



The NCYC: brewing up biodiversity for biotechnology

Steve James

National Collection of Yeast Cultures

(A BBSRC supported National Capability)



Where is the NCYC?

- Based at the Institute of Food Research (IFR), Norwich, UK [Since 1981]



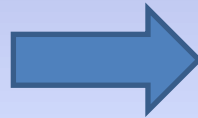
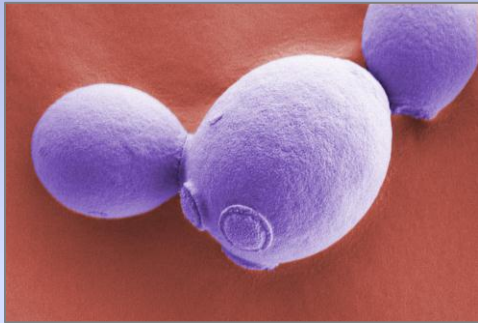
- Located on the Norwich Research Park (NRP)



- **Institute of Food Research**
- John Innes Centre
- The Sainsbury Laboratory
- The Genome Analysis Centre
- Norfolk & Norwich Univ. Hospital
- University of East Anglia (UEA)

NCYC: Brewing collection

Collection set up in 1948



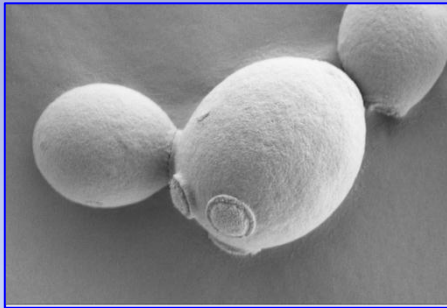
S. bayanus
S. cerevisiae
S. pastorianus
S. uvarum

Ale
Cider
Lager
Wine

500+ brewing strains

How has the NCYC collection evolved?

Brewing

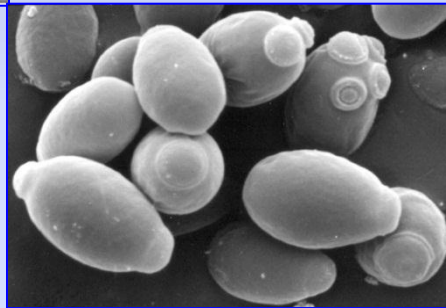


Saccharomyces cerevisiae

UK's largest non-pathogenic yeast collection

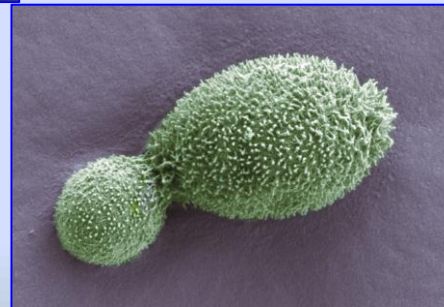
(4000+ strains; 500+ species)

Spoilage



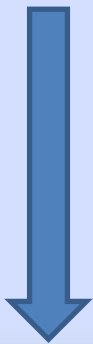
Zygosaccharomyces bailii

Environmental



Cryptococcus shivajii

1980s



Present

Biorefinery Centre

Aim: Convert waste biomass into added value products



- Second generation biofuel production
- Biomass exploitation
- Fibre modification
- **Yeast screening & propagation**
- Lab scale → Small pilot



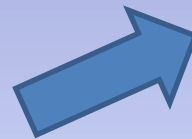
Steam explosion unit



www.biorefinerycentre.ifr.ac.uk

NCYC: Biotechnological resource

Agri-food waste



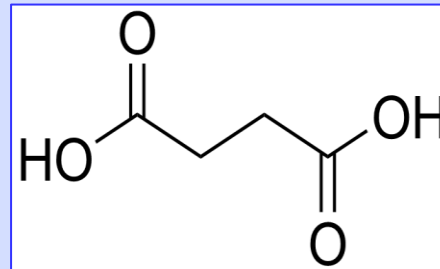
Yeast
screening



Biofuels



Platform chemicals



Genome sequencing (96 strains)

Yeast biodiversity projects

1. Yeast diversity in Ecuador (2006-)

Collaborator: Javier Carvajal
CLQCA, Ecuador



2. Yeasts from wood-boring beetles (2014-)

Collaborator: Tom Harrington
Iowa State University, USA



Redbay ambrosia beetle
(*Xyleborus glabratus*)



1. Yeast diversity in Ecuador



“A yeast bio-prospecting project initiated in 2006 by Enrique Javier Carvajal Barriga (CLQCA). The primary aim of the project is to collect, catalogue, characterise and compare the indigenous yeast species present in the many differing ecological habitats found in Ecuador.”

