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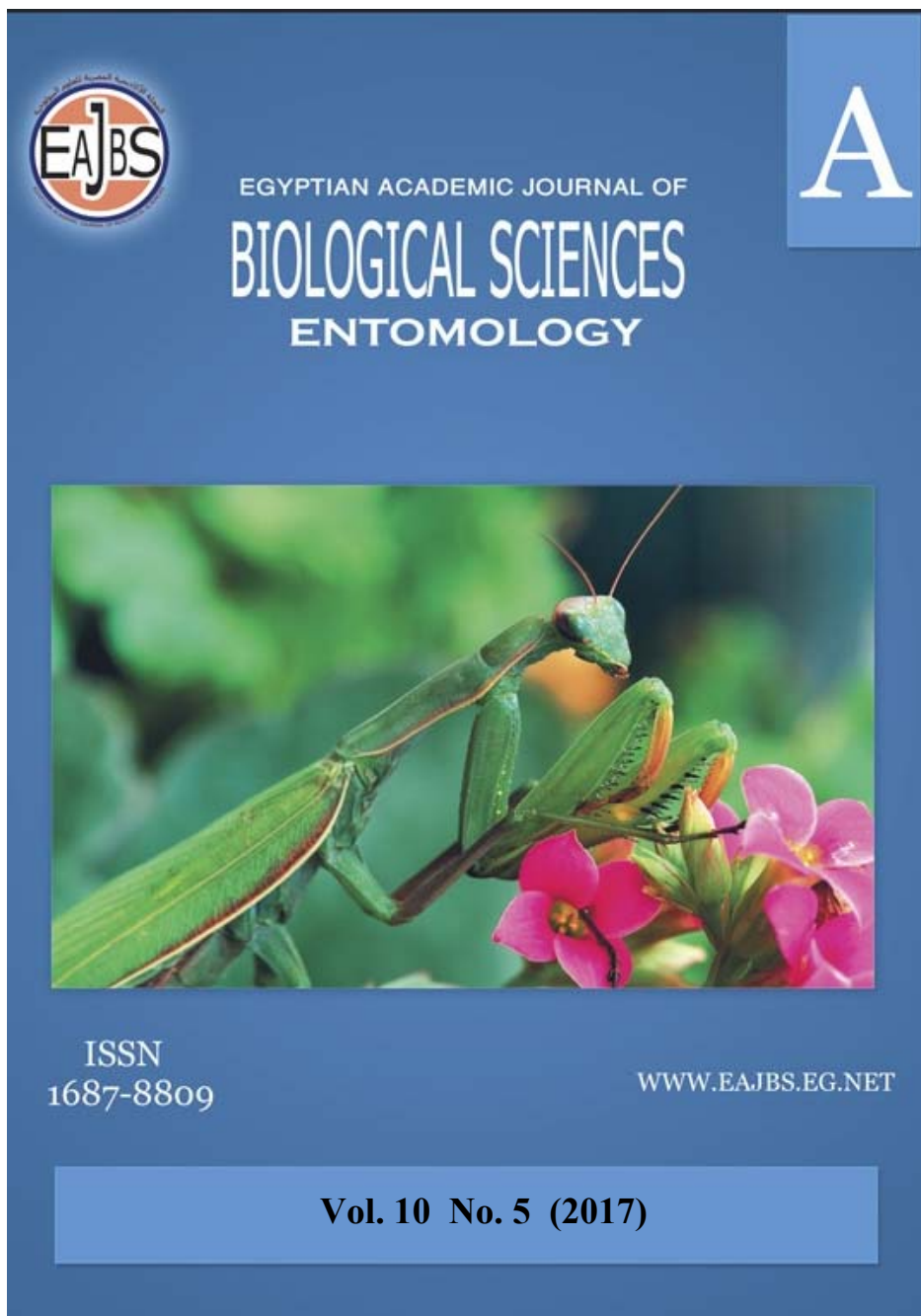


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Attractiveness of Certain Popular Food Products to the German Cockroach, *Blattella germanica*, Adults under Field Conditions

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ABSTRACT

The attractiveness of twenty seven materials (11 of fresh vegetables, 8 of plant seeds, and 8 of oily materials) to adult male and female of German cockroaches, *Blattella germanica*, was evaluated singly and as mixtures under field conditions. The comparison of attractiveness was done between materials in the same group and between the most attractive materials of each group. Results showed that fresh coriander leaves, dill leaves, and zucchini fruit were the most attractive materials of the green vegetables group to both sexes and a combination of coriander leaves and zucchini fruit increased the number of attracted male and female cockroaches. In case of plant seeds, roasted peanut was the most attractive to males and females, whereas peanut butter was the most attractive from oily materials. A mixture composed of equal amounts of roasted peanut, coriander oil, fresh coriander leaves, and zucchini fruit attracted more cockroaches than peanut butter. Addition of cockroach's feces to the mixture increased its attractiveness against cockroaches.

