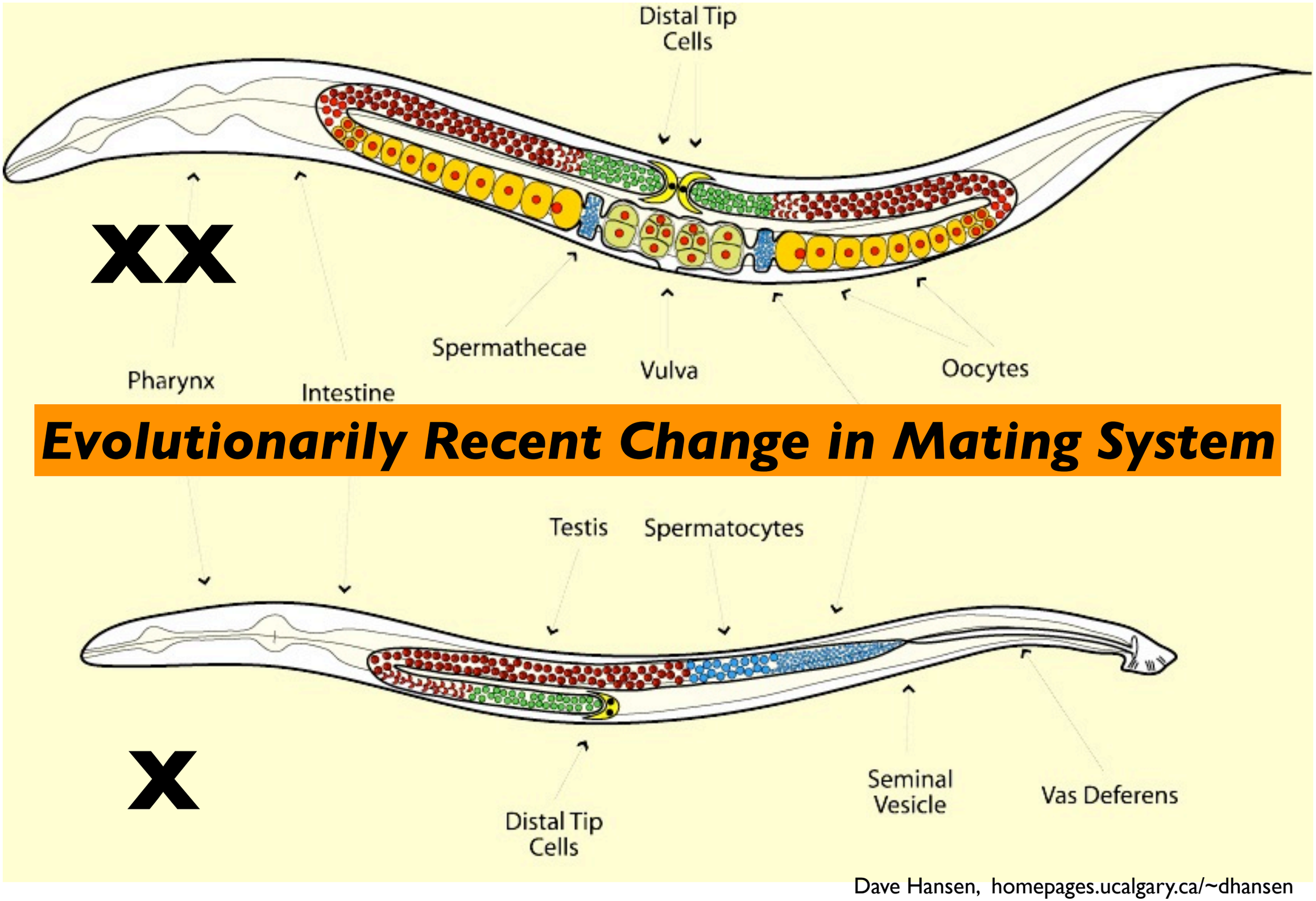
What happens when worms evolve hermaphroditism?

Matt Rockman
NYU

C. elegans
has rare males and self-fertile hermaphrodites

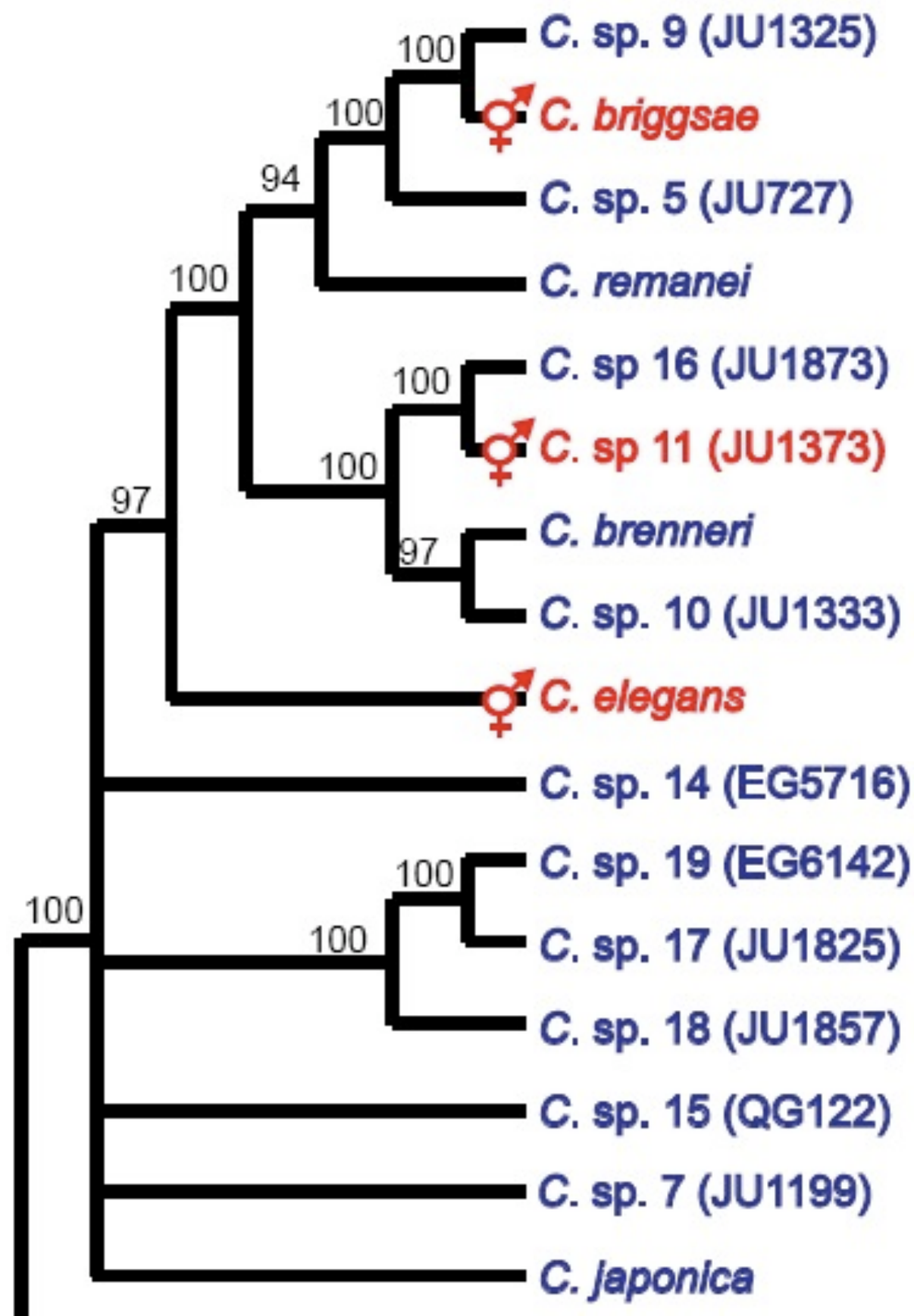


Evolutionarily Recent Change in Mating System

Dave Hansen, homepages.ucalgary.ca/~dhansen

Replicated Evolution:

Independent origins of androdioecy



Kiontke, Felix *et al*. 2011

Obligate Outcrossing

Androdioecy

Obligate Selfing

mating behavior

essential

superfluous

Obligate Outcrossing

Androdioecy

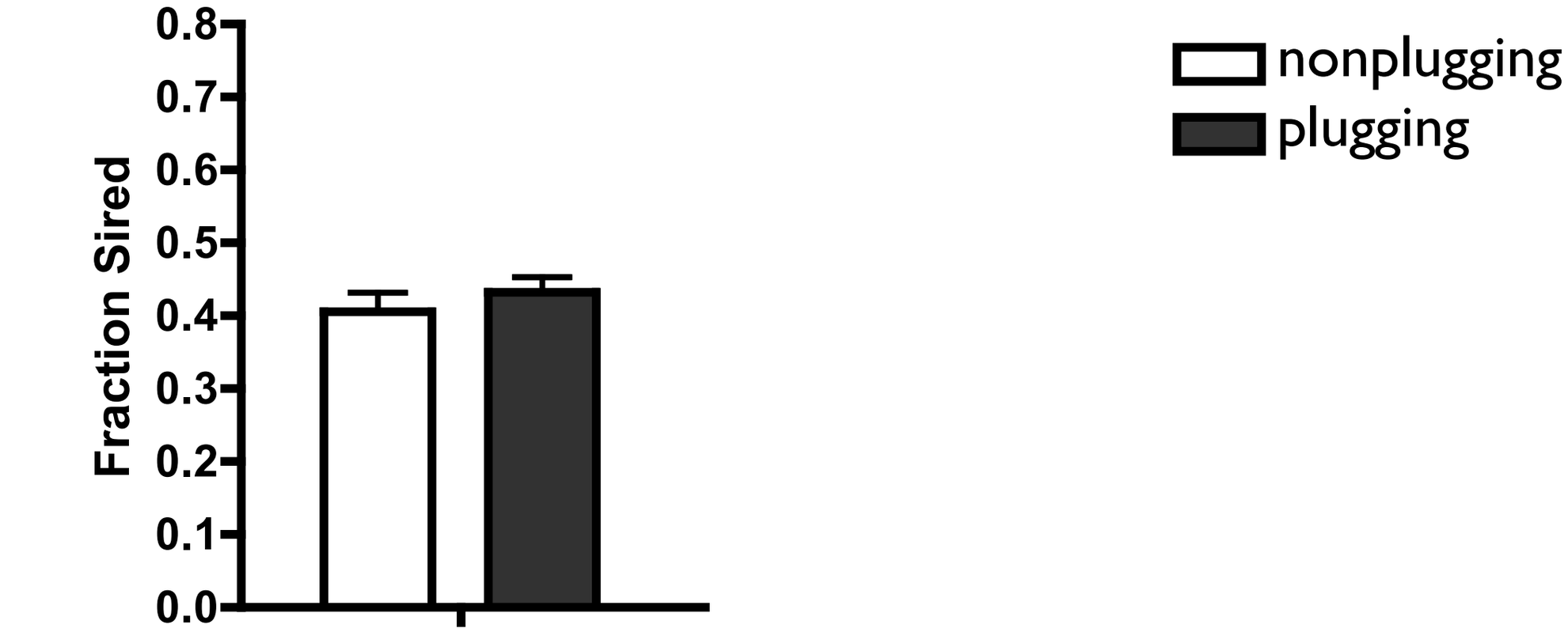
Obligate Selfing

mating behavior

essential *superfluous*

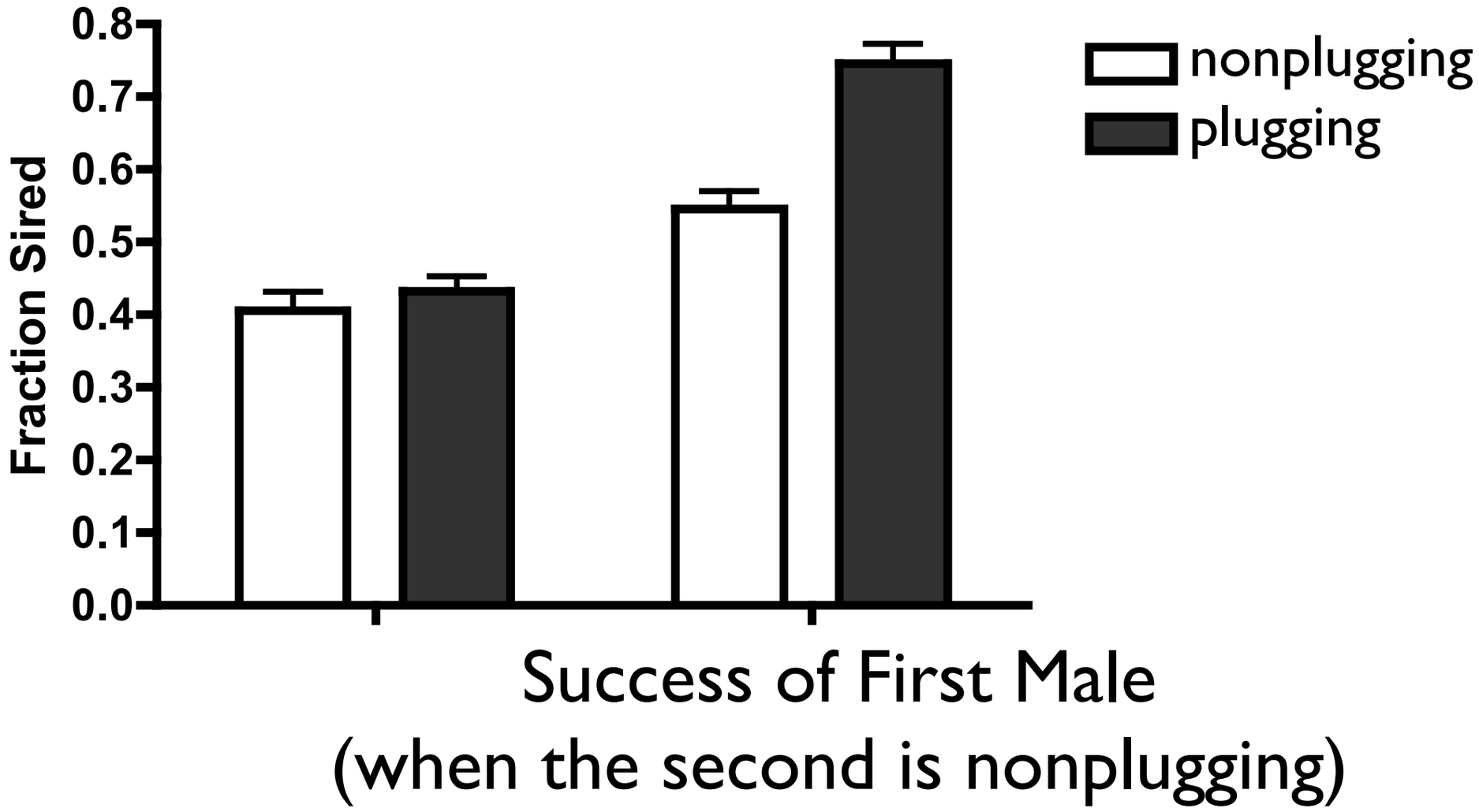
Does male degradation result from
mutation accumulation or
selection on pleiotropic effects?

