Data Collection on Intergeneric Hybrids and Basic Types: ALGAE

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"ALGAE"

Systematics according to AlgaeBase: Guiry MD & Guiry GM (2014) AlgaeBase. World-wide electronic publication. National University of Ireland, Galway. https://www.algaebase.org/browse/taxonomy/?tc=accept&id=4586

Abbreviations:

° = taxa actually not accepted in the rank of a genus, e. g. *Cerasus*° (= *Prunus* p. p.)
10: 50 etc. The numbers behind the names of families etc. refer to extant genera and species
IS = interspecific hybrid. **IG** = intergeneric hybrid. **IST** = intersubtribal hybrid.
IT = intertribal hybrid. **ISF** = intersubfamilial hybrid. **IF** = interfamilial hybrid
EC = embryo culture or ovule culture
SO = somatic hybrid by cell fusion; normally these hybrids are asymmetric
AS = asymmetric hybrids, they do not equally express maternal and paternal features
HY = assumed intergeneric hybridogeneous origin of a taxon
nat. hyb. = natural hybrid **art. hyb.** = artificial hybrid

Colours within the crosses:

Red letters: intergeneric hybrids (incl. former IG).
Gray letters: hybridity unconfirmed or erroneous.
Green letters: notes on tribes, subfamilies etc. involved in the hybridization.

Yellow shaded: Notes concerning basic types.

Class
CHLOROPHYCEAE
green algae = Grünalgen

Only somatic intergeneric hybrids are known so far in green algae = **SO**

References on Chlorophyceae:

Lee SY & Brown RM Jr (1987) Experimental cell fusion with selected Siphonocladalean algal cells. pp. 167–178 in Sowers AE (ed.) Cell fusion. Plenum Press: New York, USA; London, England, UK. Cladophorales (Siphonocladales) **SO**

Guiry MD & Guiry GM (2014) AlgaeBase. World-wide electronic publication. National University of Ireland, Galway. https://www.algaebase.org/browse/taxonomy/?tc=accept&id=4586

Leible MB, Shoeman RL & Schweiger HG (1982) Ribulose 1 5 bis phosphate carboxylase EC-4.1.1.39 - a marker for chloroplast species specifity in *Acetabularia*. Biochimica et Biophysica Acta 699 (1), 60–66. Dasycladales **SO**

Reddy CRK, Iima M & Fujita Y (1992) Induction of fast-growing and morphologically different strains through intergeneric protoplast fusions of *Ulva* and *Enteremorpha*. Chlorophyta. J. Applied Phycology 4 (1), 57–65. Ulvales *Enteromorpha* × *Ulva* **SO**

Ohiwa T (1978) Behavior of cultured fusion products from *Zygnema extenue* and *Spirogyra gracilis* protoplasts. Protoplasma 97 (2–3), 185–200. Zygnematales *Spirogyra* × *Zygnema* **SO** asymmetric

Ohiwa T (1980) Fine structure of degenerating nuclei in intergeneric fusion products from Zygnemataceae protoplasts. Protoplasma 102 (1–2), 77–96. Zygnematales: *Spirogyra* × *Zygnema* **SO** asymmetric

Ohiwa T (1981) Intergeneric fusion of Zygnemataceae protoplasts. Bot. Magazine-Tokyo 94 (1035), 261–272. Zygnematales: *Spirogyra* × *Zygnema* **SO** asymmetric

Class
PHAEOPHYCEAE 265: 1500–2500
brown algae = Braunalgen

4 subclasses, 23 orders
Arrangement according to the order.

Ectocarpales 6 families (subclass Fucophycidae)

Ectocarpales: Ectocapaceae 4–7

Montecinos AE et al. (2017) Hybridization between two cryptic filamentous brown seaweeds along the shore: analysing pre- and postzygotic barriers in populations of individuals with varying ploidy levels. Mol. Ecol. 26 (13), 3497–3512. doi: 10.1111/mec.14098. *Ectocarpus* **IS**

Fucales 9 families, 522 species (subclass Fucophycidae)

Fucales: Fucaceae 6: 23

IS: *Fucus* (Williams 1899, Scott & Hardy 1994, Coyer et al. 2002)

Ascophyllum 1, Fucus 15, Hesperophycus 1, Pelvetia 1, Pelvetiopsis 2, Silvetia 3

Fucus vesiculosus × *Ascophyllum nodosum* Williams 1899 (nat. hyb.), Kim et al. 1997 (art. hyb.; only up to embryos with a few cells)

Fucales: Sargassaceae 30: 541

Carpophyllum 6, Halidrys 2, Sargassum 358, ...

