

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.



[view this species on IUCN Red List](#)

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 inlets (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).

G. vermiculophylla is able to grow in a wide range of temperatures (5-35 °C), light intensities (20-100 $\mu\text{mol photons m}^{-2} \text{s}^{-1}$) 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 stresses 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).

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 many 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).

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).

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).

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).

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).

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).

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] CANADA

[1] EUROPE

[1] GERMANY

[1] MEXICO

[1] NETHERLANDS

[1] PORTUGAL

[1] SWEDEN

[1] ATLANTIC - NORTHWEST

[1] DENMARK

[1] FRANCE

[1] ITALY

[1] MOROCCO

[1] PACIFIC - NORTHEAST

[1] SPAIN

[6] UNITED STATES

BIBLIOGRAPHY

38 references found for *Gracilaria vermiculophylla*

Management information

General information

[AlgaeBASE, 2010. *Gracilaria vermiculophylla* \(Ohmi\) Papenfuss](#)

Summary: Available from: http://www.algaebase.org/search/species/detail/?species_id=4417 [Accessed 20 August 2010]

[Anon. 2009. Seaweed invasion hurts shrimpers. Associated Press.](#)

Summary: Available from: <http://www.aikenstandard.com/State/m1025-BC-SC-SeaweedInvasion-1stLd-Writethru-07-09-0693> [Accessed 16 March 2011]

Bellorin, Alexis M.; Oliveira, Mariana C.; Oliveira, Eurico C., 2004. *Gracilaria vermiculophylla*: A western Pacific species of Gracilariaceae (Rhodophyta) first recorded from the eastern Pacific. *Phycological Research*. 52(2). June 2004. 69-79.

[Borbara, Ignacio; Javier Cremades; Silvia Calvo; M. Carmen López-Rodríguez & Javier Dosil. 2005. Checklist of the benthic marine and brackish Galician algae \(NW Spain\) *Anales del Jardín Botánico de Madrid* 62\(1\): 69-100](#)

Summary: Available from: <http://rjb.revistas.csic.es/index.php/rjb/article/view/32/30> [Accessed 20 August 2010]

[Council of Europe, 2009. Compilation of National Reports on Activities Related to Biological Diversity of European Islands, Bern Convention Group of Experts on European Islands Biological Diversity. T-PVS/Inf \(2009\) 12](#)

Summary: Available from: http://www.coe.int/t/dg4/cultureheritage/nature/bern/iles/2009TPVSIInf12_en.pdf [Accessed 20 August 2010]

Freshwater, D. Wilson; Greene, Julie K.; Hamner, Rebecca M.; Montgomery, Frank, 2006. Seasonality of the invasive seaweed *Gracilaria vermiculophylla* along the southeastern coast of North Carolina. *Journal of the North Carolina Academy of Science*. 122(2). SUM 2006. 49-55.

Freshwater, D. Wilson; Montgomery, Frank; Greene, Julie K.; Hamner, Rebecca M.; Williams, Melissa; Whitfield, Paula E., 2006. Distribution and identification of an invasive *Gracilaria* species that is hampering commercial fishing operations in southeastern North Carolina, USA. *Biological Invasions*. 8(4). JUN 2006. 631-637.

[Gollasch, Stephan and Stefan Nehring, 2006. National checklist for aquatic alien species in Germany. *Aquatic Invasions \(2006\) Volume 1, Issue 4: 245-269*](#)

Summary: Available from: http://www.aquaticinvasions.ru/2006/AI_2006_1_4_Gollasch_Nehring.pdf [Accessed 18 November 2009]

Gollasch, Stephan; Deniz Haydar; Dan Minchin; Wim J. Wolff and Karsten Reise, 2009. Chapter 29 Introduced Aquatic Species of the North Sea Coasts and Adjacent Brackish Waters. In G. Rilov, J.A. Crooks (eds.) *Biological Invasions in Marine Ecosystems*. 507 *Ecological Studies* 204

Guillemin, M.L.; Akki S.A.; Givernaud, T.; Mouradi, A.; Valero, M. & Destombe, C. 2008. Molecular characterisation and development of rapid molecular methods to identify species of Gracilariaceae from the Atlantic coast of Morocco. *Aquatic Botany* 89: 324-330.

