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Chemical Attractants for Females of Pest Pyralids and Phycitids (Lepidoptera: Pyralidae, Phycitidae)

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In field trapping tests conducted in Hungary large numbers of *Pyralis costalis* F. (Lepidoptera: Pyralidae), a secondary pest, were attracted to traps baited with iso-amyl alcohol (3-methyl-1-butanol) and acetic acid. The same bait attracted lower numbers of *P. farinalis* L., a well-known stored product pest. In both spp. the capture of the two-component blend was significantly higher than the catch in traps with the single components. In tests conducted in a country mill, the blend of the above two compounds proved to be attractive towards *Anagasta kuehniella* Zell. and *Plodia interpunctella* Hbn. (Lepidoptera: Phycitidae), both important pests of stored products worldwide. The majority of captured insects were females. The optimal ratio for attracting *A. kuehniella* was 1:1 to 1:10 iso-amyl alcohol:acetic acid. The related iso-amyl acetate was inactive. The addition of iso-butyl alcohol (2-methyl-1-propanol) did not influence activity of the iso-amyl alcohol / acetic acid blend. Polyethylene dispensers with 0.2 ml of the blend started to loose activity only after 3 weeks of field exposure. Application possibilities of the newly discovered attractant are discussed.

Keywords: female attractant, iso-amyl alcohol, acetic acid, *Anagasta kuehniella, Plodia interpunctella, Pyralis costalis, Pyralis farinalis,* Lepidoptera, Pyralidae, Phycitidae.

Pheromone traps are widely used for detection and monitoring of many insect pests all over the world. One disadvantage of such traps in case of Lepidoptera is that they attract only the males and females remain unaffected. To overcome this difficulty, recent efforts to define attractants active towards the females resulted in the identification of several short-chain alcohols, which, in the presence of acetic acid attracted both females and males of several noctuid pests in North America (Landolt, 2000). Our tests were started to check whether the componds described by Landolt (2000) were also attractive towards species of the European noctuid fauna. In the course of the tests many noctuids were captured (a detailed report will be published elsewhere), but, to our surprise, also several pest microlepidoptera belonging to the Pyralidae and Phycitidae families were attracted. In the present report we describe results concerning pyralids and phycitids.

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Materials and Methods

Baits

For bait dispenser a 1 cm piece of dental roll (Celluron®, Paul Hartmann Ag. Heidenheim, Germany) was put into a tight polythene bag made of 0.02 mm linear polyethylene foil. The dispenser was attached to 8 × 1 cm plastic handle for easy handling when assembling the traps. For making up the baits 0.1 ml of each compound was administered onto the dental roll and the opening of the polythene bag was heat sealed. Dispensers were wrapped singly in pieces of alufoil and were stored at –30 °C until use.

Acetic acid, iso-amyl alcohol (3-methyl-1-butanol), iso-butyl alcohol (2-methyl-1-propanol) and iso-amyl acetate were purchased from Reanal Finechamicals Co. (Budapest, Hungary) and were >95% pure as stated by the supplier.

Traps

The RAG traps were the sticky "delta" design normally used in Hungary for trapping moth species (Szőcs, 1993; Tóth and Szőcs, 1993). The trap body consisted of a transparent plastic sheet (23 × 36 cm), folded into a triangular prism (length 23 cm, all three sides 12 cm) with the two ends open. The pheromone bait was suspended centrally inside the trap. Insects entering the trap were captured on a replaceable sticky insert (16 × 10 cm) which was placed on the floor of the trap body. For preparing sticky traps in this study, TangleTrap® insect adhesive (TangleFoot Co., Grand Rapids, USA) was used.

VARL traps were plastic funnel traps produced by the Plant Protection Institute, Budapest (Hungary), except that a plastic panel (20 × 20 × 0.4 cm) was placed as a roof horizontally above the opening of the funnel. The bait dispenser was attached below the plastic roof so that the attractant-containing part was hanging into the middle of the opening of the funnel. Funnel entrance was 13 cm (i.d.), hole of funnel was 3 cm (i.d.), height ot funnel was 10 cm. Moths falling down through the funnel were caught in a ca 1 litre plastic container.

Trapping tests

Trapping tests were conducted at several sites in Hungary.

Traps were set up in blocks. Each block was comprised of one of each treatment. The distance of traps within a block was 5–10 m (in open field) or 4–5 m (inside mill). The distance between blocks ranged between 50–100 m (in open field) or 10–15 m (inside mill). Traps were moved one position forward within a block at each occasion when the traps were inspected; at the same time, captured insects were recorded and removed. Moths captured were sexed by investigating the tip part of their abdomens for the presence of ovipositors (females) or claspers (valvae; males).

