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Editorial: Nutritional ecology of wild and managed bees

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Editorial on the Research Topic
Nutritional ecology of wild and managed bees

Bees are crucial for crop production. While honey bees are often viewed as the primary pollinator workhorse, recent studies suggest that wild bees may play a more significant role than managed bees in pollinating wild plants and crops (Garibaldi et al., 2013; Garibaldi et al., 2014). Conserving wild and managed bee stocks is therefore essential for sustaining agroecosystems, particularly under projected climate change. Pollination by bees is a direct consequence of their foraging behaviour, which is intricately tied to both feeding patterns and nutritional needs. Nutritional ecology explores the intricate relationships between bees and their diet. It investigates how bees acquire, process and utilize nutrients from their environment, and how nutritional factors influence the physiology, ecology and evolution of bees and their interaction with plants and the environment. This field encompasses a broad range of topics, including nutrient uptake mechanism, utilization, and the ecological and evolutionary implications of food availability and quality.

Different bees have distinct feeding behaviours. Honey bee foragers gather bee-pollen, which is transformed into bee bread and used to nourish young adult bees including nurse bees (Ghosh and Jung, 2022). This process involves the addition of glandular secretions, honey mixing, and microbial activity. Nurse bees feed different jellies to the larvae destined to different castes (Wang et al., 2016). In contrast, most solitary bees feed pollen directly to their larvae (Austin and Gilbert, 2021). Therefore, the quality of pollen determines the overall quality of larval food and well-being of both wild solitary bees and domesticated bees. All bees utilize nectar (carbohydrate source) and pollen (source for protein, essential amino acids, fatty acids, sterols, and micro-nutrients) but their foraging behaviours vary widely. Our understanding of the nutritional requirements of bees, especially solitary wild bees, is limited. This Research Topic aims to present new research to enhance our understanding of the diverse aspects of the nutritional ecology of both managed and wild bees.

Different plant species can affect the nutrition of domesticated bees, including honey bees, bumblebees, and solitary bees like *Osmia* spp. These bees have specific preferences for the ratio of macronutrients in pollen. Bumblebees, for example, tend to prefere a pollen protein-to-lipid (P:L) ranging from 5:1 to 10: 1 in controlled laboratory conditions.In the field, *Bombus impatiens* preferred the ratio 4:1 (Vaudo et al., 2016a; Vaudo et al., 2016b; Vaudo et al., 2018). Honey bee preferred P:L ratios between 1:1 to 2:1, which indicates that they use of different sources of pollen than those collected by bumblebees (Vaudo et al., 2020). Contrary to

bumblebee and honey bees, the solitary bee *Osmia cornifrons* forage with a short flying period. Some studies on the pollen preference of *Osmia cornifrons* suggest a close affinity to flowers belonging to families Rosaceae (1.6 ± 0.3 P:L) and Fabacea (3.8 ± 0.5 P:L) (Haider et al., 2014; Nagamitsu et al., 2017; Vaudo et al., 2020).

In the field of nutritional ecology of bees, identifying pollen is crucial. Methods like microscopy or DNA sequencing are used. DNA sequencing, particularly next-generation sequencing, is the most reliable method. This Research Topic featured an article by Prudnikow et al., which provides an advanced, portable nanopore sequencing platform that utilizes long-read sequences, and enhances reliability than previous methods.

Pang et al. investigated the effect of apricot, pear, and rapeseed pollen on honey bee larvae. They measured survival rates, prepupal weight, pollen digestibility, and midgut cells of the honey bee larvae. The study's results revealed that rapeseed pollen benefited growth and development in honey bee larvae the most.

In the Research Topic, Noor-ul-Ane and Jung investigated the impact of proline, glutamic acid sugar polyol on honey bee (*Apis mellifera*) brood development in a laboratory condition. The findings showed that proline supplementation accelerated the growth of honey bee larvae and pupae, while glutamic acid only reduced the developmental time in pupae. Additionally, a low concentration (1%) of sorbitol improved larval survival, but a higher concentration (8%) resulted in reduced body weight in pupae and adults.

Non-nutritive chemical signals play a vital role in bee's selection of pollen and nectar. Bees rely on their olfactory system for foraging activities, and odorant receptors (ORs) are essential for recognizing and interpreting chemical cues. Guo et al. uncovered a mechanism in an article featured in this Research Topic, which suggest that the activity of calmodulin affects the functions of the odorant receptors AcerOr2 in *Apis cerana cerana*. This insight enhances our understanding of the molecular mechanisms driving honey bee foraging behaviour.

Nutritional stress contributes to declining bee populations, along with habitat loss, increasing pathogen load, competition with invasive species, etc. Feed supplements are beneficial for managed bees, particularly during nectar and pollen scarcity (Ghosh and Jung, 2020). Research on microalgae as feed supplements is emerging. This Research Topic features an article by Jang et al. that examines the impact of incorporating microalgae (*Chlorella*) into the diet of honey bees (*Apis mellifera*) on their physiology. The study shows that adding 2% *Chlorella* as a supplement to pollen patties significantly improves food consumption, longevity, gland development, muscle formation, and vitellogenin gene expression compared to a diet of only pollen or sugar-based diet.

