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First report of brown marmorated stink bug (Hemiptera: Pentatomidae) reproduction and localized establishment in Florida

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The brown marmorated stink bug, *Halyomorpha halys* (Stål) (Hemiptera: Pentatomidae), has emerged as one of the most significant invasive pests worldwide (Haye et al. 2015). *Halyomorpha halys* is native to eastern Asia, from Korea and Japan south to Taiwan and the Indian subcontinent. First collected in North America in 1996 near Allentown, Pennsylvania, *H. halys* has spread throughout much of the USA and Canada (Hoebeker & Carter 2003; Leskey et al. 2012). Globally *H. halys* has become an invasive pest in Europe, from Switzerland and Liechtenstein eastward through the Balkans and into Russia and Georgia within the last decade (Wermelinger et al. 2008; Musolin et al. 2017). The only established population reported from South America is present in Chile (Faúndez & Rider 2017). While not present in Australia or New Zealand, *H. halys* has been intercepted numerous times on shipments bound for these countries and is considered to be a pest of regulatory concern (Duthie et al. 2012).

In temperate climates *H. halys* moves into sheltered areas or human structures such as homes and vehicles to overwinter. This overwintering behavior has increased the human-facilitated spread of *H. halys*, contributing significantly to its widespread distribution and invasive pest status (Hoebeker & Carter 2003; Garipey et al. 2014). In Florida, *H. halys* frequently has been intercepted on vehicles moving south during the fall or winter from states with established *H. halys* populations. The extremely high propagule pressure suggests a significant likelihood of *H. halys* establishment in Florida; however, prior to the 2016 to 2018 survey of stink bugs in Florida peach orchards, there has been no evidence of *H. halys* establishment in Florida.

From 2016 to 2018, a survey of stink bug pests in Florida's subtropical peach industry was conducted. Yellow pyramid traps were deployed at peach orchards in Lake County (2 sites), Polk County (1 site), and St. Lucie County (2 sites), with the goal of providing representative coverage of Florida's developing subtropical peach industry (Fig. 1). Yellow pyramid traps were constructed following methods similar to Leskey and Hogmire (2005). Traps were baited with a multi-species stink bug pheromone lure (AgBio, Westminster, Colorado, USA) and checked biweekly from Jan to Jun.

Two orchards in Lake County, Florida, USA, were monitored during the 2016 to 2018 peach seasons. Lake County Site 1 (Lake Co. 1) was a small planting (less than 0.4 ha) of peaches. Three yellow pyramid traps were placed at Lake Co. 1 each year during the survey period. Lake County Site 2 (Lake Co. 2) was a larger planting (approximately 2 ha). A total of 5 yellow pyramid traps were placed at Lake Co. 2 during 2016, with the trap number increased to 7 during the 2017 and 2018 seasons. The 2 Lake County sites were approximately 3.65 km apart,

with similar surroundings including citrus and pine plantings, as well as rural and residential land use. Both Lake County locations were certified organic and experienced minimal pest control intervention.

The Polk County site was located near Lake Alfred, Florida, USA. The orchard is approximately 6.9 ha and is situated in a residential area. Two moderate sized lakes are present on either side of the orchard. The primary agriculture in the area is citrus, with large groves several km away. A total of 10 traps were placed at the Polk Co. orchard.

Of the 2 orchards monitored in St. Lucie County, the northernmost site (St. Lucie Co. 1) had over 48.5 ha under cultivation, and the block monitored during the survey was approximately 4 ha, bordered by adjacent peach blocks on 3 sides, and a mowed grass lawn on the fourth side. A total of 5 yellow pyramid traps were deployed at this site in 2016, increasing to 7 traps in 2017 and 2018. The second St. Lucie county site, St. Lucie Co. 2, measured approximately 4 ha and was surrounded by citrus on the south, pasture on the north and east, and a small wooded area on the western side. Similar to St. Lucie Co. 1, trap density at St. Lucie Co. 2 increased from 5 traps in 2016 to 7 traps in 2017 and 2018. Chemical pest management was aggressive at both St. Lucie County sites during the survey period, reflective of a relatively high population of *Euschistus servus* (Say) (Hemiptera: Pentatomidae) in the area.

The survey detected adult *H. halys* in all 3 yr (2016–2018) as shown in Table 1. The discovery of adult *H. halys* in peach orchards represents the first detection of this species from an agricultural setting in Florida. Specimens were identified in the field, and confirmed by Susan Halbert at the Florida Department of Agriculture and Consumer Services, Division of Plant Industry. Voucher specimens were deposited in the Florida State Collection of Arthropods in Gainesville, Florida, USA. Adult females were dissected to determine reproductive status following the method of Penca and Hodges (2017). Of the 11 female brown marmorated stink bug dissected, 6 were gravid, 4 had clear oocyte development indicative of a post-diapause status, and 1 had regressed ovaries indicating diapause (Table 1). Gravid females were detected as early as mid-Feb, and continued to be observed into Jun, suggesting a large window for potential reproduction in Florida. Because adult detections may be the result of "hitchhiking" individuals on vehicles or other items transported from states with established populations, the repeated detection of adults in consecutive years at 3 separate sites (Lake Co. 1, Lake Co. 2, Polk Co.), while significant, does not provide conclusive evidence of establishment.