Capture data were transformed to $(x+0.5)^{1/2}$ and were analysed by ANOVA. Treatment means were separated by Games-Howell test (Games and Howell, 1976). When only two treatments were compared, the Student *t*-test (unpaired) was used. In case one of the treatments was catching nil, the difference of the catch of other teatments from zero catch was analysed pairwise by one-sample *t*-test.

All statistical procedures were conducted using the software packages StatView® v4.01 and SuperANOVA® v1.11 (Abacus Concepts, Inc., Berkeley, USA).

Description of single trapping tests

PRELIMINARY FIELD SCREENING TESTS FOR CATCHING PYRALIDS

2000 May 19–July 27; Agárd, Fejér county, Hungary; hedge with mixed bushes between sunflower and maize fields; RAG traps. Traps were inspected twice weekly over 69 days, providing 38 data points (19 inspections of 2 block replicates).

2000 May 19–August 3; Halásztelek, Pest county, Hungary; cherry orchard; RAG traps. Traps were inspected twice weekly over 76 days, providing 44 data points (22 inspections of 2 block replicates).

ATTRACTIVE ACTIVITY FOR PHYCITIDS IN A COUNTRY MILL

2000 September 23–October 16; Seregélyes, Fejér county, Hungary; country mill; RAG traps. Traps were inspected twice weekly over 23 days, providing 24 data points (6 inspections of 4 block replicates).

2000 October 9–October 20; Seregélyes, Fejér county, Hungary; country mill; VARL traps. Traps were inspected twice weekly over 11 days, providing 12 data points (3 inspections of 4 block replicates).

OPTIMAL RATIO OF COMPONENTS FOR PHYCITIDS

2001 May 28 – July 19; Seregélyes, Fejér county, Hungary; country mill; VARL traps; baits were replaced on June 11, 21 and July 9. Traps were inspected twice weekly over 52 days, providing 30 data points (15 inspections of 2 block replicates).

ACTIVITY OF ISO-AMYL ACETATE FOR PHYCITIDS

2001 October 4 – 19; Seregélyes, Fejér county, Hungary; country mill; VARL traps. Traps were inspected twice weekly over 15 days, providing 16 data points (4 inspections of 4 block replicates).

INFLUENCE OF ADDITION OF ISO-BUTYL ALCOHOL FOR PHYCITIDS

2001 July 23 – August 2; Seregélyes, Fejér county, Hungary; country mill; VARL traps. Traps were inspected twice weekly over 10 days, providing 18 data points (3 inspections of 6 block replicates).

LONGEVITY OF DISPENSERS IN A COUNTRY MILL

2001 August 6 – September 7; Seregélyes, Fejér county, Hungary; country mill; VARL traps. In half of the traps the same dispenser was left in throughout all the test. In the other half dispensers were replaced by fresh ones weekly. Traps were inspected twice weekly, providing 12 data points per week (2 inspections of 6 block replicates).

Results and Discussion

In the field screening tests at both sites large numbers of *Pyralis costalis* F. (Lepidoptera: Pyralidae) were captured in traps baited with a binary mixture of iso-amyl alcohol (3-methyl-1-butanol) and acetic acid *(Fig. 1).* In the test at Agárd no moths were caught by the single compounds, while at Halásztelek negligible numbers were recorded also in traps baited with the alcohol only, not differing significantly from zero catch.

