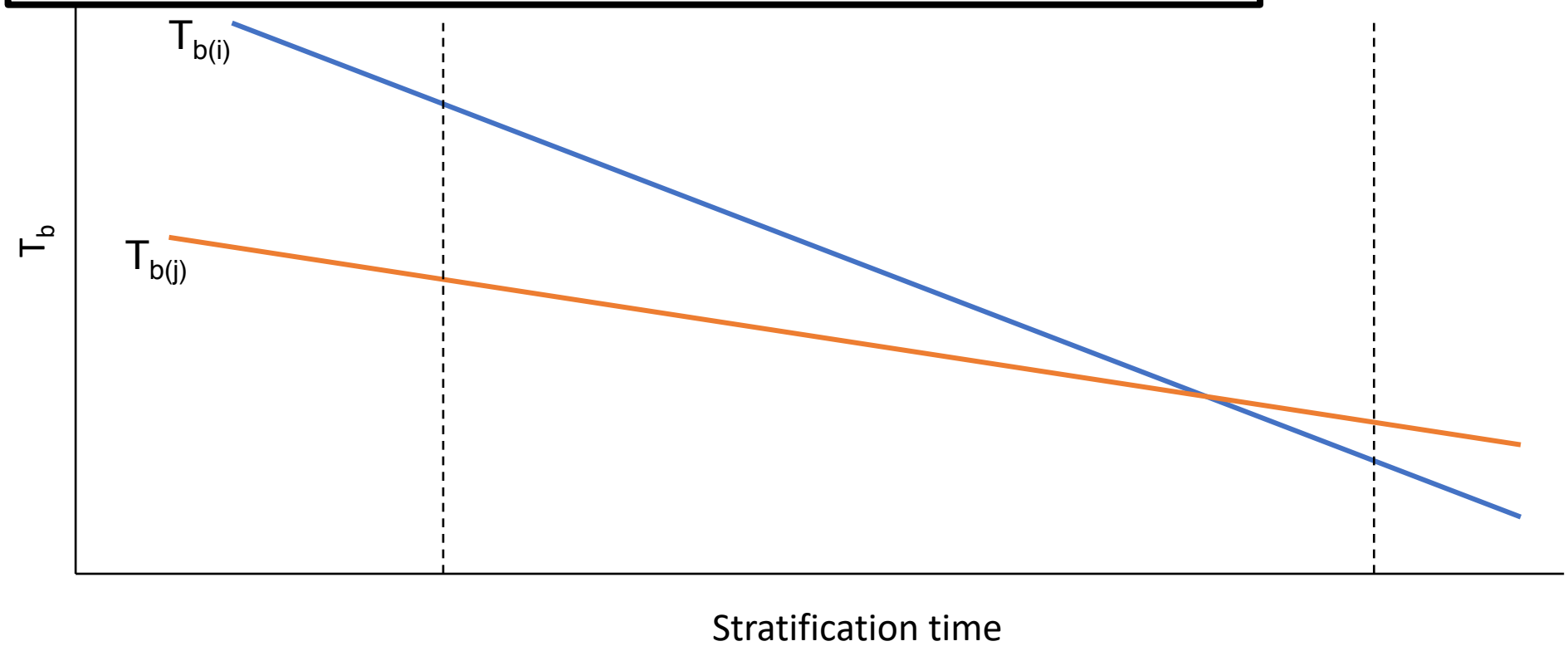
Germination Update

30-January-2019

GOALS:

1. Select species for competition trial
2. Quantify sensitivity to winter temperature for a suite of temperate herbs

Seasonal Priority Effects and phenological sensitivity

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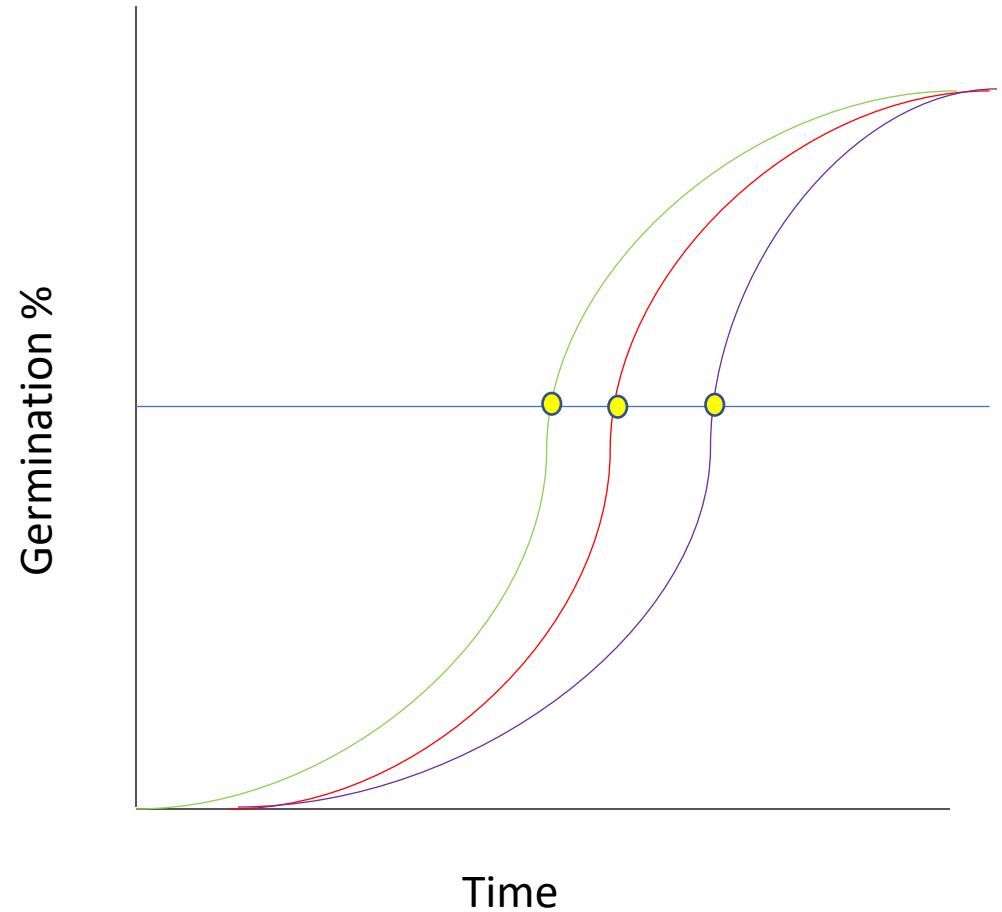
Day	Seed Lot 1	Seed Lot 2	Seed Lot 3	Seed Lot 4
1	13.5	19	31.6	95
2	13.5	19	31.6	0
3	13.5	19	31.6	0
4	13.5	19	0	0
5	13.5	19	0	0
6	13.5	0	0	0
7	13.5	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
Parameters				
FGP (%)	95	95	95	95
MGT (day)	3.9	3.0	1.9	1.0
GI	661.5	760	853.2	950
CVG	25.0	33.3	50.0	100.00
GRI (%/day)	24.3	31.6	50.0	95.0
FDG (day)	1	1	1	1
LDG (day	7	5	3	1
TSG (day)	6	4	2	0

