EXPLOSIVE RANGE EXPANSION OF EULOPHIA GRAMINEA (ORCHIDACEAE)
IN PUERTO RICO AND THE WEST INDIES

JAMES D. ACKERMAN1–2 & NORMANDIE GONZÁLEZ-ORELLANA1

1Department of Biology, University of Puerto Rico, 17 Avenida Universidad Suite 1701, San Juan, Puerto Rico, 00925-2537, U.S.A.
2Author for correspondence: ackerman.upr@gmail.com

ABSTRACT. Eulophia graminea Lindley (Orchidaceae), a native orchid of tropical and subtropical Asia, was first reported in the Western Hemisphere from populations in Miami, Florida, U.S.A. where it spread rapidly through the southern part of the state. Here we report the first record of this species for Puerto Rico and sightings in the Bahamas and Cuba, reflecting the rapid spread seen in southern Florida (U.S.A).

RESUMEN. Eulophia graminea Lindley (Orchidaceae), una orquídea nativa de Asia tropical y subtropical se informó por primera vez en el hemisferio occidental en poblaciones de Miami, Florida, EE. UU., donde se extendió rápidamente por la parte sur del estado. Aquí informamos el primer registro de esta especie para Puerto Rico y también avistamientos en las Bahamas y Cuba, lo que refleja la rápida propagación observada en sur de Florida (EE. UU.).

KEY WORDS/PALABRAS CLAVE: Caribbean, Caribe, Chinese Crown Orchid, especie invasora, invasive species, range expansion, rango de distribución, Grass-Leaved Eulophia, orchid, Orquídea Corona China

Introduction. Native orchid species do not often exhibit rapid range expansion (e.g., Oncidium polikilostalix (Kraenzl.) M.W.Chase & N.H.Williams, García-González et al. 2013; Microtis media R.Br., Bonnardeaux et al. 2007), but the incidence of non-indigenous orchids invading new regions has become more noticeable (Stern 1988, Ackerman 2007, 2017). Herein we report the continuation of a rapid range expansion by the non-indigenous species Eulophia graminea Lindley (Orchidaceae), a terrestrial orchid commonly known as the Chinese Crown Orchid or Grass-Leaved Eulophia. Eulophia graminea is native to Sri Lanka, India, Nepal, Pakistan, Kashmir, Myanmar, Thailand, Laos, Vietnam, Malaysia, Indonesia, Philippines, northward to subtropical China, Taiwan, and the Ryukyu Islands. Within its native range, it has considerable ecological amplitude growing in open areas, grasslands, beaches, lawns, roadsides, shrubby habitats, and in open forests at elevations from sea level to 1200 m (Pemberton et al. 2008, Ang et al. 2011, Orchid Species 2021).

In the last two decades, E. graminea has become naturalized in Australia, South Africa, and Florida, U.S.A. (Macrae 2002, O’Conner et al. 2006, Pemberton et al. 2008, PIER 2021). In just a few years, reports of E. graminea in southern Florida increased from five populations in Miami-Dade County in 2007 to 67 locations in seven counties in 2010 (Pemberton 2013). The orchid is now known from 18 Florida counties (Wunderlin et al. 2021) and has been discovered in the Bahamas on at least three different islands (Sandy Point, Abaco; near Grand Bahama airport, Grand Bahama; Governor’s Harbour, Eleuthera; Michael Vincent and Ethan Freid, personal communications with JDA 2010, 2014, 2015, photos!), and in at least three provinces in Cuba (Camagüey, Oscar Loyola Hernández, personal communication with JDA 2018, photos! Santa Clara, Quemado de Güines, José Luis Gómez-Hechavarría, iNaturalist.org/photos/118262829!; Pinar del Río, José Lazaro Bocourt, personal communication with JDA 2020, photos!) (Fig.1A).

Eulophia graminea has strong colonizing abilities. In its native range, the grass-like plants occupy similar open, disturbed habitats as do Spathoglottis plicata Blume and Arundina graminifolia (D.Don) Hochr., both of which are also invaders on tropical islands and continental regions (Ackerman 2007, Ang et al. 2011, Kolanowska & Konowalik 2014). In native and
invaded habitats, *E. graminea* can occur in a variety of substrates from beach sands to garden wood-chip mulch, probably exploiting a wide variety of mycorrhizal fungi, including wood decaying fungi. Flowers sometimes self-pollinate and may bloom within one year of sowing *in vitro* (Chang *et al.*, 2010). Pember-ton *et al.* (2008) determined in Florida (U.S.A.), via bagging experiment, that *E. graminea* is indeed at least partially self-compatible. They estimated fruit set as 4.5% and 9.2% in two different populations in

