An old problem in Mycology solved with simple Mathematics

using...

standard methods of measurement...ratios...line's slope
piecewise linear graphs...bar charts...scatter plots
mean...median...mode...percentiles
computer language definition methods

Outline

Simple aid for analysis and comparison of
complex spore data:
spore length, spore width, spore shape,
quality of specimen from which spores came, etc.

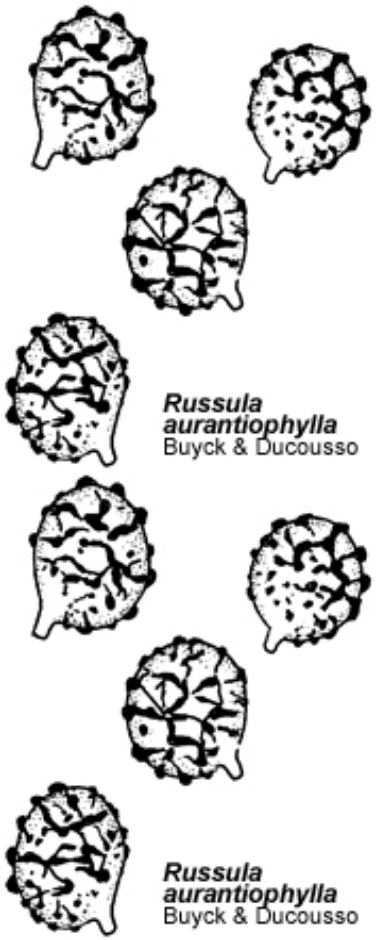
Problem history

Work booklets (simple math, simple graphs)

Results at work—mycologist's viewpoint

Problem:

Comparing spore measurements from different specimens of fungi



Microscope used very early in study of fungi

Grid in eyepiece allows measurement
when calibrated by measuring things of known size

Standards of length evolve [e.g., µm (micron)]

By mid-19th Century authors wrote, e.g., 6–8 µ diam.

Better microscopes revealed spores not all spherical; hence,
8.5–11.5 × 6–9.5 µ (e.g., Coker, 1917) then

(8.0–) 8.3–11.7 (–13.2) × (5.4–) 6.1–9.7 (–10.2) µm

Still most scientists looked for big & little spores & measured 5 or 6.

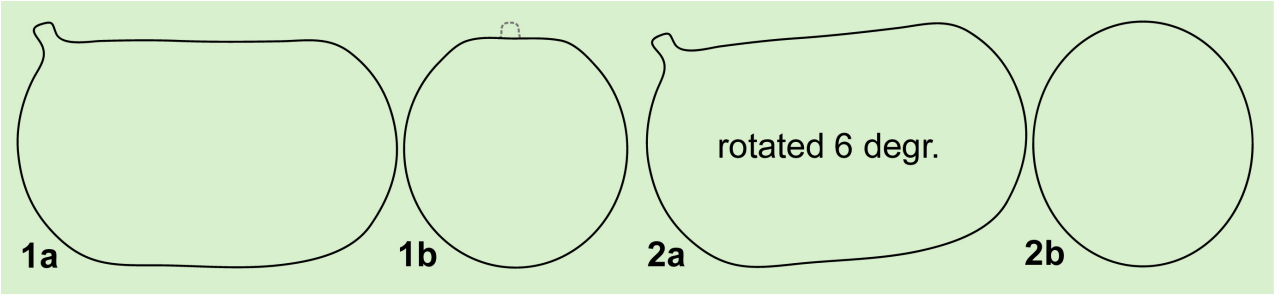
Solution begins to appear after 200 years...

Looked “scientific,” but...
different people got different numbers on different days from same specimen

Mid- to late 20th Cent.: Lights go on! Use spore length to spore width ratios.

Bas (1960s): words for spore shape standardized on ranges of
ratio of spore length to spore width

Uljé, Tulloss, others (late 20th Cent.): Spores must always be me**a**sured in **standard orientation**. Method often depends on given genus or family or order of fungus.



Problem 1: Study of Fungi (Mycology)

By the year 1969 (Bas):

[100/12] (8–) 8.5–13 (–13.5) × (6–) 6.5–8.5 (–9) µm;
length-breadth ratio 1.3–1.6 (average 1.45), ellipsoid, ...

Present day (Tulloss, 2008):

[260/12/10] (6.5–) 8.0–12.6 (–15.5) × (4.5–) 5.8–8.0 (–9.5) µm, (**L** = 8.5–11.6 (–12.0) µm; **L'** = 10.3 µm; **W** = 6.0–7.4 (–7.5) µm; **W'** = 6.8 µm; Q = (1.17–) 1.31–1.79 (–3.75); **Q** = (1.39–) 1.41–1.66; **Q'** = 1.52), ..., ellipsoid to elongate, rarely bacilliform or irregularly shaped in specimens with sporulation just beginning when dried, adaxially flattened, sometimes inflated at one end;...

How to compare/evaluate efficiently such <u>lumps</u> of data?

Problem 1: Study of Fungi (Mycology)

E. J. H. Corner (1947) invented the sporograph for use with coral fungi.
[View images of *Clavaria purpurea* and *Ramaria formosa* on web.]

