
Research Article

Field Identification of Calcified Red Algae

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Calcified red algae are important components of several marine communities where they are often responsible for bioconstructions on which depend a variety of other organisms. The vast majority of calcified red algae are the **coralline algae** which belong to the Order **Corallinales**. Most authors consider this order as comprising the single family **Corallinaceae** although the genus *Sporolithon* is sometimes placed in a separate family: the Sporolithaceae (Verheij, 1993). A few other algae, particularly in the genera *Peyssonnelia* (Order Gigartinales, Family Peyssonneliaceae) and *Galaxaura* (Order: Nemalionales, Family Chaetangiaceae) are sufficiently heavily calcified to be mistaken for corallines.

In the Central Mediterranean, the most important communities dominated by calcified red algae are:

- **Pavements** or *Trottoirs* in the lower Mediolittoral dominated by *Neogoniolithon notarisii*, often accompanied by the sessile vermetid gastropod *Dendropoma petraeum*.

- **Belts** and rims in the lower Mediolittoral / upper Infralittoral, typically on vertical rock faces, dominated by *Corallina elongata*, often accompanied by *Lithophyllum incrustans* and *Phymatolithon lenormandii*.

- **Rims** or Cornices in the middle Mediolittoral dominated by *Lithophyllum lichenoides*.

- Lower Infralittoral / upper Circalittoral **Coralligene** or Coralgal communities involving a variety of species such as *Neogoniolithon brassica-florida*, *Lithophyllum frondosum*, *Lithophyllum incrustans*, *Mesophyllum lichenoides* and a variety of sessile animals such as gorgonians and bryozoans.

- Lower infralittoral and circalittoral **Maerl** communities dominated by unattached rhodolith-forming species such as *Lithothamnion minervae*, *Lithothamnion corallioides*, *Phymatolithon calcareum*, *Lithophyllum racemosum*, *Mesophyllum alternans* and *Peyssonnelia rosamarina* (Lanfranco, 1993; Lanfranco et al. 1999).

Morphologically, coralline algae fall into two groups. The **geniculate** forms have a segmented branched thallus where calcification is weak at the joints between segments, thus conferring some degree of flexibility. The **non-geniculate** forms, on the other hand, are completely calcified and are therefore inflexible and with a stony texture and appearance. The latter may be either attached to a substrate or may be unattached thus forming part of the bottom sediments. In the latter case, such free-living corallines may occur in large populations giving rise to maerl communities, the individual plants being called rhodoliths. Some species occur in both attached and unattached forms, though most species occur predominantly in one or the other state. Of course, any species may occur accidentally in an unattached state

due to fragmentation or displacement caused by hydrodynamism or bioturbation.

Due to their importance it is essential for the ecologist to be able to identify the species accurately. However their identification is notoriously difficult. This is largely due to the great plasticity of their gross morphology which is largely dependent on ecological factors. Accurate identification generally requires microscopic examination of sections of the thallus and, in many cases, requires fertile material, making this essentially a job for the specialist. In fact the majority of available keys are based on such microscopic characters.

The aim of this contribution is to provide a key which enables the field worker to identify calcified algae with some degree of confidence, using only gross morphological features and requiring no more equipment than a hand lens and ruler. Construction of the key involved the examination of a large number of specimens by means of which the most diagnostic gross characters could be chosen; ecological characters have also been widely used. The user should however beware that the key works best at a population level, where numerous and well developed specimens of known provenance are available. Attempting to identify individual, immature or fragmentary specimens gives much less reliable results. The key includes all non-parasitic corallines and other heavily calcified red algae known from the Maltese Islands. It is adapted and augmented from a previously published simplified version (Lanfranco, 1998). In the Maltese islands, the family Corallinaceae also includes the microscopic *Choreonema thuretii* (Bornet) Schmitz which parasitises geniculate corallines. The common green alga *Halimeda tuna* (Ellis & Solander) Lamouroux is heavily calcified but cannot be mistaken for a coralline. Several species of *Peyssonnelia* have some degree of calcification; only those which are completely calcified and inflexible are included here. Specimens of nearly all species are deposited in the reference collection of the Department of Biology museum.

