. stuartiana* (Kütz.) Casanova & Karol *comb. et. stat. nov.* from Australia, and *C. corallina* Klein ex Willd. and *C. wallichii* A.Braun from Asia. A new section, *Chara* subg. *Charopsis* sect. *Protochara* (Womersley & Ophel) Casanova & Karol, *comb. et stat. nov.*, is erected to accommodate these taxa, formerly placed in sect. *Charopsis*.

Additional keywords: *Chara australis*, *Chara stuartiana*, *Chara lucida*, *Chara protocharoides*, *Chara porteri*, *Protochara*, systematics, *Tolypellopsis*.

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Introduction

Charophytes (members of the extant family Characeae, Charophyceae) are submerged water plants that grow in fresh, brackish and saline water throughout the world. They are distinguished from other aquatic macrophytes on the basis of their overall simple morphology (consisting of essentially uniseriate, branched filaments of cells), their unique reproductive organs (antheridia producing motile sperm cells, and oogonia or oosporangia containing a non-motile egg cell), and distinctive oospores patterned with helical sutures. The genus *Chara* L. is characterised by a five-celled coronula on the oogonium (oosporangium), placement of the oogonium above the antheridium where they occur together, whorls of accessory cells below the branchlet whorls (stipulodes) and essentially monopodial branchlet structure. The family Characeae was revised for Australia by Wood (1971); however, Wood's revision resulted in an unusable taxonomy (Casanova 2005, 2009) and recent studies have shown that the lumping of Australian species with those in the northern hemisphere, and the delineation of numerous subtaxa (varieties, forms) do not represent reality, or enhance utility. There are many more species in Australia than were recognised by Wood (1971) (Casanova 2005, 2009, 2013; García and Chivas 2006) and current advances in charophyte taxonomy, including investigation of oospore morphology with scanning electron microscopy, have allowed a new approach to the systematics of this group.

Historical review

Traditionally (in what has been termed the Braun–Wood taxonomy, Proctor 1980), the genus *Chara* has been divided into two groups, defined on the basis of the number of stipulode whorls. These groups have been variously treated as subgenera or sections by different authors (see Kützing 1843; Nordstedt 1883; Zaneveld 1940; Wood 1962; Wood and Imahori 1965; Proctor 1980). Current taxonomy recognises two subgenera, namely, subg. *Chara* and subg. *Charopsis* (Kütz.) Leonh. Within subg. *Charopsis*, the following two sections are currently recognised, following Wood and Imahori (1965): sect. *Charopsis* (totally ecorticate) and sect. *Agardhia* R.D.Wood (corticated axes, ecorticate branchlets), with *Chara braunii* C.C.Gmel. being the type of subg. and sect. *Charopsis.* However, phylogenetic analysis places *C. braunii* close to *C. muelleri* A.Braun, which is in sect. *Agardhia* (Meiers *et al*. 1999; McCourt *et al*. 2000). The remaining totally ecorticate *Chara* species are morphologically and phylogenetically (McCourt *et al*. 2000) more similar to each other than to *C. braunii*; however, a group comprising these ecorticate species, without *C. braunii*, has no name under the rules of the ICN (McNeill *et al*. 2012). The members of this group have

ecorticate axes and branchlets, and have a relatively simple morphology (compared with corticated species in subgenus *Chara*). Some of these species have, in the past, been allocated to different genera (e.g. *Charopsis* Kütz., *Nitella* C.Agardh, *Nitellopsis* Hy, *Tolypellopsis* (Leonh.) Mig. and *Protochara* Womersley & Ophel). The first member of the group to be described was *Chara corallina* Klein ex Willd., a monoecious species first collected in India (Willdenow 1805). Soon after, a dioecious species was described from Australia, *C. australis* R.Br. (Brown 1810). Kützing (1857) placed Brown's *C. australis* in the genus *Nitella* as *N. australis* (R.Br.) Kütz., described *N. stuartiana* Kütz. on the basis of more robust material collected from Tasmania, and illustrated both species. In a summary of all the taxa in the subgenus, presented by Nordstedt (1883), Brown's *C. australis* was retained without further description, and *N. stuartiana* was placed in synonymy of that species. From a relatively small number of specimens, an additional six taxa at different ranks were also recognised, including *C. australis* var. *lucida* A.Braun, *C. australis* var. *nobilis* A.Braun, *C. australis* subsp. *plebeja* (R.Br. ex A.Braun) A.Braun, *C. australis* var. *vieillardii* A.Braun, *C. corallina* and *C. wallichii* A.Braun. The other ecorticate *Chara* species included in this group by Nordstedt (1883), *C. braunii*, will not be dealt with in the present study.

Zaneveld (1940) treated *C. australis* and *C. australis* var. *nobilis* as synonymous, but distinguished northern Australian and New Caledonian specimens as different forms of *C. australis* var. *lucida*: i.e. f. *typica* Zaneveld, *nom. inval.*, f. *tenerior* Zaneveld and f. *vieillardii* (A.Braun) Zaneveld. Womersley and Ophel (1947) erected the genus *Protochara* to accommodate a totally ecorticate taxon from Western Australia, *Protochara australis* Womersley & Ophel, and transferred *Nitellopsis inflata* Fil. & G.O.Allen ex Fil. to that genus as *Protochara inflata* (Fil. & G.O.Allen ex Fil.) Womersley & Ophel. Filarszky (1934) also described a species with morphological similarities to *C. australis*, from Indonesia, as *Tolypellopsis simplicissima* Fil.

In the first experimental breeding study in the Characeae, Macdonald and Hotchkiss (1956) found that female *Chara australis* and a specimen from New South Wales identified by H. B. S. Womersley as male *Protochara australis* were interfertile to the point of oospore production, and so amalgamated *C. australis* and *P. australis*, separating material that had been called *P. australis* as a new subspecies, *C. australis* subsp. *estipulodica* M.B.Macdon. & Hotchk. In amalgamating *Protochara australis* with *Chara*, they also included *P. inflata* in *Chara*, as *C. inflata* (Fil. et G.O.Allen ex Fil.) M.B.Macdon. & Hotchk. Subsequently, on the basis of reproductive morphology and nucleotide sequences, García and Karol (2004) recognised *Protochara inflata* as a species of *Lamprothamnium* J.Groves, *L. inflatum* (Fil. & G.O.Allen ex Fil.) Adr.García & Karol. Wood (1962) amalgamated most of the members of subg. *Charopsis* into a single species, *C. corallina*, and delineated several infraspecific taxa, some of which were not validly published (cf. Art. 41.5 of the ICN; McNeill *et al*. 2012). These were subsequently treated as both forms and varieties of *C. corallina*, as well as being treated at 'microspecies' rank (equivalent in rank to Wood's forms as well as his 'monotypic' varieties and species, i.e. those lacking subordinate taxa) by Wood and Imahori (1965). Infraspecific taxa are treated in the main body of the monograph, with alternative 'microspecies' status presented in the *Microspecies Appendix* at the end of the work. These names are here treated as invalid, alternative names under Art. 36.2 of the ICN (McNeill *et al*. 2012). Wood (1971) later revised his taxonomy for Australian material, delineating *C. corallina* var. *corallina* as those specimens with cylindrical branchlet segments, and *C. corallina* var. *nobilis* for those specimens with inflated branchlet segments. Within *C. corallina* var. *nobilis*, he tentatively recognised the following four forms: *nobilis*, *inflata*, *simplicissima* and *stuartiana*. These formae names are here treated as invalid provisional names under Art. 36.1 of the ICN (McNeill *et al*. 2012).

In the present study, the type material of all the Australian species and their close relatives, as well as more than 200 specimens from field collections and herbaria, were examined to determine the status and morphological limits of the species previously included in *Chara* subg. *Charopsis* sect. *Charopsis* (excluding *C. braunii*).

Morphology

Chara species grow as totally submerged water plants, rooted in the sediment by colourless rhizoids, with a photosynthetic axis in the water column. The axis consists of single-celled internodes and whorls of multicellular branchlets, on which the reproductive structures are borne. The axes look very similar to submerged flowering plants, and can be confused with species of *Myriophyllum* L. Species of *Chara* in this group are entirely ecorticate, i.e. with no cortex on the axis or branchlets, and, in general, have little in the way of 'accessory cells' (i.e. stipulodes, bract cells or bracteoles). Thus, there are few morphological characteristics on which to separate species, which has led to the current taxonomic confusion. They are, in general, somewhat large, with robust axes and spreading whorls of branchlets. The antheridia and oogonia are typical of the genus, but large (up to 1 mm long) in comparison with some other species, and visible to the naked eye. The antheridia are usually bright orange, and the oogonia have few circumvolutions of the enveloping spiral cells and very small, apiculate coronula cells. Their persistent reproductive units (oospores) are among the largest recorded for Australian charophytes, but with relatively few striae (spiral sutures), and some species accumulate starch in the lower and rhizoidal nodal cells (bulbils), which allows them to persist vegetatively. The major characteristics used to separate species in this group are sexuality (monoecious *v.* dioecious), development and abundance of accessory cells, axis and branchlet diameter and length, characteristics of the branchlet nodes and oospore morphology. They are distinguished from similar species of *Lamprothamnium* by the presence, in *Lamprothamnium*, of gyrogonites (calcified covering on the oospore), rounded coronula cells, downward pointing stipulodes and verticillate bract cells.

Materials and methods

Approximately 200 fresh, pressed and spirit-preserved specimens of charophytes in Australian and overseas herbaria and several private collections were examined for the present study, including 15 specimens designated as type material of species, subspecies, varieties or forms within the group. Each specimen was allocated

a letter–number combination (*p###*, *r###*, *t###* or *v###*), so that all data obtained and stored for that specimen (i.e. measurements, photographs, chromosome counts, scanning electron micrographs) could be related back to the specimen. Initial examination involved measurements (size, number) directly from the specimen (e.g. number of branchlets, number of branchlet segments) and with the use of a microscope (e.g. axis and branchlet diameter, number and morphology of stipulodes and bract cells, arrangement of gametangia). Oospore features were examined and measured with the aid of light microscopy and scanning electron microscopy.

Fresh specimens were obtained in field surveys in all states of Australia (following the methods of Casanova 2004), and from culture of seed-bank material in a greenhouse (following the methods of Casanova 2004). In the greenhouse, plastic containers (185 mm × 125 mm × 50 mm) containing ~300 g of wetland soil were inundated to a depth of 10–14 cm in large tanks and the charophytes that germinated from them were examined. When oospores were present they were removed from the specimens for examination with a scanning electron microscope (SEM), then plants were gathered and pressed, or preserved in 70% alcohol. If oospores were not present, the plants were either returned to culture to mature, or kept in jars on a windowsill until they matured and oospores were freely released. If antheridia were present, chromosome counts were attempted, following the methods outlined in Casanova (1997).

