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Evaluation of New Schemes Efficacy for *Blatta Orientalis* and *Blattella Germanica* Control in Food Units with HACCP Implementation

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Abstract

Blatta orientalis and *Blattella germanica* are the most common pests in the food industry. The aim of this study is the evaluation of new treatment schemes effectiveness as well as the monetary cost, humans and environment toxicity against *Blatta orientalis* and *Blattella germanica*. The study was carried out in 28 food units infested with *Blattella germanica* and *Blatta orientalis* in Tirana. The duration of the study was 24 months. The treatment efficacy of 2.15% imidacloprid (in gel form) is tested for 12 months, in thirteen units meanwhile one unit served as a control unit. The monetary cost of insecticide mentioned was calculated using the quantity and treatment duration of insecticide applied. For this reason, we calculated the quantity of gel baits used in seven food units as well as the quantity of insecticide in spray form used in seven others food units for a period of 12 months. Technical and safety data sheets were used to assess human and environment safety. Insect elimination was achieved by the end of the ninth week. This study found that in the units which used imidacloprid the short term cost was 21 Euro / unit, while in other units which used the classic method the cost was 8.3 Euro / unit. Our study identified that at the units which used imidacloprid the annual cost was 68 Euro while in the other category the cost was 78 Euro.Technical and safety data sheets detected that insecticides in gel form are safer for human and environment. As in analog studies conducted by foreign researchers, we found that the use of insecticides in gel form is the right choice for *Blatta orientalis* and *Blattella germanica* control.

Keywords: Blatella; insecticide; imidacloprid; food industry; cost use.

Abbreviations: Hazard Analysis Critical Control Point (HACCP), Integrated Pest Management (IPM), *Blattella germanica (B.germanica), Blatta orientalis (B.orientalis),* Percentage (%), World Health Organisation (WHO).

1. Introduction

B. orientalis and B. germanica are the most common urban cockroaches found in houses, restaurants, food stores, etc and remain one of the most economically and medically important pests. It is omnivorous and consumes a wide range of food types and may hitchhikes into the house on food material cartons, sacks of potatoes or onions, used furniture or appliances, beer cases, etc. It is proven or suspected carrier of the organisms causing diarrhea, dysentery, cholera, leprosy, plague, typhoid fever [6] and viral diseases such as poliomyelitis [7]. The control of *B. orientalis* and *B. germanica* in food units poses not only a legal requirement but a serious problem since their presence may have health, economic and ecological consequences. The above insects are classified as harmful due to environmental pollution, economic damages and as potential vectors for the transmission of bacteria (*Salmonella, Shigella, Escherichia coli O157*, etc,) viruses, protozoa, helminthes, etc [3] causing gastroenteritis, dysentery, typhoid, hepatitis, toxoplasmosis, etc. The mentioned diseases are developed as a result of food contamination with insect salivary secretion and dissemination of the pathogens in foods while allergic diseases are developed as a result of allergens [10] (dried feces, body parts, etc) presence in the air inhaled through the respiratory tract.

Effective control is based on early detection, right identification and effective treatment through methods/techniques based on Integrated Pest Management (IPM). IPM practices aimed the suppression of pest population below the health injury level as well as the economic and environmental level [12]. IPM is based on pest exclusion, sanitation and a selective selection of

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pesticides, leaving more space to the problem prevention [5].

Until recently, the control of *B.germanica* and *B.orientalis* relied largely on sprays based on synthetic insecticides. With the development of baits, which can be selectively applied where the insects live, the situation has now changed. Compared with residual sprays, baits take advantages of long residual activity, safer application and less environmental pollution. Gel baits with imidacloprid (as an active ingredient, elements of IPM practices) is more effective in cockroach control because lethal dose is consumed in a single meal [8]. Gel baits advantages are: they do not act through contact, do not evaporate in the environment and are placed in precise locations inaccessible by animals and humans avoiding environmental pollution. Target insects are fed continuously until the final consumption of the bait. Gel baits offer long-term protection since dose receipt time to death allows the insects to transport the gel in their nest, where stools serve as a food source for others insects starting a domino style death process. This method was considered the main method for cockroach control in the United States for at least 5-8 years [6].

