Gracilaria vermiculophylla **System:** Marine

Kingdom	Phylum	Class	Order	Family
Plantae	Rhodophycota	Rhodophyceae	Gigartinales	Gracilariaceae

Common name

Synonym *Gracilaria asiatica* , Zhang & Xia
Gracilariopsis vermiculophylla , Ohmi

Similar species *Gracilaria gracilis, Gracilariopsis longissima*

Summary

Gracilaria vermiculophylla (Ohmi) Papenfuss is a red alga and was originally described in Japan in 1956 as *Gracilariopsis vermiculophylla*. It is thought to be native and widespread throughout the Northwest Pacific Ocean. *G. vermiculophylla* is primarily used as a precursor for agar, which is widely used in the pharmaceutical and food industries. It has been introduced to the East Pacific, the West Atlantic and the East Atlantic, where it rapidly colonises new environments. It is highly tolerant of stresses and can grow in an extremely wide variety of conditions; factors which contribute to its invasiveness. It invades estuarine areas where it outcompetes native algae species and modifies environments.

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Species Description
Gracilaria vermiculophylla is a red macroalga that is cartilaginous, cylindrical and up to 50 cm long. It is coarsely branched, often profusely so. *G. vermiculophylla* can be found as loose-lying thalli or attached to small stones or shells. Red algae are often found in the vegetative state, and characterisation of reproductive structures is often necessary for correct identification of *Gracilaria* species (AlgaeBase 2010; Liao & Hommersand 2003; Nyberg *et al*. 2009; Rueness 2005).

Notes
Over 179 species are included in the genera *Gracilaria* and *Gracilariopsis*. The delineation of species in these genera has been notoriously difficult due to morphological similarities between species (Goff *et al*. 1994; Rueness 2005). Taxonomic problems have been particularly pronounced for *Gracilaria vermiculophylla* (Bellorin *et al*. 2004).
In a recent review Terada and Yamamota (2002 in Rueness 2005) reduced *G. asiatica* Zhang & Xia into synonymy with *G. vermiculophylla*.
The morphological similarities between *G. vermiculophylla* and other related algal species mean that the invasion of this alga is often cryptic, requiring DNA analysis for reliable identification (Thomsen *et al*. 2006a; Thomsen *et al*. 2006b). To avoid future taxonomic confusion Thomsen *et al*. (2006b) recommend researchers create silica-gel, air-dried, and/or herbarium presses as voucher specimens so that the correct identification can be confirmed using morphological and molecular analysis.

Lifecycle Stages
Gracilaria vermiculophylla is a perennial species with alternating generations (isomorphic life cycle). Dioecious haploid gametophytes produce either male or female gametes. These fuse to create a diploid zygote which grows into a diploid tetrasporophyte, (Nyberg *et al*. 2009; Rueness 2005; Thornber 2006). There is also a parasitic heteromorphic carposporophyte generation (Xie *et al*. 2010).

Uses
G. vermiculophylla is widely collected for the production of the biopolymer agar, which is used extensively in the pharmaceutical and food industries (Mollet *et al*. 1998; Sousa *et al*. 2010).

Habitat Description
Gracilaria vermiculophylla is thought to be a temperate to subtropical alga, and can grow in both temperate and tropical regions. It is well-adapted to low energy, shallow-bottom bays, lagoons, estuaries, harbours and inslets (Yokoya *et al*. 1999; Thomsen & McGlathery 2007; Nyberg *et al*. 2009; M. S. Thomsen, pers. comm.). It forms extensive beds in the intertidal zone and upper sublittoral zones, where it attaches to rocks or pebbles, often covered with sand and mud (Bellorin *et al*. 2004). It often occurs as pure stands to the exclusion of other algae species (Rueness 2005).\r\n\r\n
G. vermiculophylla is able to grow in a wide range of temperatures (5-35 °C), light intensities (20–100 µmol photons m-2 s-1) and salinities (5-60 psu). Optimum growing conditions are between 15-25 °C and 10-45 psu (Rainkar *et al*. 2001; Rueness 2005). It is also tolerant to other stressses including sedimentation, desiccation, grazing and low nutrients (Rueness 2005). Nybert *et al*. (2009) found in one instance that this alga was able to survive in complete darkness for more than five months in the laboratory.

Reproduction
Gracilaria vermiculophylla reproduces by spores, which are non-motile, therefore restricting this alga to passive dispersal mechanisms. Male and female gametophytes and tetrasporophytes have a similar morphology (Freshwater *et al*. 2006; Nyberg *et al*. 2009; Woelkerling 1990, in Freshwater *et al*. 2006).