Where possible and appropriate, oospores were removed from the herbarium specimens or obtained as above from live material. Approximately a quarter (50) of the specimens examined had oospores. They were prepared for SEM examination by cleaning (if required) with a detergent solution, using a modification of the methods of Crawford *et al*. (2001). Sometimes the enveloping cells were removed by hand, using fine needles. For type specimens, very old material, or specimens with a single oospore available for examination, the oospores were handled with great care, with minimal manipulation. Oospores were removed from the stubs after microscopy and are stored in alcohol and deposited with the specimen for possible future examination.

Results

Chara L., *Sp. Pl.* 2: 1156 (1753)

Type: *Chara vulgaris* L.

Chara subgen. ***Charopsis*** (Kütz.) Leonh., *Lotos* 13: 73 (1863)

Type: *Chara braunii* C.C.Gmel.

Monoecious or dioecious. Plant axis corticated or ecorticate, stipulodes in a single whorl (*haplostephanous*), bract cells unilateral or verticillate, branchlets ecorticate and terminated by a single cell, a cluster of bract cells or a group of three equal-sized cells (*corona*).

Chara subgen. ***Charopsis*** sect. ***Protochara*** (Womersley & Ophel) Casanova & Karol, *comb. et stat. nov.*

Protochara Womersley & Ophel, *Trans. Roy. Soc. S. Australia* 71: 311 (1947).

Chara sect. *Monosiphoniae* Wallr., *Fl. crypt. Germ*.2 107 (1833), *p.p.*; *Chara hypogynae* a. *Monosiphoniae* A.Braun, *Ann. Sci. Nat.* ser. 2, 1: 353 (1834) *p.p.* (excluding *C. braunii*); *Chara* sect. *Charopsis* (Kütz.) R.D.Wood, *Taxon* 11: 12 (1962), *p.p.* (excluding *C. braunii*).

Type: *Chara protocharoides* Casanova & Karol.

Axes ecorticate. Stipulodes in a single tier when present, sometimes obscure, up to 2 per branchlet. Branchlets ecorticate, with a single-celled end segment, sometimes surrounded by smaller bract cells. Bract cells 2 or 3, often obscure. Bracteoles 2, often replaced by gametangia or obscure. Gametangia sessile; solitary, geminate or aggregate, on the branchlet nodes and at the base of the branchlets, conjoined (monoecious) or on separate plants (dioecious). Oogonia with few circumvolutions, coronula cells slightly apiculate. Oospores with fewer than 8 striae, without a gyrogonite. Annual or perennial.

Species in this section have been variously placed in *Chara*, *Nitella*, *Nitellopsis*, *Protochara* and *Tolypellopsis* by previous authors. All these names refer to currently recognised genera, except *Protochara* and *Tolypellopsis* (=*Nitellopsis*). Thus, the name *Protochara* appears to be an appropriate name for the new section.

Key to the species in *Chara* subgen. *Charopsis* sect. *Protochara*

1. Plants monoecious ..... ***C. corallina***
   Plants dioecious 2
2. Bract cells and stipulodes elongate and inflated ..... ***C. wallichii***
   Bract cells and stipulodes small or absent 3
3. Axis diameter <1 mm, branchlets thin 4
   Axis diameter usually >1.1 mm, branchlets somewhat inflated, 6–13 mm long 5
4. Branchlets <20 mm long, branchlets incurved ..... ***C. porteri***
   Branchlets 20–50 mm long, axes tangled and wiry ..... ***C. lucida***
5. Stipulodes, bract cells and bracteoles clearly present 6
   Stipulodes, bract cells or bracteoles absent ..... ***C. protocharoides***
6. Branchlets and internodes ≥2 mm in diameter ..... ***C. stuartiana***
   Branchlets and internodes 1.2–1.8 mm in diameter ..... ***C. australis***

Chara australis R.Br., *Prodr.* 1: 346 (1810)

(Fig. 1)

Nitella australis (R.Br.) Kütz. *Tab. phycol.* 7: 11 (1857)

Type: NEW SOUTH WALES: Port Jackson, 1804, *R.Brown 277*. Holo: BM; iso: LD.

Chara australis var. *nobilis* A.Braun in C.F.O.Nordstedt, *Abh. Königl. Akad. Wiss. Berlin 1882*: 105 (1883); *Chara corallina* var. *nobilis* R.D.Wood, *nom. inval.*, *Taxon* 11: 12 (1962); *Chara corallina* f. *nobilis* R.D.Wood, *nom. inval.*, *Taxon* 11: 12 (1962); *Chara corallina* var. *nobilis* (A.Braun) R.D.Wood, *Rev. Characeae* 1: 274 (1965); *Chara corallina* f. *nobilis* (A.Braun) R.D.Wood, *Rev. Characeae* 1: 274 (1965).

Type: NEW ZEALAND: Whangape [Whangapa?] Lake, *T.K* [*irk*] *s.n.*, v.-1870, Lecto: NY (*fide* Wood and Imahori (1965: 275)); ?isolecto: WELT A9062 *n.v.*, CHR *n.v.*

Dioecious. *Plants* robust, translucent and turgid, up to 40 cm high. *Axes* 0.9–1.75 mm wide, totally ecorticate, *internodes* 30–100 mm long. No spine cells. *Stipulodes* in a single row

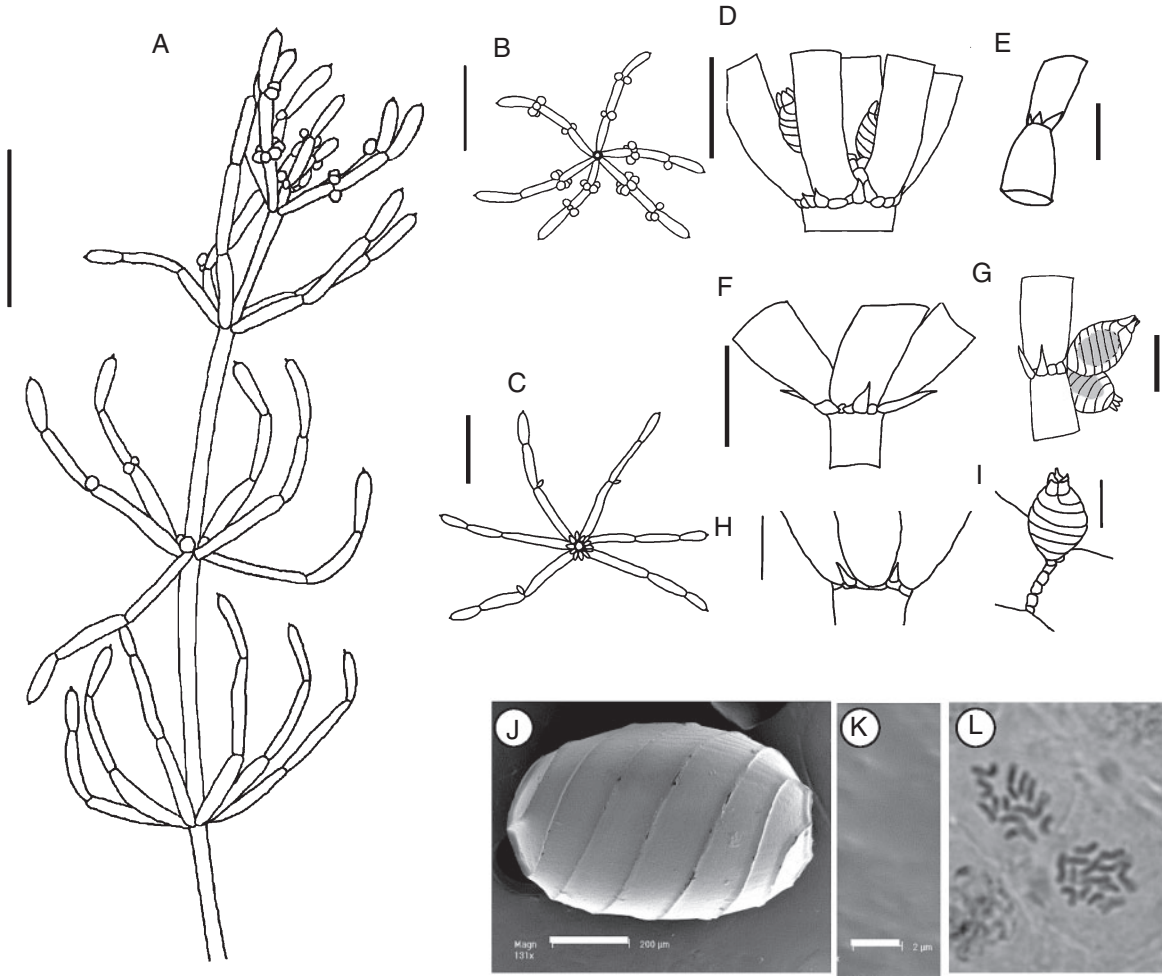

Fig. 1. *Chara australis* R.Br. A. Habit of whole plant; scale bar: 1 cm. B. Fertile antheridial whorl; scale bar: 10 mm. C. Fertile oogonial whorl; scale bar: 10 mm. D. Base of fertile oogonial whorl; scale bar: 1 mm. E. Branchlet node; scale bar: 0.5 mm. F. Base of sterile whorl; scale bar: 0.5 mm. G. Geminate oogonia; scale bar: 0.5 mm. H. Base of sterile whorl; scale bar: 1 mm. I. Fertile oogonial node; scale bar: 0.5 mm. J. Oospore; scale bar: 200 µm. K. Detail of smooth oospore wall; scale bar: 2 µm. L. Chromosomes $n = 14$, ×1000 magnification. A–C and J from *M.T.Casanova r186*; D, E from *M.T.Casanova r612*; F, G from *D.McNeil r692*; H, I from *M.T.Casanova r952* and K, L from *M.T.Casanova p788*.

when present, 6–12 in a whorl, up to 0.38 mm long, but often absent or obscure. *Branchlets* almost uniformly 6 in a whorl, rarely 7, completely ecorticate, 3–5 cells long, cylindrical, 15–43 mm long, *basal branchlet cell* elongate, up to 15 mm long, *branchlet end segments* usually a single mucronate cell, sometimes with up to two subtending bract cells, *bract cells* 2–4 at a node, up to 0.2 mm long, frequently obscure or absent. Branchlets are often strongly incurved at the apices, especially in shallow water. *Bracteoles* obscure, possibly 2 per oogonium. *Gametangia* solitary, geminate or aggregate at the lowest 1 or 2 branchlet nodes and inside the base of the whorl, rarely antheridia sessile outside the base of the whorl. *Oogonia* orange, up to 1 mm long, 0.8 mm wide, *coronula* cells obtuse to slightly apiculate and usually very small on mature oogonia. *Oospores* black, cylindrical to ovate, 700–800 µm long, 450–600 µm wide, with 5 or 6 striae, appearing smooth or finely granulate, impression of the basal cell 180–200 µm in diameter. *Antheridia* up to 800 µm in diameter, orange and often very obvious. *Vegetative reproduction* by perennial basal internodes and the deposition of starch in the lower and rhizoid nodes. *Chromosomes* $n = 14$ (*M.T.Casanova p426*, *p788*).