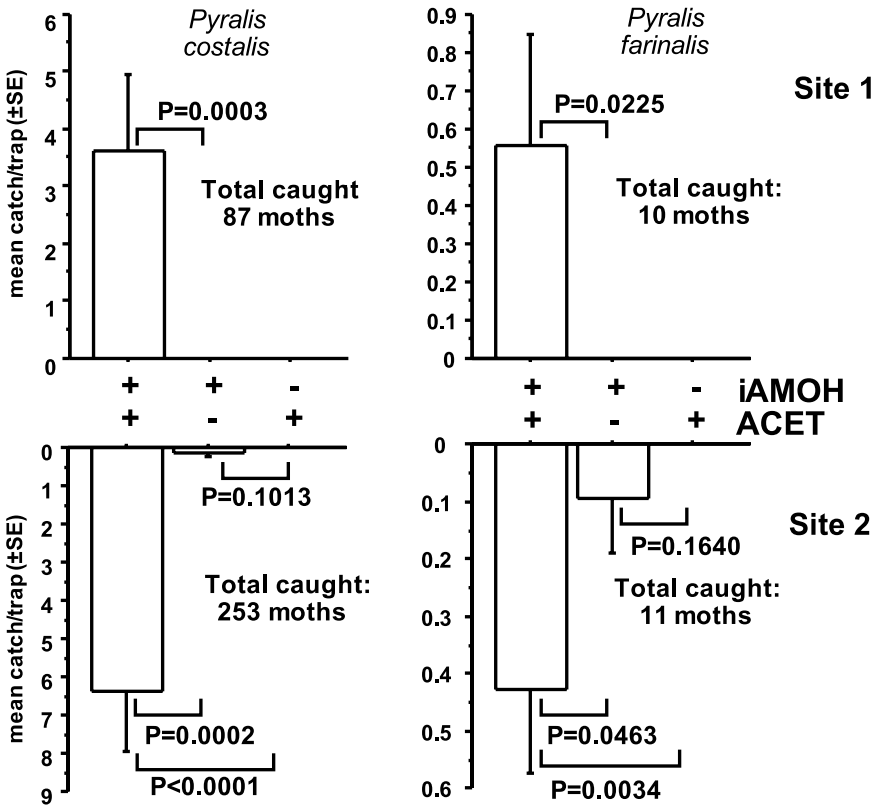

Fig. 1. Captures of pyralids in traps baited with iso-amyl alcohol, acetic acid and their mixture in field trapping tests in Hungary in 2000. Site 1 = Agárd, Fejér county; Site 2 = Halásztelek, Pest county. Abbreviations: iAMOH = iso-amyl alcohol; ACET = acetic acid; P = P value of Student's *t*-test (unpaired; in comparisons with zero catch: one-sample *t*-test)

Of randomly selected *P. costalis* specimens from the catch by the binary mixture, 90.3% and 87.3% were females (out of 31 and 55 moths caught at Agárd and Halásztelek, resp.).

Lower numbers were caught from *Pyralis farinalis* L. (Lepidoptera: Pyralidae). The trend of captures was similar to the previous case at both sites, with the binary mixture catching significantly more than any other bait *(Fig. 1).* In this case out of the 6

sexed specimens caught at Agárd, 50% were females (specimens caught at Halásztelek were not sexed).

The above results demonstrated that iso-amyl alcohol and acetic acid can be attractive not only towards noctuids, but also towards some pyralids. This evoked our interest as many important stored product pests belong to Pyralidae and related families. Also, as a chance finding we observed in another preliminary experiment which was set up in the vicinity of a small mill, that a total of 58 Mediterranean flour moths *Anagasta kuehniella* Zell. (Lepidoptera: Phycitidae) were captured in traps with a bait containing iso-amyl alcohol and acetic acid, while only 1 moth was found in unbaited traps (2000 September 12–21, Seregélyes, Fejér county, Hungary, RAG traps). This encouraged us to investigate in detail the possible attractive activity of these compounds on stored products phycitids.

In pairwise comparisons using RAG sticky traps baited with the binary mixture of iso-amyl alcohol and acetic acid and unbaited ones, the attractive activity of the mixture towards *A. kuehniella* was highly significant and clearly confirmed our preliminary results *(Fig. 2).* In this test the bait also attracted the Indian meal moth *Plodia interpunctella* Hbn.