Biodiversity survey
(On-going)



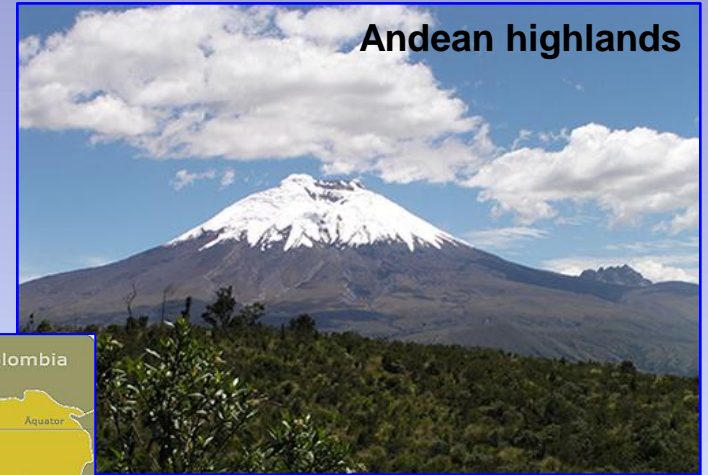
Population genomics study
(2012 -)

Major Climatic Regions of Ecuador



Galapagos Islands

Temp: ~23°C; Rainfall: <1000 mm



Andean highlands

Temp: 4-8°C; Rainfall: 800-2000 mm



Pacific coast

Temp: ~25°C; Rainfall: 500-1000 mm



Amazon basin

Temp: ~25°C; Rainfall: 3000-6000 mm

Maquipucuna Site



- Cloud forest reserve
- North-west Ecuador
- Western slopes of the Andes
- Located within the **Choco-Andean Corridor** (Global biodiversity hotspot*)
- Reserve harbours:
 - 2200+ plant spp.
 - 350+ bird spp.
 - 250+ butterfly spp.
- **What about yeast biodiversity?**

* Myers *et al.* 2000 (Nature **403**, 853-858)

Maquipucuna: Sample sources

- **Fauna**

 - Insects

 - Spiders

- **Flora**

 - Flowering plants

 - Fruit

 - Trees

- **Environment**

 - Soil & Water

 - Guano

Maquipucuna: Yeast species

71 isolates → 26 species from 14 genera

Barnettozyma (1)

Rhodotorula (1)

Candida (6)

Saccharomyces* (1)

Hanseniaspora (2)

Saturnispora (1)

Lachancea (1)

Trichosporon (2)

Lodderomyces (1)

Wickerhamomyces (3)

Metschnikowia (2)

Yamadazyma (1)