Plugging protects paternity

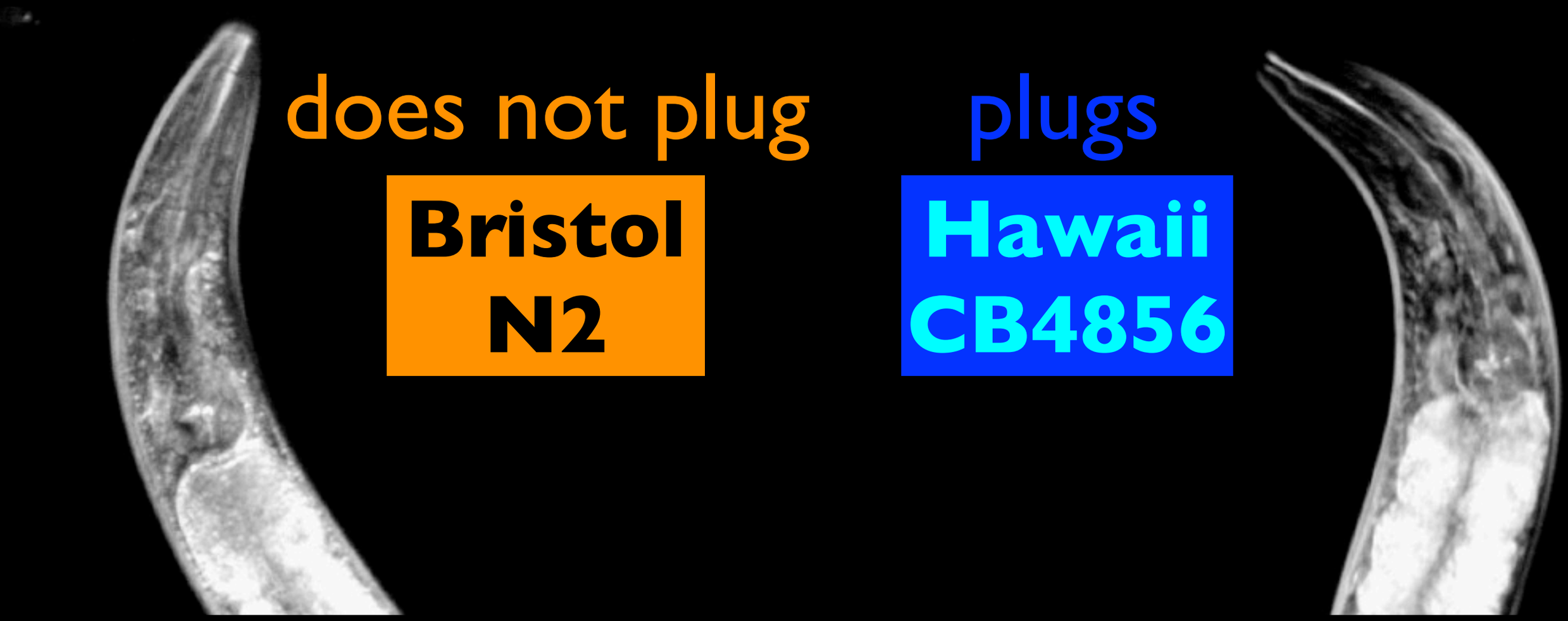


Success of Second Male
(when the first is nonplugging)

Plugging protects paternity



284,700 differences

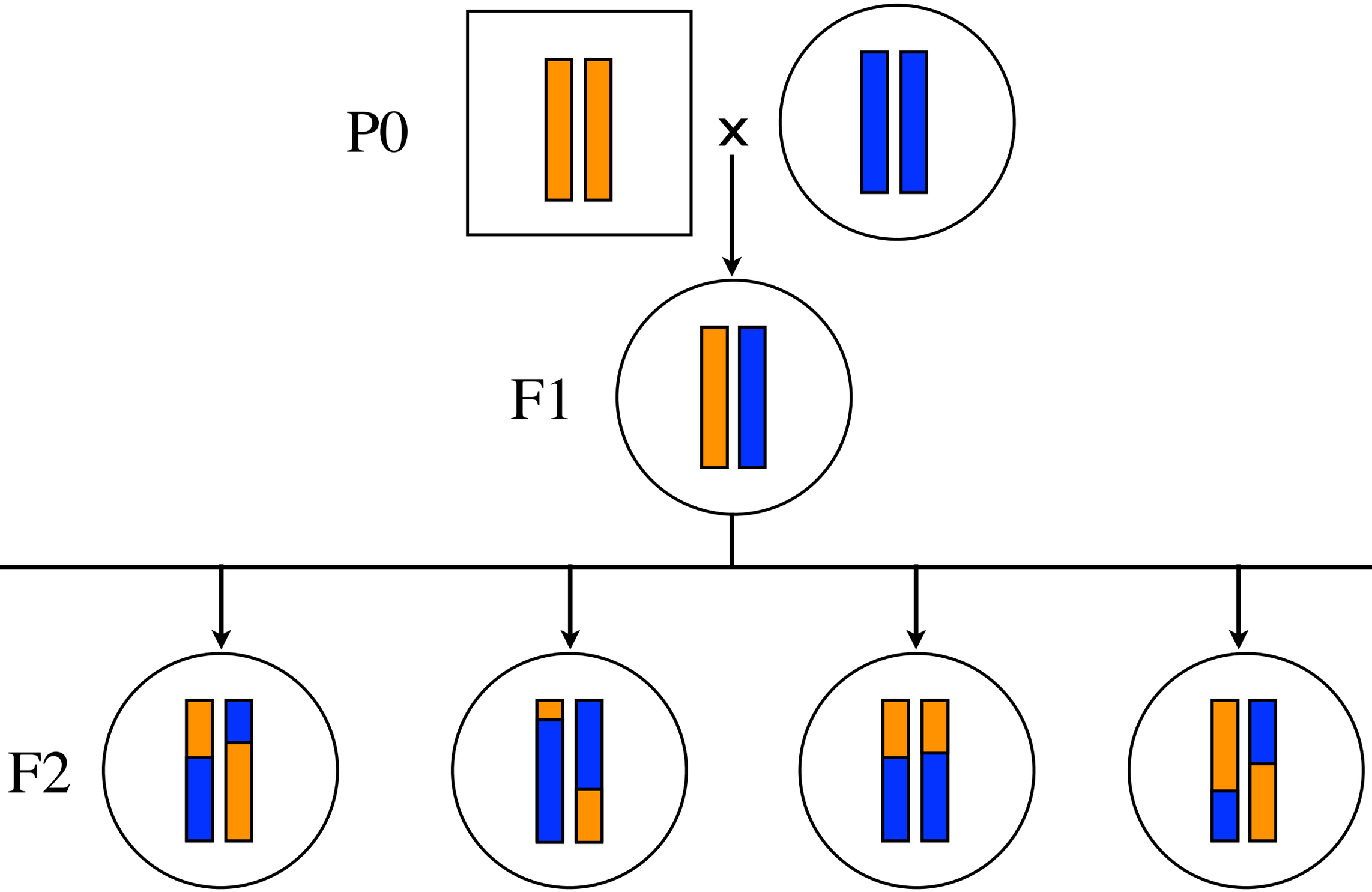


does not plug

Bristol N2

plugs

Hawaii CB4856

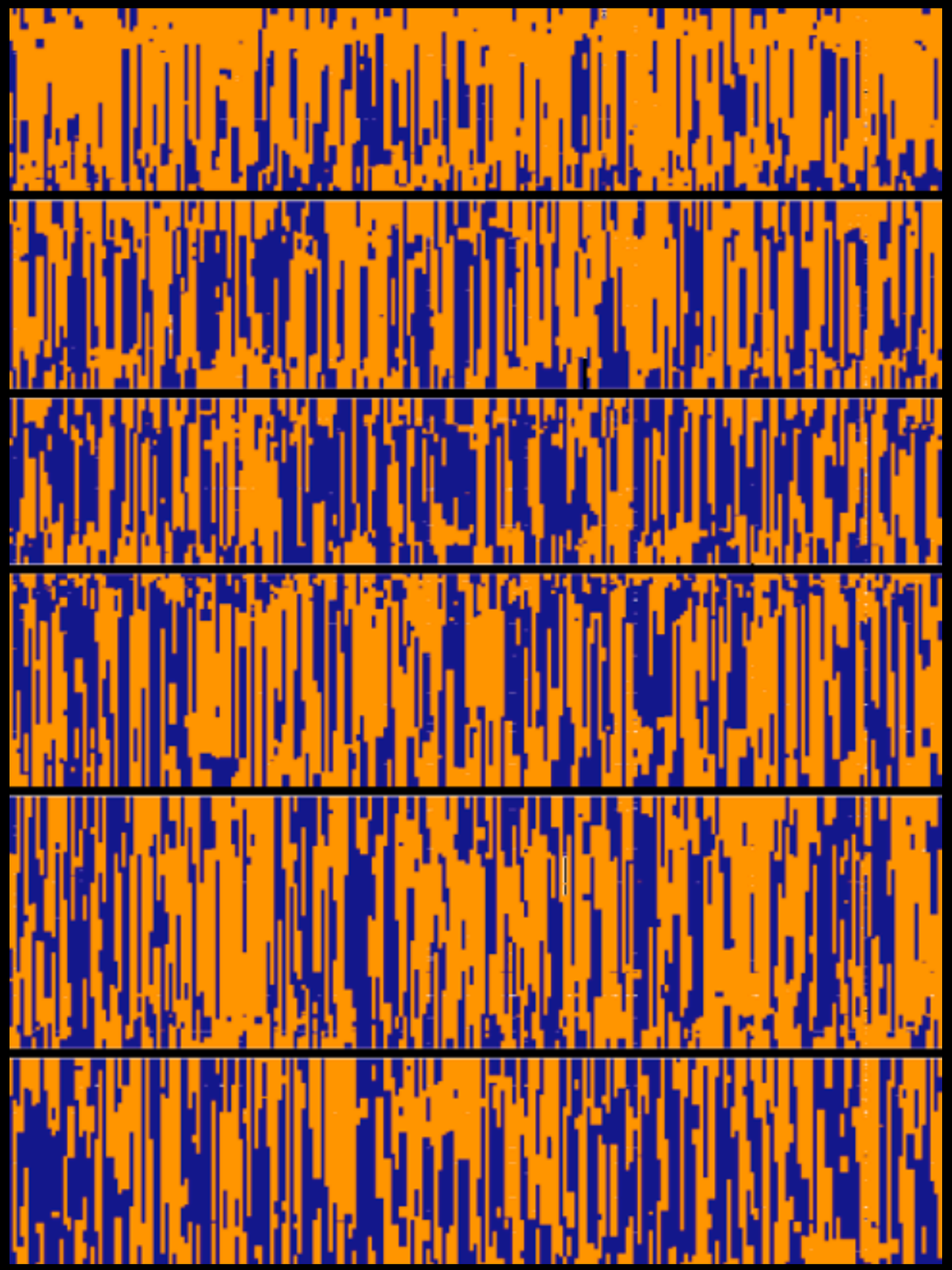

P0
x
F1
F2

F1

F2

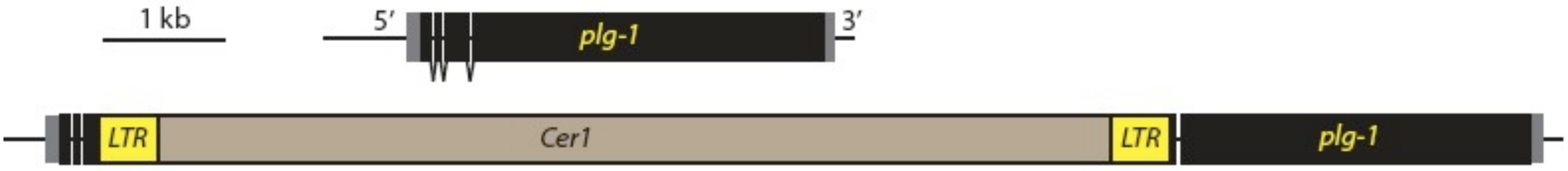
F10

RIAIL



Recombinant Inbred Advanced Intercross Line Genotypes

PLoS Genetics **5,**e1000419



100 aa

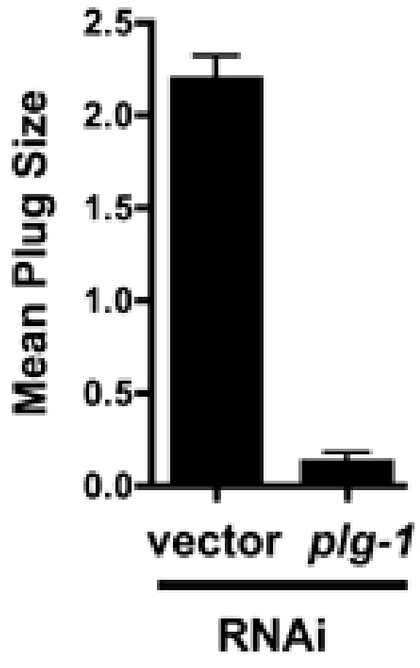
%Thr+Ser	%Pro	
43	17	ASPPTGTTEKSGSSVETTPHTGETSPTWGPPGGST
52	10	GSTAETTPYTGETSPSSEGTSGTGSTETP

Mucin!

