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ANGOUMOIS GRAIN MOTH SPATIAL DISTRIBUTION IN WHEAT PHOSPHINE TREATED AND UNTREATED STORAGES MONITORED BY SEX PHEROMONE TRAPPING

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ABSTRACT

Study was conducted in two identical horizontal (flat) Storages. One of the tested storages was treated by Aluminum Phosphide (fumigant) insecticide and the other storage was untreated. An array or regular grid of pheromone traps was placed in both storages for *Sitotroga cerealella* (Olivier) moths population monitoring. Contour maps was created using Geographic Information System (GIS) ArcView® 3.2. An average of 16.014/trap *S. cerealella* moths were found during the entire sampling period in both untreated and treated (fumigated) storages. Results indicated that *S. cerealella* moth population was much higher in the untreated storage 15.838/trap during the entire study period compared to the treated storage 0.175/trap due to the great impact of phosphine treatment. Pheromone trap counts in the untreated storage indicated that the greatest mean monthly number of captured moths was 41.0/trap occurred in July, while the lowest number of captured moths was 0.2/trap recorded in December (Table 1). In comparison to the storage treated with phosphine number of trap catch was significantly low due to potential effect of the fumigant as a control method, the highest number of *S. cerealella* moths captured in pheromone traps was 0.583/trap observed in August, while zero moths was recorded in December. Contour maps illustrated that the source of moths infestation found in the center of the storage in the beginning of spring months. Subsequently, contour maps showed that the hot spot spread through the entire untreated storage during summer months. While, it was still in the center with samller number of captured moths in the treated storage. Then, in both storages infestation went back to the center of the storage during the autumn months tell reached to the lowest number of trap catch during December. Trapping provides an effective method for detecting stored product insects in buildings (e.g., warehouses, processing plants, and retail stores), and when combined with contour analysis of trap catch, it is also provides a convenient means of locating source of infestation. Trapping with contour mapping provides permanent documentation of pest problems and their management, which can be useful for decision making in the integrated pest management.

Keywords: *Sitotroga cerealella,* Aluminum Phospide, Pheromone Trapping, Contour Mapping

INTRODUCTION

Angoumois grain moth *Sitotroga cerealella* (Olivier) is one of the major insect pests of stored grain in the tropics and subtropics. Sorghum, maize, wheat, barley, and millets are the main crops infested by this pest. Infestations start in the field when crops are carried to storage facilities, immature stages from the field infestations complete their life cycles to pupate and emerged as adult in storage. Population of *S. cerealella* multiplied 112.27 times between two successive generations (Teotia and Singh 1976). *S. cerealella* female moth deposits egg inside grains with gaping or broken hulls and in the space beneath the secondary glumes. Cogburn and Bollich (1980) reported that *S. cerealella* usually found in the upper 40 cm layer of the grain. Phosphine is the most widely used fumigant for disinfesting and stored grain. Phosphine considered the only fumigant available for this purpose in many countries (Waterford *et al.* 1994). Phosphine is a colourless gas, which is odourless when pure, but the technical product has an odour of garlic. Aluminum phosphide (AlP) is the most commonly used to generate phosphine for disinfestations of stored products. Use of phosphine in a solid formulation is commercially available as tablets or pellets with different commercial names (Banks and Waterford 1991). Effective management of the problem requires good sanitation, inspection of incoming goods, frequent rotation of stock, monitoring for pests, removal of infested stock, and judicious application for of biorational or conventional chemical insecticides. Historically, retailers and pest control operators have relied heavily on chemical pesticides, but increasing awareness of risk to environmental quality and human health has made it necessary to seek safer methods (Athanassiou *et al.* 2005).Vick *et al.* (1979) reported that Z, E-7, 11-hexadecadien-1-o1 is the major component of *S. cerealella* sex pheromone produced by female moth to attract male. Pheromone traps are effective tools for monitoring stored product pests, especially moths. Pheromone traps generally catch adults when pest numbers are very low and so they can be used qualitatively to provide an early warning of pest incidence in cropping ecosystem. Pheromone traps can also be useful to define areas of pest infestation (Campion 1984, Subramanyam & Harein 1990). Regular monitoring of insect pests is an essential component of integrated pest management, and trapping combined with spatial analysis of trap catch by contour mapping has shown considerable promise as a reliable and practical method (Brenner *et al.* 1998, Arbogast 2001, Weir 2003). Spatial analysis of trap catch, as means of locating infestation, relay on the assumption that there is a relationship between trap catch (number captured by a trap in a specified period of time) and proximity to a source of infestation. Trapping and spatial analysis of numbers captured provide a powerful tool for indicative interpretation. (Arbogast *et al.* 1998, Brenner *et al.* 1998). The contour maps provide graphic, easily understood evidence of insect infestation and the effectiveness of control intervention. Studies have emphasized the possibilities and constrains in the use of contour and interpolation maps with small number of sample points (Arbogast *et al.* 2002).

