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Influence of Decis spraying on the community structure and species composition of beetles (Insecta: Coleoptera) on a potato field

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The researches were carried out on a potato field in the vicinities of Omgovitchy village (53°06'04''N and 27°40'35''E, about 20 km to the E of Slutzk, Minsk District, Belarus), in June-October, 1998. On 29[th] of June, half of the field (28 ha) was treated with Decis insecticide (0.3 kg /ha) to control Colorado beetle's larvae population. And on the other half of the field the beetle's larvae were collected manually. For the collection of the beetles plastic pitfall traps (volume 200 ml, diameter 72 mm) were used filled with a formalin solution (4 %). 10 traps were placed in each plot in line. After 10-12 days the traps were inspected. Representatives of 120 species of beetles from 14 families were collected in the entire field. In the treated plot about 1919 specimen (10 families, 74 species) were collected. In the control plot 2636 specimen (13 families, 93 species) was found. Beetle activity in the experimental plot was reduced after Decis spraying and it was restored only at the end of August. The application of Decis did not influence the zoogeographical structure of beetle community. We found the reduction of species number and number of the recedent and subrecendent species. The number of saprophagous species and percentage of specimens had decreased in the treated plot. The percentage of necrophagous specimens had increased.

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INTRODUCTION

The study of the effect of insecticides used to control Colorado beetle *(Leptinot arsa decemlineata* Say, 1824) population in potato crops was began by Scherny (1958) and Scherf (1959) in Germany, Skuhravy (1959) in the Czech Republic, Cinitis and Vilks (1961) in Latvia. In these studies the negative effect of DDT and its analogues to carabids community was found out.

After the phosphor organic insecticides had been practically used, similar researches were carried out by Goos et al. (1976) in Poland and Zherebtsov (1989) in Tartarian. It was proved that also this group of insecticides has a negative effect to carabid community, similarly as in the case of chlorine organic insecticides.

Kaczmarek (1992) observed the catastrophic reduction of carabids population number after using of Decis 2,5EC in potato crops in Poland.

To similar conclusion came Koval' et al. (1995) in Crimea studying the effects of synthetic pyrethroid insecticide Fjury and inhibitor of insect growth Sonet, and a bacterial preparation based on *Bacillus thuringiensis* on predatory carabids in potato crops and eggplants.

The effect of Decis (Deltamethrin) treatment on the whole potato beetle community was not known yet.

METHODS AND MATERIALS

The researches were carried out in potato field in the vicinities of Omgovitchy village (53°06'04"N and 27°40'35"E , about 20 km to the E of city Slutzk, Minsk District), placed on the sod-pod-zol sandy clay ground with underlay of marine loam.

The potato field occupied 28 ha, and the previous culture was winter rye. In autumn the basic ground cultivation was made, the organic fertilizers (manure, 20 t/ha) and the potash fertilizers at the rate of 0.3 t/ha potassium chloride were applied. In the spring cultivation was carried out in two traces and nitric fertilizers (Carbamid) were applied in the amount of 0.2 t/ha, and phosphoric-double superphosphate - 0.2 t/ha. Seedbed preparation was also carried out on the occasion.

Automated (tractor track) planting of potatoes was done by April, 18-23. The seeds were the Prygozhy variety, and the density was 55-60 thousand plants per ha. The tending of crops consisted of blind hilling 5-10 days after, and the hilling without harrowing after the emergence of seedlings.

On 29th of June t half of the field was treated with insecticide Decis 0.3 kg /ha to control Colorado beetle larvae population, while on the remaining area of the field the beetle larvae were collected manually. The top off was done by 20th of August. The gathering of the crop was carried out beginning with 1st of September.

For the collection of the beetles were used plastic pitfall traps (volume 200 ml, diameter 72 mm) with a formalin solution (4 %). At each half of the field 10 traps were placed in line (the distance between traps was about 10 meters). The traps were changed in 10-12 days. The pitfall trapping was started on the 20th of June and all traps were removed by the 15th of October.

