Influence of the simultaneous use of pheromonic sources on the capture of *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) and *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) on cotton

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ABSTRACT

Field studies were conducted, in order to evaluate capture parameters of the cotton pink bollworm, Pectinophora gossypiella *(Saunders) (Lepidoptera: Gelechiidae), and the American bollworm,* Helicoverpa armigera *(Hübner) (Lepidoptera: Noctuidae) when pheromonic lures of these two species are used simultaneously in the same trapping device. These two species were monitored by using funnel traps and Pherocon 1C adhesive traps, in an experimental field in the region of Polydamas, Thessaly, and central Greece during the 2002 growing season. Funnels were proved significantly more efficient for the capture of* H. armigera *when compared to Pherocon 1C traps. On the contrary, both traps were equivalent in monitoring* P. gossypiella. *For both trap types, no significant differences were recorded for* H. armigera *males between traps, which were baited with the* H. armigera *pheromone only, and traps, which were baited with this pheromone and the pheromone of* P. gossypiella. *However, in the case of* P. gossypiella, *approximately five times more adults were captured in traps baited with the pheromone of this species only, in comparison with traps, which were baited with both pheromonic sources.*

Introduction

Greece is regarded as one of the main cotton productive countries in the world. Four hundred thirty thousand (430,000) ha in total, are cultivated every year, which yield more than 420,000 tons of ginned cotton (Deligeorgidis *et al.*, 2002). Each year, Greek cotton is seriously damaged by various pests (Tolis, 1988; Buchelos *et al.*, 1999; Deligeorgidis *et al.*, 2002). Among them the pink bollworm *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) and the American bollworm *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) are considered as major pests of cotton in Greece and elsewhere causing important yield losses each year (Abate, 1988; Nyambo, 1989; Hutchinson *et al.*, 1991; Dhandapani *et al.*, 1992; Henneberry and Naranjo, 1998; Athanassiou *et al.*, 2002a, b). The producers are often obliged to monitor the seasonal occurrence of these two species, by means of pheromone-baited traps, because "absolute" sampling of fruiting bodies requires time, and it is a more "laborious" method. However, much labor is needed, for developing a reliable "network" of traps, which can provide accurate estimation of these pests' presence. The adult males of these two species can be easily separated due to the differences in their body size (*H. armigera*: wing expanse: 30-40 mm, body length: 18 mm, *P. gossypiella*: wing expanse: 15-20 mm, body length: 8-9 mm). Hence, if a "multi-attractive" could be developed, baited with both pheromones, *P. gossypiella* and *H. armigera* could be monitored within the same trap. In general, when two pheromonic sources are combined, it is expected to interact by one of three mechanisms. Firstly, the combination of two sources has no effect on the capture of the two species. Secondly, the addition of another pheromone to a given species' pheromone results in a reduction of this species' response, due to repulsive action. Finally, this combination is likely to increase captures, due to a synergistic effect. The aim of our study was to investigate the influence and the potential use of traps baited with both pheromonic lures, for monitoring *P. gossypiella* and *H. armigera*.

Experimental procedure

The main experiment was carried out in the region of Polydamas (Farsala, Thessaly, Central Greece), during the 2002 growing season. Preliminary tests at the same region, during the 2001 growing season (not included in the results), indicated that, the combination of the two pheromones, the sex pheromones for *P. gossypiella* and *H. armigera*, could be used together in the same trapping device. However, a decline in the pink bollworm catches was noted, but this reduction was not assessed quantitatively, because only sticky traps were used, and poor results could be attributed to saturation of the sticky surfaces.