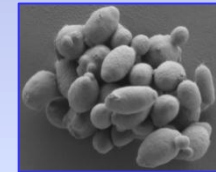
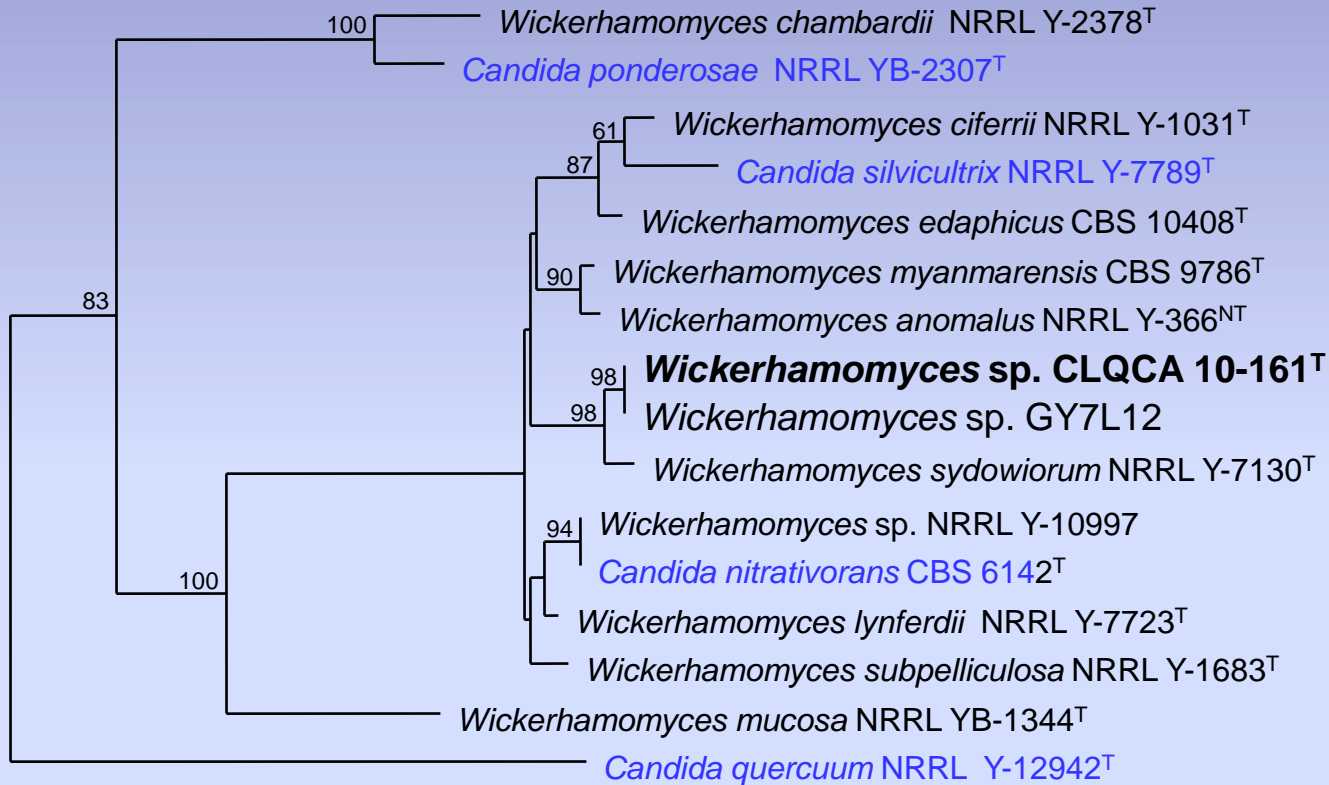
Pichia (3)

Yarrowia (1)

Rich yeast diversity; 3 new species discovered!

* *S. cerevisiae* (ex beetle)

Discovery of a novel *Wickerhamomyces* species



D1/D2 tree

CLQCA 10-161^T (NCYC 3743^T): white flower, unidentified sp., Ecuador

GY7L12 (NCYC 3749) : leaf of a nutgall tree, Taiwan

Wickerhamomyces arborarius f.a., sp. nov., an ascomycetous yeast species found in arboreal habitats on three different continents

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Key physiological characteristics: *Wick. arborarius*

- Fermentative (Glucose)
- Degrades xylose
- Degrades xylitol
- Osmotolerant

Sugar (60% Glucose)

Salt (10% NaCl)