The objective of this present study is to mapping the population fluctuation and the spatial dispersal of *S. cerealella* in the phosphine treated and untreated wheat storages using sex pheromone trapping during study storage period.

MATERIALS AND METHODS

The study was conducted in two identical horizontal (flat) Storages, located in Cairo-Egypt. Each storage was rectangular shape (60 x 40 m), concrete and had a metal roof. Each storage was filled with imported hard wheat *Triticum durum* (Desf.). Wheat bags were occupied uniformly in the entire storages area. One of the tested storages received two treatments fumigation (in the middle of Aril and middle of September) by Aluminum Phosphide (Phostoxin®) produced by (D&D Holdings, INC, Weyers Cave, Virginia, USA). While, the other storage was untreated. An array or regular grid of pheromone traps was placed in both storages. Pheromone trap grid in the storages consisted of 20 Delta traps (Trece Salinas, CA, USA) and was placed from the April tell the end of the year of 2000. Delta traps are 18 cm long, 10 cm wide and 12 cm height, with pyramidal shape and manufactured from carton, with openings at both ends with the interior of trap having a removable sheet of sticky surface (200 cm^2) for holding the captured moths. This type of trap is designed to capture flying insects and traps were suspended 2 m off the floor. The trap height used in this study is commonly used in commercial monitoring programs. The sex pheromone septa rubber lures for *S. cerealella* contain a100 micro liter of the synthetic sex pheromone (Z,E)-7, 11-hexadecadien-1-ol acetate, pheromone lures obtained form (Trece Salinas, CA, USA) in commercial name (Storgard®) Cap Sandoz, LTD, lures were suspended at the middle of each trap. The lures were replaced every two month. Pheromone traps were checked every ten days (three times a month), sticky sheet were replaced every ten days as well, captured *S. cerealella* moths were identified and counted. Spatial analysis of trap catch data were visualized using contour maps created using Geographic Information System (GIS) ArcView®3.2 Software. The trap catch data of each trap location were used to create a grid. The grid data used in ASCII format and subsequently exported in the ArcView®3.2, then converted to Raster format to create a graduated color raster grid. The grid with the default parameters of the spatial analysis was interpolated using one of several algorithms, with assign proximity method to create a contour lines and maps.

Analysis of variance (ANOVA) was performed using a computer software SAS (SAS Institute 1988). Monthly means were detected and compared by Duncan multiple range test at 0.05% probability level (Duncan, 1955).