[Hammann, M., B. Buchholz, R. Karez, F. Weinberger, n.d. Impact of the invasive red alga *Gracilaria vermiculophylla* upon native *Fucus* communities in the Baltic Sea](#)

Summary: Available from: http://www.ifm-geomar.de/fileadmin/ifm-geomar/fuer_alle/institut/PR/science/EXOEK-B-Weinberger-s.pdf [Accessed 20 August 2010]

Hoeffle, H.; Thomsen, M.S. & Holmer, M. 2011. Effects of the invasive macroalgae *Gracilaria vermiculophylla* on the seagrass *Zostera marina* under different temperature regimes. *Estuarine, Coastal and Shelf Science*.

Kim, Su Yeon; Weinberger, Florian; Boo, Sung Min. 2010. Genetic data hint at a common donor region for invasive Atlantic and Pacific populations of *Gracilaria vermiculophylla* (Gracilariales, Rhodophyta) *Journal of Phycology*. 46. JUN 2010. 1346-1349.

Martinez-Luscher, Johann; Holmer, Marianne, 2010. Potential effects of the invasive species *Gracilaria vermiculophylla* on *Zostera marina* metabolism and survival. *Marine Environmental Research*. 69(5). JUN 2010. 345-349.

Mathieson, Arthur C.; Pederson, Judith R.; Neefus, Christopher D.; Dawes, Clinton J.; Bray, Troy L., 2008. Multiple assessments of introduced seaweeds in the Northwest Atlantic. *ICES Journal of Marine Science*. 65(5). JUL 2008. 730-741.

Nyberg, Cecilia D.; Thomsen, Mads S.; Wallentinus, Inger, 2009. Flora and fauna associated with the introduced red alga *Gracilaria vermiculophylla*. *European Journal of Phycology*. 44(3). 2009. 395-403.

Nyberg, Cecilia D.; Wallentinus, Inger, 2009. Long-term survival of an introduced red alga in adverse conditions. *Marine Biology Research*. 5(3). 2009. 304-308.

Rueness, Jan, 2005. Life history and molecular sequences of *Gracilaria vermiculophylla* (Gracilariales, Rhodophyta), a new introduction to European waters. *Phycologia*. 44(1). January 2005. 120-128.

