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Full Length Article

Growth rate and light-based non-cryogenic preservation method for *Symbiodinium* sp. Clade A isolated from *Platygyra daedalea* in the Arabian gulf

Ons Kefi^{a,b}, Sami Sayadi^c, Sandy K. Sawh^d, Radhouane Ben Hamadou^e, Fatma Karray^f, Pedro Range^g, Mohamed Nejib Daly Yahia^{d,*}

^a Research Group in Oceanography and Plankton Ecology, Tunisian National Institute of Agronomy (INAT), 43 Avenue Charles Nicolle, Tunis, 1082, Tunisia
^b IRESA- Carthage University, LR18ES41 (Tunis El Manar University), Tunisia
^c Center for Sustainable Development, College of Arts and Sciences, Qatar University, PO Box 2713, Doha, Qatar
^d Environmental Sciences Program, Department of Biological and Environmental Sciences, College of Arts and Sciences, Qatar University, PO Box 2713, Doha, Qatar
^e Earthina Center for a Sustainable Future, Qatar Foundation, PO Box 5825, Doha, Qatar
^f Laboratory of Environmental Bioprocesses, Centre of Biotechnology of Sfax, University of Sfax, PO Box 1177, 3018, Sfax, Tunisia
^g Environmental Science Center, Qatar University, PO Box 2713, Doha, Qatar

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ABSTRACT

Coral reefs in the Arabian Gulf are exposed to extreme temperatures and salinities, resulting in some of the highest coral bleaching and mortality rates worldwide. Preserving heat-tolerant Symbiodiniaceae is therefore an urgent priority to sustain coral resilience and support emerging restoration and assisted-evolution strategies. Existing cryopreservation protocols for Symbiodinium are technically demanding, costly, and may compromise long-term cell viability, limiting their applicability in resource-constrained settings. This study reports the molecular taxonomic identification, growth characteristics, and long-term performance of a *Symbiodinium* sp. Clade A strain isolated from the brain coral *Platygyra daedalea* under a simple, non-cryogenic preservation regime. Under controlled laboratory conditions (40 psu, 26 °C, 130 $\mu\text{mol photons m}^{-2} \text{s}^{-1}$, 12:12 h light:dark), the strain exhibited a high maximum growth rate of $0.50 \pm 0.03 \text{ day}^{-1}$, indicating strong physiological performance in the Arabian (Persian) Gulf conditions. To evaluate a non-cryogenic preservation approach, cultures were stored under continuous light or complete darkness for 1, 3, and 6 months. Light-based storage consistently supported

1. Introduction

Global climate change is accelerating coral reef degradation through more frequent and severe thermal anomalies, mass bleaching events, and associated biodiversity loss (Hughes et al., 2017; Sully et al., 2019). In contrast to other regions where bleaching is often associated with

acute thermal events, Arabian Gulf corals experience long-term physiological exposure to extreme baselines, making this region suitable for identifying highly resilient coral-symbiont partnerships (Hume et al., 2018; Paparella et al., 2019). Reefs in this region survive under elevated summer sea surface temperatures exceeding 34–36 °C and salinities frequently above 40 psu, conditions that surpass those typically

* Corresponding author.

E-mail addresses: onskefidaly@gmail.com (O. Kefi), ssayadi@qu.edu.qa (S. Sayadi), sandy@qu.edu.qa (S.K. Sawh), rbenhamadou@qf.org.qa (R. Ben Hamadou), fatma.karray@cbs.nrnt.tn (F. Karray), Prange@qu.edu.qa (P. Range), nejibdaly@qu.edu.qa (M.N. Daly Yahia).

