Genotype by Social Environmental Interaction for Male Aggressive Behavior in Drosophila melanogaster

Palle Jensen 1,2, Bryna Gaertner 3,4, Kirsty Ward 3,4 and Trudy F. C. Mackay 3,4

1 Centre for Quantitative Genetics and Genomics, Department of Molecular Biology and Genetics 2 Section for Genetics, Ecology and Evolution, Department of Bioscience, Aarhus University (DK) 3 Department of Biological Sciences and Program in Genetics. 4 W. M. Keck Center for Behavioral Biology, North Carolina State University (USA)

INTRODUCTION

Aggressive behavior in animals plays an important role in acquisition and defense of resources, and in establishing dominance hierarchies among social animals. In humans, elevated aggressive behavior is associated with some psychiatric and neurodegenerative disorders. Thus it is of great importance to obtain knowledge of the genetic architecture underlying aggressive behavior. Social deprivation is known to increase different aspects of aggression in humans and other mammals, and is also observed in invertebrates. Aggressive behavior is a quantitative trait, with variation in natural populations due to segregating variation at many interacting loci, environmental variation, and variation in the extent to which different genotypes respond to the same environmental perturbation (genotype by environmental interaction, GEI), for example, changes in the social environment.

OBJECTIVE To evaluate genetic variation in aggressive behavior and GEI for aggression under different social environments in Drosophila melanogaster.

METHODS

AGGRESSION ASSAY We used a subset of the Drosophila melanogaster Genetic Reference Panel (DGRP, 87 lines), a population of 205 inbred lines with complete genome sequences. We developed an assay to facilitate high-throughput acquisition of aggression data on pairs of individuals (Flydiator arenas, figure 1A). Up to twenty-four 1-3 day old males from each experimental condition (reared in social groups, or isolated) were placed into Flydiator arenas with access to food. In each sub-arena a Canton SB male (CSB, control) was added, but separated from the DGRP fly by a removable barrier. The following morning flies were starved for 90 minutes. Two minutes before starting the assay, a drop of food was introduced to each of the pairs. The barrier between the two flies was removed and two minute video recordings were obtained. Subsequently, aggressive encounters were manually scored for the DGRP and the CSB individuals in the two social environments.

STATISTICAL ANALYSIS I To approximate a Gaussian distribution data were square root transformed. Using a linear mixed model approach and parametric bootstrapping we evaluated the effect of the difference between the two rearing conditions, the random DGRP line effect, and the interaction between the two. From the variance components the overall broad sense heritability (H2) was estimated. The genotype by social environmental interaction (GxE) was evaluated as the covariance between the two social environments scaled by the product of the standard deviation of the genotype variance components from the two environments.

STATISTICAL ANALYSIS II Line-specific differences in aggressive behavior between rearing conditions were used in a genome wide association study (GWAS), using linear regression models (figure 1C).

RESULTS

Figure 3 Genotype by social environmental interaction. Line mean aggression in the two social environments (isolated males vs. social males).

Table 1 Model summary from the mixed model analysis, the overall heritability (H2) and the correlation coefficient between genotype and environment (rGxEd).

CONCLUSION We found substantial genetic variation in aggressive behavior in the DGRP for both social environments, and further showed that the same genotypes do not respond equally to the different environments, i.e., there is genotype by social environmental interaction.

Using the difference in aggressive behavior we found evidence for association for 30 genes. Two genes (TrpA1 and Syn) have previously been associated with aspects of aggressive behavior. Interestingly, several of the associated Drosophila genes have human orthologs related to different psychiatric disorders.