Cold-adapted yeasts: a restricted club of extremophilic organisms

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[1] University of Perugia, Perugia, Italy & Industrial yeasts Collection DBVPG (www.dbvpg.unipg.it)

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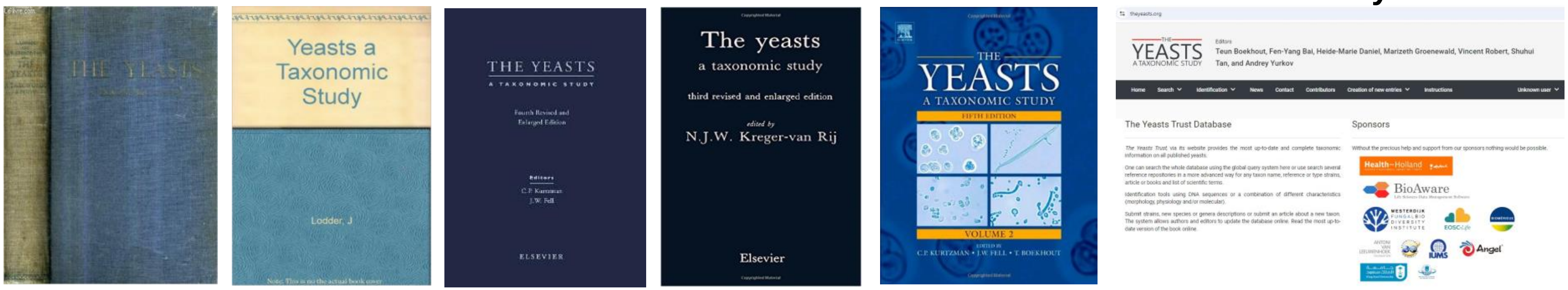
General summary

1. Yeast diversity – the state of the art
2. Extremophilic yeasts
3. Cold-adapted yeasts
4. Cold environments worldwide
5. Culturable diversity of cold-adapted yeasts in worldwide cold environments
6. 6. Unculturable diversity (NGS) of cold-adapted fungi (including yeasts)
7. Predicting the impact of climate change on Alpine soil fungal community
8. Physiological/molecular adaptation to cold
9. A look to biotechnology of cold-adapted yeasts
10. Take home message
11. Acknowledgements
12. Sampling pictures
13. A bit of humor…

phillipmartin.info

1. Yeast diversity – the state of the art

1952 1970 1984 1998 2012 Today



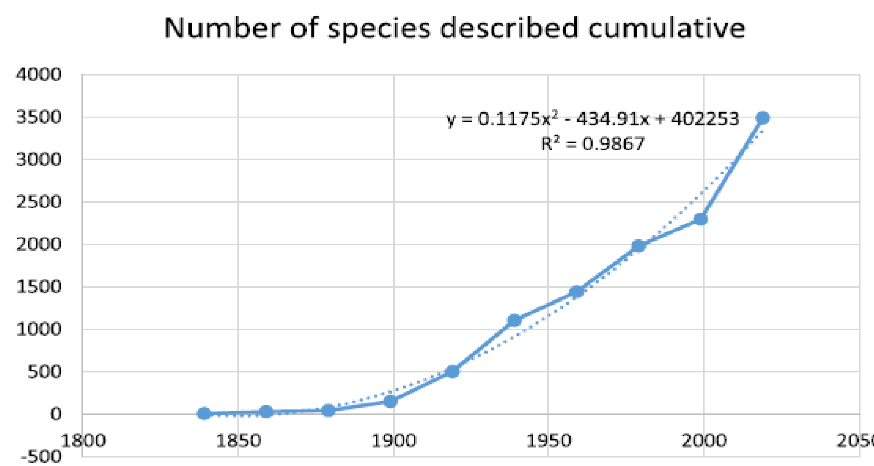
- ✓ Yeasts → probably **the most ancient eukaryotic organisms**
- ✓ <1% → **estimated ratio** between described & existing yeast species
- ✓ <u>**Expected number of yeast species**</u> on Earth → around <u>**150,000**</u>

Fungal Diversity
https://doi.org/10.1007/s13225-021-00494-6

REVIEW

Trends in yeast diversity discovery

Teun Boekhout[1,2] · Anthony S. Amend[3] · Fouad El Baidouri[3] · Toni Gabaldón[4,5,6] · József Geml[7] · Moritz Mittelbach[8] · Vincent Robert[1] · Chen Shuhui Tan[9] · Benedetta Turchetti[10,11] · Duong Vu[1] · Qi-Ming Wang[12] · Andrey Yurkov[13]



2. Extremophilic yeasts (A)

Received: 18 December 2017 | Revised: 31 January 2018 | Accepted: 6 March 2018
DOI: 10.1002/yea.3314

ECOYEAST REVIEW

WILEY Yeast

Extremophilic yeasts: the toughest yeasts around?

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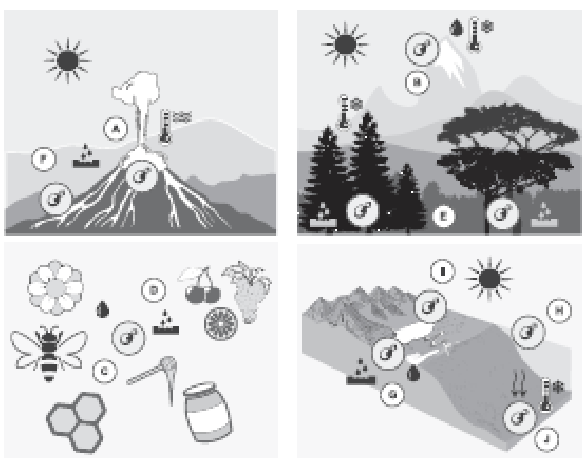
Pietro Buzzini, Department of Agricultural, Food and Environmental Sciences, University of Perugia, Italy.
Email: pietro.buzzini@unipg.it



Abstract

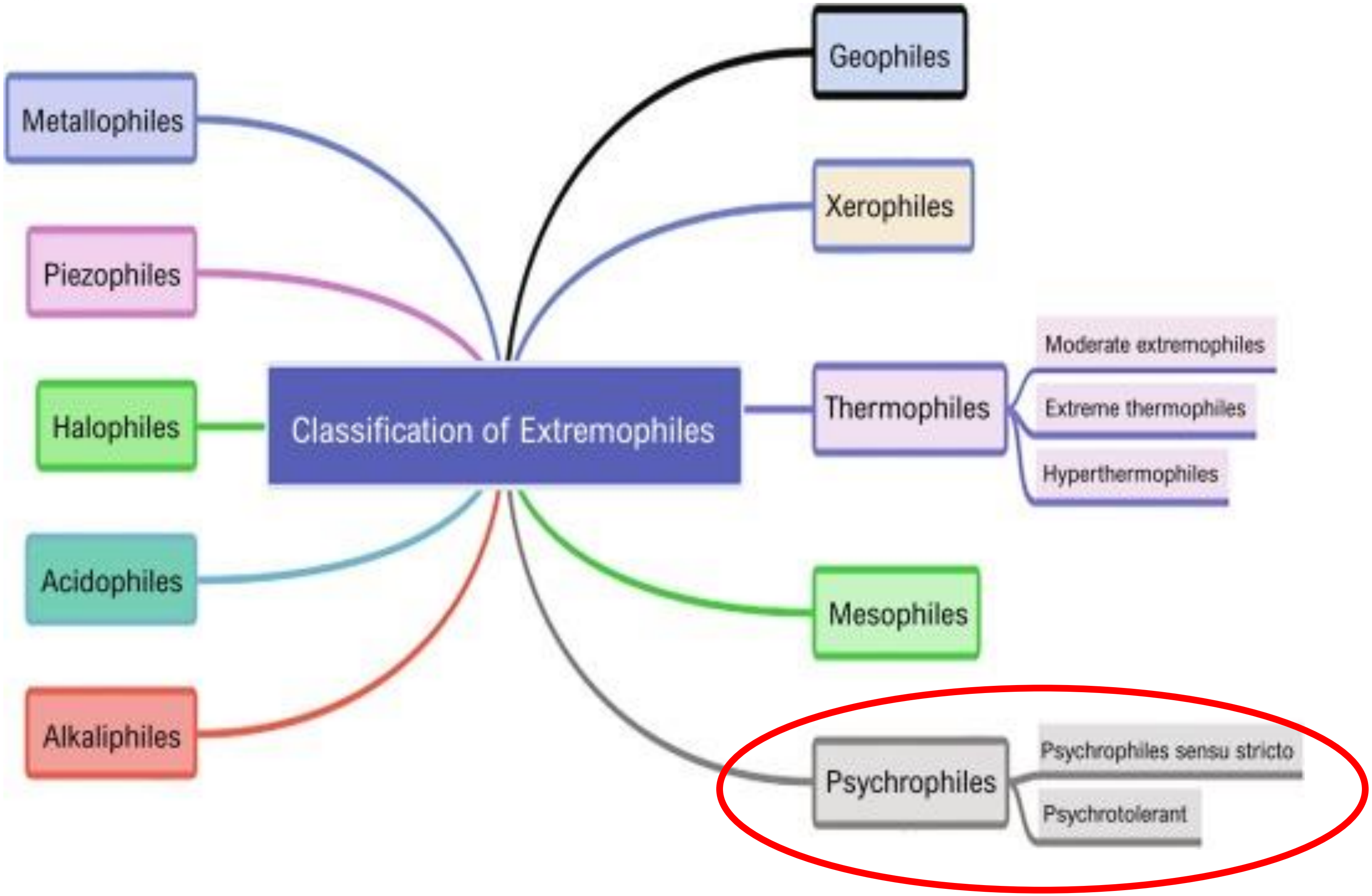
Microorganisms are widely distributed in a multitude of environments including eco-systems that show challenging features to most life forms. The combination of extreme physical and chemical factors contributes to the definition of extreme habitats although the definition of extreme environments changes depending on one's point of view: anthropocentric, microbial-centric or zymo-centric. Microorganisms that live under conditions that cause hard survival are called extremophiles. In particular organisms that require extreme conditions are called true extremophiles while organisms that tolerate them to some extent are termed extremotolerant. Deviation of temperature, pH, osmotic stress, pressure and radiation from the common range delineates extreme environments. Yeasts are versatile eukaryotic organisms that are not frequently considered the toughest microorganisms in comparison with prokaryotes. Nevertheless extremophilic or extremotolerant species are present also within this group. Here a brief description is provided of the main extreme habitats and the metabolic and physiological modifications adopted by yeasts depending on their adverse conditions. Additionally the main extremophilic and extremotolerant yeast species associated with a few extreme habitats are listed.

