Phytotaxa 158 (2): 133–153
www.mapress.com/phytotaxa/

Article

ISSN 1179-3155 (print edition)
PHYTOTAXA
ISSN 1179-3163 (online edition)

http://dx.doi.org/10.11646/phytotaxa.158.2.2

Pyropia orbicularis sp. nov. (Rhodophyta, Bangiaceae) based on a population previously known as *Porphyra columbina* from the central coast of Chile

MARÍA ELIANA RAMÍREZ[1], LORETTO CONTRERAS-PORCIA[2,*], MARIE-LAURE GUILLEMIN[3], JULIET BRODIE[4], CATALINA VALDIVIA[2], MARÍA ROSA FLORES-MOLINA[5], ALEJANDRA NÚÑEZ[2], CRISTIAN BULBOA CONTADOR[6] & CARLOS LOVAZZANO[2]

[1]*Museo Nacional de Historia Natural, Área Botánica, Casilla 787, Santiago, Chile*
[2]*Departamento de Ecología y Biodiversidad, Facultad de Ecología y Recursos Naturales, Universidad Andres Bello, República 470, Santiago, Chile*
[3]*Instituto de Ciencias Ambientales y Evolutivas, Universidad Austral de Chile, Casilla 567 Valdivia, Chile*
[4]*Natural History Museum, Department of Life Sciences, Cromwell Road, London SW7 5BD, UK*
[5]*Instituto de Ciencias Marinas y Limnológicas, Facultad de Ciencias, Universidad Austral de Chile, Casilla 567, Valdivia, Chile*
[6]*Ingeniería en Acuicultura, Facultad de Ecología y Recursos Naturales, Universidad Andres Bello, República 470, 8370251 Santiago, Chile*
** Corresponding author: Loretto Contreras-Porcia. lorettocontreras@unab.cl*

Abstract

A new species of bladed Bangiales, *Pyropia orbicularis sp. nov.*, has been described for the first time from the central coast of Chile based on morphology and molecular analyses. The new species was incorrectly known previously as *Porphyra columbina* (now *Pyropia columbina*), and it can be distinguished from other species of *Pyropia* through a range of morphological characteristics, including the shape, texture and colour of the thallus, and the arrangement of the reproductive structures on the foliose thalli. Molecular phylogenies based on both the mitochondrial COI and plastid *rbc*L gene regions enable this species to be distinguished from other species within *Pyropia*. *P. orbicularis sp. nov.* belongs to a well-supported clade of *Pyropia* from the southern oceans that include specimens from the South Pacific (North, South, Chatham, Stewart, Auckland, and Campbell Island, New Zealand, New South Wales, and Macquarie Island, Australia) including *P. columbina* and *P. plicata*. Within this clade, the highest sequence identity was observed between *Pyropia orbicularis sp. nov.* and *Pyropia* sp. FIC from the Falkland Islands.

Key words: Bangiales, COI, Morphology, *Porphyra*, *Pyropia, rbc*L, South Pacific

Introduction

In a recent worldwide study of Bangiales (Rhodophyta) based on molecular analysis using nuclear SSU rRNA and chloroplast *rbc*L regions, Sutherland *et al*. (2011) recognized the existence of fifteen genera of which seven are filamentous and eight foliose. Of the foliose genera, *Porphyra* sensu lato, which has representatives in all seas, has undergone many changes in its classification in the last decade (e.g. Anilkumar & Rao 2005, Yoshida *et al*. 2005, Kikuchi *et al*. 2010, Nelson & Broom 2010, Kucera & Saunders 2012, Mateo-Cid *et al*. 2012, Nelson 2013).

