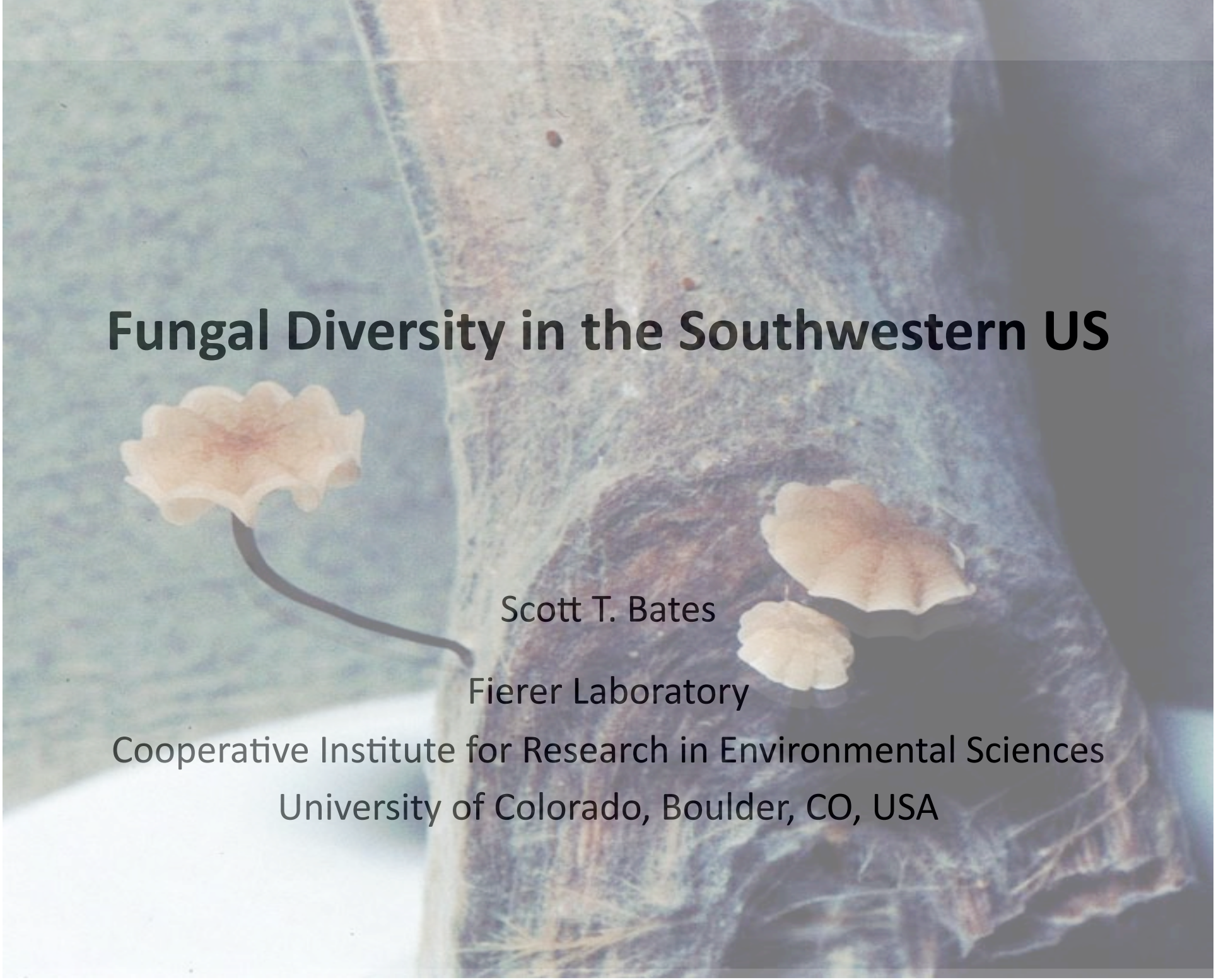


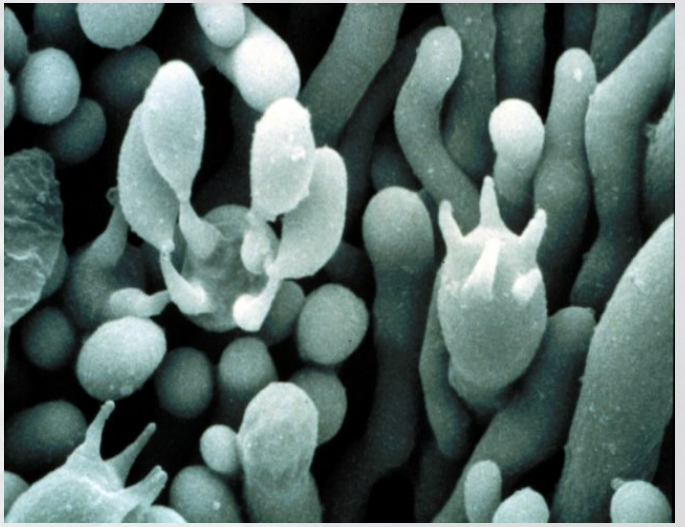
Fungal Diversity in the Southwestern US

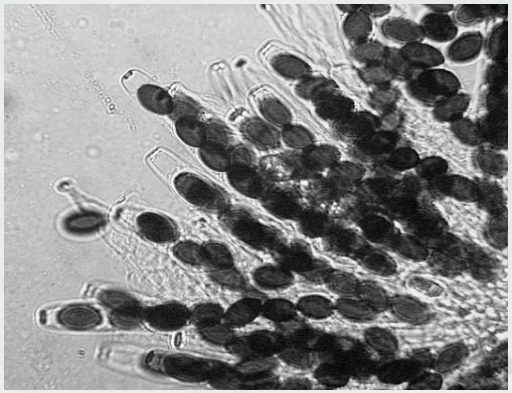
Scott T. Bates

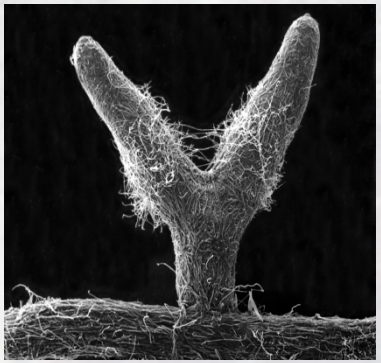
