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PEST MANAGEMENT

Management of *Euxesta* spp. in Sweet Corn with McPhail Traps

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Keywords

Bio Anastrepha®, food attractant, maize ear fly, natural control, traps

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Abstract

Pests attacking the ear of sweet corn, such as *Helicoverpa* and *Euxesta* species, cause economic losses for the producer and the processing industry. Feeding on the style-stigmata preventing fertilization and on the developing grain and the association with pathogens are the main causes of product depreciation. The traditional control such as spraying with chemicals is not effective, even with several applications directed to the corn ear. *Bacillus thuringiensis* (Bt) corn also does not reach the fly. McPhail traps that have been used to monitor the pest can be a control strategy. This work evaluated the efficiency of food attractants placed inside McPhail traps to remove adult insects, in order to reduce ear damage. Twelve McPhail-type traps were installed in a randomized complete block design containing Bio Anastrepha® alone or combined with different doses of insecticide. Every 10 days, all the captured insects were counted and separated by species and sex. Only *Euxesta eluta* and *Euxesta mazorca* were found. The occurrence of insects was greater in the period between silk emergence and grain filling. The number of females was higher, probably due to the need to feed before oviposition. The number of *E. mazorca* females caught in the treatment containing only Bio Anastrepha® was higher compared with that of others. The mean ear damage was very low, and there was no interaction between the production parameters and the distance between the trap and the harvested plant. In short, the use of McPhail trap containing food attractants may be a viable alternative to control corn silk flies.

Introduction

Sweet corn is a "special crop" in Brazil, and all production is destined to canned food companies. This market has been growing in recent years, especially when it comes to exports (Figueiredo *et al* 2015). The same insect species that attack conventional grain corn can be found in sweet corn. However, sweet corn is known to be more susceptible to phytophagous insects. According to Cruz *et al* (1999), maize yield reductions due to *Spodoptera frugiperda* (J.E. Smith) leaf damage were 57.6, 28.9, and 21%, for insect feeding on a sweet maize BR 400, a white high-quality protein maize BR 451, and a conventional yellow maize BR 201, respectively.

Reduction on the quality of the ear due to requirements of the processing industry may occur by insect damage directly to the grains. Injuries caused to the tip of the ear may not cause so much damage to the industry as they can be mechanically eliminated in processing. However, when damage occurs along the ear, caused by Lepidoptera and ear fly larvae, the loss in this case is total for the industry.

The sweet corn pests with the greatest potential to cause injury and, consequently, to cause losses to both the agricultural and industrial sectors are those that affect specifically the ear, such as the Lepidoptera larvae *S. frugiperda* and *Helicoverpa* complex, which also cause leaf damage, and *Euxesta* spp. (Diptera) (Cruz *et al* 2016). Insects feeding on corn ears are usually sheltered from conventional pest control technologies such as chemical application. There is also the possibility of unacceptable residues in the harvest product. Even the use of transgenic maize

(Bacillus thuringiensis [Bt] maize) has not been an alternative, due to non-acceptance by consumers. Therefore, there is a need for new low-cost, efficient control technologies to increase field and industrial yield. For Lepidoptera species, biological control has been successfully performed by releasing egg parasitoids such as *Trichogramma* spp. (Figueiredo *et al* 2015, Cruz *et al* 2016). Unfortunately, there is still no technology to control efficiently the corn silk fly while providing residue-free grain.

The damage caused by the fly is a consequence of the injury caused by the larvae initially feeding on the silk (thus reducing pollination and consequently fertilization) and then attacking the grains in the milk stage, reducing the quality and yield of the crop (Frias 1981; Painter 1985; Branco *et al* 1994). The problem is exacerbated by the attempt to control with chemical insecticides, since the high number of applications leads to an increase in the concentration of chemical residues in the final product. Pesticide residues above the maximum residue limits allowed by the law constitute a barrier to processed food exports (Figueiredo *et al* 2015).

In one of the first Brazilian works in the field, Cruz *et al* (2011) demonstrated the efficiency of different food attractants associated with McPhail traps to monitor *Euxesta* spp. in maize areas, which would allow its use for pest management. In the same work, the authors reported for the first time in the country the presence of *Euxesta mazorca* in ears of corn.