In Albania, the control against *B.germanica* and *B.orientalis* was performed with insecticide in dust or liquid form and was not relied on IPM (which is associated with insect resistance, environmental contamination). It is evident that the spray or dust insecticides eliminate only visible insects, but the problem continues as long as the colony/nest remain unaffected.

Hazard Analysis Critical Control Point (HACCP) system and Hygiene Implementation Rules in the food industry recommend the necessity of new techniques/schemes usage. The implementation of new schemes are based on Integrated Pest Management (IPM) practices, where are included the gel baits with 2.15% imidacloprid.

In our country, the use of insecticide gel against *B.germanica* and *B.orientalis* has been studied less. This fact enabled few data for efficiency on human and environment toxicity as well as monetary cost, compared with the data based on spray/dust insecticides use.

The aim of this study is to evaluate the effectiveness of the treatment, the monetary cost, toxicity to humans and the environment of new schemes for the control of *Blatta orientalis* and *Blattella germanica* in Albanian food units.

2. Material and Methods

The study was carried out in 28 food units located in Tirana district, for a period of 24 months. All food units have demonstrated problems with cockroaches infestation. At the first year of the study, in thirteen infested units, is used the insecticide: 2.15% imidacloprid (in gel form) while one unit is used as a control unit. The units separation is done in order to calculate better the treatment efficacity as well as the reduction of insects' number. Monitor traps and visual inspection were used to evaluate insects number before and after treatment, in order to determine units infestation level and efficacy treatment also. In the second year of the study, we investigated the monetary cost and human & environment toxicity for both methods. In order to calculate the monetary cost of both methods, we tested seven infested units which used 2.15 % imidacloprid (gel bait) and seven other units which used 2.5% *Deltamethrin* (in spray form) for 12 months.The insects number was monitored monthly through monitor traps in both methods.

2.1. Monitoring and pre-treatment infestation level evaluation during the first year of study

We placed 10 monitor traps in most preferred cockroaches' sites. After 24 h, the monitor traps were checked for the insect type, number, life stage and traps placement. We realized visual inspection around 23:00 h because is evident that during the night the insects are more visible. The procedure of cockroaches counting continued for 5 minutes with switched on the light at the time of counting [11].

The infestation level was calculated as below:

> 75 individuals counted – was considered as a severe infestation, 25-75 individuals counted - was considered as a moderate infestation, < 25 individuals counted – was considered as a light infestation [8].

2.2. Facilities sanitation

The procedure of sanitation is considered very important for the control of *B.germanica* and *B.orientalis* because these insects cannot live without food and water. Unit sanitation included cleaning, daily removal of waste, emptying the sink and floor water collection pipes, removal of any potential source of food and water.

2.3.Treatment with 2.15% imidacloprid in gel form and percentage reduction evaluation

13 infested units were treated with 2.15% imidacloprid in gel form and the procedure is realized according to the quantity shown at the table below.

Table 1. Imidacloprid gel baits amount used in different infestation level and insect type

Insect type	Light/moderate infestation	Severe infestation
B.germanica	1 drop*/ m^2	2 drops /m^2
B.orientalis	2 drops /m^2	3 drops/m^2

drop weight is about 0.03g

Every week we realized drops replacement and the control was carried out for nine weeks consequently. The same way we used to monitor traps and visual inspection in order to identify the evaluation of infested level. The calculation of insect reduction (in percentage) was done under the formula: % reduction =100 - (C1/T1*T2/C2) *

100 [7]. where C1= the number of cockroaches in the control unit, pre-treatment; T1= the number of cockroaches in the treatment unit, pre-treatment; C2= the number of cockroaches in the control unit, post-treatment; T2= the number of cockroaches in the treatment unit, post-treatment.

2.4 Long term and short term monetary cost as well as the toxicity evaluation of insecticide in both methods used during the second year of study

Seven infested units out of 14 units (they have structural similarities and belonged to the same production line with severe infestation level) were treated with gel baits and seven with spray insecticide (2.5% Deltamethrin in liquid form, classic scheme). Gel baits treatment was conducted according to the methods described above while the spray insecticides were applied with manual pumps (classic method). After the first clean out the imidacloprid gel was applied only as needed. Time service and the product amount applied was used to evaluate the cost for two methods; the long-term cost was evaluated over a 12 month period of treatment.