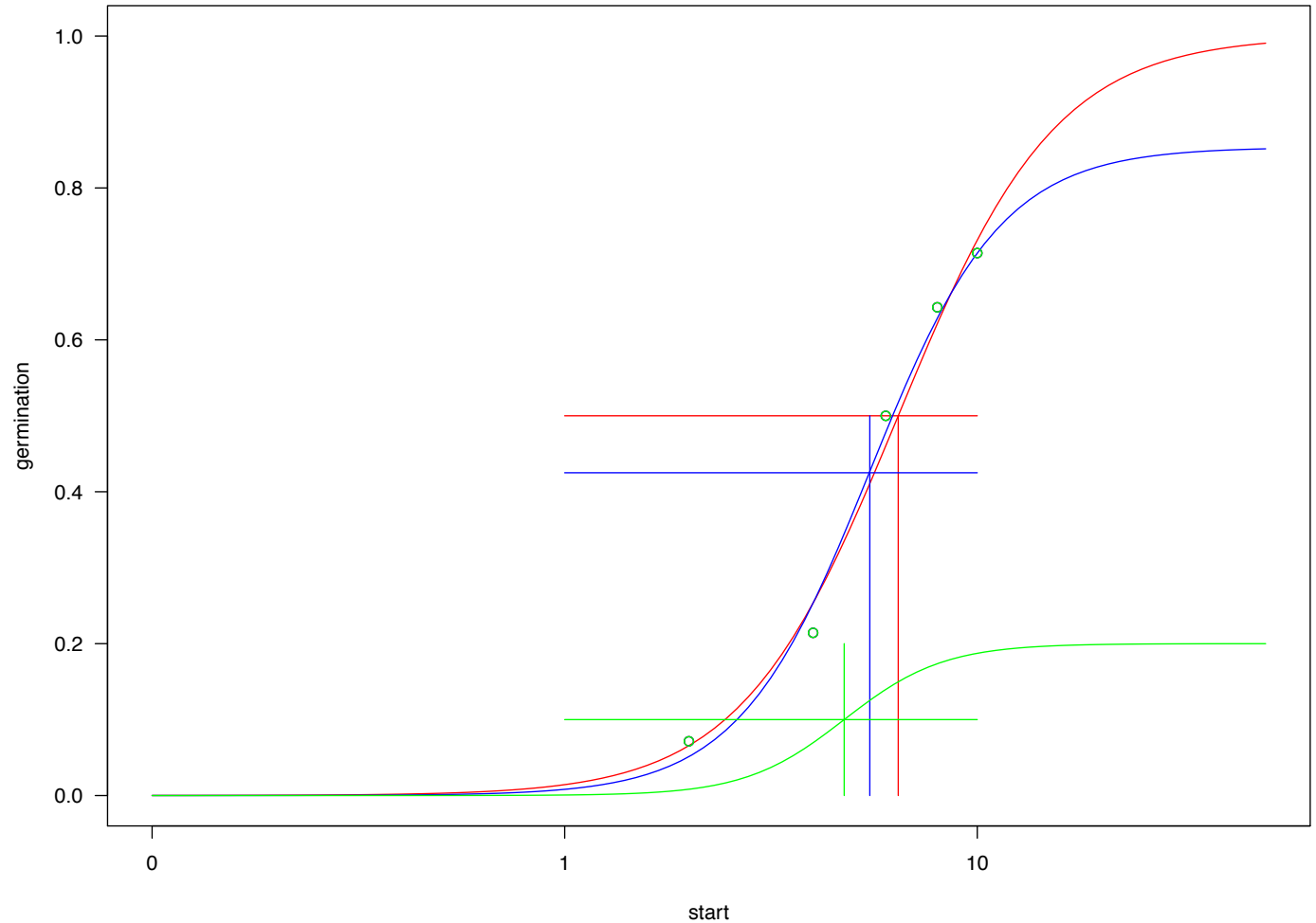
Table 6. Time course of germination impacts on measurement data.



Kader 2005

Day	Seed Lot 1	Seed Lot 2	Seed Lot 3	Seed Lot 4
1	9.5	18.7	27.5	35
2	9.5	18.7	27.5	0
3	9.5	18.7	0	0
4	9.5	18.7	0	0
5	9.5	0	0	0
6	9.5	0	0	0
7	9.5	0	0	0
8	9.5	0	0	0
9	9.5	0	0	0
10	9.5	0	0	0
Parameters				
FGP (%)	95	75	55	35
MGT (day)	5.5	2.4	1.5	1
GI	495.5	635.8	522.5	350
CVG	18.1	40.0	66.6	100
GRI (%/day)	17.2	31.2	36.6	35
FDG (day)	1	1	1	1
LDG (day	10	4	2	1
TSG (day)	9	3	1	0

Table 8. Percentage and spread of germination effects on measurement parameters.



- % will germination in pre-treatment (**left censor**)
- % will germinate in the trial (**yay**)
- % will die during the trial (**mold…ewww**)
- % will not germinate **(right censor**…or **is it?)**

Baskin and Baskin suggest reporting:

- Final germination percentage
- A measure of germination speed (ie mean germination time, T50)
- A measure of germination synchrony

Modeling option 1:

Each of the above~ stratification duration * incubation temp |species

Seems hard to make direct interspecific comparison

1a. Add a germination index

Germination Index	GI	—	GI=(10×n1) + (9×n2) + ⋯ + (1×n10)	n1, n2 . . . n10 = No. of germinated seeds on the first, second and subsequent days until the 10th day; 10, 9 . . . and 1 are weights given to the number of germinated seeds on the first, second and subsequent days, respectively	In the GI, maximum weight is given to the seeds germinated on the first day and less to those germinated later on. The lowest weight would be for seeds germinated on the 10th day. Therefore, the GI emphasizes on both the percentage of germination and its speed. A higher GI value denotes a higher percentage and rate of germination. Bench Arnold et al. (1991)

More complicated….

