**SUPPLEMENTARY MATERIAL**

**Natural and sexual selection on cuticular hydrocarbons: A quantitative genetic analysis**

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**Supplementary Table 1.** Univariate animal model results for attractiveness, desiccation-resistance, the seven most abundant cuticular hydrocarbon (CHC) compounds and the predicted CHC profile attractiveness (Att-CHCβ) and desiccation resistance (Des-CHCβ) for the Australian field cricket, *Teleogryllus oceanicus*.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Trait | Mean | N | VA | VR | VP | CVA | CVR | CVP | IA | h2 | VA *P* | Mat *P* |
| Attractiveness | 0.523 | 736 | 0.014 (0.010) | 0.236 (0.015) | 0.250 (0.013) | 0.229 (0.080) | 0.928 (0.029) | 0.956 (0.025) | 0.052 (0.037) | 0.057 (0.040) | **0.025** | ~1 |
| Desiccation resistance | 0.544 | 669 | 0.041 (0.017) | 0.209 (0.017) | 0.250 (0.014) | 0.370 (0.077) | 0.841 (0.034) | 0.918 (0.026) | 0.137 (0.057) | 0.162 (0.064) | **<0.001** | 0.279 |
| 4-MeC30 | 0.485 | 256 | 0.005 (0.002) | 0.007 (0.002) | 0.012 (0.001) | 0.148 (0.028) | 0.172 (0.019) | 0.227 (0.011) | 0.022 (0.008) | 0.424 (0.142) | **<0.001** | ~1 |
| C31:1 | 0.58 | 256 | 0.019 (0.006) | 0.011 (0.004) | 0.030 (0.003) | 0.237 (0.035) | 0.178 (0.032) | 0.296 (0.015) | 0.056 (0.017) | 0.639 (0.147) | **<0.001** | ~1 |
| C31:2 | 0.997 | 256 | 0.061 (0.021) | 0.062 (0.016) | 0.122 (0.012) | 0.247 (0.042) | 0.249 (0.031) | 0.351 (0.017) | 0.061 (0.021) | 0.495 (0.141) | **<0.001** | ~1 |
| 4-MeC33 | 0.293 | 256 | 0.001 (0.001) | 0.002 (0.000) | 0.003 (0.000) | 0.128 (0.025) | 0.153 (0.017) | 0.199 (0.010) | 0.016 (0.006) | 0.411 (0.143) | **<0.001** | 0.414 |
| C33:1 | 0.463 | 256 | 0.004 (0.002) | 0.008 (0.002) | 0.013 (0.001) | 0.139 (0.031) | 0.198 (0.019) | 0.242 (0.011) | 0.019 (0.009) | 0.332 (0.136) | **<0.001** | 0.325 |
| C33:2 | 0.821 | 256 | 0.026 (0.009) | 0.021 (0.006) | 0.047 (0.005) | 0.196 (0.032) | 0.175 (0.026) | 0.263 (0.013) | 0.039 (0.013) | 0.556 (0.148) | **<0.001** | 0.487 |
| C33:2 | 2.029 | 256 | 0.097 (0.035) | 0.113 (0.027) | 0.210 (0.021) | 0.153 (0.028) | 0.166 (0.020) | 0.226 (0.011) | 0.023 (0.009) | 0.461 (0.143) | **<0.001** | ~1 |
| Att-CHC | 0 | 256 | 0.071 (0.018) | 0.008 (0.011) | 0.079 (0.009) | - | - | - | - | 0.895 (0.145) | **<0.001** | 0.348 |
| Des-CHC | 0 | 256 | 0.018 (0.005) | 0.008 (0.003) | 0.026 (0.003) | - | - | - | - | 0.687 (0.148) | **<0.001** | 0.468 |

Supplementary Table 1 includes estimates of additive genetic variance (VA), residual variance (VR), total phenotypic variance (VP), coefficients of variation for each variance component (CV), a measure of evolvability (IA) and heritability (h2). Inference for significant additive genetic (VA *P*) and maternal (Mat *P*) effects were derived from log-likelihood ratio tests assuming a chi-square distribution with a mixture of zero and one degrees of freedom [1]. A *P*-value of ~1 indicates that the relevant random effect was estimated to be on the boundary of the parameter space. Standard errors are presented in parentheses. Heritability was calculated as VA / VP, with VP calculated as VA + VR. Following Garcia-Gonzalez, Simmons [2] we calculated the coefficients of variation without the 100 multiplier as √VA/R/P / X̅. IA was calculated as VA / X̅2 [3, 4]. Approximate standard errors for the coefficients of variation and IA were calculated following equations six and nine of Garcia-Gonzalez, Simmons [2] respectively. Coefficients of variation and IA were not calculated for Att-CHCβ and Des-CHCβ as these both have means of zero. Note that the h2 estimates for the binary traits Attractiveness and Desiccation resistance were calculated on the observed scale, converting these to the liability scale following Dempster and Lerner [5] results in h2 estimates of 0.090 for Attractiveness and 0.256 for Desiccation resistance. The CHC compounds correspond to those labelled Peaks 5, 9, 12, 14, 17, 21 and 22 in Thomas and Simmons [6].

