Correction of phenology measure

213 is the Julian date used as reference (01-Aug)

If we suppose the duration of each stage is one week:

In populations sampled 1 week before 🡪 + 1 to phenology measure

In populations sampled 1 week after 🡪 -1 to phenology measure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| LokalID | sampling date | sampling julian date | year | stage of most advanced bud + … |
| Ale001 | 30/07/2010 | 211 | 2010 | 0,285714286 |
| Ale010 | 04/08/2010 | 216 | 2010 | -0,428571429 |
| Bor012 | 29/07/2010 | 210 | 2010 | 0,428571429 |
| Göt009a | 31/07/2010 | 212 | 2010 | 0,142857143 |
| Göt009b | 31/07/2010 | 212 | 2010 | 0,142857143 |
| Göt016 | 02/08/2010 | 214 | 2010 | -0,142857143 |
| Her003 | 01/08/2010 | 213 | 2010 | 0 |
| Her004 | 01/08/2010 | 213 | 2010 | 0 |
| Her005 | 01/08/2010 | 213 | 2010 | 0 |
| Ler010 | 05/08/2010 | 217 | 2010 | -0,571428571 |
| Mar001 | 03/08/2010 | 215 | 2010 | -0,285714286 |
| Par003 | 02/08/2010 | 214 | 2010 | -0,142857143 |
| Sve001 | 27/07/2010 | 208 | 2010 | 0,714285714 |
| Sve005 | 27/07/2010 | 208 | 2010 | 0,714285714 |
| Sve011 | 27/07/2010 | 208 | 2010 | 0,714285714 |
| Sve013 | 29/07/2010 | 210 | 2010 | 0,428571429 |
| Tra001 | 03/08/2010 | 215 | 2010 | -0,285714286 |
| Tra002 | 03/08/2010 | 215 | 2010 | -0,285714286 |
| Vår004 | 28/07/2010 | 209 | 2010 | 0,571428571 |
| Vår009 | 28/07/2010 | 209 | 2010 | 0,571428571 |
| Ale001 | 23/07/2011 | 204 | 2011 | 1,285714286 |
| Ale010 | 08/08/2011 | 220 | 2011 | -1 |
| Bor012 | 09/08/2011 | 221 | 2011 | -1,142857143 |
| Göt009a | 24/07/2011 | 205 | 2011 | 1,142857143 |
| Göt009b | 24/07/2011 | 205 | 2011 | 1,142857143 |
| Göt016 | 26/07/2011 | 207 | 2011 | 0,857142857 |
| Her003 | 27/07/2011 | 208 | 2011 | 0,714285714 |
| Her004 | 27/07/2011 | 208 | 2011 | 0,714285714 |
| Her005 | 27/07/2011 | 208 | 2011 | 0,714285714 |
| Ler010 | 24/07/2011 | 205 | 2011 | 1,142857143 |
| Mar001 | 09/08/2011 | 221 | 2011 | -1,142857143 |
| Par003 | 25/07/2011 | 206 | 2011 | 1 |
| Sve001 | 22/07/2011 | 203 | 2011 | 1,428571429 |
| Sve005 | 22/07/2011 | 203 | 2011 | 1,428571429 |
| Sve011 | 21/07/2011 | 202 | 2011 | 1,571428571 |
| Sve013 | 21/07/2011 | 202 | 2011 | 1,571428571 |
| Tra001 | 28/07/2011 | 209 | 2011 | 0,571428571 |
| Tra002 | 28/07/2011 | 209 | 2011 | 0,571428571 |
| Vår004 | 20/07/2011 | 201 | 2011 | 1,714285714 |
| Vår009 | 20/07/2011 | 201 | 2011 | 1,714285714 |

Results with corrected phenology measure

Table 3

Attack, 2010

> Anova(glm(attack~phen\_corr+n\_fl+h\_shoot+LokalID\*phen\_corr+

+ LokalID\*n\_fl+LokalID\*h\_shoot,data=subset(data10[1:2001,],predator==1&LokalID!="Göt016"),family="binomial"),type="II")

Analysis of Deviance Table (Type II tests)

Response: attack

LR Chisq Df Pr(>Chisq)

phen\_corr 38.838 1 4.604e-10 \*\*\*

n\_fl 13.324 1 0.000262 \*\*\*

h\_shoot 1.763 1 0.184218

LokalID 162.814 9 < 2.2e-16 \*\*\*

phen\_corr:LokalID 9.099 9 0.428191

n\_fl:LokalID 44.035 9 1.390e-06 \*\*\*

h\_shoot:LokalID 10.152 9 0.338293

---

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

> summary(glm(attack~phen\_corr+n\_fl+h\_shoot+LokalID\*phen\_corr+

+ LokalID\*n\_fl+LokalID\*h\_shoot,data=subset(data10[1:2001,],predator==1&LokalID!="Göt016"),family="binomial"),type="II")

