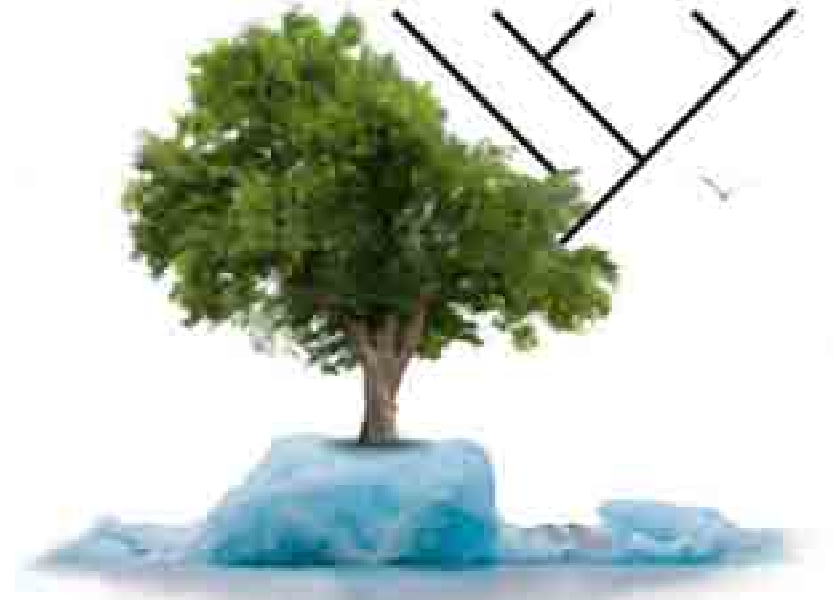


FUNGAL EVOLUTION ON THE EDGE

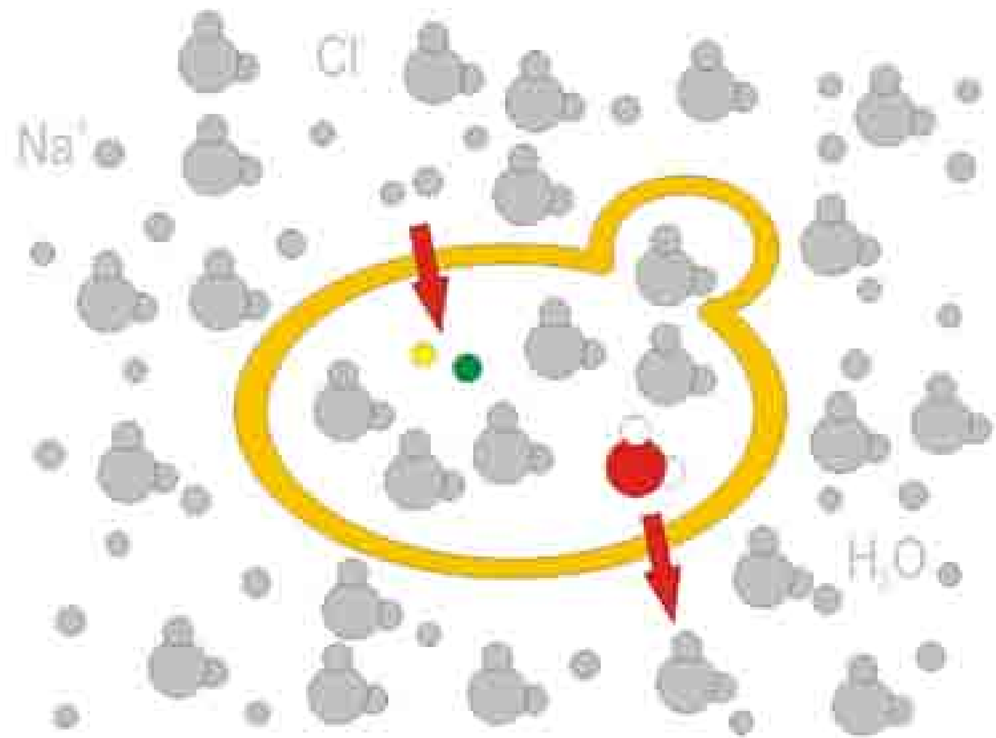
Cene Gostinčar, Martin Grube,
Sybren de Hoog, Polona Zalar, Nina Gunde - Cimerman

Extreme environments

Salterns: lack of water, high concentrations of anorganic ions.

water on ions

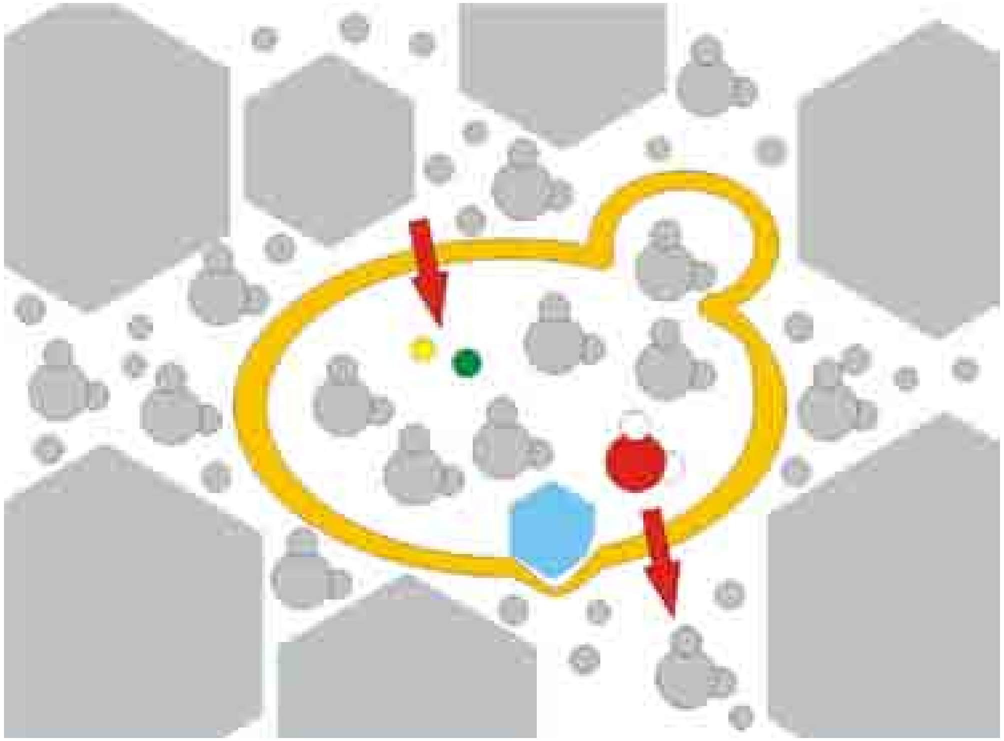
Na^+ ions are toxic



Ice: lack of water, ice crystals, high concentrations of anorganic ions.

water in ice crystals

physical damage



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Different fungi – different levels of stress-tolerance:

Aureobasidium pullulans

Penicillium crustosum

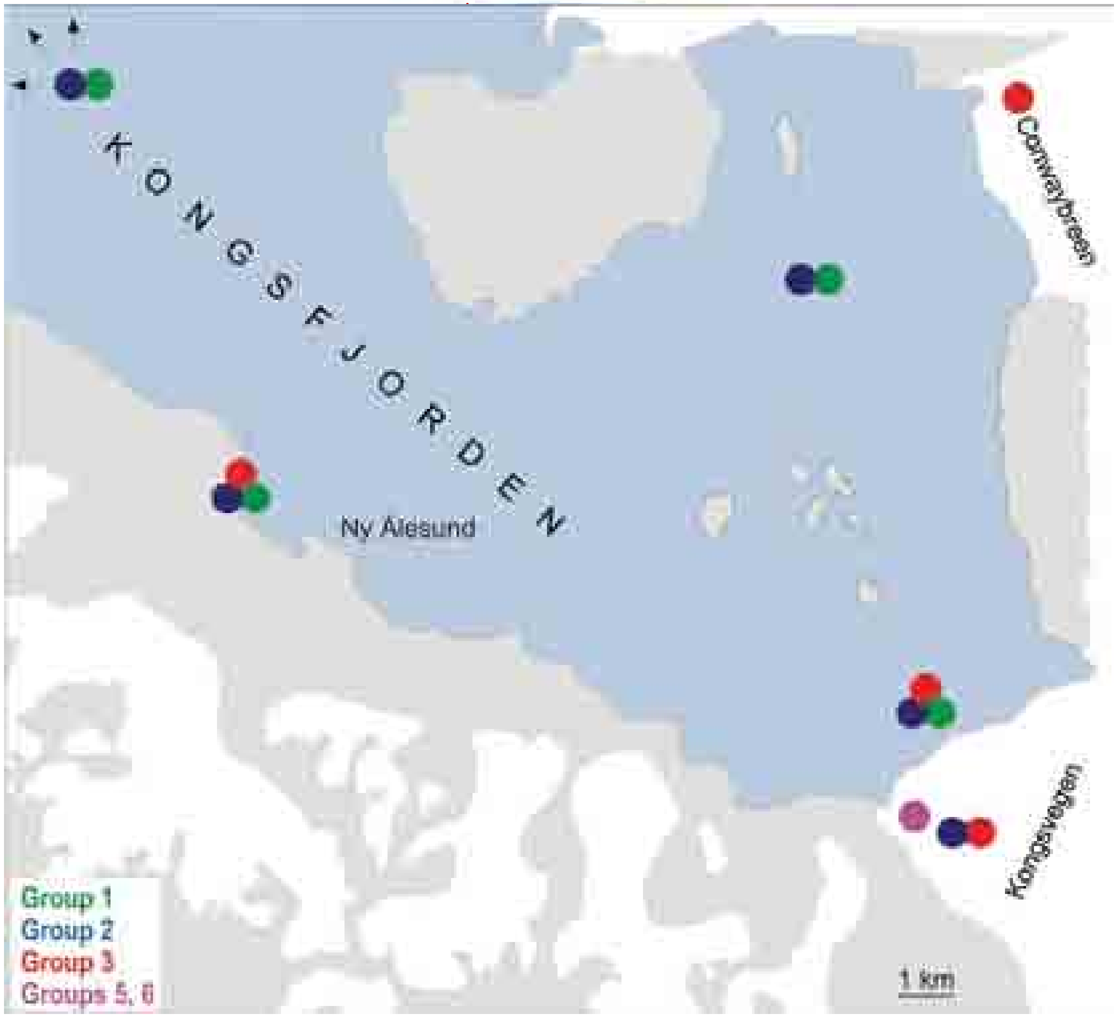
Thelebolus sp.

Cladosporium sp.

Hortaea werneckii

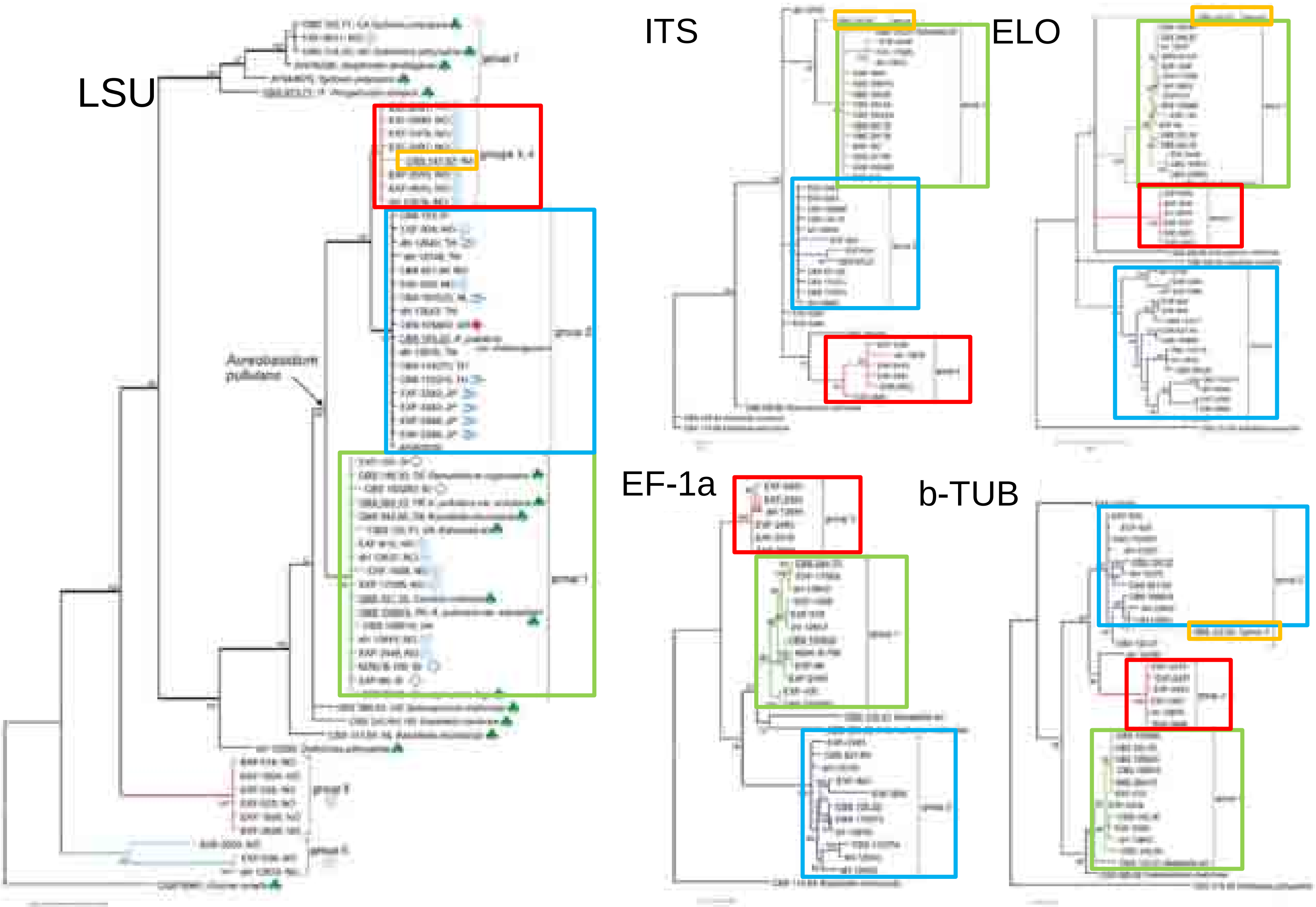
Wallemia ichthyophaga

Four varieties of *A. pullulans* inhabit different environments.



Zalar P., Gostinčar C., de Hoog G. S., Uršič V., Sudhadham M., Gunde-Cimerman N. 2008. Redefinition of *Aureobasidium pullulans* and its varieties. Studies in Mycology, 61: *21–38*.

Four varieties of *A. pullulans* inhabit different environments.



Four varieties of *A. pullulans* inhabit different environments.