Palopoli et al. *Nature* 2008

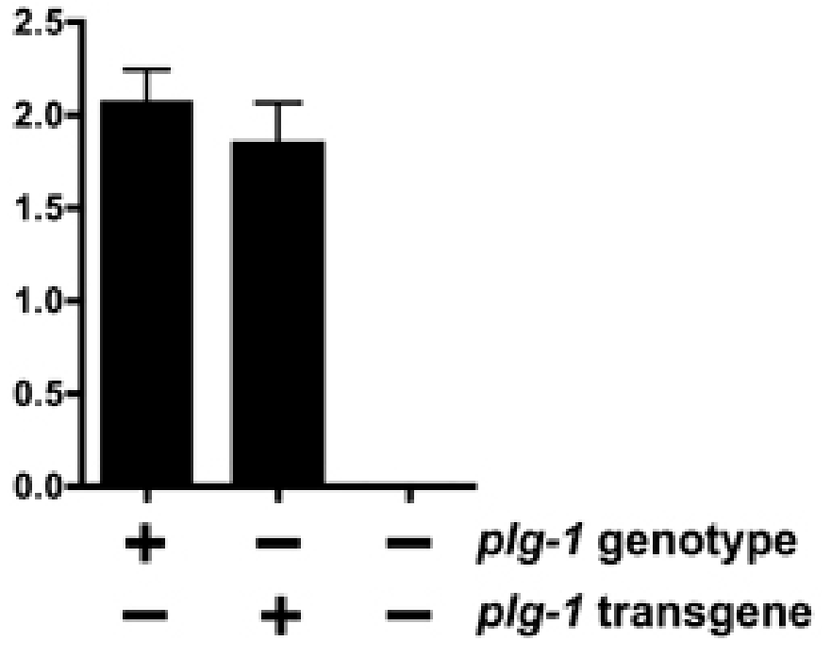
Knock-down

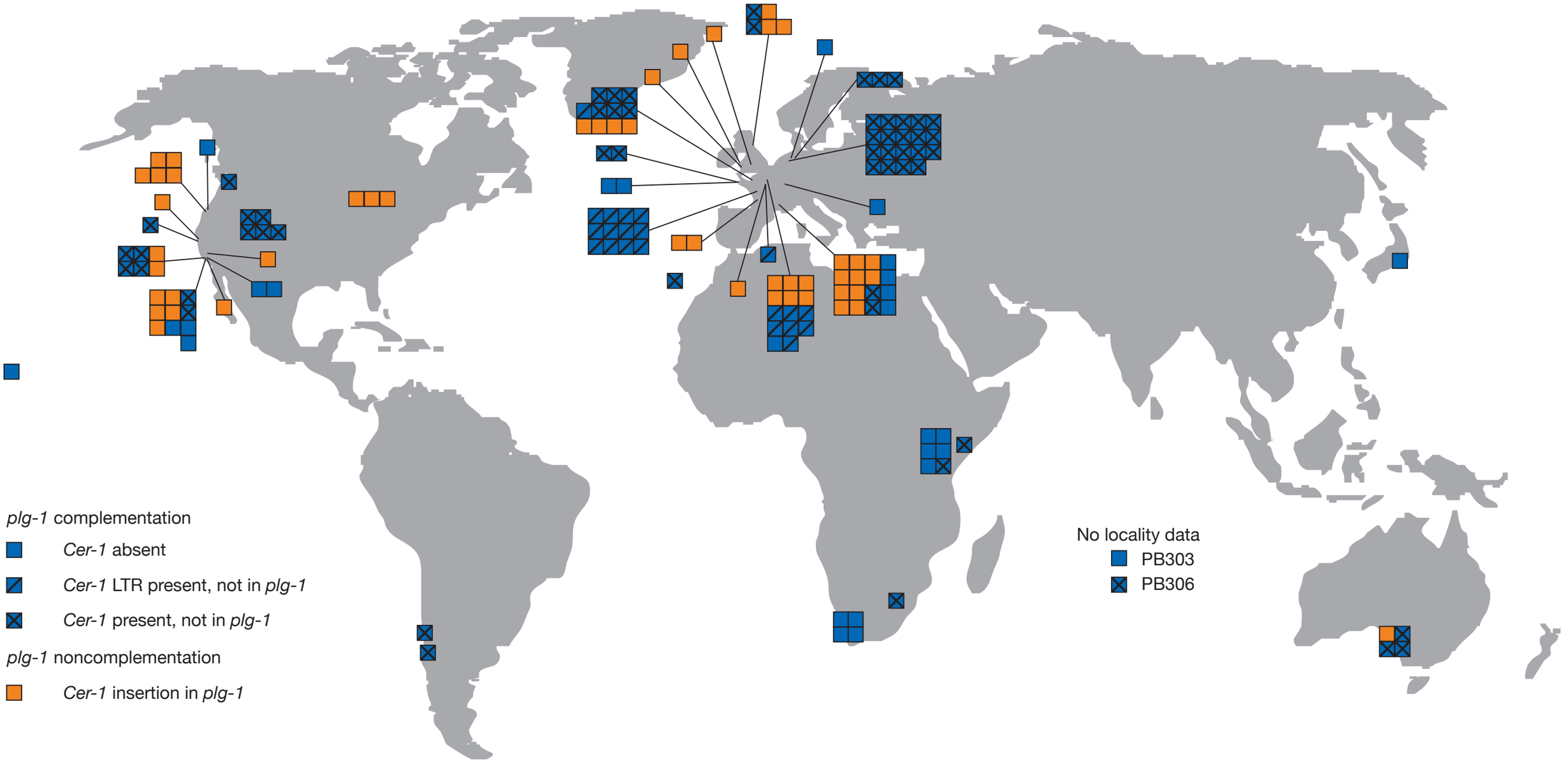
RNAi



Knock-in

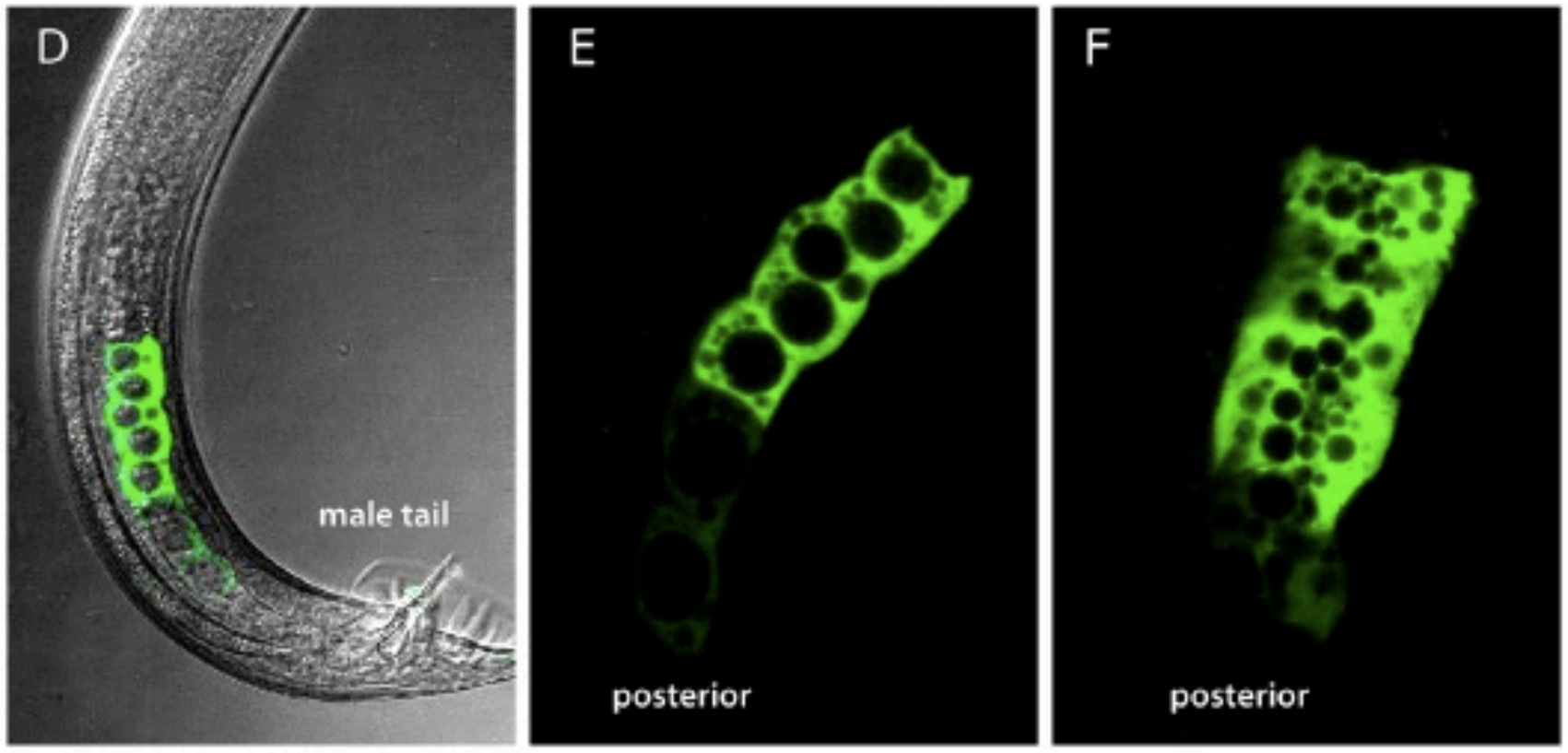
biolistic transformation





Palopoli et al. *Nature* 2008

plg-1 expression is limited to male vas deferens



Palopoli et al. *Nature* 2008

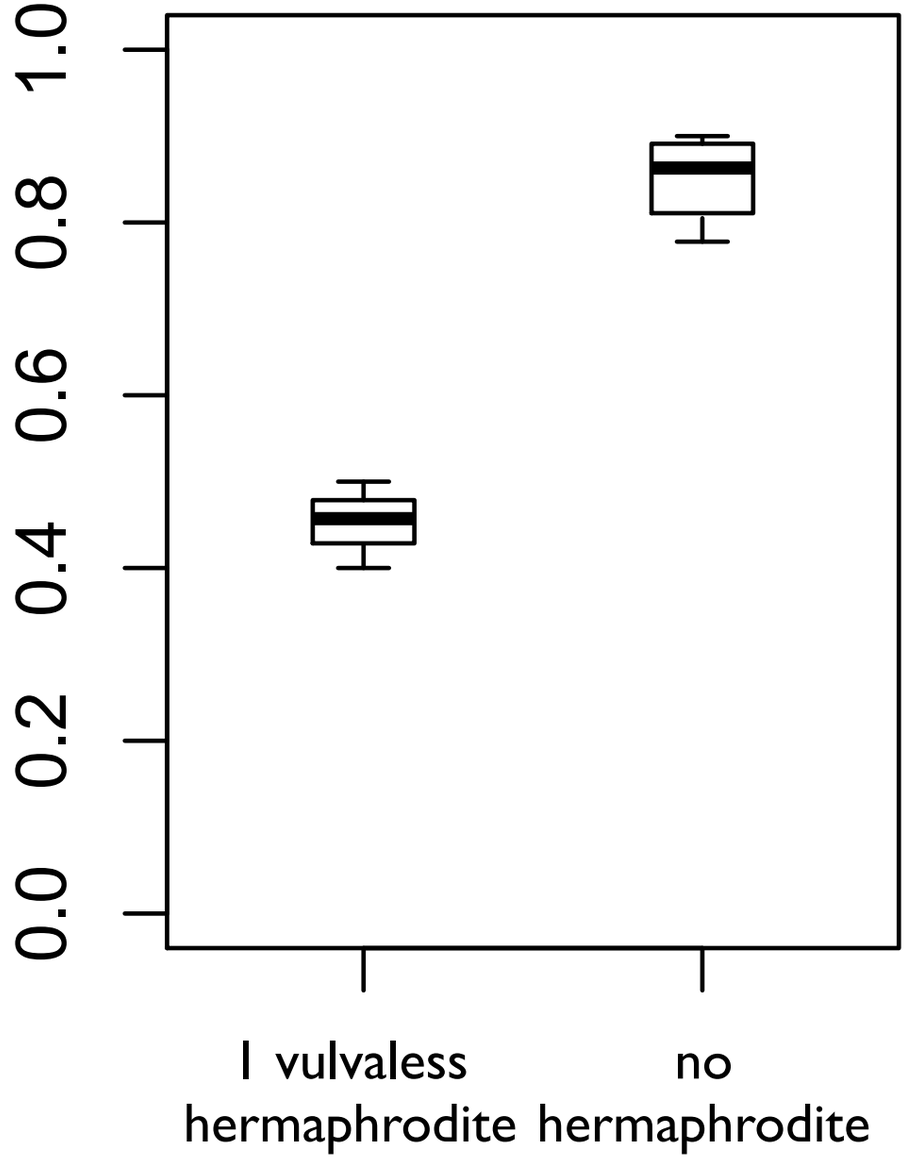
CB4856

AB2

Hermaphrodites diminish male plugging

Proportion of 40 QG71 males plugged

$p = 10^{-10}$



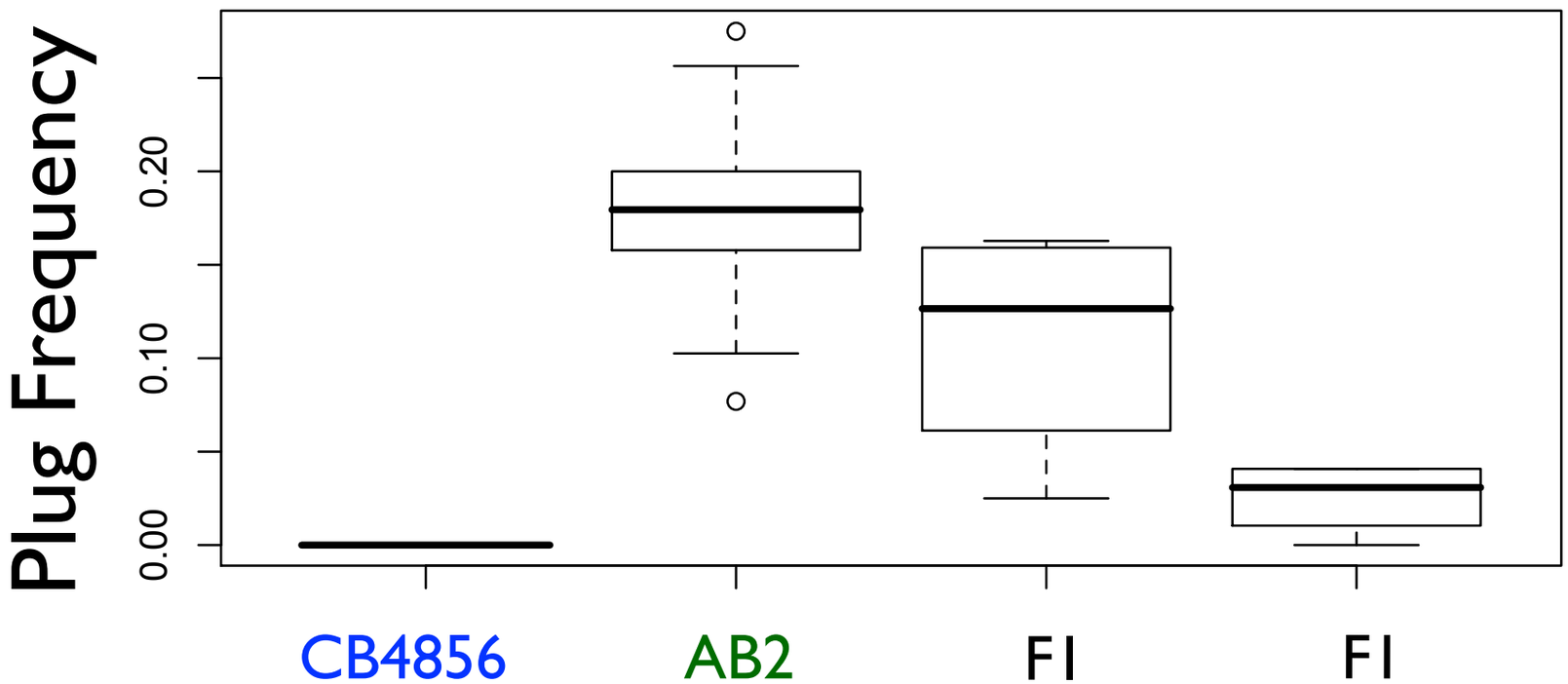
AB2

lin-4$_{RNAi}$

mex-3$_{RNAi}$

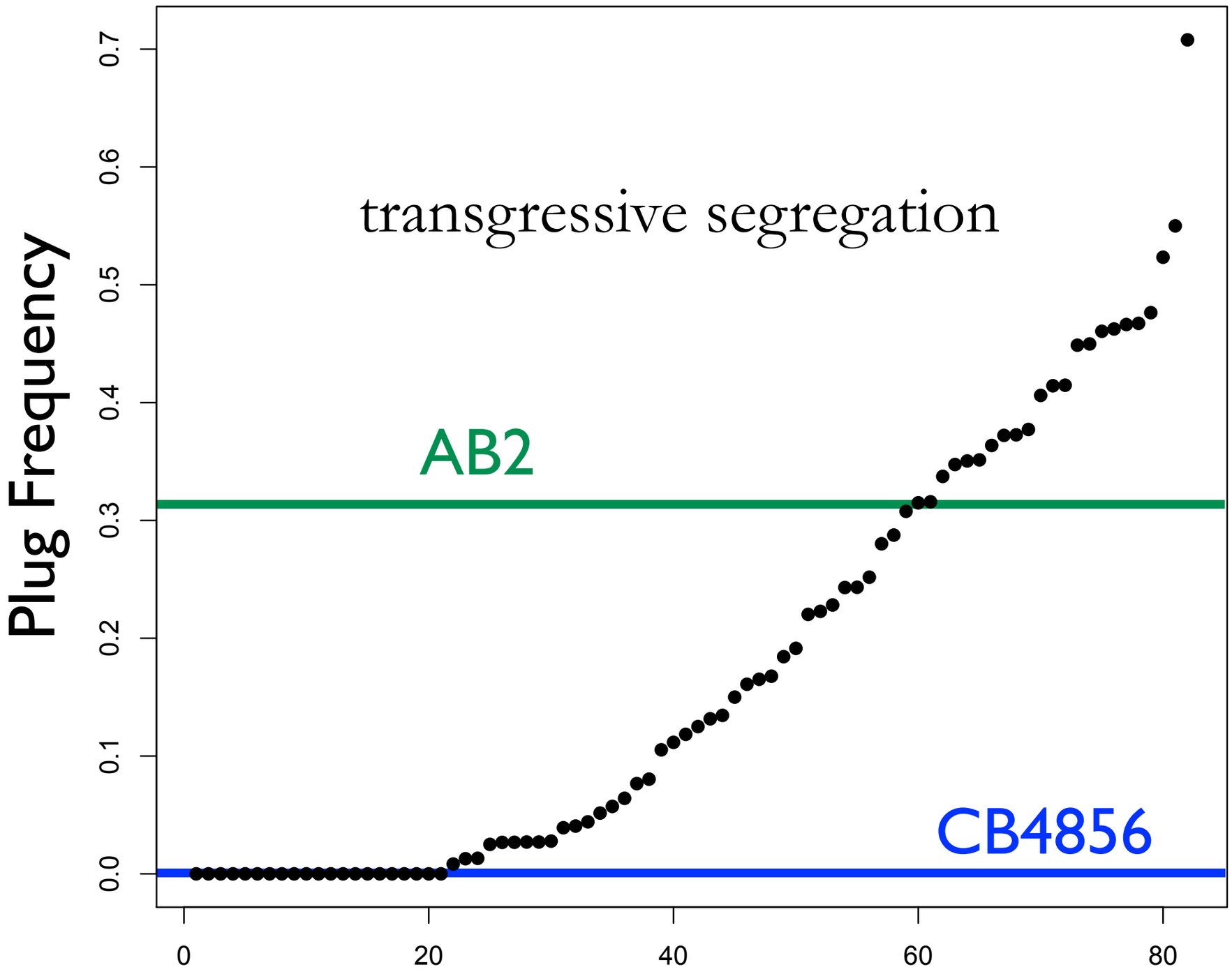
Mimi Yen

Genetic complexity



40 males + 4 days

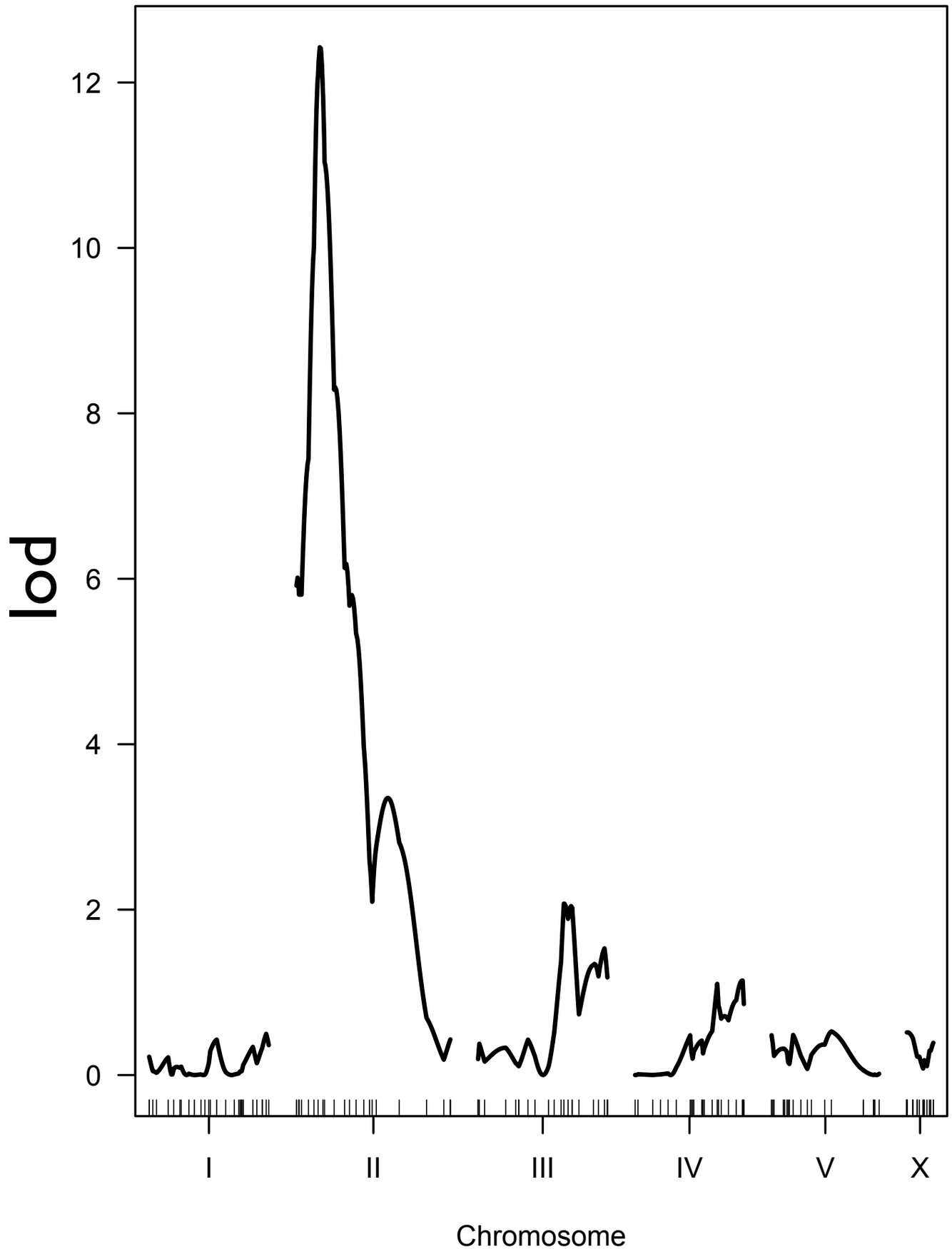
phenotypes in AB2 (*him-5*) x CB4856 (*him-5*) RILs



Max Kramer
Audrey Chang

deposition or receipt?