In 2018, the detection of 3 nymphs and 2 egg masses at 1 of the field sites (Lake Co. 2) represented the first observation of reproduc-

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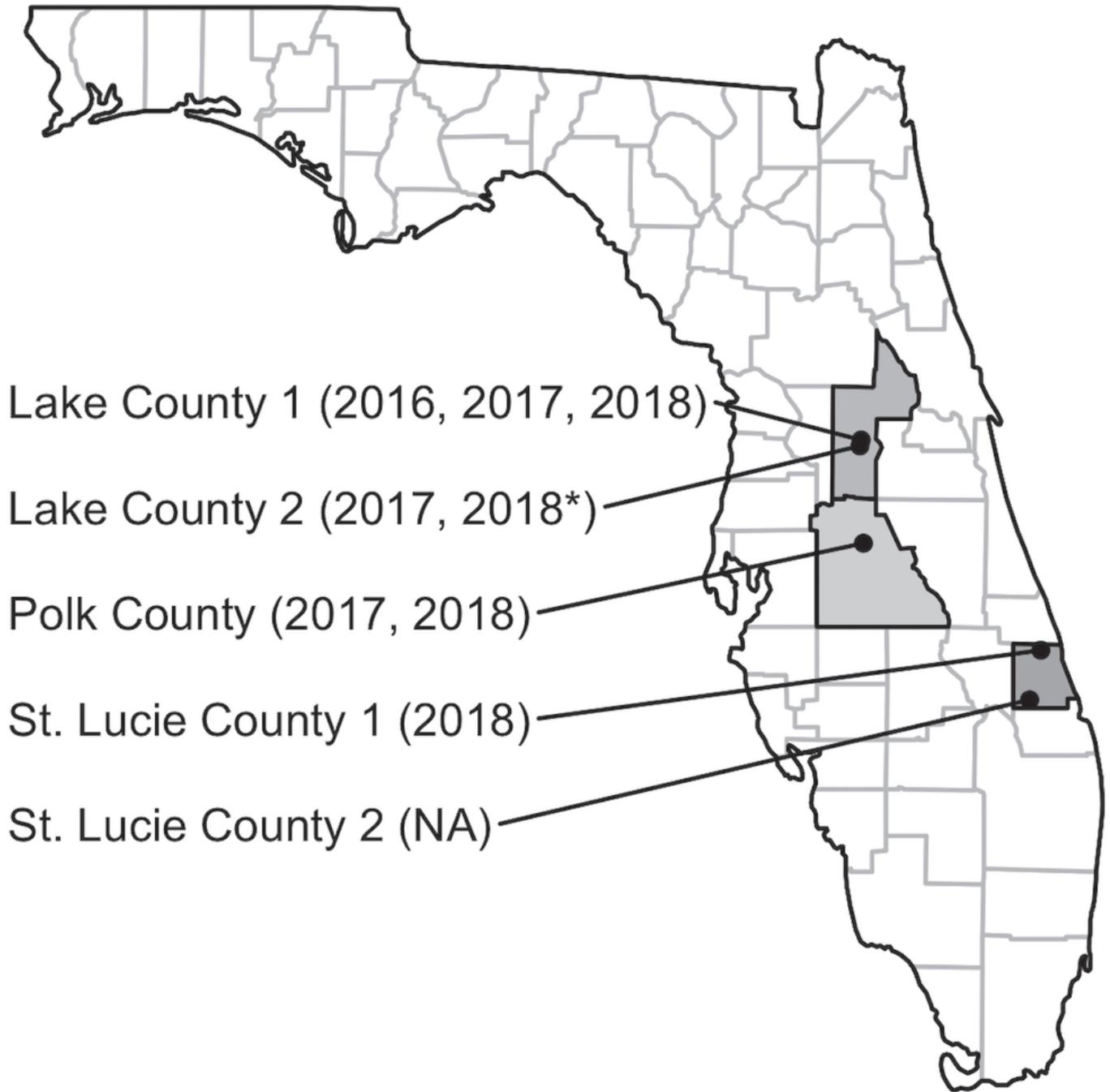


Fig. 1. Location of peach orchards monitored during the 2016, 2017, and 2018 peach seasons. Years in parenthesis indicate years with detections of adult *Halyomorpha halys*. Asterisks (*) indicate the detection of *H. halys* nymphs.

tion in Florida. Nymphal specimens and egg clutches were detected by visual survey within the vicinity of a baited yellow pyramid trap. Within the state of Florida, the Florida Department of Agriculture and Consumer Services, Division of Plant Industry is the plant protection agency with the regulatory authority to determine pest status. The Florida Department of Agriculture and Consumer Services, Division of Plant Industry has declared previous reports of adult *H. halys* as interceptions per the International Plant Protection Convention glossary of phytosanitary terms (IPPC 2007). The repeated detection of adult *H. halys* in 2016, 2017, and 2018, and the detection of reproductive stages in 2018 suggests *H. halys* is likely established at the

Lake County 2 site. As such, the Lake County population of *H. halys* has been declared a pest incursion of limited distribution by the Florida Department of Agriculture and Consumer Services, Division of Plant Industry.

