RESPONSES OF SOLITARY BEES TO FIRE: A TRAIT-BASED APPROACH

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Bees (Hymenoptera: Apidae s.l.), the most prominent pollinator group, are facing a worldwide decline due to a series of anthropogenic disturbances (Biesmeijer *et al*., 2006; Potts *et al*., 2010). In Mediterranean-type ecosystems, fire is among the most important disturbances, affecting the abundance and structure of post-fire solitary bee communities. As an immediate effect, bee diversity decreases due to direct mortality by fire, the limited food resources and the limited dispersal ability of the most bees. During the first post-fire years, bee diversity increases, as floral diversity coverage peaks, and decreases during later post-fire years (Petanidou & Ellis, 1996; Potts *et al*., 2003).

Species functional traits reflect species behavior, physiology and morphology and consequently shape species responses to changing environmental conditions (McGill *et al*., 2006). Therefore, traits can be used to predict bee community responses to disturbance and hence to determine appropriate management practices (Williams *et al*., 2010).

The aim of our study was to explore the effect of fire on the taxonomic and functional composition of solitary bees across a sequence of pine post-fire regeneration in Rhodes Island, Greece. Specifically, we aimed to answer two research questions: Are there significant taxonomical differences across sites of different fire history? Do and how functional traits mediate bee responses to fire?

The study region is situated in south-central Rhodes, Greece. Over, the last 50 years, major fires (in 1984, 1987, 1988, 1989, 1992 and 2008) have resulted in a mosaic of different-aged scrub and mature pine forests (*Pinus brutia*). We selected 28 sites assigned to four fire regimes according to their fire history (post-fire age and fire frequency): (i) Unburnt, (ii) Old burnt, (iii) Twice burnt and (iv) Recently burnt.

Bees were captured using UV-bright pan traps, identified to species and assigned to groups according to body size, nesting preference and trophic specialization. To detect differences among fire regimes in terms of abundance and species richness we used permutational one-way ANOVA. To explore how species traits can mediate solitary bee responses to fire we used a fourth corner analysis at assemblage level, which associates species traits with environmental variables through species abundance to identify the relationship between traits and environmental parameters (Legendre *et al*., 1997; Brown *et al*. 2014).

A total of 1707 bees were recorded with 100 species represented; 30 of the family Apidae, 24 of Andrenidae, 24 of Megachilidae, 21 of Halictidae, and one of Colletidae. We did not detect significant differences in mean abundance and mean richness across fire regimes either at community or at family level.

From a functional point of view, the fourth corner model revealed significant associations between bee traits and fire history. There was a significant positive association between ground nesting bees and recently burnt sites and a significant negative association with old burnt sites. Bees with variable nesting preference were positively associated with old burnt sites and negatively associated with unburnt sites. The cleptoparasitic bees demonstrated a significantly positive association with twice burnt sites and negative association with old burnt sites. Regarding trophic specialization, polylectic bees were positively related to twice burnt sites and negatively related to old burnt sites. Finally, large bees showed significantly positive association with old burnt and unburnt sites and negative with the twice and recently burnt sites.

The lack of significant differences in abundance and species richness of bees by fire regime could be at least partly due to the fact that the most recent fire occurred four years before sampling, which means we missed the first post-fire years. During the first post-fire years, bee diversity peaks due to the dominance of annual plants providing diverse and abundant flower resources (Petanidou & Ellis 1996; Potts *et al*. 2003).

The functional traits, however, provided valuable insights into the bee community responses to fire history. The negative association between ground nesting bees and post-fire age is possibly due to lower availability of bare ground in old burnt sites (Potts *et al*. 2005; Williams *et al*. 2010). This may also explain the positive association between bees with variable nesting preferences and old burnt sites and the negative association with unburnt sites. During the first post-fire years there is a wide array of available resources which favor generalist species like polylectic bees. Finally, taking into account bee body size, our data showed that smaller bees, which require fewer but diverse floral resources (Potts *et al*. 2004; Potts *et al*. 2006), are favored in first post-fire years where a burst of flower resources is observed.

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REFERENCES

1. Biesmeijer, J. C., Roberts, S. P. M., Reemer, M., Ohlemüller, R., Edwards, M., Peeters, T., *et al*. (2006). Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. Science, 313(5785), 351–354.
2. Brown, A. M., Warton, D. I., Andrew, N. R., Binns, M., Cassis, G., & Gibb, H. (2014). The fourth-corner solution-using predictive models to understand how species traits interact with the environment. Methods in Ecology and Evolution, 5(4), 344–352.
3. Legendre, P., Galzin, R., & Harmelin–Vivien, M. L. (1997). Relating behavior to habitat: solutions to the fourth–corner problem. Ecology, 78(2), 547–562.
4. McGill, B. J., Enquist, B. J., Weiher, E., &Westoby, M. (2006). Rebuilding community ecology from functional traits. Trends in ecology & evolution, 21(4), 178–185.
5. Petanidou, T., & Ellis, W. N. (1996). Interdependence of native bee faunas and floras in changing Mediterranean communities. The Conservation of Bees (eds Matheson, A., Buchmann, S.L., O'Toole, C., Westrich, P. & Williams, I.H). Academic Press, London, pp. 201–226.
6. Potts, S. G., Vulliamy, B., Dafni, A., Ne'eman, G., O'Toole, C., Roberts, S., & Willmer, P. (2003). Response of plant-pollinator communities to fire: changes in diversity, abundance and floral reward structure. Oikos, 101(1), 103–112.
7. Potts, S. G., Vulliamy, B., Roberts, S., O'Toole, C., Dafni, A., Ne'eman, G., & Willmer, P. G. (2004). Nectar resource diversity organises flower-visitor community structure. Entomologia experimentalis et applicata, 113(2), 103-107.

8. Potts, S. G., Vulliamy, B., Roberts, S., O'Toole, C., Dafni, A., Ne'eman, G., & Willmer, P. (2005). Role of nesting resources in organising diverse bee communities in a Mediterranean landscape. Ecological Entomology, 30(1), 78–85.
9. Potts, S. G., Petanidou, T., Roberts, S., O'Toole, C., Hulbert, A., & Willmer, P. (2006). Plant-pollinator biodiversity and pollination services in a complex Mediterranean landscape. Biological conservation, 129(4), 519-529.
10. Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W. E. (2010). Global pollinator declines: trends, impacts and drivers. Trends in ecology & evolution, 25(6), 345–353.
11. Williams, N. M., Crone, E. E., Minckley, R. L., Packer, L., & Potts, S. G. (2010). Ecological and life–history traits predict bee species responses to environmental disturbances. Biological Conservation, 143(10), 2280–2.