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The Key

1. Geniculate: thallus jointed, profusely branched and flexible.....2
 - 1a. Non-geniculate: thallus solid, inflexible12
2. All branching pinnate throughout, thallus clearly flattened and in one plane*Corallina elongata*
 Most Mediterranean records for *Corallina officinalis*, which has much sparser branching and clearly cylindrical axes, are probably misidentifications of this species.
 - 2a. Branching dichotomous with or without pinnate terminal branches.....3
3. Branches normally less than 0.5mm in diameter.....4
 - 3a. Branches normally more than 0.5mm in diameter or, if slightly less, regularly dichotomous with open branching7
4. Basal axes up to 0.5mm in diameter. Apparently rare species from the lower infralittoral/ circalittoral*Jania longifurca*
 - 4a. Basal axes up to c. 0.2mm in diameter5
5. Ultimate branches with some segments bearing horn-like appendages at the apex which may give rise to segmented pinnate branches.....*Jania corniculata*
 - 5a. No horn-like appendages or pinnate branches present.....6
6. Branches forking at less than 45°, plants often longer than 2cm, usually very densely branched, growing profusely on other seaweeds, often covering them completely; very common.....*Jania rubens*
 - 6a. Branches forking at over 60°, very delicate, bases creeping and attached to host plant by sucker-like haustoria; very common.....*Jania adhaerens*
7. Most dichotomies covered by pinnate branches. Usually epiphytic but sometimes on rock; base creeping; frequent. Easily confused with *Corallina elongata* which has no dichotomous branching, and with *Jania corniculata* where any pinnate branches start off as a projection from the apex of a segment *Halpilton virgatum*
 The larger *Halpilton squamatum*, with a creeping basal system, may also be present.
 - 7a. No pinnate branches present8
8. Branching irregularly dichotomous; on rock; common*Amphiroa rigida*
 - 8a. Branching regularly dichotomous9
 9. Very flexible at the joints, tips of branches appearing tubular; rather uncommon. Easily mistaken for species of *Amphiroa**Galaxaura oblongata*
 - 9a. Less flexible at the joints, not hollow tipped10
 10. Small plants with branches < 0.4mm diameter; epiphytic on *Lithophyllum frondosum**Amphiroa verruculosa*
 - 10a. Plants usually more than 2cm long11
 11. Joints thin (c. 0.4mm diameter), usually on rock*Amphiroa cryptarthrodia*
 - 11a. Joints thicker (c. 1mm).....*Amphiroa beauvoisii*
 12. Free living on bottom sediments 13
 - 12a. Attached18
 13. Profusely branched in all directions14
 - 13a. With few or no branches17
 14. Branching very dense, branches generally more than 3mm diameter.....15
 - 14a. Branching open16
 15. Branches constricted at the base ...*Lithophyllum racemus*
 - 15a. Branches not constricted at the base. Easily confused with *Phymatolithon calcareum* which is generally smaller and has more open branching. Rhodoliths often reach several centimetres in diameter. Together with *Lithothamnion corallioides*, it is the most abundant component of Maltese maerl beds.....*Lithothamnion minervae*
 16. Branches less than 1.5 mm diameter, very open*Lithothamnion corallioides*
 - 16a. Branches 2-3mm diameter, open to slightly crowded; rather uncommon. Specimens with crowded branching are easily confused with *Lithothamnion minervae*; small specimens can be confused with *Lithothamnion corallioides*.....*Phymatolithon calcareum*
 - 16b. Branches usually more than 4mm diameter, often longer than 5mm and branched. Rhodoliths may be several centimetres in diameter. Not yet recorded with certainty from the Maltese Islands but is likely to occur*Lithothamnion valens*
 17. Well developed specimens in the form of a series of overlapping lamellae, bright purple red, looking somewhat like a tight-petalled rose*Peyssonnelia rosa-marina*

