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INFLUENCE OF THE INSECTICIDE FOZALON ON THE STRUCTURE OF SYRPHID COMMUNITY (DIPTERA: SYRPHIDAE) IN AN ALFALFA ECOSYSTEM

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Abstract

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The goal of the study was to establish the influence of the insecticide fozalon upon main population and coenotic parameters of the syrphid flies (Diptera: Syrphidae) – a basic component in the useful entomofauna of the agro-coenoses. The effect of the insecticide on the number of species and qualitative composition of the syrphid coenosis was unessential. The influence of the insecticide fozalon on the population density of each species and the total average density of the community was negative and clearly manifested. The negative effect occurs immediately after the treatment and it was longer for some species. The dominant structure shows no significant change after treatment compared to the same area before the treatment. The used indices for the species structure of the communities in the investigation show a relatively less unfavorable ecological situation for the syrphid cenosis in the field after insecticide treatment.

Key words: Diptera, Syrphidae, insecticide, fozalon, species composition, community

Introduction

Chemical method of pest control in agriculture continues to be a major and reliable method. The usage of pesticides still is inevitable and it's considered that in the next decades their production will be increased (Chalmers, 1970; Melnikov, 1973; Milanova, 1973; Graham-Bryce, 1977; Sohrmann, 1978). One of the main problems of plant protection activities remains the search of chemicals preparations, which poses a high selectivity to the pests and save to the maximum the valuable components of the biocenoses (Berim, 1971; Gar, 1974, 1978; Medved, 1977). In this sense, the study is of a great significance for clarifying the influence the widely used in agriculture fozalon insecticide on one outstandingly useful in biological pest control insect group – hover flies.

Most of the investigations which concern the influence of different pesticides on the hover flies are associated mostly with the effect of the preparations on mortality in pre-imago stage (Hellpap, 1982; Wojciech, 1988). The data in the specialized literature, that specify the influence of fozalon on the hover flies is found in only one research (Radeva, 1984),

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which concerns the survival of larva stages of some species hover flies in laboratory treatment with fozalon. However data for the influence of phosphorous-organic insecticide fozalon on the structure of syrphid communities is not on our disposal. The present study is first to analyze in details the effect of fozalon on basic population and cenosis characteristics of the hover fly communities in field conditions.

Materials and Methods

The influence of the insecticide fozalon on the structure of hover fly community was investigated during a field experiment in an alfalfa ecosystem in the environs of the town of Yambol. The insecticide, used in the form of the perparation Agria 1060 (Bg) was applied against the pests on alfalfa - *Otiorrynchus ligustici* L. and *Phytodecta fornicata* Brügg.

The experiment took place between 24 of May and 19 of June 2007. The insecticide was spread over a five ha area in 2 $l.ha^{-1}$ dosage. The treatment with the insecticide was done on 25 of May by using terrestrial agricultural machinery.

The investigated material was taken by the generally-accepted and recognized "mowing" method with a standard entomological sack with diameter 0.3 m. The total number of collections was nine. The first collection of material was realized on the day before the treatment on the crop with insecticide – 24.05. The influence of preparation was noted on 26.05., 28.05., 30.05., 01.06., 04.06., 09.06., 14.06. and 19.06., respectively on the 1^{st}, 3^{rd}, 5^{th}, 7^{th}, 10^{th}, 15^{th}, 20^{th} and 25^{th} post-treatment days. In each collection were taken by 50 samples and every sample consisted of 50 sweeps with entomological sack, with an average sweep-length of 1m. All the samples were collected before noontime under similar conditions – quiet and sunny weather.

The effect of the insecticide over the taxonomic composition and the complex of dominant species in the treated field were established through the Jaccard index (after Wallwork, 1976). The taxonomic similarity between hover fly communities was evaluated on the Zlotin scale (Zlotin, 1975).

The population density was calculated by the method, recommended by Gilyarov (1974). The quantitative data about the changes in the population's density and the general average density of the community were processed according with the commonly-accepted statistical methods. The quantitative differences between the syrphid complexes were determined through the Jaccard-Naumov index (after Chernov, 1975). The dominant structure was evaluated by the classification of Arzamasov et al. (after Hotko et al., 1982).