15% NaCl

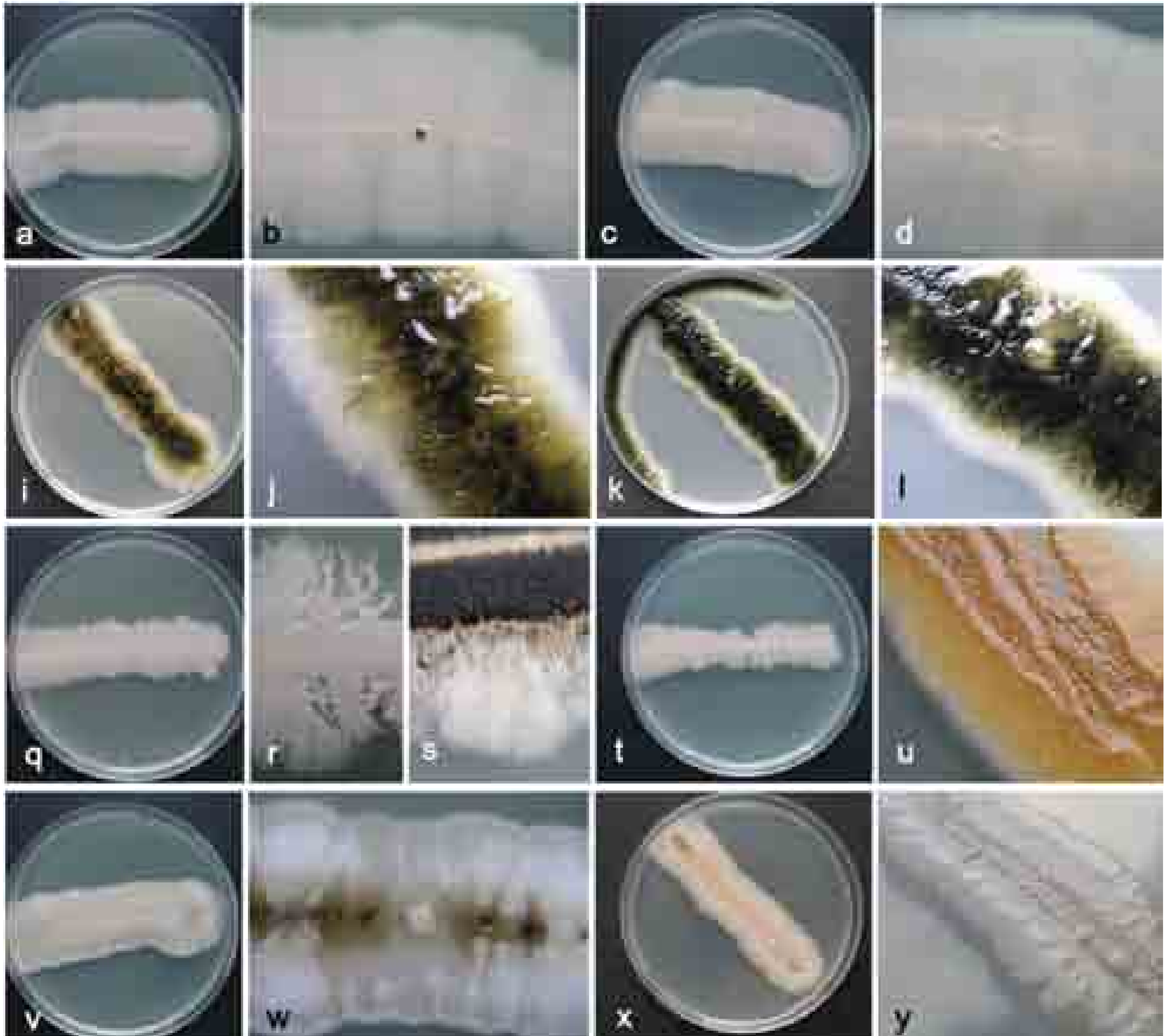
4/25/30°C

var. *pullulans*

var. *melanogenum*

10% NaCl

10/30/35°C



10% NaCl

4/25/25°C

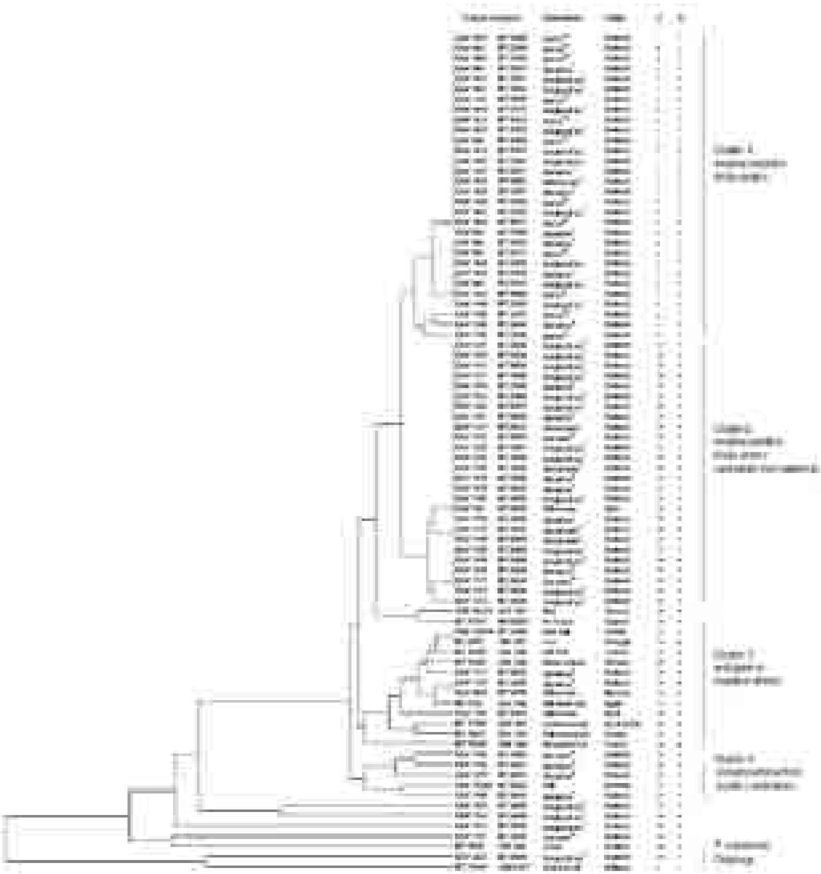
var. *subglaciale*

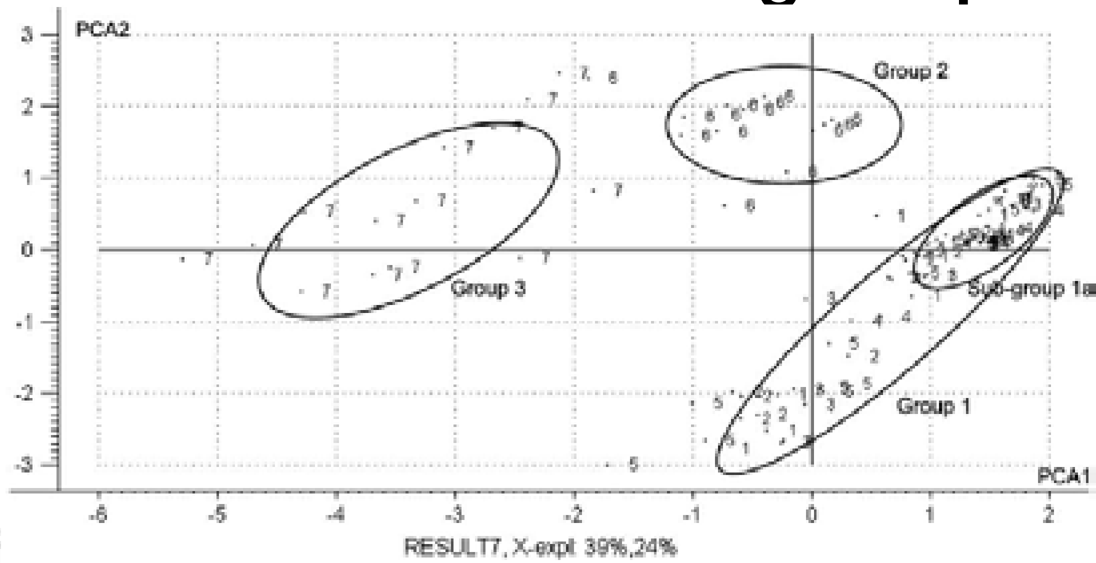
var. *namibiae*

10% NaCl

10/25/30°C

Glacier strains of *Penicillium crustosum* form distinct groups.