The Renkonen technique (Renkonen, 1938) was used for the evaluating of domination. According to the scale the following groups were identified: dominants (more than 5 %), subdominants (3-5 %), recedent (1-3 %) and subrecedent (less than 1 %) species.

The verification of differences of average values was estimated with the help of Student test and standard error.

The structural heterogeneity of the communities was expressed in terms of variability of species structure.

For the rating of community structure the following tools were used:

1. The Shannon-Weaver diversity index:

$$H' = - \; p_i \ln p_i \qquad (1)$$

2. Standard error of diversity measure:

$$m^2_{H'} = 1/N \, [1/N(N\ln^2 N - \; n_i \ln^2 n_i) - (H')^2 + + (S-1)/2N^2 + ...] \qquad (2)$$

3. Simpson index of the dominant concentration:

$$C = \; p_i^2 \qquad (3)$$

4. Pielou index of evenness

$$J' = H'/H'_{max} \qquad (4)$$

where: p_i - share of a species a in the whole collection N.

The formulas for accounts are given according to the version by Pesenko (1982).

For the description of the areal types we used the terminology proposed by Gorodkov (1984).

RESULTS AND DISCUSSION

A total of 4555 beetle specimens belonging to 14 families and 120 species have been collected during the entire study period. 2636 specimens (93 species from 13 families) were caught in the control plot, and 1919 specimens (74 species from 10 families) in the treated ones (application of Decis (Tabl. 1,2). In the experimental plot the representatives of Dytiscidae, Hydrophilidae, Lathridiidae, Cerambycidae were not found. A reduction in number of specimens of Carabidae, Histeridae, Scarabaeidae, and Chrysomelidae was proved (p > 0,05). The representatives of Elateridae were found only in the treated plot. The number of necrophagous *(Necrophorus* sp.) and myxophagous species *(Silpha* sp.sp.) from the Silphidae family was found to be increased.

The activity of the beetles decreased from 2.40 ± 0.45 to 1.57± 0.33 specimens per trap per day in the treated plot.

There were found representatives of the four holarctic distribution types: the circumtemperate, transpalearctic, euro-siberian and west-palaearctical ones (Fig. 1).

The species of the Euro-Siberian type of distribution prevailed, but considering the absolute number of specimens, the transpalearctic ones were more numerous.

The application of Decis had not caused any essential changes of zoogeographical structure. The reduction of species number occurred in all types of distribution in approximately equal shares.
The value of Shannon-Weaver diversity index (H') did not significantly differ between the control and the treated plots. Some increase was, however, observed in the treated plot in the value of Simpson index concentration of domination (C) and Pielou index of evenness (J') (Tab. 1).

Table 1. The effect of pesticide treatment to the family composition and structure of beetle community on potato field. Minsk district, 1998

FAMILY	Number of specimens		Number of species	
	Treated plot	Control plot	Treat plot	Control plot
Carabidae Latreille,1802	1427*	2024	38	41
Dytiscidae Leach,1815		1		1
Hydrophilidae Latreille,1802		1		1
Silphidae Latreille,1807	195*	6	6	4
Staphylinidae Latreille,1802	49	31	12	10
Histeridie Gyllenhal,1808	6*	24	2	5
Scarabacidae Latreille,1802	2*	159	2	15
Elateridae Leach,1815	19		4	
Coccinellidae Latreille,1807	30	31	2	4
Lathridiidae L.Redtenbacher,1845		1		1
Anthicidae Lacordaire,1825	1	2	1	1
Cerambycidae Latreille,1802		1		1
Chrysomelidae Latreille,1802	188*	340	5	3
Curculionidae Latreille,1802	2	15	2	6
Total specimens and species	1919*	2636	74	93
Dynamic density, Specimens per trap per day ± SE	1,57±0,33	2,40±0.45		
Shannon index of diversity H” ± $m_{H'}$	2,69±0,09	2,71±0.07		
Simpson index of concentration of domination C	0,163	0,153		
Pielou index of evenness J'	0,625	0,598		

* Difference is significant (p < 0.05)

The structure of domination was similar in both plots (Fig. 2). There were revealed 4 dominant species, 7 and 6 subdominant species, 5 and 6 recedent ones. The number of subrecedent species was much higher in the control plot (77 against 58).

