**Higher Order Epistasis Networks Tables and Figures**

**Table 1 Simulation results when the truth obeys strong heredity**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **T1\_tpr** | **T1\_tnr** | **T1\_fpr** | **T1\_fnr** | **T2\_tpr** | **T2\_tnr** | **T2\_fpr** | **T2\_fnr** | **T3\_tpr** | **T3\_tnr** | **T3\_fpr** | **T3\_fnr** | **Train\_MSE** | **Train\_Rsq** | **Test\_MSE** | **Test\_Rsq** | **RunTime** |
| **forward\_select** | **1.000** | **0.999** | **0.001** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **3.330** | **0.727** | **3.490** | **0.711** | **0.757** |
| **iform\_order\_2\_weak** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **1.128** | **0.907** | **1.252** | **0.895** | **5.896** |
| **iform\_order\_2\_strong** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **1.102** | **0.909** | **1.198** | **0.900** | **1.557** |
| **forward\_select\_2** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **1.086** | **0.910** | **1.198** | **0.900** | **25.481** |
| **forward\_select\_3** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.992** | **0.918** | **1.121** | **0.906** | **471.881** |
| **iform\_order\_3\_weak** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **1.020** | **0.916** | **1.135** | **0.905** | **11.346** |
| **iform\_order\_3\_strong** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.968** | **0.920** | **1.060** | **0.911** | **1.872** |
| **glinternet** | **1.000** | **0.559** | **0.441** | **0.000** | **1.000** | **0.982** | **0.018** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **1.246** | **0.898** | **1.446** | **0.880** | **208.167** |
| **hierNet** | **1.000** | **0.697** | **0.303** | **0.000** | **1.000** | **0.976** | **0.024** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.906** | **0.925** | **1.421** | **0.882** | **27.521** |
| **Oracle** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **0.953** | **0.921** | **1.050** | **0.912** | **NA** |

**Table 2 Simulation results when the truth obeys weak heredity**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **T1\_tpr** | **T1\_tnr** | **T1\_fpr** | **T1\_fnr** | **T2\_tpr** | **T2\_tnr** | **T2\_fpr** | **T2\_fnr** | **T3\_tpr** | **T3\_tnr** | **T3\_fpr** | **T3\_fnr** | **Train\_MSE** | **Train\_Rsq** | **Test\_MSE** | **Test\_Rsq** | **RunTime** |
| **forward\_select** | **1.000** | **0.999** | **0.001** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **3.326** | **0.731** | **3.480** | **0.716** | **4.355** |
| **iform\_order\_2\_weak** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **1.119** | **0.910** | **1.200** | **0.901** | **8.342** |
| **iform\_order\_2\_strong** | **1.000** | **0.992** | **0.008** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **1.580** | **0.872** | **1.707** | **0.859** | **2.952** |
| **forward\_select\_2** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **1.083** | **0.912** | **1.167** | **0.904** | **38.872** |
| **forward\_select\_3** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.979** | **0.921** | **1.089** | **0.910** | **569.983** |
| **iform\_order\_3\_weak** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **1.003** | **0.919** | **1.079** | **0.911** | **13.054** |
| **iform\_order\_3\_strong** | **1.000** | **0.992** | **0.008** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **1.578** | **0.872** | **1.705** | **0.859** | **2.787** |
| **glinternet** | **1.000** | **0.469** | **0.531** | **0.000** | **1.000** | **0.980** | **0.020** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.906** | **0.927** | **1.425** | **0.883** | **29.975** |
| **hierNet** | **1.000** | **0.657** | **0.343** | **0.000** | **1.000** | **0.973** | **0.027** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.856** | **0.931** | **1.412** | **0.884** | **33.302** |
| **Oracle** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **0.940** | **0.924** | **1.034** | **0.915** | **NA** |