Nutrition
Gracilaria vermiculophylla belongs to the phylum Rhodophyta (red algae). Red algae are primitive photosynthetic eukaryotes (Xie *et al*. 2010).

General Impacts
Ecosystem impacts: *Gracilaria vermiculophylla* inhibits the growth and survival of native algae through competition (Council of Europe 2009; Hamman *et al*. n.d.). It has been demonstrated to have negative effects on native seagrass beds of *Zostera marina* by decreasing net leaf photosynthesis and survival rates. Negative effects on seagrass are greater at higher temperatures, suggesting that impacts could increase with future ocean warming (Martínez-Lüscher & Holmer, 2010). In some areas such as Hog Island Bay in Virginia *G. vermiculophylla* dominate algal assemblages, in all seasons and elevation levels (Thomsen *et al*. 2006b). Accumulation of *G. vermiculophylla* may also impair environmental conditions for threatened Charophytes and *Zostera noltii* in Sweden (Gärdenfors 2005 in Nyberg *et al*., 2009).\r\n
In high abundance *G. vermiculophylla* may have dramatic effects on ecosystems. The introduction of G. vermiculophylla adds structural complexity to relatively homogenous soft-bottom systems and add new attachment sites for filamentous algae and sessile animals (Thomsen *et al*. 2006a; Nyberg *et al*., 2009). Thus *G. vermiculophylla* can provide shelter and food for other organisms, including microalgae, gastropods, crustaceans, polychaetes, and mny other small invertebrates. In Virginia research has shown that most invertebrate groups were positively affected by the presence of *G. vermiculophylla* in native algae (Thomsen *et al*., 2010).\r\n
While *G. vermiculophylla* may enhance local diversity, the ability to utilize increased habitat complexity will vary between species (Nyberg *et al*. 2009). Furthermore these changes could lead to effects on higher trophic levels (Aikins & Kukuchi 2002; Freshwater *et al*. 2006; Gustafsson 2005 in Nyberg *et al*. 2009; Nyberg *et al*. 2009; Thomsen *et al*. 2007c).\r\n
Loose-lying *G. vermiculophylla* populations have the potential to develop into dense mats, particularly in shallow bays, lagoons, harbours and estuaries. These mats can modify the habitat available for the benthic faunal community and bottom dwelling fish. Algal mats can also form physical barriers for settling larvae, decrease light intensity, increase the likelihood of anoxia and change water movement patterns, which in turn affects sedimentation rate and thus food availability for deposit feeders (Nyberg *et al*. 2009).\r\n
Additionally, the movement, accumulation and decomposition of *G. vermiculophylla* is likely to have important implications for nutrient cycling and trophic dynamics in areas it invades (Thomsen *et al*. 2009).\r\n
Fisheries: *G. vermiculophylla* is reported to be a problem in fishing industries through fouling of nets (Freshwater *et al*. 2000).

Management Info
Accurate identification of *Gracilaria vermiculophylla* has been problematic in the past, leading to much confusion with similar species. DNA analysis, including rapid DNA barcoding, is now used for accurate identification (Bellorin *et al*. 2004; Saunders 2009).\r\n
Prevention: Movement of oysters is a major vector for the introduction of *G. vermiculophylla* to new locations worldwide. Thus making sure oysters are not transplanted may reduce the incidences of new infestations (M.S. Thomsen, pers. comm. 2011).\r\n
Physical control: Mechanical removal (harvesting) of *G. vermiculophylla* for use in the production of agar and other applications is a potential control method (Sousa et al. 2010; Villanueva et al. 2010).

Pathway
Spread is likely to occur on vectors such as fishing and leisure boats (Nyberg 2007 in Nyberg *et al*. 2009).Fishing gear (Nyberg *et al*. 2009).

Principal source:

Compiler: National Biological Information Infrastructure (NBII) & IUCN/SSC Invasive Species Specialist Group (ISSG)

Review: M. S. Thomsen, Marine Department, National Environmental Research Institute, University of Aarhus.

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ALIEN RANGE

[6] ATLANTIC - NORTHEAST
[1] ATLANTIC - NORTHWEST
[1] CANADA
[1] DENMARK
[1] EUROPE
[1] FRANCE
[1] GERMANY
[1] ITALY
[1] MEXICO
[1] MOROCCO
[1] NETHERLANDS
[1] PACIFIC - NORTHEAST
[1] PORTUGAL
[1] SPAIN
[1] SWEDEN
[6] UNITED STATES

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Managment information

General information

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