IS: *Carpophyllum angustifolium* × *C. maschalocarpum* Hodge et al. 2010

References on Fucales:

Coyer JA et al. (2002) Hybridization of the marine seaweeds, *Fucus serratus* and *Fucus evanescens* (Heterokontophyta: Phaeophyceae) in a 100-year-old zone of secondary contact. Proc. R. Soc. Lond. Ser. B-Biol. Sci. 269, 1829–1834.

Hodge FJ et al. (2010) Hybridization between the endemic brown algae *Carpophyllum maschalocarpum* and *Carpophyllum angustifolium* (Fucales): Genetic and morphological evidence (2010) Phycological Research. https://doi.org/10.1111/j.1440-1835.2010.00583.x

Kim KY, O'Leary SJ & Garbary DJ (1997) Artificial hybridization between *Ascophyllum nodosum* and *Fucus vesiculosus* (Phaeophyceae) from Nova Scotia, Canada. Canad. J. Bot. 75, 1133–1136.

Scott GW & Hardy FG (1994) Observations of the occurence of hybrids between 2 sympatric species of fucoid algae. Cryptogam. Algol. 15, 297–305. *Fucus* **IS**

Williams KL (1899) New *Fucus* hybrids. Ann. Bot. (London) 13, 187–188. **IS**

Laminariales 38: 143 (subclass Fucophycidae)

7 families (The circumscription has recently been changed, see AlgaeBase 2025):

Agaraceae (= Costariaceae) 5: 11 *Agarum 4, Costaria 2, Dictyoneurum* (incl. *Dictyoneuropsis*) *2, Neoagarum 2, Thalassiophyllum 1*

Akkesiphycaceae 1: 1 *Akkesiphycus lubricum*

Alariaceae 7: 24 *Alaria 17, Eualaria 1, Lessoniopsis 1 littoralis, Orgya 1, Pleurophycus 1, Undaria 2, Undariella 1.*
(Arthrothamnaceae see Laminariaceae)
Aureophycaceae 1: 1 *Aureophycus 1*
Chordaceae 1: 6 *Chorda 6*
Laminariaceae 15: 65 see below
Lessoniaceae 5: 32 *Ecklonia 6, Eckloniopsis 1, Egregia 1, Eisenia 2, Lessonia 10,*
incertae sedis 3: 3

Attention: Druehl et al. 2005 write that in many putative hybrids of Laminariales only the DNA of one parental genome could be detected; exception: *Alaria* × *Lessoniopsis*.

Probably basic type **order Laminariales**. The order is well defined, but the subdivision is matter of debate. The order includes 38 genera and 143 species in 7 families. Of these, Agaraceae, Laminariaceae and Lessoniaceae are connected by interfamilial hybridization, thus connecting 30 genera and 108 species.

Laminariales: Agaraceae (= Costariaceae) 5: 11

Agarum 4, Costaria 2, Dictyoneurum (incl. *Dictyoneuropsis*) *2, Neoagarum 2, Thalassiophyllum 1.*

Dictyoneuropsis° (= *Dictyoneurum*) *reticulatum* × *Dictyoneurum californicum* **IS** Lewis & Neushul 1995 → now interspecific hybrid
Dictyoneuropsis° (= *Dictyoneurum*) *reticulatum* × *Pelagophycus porra* **IF** Agaraceaee × Laminariaceae = (art. hyb.) Coyer et al. 1992
Dictyoneurum californicum × *Macrocystis* **IF** Agaraceae × Laminariaceae (art. hyb.) Lewis & Neushul 1995

Laminariales: Alariaceae 7: 24

Alaria 18, Eualaria 1, Lessoniopsis 1 (formerly Lessoniaceae), *Orgyia 1, Pleurophycus 1, Pterygophira 1, Undaria* (incl. *Undariopsis) 2, Undariella 1*