KEYWORDS

extremophilic yeasts, extremotolerant yeasts, extreme environments

2. Extremophilic yeasts (B)

2.1 Some basic definitions



3. Cold-adapted yeasts (A)

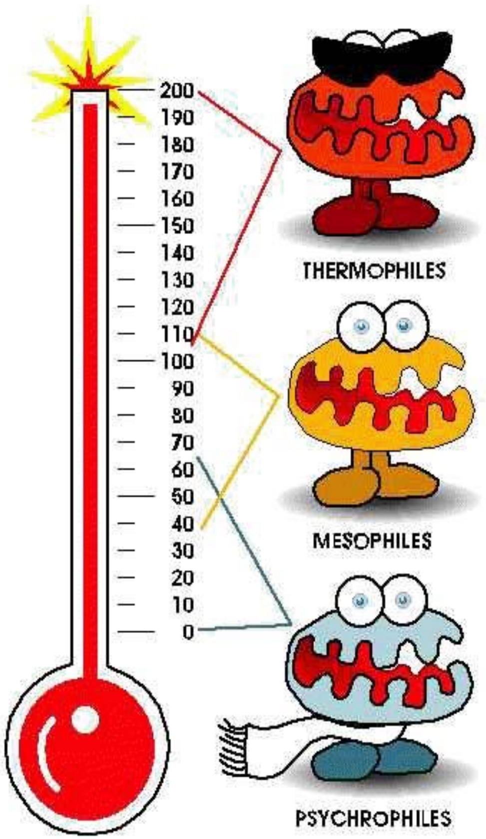
3.1 Some basic definitions

Obligate (true or *sensu stricto*) psychrophiles

- optimal growth temperature ≈ 15°C (or below)
- minimum growth temperature ≈ 0°C (or below)
- maximum growth temperature < 20°C

Facultative psychrophiles (psychrotolerant or psychrotrophic)

- optimal growth temperature ≈ 25°C (or higher)
- minimum growth temperature ≈ 0°C
- maximum growth temperature ≈ 30°C (or higher)



3. Cold-adapted yeasts (B)

3.2 Current literature

ELSEVIER

FEMS Microbiology Ecology 53 (2005) 117–128

FEMS MICROBIOLOGY Ecology

www.fems-microbiology.org

Biodiversity of cryopegs in permafrost

David Gilichinsky [a,*], Elizaveta Rivkina [a], Corien Bakermans [b], Viktoria Shcherbakova [c], Lada Petrovskaya [d], Svetlana Ozerskaya [c], Natalia Ivanushkina [c], Galina Kochkina [c], Kyastus Laurinavichuis [c], Svetlana Pecheritsina [c], Rushania Fattakhova [a], James M. Tiedje [b]

Environmental Microbiology (2009) 11(2), 360–381

doi:10.1111/j.1462-2920.2008.01777.x

Microbial eukaryotes in the hypersaline anoxic L'Atalante deep-sea basin

Eva Alexander,[1] Alexandra Stock,[1] Hans-Werner Breiner,[1] Anke Behnke,[1] John Bunge,[2] Michail M. Yakimov[3] and Thorsten Stoeck[1*]

[1]*University of Kaiserslautern, School of Biology, Erwin-Schroedinger-Strasse 14, D-67773, Kaiserslautern, Germany.*

ing in the evolution of an exceptional and distinctive assemblage of protists. The deep hypersaline anoxic basins in the Mediterranean Sea provide an ideal platform to test for this hypothesis and are promising targets for the discovery of undescribed protists with unknown physiological capabilities.

OXFORD

FEMS JOURNALS investing in science

FEMS Microbiology Ecology, 92, 2016, fiw018

doi: 10.1093/femsec/fiw018

Advance Access Publication Date: 31 January 2016

Research Article

Growth kinetics of microorganisms isolated from Alaskan soil and permafrost in solid media frozen down to −35 °C

Nicolai S. Panikov & Maria V. Sizova

Department of Chemistry & Chemical Biology, Stevens Institute of Technology, NJ, USA

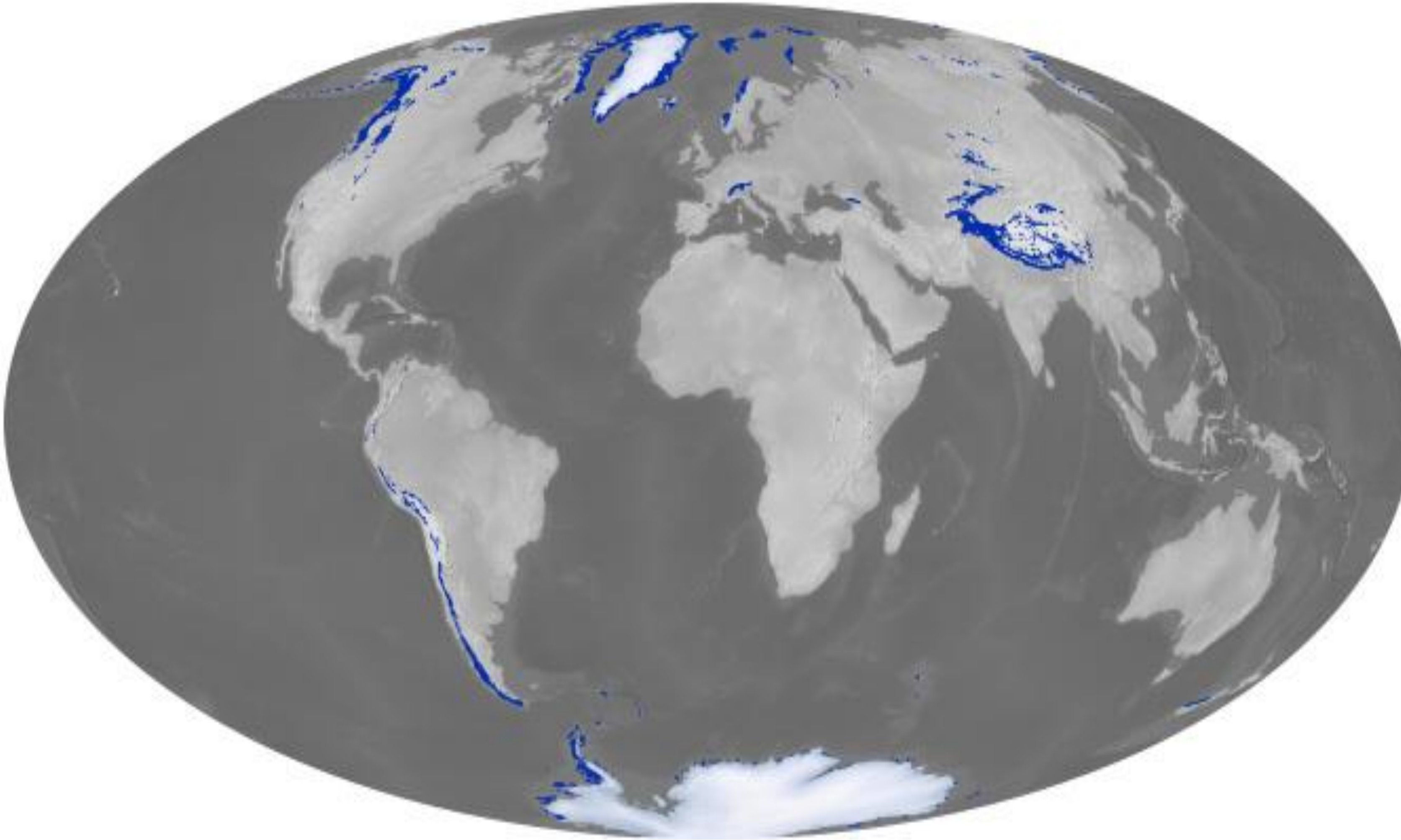
RESEARCH ARTICLE

Microbial diversity in European alpine permafrost and active layers

Beat Frey[1], Thomas Rime[1], Marcia Phillips[2], Beat Stierli[1], Irka Hajdas[3], Franco Widmer[4] and Martin Hartmann[1,*]

4. Cold environments worldwide (A)

4.1 The Randolph Glacier Inventory

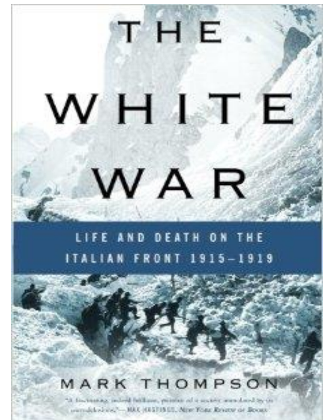


4. Cold environments worldwide (B)

4.2 Impact of ongoing climate change: “Only 17 years to try to reverse the retreating trend” (IPCC, 2014)

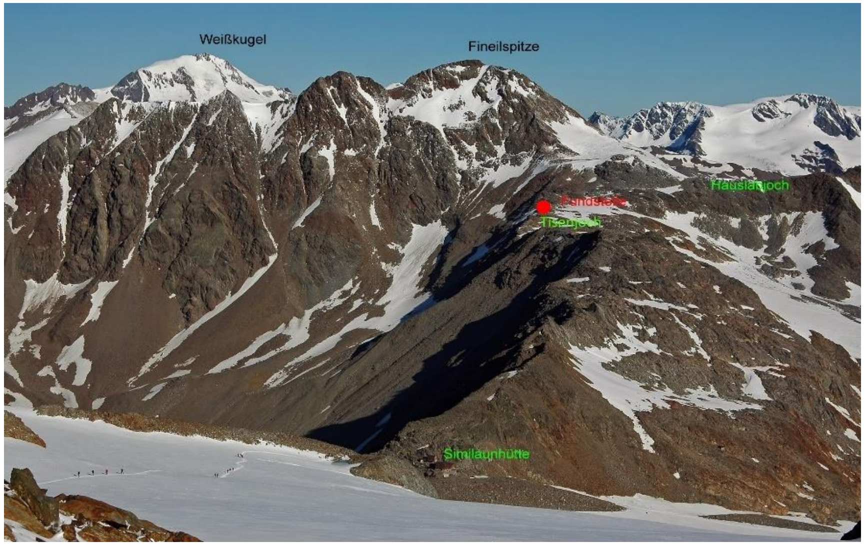
4. Cold environments worldwide (C)

