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Marine algae of the Eastern Caraga Region, Philippines, III: an annotated list of the red algae (Rhodophyta)

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Abstract
The diversity of marine algae of the eastern Caraga in the southern Philippines has remained largely undocumented and this presents an obstacle towards their utilization and conservation. Published literature was surveyed extensively and yielded 64 species and one variety classified under 42 genera, 21 families and 10 orders of marine red algae. A number of potential economic species with food, medicinal and industrial applications was found. However, this number is considered low when compared with similar environments and is likely not representative of the actual diversity there but instead suggesting lower sampling efforts, among other things. The baseline information may be useful in the formulation of policies for guided economic exploitation and contributing towards species and marine ecosystem conservation.

Keyword: botanical inventory, Mindanao, phycology, seaweeds, taxonomy.

INTRODUCTION

Records of marine algae from the southern Philippine island of Mindanao are few and scattered. The marine biodiversity of the Caraga region on the northeastern section of Mindanao is particularly poorly known due to difficult accessibility and exposure to frequent tropical storms coming from the Pacific Ocean (Bataan *et al*., 2021). Furthermore, the large nickel mining industry in the region, while providing some livelihood opportunities for the human population there, has brought greater social inequality and untold environmental damage (Holden *et al*., 2011). This year, marine tourism activities have resumed especially on Siargao Island after the slump caused by the Covid-19 pandemic, and may impact on benthic

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algal communities there. There is a plan to build an international cruise ship terminal which would necessarily impact benthic populations due to dredging and reclamation activities. Therefore, the marine algae found in the regional waters, their mass propagation and sustainable harvesting may represent promising yet untapped natural resources for income generation and poverty alleviation.

As a step towards the exploitation of the marine algal resources in the Caraga region, an exhaustive inventory of seaweed species was conducted through the compilation of records obtained from the published literature. Bataan *et al*. (2021) recorded 32 species of macrobenthic brown algae (Phaeophyceae), while Liao *et al*. (2022) accounted for 62 species of marine green algae (Ulvophyceae). The present report lists all published records of the marine red algae (Rhodophyceae) and constitutes the third and final part of this comprehensive literature survey of Caraga region seaweeds.

MATERIALS AND METHODS

An exhaustive survey of the published but scattered literature on the marine algae reported from the eastern Caraga region was conducted. Names gathered from the literature were verified following the steps described by Bataan *et al*. (2021) which were then validated by referring to the AlgaeBase names database (Guiry, 2023). Remarks were provided for most species for further clarification and information.

RESULTS AND DISCUSSION

This comprehensive survey of the literature revealed a total of 64 species and one variety of marine red algae which can be classified under 42 genera, 21 families and ten orders. Seven species can only be determined until the genus level. One record, *Gracilaria fastigiata* J.Agardh is removed from the Philippine marine flora as it is now a name applied to *Callophyllis fastigiata* (J.Agardh) J.Agardh, a sub-Antarctic species.

The list is provided below following the classification scheme of Dawes and Mathieson (2008). The sources of the original reports are indicated inside the brackets that follow the scientific names.

RHODOPHYTA
Class RHODOPHYCEAE

Order CORALLINALES
Family LITHOPHYLLACEAE

***Amphiroa anceps* (Lamarck) Decaisne** [Trono, 2017b]

Remarks: Among Philippine species of *Amphiroa*, this species is distinctive in having slightly compressed segments [=intergenicula] with dull and parallel marginal edges. However, some records from northern Luzon (Trono, 2004) warrant further investigation as they are different from authentic specimens from Australia which have broader segments with distinctly dilated and rounder apices (Harvey *et al*., 2013).

***Amphiroa dimorpha* Lemoine** [Trono, 2004; 2017a]

Remarks: The occurrence of this eastern Pacific species in the Philippines should be treated cautiously as it was discriminated solely by having “dichotomous branches with conspicuously dark genicula” (Trono, 2004). In addition, Philippine samples represent the only reports from the western Pacific of this otherwise widespread Eastern Pacific species distributed from Mexico down to the temperate coast of Chile.

***Amphiroa foliacea* Lamouroux** [Mapatac *et al*., 2015; Fajardo *et al*., 2016; Trono, 2017b; Orboc *et al*., 2022]

Remarks: This is a species widely reported from throughout the tropical Indo-Pacific region, from East Africa to Central America, and from southernmost Korea and Ryukyu archipelago to the northern and western coasts of Australia. Intergenicula are polymorphic from terete to compressed, and branching is multiplanar [projecting in different planes; Harvey *et al*. (2013)]. However, flattened intergenicula are prominent, with tapered ends, margins are sometimes wavy and thinner than the prominent central axis of the intergeniculum. A report of this species collected by Mapatac *et al*. (2014) from Dinagat Island seems erroneous. Looking at their Figure 5, the species looks very similar to a species of *Acanthophora.* Another species identified as *Amphiroa* sp. by the same authors is similar to *Gracilaria edulis* (Gmelin) P.Silva. Unfortunately, the same paper with the accompanying errors in identification pointed out above has been republished in its entirety without corrections by Mapatac *et al*. (2015).

***Amphiroa fragilissima* (Linnaeus) Lamouroux** [Trono, 2017b]

Remarks: All intergenicula in this species are cylindrical and thin, usually no more 1 mm in diameter (Harvey *et al*., 2013) with dichotomous branches issued from the genicular region. Some authors employed the angle of dichotomy to distinguish infraspecific forms. Another species with terete intergenicula throughout is *A. gracilis* Harvey which differs from *A. fragilissima* in having polychotomous branching. *A. fragilissima* is a cosmopolitan species while *A. gracilis* appears to be limited to Australia, with a new record from northern Madagascar noted recently by Vieira *et al*. (2021).

Family HYDROLITHACEAE

***Hydrolithon farinosum* (Lamouroux) Penrose and Chamberlain**

=*Fosliella farinosa* (Lamouroux) Howe [Trono, 1997]

Remarks: This minute species forms circular calcareous crusts on the surfaces of large seaweed and seagrass and is often overlooked unless it becomes very abundant. It is the only epiphytic member of this genus and is cosmopolitan throughout the tropical regions (Mendoza-González *et al*., 2009).

Family CORALLINACEAE

***Jania capillacea* Harvey** [Trono, 2017b]

Remarks: This species has the finest intergenicula (<1 mm in diameter) among local species and becomes remarkably fragile in the dried state. Living samples form clumps that are epiphytic on larger seaweed.

***Jania cultrata* (Harvey) J.M.Kim, Guiry and H.-G. Choi** [Trono, 2017b]

Remarks: For a long time, this species was more popularly known under its older name, *Cheilosporum cultratum* (Harvey) Areschoug, characterized by genicula borne on lateral wings.

***Jania ungulata* var. *brevior* (Yendo) Cordero** [Cadano and Trono, 1987; Trono, 2004; 2017a, erroneously as var. *brevior* (Yendo) Yendo]

Remarks: This taxon is reported as a variety but is currently recognized at the form level as *J. ungulata* f. *brevior* (Yendo) Yendo.

Mastophora rosea **(C.Agardh) Setchell** [Sajot, 2006 as *Mastophora* sp.; Trono, 2017b]

Remarks: This species is common on Philippine reefs and could be confused with another superficially similar species, *M. pacifica* (Heydrich) Foslie. The latter is heavily calcified and breaks easily upon handling whereas *M. rosea* is more flexible (Keats *et al*., 2009). The two species are widespread all over the Indo-West Pacific, with *M. pacifica* at times recorded as a species of *Lithoporella*. It is just a matter of time when authentic Philippine samples of *M. pacifica* are reported.

