information on the environment necessary for egg and larval development, which may in turn provide additional control options.

While such chemical manipulations are possible using 2D petri-dish sheets of juice infused agar or other materials (*e.g.*, Takahara and Takahashi, 2017), our berries look very much like real berries which may provide some advantages. Admittedly, more work remains to increase the firmness of the artificial berries to match that of their real counterparts. We are, however, able to manipulate berry size along with their firmness, providing more realism and the ability to independently vary physical parameters separate from chemical characteristics. This capability may be of particular importance when studying the effect of fruit ontogeny where different aspects may vary at different time points. Overall, we have found that this method of producing artificial berries provides an easy and versatile approach to studying the reproductive and nutritional needs of an important agricultural pest species.

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Trap model for capturing *Drosophila suzukii* (Matsmura, 1931).

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Abstract

The monitoring of the Spotted Wing Drosophila relies on a variety of correlating factors, necessary for an effective detection of population density of a given place. The type of trap is one of said factors, and

several prototypes have been developed in countries that have had their fruit crops harshly damaged by this pest. However, although there are countless models made from different materials and arrangements, there is still no one standard model to be followed. Based on the studies that have displayed the most effectiveness in capturing *Drosophila suzukii*, a trap model targeting an effective monitoring was developed, made from durable and easily accessible materials, at a low cost for producers.

Introduction

The *D. suzukii* (Matsmura, 1931) (Diptera: Drosophilidae) species, known as the Spotted Wing Drosophila (SWD), is an Asian native species that has been spreading rapidly throughout North America and Europe since 2008 (Hauser, 2011; Cini *et al*., 2012;), causing major economic losses, especially to blueberry, blackberry, cherry, raspberry, and strawberry crops (Bolda *et al*., 2010; Burrack *et al*., 2013). The first record in South America dates back to 2013, in Brazil (Deprá *et al*., 2014; Schlesener *et al*., 2014; Geisler *et al*., 2015), and the fly has recently been detected in Uruguay (González *et al*., 2015).

Drosophila suzukii has a high reproductive potential and it can rapidly disperse to new areas (Cini *et al*., 2012). A recent study indicated a high environmental adequacy, particularly in temperate and subtropical regions, such as found in the Asian, European, North and South American continents, all of which already have records for the species, and potential occurrences in Oceania and Africa, places that have not yet recorded occurrences, but that do have propitious environmental conditions for the fly's establishment (Dos Santos *et al*., 2017).

Spotted Wing Drosophila females present an ovipositor with two rows of serrated teeth, enabling the laying of eggs inside ripe or ripening fruits (Lee *et al*., 2011). Once the egg is deposited, the eclosion of larvae occurs and they begin feeding upon the endocarp, as a secondary damage may be caused by the pathogens infestation, accelerating fruit decomposition and possibly compromising the entire crop (Walsh *et al*., 2011; Anfora *et al*., 2012).

Detecting the pest early and accompanying the evolution of its populations is fundamentally important when it comes to crop management and making decisions regarding the necessity of control. Regular monitoring is the first step for a successful integrated pest management (IPM) program (Gallo *et al*., 2002), and it is particularly important for *D. suzukii*, since the pest has been recently introduced and its expansion and distribution are irregular (Basoalto *et al*., 2013). The monitoring of SWD includes a trap-and-lure system, which uses visual and olfactory stimuli for capture (Iglesias *et al*., 2014). Therefore, the proper design for a species ought to consider the fly's color, shape, and structure (Cini *et al*., 2012), as well as density and trap positioning, around and within the crop area (Basoalto *et al*., 2013). A trap for the SWD must be effective, lasting, and have a low acquisition cost (Lee *et al*., 2012) so that, when combined with an attractant solution, it will lead to effective monitoring.

The development of different types of traps for capturing the SWD has been targeted by many researchers in the last few years. Traps using PET (Polyethylene terephthalate) bottles were the first ones used for prototypes, but today there are other versions, amongst commercial models and/or the ones developed by researchers that seek not only to be efficient for *D. suzukii*, but also to be selective to non-target organisms.

