Appendix A

Full models and model selection

Comparison of random intercept model, additive and interaction models for total flower visits.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | DF | AIC | BIC | Chisq | P > Chisq |
| Null | 4 | 1164.8 | 1178.6 |  |  |
| Additive | 6 | 1111.6 | 1132.3 | 57.1788 | <0.00001 |
| Interaction term | 7 | 1113.6 | 1137.8 | 0.0322 | 0.8576 |

Total visits model comparison

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | DF | AIC | BIC | Chisq | P > Chisq |
| Null | 4 | 1066.0 | 1079.8 |  |  |
| Additive | 6 | 1000.7 | 1021.5 | 69.2940 | <0.00001 |
| Interaction term | 7 | 1002.7 | 1026.9 | 0.0072 | 0.9326 |

For hypothesis testing:

Null models are random intercept + flowers in the pot

Full model for flower visits, output from Wald’s Type 3 test.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Chisq | Df | P |  |
| Flowering | 16.3114 | 1 | <0.0001 |  |
| Rtu | 121.6832 | 5 | <0.0001 |  |
| Treatment | 6.7008 | 1 | 0.009637 |  |
| Flowers.pot | 9.4194 | 1 | 0.002147 |  |
| Flowering:rtu | 56.9111 | 5 | <0.0001 |  |
| Flowering:treatment | 3.6394 | 1 | 0.056426 |  |
| Rtu:treatment | 5.4996 | 5 | 0.357984 |  |
| Flowering:rtu:treatment | 7.5190 | 5 | 0.184812 |  |
|  |  |  |  |  |
|  |  |  |  |  |

Full model for plant visits

flowering 11.2812 1 0.0007829 \*\*\*

rtu 131.3404 5 < 2.2e-16 \*\*\*

treatment 3.6569 1 0.0558390 .

flowers.pot 4.5640 1 0.0326507 \*

flowering:rtu 53.0033 5 3.358e-10 \*\*\*

flowering:treatment 2.3436 1 0.1258002

rtu:treatment 3.8289 5 0.5743031

flowering:rtu:treatment 4.1995 5 0.5210663

Models:

m2: abun ~ treatment + blooming + (1 | repID)

m1: abun ~ treatment \* blooming + (1 | repID)

Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)

m2 5 1372.2 1389.3 -681.08 1362.2

m1 6 1370.7 1391.3 -679.37 1358.7 3.4254 1 0.0642 .

m3 3 1426.5 1436.8 -710.27 1420.5

m2 5 1372.2 1389.3 -681.08 1362.2 58.3768 2 2.107e-13 \*\*\*

m1 6 1370.7 1391.3 -679.37 1358.7 3.4254 1 0.0642 .

No difference between models so choosing simplest?

With beetles:

Models:

m3: abun ~ (1 | repID)

m1: abun ~ blooming + treatment + (1 | repID)

m2: abun ~ blooming \* treatment + (1 | repID)

Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)

m3 3 1586.9 1597.2 -790.46 1580.9

m1 5 1560.1 1577.3 -775.05 1550.1 30.8081 2 2.042e-07 \*\*\*

m2 6 1561.8 1582.4 -774.91 1549.8 0.2883 1 0.5913

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Melyridae only

m3: abun ~ (1 | repID)

m2: abun ~ blooming + treatment + (1 | repID)

m1: abun ~ blooming \* treatment + (1 | repID)

Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)

m3 3 1267.5 1277.8 -630.74 1261.5

m2 5 1238.9 1256.1 -614.46 1228.9 32.5610 2 8.501e-08 \*\*\*

m1 6 1234.0 1254.5 -610.99 1222.0 6.9548 1 0.00836 \*\*

Used poisson for species richness

Anova

Models:

s3: Species ~ (1 | repID)

s1: Species ~ blooming + treatment + (1 | repID)

s2: Species ~ blooming \* treatment + (1 | repID)

Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)

s3 2 1170.9 1177.7 -583.44 1166.9

s1 4 1142.5 1156.2 -567.23 1134.5 32.4159 2 9.141e-08 \*\*\*

s2 5 1143.0 1160.2 -566.52 1133.0 1.4229 1 0.2329

Used poisson for bee abundance

beenull: Quantity ~ (1 | repID)

bee2: Quantity ~ blooming + treatment + (1 | repID)

bee1: Quantity ~ blooming \* treatment + (1 | repID)

Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)

beenull 2 489.58 496.44 -242.79 485.58

bee2 4 493.29 507.01 -242.65 485.29 0.2911 2 0.8645

bee1 5 495.04 512.19 -242.52 485.04 0.2514 1 0.6161

Visit duration

Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)

m2 3 -3497.8 -3484.2 1751.9 -3503.8

m1 6 -3515.2 -3487.9 1763.6 -3527.2 23.366 3 3.388e-05 \*\*\*

Bee visit duration

Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)

l2 3 230.88 236.95 -112.44 224.88

l1 4 230.94 239.04 -111.47 222.94 1.935 1 0.1642

Other visit duration

l2: log(dec.total.time) ~ (1 | repID)

l1: log(dec.total.time) ~ flowering + (1 | repID)

Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)

l2 3 863.53 873.41 -428.77 857.53

l1 4 853.55 866.73 -422.78 845.55 11.979 1 0.0005382 \*\*\*

$contrasts - Proportions

contrast estimate SE df z.ratio p.value

pre,open - bloom,open 0.03537548 0.04843350 NA 0.730 0.8849

pre,open - pre,shrub -0.08050042 0.08029773 NA -1.003 0.7479

pre,open - bloom,shrub 0.15930471 0.08775466 NA 1.815 0.2660

bloom,open - pre,shrub -0.11587589 0.08384195 NA -1.382 0.5106

bloom,open - bloom,shrub 0.12392924 0.09113159 NA 1.360 0.5247

pre,shrub - bloom,shrub 0.23980513 0.05952906 NA 4.028 0.0003

Proportions: RTU \* microsite

floweringbloom -0.116064 0.140156 -0.828 0.40761

rtu.agbombylid -0.247470 0.112323 -2.203 0.02758 \*

rtu.aghoneybee 0.186243 0.240711 0.774 0.43910

rtu.aglep -0.329590 0.262264 -1.257 0.20886

rtu.agother -0.300436 0.095633 -3.142 0.00168 \*\*

rtu.agsyrphid -0.173276 0.085192 -2.034 0.04196 \*

floweringbloom:rtu.agbombylid 0.202234 0.174650 1.158 0.24689

floweringbloom:rtu.aglep 0.069411 0.297303 0.233 0.81540

floweringbloom:rtu.agother 0.033465 0.153065 0.219 0.82693

floweringbloom:rtu.agsyrphid 0.006737 0.171338 0.039 0.96863

Proportions: RTU\*microsite

$contrasts

contrast estimate SE df z.ratio p.value

open,bee - shrub,bee 0.2956276573 0.14985202 NA 1.973 0.7122

open,bee - open,bombylid 0.3373346514 0.12256770 NA 2.752 0.2009

open,bee - shrub,bombylid 0.3441132058 0.14651352 NA 2.349 0.4416

open,bee - open,honeybee nonEst NA NA NA NA

open,bee - shrub,honeybee -0.0574869201 0.25355693 NA -0.227 1.0000

open,bee - open,lep 0.4733697023 0.14724349 NA 3.215 0.0588

open,bee - shrub,lep 0.5633106534 0.17433386 NA 3.231 0.0559

open,bee - open,other 0.4737968665 0.11166278 NA 4.243 0.0013

open,bee - shrub,other 0.5039043466 0.13091459 NA 3.849 0.0066

open,bee - open,syrphid 0.3420691106 0.10785656 NA 3.172 0.0669

open,bee - shrub,syrphid 0.2850254482 0.12878960 NA 2.213 0.5399

shrub,bee - open,bombylid 0.0417069941 0.12615312 NA 0.331 1.0000

shrub,bee - shrub,bombylid 0.0484855485 0.12020937 NA 0.403 1.0000

shrub,bee - open,honeybee nonEst NA NA NA NA