Order NEMALIALES
Family LIAGORACEAE

Liagora ceranoides **Lamouroux** [Trono, 2017b]

Remarks: This species has been widely reported around the Philippines and indeed, in many localities around the world. Cryptic species will likely be detected within this species complex through molecular work, in the same way that the polyphyletic genus had many segregate genera recognized lately (Lin *et al*., 2015; Suzuki *et al*., 2016).

Trichogloea requienii **(Montagne) Kützing** [Trono, 2017b]

Remarks: This is another cosmopolitan but rare lubricous species easily distinguished in the field by the clear thin strip of calcification along the inner central axis.

Family LIAGOROPSIDACEAE

Liagoropsis schrammii **(P.Crouan and H.Crouan) Doty and Abbott** [Trono, 2017b]

Remarks: This species was first described from Guadeloupe in the Caribbean under the name *Helminthocladia schrammii* P.Crouan and H.Crouan. Since then it has been reported throughout the Caribbean reaching as far as the eastern tropical South America and Macaronesia. Within the Indo-West Pacific basin, there have been sporadic reports in India, Taiwan and the Philippines under the current name. Doty and Abbott (1964) provided a very comprehensive description of vegetative and reproductive structures based on samples from Albay to justify its transfer to *Liagoropsis*. Philippine samples are comparable with those from the Caribbean except for the well-developed ramification and thus, warrant further investigation. The generitype species of *Liagoropsis*, *L. maxima* Yamada first described from Taiwan is listed as a synonym of this species by Silva *et al*. (1996). Lin *et al*. (2015) provided molecular evidence to justify the creation of a new family to accommodate this genus.

Family YAMADAELLACEAE

Yamadaella caenomyce **(Decaisne) Abbott** [Trono, 2017b]

Remarks: This species is widely distributed throughout the Indo-Pacific with occasional records from the Greater Antilles. One of the earliest genera segregated from the large genus *Liagora*, it has remained monotypic until one new species was described from Western Australia (*Yamadaella australis* Huisman and S.M.Lin) and another from Bermuda (*Y. grassyi* Popolizio, C.W.Schneider and C.E.Lane).

Family GALAXAURACEAE

***Actinotrichia fragilis* (Forsskål) Børgesen** [Trono, 2017b]

Remarks: Widely distributed around the Philippines (Cordero, 1975) and throughout the Indo-Pacific, it is easily distinguished in the field by the concentric bands of short hairs (assimilatory filaments) on its thallus. Other recently described species of *Actinotrichia* differ externally by the arrangement of assimilatory filaments, degree of calcification and angles of branching. These species may also be discovered in the Philippines after a thorough examination of extant collections.

Actinotrichia sp. [Sajot, 2006]

Remarks: In all likelihood this particular report represents a collection of *A. fragilis* (Forsskål) Børgesen.

***Dichotomaria apiculata* (Kjellman) Kurihara and Masuda** [Trono, 2017b]

***Dichotomaria marginata* (Ellis and Solander) Lamarck** [Trono, 2017b]

=*Galaxaura marginata* (Ellis and Solander) Lamouroux [Trono, 2004]

Remarks: Flattened species of *Galaxaura* in the Philippines are 'conveniently' placed under *Dichotomaria* although there are also terete species within the latter. The name *D. marginata* includes a species complex that is widespread and discriminated based on morphological and molecular evidence by Huisman *et al*. (2004). Assignment of local species under *Dichotomaria* should proceed with caution.

***Dichotomaria obtusata* (Ellis and Solander) Lamarck** [Trono, 2017b]

=Galaxaura robusta Kjellman [Trono, 2017b]

Remarks: The synonymy of *G. robusta* with the above species was first proposed by Papenfuss and Chiang (1969, as *Galaxaura obtusata* Ellis and Solander).

***Dichotomaria tenera* (Kjellman) Huisman, Harper and G.W.Saunders**

=Galaxaura tenera Kjellman [Cordero, 1977]

***Galaxaura divaricata* (Linnaeus) Huisman and Townsend** [Trono, 2017b]

***Galaxaura filamentosa* Chou** [Trono, 2017b]

***Galaxaura rugosa* (Ellis and Solander) Lamouroux** [Trono, 2004; 2017a]

=*Galaxaura elongata* J.Agardh [Cordero, 1977]

=Galaxaura subverticillata Kjellman [Trono, 2017b]

Remarks: The conspecificity of *G. elongata* with *G. rugosa* was first proposed by Papenfuss *et al*. (1982), while that with *G. subverticillata* was suggested by Huisman and Borowitzka (1990).

***Tricelocarpa cylindrica* (Ellis and Solander) Huisman and Borowitzka** [Trono, 2017b]

***Tricleocarpa fragilis* (Linnaeus) Huisman and Townsend** [Wiriyadamrikul *et al*., 2013]

=*Galaxaura oblongata* (Ellis and Solander) Lamouroux [Cordero, 1977; Trono, 1997]

Order BONNEMAISONIALES
Family BONNEMAISONIACEAE

***Asparagopsis taxiformis* (Delile) Trevisan** [Liao, 1990; Trono, 2017b]

Remarks: This distinctively heterothallic species is packed with bromoform secondary metabolites which function mainly as anti-herbivory compounds. Studies have shown that adding this seaweed into cow fodder reduces methanogenic emission from cattle that can potentially cut its current share of greenhouse gas release. There is currently a race to develop effective mass propagation techniques of this species.

Order CERAMIALES
Family CALLITHAMNIACEAE

***Crouania minutissima* Yamada** [Trono, 2017b]

Remarks: This bright red epiphytic species is one of the few microscopic ceramialean entities reported from the Caraga region thus far. Conspicuously absent but likely abundant and overlooked are common epiphytic representatives of *Centroceras*, *Ceramium*, *Gayliella*, etc. underscoring the need for more surveys to focus on minute epiphytes.

Family DELESSERIACEAE

Dasya sp. [Trono, 2017b]

Remarks: *Dasya* is another genus that is fairly abundant in Philippine waters but which needs a thorough re-assessment backed by more collections. Formerly recognized under its own family, the Dasyaceae, it has now been placed under an emended Delesseriaceae mainly on molecular grounds (Choi *et al*., 2002; Diaz-Tapia *et al*., 2019).

***Martensia flabelliformis* Harvey ex J.Agardh** [Trono, 2017b]

Remarks: This showy species was reported at one time as *Neomartensia flabelliformis* (Harvey ex J.Agardh) Yoshida and Mikami by Kraft *et al*. (1999) from Sorsogon. Thus far, reports of this species from the Philippines have not been supported by molecular evidence and may represent another undescribed entity. A critical review of all reported *Martensia* species from the country is needed. Recent molecular phylogenetic study of Hawaiian *Martensia* (Sherwood *et al*., 2020) suggested a number of undescribed species from the Philippines.

Family RHODOMELACEAE

***Acanthophora muscoides* (Linnaeus) Bory de Saint-Vincent** [Trono, 2017b]

Remarks: There is confusion in trying to distinguish this species from its congener, *A. spicifera* especially when their geographical distribution is almost identical. The key provided by de Jong *et al*. (1999) indicated *A. muscoides* as "densely branched and bushy, with spine-like branchlets present all over" whereas *A. spicifera* is "sparingly branched" and generally lacking the spines.

***Acanthophora spicifera* (Vahl) Børgesen** [Cordero, 1980; Trono 1997; 2017b]

Remarks: This underappreciated species is loaded with many useful phytochemicals (Budiyanto *et al*., 2022) including lambda-carrageenan that can potentially be extracted from high biomass found in many parts of the Philippines (Trono and Buchan-Antalan, 1987).