- Grows at 30°C (not at 37°C)
- **Biotechnological use?**

CLQCA 10-161^T, white flower, Ecuador

A543, A546 & A563, wood-boring beetles, USA

GY7L12, nutgall tree, Taiwan

South American *S. cerevisiae* isolates



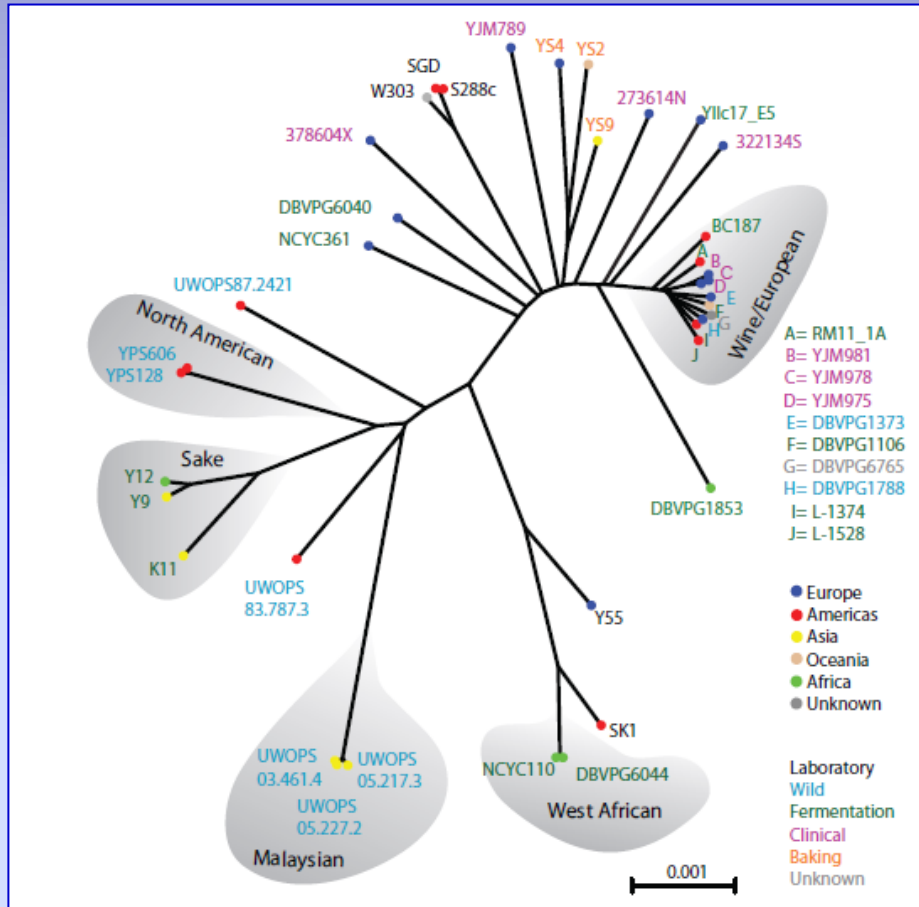
Ecuadorian *S. cerevisiae* collection

Strain	Source	Location	Altitude (m)
CLQCA 02-003	Palm heart	Santo Domingo	485
CLQCA 10-003	Stingless bee	Quito	2811
CLQCA 10-027	Grass	Rumipamba forest	2976
CLQCA 10-619	Beetle	Maquipucuna cloud forest	1120
CLQCA 17-084	Spider	Podocarpus National Park	2000-2223
CLQCA 19-011	Horse dung	Paramo de la Virgen	4300
CLQCA 20-060	Water in leaf	Yasuní National Park	?
CLQCA 24SC-235	Tree exudate	Santa Cruz, Galapagos	?

50+ isolates collected

Origins?

S. cerevisiae global population structure



1. Clean Lineages

- Malaysian
- North American
- Saké
- West African
- Wine/European

- New Zealand
- Chinese (8)