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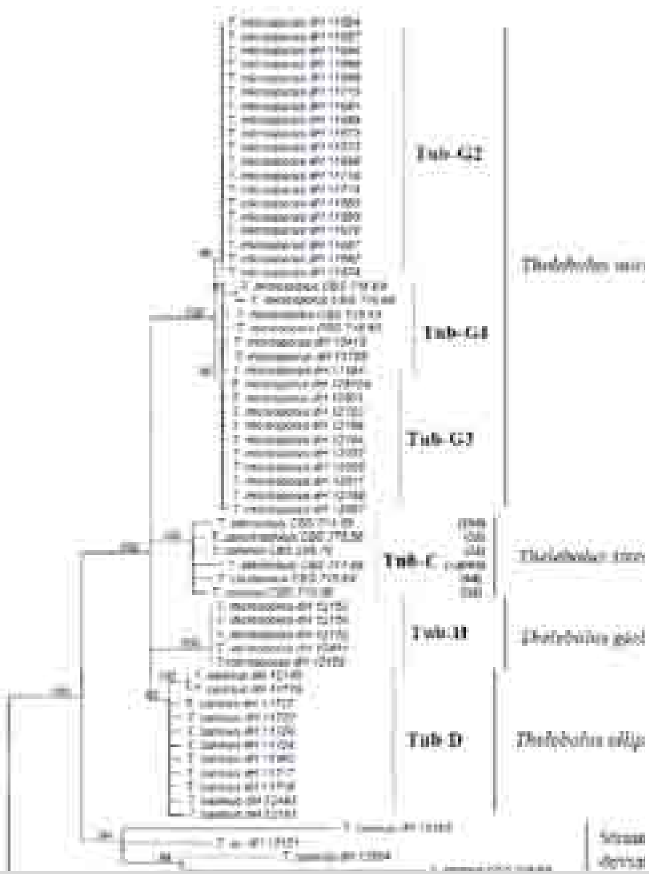
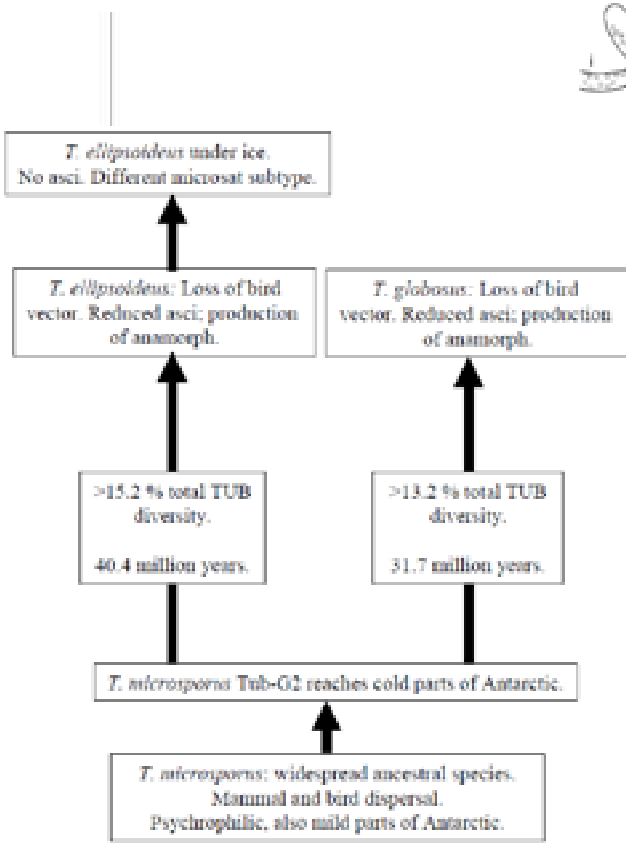
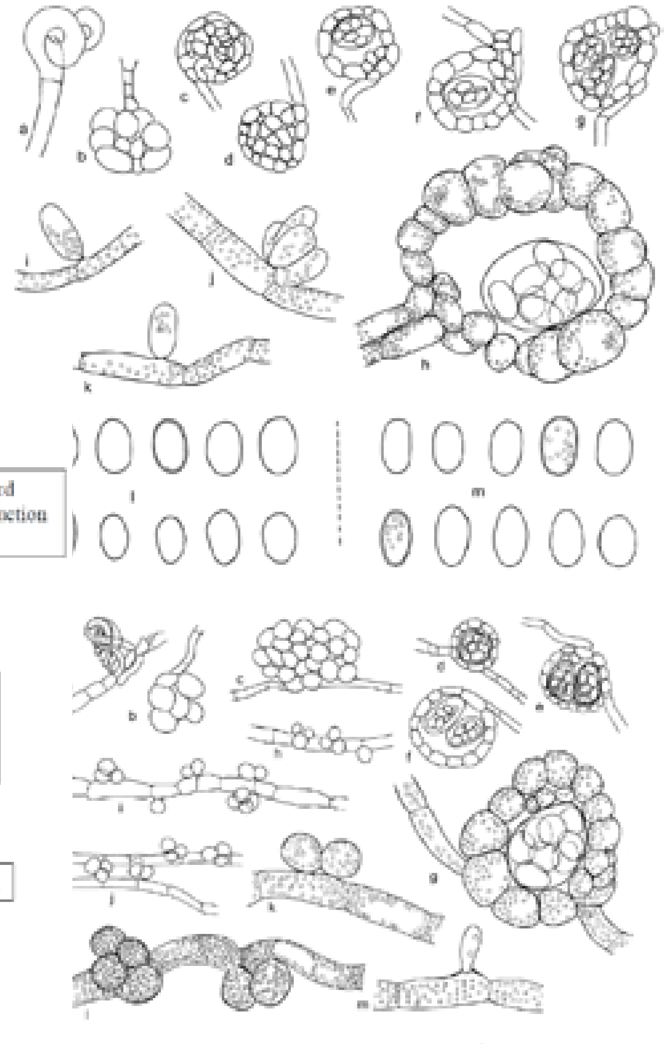
Sonjak S., Frisvad J. C., Gunde-Cimerman N. in press. Fingerprinting using extrolite profiles and physiological data shows sub-specific groupings of *Penicillium crustosum* strains. Mycological Research.