***Amansia glomerata* C.Agardh** [Trono, 2017b]

***Chondrophycus cartilagineus* (Yamada) Garbary and Harper** [Trono, 2017b]

=*Laurencia cartilaginea* Yamada [Saito, 1969]

Remarks: Several Philippine *Chondrophycus* species are similar superficially despite being assigned different names by various authors. The record of Trono (2017b) cited above appears to be erroneous as anatomical descriptions are not representative of this species. This will need to be further investigated.

***Herposiphonia pacifica* Hollenberg** [Hollenberg, 1968b]

***Herposiphonia secunda* (C.Agardh) Ambronn**

=*Herposiphonia tenella* f. *secunda* (C. Agardh) Hollenberg [Hollenberg, 1968b]

***Laurencia nidifica* J.Agardh** [Trono, 2017b]

Laurencia sp. [Sajot, 2006]

Melanothamnus savatieri **(Hariot) Díaz-Tapia and Maggs**

=*Polysiphonia savatieri* Hariot [Hollenberg, 1968a]

Remarks: This and many other species formerly recognized under *Polysiphonia* have been placed into a segregate genus *Neosiphonia* by Kim and Lee (1999) on the basis of unique vegetative and reproductive morphological characters. However, the name *Neosiphonia* is a heterotypic synonym of *Fernandosiphonia* which in turn is a latter synonym of *Melanothamnus*, necessitating the transfer of many species into *Melanothamnus* (Díaz-Tapia *et al*., 2017).

Neurymenia fraxinifolia **(Mertens ex Turner) J.Agardh** [Trono, 2017b]

Remarks: This is a distinctive and widespread species distributed across the vast Indo-Pacific from eastern Africa to New Caledonia and Fiji. A monotypic genus for a long time, a second disjunct species was first described from subtropical Japan as *N. nigricans* Tanaka and Itono and which was subsequently reported from subtropical Natal in South Africa by Norris (1988). Tanaka and Itono (1969) cited vegetative and reproductive features to differentiate the two, such as overall size (up to 30 cm tall in *N. fraxinifolia*, half the size in *N. nigricans*) and color upon drying (purplish in *N. fraxinifolia*, reddish black in *N. nigricans*). In addition, Norris (1988) cited ruffled margins with deeply incised apices in *N. fraxinifolia*, while straight margins with tapering apices in *N. nigricans*. Should *N. nigricans* be found in points between the type locality in Japan and in South Africa, it will likely be collected from subtidal depths.

Ohelopapa flexilis **(Setchell) Rousseau, Martin-Lescanne, Payri and Le Gall** [Trono, 2017b]

Remarks: This species was well known as *Laurencia flexilis* Setchell before its segregation into *Ohelopapa* largely on molecular grounds. It is widespread throughout the Indo-Pacific. Records from the Islas Canarias and the Madeiras off the western coast of Africa have been questioned by Machín-Sánchez *et al*. (2018) while a single record from the Caribbean coast of Mexico by Ortega *et al*. (2001) needs further verification. This species is easily confused in the field with another common bushy species, *Gelidiella acerosa* (Forsskål) Feldmann and Hamel, but the discoid attachment in *O. flexilis* is distinct from the multiple, rhizoidal organs found in *G. acerosa*.

Palisada perforata **(Bory) K.W.Nam** [Trono, 2017b]

=*Laurencia papillosa* (C.Agardh) Greville [Cordero, 1980; Trono, 1997; Fajardo *et al*., 2016; Orboc *et al*., 2022]

Remarks: In the Philippines, the corn-cob shaped branches of this species are distinctive. These often catch sand grains lodged between the small ultimate branchlets.

Polysiphonia sp. [Trono, 2017b]

Tolypiocladia glomerulata **(C.Agardh) Schmitz** [Trono, 2017b]

Remarks: This epiphytic species forms dark brown to black filaments on large host plants and is easily distinguished by its four almost cuboidal periaxial cells upon microscopic examination (Norris, 1992).

Womersleyella setacea **(Hollenberg) R.E.Norris**

=*Polysiphonia setacea* Hollenberg [Hollenberg, 1968a]

Remarks: Species placed under *Womersleyella* are defined by a suite of characters summarized by Norris (1992) with indeterminate prostrate branching system devoid of scar cells as one of the most prominent. Originally described as a species of *Polysiphonia* from Hawaii, this species is widespread in the western Pacific with a report from South Africa (Norris, 1992) as its westernmost occurrence. First discovered in Italy in 1986, it became an invasive species that spread from the Adriatic to almost every corner of the Mediterranean where they form dense and persistent turfs even in low light environments (Cebrian *et al*., 2021).

Order GELIDIALES
Family GELIDIELLACEAE

***Gelidiella acerosa* (Forsskål) Feldmann and Hamel** [Cordero, 1980; Trono, 1997; 2017b; Rollon *et al*., 2003; Sajot, 2006]

Remarks: This cosmopolitan species produces high quality agar but generally found in low biomass to warrant harvesting without depleting natural stocks. Hence, its exploitation has taken a backseat in favor of higher biomass yielding gracilarioids. It is easily confused with another agarophyte, *Ohelopapa flexilis* (formerly known as *Laurencia flexilis*) with which it shares a similar morphology (Rollon *et al*., 2003).

Order GIGARTINALES
Family CYSTOCLONIACEAE

***Hypnea boergesenii* Tanaka** [Trono, 2017b]

***Hypnea caespitosa* Geraldino and S.M. Boo** [Geraldino *et al*., 2010]

Remarks: This species commonly forms cushions on local reefs where it mixes with *H. pannosa* J.Agardh, another prominent element of the reef-associated turf-forming seaweed community. Despite subtle morphological differences, the species was recognized as distinct through molecular comparisons (Geraldino *et al*., 2010).

***Hypnea cervicornis* J.Agardh** [Cordero, 1980; Trono, 1997; 2017b]

***Hypnea musciformis* (Wulfen) Lamouroux** [Trono, 2017b]

Remarks: This species was introduced to Hawaii for trial cultivation as a potential source of kappa carrageenan where it became invasive (Russell and Balazs, 1994). Reported from various tropical regions, it is recognized as part of a large *H. musciformis*-*H. pseudomusciformis* species complex by Nauer *et al*. (2019). A related species, *H. esperi* Bory de St.-Vincent was reported by Trono (2017b) and is usually regarded as a variety of *H. musciformis.* The ambiguous name and status of *H. esperi* have been discussed in detail by Silva *et al*. (1996).

***Hypnea pannosa* J.Agardh** [Trono, 2017b]

Remarks: This and other *Hypnea* species are candidates for mass propagation due to their kappa-carrageenan content.

Family DUMONTIACEAE

***Rhodopeltis borealis* Yamada** [Trono, 2017b]

Family SOLIERIACEAE

***Eucheuma denticulatum* (N.L.Burman) Collins and Hervey** [Fajardo *et al*., 2016; Orboc *et al*., 2022]

***Kappaphycopsis cottonii* (Weber Bosse) Dumilag and Zuccarello**

=*Kappaphycus cottonii* (Weber Bosse) Doty *ex* H.D.Nguyen and Q.N.Huynh [Trono, 2017b]

Remarks: Originally described as a species of *Eucheuma*, it was transferred into *Kappaphycus* owing to the presence of kappa-carrageenan on its cell wall. Recent phylogenetic analysis using DNA sequences coupled with a distinctively anaxiferous medullary core structure provided justification for its placement in the segregate genus, *Kappaphycopsis* (Dumilag and Zuccarello, 2022).