Fierer Laboratory

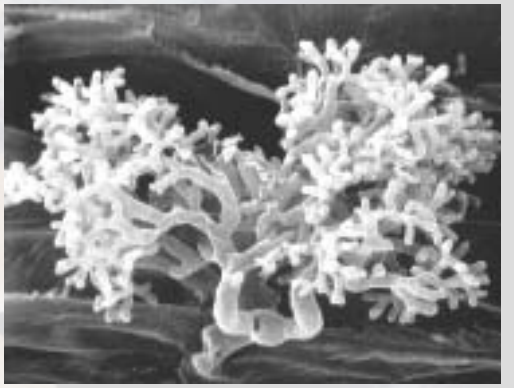
Cooperative Institute for Research in Environmental Sciences

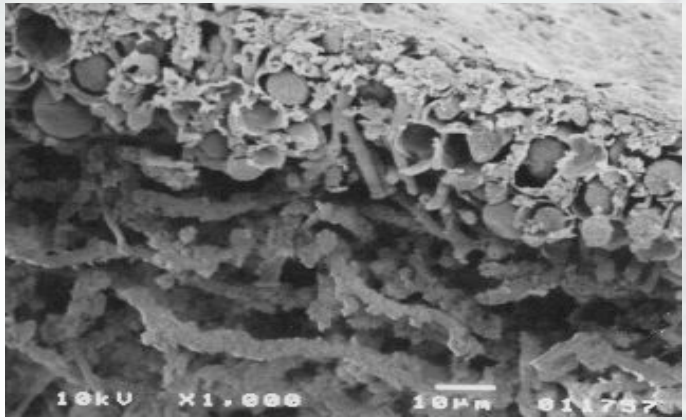
University of Colorado, Boulder, CO, USA