Recognition

Chara australis is the most common totally ecorticate species of *Chara* in eastern mainland Australia. It can be distinguished as dioecious, robust, ecorticate plants with large gametangia and small, often inconspicuous, stipulodes, bract cells and bracteoles. The internodes are usually as long as or longer than the branchlets and the axes are usually greater than 1 mm in diameter.

Distribution

Occurring in cool, deep, still or slow-flowing water from east of Brisbane in Queensland, south through New South Wales (including the Australian Capital Territory) to Victoria, with an

isolated collection from the Flinders Ranges in South Australia. Also occurs in New Zealand.

Etymology

From the Latin '*australis*', referring to the southern distribution of the species.

Specimens examined

SOUTH AUSTRALIA: Mawson Plateau, Flinders Ranges, 20 May 2010, *D.McNeil r692* (MEL). NEW SOUTH WALES: Dumaresq Creek above Dumaresq Dam near Armidale, 13 May 1990, *M.T.Casanova p306* (MEL), *p463* (NE), *r396* (MEL); Dumaresq Creek below the dam near Armidale, 13 May 1990, *M.T.Casanova p307* (MEL); Llangothlin Lagoon, seed-bank culture, 31 July 1992, *M.T.Casanova p426*, r977 (MEL); Beardy Waters, outside Glen Innes, *M.T.Casanova*, *M.Feist & A. García r395* (MEL, NE); Little Manning River, between Gloucester and Walcha, 31 Oct. 1996, *M.T.Casanova r397* (MEL); Deua River (Moruya River) Araluen Road, 9 Jan. 2009, *M.T.Casanova r510*, *r514* (BM, MEL, NY); Tuross River on Comerang Road, Silo Farm Bridge, 10 Jan. 2009, *M.T.Casanova r523* (BM, MEL, NY); Tuross River at Eurobodalla, Tyrone Bridge on Nerrigundah Road, 10 Jan. 2009, *M.T.Casanova r528* (MEL); Dumaresq Dam, 17 Feb. 1988, *M.T.Casanova r996* (MEL); Gledwood, Camden, cultured in biophysics laboratory, University of Sydey, 5 Dec. 1960, *R.D.Wood 60-12-5-1* (AD, PC); Duval Creek, near Armidale, 17 Nov. 1960, *R.D.Wood 60-11-17-14A and 15*A (AD). AUSTRALIAN CAPITAL TERRITORY: Paddys River, 5 Apr. 1964, *N.Burbidge 7428* (CANB); Point Hutt, Murrumbidgee River, 8. Jan. 1966, *E.D'Arnay 466* (CANB, MEL); Murrumbidgee River, Uriarra, 4 Apr. 1964, *H.S.McKee 11431* (CANB). VICTORIA.: Fitzroy River bridge, Tyrrendarra, *A.C.Beauglehole 203* (MEL); Mount Emu Creek, Panmure Waterhole, 3 Mar. 2004, *M.T.Casanova & R.L.A.Casanova p587* (MEL, NY); Lake Fyans, 24 Oct. 2005, *M.T.Casanova p788* (MEL); Woorndoo Olympic Wetland, 24 Feb. 2008, *M.T.Casanova r058* (MEL); Darlots Creek, Tyrendarra Bridge at the Budj Bim IPA, 29 Mar. 2011, *M.T.Casanova r952* (MEL, NY); The Woolwash, Surry River, 2.5 miles SE of Heathmere, 31 Mar. 1962, *A.Fuhrer & A.C.Beauglehole 181* (MEL, NY); Snowy River upstream of Sandy Creek confluence, 24 Jan. 1994, *N.G.Walsh 2417* (MEL); Wonga Park, Warrandyte State Park, 3 Apr. 1994, *D.J.van Bockel 384 & P.Coupar* (MEL). NEW ZEALAND: Lake Oahu, Canterbury, South Island, 3 Mar. 2001, *J.S.Clayton r402* (MEL).

Chara corallina Klein ex Willd., *Mém. Acad. Roy. Sci. Hist. (Berlin)*: 89 (1805)

(Fig. 2)

Nitella corallina (Klein ex Willd.) C.Agardh, *Syst. alg.* 123 (1824).

Type: INDIA: Wöppanpasi, Tranquebar (Tharamgambadi), near Madras (Chennai), Tamil Nadu, 7 Jan. 1799, *Klein 510*. Holo: B-W 17105; iso: MEL 2315415 & 2367911.

Monoecious. *Plants* usually elongate with stout branchlets, up to 40 cm tall, sometimes lightly encrusted with calcium carbonate. *Axes* up to 1.5 mm in diameter (~2 mm in flattened, preserved specimens), ecorticate, *internodes* up to 30 mm long, as long as or longer than the branchlets. *Stipulodes* crowded out by gametangia, 1 per branchlet, up to 380 µm long, often difficult to discern on pressed specimens. *Branchlets* 6 or 7 in a whorl, 20–60 mm long, somewhat pinched-in at the nodes, and appearing quite wide on pressed material, ecorticate, 4 or 5 cells long, *branchlet end segment* pointed, conical and acute, *basal branchlet cell* long, in diameter similar to the other branchlet cells. *Bract cells* small, 2–4 per branchlet node, 200–600 µm long, *bracteoles* difficult to distinguish, 2, similar to bract cells. *Gametangia* conjoined, clustered inside and below the branchlet whorls, and solitary or geminate on the lowest two branchlet nodes. *Oogonia* 0.8–1.0 mm long, 0.6–0.8 mm wide, *coronula* cells appressed, slightly apiculate. *Oospores* black, cylindrical, 600–830 µm long (778 ± 5 µm: Mandal *et al*. 2008) and 450–600 µm wide, 6 or 7 striae of low ridges, sometimes slightly flanged, the impression of the basal cell 165–180 µm in diameter. In a population from China (*Lu & Soulié-Märshe*, *1996*), a proportion of the oospores had a 6-sided basal-cell impression, rather than a pentagonal basal-cell impression. *Antheridia* below or adjacent to the oogonia where they are at the same node, 500–750 µm in diameter. The antheridia appear tetrascutate. *Chromosomes* $n = 42$ (Khatun *et al*. 2009).

Nomenclatural notes

Living material of *Chara corallina* was not available for examination and the above description is based on the type material, the protologue, Nordstedt (1883), Imahori (1954) and the description of Indian material by Wood and Imahori (1964, icon 111). The status of *C. corallina* var. *basilaris* A.Braun, with gametangia absent from the branchlets and restricted to the base of the whorls, and *C. corallina* var. *kyusyensis* Imahori characterised by an almost complete absence of bract cells and stipulodes, cannot be commented on without reference to fresh specimens. The holotype material of *C. corallina* is lodged in the Willdenow collection in B, but oospores were not available for examination, apparently having been removed (R. Jahn, pers. comm.). Examination of material in the Sonder Herbarium at MEL revealed two specimens with morphology identical to the type material in B-W. One appears to have been used as the model for Kützing's (1857) tabulae 80. These have been identified as isotypes of *C. corallina*, and the material is in good condition compared with the material in B-W (which appears to have been moistened, dissected and re-pressed).

Recognition

Chara corallina is the only monoecious member of *Chara* sect. *Protochara*.

Distribution

Chara corallina is apparently widespread in Asia, occurring in India, Bangladesh, Malaysia, Japan and China, at least as far north as Nanjing.

Etymology

The term '*corallina*' is derived from Latin *corallinus* meaning 'coral-red', referring to the bright colour of the gametangia.

Specimens examined

INDIA: near Bombay, *G.O.Allen 105* (BM). CHINA: Chengdu City, Sichuan, 1996, *Lu Hui-nan & I.Soulié-Märsche s.n.*,(NY, MEL: oospores only).