Endemic Antarctic species *Thelebolus ellipsoideus* and *T. globosus.*







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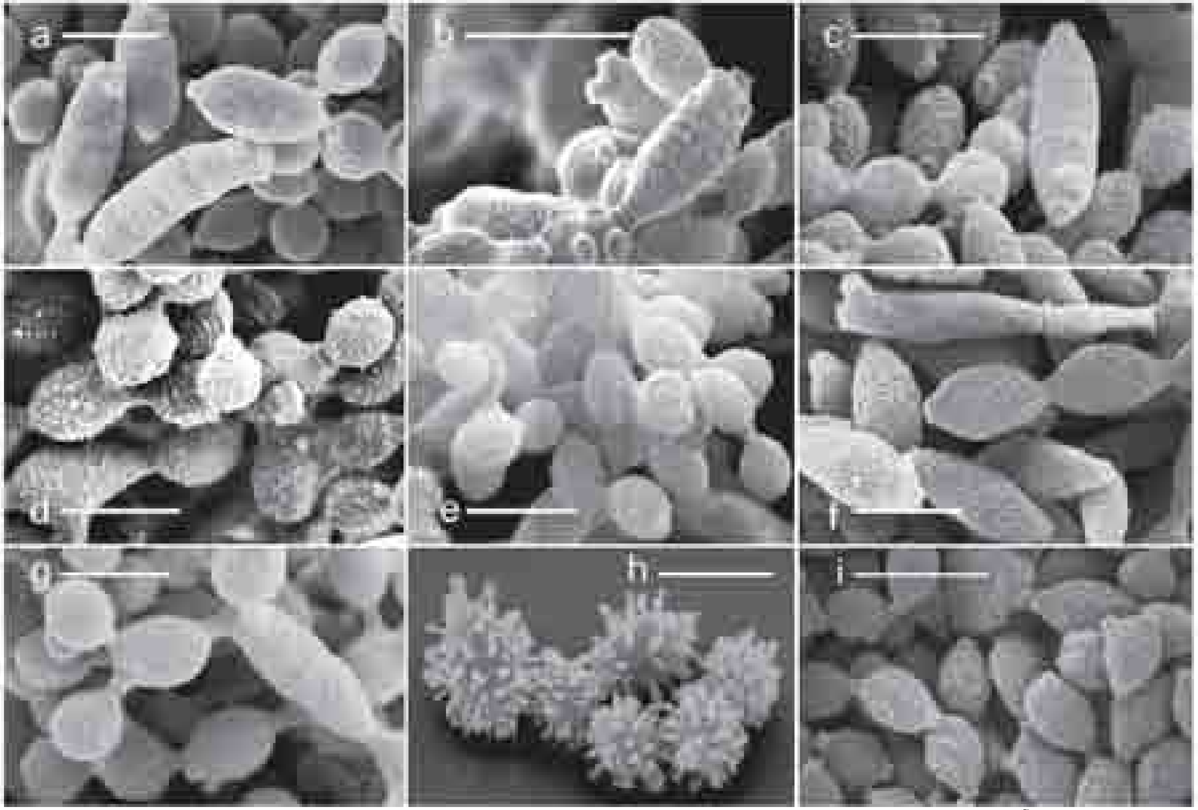
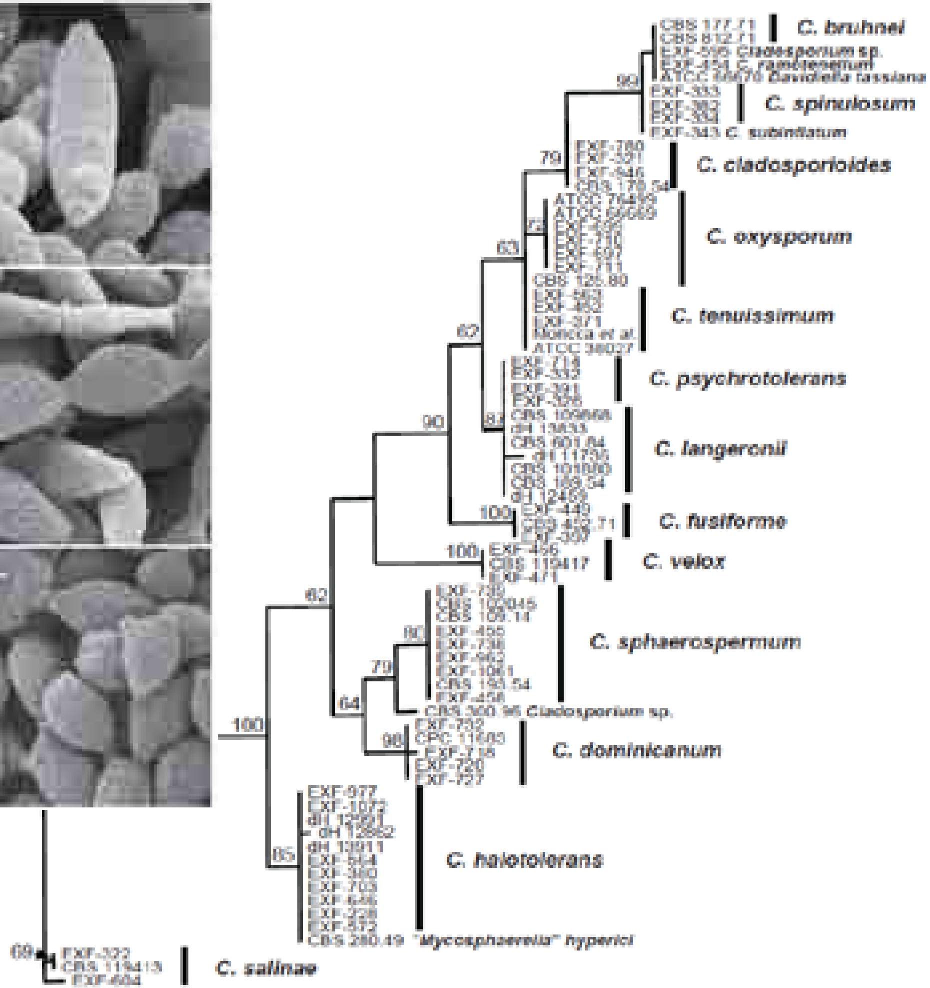
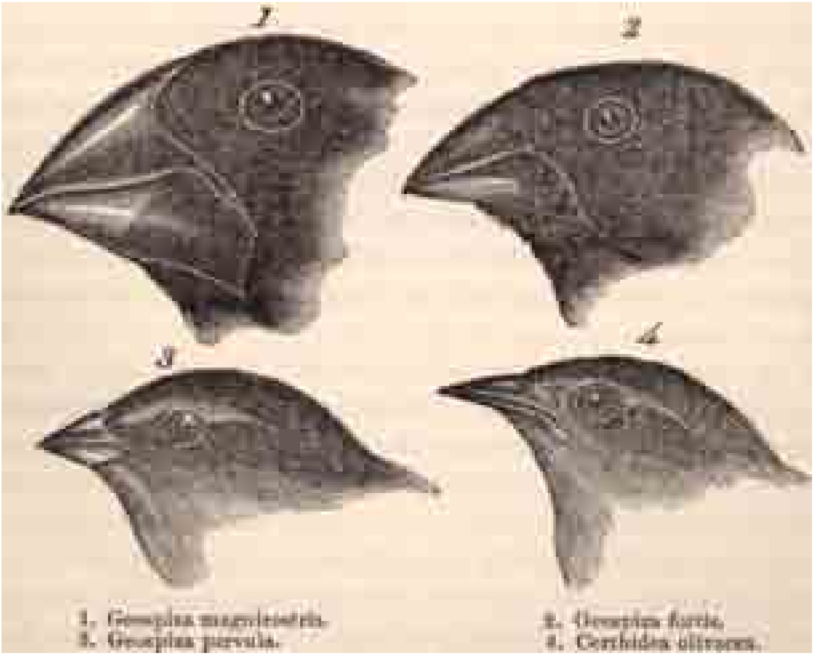
Seven new *Cladosporium* sp. species from hypersaline environments.





Zalar P., De Hoog G. S., Schroers H. J., Crous P. W., Groenewald J. Z., Gunde-Cimerman N. 2007. Phylogeny and ecology of the ubiquitous saprobe *Cladosporium sphaerospermum*, with descriptions of seven new species from hypersaline environments. Studies in Mycology, 58, 1: 157-183.



