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Spread and distribution of the naturalized orchid bee *Euglossa dilemma* in Florida

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The orchid bee, *Euglossa dilemma* Bembè and Eltz (as *E. viridissima* Friese) (Hymenoptera: Apidae), was first documented in Broward County, Florida, in 2003. Males were captured in fruit fly traps (Skov & Wiley 2005), and a female was observed collecting pollen from a *Begonia* cultivar (Begoniaceae) (Pemberton & Wheeler 2006). This Mesoamerican bee has been found to pollinate and promote invasive plants (Pemberton & Liu 2008; Liu & Pemberton 2009), and to visit and likely pollinate numerous native and ornamental plants (Pemberton & Wheeler 2006; Pemberton 2007). Eltz et al. (2011) determined that *E. viridissima* in Florida was a novel cryptic sibling species, also from Mesoamerica, which they named *E. dilemma*.

Hinojosa-Díaz et al. (2009) employed the Maxent model (Phillips et al. 2004) using collection localities from the native range of *E. viridissima* in Mexico and Central America to predict its potential range in Florida. Pascarella (2017) trapped the bee along the coast at Flamingo in the Everglades National Park (Monroe County), communicated Discover Life records for Collier and Lee counties, and indicated that the species had effectively colonized its potential range in Florida as predicted by Hinojosa-Díaz et al. (2009), shown as the gray area in Figure 1. The objective of this study was to assemble collection records and observations of *E. dilemma* to document its spread and current distribution.

Two data sources were used to obtain locality information and collection and observation dates. First were the 142 collection and identification records for *E. dilemma* (including *E. viridissima*) made by the entomologists of the Florida State Collection of Arthropods in Gainesville. These identifications were made primarily of bees captured in various fruit fly traps in the large cooperative US Department of Agriculture, Animal and Plant Inspection Service at the Florida Department of Agriculture and Consumer Services program in Gainesville, Florida, to detect potential invasions of pest fruit flies that could threaten Florida's agriculture. This effort utilizes about 55,000 traps in Florida and deployed similar numbers in the past 20 yr (P. Skelley and C. Welsh, personal communication). In addition, identifications were made of bees submitted by Florida Department of Agriculture and Consumer Services agricultural inspectors and other interested parties including the public. The locality data were street addresses that were converted to latitude and longitude, and then to GIS points for mapping. The second source of data was 514 iNaturalist observations made of *E. dilemma* in Florida. These iNaturalist observations consist of photographs of *E. dilemma* posted on this citizen scientist organization's website (https://www.inaturalist.org). Each observation includes the latitude and longitude of the location where the photograph was taken. The accuracy of iNaturalist identifications of *E. dilemma* was easy to validate because the bee's size, coloration, and form make it a distinctive and unique bee in Florida, even when depicted in suboptimal photographs. The iNaturalist locality data were converted to GIS points for mapping, and the maps were created using ArcMap (ESRI Company, Redlands, California, USA). The time related spread is based on Florida State Collection of Arthropods records from Jun 2003 (the first record) to Mar 2022, and iNaturalist observations from Jun 2015 (the first observation recorded) to Mar 2022.

The current distribution of *E. dilemma* as of 18 Mar 2022 is shown on the map in Figure 1. The Florida State Collection of Arthropods records are shown in red and the iNaturalist observations in blue. All data points are mapped on Figure 1 except for an iNaturalist observation in Tallahassee, which probably represents a transient occurrence of the bee. The shaded gray area is predicted potential range using the Maxent model (Hinojosa-Díaz et al. 2009). The bee now occurs from the northeastern part of its Florida range in Seminole County (just south of 29°N latitude) to the Florida Keys (24.5°N) in the south. Its most northwestern occurrence is in Pinellas County (about 28°N) in the Tampa Bay area of Florida. *Euglossa dilemma* has been detected in all of the interior counties between these coastal locations except for Desoto County east of Sarasota, Florida, and now occurs in between half and two-thirds of the Florida peninsula.