***Kappaphycus alvarezii* (Doty) L.M.Liao** [Dumilag *et al*., 2016; Fajardo *et al*., 2016; Orboc *et al*., 2022; Pastor and Magdugo, 2024]

Remarks: The presence of this and other eucheumatoid species suggests the feasibility for their mass commercial cultivation in this area. In a study of samples obtained from Butuan Bay, Pastor and Magdugo (2024) found greater cytotoxic activity of this species compared to another congener, *K. striatus* (Schmitz) L.M.Liao. This observation suggests that this species shows potentials for biomedical applications (Nunes *et al*., 2024) including anti-viral properties against common mosquito-borne diseases in the tropics (Barros *et al*. 2024).

***Kappaphycus striatus* (Schmitz) L.M.Liao** [Dumilag, *et al*. 2016; Trono, 2017b; Pastor and Magdugo, 2024]

Order GRACILARIALES
Family GRACILARIACEAE

***Gracilaria arcuata* Zanardini** [Trono, 2017b]

***Gracilaria edulis* (Gmelin) P.Silva** [Trono, 2017b]

=*Polycavernosa fastigiata* Chang and Xia [Xia and Abbott, 1987]

=*Hydropuntia edulis* (Gmelin) Gurgel and Fredericq [Ferrer *et al*., 2020]

Remarks: This and the next listed species were previously recognized as species of *Hydropuntia* owing to the presence of multicavitied spermatangial conceptacles in them and the recognition of distinct molecular data that supported firmer generic circumscription within the Gracilariaceae (Gurgel *et al*., 2018). However, Lyra *et al*. (2015) found that cystocarpic and spermatangial features do not delineate genera. This view was furthered reinforced with historical biogeographic evidence presented by Vieira *et al*. (2025).

Gracilaria eucheumatoides Harvey [Trono, 2017b]

Remarks: This is easily identified in the field as it is a creeping greenish-purplish species, semi-terete or slightly compressed with coarse marginal teeth.

***Gracilaria fastigiata* J.Agardh** [Trono, 2017b]

Remarks: This name was used twice by J.Agardh on two different species, the first time in 1852, and the second time in 1901, rendering the second one as a later homonym, and therefore, illegitimate. The first name is now regarded as *Callophyllis fastigiata* (J.Agardh) J.Agardh, originally from the Falkland Islands (Silva *et al.*, 1996) and apparently a temperate South American species, obviously not expected to occur in the Philippines, although there is a doubtful record from the Islas Canarias (Guiry, 2023). Should the type of the second entity be determined to represent a distinct species, it would need a new name. Referring to Figure 71 in Trono (2017b), the sample looks like a representative of the common species *Gracilartia edulis* (Gmelin) P.Silva. Among the many synonyms ascribed to *G. edulis* is *Polycavernosa fastigiata* Chang and Xia, the type of *Polycavernosa*. Trono (2017b) may have erred using the current name (*G. fastigiata*) due to the similar species epithet used here. The current record of *G. fastigiata* from eastern Caraga region should therefore be excluded and treated as *G. edulis*.

***Gracilaria firma* Chang and Xia** [Trono, 2017b]

Remarks: Together with *Gracilaria changii* Xia and Abbott, these taxa represent widely cultivated species around Southeast Asia showing branches with deeply constricted bases that taper into acute apices. Any gracilarioid species with deeply constricted branch bases are given either one of these two names. However, Ng *et al*. (2017) provided evidence to recognize these two taxa as synonymous with *G. firma* as the correct name.

Gracilaria gigas **Harvey** [Trono, 2017b]

Remarks: Trono *et al*. (1983) first reported this species from Sorsogon which is characterized as robust and up to 20 cm tall. The lectotype deposited at the Trinity College in Dublin, Ireland (TCD) has been shown to be a large plant of up to 48 cm tall by Masuda *et al*. (1995, Figure 16).

Gracilaria salicornia **(C.Agardh) Dawson ex H.Ohmi** [Cordero, 1980; Trono, 1997; 2017b; Yang *et al*., 2013; Fajardo *et al*., 2016; Ferrer *et al*., 2019; Orboc *et al*., 2022]

Remarks: In proposing the newly combined name *G. salicornia*, Dawson (1954) did not provide a full and direct reference to the place of publication and pagination, even if the intended basionym was listed within the species account, thus failing to satisfy Art. 41.5 of the International Code of Nomenclature for Algae, Fungi, and Plants (Turland *et al*., 2018). However, for the sake of nomenclatural stability and to keep the name of this widespread and common species, no new combination is suggested herein but instead, the current name should be ascribed to the first author who used the new name and cited the basionym with full reference to its place of valid publication, pagination and illustration. That author appears to be Hikoei Ohmi (1958). Although for the last half century the combining author was cited as E.Y.Dawson, the correct authorship must hereinafter be cited as E.Y.Dawson *ex* H.Ohmi or simply H.Ohmi in accordance with Art. 46.5 of the Code (Turland *et al*., 2018).

Gracilaria sp. [Sajot, 2006; Fajardo *et al*., 2016; Orboc *et al*., 2022]

Order HALYMENIALES
Family HALYMENIACEAE

Halymenia dilatata **Zanardini** [De Smedt *et al*., 2001; Trono, 2017b]

Remarks: Many foliose species have been described recently that compare well with this species and which may be easily confused with it. *H. dilatata* is shown to have a short stipe with discoid holdfast as one its distinguishing characters (Tan *et al*., 2015).

Halymenia durvillei **Bory de Saint-Vincent** [Trono, 2017b]

Remarks: This is perhaps the most widespread among *Halymenia* species in the Philippines (De Smedt *et al*., 2001) with variations in its proliferous laterals leading to the recognition of a number of forms and varieties. There are suggestions that such variations are induced by the environment but these plants were shown to be genetically similar (Kawaguchi *et al*., 2006). Lately, extracts from *H. durvillei* have been tested for its anticancer (Sangpairoj *et al*., 2022), anti SARS-Cov-2 (Tassakka *et al*., 2021) and biofuel potentials (Roslee and Munajat, 2018).

Halymenia malaysiana **P.-L.Tan, P.-E.Lim, S.-M.Lin and S.-M.Phang** [Tan *et al*., 2015]

Remarks: Long recognized as the superficially similar *H. porphyraeformis* Parkinson and *H. dilatata* (De Smedt *et al*., 2001), its distinctiveness was established based on morphological and molecular grounds by Tan *et al*. (2015).

Halymenia sp. [Sajot, 2006]

Order GIGARTINALES
Family RHIZOPHYLLIDACEAE

Portieria hornemannii **(Lyngbye) P.Silva** [Sajot, 2006; Trono, 2017b]

Remarks: This species has been the subject of much biomedical interest when cytotoxic compounds against human tumor cells were extracted from it (Fuller *et al*., 1992). However, studies have shown that Philippine populations of *Portieria* may represent many cryptic species (Payo *et al*., 2013) that may have evolved in different microhabitats and which in turn influenced secondary metabolite chemical diversity (Yang and Kim, 2018).

Order NEMASTOMATALES
Family SCHIZYMENIACEAE

Titanophora weberae Børgesen [Trono, 2017b]

Remarks: This lightly calcified species with a pliable frond seems rare in the Caraga region and other localities around the Philippines although it is widely reported from throughout the tropics.