For an evaluation of the impact of the used insecticide on the hover fly cenosis and for analysis of the ecological status were used some of the basic structural indices for species structure of the communities, recommended by Odum (1975) – Simpson's index for dominant concentration (D), Margalef's species richness index (d), Pielou's equality index (e) and Shannon-Weaver index for total species diversity ($\overline{H}$).

Results and Discussion

Species composition

Ten hover fly species, which belong to eight genuses from family Syrphidae (Peck, 1988), were identified as a result of the investigation. Six of these were from subfamily Syrphinae, and other four were from subfamily Milesiinae. Syrphinae larvae are carnivorous and naturally regulate the population density of many forest and agricultural pests (Zimina, 1954; Adashkevich, 1975; Pavlov, 1976). Milesiinae larvae are saprophagous and xilophagous. Accelerating the process of decomposition of the organic compounds they play a significant role in the circumrotation of the substances (Zimina, 1968; Chernov, 1978).

The distribution of species in each sample and their population densities are presented in Table 1.

The data from the table shows that the greatest reduction of the number of species is reported during the first two samples - 1^{st} and 3^{rd} days after treatment with preparation. The reduction was with 37.5 % compared to the number of recorded species just before the treatment with insecticide. On the 7^{th} and the 15^{th} post-treatment days the number of species

Table 1
Established species and their density (number individuals/ha) in the field before (A) and after (F) the fozalon treatment

Species	Number individuals/ha								
	A				F				
	24 May	26 May	28 May	30 May	01 June	04 June	09 June	14 June	19 June
Episyrphus balteatus (De Geer, 1776)	93	27	40	27	53	80	93	107	93
Metasyrphus corollae (Fabricius, 1794)	27		13	13	27	40	27	40	40
Sphaerophoria philanthus (Meigen, 1822)	27				13	27	40	53	40
Sphaerophoria scripta (Linnaeus, 1758)	227	67	67	53	93	173	187	187	200
Melanostoma mellinum (Linnaeus, 1758)	67	27	27	40	13	27	53	67	80
Paragus tibialis (Fallen, 1817)	13						13	13	
Eristalinus aeneus (Scopoli, 1763)				27	13	13			27
Eristalis arbustorum (Linnaeus, 1758)	53	40	27	13	40	53	53	67	67
Eristalis tenax (Linnaeus, 1758)	27	13		27	27			27	40
Syritta pipiens (Linnaeus, 1758)							27	40	27

was equal to the number on the pre-treatment day, and on the 20th and the 25th days the number increased compared to the number recorded before the treatment with insecticide. The insecticide fozalon shows less influence to the number of species of hover flies compared to phenitrotion and chlorpyriphos (from the same phosphorus-organic the group of insecticides), which indicated a strong and long-lasting effect on the number of identified species (Markova, 1996a); Markova and Dimcheva, 1998).

Four species persisted in samples through the through the entire period of investigation: *E. balteatus*, *S. scripta*, *M. mellinum* and *E. arbustorum*. At a similar investigation of the influence of the herbicide tribenuron-methyl on the structure of the hover fly community in wheat ecosystem was reported the same steadiness of *E. balteatus*, *M. corollae* and *S. scripta* (Markova, 2007). Analogical results for *S. scripta* have been shown about the treatment with another pesticide – the herbicide 2.4-D, in a barley ecosystem (Markova, 2003). A relatively low level of insecticide effect was noted for another species, *M. corollae* and *E. tenax*. Two species - *P. tibialis* and *S. philanthus* were more significantly affected by the insecticide. *P. tibialis* was found in the samples just on 15th post-treatment day, and the *S. philanthus* - on the 7th post-treatment day. Two species - *E. aeneus* and *S. pipiens* were found only in post-treatment samples.

The derived data showed no essential influence of the fozalon on the number of species of hover flies. Identical results demonstrated the Jaccard index, which indicates a taxonomic similarity between species composition in the area in the pre-treatment and post-treatment days. The Jaccard index varied between 62.5% and 88.8%. Highest taxonomic similarity (88.8%) between hover fly complex was reported on the pre-treatment day and on the 20th post-treatment day. The values of the taxonomic similarity evaluated on the Zlotin scale (Zlotin, 1975), were two categories - “high” and “very high”, which showed no difference in quality relation between taxonomic composition before treatment with insecticide and all of the reported samples of preparation. In an environmental sense the data from the investigation give a reason to consider that fozalon does not affect the qualitative composition on the hover fly coenosis.

