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1 Research review paper

Q13 Thermophiles in the genomic era: Biodiversity, science, and applications

Q14 M. Sofía Urbieta ^a, Edgardo R. Donati ^a, Kok-Gan Chan ^b, Saleha Shahar ^c, Lee Li Sin ^c, Kian Mau Goh ^{c,*}4 ^a CINDEFI (CCT La Plata-CONICET, UNLP), Facultad de Ciencias Exactas, Universidad Nacional de La Plata, Calle 47 y 115, 1900 La Plata, Argentina5 ^b Division of Genetics and Molecular Biology, Institute of Biological Sciences, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia6 ^c Faculty of Biosciences and Medical Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia

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A B S T R A C T

Thermophiles and hyperthermophiles are present in various regions of the Earth, including volcanic environments, hot springs, mud pots, fumaroles, geysers, coastal thermal springs, and even deep-sea hydrothermal vents. They are also found in man-made environments, such as heated compost facilities, reactors, and spray dryers. Thermophiles, hyperthermophiles, and their bioproducts facilitate various industrial, agricultural, and medicinal applications and offer potential solutions to environmental damages and the demand for biofuels. Intensified efforts to sequence the entire genome of hyperthermophiles and thermophiles are increasing rapidly, as evidenced by the fact that over 120 complete genome sequences of the hyperthermophiles Aquificae, Thermotogae, Crenarchaeota, and Euryarchaeota are now available. In this review, we summarise the major current applications of thermophiles and thermozyymes. In addition, emphasis is placed on recent progress in understanding the biodiversity, genomes, transcriptomes, metagenomes, and single-cell sequencing of thermophiles in the genomic era.

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* Corresponding author.
E-mail address: gohkianmau@utm.my (K.M. Goh).

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65 **1. Introduction**

66 Thermophiles and hyperthermophiles dominate heated environ-
 67 nments. The optimum growth temperature (OGT) for thermophiles is
 68 generally >55 °C, whereas that for hyperthermophiles is >80 °C. Hot
 69 springs are one of the main sites where hyperthermophiles and thermo-
 70 philes are isolated, although they can also thrive in man-made environ-
 71 ments, such as the compost facilities (Rastogi et al., 2010). Fig. 1 shows
 72 images of several types of hot springs and biomats taken from around

73 the world. Hot springs adjacent to volcanic environments are usually
 74 acidic (Urbieto et al., 2014b), but the pH is neutral or slightly alkaline in
 75 regions near limestone. Thermophiles may also live under harsh condi-
 76 tions involving extreme pH or high salt concentrations (Futterer et al.,
 2004; Giaveno et al., 2013; Ruepp et al., 2000; Urbieto et al., 2014a).
 77 Most early biodiversity studies adopted culture-dependent approaches.
 78 Findings from these studies demonstrated that typically only 1–10% of
 79 the total population from any biosphere is cultivable. Because of this
 80 limitation, microbiologists later chose culture-independent approaches 81

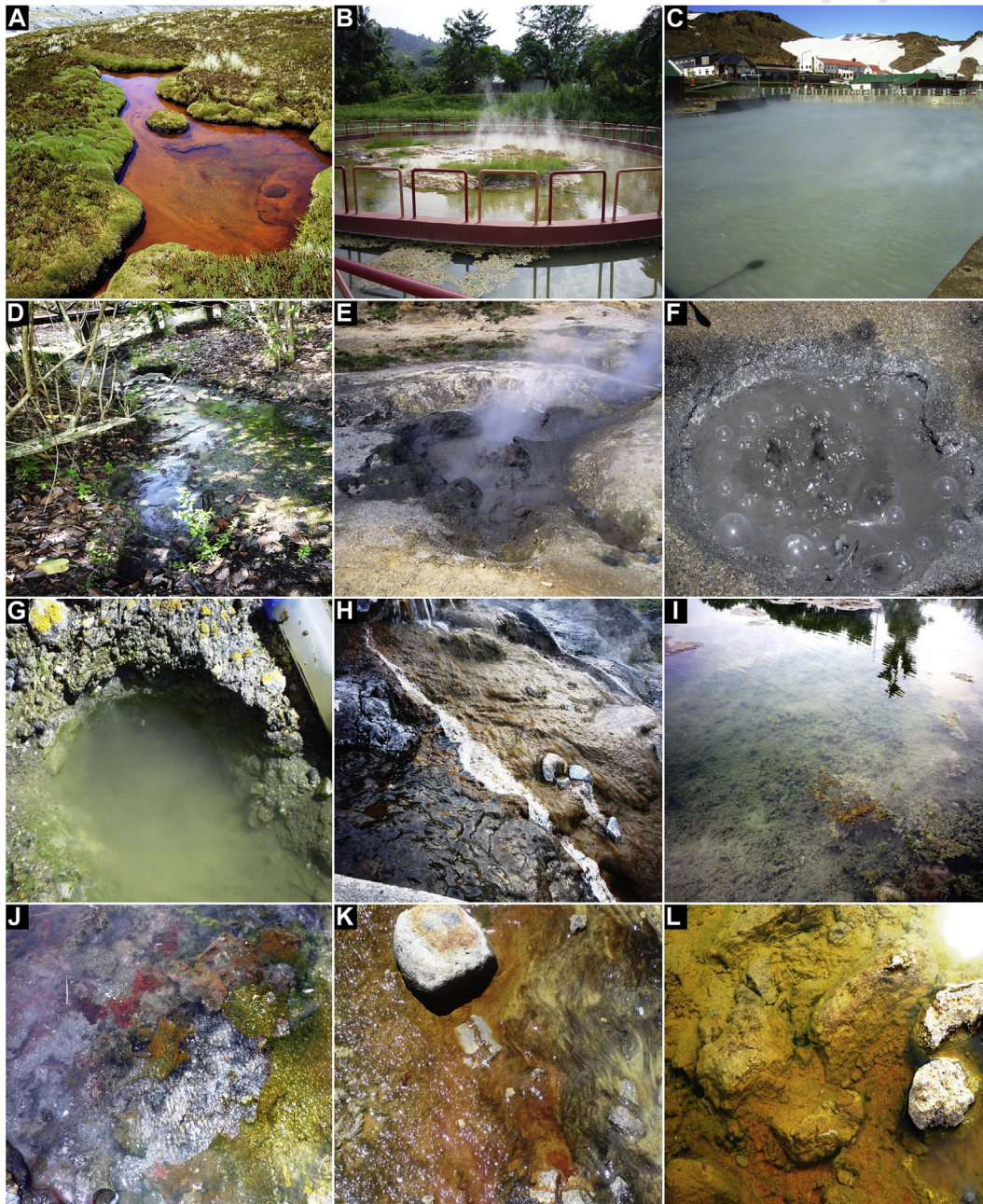


Fig. 1. Photographs of hot springs in the form of a pool or basin (A–C), a stream (D), heated mud (E–F), and a pot (G). Various colours of biomats and sediments that can form in hot springs (H–L).

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