
Chrysomenia tigillis sp. nov. (Rhodymeniales, Rhodophyta) from the Sultanate of Oman, with a census of currently recognized species in the genus *Chrysomenia*

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SUMMARY

Chrysomenia tigillis sp. nov. is described on the basis of a few specimens collected from Dhofar, Sultanate of Oman. The new species is known only from southern Oman, a region of the northern Arabian Sea that is strongly impacted by the upwelling from the summer-time monsoon. It is distinguished from other species of the genus by the simple nature of the blades, their dimensions (to 75 cm in length and to 21 cm in width), the rough, bumpy surface of the blades, and the presence of internal struts connecting the inner sides of the blades. A census of the currently recognized species in the genus *Chrysomenia* is provided.

Key words: *Chrysomenia*, *Chrysomenia tigillis*, marine algae, new species, Omani flora, red algae.

INTRODUCTION

In recent years the benthic marine algal flora of the Sultanate of Oman, northern Arabian Sea, has been receiving greater attention. The publication of several newly described taxa and new records for this region has resulted (Nizamuddin & Campbell 1995; Wynne 1998, 1999a,b, 2000, 2001a,b, 2002a,b, 2003a,b, 2003c, 2004, 2005; Wynne & Jupp 1998; Wynne & Leliaert 2001; Schils & Copejans 2002; Wynne & de Jong 2002; Wynne & Freshwater 2004).

The Rhodymeniacean genus *Chrysomenia* is characterized as having erect or repent thalli, terete, compressed, or flattened, entirely hollow and lacking diaphragms or regular constrictions, the cavity with or without medullary filaments, unstalked gland cells usually present on inner cortical/medullary cells, and cystocarps without an enveloping network of filaments. The consistency of the thalli in the various species ranges from soft to firm, and abundant mucilage is present in the hollow interior. The closely related genus *Botryocladia* differs because its thalli have solid portions (Feldmann 1945; Kylin 1956), whereas the only solid portion of thalli in *Chrysomenia* is the basal stipe, or region of attachment. *Botryocladia* also differs by its

ramisymphodal growth (Kylin 1956; Millar 1990). The genus *Irvinea*, segregated from *Botryocladia* by Guiry (in Saunders *et al.* 1999), also has terete solid axes terminating in sympodially developed hollow vesicles (Brodie & Guiry 1988, as *Botryocladia ardreana* Brodie *et Guiry*). But it possesses distinctive features, such as the arrangement of cortical cells in rosettes, strongly protruding cystocarps, and the formation of gland cells on special initials. Like *Botryocladia*, its terete axes separate it from *Chrysomenia*. *Hymenocladia*, with large foliose blades, is distinctive in the family because of its tetrahedrally divided tetrasporangia and the medulla being composed of intermixed large and small cells (Harvey 1860b, as *Rhodymenia polymorpha* Harvey; Sparling 1957; Womersley 1996). *Cenacrum*, a genus also with thalli that are large, foliose, and usually deeply dissected, is separated on the basis that its initially hollow regions become progressively filled with ingrowing rhizoidal filaments such that proximally the interior becomes solidly packed with filaments (Ricker & Kraft 1979).

The only previously recorded *Chrysomenia* from Oman is *Chrysomenia grandis* Okamura (1933) reported by Wynne (2001b), on the basis of numerous collections made from Dhofar. The occurrence of that species from Oman was the first record outside of its then known range in Japan (Yoshida 1998).

MATERIALS AND METHODS

The specimens were gathered by scuba diving. The several specimens were then pressed as herbarium specimens. Smaller amounts were preserved in 5% formalin in seawater. Voucher material has been deposited in the Natural History Museum, London (BM), the Herbarium of the University of Michigan (MICH), and the Natural History Museum of Oman, Muscat (ON). Herbarium abbreviations are according to Holmgren *et al.* (1990).

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For comparison, these other species were examined:
Chrysomenia grandis Okamura.

Japan. Off Tsudo, Oki Islands: 3.vii. 1986. *leg.* M. Kajimura no. 726, 40 m, tetrasporic (MICH).

Chrysomenia planifrons (Melvill) J. Agardh.

USA, Florida. Indian River Inlet (now Fort Pierce Inlet) (27.4700°N, 80.2883°W): v. 1899, *leg.* Mrs G. A. Hall, two cystocarpic specimens, washed ashore (NY). Jupiter Inlet 26.9433°N, 80.0733°W: 14.ix. 1896, *leg.* Mrs G. A. Hall, Phycotheca Boreali-Americana 388 (cystocarpic in MICH; cystocarpic in NY; male in NY).