Order RHODYMENIALES
Family LOMENTARIACEAE

***Ceratodictyon spongiosum* Zanardini** [Fajardo *et al*., 2016; Trono, 2017b; Orboc *et al*., 2022; Buyog *et al*., 2024]

Remarks: This unique species is one of the few examples of an obligate algal-sponge symbiotic unit (Price and Kraft, 1990). The algal component was first cultured *in vitro* without the sponge but showed only protracted vegetative development and did not survive field transplantation (Price *et al*., 1984). Its vegetative similarity with species of *Gelidiopsis* was the basis for merging the two genera by Norris (1987). Subsequent authors like Price and Kraft (1990) maintained the two genera as distinct pending the study of *G. variabilis* (J.Agardh) Schmitz, the type species of *Gelidiopsis*. A number of bioactive secondary metabolites have been isolated from *C. spongiosum* which merit further bioprospecting (Bugni *et al*., 2002). Samples obtained from Butuan Bay showed promising biochemical profiles with bioactive functions (Buyog *et al*., 2024).

***Gelidiopsis intricata* (C.Agardh) Vickers** [Trono, 2017b]

Family RHODYMENIACEAE

Rhodymenia sp. [Trono, 2017b]

Remarks: The dichotomously branched, flattened plant with numerous proliferous nodal outgrowths as illustrated (Trono, 2017b: Figure 84) resembles species of *Yonagunia* which are thicker. It is unfortunate that no information is available about its internal anatomy.

GENERAL DISCUSSION

The current survey of marine red algae in the eastern Caraga region has revealed several species that show potential for human food, fodder and industrial applications. In the absence of seaweed biomass and seasonality data from the region however, it will be difficult to fully appreciate the value of these seaweed resources. Mass propagation of these economic species in sea-based farms could be suggested using technology already developed in other localities. However, the operation of these offshore maricultural facilities will likely be affected by the frequent weather disturbances typical of the Caraga region, resulting in shorter growing seasons. A more ambitious and capital-intensive approach would be land-based tanks fitted with seawater circulating systems which would be less affected by typhoons and monsoon winds and whose culture conditions may be more manageable. These land-based tanks have higher productivity than most terrestrial vegetation (Lüning and Pang, 2003). Integrating fish and molluscan species with seaweeds can boost productivity and economic returns while serving to minimize the impact of animal wastes on the environment. Such an Integrated Multi-Trophic Aquaculture (IMTA) system was tested in the Philippines with limited success (Largo *et al*., 2016). Expectedly, many more challenges will be encountered in developing countries like the Philippines. Moreover, providing desirable culture conditions in land-based tanks may be a species-specific task (Lawton *et al*., 2021) that will need more research particularly for less popular species.

The culture of economically important eucheumatoids (Solieriaceae) for carrageenan extraction has a long history in some parts of the Philippines like the Sulu archipelago, northern Bohol and Palawan. The main factors for their successful mariculture include the presence of large shallow reef flats and their location away from the typhoon belt. In the absence of shallow reef flats that restricts setting up monolines on the bottom, these culture lines may be suspended by floating bamboo frames used over deeper waters. The latter can probably be used in eastern Caraga which is characterized by narrow intertidal areas due to its proximity to the deep Mindanao Trench a few kilometers to the east. Nevertheless, the occurrence of species such as *Kappaphycus alvarezii*, *K. striatum*, *Kappaphycopsis cottonii* and *Eucheuma denticulatum* presents much promise (Dumilag *et al*., 2016). Other carrageenan-bearing species have also been reported like *Halymenia durvillei*, *H. malaysiana*, *Acanthophora spicifera*, and various species of *Hypnea*. Agar-bearing species from eastern Caraga may also be candidates for mass propagation in the future including *Gelidiella acerosa*, various species of *Gracilaria* and *Laurencia* (Rollon *et al*., 2003; Ng *et al*., 2017; Ferrer *et al*., 2020). Many species of *Gracilaria* tolerant of habitats with lower salinity, of which there are many around the region, can be tested for mass cultivation.

One noteworthy feature of the red algae in eastern Caraga is its low diversity. In a tropical country like the Philippines, the number of marine red algae is usually double that of the green algae and about triple that of the brown algae (Silva *et al*., 1987, Ang *et al*., 2013, Lastimoso and Santiañez, 2020). The low number of marine red algae documented in this study, comparable to previous studies in Romblon (Clemente *et al*., 2017) and Negros Oriental (Reyes, 1970) may be partly attributed to many microscopic forms being overlooked as many red algae are minute epiphytes and small turf-forming species. In addition, many non-geniculate coralline red algae are often sidelined because they are difficult to identify.

CONCLUSION

This 3-part regional listing of the marine algae in eastern Caraga demonstrated the rich marine biodiversity of the Philippines, and specifically of the poorly explored Caraga region. It also showed the importance of compiling species inventories to identify potential economic species and others of special interest. To support the latter, it is imperative to maintain a corps of researchers with at least parataxonomic competence. This study also revealed research gaps that may have restricted the optimal exploitation of available marine resources especially in areas like eastern Caraga which are dependent on unsustainable industries such as mining and seasonal activities like tourism. Some economic species of marine algae have been identified in this study and more species will likely be found by additional comprehensive studies in the future.

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REFERENCES

Ang, P.O., S.M. Leung and M.M. Choi. 2013. A verification of reports of marine macroalgal species from the Philippines. *Philippine Journal of Science* 142 Special Issue: 5–49.

Barros, C. de S., C.C. Cirne-Santos, P.O. Esteves, M.W.L. Gomes, V.W. Rabelo, T.M. Santos, V.L. Teixeira and C.N. de P. Paixao. 2024. Antiviral activity of *Kappaphycus alvarezii* seaweed against ZIKV. *Current Topics in Medicinal Chemistry* 24: 1589–1598.

Bataan, D.A.U., C.P. Sajot, P.J.L. Geraldino and L.M. Liao. 2021. Marine algae of the eastern Caraga region, Philippines, I. Historical survey and an annotated list of the brown algae (Phaeophyceae). *Thailand Natural History Museum Journal* 15: 31–37.

Budiyanto, F., M.A. Ghandourah, N.O. Bawakid, H.S. Alorfi, A. Abdel-Lateff and W.M. Alarif. 2022. Threat and gain: The metabolites of the red algae genus *Acanthophora*. *Algal Research* 65: 102751.

Bugni, T.S., G.P. Concepcion, G.C. Mangalindan, M.K. Harper, R.D. James and C.M. Ireland. 2002. *p*-Sulfooxyphenylpyruvic acid from the red macro alga *Ceratodictyon spongiosum* and its sponge symbiont *Haliclona cymaeformis*. *Phytochemistry* 60: 361–363.

Buyog. C.C., R.P. Magdugo and M.E.Q. Won. 2024. Biochemical characterization and bioactivity of red alga, *Ceratodictyon spongiosum* (Zanardini) from Goso-on, Carmen, Agusan del Norte, Philippines. *Annals of Studies in Science and Humanities* 5(1): 1–9.

Cadano, M.A. and G.C. Trono. 1987. The genus *Jania* (Cryptonemiales, Rhodophyta) in the Philippines. *Philippine Journal of Science Monograph* 17: 99–117.

Cebrian, E., C. Linares and J. Garrabou. 2021. Warming may increase the vulnerability of calcareous algae to bioinvasions. *Marine Pollution Bulletin* 173: 113099 doi.org/10.1016/j.marpolbul.2021.113099

Choi, H.-G., G.T. Kraft, I.K. Lee and G.W. Saunders. 2002. Phylogenetic analyses of anatomical and nuclear SSU rDNA sequence data indicate that the Dasyaceae and Delesseriaceae (Ceramiales, Rhodophyta) are polyphyletic. *European Journal of Phycology* 37: 551–569.