4.3 A few “collateral” effects of Alpine glacier retreat (1)



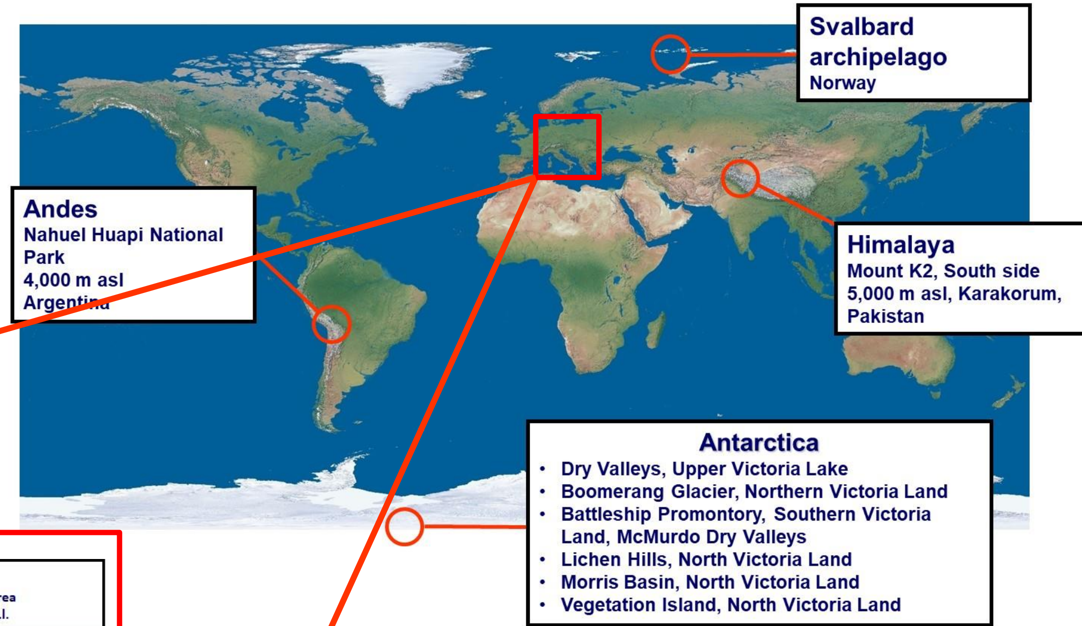
4. Cold environments worldwide (D)

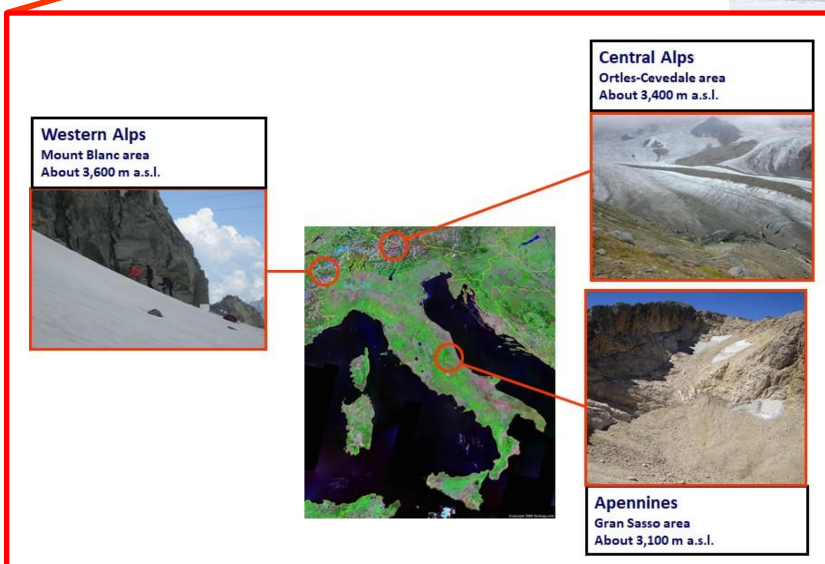
4.4 A few “collateral” effects of Alpine glacier retreat (2)



5. Culturable diversity of cold-adapted yeasts in worldwide cold environments (A)

5.1 Sampling sites (2002-2020)





5. Culturable diversity of cold-adapted yeasts in worldwide cold environments (B)

5.2 Samples

Snow

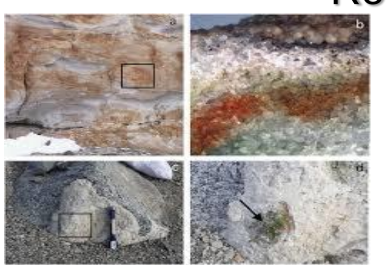
Melt waters

Ice cores

Supra- & sub-glacial debris (1-2°C *in situ*)

Permafrost, ice cores & brines

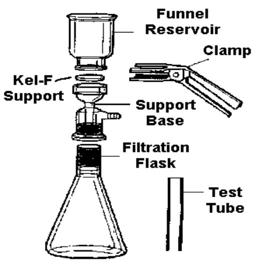
Rocks



5. Culturable diversity of cold-adapted yeasts in worldwide cold environments (C)

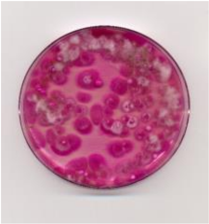
5.3 Isolation protocols (incubation at 4°C and 20°C for 12 and 4 weeks)

Melt waters, snow (after melting under asepsis) and brines



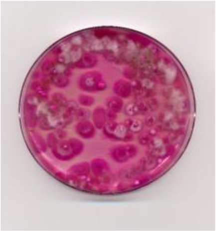
Cutoff = 0.22 µm

Lab surface decontamination protocols for ice and permafrost



- Surface washing (20'') with 5%) NaClO
- Series of surface washings with sterile water
- Melting of cores into a sterile funnel and discharge of the first melt aliquots
- Harvesting and streaking of subsequent aliquots of melt cores on Petri dishes
- Incubation: 4°C and 20°C for 12 and 4 weeks

Lab surface decontamination protocols for rocks

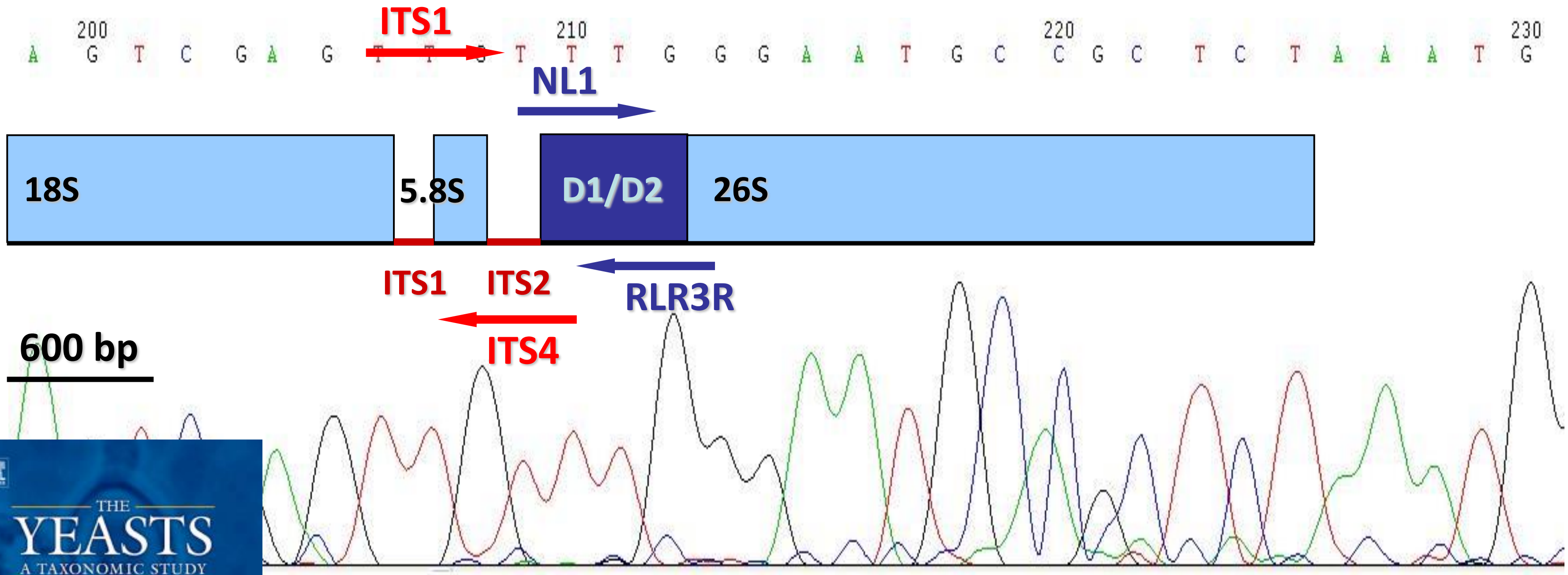


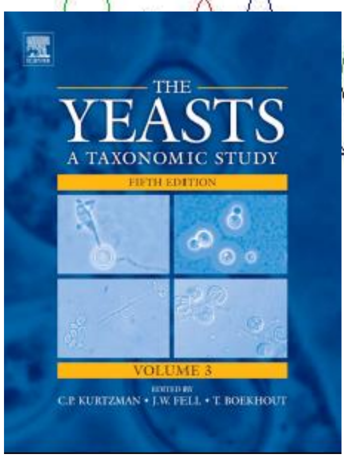
- **Surface washing (20'') with 5%) NaClO**
- **Series of surface washings with sterile water**
- **Rock crushing and grinding in pestle (under aseptic conditions)**
- **Preparation of a water suspension 1:10 (v/v) and streaking on Petri dishes**

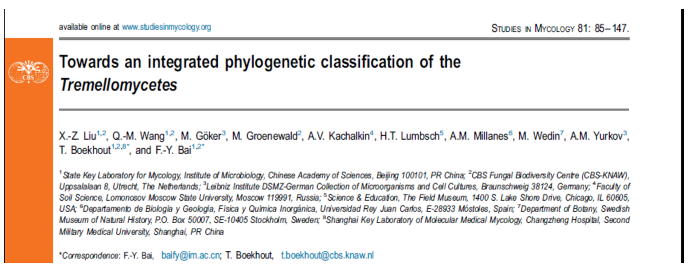
Debris (aseptically collected)

5. Culturable diversity of cold-adapted yeasts in worldwide cold environments (D)

5.4 Identification by sequencing of D1/D2 of 26S rRNA gene and ITS (1&2)







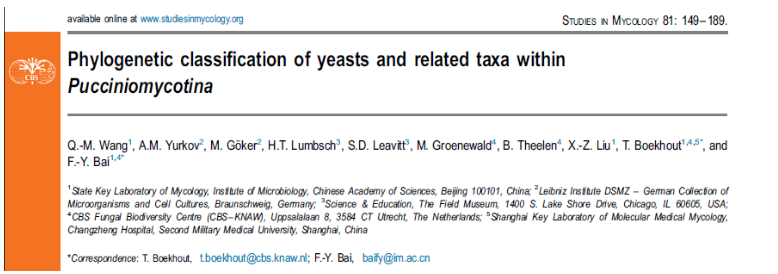
available online at www.studiesinmycology.org STUDIES IN MYCOLOGY 81: 85–147.