2. Tradition nonlinear modeling:

- Uses cumulative distribution counts
- Violates assumptions of independence at each observation
- Is there a repeat measure type analysis for nonlinear models?

3. Time to event analysis:

Survival models and dose-response curves

- Assume all seeds can germinate
    - Estimates right censoring (maybe inappropriate for seeds with dormancy)
    - The typical distributions used for germination can't handle negative time values (some survival analysis can).
    - DRC-rigid packages, doesn't play well with others, hard to diagnose problems

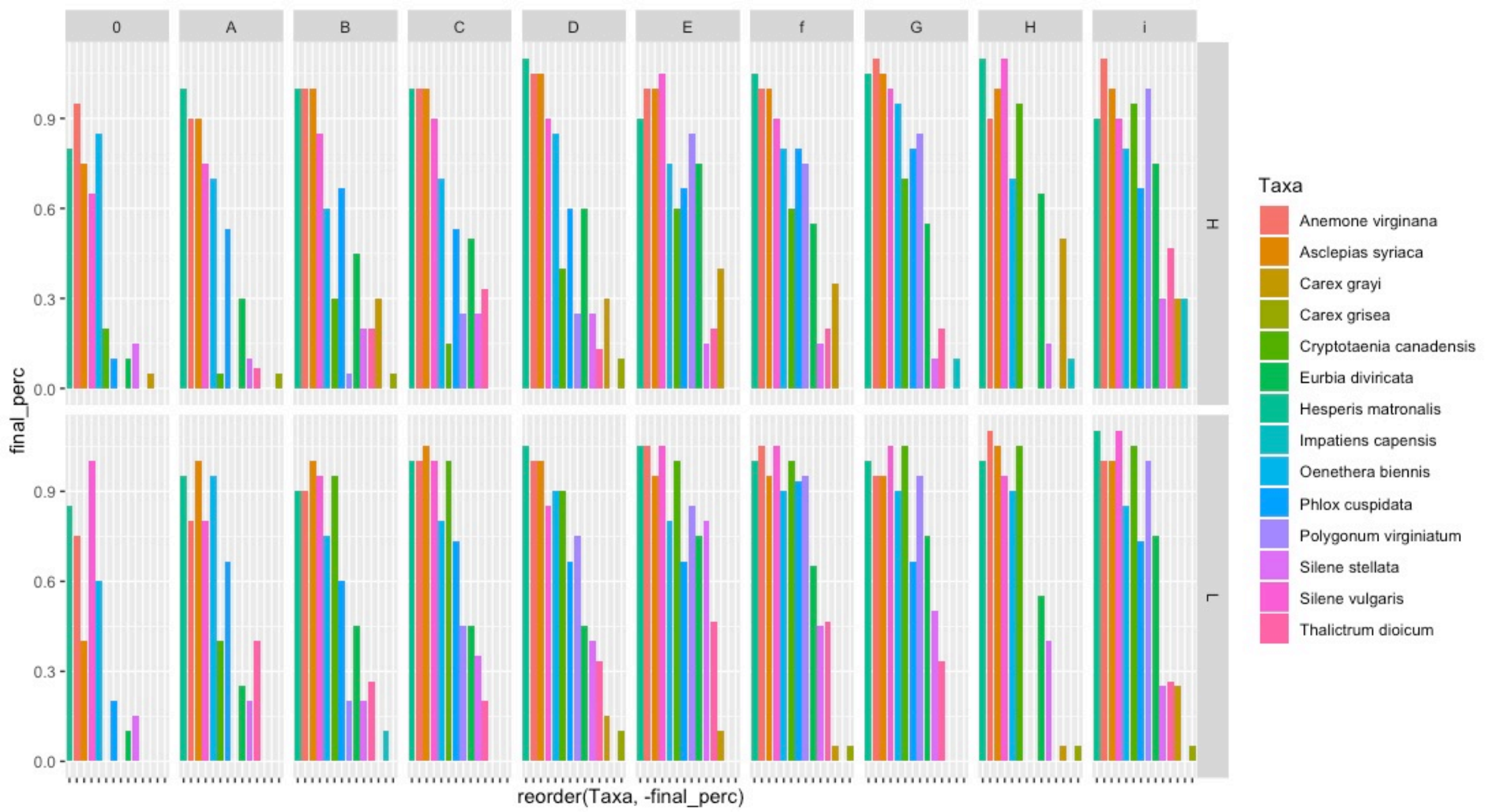
4. Some sort of four part hierarchical:

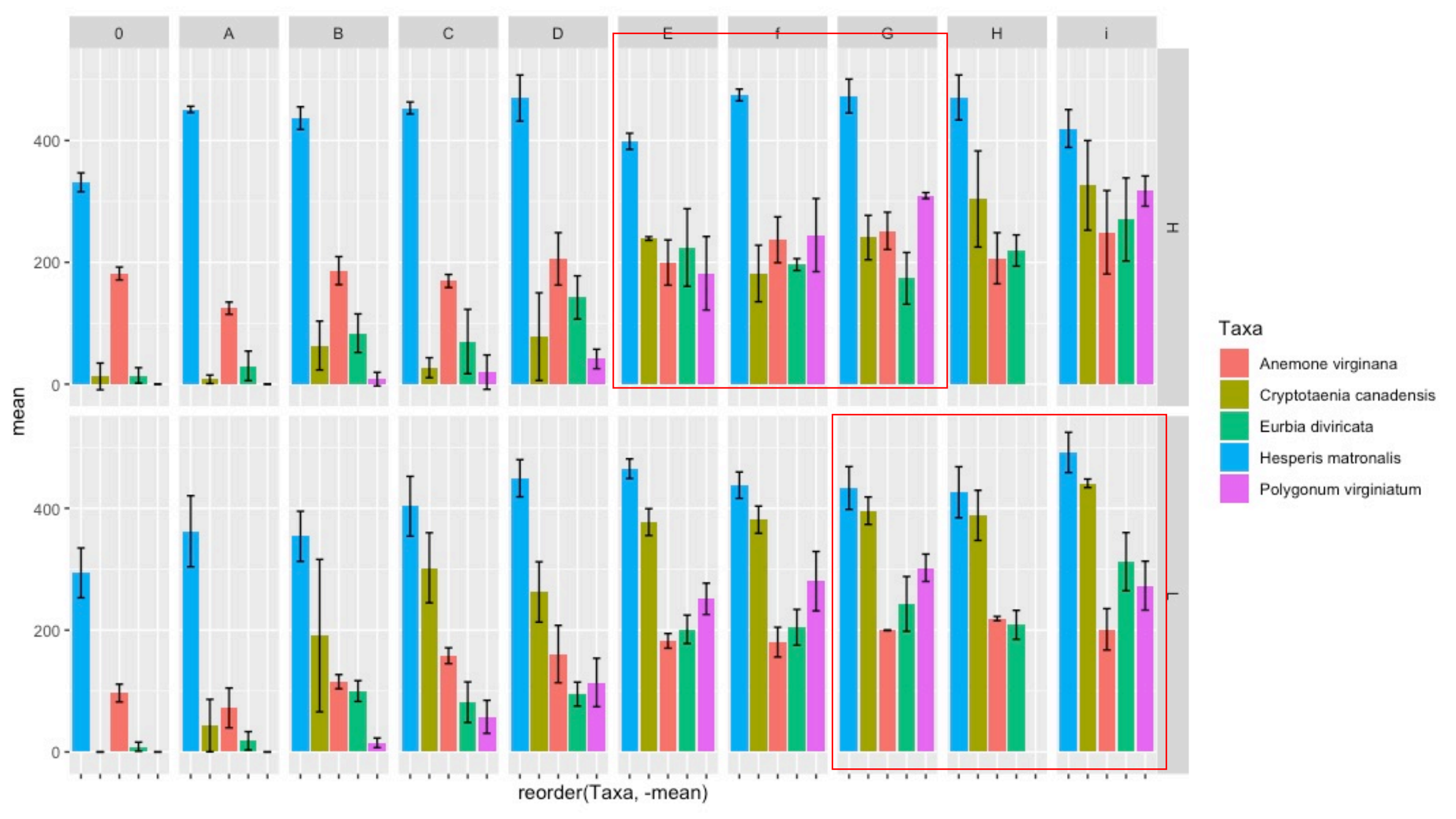
A: moldy seed # ~(chilling time, temp) + |species