Clemente, K.J.E., S.F. Baldia and P.A. Cordero. 2017. The marine macroalgal flora of the Romblon Island Group (RIG), central Philippines. *AACL Bioflux* 10: 983–1000.

Cordero, P.A. 1975. Phycological observations-III. On the occurrence of genus *Actinotrichia* in the Philippines. *Publications of the Seto Marine Biological Laboratory* 22: 267–276.

Cordero, P.A. 1977. Studies on Philippine marine red algae. *Special Publications from the Seto Marine Biological Laboratory* 4: 1–258.

Cordero, P.A. 1980. Taxonomy and distribution of Philippine useful seaweeds. *National Research Council of the Philippines Bulletin* 81: 1–78.

Dawes, C.J. and A.C. Mathieson. 2008. *The Seaweeds of Florida*. University Press of Florida, Gainesville. 591 pp.

Dawson, E.Y. 1954. Notes on tropical Pacific marine algae. *Bulletin of the Southern California Academy of Sciences* 53(1): 1–7.

De Jong, Y.S.D.M., C. Hitipeuw and W.F. Prud'homme van Reine. 1999. A taxonomic, phylogenetic and biogeographic study of the genus *Acanthophora* (Rhodomelaceae, Rhodophyta). *Blumea* 44: 217–249.

De Smedt, G., O. De Clerck, F. Leliaert, E. Coppejans and L.M. Liao. 2001. Morphology and systematics of the genus *Halymenia* C. Agardh (Halymeniales, Rhodophyta) in the Philippines. *Nova Hedwigia* 73: 293–322.

Díaz-Tapia, P., L. McIvor, D.W. Freshwater, H. Verbruggen, M.J. Wynne and C.A. Maggs. 2017. The genera *Melanothamnus* Bornet & Falkenberg and *Vertebrata* S.F. Gray constitute well-defined clades of the red algal tribe Polysiphonieae (Rhodomelaceae, Ceramiales). *European Journal of Phycology* 52: 1–30.

Díaz-Tapia, P., M.M. Pasella, H. Verbruggen and C.A. Maggs. 2019. Morphological evolution and classification of the red algal order Ceramiales inferred from plastid phylogenomics. *Molecular Phylogenetics and Evolution* 137: 76–85.

Doty, M.S. and I.A. Abbott. 1964. Studies in the Helminthocladiaceae, III. *Liagoropsis*. *Pacific Science* 18: 441–452.

Dumilag, R.V. and G.C. Zuccarello. 2022. Phylogeny and genetic diversity of the Philippine eucheumatoid genus *Mimica* (Solieriaceae, Rhodophyta) and the proposal for *Kappaphycopsis* gen. nov. to include the anomalous species of *Kappaphycus*, *K. cottonii*. *Phycologia* 61: 496–503.

Dumilag, R.V., R.C. Salvador and C. Halling. 2016. Genotype introduction affects population composition of native Philippine *Kappaphycus* (Gigartinales, Rhodophyta). *Conservation Genetic Resources* 8: 439–441.

Fajardo, D.R.M., R.P. Magdugo and R.A. Seronay. 2016. Diversity and taxonomic assessment of marine benthic macrophytes near mining situated area in Cagdianao. Claver, Surigao del Norte, Philippines. *Journal of Biology and Environmental Science* 8: 49–56.

Ferrer, M.S.R., R.N. Gomez, C.B. Narido, M.T. Moises and R.V. Dumilag. 2019. Genetic diversity of Philippine *Gracilaria salicornia* (Gracilariaceae, Rhodophyta) based on mitochondrial COI-5P sequences. *Biologia* 74: 599–607.

Ferrer, M.S.R., R.N. Gomez and R.V. Dumilag. 2020. COI-5P gene sequence variation in Philippine *Hydropuntia edulis* (Gracilariaceae, Rhodophyta). *Philippine Journal of Science* 149: 1135–1140.

Fuller, R.W., J.H. Cardellina, Y. Kato, L.S. Brinen, J. Clardy, K.M. Snader and M.R. Boyd. 1992. A pentahalogenated monoterpene from the red alga *Portieria hornemannii* produces a novel cytotoxicity profile against a diverse panel of human tumor cell lines. *Journal of Medicinal Chemistry* 35: 3007–3011.

Geraldino, P.J.L., R. Riosmena-Rodriguez, L.M. Liao and S.M. Boo. 2010. Phylogenetic relationships within the genus *Hypnea* (Gigartinales, Rhodophyta), with a description of *H. caespitosa* sp. nov. *Journal of Phycology* 46: 336–345.

Guiry, M.D. in Guiry, M.D. and G.M. Guiry. 2023. AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. https://www.algaebase.org; searched on 07 February 2023.

Gurgel, C.F.D., J.N. Norris, W.E. Schmidt, H.N. Le and S. Fredericq. 2018. Systematics of the Gracilariales (Rhodophyta) including new subfamilies, tribes, subgenera, and two new genera, *Agarophyton* gen. nov. and *Crassa* gen. nov. *Phytotaxa* 374: 1–23. https://doi.org/10.11646/phytotaxa.374.1.1

Harvey, A.S., W.J. Woelkerling, J.M. Huisman and C.F.D. Gurgel. 2013. A monographic account of Australian species of *Amphiroa* (Corallinaceae, Rhodophyta). *Australian Systematic Botany* 26: 81–144.

Holden, W., K. Nadeau and R.D. Jacobson. 2011. Exemplifying accumulation by dispossession: Mining and indigenous peoples in the Philippines. *Geografiska Annaler*: *Series B*. *Human Geography* 93: 141–161.

Hollenberg, G.J. 1968a. An account of the species of *Polysiphonia* of the central and western tropical Pacific Ocean, I. Oligosiphonia. *Pacific Science* 22: 56–98.

Hollenberg, G.J. 1968b. An account of the species of the red alga *Herposiphonia* occurring in the central and western tropical Pacific Ocean. *Pacific Science* 22: 536–559.

Huisman, J.M., J.T. Harper and G.W. Saunders. 2004. Phylogenetic study of the Nemaliales (Rhodophyta) based on large-subunit ribosomal DNA sequences supports segregation of the Scinaiaceae fam. nov. and resurrection of *Dichotomaria* Lamarck. *Phycological Research* 52: 224–234.

Huisman, J.M. and M.A. Borowitzka. 1990. A revision of the Australian species of *Galaxaura* (Rhodophyta, Nemaliales), with a description of *Tricleocarpa* gen. nov. *Phycologia* 29: 150–172.

Kawaguchi, S., S. Shimada, T. Abe and R. Terada. 2006. Morphological and molecular phylogenetic studies of a red alga, *Halymenia durvillei*, (Halymeniaceae, Halymeniales) from Indo-Pacific. *Coastal Marine Science* 30: 201–208.

Keats, D.W., G.W. Maneveldt, M. Baba, Y.M. Chamberlain and J.E. Lewis. 2009. Three species of *Mastophora* (Rhodophyta: Corallinales, Corallinaceae) in the tropical Indo-Pacific Ocean: *M. rosea* (C. Agardh) Setchell, *M. pacifica* (Heydrich) Foslie, and *M. multistrata* sp. nov. *Phycologia* 48: 404–422.

Kim, M.S. and I.K. Lee. 1999. *Neosiphonia flavimarina* gen. et sp. nov. with a taxonomic reassessment of the genus *Polysiphonia* (Rhodomelaceae, Rhodophyta). *Phycological Research* 47: 271–281.

Kraft, G.T., L.M. Liao, A.J.K. Millar, E.G.G. Coppejans, M.H. Hommersand and D.W. Freshwater. 1999. Marine benthic red algae (Rhodophyta) from Bulusan, Sorsogon province, southern Luzon, Philippines. *The Philippine Scientist* 36: 1–50.