Alaria + *Laminaria* **IF**, not a sexual hybrid Tokida et al. 1958
Alaria × *Lessoniopsis* Liptack & Druehl 2001 (*A.marginata* × *L. littoralis*) (*Lessioniopsis* was formerly placed in the Lessoniaceae, and the hybrid was at that time classified as interfamilial) true hybrid
Undaria pinnatifida × *Undariopsis*° (= *Undaria*) *peterseniana* **IS** (gametophytes) Hwang et al. 2012

Laminariales: Laminariaceae 15: 65

Arthrothamnus 2 (sometimes separated as own family Arthrothamnaceae), *Cymathere 2, Hedophyllum 5, Kjellmaniella 1, Laminaria 29, Macrocystis 4, Nereocyctis 1, Pelagophycus 1, Polyschidia 1, Postelsia 1, Postesiopsis 1, Pseudolessonia 1, Saccharina 14, Strptophyöpsis 1, Tauya 1.*

IS: *Macrocystis* Lewis et al. 1986, Lewis & Neushul 1994; *Saccharina* Li et al. 2016

Dictyoneurum californicum × Macrocystis **IF** Agaraceae × Laminariaceae (art. hyb.) Lewis & Neushul 1995

Dictyoneurum (Dictyoneuropsis°) reticulatum × Pelagophycus porra **IF** Agaraceaee × Laminariaceae interfamilial (art. hyb.) Coyer et al. 1992

Laminaria digitata, saccharina × Saccorhiza polyschides **probably erroneous** Cosson 1987 (*Saccorhiza* is now placed in Phyllariaceae, order Tilopteridales)

Macrocystis pyrifera × Nereocystis leutkeana Sanbonsuga & Neushul 1978, 1979, en.wikipedia 2025

Macrocystis × Lessonia **IF** Laminariaceae × Lessoniaceae Murua et al. 2020 (*M. pyrifera × L. spicata*, nat. hyb.)

Macrocystis × Pelagophycus porra (nat. hyb.) Neushul 1962, Coyer & Zaugg-Haglund 1982, Coyer et al. 1992, Lewis & Neushul 1995

Laminariales: Lessoniaceae 5: 29

Ecklonia 6, Eckloniopsis 1 radicosa, Egregia 2, Eisenia 2 bicyclis, nipponica, Lessonia 11

IS: *Ecklonia* Shingo et al. 2021

Ecklonia cava, kurome × Eckloniopsis radicosa Migita 1985, Shingo et al. 2021 (*E. cava × E. radicosa*)

Ecklonia cava, kurome, stolonifera × Eisenia bicyclis Migita 1984

Eckloniopsis radicosa × Eisenia nipponica Shingo et al. 2021

Macrocystis × Lessonia **IF** Laminariaceae × Lessoniaceae Murua et al. 2020 (*M. pyrifera × L. spicata*, nat. hyb.)

References on Laminariales:

Cosson J (1987) Growth of sporophytes resulting from interspecific and intergeneric hybridization in Laminariales. [French] Cryptogamie Algologie 8, 61–72.

Coyer JA, Engle JM & Zimmerman RC (1992) Discovery of a fertile *Pelagophycus × Macrocystis* (Phaeophyta) putative hybrid and subsequent production of F_2 sporophytes in the laboratory. J. Phycol. 28, 127–130.

Coyer JA & Zaugg-Haglund AC (1982) A demographic study of the elk kelp, *Pelagophycus porra* (Laminariales, Lessoniaceae), with notes on *Pelagophycus × Macrocystis* hybrids. Phycologia 21, 399–407.

Druehl LD, Collins JD, Lane CE & Saunders GW (2005) An evaluation of methods used to assess intergeneric hybridization in kelp using Pacific Laminariales (Phaeophyceae). J. Phycol. 41 (2), 250–262.

Hwang EK, Gong YG & Park CS (2012) Cultivation of a hybrid of free-living gametophytes between *Undariopsis petersenianа* and *Undaria pinnatifida*: morphological aspects and cultivation period. J. Applied Phycology 24 (3), Special Issue SI, 401–408.