RESULTS AND OBSERVATIONS

Chrysomenia tigillis M. J. Wynne sp. nov.
(Figs 1–12)

Aliis speciebus in genere natura simplici laminarum, amplitudine laminarum (tenus 75 cm in longitudine, tenus 21 cm in latitudine), pagina grossa atque aspero laminarum, et praesentia tigillorum interiorum latores interiores laminarum connexorum. Plantae feminae cystocarpiis super paginam laminae dispersis; plantae masculae et tetrasporangiae ignotae.

Chrysomenia tigillis M. J. Wynne sp. nov.
(Figs 1–12)

It is distinguished from other species of the genus by the simple nature of the blades, their long dimensions (to 75 cm in length, to 21 cm in width), the rough and bumpy surface of the blades, and the presence of internal struts connecting the inner sides of the blades. Female plants with cystocarps scattered over blade surfaces; spermatangial and tetrasporangial plants not known.

Etymology: Latin *tigillum* (s. n. II), strut; abl. pl. *tigillis*, with struts.

Holotype: Sultanate of Oman. Sadh (17.0437°N, 55.0805°E), east of Mirbat, Dhofar: 22.ix. 2001, *leg.* Glenn Richards and Henry Ford 22092001-17-03, scuba-collected from a depth of 12 m. Cystocarpic. Deposited in MICH.

Isotypes: Deposited in BM and ON. Both isotypes are also cystocarpic.

Additional collection: 22092001-17-19 (same data as for the type) (MICH).

Vegetative organization

The thallus (Fig. 1) is erect, simple, foliose, up to 75 cm in length and up to 21 cm in width, with a thickness of approximately 1 mm (860–1250 µm). The blade surface is rough, bumpy, locally corrugated. The texture is slippery, but somewhat firm and succulent.