Considering the lack of adequate control methods, the main objective of this work was to evaluate the use of McPhail traps containing food attractants to remove corn silk flies in sweet corn fields, in order to reduce kernel damage and yield losses caused by the pest in field conditions; ensure product quality, and therefore, increase processing yield; and minimize the environmental impacts and residues in food caused by chemical pesticides, making use of clean technology and Good Agricultural Practices.

Materials and Methods

The work was conducted at a sweet corn seed production area of the Brazilian National Maize and Sorghum Research Center, located in the municipality of Sete Lagoas, Minas Gerais State, Brazil (coordinates 19°28′45″S and 44°10′08″W). The planting of sweet corn seeds took place in February 25, in an area of 0.8 ha under the central pivot irrigation system. Pest control in the area is carried out mainly for Lepidoptera species, notably *Spodoptera frugiperda* (Smith) and *Helicoverpa zea* (Boddie) by releasing the egg parasitoid *Trichogramma pretiosum* Riley (Figueiredo *et al* 2015).

To capture *Euxesta* spp., we installed 12 McPhail traps in April 7, when plants were in the vegetative stage 7 (V7) according to Ciampitti et al (2011). The traps were hung by a wood pole 1.2 m above the ground and spaced 30 and 22 m apart (vertical and horizontal directions, respectively), covering an area of 666.7 m^2 (Fig 1). The experiment was carried out in a randomized block design with four treatments, each with three replicates. The treatments were as follows: (I) food attractant Bio Anastrepha®; (II) Bio Anastrepha® + 1.5 mL Karate 50 CS (lambda-cyhalothrin; Syngenta); (III) Bio Anastrepha® + 2.25 mL Karate 50 CS; (IV) Bio Anastrepha® + 3.0 mL Karate 50 CS. The commercial product is efficient, low cost and toxicological class III (moderately toxic), and legally registered for use on maize spraying especially for Lepidoptera control. According to Nuessly and Hentz (2004), relatively low doses of pyrethroids, although causing a low initial mortality rate, had enough sublethal effect to almost completely immobilized adult insects after just 1 h of exposure; however, causing 95% mortality with 2 h of exposure. Subsequently, Owens *et al* (2016b) demonstrated that both *Chaetopsis massyla* Walker and *Euxesta stigmatias* recover soon after applying different pyrethroid treatments.

All traps received the food attractant Bio Anastrepha®, whose efficiency has already been verified (Cruz *et al* 2011). The commercial product was first diluted in water to a final concentration of 5%; then, aliquots of 1.2 L were taken out. For treatments II, III, and IV, we added 1.5, 2.25, and 3.0 mL, respectively, of the commercial insecticide with lambda-cyhalothrin (50 g L^{-1}). Afterwards, 400 mL of each aliquot was transferred to three separate vials (plastic bottles), and the liquid solution without the addition of any preservatives was placed inside at the base of the McPhail trap and soon after covered by a clear plastic lid; this way, the air intake was only through the bottom of the traps.

Nine evaluations of the presence of captured insects occurred, with a 10-day interval, starting 10 days after placing the traps, that is, 45 days after plant emergence. Similar ranges had already been used (Cruz *et al* 2011), and in this experiment, no significant physical loss of the flies was verified either; therefore, no preservatives were used. After each evaluation, the traps were washed and refilled with new 400 ml of the solution; although, in this period, there was no drying of the diluted BioAnastrepha solution. In each evaluation, the captured insects were placed in 500-mL bottles, taken to the laboratory, and immediately counted after being separated by species and by sex. The task of insect counting and sex separation was relatively easy to perform since the insects remained well preserved within the McPhail trap as the solution drying was very low. Morphological characteristics, such as wing color and the presence of ovipositor in females (Steyskal 1968, 1974; Huepe *et al* 1986), were the identification tool parameters to separate sex and species of *Euxesta*. At the end of the evaluation, the insects were deposited at the Embrapa Entomology Museum in Sete Lagoas, Brazil.