Some studies suggest that red and black traps can be more attractive to the SWD (Basoalto *et al*., 2013; Renkema *et al*., 2014) in orchards that have mature and similarly colored fruits (Renkema *et al*., 2014). Lee *et al*. (2012) reason that traps that share the same color as the host fruits may be in disadvantage if visual concurrence occurs, but this may also be an advantage, if the flies are more sensitive to the color of said fruit. The attractiveness of colors might be affected by the combination of volatile cues, as well as physical contrast with the environment (Lee *et al*. 2013). The authors tested different trap colors and verified that the yellow trap caught more flies than black, clear, and white traps, and the red trap caught more flies than the clear trap. Although such factor is not yet quite established, the red color has been widely used.

Several design models already tested presented an ample variation regarding *D. suzukii* capture. As for the area of the orifice through which flies enter, results demonstrate that traps that have a larger entry area are more effective than the ones with a smaller area (Landolt *et al*., 2011; Lee *et al*., 2012). In a following study, an increase of the entry area captured more individuals and it was more selective for certain types of trap when population density was low, but the progressive entry area enlargement had diminishing returns, particularly for commercial traps (Renkema *et al*., 2014).

As for the position of the entry orifices, traps that had side holes captured more flies than the traps with a top entry (both with and without tents for shading and protection against rain) (Lee *et al*., 2013). For orifice size there are protocols that, generally, suggest an entry size between 1/8 and 3/16 of an inch on the side of the collecting flask, one inch apart from one another, and a three inch portion ought to be kept with no holes, in order to pour in the attractant when trap maintenance is due (OSU, 2011). Such dimensions mostly avoid the entering of non-target organisms that are larger than SWD, although they are not selective to insects as big or smaller. Traps with a larger surface area for exposing the attractant also seem to form an important element, since 90 cm² surface traps captured 12% more *D. suzukii* compared to 40 cm² surface traps (Lee *et al*., 2013).

Besides considering physical aspects, the ideal trap must be economically viable, easy to use, and durable (Renkema *et al*., 2014), since it is not just a monitoring tool for an integrated management program, it can also be used as a control method, providing mass capture and resulting in the suppression of a local population by a large number of traps.

Notwithstanding a series of factors necessary for attracting *D. suzukii* that are common knowledge amongst researchers, there is still no consensus about a standard trap model to be used. Therefore, aiming to register the seasonal activity of the species in Brazil, and based on the studies already performed by other researchers, a trap model for capturing *D. suzukii* was developed at the Insect Biology Laboratory from the Eliseu Maciel School of Agronomy, Universidade Federal de Pelotas, RS, Brazil. In addition to a prototype that sought to unite the characteristics that were most effective regarding capturing this drosophilid, the model also meant to better the cost-benefit relationship, so it could be used by producers and researchers alike (Figure 1). The trap was named SWDTRAP.