The economic and cultural importance of *Porphyra* sensu lato is widely known and appreciated in Asian countries, notably Japan and China, North and South America, Australia and New Zealand (Aguilar-Rosas *et al*. 1998, Jian & Chen 2001, He & Yarish 2006, Blouin *et al*. 2011) and has been one of the red algal genera with the largest production and marketing worldwide. In Chile, species of the genus *Pyropia* and *Porphyra*, specifically the taxon known as *Porphyra columbina* Montagne (now *Pyropia columbina* (Montagne) W.A Nelson), are commonly called “luche” or “luchi” and have been harvested and consumed since the late Pleistocene by coastal populations in the country (Seguel & Santelices 1988, Buschmann *et al*. 2001, González & Santelices 2003, Dillehay *et al.* 2008). It is reported that the species under the name *Porphyra columbina* is highly seasonal and grows abundantly

Accepted by Saúl Blanco Lanza: 28 Dec. 2013; published: 3 Feb. 2014

References

Aguilar-Rosas, R., Espinoza-Ávalos, J. & Aguilar-Rosas, L.E. (1998) Uso de las algas marinas en México. *Ciencia y Desarrollo* 24: 65–73.

Anilkumar, C. & Rao, P.S.N. (2005) A new species of *Porphyra* (Rhodophyta, Bangiales) from the Malvan coast of Maharashtra (India). *Feddes Repertorium* 116: 222–225. http://dx.doi.org/10.1002/fedr.200411069

Blouin, N.A., Brodie, J.A., Grossman, A.C., Xu, P. & Brawley, S.H. (2011) *Porphyra*: a marine crop shaped by stress. *Trends in Plant Science* 16: 29–37. http://dx.doi.org/10.1016/j.tplants.2010.10.004

Brodie, J., Bartsch, I., Neefus, C., Orfanidis, S., Bray, T. & Mathieson, A.C. (2007) New insights into the cryptic diversity of the North Atlantic-Mediterranean '*Porphyra leucosticta'* complex: *P. olivii* sp. *nov.* and *P. rosengurttii* (Bangiales, Rhodophyta). *European Journal of Phycology* 42: 3–28. http://dx.doi.org/10.1080/09670260601043946

Broom, J.E., Jones, W.A., Hill, D.F., Knight, G.A. & Nelson. W.A. (1999) Species recognition in New Zealand *Porphyra* using 18S rDNA sequencing. *Journal of Applied Phycology* 11: 421–428. http://dx.doi.org/10.1023/A:1008162825908

Broom, J.E.S., Farr, T.J. & Nelson, W.A. (2004) Phylogeny of the *Bangia* flora of New Zealand suggests a southern origin for *Porphyra* and *Bangia* (Bangiales, Rhodophyta). *Molecular Phylogenetics and Evolution* 31: 1197–1207. http://dx.doi.org/10.1016/j.ympev.2003.10.015

Broom, J.E.S., Nelson, W.A., Farr, T.J., Phillips, L.E. & Clayton, M. (2010) Relationships of the *Porphyra* (Bangiales, Rhodophyta) flora of the Falkland Islands: a molecular survey using *rbc*L and nSSU sequence data. *Australian Systematic Botany* 23: 27–37. http://dx.doi.org/10.1071/SB09033

Buschmann, A.H., Correa. J.A., Westermeier, R., Hernández-González, M. & Norambuena, R. (2001) Red algal farming in Chile: a review. *Aquaculture* 194: 203–220. http://dx.doi.org/10.1016/S0044-8486(00)00518-4

Contreras-Porcia, L., Thomas, D., Flores, V. & Correa, J.A. (2011) Tolerance to oxidative stress induced by desiccation in *Porphyra columbina* (Bangiales, Rhodophyta). *Journal of Experimental Botany* 62: 1815–1829. http://dx.doi.org/10.1093/jxb/erq364

Contreras-Porcia, L., Callejas, S., Thomas, D., Sordet, C., Pohnert, G., Contreras, A., Lafuente, A., Flores-Molina, M.R. & Correa, J.A. (2012) Seaweeds early development: detrimental effects of desiccation and attenuation by algal extracts. *Planta* 235: 337–348. http://dx.doi.org/10.1007/s00425-011-1512-y