Towards an integrated phylogenetic classification of the *Tremellomycetes*

X.-Z. Liu[1,2], Q.-M. Wang[1,2], M. Göker[3], M. Groenewald[2], A.V. Kachalkin[4], H.T. Lumbsch[5], A.M. Millanes[6], M. Wedin[7], A.M. Yurkov[3], T. Boekhout[1,2,8*], and F.-Y. Bai[1,2*]

[1]State Key Laboratory for Mycology, Institute of Microbiology, Chinese Academy of Sciences, Beijing 100101, PR China; [2]CBS Fungal Biodiversity Centre (CBS-KNAW), Uppsalalaan 8, Utrecht, The Netherlands; [3]Leibniz Institute DSMZ-German Collection of Microorganisms and Cell Cultures, Braunschweig 38124, Germany; [4]Faculty of Soil Science, Lomonosov Moscow State University, Moscow 119991, Russia; [5]Science & Education, The Field Museum, 1400 S. Lake Shore Drive, Chicago, IL 60605, USA; [6]Departamento de Biología y Geología, Física y Química Inorgánica, Universidad Rey Juan Carlos, E-28933 Móstoles, Spain; [7]Department of Botany, Swedish Museum of Natural History, P.O. Box 50007, SE-10405 Stockholm, Sweden; [8]Shanghai Key Laboratory of Molecular Medical Mycology, Changzheng Hospital, Second Military Medical University, Shanghai, PR China

*Correspondence: F.-Y. Bai, baify@im.ac.cn; T. Boekhout, t.boekhout@cbs.knaw.nl



available online at www.studiesinmycology.org STUDIES IN MYCOLOGY 81: 149–189.

Phylogenetic classification of yeasts and related taxa within *Pucciniomycotina*

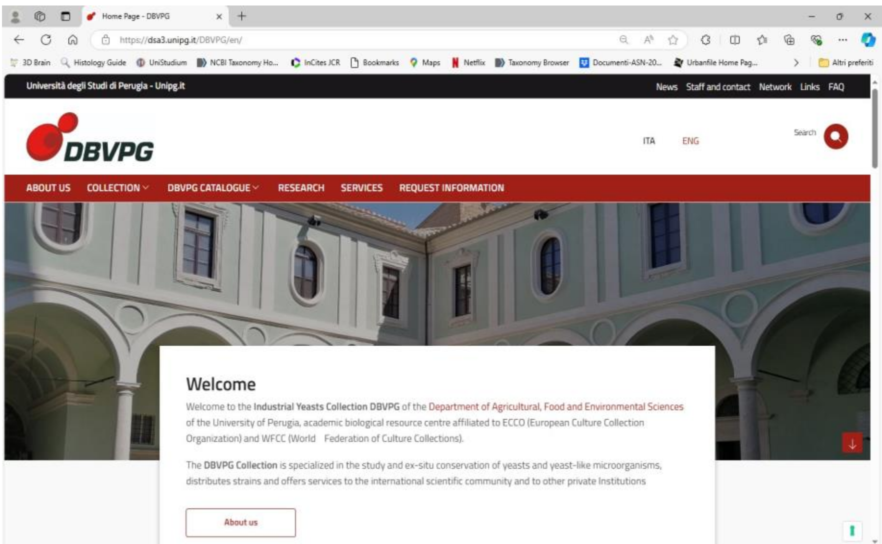
Q.-M. Wang[1], A.M. Yurkov[2], M. Göker[2], H.T. Lumbsch[3], S.D. Leavitt[3], M. Groenewald[4], B. Theelen[4], X.-Z. Liu[1], T. Boekhout[1,4,5*], and F.-Y. Bai[1,4*]

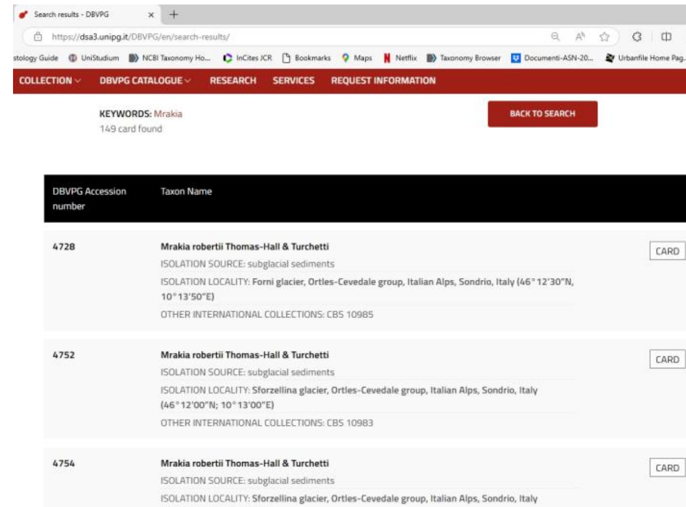
[1]State Key Laboratory of Mycology, Institute of Microbiology, Chinese Academy of Sciences, Beijing 100101, China; [2]Leibniz Institute DSMZ – German Collection of Microorganisms and Cell Cultures, Braunschweig, Germany; [3]Science & Education, The Field Museum, 1400 S. Lake Shore Drive, Chicago, IL 60605, USA; [4]CBS Fungal Biodiversity Centre (CBS–KNAW), Uppsalalaan 8, 3584 CT Utrecht, The Netherlands; [5]Shanghai Key Laboratory of Molecular Medical Mycology, Changzheng Hospital, Second Military Medical University, Shanghai, China

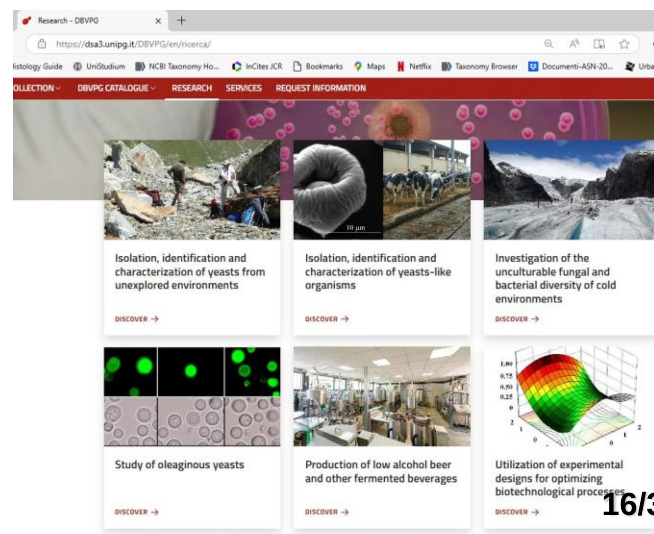
*Correspondence: T. Boekhout, t.boekhout@cbs.knaw.nl; F.-Y. Bai, baify@im.ac.cn

5. Culturable diversity of cold-adapted yeasts in worldwide cold environments (E)

5.5 *Ex-situ* conservation of yeast isolates in the Industrial Yeasts Collection DBVPG







www.dbvpg.unipg.it

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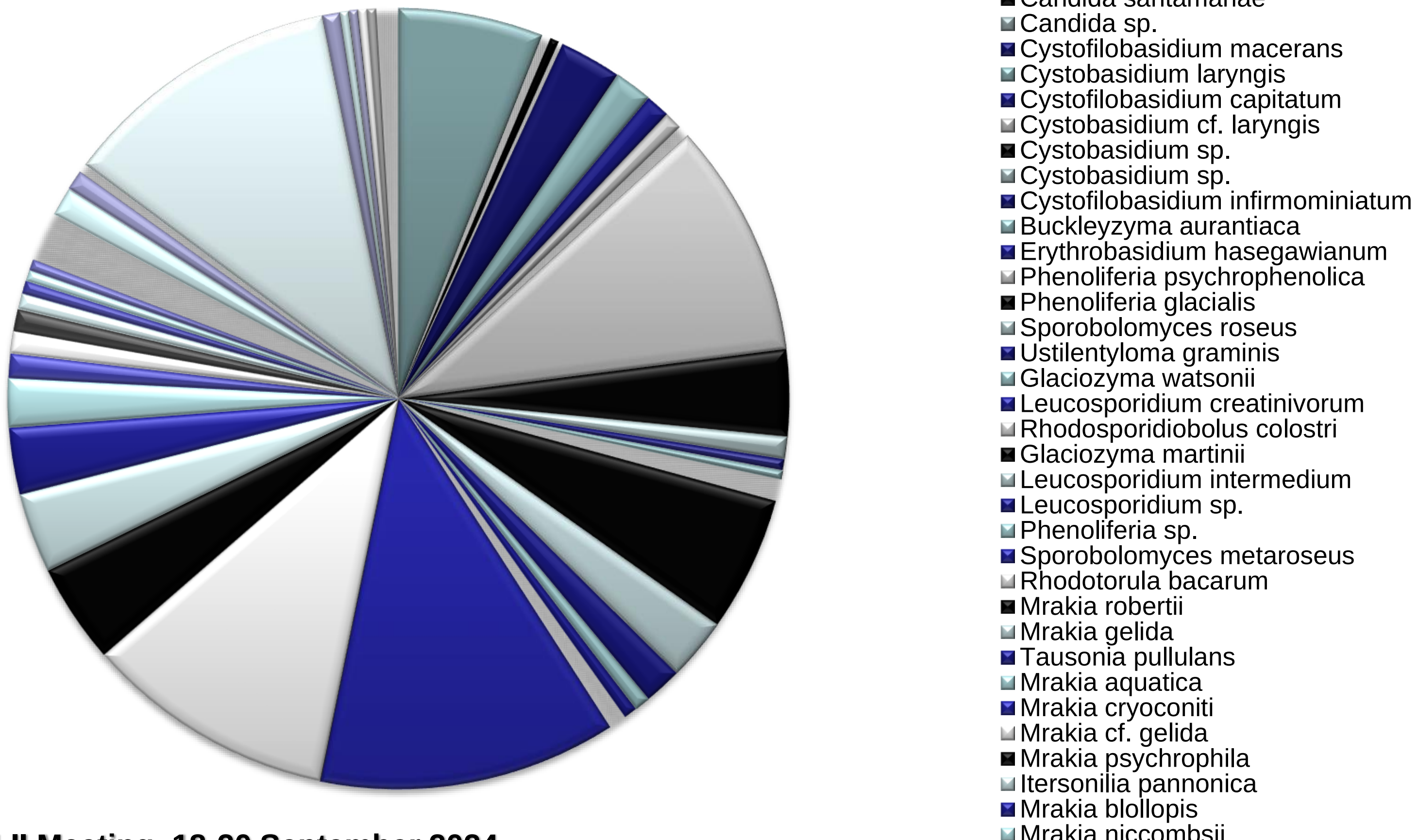
5. Culturable diversity of cold-adapted yeasts in worldwide cold environments (F)