When in R3, we harvested a total of the 36 ears around the traps at 1 m and 10.2 m on the left and right sides and at 15 m both forward and backwards (Fig 1). All ears were individually husked, weighted, and measured; they were also evaluated in relation to insect damage at the tip or in the middle of the ear. Later, they were threshed to obtain grain weight. Statistical analysis was performed in the SISVAR statistical program (Sistema Sisvar 2017). The available data were submitted to analysis of variance (ANOVA), and means were compared using the Scott-Knott test ($P < 0.05$) (Scott & Knott 1974).

Results

Only *Euxesta eluta* and *E. mazorca* were found in the sweet corn fields, in accordance with Cruz *et al* (2011). The total number of captured adult flies, considering all traps placed in the field, was 51,051. From those, we were able to identify the sex of 50,702 insects, distributed in all evaluation times, which shows the presence of the species during almost all stages of development of the plant, as reported by Frias (1981). This presence was easily verified soon after the deployment of the traps and at each food attractant solution change.

The data in Table 1 show significant difference in the mean of captured insects when considering all traps and treatments. The number of collected females from *E. mazorca* was significantly higher, with a mean of 230.3 insects per trap, followed by *E. eluta* females, also with relatively high numbers (187.9 individuals per trap). The number of males from both species was significantly lower than the number of

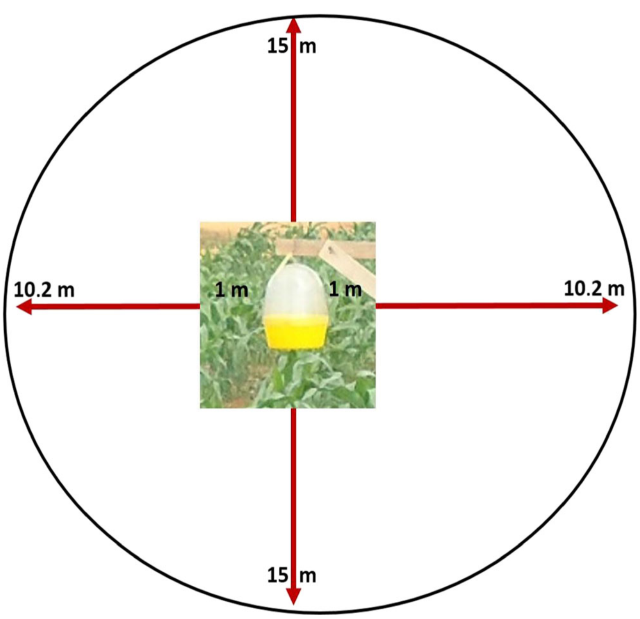

Fig 1 Maize ears harvesting sites (distance from the center of the trap).

females, and there were no significant differences between the means obtained, 43.05 and 19.3 male insects of *E. eluta* and *E. mazorca*, respectively. These averages represent, respectively, 22.9 and 8.8% of the number of captured females, indicating that females are much more attracted to this food source. This is probably due to the female's need to feed before oviposition.

The mean number of *E. eluta* males in the 4th and 5th samples (154.1 and 105, respectively) is statistically higher than the number of males from the very same species captured in the other dates (Table 1). Similar trend occurred in relation to females. In the fifth sample, the number of *E. eluta* females was significantly higher than the rest, with a mean of 722.2 females per trap. The second highest mean we found was in the 4th sampling time, with 369.6 females per traps, which means that the number of captured females from this species nearly doubled in a 10-day interval.

There was no significant difference in the number of *E. mazorca* males between surveys. For females, there were significant differences between the samples. The capture peak occurred in the fourth sampling date, with a mean of 648.8 females per trap. This peak occurred 10 days before the *E. eluta* peak, which was in the fifth sample. In fact, there was a reversal in the female population, since the second highest peak of *E. mazorca* females occurred at the same as the main *E. eluta* peak.

The peaks on the capture of females in the fourth and fifth sampling, respectively, 40 and 50 days after plant emergence overlap the beginning of flowering in the crop. This may explain the peak for both species' populations, considering the number of captured females in the first three sampling dates (175.5 females per trap) much smaller than in the fourth and fifth sampling times (1141.8), in the case of *E. eluta*. For *E. mazorca*, those values were 207.6 and 1100.6 females, respectively. The stage of greater susceptibility of the plants has most likely functioned as the principal attractor of the insect from greater distances. Within the planting area, the food attractant solution had great importance in attracting females. It was able to remove a significant number of insects from the area, helping reduce the number of deposited eggs on the plant, especially considering that an adult can live up to 100 days.