In the main test (2002 season), two rectangular fields, 2 km apart, approximately 150,000 m^2 each, were used for experimentation. In the first field, which was the cotton filed, the seeding was carried out on 26 of April 2002, (approximately 17 plants per meter on the row, 1 m between rows), followed by standard cultivation care. This field was surrounded by other cotton and bean fields. The second field had been planted with processing tomato on 6 April (approximately 10 plants per meter on the row, 50 cm between rows). This field was surrounded with cotton fields. In both fields, on 14 July, two trap types were suspended, in three replicates (one replicate was suspended at the central part of the tomato field, one at the central part of the cotton field and one in the peripheral part of the cotton field). These traps were a) Funnel trap (Agrisence BCS, UK) on which the moths are captured with the addition of a DDVP strip (Agrisence BCS, UK), containing 0.5 g of dichlorvos and b) Pherocon 1C trap, (Trécé Inc., USA), on which the moths are captured on an adhesive surface in the internal part of the bottom of the trap. One third of the traps were baited with a lure containing the male attractant of *P. gossypiella* (Z, Z and Z, E- 7, 11-hexadecadienyl acetate) and one third the male attractant of *H. armigera*, (Z, Z-9, 11-hexadecenal) (Agrisence BCS, UK). The rest one third of the traps was baited with both pheromones. The lures were placed in the center of the adhesive surface (at the Pherocon 1C traps) or on the internal part of the

top (of the Funnel traps).

The traps were checked for captured *P. gossypiella* and *H. armigera* adults, from 21 July until 10 November, at weekly intervals. Thus, 17 trap-checks were carried out. For both fields, on each trap check date, the traps within the same replicate were rotated clockwise, in order to minimize the influence of the individual trapping location. The distance among traps within replicates was approximately 100 m, while the distance between the two replicates in the cotton field was approximately 120 m. Each trap was suspended at a height of 0.80 m. No insecticides, chemical defoliators or plant growth regulators were applied during the experimental period. The lure was replaced every three weeks in each trap. The sticky surfaces of the traps were replaced every two weeks, or even every week, if this was considered necessary (contamination from foreign material, rain etc.).

The data were analysed by using the GLM procedure of SAS (Sall *et al.*, 2001), with captures of *P. gossypiella* and *H. armigera* as the response variables and trap type, type of pheromone and trapping location as main effects. Before the analysis, counts were transformed to log (x + 1) scale, in order to homogenize variances and standardize means. Means were separated by the Tukey-Kramer (HSD) test (Sokal and Rohlf, 1995) (at $P = 0.05$).

Results

The seasonal fluctuation of the two species is shown in Figures 1 to 4. In general, a considerably high number of *H. armigera* adults were recorded during the entire experimental period. On the contrary, P. *gossypiella* was totally absent in both trap types early in the season, and only later, pink bollworm males exceeded 8 adults/trap.

Significantly more pink bollworm adults were found in the cotton field, as compared to the tomato field (Figure 5). In fact, less than 2% of the total number of *P. gossypiella* adults captured was recorded from the tomato field. On the other hand, no significant differences were noted between traps, which were suspended at different locations of the cotton field; however, numerically more adults were found in the peripheral traps. No significant differences were recorded for *P. gossypiella* adults between the two trap designs examined (Figure 6), despite the fact that, as far as the overall data are concerned, approximately 1.3 times more adults were found in the Funnel traps, in comparison with the Pherocon 1C traps. Finally, significantly more adults were found in the traps, which were baited with *P. gossypiella* pheromone only, in comparison with the traps, which were baited with both pheromones (Figure 7). In addition, male catches in the latter traps did not differ significantly from traps that were baited only with *H. armigera*, where no pink bollworm adults were found.

In the case of *H. armigera*, no significant differences were noted among traps, which were suspended at different locations (Figure 8). On the contrary, the Funnel traps were significantly more effective than the adhesive traps, given that these traps were found to contain five times more adults (Figure 9). Furthermore, no significant differences were noted between traps, which were baited with *H. armigera* pheromone only, and traps that were baited with both pheromones (Figure 10). Surprisingly, approximately 1.5 times more adults were found in the traps baited with both pheromones.

A summary of the ANOVA statistics for the main effects and various interactions for *P. gossypiella* and *H. armigera* captures is given in Table 1.