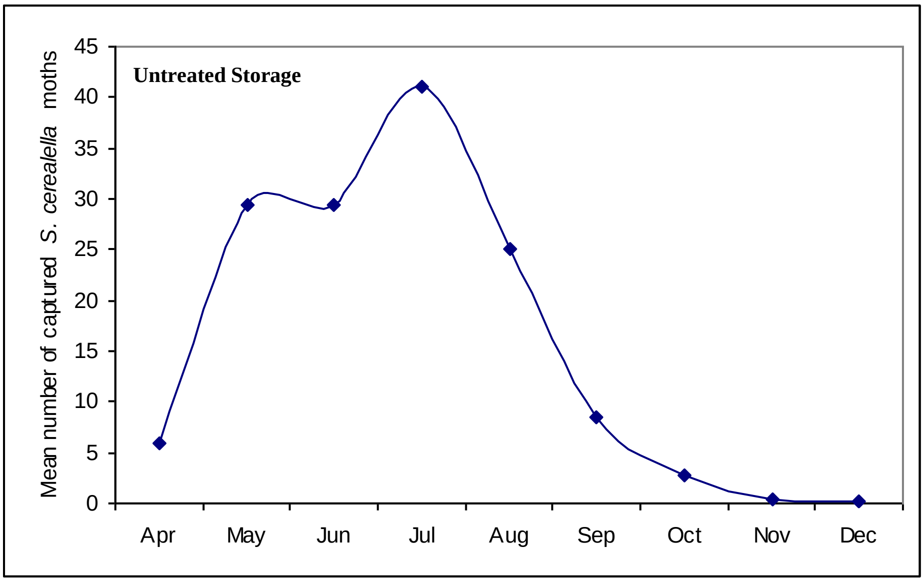
RESULTS AND DISCUSSION

Pheromone trap counts of *S. cerealella* moths found during the entire study period with an average of 16.0148/trap in both untreated and treated (fumigated) storages. Results indicated that *S. cerealella* moth population was much higher in the untreated storage 15.838/trap during the entire study period compared to the treated storage 0.175/trap due to the great impact of the phosphine treatment. Pheromone trap counts in the untreated storage during the study period indicated that the greatest mean monthly number of captured moths was 41.0/trap occurred in July, while the lowest number of captured moths was 0.2/trap recorded in December (Table 1). In comparison to the storage treated with phosphine number of trap catch was significantly low due to potential effect of the fumigant as a control method, the highest number of *S. cerealella* moths captured in pheromone traps was 0.583/trap observed in August, while zero moths was recorded in December. Table (1) shows mean monthly trap catches in the untreated storage during the sampling period. Low mean number of monthly captured moths was recorded during the beginning of spring months. Trap catches increased gradually during the spring months tell reached to the first peak of population during the month of May, with monthly mean number of captured moths 5.83 and 29.31/trap in April and May, respectively. Population of *S. cerealella* moths captured in pheromone traps greatly increased during the summer months tell reached to the second population peak during the month of July, the monthly mean number of captured moths was 29.31, 41, 25.06/trap in June, July and August, respectively. Population of captured moths decreased dramatically during the autumn months, the monthly mean number of captured moths was 8.58, 2.8 and 0.43 in September, October and November, respectively. Trap catches continue to declined tell reach to the lowest monthly mean number of trap catch of the entire study period during the month of December 0.2/trap (Figure 1).

Table 1: Average number of *S. cerealella* adult moths captured by sex pheromone traps during the study period in untreated and treated wheat storages.

	Untreated storage (Average/trap)	Treated storage (Average/trap)	LSD	SS	MS	F	P = 0.05
Apr	5.833±0.6882	0.133±0.430	1.763	3754.592	970.2064	39.768	0.0001 ***
May	29.316±20.033	0.017±0.129	5.1227	49414	25926.17	128.140	0.0001 ***
Jun	29.316±20.033	0.067±0.0312	5.752	58517.97	28897.47	113.144	0.0001 ***
Jul	41±25.377	0.317±0.701	6.500	87437.17	49611.83	152.457	0.0001***
Aug	25.067±17.552	0.583±0.0809	7.914	79591.59	23525.6	48.093	0.0001***
Sep	8.583±7.877	0.333±0.572	2.002	5702	2114	67.934	0.0001***
Oct	2.8±0.5842	0.083±0.334	1.495	2241.592	238.6034	12.932	0.0005***
Nov	0.433±1.047	0.050±0.219	0.273	71.9916	4.981	7.696	0.0064**
Dec	0.2±0.659	0.00	0.168	26.8	1.4169	5.531	0.0203*