Call:

glm(formula = attack ~ phen\_corr + n\_fl + h\_shoot + LokalID \*

phen\_corr + LokalID \* n\_fl + LokalID \* h\_shoot, family = "binomial",

data = subset(data10[1:2001, ], predator == 1 & LokalID !=

"Göt016"))

Deviance Residuals:

Min 1Q Median 3Q Max

-2.6906 -0.7766 -0.3854 0.8230 2.5976

Coefficients:

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

(Intercept) -4.329856 1.472377 -2.941 0.00327 \*\*

phen\_corr 0.300332 0.293454 1.023 0.30610

n\_fl 0.384981 0.214760 1.793 0.07304 .

h\_shoot 0.024554 0.055342 0.444 0.65727

LokalIDGöt009a -0.495194 1.959544 -0.253 0.80049

LokalIDGöt009b -4.851923 2.786019 -1.742 0.08159 .

LokalIDHer003 1.996389 1.928885 1.035 0.30067

LokalIDHer004 -1.055986 2.068821 -0.510 0.60975

LokalIDHer005 0.312151 1.903928 0.164 0.86977

LokalIDLer010 3.647231 1.745572 2.089 0.03667 \*

LokalIDPar003 2.060162 1.862484 1.106 0.26867

LokalIDVår004 -0.096860 2.161141 -0.045 0.96425

LokalIDVår009 -0.374825 2.059198 -0.182 0.85556

phen\_corr:LokalIDGöt009a -0.166667 0.415668 -0.401 0.68845

phen\_corr:LokalIDGöt009b 0.608654 0.570418 1.067 0.28596

phen\_corr:LokalIDHer003 0.191148 0.368258 0.519 0.60372

phen\_corr:LokalIDHer004 0.148644 0.363504 0.409 0.68260

phen\_corr:LokalIDHer005 -0.132118 0.369735 -0.357 0.72084

phen\_corr:LokalIDLer010 -0.004673 0.351079 -0.013 0.98938

phen\_corr:LokalIDPar003 0.441257 0.382156 1.155 0.24823

phen\_corr:LokalIDVår004 0.304489 0.360710 0.844 0.39859

phen\_corr:LokalIDVår009 0.625121 0.429380 1.456 0.14543

n\_fl:LokalIDGöt009a 0.297099 0.352971 0.842 0.39995

n\_fl:LokalIDGöt009b -0.446217 0.359990 -1.240 0.21515

n\_fl:LokalIDHer003 -0.522507 0.278558 -1.876 0.06069 .

n\_fl:LokalIDHer004 0.516567 0.387574 1.333 0.18259

n\_fl:LokalIDHer005 0.136202 0.333641 0.408 0.68311

n\_fl:LokalIDLer010 0.560420 0.358282 1.564 0.11777

n\_fl:LokalIDPar003 0.533054 0.487772 1.093 0.27447

n\_fl:LokalIDVår004 0.147191 0.302939 0.486 0.62706

n\_fl:LokalIDVår009 -0.669713 0.259518 -2.581 0.00986 \*\*

h\_shoot:LokalIDGöt009a 0.015619 0.082124 0.190 0.84916

h\_shoot:LokalIDGöt009b 0.180416 0.115594 1.561 0.11858

h\_shoot:LokalIDHer003 -0.002171 0.085245 -0.025 0.97969

h\_shoot:LokalIDHer004 0.068452 0.100468 0.681 0.49566

h\_shoot:LokalIDHer005 0.019664 0.078005 0.252 0.80098

h\_shoot:LokalIDLer010 -0.112528 0.077562 -1.451 0.14683

h\_shoot:LokalIDPar003 -0.030179 0.073358 -0.411 0.68078

h\_shoot:LokalIDVår004 0.013795 0.088996 0.155 0.87681

h\_shoot:LokalIDVår009 0.025975 0.082299 0.316 0.75230

---

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

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 1314.68 on 999 degrees of freedom

Residual deviance: 958.65 on 960 degrees of freedom

AIC: 1038.7

Number of Fisher Scoring iterations: 6

Attack, 2011

> Anova(glm(attack~phen\_corr+n\_fl+h\_shoot+LokalID\*phen\_corr+

+ LokalID\*n\_fl+LokalID\*h\_shoot,data=subset(data11,Predator==1),family="binomial"),type="II")

Analysis of Deviance Table (Type II tests)

Response: attack

LR Chisq Df Pr(>Chisq)

phen\_corr 38.242 1 6.25e-10 \*\*\*

n\_fl 81.774 1 < 2.2e-16 \*\*\*

h\_shoot 0.166 1 0.68350

LokalID 145.063 10 < 2.2e-16 \*\*\*

phen\_corr:LokalID 17.402 10 0.06592 .

n\_fl:LokalID 13.480 10 0.19807

h\_shoot:LokalID 18.248 10 0.05092 .