INTRODUCTION

Entomologists have been interested in studying cockroach food preference because cockroaches are one of the most common household pests; and the range of food substances that they utilize is greater than any other insect (Jones and Raubenheimer, 2001). Thus, there is a need to develop cockroach attractants that provide safe and effective cockroach attraction (Vandermeer *et al.*, 2012).

The term attractant is often erroneously used in reference to phagostimulants (food) that must be found randomly, e.g., by cockroaches, or must be placed in an area known to be frequently visited by cockroaches. Many approaches for controlling cockroach populations are based on attracting cockroaches to traps, insecticide baits, and onto surfaces treated with residual insecticides or biological control agents (Nalyanya and Schal, 2001). Extensive research has been conducted on household food materials as lures with the aim to incorporate them into cockroach control tactics (Tsuji, 1965; Reiersen and Rust 1977a, Rust and Reiersen 1981, Ballard and Gold, 1982). However, the documentation of food preference of the German cockroach is limited.

Bread has emerged as one of the most attractive food substances for German cockroaches; it is frequently used in trapping studies in apartments (Owens and

Bennett, 1982, 1983; Barcay *et al.*, 1990).

In a study, Nalyanya *et al.*, (2001) stated that bread was highly attractive in olfactory assays for attracting male *B. germanica* cockroaches. Tabaru and Mochizuki (2005) found that the herbs, anise (*Pimpinella anisum*), sansyo (*Zathoxylum piperitum*), onion (*Allium cepa*), vanilla (*Vanilla planifolia*), mustard (*Brassica hirta*), and eucalypt (*Eucalyptus radiata*) have an attractive effect to the German cockroach. Also, El-Sharabasy *et al.*, (2014) recorded that the percentage of adults attracted to carbohydrate foods (biscuit and banana) and protein food (cooked cheese) was significantly higher than bread and potato and luncheon (minced meat and white cheese).

Crude fecal extracts containing cockroach aggregation pheromones have shown promise in field studies by reducing repellency of contact insecticides (Rust and Reiersen, 1977b). Efforts to integrate pheromone in cockroach population management are certain to optimize trap catch, as with *Supella longipalpa* (Liang *et al.*, 1998). Kaakeh and Bennett (1996) indicated that Victor traps with aggregation pheromone trapped significantly more cockroaches than Victor traps without pheromone.

There are no commercially available cockroach attractants. For this reason, the present work aimed to study the attractiveness of the most popular food products found in our kitchens to the feeding preference of German cockroach, *B. germanica*. Results obtained from the present work may help in the selection of products that may be used in the attraction of cockroaches into baits or to toxic materials.

MATERIAL AND METHODS

Tested Products: All the tested products were purchased from local distributors. The selected products were separated and tested in three groups according to their nature as illustrated in Table (1). Combination between some of the attractants was done by mixing equal amounts of them. Also, cockroach feces, as additive materials, were collected from cockroach's aggregation sites in kitchens.

Table 1: Descriptive information on the tested products in the field trial.

Group 1 (Fresh vegetables)	Group 2 (Plant seeds)	Group 3 (Oily materials)	
		Products	Ingredients
Coriander leaves <i>Coriandrum sativum</i>	Peanut <i>Arachis hypogaea</i>	Peanut butter	Roasted peanut, sugar, peanut oil, hydrogenated rape seed, soy bean cotton seed oil, and salt
Dill leaves <i>Anethum graveolens</i>	Hibiscus <i>Hibiscus syriacus</i>	Coriander oil	Coriandrol, linalool, and limonene.
Zucchini fruit <i>Cucurbita pepo</i>	Caraway <i>Carm carvi</i>	Peppermint oil	Carvon, mentol, menthon, and limonin
Potato <i>Solanium tuberosum</i>	Black pepper <i>Piper nigrum</i>	Butter	Caw milk fat.
Peppermint leaves <i>Mentha piperita</i>	Cumin <i>Cuminum Cyminum</i>	Dill oil	Carvon, limonin, and phellandrene.
Parsley leaves <i>Petroselinum sativum</i>	Fenugreek <i>Trigonella foenum</i>	Margarine	Refined palm oil, beta carotene, flavor, and antioxidant T.B.H.Q.
Cucumber <i>Cucumis sativus</i>	Anise <i>Pimpinella anisum</i>	Animal fat	-
Tomato <i>Solanium lycopersicum</i>	Coriander	Chicken fat	-
Onion <i>Allium cepan</i>	-	-	-
Green pepper <i>Capsicum annum</i>	-	-	-
Garlic <i>Allium sativum</i>	-	-	-