The extent of *H. halys* establishment in Florida is unknown due to limited survey and trapping efforts. The nearest recorded reproductive populations are in central Georgia, several hundred km from the Lake County, Florida, population. Considering the frequent interceptions of *H. halys* in Florida on travelers and at the agricultural interdiction stations, it is assumed that the Lake County population was introduced via human activity, and not through the natural spread of

Table 1. Record of *Halyomorpha halys* capture in Florida peach orchards, 2016–2018.

Date ^a	Location	Stage	#	Reproductive Status ^a
3/31/2016	Lake 1	Adult	1	—
4/14/2016	Lake 1	Adult	1	—
2/19/2017	Lake 1	Adult	1	1/1 Gravid
2/19/2017	Lake 2	Adult	1	—
2/19/2017	Polk	Adult	1	1/1 Gravid
3/5/2017	Polk	Adult	1	—
4/2/2017	Lake 1	Adult	1	1/1 Gravid
4/14/2017	Lake 2	Adult	1	1/1 Diapause
4/29/2017	Polk	Adult	1	—
3/1/2018	Lake 2	Adult	4	1/1 Gravid
3/15/2018	Lake 2	Adult	3	2/2 Post-Diapause
4/12/2018	Lake 2	Adult	1	1/1 Post-Diapause
4/25/2018	Polk	Adult	1	1/1 Post-Diapause
5/9/2018	Lake 2	Nymphs	4	—
5/9/2018	Lake 2	Eggs	2 (clutches)	—
5/23/2018	Lake 2	Adult	1	1/1 Gravid
6/7/2018	Lake 1	Adult	1	—
6/7/2018	Lake 2	Adult	1	1/1 Gravid
6/7/2018	Polk	Adult	1	—
6/7/2018	St. Lucie 1	Adult	1	—

^aFemales were dissected to determine diapause status. Gravid females had mature, chorionated eggs. Post-diapause females had ovaries with signs of vitellogenesis, including partially developed oocytes. Diapausing females had regressed ovaries without signs of oocyte development. Specimens with a (–) indicate males or females not suitable for ovary examination.

H. halys southward from Georgia. While *H. halys* is most abundant in temperate areas, its native range includes subtropical parts of China (Lee et al. 2013). In temperate areas the reported photoperiod required for diapause termination was estimated at 12.7 h (Nielsen et al. 2017). The discovery of gravid females as early as mid-Feb, when the daylength is below 11.5 hours, suggests that cues directing diapause in *H. halys* may be less rigid than previously considered and may not pose a barrier to the expansion of this species into lower latitudes. Sustained monitoring of populations in Florida will provide more information on the ability of *H. halys* to expand its invasive range into subtropical regions.

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Summary

Halyomorpha halys has expanded its invasive range in the USA southward into Georgia, but prior to 2018 established reproducing populations have not been reported in Florida. Yellow pyramid traps placed in peach orchards detected adult *H. halys* in 2016, 2017, and 2018, with the number of positive sites and specimens captured increasing each year. During 2018, nymphs and eggs of *H. halys* were

observed at a peach orchard in Lake County, Florida. This represents the first evidence of a reproducing population of *H. halys* in Florida. The range expansion into Florida is the lowest latitude observed in the invasive range of *H. halys*, suggesting this temperate species may be able to overcome the barriers to range expansion posed by the temperature and photoperiod regimes found at lower latitudes.

Key Words: *Halyomorpha halys*; invasive; pyramid trap; peach; pheromone lure

Resumen

Halyomorpha halys ha expandido su rango invasivo en el sur de EE. UU. hacia dentro de Georgia, sin ser detectada o confirmada taxonómicamente poblaciones reproductoras previo a 2018 en Florida. Trampas piramidales amarillas localizadas en huertos de duraznos detectaron adultos de *H. halys* en 2016, 2017 y 2018, aumentando el número de adultos y sitios reportados año a año. En 2018, se observaron ninfas y huevos de *H. halys* en un huerto de duraznos en Lake County, Florida. Esto representa la primera evidencia de una población reproductora de *H. halys* dentro en Florida. La reciente detección en Florida representa la latitud más baja observada en el rango invasivo de *H. halys*, lo que sugiere que esta especie templada puede superar las barreras a la expansión del rango causado por la temperatura y el fotoperiodo en las latitudes más bajas.

Palabras Clave: *Halyomorpha halys*, especies invasivas, trampa piramidal, durazno, señuelo de feromonas

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