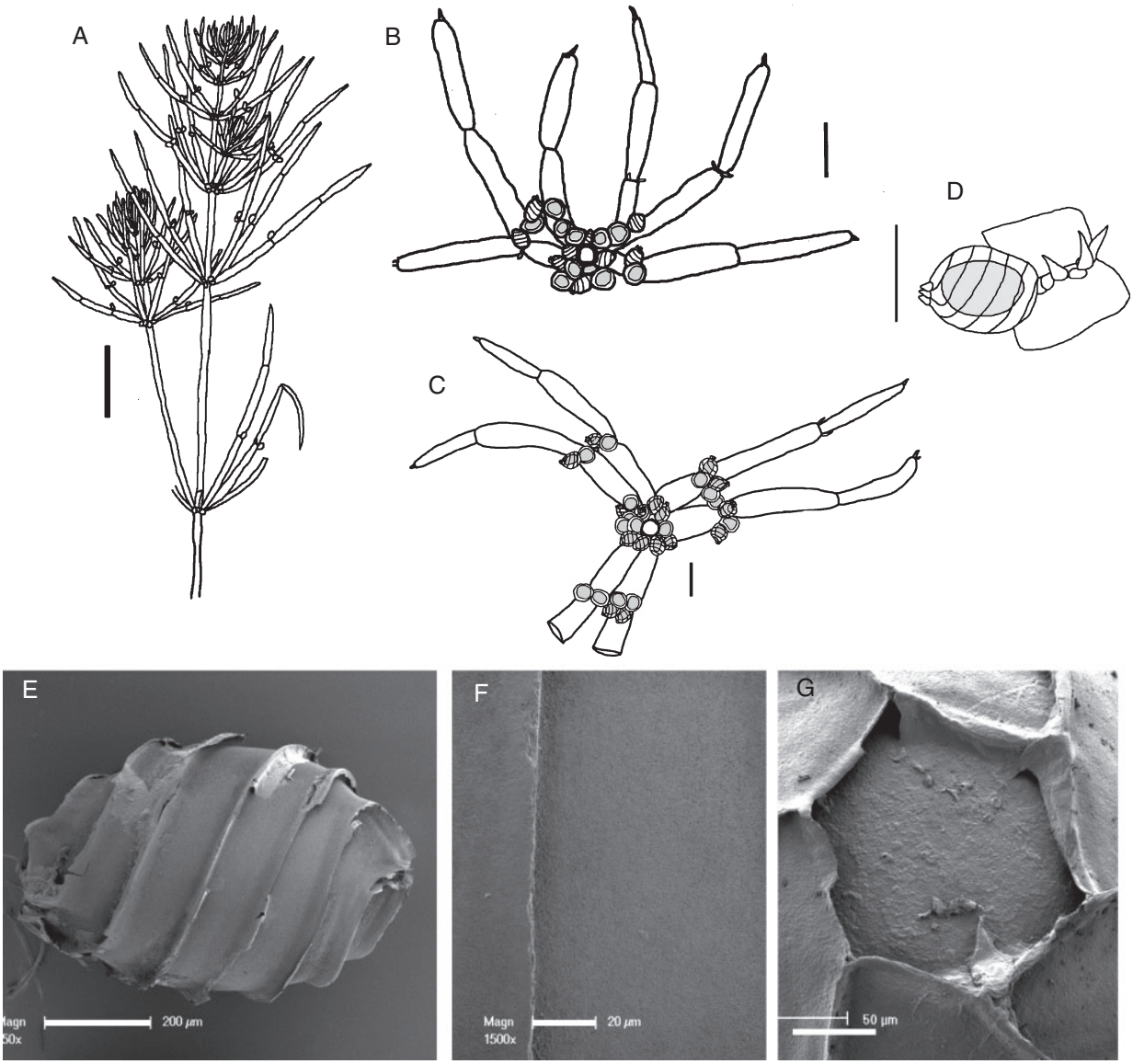

Fig. 2. *Chara corallina* Klein ex Willd. A. Habit of whole plant; scale bar: 1 cm, after Kützing (1857). B. Upper branchlet whorl; scale bar: 1 mm. C. Lower branchlet whorl, two branchlets cut short; scale bar: 1 mm. D. Oogonium and branchlet node with bract cells; scale bar: 1 mm. E. Oospore; scale bar: 200 µm. F. Detail of oospore wall; scale bar: 20 µm.; G. Basal-cell impression, atypically six-sided; scale bar: 50 µm. A–C from *J.G.Klein 510*; E, F from *G.O.Allen 104* and G from *Lu & Soulié-Märshe 1996*.

Chara lucida (A.Braun) Casanova & Karol, *comb. et stat. nov.*

(Fig. 3)

Chara australis var. *lucida* A.Braun in Nordst., *Abh. Königl. Akad. Wiss. Berlin 1882*: 106 (1883); *Chara australis* var. *lucida* f. *typica* Zaneveld, *nom. inval.*, *Blumea* 4: 126 (1940); *Chara corallina* f. *lucida* R.D.Wood, *nom. inval.*, *Taxon* 11: 13 (1962); *Chara corallina* f. *lucida* R.D.Wood, *nom. inval.*, *nom. alt.*, *Rev. Characeae* 1: 275 (1965); *Chara lucida* R.D.Wood, *nom. inval.*, *nom. alt.*, *Rev. Characeae* 1: 769 (1965).

Type: Northern Territory: Victoria River, *s. dat.*, *F.Mueller 5*. Lecto (*fide* Zaneveld 1940): LD; isolecto: L. Syn: Northern Territory: Baines Creek, 1856, *F.Mueller s.n.*: LD.

Chara australis f. *tenerior* Zaneveld, *Blumea* 4 : 127 (1940).

Type: Gulf of Carpentaria, 1856, *F.Mueller s.n.* Holo: B (destroyed; *fide* Wood and Imahori (1965: 276)); iso: LD, L.

Dioecious. *Plants* flexible, transparent, often in tangled clumps, up to 200 mm tall. *Axes* 0.35–0.7 mm wide (when flat and dried, narrower in fresh material), ecorticate, *internodes* 8–20 mm long, generally much shorter than the adjacent branchlets. *Stipulodes* in a single row, 6–12 in total, usually fewer apparent, up to 0.5 mm long. *Branchlets* 6 or 7 in a whorl, ecorticate, 11–50 mm long, 0.3–0.6 mm wide, 4 or 5 cells long, *basal branchlet cell* up to 10 mm long, *branchlet end segments* small, conical and acute, sometimes subtended by 1 or 2 bract cells, *bract cells* obscure or short. *Bracteoles* obscure or short, occasionally up to 0.5 mm long. Fertile parts sometimes somewhat contracted with shorter branchlets and internodes.

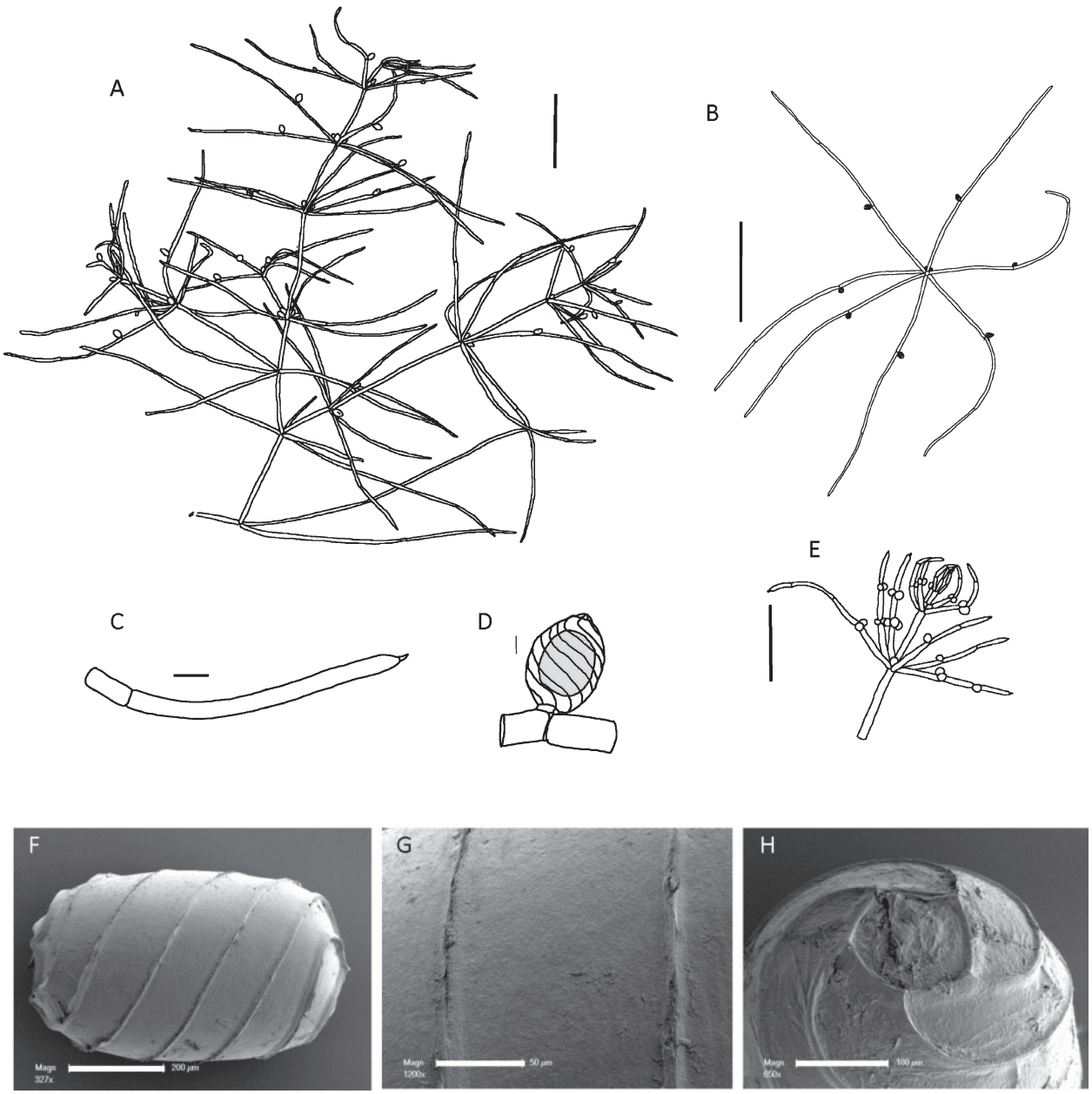

Fig. 3. *Chara lucida* (A.Braun) Casanova & Karol. A. Habit of whole plant; scale bar: 5 mm. B. Fertile oogonial branchlet whorl; scale bar: 5 mm. C. Final two branchlet cells; scale bar: 0.5 mm. D. Oogonium; scale bar: 100 µm. E. Fertile antheridial branchlet whorl; scale bar: 5 mm. F. Scanning electron micrograph (SEM) of oospore; scale bar: 200 µm. G. SEM of detail of oospore wall; scale bar: 50 µm. H. SEM of impression of basal cell on the oospore; scale bar: 100 µm. A–D from *M.T.Casanova r784*; E from *L.A.Craven 4782* and F–H from *F.Mueller 5*.

Specimens with only fertile branchlets were distinguished as form *tenerior* but recent collections (e.g. *M.T.Casanova r758*) have both long sterile and short fertile branchlets on the same plant. *Gametangia* sessile inside the base of the whorl and solitary, geminate or clustered at the lowest 1 or 2 branchlet nodes. *Oogonia* 0.9 mm long, 0.5 mm wide, *coronula* cells very short, obtuse. *Oospores* black, cylindrical, 600–670 µm long, 380–400 µm wide, 7 or 8 striae of low ridges, ornamentation smooth to minutely granulate, basal-cell impression 120–150 µm in diameter at the widest part, edges 95–100 µm long. *Antheridia* from 400–850 µm in diameter. *Vegetative reproduction* not known. *Chromosomes* not known.

Nomenclatural notes

Wood's (1962) combination *Chara corallina* f. *lucida* is here treated as invalid, under Art. 41.5 of the ICN (McNeill *et al.* 2012). Wood and Imahori (1965) subsequently simultaneously published *C. corallina* f. *lucida* and *C. lucida*, the latter at the rank of 'microspecies', equivalent in rank to Wood's forms as well as

his 'monotypic' varieties and species (i.e. those lacking subordinate taxa). Both these names are here treated as invalid alternative names, under Art. 36.2 of the ICN (McNeill *et al*. 2012).

Taxonomic notes

Zaneveld (1940) distinguished the following two formae in his concept of *C. australis* var. *lucida*, on the basis of material from New Guinea and northern Australia: f. *typica*, with somewhat stout (~600 µm wide), long branchlets, and f. *tenerior*, with shorter, narrower (~350 µm wide) branchlets. New collections from the Northern Territory (*M.T.Casanova r784*, *r758*) represent material with both long and short branchlets on apical parts of the same plant, and branchlet width varies in relation to branchlet length. Additionally, specimens from the Northern Territory and the Gulf of Carpentaria have identical oospores, and accordingly, no infraspecific taxa are here recognised in this species.

Recognition

The species can be distinguished as a totally ecorticate *Chara* species with narrow axes, distinguished from narrower morphs of *C. australis* by the short internodes in comparison with the branchlets. *C. lucida* forms tangled masses in warm waters, compared to the upright, turgid stems of *C. australis* in colder, deeper waters.

Distribution

Tropical and subtropical Queensland, Western Australia and the Northern Territory in dams, ponds, still rivers and lagoons. Also occurs in Papua New Guinea.

