RESULTS FROM FIELD DATA 2015 – 03/03/2016

Butterfly seed predation: effects on plant reproductive output and context-dependence

Objectives / questions

1) What are the effects of plant traits (phenology, flower production, shoot height), environmental context (soil temperature, height of surrounding vegetation) and community context (ant abundance at the plant level, distance to nearest plant with ants) on predispersal seed predation (probability of attack, intensity)?

H1: Plants are more prone to be attacked by the butterfly (and the interaction is more intense) when they show an early phenology, high number of flowers and higher shoots, when the surrounding vegetation is short and when ants are present in the proximity of the plant. Reasons for an effect of soil temperature?

2) What are the (direct / indirect) effects of plant traits and context on fitness / reproductive output (fruit / seed production) / (fruit / seed set)?

H2: Higher soil temperatures (speeding up fruit maturation?) and higher flower production directly increase fitness. The effects of phenology, height and ants are indirect effects through seed predation (plants flowering early, being higher than the surrounding vegetation and having high ant abundance have higher seed predation and therefore lower fitness).

3) What is the relative importance of plant traits vs. context for explaining the variation in predispersal seed predation? What is the relative importance of plant traits, context and seed predation for explaining the variation in plant fitness / reproductive output? (variation partitioning)

H3: … We could hypothesize that the context is (nearly) as important as plant traits for explaining variation in seed predation, and that the interaction is (nearly) as important as plant traits for explaining variation in fitness / reproductive output.

…

1) Effects of plant traits, environmental and community context on seed predation

First constructed a model (GLM) including the interactions of all variables \* population (results not shown), then performed model selection and model averaging using all models with AIC < 2. Explanatory variables were standardized before including them in the model (z.) in order to improve the interpretation of model coefficients. R2 is calculated with the best model (the one with lowest AIC).

Temperature effect: Tried using 4 different variables: average daily minimum (avg\_d\_min\_ja), maximum (avg\_d\_max\_ja), standard deviation (avg\_d\_sd\_ja) and range (avg\_d\_range\_ja) for july and august.

Model for probability of attack, n=301

#Model with interactions of all variables with population

> model2a<-glm(attack~(z.shoot\_h+z.most\_adv+z.n\_fl\_corrected+z.veg\_h\_mean+

z.avg\_d\_min\_ja+z.n\_redants)\*population+z.n\_redants:z.most\_adv,

family="binomial",na.action = "na.fail")

> models2a <- dredge(model2a)

#Model averaging

> summary(model.avg(models2a, subset = delta < 2))

Call:

model.avg.model.selection(object = models2a, subset = delta <

2)

Component model call:

glm(formula = attack ~ <8 unique rhs>, family = binomial, na.action = na.fail)

Component models:

df logLik AICc delta weight

1/2/3/4/6/7/10 10 -146.32 313.39 0.00 0.19

1/2/3/4/6/7 8 -148.57 313.62 0.23 0.17

1/2/3/4/5/6/7/10 11 -145.37 313.64 0.25 0.17

1/2/3/4/5/6/7 9 -147.57 313.75 0.36 0.16

1/2/3/4/6/7/9/10 12 -144.73 314.54 1.16 0.11

1/2/3/4/5/6/7/9/10 13 -143.96 315.18 1.79 0.08

1/2/3/4/5/6/7/10/11 12 -145.12 315.31 1.92 0.07

1/2/3/4/6/7/8/10 12 -145.12 315.32 1.93 0.07

Term codes:

population z.avg\_d\_min\_ja z.most\_adv

1 2 3

z.n\_fl\_corrected z.n\_redants z.shoot\_h

4 5 6

z.veg\_h\_mean population:z.most\_adv population:z.n\_fl\_corrected

7 8 9

population:z.veg\_h\_mean z.most\_adv:z.n\_redants

10 11

Model-averaged coefficients:

(full average)

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) 1.913287 0.442320 0.443891 4.310 1.63e-05 \*\*\*

populationRemmene -1.762576 0.629424 0.631883 2.789 0.005280 \*\*

populationTånga Hed -1.722016 0.706350 0.708752 2.430 0.015114 \*

z.avg\_d\_min\_ja -1.315497 0.266464 0.267539 4.917 9.00e-07 \*\*\*

z.most\_adv 0.727009 0.336469 0.337467 2.154 0.031216 \*

z.n\_fl\_corrected 0.810839 0.443812 0.445370 1.821 0.068668 .

z.shoot\_h 0.538557 0.215178 0.216048 2.493 0.012675 \*

z.veg\_h\_mean -1.242081 0.356415 0.357643 3.473 0.000515 \*\*\*

populationRemmene:z.veg\_h\_mean -0.019896 0.391902 0.393487 0.051 0.959674

populationTånga Hed:z.veg\_h\_mean 0.684401 0.639705 0.640897 1.068 0.285575

z.n\_redants 0.110633 0.166417 0.166763 0.663 0.507063

populationRemmene:z.n\_fl\_corrected 0.052851 0.425482 0.427138 0.124 0.901527

populationTånga Hed:z.n\_fl\_corrected -0.141972 0.435352 0.436300 0.325 0.744878

z.most\_adv:z.n\_redants -0.008139 0.049806 0.049942 0.163 0.870546

populationRemmene:z.most\_adv 0.074060 0.327514 0.327969 0.226 0.821346

populationTånga Hed:z.most\_adv 0.041179 0.238517 0.239126 0.172 0.863275

(conditional average)