The spread of the *E. dilemma* since its first detection in Broward County in 2003 is shown in Figure 2. The 5 maps represent 5 yr intervals after the initial 2003 to 2007 spread. The county names appear on the first map representing the time period when *E. dilemma* was collected or observed in those counties. By 2007, the bee had spread from Broward County to the adjacent Palm Beach County to the north, and to the adjacent Miami-Dade County to the south. By 2012, the bee spread north to Martin County, then leaped to the southwest coast to Collier and Lee counties and up to central Florida in Orange County. By 2017, the bee had spread to 6 additional counties including Brevard County on the east coast of central Florida, to Manatee County on the west coast in the Ft. Myers area, and to Glades County east of Ft. Myers in the interior. Finally, by 2022, *E. dilemma* was found to occur in 12 additional counties, reaching the northernmost part of its present distribution in Seminole County north of Orlando, and was detected in all of the counties along the east coast up to Brevard County, and all those on the west coast up to and including the Tampa Bay counties of Pinellas and Hillsborough, as well as all of the interior counties between the occupied coastal counties. In the 20 yr since the bee was first detected, it has spread to 22 counties in Florida.

The predicted potential range of *E. dilemma* in Florida provided by the Maxent model (Hinojosa-Díaz et al. 2009) (the shaded gray area in Fig. 1) is inaccurate. It failed to predict the extensive occurrence of *E. dilemma* on the east coast of central and southern Florida, the inte-

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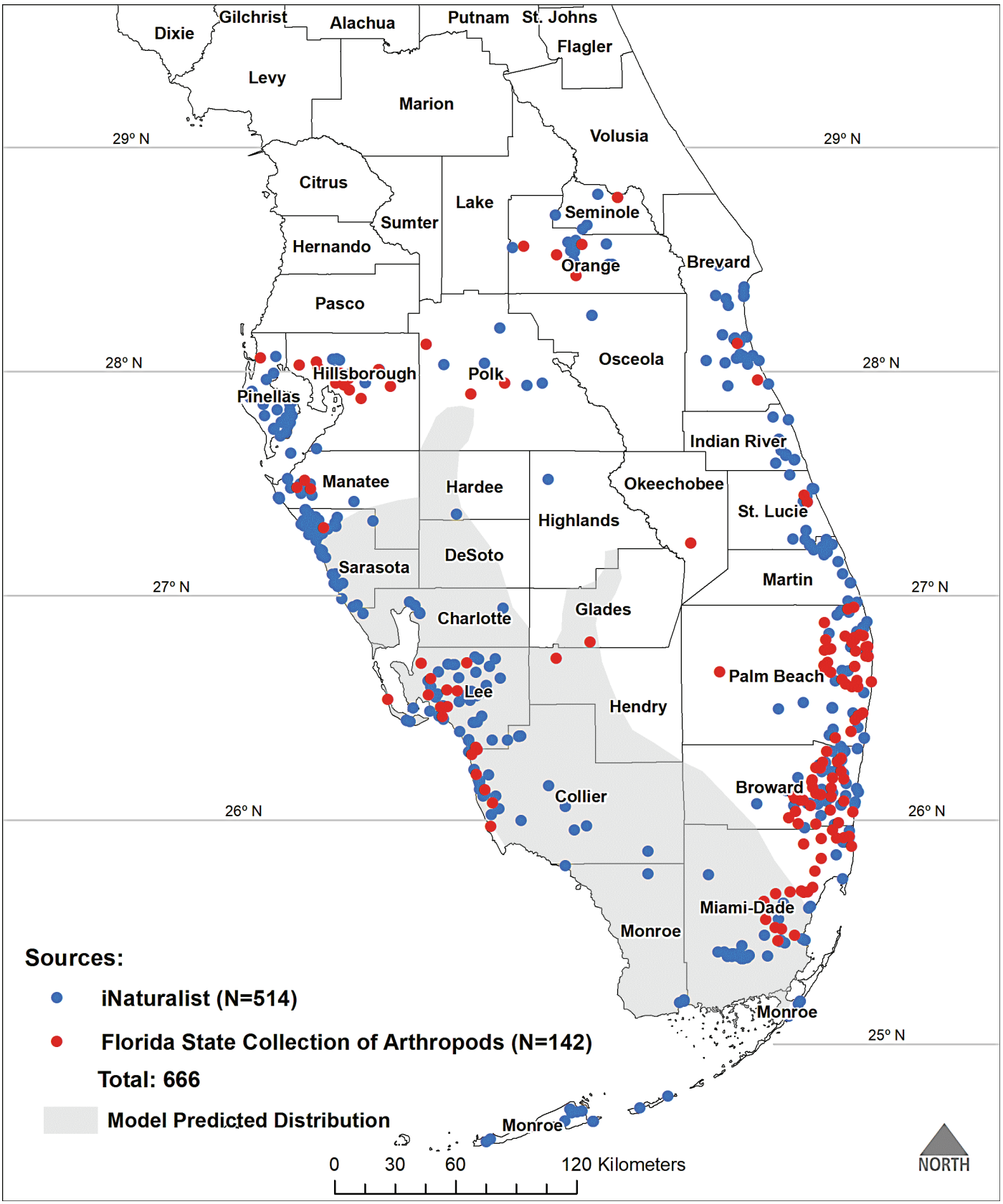