Etymology

From the Latin '*lucidus*', meaning shining, clear, transparent. Zaneveld (1940) and Wood (1971) thought this referred to a shiny surface on the pressed specimens, but that feature is neither obvious nor consistent. More likely, it refers to the clear and transparent, almost colourless appearance (*fide* Nordstedt 1883) of the pressed type material.

Specimens examined

WESTERN AUSTRALIA: Rudall River, 29 May 2004, *M.N.Lyons & D.A.Mickle 3057* (PERTH); Redrocks Granites, Pilbara Biological Survey site 080, 25 Aug. 2005, *N.M.Lyons & D.A.Mickle 3160* (PERTH); Kumina Creek, Hamersley Ranges, 13 Aug. 1991, *M.Trudgen & D.True MET10264* (CANB, AD, PERTH). NORTHERN TERRITORY: Manton Dam recreation area, *M.T.Casanova r758* (MEL, NY); roadside borrow-pit on Arnhemland Highway, *M.T.Casanova r784* (B, MEL, NY); SW of Elizabeth Downs, Daly River region, 23 June 1977, *L.A.Craven 4375* (CANB); Oenpelli, 10 Oct. 1948, *R.L.Specht A110* (AD, MEL, NY); Katherine, 14 Feb. 1961, *H.S.McKee 8427* (CANB);. QUEENSLAND: Ross River Dam overflow near Townsville, 12 May 1987, *M.T.Casanova r997*; in lagoon at Magoura Station, 18 July 1977, *L.A.Craven*, *4782* (CANB); Pig Swamp near Biboohra, N of Mareeba, 27 June 1962, *R.D.Hoogland 8492* (CANB); Hastie Swamp, Atherton Tablelands, 6 Aug. 1970, *A.P.Kershaw 10109* (CANB); Breeza Plains, 12 Aug. 1978, *K.Paijmans 2871* (CANB); Enoggera Reservoir, 21 Nov. 1960, *R.D.Wood 60-11-21-25* (AD, NY); Palm Creek at Miriam Vale, 30 Nov. 1960, *R.D.Wood 60–11–30–6* (AD, NY); South Pine River, Bunya, 22 Nov. 1960, *R.D.Wood 60-11-22-20* (AD, NY). PAPUA NEW GUINEA: Hisin Village, Kairuku, Central District, 16 Aug. 1962, *P.J.Darbyshire 813* (CANB); Laloki River, Central District, 5 Sep. 1962, *T.G.Hartley 10619* (CANB); Rouna Falls, Laoki River, Central District, 7 Sep. 1962, *R.Schodde 2946* (CANB).

Chara porteri Casanova, *sp. nov.*

(Fig. 4)

Type: Western Australia: Ethel Creek Claypan, Pilbara Biological Survey site 041, T2, 1 June 2004, *M.N.Lyons & D.A.Mickle 3077*. Holo: PERTH; iso: MEL.

Dioecious. *Plants* somewhat inflated and turgid, sometimes calcified, up to 150 mm tall, somewhat densely branched, with incurved branchlets in shallow water. *Axes* 0.7 mm wide (up to 1 mm on pressed specimens), ecorticate, *internodes* 8–25 mm long, shorter and somewhat contracted at the apices. Rarely internodes appear 2 cells long. *Stipulodes* in a single row when present, frequently obscure or absent. *Branchlets* 6 in a whorl, sometimes made up of a few elongate branchlets and some dwarf branchlets, particularly at the apices, ecorticate, 8–15 mm long, 0.4–0.6 mm wide, 3 or 4 cells long, *basal branchlet cell* up to 6 mm long, usually the longest cell in the branchlet, *branchlet end segments* small, conical and acute, occasionally subtended by bract cells, *bract cells* usually obscure, up to 0.2 mm long, or absent. *Bracteoles* obscure, up to 0.2 mm long, or absent. *Gametangia* on separate plants, sessile inside the base of the whorl, and solitary, geminate or clustered at the lowest 1 or 2 branchlet nodes. *Oogonia* 0.6–0.75 mm long, 0.5 mm wide, *coronula* cells short, somewhat spreading, slightly apiculate. *Oospores* black, cylindrical, 470–525 µm long, 250–350 µm wide, 5 or 6 striae of wide ridges (pachygyra), ornamentation smooth to minutely granulate, basal-cell impression 100–120 µm in diameter at the widest part, edges 70–76 µm long, rarely 6-sided. *Antheridia* octoscutate up to 850 µm in diameter. *Vegetative reproduction* not known. *Chromosomes* $n = 14$ (*M.T.Casanova r416*).

Recognition

Specimens are distinctly turgid and brightly festooned with gametangia, with incurved branchlets. The oospores have markedly enlarged striae (pachygyra).

Distribution

Occurs in temporary wetlands (claypans and riparian overflows) in the Paroo region of New South Wales, the Pilbara region of Western Australia and in south-western Queensland.

Etymology

Named in honour of John L. Porter, who collected the first herbarium material of this species, from the Paroo region in New South Wales.

Specimens examined

WESTERN AUSTRALIA: Coondiner Pool, Pilbara Biological Survey site 001, 15 Aug. 2006, *M.T.Casanova r416 and r417* (B, BM, MEL); Cooliarin Pool, *M.N.Lyons & D.A.Mickle 3061* (paratype) (CANB, MEL, PERTH); Myanore Creek Pool, Pilbara Biological Survey site 014,

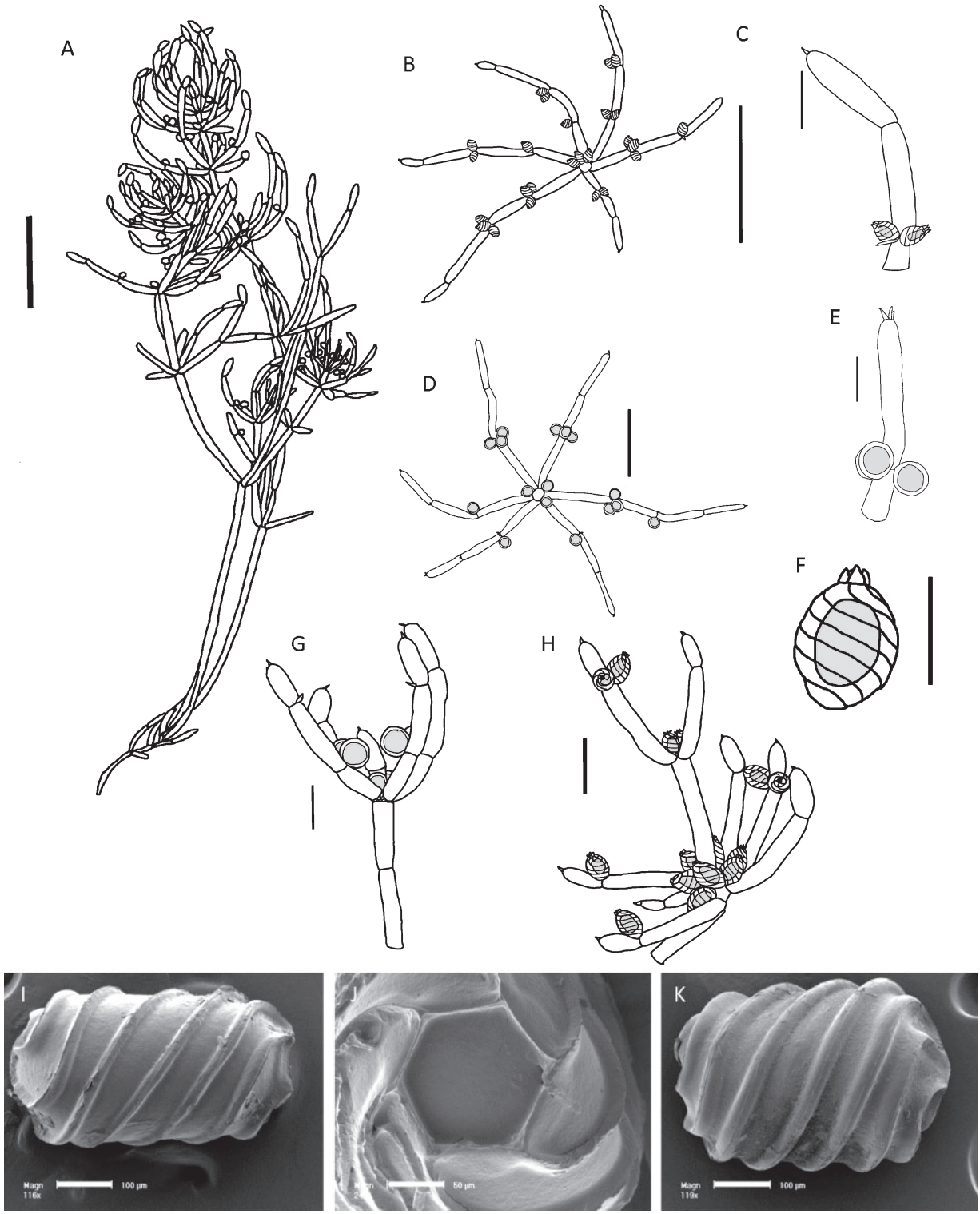

Fig. 4. *Chara porteri* Casanova. A. Habit of whole plant; scale bar: 1 cm. B. Branchlet whorl from an oogonial plant; scale bar: 5 mm. C. Individual oogonial branchlet; scale bar: 1 mm. D. Antheridial branchlet whorl; scale bar: 1 mm. E. Individual antheridial branchlet; scale bar: 1 mm. F. Oogonium; scale bar: 500 µm. G. Axis and branchlet whorl, with a bicellulate axis; scale bar: 1 mm. H. Oogonial axis tip, with clustered oogonia at the base of the branchlets; scale bar: 1 mm. I. Oospore; scale bar: 100 µm. J. Atypical six-sided basal-cell impression; scale bar: 50 µm. K. Oospore; scale bar: 100 µm. A from *M.N.Lyons & D.A.Mickle 3061*; B–F, I–J from *M.N.Lyons & D.A.Mickle 3045* and G–H and K from *M.N.Lyons & D.A.Mickle 3077*.