statistical evidence for an effect of genetic variation at that locus



CB4856

him-5

functional *plg-1*

no plugs

AB2 QTL NIL

him-5

mutant *plg-1*

qqIs1 [*Pplg-1*::GFP]

no plugs

Mixture Assay

no plugs

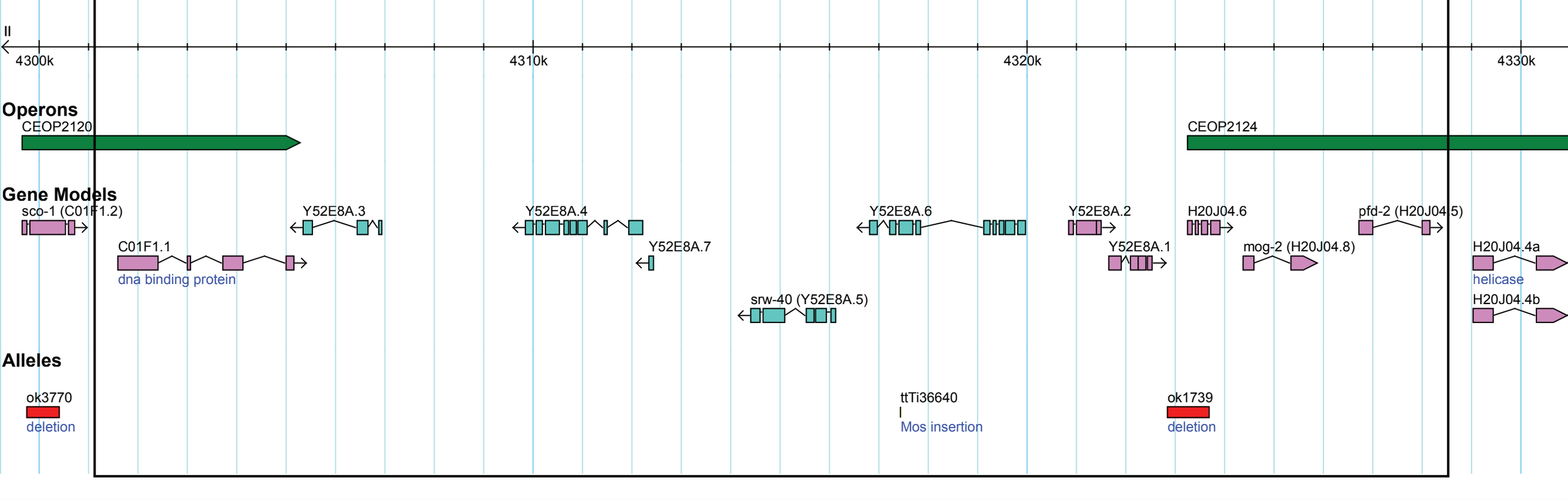
plugs!

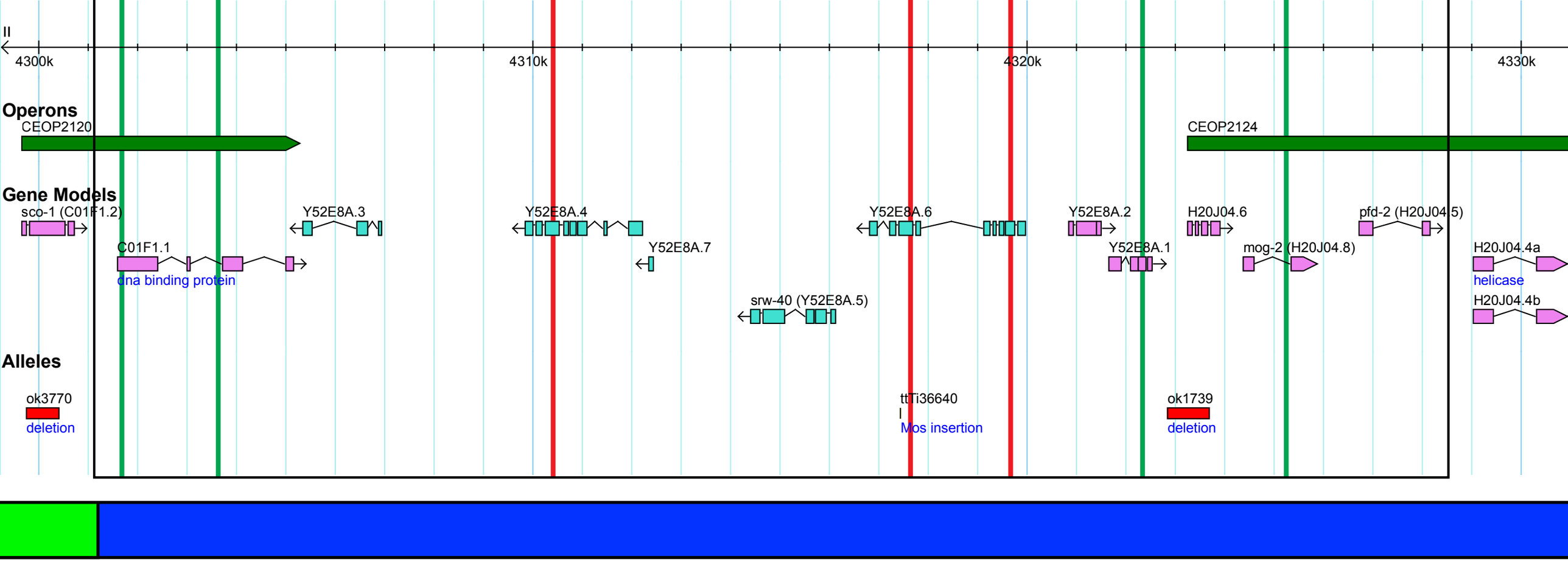
The headplugging QTL confers susceptibility

F2 assays

QTL marker genotype

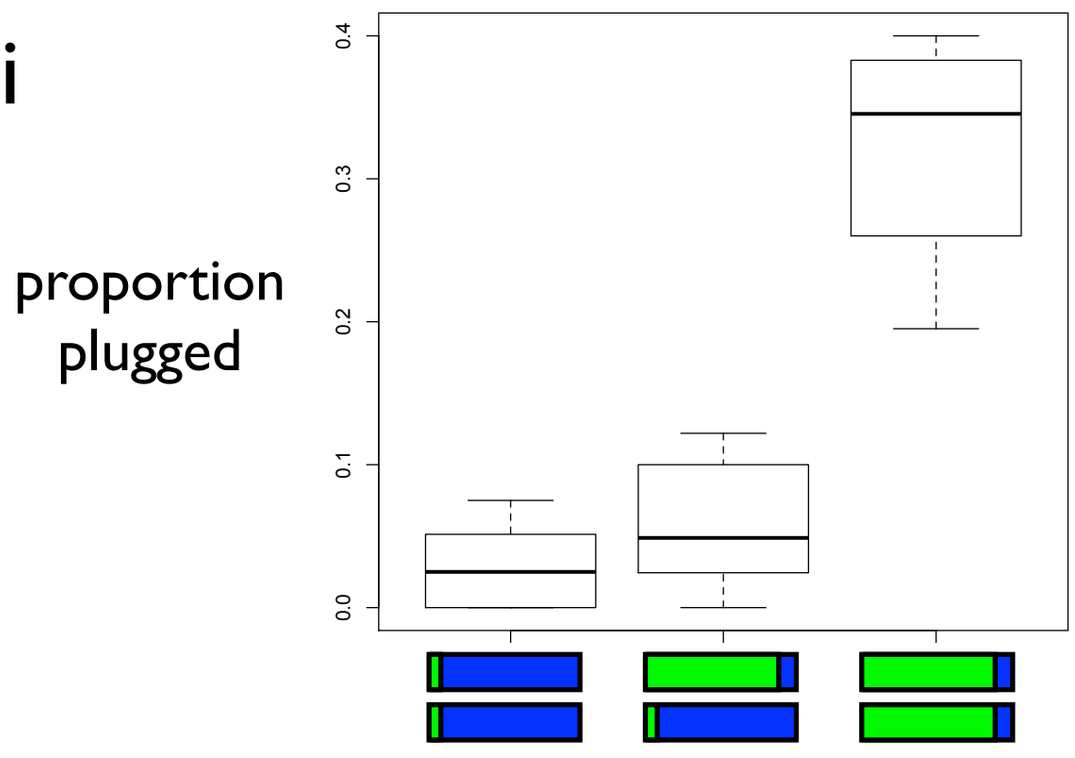
	AB2 homozygote	heterozygote	CB4856 homozygote
plugged	86%	14%	0%
not plugged	4%	25%	71%


II
4300k
4310k
4320k
4330k
Operons
CEOP2120
CEOP2124
Gene Models
sco-1 (C01F1.2)
Y52E8A.3
Y52E8A.4
Y52E8A.6
Y52E8A.2
H20J04.6
pfd-2 (H20J04.5)
C01F1.1
dna binding protein
Y52E8A.7
Y52E8A.1
mog-2 (H20J04.8)
H20J04.4a
helicase
srw-40 (Y52E8A.5)
H20J04.4b
Alleles
ok3770
deletion
ttTi36640
Mos insertion
ok1739
deletion