Fig. 1. Current distribution of *Euglossa dilemma* in Florida. Red dots are collection and identification record localities from the Florida State Collection of Arthropods from 2003 to 2022. Blue dots are iNaturalist observations from 2015 to 2022. Gray shading is the predicted potential distribution by the Maxent model (Hinojosa-Díaz et al. 2009).

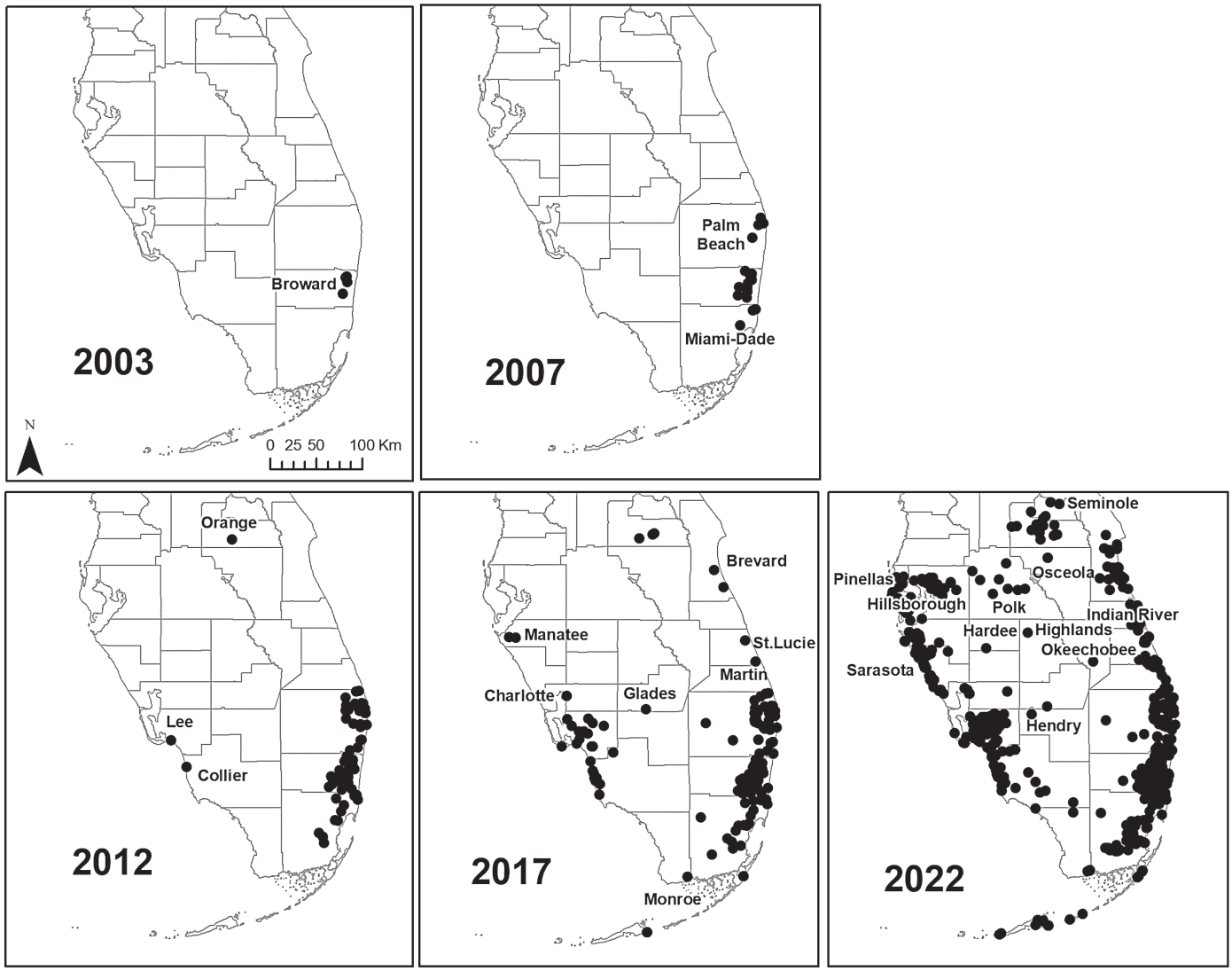

Fig. 2. Spread of *Euglossa dilemma* in Florida from the first detection in Broward County in 2003 to much of central Florida by 2022. County names appear on the map illustrating the first occurrence of the bee in the county during that time period. Locality data are from collection and identification records the Florida State Collection of Arthropods in Gainesville from 2003 to 2022, and iNaturalist observations 2015 to 2022.

rior areas of south and central Florida, and the Tampa Bay region. The model may have failed because the specimen locality data on which it was based was for a mixture of specimen localities for *E. viridissma* and *E. dilemma*, due to the 2 species not being separated when the model was run. According to the rather generalized maps of each bee's native range in Mexico and Central America in Discover Life (https://www.discoverlife.org), the 2 species appear to be broadly sympatric. This suggests that factors other than specimen localities contribute to the model's inaccuracy, but these factors are currently unknown.