**Supplementary Table 2.** Character state genotype by environment (GxE) results for the seven most abundant CHC compounds of the Australian field cricket *Teleogryllus oceanicus* measured on individuals that were either exposed to both a female and desiccating environment or neither of these. The body of the table includes estimates of the genetic correlations (rG) between each CHC compound measured in the two environments treated as separate traits. rG *P* shows the *P* values for tests against the model where the rG is constrained to zero. GxE *P* shows the *P* values for tests against a model where the rG is constrained to approximately one (0.99).

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| --- | --- | --- | --- |
| **Trait** | **rG** | **rG *P*** | **GxE *P*** |
| 4-MeC30 | 0.797 (0.164) | **<0.001** | 0.217 |
| C31:1 | 0.790 (0.145) | **<0.001** | 0.128 |
| C31:2 | 0.803 (0.173) | **<0.001** | 0.221 |
| 4-MeC33 | 0.884 (0.155) | **<0.001** | 0.478 |
| C33:1 | 0.872 (0.155) | **<0.001** | 0.406 |
| C33:2 | 0.578 (0.234) | **0.036** | 0.093 |
| C33:2 | 0.715 (0.212) | **0.006** | 0.148 |

**Supplementary Table 3.** Genetic correlations between attractiveness, desiccation resistance, Att-CHC and Des-CHC as estimated using weighted regressions of sire family means. Genetic correlations are given in the lower triangle and their associated *P* values are given in the upper triangle. Standard errors are given in parentheses.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Attractiveness | Desiccation resistance | Att-CHC | Des-CHC |
| Attractiveness |  | 0.758 | **0.028** | **0.006** |
| Desiccation resistance | 0.054 (0.164) |  | 0.752 | **0.040** |
| Att-CHC | **0.453 (0.181)** | 0.058 (0.171) |  | **<0.001** |
| Des-CHC | **-0.478 (0.168)** | **0.324 (0.149)** | **-0.692 (0.072)** |  |

**Supplementary Table 4.** Genetic correlations between each of the cuticular hydrocarbon (CHC) compounds with the measures of attractiveness and desiccation resistance as estimated using weighted regressions of sire family means. Standard errors are given in parentheses.

|  |  |  |
| --- | --- | --- |
|   | Attractiveness | Desiccation resistance |
|   | **rG** | *P* | **rG** | *P* |
| 4-MeC30 | 0.077 (0.198) | 0.706 | 0.053 (0.172) | 0.736 |
| C31:1 | 0.174 (0.174) | 0.332 | -0.157 (0.150) | 0.344 |
| C31:2 | 0.190 (0.188) | 0.330 | -0.034 (0.168) | 0.896 |
| 4-MeC33 | -0.464 (0.173) | **0.020** | 0.219 (0.178) | 0.194 |
| C33:1 | -0.456 (0.154) | **0.008** | 0.265 (0.173) | 0.150 |
| C33:2 | -0.232 (0.163) | 0.150 | 0.371 (0.165) | **0.032** |
| C33:2 | -0.399 (0.124) | **0.006** | -0.058 (0.215) | 0.802 |

**References**

[1] Self, S.G. & Liang, K.Y. 1987 Asymptotic properties of maximum likelihood estimators and likelihood ratio tests under nonstandard conditions. *Journal of the American Statistical Association* **82**, 605-610. (doi:10.2307/2289471).

[2] Garcia-Gonzalez, F., Simmons, L.W., Tomkins, J.L., Kotiaho, J.S. & Evans, J.P. 2012 Comparing evolvabilities: Common errors surrounding the calculation and use of coefficients of additive genetic variation. *Evolution* **66**, 2341-2349. (doi:10.1111/j.1558-5646.2011.01565.x).

[3] Houle, D. 1992 Comparing evolvability and variability of quantitative traits. *Genetics* **130**, 195-204.

[4] Hansen, T.F., Pélabon, C. & Houle, D. 2011 Heritability is not evolvability. *Evol. Biol.* **38**, 258. (doi:10.1007/s11692-011-9127-6).

[5] Dempster, E.R. & Lerner, I.M. 1950 Heritability of threshold characters. *Genetics* **35**, 212-236.

[6] Thomas, M.L. & Simmons, L.W. 2008 Sexual dimorphism in cuticular hydrocarbons of the Australian field cricket *Teleogryllus oceanicus* (Orthoptera: Gryllidae). *J. Insect Physiol.* **54**, 1081-1089. (doi:10.1016/j.jinsphys.2008.04.012).