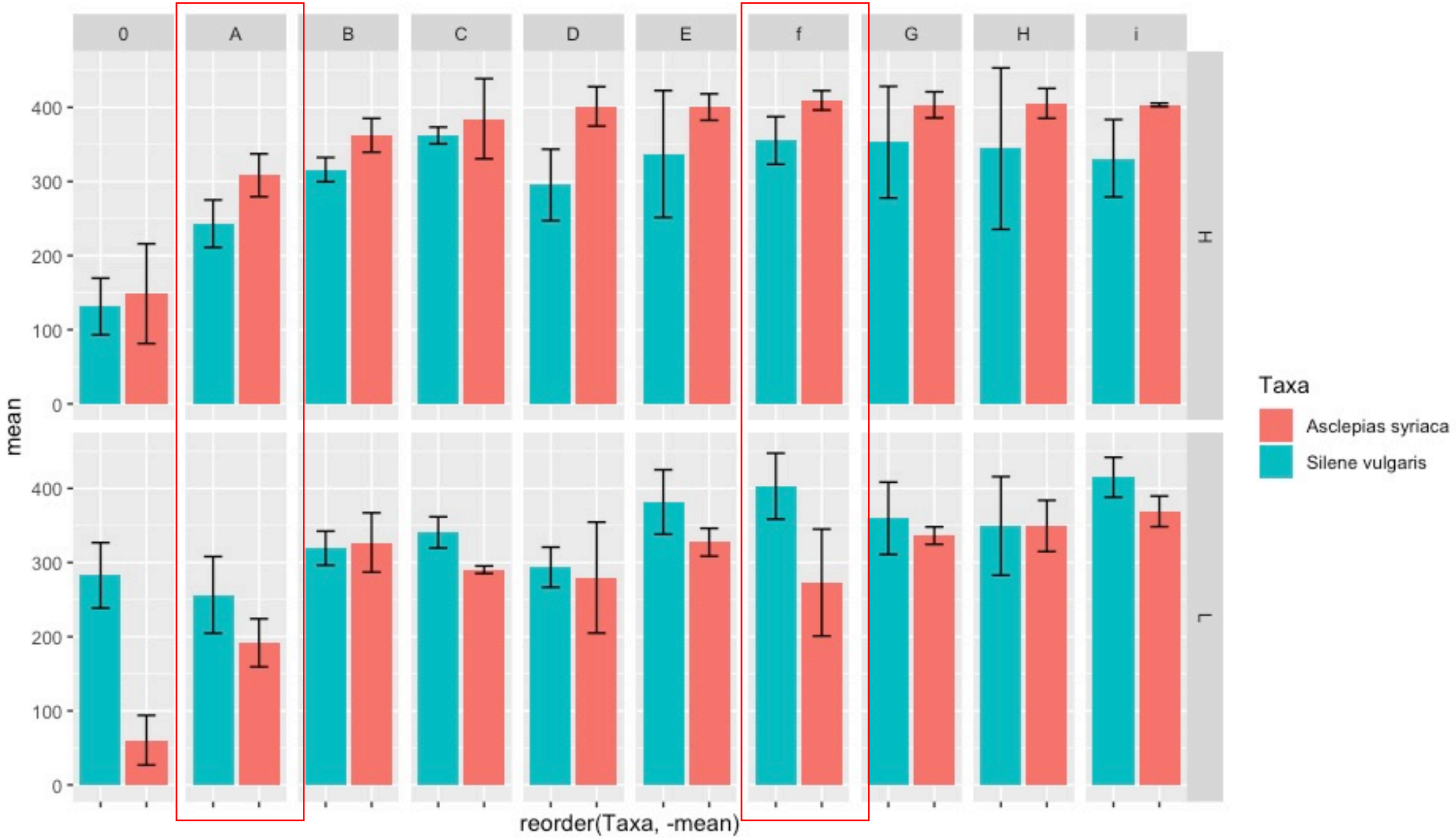
B: Cold germ~ chilling time

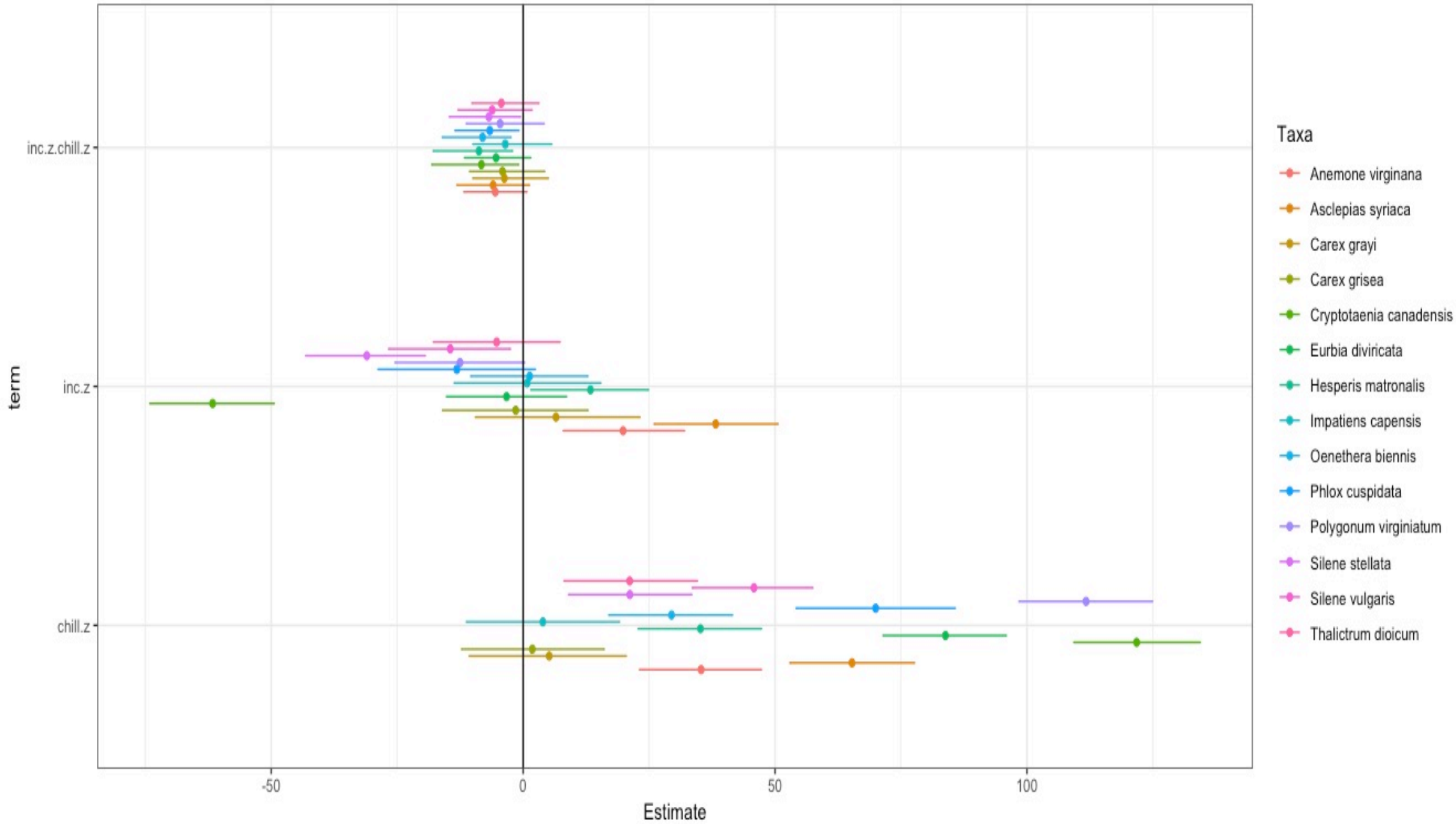
C: germination model (drc or survival)

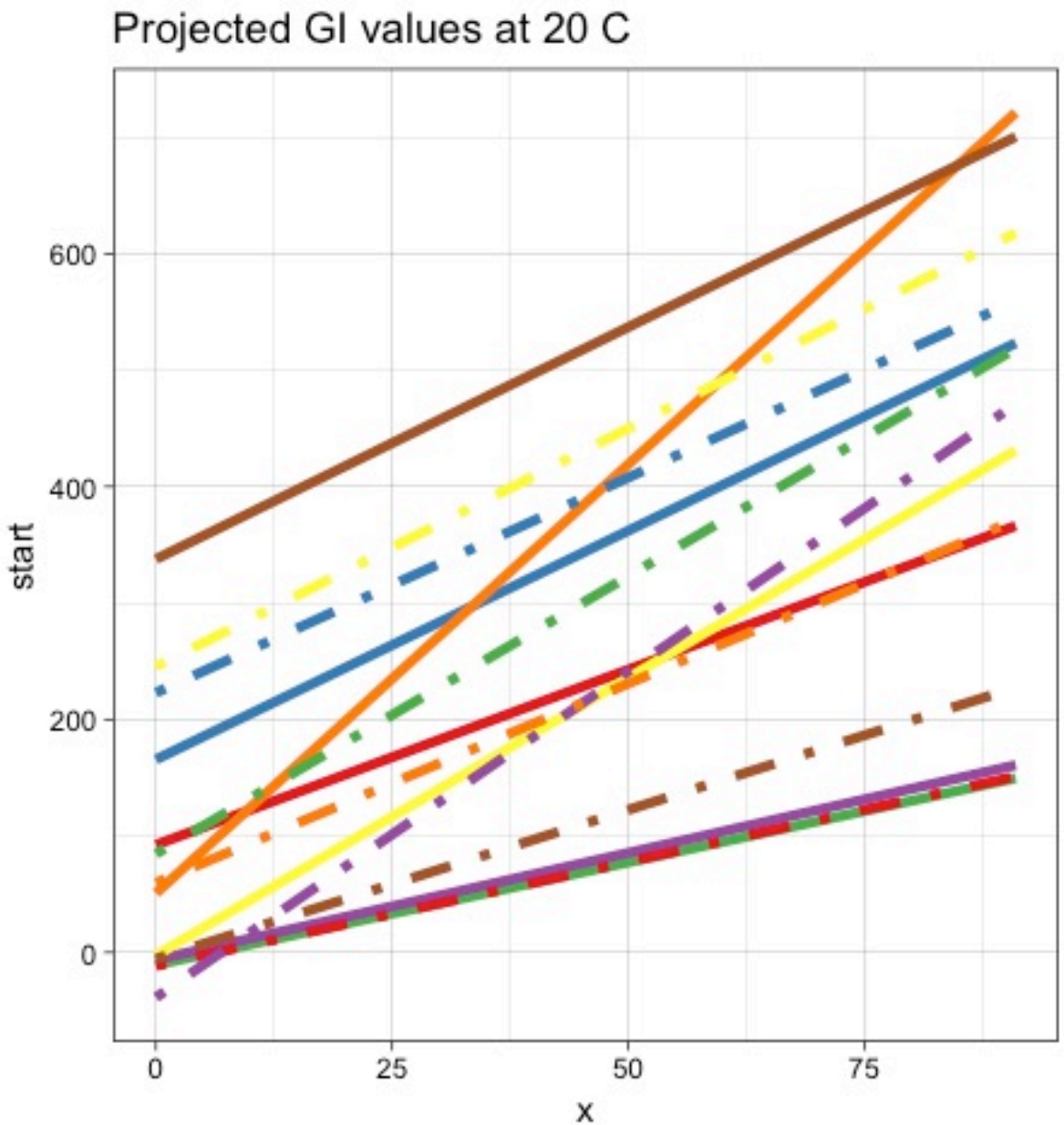
D*: Cure model- how many right censored will germination