Due to the application of the fumigant during study period in the treated storage, population of *S. cerealella* moths captured by pheromone traps greatly influenced and reduced significantly compared to the population of captured moths in the untreated storage. Population level of captured moths was slightly lower and population increased slowly during the beginning of the spring (the first halv of April) 0.83/trap. Due to receiving the first treatment of the fumigant in the middle of April, number of captured moths declined sharply to 0.166 moths/trap in the month of May (Table 1 and Figure 2). The population of *S. cerealella* start to recover slightly during the months of summer tell reached to its peak in the month of August, the monthly mean number of captured moths was 0.66, 0.316 and 0.583/trap, in June, July and August, respectively. While during the autumn months storage received the second treatment of phosphine treatment in the middle of September, population of captured moths declined rapidly tell reached to the zero moths per trap during the month of December, the monthly mean number of captured moths was 0.333, 0.083, 0.05 and 0.0/trap in September, October, November and December, respectively (Figure 1).



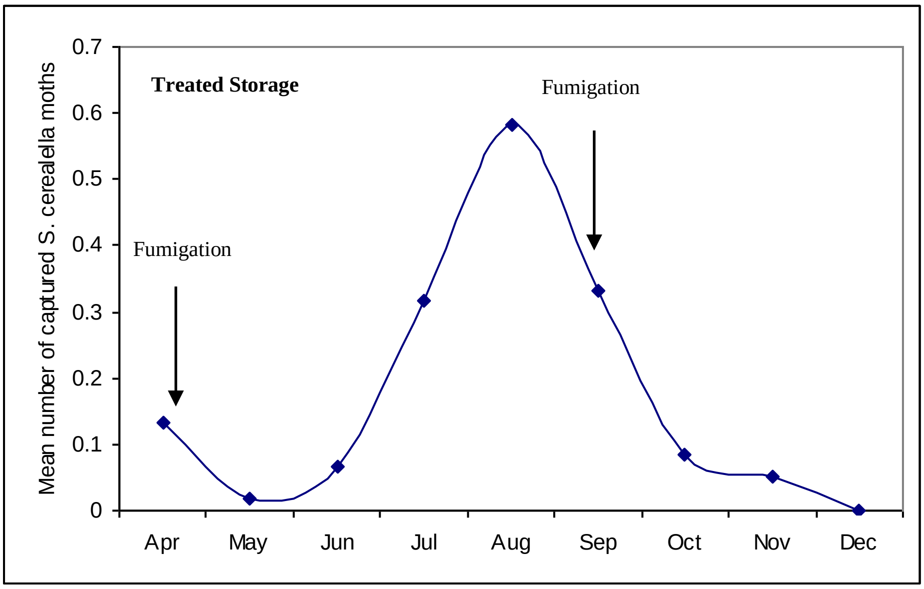


Figure 1: Mean number of *S. cerealella* adult moths captured by sex pheromone traps during the study period in untreated and treated wheat storages.

Statistical analysis revealed that there were significant differences (P = 0.05) of the number of *S. cerealella* moths captured by sex pheromone traps in both untreated and treated storages in all sampling periods (Table 1). Large moth population of *S. cerealella* was recorded by a great mean number of captured moths in the untreated storage compared to the treated (fumigated) storage. Fumigation reduced the insect population significantly with average number of captured moths in the entire study period to 0.175/trap compared to a significant high average number of capture moths 15.838/trap in untreated storage of the entire study period. In the untreated storage lack of sanitation, low ventilation, temperature, relative humidity and no fumigation or any controlling program enhanced *S. cerealella* population to increase with normal activities during the study period compared to the fumigated storage.