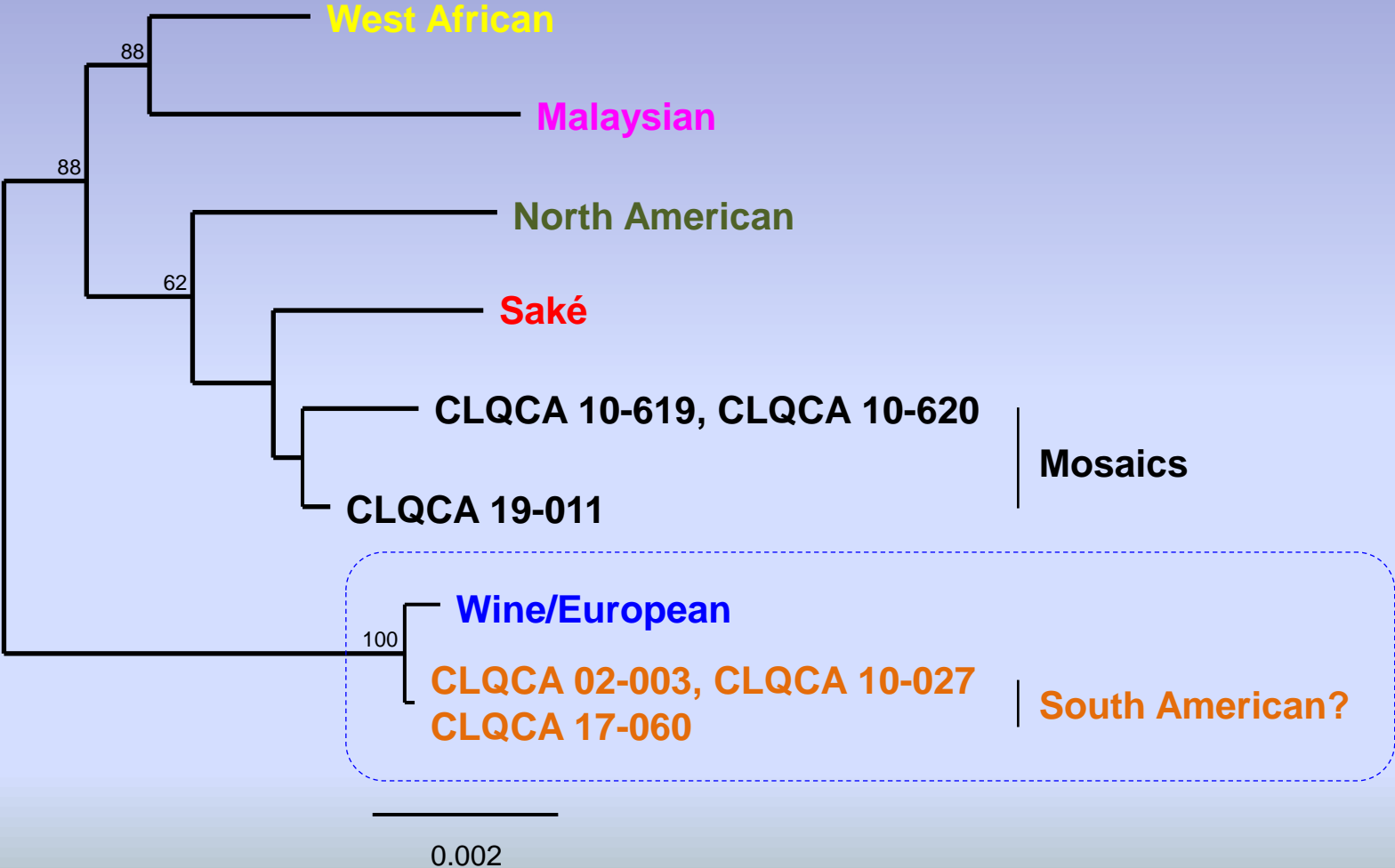
2. Mosaics/Hybrids

- SK1 (WA x W/E)

Saccharomyces Genome Re-sequencing Project

Liti *et al.* 2009 (Nature **458**, 337-341)

S. cerevisiae phylogeny



(Based on multi-locus sequencing)

Current & Future Work



- **Genome Sequencing ('1002 Yeast Genomes' Project*)**

Q. How are they related to other *S. cerevisiae* lineages?



- **Phenotypic characterisation**

Q. Do they possess any lineage-specific traits?

* Gianni Liti (Nice) & Joseph Schacherer (Strasbourg)

2. Yeasts associated with wood-boring beetles



Q. Why select beetles?

Rich source of yeast diversity!

Mycol. Res. **109** (3): 261–265 (March 2005). © The British Mycological Society
doi:10.1017/S0953756205002388 Printed in the United Kingdom.

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The beetle gut: a hyperdiverse source of novel yeasts

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Mycological Res. **109**, 261-265

650 isolates from beetles collected in the USA & Panama

Discovery of 200+ new yeast species!!!

Source of xylose* fermenting yeasts



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available at www.sciencedirect.com



journal homepage: www.elsevier.com/locate/mycres



Morphological and ecological similarities: wood-boring beetles associated with novel xylose-fermenting yeasts, *Spathaspora passalidarum* gen. sp. nov. and *Candida jeffriesii* sp. nov.

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^bOregon State Arthropod Collection, 4082 Cordley Hall, Oregon State University, Corvallis, Oregon 97331, USA

Mycological Res. **110**, 1232-1241

Yeasts may be involved in the breakdown of hemicellulose

* Xylose – key component of hemicellulose (present in plant cell walls)

Beetle yeast isolates (Pilot study)

Beetle species	Yeast isolates [†]
<i>Cyclorhipidion bodoanum</i>	1
<i>Monarthrum mali</i>	1
<i>Monarthrum fasciatus</i>	2
<i>Scolytus multistriatus</i>	1
<i>Scolytus schevyrewi</i>	4
<i>Xyleborus glabratus</i>*	33
<i>Xyleborus gracilis</i>	2
<i>Xyleborinus saxeseni</i>	1
Unknown sp.	1
Total	46