Time service included equipment, insecticide preparation time and applied treatment time for both methods. The time service cost was evaluated at 0.01 Eur/minute in gel treatment and 0.1 Eur/minute in classic method. For the calculation of the product amount applied in gel bait treatment the product was weighed before and after treatment, while in the spray treatment was calculated the product's amount applied for each unit at the end of the treatment.

The products cost was evaluated 1 gr gel ≈ 0.5 Euro and 1 ml (gr) deltamethrin 0.07 Euro (the cost of products may vary based on company size, relationship with manufacturer, etc). The monthly average cost was calculated for each unit for both methods and the annual average cost was calculated for all treated units.

An average of ten monitor traps were used to evaluate insects' number for both methods, which were checked after 24 h every months. If the monitor traps showed a decline in cockroach population after two months of application, the unit would be treated on a quarterly scheme treatment.If the cockroach number was incrested after the quarterly treatment the unit would be treated monthly.

Safety and technical data sheets were used to evaluate the human and environmental safety of each product applied.

3. Results and Discussion

Pre-treatment infestation level of food units during the first year of study is presented in chart Nr.1, where 11 food units had demonstrated a severe level of infestation and only two units had a moderate level of infestation. In tables, 2 and 3 are presented the results at the treated units of pre and post- treatment insects' number as well as at the control unit. At the same tables are presented the percentage reduction of cockroach density for nine weeks consequently. The insect reduction is detected within the first week and resulted 33.5%, 24.3%, 24.0%, 25.0%, 36.0%, 19.0%, 22.0%, 26.0%, 32.2%, 43.1%, 25.0%, 39.0%, 12.5%, in all treated units, while at the end of ninth week the reduction was 100 % in all treated units.

The control of *B. orientalis and B. germanica* in Albania is usually performed with classical methods (dust/spray insecticides) without considering IPM practices. But consequent control failures and foreign study experiences have shown that extensive insecticides use led to the development of cockroach resistance to a wide range of insecticides such as

organochlorines, organophosphates, carbamates and pyrethroids [1].

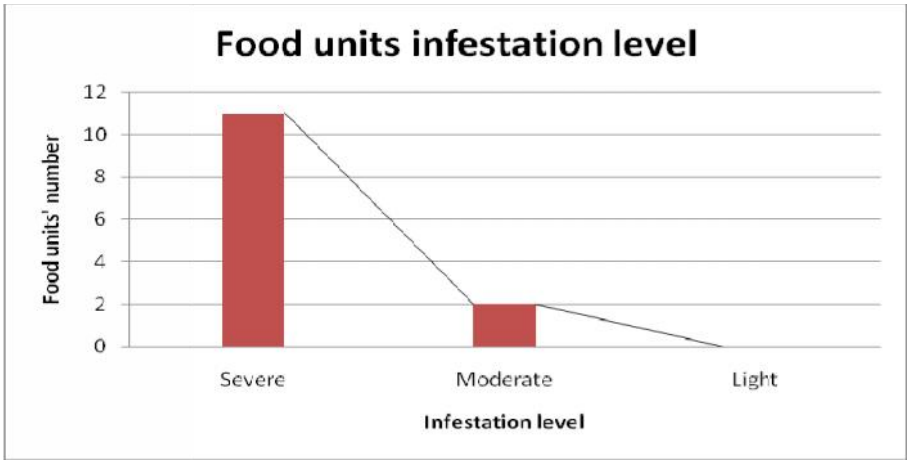

Figure 1. Infestation level of food units during the first year of study

Table 2. Pre-treatment and post- treatment insects' average number with visual inspection and monitor traps

Unit	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***Control***
Pre-treatment insects' number	125	111	183	205	75	99	72	108	98	180	120	122	153	143
Post- treatment (week)														
1	90	91	151	167	52	87	61	87	72	111	98	81	145	155
2	80	66	93	135	41	70	49	70	60	90	77	73	128	160
3	40	34	50	70	19	41	27	37	30	38	40	33	82	121
4	35	22	35	51	15	38	24	24	24	25	28	27	63	156
5	27	15	23	49	10	29	19	20	23	16	17	20	39	231
6	13	8	12	26	6	18	13	10	12	9	9	12	18	258
7	5	3	4	11	2	7	6	4	7	3	3	5	6	239
8	1	1	1	4	1	2	2	1	2	1	1	1	2	229
9	0	0	0	0	0	0	0	0	0	0	0	0	0	145