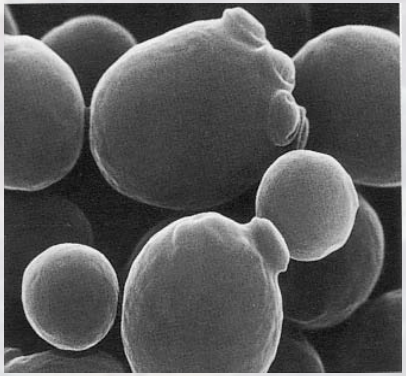








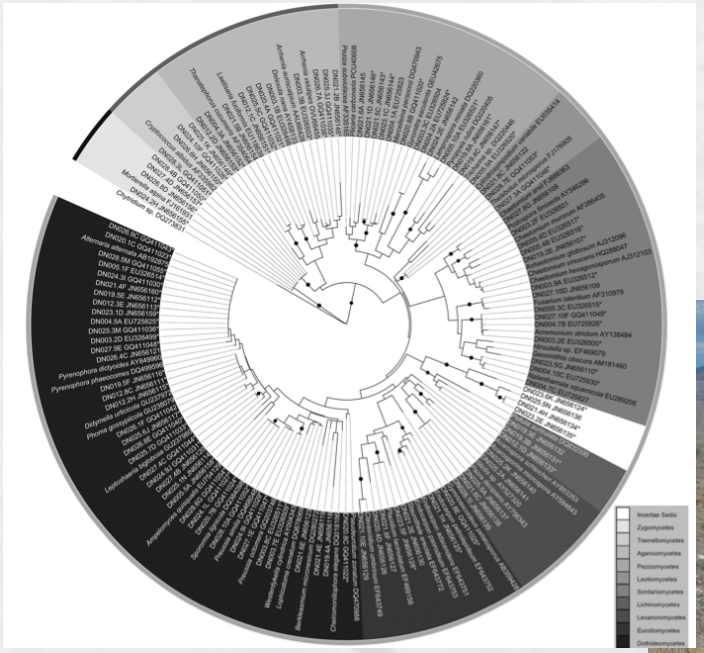

10kV X1,000 10µm 81757

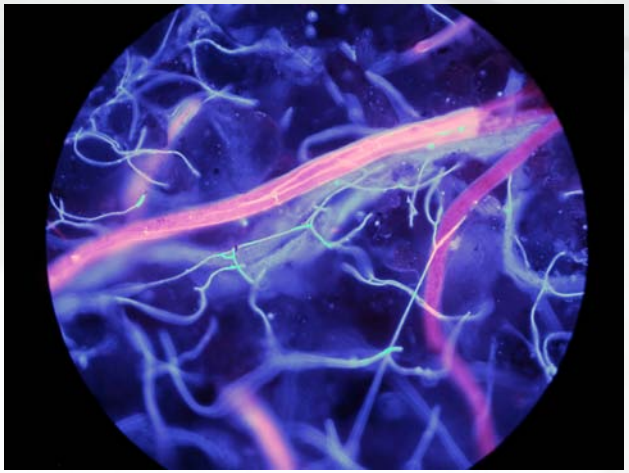



Botanical Society of America
(photo by Vernon Ahmadjian)

Mycologia, 104(2), 2012, pp. 353–361. DOI: 10.3852/11-232

Patterns of diversity for fungal assemblages of biological soil crusts from the southwestern United States





International Journal of Systematic and Evolutionary Microbiology (2006), **56**, 2697–2702 DOI 10.1099/ijs.0.64332-0

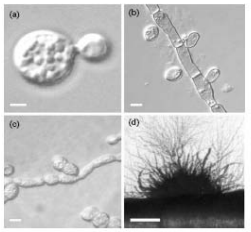
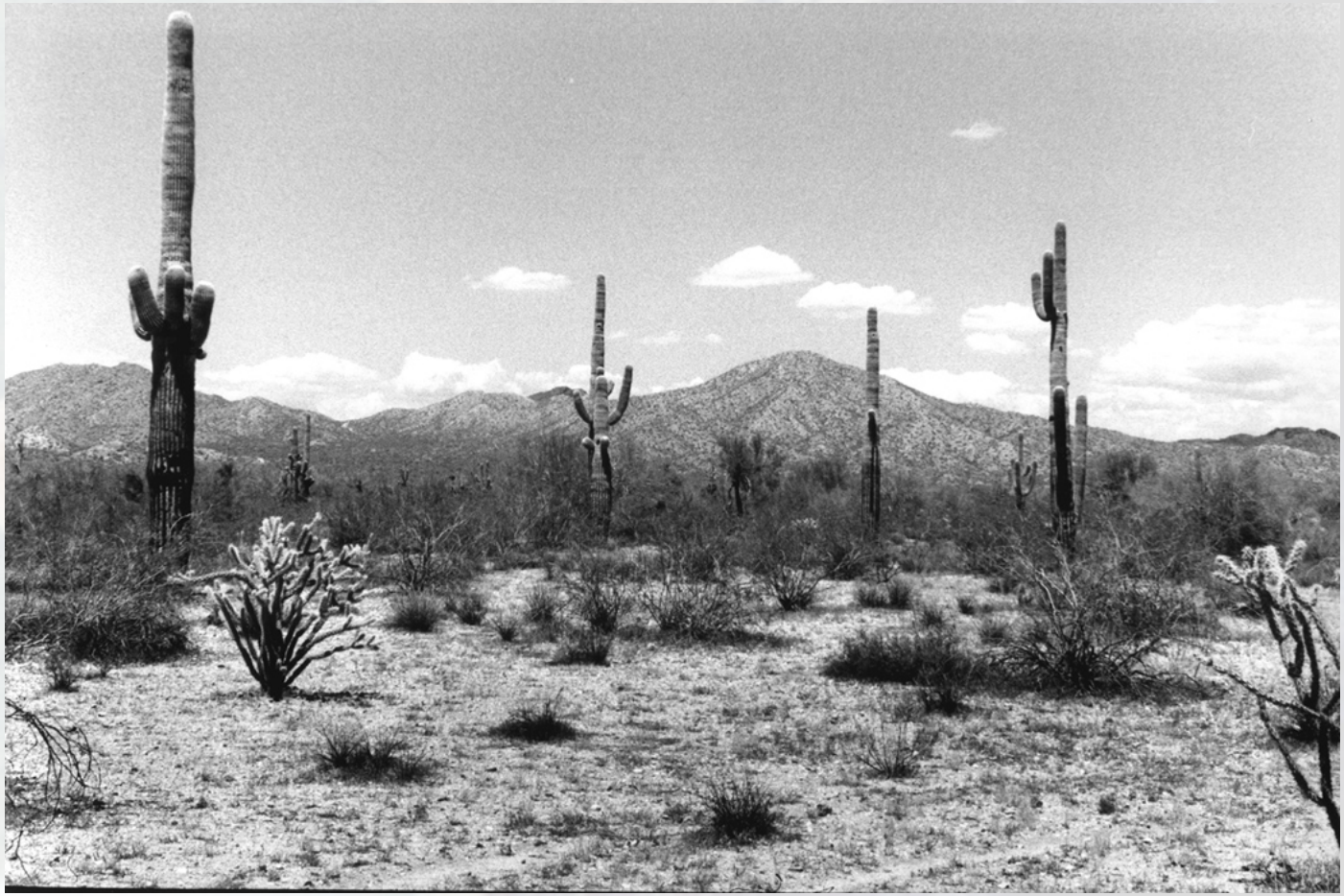


Fig. 1. *Exophiala crusticola* anam. nov. CP14.1b^T on PDA agar at 25 °C. (a) Annelate yeast-like cell; (b) conidiogenous cells producing conidia; (c) torulose hyphae; (d) fascicle of sub-merged hyphae protruding from colony margin. Bars, 1 μm (a), 2 μm (b–c), 1 mm (d).