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) 1.9133 0.4423 0.4439 4.310 1.63e-05 \*\*\*

populationRemmene -1.7626 0.6294 0.6319 2.789 0.005280 \*\*

populationTånga Hed -1.7220 0.7064 0.7087 2.430 0.015114 \*

z.avg\_d\_min\_ja -1.3155 0.2665 0.2675 4.917 9.00e-07 \*\*\*

z.most\_adv 0.7270 0.3365 0.3375 2.154 0.031216 \*

z.n\_fl\_corrected 0.8108 0.4438 0.4454 1.821 0.068668 .

z.shoot\_h 0.5386 0.2152 0.2160 2.493 0.012675 \*

z.veg\_h\_mean -1.2421 0.3564 0.3576 3.473 0.000515 \*\*\*

populationRemmene:z.veg\_h\_mean -0.0294 0.4761 0.4780 0.062 0.950960

populationTånga Hed:z.veg\_h\_mean 1.0113 0.5235 0.5257 1.924 0.054374 .

z.n\_redants 0.2355 0.1719 0.1726 1.365 0.172409

populationRemmene:z.n\_fl\_corrected 0.2909 0.9630 0.9670 0.301 0.763511

populationTånga Hed:z.n\_fl\_corrected -0.7816 0.7372 0.7403 1.056 0.291086

z.most\_adv:z.n\_redants -0.1138 0.1505 0.1512 0.753 0.451702

populationRemmene:z.most\_adv 1.0407 0.7081 0.7110 1.464 0.143303

populationTånga Hed:z.most\_adv 0.5786 0.6989 0.7018 0.825 0.409654

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Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Relative variable importance:

population z.avg\_d\_min\_ja z.most\_adv z.n\_fl\_corrected z.shoot\_h

Importance: 1.00 1.00 1.00 1.00 1.00

N containing models: 8 8 8 8 8

z.veg\_h\_mean population:z.veg\_h\_mean z.n\_redants

Importance: 1.00 0.68 0.47

N containing models: 8 6 4

population:z.n\_fl\_corrected z.most\_adv:z.n\_redants population:z.most\_adv

Importance: 0.18 0.07 0.07

N containing models: 2

> r.squaredLR(glm(attack~z.shoot\_h+z.most\_adv+z.n\_fl\_corrected+z.veg\_h\_mean+

z.avg\_d\_min\_ja+population+population:z.veg\_h\_mean,

family="binomial",na.action = "na.fail"))

[1] 0.317738

attr(,"adj.r.squared")

[1] 0.4292157

Showing below coefficients of averaged models using the other temperature variables: maximum, standard deviation and range

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) 0.84475 0.31479 0.31609 2.673 0.00753 \*\*

populationRemmene 0.91503 0.39443 0.39607 2.310 0.02087 \*

populationTånga Hed -1.01545 0.63565 0.63813 1.591 0.11154

z.avg\_d\_max\_ja -0.71623 0.31344 0.31461 2.277 0.02281 \*

z.most\_adv 0.69674 0.23935 0.24033 2.899 0.00374 \*\*

z.n\_fl\_corrected 0.77178 0.32412 0.32542 2.372 0.01771 \*

z.shoot\_h 0.65359 0.21864 0.21954 2.977 0.00291 \*\*

z.veg\_h\_mean -1.13803 0.34920 0.35016 3.250 0.00115 \*\*

populationRemmene:z.avg\_d\_max\_ja 1.38274 0.45688 0.45862 3.015 0.00257 \*\*

populationTånga Hed:z.avg\_d\_max\_ja 0.21882 0.49296 0.49476 0.442 0.65828

z.n\_redants 0.04968 0.11796 0.11823 0.420 0.67436

populationRemmene:z.veg\_h\_mean 0.16785 0.38167 0.38234 0.439 0.66067

populationTånga Hed:z.veg\_h\_mean 0.22421 0.47804 0.47872 0.468 0.63953

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) 1.12075768 0.59195822 0.59339226 1.889 0.058928 .

populationRemmene 0.32903013 0.65484366 0.65670444 0.501 0.616348

populationTånga Hed -1.56692747 0.72537168 0.72785853 2.153 0.031335 \*

z.avg\_d\_sd\_ja -0.06347082 0.31322629 0.31451481 0.202 0.840069

z.most\_adv 0.44051158 0.46084052 0.46178063 0.954 0.340113

z.n\_fl\_corrected 1.22214103 0.71884991 0.72038282 1.697 0.089788 .