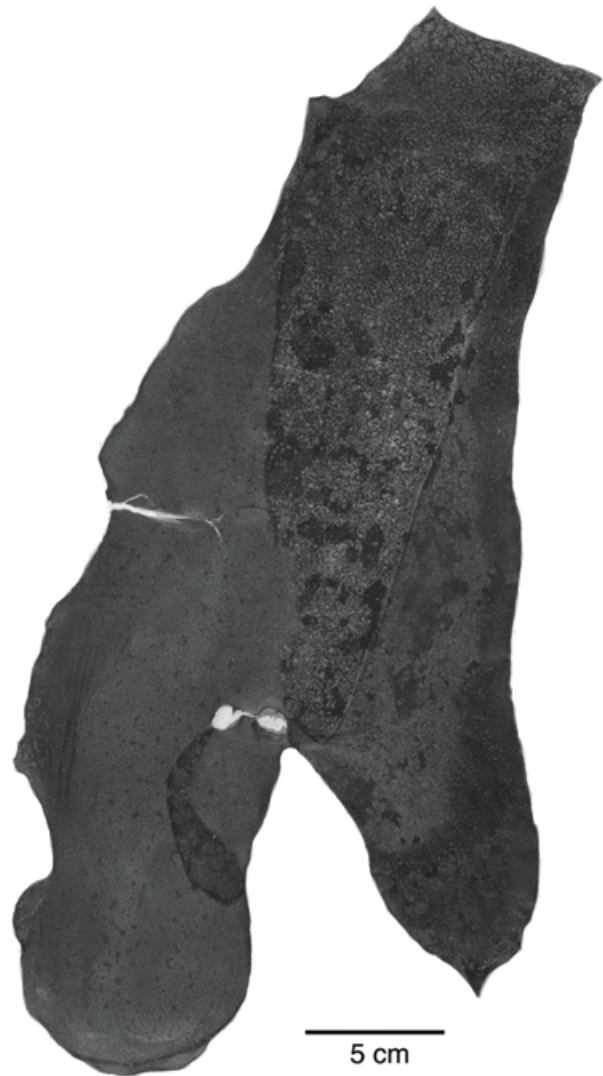
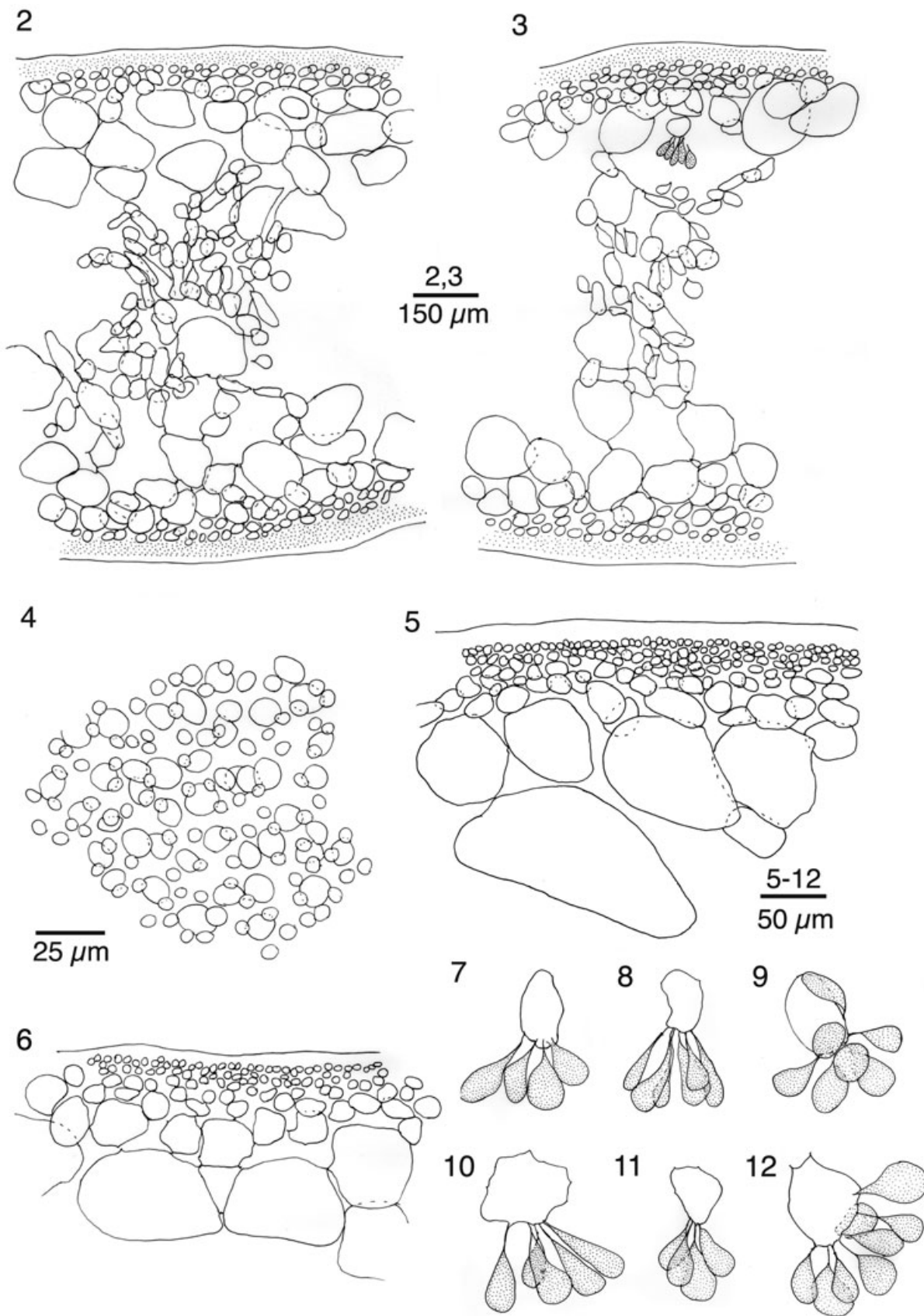


Fig. 1. *Chrysomenia tigillis*. Holotype specimen. Herbarium of the University of Michigan (MICH).