There were 2 dominants: *Harpalus rufipes* and *Leptinotarsa decemlineata.* In the treated plot the dominant species *Harpalus griseus* and *Amara fulva* became the subrecedents, and the subdominant *Calathus melanocephalus* and subrecedent *Silpha obscura* moved to the dominant group (Tab. 2).

There were 3 subdominants: *Clivina fossor, Calathus fuscipes* and *Bembidion quadrimaculatum.* In the control plot the subdominant species *Harpalus calceatus* and *Broscus cephalotes* "moved" to the recedent group in the treated plot. Their place in the treated plot was taken by *Amara bifrons, Bembidion properans* and *Loricera pilicornis.*

Table 2. The effect of pesticide treatment on the species composition on potato field. Minsk district, 1998

Species	Treated plot	Control
Harpalus rufipes (Degeer, 1 774)	37.10	34.17
Leptinotarsa decemlineata (Say, 1 824)	9.42	12.78
Harpalus griseus (Duftschmid, 1812)	0.16	8.61
Amara fulva (Degeer, 1774)	0.36	6.56
Broscus cephalotes (Linnaeus, 1 758)	0.57	3.68
Calathus fuscipes (Goeze, 1 777)	2.81	3.38
Harpalus calceatus (Duftschmid, 1812)	0.05	2.88
Calathus tnelanocephalus (Linnaeus, 1 758)	7.56	2.85
Clivina fossor (Linnaeus, 1 758)	3.70	2.66
Bembidion quadrimaculatum (Linnaeus, 1 761)	2.08	2.39
Calathus ambiguus (Paykull,1790)	0.57	1.63
Oxyomus silvestris (Scopoli, 1 763)		1.40
Aphodiusfimetarius (Linnaeus, 1 758)		133
Aphodius distinctus (O.F.Müller, 1 776)	0.05	125
Calathus erratus (Sahlberg, 1 827)	0.99	1.14
Amara bifrons (Gyllenhal, 1810)	2.81	1.10
Bembidion properans (Stephens, 1 828)	2.55	0.80
Synuchus vivalis (Illiger,1798)	0.26	0.76
Poecilus lepidus (Leske, 1785)		0.76
Coccinella septempunctata Linnaeus, 1758	1.51	0.61
Loricera pilicornis (Fabricius, 1775)	2.08	0.49
Philonthus cognatus Stephens, 1832	0.10	0.42
Bembidion femoratum Sturm, 1825	0.21	0.38
Margarinotus purpurascens (Herbst, 1792)		0.38
Aphodius niger (Panzer, 1797)		0.34
Aphodius prodromus (Brahm, 1790)		0.34
Margarinotus carbonarius (Hoffmann, 1 803)	0.05	0.30
Amara apricaria (Paykull,1790)	0.21	0.27
Coccinella quinquepunctata Linnaeus, 1758		0.27
Hypera meles (Fabricus, 1792)		0.27
Amara consularis (Duftschmid, 1812)	1.62	0.23
Propylaea quatuordecimpunctata (Linnaeus, 1758)	0.05	0.23
Aphodius subterraneus (Linnaeus, 1758)		0.23
Calathus halensis (Schaller, 1783)		0.23
Poecilus versicolor (Sturm, 1824)	2.55	0.19
Oxytelus rugosus (Fabrucuus, 1775)	0.78	0.19
Poecilus cupreus (Linnaeus, 1758)	0.47	0.19
Aphodius ictericus (Laicharting, 1781)	0.05	0.19
Aphodius pusillus (Herbst, 1789)		0.19
Aphodius rufipes (Linnaeus, 1758)		0.19
Aphodius scybalarius (Fabricius, 1781)		0.19
Curtonotus aulicus (Panzer, 1 797)	0.21	0.15
Pterostichus niger (Schaller, 1783)	0.10	0.15
Aphodius melanostictus W.L.Schmidt, 1840		0.15