Discussion

The comparison of different pheromone-baited trap types for the capture of the two species examined indicated that funnel traps could be used successfully for the capture of the two species examined. Funnels proved superior to adhesive traps for *H. armigera*. In addition, the high capture rate of funnels in the case of *P. gossypiella* makes this trap design more appealing, when developing monitoring or control strategies, based on trap catch, despite the fact that no significant differences were recorded between the two trap types examined. In a recent study, Athanassiou *et al.* (2002b) reported a significantly higher capture potential of the funnel traps for the pink bollworm, in comparison with adhesive traps. However, the authors stated that, different trap designs may produce different phenologies, and thus, the interpretation of trap catch may be inaccurate. The reliability of a given trap type is crucial, and much more important than capture potential (Hutchison *et al.*, 1991; Buchelos *et al.*, 1999). In general, it is expected for adhesive traps to have a lower capture rate, given that the sticky surface suffers from foreign material, saturation etc., which does not affect the efficiency of the funnels.

The selection of a suitable trapping location is essential for a representative sampling plan. The spots where trapping efficiency may be influenced by factors that make the results misleading, should be avoided. In our study, *H. armigera* males were equally distributed, apart from temporal changes, in the cotton and the tomato fields. This was expected, given that this species has an extremely large variety of food preferences including tomato (Abate, 1988; Judal and Upadhyay, 1989; Broza and Sneh, 1994). In addition, this species had not indicated a specific "preference" to the peripheral parts of the cotton fields. On the contrary, *P. gossypiella* males were scarce in the non-cotton crop, while captures at the within-field peripheral zone was rather increased. Leggett *et al.* (1994)

have also reported similar results about the influence of the field peripheral zones. In addition, evidence that this behavior is manifested in traps placed in non-cotton crops in the vicinity of cotton fields is recorded by Manley (1987). Athanassiou *et al*. (2002b) also noted that, despite the fact that no significant differences were noted with the centrally located traps, more adults were found at the peripheral outlines of the cotton fields. This stands in accordance with the results of the present study, including the fact that this "edge" effect results in a higher variation of captures. Hence, when a small number of traps is used for monitoring pink bollworm's seasonal activity, the peripheral outlines must be avoided because moth captures are likely to be varied, as compared to the more centrally located traps on which moth counts are more stable (Athanassiou *et al.*, 2002b).

The most interesting finding of the present study is the influence of the simultaneous use of pheromonic sources into the same trapping device. In the case of *H. armigera*, the addition of *P. gossypiella* pheromone did not affect male catches. In fact, a small "enhancement" of trapping performance was recorded, in traps containing both lures. This produced the result that *H. armigera* behaviour remains unaffected, and may be increased, by the presence of *P. gossyiella* pheromone. In contrast, pink bollworm catches are negatively influenced by the presence of the *H. armigera* pheromone, and although two-lure-baited traps did capture males, are practically ineffective for monitoring. The possible repellent action due to the presence of the other lure, or the combined volatiles of both lures, has not been investigated and needs more detailed tests in controlled conditions. These results suggest that, when these species are monitored, in regions where both species are "key" pests of cotton (such as in Greece), the pheromone-baited traps for each species must be placed at a certain distance and not very close, because otherwise pink bollworm numbers captured are likely to be reduced and not representative of its phenology. From our own observations in Greek cotton fields, often the producers or trap inspectors place the traps for these two species extremely close, and usually, at the "edge" of the fields, for easy access during inspection. According to our results, this may be fatal for a monitoring system, which is used as a decision tool. Hence, these parameters must be seriously taken into account, and this way of trap placement should be avoided. Further experimental work is needed, in order to assess the "active spaces" of pheromonic stimuli, when both pheromone sources are present.

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Table 1. *ANOVA statistics for main effects and various interactions, for* P. gossypiella *and* H. armigera *captures (total* df = *304).*

		P. gossypiella		*H. armigera*	
Source	*df*	*F*	*P*	*F*	*P*
Location	2	4.19	0.0160	0.23	0.7894
Trap type	1	1.08	0.2982	33.40	<0.0001
Pheromone	2	10.13	<0.0001	20.87	<0.0001
Location * Trap	2	0.62	0.5363	0.23	0.7894
Location * Pheromone	4	2.25	0.0629	1.43	0.2232
Trap * Pheromone	2	2.35	0.0969	11.84	<0.0001