z.shoot\_h 0.72906241 0.22172806 0.22263104 3.275 0.001058 \*\*

z.veg\_h\_mean -0.91330519 0.25822206 0.25918668 3.524 0.000425 \*\*\*

populationRemmene:z.avg\_d\_sd\_ja 1.00956856 0.42392424 0.42568383 2.372 0.017709 \*

populationTånga Hed:z.avg\_d\_sd\_ja -0.00005259 0.46064089 0.46247794 0.000 0.999909

populationRemmene:z.n\_fl\_corrected -0.27805748 0.67880081 0.68092670 0.408 0.683016

populationTånga Hed:z.n\_fl\_corrected -0.56226682 0.84486173 0.84603140 0.665 0.506311

z.n\_redants 0.07506451 0.13838451 0.13868381 0.541 0.588326

populationRemmene:z.most\_adv 0.21653479 0.53160093 0.53228407 0.407 0.684153

populationTånga Hed:z.most\_adv 0.17078507 0.45520469 0.45598454 0.375 0.708002

populationRemmene:z.veg\_h\_mean 0.01678318 0.16126974 0.16187783 0.104 0.917425

populationTånga Hed:z.veg\_h\_mean 0.08355561 0.30578455 0.30615270 0.273 0.784914

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) 1.09958 0.57638 0.57773 1.903 0.057005 .

populationRemmene 0.37412 0.64027 0.64200 0.583 0.560071

populationTånga Hed -1.53794 0.72010 0.72247 2.129 0.033277 \*

z.avg\_d\_range\_ja -0.03970 0.29788 0.29911 0.133 0.894408

z.most\_adv 0.43093 0.48442 0.48537 0.888 0.374628

z.n\_fl\_corrected 1.16821 0.69249 0.69392 1.683 0.092280 .

z.shoot\_h 0.71659 0.22075 0.22165 3.233 0.001225 \*\*

z.veg\_h\_mean -0.90003 0.23267 0.23361 3.853 0.000117 \*\*\*

populationRemmene:z.avg\_d\_range\_ja 0.93555 0.41146 0.41317 2.264 0.023555 \*

populationTånga Hed:z.avg\_d\_range\_ja -0.13910 0.42776 0.42952 0.324 0.746048

populationRemmene:z.n\_fl\_corrected -0.25650 0.64088 0.64272 0.399 0.689825

populationTånga Hed:z.n\_fl\_corrected -0.46669 0.79021 0.79126 0.590 0.555324

z.n\_redants 0.07686 0.13883 0.13915 0.552 0.580715

populationRemmene:z.most\_adv 0.24728 0.56332 0.56405 0.438 0.661093

populationTånga Hed:z.most\_adv 0.19643 0.48481 0.48564 0.404 0.685866

Model for n\_eggs\_max n=301

Refitted with a negative binomial distribution (better fit than poisson, lower AIC)

> summary(model.avg(modelseg\_a1\_nb, subset = delta < 2))

Call:

model.avg.model.selection(object = modelseg\_a1\_nb, subset = delta <

2)

Component model call:

glm.nb(formula = n\_eggs\_max ~ <15 unique rhs>, data = data1comp, na.action = na.fail, init.theta =

0.8402170378, link = log)

Model-averaged coefficients:

(full average)

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) 2.03035 0.21282 0.21359 9.506 < 2e-16 \*\*\*

populationRemmene -0.78633 0.34745 0.34873 2.255 0.024141 \*

populationTånga Hed -1.26421 0.35979 0.36119 3.500 0.000465 \*\*\*

z.avg\_d\_min\_ja -0.85878 0.20991 0.21042 4.081 4.48e-05 \*\*\*

z.most\_adv 0.52971 0.12048 0.12098 4.379 1.19e-05 \*\*\*

z.n\_fl\_corrected 0.50473 0.32007 0.32093 1.573 0.115790

z.n\_redants 0.43904 0.18139 0.18183 2.415 0.015756 \*

z.shoot\_h 0.44288 0.21202 0.21255 2.084 0.037193 \*

z.veg\_h\_mean -0.96386 0.25512 0.25587 3.767 0.000165 \*\*\*

populationRemmene:z.avg\_d\_min\_ja 0.43200 0.37109 0.37160 1.163 0.245014

populationTånga Hed:z.avg\_d\_min\_ja 0.35672 0.35742 0.35818 0.996 0.319281

populationRemmene:z.shoot\_h -0.29673 0.33928 0.33971 0.873 0.382395

populationTånga Hed:z.shoot\_h -0.10334 0.22373 0.22439 0.461 0.645132

populationRemmene:z.veg\_h\_mean 0.49467 0.35528 0.35617 1.389 0.164877

populationTånga Hed:z.veg\_h\_mean 0.83793 0.31794 0.31903 2.626 0.008627 \*\*

z.most\_adv:z.n\_redants -0.07214 0.08883 0.08895 0.811 0.417384

populationRemmene:z.n\_fl\_corrected 0.01248 0.34425 0.34521 0.036 0.971153

populationTånga Hed:z.n\_fl\_corrected -0.18705 0.33962 0.34038 0.550 0.582636

populationRemmene:z.n\_redants -0.04735 0.29023 0.29142 0.162 0.870919

populationTånga Hed:z.n\_redants -0.23166 0.26890 0.26921 0.861 0.389488

Relative variable importance:

population z.avg\_d\_min\_ja z.most\_adv z.n\_fl\_corrected z.n\_redants z.shoot\_h z.veg\_h\_mean