**Table 3 Simulation results when the truth is anti-heredity**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **T1\_tpr** | **T1\_tnr** | **T1\_fpr** | **T1\_fnr** | **T2\_tpr** | **T2\_tnr** | **T2\_fpr** | **T2\_fnr** | **T3\_tpr** | **T3\_tnr** | **T3\_fpr** | **T3\_fnr** | **Train\_MSE** | **Train\_Rsq** | **Test\_MSE** | **Test\_Rsq** | **RunTime** |
| **forward\_select** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **3.284** | **0.729** | **3.510** | **0.714** | **1.005** |
| **iform\_order\_2\_weak** | **1.000** | **0.996** | **0.004** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **3.140** | **0.741** | **3.435** | **0.719** | **7.866** |
| **iform\_order\_2\_strong** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **3.284** | **0.729** | **3.510** | **0.714** | **2.386** |
| **forward\_select\_2** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **1.081** | **0.911** | **1.171** | **0.904** | **29.095** |
| **forward\_select\_3** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.989** | **0.918** | **1.095** | **0.910** | **548.617** |
| **iform\_order\_3\_weak** | **1.000** | **0.997** | **0.003** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **3.155** | **0.739** | **3.448** | **0.719** | **13.216** |
| **iform\_order\_3\_strong** | **1.000** | **1.000** | **0.000** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **3.284** | **0.729** | **3.510** | **0.714** | **2.703** |
| **glinternet** | **1.000** | **0.290** | **0.710** | **0.000** | **1.000** | **0.971** | **0.029** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.844** | **0.931** | **1.578** | **0.871** | **26.564** |
| **hierNet** | **1.000** | **0.142** | **0.858** | **0.000** | **1.000** | **0.915** | **0.085** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.307** | **0.975** | **2.216** | **0.819** | **3.417** |
| **Oracle** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **0.952** | **0.921** | **1.031** | **0.915** | **NA** |

**Table 4 Simulation results when the truth is constructed of pure interactions**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **T1\_tpr** | **T1\_tnr** | **T1\_fpr** | **T1\_fnr** | **T2\_tpr** | **T2\_tnr** | **T2\_fpr** | **T2\_fnr** | **T3\_tpr** | **T3\_tnr** | **T3\_fpr** | **T3\_fnr** | **Train\_MSE** | **Train\_Rsq** | **Test\_MSE** | **Test\_Rsq** | **RunTime** |
| **forward\_select** | **NaN** | **0.980** | **0.020** | **NaN** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **3.316** | **0.025** | **3.445** | **-0.039** | **1.177** |
| **iform\_order\_2\_weak** | **NaN** | **0.972** | **0.028** | **NaN** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **3.007** | **0.115** | **3.181** | **0.040** | **5.840** |
| **iform\_order\_2\_strong** | **NaN** | **0.979** | **0.021** | **NaN** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **3.294** | **0.031** | **3.429** | **-0.034** | **2.081** |
| **forward\_select\_2** | **NaN** | **1.000** | **0.000** | **NaN** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **1.117** | **0.669** | **1.170** | **0.644** | **26.396** |
| **forward\_select\_3** | **NaN** | **1.000** | **0.000** | **NaN** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **1.005** | **0.703** | **1.081** | **0.671** | **530.362** |
| **iform\_order\_3\_weak** | **NaN** | **0.975** | **0.025** | **NaN** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **3.043** | **0.106** | **3.209** | **0.032** | **9.461** |
| **iform\_order\_3\_strong** | **NaN** | **0.979** | **0.021** | **NaN** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.000** | **1.000** | **3.294** | **0.031** | **3.429** | **-0.034** | **2.265** |
| **glinternet** | **NaN** | **0.429** | **0.571** | **NaN** | **1.000** | **0.983** | **0.017** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **1.002** | **0.699** | **1.445** | **0.561** | **145.078** |
| **hierNet** | **NaN** | **0.147** | **0.853** | **NaN** | **1.000** | **0.955** | **0.045** | **0.000** | **0.000** | **1.000** | **0.000** | **1.000** | **0.672** | **0.802** | **1.758** | **0.467** | **4.491** |
| **Oracle** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **0.968** | **0.713** | **1.022** | **0.689** | **NA** |

**Table 5 The detection of epistasis for the relative growth rate (*r*) of shoot length in the full-sib family of mei tree by a low-order epistatic model**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Coefficient | Estimate | SE | T-value | P-value |
| (Intercept) | 0.18285 | 0.07613 | 2.402 | 0.0174 \* |
| AATTC\_nn\_np\_2517\_a | 0.40013 | 0.06509 | 6.147 | 5.13e-09 \*\*\* |
| AATTC\_nn\_np\_2815\_a | 0.15792 | 0.06837 | 2.310 | 0.0221 \* |
| CATG\_nn\_np\_3479\_a | 0.23433 | 0.05285 | 4.434 | 1.63e-05 \*\*\* |
| CATG\_nn\_np\_1284\_a | 0.22200 | 0.05313 | 4.179 | 4.61e-05 \*\*\* |
| AATTC\_nn\_np\_2815\_a×AATTC\_lm\_ll\_3034\_a | 0.45783 | 0.09244 | 4.953 | 1.71e-06 \*\*\* |