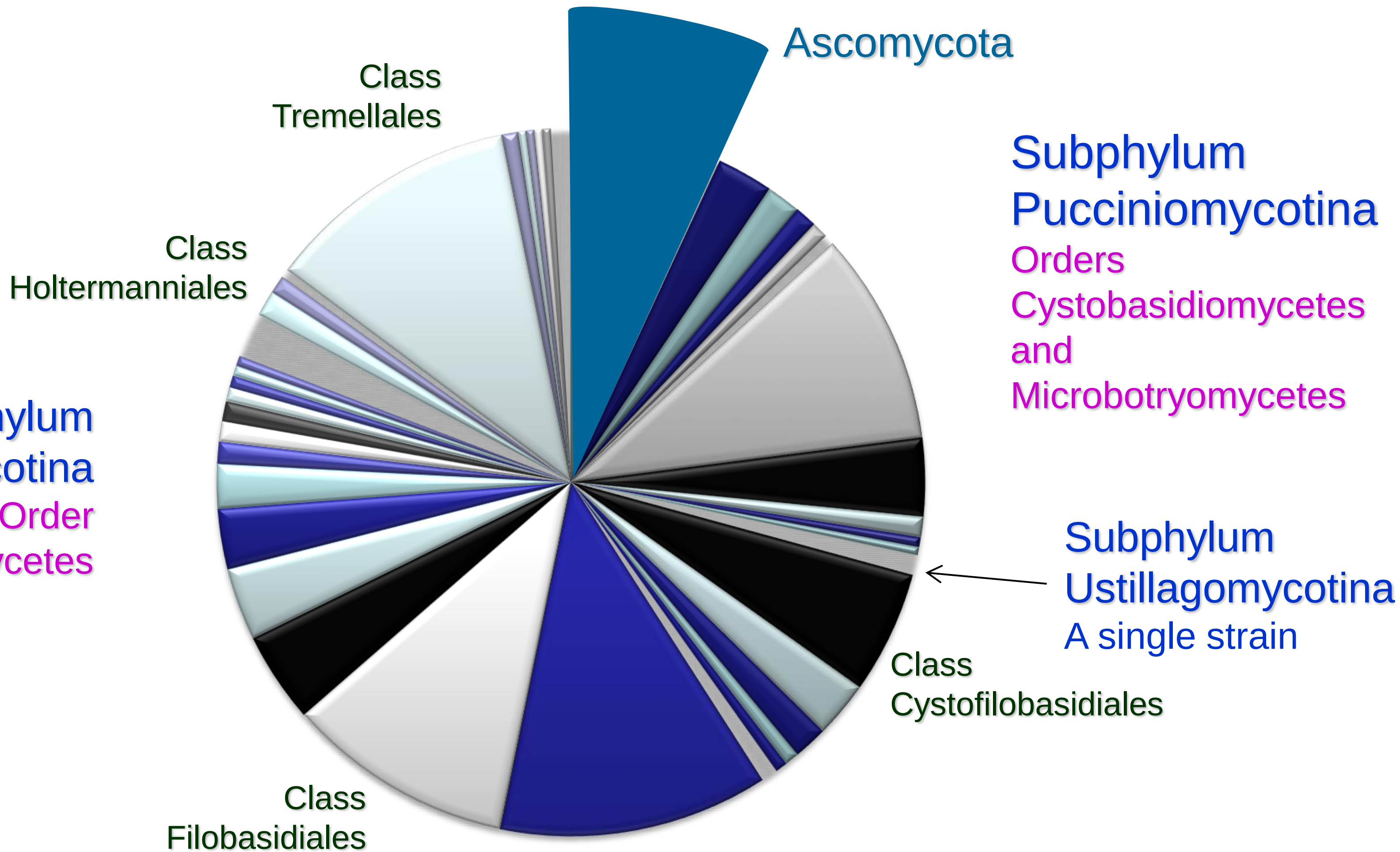
5.5 Results: culturable yeast diversity found

1,160 strains belonging to 78 species



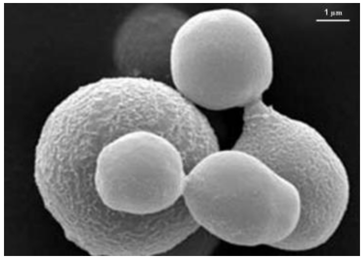
5. Culturable diversity of cold-adapted yeasts in worldwide cold environments (F)

5.5 Results: Ascomycota *vs* Badisiomycota

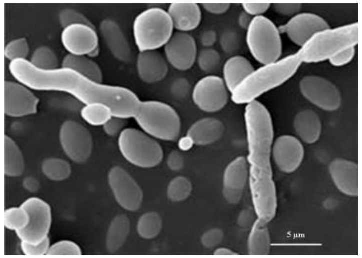


5. Culturable diversity of cold-adapted yeasts in worldwide cold environments (G)

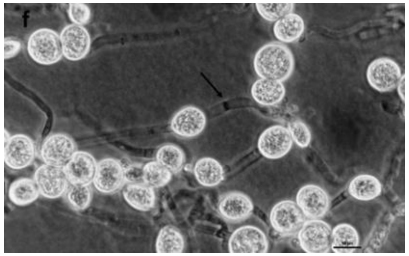
5.6 Some new genera and species recently described by DBVPG (1)



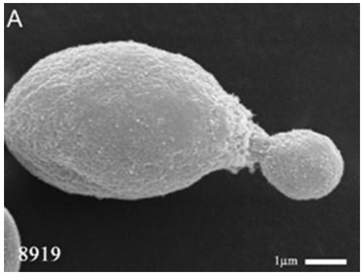
Glaciozyma martinii



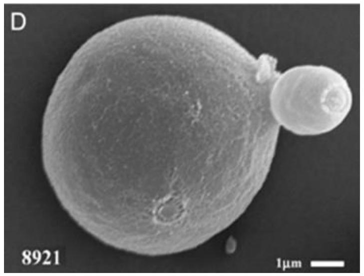
Glaciozyma watsonii



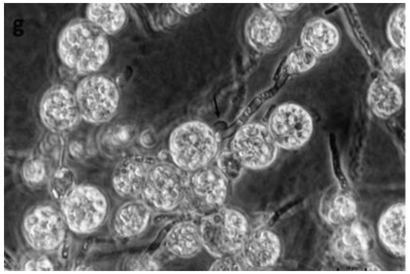
Mrakia stelvica



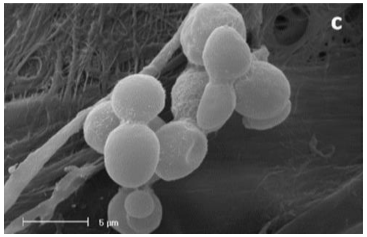
Mrakia robertii



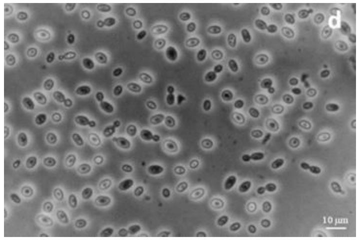
Mrakia blollopis



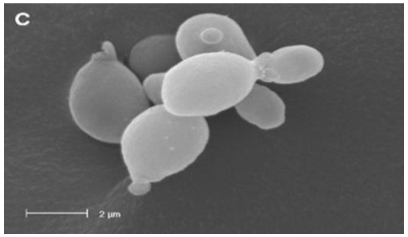
Mrakia montana



Naganishia vaughanmartiniae



Naganishia onofrii



Taphrina antarctica

Extremophiles (2011) 15:573–586
DOI 10.1007/s00792-011-0388-x

ORIGINAL PAPER

Psychrophilic yeasts from Antarctica and European glaciers: description of *Glaciozyma* gen. nov., *Glaciozyma martinii* sp. nov. and *Glaciozyma watsonii* sp. nov.

Benedetta Turchetti · Skye R. Thomas Hall · Laurie B. Connell · Eva Branda · Pietro Buzzini · Bart Theelen · Wally H. Müller · Teun Boekhout

Extremophiles (2010) 14:47–59
DOI 10.1007/s00792-009-0286-7

ORIGINAL PAPER

Cold-adapted yeasts from Antarctica and the Italian Alps—description of three novel species: *Mrakia robertii* sp. nov., *Mrakia blollopis* sp. nov. and *Mrakiella niccombsii* sp. nov.

Skye Robin Thomas-Hall · Benedetta Turchetti · Pietro Buzzini · Eva Branda · Teun Boekhout · Bart Theelen · Kenneth Watson

Extremophiles (2015) 19:149–159
DOI 10.1007/s00792-014-0692-3

ORIGINAL PAPER

***Cryptococcus vaughanmartiniae* sp. nov. and *Cryptococcus onofrii* sp. nov.: two new species isolated from worldwide cold environments**

Benedetta Turchetti · Laura Selbmann · Robert A. Blanchette · Simone Di Mauro · Elisabetta Marchegiani · Laura Zucconi · Brett E. Arenz · Pietro Buzzini

INTERNATIONAL JOURNAL OF SYSTEMATIC AND EVOLUTIONARY MICROBIOLOGY

TAXONOMIC DESCRIPTION
Turchetti *et al.*, *Int. J. Syst. Evol. Microbiol.* 2020;70:4704–4713
DOI 10.1099/ijsem.0.004336

MICROBIOLOGY SOCIETY

Mrakia stelviica sp. nov. and *Mrakia montana* sp. nov., two novel basidiomycetous yeast species isolated from cold environments

Benedetta Turchetti[1,*], Ciro Sannino[1], Ambra Mezzasoma[1], Laura Zucconi[2], Silvano Onofri[2] and Pietro Buzzini[1]

Extremophiles (2014) 18:707–721
DOI 10.1007/s00792-014-0651-z

ORIGINAL PAPER

Description of *Taphrina antarctica f.a.* sp. nov., a new anamorphic ascomycetous yeast species associated with Antarctic endolithic microbial communities and transfer of four *Lalaria* species in the genus *Taphrina*

Laura Selbmann · Benedetta Turchetti · Andrey Yurkov · Clarissa Cecchini · Laura Zucconi · Daniela Isola · Pietro Buzzini · Silvano Onofri

5. Culturable diversity of cold-adapted yeasts in worldwide cold environments (H)

5.7 Some new genera and species recently described by DBVPG (2)

Mycological Progress (2019) 18:945–971
https://doi.org/10.1007/s11557-019-01491-5