shrub,bee - shrub,honeybee -0.3531145774 0.24153215 NA -1.462 0.9507

shrub,bee - open,lep 0.1777420450 0.14698298 NA 1.209 0.9884

shrub,bee - shrub,lep 0.2676829961 0.15108510 NA 1.772 0.8336

shrub,bee - open,other 0.1781692092 0.11358834 NA 1.569 0.9205

shrub,bee - shrub,other 0.2082766893 0.09790312 NA 2.127 0.6029

shrub,bee - open,syrphid 0.0464414533 0.11193343 NA 0.415 1.0000

shrub,bee - shrub,syrphid -0.0106022091 0.09076039 NA -0.117 1.0000

open,bombylid - shrub,bombylid 0.0067785545 0.12221348 NA 0.055 1.0000

open,bombylid - open,honeybee nonEst NA NA NA NA

open,bombylid - shrub,honeybee -0.3948215715 0.24089088 NA -1.639 0.8948

open,bombylid - open,lep 0.1360350509 0.12259911 NA 1.110 0.9943

open,bombylid - shrub,lep 0.2259760021 0.15473968 NA 1.460 0.9510

open,bombylid - open,other 0.1364622151 0.07698542 NA 1.773 0.8332

open,bombylid - shrub,other 0.1665696953 0.10315326 NA 1.615 0.9041

open,bombylid - open,syrphid 0.0047344593 0.07415790 NA 0.064 1.0000

open,bombylid - shrub,syrphid -0.0523092032 0.10021837 NA -0.522 1.0000

shrub,bombylid - open,honeybee nonEst NA NA NA NA

shrub,bombylid - shrub,honeybee -0.4016001260 0.24177578 NA -1.661 0.8858

shrub,bombylid - open,lep 0.1292564964 0.14359931 NA 0.900 0.9991

shrub,bombylid - shrub,lep 0.2191974476 0.15004047 NA 1.461 0.9509

shrub,bombylid - open,other 0.1296836607 0.10918274 NA 1.188 0.9900

shrub,bombylid - shrub,other 0.1597911408 0.09347639 NA 1.709 0.8644

shrub,bombylid - open,syrphid -0.0020440952 0.10744288 NA -0.019 1.0000

shrub,bombylid - shrub,syrphid -0.0590877576 0.09455611 NA -0.625 1.0000

open,honeybee - shrub,honeybee nonEst NA NA NA NA

open,honeybee - open,lep nonEst NA NA NA NA

open,honeybee - shrub,lep nonEst NA NA NA NA

open,honeybee - open,other nonEst NA NA NA NA

open,honeybee - shrub,other nonEst NA NA NA NA

open,honeybee - open,syrphid nonEst NA NA NA NA

open,honeybee - shrub,syrphid nonEst NA NA NA NA

shrub,honeybee - open,lep 0.5308566224 0.25220463 NA 2.105 0.6193

shrub,honeybee - shrub,lep 0.6207975736 0.25742634 NA 2.412 0.3979

shrub,honeybee - open,other 0.5312837866 0.23440374 NA 2.267 0.5008

shrub,honeybee - shrub,other 0.5613912668 0.23199483 NA 2.420 0.3923

shrub,honeybee - open,syrphid 0.3995560308 0.23341944 NA 1.712 0.8633

shrub,honeybee - shrub,syrphid 0.3425123683 0.22770807 NA 1.504 0.9399

open,lep - shrub,lep 0.0899409512 0.17203545 NA 0.523 1.0000

open,lep - open,other 0.0004271642 0.10980099 NA 0.004 1.0000

open,lep - shrub,other 0.0305346444 0.12772068 NA 0.239 1.0000

open,lep - open,syrphid -0.1313005916 0.10732476 NA -1.223 0.9872

open,lep - shrub,syrphid -0.1883442541 0.12543347 NA -1.502 0.9406

shrub,lep - open,other -0.0895137870 0.14459661 NA -0.619 1.0000

shrub,lep - shrub,other -0.0594063068 0.13290699 NA -0.447 1.0000

shrub,lep - open,syrphid -0.2212415428 0.14319762 NA -1.545 0.9280

shrub,lep - shrub,syrphid -0.2782852052 0.13056337 NA -2.131 0.5999

open,other - shrub,other 0.0301074801 0.08727658 NA 0.345 1.0000

open,other - open,syrphid -0.1317277558 0.05018389 NA -2.625 0.2655