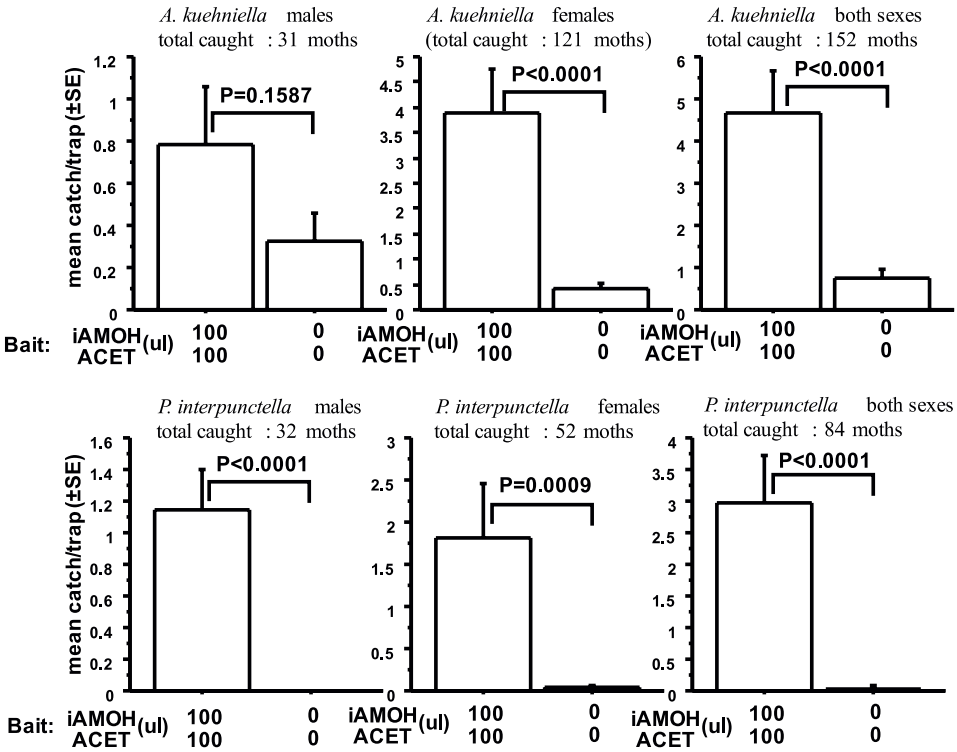

Fig. 2. Species and sex distribution of captures of phycitids in RAG sticky traps baited with a blend of iso-amyl alcohol and acetic acid and in unbaited traps in trapping tests in a country mill in 2000. Seregélyes, Fejér county, Hungary. Abbreviations: iAMOH = iso-amyl alcohol; ACET = acetic acid. Significance: see *Fig. 1*

(Lepidoptera: Phycitidae), another important stored product pest. In both phycitids the majority of the captured specimens were females (79.6% and 61.9% for *A. kuehniella* and *P. interpunctella,* resp.). Baited traps captured higher numbers in both sexes in both species than unbaited ones (in case of *A. kuehniella* males the difference was not significant, but the trend of captures was the same).

The test was repeated using VARL funnel traps also, in part for further confirmation of attractive activity of the bait, and in part because funnel traps (which have no sticky surface sensitive to dust) are more advantageous to use in a dusty environment of a mill. In fact, funnel traps baited with sex pheromone are preferred for use in mills in Hungary for detection and monitoring purposes of phycitids (Ábrahám, 1998, 2000). The results fully confirmed results obtained with sticky traps, with baited traps catching significantly higher numbers in both species *(Fig. 3).* Again, the majority of moths caught were females (68.4% and 82.6% for *A. kuehniella* and *P. interpunctella,* resp.).

