Evaluation of Food Lures for Fruit Flies (Diptera: Tephritidae) Captured in a Citrus Orchard of the Serra Gaúcha

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Evaluation of food lures for fruit flies (Diptera: Tephritidae) captured in a citrus orchard of the Serra Gaúcha

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Abstract

The aim of the current study was to evaluate the effectiveness of 5 food lures for fruit fly monitoring in citrus orchards in the municipality of Pinto Bandeira, Rio Grande do Sul State, Brazil, from Nov 2012 to Oct 2013. Food lures included: 1) CeraTrap™ (undiluted), 2) Torula™ (6 tablets of 3 g/L), 3) BioAnastrepha (5%), 4) 10% corn syrup, and 5) 25% red grape juice (control). The lures were replaced weekly with the exception of CeraTrap™, which was replaced every 45 d. McPhail traps were baited with 300 mL of each food lure, and the traps were placed 10 m apart at the edge of the orchard. Traps were rotated weekly to prevent any bias in treatment location. *Anastrepha fraterculus* (Wiedemann) (Diptera: Tephritidae) was the species with the greatest mean number of fruit fly adults per trap per day (FTD), with 7.8, 2.8, 2.6, 1.7, and 0.9 FTD for the food lures CeraTrap™, Torula™, BioAnastrepha, corn syrup, and grape juice, respectively. CeraTrap™ lured *A. fraterculus* in amounts above the economic threshold (0.5 FTD) over 73% of the study period, whereas Torula™, BioAnastrepha, corn syrup, and grape juice lured *A. fraterculus* in amounts above the control level for 28, 20, 11, and 6% of the study period, respectively. Thus, the hydrolyzed protein CeraTrap™ showed the highest efficacy for fruit fly monitoring in the citrus orchard.

Key Words: *Anastrepha fraterculus*; hydrolyzed protein; McPhail; monitoring

Resumo

Neste estudo objetivou-se avaliar a eficiência de cinco atrativos alimentares para o monitoramento de moscas-das-frutas em pomar de citros no município de Pinto Bandeira, RS, de novembro de 2012 a outubro de 2013. Avaliou-se os atrativos alimentares: CeraTrap® (sem diluição), Torula® (6 pastilhas de 3 g/L), BioAnastrepha (a 5%), glicose de milho (a 10%) e suco de uva tinto (a 25%) como testemunha. Os atrativos foram trocados semanalmente, exceto CeraTrap® trocado a cada 45 dias. Os atrativos foram dispostos no interior de armadilhas McPhail em um volume de 300 mL por armadilha, distanciadas 10 metros entre si nas bordas do pomar. As capturas foram avaliadas e as armadilhas rotacionadas semanalmente. *Anastrepha fraterculus* (Wiedemann) (Diptera: Tephritidae) foi a espécie que apresentou o maior número médio de adultos de moscas-das-frutas/armadilha/dia (MAD) capturados com 7,8, 2,8, 2,6, 1,7 e 0,9 MAD para os atrativos CeraTrap®, Torula®, BioAnastrepha, glicose e suco de uva, respectivamente. CeraTrap® indicou a presença de *A. fraterculus* acima do nível de controle (0,5 MAD) ao longo de 73% do período de estudo, diferindo de Torula®, BioAnastrepha, glicose e suco de uva com 28, 20, 11 e 6%, respectivamente. A proteína hidrolisada CeraTrap® apresenta maior eficiência para o monitoramento de mosca-das-frutas em pomar de citros.

Palavras Chave: *Anastrepha fraterculus*; proteína hidrolisada; McPhail; monitoramento

Fruit flies are responsible for significant losses of fruit production in Brazil, with damage caused by oviposition and larval feeding, which destroy the fruit's pulp, cause accelerated fruit ripening, and lead to premature fruit drop (Aguiar-Menezes et al. 2004). In southern Brazil, *Anastrepha fraterculus* (Wiedemann) (Diptera: Tephritidae) is a tephritid fruit fly species of great economic importance, also considered a major pest of fruit crops in temperate regions (Nava & Botton 2010; Garcia & Norrbom 2011; Nunes et al. 2012; Dias et al. 2013; Pereira-Rêgo et al. 2013). Although other fruit fly species are associated with citrus crops, *A. fraterculus* is a key pest that requires constant monitoring and control measures to reduce its population in citrus orchards (Nava & Botton 2010; Garcia et al. 2003; Silva et al. 2006; Gattelli et al. 2008; Zilli & Garcia 2010).