Contour maps illustrated same trend of *S. cerealella* population fluctuation and spatial distribution in both the flat (horizontal) untreated and treated storages (Fig. 2). Contour maps showed a clear illustration of the number of captured moths in the untreated storage during the sampling period (Fig 2). Low number of captured moths was recorded in the beginning of the spring months, a small hot spot of insect infestation was recorded located around the center of the storage directed toward the east side of the storage, this hot spot rapidly grow tell cover the south east corner of the untreated storage at the end of April (Figure 2). Storage corners are considered important spots of infestation (Athanssiou *et al.* 2005). Contour maps indicated that moths population gradually increased with a rapid movement of the infestation spot toward the South East and the north of the storage tell covered most of the storage area during the months of July and August (Figure 2). Contour maps indicated that the insect and mite species infestation in storage have a patchy spatial pattern (Athanssiou *et al.* 2005, Nansen *et al.* 2004). Several factors affect the insect movement in flat storage, such as deficient aeration, which can cause the increase of temperature or the development of fungi (Hubert *et al.* 2003). Slightly moths population decreased with the beginning of autumn tell the infestation spot decreased back close to the center of the storage at the end of study period (Figure 2). These results are agreed with Arbogast *et al.* (2004) reported that the decrease in temperature causes movement of insects into the center of storage and grain mass. The spatial distribution of the *S. cerealella* population of captured moths in the treated storage with even clear using contour mapping due to the low population level, spot of infestation can be more easy to be detected and located on the flat (horizontal) storage. During spring low population level was recorded in the treated storage with small spot of infestation located mainly in the center of the storage due to fumigation in the month of April (Figure 2). This small spot slightly grow during the summer months tell covers the one third of the storage in the southwest corner in the month of August (Figure 2). Population of captured moths decreased sharply to small infestation spot near the center again of the treated storage during the autumn tell reached to no moth captured was recorded in the month of December (Figure 2).

In conclusion, trapping provides an effective method for detecting stored product insects in building (e.g., warehouses, processing plants, and retail stores), and when combined with contour mapping of trap catch, it is also provides a convenient means of locating source of infestation (Arbogast *et al.* 2002, Weir 2003). Contour maps and analysis of trap counts can be used as a practical tool for monitoring and management of storage pest in retail stores. This tool identifies trouble spots, which have referred to as foci of infestation, and permits selection, timing, and precision targeting of control measures to achieve maximum pest suppression (Arbogast *et al.* 2000). Successive trapping campaigns, with a fixed array of traps and comparison of sequential contour maps will allow store mangers and pest control operators to visualize pest problems over and entire store at a glance and monitor changes that occur over time. Sequential contour maps also indicate the effectiveness of control measures, and along with records of control applications and stock rotation, they provide permanent documentation of pest problems and their management (Arbogast *et al.* 2005).