The results shown in Table 2 indicate that there was no influence of the addition of different doses of the lambda-cyhalothrin insecticide on male capture of both *E. eluta* and *E. mazorca*. The insecticide may have had repellent action contrary to what happened with the capture of females. For the *E. eluta*, there was no significant difference between the number of females caught in traps containing only the food attractant (239.4 females) or with Bio Anastrepha® + 1.5 mL lowest dose of insecticide (204.4 females). These means were significantly different from those obtained in treatments with 2.25 mL (154.2 females) and 3.0 mL (153.7 females) of

Table 1 Mean number (± SE) of *Euxesta* spp. male and female adults collected by McPhail-type traps in different sampling dates, Sete Lagoas, Brazil.

Days after plant emergence	*Euxesta eluta*		*Euxesta mazorca*	
	Male	Female	Male	Female
45	21.6 ± 9.0Ba	36.5 ± 2.8Ca	3.4 ± 0.5Aa	16.9 ± 06Ea
55	23.5 ± 2.9Ba	53.7 ± 4.0Ca	13.3 ± 1.6Aa	64.4 ± 4.6Ea
65	16.2 ± 1.3Bb	85.3 ± 7.3Ca	16.8 ± 2.1Ab	126.3 ± 17.6Da
75	154.1 ± 77.9Ac	369.6 ± 46.7Bb	44.9 ± 4.0Ad	648.8 ± 81.3Aa
85	105.1 ± 9.0Ac	772.2 ± 55.3Aa	45.2 ± 1.1Ac	451.8 ± 64.1Bb
95	8.6 ± 1.1Bb	57.16 ± 4.1Cb	16.5 ± 0.6Ab	118.2 ± 10.6Da
105	10.5 ± 1.2 Bb	73.9 ± 2.0Ca	8.9 ± 3.3Ab	144.6 ± 44.7Da
115	21.7 ± 1.7Bc	121.3 ± 5.0Cb	12.25 ± 3.6Ac	243.4 ± 29.5Ca
125	25.8 ± 1.7Bb	121.2 ± 8.7Ca	12.6 ± 4.1Ab	168 ± 67.7Da
Average	43.05c	187.9b	19.3c	220.3a

Means followed by the same uppercase letter in columns and lowercase letter in rows do not differ significantly by Scott-Knott test ($P < 0.05$).

insecticide. The latter two means did not differ significantly from each other. Owens *et al* (2016a) reported positive effect in preventing damage to corn cob due to fall armyworm, *S. frugiperda* and ulidiid flies after spraying a chemical mixed with food attractant.

For *E. mazorca*, the highest number of females was observed in the traps containing only the food attractant (357.8 females). This mean differed significantly from the others. There was no significant difference between the means of females caught in traps with the chemical, whose values were, in increasing order of dose, 191.2, 177.9, and 154.1 females per trap. In comparative terms, considering the means of females of these three treatments (174.4 females), traps with only the food attractant captured twice as many females.

Considering all insects regardless of sex and species, there was clearly a negative effect of adding the chemical to the food attractant, probably due to repellency (Table 3). Considering data from all sampling times, the mean number of captured insects in control (168.2 insects) was significantly higher than the mean number in the traps with the addition of insecticide (100.6 insects).

The females of *E. mazorca* accounted for 92.35% of the total number of individuals caught in this species (25,764), whereas for the *E. eluta* species, they represented 81.35% of the total of 24,938 individuals captured. Figure 2 shows the total number of insects from both species and in each sampling time, considering all traps. Sixty-one percent of the total number of females was caught between the fourth and fifth sampling dates, that is, a high incidence in the target area at the time of maize flowering. Before the period of greatest capture, the number of females represented only 10.44% of the total; in the last four evaluations, this value was 28.51%.

Regarding females, we can see the rapid increase in the number of collected insects starting from the third sampling date, with *E. mazorca* reaching its population peak before *E. eluta*. Overall, the number of females was impressive for both species considering the size of the sweet corn planting.