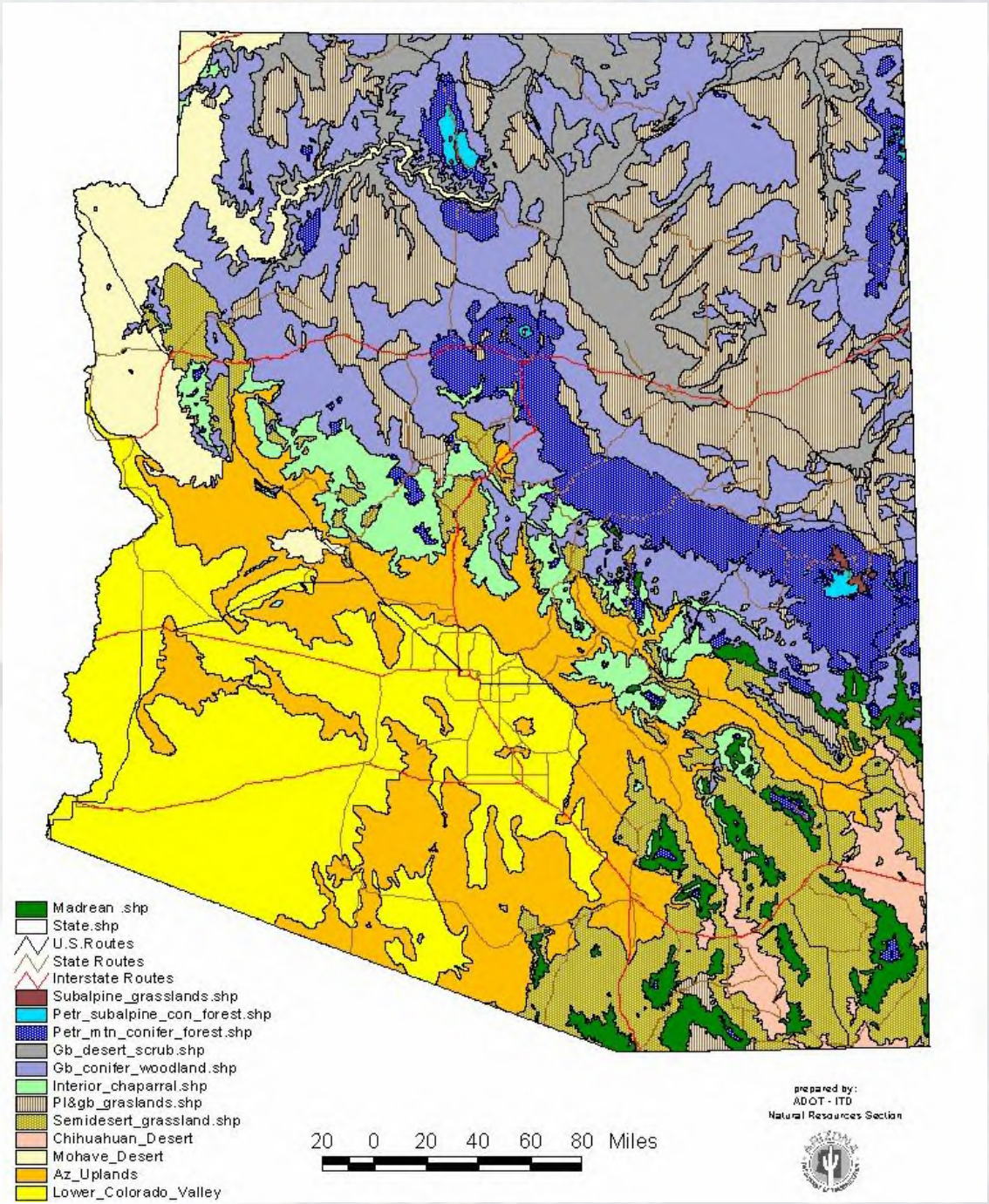
Exophiala crusticola anam. nov. (affinity *Herpotrichiellaceae*), a novel black yeast from biological soil crusts in the Western United States

Scott T. Bates,† Gundlapally S. N. Reddy† and Ferran Garcia-Pichel

School of Life Sciences, Arizona State University, Main Campus, Tempe, AZ-85287-4501, USA