Margarinotus ventralis (Marseul, 1854)		0.15
Amarafamiliaris (Duftschmid, 1812)	1.72	0.11
Calosoma auropunctatum (Herbst, 1784)	1.15	0.11
Harpalus affinis (Schrank, 1781)	026	0.11
Aclypea opaca Linnaeus,1758	0.16	0.11
Amara eurynota (Panzer, 1797)		0.11
Ocypusfuscatus (Gravenhorst, 1802)	026	0.08
Oxytelus nitidulus Gravenhorst, 1802	026	0.08
Xantholinus tricolor (Fabricius, 1787)	026	0.08
Amara plebeja (Gyllenhal, 1810)	0.05	0.08
Notoxus monoceros (Linnaeus, 176 1)	0.05	0.08
Anisodactyhis signatus (Panzer, 1797)		0.08
Aphodius haemorrhoidalis (Linnaeus, 1758)		0.08
Aphodius sordidus (Fabricius, 1775)		0.08
Atheta crassicornis (Fabricius,1892)		0.08
Atheta nigripes (Thomson, 1856)		0.08
Gastrophysa polygoni (Linnaeus, 1758)		0.08
Hippodamia tredecimpunctata (Linnaeus, 1758)		0.08
Hypera arator (Linnaeus, 1758)		0.08
Hypera plantaginis (Degeer, 1775)		0.08
Mycetoporus punctus (Gravenhorst, 1806)		0.08
Mycetoporus nifescens (Stephens, 1832)		0.08
Sitona humeralis Stephens, 1831		0.08
Silpha obscura Linnaeus, 1758	6.9.	0.04
Nicrophorus sepultor (Charpentier, 1825)	1.46	0.04
Nicrophorus vespillo (Linnaeus, 1758)	0.89	0.04
Harpalus luteicornis (Duftschmid, 1812)	0.31	0.04
Harpalus tardus (Panzer, 1797)	026	0.04
Margarinotus bipustulatus (Schrank, 1781)	026	0.04
Cassida nebulosa Linnaeus, 1758	0.16	0.04
Amara majuscula Chaudoir, 1850	0.05	0.04
Amara aenea (DeGeer, 1774)		0.04
Aphodius ater (Degeer, 1774)		0.04
Aphodius plagiatus (Linnaeus, 1767)		0.04
Bembidion tetracolum Say, 1823		0.04
Chlaenius nitidulus (Schrank, 1781)		0.04
Corticaria pubescens (Gyllenhal, 1827)		0.04
Dyschirius globosus Herbst, 1784		0.04
Graphoderus cinereus (Linnaeus, 1758)		0.04
Harpalus autumnalis (Duftschmid, 1812)		0.04
Harpalus froelichii Sturm, 1818		0.04
Harpalus smaragdinus (Duftschmid, 1812)		0.04
Hypera dauci (Olivier, 1807)		0.04
Notiophilus palustris (Duftschmid, 1812)		0.04
Oberea linearis (Linnaeus, 1761)		0.04
Otiorhynchus scaber (Linnaeus, 1758)		0.04
Philonthus debilis (Gravenhorst,1802)		0.04
Saprinus semistriatus (Scriba, 1790)		0.04
Spercheus emarginatus (Schaller,1783)		0.04
Pterostichus melanarius (Illiger, 1798)	0.99	
Agriotes lineatus (Linnaeus, 1767)	0.83	
Silpha tristis Illiger, 1798	0.57	
Ocypitsfulvipennis (Erichson, 1840)	0.42	
Oxytelus fulvipes Erichson, 1839	0.21	
Nicrophorus vespilloides Herbst,1783	0.16	
Amara similata (Gyllenhal, 1810)	0.10	
Calosoma investigator (Illiger, 1798)	0.10	
Cassidaviridis Linnaeus, 1758	0.10	
Harpalus pumilus Sturm, 1818	0.10	
Oulema melanopus (Linnaeus, 1758)	0.10	