Procedures of the Field Bioassay: The kitchen was cleaned from any materials (food or water source) which may affect the response of the insects to the tested products. The light of the kitchen was switched on all the night to reduce the insects' activity and to some extent for reducing their feeding through night. Attractant products (about 1 gm. of each) were arranged on the marble about 10cm from each other and then the light of the kitchen was switched off. The arrangement of the attractants was done in a completely randomized block design and their locations were re-randomized after each count. The number of attracted males and females was recorded each hour for 6 hours.

The count was assessed under a very faint light by visual count according to methods described by Agrawal and Tilak (2006) and Ahmad and Suliyat (2011).

Statistical Analysis:

Data were expressed as mean \pm standard error. The statistical significance of differences between individual means was analyzed using SPSS statistical analysis one way (ANOVA, version 20-32bit) program followed by Duncan's test.

RESULTS

The attractiveness of twenty seven products (11 of fresh vegetables, 8 of plant seeds, and 8 of oily products) to adult males and females of German cockroach *Blattella germanica*, singly or as mixtures are shown in the Tables (2-7).

Green Vegetables Group: Coriander leaves, dill leaves, and zucchini fruit attracted significantly more males and females in comparable to both the control and the other attractants (fresh potato, peppermint leaves, parsley leaves, cucumber, tomato, onion, green pepper, and garlic) as shown in Table (2).

Table 2: Mean number of *B. germanica* adults attracted per hour to certain fresh vegetables in field trials after the investigation period (6hrs.).

Fresh vegetables	Number of insects/hour (Mean \pm SE)	
	♂	♀
Coriander leaves	6.8 \pm 0.60 ^a	4.8 \pm 0.47 ^a
Dill leaves	6.2 \pm 0.47 ^a	3.0 \pm 0.44 ^b
Zucchini fruit	5.8 \pm 0.60 ^a	6.5 \pm 0.47 ^c
Fresh potato	2.5 \pm 0.56 ^{ce}	0.7 \pm 0.33 ^{def}
Peppermint leaves	2.2 \pm 0.54 ^{de}	1.5 \pm 0.34 ^d
Parsley leaves	2.0 \pm 0.44 ^{de}	0.3 \pm 0.16 ^e
Cucumber	1.8 \pm 0.40 ^{de}	2.5 \pm 0.42 ^b
Tomato	1.8 \pm 0.16 ^{de}	0.3 \pm 0.21 ^{ef}
Onion	1.0 \pm 0.36 ^{bd}	0 ^e
Green pepper	0.3 \pm 0.33 ^b	0 ^e
Garlic	0 ^b	0 ^e
Control (white bread)	3.0 \pm 0.25 ^{ce}	1.2 \pm 0.24 ^{df}

N: 6 replicates for each treatment, mean attractiveness in the same column followed by the same superscript, are not significantly different (ANOVA) followed by Duncan's test, $p < 0.05$.

The number of attracted males per hour to coriander leaves and dill leaves (6.8 and 6.2, respectively) was more than that of attracted females (4.8 and 3.0, respectively). On the other hand, zucchini fruit was more attractive to females than males. The results also showed that no females were attracted to onion, green pepper, and garlic.

It is remarkable that a mixture of coriander leaves and zucchini fruit was significantly more attractive to adult males and females (9.2 and 7.8, respectively)

than coriander leaves or zucchini fruit tested alone (4.8 and 3.0, respectively) or in combination with dill leaves (Table 3). Combination of dill leaves with coriander leaves or zucchini fruit reduced their attractiveness against females and prevented its effect against males.

Table 3: Mean number of *B. germanica* adults attracted per hour to combination of certain fresh vegetables in field trials after the investigation period (6hrs.).