Removal of the pests would only have practical value if there was a significant reduction in the damage caused to the ears. The results shown in Tables 4 and 5 indicate that there was no significant difference in production variables or in the mean damage caused by the pest regardless of the attack site. There was no significant difference in cob weight and length, insect damage at the tip or in middle of the cob, or in grain

Table 2 Mean number (± SE) of *Euxesta* spp. male and female adults collected by McPhail-type traps with different treatments, Sete Lagoas, Brazil.

Treatment	*Euxesta eluta*		*Euxesta mazorca*	
	Male	Female	Male	Female
Bio Anastrepha	46.4 ± 5.3Ac	239.4 ± 31.6Ab	29.3 ± 3.6Ac	357.8 ± 42.2Aa
Bio Anastrepha + 1.5 mL	26.3 ± 3.2Ab	204.4 ± 28.2Aa	16.2 ± 1.9Ab	191.2 ± 25.5Ba
Bio Anastrepha + 2.25 mL	36.1 ± 4.8Ab	154 ± 20.2Ba	16.7 ± 1.9Ab	177.9 ± 21.6Ba
Bio Anastrepha + 3.0 mL	63.4 ± 9.8Ab	153.7 ± 21.6Ba	15.2 ± 1.8Ab	154.1 ± 20.6Ba
Average	43.1 ± 7.9c	187.9 ± 20.9 b	19.3 ± 3.7c	220.3 ± 46.2a

Means followed by the same uppercase letter in columns and lowercase letter in rows do not differ significantly by Scott-Knott test ($P < 0.05$).

Table 3 Mean number (± SE) of *Euxesta* spp. adults collected by McPhail-type traps with different treatments in different sampling times, Sete Lagoas, Brazil.

Days after plant emergence	Treatments (food attractant + amount of insecticide)				Average
	Bio Anastrepha®	Bio Anastrepha® + 1.5 mL	Bio Anastrepha® + 2.25 mL	Bio Anastrepha® + 3.0 mL	
45	33.1 ± 10.0Ba	16.1 ± 6.6Ba	13.7 ± 5.7Ba	15.5 ± 6.0 Ba	19.6 D
55	79.2 ± 25.1Ba	23.2 ± 8.7Ba	31.7 ± 9.7Ba	20.9 ± 5.8Ba	38.7D
65	100.2 ± 45.9Ba	58.5 ± 25.9Ba	61.1 ± 25.4Ba	24.9 ± 11.4Ba	61.2D
75	392.7 ± 209.5Aa	334.7 ± 171.6Aa	211.7 ± 92.9Ab	278.3 ± 107.7Ab	304.4B
85	438 ± 196Aa	315.7 ± 163.9Ab	285.2 ± 139.9Ab	335.6 ± 182.6Ab	343.6A
95	78.2 ± 43.4Ba	44 ± 22.4Ba	37.66 ± 21.9Ba	32.41 ± 16.9Ba	50.2D
105	108.9 ± 71.7Ba	44.8 ± 22.4Ba	40.8 ± 18.1Ba	43.5 ± 20.8Ba	59.5D
115	114.2 ± 57.5Ba	88.6 ± 45.4Ba	120.3 ± 73.5Ba	75.6 ± 42.0 Ba	99.7C
125	169.6 ± 97.7Ba	60.3 ± 25.8Bb	59.5 ± 28.8Bb	38.3 ± 19.4Bb	81.9C
Average	168.2a	109.5b	96.2b	96.2b	

Means followed by the same uppercase letter in columns and lowercase letter in rows do not differ significantly by Scott-Knott test ($P < 0.05$).

weight, regardless of the distance between the trap and the evaluated plant. The results obtained here indicate that the use of McPhail traps containing the attractive food can be used as a pest control strategy in maize providing a grain of fundamental quality for both the canning industry and the fresh market.

Discussion

Euxesta spp. can cause significant injuries that occur even when insecticides are used, and infestations in ears above 30% usually result in batch rejection in the sweetcorn market for industrial processing (Cruz *et al* 2011; Kalsi 2011).