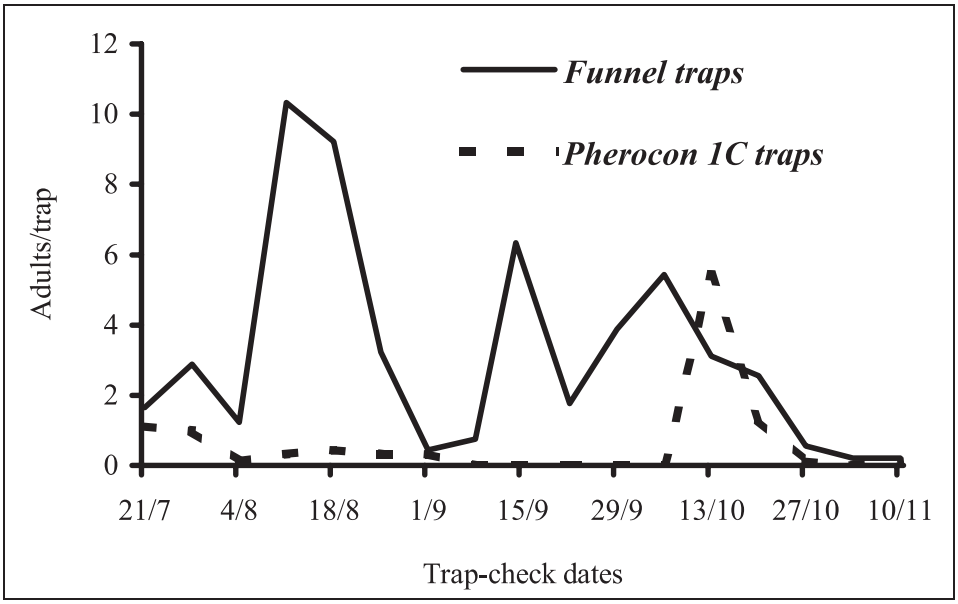

Figure 1. *Mean number of* H. armigera *adults per trap, on each trap type, during the experimental period.*

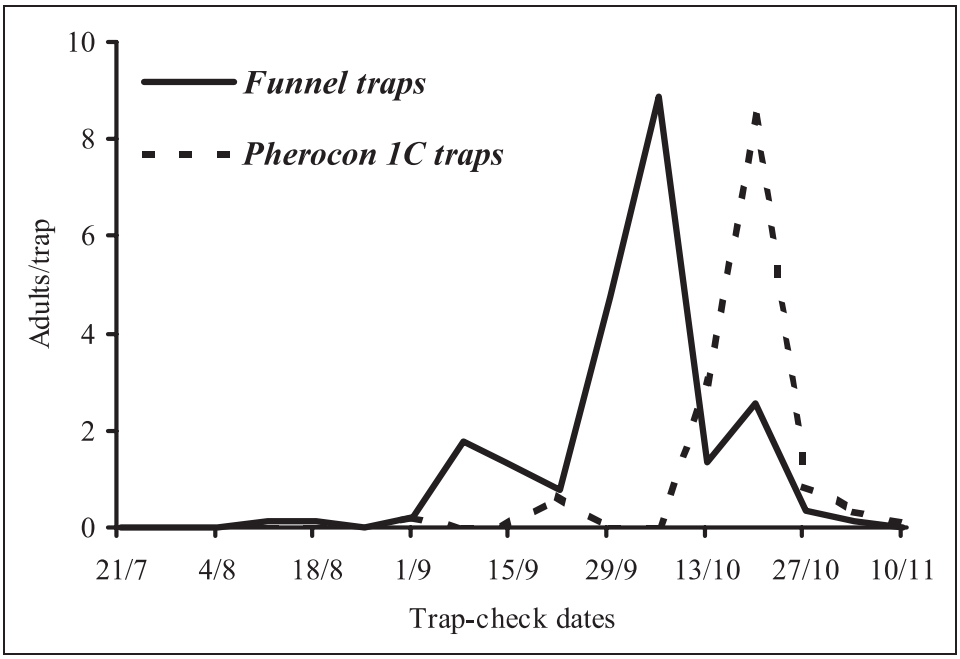

Figure 2. *Mean number of* P. gossypiella *adults per trap, on each trap type, during the experimental period.*