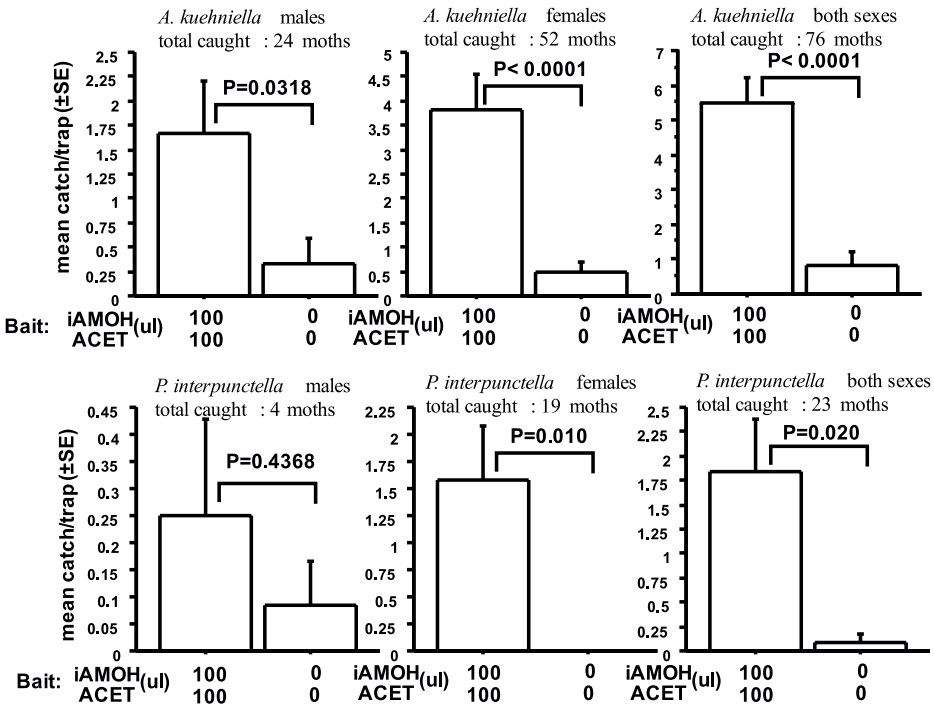

Fig. 3. Species and sex distribution of captures of phycitids in VARL funnel traps baited with a blend of iso-amyl alcohol and acetic acid and in unbaited traps in trapping tests in a country mill in 2000. Seregélyes, Fejér county, Hungary. Abbreviations: iAMOH = iso-amyl alcohol; ACET = acetic acid. Significance: see *Fig. 1*

We concluded that the binary mixture of iso-amyl alcohol and acetic acid was clearly attractive towards both females and males of both important pest phycitids.

When comparing component ratios in the bait, the catches of *A. kuehniella* females with the 1:1 and 1:10 iso-amyl alcohol:acetic acid blends were significantly higher than those of the 10:1 blend or the single compounds *(Fig. 4).* Traps baited with the single compounds and with the 10:1 blend did not catch significantly higher numbers than unbaited traps. In male *A. kuehniella* the general trend of catches was similar to that of females; again the only ratios catching significantly higher numbers than unbaited traps were the 1:1 and 1:10 blends *(Fig. 4).* In this test only few *P. interpunctella* were captured and numbers were too low to allow for a meaningful statistical analysis. However, based on the results on *A. kuehniella* in further tests the 1:1 ratio was used.

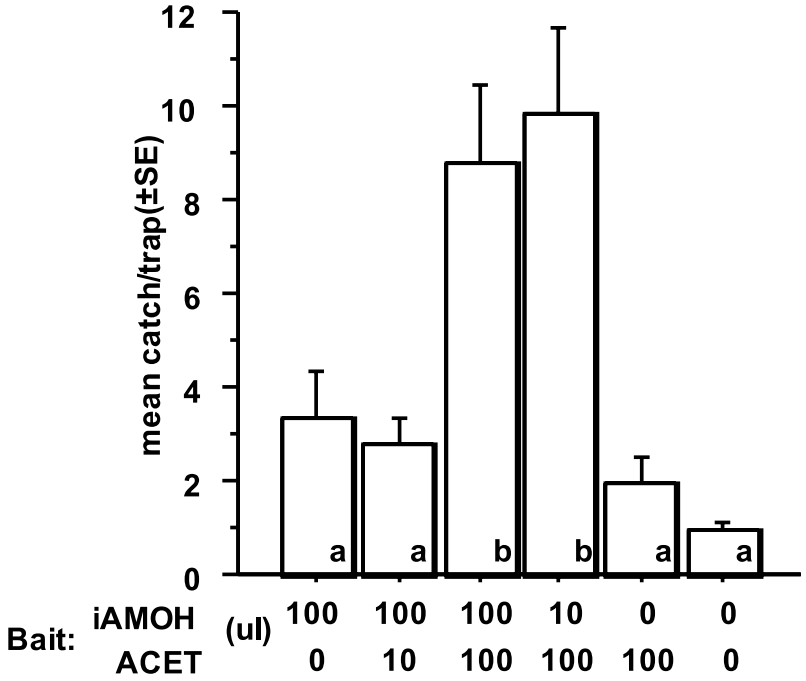

Fig. 4. Captures of *A. kuehniella* in VARL funnel traps baited with different ratios of iso-amyl alcohol and acetic acid and in unbaited traps in trapping tests in a country mill in 2001. Seregélyes, Fejér county, Hungary. A total of 756 *A. kuehniella* (61.5% females) were captured in the test. Abbreviations: iAMOH = iso-amyl alcohol; ACET = acetic acid. Significance: columns with same letter are not significantly different at P=5% by ANOVA followed by Games Howell test

When testing possible activity of iso-amyl acetate (which can dissociate to iso-amyl alcohol and acetic acid), traps baited with this compound caught 0.17±0.10 moths (mean±SE), which was not different significantly from the catch in unbaited traps (0.08±0.06 moths), but was lower than catch in traps baited with the 1:1 iso-amyl

alcohol:acetic acid blend [1.21±0.21 moths; in this test a total of 32 *A. kuehniella* (56.3% females) and only 3 *P. interpunctella* (66.7 % females) were caught]. Probably the release rate of the alcohol and the acid originating from iso-amyl acetate was not sufficient in the dispenser type we used for biological activity. We concluded that it is sufficient to use the 1:1 blend of single compounds in further tests.