The color is dull reddish when the specimen is pressed. In one isotype specimen (in BM) a pair of blades share an attachment stipe of 3 mm in height and 2 mm in diameter. The larger blade of the pair then has a stipe of 6 mm before abruptly expanding into the lamina. The blade is essentially hollow and filled with mucilage, but transversely oriented struts are present (Figs 2,3). These struts are composed of branched chains of variously sized cells that connect the inner surfaces of the blade. Inner polygonal subcortical cells cut off chains of cylindrical cells inwardly, and they form branching chains of cells that extend in various directions, connecting with cells on the opposite inner face of the hollow medulla. Each strut is composed of a plexus of 3-D branched chains of cells of various sizes (spherical and elongate). The struts are not continuous diaphragms, but are sporadic discrete columns. The cortex



Figs 2–12. *Chrysymenia tigillis*. 2,3. Medullary struts between insides of surface layers. 4. Surface view of cortex. 5,6. Cross-sections of blade, showing portion of cortex, subcortex, and medullary cells. 7–12. Examples of gland cell arrangements.

has a continuous layer of surface cells (Fig. 4) and is made up of 3–5 layers of small pigmented cells in depth (Figs 5,6). The edges of the blade are much more thickened, comprised of a dozen or more layers of cortical cells. The cells of the cortex are subtended by larger subcortical cells and then by even larger medullary cells, 145–178 $\mu\text{m} \times$ 62–132 μm in size. The subcortex is composed of a mixture of smaller cells and larger cells. The subcortical and medullary cells are 2–3 cell layers in total (Figs 5,6). Gland cells are common and are borne on innermost medullary cells, facing into the central cavity. Gland cells are pyriform, 36–46 μm in length and 16–32 μm in diameter, darkly staining (with aniline blue). There are usually 5–8 gland cells per bearing cell (Figs 7–12), but occasionally only 2 or 3 gland cells are present per bearing cell. Usually the bearing cells are small, are often refractive, and, like the gland cells, stain densely with aniline blue. Rarely, the gland cells are located on larger bearing cells, but they do not absorb aniline blue stain intensely and are not refractive.