The occurrence of the tropical orchid bee in central Florida, which experiences nighttime freezes during most winters, is unexpected. The northern tier of counties in the range of *E. dilemma* are in USDA Hardiness Zone 9B, defined with minimum temperatures ranging from −3.9 to −1.1 °C (25–30 °F). (USDA 2012). Orchid bees are known to be long-distance fliers (Janzen 1971), so its occurrence in this region could be considered to represent visitors that do not overwinter. This is likely the case with the single unmapped iNaturalist observation of *E. dilemma* in Tallahassee, which is in USDA Hardiness Zone 8B (−9.4 to −6.7 °C; 15–20 °F). The numerous specimens collected from central Florida and the many iNaturalist observations of the bee there during all seasons, including 4 iNaturalist observations of active nests near Orlando, in St. Petersburg, and in Brandon east of Tampa, indicate that *E. dilemma* is probably a breeding resident in those areas. The nesting behavior of *E. dilemma* may account for its ability to survive short periods of freezing temperatures. *Eulgossa dilemma* nests in enclosed spaces and closes the entrance hole of the nest each night with resin. During cold periods the nest remains closed. Some orchid bees are known to build their nests in houses (D. Roubik, personal communication). One of the authors (RWP) has observed female *E. dilemma* bees examining holes in the sheltered outer walls of a Ft. Lauderdale house presumably looking for potential nest sites.