The addition of iso-butyl alcohol (2-methyl-1-propanol) as third component to the 1:1 iso-amyl alcohol:acetic acid blend did not influence catches of any sex of the two species *(Table 1).* Iso-butyl alcohol in the presence of acetic acid has been described as attractant component for several yellowjackets (*Vespa* spp.) (Hymenoptera: Vespidae) (Landolt, 1998, Landolt et al., 1999, 2000), and was found to enhance captures of some noctuids to the iso-amyl alcohol / acetic acid bait in our unpublished tests.

Table 1

Influence of the addition of iso-butyl alcohol on captures of phycitids in traps baited with iso-amyl alcohol and acetic acid in 2001. Seregélyes, Fejér county, Hungary. A total of 257 *A. kuehniella* (69.3% females) and 5 *P. interpunctella* (60 % females) were caught in the test

Bait			Mean captures					
			P. interpunctella			*A. Kuehniella*		
iso-amil alcohol	acetic acid	iso-butyl alcohol	males	females	both sexes	males	females	both sexes
+	+	+	0.04	0.09	0.13	2.04	3.39	5.43
+	+	–	0.04	0.04	0.09	1.39	4.35	5.74
P value (Student *t*-test, unpaired)			not applic.	0.5607	0.6446	0.7070	0.5617	0.7758

When studying longevity of bait dispensers loaded with iso-amyl alcohol and acetic acid, captures of female *A. kuehniella* with aged dispensers (not replaced during the test) showed a tendency of decreasing, but became significantly lower than those with fresh dispensers (replaced weekly) only from the 4th week onward *(Fig. 5).* Male catches showed the same trend, but probably because of the much lower numbers caught results were not as clearcut as with females. In this test only sporadic catches of *P. interpunctella* were recorded, not sufficient for meaningful statistical analysis. We conclude on the basis of the *A. kuehniella* catches that bait dispensers can be used without apparent loss of activity during two to three weeks, which is already acceptable for practical applications.

In conclusion, iso-amyl alcohol and acetic acid, the new chemical attractants discovered in this study may show some promise in practical applications for trapping pyralid and phycitid pests. Three of the species captured *(A. kuehniella, P. interpunctella, P. farinalis)* are stored product pests of worldwide importance. The fourth species, *P. costalis* may cause some damage in stored hay and similar plant material (Mészáros, 1993). The clear advantage of the new bait over the application of sex pheromone in traps is that it is capable of attracting large numbers of females, too. Further studies are needed to show whether the female ratio captured reflects the natural sex ratio in the neighbouring population or is distorted towards females.

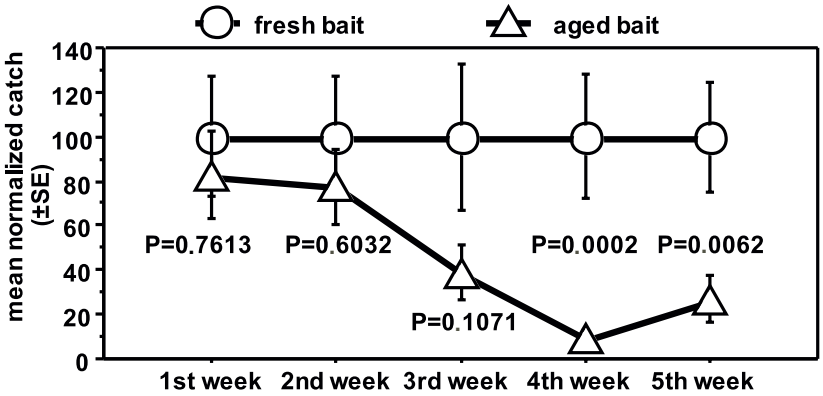

Fig. 5. Captures of *A. kuehniella* in VARL funnel traps baited with fresh (replaced weekly) or aged (not replaced throughout test) bait dispensers containing iso-amyl alcohol and acetic acid in trapping tests in a country mill in 2001. Seregélyes, Fejér county, Hungary. A total of 581 *A. kuehniella* (80.2% females) were captured in the test. P = P value of Student *t*-test (unpaired)

Another tempting opportunity may arise from applying the new attractant together with the sex pheromone, to increase efficacy of mass trapping or "lure and kill" control methods. Such control techniques using the synthetic pheromone as lure are already in use in *A. kuehniella* (Trematerra and Battaini, 1987; Trematerra and Capizzi, 1991).

Acknowledgement

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