Agrypnus murinus (Linnaeus,1758)	0.05	
Amara municipalis (Duftschmid, 1812)	0.05	
Anchomenus dorsalis (Pontoppidan, 1763)	0.05	
Atheta nigricornis (Thomson, 1852)	0.05	
Athous haemorrhoidalis (Fabricius,1801)	0.05	
Athous niger (Linnaeus, 1758)	0.05	
Chaetocnema hortensis (Geoffroy in Fourcroy,1785)	0.05	
Cleonus pigra (Scopoli, 1763)	0.05	
Notiophilus aquations (Linnaeus, 175 8)	0.05	
Ocypus brunnipes (Fabricius, 1781)	0.05	
Paragabrius micans Gravenhorst, 1802	0.05	
Pterostichus oblongopunctatus (Fabricius, 1787)	0.05	
Sitona hispidulus (Fabricius, 1777)	0.05	
Tachyporus chrysomelinus (Linnaeus, 1758)	0.05	
Tachyporus pusillus Gravenhorst, 1806	0.05	
Trechus quadristriatus (Schrank,1781)	0.05	
Number of species	74	93
Number of specimens	1919	2636

The largest changes were found in the recedent group composition. In the control plot among of the recedent species there appeared the saprophagous (coprophagous *Aphodius* sp.sp. and *Oxyomus silvestris),* predatory *(Calathus ambiguus, C. erratus)* and myxophagous *{Amara bifrons)* species. The predatory species *Coccinella septempunctata, Calosoma auropunctatum,* and necrophagous *Nicrophorus sepultor,* and myxophagous *Amara familiaris, A. consular is* are presented in the group of recedent in the treated plot.

The percentage and number of species of the subrecedents were reduced in the treated plot (Fig. 2).
Thus, significant changes in the structure of domination in the beetle community after they had been sprayed with Decis were found. The reduction in number of species and specimens of recedents and subrecedents was observed.

The representatives of 5 trophic groups were found in the potato field (Fig. 3).

Such predators as Carabidae (part), Dytiscidae, Staphylinidae (part), Histeridae, Coccinellidae, Anthicidae) predominated concerning the number of species.

The myxophagous species *(Harpalus* spp., *Amara* spp., *Silpha* spp.) predominated in respect with the number of specimens.

After the application of Decis the composition of trophic groups has changed (Fig. 3). The number of species was reduced in the treated plot (from 23 to 7) and the percentage of saprophagous specimens (mainly *Aphodius* sp.sp.) also dropped (from the initial 6.3% down 1.5%). The percentage of necrophagous beetles has increased from 0.1 to 2.6 %. The number of species from other trophic groups has practically not changed.

The dynamics of the seasonal activity of beetles in control and treated plots was differentiated (Fig. 4). Eight days after spraying the activity of beetles in treated plot was reduced and it was restored only at the end of August. In September and October after potatoes had been harvested, the activity of beetles in the treated plot was lower.

The activity of dominant species (Fig. 5) *Harpalus rufipes, Leptinotarsa decemlineata, Harpalus griseus* and *Amara fulva* has decreased after spraying. Decis is a contact insecticide. Therefore species creeping on plants got under its action. In an equal measure it concerns to *Leptinotarsa decemlineata* and specified myxophagous carabids.

In the experimental plot the density of two species has increased: the mixophagous *Silpha obscura* and the predatory *Calathus melanocephalus* (Fig. 5).

This last mentioned phenomenon could possibly explain the increasing of these species' activity by elimination of the competing species.