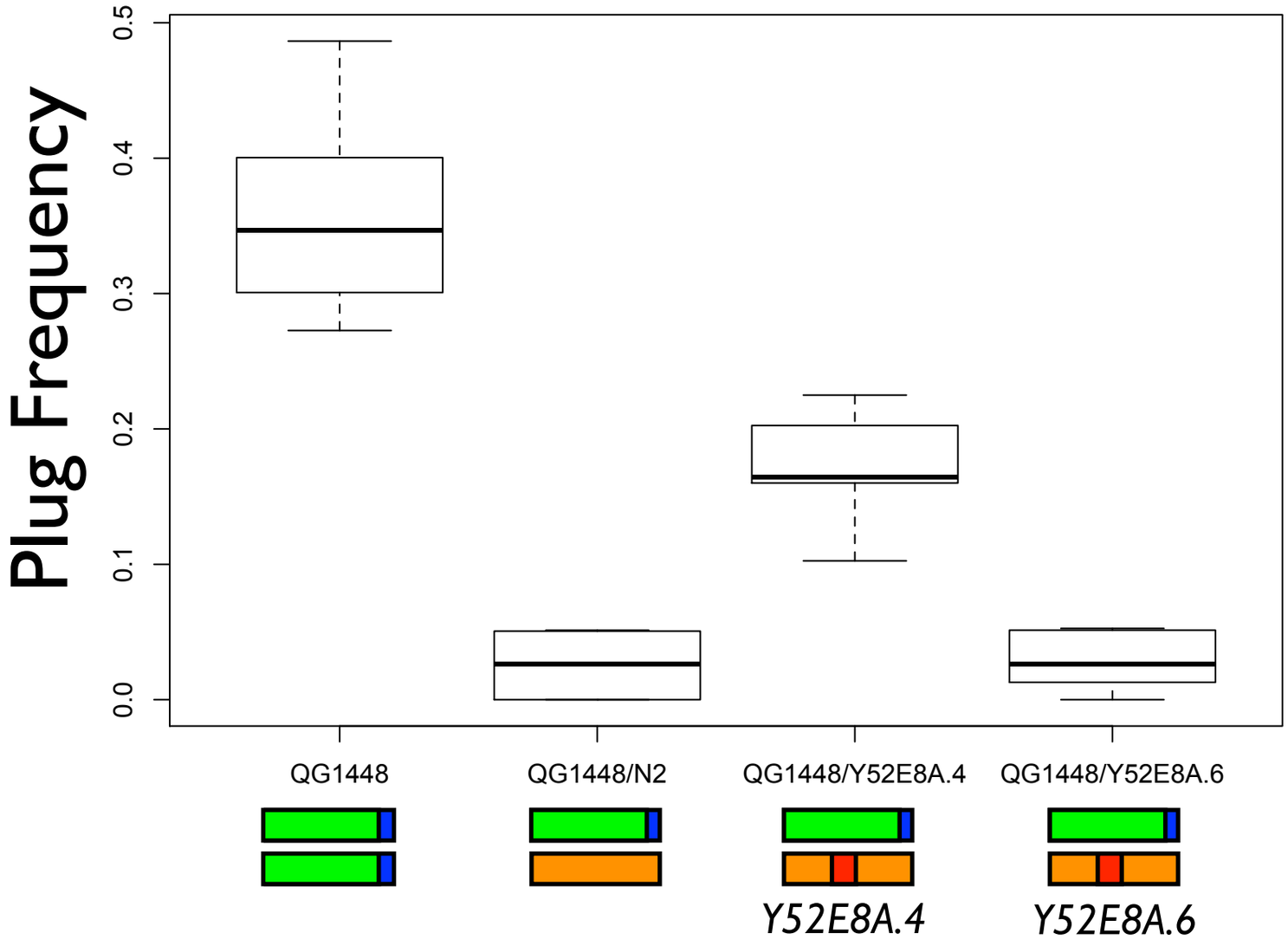


David Riccardi

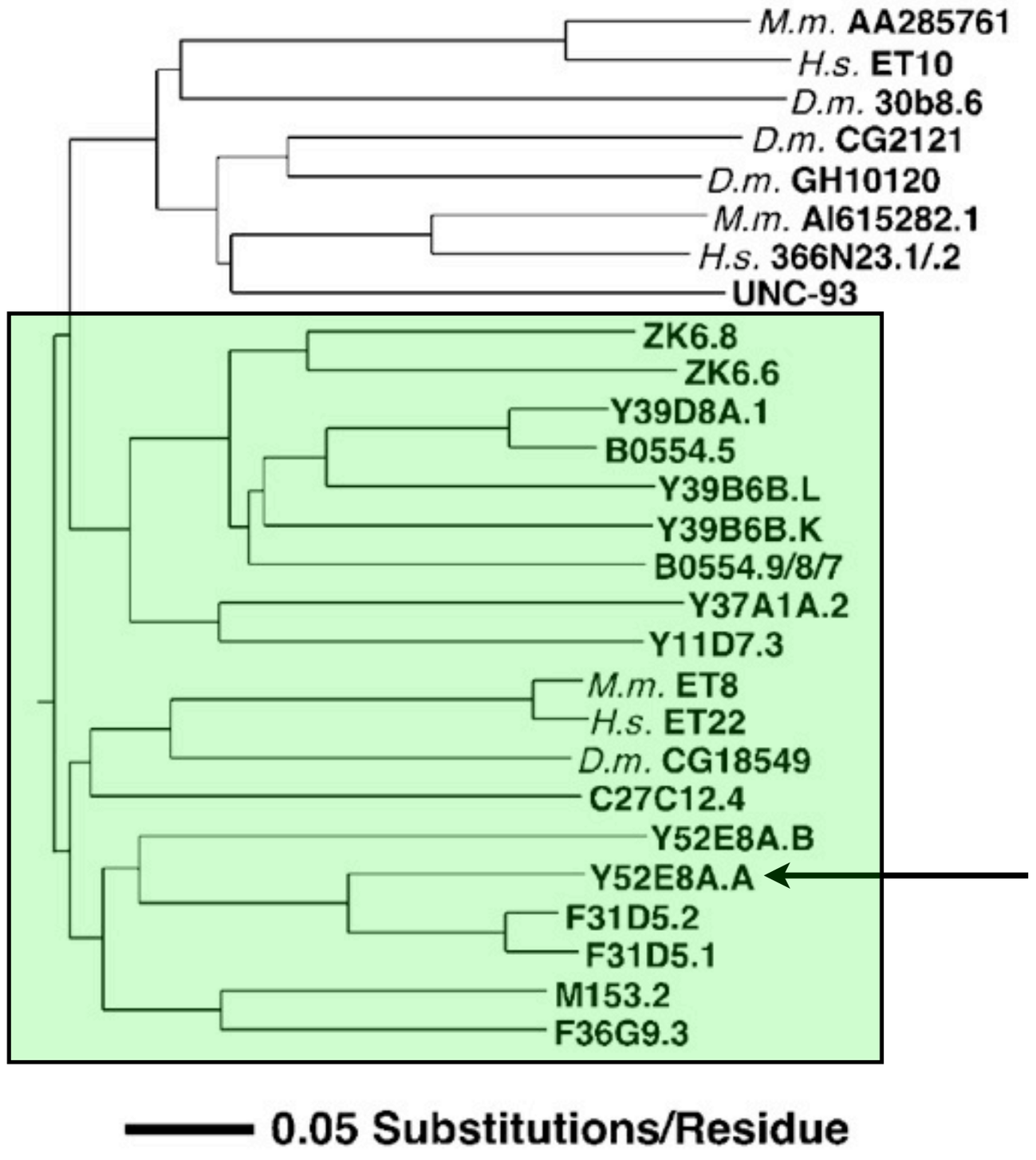
Association Mapping



Y52E8A.4 fails to complement

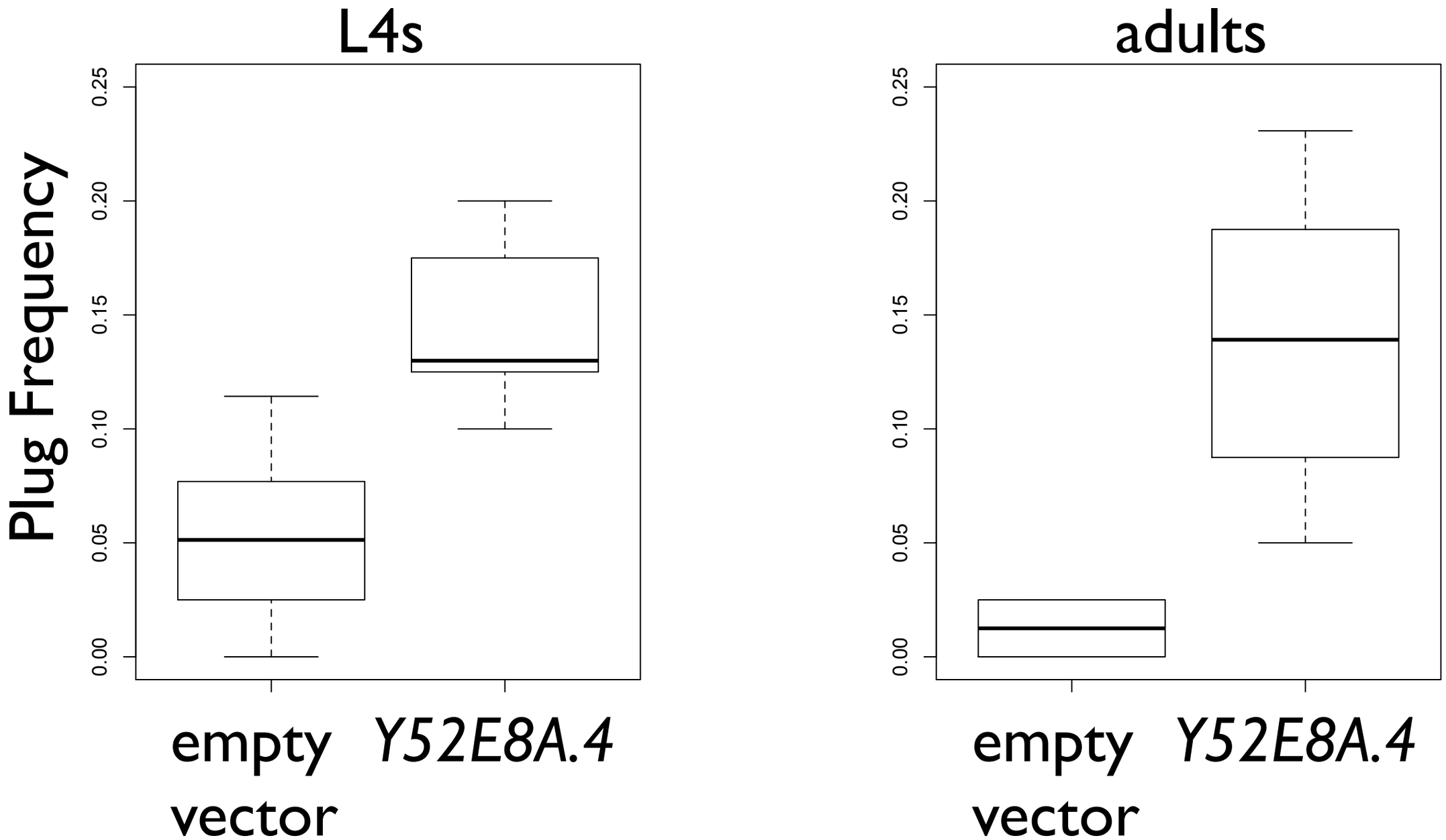


V278D



Perez de la Cruz et al. *J. Neurosci.* 2003

CB4856 *Y52E8A.4*$_{RNAi}$



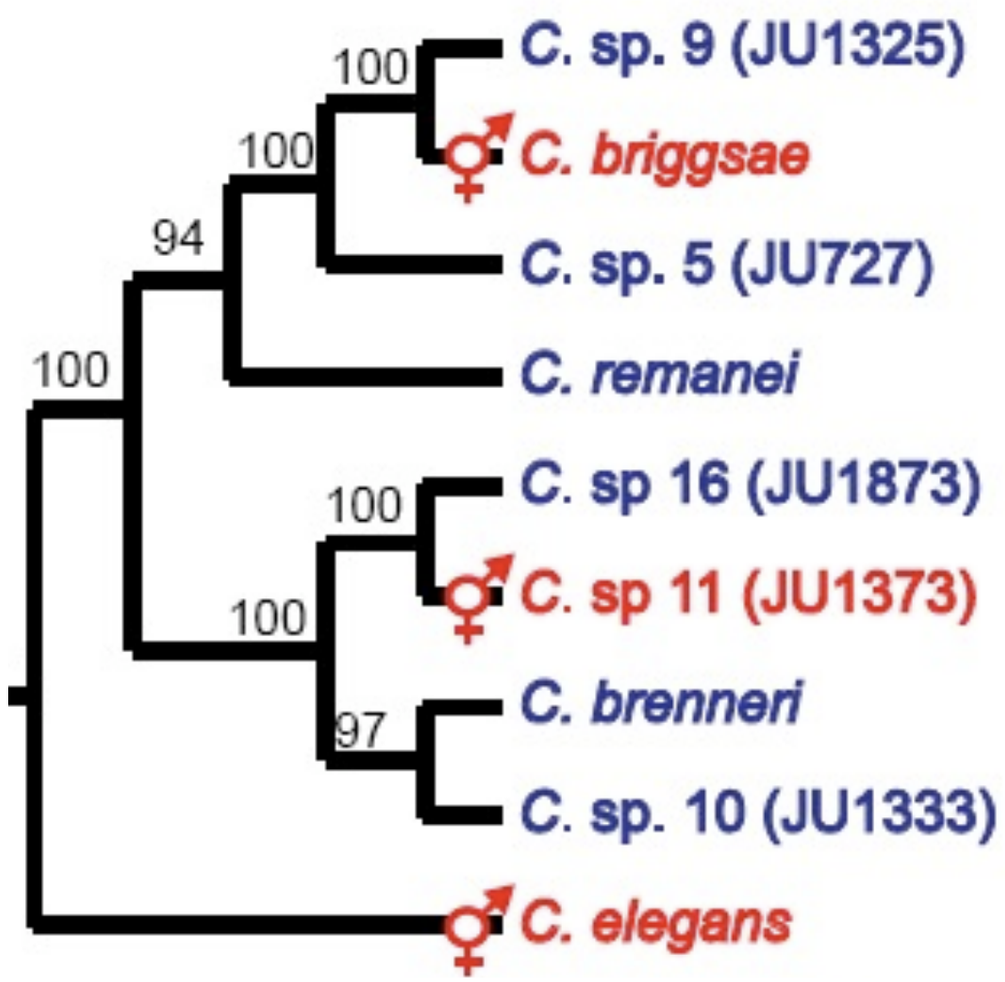
p = 0.00013

p = 0.00003

Replicated Evolution:

Independent origins of androdioecy

Kiontke, Felix et al. 2011



absent

polymorphic

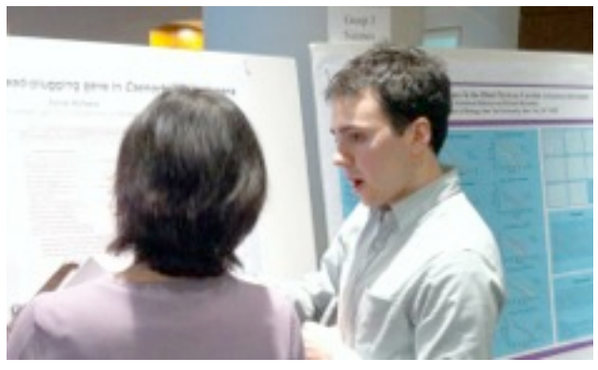
absent

absent

absent

polymorphic

Self-plugging in *C. briggsae*



Dan McNelis

Strain	1 worm	40 worms
PS9392	92.6%	95.9%
VT847	100%	94.4%
AF16	94.1%	94.0%
PS9393	70.8%	92.9%
QG129	84.3%	91.6%
NIC17	47.4%	88.3%
QG574	44.8%	56.3%
NIC107	50%	55.6%
QG119	17.6%	35.0%
QG110	12.9%	23.5%
QG117	5.7%	23.1%
QG111	81.5%	19.4%
QG584	0%	18.9%