Contreras-Porcia, L., López-Cristoffanini, C., Lovazzano, C., Flores-Molina, M.R., Thomas, D., Núñez, A., Fierro, C., Guajardo, E., Correa, J.A., Kube, M. & Reinhardt, R. (2013) Differential gene expression in *Pyropia columbina* (Bangiales, Rhodophyta) under natural hydration and desiccation conditions. *Latin American Journal of Aquatic Research* 41: 933–958. http://dx.doi.org/103856/vol41-issue5-fulltext-13

Dillehay, T. D., Ramírez, C., Pino, M.B., Collins, M., Rossen, J. & Pino-Navarro, J.D. (2008) Monte Verde: Seaweed, food, medicine and the peopling of the South America. *Science* 320: 784–786. http://dx.doi.org/10.1126/science.1156533

Faugeron, S., Valero, M., Destombe, C., Martínez, E.A. & Correa, J.A. (2001) Hierarchical spatial structure and discriminant analysis of genetic diversity in the red alga *Mazzaella laminarioides* (Gigartinales, Rhodophyta). *Journal of Phycology* 37: 705–716. http://dx.doi.org/10.1046/j.1529-8817.2001.01072.x

Flores-Molina, M.R., Thomas, D., Lovazzano, C., Núñez, A., Zapata, J., Kumar, M., Correa, J.A. & Contreras-Porcia, L. (2014) Desiccation stress in intertidal seaweeds: Effects on morphology, antioxidant responses and photosynthetic performance. *Aquatic Botany* 113: 90–99. http://dx.doi.org/10.1016/j.aquabot.2013.11.004.

Fredericq, S. & Lopez-Bautista, J. (2002) Characterization and phylogenetic position of the red alga *Besa papillaeformis* Setchell: an example of progenetic heterochrony? *Constancea* 83: 1–12.

González, A. & Santelices, B. (2003) A re-examination of the potential use of central Chilean *Porphyra* (Bangiales, Rhodophyta) for human consumption. *In*: Chapman A.R.O., Anderson R.J., Vreeland V.J. & Davidson I.R. (eds.) *Proceedings of the 17th International Seaweed Symposium*. Oxford University Press, Oxford, pp. 249–255.

He, P. & Yarish, C. (2006) The developmental regulation of mass cultures of free-living conchocelis for commercial net seeding of *Porphyra leucosticta* from Northeast America. *Aquaculture* 257: 373–381. http://dx.doi.org/10.1016/j.aquaculture.2006.03.017

Hoffmann, A. & Santelices, B. (1997) *Flora marina de Chile Central*. Ediciones Universidad Católica de Chile, Santiago, 434 pp.

Hommersand, M.H., Fredericq, S. & Freshwater, D.W. (1994) Phylogenetic systematics and biogeography of the Gigartinaceae (Gigartinales, Rhodophyta) based on sequence analysis of rbcL. *Botanica Marina* 37: 193–203.