13 May 2006, *D.A.Mickle & N.Y.Huang 3108*, *3109 and 29-3108* (BM, MEL, PERTH); Watrara Creek Pool, Pilbara Biological Survey site 028, 8 Sep. 2003, *M.N.Lyons & S.D.Lyons 3045* (PERTH); Cooliarin Pool, Pilbara Biological Survey site 033, 18 May 2004, *M.N.Lyons & D.A.Mickle*, *3064* (CANB, MEL, PERTH); Cooliarin Pool, Pilbara Biological Survey site 033, 20 Apr. 2006, *M.N.Lyons & D.A.Mickle 3087* (AD); Cooliarin Pool, Pilbara Biological Survey site 033, 20 Apr. 2006, *M.N.Lyons & D.A.Mickle 3089*, *3090 and 13-3092* (PERTH); Sweetwell Claypan, Pilbara Biological Survey site 038, 21 May 2004, *M.N.Lyons & D.A.Mickle 3069* (PERTH); Ethel Creek Claypan, Pilbara Biological Survey site 041, 1 June 2004, *M.N.Lyons & D.A.Mickle 3074* (NY, BM); Redrocks Granites, Pilbara Biological Survey site 080 T1, 25 Aug. 2005, *M.N. Lyons & D.A. Mickle 3159* (PERTH). QUEENSLAND: Cravens Peak site 4, Little Kanamuka, 17 Apr. 2007, *I.J.Powling r399* (MEL). NEW SOUTH WALES: Pied Stilt Swamp, 27 Jan. 2000, *J.L.Porter 239 & 240* (MEL).

Chara protocharoides Casanova & Karol, *nom. nov.*

(Fig. 5)

Protochara australis Womersley & Ophel, *Proc Roy. Soc. S. Australia* 71: 311 (1947); *Chara australis* subsp. *estipulodica* M.B.Macdon. & Hotchk., *Proc. Linn. Soc. New South Wales* 80: 282 (1956) (*non Chara australis* R.Br., *Prodr.* 346 (1810)).

[*Chara australis* f. *inflata auct. non* R.D.Wood, *nom. inval.*: R.D. Wood, *Nova Hedwigia* 22: 25 (1972), *p.p.*].

Type: Western Australia: In shallow swamp on peneplain of breakaway country between Mingenew and Irwin River coal seam, south-west of Geraldton, 28 Aug. 1947, *H.B.S.Womersley s.n.* Holo: AD *A5917a*; Iso: AD *A5917c*, NY *01089127*.

Dioecious. *Plants* up to 40 cm high, somewhat branched, variably inflated. *Axes* ecorticate, internodes 10–100 mm long, 0.9–1.5 mm in diameter in life (up to 2 mm when flattened in pressing). *Stipulodes* completely absent. *Branchlets* 6 or 7 in a whorl, entirely ecorticate, segments swollen or inflated in shallow water, elongate and cylindrical in deep-water populations, pinched in at the nodes, similar in diameter to the axes, 14–30 mm long, 3 or 4 cells long including end segment, *basal branchlet cell* variable in size, ~300 µm long in upper, *fertile branchlets*, similar to second branchlet segments on sterile branchlets, *branchlet end segments* unicellular, very small and mucronate, up to 200 µm long, with nodal cells at the base, *bract cells* and *bracteoles* completely absent from all branchlet nodes. Upper axes somewhat contracted. *Gametangia* on separate plants, singly and geminate on first and second branchlet nodes, occasionally oogonia inside the base of the branchlet whorl. *Oogonia* 670–900 µm long × 600–780 µm wide with 6 or 7 convolutions, *coronula* cells connivent and blunt, 80 µm high. *Oospores* black, 490–560 µm long and 310–390 µm wide, almost rectangular in side view, with 4 or 5 striae, sometimes flanged, and impression of the basal cell 80 µm in diameter. *Antheridia* 800–1150 µm in diameter, octoscutate. *Vegetative reproduction* not known; appears to be an annual in temporary water bodies. *Chromosomes* not known.

Taxonomic notes

Originally placed in the segregate genus *Protochara* on the basis of very simple, inflated axes and the lack of accessory cells (bract cells, stipulodes or bracteoles) (Womersley and Ophel 1947). Apart from the absence of any accessory cells, type material of *Protochara australis* is otherwise consistent with the morphology of the genus *Chara*. The epithet *australis* is preoccupied in *Chara* (*C. australis* R.Br., 1810), and a new name is required for this taxon.

Recognition

The complete absence of stipulodes, bract cells and bracteoles are the main characteristics that allow this species to be distinguished.

Distribution

Grows in permanent, seasonal and temporary water bodies in Western Australia.

Etymology

From the Latin '*protocharoides*' in reference to the genus *Protochara* for which this species remains the type.

Specimens examined

WESTERN AUSTRALIA: Bluegum Lake, Brentwood, Perth, 3 Oct. 2002, *M.T.Casanova r392* (MEL); Swan Lake, Bayswater, Perth, 3 Oct. 2010, *M.T.Casanova r805* (B, BM, MEL, NY, PERTH); small lake near inflow of Lake Leschenaultia, 5 Oct. 2010, *M.T.Casanova r812* (MEL, NY, PERTH); River pool 2 km NNW of Tindellara Well, 20 Sep. 1987, *R.J.Cranfield 6246* (PERTH); Hammersley River, in freshwater holes, 12 Oct. 1901, *F.L.E.Diels 4913* (B); interior of western Australia, 1890, *M.Heal* (LD, MEL); Cape Bertholet, Dampierland, N of Broome, 18 Apr. 1977, *K.F.Kenneally 6009* (PERTH); Yaladinia Rock Hole, 18 Sep. 1980, *K.R.Newbey 7462A* (PERTH); pool in woods, immediately S of Piesseville, 11 Oct. 1960, *R.D.Wood 60-10-11-9a* (AD); roadside pool, 3 miles (~4.83 km) S of Gnowangerup Road intersection, Tambellup, 10 Oct. 1960, *R.D.Wood 60-10-10-11A* (AD, CANB, PC).

Chara stuartiana (F.Muell. ex Kütz.) Casanova & Karol, *comb. et stat. nov.*

(Fig. 6)

Nitella stuartiana F.Muell. ex Kütz., *Tab. phycol.* 7: 28 (1857); *Chara stuartiana* A.Braun, *Linnaea* 25: 707 (1853), *nom. inval.*, *pro syn.*; *Chara australis* f. *stuartiana* (F.Muell. ex Kütz.) Zaneveld, *Blumea* 4: 126 (1940); *Chara corallina* f. *stuartiana* R.D.Wood, *nom. inval.*, *Taxon*, 11: 13 (1962); *Chara corallina* f. *stuartiana* R.D.Wood, *nom. inval.*, *nom. alt.*, *Rev. Characeae* 1: 275 (1965); *Chara stuartiana* R.D.Wood, *nom. inval.*, *nom. alt.*, *Rev. Characeae* 1: 769 (1965).

Type: Tasmania: South Esk River, *R.C.Gunn 1565*, 1852. Holo: L; iso: PC.

[*Chara australis* var. *nobilis auct. non* A.Braun in C.F.O.Nordstedt, *Abh. Königl. Akad. Wiss. Berlin 1882*: 105 (1883).]

Dioecious. *Plants* large and inflated, transparent and turgid, up to 27 cm high, but fragile, fragmenting easily when handled. *Axes* 1.5–2.8 mm wide, ecorticate, *internodes* 30–120 mm long. *Stipulodes* in a single row, tiny, up to 12 per whorl, up to 400 µm long, alternate to the branchlets and pointing upwards. *Branchlets* 6 in a whorl, 20–30 mm long, 1.6–2.8 mm wide, 3 or 4 cells long, all cells cylindrical, end segment a single cell, or subtended by small bract cells, *basal branchlet cell* elongate and cylindrical, the second branchlet cell is usually shorter than the basal branchlet cell, abbreviated and sometimes almost spherical, particularly on the upper parts of the

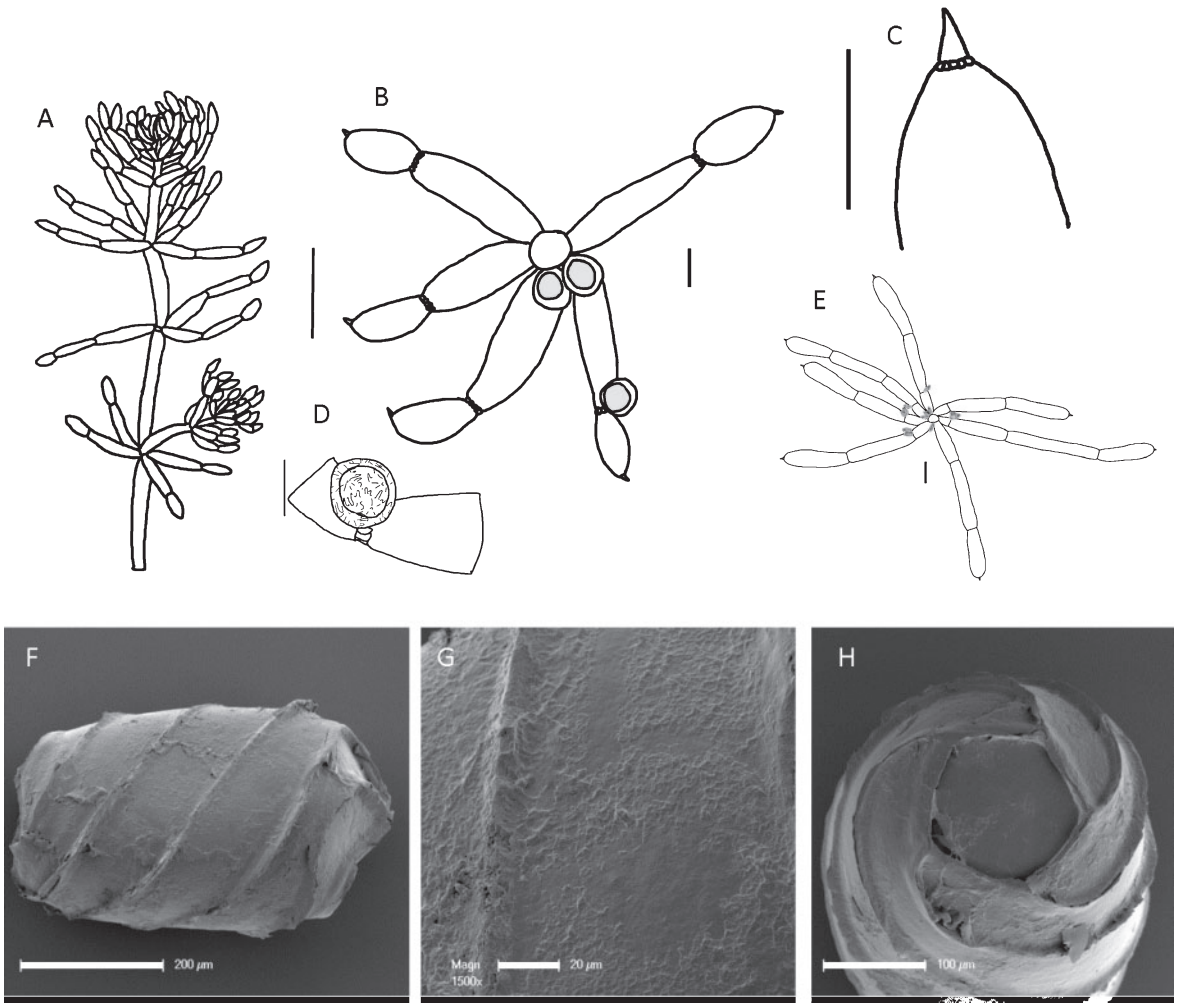

Fig. 5. *Chara protocharoides* Casanova & Karol. A. Habit of plant; scale bar: 1 cm. B. Whorl of antheridial branchlets; scale bar: 1 mm. C. Branchlet tip with single end cell; scale bar: 1 mm. D. Branchlet node and antheridium; scale bar: 0.5 mm. E. Oogonial branchlet whorl; scale bar: 1 mm. F. Oospore; scale bar: 200 µm. G. Detail of oospore wall; scale bar: 20 µm. H. Impression of end cell; scale bar: 100 µm. A–D, F–H from *H.B.S.Womersley 28-Aug-1947*; E from *M.T.Casanova r812.*

axis; *bract cells* 2 or 3 at branchlet nodes, up to 400 µm long. *Bracteoles* 2, up to 200 µm long. *Gametangia* on separate plants, solitary or geminate at all branchlet nodes. *Oogonia* at the lowest branchlet node, up to 1 mm long and 700 µm wide, with 8 convolutions, *coronula* very small and minutely apiculate. *Oospores* black, cylindrical to ovate, 615–700 µm long, 450–550 µm wide, with 6 or 7 striae of low ridges, basal-cell impression up to 140 µm in diameter at widest point, edges 85–115 µm long. *Antheridia* up to 500 µm in diameter, solitary, geminate or aggregate at the lowest branchlet node and inside the base of the whorl. *Vegetative reproduction* by starch accumulations in the lower and rhizoidal nodes. *Chromosomes* not known.