Table 3. Percentage reduction of insects' density in treated units versus control unit

Unit	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***
Post-treatment (week)													
1	33.5	24.3	24.0	25.0	36.0	19.0	22.0	26.0	32.2	43.1	25.0	39.0	12.5
2	42.8	47.0	54.5	41.1	51.1	37.0	39.1	42.0	45.2	55.3	43.0	46.5	25.2
3	43.1	52.1	57.5	46.3	53.1	40.0	43.3	45.5	47.0	56.1	48.0	48.0	27.5
4	55.1	66.0	61.4	61.2	62.4	44.3	50.0	65.0	59.0	71.5	63.0	62.0	49.5
5	65.0	77.0	76.0	63.3	72.4	63.0	63.1	72.0	60.0	78.0	78.0	68.2	75.0
6	77.5	78.0	79.2	69.1	76.0	71.3	67.2	75.0	70.0	78.2	80.5	73.1	83.0
7	82.1	81.0	83.1	78.3	80.1	77.0	70.0	81.0	70.5	82.0	83.0	76.0	85.1
8	91.3	86.0	91.0	83.0	81.2	87.4	83.0	89.0	81.2	87.4	87.4	91.0	88.4
9	100	100	100	100	100	100	100	100	100	100	100	100	100

In the Table 4 are presented the results of the average cost/ treated unit for both methods. As we can see the cost in the first month was 21 Euro/unit, while the average cost for the classical method was 8.3 Euro/ unit**.** After three months, we can see that the average cost between methods started to equate because in many units where is used gel baits started a quarterly treatment schedule. We arrived at the conclusion that during the first month the cost of gel baits was greater because is greater service time and the amount of insecticide applied. After the first clean out the service time and the amount of gel baits applied was reduced continuously. Service time is reduced because the technician was more familiar with the infrastructure and the problematic areas. The monitor traps indicated also that the gel treated units insects' population remained suppressed after the first clean out while in the spray treated units the insect's number was multiplied during the summer months and unfortunately begun to appear the insect resistance. Foreign studies also, have reported the resistance to deltamethrin in B. germanica [4].

Comparison of safety and technical data sheets for both methods indicates that the use of 2.15% imidacloprid gel results more safety for human and environment. We analysed physico-chemical indicators as odor, form, dispersion, technology and application procedures, degradation and toxicological classification. Insecticides in bait formulations tend to exhibit much less passive drift to nontarget areas than sprays, in part because they are in a gel or solid matrix, but also because they have a much lower surface area that interacts with the atmosphere [14]. They also offer safe application technology and reduced odour (imidacloprid has low vapor pressure) when compared with residual sprays. They also have little dispersion in contrast with liquid or dust forms. Baits greatly reduce problems encountered with run off and drift from liquid and dust insecticide formulations [9]. Baits offer the advantage of low odor, stability and ease of application compared with aerosol and spray formulations [2].

The most important factors that contribute to the toxicity are quantity of the products applied and the frequency of exposure. Since the quantity of the imidacloprid gel is reduced during time period and precise in specific location inaccessible for human the probability of the exposure is lower.

According to the WHO imidacloprid is rated as moderately toxic and is included in class II or III.The chemical breaks down to inorganic molecules by both photolysis and microbial action, in the air and with a half-life of 30 days in water and 27 days in soil anaerobically. The total amount of imidacloprid was around130gr while the total amount of deltamethrin was around 475 ml (475gr) for the whole period of study.

Deltamethrin is also included in class II or III and is rated as moderately toxic, but in dust or spray form they exhibit much more passive drift to non-target area. Deltamethrin is quite resistant to photodegradation, i.e. exposed to sunlight it breaks down rather slowly. It has a half-life ranging from 5.7- 209 days.