There is broad overlap in the occurrence of the bees according to the Florida State Collection of Arthropods records and the iNaturalist observations. Both relate to higher human populations. Most fruit fly traps are placed in high-risk areas for fruit fly introductions such as near transportation hubs and residential areas

(P. Skelley and C. Welsh, personal communication). iNaturalist observation numbers relate directly to the number of observers and human population, which results in fewer observations in sparser populated rural areas. The iNaturalist observations in Everglades National Park, Big Cypress, and other natural areas are noteworthy exceptions and are valuable because few, if any, fruit fly traps are placed in such areas. Orchid bees and other insects in fruit fly traps are known as "bycatch" in the fruit fly program, so are fortuitous. Some fruit fly traps, however, are baited using methyl eugenol as an attractant. This chemical is one of the chemical baits used by orchid bee researchers to detect the occurrence of *E. dilemma* and to estimate its population sizes, due to the compound being a fragrance component of some of the bee's orchid mutualists, which male bees collect to use as their sexual pheromone (Pemberton & Wheeler 2006).

Whereas the data used in this study appear to be a good indicator of the *E. dilemma* spread and current distribution, the densities of locations shown on the maps should not be inferred to indicate bee abundance or changes in bee densities. The number of iNaturalist observers globally doubles every yr (https://en.wikipedia.org/wiki/INaturalist), and the number of observations has increased dramatically in recent yr in Florida. This means that more observations of *E. dilemma* probably indicate more observers and not necessarily more bees, although the bee has spread more widely in recent yr. The number of submitted specimens to Florida State Collection of Arthropods for identification has varied through time, at times declining even during periods of increased spread of the bee. The fruit fly trappers and agricultural inspectors most often submit insect specimens whose identities they wish to know, and then stop submitting specimens of these species after they learn the identity. Some people, however, will submit known species when it appears in a new county, earning themselves a new county record (P. Skelley, personal communication).

It is not known whether *E. dilemma* has reached its northern limit in Florida. The recency of its occurrence in many counties at the northern edge of its distribution suggests that it has not reached its northern limit. The USDA Cold Hardiness Zone 9B extends farther north than the bee's current distribution. *Eulgossa dilemma* was detected in the Dominican Republic on Hispaniola Island in the West Indies in 2020 (Genaro et al. 2020). The potential for the spread of this bee to other islands in the West Indies is great. The accidental movement of a nest in an enclosed object, such as a hollow door or interior of a boat, could have been how the bee was introduced to Florida, and is how it could be spread to other countries. The bee's independence from its orchid mutualists (the mutualism is facultative for the bees) (Pemberton & Wheeler 2006) has allowed it, in part, to establish and spread in Florida and Hispaniola, which have none of its orchid mutualists. The male bees obtain the fragrance compounds needed for their mating from leaves, flowers, and fungi (Pemberton & Wheeler 2006). The bee's great expansion and probable increased abundance in Florida suggest that its role as pollinator of native plants, weeds, and economic plants likewise has increased.

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Summary

The current distribution of *Euglossa dilemma* in Florida and spread from Broward County in 2003 to 23 counties in south and central Florida by 2022, is mapped using 142 specimen collection and identification records from the Florida State Collection of Arthropods, and 514 iNaturalist observations. This nonnative tropical orchid bee now appears to be a breeding resident in central Florida despite periodic, annual nighttime freezes.

Key Words: citizen science; geographic range; iNaturalist; orchid bee; Florida State Collection of Arthropods

Sumario

La distribución actual de *Euglossa dilemma* en Florida, y su propagación desde el condado de Broward en 2003 a 23 condados en el sur y centro de Florida para 2022, se mapea usando 142 registros de recolección y identificación de especímenes de la Colección de Artrópodos del Estado de Florida, y 514 observaciones en iNaturalist. Esta abeja orquídea tropical no nativa es ahora un residente reproductor en el centro de Florida a pesar de las heladas nocturnas anuales periódicas.

Palabras Clave: ciencia ciudadana; distribución geográfica; iNaturalist; abeja orquídea; Florida State Collection of Arthropods

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