* Redbay ambrosia beetle

[†] c/o Tom Harrington/Doug McNew (Iowa State University)

Redbay ambrosia beetle, *Xyleborus glabratus*



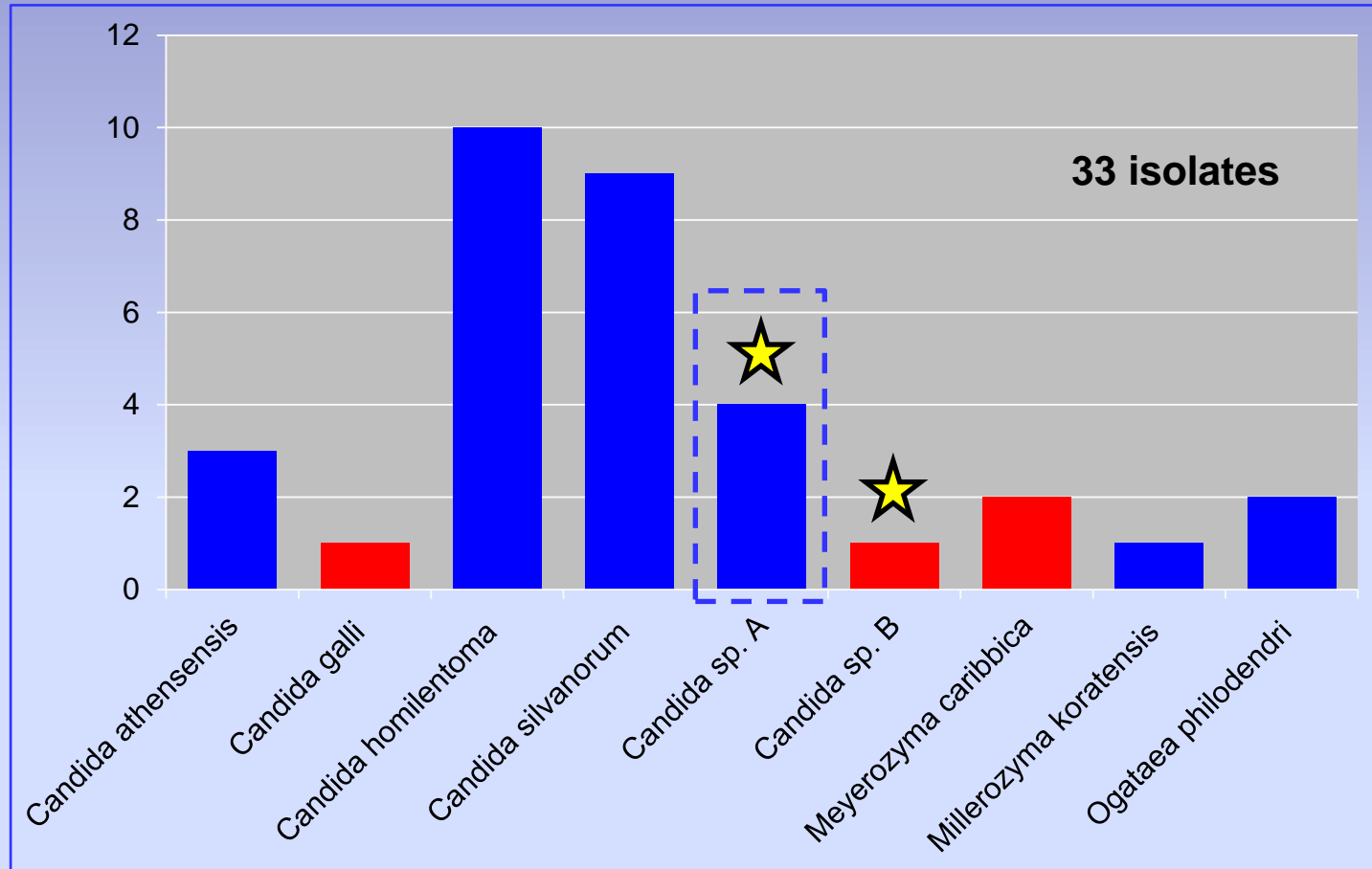
Size: 1-2 mm

- Flightless beetle
- Native to Asia
- Feeds on its fungal symbiont*
- First detected in the US in 2002
- Fungal symbiont causes **laurel wilt**
- Disease affects and kills members of the laurel family (incl. avocado)

* *Raffaelea lauricola*

What yeast species do they carry?