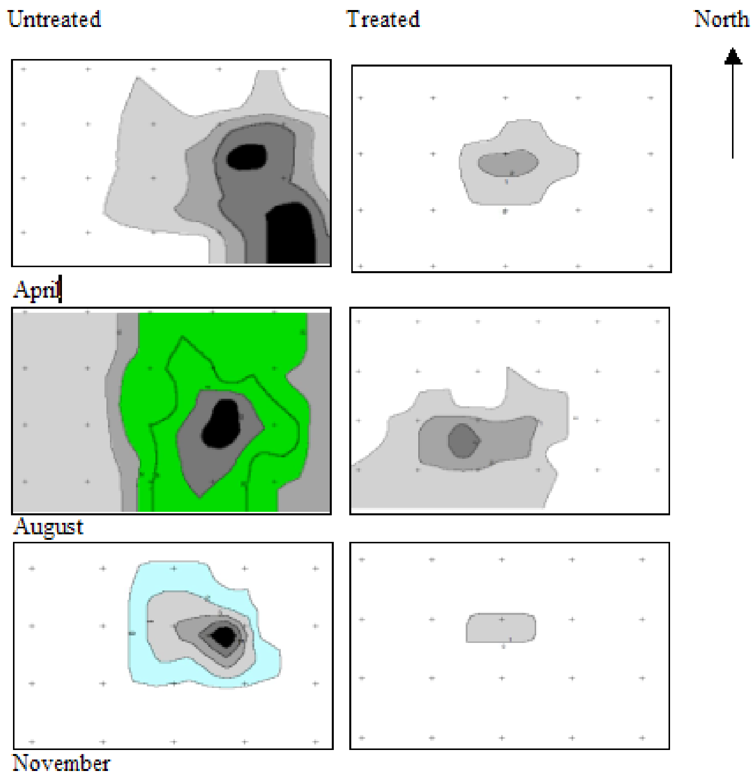


Figure 2: Spatial distribution illustrated by contour maps of *S. cerealella* adult moths captured by sex pheromone traps in untreated and treated wheat storage.

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التوزيع السطحى لفراشة الحبوب فى مخازن القمح المعاملة وغير المعاملة بالفوسفين بإستخدام مصائد الفرمونات

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أجريت الدراسة فى مخزنين متماثلين لحبوب القمح تمت معاملة إحداهما بفوسفيد الألومنيوم بينما كان الآخر غير معامل وقم تم وضع شبكة من مصائد الفرمون فى كلا المخزنين لحصر أعداد الفراشات المصادة وتمت الاستعانة بخرائط كنتورية وذلك بإستخدام نظام المعلومات الجغرافية (**GIS**) بواسطة برنامج الحاسب ArcView®3.2. كان المتوسط الإجمالى لأعداد الفراشات فى كلا المخزنين ١٦,٠١٤ طول فترة الدراسة وقد أوضحت النتائج أن الأعداد الأكبر كانت فى المخزن غير المعامل بمتوسط ١٥,٨٣ فراشة /مصيدة بالمقارنة بـ ٠,١٧٥ فراشة /مصيدة فى المخزن المعامل بالفوسفين. إن حصيلة المصائد فى الخزن غير المعامل أوضحت بأنه متوسط أعداد الفراشات الشهرى كانت ٤١,٠ فراشة/مصيدة فى يوليو بينما كان أقل متوسط للأعداد ٠,٢ فراشة /مصيدة فى ديسمبر. بالنسبة للمخزن المعامل بفوسفيد الألومنيوم كان عدد الحشرات للمصيدة منخفضا وذلك للتأثر الفعال للمبيد كطريقة للمكافحة ، وكان أكبر متوسط لأعداد الحشرات ٠,٥٨٣ فراشة /مصيدة فى أغسطس بينما لم تسجل أى حشرات لفراشة الحبوب فى شهر ديسمبر. أوضحت الخرائط الكنتورية أن بداية الإصابة كانت فى منتصف المخزن فى بداية الربيع وقد أظهرت الخرائط الكنتورية أن نقطة الإصابة الشديدة فى المخزن غير المعامل قد إنتشرت فى جميع أنحاء المخزن وكان ذلك خلال أشهر الصيف بينما كانت نقطة الإصابة فى منتصف المخزن بأعداد أقل من الفراشات المصادة فى المخزن المعامل ثم تراجعت الإصابة للحشرات إلى منتصف المخزن خلال أشهر الخريف حتى وصلت إلى أقل عدد / مصيدة خلال ديسمبر فى كلا المخزنين. يعتبر إستخدام المصائد الفرمونية طريقة فعالة لإكتشاف مصدر ومكان الإصابة بالحشرات داخل الأبنية (المستودعات ، مصانع الأغذية ، المخازن) وعندما يتم إستخدامها مع الخرائط الكنتورية تعطى دلائل وافية لتحديد موضع الإصابة ويعتبر إستخدام الطريقتين معا من أهم الوسائل التى تعطى دلائل مؤكدة للإصابة بهذه الآفات ومكافحتها والتى تفيد فى صنع القرار فى مجال المكافحة المتكاملة داخل المخازن.

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