Tulloss (1984) modified the sporograph & applied to gilled mushrooms.
[*Amanita mutabilis*] *[*Amanita mutabilis*]

Graphics (& the math to back them up) can help.

Let's take a look at the work booklets...

Problem 1: Study of Fungi (Mycology)

Approximately **70 students**
9 work booklets (1-9) each representing separate specimen
Real data from specimens collected around world
18 working groups, 3-4 researchers each.
If you wish, you can share tasks &/or do tasks in parallel.

5 TASKS

1. Present data in standard format.
2. Compute mean, mode, & median of spore length data set.
3. Make barchart of spore lengths.
4. Make scatter plot.
5. Make initial sporograph.

Groups w/ same work booklet combine, cross-check each other.

Problem 1: Study of Fungi (Mycology)

Now that you are in your groups...

Those of you in a group can all choose to do all tasks jointly
OR
you can split up the tasks.
The point is to **work efficiently** so that we can get on to
what our work will reveal to us.

Note: **Task no. 5** can only be done after **Task no. 1** is finished.

Yes, I know there is a **Task no. 6**. We're going to have a **discussion** before we **jointly develop instructions** for Task no. 6.

Let's make sure we all understand the instructions for Tasks nos. 1-5...

Problem 1: Study of Fungi (Mycology)

Read instructions for Task no. 1 & make notes if you have any questions to ask (we'll take care of them in a moment).

Read instructions for Task no. 2 & make notes if you have any questions to ask (we'll take care of them in a moment).

Read instructions for Task no. 3 & make notes if you have any questions to ask (we'll take care of them in a moment).

Read instructions for Task no. 4 & make notes if you have any questions to ask (we'll take care of them in a moment).

Read instructions for Task no. 5 & make notes if you have any questions to ask (we'll take care of them in a moment).

Problem 1: Study of Fungi (Mycology)

In case of questions: Task no. 1: **Standard Data Presentation**

<a>:: <b> is read “the string <a> is defined to be the string <b>, where <b> can be a concatenation of symbols and substrings. [Blank space is a “blank” character.]

<standard data form>:: <data counts> <length range data> × <width range data> µm, (**L** = <average length> µm; **W** = <average width> µm; Q = <Q range data>; **Q** = <average Q>), ...<qualitative shape data>...

Q = length:width ratio for a single spore OR the observed range of such ratios

<data counts>:: [<x>/<y>/<z>]
<x>:: <total spores measured>
<y>:: <total specimens from which spores were measured>
<z>:: <total collections from which came specimens from which spores were measured>

Problem 1: Study of Fungi (Mycology)

The parts of a <... range string>:

(*m*–) *n*–*o* (–*p*)

m = the "lower extreme" value from given data (length, width, or Q). May be no *m* in a given case.

p = the "upper extreme" value from given data. May be no *p* in a given case.

n = least number in the given data not in the 5th-%ile of given data (if 5th-percentile value exists) ELSE, if an *r*th-%ile exists for 0 <= *r* < 5, the least number not in the *r*th percentile for the greatest such *r*. Note: In cases when the greatest *r*=0, no value of *m* is reported.

o = 95th-&ile value for given data (if exists) ELSE, if an *s*th-%ile exists for 95 < *s* <= 100, *o* = the least such *s*. In cases when the least *s* = 100, no value of *p* is reported.

Problem 1: Study of Fungi (Mycology)

In case of questions: Task no. 2:
Mean, mode, & median of spore length data set.

The mean has already been computed in Task no. 1.

If needed, volunteer can give review of median &/or mode.

Problem 1: Study of Fungi (Mycology)

In case of questions: Task no. 3: Barchart of spore lengths

The standard column headings:

6-7	7.5-8.5	9-10	10.5-11.5	12-13	13.5-14.5	15-16	16.5-17.5

Rounded from:

5.8-7.2	7.3-8.7	8.8-10.2	10.3-11.7	11.8-13.2	13.3-14.7	14.8-16.2	16.3-17.7

I actually make chart “upside down”—writing down spore measurements as they are made. I use lined or graph paper; each line with data on it extends one column/bar downward one line-space. With time &/or money this could be automated easily.

Problem 1: Study of Fungi (Mycology)

In case of questions: Tasks nos. 4 & 5:

Warning: Length is traditionally presented before width in measurements of everything from furniture to spores.
HOWEVER, “length” corresponds to the “y” coordinate
in the graphs you will be preparing.
“Length” is <u>not</u> the “x” coordinate.

Each division on both axes of your graphs represents **1.0 µm**.

<u>This is important</u> <u>so that your drawings can be **laid on top of each other**
and have the combined graph **mean** something.
¡Muy, muy importante!</u>

Problem 1: Study of Fungi (Mycology)

2 research groups for each *n*, where *n* is the number of a work booklet.

Organize for Cross Checking
[hands up when done]

THANKS! To the computation "engines" who made the rest of our analysis possible.
[applesauce]

THANKS! To the charters and graphers who have created
the objects of our next discussion.
[applesauce]