DGfM

ORIGINAL ARTICLE

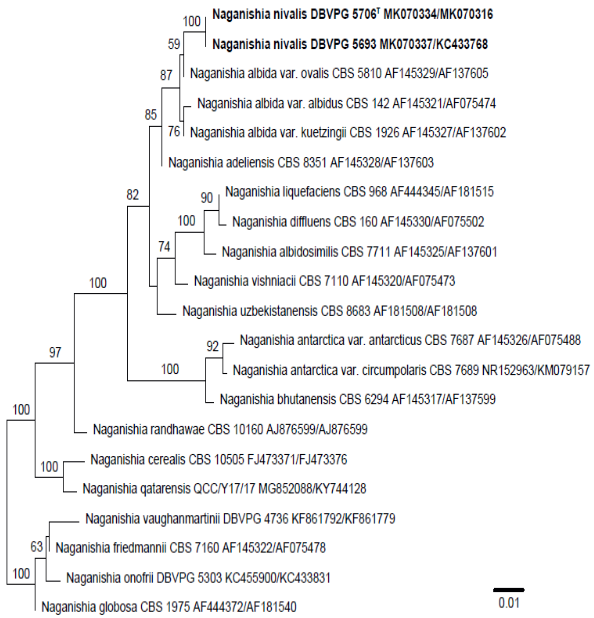
Check for updates

Rare and undersampled dimorphic basidiomycetes

A. V. Kachalkin[1,2] · B. Turchetti[3] · J. Inácio[4,5] · C. Carvalho[6] · T. Mašínová[7] · A. Pontes[6] · O. Röhl[8] · A. M. Glushakova[1] · A. Akulov[9] · P. Baldrian[7] · D. Begerow[8] · P. Buzzini[3] · J. P. Sampaio[6] · A. M. Yurkov[10]

<u>New genera and species described</u>

- ✓ ***Vustinia terrea***
- ✓ ***Udeniomyces* (*U. caspiensis*, *U. orazovii*)**
- ✓ ***Tausonia rosea***
- ✓ ***Itersonilia diksonensis***
- ✓ ***Krasilnikovozyma fibulata***
- ✓ ***Gelidatrema glaciarii***
- ✓ ***Kwoniella fici***
- ✓ ***Heterocephalacria* (*H. fruticeti*, *H. gelida*, *H. hypogea*, *H. lusitanica*)**
- ✓ ***Piskurozyma* (*P. arborea*, *P. silvicultrix*, *P. stramentorum*)**
- ✓ ***Naganishia nivalis***
- ✓ ***Yurkovia nerthusi***



5. Culturable diversity of cold-adapted yeasts in worldwide cold environments (I)

5.7 Some new genera and species yet to be described by DBVPG

- ✓ ~ **13%** of total strains resulted to belong to new species
- ✓ ~ **20%** of species found were new species

A few examples

***FILOBASIDIUM* sp.**				***DOSZEGIA* sp. 1**			
No of strains	year of	Locality	isolation sources	No of strains	year of	Locality	isolation sources
13	from 2007 to 2010	Apennines	sediments, ice cores, snow	15	from 2010 to 2014	Alps	snow, sediments, melt water
***VISHNIACOZYMA* sp.**				***DOSZEGIA* sp. 2**			
No of strains	year of	Locality	isolation sources	No of strains	year of	Locality	isolation sources
3	2008, 2009	Alps	sediments,	2	2010, 2011	Alps	snow
***GELIDATREMA* sp.**				***DOSZEGIA* sp. 3**			
No of strains	year of	Locality	isolation sources	No of strains	year of	Locality	isolation sources
1	2008	Alps	snow	1	2011	Alps	snow
***CYSTOBASIDIUM* sp.**				***NAGANISHA* sp.**			
No of strains	year of	Locality	isolation sources	No of strains	year of	Locality	isolation sources
11	from 2008 to 2014	Alps	soils, sediments, snow	23	from 2008 to 2014	Alps	soils, sediments
***LEUCOSPORIDIUM* sp.**				***MRAKIA* sp.**			
No of strains	year of	Locality	isolation sources	No of strains	year of	Locality	isolation sources
1	2008	Alps	soil	3	2009, 2010	Alps	sediments, ice cores,
***CRYPTOCOCCUS* sp.**				***AUREOBASIDIUM* SP.**			
No of strains	year of	Locality	isolation sources	No of strains	year of	Locality	isolation sources
1	2009	Miage	sedimenti	1	2009	Alps	sediments

6. Unculturable diversity (NGS) of cold-adapted fungi (including yeasts) (A)

6.1 A paradigm shift (2020-today)

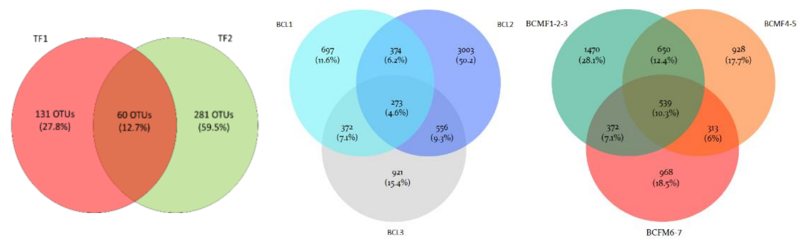
- Most microbial taxa (including yeasts) cannot be cultured under laboratory conditions
- As a consequence, culturomic results represent at best only a partial picture of the yeast diversity occurring in worldwide cold ecosystems

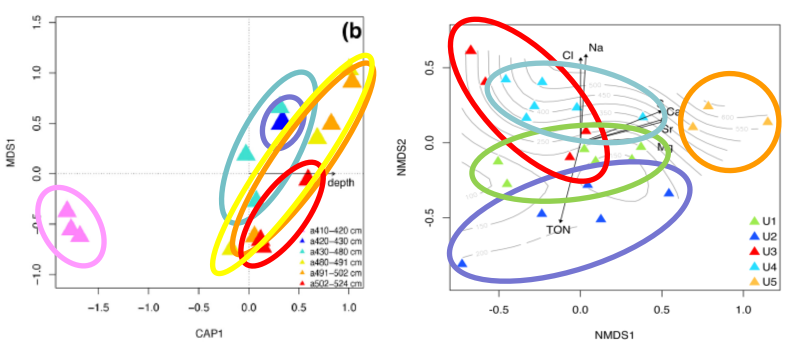
- Non-culturable yeast (fungal) diversity → Next Generation Sequencing of Antarctic and Alpine samples

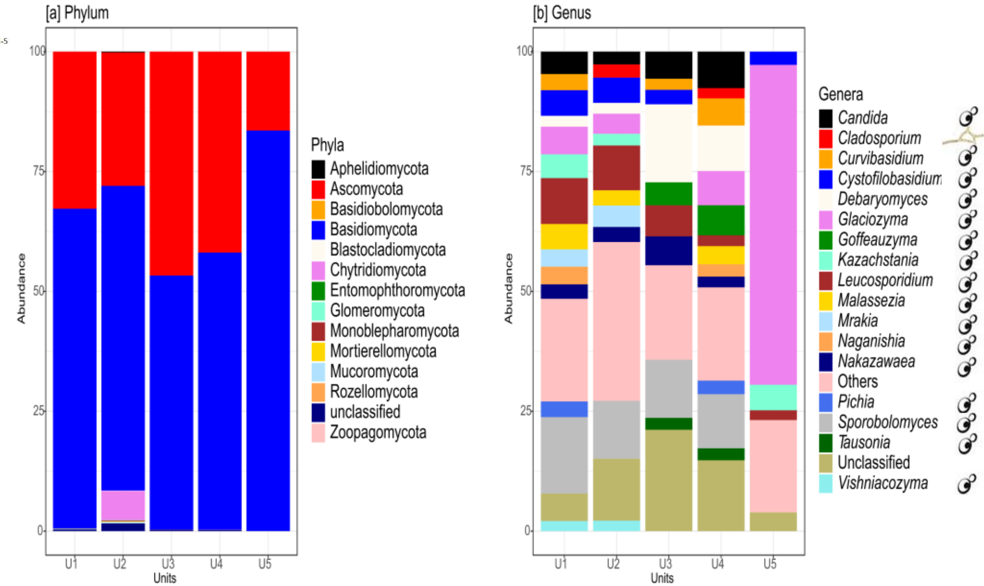
6. Unculturable diversity (NGS) of cold-adapted fungi (including yeasts) (B)

6.2 Recent results on fungal biodiversity found on Antarctic and Alpine habitats: a general overview (2020-today)

- ✓ Alpha-diversity and beta-diversity → fungal (including yeasts) communities well adapted to cold ecosystems
- ✓ High differentiation of fungal communities among different sites/layers → predominance of specialist OTUs







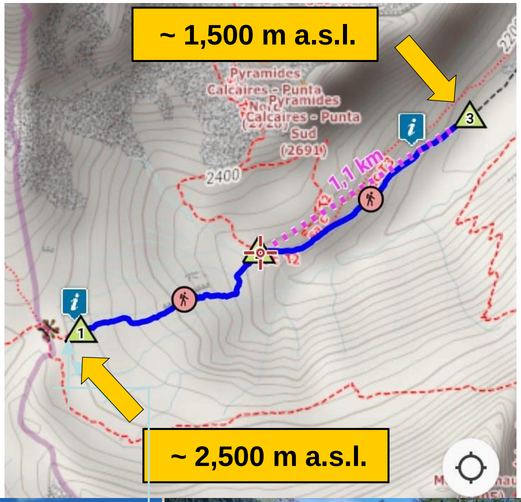
- ✓ Yeasts dominated the fungal biodiversity in almost all studied habitats

7. Predicting the impact of climate change on Alpine soil fungal community

7.1 Ongoing project (2022-2025): “MICROPLANTALP”

https://sites.google.com/unitus.it/microplantalp/home

PRIN 2020



8. Physiological/molecular adaptation to cold (A)

8.1 Cold-active enzymes

- ✓ **Extracellular cold-active enzymes degrading organic polymers → *in-situ* C and N co-mineralizers?**

RESEARCH ARTICLE

Psychrophilic yeasts in glacial environments of Alpine glaciers

Benedetta Turchetti[1], Pietro Buzzini[1], Marta Goretti[1], Eva Branda[1], Guglielmina Diolaiuti[2], Carlo D'Agata[2], Claudio Smiraglia[2] & Ann Vaughan-Martini[1]