One fundamental aspect of fruit fly management is population monitoring. The goal of monitoring programs is to provide information on pest population in the monitored area; therefore, the evaluation of effective and reliable food lures should be performed on an on-going basis (Nora & Sugiura 2001). Several studies have evaluated the efficacy of attractants for monitoring *A. fraterculus* in southern Brazil (Garcia et al. 1999; Chiaradia & Milanez 2000; Kovaleski 2004; Scoz et al. 2006; Pogerre 2007), but compared with more heavily studied species, such as *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae), there is still relatively little information on attractants for *A. fraterculus*.

Currently, solutions of 25% grape juice are recommended as the standard attractant for monitoring South American fruit flies in apple

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and other fruit orchards (Kovaleski 2004; Fioravanço & Santos 2013). However, grape juice is not an effective attractant in vineyards (Zart et al. 2009), and questions have been raised regarding its efficacy in apple orchards (Zuanazzi 2012). Because of failures in population detection in orchards where grape juice is used as an attractant, there is an urgent need to find alternatives. Hydrolyzed proteins and Torula™ yeast are among the main options available on the market for fruit fly monitoring in orchards (Raga et al. 2006; Scoz et al. 2006; Monteiro et al. 2007; Pogerre 2007; Azevedo et al. 2012). In addition to these attractants, 10% reversed glucose aqueous solutions have been used in faunal and population dynamics studies of fruit fly species (Garcia et al. 1999, 2003; Zilli & Garcia 2010).

Recently, a new formulation of hydrolyzed proteins has been evaluated for monitoring fruit flies in vineyards (Machota Junior et al. 2013). The main advantage of this new formulation is its stability, which allows for the replacement of the attractant at intervals of 60 d, or upon total evaporation of the product from the trap. Due to the variability of information regarding food lures available on the market, as well as the increased incidence of fruit flies in citrus orchards, the current study aimed to evaluate the efficacy of food lures for monitoring fruit flies in citrus orchards in the municipality of Pinto Bandeira, Rio Grande do Sul State, Brazil. The municipality of Pinto Bandeira is a new production center of citrus fruits in the state.

Materials and Methods

Data were collected from Nov 2012 to Oct 2013 in a citrus orchard growing *Citrus sinensis* (L.) Osbeck (Rutaceae) of the cultivar 'Valência.' The orchard is located at 29.0315667°S, 51.5009889°W and 295 m asl in the municipality of Pinto Bandeira, Rio Grande do Sul State, Brazil. The orchard has an area of 2.0 ha and was established in 2006 with a spacing of 5.0 × 4.5 m between the trees. No pesticides were used during the current study. Adult plants of Surinam cherry (*Eugenia uniflora* L.), guabiju [*Myrcianthes pungens* (Berg) Legrand], and guava [*Psidium guajava* (L.)] from the Myrtaceae family and loquat [*Eriobotrya japonica* (Thunb.) Lindley] from the Rosaceae family were identified at the orchard's borders. In the neighboring properties, there are peach (*Prunus persica* L. Batsch; Rosaceae) and grape (*Vitis* spp. L.; Vitaceae) commercial orchards, typical of the agricultural diversity of the region where the study was performed.

The food lures evaluated in the current study were CeraTrap™ hydrolyzed protein (BioIberica S.A., undiluted); Torula™ yeast (Isca Technologies, Inc., 6 tablets of 3 g/L); BioAnastrepha hydrolyzed protein (BioControle – Métodos de Controle de Pragas Ltda., 50 mL/L); corn syrup (Yoki™ Alimentos Ltda., 100 mL/L); and red grape juice (Embrapa Grape and Wine, 250 mL/L), a current standard for monitoring, used as a control. All of the attractants were replaced weekly, with the exception of CeraTrap™, which was replaced every 45 d, according to the manufacturer's instructions.

McPhail traps were baited with 300 mL of each attractant (Salles 1999) and distributed in the canopy of fruit trees at 1.5 m above ground level and 10 m apart (Nascimento et al. 2000) on the orchard's border. Two traps baited with each attractant, 10 traps in total, were placed in the orchard. The evaluation of the traps' content was performed weekly when the traps were rotated to avoid a positional bias (Mendonça et al. 2003), for 45 wk of monitoring.