Sonoran Desertscrub


Madrean .shp
State.shp
U.S.Routes
State Routes
Interstate Routes
Subalpine_grasslands.shp
Petr_subalpine_con_forest.shp
Petr_mtn_conifer_forest.shp
Gb_desert_scrub.shp
Gb_conifer_woodland.shp
Interior_chaparral.shp
Pl&gb_graslands.shp
Semidesert_grassland.shp
Chihuahuan_Desert
Mohave_Desert
Az_Uplands
Lower_Colorado_Valley
20 0 20 40 60 80 Miles
prepared by:
ADOT - ITD
Natural Resources Section

Arizona Biotic Communities

- Alpine Tundra
- Petran Subalpine Conifer Forest
- Petran Montane Forest
- Great Basin Conifer Woodland
- Madrean Evergreen Woodland
- Interior Chaparral
- Subalpine Grassland
- Plains & Great Basin Grassland
- Semidesert Grassland
- Great Basin Desertscrub
- Mojave Desertscrub
- Chihuahuan Desertscrub
- Sonoran Desertscrub
  - Lower Colorado R.V.
  - AZ Uplands

Fungal Biodiversity

6 fungal species per single plant species

=1.5 million fungal species worldwide

Hawksworth, D.L. (1991) The fungal dimension of biodiversity : magnitude, significance, and conservation. *Mycological Research* 95: 641-655

74,000 to120,000 fungi known

500,000 to 9.9 million estimated

0. 75% - 24% of total described

Fungal Biodiversity in Arizona

vascular plants = ~4000 species

4000 **x 6**

= 24,000 potential species of fungi

Macrofungi ~1200 spp. (S.T. Bates 2006)

Lichenized Fungi ~900 spp. (T.H. Nash III et al. 2002-2004)

Soil Fungi and Fungi Associated w/ BSCs ~300 spp.

Endophytic ~ 500 spp. (pers. comm. A.E. Arnold)

~2900 fungal species known from Arizona

21,100 fungal species left to document

A PRELIMINARY CHECKLIST OF ARIZONA MACROFUNGI

Scott T. Bates
School of Life Sciences
Arizona State University
PO Box 874601
Tempe, AZ 85287-4601

ABSTRACT

A checklist of 1290 species of nonlichenized ascomycetaceous, basidiomycetaceous, and zygomycetaceous macrofungi is presented for the state of Arizona. The checklist was compiled from records of Arizona fungi in scientific publications or herbarium databases. Additional records were obtained from a physical search of herbarium specimens in the University of Arizona's Robert L. Gilbertson Mycological Herbarium and of the author's personal herbarium. This publication represents the first comprehensive checklist of macrofungi for Arizona. In all probability, the checklist is far from complete as new species await discovery and some of the species listed are in need of taxonomic revision. The data presented here serve as a baseline for future studies related to fungal biodiversity in Arizona and can contribute to state or national inventories of biota.

INTRODUCTION

Arizona is a state noted for the diversity of its biotic communities (Brown 1994). Boreal forests found at high altitudes, the 'Sky Islands' prevalent in the southern parts of the state, and ponderosa pine (*Pinus ponderosa* P.& C. Lawson) forests that are widespread in Arizona, all provide rich habitats that sustain numerous species of macrofungi. Even xeric biomes, such as desertscrub and semidesert-grasslands, support a unique mycota, which include rare species such as *Itajahya galericulata* A. Møller (Long & Stouffer 1943b, Fig. 2c). Although checklists for some groups of fungi present in the state have been published previously (e.g., Gilbertson & Budington 1970, Gilbertson et al. 1974, Gilbertson & Bigelow 1998, Fogel & States 2002), this checklist represents the first comprehensive listing of all macrofungi in the kingdom Eumycota (Fungi) that are known from Arizona. In addition to providing a taxonomic framework to aid those workers whose investigations involve macrofungi found in Arizona, checklists such as this contribute to state and national inventories of biota and can aid future studies related to fungal and biological diversity.

This checklist includes 1290 nonlichenized species of macrofungi in the phyla Ascomycota, Basidiomycota, and Zygomycota that are present in Arizona. Species of lichenized fungi that are found in the region have been covered extensively in other publications (e.g., Nash et al. 2002, Nash et al. 2004, Sweat et al. 2004). The term macrofungi (or macromycetes) can be defined as species of fungi that produce fruiting bodies visible without the aid of a microscope (Kirk et al. 2001), and can be further defined to include only those fungi that produce fruiting bodies greater than one centimeter in height and/or width (Redhead 1997). The term refers specifically to the sporocarp of the fungal organism rather than the mycelium, which lives underground or within decomposing substrata such as rotting logs. Macrofungi

A Checklist of Arizona Macrofungi, Lichens, and Slime Molds - Windows Internet Explorer

http://www.azfungi.org/checklist/

how to identify mushrooms to genus

Google mushroom observer Search scott.... Convert Select

Favorites http--www.mycologia FastGroupII homepage Access Bacterial competit... Alan Silverside's images o...