0
A
B
C
D
E
f
G
H
i
H
L
final_perc
0.0
0.3
0.6
0.9
reorder(Taxa, -final_perc)
Taxa
Anemone virginana
Asclepias syriaca
Carex grayi
Carex grisea
Cryptotaenia canadensis
Eurbia diviricata
Hesperis matronalis
Impatiens capensis
Oenethera biennis
Phlox cuspidata
Polygonum virginiatum
Silene stellata
Silene vulgaris
Thalictrum dioicum

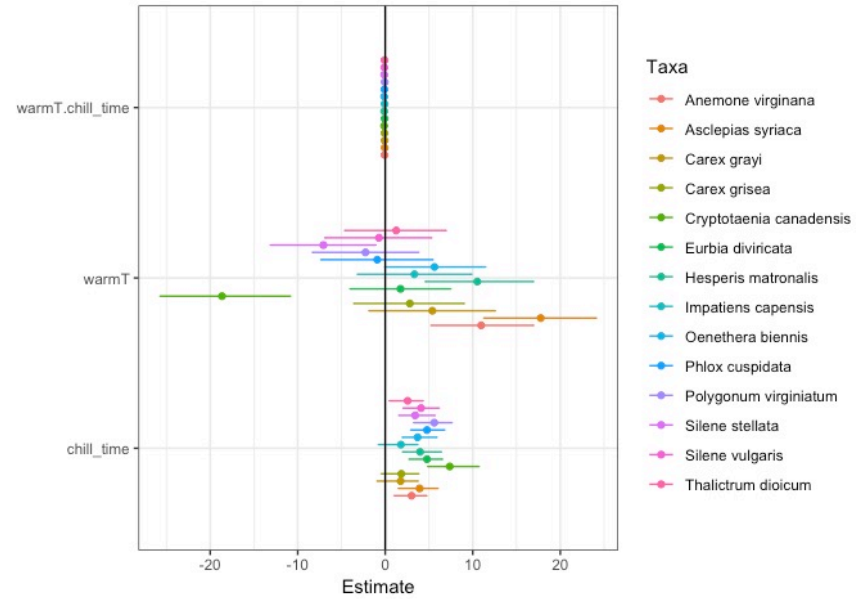

0
A
B
C
D
E
f
G
H
i
H
L
400
200
0
mean
reorder(Taxa, -mean)
Taxa
Anemone virginana
Cryptotaenia canadensis
Eurbia divaricata
Hesperis matronalis
Polygonum virginiatum


0
A
B
C
D
E
f
G
H
i
H
L
mean
400
300
200
100
0
reorder(Taxa, -mean)
Taxa
Asclepias syriaca
Silene vulgaris

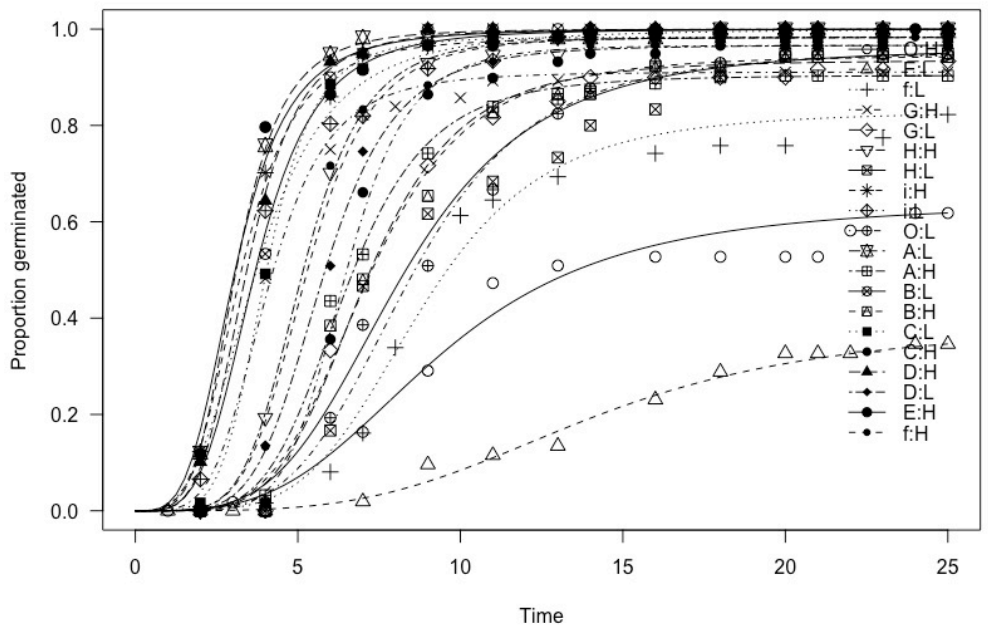

inc.z.chill.z
inc.z
chill.z
term
-50
0
50
100
Estimate
Taxa
Anemone virginana
Asclepias syriaca
Carex grayi
Carex grisea
Cryptotaenia canadensis
Eurbia divricata
Hesperis matronalis
Impatiens capensis
Oenethera biennis
Phlox cuspidata
Polygonum virginiatum
Silene stellata
Silene vulgaris
Thalictrum dioicum