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**Figure 1.** Distribution of *Eulophia graminea* in the Western Hemisphere. **A.** Distribution in Florida and the West Indies. We placed the stars in the center of the counties (Florida), islands (Bahamas), and provinces (Cuba) where *E. graminea* has been reported. **B.** Distribution within Puerto Rico. Placement of stars is based on coordinates of each locality. Maps were created with ggplot2, ggmap, and ggstar in R Studio Team (2021).
Eulophia graminea was first discovered in Puerto Rico in 2018. Adolfo Rodríguez Velázquez, a graduate student at the University of Puerto Rico, Río Piedras, found a single plant in disturbed, secondary vegetation in the limestone region “mogotes” on the northern side of the island. While only one plant was discovered, there may have been more because they are difficult to detect since the leaves are fugacious, withering before the onset of anthesis. Two years later, Dr. Tamara Heartsill Scalley sent JDA photos of this orchid growing in thick Bermuda grass under street trees in the city of San Juan. At this site, we found ten inflorescences, averaging 12 flowers apiece. Half the inflorescences showed no signs of developing fruit. From the remainder, we estimated the average fruit set for the population was 10.6%. Since then, we have discovered a population in the municipalities of Dorado (Dorado Beach Hotel; Steve Maldonado Silvestrini and Christian Torres Santana, personal communications with JDA, 2020); Vega Alta (Sabana, Cerro Gordo, Ritirene observer, iNaturalist; accessed 21 April 2021); Humacao and two populations observed by us in San Juan on campus of the University of Puerto Rico, Río Piedras (Fig. 1B). The march of the species may have been more because they are difficult to detect since the leaves are fugacious, withering before the onset of anthesis. Two years later, Dr. Tamara Heartsill Scalley sent JDA photos of this orchid growing in thick Bermuda grass under street trees in the city of San Juan. At this site, we found ten inflorescences, averaging 12 flowers apiece. Half the inflorescences showed no signs of developing fruit. From the remainder, we estimated the average fruit set for the population was 10.6%. Since then, we have discovered a population in the municipalities of Dorado (Dorado Beach Hotel; Steve Maldonado Silvestrini and Christian Torres Santana, personal communications with JDA, 2020); Vega Alta (Sabana, Cerro Gordo, Ritirene observer, iNaturalist; accessed 21 April 2021); Humacao and two populations observed by us in San Juan on campus of the University of Puerto Rico, Río Piedras (Fig. 1B). The march of the species may become as fast as other naturalized orchids of Puerto Rico: Eulophia maculata (Lindl.) Reichb.f. (synonym: Oeceoclades maculata (Lindl.) Lindl.), Spatiglottis plicata, Dendrobium crumenatum Sw., and Arundina graminifolia (Ackerman 2007, Falcón et al. 2017, Foster & Ackerman 2021).

Should we be concerned that E. graminea is spreading rapidly? While invasive species are usually tagged in a negative fashion (Larson 2005), the spread of some non-indigenous species have little or no negative consequences, sometimes can be beneficial, and effects are often context dependent (Daehler 2003). Concerning orchids, roots of non-indigenous Vanda tricolor Lindl. were seen “nearly smothering” a native host tree (Oppenheimer 2006). Epipactis hel-leborine (L.) Crantz is perhaps the first non-indigenous orchid to invade North America, where it is considered a troublesome weed in lawns and gardens in some urban areas (Squirrell et al. 2001). Donald Dod (1986) reported that E. maculata in the Dominican Republic was an agricultural pest in sugar cane fields requiring heavy farm machinery to eradicate them. Several studies of invasive orchids have focused on whether or not they had negative consequences on native orchids; the results are usually equivocal (e.g., Bonnardeaux et al. 2007, Cohen & Ackerman 2009), but significant negative results can be subtle through various means, including apparent competition (Recart et al. 2013). While E. graminea can form dense monocultures (UF/IFAS 2021), we do not expect the invasion of E. graminea to be ecologically harmful on a large scale. Nevertheless, it is wise to monitor populations just as it would be for any non-indigenous species.