Table 4. Monthly average cost of treated units in Euro

Months	***Gel treatment***	***Spray treatment***
1	21.5	8.3
2	17.6	8.2
3	11.9	5.8
4	5.4	6.5
5	6.4	5.9
6	2.8	4.5
7	0	8.2
8	1.1	9.5
9	1.61	6.25
10	0	5.5
11	0.1	3.6
12	0.1	3.2
Total	68	78

4. Conclusions

The use of insecticide 2.15% imidacloprid (gel bait) against *Blattella germanica* and *Blatta orientalis* in food units resulted effective, economically more profitable and with safe guaranty for human and environment, comparing with the spray insecticide randomly used. In this study, the results of IPM practices are very effective for *B. germanica and B. orientalis* control and contradicts the facts that insecticides in spray/dust form are more effective. Results that the IPM system is more expensive than the conventional method at the initial stage, but subsequent application is cheaper because the educational program does not need to be repeated and also the amount of gel bait to be applied is substantially reduced. Service time was the greates expence in the in the gel bait treatment, because they should be placed in specific places (precision targeting). To find the specific places which varies between units, requires a detailed inspection of units. The spray treatment was cheaper at the beginning but at the end the cost was greater because the population has doubled during the summer months, which means that at the beginning of the test we have eliminated the susceptible portion of the population.

5. References

1. Agbodaze D, Owusu SB. **Cockroaches (Periplanetta americana) as carriers of bacterial diarrhoea in Accra, Ghana.** Central African Journal of Medicine 1989, **35**: 484–486.
2. Appel AG. **Contamination affects the performance of insecticidal baits against German cockroaches (Dictyoptera: Blattellidae)**. J Econ Entomol 2004, **97**: 2035-2042.
3. Burgess NRH, Chetwyn KN. **Association of cockroaches with an outbreak of dysentery**. Trans. R. Soc. Trop. Med. Hyg 1981, **75**: 332-333.
4. Choo LE, Tang CS, Pang FY, Ho SH. **Comparison of two bioassay methods for determining deltamethrin resistance in German cockroaches**. J Econ Entomol 2000, **93**(3): 905–10)
5. Cochran DG (1999). **Cockroaches: their biology, distribution and control**. Document WHO/CDS/CPC/WHOPES/99.3. World Health Organization, Geneva.
6. Czajka E, Pancer K, Kochman M, Gliniewicz A, Sawicka B, Rabczenko D, Stypuł- kowska Misiurewicz H. **Characteristics of bacteria isolated from body surface of German cockroaches caught in hospitals**. Przegl Epidemiol. 2003, **57**: 655-662
7. Dosland O **Integrated Pest Management. An IPM Update** http://www.ksre.ksu.edu/grsc_subi/Conference/Pest_Management_Workshop_2004/15_Ole%20Dosland.pdf2004.
8. Harbison B, Kramer R, Dorsch J . Stayin alive. **Pest control technology**. 2003, 83:24-29
9. Jech LE, Foster RN, Colletto D, Walgenbach DD, Roland TJ, Rodriguez GD. **Field evaluation of diflubenzuron and carbaryl bran baits against grasshopper (Orthoptera: Acrididae) populations in South Dakota**. J Econ Entomol 1993, **86**: 557-565.
10. 7.Mulla MS **Control of chironomid midges in recreational lake**. J Econ En-tomol. 1971, **64**: 300-307
11. Nasirian H. **Rapid Elimination of German Cockroach, Blatella germanica, by Fipronil and Imidacloprid Gel Baits**. Tehran University of Medical Sciences, Iran. Iranian J Arthropod-Borne Dis, 2008, 37-43
12. Roberts J. **Cockroaches linked with asthma**. Br Med J. 1996, **312** (7047): 1630.
13. Tilak R, Tilak VW, Yadav JD, Dutta Gupta KK **Efficacy of fipronil and propoxur in the control of German cockroaches (Dictyoptera: Blatellidae)**. J Commun Dis. 2002, **34**: 65-9
14. Williams G. M, Linker H.M, Waldvogel M.G, Leidy R.B, Schal C. **Comparison of conventional and Integreted Pest Management Programs in Public Schools**. J. Econ. Entomol. 2005, **98**(4): 1275Ð1283.