Obligate Outcrossing

Androdioecy

Obligate Selfing

mating behavior

essential

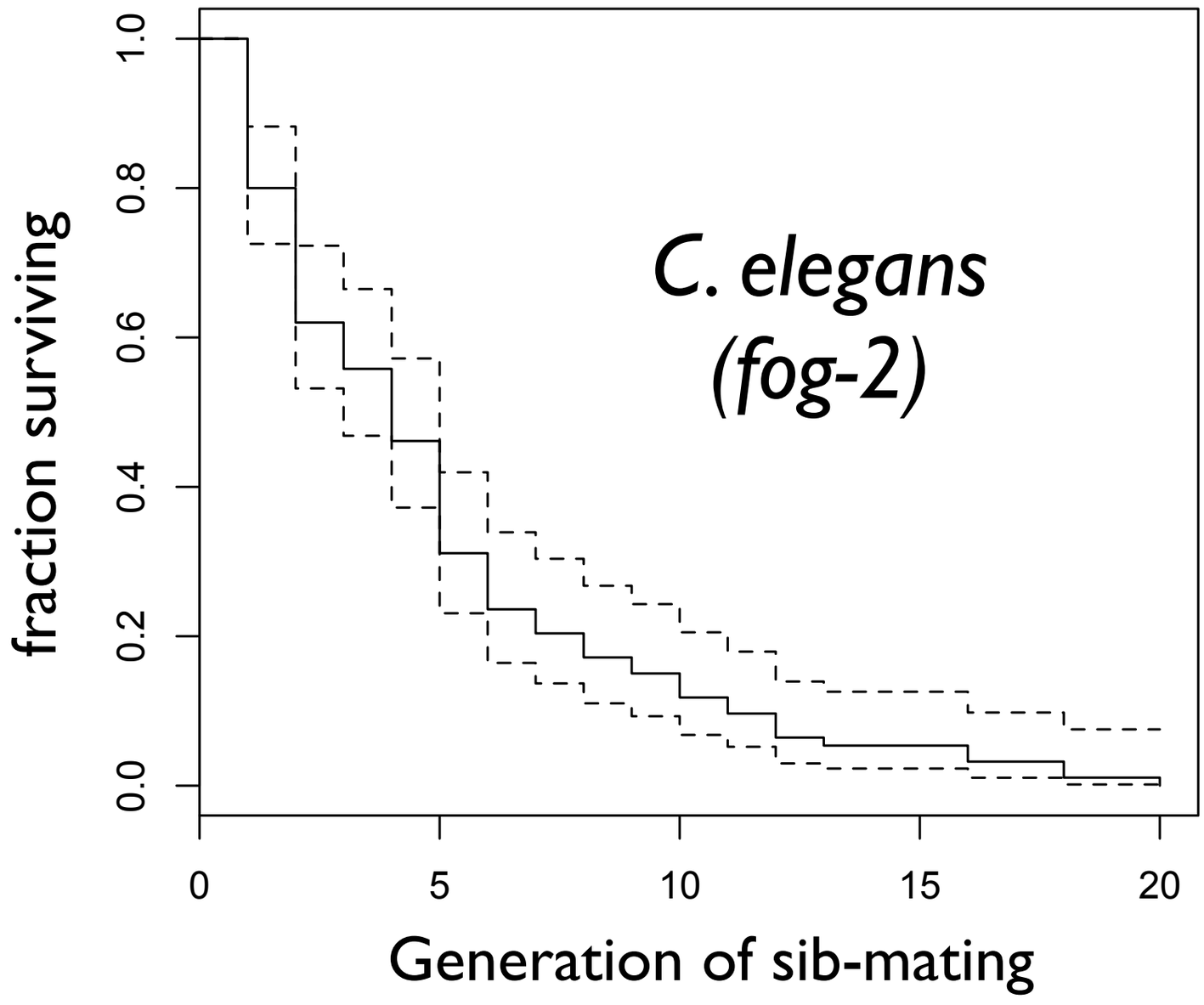
superfluous

recessive mutations

masked

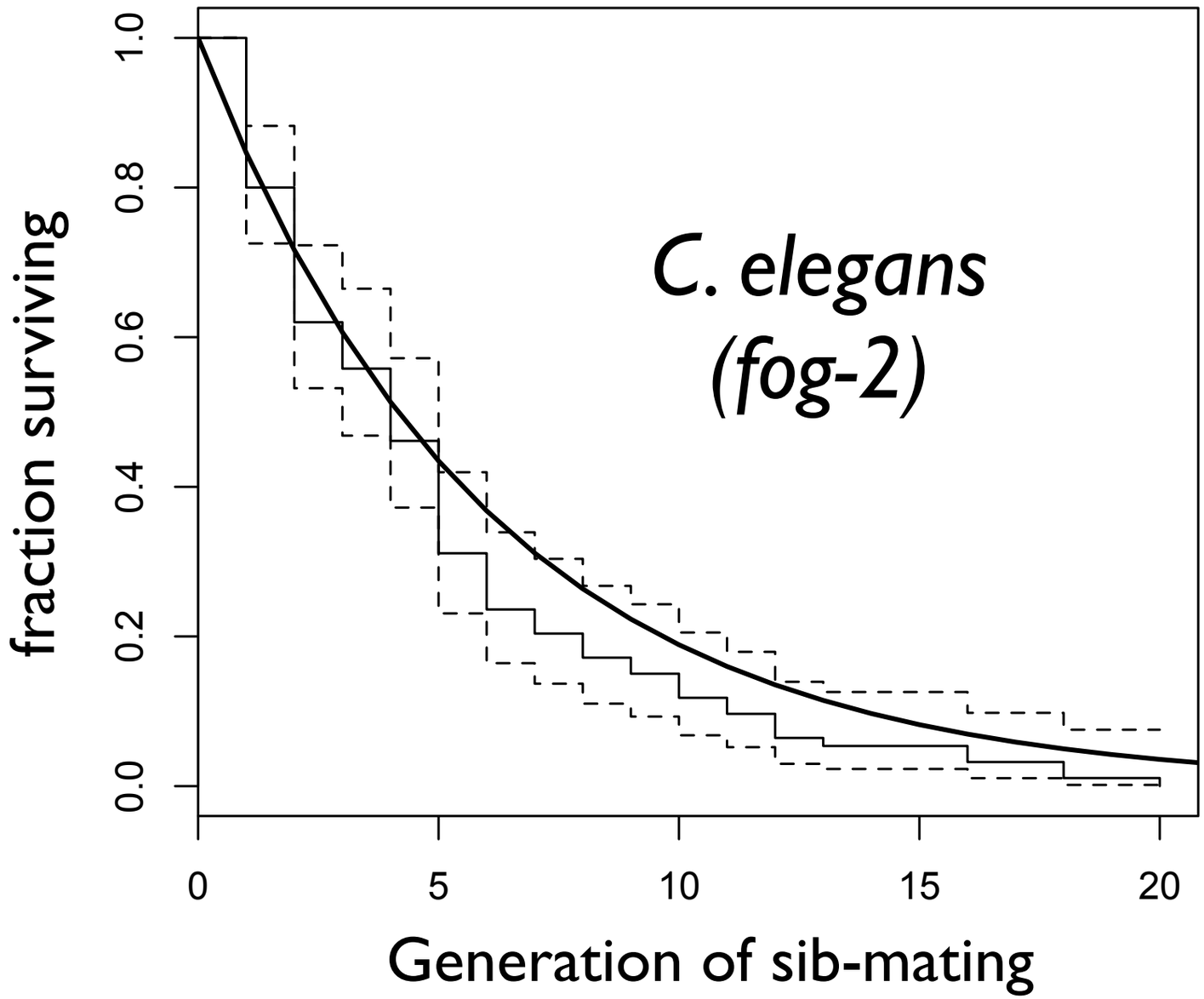
exposed

experiment: serial sib-mating



mating failure:
20% per cross

Vicky Cattani
Annalise Paaby
Max Bernstein
Taniya Kaur
Audrey Chang
Jia Shen

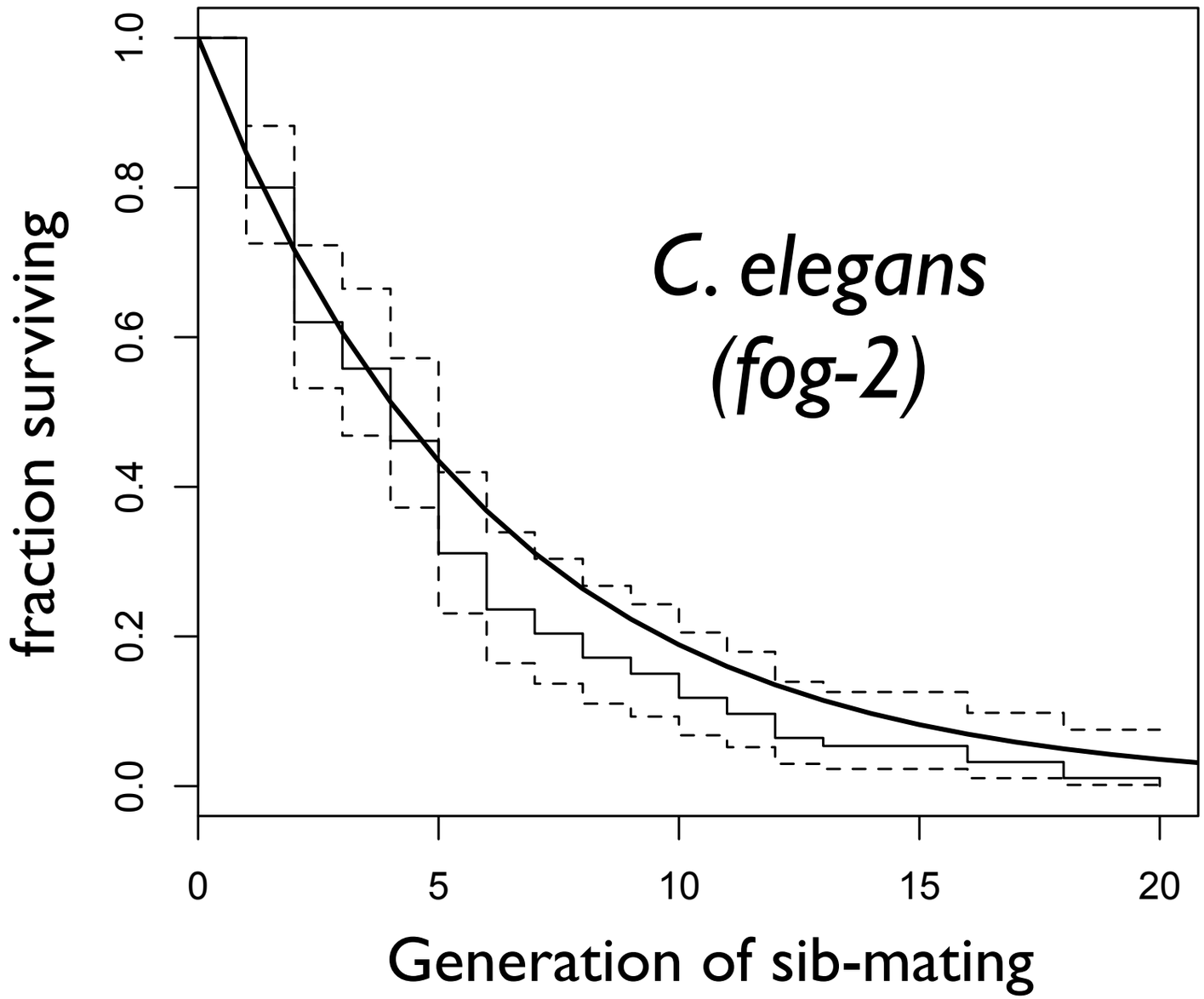


mating failure:

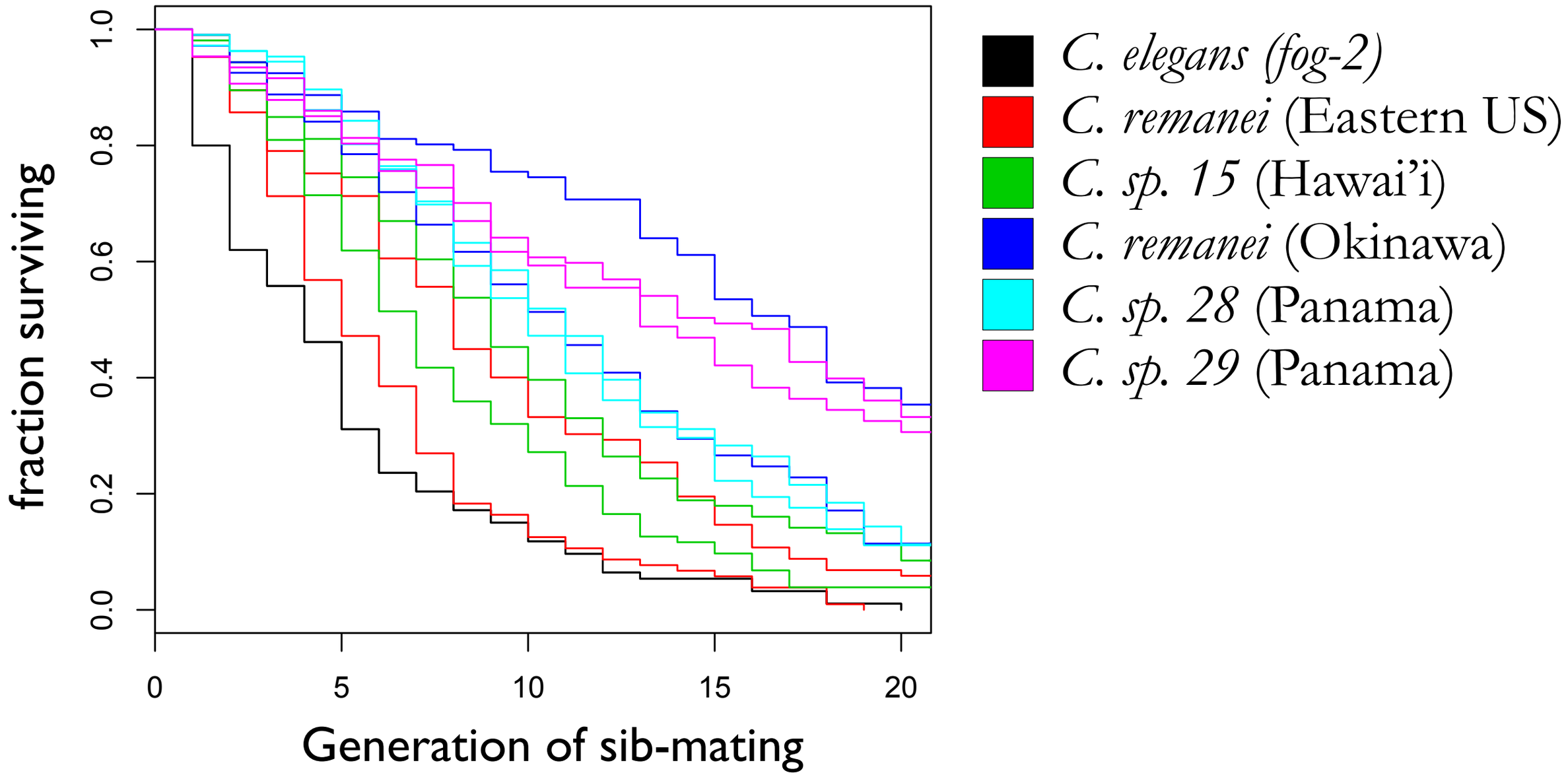
20% per cross

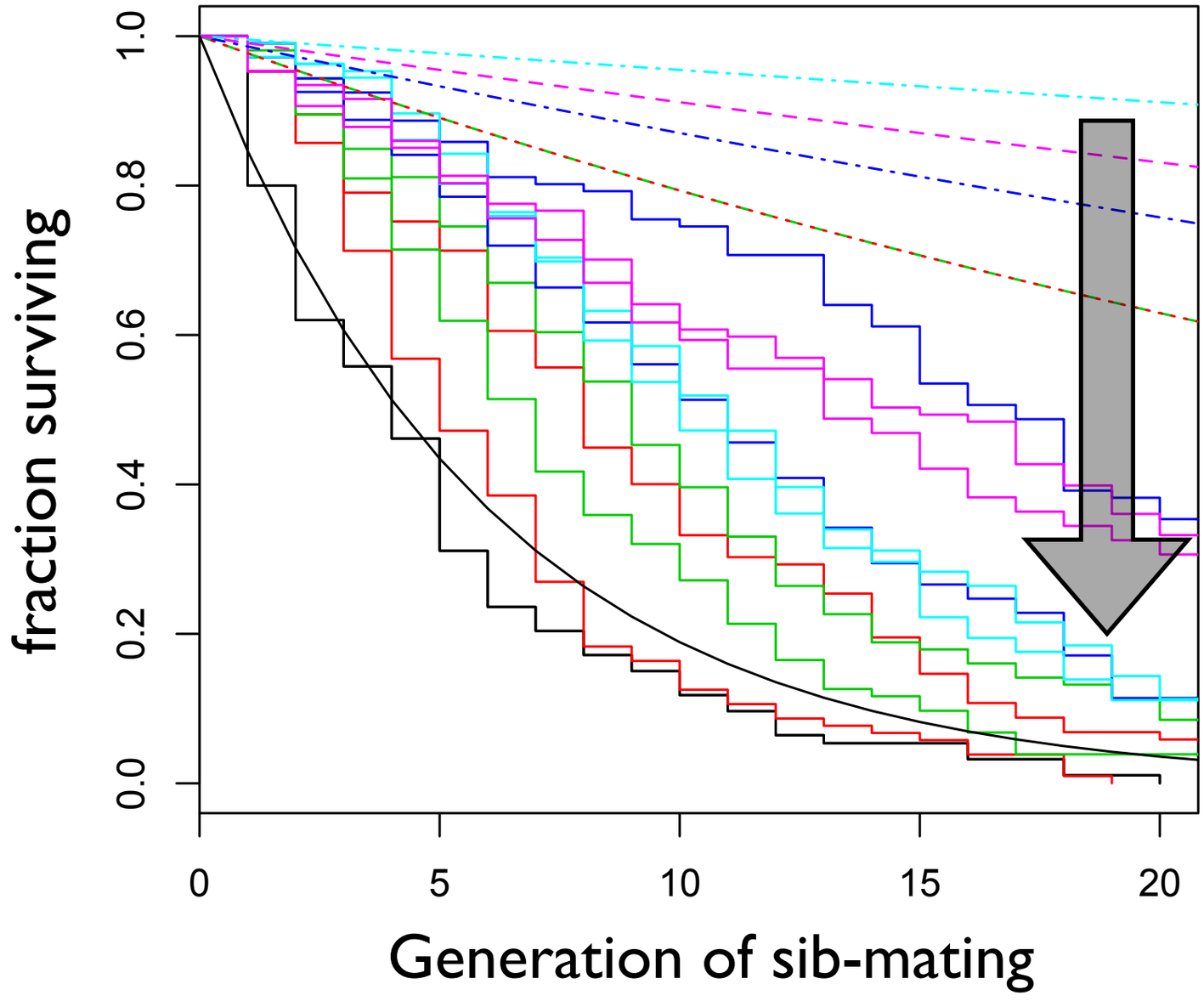
constant

Vicky Cattani
Annalise Paaby
Max Bernstein
Taniya Kaur
Audrey Chang
Jia Shen



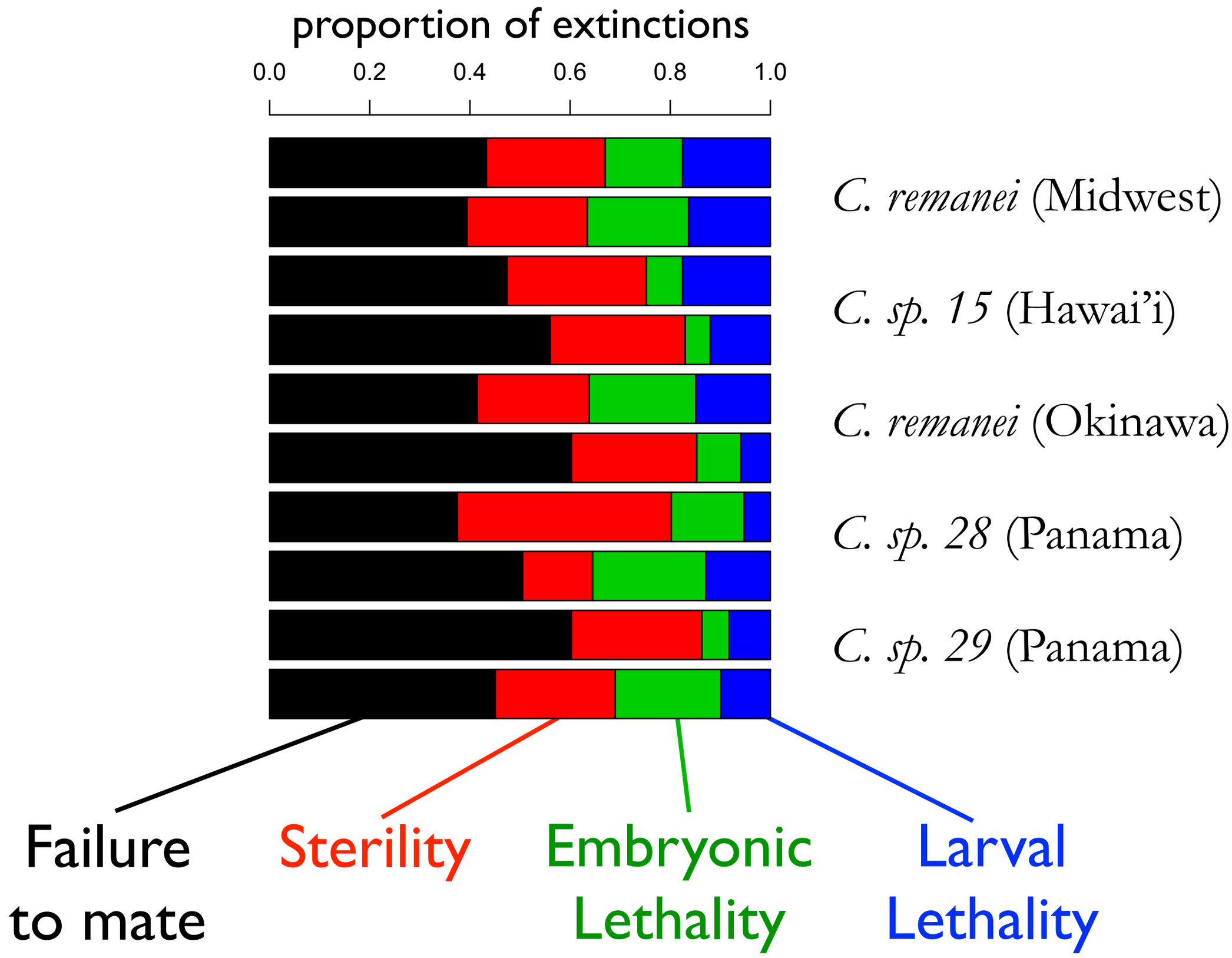
C. elegans (fog-2)
C. remanei (Eastern US)
C. sp. 15 (Hawai'i)
C. remanei (Okinawa)
C. sp. 28 (Panama)
C. sp. 29 (Panama)

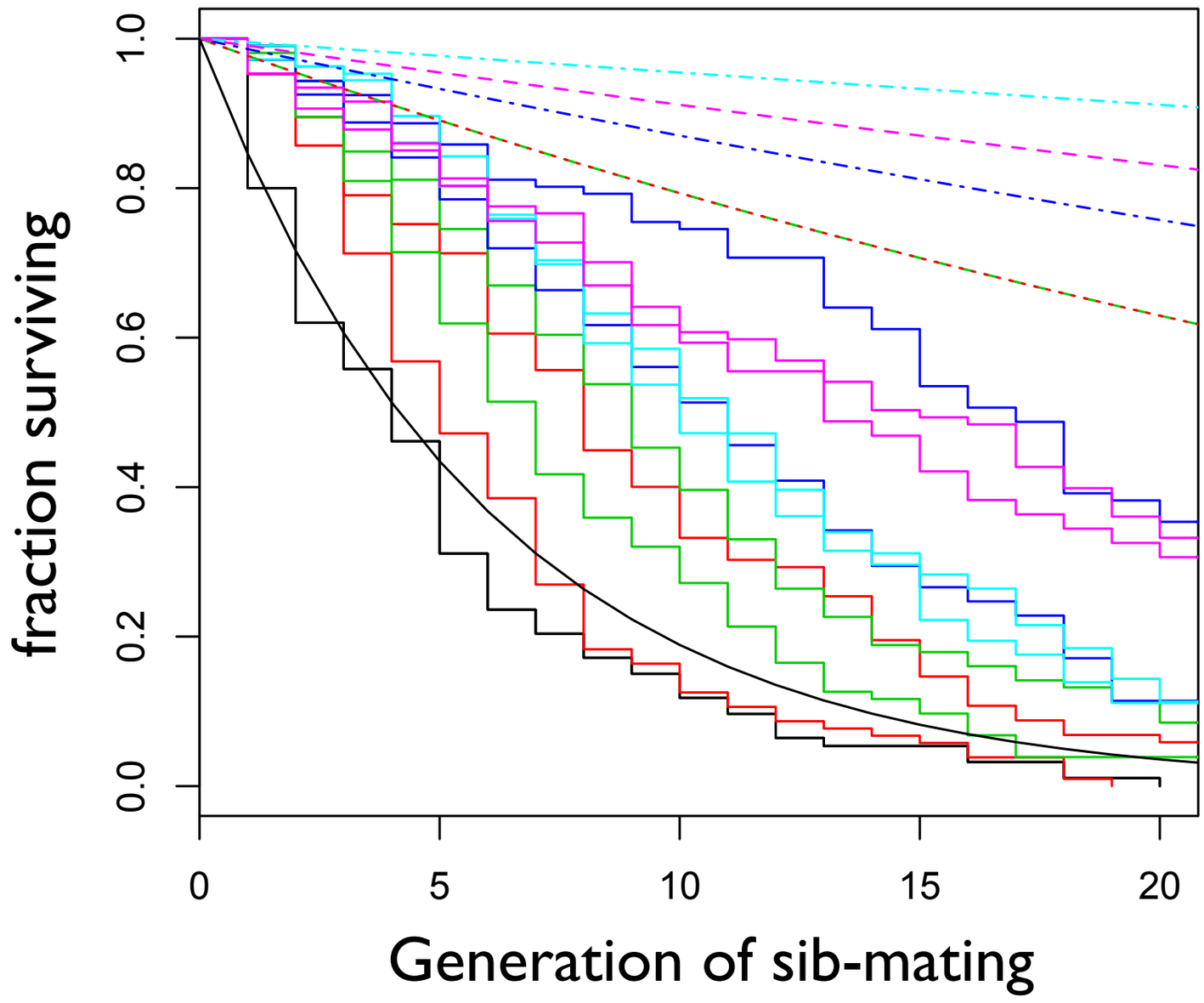

fraction surviving
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
20
Generation of sib-mating
C. elegans (fog-2)
C. remanei (Eastern US)
C. sp. 15 (Hawai'i)
C. remanei (Okinawa)
C. sp. 28 (Panama)
C. sp. 29 (Panama)



C. elegans (fog-2)
C. remanei (Eastern US)
C. sp. 15 (Hawai'i)
C. remanei (Okinawa)
C. sp. 28 (Panama)
C. sp. 29 (Panama)

severe inbreeding depression


proportion of extinctions
0.0
0.2
0.4
0.6
0.8
1.0
C. remanei (Midwest)
C. sp. 15 (Hawai'i)
C. remanei (Okinawa)
C. sp. 28 (Panama)
C. sp. 29 (Panama)
Failure to mate
Sterility
Embryonic Lethality
Larval Lethality



C. elegans (fog-2)
C. remanei (Eastern US)
C. sp. 15 (Hawai'i)
C. remanei (Okinawa)
C. sp. 28 (Panama)
C. sp. 29 (Panama)

Why do species differ in inbreeding depression?