Nomenclatural notes

Wood's (1962) combination *Chara corallina* f. *stuartiana* is here treated as invalid, under Art. 41.5 of the ICN (McNeill *et al.* 2012). Wood and Imahori (1965) subsequently simultaneously published *C. corallina* f. *stuartiana* and *C. stuartiana*, the latter at the rank of 'microspecies', equivalent in rank to Wood's forms as well as his 'monotypic' varieties and species (i.e. those lacking subordinate taxa). Both these names are here treated as invalid alternative names, under Art. 36.2 of the ICN (McNeill *et al.* 2012).

Taxonomic notes

Braun (1852) included a specimen collected by C. Stuart in Tasmania (*Stuart 1565*) in *Chara australis*. Kützing (1857) named the species *Nitella stuartiana* based on *Stuart 1565* and provided an illustration (t. 28). Braun (1860) listed a collection from Tasmania, *Gunn 1565*, in his concept of *C. australis*. This is likely to refer to the same specimen as cited by Braun (1852) and Kützing (1857), and was collected by Gunn rather than Stuart, because the specimens attributed to Gunn have collection numbers for charophytes in the vicinity of Launceston (and the South Esk River) in the 1560s, and Stuart's collection numbers for the South Esk River are either very low (3, 4, 5), in the 210s or in the 1020s. Only two specimens in sect. *Protochara* collected

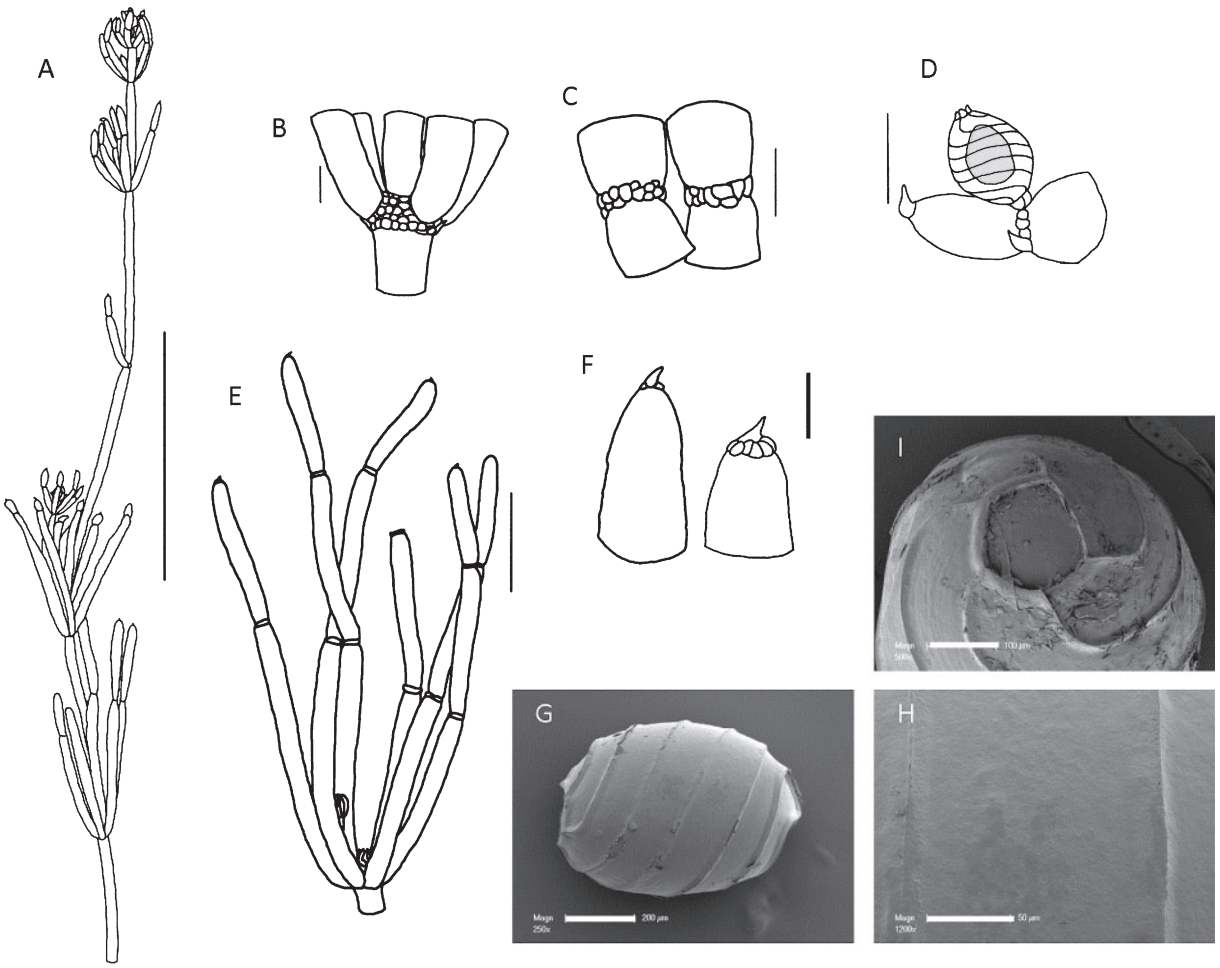

Fig. 6. *Chara stuartiana* (F.Muell. ex Kütz.) Casanova & Karol, from specimen from the type locality, *H. & A.Wapstra HAW044.* A. Habit of whole plant; scale bar: 5 cm. B. Base of a branchlet whorl; scale bar: 200 μm. C. Two branchlet nodes; scale bar: 1 mm. D. Oogonium and end cells of branchlet; scale bar: 1 mm. E. Sterile branchlet whorl; scale bar: 1 cm. F. Branchlet end cells; scale bar: 0.5 mm. G. Scanning electron micrograph (SEM) of oospore; scale bar: 200 μm. H. SEM of detail of oospore wall; scale bar: 50 μm. I. SEM of impression of the basal cell; scale bar: 100 μm.

from Tasmania in the 1800s are known, including material used by Kützing for his illustration, almost certainly obtained from Sonder's herbarium (L), and a specimen labelled '*Nitella australis* R.Br. Donné par Sir William Hooker, 1863; *Ex Herb. Hook. Chara australis Br*, *Tasmania*, *Coll. R.C.Gunn*' (PC). It is possible that these are parts of the same gathering, and therefore the PC specimen would constitute isotype material. Braun, in Nordstedt (1883), retained *N. stuartiana* in synonymy of *C. australis*, but cited another specimen from Tasmania (*Oldfield 283 n.v.*) as *C. australis* var. *nobilis.* Zaneveld (1940) treated *N. stuartiana* as a form of *C. australis* var. *nobilis.* Proctor (1999) found that specimens identified as *C. australis* and *C. stuartiana* could be crossed to produce oospores, and explained *C. stuartiana* as a 'genetically fixed morphotype of *C. australis*'. Examination of the type material and more recent collections indicated that most of specimens from Tasmania in sect. *Protochara* can be clearly separated from *C. australis* on the basis of more robust axes and branchlets, complex axial and branchlet nodes, overall fragility and different oospores. *C. stuartiana* is rarely collected as a whole plant, because the heavy, turgid axes are fragile and tend to break as they are removed from the water. The species still occurs in what is presumed to be the type locality, namely, the first basin of Cataract Gorge in Launceston. Specimens collected from Kimberley Warm Springs (*T.Dugdale & S.Talman 20*, HO, MEL, NY*; H. & A.Wapstra HAW002*, MEL, HO) appear to be *C. australis* rather than *C. stuartiana*, but if so, that is the only occurrence of *C. australis* known from Tasmania.

Recognition

Chara stuartiana has large, fragile, often inflated, ecorticate axes and branchlets, with orange antheridia and oogonia. It can be distinguished from *C. australis* by its wide axes and branchlets, and by the abbreviated penultimate cell on the upper branchlet whorls.

Distribution

Grows in Tasmania in rivers and streams, at depth.

Etymology

Named for Charles Stuart (1802–1877) who collected charophytes in Tasmania from 1842 to 1852, initially for R.C. Gunn, later for F. von Mueller (Orchard 1999).

Specimens examined

TASMANIA: Apsley River at Coles Bay Road, 7 July 2008, *H. & A.Wapstra HAW009* (HO, MEL); Prosser River, Paradise Gorge, 1 Oct. 2008, *H. & A.Wapstra HAW027* (HO, MEL); South Esk River, Glen Esk Bridge, 21 Oct. 2008, *H. & A.Wapstra HAW044* (B, HO, MEL, NY); South Esk River, 22 Oct. 2008, *H. & A.Wapstra HAW048* (HO, MEL, NY); Meredith River at Swansea, 22 Apr. 2009, *H. & A.Wapstra HAW133* (HO, MEL); Curries River reservoir, 14 Oct. 2008, *M.Wapstra HAW034* (HO, MEL); farm dam, Bridport road between Yarrow Creek and Pipers River, 15 Oct. 2008, *M.Wapstra HAW036* (HO, MEL, NY); first basin of Cataract Gorge, 20 Feb. 2013, *M.Wapstra HAW145* (HO, MEL); Elizabeth River, Campbell Town, 19 Jan. 1961, *R.D.Wood 61-1-19-3* (AD, NY, PC); stream 6 miles (~9.66 km) S of Sorrel, 1 Feb. 1961, *R.D.Wood 61-2-1-2* (AD, NY, PC); 15 miles (~24.14 km) S of Seymour, 2 Feb. 1961, *R.D.Wood 61-2-2-6* (AD, NY); St Pauls River, 3 Feb. 1961, *R.D.Wood 61-2-3-6* (AD, NY); South Esk River, 3 Feb. 1961, *R.D.Wood 61-2-3-7* (AD); 2 miles (~3.22 km) N of Longford, 4 Feb. 1961, *R.D.Wood 61-2-4-14* (AD, NY).