Importance: 1.00 1.00 1.00 1.00 1.00 1.00 1.00

N containing models: 15 15 15 15 15 15 15

population:z.veg\_h\_mean population:z.avg\_d\_min\_ja population:z.shoot\_h population:z.n\_redants

Importance: 1.00 0.67 0.53 0.51

N containing models: 15 8 7 8

z.most\_adv:z.n\_redants population:z.n\_fl\_corrected

Importance: 0.49 0.43

N containing models: 7 7

 > r.squaredLR(modeleg\_a1\_nb\_best)

[1] 0.3557502

attr(,"adj.r.squared")

[1] 0.3583122

Results using other temperature variables

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) 1.47574 0.23807 0.23886 6.178 < 2e-16 \*\*\*

populationRemmene 0.47902 0.32445 0.32565 1.471 0.14130

populationTånga Hed -0.65473 0.37595 0.37751 1.734 0.08286 .

z.avg\_d\_max\_ja -0.87895 0.19333 0.19415 4.527 6.00e-06 \*\*\*

z.most\_adv 0.49496 0.12111 0.12163 4.070 4.71e-05 \*\*\*

z.n\_fl\_corrected 0.78565 0.40914 0.40995 1.916 0.05531 .

z.n\_redants 0.59116 0.19933 0.19991 2.957 0.00311 \*\*

z.shoot\_h 0.31428 0.12470 0.12514 2.511 0.01202 \*

z.veg\_h\_mean -1.20728 0.23406 0.23500 5.137 3.00e-07 \*\*\*

populationRemmene:z.avg\_d\_max\_ja 1.36467 0.27572 0.27687 4.929 8.00e-07 \*\*\*

populationTånga Hed:z.avg\_d\_max\_ja 0.66952 0.28054 0.28172 2.377 0.01748 \*

populationRemmene:z.n\_fl\_corrected -0.31534 0.37715 0.37822 0.834 0.40442

populationTånga Hed:z.n\_fl\_corrected -0.49701 0.43710 0.43783 1.135 0.25630

populationRemmene:z.n\_redants -0.09501 0.37573 0.37729 0.252 0.80118

populationTånga Hed:z.n\_redants -0.45282 0.28594 0.28643 1.581 0.11390

populationRemmene:z.veg\_h\_mean 0.84672 0.28009 0.28122 3.011 0.00261 \*\*

populationTånga Hed:z.veg\_h\_mean 1.08003 0.30600 0.30725 3.515 0.00044 \*\*\*

z.most\_adv:z.n\_redants -0.03244 0.07388 0.07393 0.439 0.66080

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) 1.72273 0.25491 0.25599 6.730 < 2e-16 \*\*\*

populationRemmene -0.06137 0.31940 0.32075 0.191 0.848279

populationTånga Hed -0.97720 0.39717 0.39884 2.450 0.014281 \*

z.avg\_d\_sd\_ja -0.41148 0.20829 0.20918 1.967 0.049169 \*

z.most\_adv 0.46662 0.12556 0.12609 3.701 0.000215 \*\*\*

z.n\_fl\_corrected 1.19283 0.32679 0.32818 3.635 0.000278 \*\*\*

z.n\_redants 0.52514 0.19876 0.19927 2.635 0.008404 \*\*

z.shoot\_h 0.31222 0.11699 0.11748 2.658 0.007866 \*\*

z.veg\_h\_mean -0.91088 0.22178 0.22265 4.091 4.29e-05 \*\*\*

populationRemmene:z.avg\_d\_sd\_ja 0.87292 0.25587 0.25695 3.397 0.000681 \*\*\*

populationTånga Hed:z.avg\_d\_sd\_ja 0.39761 0.28333 0.28454 1.397 0.162290

populationRemmene:z.n\_fl\_corrected -0.61930 0.38029 0.38191 1.622 0.104886

populationTånga Hed:z.n\_fl\_corrected -0.92658 0.33239 0.33380 2.776 0.005506 \*\*

populationRemmene:z.n\_redants -0.04732 0.34915 0.35062 0.135 0.892635

populationTånga Hed:z.n\_redants -0.35608 0.29712 0.29751 1.197 0.231355

populationRemmene:z.veg\_h\_mean 0.50584 0.27551 0.27661 1.829 0.067442 .

populationTånga Hed:z.veg\_h\_mean 0.87492 0.30108 0.30228 2.894 0.003799 \*\*

z.most\_adv:z.n\_redants -0.04923 0.08274 0.08283 0.594 0.552285

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) 1.77730 0.24757 0.24862 7.149 < 2e-16 \*\*\*

populationRemmene -0.09483 0.31266 0.31398 0.302 0.762628

populationTånga Hed -1.00062 0.39034 0.39198 2.553 0.010688 \*

z.avg\_d\_range\_ja -0.37404 0.19889 0.19973 1.873 0.061114 .