The reduction of damage caused by *Helicoverpa* larvae, one of the main insect pests of the sweet corn ear, as a consequence of the overall management of Lepidoptera through the release of the egg parasitoid *Trichogramma pretiosum* in the target area should also be considered as a factor influencing the lower damage index attributed to the corn ear fly. These flies frequently use the damage caused by other insects to increase their attack on corn cobs (Cruz *et al* 2011). According to Kalsi (2011) and Kalsi *et al* (2014), the

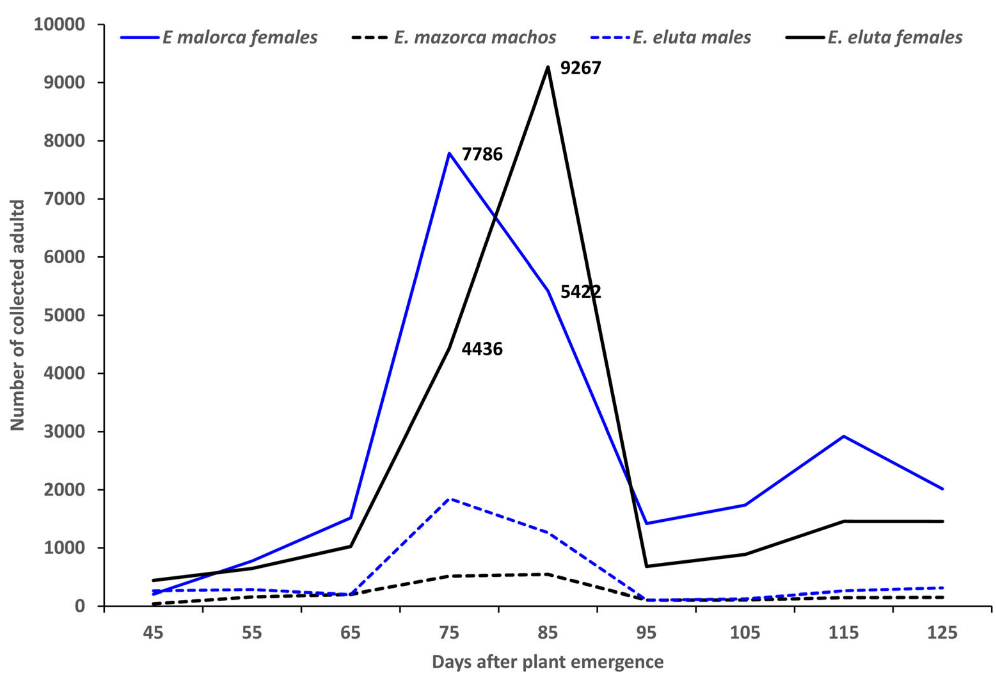

Fig 2 Total number of *Euxesta mazorca* and *Euxesta eluta* male and female adults collected in 12 McPhail-type traps, Sete Lagoas, Brazil.

Table 4 Damage (± SE) in the middle or at the tip of cobs (length of damage in centimeters) of sweet corn in function of a food attractant solution on McPhail traps used to monitor *Euxesta* spp. Sete Lagoas, Brazil.

Food attractant (FA) + insecticide dose	Damage in the middle of cobs (cm)[1]			Damage at the tip of cobs (cm)[1]		
	Trap distance (m)					
	1	10.2	15	1	10.2	15
FA	1.7 ± 1.1Aa	1.6 ± 1.1Aa	1.8 ± 0.8Aa	1.1 ± 0.2Aa	0.8 ± 0.3Aa	0.8 ± 0.2Aa
FA + 1.5 mL	1.4 ± 0.4Aa	0.8 ± 0.1Aa	1.5 ± 0.9Aa	0.9 ± 0.4Aa	0.5 ± 0.4Aa	0.9 ± 0.2Aa
FA + 2.25 mL	1.3 ± 0.4Aa	1.2 ± 0.6Aa	1.1 ± 0.1Aa	0.9 ± 0.4Aa	1.1 ± 0.5Aa	0.7 ± 0.2Aa
FA +3.0 mL	0.9 ± 0.1Aa	1.2 ± 0.4Aa	0.6 ± 0.1Aa	1.0 ± 0.5Aa	0.8 ± 0.3Aa	1.0 ± 0.2Aa

[1] Means followed by the same uppercase letter in columns and lowercase letter in rows do not differ significantly by Scott-Knott test (*P* < 0.05).

decrease in *H. zea* infestation results in less attraction and consequent reduction of the ear fly. In fact, adult females can easily enter the ears to feed and lay eggs after previous damage by corm earworm (Matrangolo *et al* 1998). Nuessly *et al* (2007) reported that ears containing damage caused by *S. frugiperda* on straw, style-stigma, and grains were more damaged by *E. stigmatias* larvae than ears without damage.