---

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

Warning messages:

1: glm.fit: fitted probabilities numerically 0 or 1 occurred

2: glm.fit: fitted probabilities numerically 0 or 1 occurred

3: glm.fit: fitted probabilities numerically 0 or 1 occurred

4: glm.fit: fitted probabilities numerically 0 or 1 occurred

5: glm.fit: fitted probabilities numerically 0 or 1 occurred

6: glm.fit: fitted probabilities numerically 0 or 1 occurred

7: glm.fit: fitted probabilities numerically 0 or 1 occurred

> summary(glm(attack~phen\_corr+n\_fl+h\_shoot+LokalID\*phen\_corr+

+ LokalID\*n\_fl+LokalID\*h\_shoot,data=subset(data11,Predator==1),family="binomial"),type="II")

Call:

glm(formula = attack ~ phen\_corr + n\_fl + h\_shoot + LokalID \*

phen\_corr + LokalID \* n\_fl + LokalID \* h\_shoot, family = "binomial",

data = subset(data11, Predator == 1))

Deviance Residuals:

Min 1Q Median 3Q Max

-2.5248 -0.7325 -0.3211 0.7623 2.6140

Coefficients:

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

(Intercept) -5.924581 1.767696 -3.352 0.000804 \*\*\*

phen\_corr 0.968432 0.309151 3.133 0.001733 \*\*

n\_fl 0.532965 0.238387 2.236 0.025370 \*

h\_shoot -0.057540 0.061588 -0.934 0.350164

LokalIDGöt009a 1.919960 2.261060 0.849 0.395803

LokalIDGöt009b 2.456096 2.295010 1.070 0.284534

LokalIDGöt016 0.683257 2.611425 0.262 0.793598

LokalIDHer003 4.342305 2.435329 1.783 0.074579 .

LokalIDHer004 3.706806 1.985051 1.867 0.061851 .

LokalIDHer005 1.773271 2.246893 0.789 0.429989

LokalIDLer010 4.237426 2.229335 1.901 0.057334 .

LokalIDPar003 -17.014844 559.701277 -0.030 0.975748

LokalIDVår004 1.569021 2.380744 0.659 0.509866

LokalIDVår009 0.768178 2.308806 0.333 0.739348

phen\_corr:LokalIDGöt009a -0.618550 0.399852 -1.547 0.121876

phen\_corr:LokalIDGöt009b -0.586277 0.435794 -1.345 0.178527

phen\_corr:LokalIDGöt016 -0.271620 0.487268 -0.557 0.577231

phen\_corr:LokalIDHer003 -0.664059 0.381405 -1.741 0.081668 .

phen\_corr:LokalIDHer004 -0.641846 0.377631 -1.700 0.089194 .