Population density

The influence of the insecticide fozalon upon the density of the hover flies species was much more clearly and strongly manifested compared to its influence upon species composition (Table 1).

The data from the investigation showed that the insecticide effect on the population density was by all means negative and varied by strength and duration from a species for each one of the species. All of the species found on the 1st day reporting were with a significantly reduced density (from 2.1 times to 3.4 times) from those we found in the area before the treatment. Most detrimental effect was established for the species *S. philanthus* and *P. tibialis*. The influence upon the rest of the species was less manifested but with longer duration. Some of the species like *E. balteatus* and *M. melinum* reached their initially established density on the 15th and 20th days after treatment, and one species *S. scripta* does not reach the density recorded before the treatment (up to the 25th day). With *S. scripta* it was showed the same negative and continued effect on the density of another phosphororganic insecticide - phenitrotion in a cabbage ecosystem treatment (Markova, 1996).

The negative influence of the insecticide fozalon on the hover fly community is observed also with Jaccard-Naumov index for quantitative similarity between the complexes. To 5th day of reporting the index had low values of 32.5%, 32.5% and 31% on the 1st, 3rd and 5th days after the treatment respec-

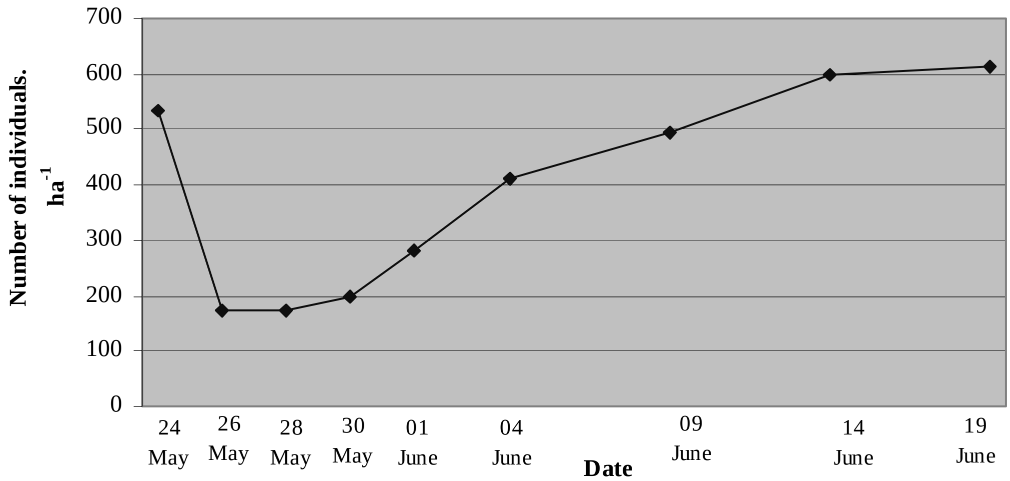

Fig.1. Influence of the insecticide fozalon on the total density of the syrphid flies. Reliability criteria tD for post-treatment days from 24th of May to 19th of June showed the following values: 3.20, 3.20, 2.95, 2.14, 0.96, 0.29, 0.52, 0.60

tively. This values showed a major quantitative difference between the community before and after the application of the insecticide. On the 7th post-treatment day, the similarity index accepted average values - 48.7% in comparison with the population density in untreated area. From the 10th to 25th days reporting the similarity index has already accepted higher values - 69%, 79.1%, 73.5% and 75.5% for 10th, 15th, 20th and 25th post-treatment days respectively, compared to non-treated area. From the 10th post-treatment day up to the end of the investigation, there was no quantitative difference between the hover flies communities.The total average density of hover flies was also changed significantly, under the influence of researched insecticide (Figure 1). The density is significantly decreased compared to the established one in the non-treated area immediately after the treatment (till the 5th day of reporting, including) and the decrease was 3 times (on the first and the 3rd day) and 2.8 times (on the 5th day) and it was with high level of statistical reliability ($P<0.01$). On the 7th post-treatment day the total average density continued to be 1.9 times ($P<0.05$) lower than the one in non-treated area. Just on the 20th and 25th post-treatment day the total average density already exceeded the one, which was established before the treatment, but the difference was negligible and was not statistically confirmed. The results showed that phosphorous-organic insecticide fozalon had a less effect upon the quantitative parameters of the studied communities compared to chlorpyriphos, which even a month after the treatment with chlorpyriphos, density of the hover flies communities is still lower than the found in untreated area (Markova and Dimcheva, 1998).

