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Editorial: Adaptation of Invasive Species to Islands and the Puerto Rican Honey Bee

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Editorial on the Research Topic

Adaptation of Invasive Species to Islands and the Puerto Rican Honey Bee

Honey bees critically impact global food security as pollinators in agricultural systems worldwide (Aizen and Harder, 2009; Potts et al., 2016). They are also considered one of the most successful invasive organisms, having been transported by humans to all continents except for the Arctic and the Antarctic. However, along with other insects, they are increasingly under threat by anthropogenic activities (Wagner et al., 2021). We explored the adaptation of honey bees introduced by humans to the Americas.

Africanized honey bees (AHB) are the product of human introduction of *Apis mellifera scutellata* bees from Africa to the Americas in 1956. These African bees later hybridized with European honey bees previously brought to the Americas and resulted in the hybrid AHB, infamous for their high defensive behavior and serious economic and ecological impact (reviewed in Guzman-Novoa et al.). The adaptation of AHB to the island of Puerto Rico, such as the reduced defensive behavior, provides insight into changes that can occur to invasive organisms and the invaded ecosystem after colonization (Rivera-Marchand et al., 2012; Avalos et al., 2017). An advantage of research focused on island populations is that adaptive processes on islands are accelerated and may readily show similar patterns across species. Examples of adaptations on islands include the breakdown of the usually observed mutualism between *Cecropia* trees and *Azteca* ants and the reduced aggression of *Solenopsis geminata* on Puerto Rico (Rivera-Marchand et al., 2012 and references therein). Thus, data from island populations can be particularly useful to develop and test models of invasion biology.

This collection of research articles was inspired by the "Puerto Rico Honey Bees and Evolution of Invasive Organisms on Islands" conference, held in July 2019, in person, in Puerto Rico (PRHB, 2019). The focus of the conference was the Puerto Rico Gentle Africanized honey bee and other non-native organisms, through the lens of invasion biology and island biogeography. This Frontiers Research Topic broadens the scope of the conference presentations by including new organisms, data, and perspectives, in the post-pandemic world. Several articles were completed and submitted before the pandemic, and some produced under pandemic conditions, resulting in a collection of papers with publication dates in 2020 and 2021.

This Frontiers Research Topic highlights the study of island invasion biology from the perspective of different disciplines and approaches, including genomics, morphology, behavior, ecology, and long-term data analyses. The result of this interdisciplinary approach is an

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In Memoriam:
This paper is dedicated to the memory of Prof. Modesto Matias (1951–2022).

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examination of: 1. The invasive species on the island of Puerto Rico; 2. Ancestral populations of the invasives; 3. Adaptations of invasives and characteristics of Puerto Rico honey bees.

THE INVASIVE SPECIES ON THE ISLAND OF PUERTO RICO

Three articles examine invasive species in Puerto Rico. Zimmerman et al. review invasive species of Puerto Rico in general, based on long-term research in El Yunque National Forest. Next Ackerman reviews the positive and negative impacts of honey bees on other bees and plants in Puerto Rico and the Caribbean. The negative and positive effects of invasives in Puerto Rico are explored by Cabrera-Asencio and Meléndez-Ackerman using mango cultivars and their honey bee pollinator.

Zimmerman et al. using data from the El Yunque National Forest, conclude that the invasives they examined were able to establish in Puerto Rico independent of disturbance of habitat. An exception to their findings were vascular plants, determined to be less likely to invade minimally disturbed forest habitat. The presence of honey bees as well as other invertebrates, was not influenced by level of disturbance.

The impact of the successful invasive honey bee on islands is reviewed by Ackerman. This review, with its presentation of positive and negative effects, highlights the need for future research on the impact of invasive bees on islands. Honey bees, when present, add to the resilience of pollination networks, as in the case of a key rainforest resource, the Sierra Palm (*Prestoea montana*). However, the effectiveness of honey bees as pollinators may also have negative results by facilitating the establishment of undesirable invasive plants.

The influence of honey bee pollination on invasive plants can be illustrated using the introduced mango cultivar in Puerto Rico. Honey bee pollination was not considered important to the productivity of this agricultural commodity. However, the work of Cabrera-Asencio and Meléndez-Ackerman, demonstrated a 90% decrease in honey bee visits to mango flowers after Hurricane María, a finding concomitant to a 60–70% decrease in fruit production.

ANCESTRAL POPULATIONS OF INVASIVES

The ancestral populations that gave rise to the Puerto Rico honey bee include the highly mixed European and Africanized honey bees from the Americas (Acevedo-Gonzalez et al., 2019). Guzman-Novoa et al. outlines the process and outcomes of the Africanization in Mexico while Bianchi et al. demonstrate the potential variation in a continental population that include phenotypes and genotypes like those found in the Puerto Rico population. Furthermore, this admixture variation can be compared with patterns exhibited by locally adapted populations of honey bees in their native range, as discussed by Kükrer et al. for honey bees in Turkey.

POTENTIAL "PRE-ADAPTATIONS"

Puerto Rico has two prominent social insect invaders, fire ants and honey bees (Torres and Gaud, 1998). Ortiz-Alvarado and Rivera-Marchand, discuss the unique behavioral plasticity of fire ant queens in Puerto Rico. In this species, in Puerto Rico, unlike in any other described ant species, queens demonstrate worker behaviors in response to colony demographic changes. The flexibility of this characteristic can function as a pre-adaptation that may contribute to a successful invasion.

Honey bee, physiological, morphological, and behavioral traits may contribute to their success across the world and in Puerto Rico. Smith et al. explore the morphological characteristics of honey bee mandibles that enable them to bite and inflict damage to their parasitic mites *Varroa destructor*. The biting behavior and associated resistance of Africanized (Guzman-Novoa et al.) and Puerto Rico honey bees (Rivera-Marchand et al., 2012) to *V. destructor* are now well-established characteristics. In this issue, Russo et al. also discuss this topic with reference to honey bees from Argentina. The morphological basis that underpins the *V. destructor* resistance has only recently begun to be explored.

Temperature and seasonal effects on physiology and behavior are usually thought of as important for honey bees in temperate zones. However, these aspects may become relevant under the novel contexts honey bees encounter in island environments. Saleem et al. explore the role of temperature in altering the toxicity of commonly used neonicotinoid insecticides. Feliciano-Cardona et al. explore the importance of the seasonal production of long-lived bees for colonies with respect to seasonal resource availability, even in the absence of a temperate winter.

An important feature of invasion biology is the ability of invaders to find and mate with conspecifics in the new environment. The work of Galindo-Cardona et al. addresses the risks and benefits of sexual reproduction for honey bees, with respect to finding mates and transmission of disease. Galindo-Cardona et al. show that in their study sites in Argentina, findings obtained from drone congregation areas reflect the health status of colonies present in the same study areas.

This Frontiers Research Topic is a testament to the rich research base that honey bees provide and can lead to interdisciplinary and integrated examinations of invasion biology of this one species. The knowledge regarding the impact and adaptations of introduced populations may also answer practical concerns such as the movement of bees for apiculture and agriculture. In fact, the conference helped to catalyze the formation of a technical working group to study risks and benefits of honey bee movement in the example of one country, i.e. the United States. (Marcelino et al.). The example of honey bee invasive biology can also lead to significant and novel research and applications for other biological invasions on islands.

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RG, AG-C, EM-A, S-CC, and TG contributed to the conception and design of the special issue. All authors contributed to the editorial writing and revision, read and approved the submitted version.

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