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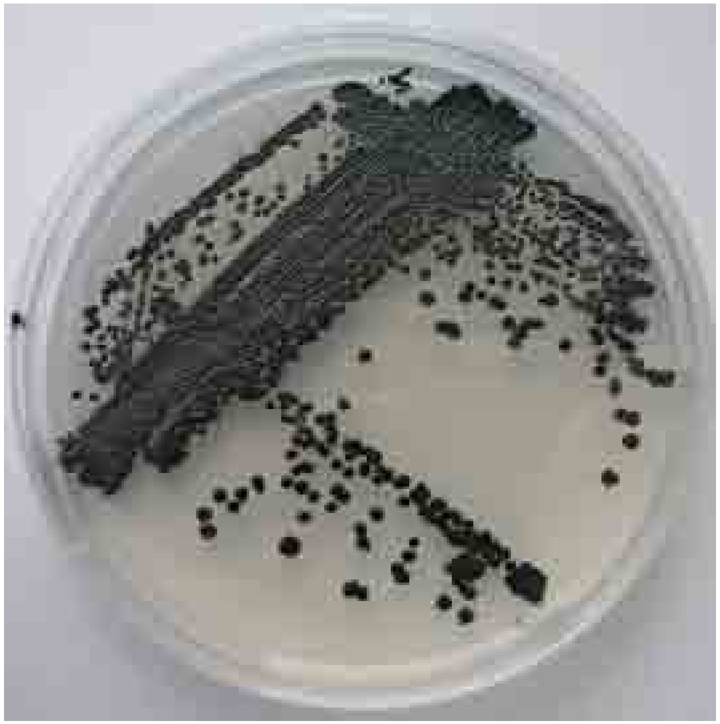
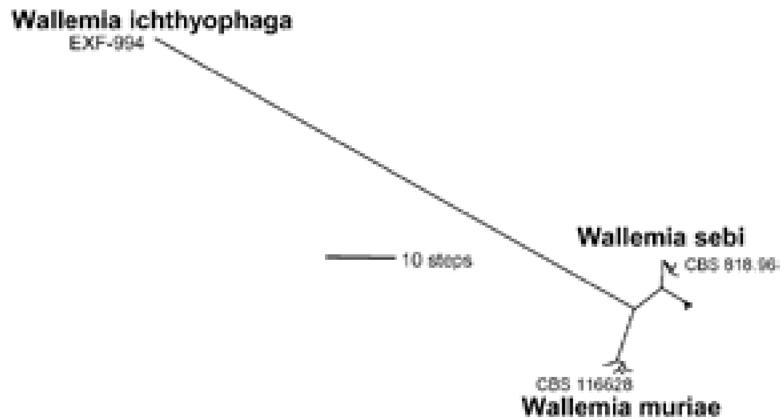
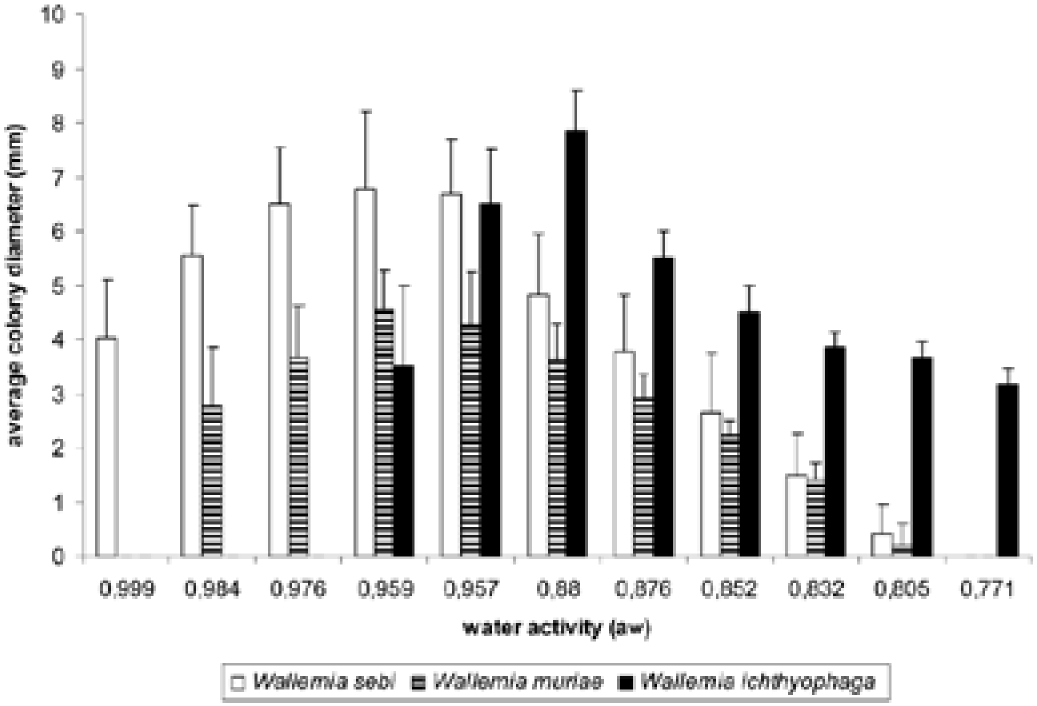
Gould J. 1841. Birds. In: The Zoology of the Voyage of H.M.S. Beagle, under the command of Captain Fitzroy, R.N., during the years 1832 to 1836. C. Darwin, editor. pp. 156

Hortaea werneckii – an extremely halotolerant black yeast.



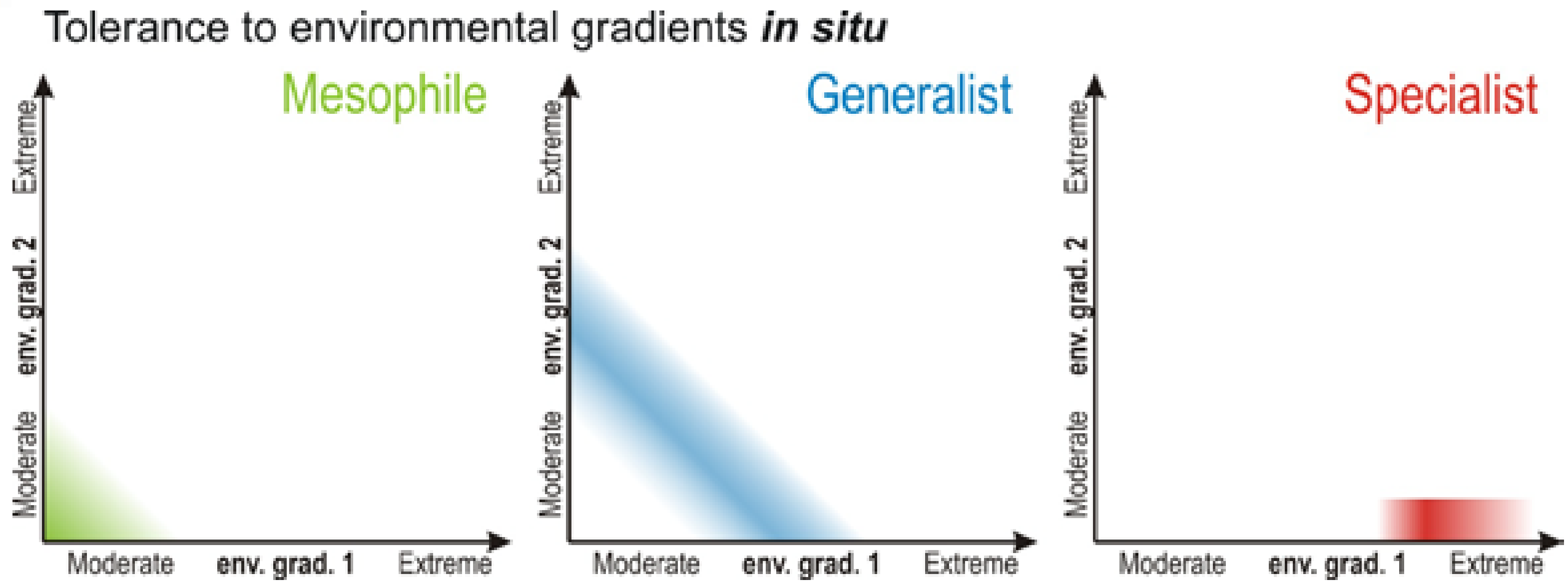
Wallemia ichthyophaga, the most halophilic fungus known.