z.most\_adv 0.47590 0.12559 0.12612 3.773 0.000161 \*\*\*

z.n\_fl\_corrected 1.23277 0.32705 0.32844 3.753 0.000174 \*\*\*

z.n\_redants 0.51071 0.19789 0.19839 2.574 0.010044 \*

z.shoot\_h 0.29422 0.11682 0.11730 2.508 0.012135 \*

z.veg\_h\_mean -0.87662 0.21953 0.22038 3.978 6.96e-05 \*\*\*

populationRemmene:z.avg\_d\_range\_ja 0.80567 0.25112 0.25218 3.195 0.001399 \*\*

populationTånga Hed:z.avg\_d\_range\_ja 0.28528 0.27004 0.27118 1.052 0.292799

populationRemmene:z.n\_fl\_corrected -0.65707 0.38060 0.38222 1.719 0.085595 .

populationTånga Hed:z.n\_fl\_corrected -0.96558 0.33238 0.33379 2.893 0.003819 \*\*

populationRemmene:z.n\_redants -0.05639 0.34492 0.34637 0.163 0.870670

populationTånga Hed:z.n\_redants -0.33878 0.29566 0.29605 1.144 0.252477

populationRemmene:z.veg\_h\_mean 0.46476 0.27324 0.27433 1.694 0.090243 .

populationTånga Hed:z.veg\_h\_mean 0.81831 0.30057 0.30177 2.712 0.006693 \*\*

z.most\_adv:z.n\_redants -0.05181 0.08357 0.08366 0.619 0.535778

2) Effects of plant traits, environmental and community context on fitness / reproductive output

Same procedure: first constructed a model including the interactions of all variables \* population (results not shown), then performed model selection and model averaging using all models with AIC < 2.

Response variables: number of intact fruits, number of developed seeds per plant.

n plants where information on seeds is available (many with n fruits = 0)

population n plants n plants with >0 seeds prop plants >0 seeds

Högsjön 96 26 0,27083333

Remmene 84 8 0,0952381

Tånga Hed 71 60 0,84507042

After removal of some plants with missing data for temperature and two outliers, n=244 plants (93 Högsjön, 82 Remmene, 69 Tanga).

The effect of the interaction with the seed predator was included in the models in three ways as the number of eggs per plant.

2.1) Response = n\_intact\_fruits

> model1fr\_a1<-glm(n\_intact\_fruits~(z.shoot\_h+z.most\_adv+z.n\_fl\_corrected+z.avg\_d\_min\_ja+

z.n\_eggs\_max)\*population ,family="poisson",na.action = "na.fail")

> summary(model.avg(models1fr\_a1, subset = delta < 2))

Call:

model.avg.model.selection(object = models1fr\_a1, subset = delta <

2)

Component model call:

glm(formula = n\_intact\_fruits ~ <4 unique rhs>, family = poisson, na.action = na.fail)

Model-averaged coefficients:

(full average)

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) -1.13017 0.21891 0.21975 5.143 3e-07 \*\*\*

populationRemmene -0.22923 0.36930 0.37073 0.618 0.5364

populationTånga Hed 1.63968 0.24364 0.24453 6.705 <2e-16 \*\*\*

z.avg\_d\_min\_ja 0.22734 0.10985 0.11029 2.061 0.0393 \*

z.most\_adv 0.12481 0.09436 0.09459 1.320 0.1870

z.n\_eggs\_max -0.40369 0.06042 0.06066 6.655 <2e-16 \*\*\*

z.n\_fl\_corrected 0.29779 0.20815 0.20870 1.427 0.1536

z.shoot\_h 0.16633 0.12433 0.12469 1.334 0.1822

populationRemmene:z.shoot\_h 0.09555 0.22530 0.22560 0.424 0.6719

populationTånga Hed:z.shoot\_h 0.03669 0.11106 0.11133 0.330 0.7417

populationRemmene:z.n\_fl\_corrected 0.12193 0.33861 0.33911 0.360 0.7192

populationTånga Hed:z.n\_fl\_corrected 0.05410 0.19757 0.19809 0.273 0.7847

Relative variable importance:

population z.avg\_d\_min\_ja z.n\_eggs\_max z.n\_fl\_corrected z.shoot\_h z.most\_adv

Importance: 1.00 1.00 1.00 1.00 1.00 0.81

N containing models: 4 4 4 4 4 3

population:z.shoot\_h population:z.n\_fl\_corrected

Importance: 0.21 0.17

N containing models: 1 1

When removing temperature from the model, the effect of phenology turns significant 🡪Could this be due to temperature having an indirect effect through phenology?

Higher temperature 🡪 earlier phenology 🡪higher fruit production?