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

Residual standard error: 0.3504 on 176 degrees of freedom

Multiple R-squared: 0.3428, Adjusted R-squared: 0.3241

F-statistic: 18.36 on 5 and 176 DF, p-value: 1.189e-14

**Table The detection of epistasis for the relative growth rate (*r*) of shoot length in the full-sib family of mei tree by a high-order epistatic model**

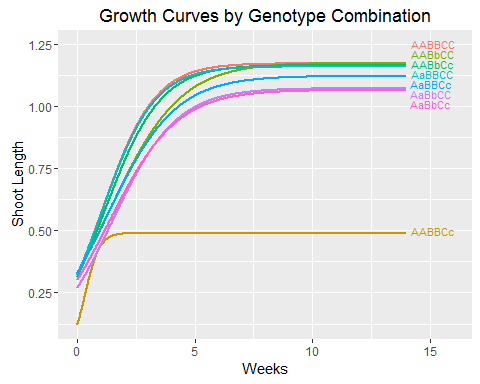
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Coefficient | Estimate | SE | T-value | P-value |
| (Intercept) | 0.16859 | 0.05801 | 2.906 | 0.00415 \*\* |
| AATTC\_nn\_np\_2517\_a | 0.27773 | 0.04396 | 6.318 | 2.27e-09 \*\*\* |
| AATTC\_nn\_np\_2815\_a | 0.26382 | 0.05295 | 4.983 | 1.54e-06 \*\*\* |
| CATG\_nn\_np\_3479\_a | 0.20767 | 0.03467 | 5.990 | 1.23e-08 \*\*\* |
| CATG\_nn\_np\_1284\_a | 0.04522 | 0.04265 | 1.060 | 0.29055 |
| AATTC\_nn\_np\_2815\_a×AATTC\_lm\_ll\_3034\_a | 1.82572 | 0.17925 | 10.185 | < 2e-16 \*\*\* |
| AATTC\_nn\_np\_2815\_a×AATTC\_hk\_hk\_278\_a | 0.25935 | 0.03888 | 6.671 | 3.48e-10 \*\*\* |
| CATG\_lm\_ll\_3153\_a | 0.14877 | 0.03491 | 4.262 | 3.36e-05 \*\*\* |
| CATG\_nn\_np\_1284\_a×AATTC\_nn\_np\_554\_a | 0.22994 | 0.05104 | 4.505 | 1.23e-05 \*\*\* |
| AATTC\_nn\_np\_2815\_a.AATTC\_lm\_ll\_3034\_a×AATTC\_nn\_np\_1615\_a | -1.51714 | 0.19060 | -7.960 | 2.39e-13 \*\*\* |
| AATTC\_nn\_np\_2815\_a×AATTC\_nn\_np\_929\_a | -0.30805 | 0.05477 | -5.624 | 7.57e-08 \*\*\* |
| AATTC\_hk\_hk\_479\_d | 0.16044 | 0.03443 | 4.660 | 6.37e-06 \*\*\* |
| AATTC\_nn\_np\_2517\_a×CATG\_hk\_hk\_648\_a | 0.14537 | 0.02840 | 5.118 | 8.33e-07 \*\*\* |

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

Residual standard error: 0.2268 on 169 degrees of freedom

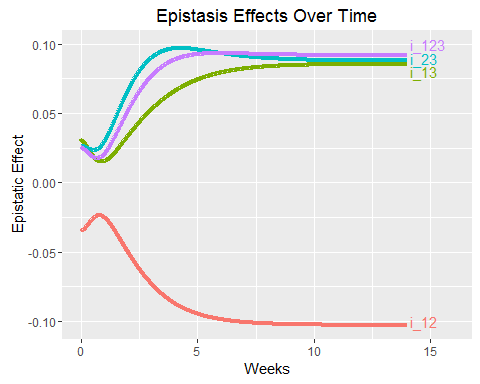
Multiple R-squared: 0.7356, Adjusted R-squared: 0.7168

F-statistic: 39.19 on 12 and 169 DF, p-value: < 2.2e-16



**Figure 1 Growth curves of shoot length in mei drawn from estimated growth**

**parameters at three loci of significant high-order epistasis**



**Figure 2 Curves of epistatic effects on shoot length growth in mei at three**

**significant loci**