N: 6 replicates for each treatment, mean attractiveness in the same column followed by the same

Fresh vegetables	Number of insects/hour (Mean ± SE)	
	♂	♀
Coriander leaves + zucchini fruit	9.2 ± 0.30 ^a	7.8 ± 0.30 ^a
Coriander leaves	4.8 ± 0.47 ^b	2.0 ± 0.25 ^b
Zucchini fruit	3.0 ± 0.25 ^b	3.0 ± 0.51 ^c
Coriander leaves + zucchini fruit + dill leaves	1.8 ± 0.47 ^d	3.0 ± 0.51 ^c
Dill leaves + zucchini fruit	0 ^e	0.8 ± 0.30 ^d
Dill leaves + coriander leaves	0 ^e	0.3 ± 0.21 ^d
Dill leaves	0 ^e	0 ^d
Control (white bread)	2.2 ± 0.30 ^{cd}	0 ^d

superscript, are not significantly different (ANOVA) followed by Duncan's test, $p < 0.05$.

Plant Seeds: Data presented in Table 4 indicated that roasted peanut attracted significantly more insects (8.5 and 5.8 insect/hr. for males and females, respectively) in comparison with the other seeds and the control.

Table 4: Mean number of *B. germanica* adults attracted per hour to certain dry plant seeds in field trials after the investigation period (6hrs.).

Plant seeds	Number of insects/hour (Mean ± SE)	
	♂	♀
Roasted peanut	8.5 ± 0.50 ^a	5.8 ± 0.47 ^a
Fresh peanut	4.0 ± 0.36 ^b	3.2 ± 0.30 ^{bc}
Hibiscus	3.7 ± 0.33 ^b	2.8 ± 0.47 ^b
Caraway	1.8 ± 0.30 ^c	0 ^d
Black pepper	0 ^d	0 ^d
Cumin	0 ^d	0 ^d
Fenugreek	0 ^d	0 ^d
Anise	0 ^d	0 ^d
Coriander	0 ^d	0 ^d
Control (white bread)	5.8 ± 0.60 ^c	3.0 ± 0.36 ^c

N: 6 replicates for each treatment, mean attractiveness in the same column followed by the same superscript, are not significantly different (ANOVA) followed by Duncan's test, $p < 0.05$.

Black pepper, cumin, fenugreek, anise, and coriander were not attractive for both sexes. On the other hand, fresh peanut, hibiscus, and caraway attracted number of insects less than the control.

Oily Products: The data summarized in Table (5) indicated that peanut butter was the most accepted product for both sexes and significantly attracted more insects (12.0 and 9.5 insect/hr. for males and females, respectively) than the other materials and the control. There were also significant differences in the numbers of attracted insects to coriander oil (5.7 male/hr and 3.0 female/hr) and peppermint oil (5.0 male/hr and 2.5 female/hr) from the control (0.3 male/hr. and zero/hr females). Dill oil and chicken fat reduced the number of males attracted, while no females were attracted. Animal fat and margarine did not attract any males or females.

Table 5: Mean number of *B. germanica* adults attracted per hour to certain oily materials in field trials after the investigation period (6hrs.).

Oily materials	Number of insects/hour (Mean ± SE)	
	♂	♀
Peanut butter	12.0 ± 0.36 ^a	9.5 ± 0.42 ^a
Coriander oil	5.7 ± 0.66 ^d	3.0 ± 0.57 ^b
Peppermint oil	5.0 ± 0.57 ^d	2.5 ± 0.34 ^{bd}
Butter	3.3 ± 0.42 ^b	0.5 ± 0.34 ^c
Dill oil	1.0 ± 0.44 ^c	0 ^c
Chicken fat	0.2 ± 0.16 ^c	0 ^c
Animal fat	0 ^c	0 ^c
Margarine	0 ^c	0 ^c
Control (white bread)	0.3 ± 0.52 ^c	0 ^c

N: 6 replicates for each treatment, mean attractiveness in the same column followed by the same superscript, are not significantly different (ANOVA) followed by Duncan's test, p< 0.05.

Comparative Attractiveness of Certain Combinations of Attractants: The visual counts of cockroaches attracted to certain combinations of attractants in comparison with peanut butter are shown in Table (6).

Table 6: Mean number of *B. germanica* adults attracted per hour to combinations of certain attractants in field trials after the investigation period (6hrs.).