Largo, D.B., A.S. Diola and M.S. Marababol. 2016. Development of an integrated multi-trophic aquaculture (IMTA) system for tropical marine species in southern Cebu, central Philippines. *Aquaculture Reports* 3: 67–76.

Lastimoso, J.M.L. and W.J.E. Santiañez. 2020. Updated checklist of the benthic marine macroalgae of the Philippines. *Philippine Journal of Science* 150 Special Issue: 29–92.

Lawton, R.J., J.E. Sutherland, C.R.K. Glasson and M.E. Magnusson. 2021. Selection of temperate *Ulva* species and cultivars for land-based cultivation and biomass applications. *Algal Research* 56: 102320.

Liao, L.M. 1990. Discovery of the "*Falkenbergia*" phase of *Asparagopsis taxiformis* (Rhodophyta: Bonnemaisoniales) from Philippine waters. *The Philippine Scientist* 27: 5–10.

Liao, L.M., D.A.U. Bataan, A.A. Tahil, C.P. Sajot and P.J.L. Geraldino. 2022. Marine algae of the eastern Caraga region, Philippines, II. An annotated list of the green algae (Ulvophyceae). *Thailand Natural History Museum Journal* 16: 1–10.

Lin, S.M., C. Rodríguez-Prieto, J.M. Huisman, M.D. Guiry, C. Payri, W.A. Nelson and S.L. Liu. 2015.

A phylogenetic re-appraisal of the family Liagoraceae *sensu lato* (Nemaliales, Rhodophyta) based on sequence analyses of two plastid genes and postfertilization development. *Journal of Phycology* 51: 546–559.

Lüning, K. and S. Pang. 2003. Mass cultivation of seaweeds: Current aspects and approaches. *Journal of Applied Phycology* 15: 115–119.

Lyra, G. de M., E. da S. Costa, P.B. de Jesus, J.C.G. de Matos, T.A. Caires, M.C. Oliveira, E.C. Oliveira, Z. Xi, J.M. de C. Nunes and C.C. Davis. 2015. Phylogeny of Gracilariaceae (Rhodophyta): evidence from plastid and mitochondrial nucleotide sequences. *Journal of Phycology* 51: 356–366.

Machín-Sánchez, M., M.C. Gil-Rodríguez and R. Haroun. 2018. Phylogeography of the red algal *Laurencia* complex in the Macaronesia region and nearby coastal areas: Recent advances and future perspectives. *Diversity* 10: 10 doi:10.3390/d10010010

Mapatac, L.C., N.R. Mamaoag, C.A. Cubillas and J.M.D. Dalago. 2015. Phytochemical screening and cytotoxicity level of macroalgae in Loreto, Dinagat Island, Philippines. *BIMP-EAGA Journal of Sustainable Tourism Development* 4: 121–131.

Mapatac, L.C., N.R. Mamaoag and J.M.D. Dalago. 2014. Evaluation of cytotoxicity and presence of secondary metabolites of selected macroalgae along Loreto Dinagat Island. *College of Science Education Journal [Caraga State University]* 1: 15–31.

Masuda, M., T. Kudo, S. Kawaguchi and M.D. Guiry. 1995. Lectotypification of some marine red algae described by W.H. Harvey from Japan. *Phycological Research* 43: 191–202.

Mendoza-González, C., F.F. Pedroche and L.E. Mateo-Cid. 2009. The genus *Hydrolithon* Foslie (Corallinales, Rhodophyta) along the Atlantic and Caribbean coasts of Mexico. *Gayana* 66: 217–235.

Nauer, F., C.F.D. Gurgel, L.M. Ayres-Ostrock, E.M. Plastino and M.C. Oliveira. 2019. Phylogeography of the *Hypnea musciformis* species complex (Gigartinales, Rhodophyta) with the recognition of cryptic species in the western Atlantic Ocean. *Journal of Phycology* 55: 676–687.

Ng, P.-K., S.-M. Lin, P.-E. Lim, A.Q. Hurtado, S.-M. Phang, Y.-Y. Yow and Z. Sun. 2017. Genetic and morphological analyses of *Gracilaria firma* and *G. changii* (Gracilariaceae, Rhodophyta), the commercially important agarophytes in western Pacific. *PLoS ONE* 12(7): e0182176.

Norris, R.E. 1987. The systematic position of *Gelidiopsis* and *Ceratodictyon* (Gigartinales, Rhodophyta), genera new to South Africa. *South African Journal of Botany* 53: 239–246.

Norris, R.E. 1988. The specific identity of *Neurymenia* (Rhodophyceae, Rhodomelaceae) in southeastern Africa. *Sorui*, *Japanese Journal of Phycology* 36: 271–276.

Norris, R.E. 1992. Ceramiales (Rhodophyta) genera new to South Africa, including new species of *Womersleyella* and *Herposiphonia*. *South African Journal of Botany* 58: 65–76.

Nunes, A., G.Z. Acevedo, F. de S. Duta, B.R. dos Santos, A.R. Schneider, E.R. Oliveira, S. Moura, F. Vianello, M. Maraschin and G.P. Pereira Lima. 2024. Uses and applications of the red seaweed *Kappaphycus alvarezii*: A systematic review. *Journal of Applied Phycology* 36: 3409–3450.

Ohmi, H. 1958. The species of *Gracilaria* and *Gracilariopsis* from Japan and adjacent waters. *Memoirs of the Faculty of Fisheries Hokkaido University* 6: 1–66.

Orboc, D.R.F., J.C. Jumawan, L.A. Ombat, R.Y. Capampangan and R.A. Seronay. 2022. Marine benthic macrophytes diversity and concentration of heavy metals in *Thalassia hemprichii* near mining area of Claver, Surigao del Norte, Philippines. *Journal of Ecosystem Science and Eco-Governance* 4: 29–39.

Ortega, M.M., J.L. Godínez and G. Garduño-Solórzano. 2001. *Catálogo de las Algas Bénticas de las Costas Mexicanas del Golfo de México y Mar Caribe*. Ciudad de México, Universidad Nacional Autónoma de México. 594 pp.

Papenfuss, G.F., K.E. Mshigeni and Y.-M. Chiang. 1982. Revision of the red algal genus *Galaxaura* with special reference to the species occurring in the western Indian Ocean. *Botanica Marina* 25: 401–444.

Papenfuss, G.F. and Y.-M. Chiang. 1969. Remarks on the taxonomy of *Galaxaura* (Nemaliales, Chaetangiaceae). *Proceedings of the International Seaweed Symposium* 6: 303–314.

Pastor, P.J.B. and R.P. Magdugo. 2024. A comparative assessment on the cytotoxicity of *Kappaphycus alvarezii* and *Kappaphycus striatus* seaweeds using brine shrimp lethality assay. *Annals of Studies in Science and Humanities* 5(2): 1–11.

Payo, D.A., F. Leliaert, H. Verbruggen, S. D'Hondt, H.P. Calumpong and O. De Clerck. 2013. Extensive cryptic species diversity and fine-scale endemism in the marine red alga *Portieria* in the Philippines. *Proceedings of the Royal Society B* 280: 2012.2660.

Price, I.R. and G.T. Kraft. 1990. Reproductive development and classification of the red algal genus *Ceratodictyon* (Rhodymeniales, Rhodophyta). *Phycologia* 30: 106–116.

Price, I.R., R.L. Fricker and C.R. Wilkinson. 1984. *Ceratodictyon spongiosum* (Rhodophyta), the macroalgal partner in an alga-sponge symbiosis, grown in unialgal culture. *Journal of Phycology* 20: 156–158.