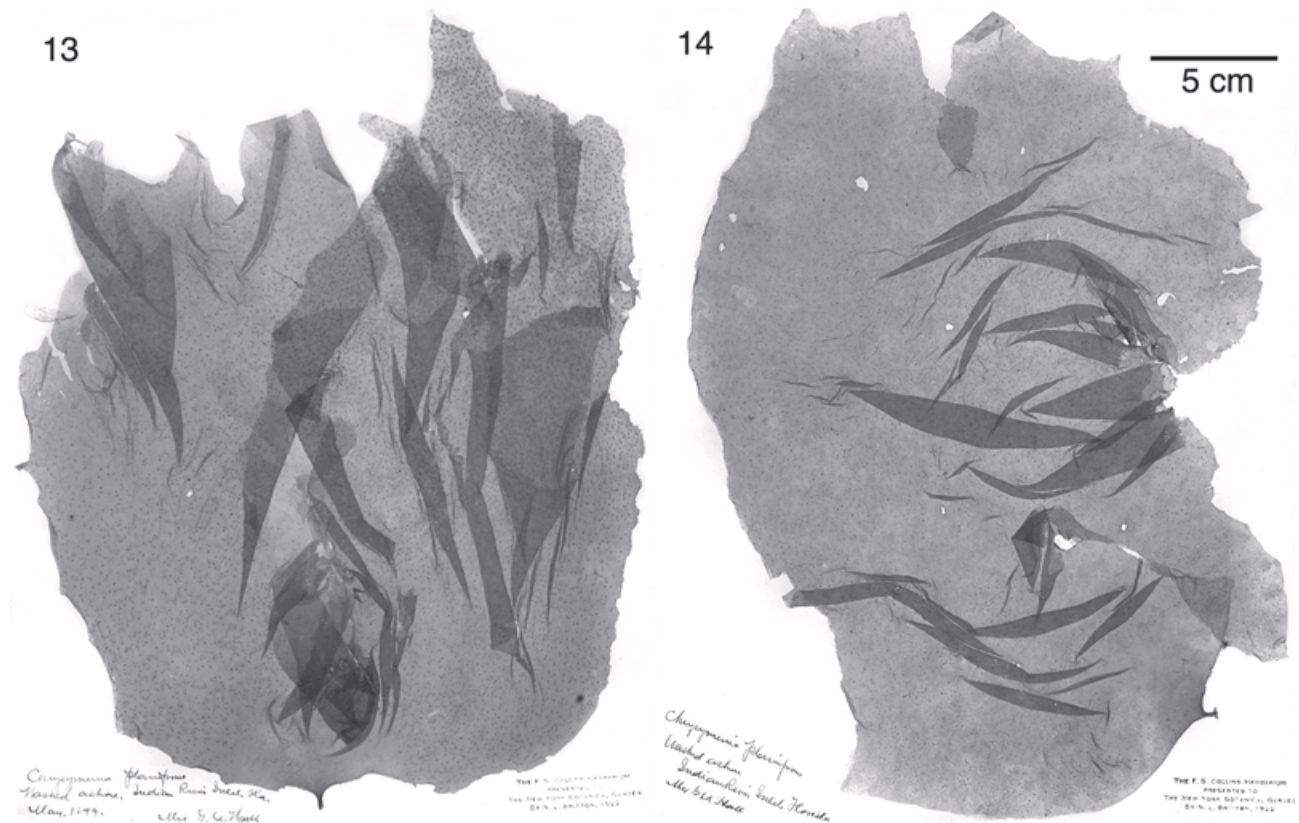
Reproductive structures

Female thalli bear abundant cystocarps, scattered randomly over both blade surfaces. At maturity, the peri-

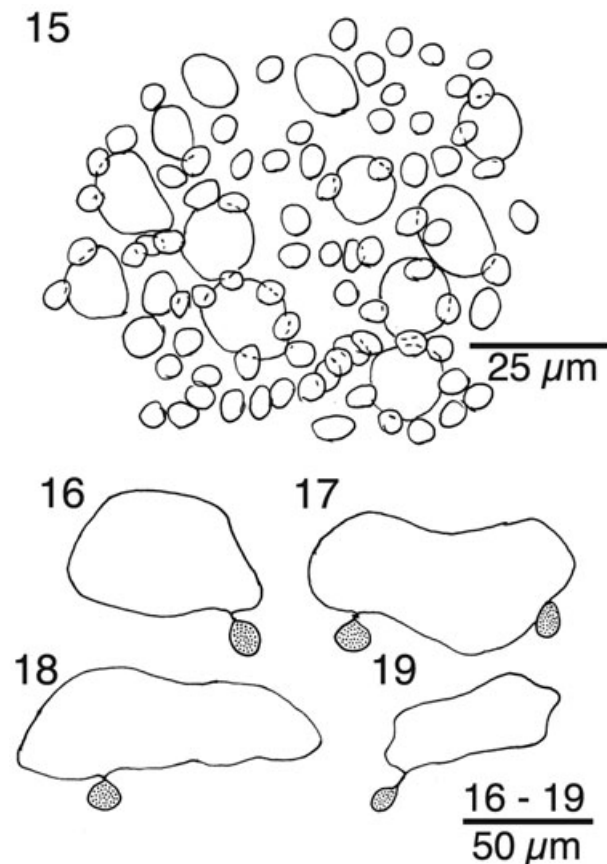
carps are hemispherical, protruding from the blade surface, ostiolate, and the discrete carposporophytic mass is 360–545 μm in diameter. Male and tetrasporangiate thalli were not seen.

Chrysomenia planifrons (Figs 13–19)

Because the species *C. planifrons* is not a well-known species and because of its similarity to the new species being described from the Sultanate of Oman, it is appropriate to include some observations on specimens of the former species. It is the only species of *Chrysomenia* which comes close to *C. tigillis* in its overall dimensions (height and width). Specimens of *C. planifrons* on loan from NY were essentially large simple blades. One of the pressed specimens (Fig. 13) measured about 31 cm in length and 25 cm in width (it was much folded over, and so its actual width was certainly greater). The second specimen (Fig. 14) was 32 cm in length and approximately 19 cm in width. Both specimens bore abundant scattered cystocarps, but the blade surface was smooth compared to the very rough surface of *C. tigillis*. Cross-sections of this material revealed a cortex that consisted of fewer layers of cells than that of *C. tigillis*. The cortical cells in the surface layer of



Figs 13,14. *Chrysomenia planifrons*, specimens from Indian River Inlet, Florida (NY).



Figs 15–19. *Chrysymenia planifrons*. 15. Surface view of cortex. 16–19. Examples of gland cell arrangements.

C. planifrons (Fig. 15) were more dispersed than seen in *C. tigillis*, and they were underlain by larger subcortical cells. Gland cells were observed in *C. planifrons*, but they tended to occur singly or in pairs from the bearing cells (Figs 16–19).

In NY is a photograph of an isotype specimen of '*Chrysymenia Agardhii planifrons* Melvill' in the Agardh Herbarium (LD), with notes indicating that there were three such 'co-types' from Key West, Florida, in LD. One specimen was said to be 'with conspicuous cystocarps'. The single photograph was of no. 26451 (LD), said to be the 'largest, though sterile'. It depicts a blade broader than long, deeply lobed, with a proliferous margin.