After the harvest of potato crop in September and beginning of October the activity of coprophagous *(Aphodius* sp.sp) in the control plot had increased. Probably, it was the consequence of non—uniform disperasion of manure over the field, and was not connected with the application of the insecticide.

So, the results of the present investigation are in agreement with the opinion of Kaczmarek (1992) who observed negative effects of Decis spraying for the beetle community in potato fields.

CONCLUSION

120 beetle species from 14 families were collected in the potato field. In the treated plot there were collected about 1919 specimens (10 families, 74 species). In the control plot the number was 2636 specimens (13 families, 93 species).

The density of beetles was reduced in the treated plot.

The species characteristic of the Euro-Siberian type of distribution prevailed. The transpalearctic elements were prevailing with respect to the number of specimens. The application of Decis did not cause anyessential changes of zoogeographi-cal structure of the beetle community.

We observed changes in the structure of domination. The reduction in species number and number of the recedent and subrecendent species was found.

The number of saprophagous species and percentage of specimens have both decreased in the treated plot. The percentage of necrophagous specimens has increased.
The activity of beetles in the experimental plot was reduced after the Decis application and it was restored only by the end of August.

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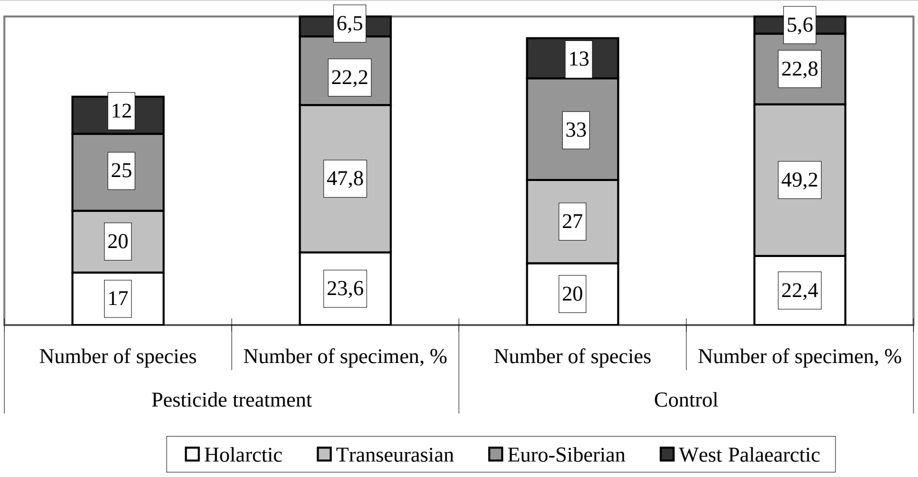

Fig. 1. The effect of pesticide treatment to the zoogeographical structure of beetles' assemby at potatoes field. Minsk district, 1998

