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RESEARCH

First Report of *Zaprionus indianus* (Diptera: Drosophilidae) in Commercial Fruits and Vegetables in Pennsylvania

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ABSTRACT. *Zaprionus indianus* (Gupta) (Diptera: Drosophilidae), an invasive vinegar fly, was found for the first time in Adams County, Pennsylvania, in 2011. It was found in a commercial tart cherry orchard using apple cider vinegar (ACV) traps that were monitoring another invasive vinegar fly, the spotted wing drosophila, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae). Coincidentally, the first record of *D. suzukii* found in Pennsylvania was also found in this same cherry orchard only 3 months earlier as part of a spotted wing drosophila survey effort in raspberry, blackberry, grape, and tart cherry in Adams County. These same crops plus blueberry and tomato were monitored again in 2012. In this article, adult *Z. indianus* captures in ACV traps and other traps deployed in the aforementioned crops during 2012 season are presented and the economic importance of *Z. indianus* is discussed.

RESUMEN. *Zaprionus indianus* (Gupta) (Diptera: Drosophilidae), es una especie invasora del vinagre encontrada por primer vez en Adams County, Pennsylvania en 2011. Esta fue encontrada en un cultivo comercia de cereza acida usando trampas de vinagre de sidra de manzana (VSM), que monitoreaban otra mosca del vinagre invasora, mosca de alas manchadas *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae). Al mismo tiempo, el primer registro de D. susuzkii encontrado en Pennsylvania fue encontrando en el mismo cultivo de frambuesa, mora, cereza y uva agria en el condado de Adams. Los mismos cultivos más mora y tomate fueron monitoreados otra vez en 2012. En este reporte, adultos de *A. inianaus captures* en trampas ACV y otras trampas anteriormente mencionadas durante el período 2012 son presentadas y la importancia económica de *Z. indianus* es discutida.

Key Words: African fig fly, apple cider vinegar, spotted wing drosophila, invasive pest, raspberry

Zaprionus indianus (Gupta) (Diptera: Drosophilidae) is thought to have been introduced into the New World through Brazil from Africa (Yassin et al. 2008). Recently, it has been reported from several regions in the United States (Vilela 1999, Castro and Valente 2001, De Toni et al. 2001, Santos et al. 2003, Tidon et al. 2003, van der Linde et al. 2006). Although *Z. indianus* is not considered a pest in Africa, this fly quickly spread throughout Brazil and was responsible for the economic loss of over 40% of the fig crop in one region in 1999 (Stein et al 2003), which gave rise to its common name African fig fly in South America (Commar et al 2012). Although it can utilize over 80 host plants (Yassin and David 2010), *Z. indianus* feeds principally on the yeast, *Candida tropicalis* Berkhout (Gomes et al. 2003), and bacteria found on decomposing fruits. It is not considered to attack unripe and undamaged fruit like *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae). In figs, however, the adults oviposit in and around the ostiole, where the larvae can easily access to the fruit interior (Vilela et al. 2001). Covering the ostiole of the fig fruit with a self-stick label has proven to be an effective control measure (Raga et al. 2003). In the United States, *Z. indianus* was first recorded in St. Lucie County, Florida, in July 2005 (van der Linde et al. 2006), and has since been found in other states, such as Arizona, California, Mississippi, and Texas (Sigler 2013, van der Linde 2013). Here, we report the first detection of *Z. indianus* in tree and small fruit plantings in several fruit growing regions in Pennsylvania.

Materials and Methods

Because of its initial discovery in *D. suzukii* traps in 2011, *Z. indianus* adults were also monitored in surveys for *D. suzukii* in various small fruit plantings in Adams, York, Dauphin, Tioga, Lehigh, Clearfield, and Centre Counties in Pennsylvania in 2012. In Adams County, cylindrical traps made of clear plastic deli cup (1 liter) ($n = 16$, $n = 4$ per crop type), each containing approximately 200–250 ml of apple cider vinegar (ACV; 5% acidity) as bait, were used for monitoring *D. suzukii* and *Z. indianus* adults in raspberry, blackberry, grape, and tart cherry fields. The traps were checked weekly and ACV was replaced in each trap at that time. All insect captures were filtered from the ACV using a fine-mesh sieve funnel and stored in 70% ethyl alcohol for identification in the laboratory. Insect specimens captured in *D. suzukii* ACV traps during 2011 in Adams County were also re-examined for the presence of *Z. indianus* adults. All specimens were identified to species level and voucher specimens were sent to the Pennsylvania Department of Agriculture (PDA)/USDA and then on to United States Department of Agriculture - Animal and Plant Health Inspection Service for confirmation. *Z. indianus* weekly capture in each crop was analyzed using a simple analysis of variance. For each week, pairwise comparisons were done among all crops using Tukey's honest significant differences post hoc test (Zar 1999).