Another species of the genus also described from Florida was *Chrysymenia curtissiana* J. Agardh (1885), which Kylin (1931) treated as a taxonomic synonym of *C. planifrons*, saying that it was merely a large form of *C. planifrons*. According to Kylin (1931) a single specimen of *C. curtissiana* in the Agardh Herbarium (LD) was 42 cm long and 25 cm broad, with the upper part of the thallus divided into some large, broad lobes.

DISCUSSION

Chrysymenia J. Agardh (1842), based on the type species *Chrysymenia ventricosa* (J. V. Lamour.) J. Agardh, is assigned to the family Rhodymeniaceae (order Rhodymeniales) (Saunders *et al.* 1999). Currently, most workers in the Rhodymeniaceae treat *Cryptarachne* (Harvey) Kylin as congeneric with *Chrysymenia*. Harvey's (1853) subgenus *Cryptarachne* was raised to generic rank by Kylin (1931) on the basis of the presence of internal rhizoids filling the hollow center in species assigned to *Cryptarachne* and their alleged absence in *Chrysymenia sensu stricto*. Børgesen (1910), however, observed that although in young parts of the thalli of *C. ventricosa* rhizoidal filaments were absent, they appeared in mid portions of the thalli and 'occurred richly' in lower (older) portions. These observations, therefore, cast doubt on the reliability of this feature to distinguish *Chrysymenia* and *Cryptarachne*. Okamura (1936) chose not to recognize *Cryptarachne* as distinct from *Chrysymenia*, and this taxonomic opinion was followed by Yamada and Segawa (1953), Abbott and Littler (1969), Silva *et al.* (1996), and Saunders *et al.* (1999). Yet other workers have maintained *Cryptarachne* as distinct, such as Taylor (1960), Yoshida (1998), and Xia and Zhang (1999). Xia and Zhang (1999) recognized *Cryptarachne kairnbachii* (Grunow) Kylin, *Cryptarachne okamurae* (Yamada et Segawa) Zhang et Xia (1983); and *Cryptarachne reticulata* Xia et Wang, a name that appears to be a *nomen nudum*.

In the present study, *Cryptarachne* is treated as congeneric with *Chrysymenia* and, therefore, *Chrysymenia polyglandulosa* Okamura (1930) is retained within *Chrysymenia*. If *Cryptarachne* were to be maintained, *Chrysymenia* would then be reduced to approximately a dozen species. Therefore, a total of 20 species are here recognized as being assigned to *Chrysymenia* (Appendix 1). The species of *Chrysymenia* were assigned to three artificial divisions, or morphological 'form-groups', by Norris and Ballantine (1995). The first form-group, including *C. ventricosa*, *C. halymenioides*, *C. enteromorpha*, *C. vesiculosa*, *C. wrightii*, and *C. grandis*, have erect thalli that are terete to moderately compressed. The second form-group, including *C. agardhii*, *C. planifrons*, *C. dickieana*, *C. lobata*, *C. polyglandulosa*, and *C. ornata*, have erect thalli that are flattened and blade-like. The final group were those species with repent thalli with flattened or lobed forms; this group included *C. kaernbachii*, *C. procumbens*, *C. okamurae*, and *C. glebosa*. Norris and Ballantine (1995) assigned their two newly described species, *C. littleriana* and *C. nodulosa*, to the first form-group because of their thalli being slightly too moderately compressed throughout. Two other species, *C. polydactyla* Hooker