A Checklist of Arizona Macrofungi, Lichens, and ... Page Safety Tools

Find: gen Previous Next Options

CHECKLIST OF ARIZONA MACROFUNGI, LICHENS, and SLIME MOLDS

AZ MACROFUNGI LICHENS AND SLIME MOLDS HOME

CONTRIBUTING HERBARIA

RELEVANT LINKS

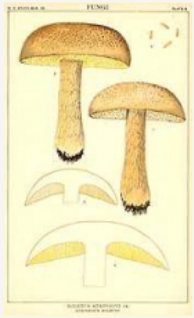
LITERATURE CITED

CONTACT US

Maintained by S.T. Bates

Powered by Ruby on Rails

Preliminary checklists of Arizona macrofungi (Bates 2006, Vol. 2 (2): 47-78) and slime molds (Bates & Barber 2008, Vol. 4(1): 8-19) have been published in Canotia. Records for these checklists were obtained from the literature, private herbaria, as well as public herbaria databases that were available online at the time of publication. Prior to publication, databases of macrofungi (true fungi) and slime molds (a polyphyletic group of organisms outside of the true fungi that produce fungus-like fruiting bodies) records were compiled seperately by the author/s that included the source of the record, the binomial as it was originally published, and the species name that was accepted in the CABI Index Fungorum at that time. Those data were combined into a single database and are presented online here as the *Checklist of Arizona Macrofungi and Slime Molds*.



Search

Browse By

Phylum Order Images

The preliminary checklists reported 1290 species of nonlichenized macrofungi and 147 species of slime molds for the state, and although those numbers are impressive, it is likely that many more species (perhaps several thousand for the macrofungi) are present in the state. By making the checklist database accessible online, it can be continually updated as more records become available. Nomenclature and classification schemes can also be changed to conform with current taxonomic concepts so that the checklist will retain its relevancy in the future. In addition to making the source for each record available to researchers, the checklist is now linked to digital images of taxa (when available) through the Arizona Mycota Project. This site was initially entitled the *Checklist of Arizona Macrofungi* and was developed at Arizona State University in the School of Life Sciences by S.T. Bates and R.T. Schroeder as an ASU Natural History resource.

Done Internet | Protected Mode: On 100%

The Arizona Mycota Project (AMP) - Windows Internet Explorer

http://www.azfungi.org/amp/index.html

The Arizona Mycota Project (AMP)

THE ARIZONA MYCOTA PROJECT

AMP
HOME PAGE

ARIZONA CHECKLISTS

ARIZONA FUNGI

ARIZONA MYCOLOGISTS

CONTRIBUTE SPECIMENS

CONTRIBUTORS

HERBARIA

RELEVANT LINKS

SELECTED IMAGES

SPECIES IMAGE LIST

SPECIMEN REQUESTS

TAXONOMIC KEYS

CONTACT AMP

Arizona, contrary to what some may think, has more to offer by way of habit than just desert. Rugged mountains, flowing rivers, and expansive forests are also prevalent within the state. These features contribute to a rich diversity of biotic communities. In fact, only a few states, such as California, rival Arizona in this aspect.

In 1990, British mycologist David Hawksworth suggested that only 5% of the Earth's fungal species had been described. Although opinions differ, the Hawksworth estimate is still widely accepted today. The situation is quite similar in Arizona where recent estimates suggest several thousand fungal species that occur in the state have never been recorded. When we consider the diversity of habitats found in Arizona, it is likely that many new records of macrofungi or even new fungal species are awaiting discovery.

Historically, amateur enthusiasts have made numerous contributions to the science of mycology. Recent technological advances, such as GPS units, have enhanced the average citizen's ability to record accurate scientific data, while the advent of digital cameras has greatly improved our ability to capture and transmit images. In the past, it has been proposed that a virtual 'army' of trained mycologist would be needed to truly advance our understanding of the North American fungal flora. However, when considering today's technology and the information that the world wide web has made available to the public, perhaps 'virtual mycologists' can make a significant contribution toward that goal.

The Arizona Mycota Project (AMP) has been created in an attempt to harness this potential resource. This site solicits the help of volunteer contributors, like you, to help advance our knowledge of the Arizona fungal flora (mycota). We encourage persons who have come across interesting fungal finds in the state, to collect specimens and record basic field data OR merely contribute fungal digital images. Specimens of macrofungi sent to AMP will be identified and the field data added to our database. Specimens with significant scientific value will eventually be housed in the University of Arizona's Robert L. Gilbertson Mycological

A macrofungus growing from a rotting stump
(image by S.T. Bates).