In September and October 2012, *Z. indianus* adults were collected in PDA grape and tomato commodity pest surveys in York and Dauphin Counties, Pennsylvania. These captures were made with a plastic delta trap baited with European Grapeberry Moth, *Lobesia botrana* (Lepidoptera: Tortricidae) lure ((E,Z)-7,9-dodecadien-1-yl acetate, Bedoukian Research, Inc., Danbury, CT), a paper delta trap baited with *Tuta absoluta* (Lepidoptera: Gelechiidae) lure(Iscalure-Tuta, ISCA Technologies, Inc., Riverside, CA), and bucket traps baited with *Spodoptera littoralis* (Lepidoptera: Noctuidae) lure ((*Z*,*E*)-9,12-tetradecadien-1-ol, Bedoukian Research, Inc.).

After these initial discoveries of *Z. indianus*, additional monitoring late in the growing season (October) of the same year, using deli cup

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style traps baited with ACV or other lures (such as red wine with ACV) in various small fruit plantings (e.g., blueberry, red and black raspberry, blackberry) in Tioga, Lehigh, Clearfield, and Center Counties in Pennsylvania, found additional records of *Z. indianus*. Red wine-based "superbait" used in the monitoring traps consisted of 650 ml of water, 235 ml of Fisheye Merlot red wine (imported from Australia by FishEye Winery, Ripon, CA), 45 ml of unsulfured molasses (Brer Rabbit, B&G Foods, Inc., Roseland, NJ), and 22 ml of ACV diluted with water to 5% acidity (Great Value store brand, Walmart Stores, Inc., Bentonville, AR).

Results and Discussion

The first identification of *Z. indianus* in Pennsylvania was made by the PDA on 5 October 2012 and was subsequently confirmed by USDA. The specimen was from a PDA grape commodity pest survey. Approximately a week later, adults of *Z. indianus* (Fig. 1) were discovered in Adams County while monitoring for the more serious invasive fruit fly pest *D. suzukii* (spotted wing drosophila), which was first found in Adams County in July 2011 (Biddinger et al. 2011, 2012). A re-examination of the spotted wing drosophila fruit fly samples saved from 2011 found many additional specimens of *Z. indianus* which had not been identified at that time. During 2012 season, *Z. indianus* adults were found in *D. suzukii* ACV traps placed in raspberry, blackberry, grape, and tart cherry commercial fields. Late seasonal capture of *Z. indianus* adults in *D. suzukii* ACV traps deployed in various small fruit crops is presented in Fig. 2. Weekly capture of *Z. indianus* was not significantly different ($P > 0.05$, df = 3) among the crops monitored in this study (Fig. 2). In all crops, the highest number of *Z. indianus* adults peaked in ACV traps during the second week of October, but quickly declined and no adults were captured during the first 2 wk of November (Fig. 2). The late season captures of *Z. indianus* during October in Pennsylvania's climatic regime indicate its potential of becoming a pest and the possibility of rapid colonization in agroecosystems of Pennsylvania. The unusually mild winter of 2011–2012 may have allowed *Z. indianus* to survive, but the fact we found them also after the more typical winter of 2010–2011 means this "tropical" pest can survive the subzero winters in Pennsylvania. Similar trend in the weekly capture of *Z. indianus* was found while conducting a co-operative survey of *D. suzukii* and other invasive fruit flies in various fruit crops in Pennsylvania and Maryland (Biddinger et al. 2014).

In September and October 2012, four specimens of *Z. indianus* were collected in PDA grape and tomato commodity pest surveys in York and Dauphin Counties. These captures were made with different traps and lures intend for monitoring *L. botrana*, *T. absoluta*, and *S. littoralis*. In York County, *Z. indianus* was recorded in three trap locations (40.010167°N–76.610919°W, 40.010718°N–76.611333°W, and 39.790702°N–76.695272°W), while in Dauphin County, it was found in only one trap location (40.248073°N–76.770494°W). There were no repeat captures of *Z. indianus* adults in any individual trap location.

In addition to captures in Adams, Dauphin and York Counties, *Z. indianus* adults were also found in traps deployed to monitor *D. suzukii* in several other locations/counties in Pennsylvania late in the 2012 growing season. In Tioga County (northeastern Pennsylvania bordering New York), deli cup style traps baited with ACV were deployed in a commercial blueberry planting and nearby wild black raspberry and wild blackberry bushes. *Z. indianus* adults were found in all 3 fruit species in very low numbers (2, 1, and 1, respectively) in traps collected on 11 November 2012 from traps deployed for the previous 2 wk. Three *Z. indianus* adults were also caught in deli cup style traps baited with ACV in Lehigh County (southeastern Pennsylvania) in grapes. These samples were collected on 29 October 2012 and had also been deployed for 2 wk. Thirty-four *Z. indianus* adults were caught in an experiment in Clearfield County, Pennsylvania (central Pennsylvania) that was intended to compare differences in bait attractiveness to *D. suzukii*. Deli cup style traps were deployed in a patch of wild blackberries (*Rubus allegheniensis*) in Clearfield County, Pennsylvania, growing in a former pasture surrounded by a mixed species woods (primarily *Prunus serotina*, *Acer rubrum*, *Robinia pseudoacacia*, and *Picea abies*). Four blocks of traps used to test various baits were deployed in a randomized complete block design. Traps were deployed on 4 October 2012 and collected on 28 October 2012. At least three times as many *Z. indianus* adults were caught in a 60:40 mixture of Merlot red wine:ACV than in other baits (ACV, ACV + white grape juice, or superbait; Eaton 2012) tested. Five *Z. indianus* adults were also caught in Centre County, Pennsylvania, in an identical experiment that was conducted in high tunnels of red raspberries with four blocks, and traps were deployed on 24 October 2012 and collected on 31 October 2012. Although the numbers were too low to detect significant differences, red wine and ACV again numerically attracted the most *Z. indianus* adults.