- Saunders, Gary W., 2009. Routine DNA barcoding of Canadian Gracilariales (Rhodophyta) reveals the invasive species *Gracilaria vermiculophylla* in British Columbia. *Molecular Ecology Resources*. 9(Suppl. 1). MAY 2009. 140-150.
- Sfriso, Adriano; Maistro, Silvia; Andreoli, Carlo; Moro, Isabella. 2010. First record of *Gracilaria vermiculophylla* (Gracilariales, Rhodophyta) in the Po Delta lagoons, Mediterranean Sea (Italy). *Journal of Phycology*. 46. JUN 2010. 1024-1027.
- Skriptsova, A.V. & Choi, H.G. 2009. Taxonomic revision of *Gracilaria verrucosa* from the Russian Far East based on morphological and molecular data. *Botanica Marina* 52: 331-340.
- [Thomsen, Mads Solgaard, 2010. Experimental evidence for positive effects of invasive seaweed on native invertebrates via habitat-formation in a seagrass bed. *Aquatic Invasions \(2010\) Volume 5, Issue 4*](#)
- Summary:** Available from: http://www.aquaticinvasions.net/2010/AI_2010_5_4_Thomsen_correctedproof.pdf [Accessed 20 August 2010]
- Thomsen, Mads Solgaard; Frederico, Carlos; Gurgel, Deluqui; Fredericq, Suzanne; McGlathery, Karen J., 2006. *Gracilaria vermiculophylla* (Rhodophyta, Gracilariales) in Hog Island Bay, Virginia: A cryptic alien and invasive macroalga and taxonomic correction. *Journal of Phycology*. 42(1). FEB 2006. 139-141.
- Thomsen, Mads Solgaard; McGlathery, Karen J.; Tyler, Anna Christina, 2006. Macroalgal distribution patterns in a shallow, soft-bottom lagoon, with emphasis on the nonnative *Gracilaria vermiculophylla* and *Codium fragile*. *Estuaries & Coasts*. 29(3). JUN 2006. 465-473.
- [Thomsen, Mads S., Peter A. Staehr, Cecilia D. Nyberg, Steen Schwörter, Dorte Krause-Jensen and Brian R. Silliman, 2007c. *Gracilaria vermiculophylla* \(Ohmi\) Papenfuss, 1967 \(Rhodophyta, Gracilariaceae\) in northern Europe, with emphasis on Danish conditions, and what to expect in the future. *Aquatic Invasions \(2007\) Volume 2, Issue 2: 83-94*](#)
- Summary:** Available from: http://www.aquaticinvasions.net/2007/AI_2007_2_2_Thomsen_etal.pdf [Accessed 20 August 2010]
- [Thomsen, Mads S., Thomas Wernberg, Peter A. Støhr, Brian R. Silliman, Alf B. Josefson, Dorte Krause-Jensen and Nils Risgaard-Petersen, 2008. Annual changes in abundance of non-indigenous marine benthos on a very large spatial scale. *Aquatic Invasions \(2008\) Volume 3, Issue 2: 133-140*](#)
- Summary:** Available from: http://www.aquaticinvasions.ru/2008/AI_2008_3_2_Thomsen_etal.pdf [Accessed 20 August 2010]
- Thomsen, Mads S.; Wernberg, Thomas; Staehr, Peter; Krause-Jensen, Dorte; Risgaard-Petersen, Nils; Silliman, Brian R., 2007a. Alien macroalgae in Denmark - a broad-scale national perspective. *Marine Biology Research*. 3(2). 2007. 61-72.
- Thomsen, M.S. & McGlathery, K. 2005. Facilitation of macroalgae by the sedimentary tube forming polychaete *Diopatra cuprea*. *Estuarine, Coastal and Shelf Science* 62: 63-73.
- Thomsen, M.S. & McGlathery, K. 2006b. Effects of accumulations of sediments and drift algae on recruitment of sessile organisms associated with oyster reefs. *Journal of Experimental Marine Biology and Ecology* 328: 22-34.
- Thomsen, M. S.; McGlathery, K. J., 2007. Stress tolerance of the invasive macroalgae *Codium fragile* and *Gracilaria vermiculophylla* in a soft-bottom turbid lagoon. *Biological Invasions*. 9(5). JUL 2007. 499-513.
- Thomsen, M. S.; McGlathery, K. J.; Schwarzschild, A.; Silliman, B. R., 2009. Distribution and ecological role of the non-native macroalga *Gracilaria vermiculophylla* in Virginia salt marshes. *Biological Invasions*. 11(10). DEC 2009. 2303-2316.
- Thomsen, M. S.; Silliman, B. R.; McGlathery, K. J., 2007b. Spatial variation in recruitment of native and invasive sessile species onto oyster reefs in a temperate soft-bottom lagoon. *Estuarine Coastal & Shelf Science*. 72(1-2). MAR 2007. 89-101.
- Thomsen, M.S.; Wernberg, T.; Altieri, A.H.; Tuya, F.; Gulbrandsen, D.; McGlathery, K.J.; Holmer, M. & Silliman, B.R. 2010. Habitat Cascades: The Conceptual Context and Global Relevance of Facilitation Cascades via Habitat Formation and Modification. *Integrative and Comparative Biology* 50: 158-175.
- Tseng, C.K.; Xia, B.M. 1999. On the *Gracilaria* in the western Pacific and southeastern Asia region. *Botanica Marina*. 42. 209-218.
- Villanueva, R. D.; Sousa, A. M. M.; Goncalves, M. P.; Nilsson, M.; Hilliou, L., 2010. Production and properties of agar from the invasive marine alga, *Gracilaria vermiculophylla* (Gracilariales, Rhodophyta). *Journal of Applied Phycology*. 22(2). APR 2010. 211-220.
- Weinberger, Florian; Buchholz, Bjoern; Karez, Rolf; Wahl, Martin, 2008. The invasive red alga *Gracilaria vermiculophylla* in the Baltic Sea: adaptation to brackish water may compensate for light limitation. *Aquatic Biology*. 3(3). 2008. 251-264.
- Williams, Susan L. and Jennifer E. Smith, 2007. A Global Review of the Distribution, Taxonomy, and Impacts of Introduced Seaweeds. *Annu. Rev. Ecol. Syst.* 2007. 38:327-359
- Yakovleva, I. 2008. Antioxidant status of the red alga *Gracilaria vermiculophylla* from the Russian Pacific coast and its susceptibility to high light. *Comparative Biochemistry and Physiology a-Molecular & Integrative Physiology* 151: S18-S18.