http://www.azfungi.org/amp/arizonafungi.html

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100%

Boletus pulchriceps

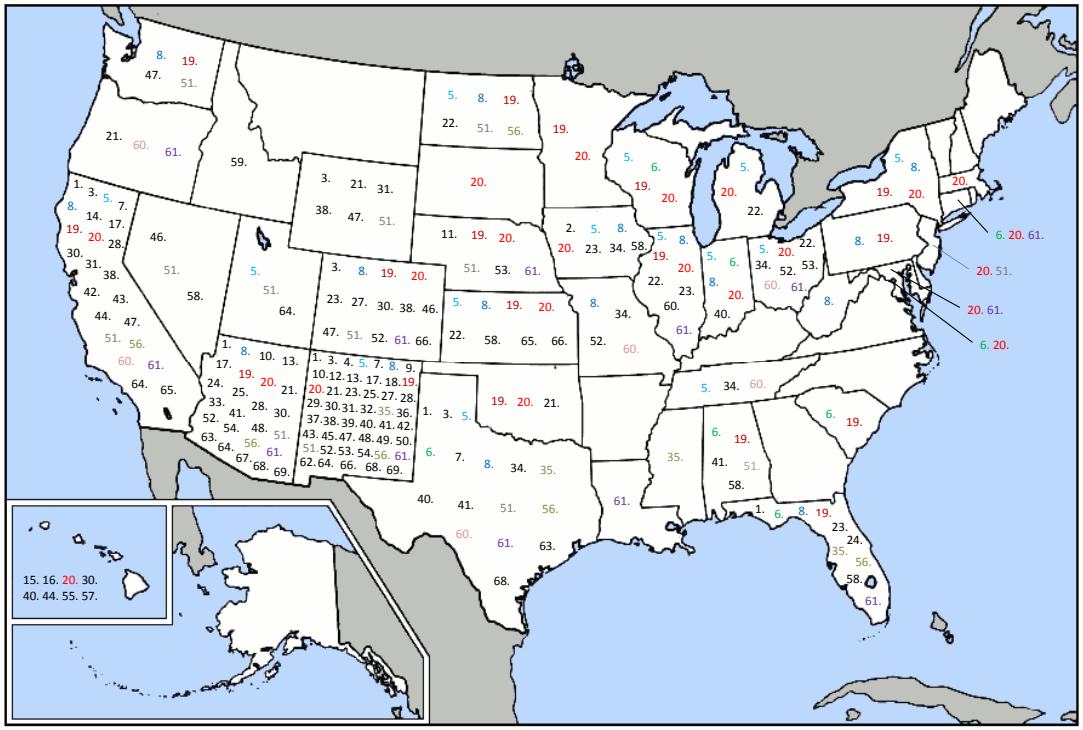
Did sequencing reveal unexpected changes in identification or unexpected diversity?

Did examining specimens reveal previously undocumented fungal diversity?

New Arizona records of gasteroid fungi

- ***Bovista aestivalis***
- ***Bovista dermoxantha***
- ***Bovista plumbea***
- ***Calvatia bicolor***
- ***Calvatia booniana***
- ***Calvatia craniiformis***
- ***Calvatia cyathiformis***
- ***Calvatia fragilis***
- ***Calvatia* cf. *leiospora***
- ***Calvatia pachyderma***
- ***Calvatia rugosa***
- ***Disciseda candida***
- ***Disciseda cervina***
- ***Disciseda hyalothrix***
- ***Disciseda verrucosa***
- ***Holocotylon brandegeeanum***
- ***Lycoperdon lividum***
- ***Lycoperdon marginatum***
- ***Lycoperdon molle***
- ***Lycoperdon perlatum***
- ***Lycoperdon pulcherrimum***
- ***Lycoperdon rimulatum***
- ***Lycoperdon umbrinum***
- ***Lycoperdon pyriforme***
- ***Mycenastrum corium***
- ***Vascellum intermedium***
- ***Vascellum lloydianum***
- ***Vascellum texense***

The Distribution of *Tulostoma* species in the United States (more widely distributed taxa are color coded)



Record origin: BPI (National Fungus Collections); NY (New York Botanical Garden); SFSU (Thiers Herbarium, San Francisco State University).