Table 1. Comparison of selected species of *Chrysomenia*

	<i>Chrysomenia agardhii</i>	<i>Chrysomenia polyglandulosa</i>	<i>Chrysomenia ornata</i>	<i>Chrysomenia planifrons</i>	<i>Chrysomenia tigillis</i>
Habitat/depth	24–32 m	–	10–13 m	30 m	8 m
Height (cm)	10–20	9	20	to 40	to 75
Width (cm)	1–5; segments 2.0–2.5	5–10 overall, but narrow segments	3–5	25	9–21
Thickness (mm)	0.7–1.1	–	1 mm	–	–1 mm
Branching pattern	Simple, forked	Irregularly dichotomous, deeply lobed	irregularly deeply cleft or lobed	simple, with deltoid lobes	simple
No. cortical layers	2–3	1–2	1–2	1	3–5
No. subcortex/ medullary layers	1–2	2–4	1–2	1–2	2–3
No. gland cells per bearing cell	2–4	Present	1–several	1–few	5–8
Hollow	Yes, mucilage filled	Yes	Yes; gelatinous	More or less hollow	Yes; mucilage filled
Presence of medullary filaments	A dense plexus; numerous; few-several	Few oblong medullary cells	None, but rarely inner cortical cells contiguous	'Lacking'; 'some hyphae'	Transverse 'struts' between inner surfaces
Female thalli; cystocarps	Scattered over surface	Scattered over surface	–	Scattered over surface	Scattered over surface
Size of tetrasporangia	Approximately 27 µm	–	25 µm × 18 µm	–	–
Type locality; distribution	Key West, FL, USA; North Carolina, Caribbean, Bermuda	Yoshikawa, Hatidyo I., 7 Islands of Idzu, Japan	Port Jackson, NSW; eastern Australia and New Zealand	Key West, FL, USA; Virgin Islands, Netherland Antilles, Bermuda?	Sadh, Oman
References†	1,2,3,4,5	9	4,6,7	1,2,4,8,10	10

†(1) Børgesen (1910); (2) Børgesen (1920); (3) Harvey (1853); (4) Kylin (1931); (5) Taylor (1928); (6) Agardh 1885); (7) Millar (1990); (8) Taylor (1960); (9) Okamura (1930); (10) the present paper. –, no data.

f. et Harvey and *C. coelarthroides* Feldm.-Maz., would appear to belong to the first form group. According to Adams (1994), however, the generic assignment of the former species remains uncertain.

The new species of *Chrysomenia* from Oman, with its broadly foliose thalli, clearly belongs to the second form-group, and so a comparison will be restricted to those species with erect and flattened forms. *C. ornata*, reported from eastern Australia (Agardh 1885), New Zealand (Adams 1994), and Norfolk Island (Millar 1999), has been shown by Kylin (1931) and Millar (1990) to have a foliose thallus, to be deeply and irregularly divided and with many marginal blades. Harvey (1863, as *Halosaccion digitatum*) depicted it as dichotomously branched. The much divided habit of *C. ornata* separates it from the Omani alga under discussion. Further comparison will be made with three other species assigned to form-group 2 (Table 1). Interestingly, if *Cryptarachne* were to be recognized as distinct, three of these four species being compared (*C. agardhii*, *C. planifrons*, and *C. polyglandulosa*) have all been placed in *Cryptarachne*.

Chrysomenia agardhii has flat, undulate thalli, cuneate at the base, expanding into dichotomously to palmately lacinate distal lobes, to 2.5 cm broad (Harvey 1853; Taylor 1960). Margins of the blades are irregularly erose-dentate, and the medulla is densely packed with numerous rhizoidal filaments (Harvey 1853). *C. dickieana* is eliminated from further consideration in that thalli in that species consist of much branched, flattened axes, but the branches reach up to only 5 mm in width (Taylor 1960). Kylin (1931; pl. 3, fig. 7) has depicted the type specimen of *C. dickieana*.

The habit of *C. planifrons* most approximates that of the Omani species in being erect, broadly foliose. The distribution of *C. planifrons* includes the east coast of Florida, extending southward to Key West (the type locality), and the West Indies (Børgesen 1920; Taylor 1960). Schneider (2003) queried its occurrence in Bermuda. Taylor (1942) later corrected his earlier report (Taylor 1930) of *C. planifrons* from Cabo Frio, Brazil, describing the Brazilian material as the new species *Fauchea peltata* W. R. Taylor, now known as *Asteromenia peltata* (W. R. Taylor) Huisman and Millar (1996).

Chrysymenia grandis has been described as 'large, tubular, elongated, filled with jelly', shortly stipitate at the base (Okamura 1933). Okamura characterized the thalli to be simple, oblong or ovate when young and later become branched into a few segments, whereas Kajimura (1998) observed thalli from the Oki Islands to be terete, unsegmented, entirely hollow, mostly simple, reaching 25 cm in height and with a diameter of 5 cm. A pressed specimen of *C. grandis* in MICH (from the Oki Islands, Japan) has a broadly foliose aspect with a single erect habit (16 cm in length by 6.5 cm in width). Both Okamura (1933) and Kajimura (1998) were in agreement that the thalli in this species have a cylindrical or terete form, and it is when pressed that the specimens give the false impression of being foliose. Therefore, *C. grandis* can be eliminated from consideration.