phen\_corr:LokalIDHer005 -1.008820 0.403330 -2.501 0.012376 \*

phen\_corr:LokalIDLer010 -0.490353 0.383346 -1.279 0.200848

phen\_corr:LokalIDPar003 0.359441 0.463488 0.776 0.438036

phen\_corr:LokalIDVår004 -0.581673 0.380756 -1.528 0.126592

phen\_corr:LokalIDVår009 -0.705836 0.454055 -1.555 0.120061

n\_fl:LokalIDGöt009a 0.022877 0.320112 0.071 0.943026

n\_fl:LokalIDGöt009b 0.183190 0.355069 0.516 0.605906

n\_fl:LokalIDGöt016 -0.030219 0.367203 -0.082 0.934412

n\_fl:LokalIDHer003 0.570228 0.386264 1.476 0.139872

n\_fl:LokalIDHer004 0.332160 0.397216 0.836 0.403031

n\_fl:LokalIDHer005 0.498751 0.443192 1.125 0.260437

n\_fl:LokalIDLer010 -0.204690 0.306854 -0.667 0.504734

n\_fl:LokalIDPar003 15.126287 559.695451 0.027 0.978439

n\_fl:LokalIDVår004 0.262560 0.367888 0.714 0.475415

n\_fl:LokalIDVår009 0.253623 0.385340 0.658 0.510422

h\_shoot:LokalIDGöt009a 0.094744 0.078540 1.206 0.227696

h\_shoot:LokalIDGöt009b -0.016816 0.105191 -0.160 0.872989

h\_shoot:LokalIDGöt016 0.018315 0.089121 0.206 0.837174

h\_shoot:LokalIDHer003 -0.078353 0.097249 -0.806 0.420420

h\_shoot:LokalIDHer004 0.029531 0.079841 0.370 0.711474

h\_shoot:LokalIDHer005 0.117808 0.081322 1.449 0.147433

h\_shoot:LokalIDLer010 0.008444 0.076388 0.111 0.911978

h\_shoot:LokalIDPar003 0.207285 0.086545 2.395 0.016616 \*

h\_shoot:LokalIDVår004 0.088937 0.082490 1.078 0.280961

h\_shoot:LokalIDVår009 0.144923 0.085933 1.686 0.091705 .

---

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

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 1512.3 on 1098 degrees of freedom

Residual deviance: 1024.6 on 1055 degrees of freedom

(1 observation deleted due to missingness)

AIC: 1112.6

Number of Fisher Scoring iterations: 17

Warning message:

glm.fit: fitted probabilities numerically 0 or 1 occurred

Eggs, 2010

> Anova(int1\_10b,type="II") #Only slight change in population effect

Anova Table (Type II tests)

Response: n\_eggs

Sum Sq Df F value Pr(>F)

phen\_corr 759.1 1 85.2452 < 2.2e-16 \*\*\*

n\_fl 419.6 1 47.1219 1.196e-11 \*\*\*

h\_shoot 0.1 1 0.0122 0.9121

LokalID 2709.4 9 33.8076 < 2.2e-16 \*\*\*

phen\_corr:LokalID 743.4 9 9.2765 1.380e-13 \*\*\*

n\_fl:LokalID 955.0 9 11.9169 < 2.2e-16 \*\*\*

h\_shoot:LokalID 41.9 9 0.5223 0.8591

Residuals 8548.5 960

---

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

Eggs, 2011

> Anova(int1\_11b,type="II")

Anova Table (Type II tests)

Response: n\_eggs

Sum Sq Df F value Pr(>F)

phen\_corr 1311.9 1 47.4229 9.810e-12 \*\*\*

n\_fl 5479.6 1 198.0862 < 2.2e-16 \*\*\*

h\_shoot 0.6 1 0.0221 0.8818

LokalID 15549.2 10 56.2096 < 2.2e-16 \*\*\*

phen\_corr:LokalID 1520.2 10 5.4955 5.347e-08 \*\*\*

n\_fl:LokalID 10482.7 10 37.8944 < 2.2e-16 \*\*\*

h\_shoot:LokalID 199.6 10 0.7216 0.7046

Residuals 29184.3 1055

---

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

Table 4 (coefficients paths – model for each population)

Very similar results

Figure 3 (general piecewise SEMs)

Very similar results

Results population level

Differences in mean flowering phenology (corrected measure) among populations with and without predator – not very clear

|  |  |
| --- | --- |
| **year=2010**    p = 0,9416 | **year=2011**    p = 0,0854 |

Both years together

|  |  |
| --- | --- |
| **Including population D in 2016**    p = 0,1378 | **Excluding population D in 2016**    p = 0,0837 |

Within the populations with the predator, earlier-flowering populations tend to have greater attack rates

(sum of number of eggs per population /year vs corrected phenology measure)



(proportion of plants attacked per population/year vs corrected phenology measure)

 p=0.0530

But, within the populations with the predator, selection for late flowering (negative selection gradient) is stronger in later-flowering populations! (despite of having lower attack rates)

(selection gradient for phenology for each population/year vs corrected phenology measure)

p=0.0517

Early-flowering plants in early-flowering populations and late flowering plants in late-flowering populations are able to escape predation (and thus have higher fitness)?

I.e. the butterfly preference for early-flowering plants is stronger in later-flowering populations?

(plot coefficient phenology🡪n\_eggs from path models vs corrected phenology measure is not significant)

 p = 0,3082

BUT butterfly preference for early-flowering plants is stronger in populations/years that have higher attack rates

(plot coefficient phenology🡪n\_eggs from path models vs proportion of plants attacked per population/year)

 p = 0,0019

Why is the direct effect of phenology on fitness negative in populations with the predator?

(plot coefficient phenology🡪n\_intact\_fruits from path models vs corrected phenology measure)

 p = 0,0324

Referee suggestion: Very early-flowering populations could escape butterfly attack, but still experience selection against early flowering due to temporal mismatch with pollinators, poor seasonal climate, etc.

BUT the graph shows the opposite! –Early-flowering populations show selection FOR early flowering.