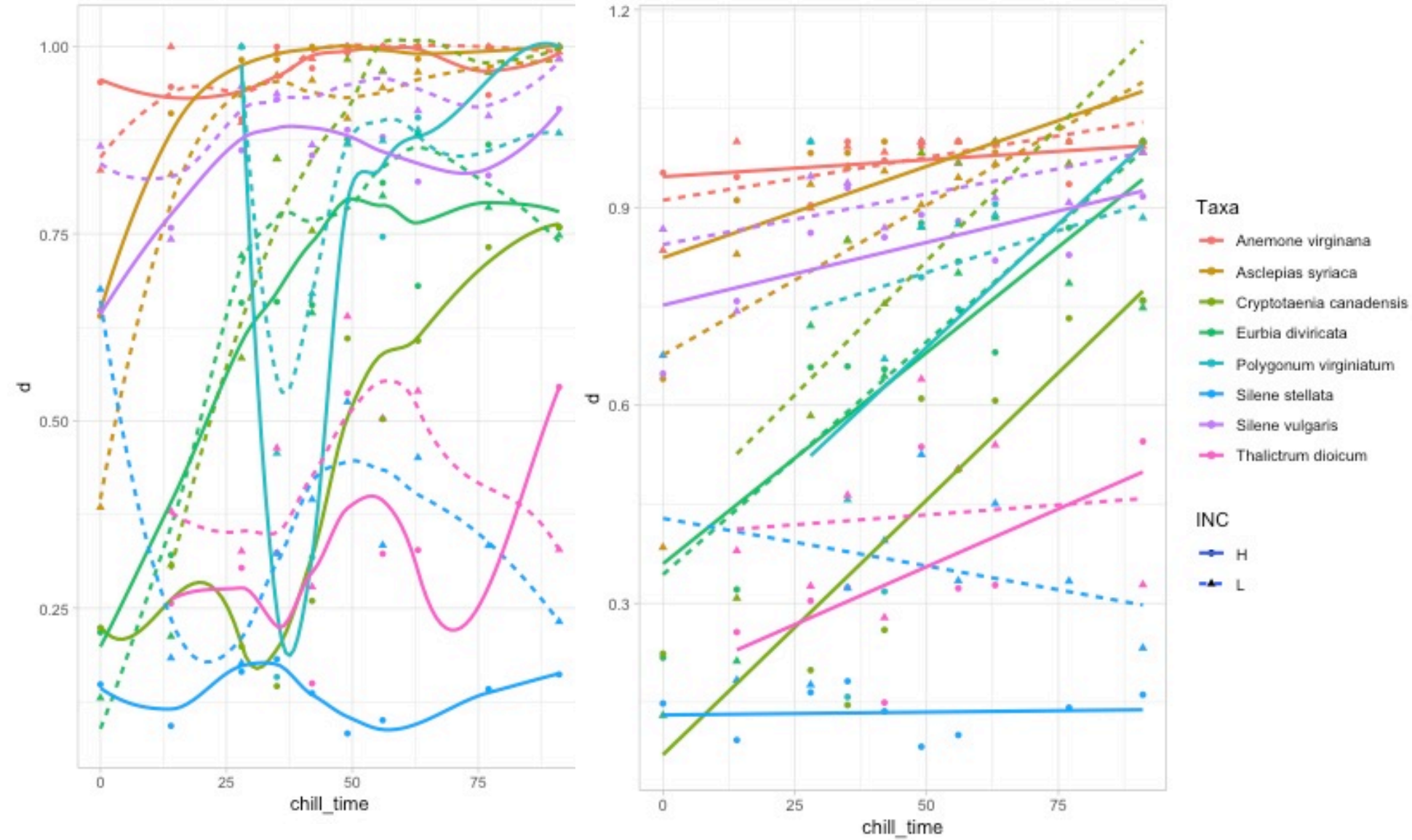

Projected GI values at 20 C
start
x
0
200
400
600
0
25
50
75


Taxa
Anemone virginana
Asclepias syriaca
Carex grayi
Carex grisea
Cryptotaenia canadensis
Eurbia divaricata
Hesperis matronalis
Impatiens capensis
Oenethera biennis
Phlox cuspidata
Polygonum virginiatum
Silene stellata
Silene vulgaris
Thalictrum dioicum


warmT.chill_time
warmT
chill_time
-20
-10
0
10
20
Estimate
Taxa
Anemone virginana
Asclepias syriaca
Carex grayi
Carex grisea
Cryptotaenia canadensis
Eurbia divaricata
Hesperis matronalis
Impatiens capensis
Oenethera biennis
Phlox cuspidata
Polygonum virginiatum
Silene stellata
Silene vulgaris
Thalictrum dioicum

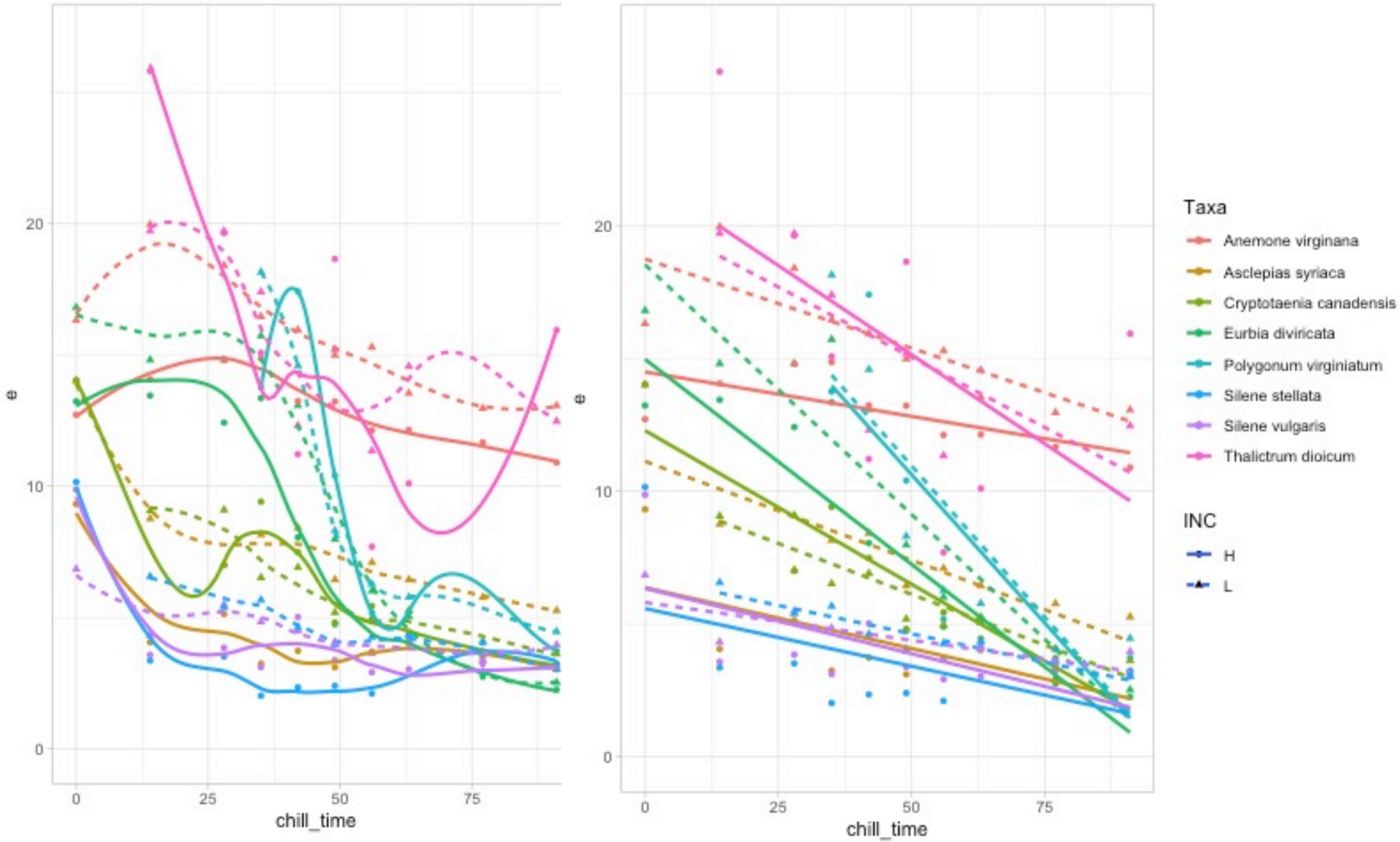
```
> summary(As.global)

Model fitted: Log-logistic (ED50 as parameter) with lower limit at 0 (3 parms)

Parameter estimates:

      Estimate Std. Error t-value   p-value
b:H -3.5007724  0.1418376 -24.682 < 2.2e-16 ***
b:L -4.2078749  0.1715252 -24.532 < 2.2e-16 ***
d:H  0.9516189  0.0090212 105.487 < 2.2e-16 ***
d:L  0.8859136  0.0134762  65.739 < 2.2e-16 ***
e:H  3.8487904  0.0860664  44.719 < 2.2e-16 ***
e:L  7.0300313  0.1317684  53.351 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
>
```