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7. *C. halymenioides* Harvey (1853): 188, pl. XX, fig. A (type locality: Key West, Florida, USA).
8. *C. kaernbachii* Grunow in Schumann and Hollrung (1889): 4 (type locality: Kelana, Papua New Guinea).
9. *C. littleriana* Norris and Ballantine (1995): 154, figs 1a,1b,6,10–14 (type locality: Diamond Rock, Martinique, French West Indies, Lesser Antilles).
10. *C. (?) lobata* Howe (1914): 129, fig. 41, pl. 53 (type locality: 9 fathoms, Ancón Bay, Peru).
11. *C. nodulosa* Norris and Ballantine (1995): 159, figs 2a,b, 4,5,7,8a,b and 9 (type locality: Media Luna Reef, La Parguera, Puerto Rico, Greater Antilles).
12. *C. okamurae* Yamada and Segawa (1953): 110, fig. 3, as '*okamurai*': (syntype localities: Sokodo and Borawazawa, Hachijo Island, off SE Honshu, Japan); *C. kaernbachii sensu* Okamura (1932; pl. 288, figs 1–8).
13. *C. ornata* (J. Agardh) Kylin (1931): 10, pl. 3, fig. 6; basionym: *Callophyllis ornata* J. Agardh (1885): 35 (type locality: Port Jackson, New South Wales, Australia); taxonomic synonym *C. digitata* (Harvey) J. Agardh (1876): 323 nom. illeg.; basionym: *Gloiosaccion? digitatum* Harvey (1863): pl. 259 (type locality: in deep water, Port Jackson, New South Wales, Australia). J. Agardh's name is a later homonym of *C. digitata* Zanardini (1863), which has been regarded as a possible forma of (Hauck 1883) or conspecific with *C. ventricosa* (Kylin 1931). Millar (1999) proposed to treat *C. digitata* as conspecific with *C. ornata*.
14. *C. planifrons* (Melvill) J. Agardh (1876): 319; basionym: *Chrysymenia agardhii* (var.) *planifrons* Melvill (1875): 263 (type locality: Key West, Florida, USA); taxonomic synonym *C. curtissiana* J. Agardh (1885) *vide* Kylin (1931).
15. *C.? polydactyla* Hooker f. et Harvey in Harvey (1855): 253 (type locality: Port Pegasus, South Harbor, New Zealand).
16. *C. polyglandulosa* Okamura (1930): 96, pl. VI (type locality: Yoshikawa, Japan); *Cryptarachne glandulosa* (Okamura) Segawa (1949).
17. *C. procumbens* Weber-van Bosse (1928): 470, pl. V, fig. 2a,b (syntype localities: 'Banc de Borneo' and 'Ile Tiur').
18. *C. vesiculosa* J. Agardh (1851): 213 (type local- ity: 'Tingin' = Tangier, Morocco).
19. *C. ventricosa* (Lamouroux) J. Agardh (1842): 106; basionym: *Dumontia ventricosa* Lamouroux (1813): 45, pl. 10, fig. 6 (type locality: French Mediterranean).
20. *C. wrightii* (Harvey) Yamada (1932): 118, fig. 4; pl. XX; basionym: *Halosaccion wrightii* Harvey (1860a): 332 (type locality: 'Hakodadi' = Hakodate, Japan).

APPENDIX 1

Currently recognized species of *Chrysymenia*:

1. *C. agardhii* Harvey (1853): 189, pl. XXX, fig. A (type locality: Key West, Florida, USA).
2. *C. coelarthroides* Feldm.-Maz. (1941): 299, figs 1–3 (type locality: near Bougie (*anc.* Saldae), Algeria, Mediterranean Sea).
3. *C. dickieana* J. Agardh (1892): 90 (type locality: Bahia, Brazil).
4. *C. enteromorpha* Harvey (1853): 187–188. (type locality: Key West, Florida, USA).
5. *C. glebosa* Abbott and Littler (1969): 167, fig. 3 (type locality: War Memorial Natatorium, Waikiki, Honolulu, Hawaii, USA).
6. *C. grandis* Okamura (1933): 1, pl. 301 (type local- ity: deep waters, Tateyama Bay, Japan).

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