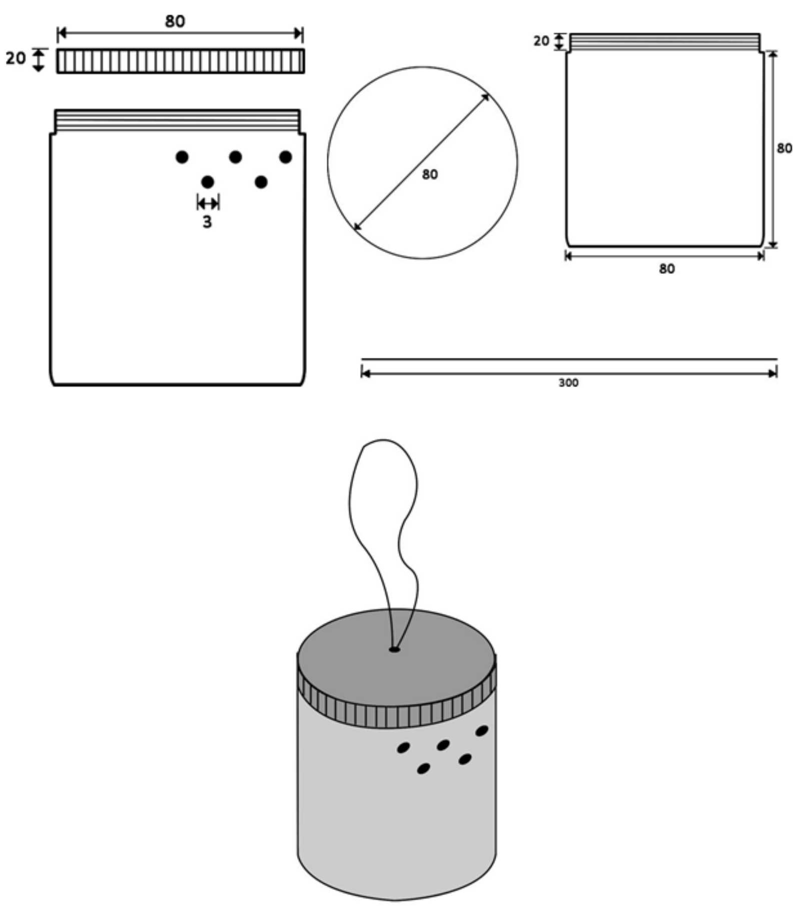

Figure 1. Illustrative drawing of the SWDTRAP (Scale: millimeter).

SWDTRAP design

Traps were made of virgin polypropylene plastic 500 mL vessels (Cloroplast®) closed with a screw cap (Figure 1). Polypropylene is a white, opaque, thermoplastic polymer, characteristically a material that has low cost, it is versatile, and particularly chemically resistant to solvents (Bonelli *et al*., 2001). This resistance to chemical abrasion is a relevant characteristic considered when developing a prototype, because the type of attractant substance used as bait may cause desiccation, followed by vessel breakage. For instance, baits that use vinegar as well as wine are basically composed of acetic acid and ethanol, respectively. Also, traps are exposed to climate variations, which also reduce its lifespan.

Figure 2. New SWDTRAP trap for capturing *Drosophila suzukii* in guava (A), blackberry (B), and blueberry (C) crops.

On the side of the vessel, 16 three millimeter orifices were cut, and approximately three inches were left with no holes, so attractant liquid could be poured inside the vessel. Traps were painted red (Suvinil® multi use spray, 54631753 color), and before painting the vessels were sanded with a fine grain sandpaper, as to better allow the paint to adhere. At the center of the cap an orifice was cut and one millimeter diameter nylon thread was introduced (D Tools®), in order to suspend the trap at the orchard. In order to stop rainwater from falling inside the trap through the gap between the cap's orifice and the nylon thread, a few drops of instant glue were placed (Super Bonder Gel Loctite®) as a sealing agent.

The proposition of this new trap to be used in monitoring *D. suzukii* constitutes an alternative to other models that have already been developed, with the objective of producing a prototype that could be easily managed, made from readily found materials, low cost, resistant to field conditions, with the option for storage so it could be reused later. This model is already being used for monitoring SWD in upcountry Pelotas, Rio Grande do Sul, Brazil, for commercial blackberry (*Rubus* sp), blueberry (*Vaccinium myrtillus*), strawberry

(*Fragaria* x *ananassa*), surinam cherry (*Eugenia uniflora*), strawberry guava (*Psidium cattleianum*), and guava (*Psidium guajava*) crops (Figure 2).

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Rearing method for *Drosophila suzukii* and *Zaprionus indianus* (Diptera: Drosophilidae) on artificial culture media.

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Introduction

The Spotted Wing Drosophila (SWD), *Drosophila suzukii* (Matsumura, 1931) (Diptera: Drosophilidae), is an alien species whose main characteristic is an ability to infest intact fruit, perforating it in order to lay eggs and allowing the possibility of larval development.

Since *D. suzukii* was identified in a Californian raspberry field in 2008 (Hauser, 2009), it has spread rapidly throughout North America (Walsh *et al*., 2011; Hauser, 2011), Europe (Cini *et al*., 2012), and South America (Deprá *et al*., 2014), causing damage to a series of commercial fruit crops, wild fruits, and ornamental plants (Lee *et al*., 2015; Schlesener *et al*., 2015; Arnó *et al*., 2016). A recent study indicates environmentally adequate areas in Oceania and Africa where a particular predisposition to the occurrence of *D. suzukii* is found, although there has been no record of the species occurring in those continents. Models indicate that -