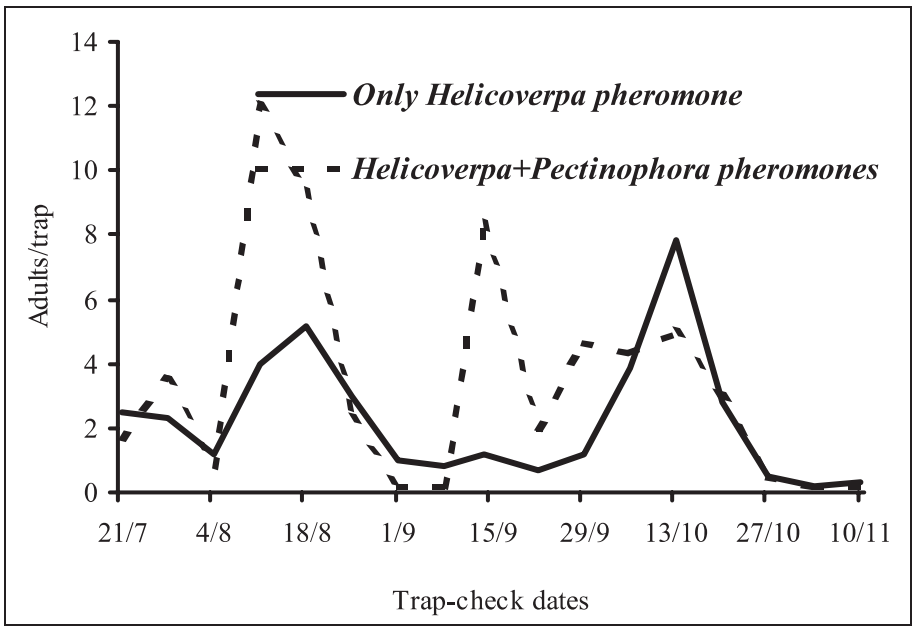

Figure 3.
Mean number of H. armigera *adults per trap, on traps baited with different lure combination, during the experimental period.*

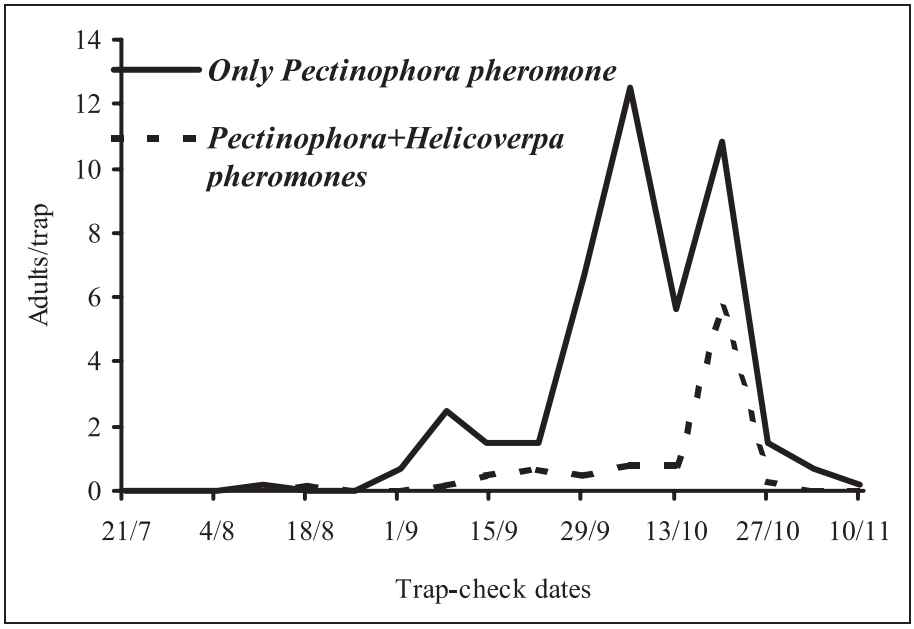

Figure 4.
Mean number of P. gossypiella *adults per trap, on traps baited with different lure combination, during the experimental period.*