open,other - shrub,syrphid -0.1887714183 0.08385587 NA -2.251 0.5120

shrub,other - open,syrphid -0.1618352360 0.08503134 NA -1.903 0.7575

shrub,other - shrub,syrphid -0.2188788984 0.06367091 NA -3.438 0.0290

open,syrphid - shrub,syrphid -0.0570436624 0.08160285 NA -0.699 0.9999

odels:

m2null: prop.visited ~ (1 | repID)

m3: prop.visited ~ microsite \* rtu.ag + (1 | repID)

Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)

m2null 3 -2221.5 -2207.8 1113.7 -2227.5

m3 13 -2240.1 -2181.0 1133.1 -2266.1 38.652 10 2.921e-05 \*\*\*

So decrease in proportion of flowers visited, per visit at the shrub microsite as well with blooming. Does not appear to be strongly driven by any one species.

Table 7: Results from post-hoc test (lsmeans, Tukey’s) for the negative binomial generalized linear mixed model on significant interaction. Significance was denoted at α = 0.05 and shown in bold.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Melyridae Abundance | | | |
| Contrast | **Estimate** | **SE** | **t.ratio** | **p** |
| pre,open - post,open | 0.2989089 | 0.1633482 | 1.830 | 0.2592 |
| pre,open - pre,shrub | 1.1920062 | 0.1932688 | 6.168 | **<.0001** |
| pre,open - post,shrub | 0.8388073 | 0.1826136 | 4.593 | **<.0001** |
| post,open - pre,shrub | 0.8930973 | 0.1906721 | 4.684 | **<.0001** |
| post,open - post,shrub | 0.5398984 | 0.1799142 | 3.001 | **0.0143** |
| pre,shrub - post,shrub | -0.3531989 | 0.1815186 | -1.946 | 0.2090 |

Table 12: Results from post-hoc test (lsmeans, Tukey’s) for the Gamma generalized linear mixed model on significant interaction for proportion of flowers visited. Significance was denoted at α = 0.05 and shown in bold.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Proportion of flowers visited | | | |
| **Contrast** | **Estimate** | **SE** | **t.ratio** | **p** |
| **pre,open - post,open** | 0.03537548 | 0.04843350 | 0.730 | 0.8849 |
| **pre,open - pre,shrub** | -0.08050042 | 0.08029773 | -1.003 | 0.7479 |
| **pre,open - post,shrub** | 0.15930471 | 0.08775466 | 1.815 | 0.2660 |
| **post,open - pre,shrub** | -0.11587589 | 0.08384195 | -1.382 | 0.5106 |
| **post,open - post,shrub** | 0.12392924 | 0.09113159 | 1.360 | 0.5247 |
| **pre,shrub - post,shrub** | 0.23980513 | 0.05952906 | 4.028 | 0.0003 |

Structure: fixed weights

Formula: ~invwt

Fixed effects: total.flowers ~ flowering + rtu \* treatment + offset(log(dec.Length))

Value Std.Error DF t-value p-value

(Intercept) -0.389561 0.24 1277 -1.630779 0.1032

floweringbloom -1.164789 0.14 1277 -8.383796 0.0000

rtubombylid -0.405465 0.35 1277 -1.159210 0.2466

rtuhoneybee -26.672531 83088.62 1277 -0.000321 0.9997

rtulep -1.280934 0.47 1277 -2.699769 0.0070

rtuother 0.567521 0.28 1277 2.049444 0.0406

rtusyrphid 1.396657 0.25 1277 5.652776 0.0000

treatmentshrub -0.780113 0.42 120 -1.863456 0.0648

rtubombylid:treatmentshrub 0.582396 0.58 1277 1.011929 0.3118

rtuhoneybee:treatmentshrub 25.541129 83088.62 1277 0.000307 0.9998

rtulep:treatmentshrub 0.331853 0.80 1277 0.417302 0.6765

rtuother:treatmentshrub 0.623465 0.47 1277 1.314708 0.1888

rtusyrphid:treatmentshrub 0.334142 0.44 1277 0.756989 0.4492

Correlation:

(Intr) flwrng rtbmby rthnyb rtulep rtuthr rtsyrp trtmnt rtbmb: rthny:

floweringbloom -0.167

rtubombylid -0.586 0.000

rtuhoneybee 0.000 0.000 0.000

rtulep -0.432 0.000 0.295 0.000

rtuother -0.740 0.000 0.505 0.000 0.372

rtusyrphid -0.829 0.000 0.566 0.000 0.417 0.715

treatmentshrub -0.554 -0.002 0.334 0.000 0.246 0.422 0.473

rtubombylid:treatmentshrub 0.356 0.000 -0.608 0.000 -0.179 -0.307 -0.344 -0.675

rtuhoneybee:treatmentshrub 0.000 0.000 0.000 -1.000 0.000 0.000 0.000 0.000 0.000

rtulep:treatmentshrub 0.258 0.000 -0.176 0.000 -0.597 -0.222 -0.249 -0.488 0.355 0.000

rtuother:treatmentshrub 0.432 0.000 -0.295 0.000 -0.218 -0.584 -0.418 -0.819 0.596 0.000

rtusyrphid:treatmentshrub 0.464 0.000 -0.317 0.000 -0.234 -0.400 -0.560 -0.880 0.640 0.000

rtlp:t rtthr:

floweringbloom

rtubombylid

rtuhoneybee

rtulep

rtuother

rtusyrphid

treatmentshrub

rtubombylid:treatmentshrub

rtuhoneybee:treatmentshrub

rtulep:treatmentshrub

rtuother:treatmentshrub 0.431

rtusyrphid:treatmentshrub 0.463 0.777

Rejected models containing interaction terms:

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Total flower visits | | | Plant visits | | | Proportion of flowers visited | | | Visit Duration | | |
|  | **Coeff** | **χ2** | **p** | **Coeff** | **χ2** | **p** |  |  |  | **Coeff** | **χ2** | **p** |
| Microsite (shrub) | -0.3752 | **2.964** | **0.08512** | -0.33984 | 3.3532 | **0.067076** |  |  |  |  |  |  |
| Blooming (bloom) | -1.27421 | 34.0384 | **<0.00001** | -1.26759 | 42.7007 | **<0.00001** |  |  |  |  |  |  |
| Flowers.pot | 0.06938 | 6.9100 | **0.00857** | 0.04735 | 4.1287 | **0.042161** |  |  |  |  |  |  |
| Microsite \* Blooming | 0.05608 | 0.0324 | 0.85707 | 0.03522 | 0.0160 | 0.899375 |  |  |  |  |  |  |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Flower visits | | | Foraging bouts | | |
|  | Chisq | Df | P |  |  |  |
| Flowering | 16.3114 | 1 | <0.0001 | 11.2812 | 1 | 0.0007829 |
| Rtu | 121.6832 | 5 | <0.0001 | 131.340 | 5 | < 2.2e-16 |
| Treatment | 6.7008 | 1 | 0.009637 | 3.6569 | 1 | 0.0558390 |
| Flowers.pot | 9.4194 | 1 | 0.002147 | 4.5640 | 1 | 0.0326507 |
| Flowering:rtu | 56.9111 | 5 | <0.0001 | 53.0033 | 5 | 3.358e-10 |
| Flowering:treatment | 3.6394 | 1 | 0.056426 | 2.3436 | 1 | 0.1258002 |
| Rtu:treatment | 5.4996 | 5 | 0.357984 | 3.8289 | 5 | 0.5210663 |
| Flowering:rtu:treatment | 7.5190 | 5 | 0.184812 | 4.1995 | 5 | 0.5210663 |