Attractants	Number of insects/hour (Mean ± SE)	
	♂	♀
Peanut butter	9.5 ± 0.34^a	8.2 ± 0.65^a
Roasted peanut + coriander oil + fresh coriander leaves + zucchini fruits	7.3 ± 0.49^b	6.8 ± 0.65^b
Coriander leaves + zucchini fruits	4.3 ± 0.42^c	5.0 ± 0.51^c
Roasted peanut + coriander oil	1.3 ± 0.49^d	0^d
Roasted peanut + peppermint oil + fresh coriander leaves + zucchini fruits	1.2 ± 0.40^{de}	0.2 ± 0.16^d
Roasted peanut + peppermint oil	0^e	0.7 ± 0.21^d
Control (white bread)	0^e	0^d

N: 6 replicates for each treatment, mean attractiveness in the same column followed by the same superscript, are not significantly different (ANOVA) followed by Duncan's test, p< 0.05.

No significant difference was found between the attractiveness of peanut butter, which was proved to be the best of oily products (9.5 and 8.2 insect/hr. for males and females, respectively), and a mixture composed of equal amounts of roasted peanut, coriander oil, fresh coriander leaves, and zucchini fruit (7.3 and 6.8 insect/hr. for males and females, respectively). The other tested mixtures (coriander leaves + zucchini, roasted peanut + coriander oil, roasted peanut + peppermint oil + fresh coriander leaves + zucchini and roasted peanut + peppermint oil) were not significantly attractive to both sexes. No insects attracted to the control (white bread).

In a separated assay, addition of cockroach feces to the mixture composed of roasted peanut, coriander oil, fresh coriander leaves, and fresh zucchini ranked it to be significantly the most attractive mixture for both male and female adults compared with the control or the other used mixtures of attractants (peanut butter, roasted peanut + coriander oil + fresh coriander leaves + zucchini fruit) as shown in Table (7). This mixture also attracted more insects than peanut butter.

Table 7: Mean number of *B. germanica* adults attracted per hour to combinations of certain attractants in field trials after the investigation period (6hrs.).

Attractants	Number of insects/hour (Mean \pm SE)	
	♂	♀
Feces + *	10.2 \pm 0.60 ^a	9.3 \pm 0.49 ^a
Peanut butter	9.8 \pm 0.30 ^a	7.7 \pm 0.33 ^a
Bread + *	5.3 \pm 0.42 ^b	3.0 \pm 0.51 ^b
Dry milk + *	4.5 \pm 0.61 ^b	0.8 \pm 0.30 ^c
Vanillin + *	4.0 \pm 0.51 ^{bc}	2.2 \pm 0.30 ^b
Sugar + *	2.8 \pm 0.47 ^c	0.3 \pm 0.21 ^c
Control (white bread)	0 ^d	0 ^c

N: 6 replicates for each treatment, mean attractiveness in the same column followed by the same superscript, are not significantly different (ANOVA) followed by Duncan's test, $p < 0.05$.

*: 1:1:1:1:1 of roasted peanut + coriander oil + fresh coriander leaves + fresh zucchini.

DISCUSSION

Data of the present study clearly showed that coriander leaves, dill leaves, and zucchini fruit (from the green vegetables group) were the most attractive materials to both males and females. A combination of coriander leaves and zucchini increased the number of the attracted males and females which may be due to the high water, carbohydrates, and protein contents of them. Carbohydrates are one nutrient that both sexes use as a primary energy source (Carrel and Tanner, 2002). Muntean (2007) recorded that raw zucchini fruit contain water (92.73%), carbohydrates (3.11%), protein (2.71%), total lipids (0.40%), ash (1.05%), and total dietary fiber (1.1%).

Also, El-Sharabasy *et al.*, (2014) recorded that the percentage of adults attracted to carbohydrate foods (biscuit and banana) and protein food (cooked cheese) was significantly higher than (bread and potato) and luncheon (minced meat and white cheese). Results of the current investigation strongly favor the concept given by Quan *et al.*, (1995) who have reported that vegetable juice was more attractive than wormwood, onion, celery, and garlic. Similar conclusion has been made by Tabaru and Mochizuki (2005) who found that the herbs, anise (*Pimpinella anisum*), sansyo (*Zathoxylum piperitum*), onion (*Allium cepa*), vanilla (*Vanilla planifolia*), mustard (*Brassica hirta*), and eucalypt (*Eucalyptus radiata*) have an attractant effect to the German cockroach.