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- Downs, C.A., McDougall, K.E., Woodley, C.M., Fauth, J.E., Richmond, R.H., Kushmaro, A., et al., 2013. Heat-stress and light-stress induce different cellular pathologies in the symbiotic dinoflagellate during coral bleaching. *PLoS One* 8, e77173. <https://doi.org/10.1371/journal.pone.0077173>.
- Dungan, A.M., Hartman, L.M., Blackall, L.L., van Oppen, M.J.H., 2022. Exploring microbiome engineering as a strategy for improved thermal tolerance in *Exaiptasia diaphana*. *J. Appl. Microbiol.* 132, 2940–2956. <https://doi.org/10.1111/jam.15465>.
- Eckert, R.J., Reaume, A.M., Sturm, A.B., Studivan, M.S., Voss, J.D., 2020. Depth influences symbiodiniaceae associations among *Montastraea cavernosa* corals on the Belize barrier reef. *Front. Microbiol.* 11, 518. <https://doi.org/10.3389/fmicb.2020.00518>.
- Edgar, R.C., 2004. MUSCLE: multiple sequence alignment with high accuracy and high throughput. *Nucleic Acids Res.* 32, 1792–1797. <https://doi.org/10.1093/nar/gkh340>.
- Fang, J.K.H., Schönberg, C.H.L., Hoegh-Guldberg, O., Dove, S., 2017. Symbiotic plasticity of symbiodinium in a common excavating sponge. *Mar. Biol.* 164, 104. <https://doi.org/10.1007/s00227-017-3088-y>.
- Felsenstein, J., 1985. Confidence limits on phylogenies: an approach using the bootstrap. *Evolution* 39, 783–791. <https://doi.org/10.1111/j.1558-5646.1985.tb00420.x>.
- Fisher, P.L., Malme, M.K., Dove, S., 2012. The effect of temperature stress on coral-symbiodinium associations containing distinct symbiont types. *Coral Reefs* 31, 473–485. <https://doi.org/10.1007/s00338-011-0853-0>.
- Frommlet, J.C., Wangpraseurt, D., Sousa, M.L., Guimarães, B., Medeiros da Silva, M., Kühl, M., et al., 2018. Symbiodinium-induced formation of microbialites: Voolstra, C.R., et al., 2018. Systematic revision of symbiodiniaceae highlights the antiquity and diversity of coral endosymbionts. *Curr. Biol.* 28, 2570–2580. <https://doi.org/10.1016/j.cub.2018.07.008>.
- Liddell, W.D., Ohlhorst, S.L., 1986. Changes in benthic community composition following the mass mortality of *Diadema* at Jamaica. *J. Exp. Mar. Biol. Ecol.* 95, 271–278. [https://doi.org/10.1016/0022-0981\(86\)90259-5](https://doi.org/10.1016/0022-0981(86)90259-5).
- Lin, C., Thongpoo, P., Juri, C., Wang, L.H., Meng, P.J., Kuo, F.W., et al., 2019. Cryopreservation of a thermotolerant lineage of the coral symbiont *symbiodinium*. *Biopreserv. Biobanking* 17, 487–496. <https://doi.org/10.1089/bio.2019.0019>.
- Magañon, H., Flot, J.F., Baudry, E., 2007. Molecular identification of symbiotic dinoflagellates in Pacific corals in the genus *Pocillopora*. *Coral Reefs* 26, 551–558. <https://doi.org/10.1007/s00338-007-0215-0>.
- Mahmoud, H.M., Al-Sarraf, M., 2016. Molecular phylogeny and community fingerprinting of coral-associated *symbiodinium* north of the Arabian Gulf. *Mar. Pollut. Bull.* 108, 94–104. <https://doi.org/10.1016/j.marpolbul.2016.04.053>.
- Mashini, A.G., Parsa, S., Mostafavi, P.G., 2015. Comparison of symbiodinium populations in corals from subtidal region and tidal pools of northern coasts of Hengam Island, Iran. *J. Exp. Mar. Biol. Ecol.* 473, 202–206. <https://doi.org/10.1016/j.jembe.2015.09.007>.
- Medlin, L., Elwood, H.J., Stickel, S., Sogin, M.L., 1988. The characterization of enzymatically amplified eukaryotic 16S-like rRNA-coding regions. *Gene* 71, 491–499. [https://doi.org/10.1016/0378-1119\(88\)90066-2](https://doi.org/10.1016/0378-1119(88)90066-2).