Excessive use of synthetic pesticides harms bee populations (Ghosh et al., 2022), disrupting physiology and gut symbionts. One article in the Research Topic, authored by Li et al., demonstrated that pesticide exposure affects expression of various heat shock proteins, causing elevated oxidative stress and reduced antioxidative capacity in *Apis cerana cerana*. Another study by Zhang et al. featured in the Research Topic uncovered the gut bacterial communities of two subspecies of *Vespa velutina*.

This Research Topic on the *Nutritional Ecology of Wild and Managed Bees* has shed light on the recent scientific endeavours to gain better understanding of the subject. It offers valuable insights into the bee nutrition, including feed supplements, molecular mechanisms associated with bee nutrition and physiology, gut symbionts, and advancement in pollen identification. These findings are significant for academics, beekeepers, farmers, and policymakers, supporting bees' access to essential nutrients and habitats. Recognizing the importance of nutrition in the well-being of bees can lead to collaborative efforts to protect their health, which is vital for pollination and sustainable food production.

Author contributions

SG prepared the Editorial manuscript and revised it with the help of YW. CJ supervised and reviewed the whole process. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Austin, A. J., and Gilbert, J. D. J. (2021). Solitary bee larvae prioritize carbohydrate over protein in parentally provided pollen. *Funct. Ecol.* 35, 1069–1080. doi: 10.1111/1365-2435.13746

Garibaldi, L. A., Carvalheiro, L. G., Leonhardt, S. D., Aizen, M. A., Blaauw, B. R., Isaacs, R., et al. (2014). From research to action: enhancing crop yield through wild pollinators. *Front. Ecol. Environ.* 12, 439–447. doi: 10.1890/130330

Garibaldi, L. A., Steffan-Dewenter, I., Winfree, R., Aizen, M. A., Bommarco, R., Cunningham, S. A., et al. (2013). Wild pollinators enhance fruit set of crops regardless of honey bee abundance. *Science* 339, 1608–1611. doi: 10.1126/science.1230200

Ghosh, S., Begna, T., Kafle, L., and Jung, C. (2022). "Risk of neonicotinoids on pollinators," in *Risk assessment of neonicotinoids in the Asia-pacific region*. (Seoul, Korea: The Association of Academics and Societies of Sciences in Asia (AASSA), The Interacademy Partnership (IAP)).

Ghosh, S., and Jung, C. (2020). Changes in nutritional composition from bee pollen to pollen patty used in bumblebee rearing. *J. Asia-Pac. Entomol.* 23, 701–708. doi: 10.1016/j.aspen.2020.04.008

Ghosh, S., and Jung, C. (2022). Temporal changes of nutrient composition from pollen patty to bee bread with special emphasis on amino and fatty acids composition. *J. Asia-Pac. Entomol.* 25, 101873. doi: 10.1016/j.aspen.2022.101873

Haider, M., Dorn, S., Sedivy, C., and Müller, A. (2014). A phylogeny and floral hosts of a predominantly pollen generalist group of mason bees (Megachilidae: osmiini). *Biol. J. Linn. Soc* 111, 78–91. doi: 10.1111/bij.12186

Nagamitsu, T., Suzuki, M. F., Mine, S., Taki, H., Shuri, K., Kikuchi, S., et al. (2017). Effects of forest loss and fragmentation on pollen diets and provision mass of the mason bee, *Osmia cornifrons*, in central Japan. *Ecol. Entomol.* 43, 245–254. doi: 10.1111/een.12494

Vaudo, A. D., Farrell, L. M., Patch, H. M., Grozinger, C. M., and Tooker, J. F. (2018). Consistent pollen nutritional intake drives bumble bee (*Bombus impatiens*) colony growth and reproduction across different habitats. *Ecol. Evol.* 8, 5765–5776. doi: 10.1002/ece3.4115

Vaudo, A. D., Patch, H. M., Mortensen, D. A., Tooker, J. F., and Grozinger, C. M. (2016a). Macronutrient ratios in pollen shape bumble bee (*Bombus impatiens*) foraging strategies and floral preferences. *Proc. Nat. Acad. Sci. U.S.A.* 113, E4035–E4042. doi: 10.1073/pnas.1606101113

Vaudo, A. D., Stabler, D., Patch, H. M., Tooker, J. F., Grozinger, C. M., and Wright, G. A. (2016b). Bumble bees regulate their intake of essential protein and lipid macronutrients. *J. Exp. Biol.* 219, 3962–3970. doi: 10.1242/jeb.140772

Vaudo, A. D., Tooker, J. F., Patch, H. M., Biddinger, D. J., Coccia, M., Crone, M. K., et al. (2020). Pollen protein: lipid macronutrient ratios may guide broad patterns of bee species floral preferences. *Insects* 11, 132. doi: 10.3390/insects11020132

Wang, Y., Ma, L., Zhang, W., Cui, X., Wang, H., and Xu, B. (2016). Comparison of the nutrient composition of royal jelly and worker jelly of honey bees (*Apis mellifera*). *Apidologie* 47, 48–56. doi: 10.1007/s13592-015-0374-x