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Experimental Entomology in the Age of Video

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Abstract

ARTICLES DISCUSSED:

Smodiš Škerl, M. I. Histology basics and cell death detection in honeybee tissue. *Journal of Visualized Experiments*. (185), e64141 (2022).

Fine, J. D., Torres, K. M., Martin, J., Robinson, G. E. Assessing agrochemical risk to mated honey bee queens. *Journal of Visualized Experiments*. (169), e62316 (2022).

Topitzhofer, E., Lucas, H., Carlson, E., Chakrabarti, P., Sagili, R. Collection and identification of pollen from honey bee colonies. *Journal of Visualized Experiments*. (167), e62064 (2022).

Nogueira, B. R., de Oliveira, A. A., Silva, D., Pereira da Silva, J., Bueno, O. C. Collection and long-term maintenance of leaf-cutting ants (*Atta*) in laboratory conditions. *Journal of Visualized Experiments*. (186), e64154 (2022).

Discussion

Entomology, the science of insects, has developed over thousands of years of human–insect interactions. As insects exist across essentially all terrestrial surfaces and play various critical ecological roles, theoretical and applied entomology are central research domains for the 21st century and beyond.

Recent technological developments, including international accessibility to transparent video creation, are transforming social processes of education, research, and governance. This editorial summarizes the protocols associated with modern entomology and aims to communicate recent methodological developments in entomology in order to facilitate their adoption.

In “Collection and long-term maintenance of leaf-cutting ants (*Atta*) in laboratory conditions”, Nogueira et al. review the life history of *Atta* leaf-cutting ants and present a protocol for obtaining, maintaining, and studying colonies in laboratory settings[1]. The methods described begin with obtaining either a mated queen or a young colony. Various details are then provided on nest architecture and a dietary regime that support healthy and observable *Atta* colonies.

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The expertise involved in developing this method is the product of more than three decades of fine-tuning, and the method is highly scalable for research and education purposes. Ants constitute a successful and diverse global clade, and leaf-cutting ants specifically embody a fascinating and elaborate mycological lifestyle. Hence, improved methods for studying the development and behavior of leaf-cutting ants have implications for fields such as eusocial physiology and collective behavior studies, as well as science communication.

In "Collection and identification of pollen from honey-bee colonies", Topitzhofer et al. describe a method for the efficient processing of pollen brought back by honey bee (*Apis mellifera*) foraging nestmates[2]. In the presented method, bulk pollen is collected from returning foragers as they squeeze through a metal mesh, which displaces grains of pollen from their pollen basket. The collected pollen pellets are initially sorted by color, and they can then be chemically processed and analyzed with a microscope to determine which species the pollen is from.

Importantly, the pipeline uses the passive collection of pollen with an installed mesh (as opposed to manual collection from single bees) and low-cost visual methods of pollen identification (as opposed to electron microscopy or metabarcoding). Honey bees forage for pollen from plants, acquiring vital nutrition for themselves while also performing important services for human economic, agricultural, and social-cultural systems. Therefore, improved methods for the assessment of honey bee health and foraging productivity would be of interest to those involved in food production, regional planning, and the modeling of natural capital.

In "Histology basics and cell death detection in honeybee tissue", Smodiš Škerl describes methods for isolating honey bee tissues and evaluating them for different patterns of cell turnover and death[3]. The protocol describes a method for dissecting and analyzing two tissues important for digestion and environment interfacing: the hypopharyngeal glands (HPG) and the midgut. Patterns of cell death can be estimated from the dissected tissues, allowing for the assessment of the tissue-specific effects of sub-lethal chemical exposures.

Understanding the developmental bases of physiological, behavioral, and ecological traits often requires tissue-specific analyses. However, dissecting out specific tissues can be a time-intensive enterprise requiring specific skills and expertise. Smodiš Škerl's manuscript provides a valuable road map for researchers conducting work on the midgut and/or the HPG of honeybees. The presented methods will facilitate otherwise uncommon histological analyses in honey bees and, thus, are relevant for those studying the tissue-specific basis of development, aging, and evolution in insects.

In "Assessing agrochemical risk to mated honey bee queens", Fine et al. describe a method to study how honey bee workers treated with agrochemicals provision their queen and, thus, influence colony fecundity[4]. The protocol begins with the assembly of a special enclosure for queen observation in the context of a known number of nestmate workers fed a known dose of nutrients and agrochemicals (in the case of the study, imidacloprid). Egg production, embryo viability, food consumption, and worker mortality can then be tracked and related to agrochemical treatments.

The methods serve to bridge a divide between field and laboratory methods and contribute to essential discussions regarding global agricultural and apicultural practices. Contemporary farming practices often rely upon the application of agrochemicals with complex dose-dependent effects on arthropod health, but the complexity of honeybee

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hives can hinder efforts to precisely measure these effects. This manuscript provides an elegant solution to help understand the “real-world” entomological impacts of agricultural practices.

The articles described above highlight various scientific methods that can be used to study the morphology, physiology, and behavior of ants and bees. The study of eusocial insects *in vivo* has long been complicated by difficulties in the laboratory and field in terms of the direct manipulation and observation of nestmates, the long generation time of many species, and challenges in scaling up experiments to the colony level. Two methods here[1,4] address these challenges with different approaches. Specifically, in Fine et al.[4], the authors report a method for directly assessing the impact of single chemicals on the fecundity of queens (and, thus, colonies). Additionally, Nogueira et al.[1] present a large-scale system for rearing and observing multiple leaf-cutter ant colonies. Both these methods have broad applicability to entomologists and agriculturalists.

More broadly, the video presentation of methods may increase the adoptability, proficiency, and reproducibility of methods developed by researchers globally. This type of methodological entomology can be seen within the context and history of visuality[5,6], tacit knowledge[7], and community participation[8] in entomology.

Future work could develop along several dimensions. The scope of species could expand beyond ants and bees to include other insects and non-insects. Ecological databases could be leveraged to highlight niches and species where methods might be fruitfully applied. Entomology education and research could explore emerging technologies such as augmented reality, interspecies communication, robotics, and cognitive modeling of insect-based cyberphysical systems. More effective methods and improved empirical data will be useful for studies applying the techniques of complexity science (e.g., agent-based modeling, stigmergy, multi-scale systems analysis) to insects and beyond.

Disclosures

The authors have nothing to disclose.

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