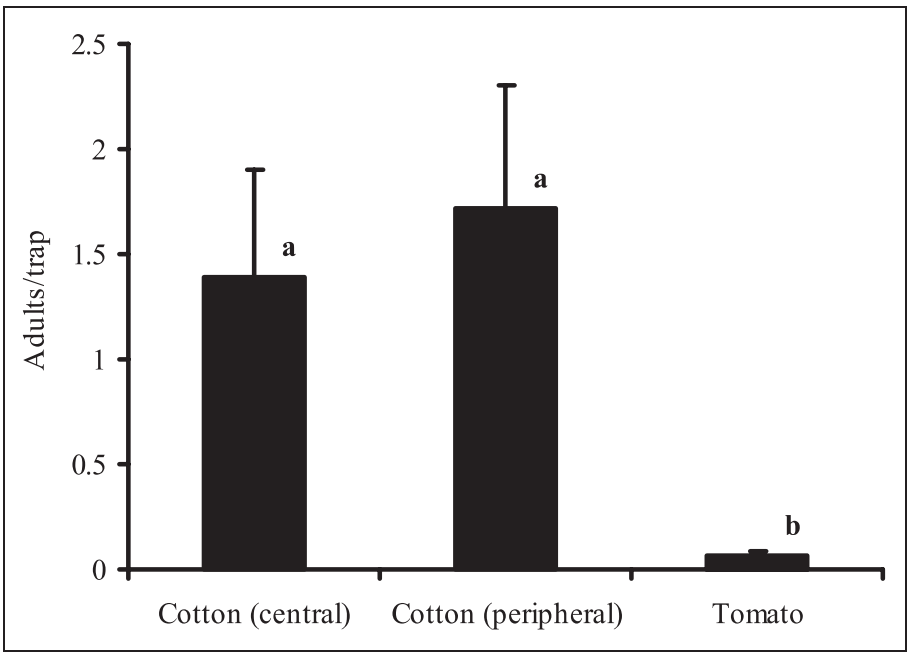

Figure 5.
Mean number (± SE) of P. gossypiella *adults per trap, on each trapping location (means followed by the same letter, are not significantly different; HSD test at P=0.05).*

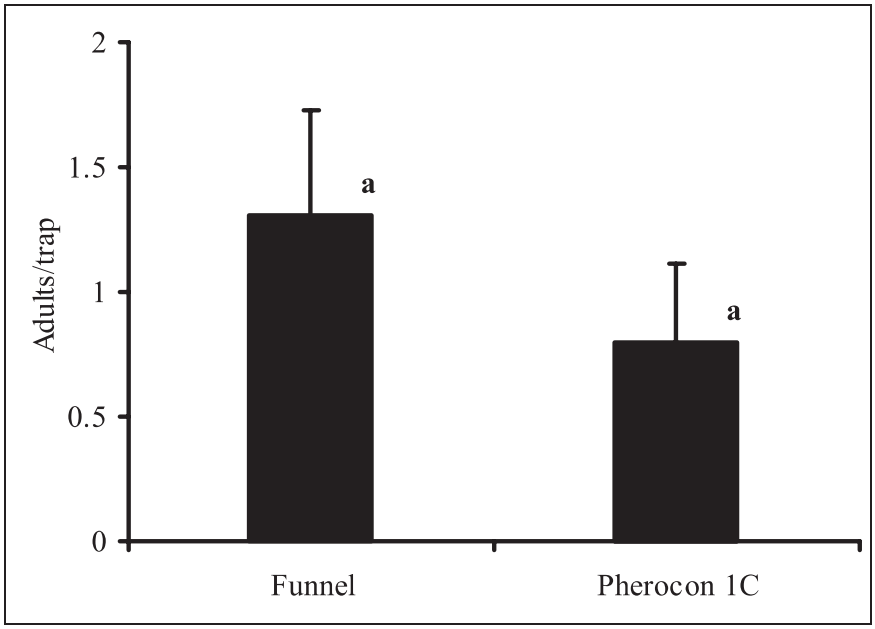

Figure 6.
Mean number (± SE) of P. gossypiella *adults per trap, on each trap design (means followed by the same letter, are not significantly different; HSD test at P=0.05).*