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) -0.99547 0.23107 0.23186 4.293 1.76e-05 \*\*\*

populationRemmene -0.57339 0.34207 0.34329 1.670 0.0949 .

populationTånga Hed 1.56263 0.26370 0.26464 5.905 < 2e-16 \*\*\*

z.most\_adv 0.18240 0.07949 0.07982 2.285 0.0223 \*

z.n\_eggs\_max -0.51325 0.26415 0.26462 1.940 0.0524 .

z.n\_fl\_corrected 0.29557 0.23176 0.23234 1.272 0.2033

z.shoot\_h 0.12759 0.12322 0.12357 1.033 0.3018

populationRemmene:z.shoot\_h 0.09377 0.22483 0.22512 0.417 0.6770

populationTånga Hed:z.shoot\_h 0.03357 0.10899 0.10927 0.307 0.7587

populationRemmene:z.n\_fl\_corrected 0.14409 0.37342 0.37394 0.385 0.7000

populationTånga Hed:z.n\_fl\_corrected 0.06901 0.22495 0.22549 0.306 0.7596

populationRemmene:z.n\_eggs\_max 0.11549 0.31431 0.31482 0.367 0.7137

populationTånga Hed:z.n\_eggs\_max 0.09596 0.26249 0.26293 0.365 0.7151

When removing predation from the model, the effect of phenology is not even included in the set of best models (so no selection for late flowering when not considering the effect of predation)

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) -1.15387 0.21122 0.21199 5.443 1e-07 \*\*\*

populationRemmene -0.17953 0.37426 0.37578 0.478 0.6328

populationTånga Hed 1.78983 0.22585 0.22665 7.897 <2e-16 \*\*\*

z.avg\_d\_min\_ja 0.33347 0.15633 0.15676 2.127 0.0334 \*

z.n\_fl\_corrected 0.30983 0.05279 0.05298 5.848 <2e-16 \*\*\*

z.shoot\_h 0.01553 0.08767 0.08797 0.177 0.8598

populationRemmene:z.shoot\_h 0.08609 0.21781 0.21806 0.395 0.6930

populationTånga Hed:z.shoot\_h 0.01428 0.08127 0.08155 0.175 0.8610

populationRemmene:z.avg\_d\_min\_ja -0.06639 0.22465 0.22514 0.295 0.7681

populationTånga Hed:z.avg\_d\_min\_ja -0.05389 0.15700 0.15723 0.343 0.7318

Using other variables, the effect of temperature is not significant

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) -0.91463 0.21107 0.21182 4.318 1.57e-05 \*\*\*

populationRemmene -0.62188 0.35944 0.36063 1.724 0.0846 .

populationTånga Hed 1.36990 0.26724 0.26820 5.108 3.00e-07 \*\*\*

z.avg\_d\_max\_ja 0.16840 0.14440 0.14470 1.164 0.2445

z.most\_adv 0.14086 0.09249 0.09275 1.519 0.1288

z.n\_eggs\_max -0.45327 0.20513 0.20550 2.206 0.0274 \*

z.n\_fl\_corrected 0.35242 0.17361 0.17405 2.025 0.0429 \*

z.shoot\_h 0.16066 0.10158 0.10191 1.576 0.1149

populationRemmene:z.avg\_d\_max\_ja -0.09843 0.27390 0.27422 0.359 0.7196

populationTånga Hed:z.avg\_d\_max\_ja -0.03537 0.11643 0.11667 0.303 0.7618

populationRemmene:z.shoot\_h 0.05551 0.17735 0.17757 0.313 0.7546

populationTånga Hed:z.shoot\_h 0.01611 0.07863 0.07886 0.204 0.8381

populationRemmene:z.n\_eggs\_max 0.06028 0.23204 0.23243 0.259 0.7954

populationTånga Hed:z.n\_eggs\_max 0.05273 0.19948 0.19980 0.264 0.7918

populationRemmene:z.n\_fl\_corrected 0.07185 0.26709 0.26747 0.269 0.7882

populationTånga Hed:z.n\_fl\_corrected 0.03486 0.16155 0.16194 0.215 0.8296

(full average)

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) -0.97663 0.22807 0.22884 4.268 1.98e-05 \*\*\*

populationRemmene -0.59108 0.33764 0.33885 1.744 0.0811 .

populationTånga Hed 1.53676 0.26705 0.26797 5.735 < 2e-16 \*\*\*

z.most\_adv 0.18219 0.07950 0.07982 2.282 0.0225 \*

z.n\_eggs\_max -0.49782 0.24560 0.24603 2.023 0.0430 \*

z.n\_fl\_corrected 0.30797 0.21549 0.21603 1.426 0.1540

z.shoot\_h 0.13368 0.11718 0.11753 1.137 0.2553

populationRemmene:z.shoot\_h 0.07863 0.20875 0.20902 0.376 0.7068

populationTånga Hed:z.shoot\_h 0.02815 0.10056 0.10082 0.279 0.7801

z.avg\_d\_sd\_ja 0.00853 0.03568 0.03578 0.238 0.8116

populationRemmene:z.n\_fl\_corrected 0.12082 0.34603 0.34650 0.349 0.7273

populationTånga Hed:z.n\_fl\_corrected 0.05787 0.20754 0.20804 0.278 0.7809

populationRemmene:z.n\_eggs\_max 0.09684 0.29093 0.29140 0.332 0.7396

populationTånga Hed:z.n\_eggs\_max 0.08047 0.24294 0.24334 0.331 0.7409

(full average)