Chara wallichii A.Braun in C.F.O. *Abh. Königl. Akad. Wiss. Berlin 1882*: 107 (1883)

(Fig. 7)

Chara corallina var. *wallichii* R.D.Wood, *nom. inval.*, *Taxon* 11: 13 (1962); *Chara corallina* var. *wallichii* (A.Braun) R.D.Wood, *Rev. Characeae* 1: 278 (1965), *nom. inval.*, *nom. alt.*

Type: INDIA: Gangetic Plain, *leg. ign.*, 9 Jan. 1809. Holo: LINN, *n.v.*

Dioecious. Plants up to 25 cm high, prickly in appearance. *Axes* ecorticate, 875–1100 µm wide, *internodes* somewhat shorter than the branchlets. *Stipulodes* well developed and somewhat inflated where present, up to 450 µm long. *Branchlets* 6 in a whorl, ecorticate, up to 30 mm long, 4–6 cells long, *basal branchlet cell* longest, the *end segment* short, conical and acute. *Bract cells* well developed, 1–4 at a node, up to 2 mm long. *Gametangia* on separate plants, clustered at the base of the whorl and singly or geminate at all branchlet nodes. *Oogonia* up to 745 µm long, 700 µm wide, with 7 or 8 convolutions. *Oospores* 500–610 µm long, 330–440 µm wide with 6 or 7 flanged ridges. *Antheridia* 750–950 µm in diameter, tetrascutate (Wood and Imahori 1965). *Chromosomes* not known.

Nomenclatural notes

Wood's (1962) combination *Chara corallina* f. *wallichii* is here treated as invalid, under Art. 41.5 of the ICN (McNeill *et al.* 2012). Wood and Imahori (1965) subsequently simultaneously published *C. corallina* var. *wallichii* and *C. wallichii*, the latter at the rank of 'microspecies', equivalent in rank to Wood's forms as well as his 'monotypic' varieties and species (i.e. those lacking subordinate taxa)). *C. corallina* var. *wallichii* is here treated as invalid, under Art. 36.2 of the ICN (McNeill *et al.* 2012).

Recognition

Chara wallichii is a dioecious species that, in contrast to most other species in the group, is distinguished by well developed,

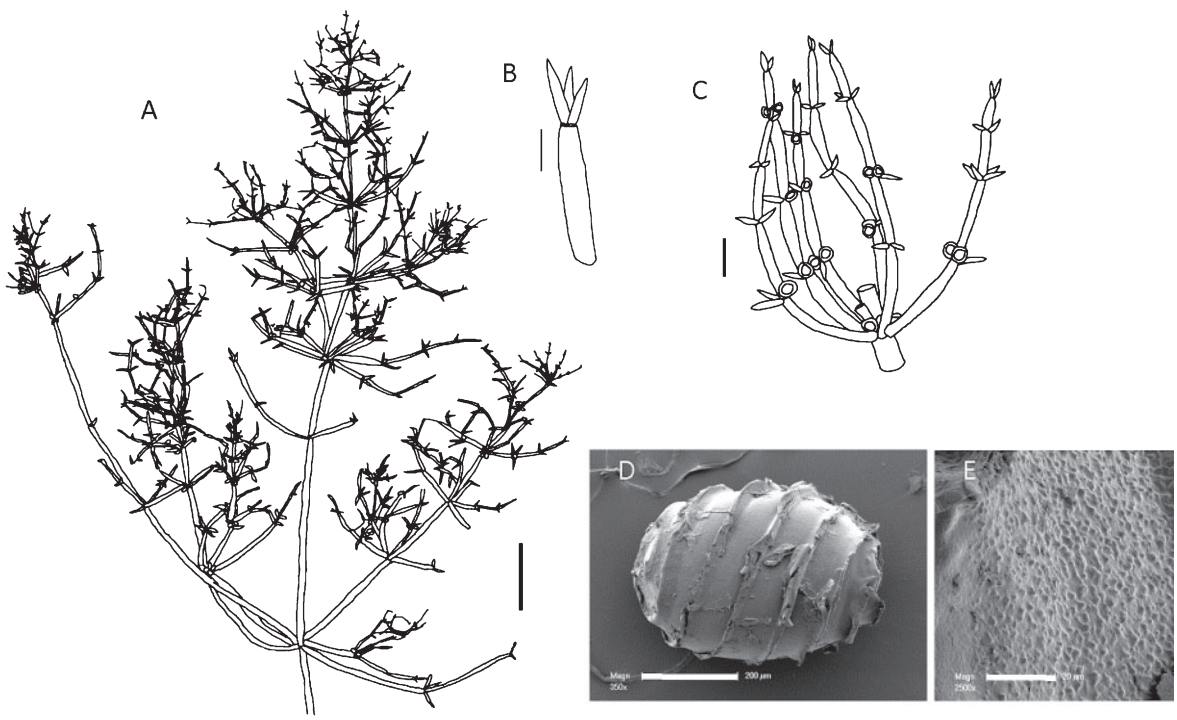

Fig. 7. *Chara wallichii* A.Braun, from *Parsotam 230*. A. Habit of whole plant; scale bar: 1 cm. B. Branchlet tip; scale bar: 1 mm. C. Branchlet whorl from an antheridial plant; scale bar: 1 mm. D. Oospore; scale bar: 200 µm. E. Detail of oospore wall; scale bar: 20 µm.

somewhat inflated, stipulodes and bract cells. Material seen in BM and BP is relatively uniform.

Distribution

India and Bangladesh.

Etymology

Named in honour of Nathaniel Wallich (1786–1854), a Danish botanist involved in the development of the Calcutta Botanic Garden.

Specimens examined

INDIA: Sarmalt, Benares, Uttar Pradesh, Jan. 1934, *Parsotam 230*, (BP, BM).

Additional taxa of uncertain status

Tolypellopsis simplicissima *Fil.,* Arch. Hydrobiol.*, Suppl. 12,* Tropische Binnengewässer *3: 716 (1934)*

Known only from the type gathering from Lake Toba, a deep, oligotrophic caldera in Sumatra, in 1929. The morphology of this species is similar to that of *C. australis*; however, the oogonia are much smaller and more spherical than those of any other species in sect. *Protochara*. Because of its overwhelming morphological similarity to other species in sect. *Protochara*, it is likely to be a species of *Chara*. It does not appear to have many accessory cells (stipulodes, bract cells); however, further collections of mature female material is required for confirmation of the identity and placement of this taxon.

Chara plebeja *R.Br.* ex *A.Braun, Linnaea 17: 118 (1843)*

Known only from the type gathering from 'Carpentaria Point', possibly the 'Carpentaria Main' of Brown's and Flinders' diaries, now known as Cape Shield (Groves and Moore 1989), in Arnhem Land near Groote Eylandt in the Gulf of Carpentaria. Satellite images of the locality of Cape Shield revealed a hind-dune wetland area that could be where Brown collected this species. Treated as a subspecies of *C. australis* by Braun in Nordstedt (1883) and as a variety of *C. australis* by Zaneveld (1940), and distinguished from *C. australis sens. str.* on the basis of obtuse end cells on the branchlets. Detailed examination of the type material revealed a few stipulodes and bract cells, and what appear to be obtuse end cells are probably penultimate cells, with the end cells dehiscent. Given the possible habitat and evidence from the morphology (7 or 8 branchlets rather than 6, stipulodes opposite the branchlet and somewhat decumbent), it seems likely that *C. plebeja* is a species of *Lamprothamnium*. If so, it would be the only known coastal *Lamprothamnium* from the tropics. Further collections of fertile female material are required to confirm this.

Chara *sp. Woorndoo (M.T.Casanova p246)*

This specimen is likely to represent a new species. Oospores are similar in appearance to those of *C. porteri*, but are over 700 μm long (c.f. *C. porteri* with oospores 470–525 μm long), and its distribution is disjunct from *C. porteri*. However, there are insufficient gatherings to confirm its status at the present time.

Several other species have been recorded from the Indian subcontinent (*Chara fulgens* Fil., *C. pashanii* S.C.Dixit and *C. nuda* Pal) and oceanic islands of the southern hemisphere (*Chara socotrensis* Nordst. from Socotra, *C. corallina* f. *vieillardii* (A.Braun) R.D.Wood from New Caledonia, *C. corallina* f. *vitiensis* Nordst. from Fiji and *C. corallina* f. *mascarensis* J.Groves & Stephens, *nom. inval.*, *nom. prov.* from Mauritius); however, because specimens have not been examined, no comment on their status can be made in the present study.

Discussion

Species in sect. *Protochara* have few characters to aid discrimination, a fact that has contributed to the confused history of generic and species names in this group. Axis and branchlet diameter and the expression of accessory cells (stipulodes, bract cells) can allow discrimination in well grown plants; however, the occurrence and expression of basal gametangia and abundance of branchlet gametangia probably vary in relation to plant nutrition and age and there are examples of specimens that fail to conform to the 'average' morphology (e.g. from cultured material, young plants growing in shallow water, or etiolated plants from deep water). Reference to the oospore morphology is necessary to distinguish such doubtful specimens.

Separation of *Chara* sect. *Protochara* and the genus *Lamprothamnium* (also ecorticate, sometimes inflated, sometimes with few accessories) on the basis of vegetative morphology will always be something of a challenge, particularly with material lacking diagnostic characters. These two taxa appear to be closely related on the basis of nucleotide-sequencing studies (Meiers *et al*. 1999; McCourt *et al*. 2000). The main characters to aid identification are that *Lamprothamnium* species usually have more than six branchlets in a whorl, their stipulodes are opposite and decumbent when present, and the oospores possess gyrogonites (a calcified covering). Additionally, most members of sect. *Protochara* occur in freshwater, whereas *Lamprothamnium* species occur in brackish to saline water.

Chara braunii (sect. *Charopsis*) can be separated from members of sect. *Protochara* phylogenetically (Meiers *et al*. 1999; McCourt *et al*. 2000) and morphologically. *C. braunii* has well developed stipulodes and bract cells, and the branchlets are terminated by a 'corona' of approximately three equal-sized cells, rather than a single cell, as in sect. *Protochara. C. braunii* is a relatively ephemeral charophyte, and is rarely found in Australia, with most specimens referred to *C. braunii* in Australian herbaria being referable to *C. muelleri*.

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