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Psychology

Genes coordinating selfishness and altruism between parents and offspring

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The social bond between parent and offspring balances selfishness and altruism. We investigated how genes control these behaviors in European earwigs, and found 1600 genes associated with parenting, and two genes coordinating selfishness and altruism. Our results suggest that internal reward and communication, encoded by these genes, help maintain parent-offspring interactions.

Forficula auricularia adult male
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Parental care is an altruistic behavior broadly observed in nature. Altruistic parents provide their offspring with food and protection. These are costly behavior for parents, that are beneficial for the offspring's development and survival. However, parents can also be selfish. Selfish parents are interested in producing more offspring while minimizing the cost of caring for them. The offspring are also not passive recipient of parental care. They actively demand care and influence their parents' behavior and future reproduction. Selfish offspring prefer to boost their own chances of survival at the cost of their parents' needs. Instead of optimizing the performance of one or the other, natural selection favors a compromise between them. The balance between selfishness and altruism between parents and offspring is called parent-offspring coadaptation.

Like any evolutionary adaptation, parent-offspring coadaptation is coded in the genetic material. However, the way genes coordinate selfish and altruistic behaviors is poorly understood. In order to identify genes that might be involved, we looked for genes that affect the interaction between parent and offspring. Of these, a gene with selfish function should be beneficial to self and potentially harmful to the other, and a gene with altruistic function should be beneficial to the other and costly to self.

In this study, we focused on the European earwig, an insect exhibiting maternal care. Earwig mothers produce one or two clutches during their lifetime and they can communicate with their offspring via chemical signals. They groom their eggs to reduce fungus infection and increase hatching success. The hatched could survive independently, but often the mother would feed the nymphs herself.

To test how social interaction effected gene expression, we physically separate earwig mothers and their hatched nymphs and compare them to normally interacting parent-offspring pairs. This produced a list of over 1600 genes associated with parenting in general. Among these, only two earwig genes altered their expression level in both mothers and their nymphs during their social interaction, and qualified as our strongest candidates potentially regulating parent-offspring coadaptation.

We then asked how these two genes influence animal behaviors. To answer this, we specifically suppressed each of these genes during parent-offspring interaction in earwigs. We then followed up on any changes in their subsequent social behavior to identify those that are caused by the of the specific gene.

The first gene of interest is *Th*. It is involved in the synthesis of dopamine, a molecule that makes one feel rewarded and motivated. We found that *Th* expression was increased in both mothers and nymphs during their interactions, suggesting an increase in the feeling of internal reward. We further showed that higher *Th* expression in mothers directly enhanced their feeding of their young. Its expression in the nymphs indirectly raised their mother's likelihood to have a second clutch. It is likely that nymphs with high *Th* expression were less demanding, and caring for them took less effort by the mother, that was then able to have additional offspring. Therefore, the gene *Th* promotes reciprocally altruistic behavior between mothers and offspring.

Our results suggest that parents and offspring may spend time together simply because it brings them joy and happiness. Interestingly, this dopamine-related internal reward system may have retained its function from insects to human in the context of parent-offspring interactions. Researchers have already shown a connection between dopamine receptor genes and behavioral interactions between parent and their young in monkeys and humans. This link may be encoded in our ancestral genes, from insects to primates.

The second gene we found is *PebIII*, which is involved in the sense of smell and possibly in chemical signaling between individuals. We showed *PebIII* expression resulted in mothers whose second clutch was larger, and the development of their offspring was slower. In offspring, higher *PebIII* expression increased their own survival. In both cases, individuals benefited from higher expression of *PebIII*. Therefore, the gene *PebIII* promotes reciprocally selfish behavior between mothers and offspring.

Well-coordinated cooperation between parent and offspring not only involves close attachment potentially via the dopamine reward system, but also requires good communication reflecting individual needs from both parent and their young. *PebIII* evolved to allow better communication in species with more complex social lifestyle. our results from earwig mothers suggest that this was achieved through hormonal regulation.

In conclusion, we found over 1600 gene associated with parenting, and two genes coordinating selfishness and altruism. Our results show that internal reward and good communication help maintain the social bond between parent and

offspring. These things we learn from the earwigs could stay true as the key to our own family and social life as human.