- 17a. Well developed specimens usually longer than broad, made up of overlapping pink lamellae*Mesophyllum alternans*
- 17b. Stone-like, more or less featureless, often with a pustulate surface.....*Neogoniolithon brassica-florida*
18. Thalli generally epiphytic19
- 18a. Thalli generally epilithic22
19. Thalli very thin, translucent20
- 19a. Thalli not translucent21
20. Thallus often more than 1cm wide*Melobesia membranacea*
- 20a. Thallus usually less than 1cm widegenera *Hydrolithon* and *Pneophyllum*
- Species of these genera can only be separated by microscopic characters. Some species, particularly *Hydrolithon farinosum*, are extremely common epiphytes being particularly abundant on the leaves of the seagrass *Posidonia oceanica*. Other species known to occur are *H. cruciatum* and *Pneophyllum fragile*, but more are likely to be present.
21. Thallus minute (2 - 6mm), epiphytic on *Corallina* and *Haliptilon**Lithophyllum corallinae*
- 21a. Thallus usually around 1cm diameter (up to 3cm), with prominent conceptacles. Very common on a variety of algae*Lithophyllum pustulatum*
- 21b. Thallus thick and irregular. Epiphytic on a variety of larger algae, particularly species of *Cystoseira* and *Sargassum**Lithophyllum cystoseirae*
- 21c. Thallus consisting of relatively large (over 2cm) flat lamellae, easily separable from their substrate*Mesophyllum lichenoides*
22. Thallus thick provided with various crests, branches or other appendages perpendicular to it's plane23
- 22a. Thallus flat with few or no excrescences24
23. Thallus having a spongy appearance, made up of numerous anastomosing cylindrical branches of about 1mm thickness; rare.*Lithophyllum byssoides*
- 23a. Thallus with cylindrical branches thicker than 1mm.....*Sporolithon ptychoides* and *Spongites fruticulosa*
- Most plants with this feature are probably *Sporolithon*. Most Mediterranean records of *Spongites fruticulosa* require confirmation while most records for unattached plants refer to *Lithothamnion minervae* (Basso, 1995). Some variants of *Lithophyllum incrustans* and *Neogoniolithon brassica-florida* may also key here.
- 23b. Thallus consisting of large smooth crests; rare*Lithophyllum dentatum*
- Also known in the unattached state.
- 23c. Thallus with a spongy appearance, being made up of a dense mass of small crests. Always in the Mediolittoral; rare*Lithophyllum lichenoides*
24. Thallus made up of wide, usually smooth lamellae, easily separable from the substrate25
- 24a. Thallus strongly adherent to the substrate26
25. Thallus rather thick but brittle, usually without a whitish edge.....*Lithophyllum frondosum*
- 25a. Thallus as above but having a whitish border, usually thinner, smaller and with a glossy surface*Mesophyllum lichenoides*
- The two species above are often quite difficult to separate on gross morphological grounds
- 25b. Thallus usually adherent, though loosely, over a larger area of its undersurface, irregular*Lithothamnion philippii*
- This species has not yet been recorded with certainty from the Maltese islands but is most likely to occur. There is much taxonomic confusion with *Mesophyllum lichenoides* (Basso, 1995a, 1995b)
- 25c. Thallus deep purplish red, usually more adherent to the substrate but with clearly raised edges*Peyssonnelia polymorpha*
26. Thallus thin with prominent dome-shaped conceptacles, circular, usually larger than 2cm diameter. Very common in the upper infralittoral and lower mediolittoral, often associated with *Corallina elongata**Phymatolithon lenormandii*
- 26a. Thallus rather thick with prominent raised ridges where adjacent thalli meet. Sometimes with short branches. Very common in the upper infralittoral and also deeper*Lithophyllum incrustans*
- Extremely variable. Branched specimens easily confused with *Sporolithon ptychoides*. Also occurs in the free living state in maerl beds where it can easily be confused with *Neogoniolithon brassica-florida*.
- 26b. Thallus rather thick and featureless though often with short protuberances. Very common*Neogoniolithon notarisii* and *N. brassica-florida*
- The two species are often held to be conspecific but *N. notarisii* is particularly common in the mediolittoral as the chief algal component of extensive pavement-like formations (trottoirs), usually accompanied by the vermetid gastropod *Dendropoma petraeum*. *N. brassica-florida* tends to occur in deeper waters and often forms rhodoliths in maerl beds.

Taxonomic List of Species

Classification of non-geniculate genera is based on Woelkerling (1988). Recently/ commonly used synonyms are included.

Order: NEMALIONALES

Family: CHAETANGIACEAE

Galaxaura oblongata (Ellis & Solander) Lamouroux
= *Galaxaura adriatica* Zanardini

Order: GIGARTINALES

Family: PEYSSONNELIACEAE

Peyssonnelia rosa-marina Boudouresque & Denizot
Peyssonnelia polymorpha (Zanardini) Schmitz

Order: CORALLINALES

Family: CORALLINACEAE

sub-family: CORALLINOIDEAE

Amphiroa beauvoisii Lamouroux
= *Amphiroa exilis* Harvey
Amphiroa cryptarthrodia Zanardini
Amphiroa rigida Lamouroux
Amphiroa verruculosa Kützing
Corallina elongata Ellis & Solander
= *Corallina mediterranea* Areschoug
Corallina officinalis L.
Halitilon squamatum (L.) Johansen, L. Irvine & Webster
= *Corallina squamata* Ellis
Halitilon virgatum (Zanardini) Garbary & Johansen
= *Corallina granifera* Ellis & Solander
Jania adhaerens Lamouroux
Jania corniculata (L.) Lamouroux
= *Jania rubens* (L.) Lamouroux var. *corniculata* (L.) Yendo
Jania longifurca Zanardini
Jania rubens (L.) Lamouroux
= *Corallina rubens* L.