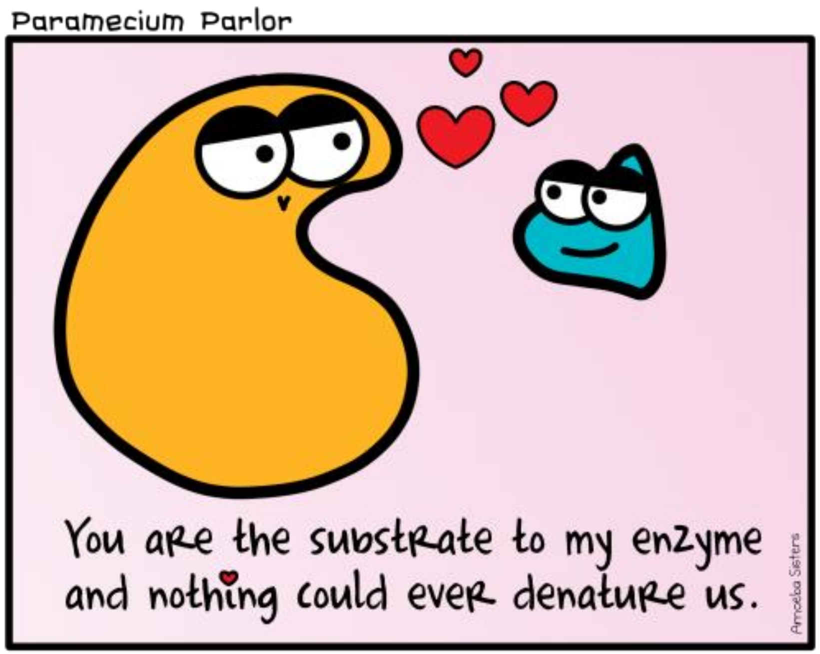
[1]Dipartimento di Biologia Applicata, Sezione di Microbiologia, University of Perugia, Perugia, Italy; and [2]Dipartimento di Scienze della Terra 'Ardito Desio', University of Milan, Milan, Italy

RESEARCH ARTICLE

Yeast and yeast-like diversity in the southernmost glacier of Europe (Calderone Glacier, Apennines, Italy)

Eva Branda[1], Benedetta Turchetti[1], Guglielmina Diolaiuti[2], Massimo Pecci[3], Claudio Smiraglia[2] & Pietro Buzzini[1]

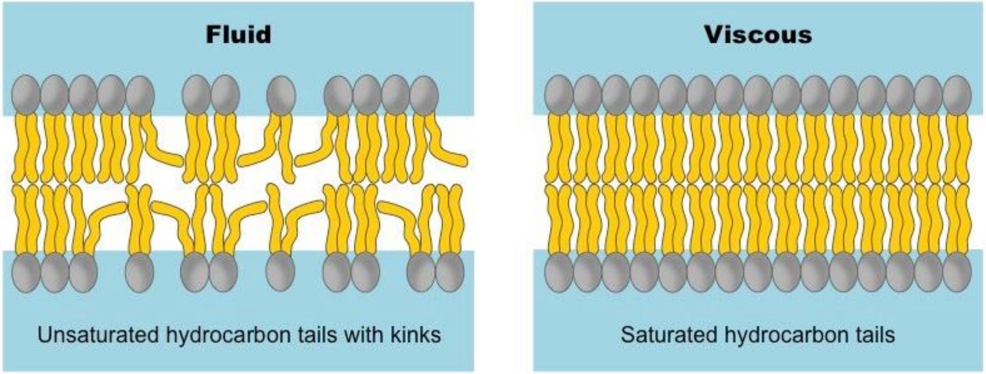
[1]Department of Applied Biology and Industrial Yeasts Collection DBVPG, University of Perugia, Italy; [2]Department of Health Sciences 'Ardito Desio', University of Milan, Italy; and [3]Italian Mountain Institute (EIM), Rome, Italy



8. Physiological/molecular adaptation to cold (B)

8.2 Lipid composition

- High concentration of intracellular unsaturated lipids (e.g. PUFAs) → increased fluidity of cell cytoplasm and membranes at low temperatures



RESEARCH ARTICLE

Growth, lipid accumulation, and fatty acid composition in obligate psychrophilic, facultative psychrophilic, and mesophilic yeasts

Maddalena Rossi[1], Pietro Buzzini[2], Lisa Cordisco[3], Alberto Amaretti[1], Maurizio Sala[1], Stefano Raimondi[1], Chiara Ponzoni[1], Ugo Maria Pagnoni[1] & Diego Matteuzzi[3]

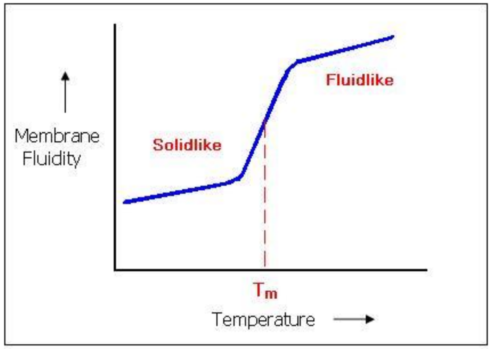
[1]Department of Chemistry, University of Modena and Reggio Emilia, Modena, Italy; [2]Department of Applied Biology, Industrial Yeasts Collection DBVPG, University of Perugia, Perugia, Italy; and [3]Department of Pharmaceutical Sciences, University of Bologna, Bologna, Italy

Chapter 10
Changes in Lipids Composition and Fluidity of Yeast Plasma Membrane as Response to Cold

Nina Gunde-Cimerman, Ana Plemenitaš and Pietro Buzzini

DOI: 10.1007/978-3-642-39681-6_5, © Springer-Verlag Berlin Heidelberg 2014

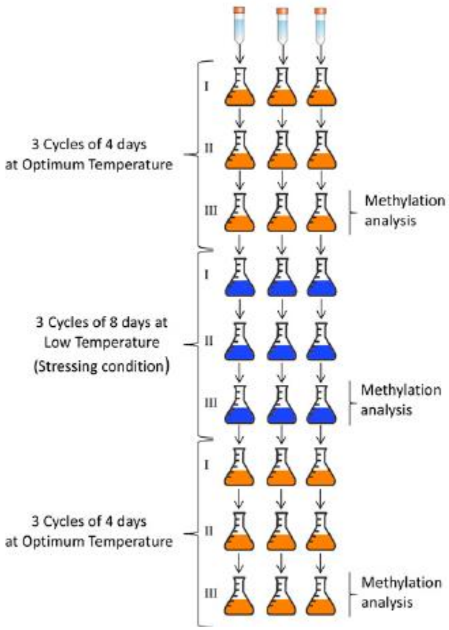
Membrane Fluidity vs. Temperature

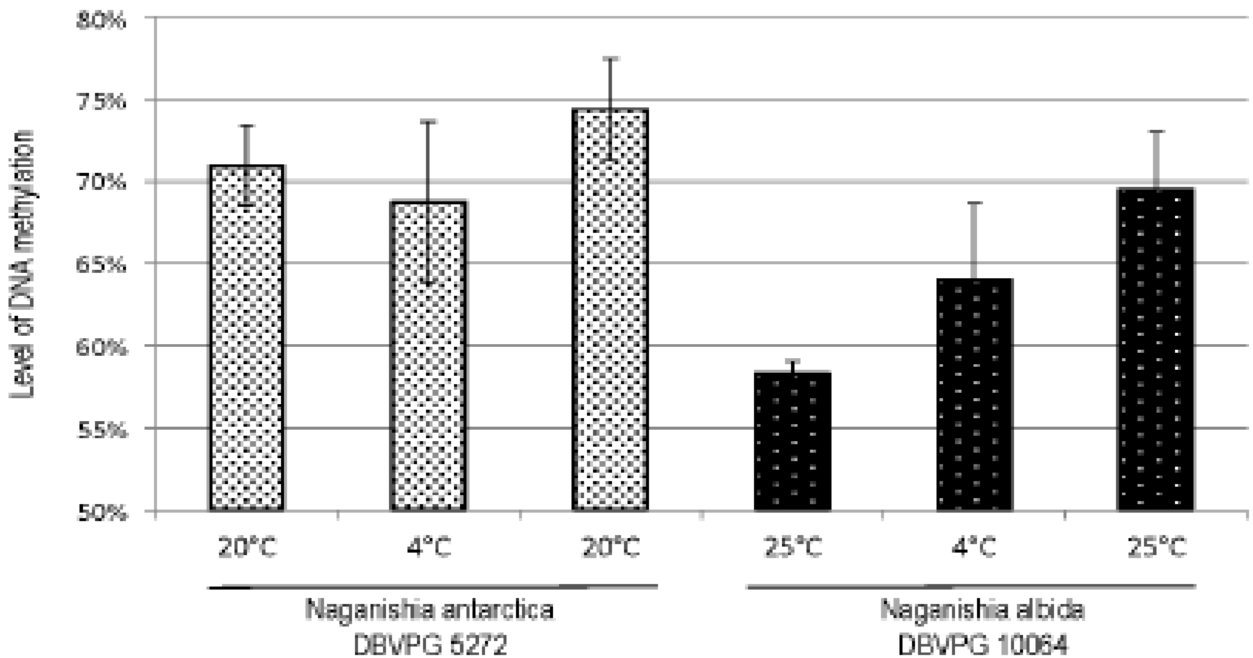


With an increase in temperature, the sharp transition is made from a more rigid membrane to a more fluid one.

8. Physiological/molecular adaptation to cold (C)

8.2 DNA methylation





- ✓ *N. antarctica* → no increase of methylation level after recovery from stress → reversible cold-induced physiology and biochemistry

- ✓ *N. albida* → increase of methylation level after recovery from stress → not-reversible cold-induced physiology and biochemistry

microorganisms MDPI

Article

DNA Methylation Changes Induced by Cold in Psychrophilic and Psychrotolerant *Naganishia* Yeast Species

Benedetta Turchetti *,†, Gianpiero Marconi †, Ciro Sannino, Pietro Buzzini and Emidio Albertini

Department of Agricultural, Food and Environmental Sciences, University of Perugia, Borgo XX Giugno, 74, 06121 Perugia, Italy; gianpiero.marconi@unipg.it (G.M.); ciro.sannino@unipg.it (C.S.); pietro.buzzini@unipg.it (P.B.); emidio.albertini@unipg.it (E.A.)
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† Contributed equally to this work.