1. *Tulostoma albicans* (BPI, NY)
2. *Tulostoma album* (BPI)
3. *Tulostoma americanum* (BPI)
oo. *Tulostoma asperum* = ***T. lloydii*** (BPI)
4. ***Tulostoma australianum*** (BPI)
5. ***Tulostoma beccarianum*** (BPI)
6. ***Tulostoma berkeleyi*** (BPI)
7. ***Tulostoma berteroanum*** (BPI)
oo. *Tulostoma bonianum* = ***T. pusillum*** (BPI)
8. ***Tulostoma brumale*** (BPI)
9. ***Tulostoma caespitosum*** (BPI)
oo. *Tulostoma campestre* = ***T. f. var. campestre*** (BPI, NY)
oo. *Tulostoma carneum* = ***T. giovanellae*** (BPI)
10. ***Tulostoma chudaei*** (BPI)
11. ***Tulostoma cineraceum*** (BPI)
12. ***Tulostoma clathrosporum*** (BPI)
13. ***Tulostoma cretaceum*** (BPI, NY)
14. ***Tulostoma cyclophorum*** (BPI)
15. ***Tulostoma dumeticola*** (SFSU)
oo. *Tulostoma egranulosum* = ***T. f. var. egranulosum*** (BPI)
16. ***Tulostoma exasperatum***
17. *Tulostoma excentricum* (BPI)
18. *Tulostoma ferrugineum* (BPI)
oo. *Tulostoma fibrillosum* = ***T. f. var. campestre*** (BPI, NY)
19. ***Tulostoma fimbriatum* var. *fimbriatum*** (BPI)
20. ***Tulostoma fimbriatum* var. *campestre*** (BPI)
21. ***Tulostoma fimbriatum* var. *egranulosum*** (BPI)
22. ***Tulostoma fimbriatum* var. *punctatum***
23. ***Tulostoma fimbriatum var. tuberculatum*** (BPI)
24. ***Tulostoma floridanum*** (BPI, NY)
25. ***Tulostoma fusipes*** (BPI)
26. ***Tulostoma giganteum*** (NY)
27. ***Tulostoma giovanellae*** (PBI)
oo. *Tulostoma gracile* = ***Chlamydopus meyenianus*** (NY)
oo. *Tulostoma granulosum* = ***T. fimbriatum*** (BPI)
oo. *Tulostoma granulosum var. campestre* = ***T. f. var. campestre*** (BPI)
oo. *Tulostoma granulosum var. punctatum* = ***T. f. var. punctatum*** (BPI)
oo. *Tulostoma granulosum var. tuberculatum* = ***T. f. var. tuberculatum*** (BPI)
28. ***Tulostoma herteri*** (BPI)
29. *Tulostoma innermongolicum* (BPI)
30. ***Tulostoma involucratum*** (BPI)
31. ***Tulostoma jourdanii*** (BPI)
32. *Tulostoma juniperense* ? (NY)
oo. *Tulostoma kansense* = ***T. v. var. obesum*** (BPI, NY)
oo. *Tulostoma laceratum* = ***Schizostoma laceratum*** (BPI)
33. ***Tulostoma leiosporum*** (BPI)
oo. *Tulostoma leveilleanum* = ***T. exasperatum*** (BPI)
34. ***Tulostoma lloydii*** (BPI)
35. ***Tulostoma longii*** (BPI)
36. ***Tulostoma lysocephalum*** (BPI)
37. ***Tulostoma macalpinianum*** (BPI)
38. ***Tulostoma macrocephalum*** (BPI)
39. ***Tulostoma macrosporium*** (BPI)
oo. *Tulostoma mammosum* = ***T. brumale*** (BPI, NY)
40. ***Tulostoma melanocyclum*** (BPI)
41. ***Tulostoma meridionale*** (BPI)
42. ***Tulostoma meristostoma*** (BPI)
oo. *Tulostoma meyenianum* = ***Chlamydopus meyenianus***
oo. *Tulostoma minutum* ***T. pulchellum*** = (NY)
oo. *Tulostoma moellerianum* = ***T. giovanellae*** (BPI)
43. ***Tulostoma mohavei*** (BPI)
44. ***Tulostoma montanum*** (BPI)
45. ***Tulostoma nanum*** (BPI)
oo. *Tulostoma obesum* = ***T. v. var. obesum*** (BPI, NY)
46. ***Tulostoma obscurum*** (BPI)
47. *Tulostoma occidentale* (BPI)
48. ***Tulostoma opacum*** (BPI)
oo. *Tulostoma orogrande* = ***T. purpusii*** (BPI)
oo. *Tulostoma pedunculatum* = ***T. brumale*** (BPI)
49. *Tulostoma perplexum* (BPI)
oo. *Tulostoma petrii* = ***T. fimbriatum*** (BPI)
oo. *Tulostoma poculatum* = ***T. pulchellum*** (BPI, NY)
50. *Tulostoma polymorphum* (BPI)
51. ***Tulostoma pulchellum* var. *pulchelllum*** (BPI)
52. ***Tulostoma pulchellum var. subfuscum*** (BPI)
oo. *Tulostoma punctatum* = ***T. f. var. punctatum*** (BPI, NY)
53. *Tulostoma puncticulosum* (BPI)
54. ***Tulostoma purpusii*** (BPI)
55. ***Tulostoma pusillum*** (BPI)
56. ***Tulostoma pygmaeum*** (BPI)
oo. *Tulostoma readeri* = ***T. fimbriatum*** (BPI)
57. ***Tulostoma rivulosum*** (BPI)
58. ***Tulostoma rufum*** (PBI, NY)
oo. *Tulostoma simulans* = ***T. beccarianum***(BPI, NY)
59. *Tulostoma slaviforme* ? (NY)
60. ***Tulostoma squamosum*** (BPI)
61. ***Tulostoma striatum*** (BPI, NY)
oo. *Tulostoma subfuscum* = ***T. p var. subfuscum*** (BPI, NY)
62. *Tulostoma subsquamosum* (BPI)
63. ***Tulostoma thiersii*** (BPI, NY)
oo. *Tulostoma tuberculatum* = ***T. f. var. tuberculatum*** (BPI)
64. ***Tulostoma utahense*** (BPI, NY)
oo. *Tulostoma verrucosum* = ***T. squamosum*** (BPI)
65. ***Tulostoma volvulatum* var. *volvulatum*** (BPI)
66. ***Tulostoma volvulatum* var. *obesum***
67. *Tulostoma vulgare* (BPI)
68. *Tulostoma wrightii* (BPI)
69. ***Tulostoma xerophilum*** (BPI)

What is our contribution from the mycological community to the public sequence databases?

Illumina Sequencing Results:

5,214,389 Sequences passed quality control

1,344,226 Sequences matched sequences in the reference DB

from ~3-67% matched the reference database at the 99% sequence similarity level

~25% on average