Table 2
Dominance (relative significance, %) and some basic cenotic parameters of the syrphid community in the field before (A) and after (F) the fozalon treatment

Species	Relative significance, %								
	A	F							
	24 May	26 May	28 May	30 May	01 June	04 June	09 June	14 June	19 June
E. balteatus	17.4	15.5	23	13.5	19	19.4	18.9	17.8	15.1
M. corollae	5.1		7.5	6.5	9.7	9.7	5.5	6.7	6.5
S. philanthus	5.1				4.7	6.5	8.1	8.8	6.5
S. scripta	42.5	38.5	38.5	26.5	33.3	41.9	37.9	31.1	32.6
M. mellinum	12.5	15.5	15.5	20	4.7	6.5	10.8	11.1	13
P. tibialis	2.4						2.6	2.2	
E. aeneus				13.5	4.7	3.1			4.4
E. arbustorum	10	23	15.5	6.5	14.3	12.8	10.8	11.1	10.9
E. tenax	5.1	7.5		13.5	9.7			4.5	6.5
S. pipiens							5.5	6.7	4.4
D	0.2449	0.255	0.2073	0.1726	0.1909	0.2527	0.2287	0.1715	0.1788
d	1.89	1.54	1.54	2.2	2.3	1.8	1.94	2.1	2.09
$\overline{H}$	1.706	1.5	1.5	1.84	1.918	1.741	2.029	2.12	1.96
e	0.8	0.93	0.93	0.945	0.91	0.89	0.92	1.01	0.89
S	8	5	5	7	8	7	8	9	9

D – Simpson's index for domination concentration; d – Margalef's species richness index ;
$\overline{H}$ – Shannon-Weaver's index for total species diversity; e – Pielou's equality index;
S – number of species

Dominant structure

The effect of the insecticide on the number of each species reflects in difference in the dominant structure of the hover fly community. The influence was not strong enough to produce significant changes in "importance" of different species.

The dominant structure of the hover flies communities for each report is given in Table 2. In the non-treated area of the syrphid complex the dominants were four - *E. balteatus*, *S. scripta*, *M. mellinum*, and *E. arbustorum*. The dominant species covered 82.4% of the all individuals in the complex. The number of dominant species immediately after the treatment (on the 1st and 3rd post-treatment day) was not changed. Only the relative importance of various dominant is changed. The biggest difference between the basic species and the species that are found in non-treated area was found on the 5th day reporting. The largest number of dominant species - five *E. balteatus*, *S. scripta*, *M. mellinum*, *E. aeneus* and *E. tenax*, was established on the 5th post-treatment day. Their total relative importance was 87%. On the 7th and the 10th post-treatment days there were three species - *E. balteatus*, *S. scripta* and *E. arbustorum* with the biggest importance, and they covered respectively 66.6% of all individuals in the complex on the 7th post-treatment day and 74.1% on the 10th post-treatment day. Overall the dominant structure in the remaining days of reporting (15th, 20th and 25th post-treatment days) was similar. The dominant species were four - *E. balteatus*, *S. scripta*, *M. mellinum* and *E. arbustorum* with insignificant difference in their relative importance. The total percentage share of the main species during three days of reporting was close 78.4%, 71.1% and 71.6% respectively on the 15th, 20th and 25th post-treatment days.

Constant dominants throughout the investigated period were two - *E. balteatus* and *S. scripta*. The species *E. arbustorum* was not in the dominants only on the 5th post-treatment day.

The similarity in the complex of dominants in each reported day was quantified by Jaccard index. The value of the Jaccard index for the taxonomic similarity in the dominant species of the syrphid complex was 100%, respectively for the 1st, 3rd, 15th, 20th and 25th post-treatment days. The index assumed a 75% value for the high similarity between the complexes on the day before the application of the insecticide and the 7th and the 10th post-treatment days. The index assumed a 50% value on the 5th post-treatment day and shows a bigger difference compared to the complexes of major species in non-treated area. This shows some changes compared to dominant complex in non-treated area and it is within the limits of "middle" similarity, but the changes were unessential.