Kim KY, O'Leary SJ & Garbary DJ (1997) Artificial hybridization between *Ascophyllum nodosum* and *Fucus vesiculosus* (Phaeophyceae) from Nova Scotia, Canada. Canad. J. Bot. 75, 1133–1136.

Lane EC, Mayes C, Druehl D & Saunders QW (2006) A multi-gene molecular investigation of the kelp (Laminariales, Phaeophyceae) supports substantial taxonomic re-organization. J. Phycol. 42, 493–512.

Lewis RJ et al. (1986) Interspecific hybridization of the species of *Macrocystis* in California. Aquaculture 57, 203–210. https://www.sciencedirect.com/science/article/abs/pii/0044848686901985

Lewis RJ & Neusul M (1994) Northern ans southern hemisphere hybrids of *Macrocystis* (Phaeophyceae). J. Phycol. 30, 346-353. https://doi.org/10.1111/j.0022-3646.1994.00346.x

Lewis RJ & Neushul M (1995) Intergeneric hybridization among five genera of the family Lessoniaceae (Phaeophyceae) and evidence for polyploidy in a fertile *Pelagophycus* × *Macrocystis* hybrid. J. Phycol. 31 (6), 1012–1017. http://bio.research.ucsc.edu/people/carr/publications/Nereo-lit/Nereo%20online%20PDFs/Lewis%201995.pdf

Li X et al. 2016) Breeding of an intraspecific kelp hybrid Dongfang no. 6 (*Saccharina japonica*, Phaeophyceae, Laminariales) for suitable processing products and evaluation of its culture performance. J. Appl. Phycol 28, 439–447 . https://doi.org/10.1007/s10811-015-0562-0

Liptack MK & Druehl LD (2000) Molecular evidence for an interfamilial laminarialean cross. Europ. J. Phycology 35, 135–142. *Alaria* × *Lessoniopsis*

Migita S (1984) Intergeneric and interspecific hybridization between four species of *Eisenia* and *Ecklonia*. [Japanese] Bull. Fac. Fish., Nagasaki Univ. 56, 15–20.

Migita S (1985) Life history and culture experiment of *Eckloniopsis radicosa*, Phaeophyceae Laminariaceae. [Japanese] Bull. Fac. Fish., Nagasaki Univ. 58, 105–111.

Murua P et al. (2020) Morphological, genotypic and metabolomic signatures confirm interfamilial hybridization between the ubiquitous kelps *Macrocystis* (Arthrothamnaceae) and *Lessonia* (Lessoniaceae). Scientific Reports 10 (1). Attention: *Macrocystis* is now part of Laminariaceae as defined today

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Sanbonsuga Y & Neushul M (1978) Hybridization of *Macrocystis* (Phaeophyta) with other float bearing kelps. J. Phycology 14 (2), 214–224. *Macrocystis* × *Pelagophycus*

Sanbonsuga Y & Neushul M (1979) Cultivation and hybridization of giant kelps (Phaeophyceae]. Proc. Int. Seaweed Symp. 9, 91–96.

Saunders GW & Druehl LD (1993) Revision of the kelp family Alariaceae and the taxonomic affinities of *Lessoniopsis* Reinke (Laminariales, Phaeophyta). Fourteenth Internat. Seaweed Symposium, 689–697.

Shingo A et al. (2021) Molecular evidence for naturally occurring intra- and inter-generic hybridization in the genus *Ecklonia* (Laminariales, Phaeophyceae). Phycologia 60 (2). https://doi.org/10.1080/00318884.2021.1885246

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Class „Rhodophyceae“

References on Rhodophyceae:

Mizukami Y, Okauchi M, Kito H, Ishimoto SI, Ishida T & Fuseya M (1995) Culture and development of electricaly fused protoplasts from red marine-algae, *Porphyra yeozensis* and *P. suborbiculata*. Aquaculture 132, 361–367. *Porphyra* interspecific, somatic hybrid

Mine I & Tatewaki M (1993) Life history of *Halosaccion yendoi* I. K. Lee (Palmariales Rhodophyta) and interspecific spermatium inoculation wth *Palmaria* sp. from Hokkaido Japan. Japanese J. Phycology 41 (2), 123–130. Palmariales *Halosaccion* × *Palmaria* unsuccessful