As already pointed out, corn silk fly is a limiting factor in the production of sweet corn, whether for *in natura* or processed consumption. Unfortunately, there is still little information about different biological aspects of this pest, including about the species that occur in Brazil. Among the few papers published in the country about this subject, almost all mention the presence of *Euxesta eluta* in corn crops, without, however, indicating any management strategy.

In a recent work, Cruz *et al* (2011) reported the presence of *E. mazorca* in the country. In this work, the authors demonstrated the feasibility of monitoring adult insects using McPhail-type traps containing food attractants, especially the hydrolyzed maize protein, Bio Anastrepha®. Such a procedure has been used to monitor additional species (Lasa et al 2015, Owens et al 2017). As the genus *Euxesta* has similarities with insects belonging to other genera, especially those that encompass true fruit flies, the results demonstrated by Cruz *et al* (2011) and in this work suggest the possibility of using this technology in sweet corn production systems, although further studies are required. In this work, we distributed 12 traps in an approximate area of 8000 m^2 containing about 35,000 plants. The total number of caught insects was 51,051. Of those, 44,082 were females, directly responsible

Table 5 Cob weight, grain weight and cob length of sweet corn in function of food attractant solution on McPhail traps used to monitor *Euxesta* spp. Sete Lagoas, Brazil.

Food attractant (FA) + insecticide dose	Trap distance (m)		
	1	10.2	15
	Cob weight (g)[1]		
FA	45.3 ± 9Aa	46.6 ± 7Aa	40.3 ± 5Aa
FA + 1.5 mL	41.8 ± 3Aa	41.6 ± 4Aa	43.9 ± 6Aa
FA + 2.25 mL	50.8 ± 3Aa	40.6 ± 4Aa	45.5 ± 6Aa
FA + 3.0 mL	45.6 ± 5Aa	40.3 ± 6 Aa	47.1 ± 6Aa
	Grain weight (g)[1]		
FA	28.6 ± 6Aa	30.1 ± 4Aa	26.1 ± 2Aa
FA + 1.5 mL	25.8 ± 1Aa	23.2 ± 3Aa	26.3 ± 5Aa
FA + 2.25 mL	30.13 ± 1Aa	23.4 ± 3Aa	26.4 ± 4Aa
FA + 3.0 mL	27.7 ± 3Aa	23.8 ± 5Aa	26.8 ± 4Aa
	Cob length (cm)[1]		
FA	12.2 ± 1Aa	12.4 ± 1Aa	11.8 ± 1Aa
FA + 1.5 mL	11.6 ± 0Aa	12.3 ± 0Aa	11.8 ± 1Aa
FA + 2.25 mL	14.0 ± 3Aa	11.6 ± 0Aa	11.9 ± 0Aa
FA + 3.0 mL	12.0 ± 0Aa	11.4 ± 0Aa	11.9 ± 0Aa

[1] Means followed by the same uppercase letter in columns and lowercase letter in rows do not differ significantly by Scott-Knott test (*P* < 0.05).

for the population growth of the pest and, therefore, for potential damages on the crop, initiated when laying eggs on the plants.

According to Frías (1978), *E. eluta* begins oviposition at 11.5 and 6.4 days after adult emergence at 16° and 25°C, respectively. Under these same conditions, the egg to adult cycle is 55.8 and 28.3 days. The insect lays eggs preferentially based on silks of more developed ears, in places protected by husk. The author also points out that oviposition can also occur in areas of fermentation caused by caterpillars, that is, at the tip of the cob; or in exit holes of developed caterpillars, usually in the middle or the base of the cob. According to Seal and Jansson (1978), *E. stigmatias* larvae have preference for the tip (58.8%) than to the middle (20.4%) and the base of the cob (20.4%). On the other hand, the preferred place to become a pupa is mostly at the tip (83%).