Estimate Std. Error Adjusted SE z value Pr(>|z|)

(Intercept) -0.97374 0.22787 0.22863 4.259 2.05e-05 \*\*\*

populationRemmene -0.59331 0.33698 0.33819 1.754 0.0794 .

populationTånga Hed 1.53177 0.26803 0.26895 5.695 < 2e-16 \*\*\*

z.most\_adv 0.18199 0.07950 0.07983 2.280 0.0226 \*

z.n\_eggs\_max -0.49569 0.24369 0.24412 2.031 0.0423 \*

z.n\_fl\_corrected 0.30970 0.21382 0.21435 1.445 0.1485

z.shoot\_h 0.13400 0.11642 0.11676 1.148 0.2511

z.avg\_d\_range\_ja 0.01089 0.03795 0.03805 0.286 0.7747

populationRemmene:z.shoot\_h 0.07704 0.20693 0.20719 0.372 0.7100

populationTånga Hed:z.shoot\_h 0.02758 0.09962 0.09988 0.276 0.7824

populationRemmene:z.n\_fl\_corrected 0.11839 0.34295 0.34341 0.345 0.7303

populationTånga Hed:z.n\_fl\_corrected 0.05670 0.20560 0.20609 0.275 0.7832

populationRemmene:z.n\_eggs\_max 0.09489 0.28831 0.28877 0.329 0.7425

populationTånga Hed:z.n\_eggs\_max 0.07885 0.24075 0.24114 0.327 0.7437

2.2) Response = seed\_n\_per\_shoot

> model2se\_c1<-zeroinfl(round(seed\_n\_per\_shoot)~(z.shoot\_h+z.most\_adv+z.n\_fl\_corrected+

+ z.avg\_d\_min\_ja+z.n\_eggs\_max)\*population,dist="negbin",na.action="na.fail",data=data2compA)

> summary(model.avg(get.models(models2se\_c1,subset=delta<2,cluster=clust)))

Call:

model.avg.default(object = get.models(models2se\_c1, subset = delta <

2, cluster = clust))

Component model call:

zeroinfl(formula = <13 unique values>, data = data2compA, na.action = na.fail, dist =

negbin)

Model-averaged coefficients:

(full average)

Estimate Std. Error z value Pr(>|z|)

count\_(Intercept) 5.70507 0.30526 18.689 < 2e-16 \*\*\*

count\_populationRemmene 0.33328 0.40905 0.815 0.415206

count\_populationTånga Hed 1.36662 0.34003 4.019 5.84e-05 \*\*\*

count\_z.avg\_d\_min\_ja -0.03379 0.10676 0.317 0.751603

count\_z.most\_adv 0.56884 0.49693 1.145 0.252334

count\_z.n\_eggs\_max -0.32881 0.08843 3.718 0.000200 \*\*\*

count\_z.n\_fl\_corrected 0.23521 0.34438 0.683 0.494603

count\_populationRemmene:z.most\_adv -0.69185 0.71937 0.962 0.336178

count\_populationTånga Hed:z.most\_adv -0.44769 0.49808 0.899 0.368737

zero\_(Intercept) 0.98430 0.56033 1.757 0.078976 .

zero\_populationRemmene 0.91582 0.86267 1.062 0.288410

zero\_populationTånga Hed -1.07497 0.70367 1.528 0.126600

zero\_z.avg\_d\_min\_ja -0.36760 0.36950 0.995 0.319796

zero\_z.most\_adv -0.57689 0.55409 1.041 0.297814

zero\_z.n\_eggs\_max 1.35102 0.36058 3.747 0.000179 \*\*\*

zero\_z.n\_fl\_corrected -0.72819 0.72328 1.007 0.314039

zero\_populationRemmene:z.most\_adv -0.17425 0.59271 0.294 0.768773

zero\_populationTånga Hed:z.most\_adv -0.39946 0.71175 0.561 0.574632

count\_z.shoot\_h 0.06526 0.09956 0.655 0.512155

zero\_z.shoot\_h -0.21535 0.28000 0.769 0.441824

count\_populationRemmene:z.n\_fl\_corrected 0.23725 0.48280 0.491 0.623141

count\_populationTånga Hed:z.n\_fl\_corrected 0.21905 0.33502 0.654 0.513217

zero\_populationRemmene:z.n\_fl\_corrected -0.37865 0.72687 0.521 0.602417

zero\_populationTånga Hed:z.n\_fl\_corrected -0.82108 1.09926 0.747 0.455100

Relative variable importance:

count\_population count\_z.most\_adv count\_z.n\_eggs\_max count\_z.n\_fl\_corrected

Importance: 1.00 1.00 1.00 1.00

N containing models: 13 13 13 13

zero\_population zero\_z.most\_adv zero\_z.n\_eggs\_max zero\_z.n\_fl\_corrected

Importance: 1.00 1.00 1.00 1.00

N containing models: 13 13 13 13

count\_z.avg\_d\_min\_ja zero\_z.avg\_d\_min\_ja count\_population:z.most\_adv

Importance: 0.60 0.60 0.54

N containing models: 7 7 7

zero\_population:z.most\_adv count\_z.shoot\_h zero\_z.shoot\_h

Importance: 0.54 0.50 0.50

N containing models: 7 7 7

count\_population:z.n\_fl\_corrected zero\_population:z.n\_fl\_corrected

Importance: 0.43 0.43

N containing models: 6 6

Temperature is not significant and the same happens when including the other temperature variable (not shown)

PATH ANALYSES!!!