Fig. 1. *Zaprionus indianus* (adult specimens) collected from ACV traps in Adams County, Pennsylvania, during 2012 (Picture by D.J.B.).

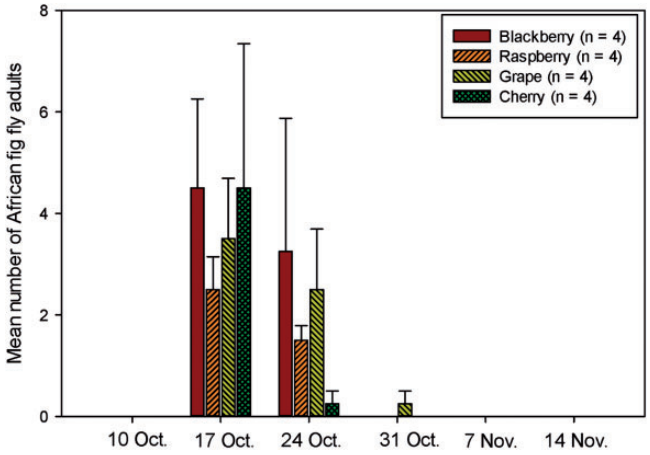


Fig. 2. Mean seasonal weekly adult captures of *Zaprionus indianus*, African fig fly, in ACV traps in various fruit crops (blackberry, raspberry, grape, and cherry) in Adams County, Pennsylvania, during 2012. Each bar represents standard error of mean.

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Z. indianus is a polyphagous species, which is known to infest fruits of over 70 plant species in its native African region (Lachaise and Tsacas 1983). Similarly in Florida (USA), it has been reported from different host plants, and had been reared on fruits of many tropical and subtropical fruits such as loquat, guava, oranges, palm, longan, cashew, pomegranate, and grape (Steck 2005, van der Linde et al. 2006). *Z. indianus* had also been reared on some temperate fruits such as apricot and cherries (Al-Jboory and Katbeh-Bader 2012).

Unlike *D. suzukii*, the female *Z. indianus* adults are unable to insert eggs into the fruit surface; in general, *Z. indianus* oviposit on the surface of previously damaged fruit (Tidon et al. 2003, Steck 2005). In its primary host (fig, *Ficus carica*), *Z. indianus* adult females are known to deposit eggs on the ostiole of fresh fruits from where maggots enter the soft and fleshy internal part of the fruit (Vilela et al. 2001). It has been reported to damage up to 50% of the fig fruit (Vilela 1999). *Z. indianus* also oviposit on fallen fig fruit around trees.

The United States is ranked sixth in the world with over 38,000 tons of fig production (FAOStat 2009). *Z. indianus* had been reported from several fig producing states, including California, which contributes 98% of the total fig production in the United States (United States Department of Agriculture-National Agricultural Statistics Service 2012). However, in Pennsylvania, fig is a minor specialty crop, but can be grown in high tunnels from late spring to fall (Orzolek et al. 2010). *Z. indianus* may establish as a primary fig pest in Pennsylvania and the mid-Atlantic region where cold-tolerant and other varieties of fig are currently sold commercially or are being developed for production.

In addition to its primary host, *Z. indianus* has been reported to infest ripened peaches in Brazil (Santos et al. 2003). Peach production in Pennsylvania is ranked fifth nationally with 17,690 tons of production in 2011 valued at $23.5 million (United States Department of Agriculture -National Agricultural Statistics Service 2012). Currently, several species of pests infest peaches in Pennsylvania's fruit-growing region (Hull et al. 2009a,b; Hull and Joshi 2011a,b). This invasive species could become another pest in peaches, mainly in "you-pick" orchards with tree ripen fruits and orchards with peach fruits with split pits growth deformities or from previous injuries. In commercial peach orchards, however, *Z. indianus* is unlikely to be a significant pest, as peaches are commercially picked very green and the peach pubescence should provide some protection from such a small fly. However, smooth-skinned nectarines and plums which are picked closer to maturity for sale at road-side stands could be more vulnerable to *Z. indianus* and should be monitored in the future. Most at risk from *Z. indianus* could be wine grapes or juice grapes, which often have low levels of damaged berries from other insects or diseases at harvest and are valued at $26.7 million in Pennsylvania in 2011 (United States Department of Agriculture-National Agricultural Statistics Service 2012). Other small fruits such as blackberry and raspberry, already damaged by *D. suzukii* or other pests, could also be at risk of infestation by *Z. indianus* for the same reason.

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