The results show that the dominant structure on the hover fly communities was not significantly affected by the application of insecticide fozalon. The influence of the insecticide shows a slight change in the relative importance of different species, and no significant difference between the levels of dominant structure. The similar results were recorded for the effect of phenitrotion and chlorpyrifos on the hover fly community (Markova, 1996; Markova and Dimcheva, 1998).

Indices for species structure of the community

The values of the indexes for community structure used in our analysis are given on Table 2. Used indexes represent a numerical expression of ecological conditions in the environment and they are very informative in rich communities giving a detailed assessment compared with other qualitative and quantitative parameters of communities (Odum, 1975).

The index for dominance concentration (D) is too demonstrative at limited factors in the system. As a result many of the species reduce the number of individuals or even disappear from the composition of communities. Only few of the species (the persistent) retain the possibility for quantitative performance and retain or increase in number, and thus the less species concentrate more individuals – "dominance concentration". In this investigation the index for dominance concentration (D) on the 1st post-treatment day was 1.04 times higher than that in non-treated area and indicates aggravated conditions for hover fly communities immediately after treatment.

The values of Shannon-Weaver index ($\overline{H}$) correlates inversely with the value of the dominance concentration index (D). The Shannon-Weaver index ($\overline{H}$) has a valuable quality that does not depend on the number of the samples, and shows information for both indices, Margalef's species richness (d) and Pielou's equality (e), integrating them into a general index for diversity. This applies especially for species richness community. In some cases, when dependencies are poorly developed, and recommended calculations on the other indices (Odum, 1975). The Shannon-Weaver index was 1.14 times lower than that in non-treated area and indicates aggravated conditions of environment immediately after the treatment (on the 1st and 3rd post-treatment days). The same tendency of change occurred in the species richness index (d). It value was 1.23 times lower than the values reported in non-treated area, immediately after the treatment with the insecticide (on the 1st and 3rd post-treatment days). The registered values illustrated a stressing ecological situation in the field for syrphid cenosis, immediately after the treatment and the most favorable – the area before the treatment with the insecticide.

The Pielou equality index (e) also correlates positively with the value of the Shannon-Weaver index ($\overline{H}$). Hence it is logical to expect that its value will be lower in the area after treatment. However the data obtained were opposed. In this case the Pielou index (e) lost the information because of the "double stress" effect, which frequently occurred with re-stressed in poor of species composition community, such as the agrocenoses. According to Odum (1975) in a similar secondary stressing (in this case as a result of treatment with the insecticide), more often the species composition does not change significantly in most of the cases, but the number of dominant species is reduced, which leads to greater equality of species in communities. There was just such a situation, and the values of the Pielou index (e) were greater in the treated area. Similar observations on the "double stress" effect have been seen in other studies on the syrphid communities – in treatment with insecticide chlorpyriphos and synthetic pyrethroid deltametrin (Markova and Dimcheva, 1998; Markova and Aleksiev, 2005).

The indices used for the species structure of the communities completed the information obtained through other qualitative and quantitative parameters and clearly showed more adverse environmental conditions for the syphid community in the area immediately (during the first one to three days) after the fozalon treatment.

Conclusion

The studied insecticide fozalon does not affect significantly the number of the species and the qualitative composition of the syrphid flies. Under its influence the most negatively affected was the population density. With some of the species this tendency was with a significant duration. The total density of the syrphid community was significantly decreased too, and it remained such until the twentieth day after the treatment. The influence of the insecticide on the dominant structure of the community is led to unimportant changes of the relative significance of the distinct species and as a whole the dominant structure of the community was not vastly changed. From the analysis of the obtained population and coenotic factors and the parameters, characterizing the species structure of the communities it could be made a conclusion that fozalon produces even though not a quite expressive, negative influence upon the syrphid coenosis. In order to increase the yield of agricultural crops it is necessary to find the best combination between rational usage of the pesticides and the maximum preservation of the useful entomofauna – the natural bio-regulator of the pest's density in the agricultural areas.

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