Reyes, A.Y. 1970. A survey of the littoral benthic algae of the coastal areas of Dumaguete City. *Philippine Journal of Science* 99: 131–163.

Rollon, R.N., M.S. Samson, M.Y. Roleda, K.G. Araño, M.W.B. Vergara and W.Y. Licuanan. 2003. Estimating biomass from the cover of *Gelidiella acerosa* along the coasts of eastern Philippines. *Botanica Marina* 46: 497–502.

Roslee, A.N. and N.F. Munajat. 2018. Pyrolysis and kinetic parameters estimation of macroalgae biomass (*Gracilaria multifurcata* and *Halymenia durvillei*) for potential fuel production. *Advanced Science Letters* 24: 8935–8939.

Russell, D.J. and G.H. Balazs. 1994. Colonization by the alien marine alga *Hypnea musciformis* (Wulfen) J.Agardh (Rhodophyta: Gigartinales) in the Hawaiian Islands and its utilization by the green turtle, *Chelonia mydas* L. *Aquatic Botany* 47: 53–60.

Saito, Y. 1969. The algal genus *Laurencia* from the Hawaiian Islands, the Philippine Islands and adjacent areas. *Pacific Science* 23: 148–160.

Sajot, C.P. 2006. Assessment of macrobenthic algae in Lianga Bay, eastern Mindanao, Philippines. *Surigao del Sur Polytechnic State College Research, Development and Extension Journal* 2: 91–98.

Sangpairoj, K., R. Settacomkul, T. Siangcham, K. Meemon, N. Niamnont, N. Sornkaew, M. Tamtin, P. Sobhon and P. Vivithanaporn. 2022. Hexadecanoic acid-enriched extract of *Halymenia durvillei* induces apoptosis and autophagic death of human triple-negative breast cancer cells by upregulating ER stress. *Asian Pacific Journal of Tropical Biomedicine* 12: 132–140.

Sherwood, A.R., S.-M. Lin, R.M. Wade, H.L. Spalding, C.M. Smith and R.K. Kosaki. 2020. Characterization of *Martensia* (Delesseriaceae: Rhodophyta) from shallow and mesophotic habitats in the Hawaiian Islands: Descriptions of four new species. *European Journal of Phycology* 55: 172–185.

Silva, P.C., E.G. Meñez and R.L. Moe. 1987. Catalog of the marine benthic algae of the Philippines.

Smithsonian Contributions to the Marine Sciences 27: 1–179.

Silva, P.C., P.W. Basson and R.L. Moe. 1996. Catalogue of the benthic marine algae of the Indian Ocean. *University of California Publications in Botany* 79: 1–1259.

Suzuki, M., T. Segawa, H. Mori, A. Akiyoshi, R. Ootsuki, A. Kurihara, H. Sakayama, T. Kitayama, T. Abe, K. Kogame, H. Kawai and H. Nozaki. 2016. Next-generation sequencing of an 88-year-old specimen of the poorly known species *Liagora japonica* (Nemaliales, Rhodophyta) supports the recognition of *Otohimella* gen. nov. *PLoS ONE* 11(7): e0158944.

Tan, P.-L., P.-E. Lim, S.-M. Lin, S.-M. Phang, S.G.A. Draisma and L.M. Liao. 2015. Foliose *Halymenia* species (Halymeniaceae, Rhodophyta) from Southeast Asia, including a new species, *Halymenia malaysiana* sp. nov. *Botanica Marina* 58: 203–217.

Tanaka, T. and H. Itono. 1969. Studies on the genus *Neurymenia* (Rhodomelaceae) from southern Japan and vicinities. *Memoirs of the Faculty of Fisheries*, *Kagoshima University* 18: 7–27.

Tassakka, A.C.M.A.R., O. Sumule, M.N. Massi, Sulfahri, M. Manggau, I.W. Iskandar, J.F. Alam, A.D. Permana and L.M. Liao. 2021. Potential bioactive compounds as SARS-CoV-2 inhibitors from extracts of the marine red alga *Halymenia durvillei* (Rhodophyta) – A computational study. *Arabian Journal of Chemistry* 14: 103393.

Trono, G.C. 1997. *Field Guide & Atlas of the Seaweed Resources of the Philippines*. Makati City, Bookmark Inc. 306 pp.

Trono, G.C. 2004. *Field Guide & Atlas of the Seaweed Resources of the Philippines, Volume 2*. Quezon City, Bureau of Agricultural Research. 261 pp.

Trono, G.C. 2017a. *Field Guide & Atlas of the Seaweed Resources of the Philippines: Epiphytes & Microbenthic Algae, Volume III*. Quezon City, Bureau of Agricultural Research. 230 pp.

Trono, G.C. 2017b. *An Illustrated Seaweed Flora Collected Along the Pacific Seaboard of the Philippines, Part I. Cyanophyceae and Rhodophyceae.* Taguig City, National Academy of Science and Technology. 168 pp.

Trono, G.C. and A.T. Buchan-Antalan. 1987. Biomass production in *Acanthophora* associated algal communities in Bacoor Bay, Cavite, Philippines. *The Philippine Journal of Science Monograph* 17: 1–10.

Trono, G.C., R. Azanza-Corrales and D. Manuel. 1983. The genus *Gracilaria* (Gigartinales, Rhodophyta) in the Philippines. *Kalikasan*, *Philippine Journal of Biology* 12: 15–41.

Turland, N.J., J.H. Wiersema, F.R. Barrie, W. Greuter, D.L. Hawksworth, P.S. Herendeen, S. Knapp, W.-H. Kusber, D.-Z. Li, K. Marhold, T.W. May, J. McNeill, A.M. Monro, J. Prado, M.J. Price and G.F. Smith. 2018. International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) *Regnum Vegetabile 159.* Glashütten (Germany), Koeltz Botanical Books. 254 pp.

Vieira, C., A.D.R. N'Yeurt, F.A. Rasoamanendrika, S. D'Hondt, L.A. Thi Tran, D. Van den Spiegel, H. Kawai and O. De Clerck. 2021. Marine macroalgal diversity of northern Madagascar: Morpho-genetic systematics and implication for anthropic impacts for conservation. *Biodiversity and Conservation* 30: 1501–1546.

Vieira, C., P.W. Andiska, C.F.D. Gurgel, M.Y. Yang and M.S. Kim. 2025. Global phylogeny, biogeography, and evolution of the agarophyte family Gracilariaceae with key insights into broadly distributed and cultivated species. *Algal Research* 33: 103994 https://doi.org/10.1016/j.algal.2025.103994

Wiriyadamrikul, J., P.J.L. Geraldino, J.M. Huisman, K. Lewmanomont and S.M. Boo. 2013. Molecular diversity of the calcified red algal genus *Tricleocarpa* (Galaxauraceae, Nemaliales) with the description of *T. jejuensis* and *T. natalensis*. *Phycologia* 52: 338–351.

Xia, B. and I.A. Abbott. 1987. New species of *Polycavernosa* Chang & Xia (Gracilariaceae, Rhodophyta) from the western Pacific. *Phycologia* 26: 405–418.

Yang, M.Y. and M.S. Kim. 2018. Cryptic species diversity of ochtodenes-producing *Portieria* species (Gigartinales, Rhodophyta) from the northwest Pacific. *Algae* 33: 205–214.

Yang, M.Y., P.J.L. Geraldino and M.S. Kim. 2013. DNA barcode assessment of *Gracilaria salicornia* (Gracilariaceae, Rhodophyta) from Southeast Asia. *Botanical Studies* 54: 27.