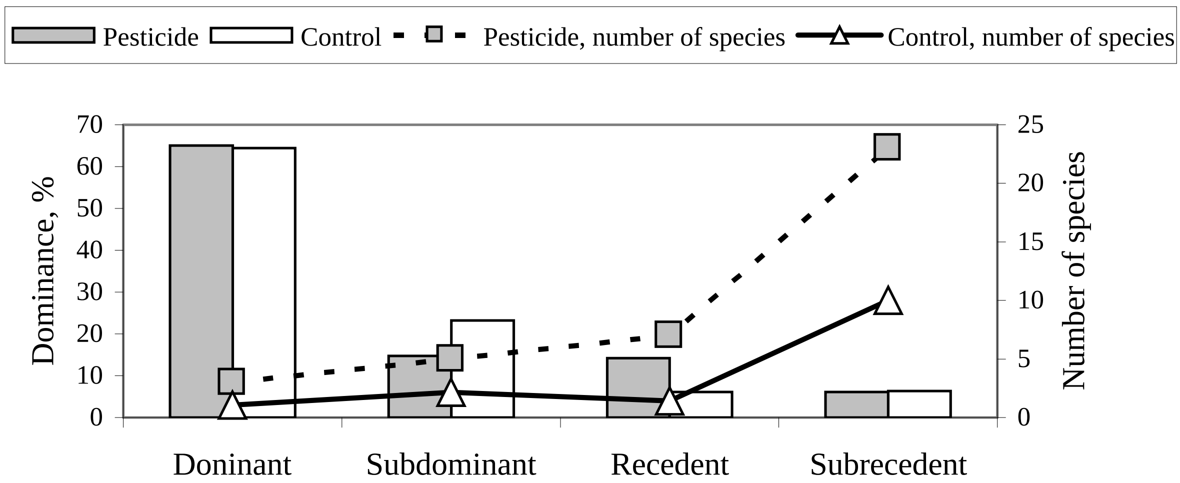

Fig. 2. A changing of dominance' structure of Carabid communities under pesticide spraying of potato field. Minsk ditrict, 1998 year

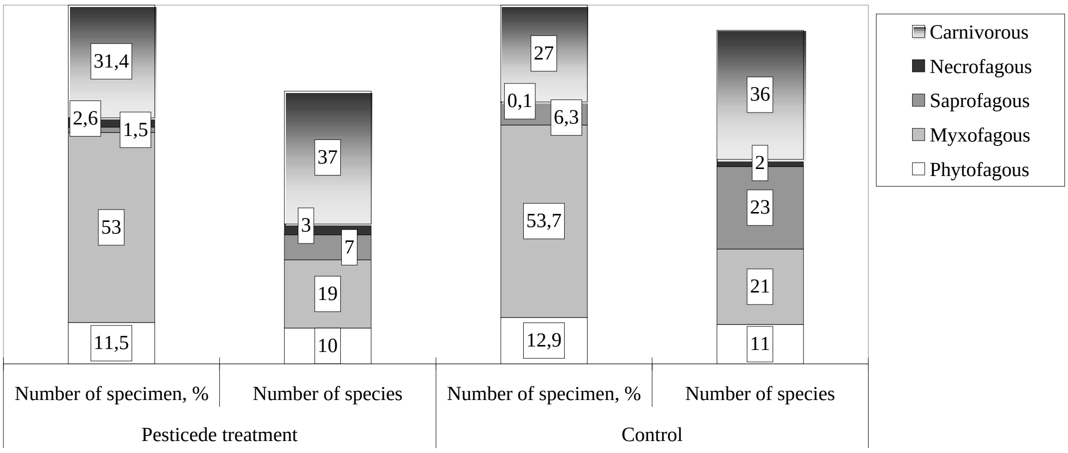

Fig. 3. The effect of pesticide treatment to the trofic spectrum of beetles' assemby at potatoes field. Minsk district, 1998

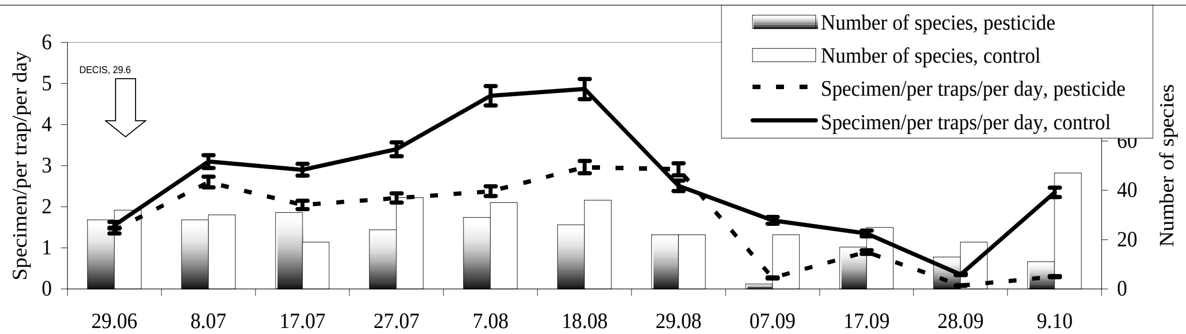

Fig. 4. Effect of the pesticide treatments to the seasonal dynamic of activity and the number of of beetles species at potatoe field. Minsk district, 1998

