Peer Community In
Evolutionary Biology

Taking advantage of facultative sociality in sweat bees to study the developmental plasticity of antennal sense organs and its association with social phenotype

Nadia Aubin-Horth based on reviews by Michael D Greenfield, Sylvia Anton and Lluís Socias-Martínez

A recommendation of:

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Sensory plasticity in a socially plastic bee

Rebecca A Boulton, Jeremy Field *(2022), bioRxiv, 2022.01.29.478030, ver. 4 peer-reviewed and recommended by Peer Community in Evolutionary Biology*
https://doi.org/10.1101/2022.01.29.478030

Data used for results
http://hdl.handle.net/11667/197

Scripts used to obtain or analyze results
http://hdl.handle.net/11667/197

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Recommendation

The study of the evolution of sociality is closely associated with the study of the evolution of sensory systems. Indeed, group life and sociality necessitate that individuals recognize each other and detect outsiders, as seen in eusocial insects such as Hymenoptera. While we know that antennal sense organs that are involved in olfactory perception are found in greater densities in social species of that group compared to solitary hymenopterans, whether this among-species correlation represents the consequence of social evolution leading to sensory evolution, or the opposite, is still questioned. Knowing more about how sociality and sensory abilities covary within a species would help us understand the evolutionary sequence. Studying a species that shows social plasticity, that is facultatively social, would further allow disentangling the cause and consequence of social evolution and sensory systems and the implication of plasticity in the process.

Boulton and Field (2022) studied a species of sweat bee that shows social plasticity, *Halictus rubicundus*. They studied populations at different latitudes in Great

Britain: populations in the North are solitary, while populations in the south often show sociality, as they face a longer and warmer growing season, leading to the opportunity for two generations in a single year, a pre-condition for the presence of workers provisioning for the (second) brood. Using scanning electron microscope imaging, the authors compared the density of antennal sensilla types in these different populations (north, mid-latitude, south) to test for an association between sociality and olfactory perception capacities. They counted three distinct types of antennal sensilla: olfactory plates, olfactory hairs, and thermos/hygro-receptive pores, used to detect humidity, temperature and CO2. In addition, they took advantage of facultative sociality in this species by transplanting individuals from a northern population (solitary) to a southern location (where conditions favour sociality), to study how social plasticity is reflected (or not) in the density of antennal sensilla types. They tested the prediction that olfactory sensilla density is also developmentally plastic in this species.

Their results show that antennal sensilla counts differ between the 3 studied regions (north, mid-latitude, south), but not as predicted. Individuals in the southern population were not significantly different from the mid-latitude and northern ones in their count of olfactory plates and they had less, not more, thermos/hygro receptors than mid-latitude and northern individuals. Furthermore, mid-latitude individuals had more olfactory hairs than the ones from the northern population and did not differ from southern ones. The prediction was that the individuals expressing sociality would have the highest count of these olfactory hairs. This unpredicted pattern based on the latitude of sampling sites may be due to the effect of temperature during development, which was higher in the mid-latitude site than in the southern one. It could also be the result of a genotype-by-environment interaction, where the mid-latitude population has a different developmental response to temperature compared to the other populations, a difference that is genetically determined (a different "reaction norm"). Reciprocal transplant experiments coupled with temperature measurements directly on site would provide interesting information to help further dissect this intriguing pattern.

Interestingly, where a sweat bee developed had a significant effect on their antennal sensilla counts: individuals originating from the North that developed in the south after transplantation had significantly more olfactory hairs on their antenna than individuals from the same Northern population that developed in the North. This is in accordance with the prediction that the characteristics of sensory organs can also be plastic. However, there was no difference in antennal characteristics depending on whether these transplanted bees became solitary or expressed the social phenotype (foundress or worker). This result further supports the hypothesis that temperature affects development in this species and that these sensory characteristics are also plastic, although independently of sociality. Overall, the work of Boulton and Field underscores the importance of including phenotypic plasticity in the study of the evolution of social behaviour and provides a robust and fruitful model system to explore this further.

References

Boulton RA, Field J (2022) Sensory plasticity in a socially plastic bee. bioRxiv, 2022.01.29.478030, ver. 4 peer-reviewed and recommended by Peer Community in Evolutionary Biology. https://doi.org/10.1101/2022.01.29.478030

Reviews

Toggle reviews

Evaluation round #1

DOI or URL of the preprint: ***https://doi.org/10.1101/2022.01.29.478030***

Version of the preprint: 2

Author's Reply, None

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Decision by Nadia Aubin-Horth, 13 Apr 2022

Dear authors,

Thank you for submitting your preprint "Sensory plasticity in a socially plastic bee " to PCI Evol Biol. We are sorry for the delays, but fortunately your manuscript has now been read by three reviewers and by myself. You will find the reviewer's comments attached.

As you will see, the reviews are largely positive, and, based on these three reviews as well as my own evaluation, I would recommend your manuscript to be included in PCI Evol Biol. However, before reaching a final decision, I would ask you to revise your manuscript according to the recommendations by the reviewers. Please address the main issues underscored by the reviewers and use their more minor comments to improve the manuscript for a wide readership when warranted. If you do not agree with a comment, please explain why in your reply.

Main issues:

-The north – south characterisation of the study sites could be presented using thermal records instead of latitude, since temperature is not entirely related to latitude in these sites. Adding to the reviewers' comments, I would say that this is important since developmental plasticity is the main driver here and your discussion focuses on this.

-Explain why there were no reciprocal transplant from south to north early in the methods and how it affects your test of predictions.

-Please address the questions concerning statistical analyses: 1) what constitute a sample: is it an individual within a site or does each site represent a n=1. There are already mentions in the ms that only one individual per nest was taken, and this type of information could be made clearer to the reader to answer the concern by one of the reviewers. 2) are there random effects in the mixed models and model fitting.

-Please specify what happened to the remaining individuals transplanted in nature.

-The wording to define the different treatments and phenotypes could be revised to be quickly understandable by a non-specialist (comment about "origin" versus "development" and comment about the different types of bees studied (B1 with year, etc)

Reviewed by Michael D Greenfield, 04 Apr 2022

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Reviewed by Sylvia Anton, 23 Mar 2022

The manuscript by Boulton and Field reports on a nice study of the plasticity of antennal morphology in a sweat bee. It shows the influence of environmental factors on the density/numbers of different classes of antennal sensilla, but does not reveal a correlation between sensilla density/numbers and degree of sociality or the social phenotype of an individual bee. The insect model is well-chosen, the experimental design is adequate and sophisticated statistical data analysis is used (but I am not competent to judge the statistical analyses). The manuscript is very well written and the authors discuss their data honestly and draw highly sound conclusions. Not being familiar with the biology of the insect, I very much appreciated figure 1 illustrating the different life cycles. However resolution of the figure is low in the pdf, but I guess a high resolution figure will be provided.

One slight shortcoming of the manuscript is the choice of geographical situations for the different types of experiments: geographical bee transplanting experiments to the south were not done to the same geographical zone as in the comparison of bees from different latitudes. Data of the two experimental series can thus not be directly compared. Nevertheless, the authors very honestly discuss these limits of their study. They also propose very interesting perspectives for future studies to clarify the points that they were not able to elucidate here.

I only have a minor recommendation concerning the use of the term “origin” :

Line 344 : the term ‘origin in this sentence is confusing, because you use “origin” for the place they were collected to start with. So rather use here “development site”

In table 2 legend “origin of emergence” is clearer than in the sentence above, but still “development site” as used in the table itself would be more precise

Reviewed by Lluís Socias-Martínez, 11 Apr 2022

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