The insects caught by the traps were placed in labeled vials containing 70% ethanol for subsequent sorting, counting, and identification. The fruit fly specimens of the genus *Anastrepha* Schiner were sexed and identified using the identification keys of Steyskal (1977) and Zucchi (2000). The number of captured fruit flies was presented as the flies per trap per day (FTD) of adults. The mean captures per trap per week were subjected to an analysis of variance (ANOVA) using Tukey's test (5% significance) with the statistical software SPSS™ for Windows 15.0.

Results

Of the 1,587 Tephritidae specimens collected in the current study, 1,544 belonged to the genus *Anastrepha*, within which 1,410 specimens were *A. fraterculus* and 89, 40, and 5 specimens were *Anastrepha pseudoparallela* (Loew), *Anastrepha grandis* (Macquart), and *Anastrepha aczeli* Blanchard, respectively. The other insects captured belong to the genera *Parastenopa* Hendel, *Tomoplagia* Coquillett, *Toxotrypana* Gerstaecker, and *Trupanea* Schrank. *Anastrepha fraterculus* was the species with the greatest number of specimens captured in the current study, with a mean number of 7.81 ± 9.55, 2.76 ± 4.52, 2.63 ± 4.67, 1.66 ± 3.38, and 0.91 ± 2.18 flies per trap per week with the attractants CeraTrap™, Torula™, BioAnastrepha, corn syrup, and grape juice, respectively (Table 1).

A comparison of the attractants evaluated in the current study showed significant differences between CeraTrap™ and the other attractants in the capture of *A. fraterculus*, *A. pseudoparallela*, and *A. grandis* (F = 22.128; df = 4; P = 0.000) (Table 1). Traps baited with CeraTrap™ captured 703 specimens (389♀/314♂) of *A. fraterculus*; Torula™, BioAnastrepha, corn syrup, and grape juice attracted 239 (116♀/123♂), 237 (119♀/118♂), 149 (76♀/73♂), and 82 (42♀/40♂) *A. fraterculus* specimens, respectively.

During the studied period, traps baited with Torula™ yeast had 7 population peaks, occurring in late Nov, Dec, mid-Jan, and mid-Jun, between early Jul and early Aug, and in late Aug and mid-Sep (Fig. 1). In the same period, the hydrolyzed protein BioAnastrepha had 6 population peaks that occurred in Dec, from the beginning of Mar, and in mid-Jun, mid-Jul, mid-Aug, and mid-Sep (Fig. 1).

Similar to BioAnastrepha, the food lure CeraTrap™ had 6 population peaks; however, the peaks were longer than the peaks detected by the other attractants evaluated in the current study. The peaks occurred from the beginning of Dec to the end of Jan, from early Feb to mid-Mar, between mid-Apr and mid-May, from late May to mid-Jul, from late Jul to mid-Aug, and in mid-Sep (Fig. 1). Corn syrup had 3 population peaks that occurred in mid-Dec, mid-Jul, and mid-Aug, whereas grape juice had only 2 population peaks, one in early Dec and another in mid-Jul (Fig. 1).

Table 1. Mean number ± SD of *Anastrepha* species captured per week with monitoring traps baited with 5 attractant solutions from Nov 2012 to Oct 2013 in a citrus orchard (*Citrus sinensis* cv. 'Valência') in the municipality of Pinto Bandeira, Rio Grande do Sul State, Brazil.

Anastrepha species	BioAnastrepha	CeraTrap™	Corn syrup	Grape juice	Torula™
A. fraterculus	2.63 ± 4.67 Ba	7.81 ± 9.55 Bb	1.66 ± 3.38 Ba	0.91 ± 2.80 Ba	2.66 ± 4.52 Ba
A. pseudoparallela	0.16 ± 0.50 Aa	0.63 ± 2.47 Ab	0.16 ± 0.62 Aa	0.01 ± 0.11 Aa	0.03 ± 0.18 Aa
A. grandis	0.14 ± 0.35 Abc	0.20 ± 0.48 Ac	0.02 ± 0.15 Aab	0.00 ± 0.00 Aa	0.08 ± 0.27 Aabc
A. aczeli	0.00 ± 0.00 Aa	0.03 ± 0.18 Aa	0.00 ± 0.00 Aa	0.00 ± 0.00 Aa	0.02 ± 0.15 Aa

[a]Means followed by the same letter (uppercase in the columns and lowercase in the rows) do not differ by Tukey's test at 5% significance.