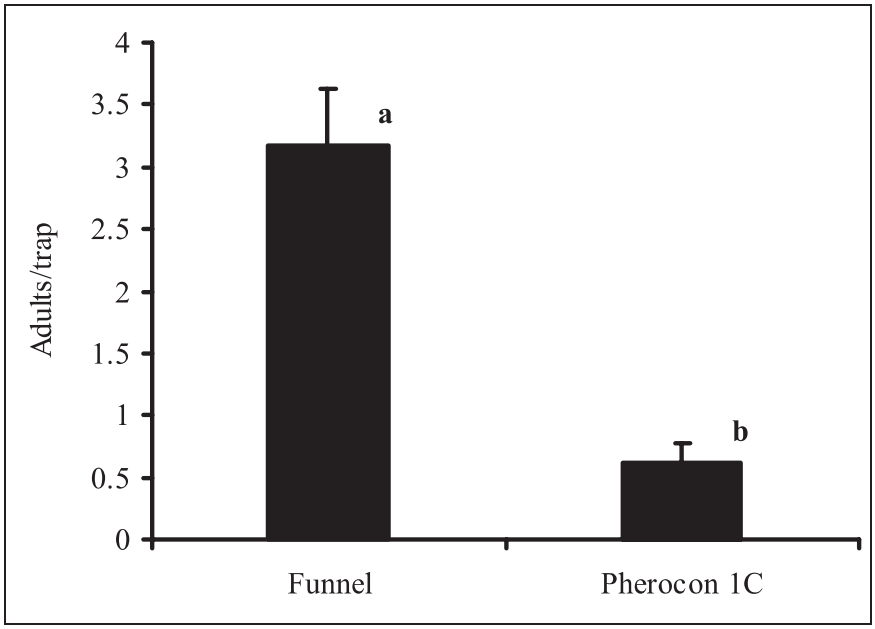

Figure 7.
Mean number (± SE) of P. gossypiella *adults per trap, on traps baited with different lures (means followed by the same letter, are not significantly different; HSD test at P=0.05).*

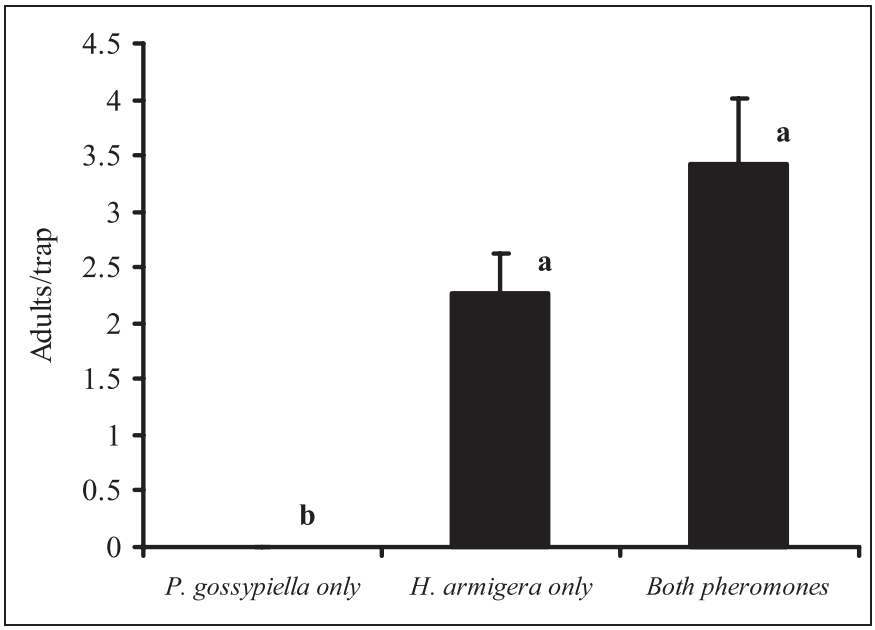

Figure 8.
Mean number (± SE) of H. armigera *adults per trap, on each trapping location (means followed by the same letter, are not significantly different; HSD test at P=0.05).*