Barro Colorado Island

Smithsonian Tropical Research Institute

10°N

8°N

6°N

82°W

80°W

78°W

km

0 75 150

m

2000

1500

1000

500

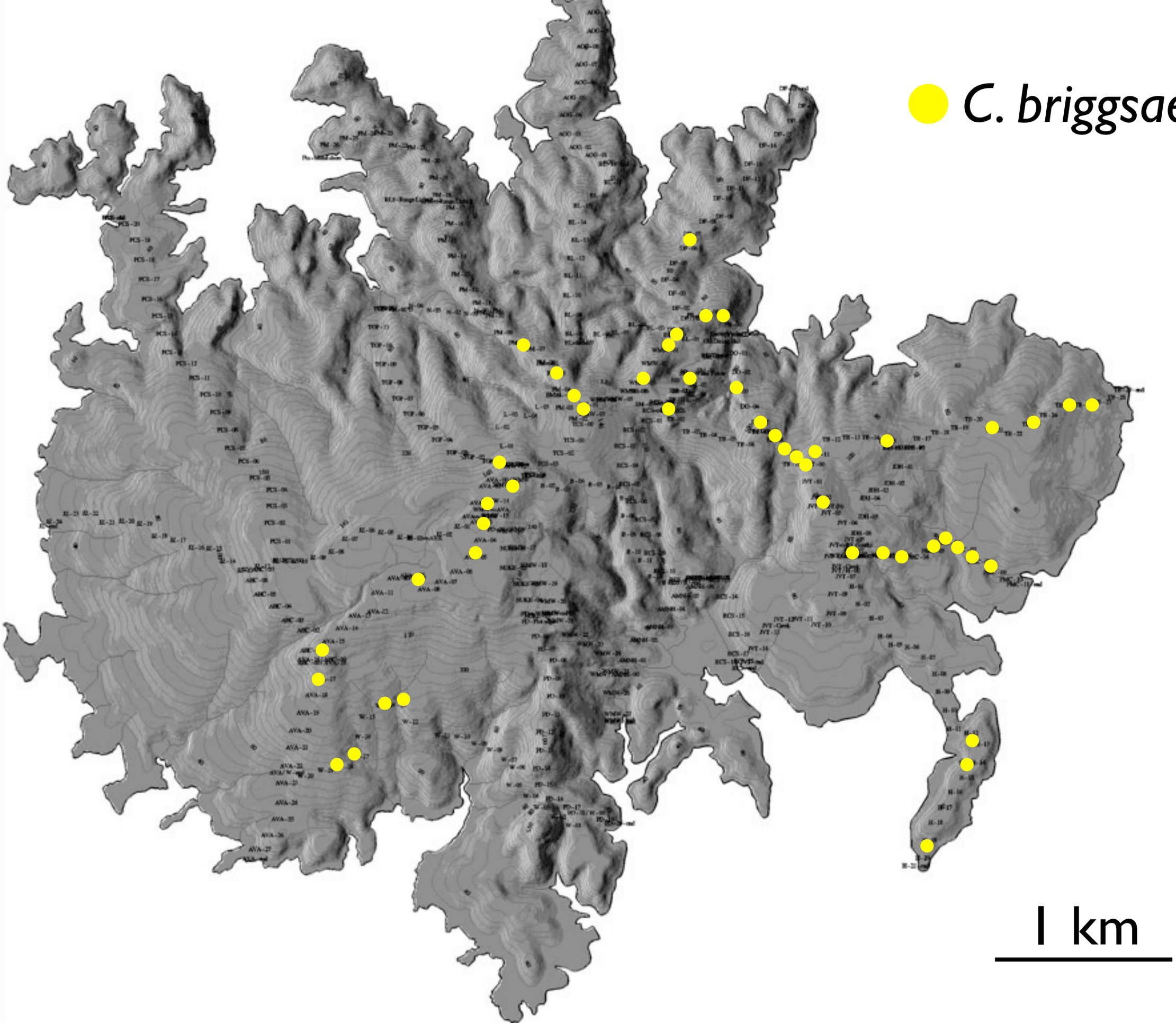
0

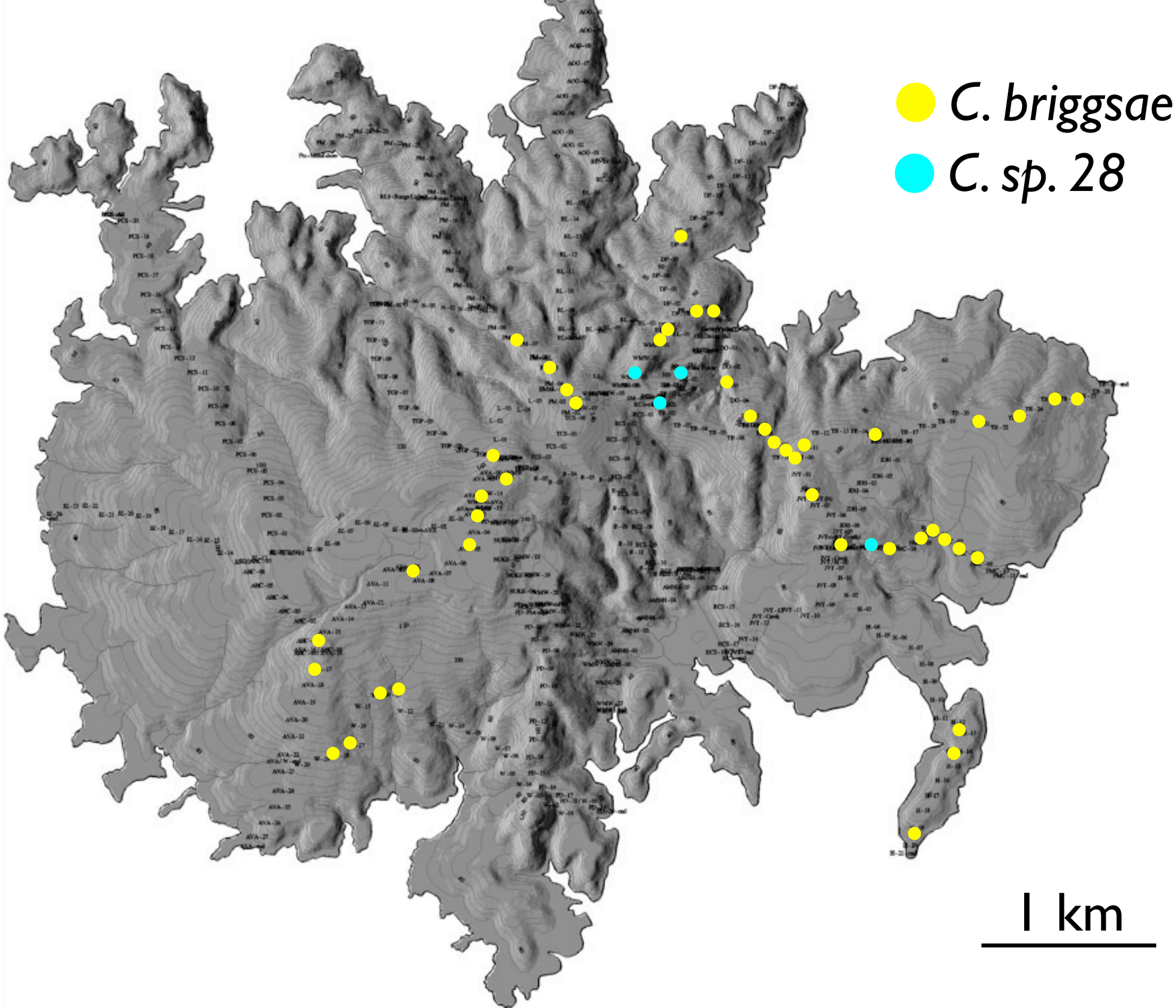
wikimedia commons

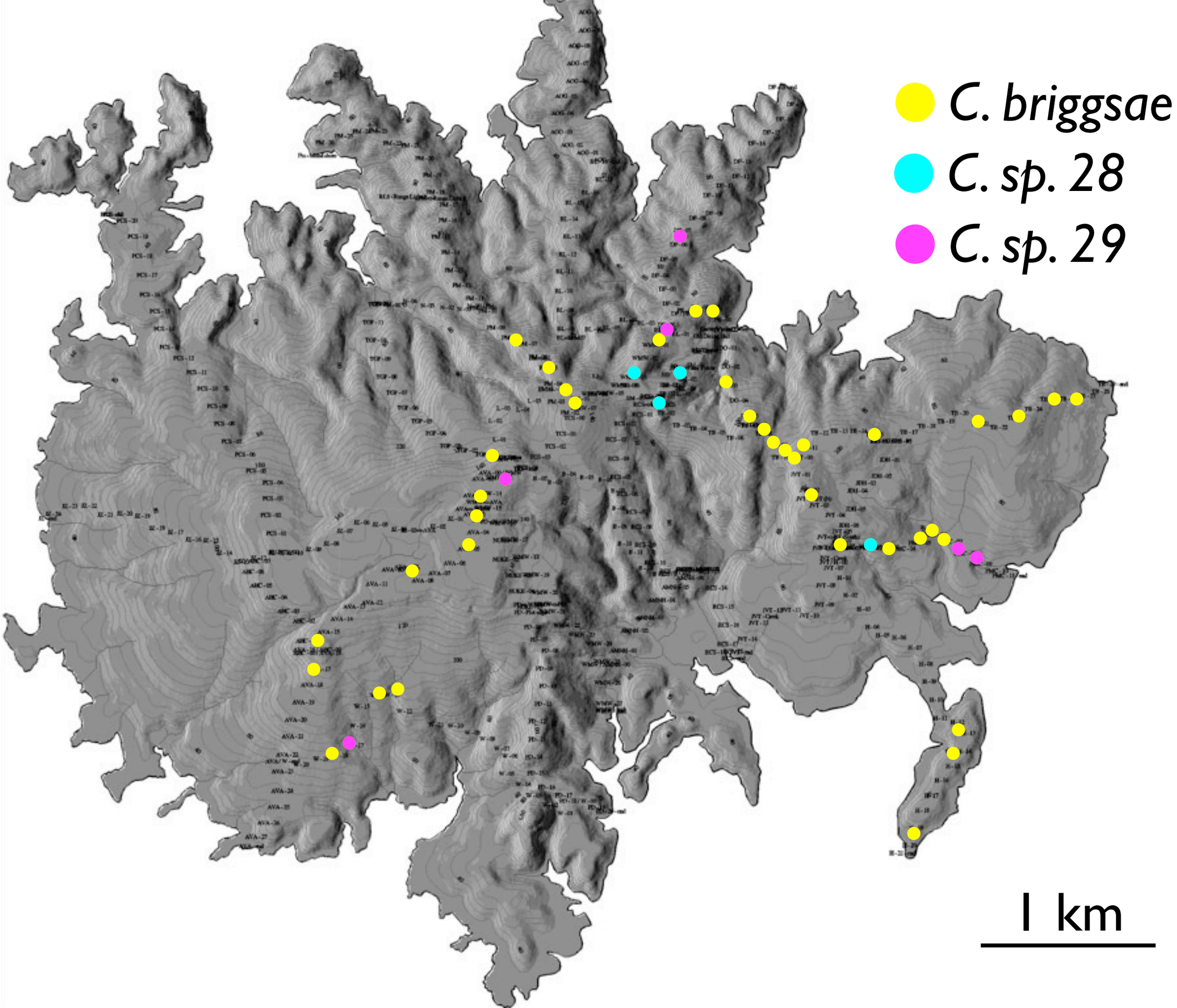

BOOKS
IN PRINT

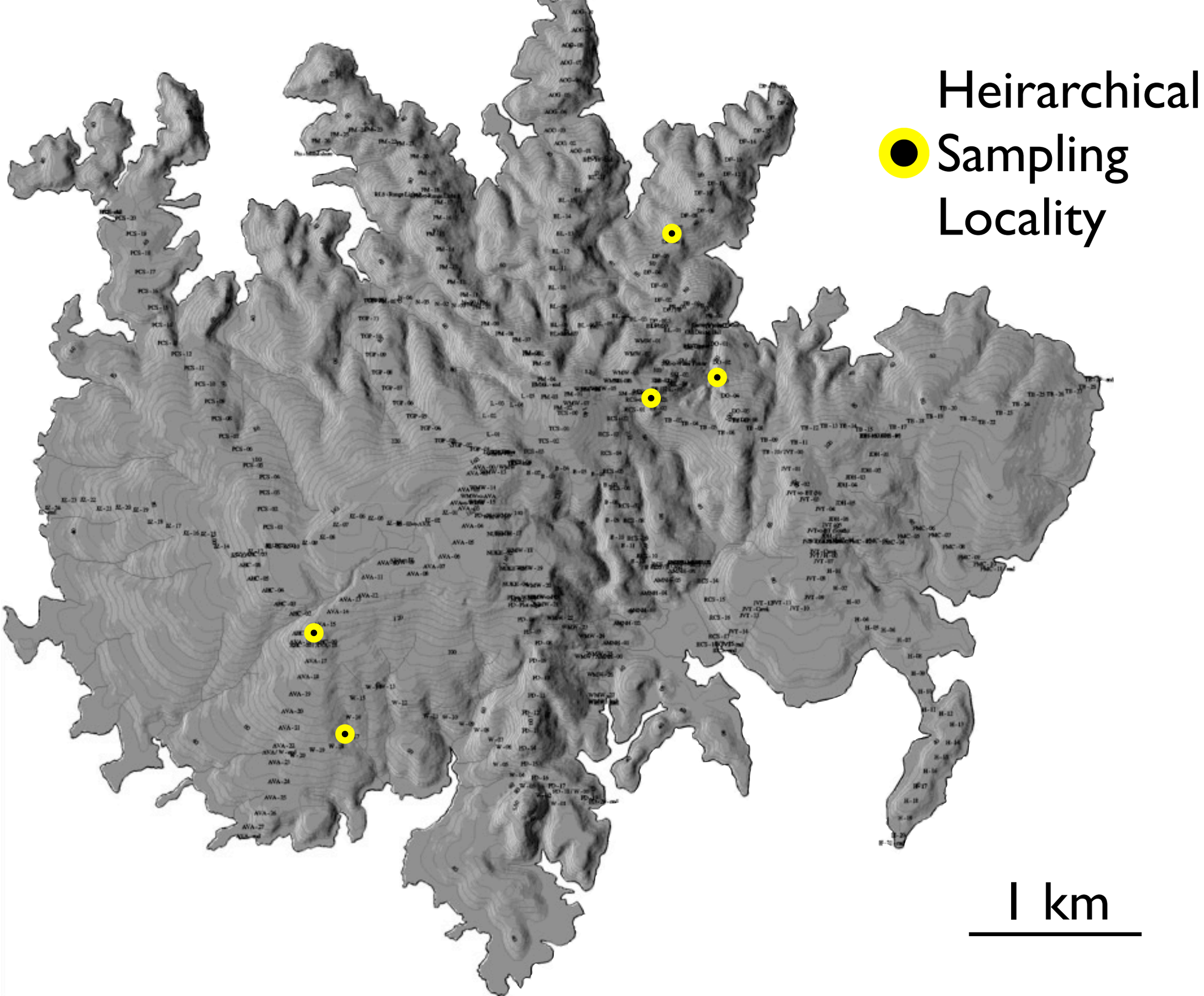
John Yuen

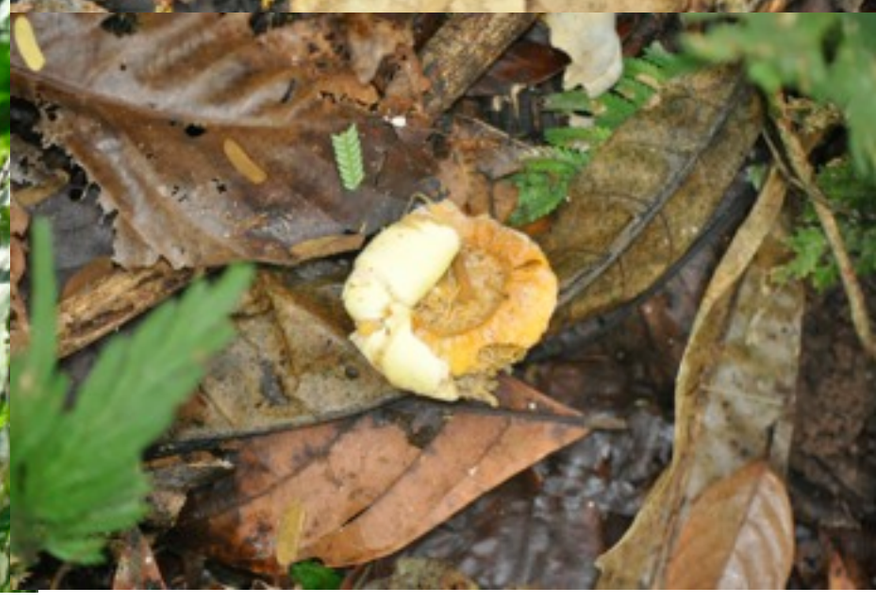
1 km


C. briggsae
1 km

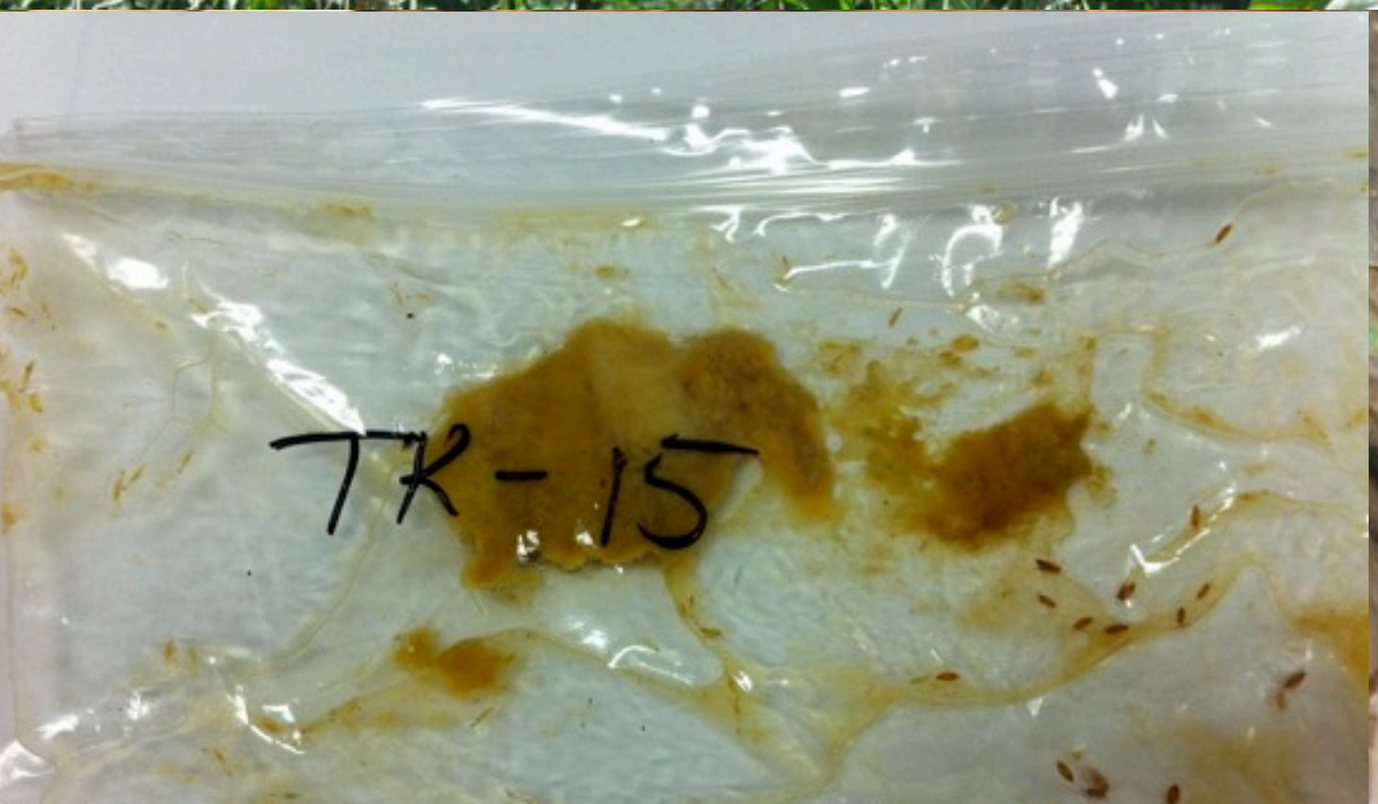

C. briggsae
C. sp. 28
1 km


C. briggsae
C. sp. 28
C. sp. 29
1 km


Heirarchical
Sampling
Locality
1 km



Gustavia superba

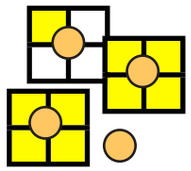

TR-15

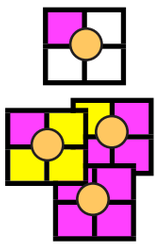
Tree DF

Gustavia superba

1 m

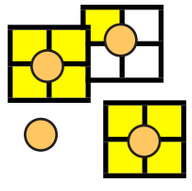
Tree DF





Gustavia superba

1 m



Metapopulation biology

biparental inbreeding

purging of dominance load

Population genomic analysis

Obligate Outcrossing

Androdioecy

Obligate Selfing

mating behavior

essential ⟷ *superfluous*

recessive mutations

masked ⟷ *exposed*

Rockman Lab

Audrey Chang
Dan McNelis
Mimi Yen
Max Kramer
David Riccardi
Taniya Kaur
Max Bernstein
Annalise Paaby
Vicky Cattani
John Yuen
Jasmine Nicodemus
Luke Noble

CGC

Bowdoin College
Michael Palopoli

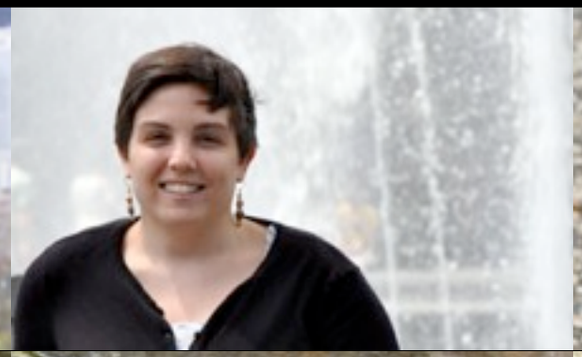
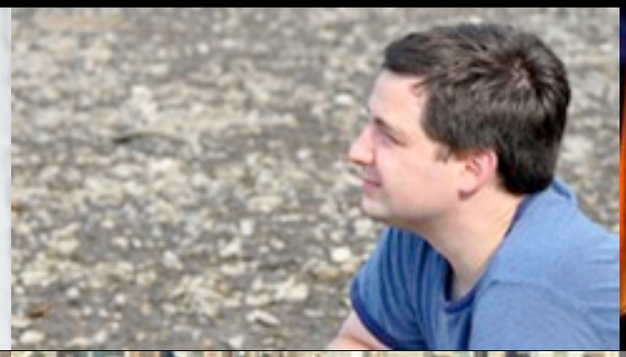
NYU

CENTER FOR GENOMICS AND SYSTEMS BIOLOGY
NEW YORK UNIVERSITY

NIGMS

The Ellison Medical Foundation
A NONPROFIT CORPORATION

HFSP
HUMAN FRONTIER SCIENCE PROGRAM
FUNDING FRONTIER RESEARCH INTO COMPLEX BIOLOGICAL SYSTEMS

SCIENCE

I LIKE
CHEMICALS