9. A look to biotechnology of cold-adapted yeasts (A)

9.1 Cold-active enzymes for mild technologies (A)

✓ **A number of yeasts strains were found to secrete extracellular enzymes active at 4°C**

A few examples:

- *Goffeauzyma gilvescens*: 90% positive for SDA, 100% for esterase activity
- *Mrakia gelida*: 100% positive for SDA* and protease activity
- *Cytstobasidium laryngis*: 100% positive for esterase activity

* Starch Degrading Activity

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RESEARCH ARTICLE

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9. A look to biotechnology of cold-adapted yeasts (B)

9.2 Cold-active enzymes for mild technologies (B)

RESEARCH ARTICLE

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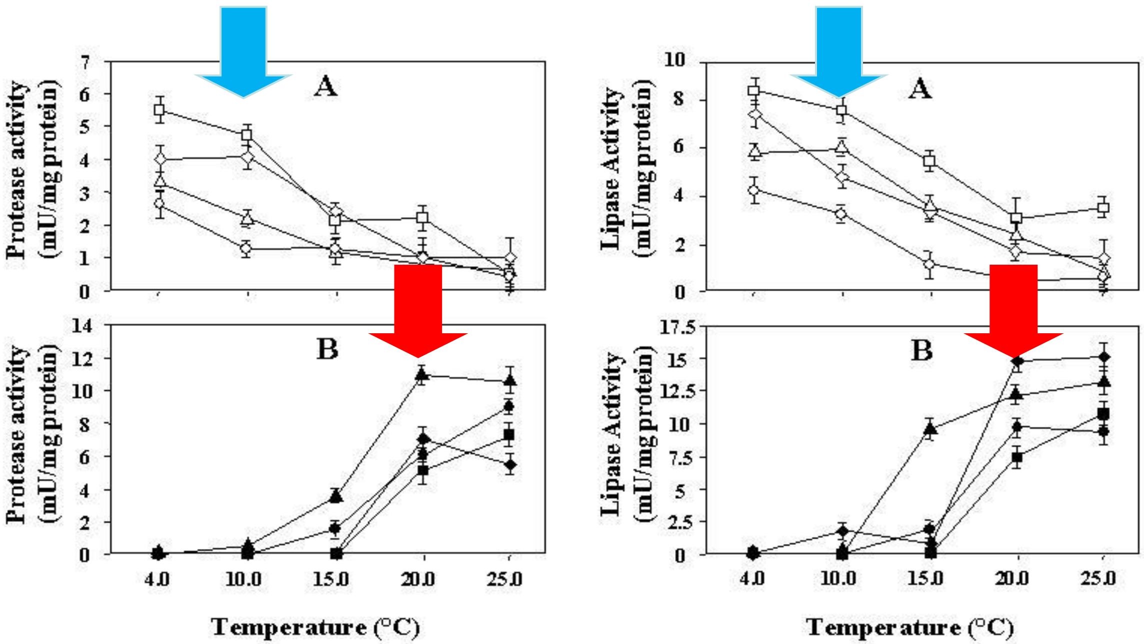
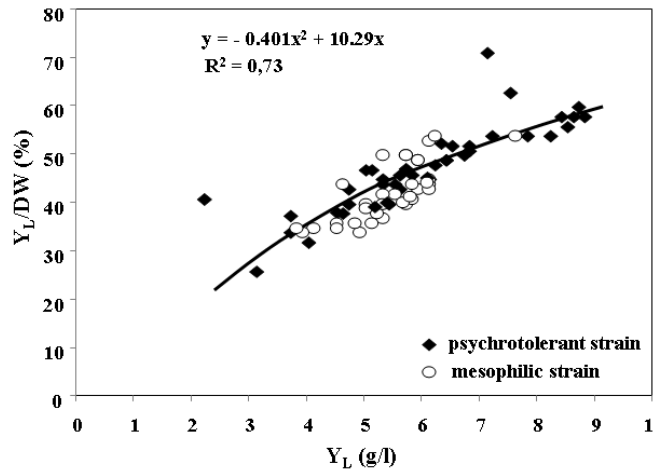


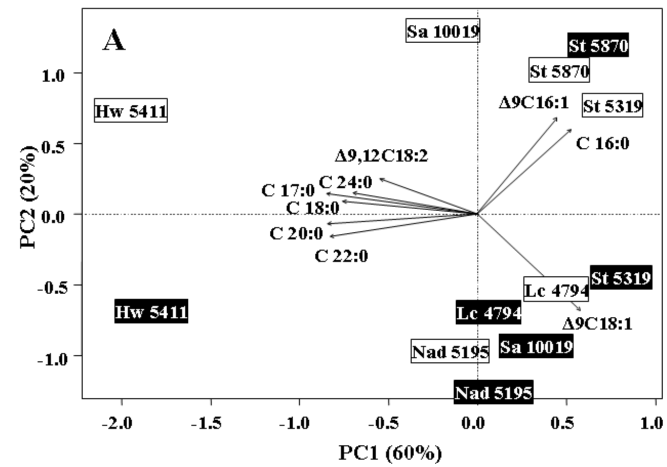
Extracellular enzymatic activity at different temperatures of cell-free extracts of psychrophilic yeasts isolated from:

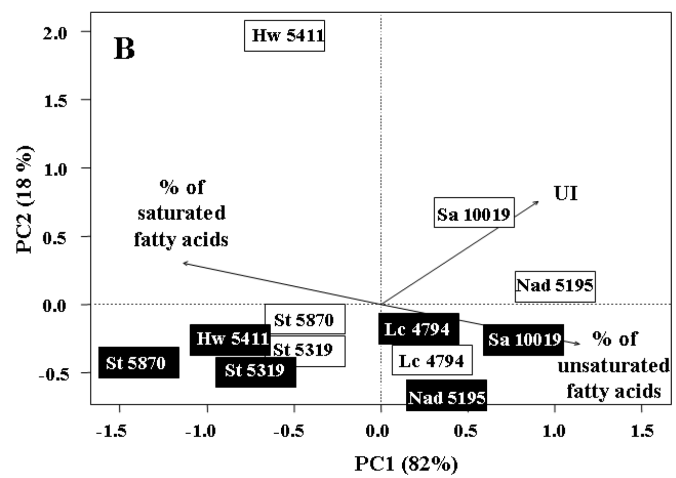
- glacial (A) habitats
- tropical (B) habitats

9. A look to biotechnology of cold-adapted yeasts (C)

9.2 Accumulation of PUFAs







Adaptation strategy to low temperatures:

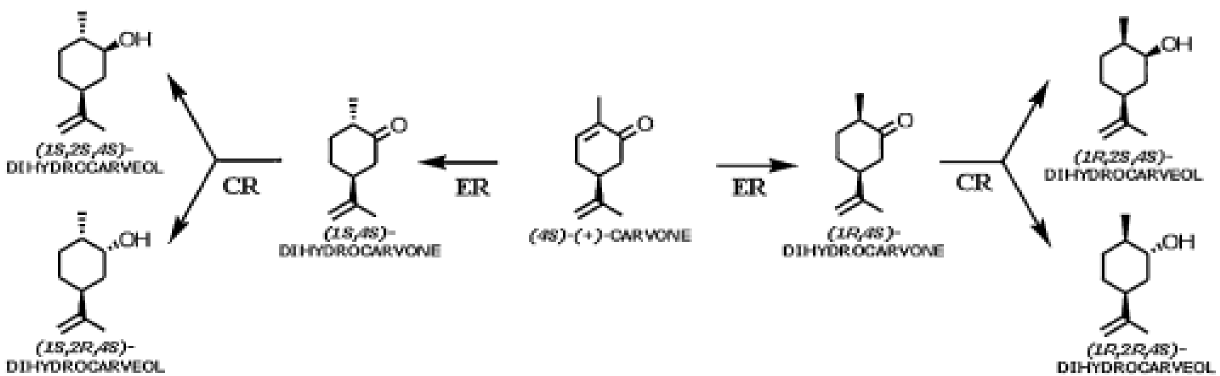
- ➢ increased lipid production
- ➢ increased lipid unsaturation

DOI 10.1186/s13068-016-0672-1
Biotechnology for Biofuels
RESEARCH Open Access

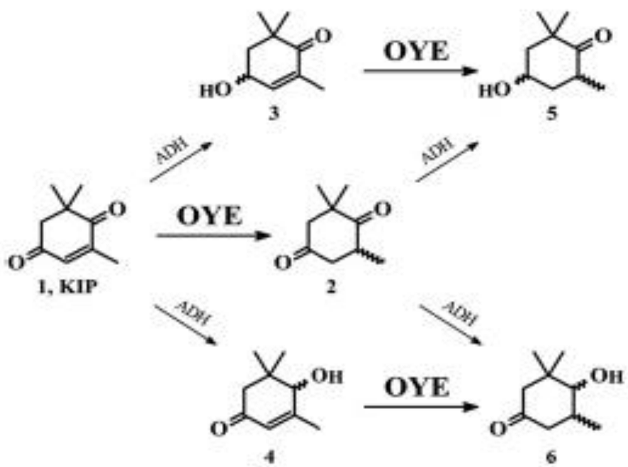
Study of *Holtermanniella wattica*, *Leucosporidium creatinivorum*, *Naganishia adeliensis*, *Solicoccozyma aeria*, and *Solicoccozyma terricola* for their lipogenic aptitude from different carbon sources

Sara Filippucci[1†], Giorgia Tasselli[1†], Alessandro Scardua[2], Simone Di Mauro[1], Maria Rita Cramarossa[3], Davide Perini[2], Benedetta Turchetti[1], Andrea Onofri[1], Luca Forti[3] and Pietro Buzzini[1*]

9.3 Stereoselective catalysis of NADH/NADPH-mediated redox reactions



- ✓ Ability to reduce α,β electron-poor compounds
- ✓ Synthesis of “building-blocks” molecules of pharmaceutical interest via biocatalysis



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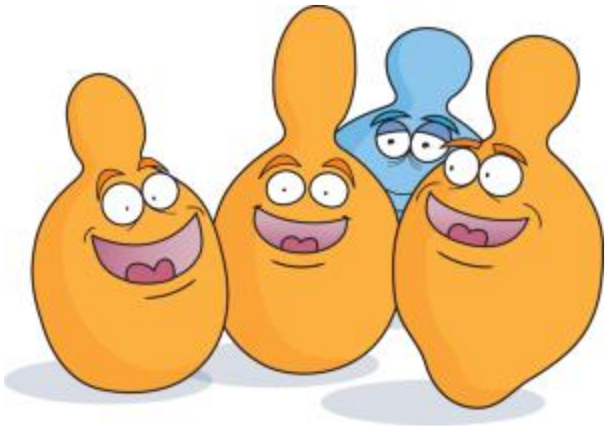
Bioreduction of α,β-unsaturated ketones and aldehydes by non-conventional yeast (NCY) whole-cells

Marta Goretti [a], Chiara Ponzoni [b], Elisa Caselli [b], Elisabetta Marchegiani [a], Maria Rita Cramarossa [b], Benedetta Turchetti [a], Luca Forti [b], Pietro Buzzini [a,*]

10. Take home messages

- Cold-adapted yeasts → extremophilic organisms inhabiting cold habitats worldwide
- A source of new genera/species
- The study of unculturable yeast diversity by NGS → a more complete picture
- Physiological/molecular adaptation to cold → peculiar mechanisms (e.g. cold-active enzymes, lipid composition, DNA methylation, etc.)
- Cold-adapted yeasts → possible biotechnological exploitation



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- ✓ L. B. Connell, University of Maine, USA
- ✓ D. Libkind, University of Comahue, CONICET, Argentina
- ✓ N. Gunde-Cimerman, Biology Department, Biotechnical Faculty, University of Ljubljana, Slovenia
- ✓ R. Margesin, Institute of Microbiology, University of Innsbruck, Austria
- ✓ M. Baeza Cancino, Universidad De Chile, Santiago, Chile

12. Sampling pictures

13. A bit of humor

100 How to Write and Publish a Scientific Paper

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