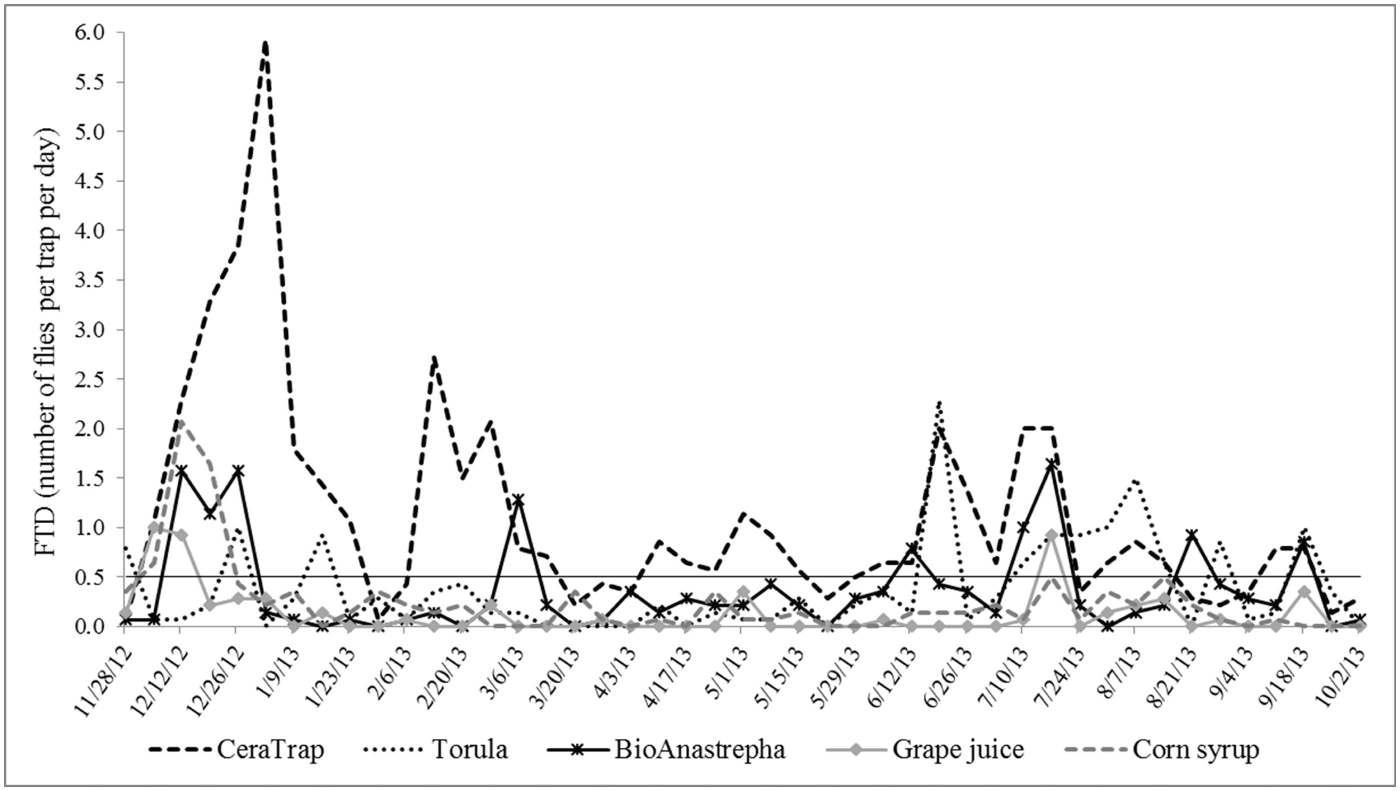

Fig. 1. Mean number of adult *Anastrepha fraterculus* (male and female) flies captured per trap per day (FTD) with McPhail monitoring traps containing food lures in a citrus orchard growing the *Citrus sinensis* cv. 'Valência' from Nov 2012 to Oct 2013. Municipality of Pinto Bandeira, Rio Grande do Sul State, Brazil. The continuous horizontal line indicates an FTD index of 0.5 (economic injury level).