The number of eggs laid by *E. eluta* at an average temperature of 25°C can reach 450 per female in an adult life of about 40 days. The highest amount of eggs can be found between the 21st and 40th days (Frias 1981). Therefore, considering that the insect has been caught in the traps before oviposition, its removal from the maize area undoubtedly means an elimination of a very significant number of offspring that could cause significant damage to production.

Although *Euxesta* sp. is a pest that attacks corn ears at reproductive stages R1 (ear formation) and R2 (milky stage) (Ritchie and Hanway 1993; Nuessly and Hentz 2004), its presence was found well before those stages, when the maize was still in V10. Our finding differs from the report of Branco *et al* (1994), which shows the appearance of *Euxesta* at the flowering stage of silk emergence. This can facilitate its handling, especially using the removal technique presented here. According to Goyal *et al* (2012), the species *Chaetopsis massyla* (Walker), *E. eluta*, and *E. stigmatias* can complete the development in different species of cultivated plants including *Brassica oleracea* L., *Capsicum chinense* Jacquin, *Capsicum annum* L., *Carica papaya* L., *Persea americana* Mill., *Raphanus sativus* L., *Saccharum officinarum* L., and *Solanum lycopersicum* L. and weed species such as *Amaranthus spinosus* L., *Portulaca oleracea* L., *Sorghum halepense* L. and *Typha* spp.; all of which are commonly present in the vicinity of corn plantations, which may help to explain the occurrence of the fly in a new plantation almost immediately, even after prolonged absence of corn plants at the site.

The presence of both species with peaks in April shows the insects' adaptability to Brazil's winter condition and complements the information of Cruz *et al* (2011), who used traps in September–October when the pest was already present in the area. As already shown, we verified the occurrence of the pest in all sampling dates, with a high concentration of females in the period that goes from silk emergence to grain filling. The two species, *E. mazorca* and *E. eluta*, were present in the area from the time of the first sampling, meaning both are potential sweet corn pests.

The peak of captured insects, males and females of both *E. eluta* and *E. mazorca*, matches the period of flowering and grain filling of the maize crop, which can be explained by the female being attracted by the ear silk, preferred locus for oviposition. The presence of the insect, even in smaller numbers than the found at the peak of occurrence, can mean a potential problem to produce sweet corn, especially in the case of weekly production demanded by the processing industry.

The use of McPhail traps may be a suitable alternative to manage the population of *E. eluta* and *E. mazorca* in maize especially in the case of canned sweet corn, considering that the production is in relatively small areas and planted and staggered throughout the year. The experiment used 12 traps on approximately 0.8 ha. In addition, considering the relatively low cost of using the McPhail trap with the attractive food and higher relative value of sweet corn for the canning industry, and the lack of other efficient and environmentally friendly control techniques, the technology presented here is an interesting alternative to the Brazilian farm producing sweet corn.

The removal of *Euxesta* sp. females by using McPhail traps containing hydrolyzed corn protein (Bio Anastrepha®) in the sweet corn production area to the point of significantly reducing the damage that would be caused by pest larvae suggests that the technique may be an important contribution to pest management, considering the low efficiency of spraying with chemicals and the risk of grain residues above legal limits.

Production of sweet corn for agribusiness in Brazil is generally staggered according to the size of the processing plant. Possible adjustments should be necessary especially for areas larger than the one used in the experiment. This fact is important because in Brazil, there is a great pressure from society against the use of chemicals in agriculture and especially when there are risks of residues in the human consumption product such as sweet corn. Similarly, there are also barriers to the consumption of genetically modified maize (Bt maize). However, even with these facts, a comparison of traps with other methods will serve to evaluate their usefulness as an important method of fly control in sweet corn.

For a planted area of 0.8 ha, the removal of 51,051 insects, most of them females, was enough to prevent damage to the ear, thus ensuring the quality of the product delivered to the processing industry. Without elimination of such females from the field, their offspring considering a fecundity of 450 eggs per female would certainly be very high. On the other hand, a low insect population in the field could be further, reduced by the presence of natural biological control agents such as the predator species *Zelus longipes* (L.) (Hemiptera: Reduviidae) and *Orius insidiosus* (Say) (Hemiptera: Anthocoridae) as reported by Kalsi *et al* (2014) and very common in Brazil.

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