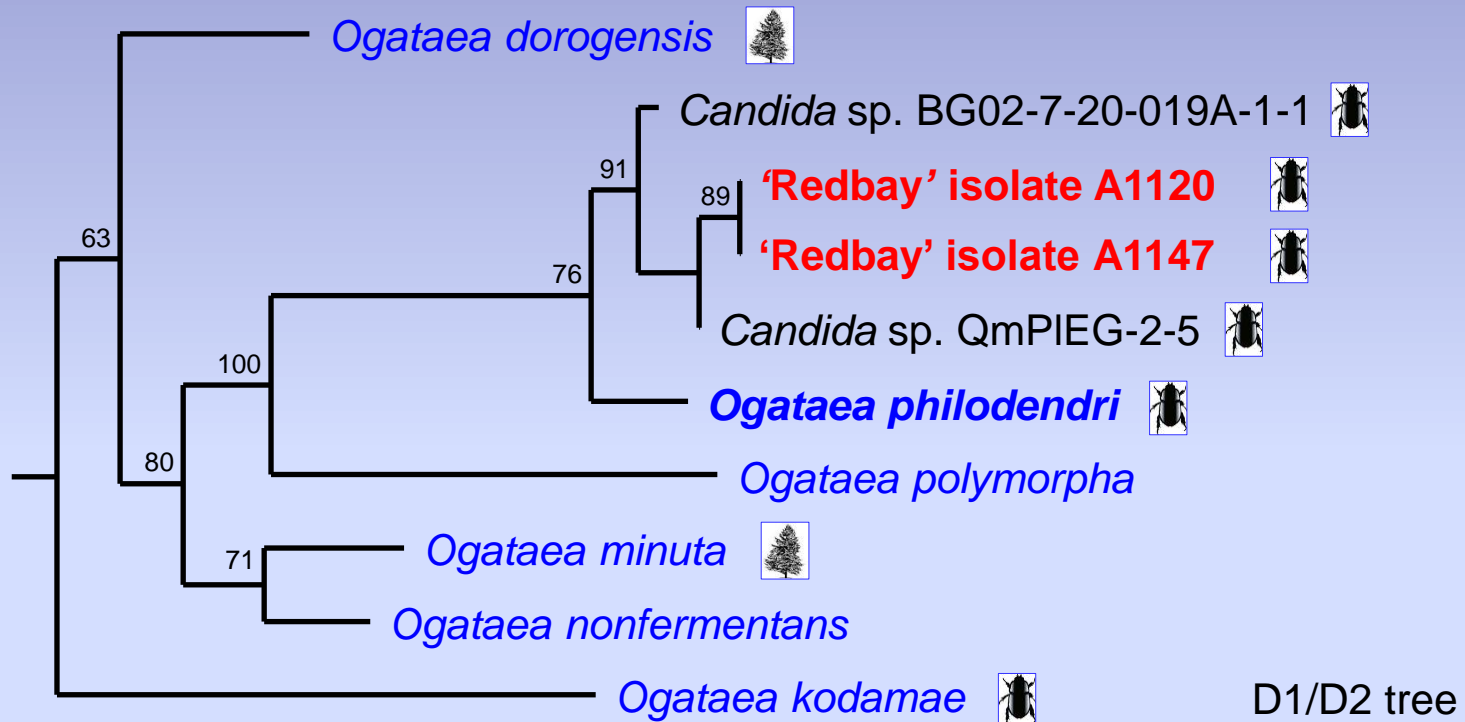
Redbay ambrosia beetle yeasts (1)



● Beetle-associated species (6)

★ Novel species (2)

Candida sp. A: a novel methanol assimilating species



Habitat:

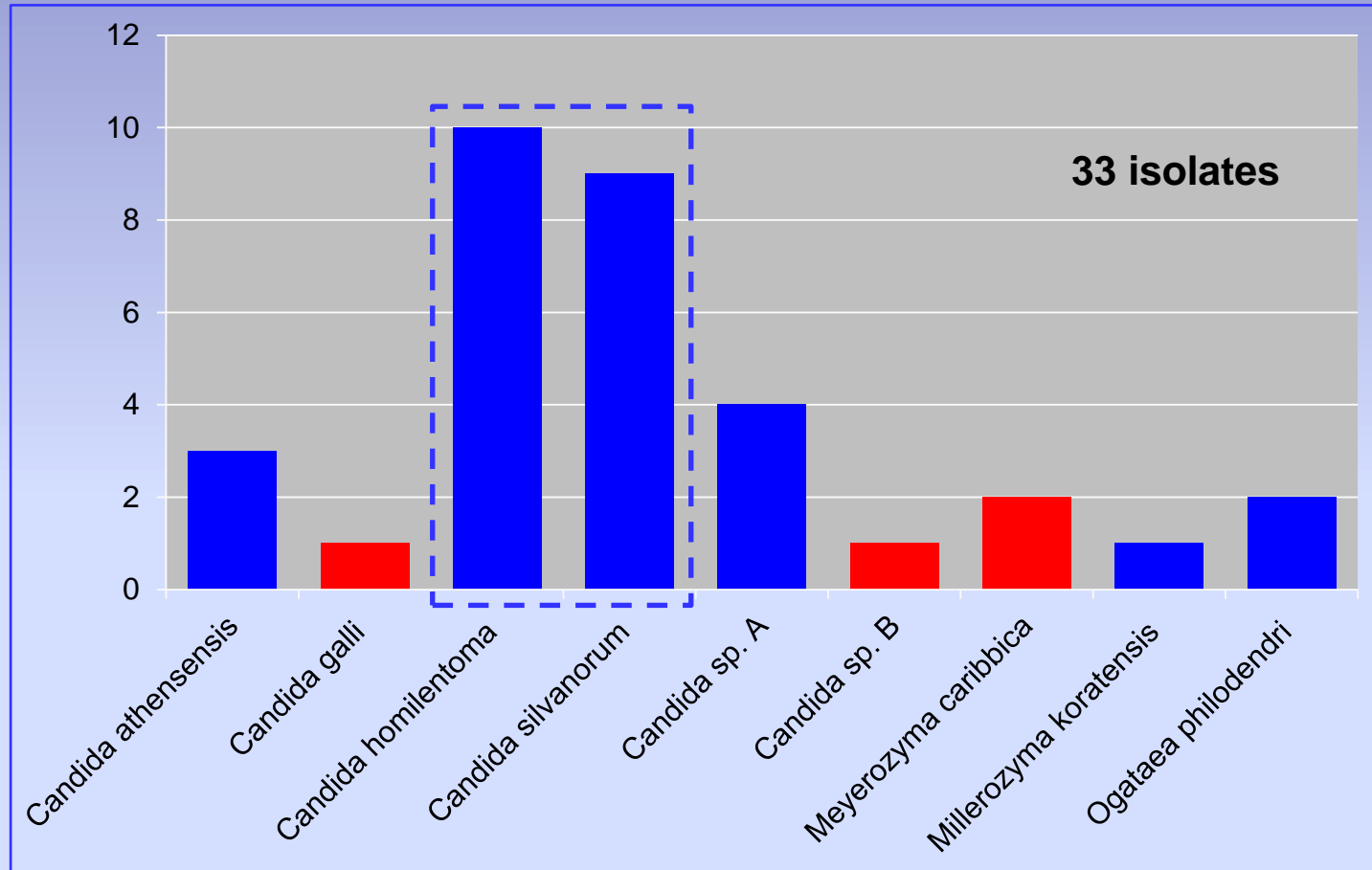


Beetle-associated



Tree-associated

Redbay ambrosia beetle yeasts (2)



● Beetle-associated species (6)

Physiology: *C. homilentoma* & *C. silvanorum*

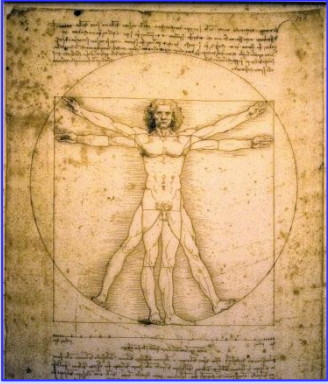
- Fermentative (Glucose)
- Xylose degrading
- Xylitol degrading
- Osmotolerant

Sugar (50% Glucose)

Salt (10% NaCl)

- Grow at 37°C
- Resistant to fermentation inhibitors?

e.g. furfurals



The NCYC has yeasts from a wide variety of different sources and diverse habitats!

Q. Do any have biotechnological uses?



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David Wilson

Gracias!

For further details:

www.ncyc.co.uk