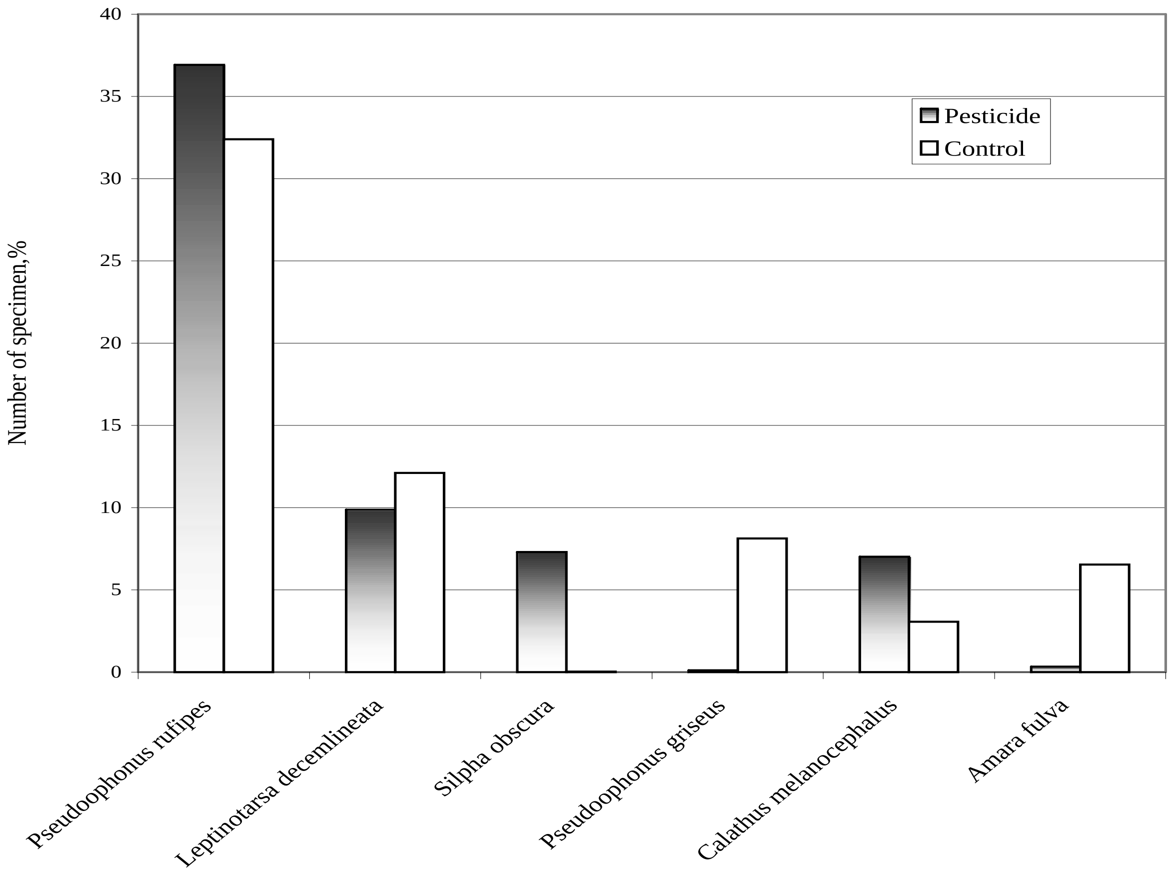

Fig.5. Effect of pesticide treatment to the domination's structure of the beetle community at potatoe filed. Minsk district, 1998