**Vouchers:** Puerto Rico. **Municipality of Arecibo:** Barrio Garrochales, Rd 682, Cambalache State Forest, 18.439461°, -66.598530°, moist limestone forest vegetation, elev. 100 m, Dec 2018, A. Rodríguez Velázquez s.n. (UPRRP). **Municipality of San Juan:** Río Piedras, Urbanization San Francisco, Avenue de Diego near intersection with Calle Verbena, 18.386124°, -66.082531°, elev. 26 m, growing under street trees of Calophyllum antillanum Britton, “Mariana”, in thick untended Bermuda grass (Cynodon dactylon (L.) Crantz is perhaps the first non-indigenous host tree (Oppenheimer 2006). Epipactis hel-leborine (L.) Crantz is perhaps the first non-indigenous orchid to invade North America, where it is considered a troublesome weed in lawns and gardens in some urban areas (Squirrell et al. 2001). Donald Dod (1986) reported that E. maculata in the Dominican Republic was an agricultural pest in sugar cane fields requiring heavy farm machinery to eradicate them. Several studies of invasive orchids have focused on whether or not they had negative consequences on native orchids; the results are usually equivocal (e.g., Bonnardeaux et al. 2007, Cohen & Ackerman 2009), but significant negative results can be subtle through various means, including apparent competition (Recart et al. 2013). While E. graminea can form dense monocultures (UF/IFAS 2021), we do not expect the invasion of E. graminea to be ecologically harmful on a large scale. Nevertheless, it is wise to monitor populations just as it would be for any non-indigenous species.

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DESCRIPTION: The following is a description of *Eulophia graminea* based on material from Puerto Rico (Fig. 2 A–G).

*Plants* terrestrial, to 1 m. *Roots* from base of pseudobulb. *Stems* pseudobulbous, ovoid to globose, sometimes compressed, composed of 3–5 internodes, 2.3–5.0 cm in diameter. *Leaves* 2–6, distichous, enclosing the stem, blades conduplicate, linear, about 10 cm long, 10 mm wide, the first leaves are shorter. *Inflorescences* 1–2, lateral from the side of the pseudobulb, erect, 20–50 cm including peduncle; *peduncle* green to purple, glaucous, partially covered by 4–5 sheathing bracts; *raceme* few to many flowered, larger inflorescences sometimes sparsely branched panicle, *floral bracts* lanceolate, acuminate 4–9 mm long. *Flowers* resupinate; pedicellate ovaries 12–16 mm long; sepals and petals pale green, with maroon veins; dorsal sepal spreading, apically reflexed, ob lanceolate, acuminate, 9–11 mm long 2.5 mm wide; lateral sepals similar, slightly asymmetrical 12 mm long, 2.5 mm wide; petals flanking the column, narrowly elliptic, acuminate, 8.5–10 mm long, 2.2–2.5

**Figure 2.** *Eulophia graminea.* **A.** Inflorescences. **B.** Flower, side view showing fleshy hairs on the mid lobe of the lip. **C.** Flower, side view, showing spur morphology. **D.** Flower, front view showing lip color patterns. **E.** Fruit. **F.** Pseudobulbs with leaves. **G.** Pseudobulb with base of an inflorescence. All photographs taken by James Ackerman and Normandie González from the University of Puerto Rico, Río Piedras population. Voucher: 16 Apr 2021, *N. González-Orellana* s.n. (UPRRP).
There are now three species of *Eulophia* in Puerto Rico and the West Indies (Ackerman 1995, Ackerman & Collaborators 2014), one of which is native (*E. alta* (L.) Fawc. & Rendle) and the other two are not, *E. graminea* and *E. maculata*. The latter species, commonly known as *Oeceoclades maculata*, has been recently reinstated as a *Eulophia* by Chase *et al.* (2021) based on interpretation of phylogenetic and morphological works by Martos *et al.* (2014) and Bone *et al.* (2015). Although *Eulophia maculata* has been resident in the Western Hemisphere at least since the early 19th century, it is regarded as non-indigenous in the region and native to Africa and may have arrived in the ballast of slave ships (Stern 1988, Kolanowska 2013). The three can be distinguished by the following key:

**Key to the Species of *Eulophia* in the West Indies**

1. Leaves solitary from apex of pseudobulb, conspicuously mottled, leathery and persistent **E. maculata**
   1a. Leaves 3 or more, concolorous, relatively thin, persistent or early deciduous 2
   2. Pseudobulbs poorly developed or absent, leafy at flowering; lip saccate; petals form a hood over the column; sepals erect vertically; lip margin pinkish purple to burgundy; inflorescences 70–150 cm tall, racemose **E. alta**
   2a. Pseudobulbs roughly globose, leafless at flowering; lip spurred; apices of sepals and petals spreading; lip margin white to pale purple; inflorescences generally are <70 cm but can reach to 100 cm, racemose or sometimes paniculate **E. graminea**

**Acknowledgements.** We thank José Lazaro Bocourt, Oscar Loyola Hernández, Ethan Freid, Michael Vincent, Tamara Heartsill, Steve Maldonado, Christian Torres, and Adolfo Rodríguez Velázquez for sharing their field observations of *E. graminea*. Betsaida Cabrera García checked for *E. graminea* collections at JBSD for which we are grateful. Support for NG-O was provided by the Puerto Rico Louis Stokes Alliance for Minority Participation Bridge to the Doctorate program (National Science Foundation HRD-1906130).

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