It is clear from our results that the attracted insects to roasted peanut were greater than that attracted to fresh peanut. This observation may be due to the release of its odorants. Quan *et al.*, (1995) found that the attractiveness of vegetable essence and pineapple essence was clearly higher than banana essence, yeast alcoholic drink essence, and almond essence.

It was observed also that the peanut butter was highly attractive to males and females. In the current trial the observed attractiveness of the peanut butter may be due to ingredients such as roasted peanut, sugar, and peanut oil. Nalyanya and Schal (2001) compared various attractants in olfactometer assays and in field experiments and found that peanut butter was more attractive to *B. germanica* than distiller's grain in the two assays. Awad *et al.*, (2002) rendered the attractiveness of cockroaches to peanut butter to β -sitosterol.

The β -sitosterol is a steroid glycoside and is considered as the mother compound that can convert, synthetically, to 7 successive compounds to produce blattellastanoside which is considered as the arrestant component of the aggregation

pheromone (Sakuma and Fukami, 1990).

From our results, we can conclude that the number of attracted insects to peanut butter was reduced when it was compared to other strong attractive mixtures like the mixture composed of roasted peanut, coriander oil, fresh coriander leaves, and zucchini fruit.

Addition of cockroach feces to this mixture render it more attractive than peanut butter. This may be due to the aggregation pheromone. The aggregation pheromone contains both attractant and arrestant components and cockroaches respond to the attractants by olfaction (Sakuma and Fukami, 1985) and to the arrestants by contact chemoreception (Sakuma and Fukami, 1991).

Efforts to integrate pheromone and food lures in cockroach population management are certain to optimize trap catch, as with *Supella longipalpa* (Liang *et al.*, 1998). Results of the current investigation strongly favor the concept given by Kaakeh and Bennett (1996) that Victor traps with aggregation pheromone trapped significantly more cockroaches than Victor traps without pheromone.

Our observation is supported by the observation of Miller *et al.*, (1997) who found that the use of fecal extract of German cockroach in combination with toxic bait may increase the attractiveness of bait stations, decrease bait repellency, and enhance cockroach mortality in the presence of competing food sources. Also, Miller *et al.*, (2000) evaluated an aqueous extract of German cockroach fecal material for inducing trail-following behavior in German cockroaches and they found that the presence of the fecal extract-treated trails significantly enhanced trap catch. Crude fecal extracts containing aggregation pheromones have shown promise in field studies by reducing repellency of contact insecticides (Rust and Reiersen, 1977b).

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ARABIC SUMMARY

جاذبية بعض المنتجات الغذائية الشائعة لبالغات الصرصور الألماني، بلاتيليا جيرمانيكيا تحت ظروف الحقل

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١- قسم علم الحشرات، كلية العلوم، جامعة بنها

٢- قسم علم الحشرات، كلية العلوم، جامعة عين شمس

٣- قسم البيولوجي - كلية العلوم - جامعة بيشة- بيشة-المملكة العربية السعودية

تم تقويم فعالية سبعة وعشرين مادة (١١ من الخضراوات الطازجة، ٨ من بذور النباتات و ٨ من المواد الزيتية) بصورة منفردة أو مخلوطة في جذب ذكور وإناث الصراصير الألمانية ، بلاتيليا جيرمانيكيا، تحت الظروف الحقلية. وقد أجريت المقارنة بين جاذبية المواد في نفس المجموعة وبين المواد الأكثر جاذبية من كل مجموعة. وأظهرت النتائج أن أوراق الكزبرة الطازجة وأوراق الشبت والكوسة كانت أكثر المواد جذبا في مجموعة الخضار الخضراء لكلا الجنسين، كما أن مزيج من أوراق الكزبرة والكوسة جذب العدد الأكبر من الذكور والإناث. وفي حالة بذور النباتات، كان الفول السوداني المحمص هو الأكثر جاذبية للذكور والإناث، وكانت زبدة الفول السوداني الأكثر جاذبية بين المواد الزيتية. وقد جذب خليط مكون من كميات متساوية من الفول السوداني المحمص وزيت الكزبرة وأوراق الكزبرة الطازجة والكوسا المزيد من الصراصير. وتبين أن إضافة براز الصرصور إلى الخليط يزيد من جاذبيتها ضد الصراصير.