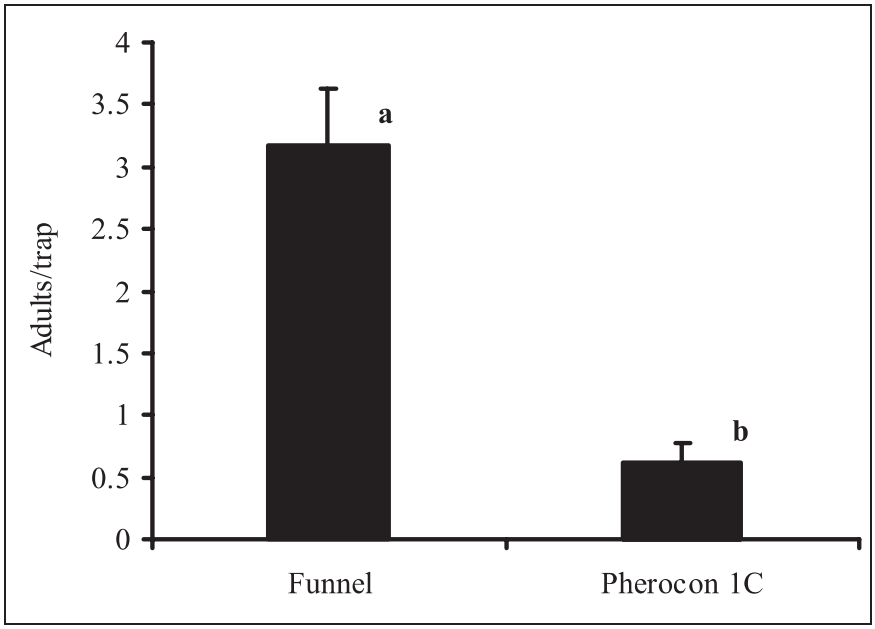

Figure 9.
Mean number (± SE) of H. armigera *adults per trap, on each trap design (means followed by the same letter, are not significantly different; HSD test at P=0.05).*

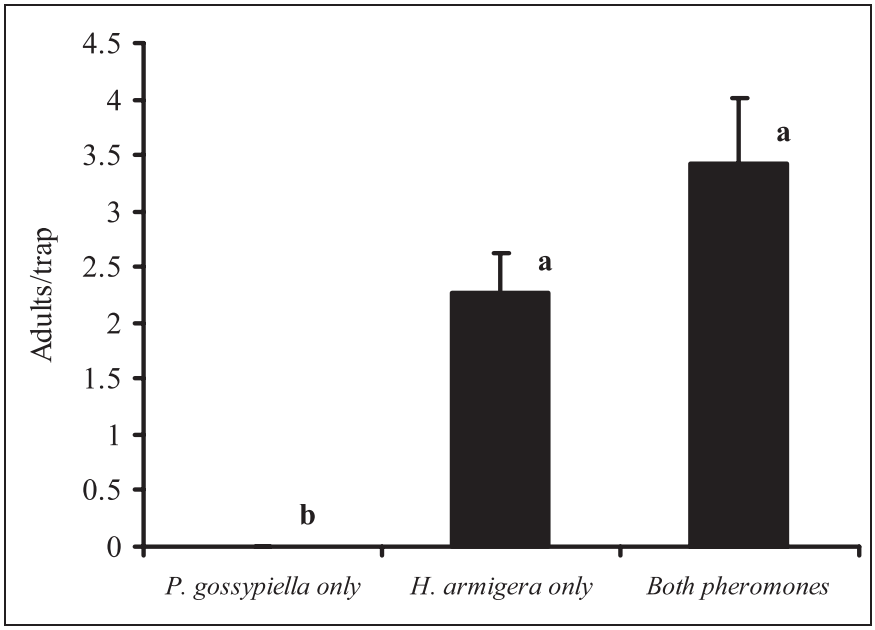

Figure 10.
Mean number (± SE) of H. armigera *adults per trap, on traps baited with different lures (means followed by the same letter, are not significantly different; HSD test at P=0.05).*