sub-family: LITHOPHYLLOIDEAE

Lithophyllum byssoides (Lamarck) Foslie
= *Titanoderma byssoides* (Philippi) Chamberlain & Woelkerling
= *Goniolithon byssoides*. (Lamarck) Foslie
Lithophyllum corallinae (P.L. & H.M. Crouan) Heydrich
= *Dermatolithon corallinae* (P.L. Crouan & H.M. Crouan) Foslie
= *Titanoderma corallinae* (P.L. Crouan & H.M. Crouan) Woelkerling, Chamberlain & Silva
Lithophyllum cystoseirae (Hauck) Woelkerling
= *Dermatolithon cystoseirae*. (Hauck) Huvé
= *Dermatolithon papillosum* (Zanardini) Foslie
= *Goniolithon papillosum* (Zanardini) Foslie
= *Lithophyllum papillosum* (Zanardini) Foslie

= *Lithothamnion papillosum* Zanardini
= *Titanoderma cystoseirae* (Hauck) Woelkerling, Chamberlain & Silva

Lithophyllum dentatum (Kützing) Foslie
Lithophyllum frondosum (Dufour) Furnari, Cormaci & Alongi
= *Lithophyllum expansum* Philippi
= *Lithophyllum grandiusculum* (Montagne) Woelkerling, Penrose & Chamberlain
= *Pseudolithophyllum cabiochae* Boudouresque & Verlaque
= *Pseudolithophyllum expansum* (Philippi) Lemoine
Lithophyllum incrustans Philippi
Lithophyllum lichenoides Philippi
Lithophyllum pustulatum (Lamouroux) Foslie
= *Dermatolithon pustulatum* (Lamouroux) Foslie
= *Melobesia pustulata* Lamouroux
= *Titanoderma pustulata* (Lamouroux) Nägeli
Lithophyllum racemus (Lamarck) Foslie

sub-family: MASTOPHOROIDEAE

Hydrolithon cruciatum (Bressan) Chamberlain
= *Fosliella cruciata* Bressan
Hydrolithon farinosum (Lamouroux) Penrose & Chamberlain
= *Fosliella farinosa* (Lamouroux) Howe
= *Meelobesia farinosa* Lamouroux
Neogoniolithon brassica-florida (Harvey) Setchell & Mason
= *Goniolithon brassica-florida* (Harvey) Foslie
= *Neogoniolithon mamillosum* (Hauck) Setchell & Mason
Neogoniolithon notarisii (Dufour) Setchell & Mason
= *Goniolithon notarisii* (Dufour) Foslie
Pneophyllum fragile Kützing
= *Fosliella lejolisii* (Rosanoff) Howe
= *Pneophyllum lejolisii* (Rosanoff) Chamberlain
Spongites fruticulosa Kützing
= *Lithothamnion fruticulosum* (Kützing) Foslie

sub-family: MELOBESIOIDEAE

Lithothamnion corallioides (P.L. Crouan & H.M. Crouan) P.L. Crouan & H.M. Crouan
= *Lithophyllum solutum* (Foslie) Lemoine
= *Lithothamnium solutum* Foslie
= *Mesophyllum corallioides* (P.L. Crouan & H.M. Crouan) Foslie
= *Spongites corallioides* P.L. Crouan & H.M. Crouan
Lithothamnion minervae Basso
Lithothamnion philippii Foslie
Lithothamnion valens Foslie
Melobesia membranacea (Esper) Lamouroux
= *Epilithon membranaceum* (Esper) Heydrich
Mesophyllum alternans (Foslie) Cabioch & Mendoza
= *Lithothamnion philippii* Foslie forma *alternans* Foslie

Mesophyllum lichenoides (Ellis) Lemoine
Phymatolithon calcareum (Pallas) Adey & McKibbin
 = *Lithothamnion calcareum* (Pallas) Areschoug
 in J. Agardh
Phymatolithon lenormandii (Areschoug in J. Agardh)
 Adey
 = *Lithothamnion lenormandii* (Areschoug in J.
 Agardh) Foslie
Sporolithon ptychoides Heydrich
 = *Archaeolithothamnion mediterraneum* (Heydrich)
 Foslie
 = *Sporolithon mediterraneum* Heydrich

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