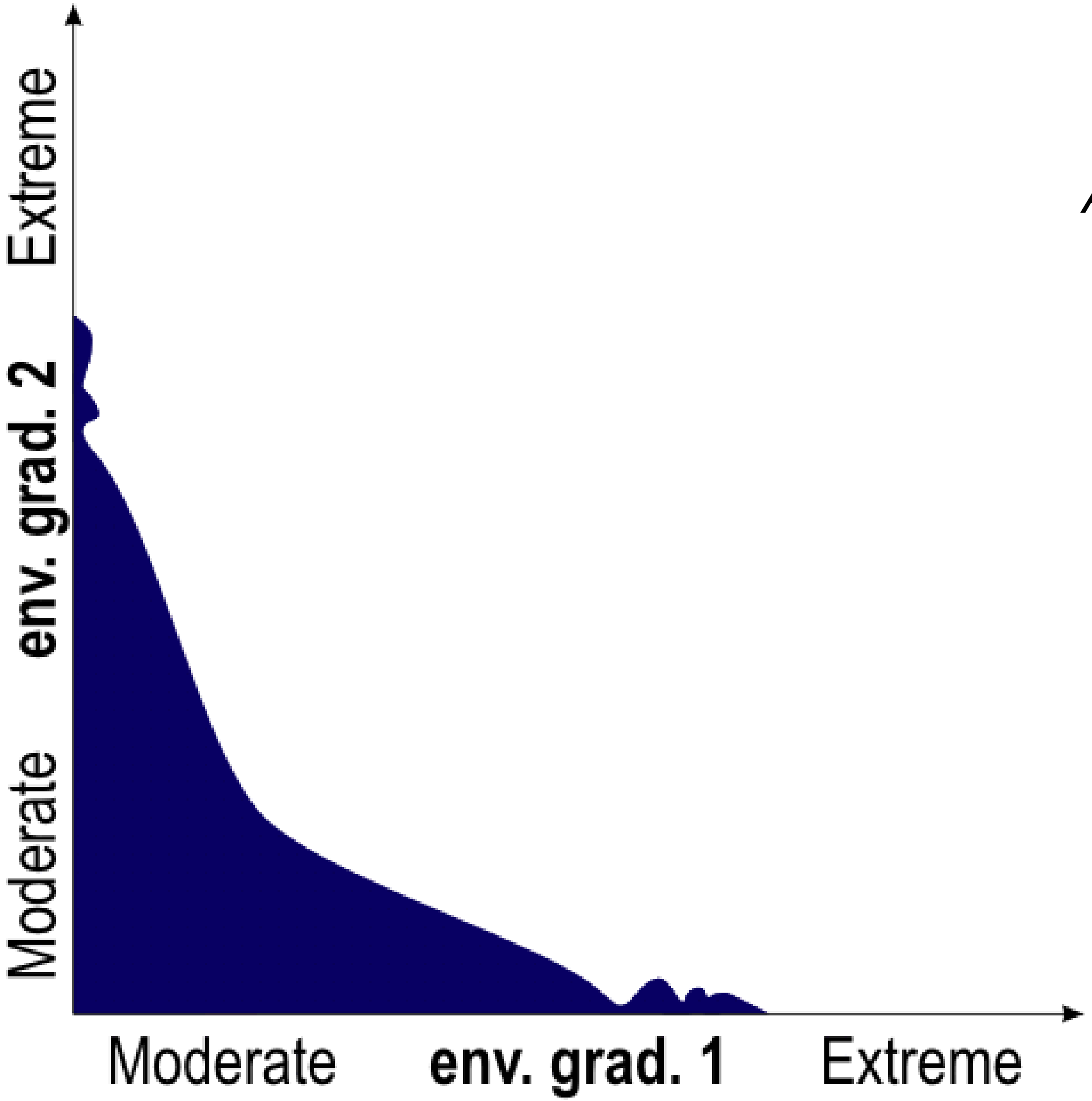


Zalar P., Sybren de Hoog G., Schroers H. J., Frank J. M., Gunde-Cimerman N. 2005. Taxonomy and phylogeny of the xerophilic genus *Wallemia* (*Wallemiomycetes* and *Wallemiales*, cl. et ord. nov.). Antonie van Leeuwenhoek, 87, 4: 311-328.

Three eco-types of Fungi.



Persistence



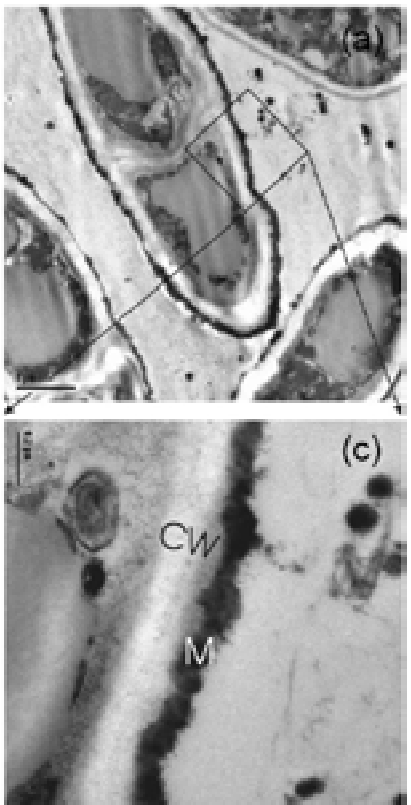
Penicillium crustosum

Aureobasidium pullulans

phenotypic plasticity
increased mutation rates?

H. werneckii, cell wall

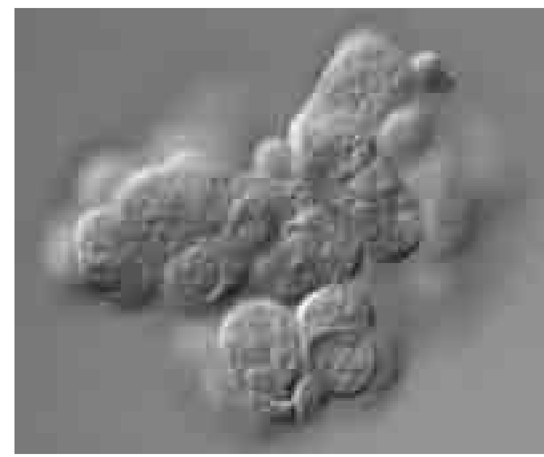
T. Kogej, M. Stein, M. Volkmann, A.A. Gorbushina, E.A. Galinski and N. Gunde-Cimerman. 2007. Osmotic adaptation of the halophilic fungus Hortaea werneckii: role of osmolytes and melanization. Microbiology, 153, 4261–4273.