http://dx.doi.org/10.1515/botm.1994.37.3193
Huelsenbeck, J.P & Ronquist, F. (2001) MRBAYES: Bayesian inference of phylogenetic trees. *Bioinformatics* 17: 754–755. http://dx.doi.org/10.1093/bioinformatics/17.8.754
Jian, J. & Chen, J. (2001) *Sea Farming and Sea Ranching in China*. FAO Fisheries Technical Paper No. 418, FAO, Rome, Italy, 71 pp.
Jobb, G., von Haeseler, A. & Strimmer, K. (2004) TREEFINDER: a powerful graphical analysis environment for molecular phylogenetics. *BioMed Central Evolutionary Biology* 4: 18. http://dx.doi.org/10.1186/1471-2148-4-18
Kikuchi, N., Arai, S., Yoshida, G., Shin, J.-A., Broom, J.E., Nelson, W.A. & Miyata, M. (2010) *Porphyra migitae* sp. nov. (Bangiales, Rhodophyta) from Japan. *Phycologia* 49: 345–354. http://dx.doi.org/10.2216/09-82.1
Kucera, H. & Saunders, G.W. (2012) A survey of Bangiales (Rhodophyta) based on multiple molecular markers reveals cryptic diversity. *Journal of Phycology* 48: 869–882. http://dx.doi.org/10.1111/j.1529-8817.2012.01193.x
Lindstrom, S.C. (2008) Cryptic diversity, biogeography and genetic variation in Northeast Pacific species of *Porphyra* sensu lato (Bangiales, Rhodophyta). *Journal of Applied Phycology* 20: 951–962. http://dx.doi.org/10.1007/s10811-008-9313-9
López-Cristoffanini, C., Tellier, F., Otaíza, R., Correa, J.A. & Contreras-Porcia, L. (2013) Tolerance to air exposure: a feature driving the latitudinal distribution of two sibling kelp species. *Botanica Marina* 56: 431–440. http://dx.doi.org/10.1016/j.aquabot.2013.11.004
Mateo-Cid, L.E., Mendoza-González, A.C., Díaz-Larrea, J., Sentíes, A., Pedroche, F.F. & Sánchez, J.D. (2012) A new species of *Pyropia* (Rhodophyta, Bangiaceae), from the Pacific coast of Mexico, based on morphological and molecular evidence. *Phytotaxa* 54: 1–12.
McCarthy, C. (1997) *Chromas, Version 1.41.* Griffith University, Brisbane.
Montagne, C. (1842) *Prodromus generum specierumque phycearum novarum, in itinere ad polum Antarcticum Regis Ludovici Philippi Jussu ab illustri Dumont d'Urville peracto collectarum*. Gide, Paris, 16 pp.
Nelson, W.A. (2013) *Pyropia plicata* sp. nov. (Bangiales, Rhodophyta): naming a common intertidal alga from New Zealand. *PhytoKeys* 21: 17–28. http://dx.doi.org/10.3897/phytokeys.21.4614
Nelson, W.A. & Broom, J.E.S (2010) The identity of *Porphyra columbina* (Bangiales, Rhodophyta) originally described from the New Zealand subantarctic islands. *Australian Systematic Botany* 23: 16–26. http://dx.doi.org/10.1071/SB09032
Ramírez., M.E. & Santelices, B. (1991) Catálogo de las algas marinas bentónicas de la costa temperada del Pacífico de Sudamérica. *Monografías Biológicas* 5: 1–437.
Saunders, G.W. (1993) Gel purification of red algal genomic DNA: an inexpensive and rapid method for the isolation of polymerase-chain reaction-friendly DNA. *Journal of Phycology* 29: 251–254. http://dx.doi.org/10.1111/j.0022-3646.1993.00251.x
Saunders, G.W. (2005) Applying DNA barcoding to red macroalgae: a preliminary appraisal holds promise for future applications. *Philosophical Transactions of the Royal Society B* 360: 1879–1888. http://dx.doi.org/10.1098/rstb.2005.1719
Seguel, M. & Santelices, B. (1988) Cultivo masivo de la fase conchocelis de luche, *Porphyra columbina* Montagne (Rhodophyta, Bangiaceae). *Gayana Botanica* 45: 317–327.
Sutherland, J.E., Lindstrom, S.C., Nelson, W.A., Brodie, J., Lynch, M.D.J., Hwang, M.S., Choi, H.G., Miyata, M., Kikuchi, N., Oliveira, M.C., Farr, T., Neefus, C., Mols-Mortensen, A., Milstein, D. & Müller, K.M. (2011) A new look at an ancient order: generic revision of the Bangiales (Rhodophyta). *Journal of Phycology* 47: 1131–1151. http://dx.doi.org/10.1111/j.1529-8817.2011.01052.x
Tamura, K., Peterson, D., Peterson, N., Stecher, G., Nei, M. & Kumar, S. (2011) MEGA5: Molecular Evolutionary Genetics Analysis using Maximum Likelihood, Evolutionary Distance, and Maximum Parsimony Methods. *Molecular Biology and Evolution* 28: 2731–2739. http://dx.doi.org/10.1093/molbev/msr121
Yoshida, T., Shimada, S., Yoshinaga, K. & Nakajima, Y. (2005) Checklist of marine algae of Japan. *Japanese Journal of Phycology* 53: 179–228.