1.00
0.75
0.50
0.25
d
0
25
50
75
chill_time

1.2
0.9
0.6
0.3
d
0
25
50
75
chill_time

Taxa
Anemone virginana
Asclepias syriaca
Cryptotaenia canadensis
Eurbia divaricata
Polygonum virginiatum
Silene stellata
Silene vulgaris
Thalictrum dioicum
INC
H
L


20
10
0
e
0
25
50
75
chill_time
20
10
0
e
0
25
50
75
chill_time
Taxa
Anemone virginana
Asclepias syriaca
Cryptotaenia canadensis
Eurbia divaricata
Polygonum virginiatum
Silene stellata
Silene vulgaris
Thalictrum dioicum
INC
H
L

```
> coef(mod3)
$Taxa
, , Intercept

                        Estimate Est.Error      Q2.5    Q97.5
Anemone virginana       11.075629  7.358360 -3.473481 25.72061
Asclepias syriaca        7.707551  7.402953 -7.459281 22.10760
Cryptotaenia canadensis  8.387874  7.926541 -8.115892 23.57142
Eurbia diviricata        9.129981  7.721372 -7.024420 24.07118
Oenethera biennis        6.322293  7.597476 -9.734842 20.73621
Polygonum virginiatum   57.562198 15.260511 25.355510 85.78121
Silene stellata          8.529467  7.569910 -6.903557 23.17091
Silene vulgaris          7.068583  7.494040 -8.779118 21.06256
Thalictrum dioicum      12.374488  8.080528 -3.152824 28.47351

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                          Estimate Est.Error       Q2.5      Q97.5
Anemone virginana       -0.13996874 0.3157170 -0.7359230  0.5083359
Asclepias syriaca       -0.10199820 0.3151756 -0.6971373  0.5326227
Cryptotaenia canadensis -0.14518760 0.3552566 -0.8181324  0.6009390
Eurbia diviricata       -0.18270720 0.3108449 -0.7744475  0.4211574
Oenethera biennis       -0.07128396 0.3128024 -0.6597731  0.5569582
Polygonum virginiatum   -2.48999579 0.7683618 -3.8909624 -0.8237110
Silene stellata         -0.21852130 0.3234370 -0.8862183  0.4122306
Silene vulgaris         -0.08655247 0.3191880 -0.7017731  0.5557684
Thalictrum dioicum      -0.21564763 0.3744675 -0.9582616  0.5411694

, , warm.cent

                         Estimate Est.Error      Q2.5     Q97.5
Anemone virginana        0.11583917  3.019255 -6.151913  5.964735
Asclepias syriaca       -0.26649156  3.029131 -6.359421  5.651933
Cryptotaenia canadensis  0.31052641  3.186878 -6.213545  6.479225
Eurbia diviricata        0.08492252  3.047945 -6.211702  5.978514
Oenethera biennis       -0.26490387  3.018053 -6.256961  5.641419
Polygonum virginiatum   17.98791364  5.962767  5.859618 29.203779
Silene stellata         -0.59722156  3.075852 -6.723712  5.351870
Silene vulgaris         -0.03378493  2.984261 -5.844318  5.839001
Thalictrum dioicum       0.71018901  3.273065 -5.864306  7.267163

, , chill.cent:warm.cent

                           Estimate Est.Error       Q2.5      Q97.5
Anemone virginana       -0.0114207975 0.1199696 -0.2526624  0.2233558
Asclepias syriaca        0.0006711446 0.1205884 -0.2368916  0.2394652
Cryptotaenia canadensis -0.0111664586 0.1292479 -0.2669001  0.2517916
Eurbia diviricata       -0.0082030562 0.1195471 -0.2396510  0.2329198
Oenethera biennis        0.0046652633 0.1191049 -0.2245800  0.2374221
Polygonum virginiatum   -0.8207166971 0.3016332 -1.3810462 -0.1844245
Silene stellata          0.0451694837 0.1275929 -0.2029186  0.2996976
Silene vulgaris          0.0021426495 0.1209272 -0.2425686  0.2381794
Thalictrum dioicum      -0.0289486868 0.1444668 -0.3059064  0.2565626
```

This is a model for how T50 (e) is affected by treatments. As you can see, it seem like not really, but I think that because of the covariance of d (upper limit), and e

Other concerns:

- Usefulness of/methods for chilling thresh holds?