3) Relative importance of plant traits vs. context for explaining the variation in predispersal seed predation and in plant fitness

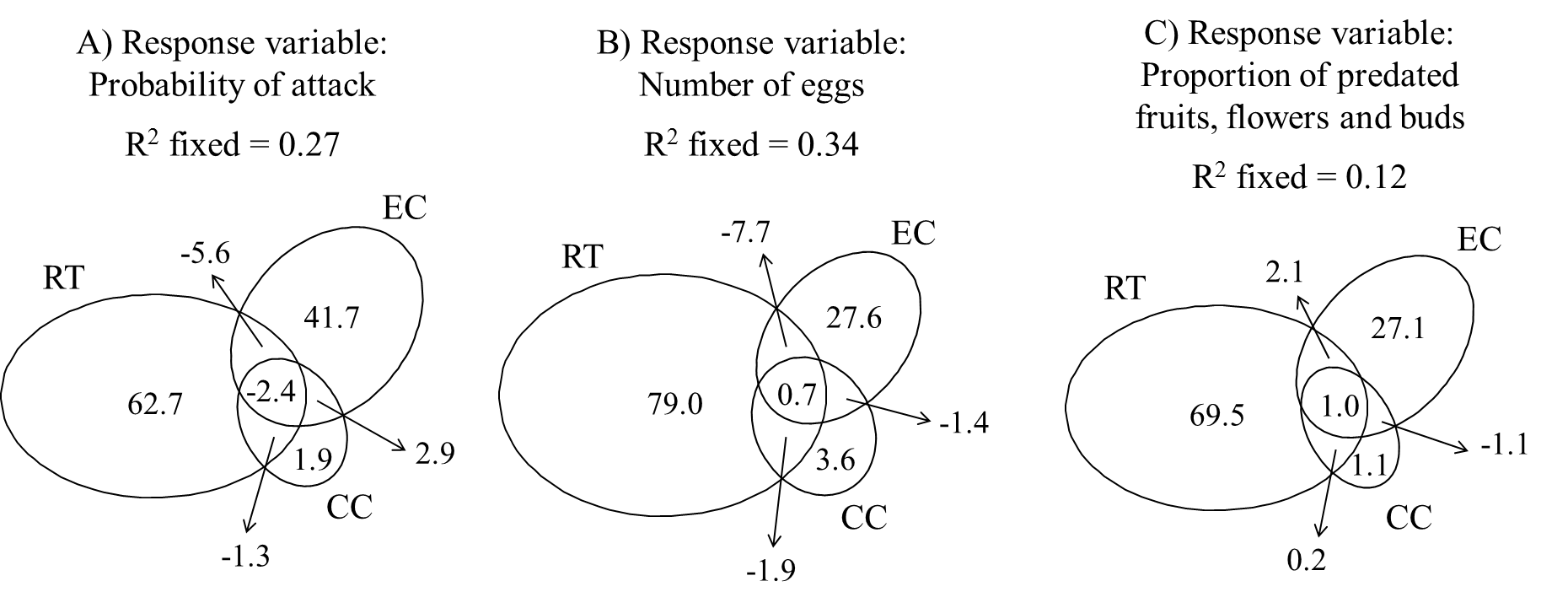
Variation partitioning analyses using GLMMs with population always as a random effect. Values shown inside the ellipses in the figures below are percentages of the total variation explained by fixed factors (R2 fixed of the model including all the variables). The calculations are made so that the percentages sum to 100%.

Response = Predispersal seed predation - 3 variable groups:

Traits: z.shoot\_h + z.most\_adv + z.n\_fl\_corrected

Environmental context: z.veg\_h\_mean + z.avg\_d\_min\_ja

Community context: z.n\_redants + z.dist\_closest\_redants



Response = Plant fitness - 3 variable groups:

Traits: z.shoot\_h + z.most\_adv + z.n\_fl\_corrected

Context: z.veg\_h\_mean + z.avg\_d\_min\_ja + z.n\_redants + z.dist\_closest\_redants (environmental + community context merged together)

Interaction: attack OR number of eggs OR prop\_predated

|  |
| --- |
|  |
|  |

For seeds: Zero-inflated model with random factors (population) is possible, but cannot get a r square (needed for the variation partitioning)

* Use 4 groups of variables? traits, context, interaction, population (hard to represent in a graph)
* Remove context variables? (as no significant effect in the model) – or remove population? (Which probably takes most of the variation)
* Use glmer with Poisson distribution? (although it fits the data quite badly)