It is important to note that the food lure CeraTrap™ caught adults of *A. fraterculus* above the FTD index of 0.5 in 33 of the 45 wk of the experiment, indicating the presence of *A. fraterculus* fruit flies above the control level throughout 73% of the study period (Fig. 1). For Torula™, BioAnastrepha, corn syrup, and grape juice, the presence of *A. fraterculus* above the control level was seen in 28, 20, 11, and 6% of the study period, respectively (Fig. 1).

Throughout the study, the greatest population peak was indicated by the food lure CeraTrap™ in the beginning of Jan (FTD = 6.0), when 84 specimens were collected (Fig. 1). Furthermore, CeraTrap™ indicated the presence of fruit flies in all 45 wk of evaluation, even in winter (Fig. 1).

Discussion

Adult fruit flies, especially females, must ingest proteinaceous compounds during the post-emergence period to reach sexual maturation (Heath et al. 1994). This can lead to a sex bias in trap recaptures, an issue in lure choice noted by Salles (1999), and this pattern was observed in the current study for all of the attractants except Torula™.

The results of the current study corroborate those obtained by Scoz et al. (2006) in a peach orchard in the Serra Gaucha region, Rio Grande do Sul State, Brazil. Those authors showed that greater numbers of adults of *A. fraterculus* were caught with traps baited with Torula™ yeast than with the hydrolyzed protein BioAnastrepha (5%) and 25% grape juice. However, Monteiro et al. (2007) conducted a study in peach orchards in the Lapa region of Paraná State, Brazil, and indicated that the protein-based attractants BioAnastrepha and Torula™ had equivalent efficacy as lures for *Anastrepha* species. Monteiro et al. (2007) also showed that captures of *Anastrepha* started earlier in the season in the BioAnastrepha and Torula™ baited traps compared with 25% grape juice.

In this study, we used corn syrup as a source of reversed glucose. Garcia et al. (1999) found that females of *A. fraterculus* were more attracted to reversed glucose than to Surinam cherry, 25% grape juice, or 25% peach juice. Chiaradia & Milanez (2000) also reported that reversed glucose was the most efficient attractant to capture fruit flies, especially *A. fraterculus*. In the study by Chiaradia & Milanez (2000), reversed glucose was a better attractant than 25% grape juice and 5% hydrolyzed protein (the authors did not mention commercial brands).

Recent studies, including research by Azevedo et al. (2012), have demonstrated the potential of fruit juices for fruit fly monitoring. According to Mendonça et al. (2003), fruit juices are the most difficult to clean off traps because they leave residues. These residues were observed in the current study for traps baited with 25% grape juice. In addition, Zart et al. (2009) indicated there can be problems with variation in grape juice composition as a result of the grape variety used in the juice production, harvest, and trademark. In contrast, Torula™ yeast has little composition variation, is more specific, and attracts a significantly greater number of fruit flies than 25% grape juice and the hydrolyzed protein 5% BioAnastrepha. The results presented in this paper suggest that the control trigger should be set to different levels depending on the attractant used.

Raga et al. (2006) showed that the hydrolyzed proteins BioAnastrepha and IscaMosca™ were equally effective in attracting fruit flies in citrus orchards. Moreover, while the efficacies of the 2 hydrolyzed proteins were equivalent, they were significantly better than the other attractants tested. Therefore, BioAnastrepha and IscaMosca™ were recommended for fruit fly monitoring in citrus orchards, and these attractants caught 44.5 and 41.3%, respectively, of the Tephritidae adults collected throughout the entire experiment. According to the results from this study, the food lure CeraTrap™, which is a new tool for *A. fraterculus* monitoring in citrus orchards, was more efficient than the attractants Torula™, BioAnastrepha, grape juice, and corn syrup.

According to Carvalho (2005), the best time to control *A. fraterculus* populations in all crops is when the FTD of adults is equal to or greater than 0.5. In the current study, all of the evaluated attractants indicated the same population peak with an FTD of fruit flies greater than 0.5. However, CeraTrap™ had the greatest mean number of captured flies (Fig. 1). This peak occurred in mid-Jul and coincided with the beginning of the harvest of orange and the ripening of loquat, a known host of fruit flies (Garcia & Norrbom 2011; Nunes et al. 2012). This consistency in the capture of *A. fraterculus* adults by CeraTrap™ lure is an important characteristic of the attractant that makes it possible to detect a fruit fly infestation in the initial stages prior to an outbreak, which should prove useful for management programs.

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