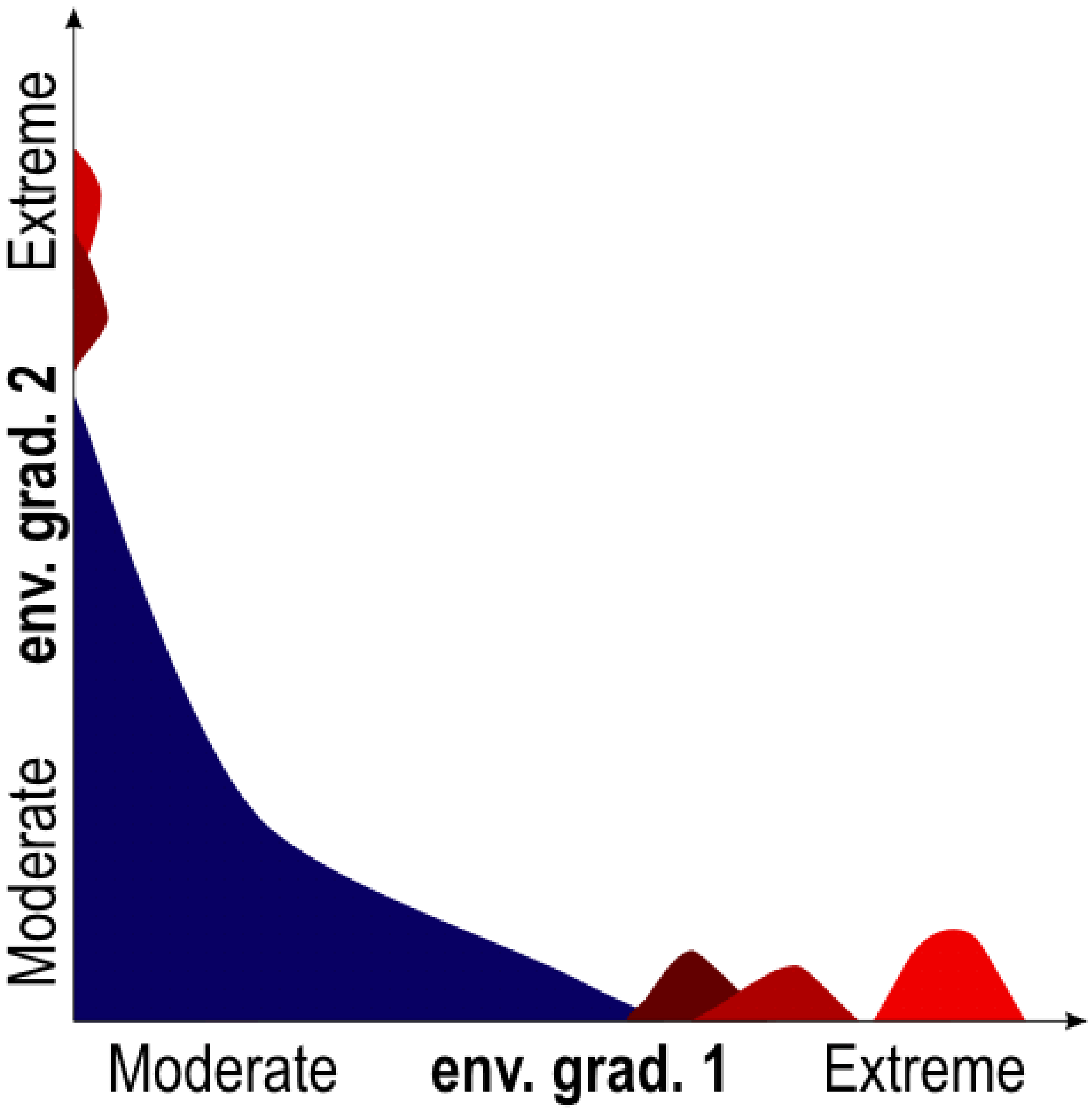
A. pullulans, 18% NaCl

C. Gostinčar, unpublished

W, ichthyophaga, 17% NaCl



Adaptive radiation

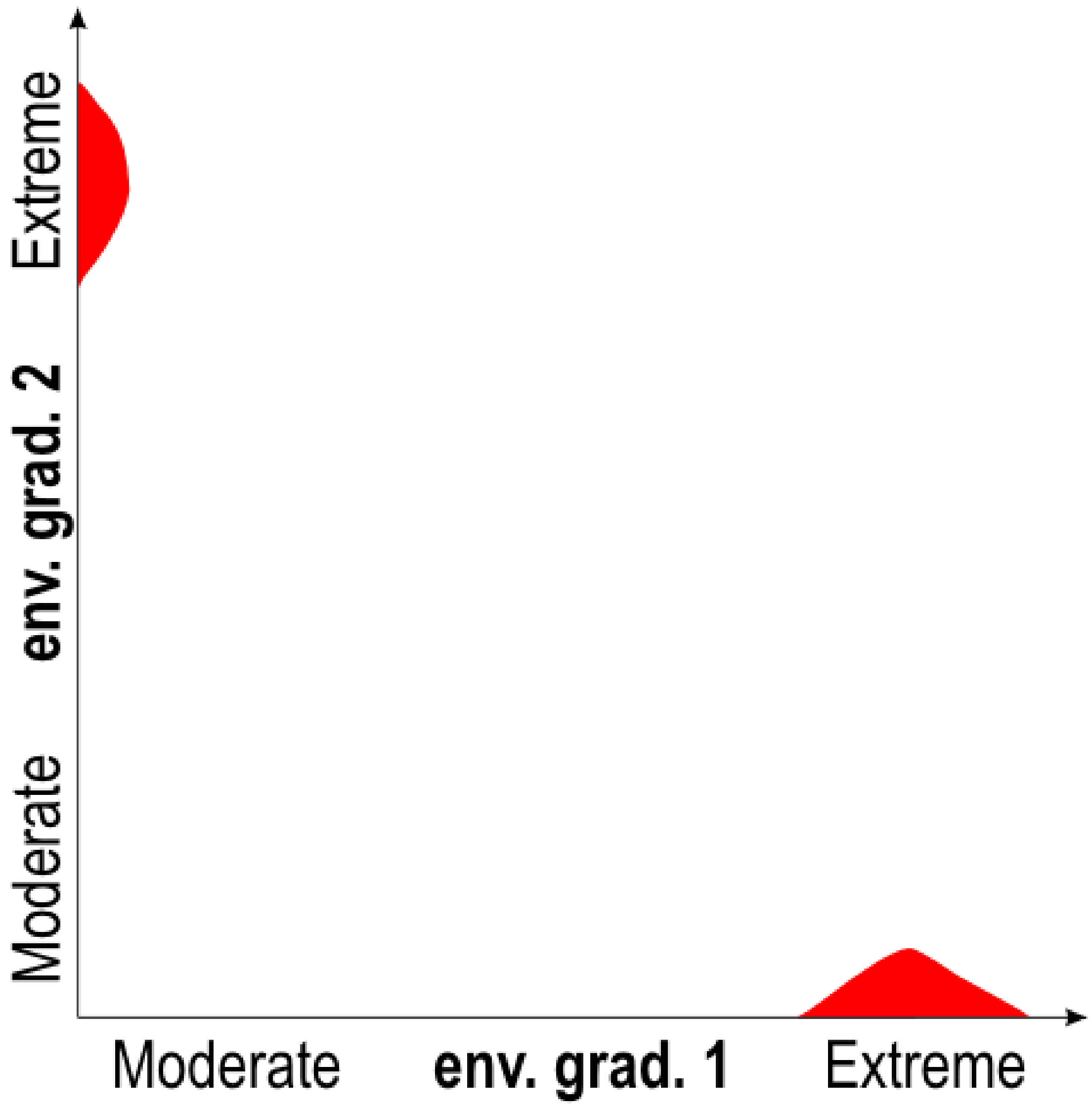


Thelebolus sp.

Cladosporium sp.

Eurotium sp.,
Trimmatostroma sp.,
Emericella sp.,
…

Specialization



Hortaea werneckii

Wallemia ichthyophaga

growth optimum shift

Publication

MINIREVIEW

Extremotolerance in fungi: evolution on the edge

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evolution; extremophile; speciation; specialist species; halophile; psychrophile.

Abstract

Our planet offers many opportunities for life on the edge: high and low temperatures, high salt concentrations, acidic and basic conditions and toxic environments, to name but a few extremes. Recent studies have revealed the diversity of fungi that can occur in stressful environments that are hostile to most eukaryotes. We review these studies here, with the additional purpose of proposing some mechanisms that would allow for the evolutionary adaptation of eukaryotic microbial life under extreme conditions. We focus, in particular, on life in ice and life at high salt concentrations, as there is a surprising similarity between the fungal populations in these two kinds of environments, both of which are characterized by low water activity. We propose steps of evolution of generalist species towards the development of specialists in extreme habitats. We argue that traits present in some fungal groups, such as asexuality, synthesis of melanin-like pigments and a flexible morphology, are preadaptations that facilitate persistence and eventual adaptation to conditions on the ecological edge, as well as biotope switches. These processes are important for understanding the evolution of extremophiles; moreover, they have implications for the emergence of novel fungal pathogens.