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Carabids in a Spring Wheat Agrocenosis to the South of Sverdlovsk Oblast and the Effect of Insecticide Treatment on Their Populations

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Abstract—Species composition, community structure, and seasonal population dynamics of carabids in spring wheat fields were studied in the vicinity of Yekaterinburg. In addition, the effects of crop treatment with the pyrethroid insecticide Decis on carabid populations was analyzed. The results showed that the numbers, species diversity, and the prevalence of certain trophic groups of carabids changed during the season. After the treatment of small areas with Decis, the number of carabids in catches decreased for a short period of time. During the second and third weeks after the treatment, the numbers of carabids increased above the control level. The structural rearrangement of the carabid community was observed in the areas treated with the insecticide.

Key words: carabids, abundance, community structure, Decis, agrocenosis.

Most papers dealing with studies on carabids of the Middle Urals concern the carabid fauna of natural biotopes. In the review by Voronin (1999), carabid complexes in forests, meadows, and riparian biotopes are considered. There are also data on the numbers and community structure of carabids in the anthropogenic landscape, mainly in villages and cities. However, the species composition, population dynamics, and community structure of carabids in agrocenoses of the Middle Urals have been studied insufficiently. Thus, Kozyrev and Koz'minykh (1998) simply listed the carabid species found in the fields under grain crops in the vicinities of Yekaterinburg and Perm.

The responses of insect populations to the effects of chemicals used for plant protection have regional specific features depending on life conditions, levels of pollution, and other factors. Published data on the effects of modern agricultural chemicals on the carabid populations of the Middle Urals are lacking.

The purpose of this work was to study carabid communities in the agrocenoses of grain crops and their responses to chemicals used for plant protection. Our tasks were as follows: to amend the list of carabid species inhabiting the fields under grain crops in the vicinity of Yekaterinburg, to study the seasonal population dynamics of individual carabid species and changes in the community structure during the vegetative period of wheat growth, and to determine the responses of the carabid community and individual species to the treatment of wheat crops at the booting stage with the pyrethroid insecticide Decis.

MATERIAL AND METHODS

For two years (1998–1999), we studied the species composition, population dynamics, and community structure of carabids in the fields under spring wheat and the effects of treatment with Decis, a pyrethroid insecticide, on these parameters. Carabids were collected using polyvinyl chloride traps (9 cm in diameter) dug in the soil and one-third full of the fixative (the Tosol antifreeze coolant diluted with water, 1 : 4). Censuses were taken in the field located 5 km southeast of the village of Kol'tsovo (the suburb of Yekaterinburg). The dark gray forest soil of the heavy loam type is characteristic of agricultural lands in Sverdlovsk oblast. The field was under spring wheat in 1998 and under wheat and clover in 1999. The traps were arranged in lines in the center of the test plot no less than 6 m away from its boundaries and 1.5–2 m apart. Insects were taken from traps every 3–4 days from June 30 to July 21 in 1998 and from June 9 to July 26 in 1999. To assess the seasonal population dynamics of carabids, the data of censuses taken during a week were pooled. The number of carabids per 10 trap days (below, referred to as capture rate) was used as an index of abundance.

Wheat crops were treated with 2.5% pyrethroid insecticide Decis (UCLAF, France; active substance, deltamethrin) at the booting stage, on June 30 in 1998

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and July 5 in 1999. Decis was applied at a dose of 300 ml per hectare using a hand sprayer. The areas treated in 1998 and 1999 were 400 and 960 m^2, respectively. In each experimental and control census, we used 20 traps in 1998 and 10 traps in 1999. Censuses were taken on days 7, 10, 14, 17, and 21 after treatment.

RESULTS AND DISCUSSION

Over the observation period, 53 species of carabids belonging to 18 genera (6859 beetles) were trapped. Species identification was performed by M.A. Kozyrev and E.V. Zinov'ev, two of the authors of this paper. The species composition, life forms, and ecological and biological characteristics of carabids are shown in Table 1. The data on life forms and ecological and biological characteristics were taken from the works of Kryzhanovskii (1983), Sharova and Denisova (1997), and Voronin (1999). We regarded the species as dominant if its proportion in the carabid community was above 10%; subdominant, 3–10%; and rare, below 3%. Ten species—*Elaphrus uliginosus* F., *Bembidion infuscatum* Duft., *Poecilus punctulatus* Schall., *Amara equestris* Duft., *Curtonotus gebleri* Dej., *Ophonus puncticollis* Pk., *Harpalus cistelloides* Motsch., *H. progrediens* Schaub., *H. rubripes* Duft., and *Microlestes maurus* Sturm—were not mentioned by Kozyrev and Koz'minykh (1998) in the lists of carabids occurring in the agrocenoses of agricultural crops in the Middle Urals. All these species were classified as rare.

The community of predatory herpetobiontic arthropods in the spring wheat field was represented by the following taxa: Aranea (spiders), Opiliones (harvest spiders), Carabidae (ground beetles), and Staphylinidae (road beetles). The proportion of carabids in the community of predatory herpetobionts was 93% at the tillering phase and decreased to 11% in the booting phase. Field species were dominant in numbers (58.9%); then followed riparian–meadow (20.3%) and meadow–field species (20.2%). The remaining ecological groups were scanty.

In both years of research, similar tendencies in the population dynamics and structure of the carabid community were observed. The peak of abundance in carabids was recorded in the third ten-day period of June (the tillering phase in wheat). At the initial stage of the booting phase in wheat (the end of June), their abundance decreased to 38 beetles per 10 trap days and then became stable (Fig. 1a). In June, species of the spring phenological group (*B. lampros*, *B. properans*, *B. quadrimaculatum*) and the spring–summer group (*P. cupreus*) prevailed. A sharp decline in the abundance of these species occurred at the end of June, which coincided with the beginning of the booting phase in wheat (Figs 1a, 1b). At the same time, the abundance of species belonging to the autumn phenological group (*H. rufipes*, *S. vivalis*) and of the multiseasonal species *H. affinis* increased.

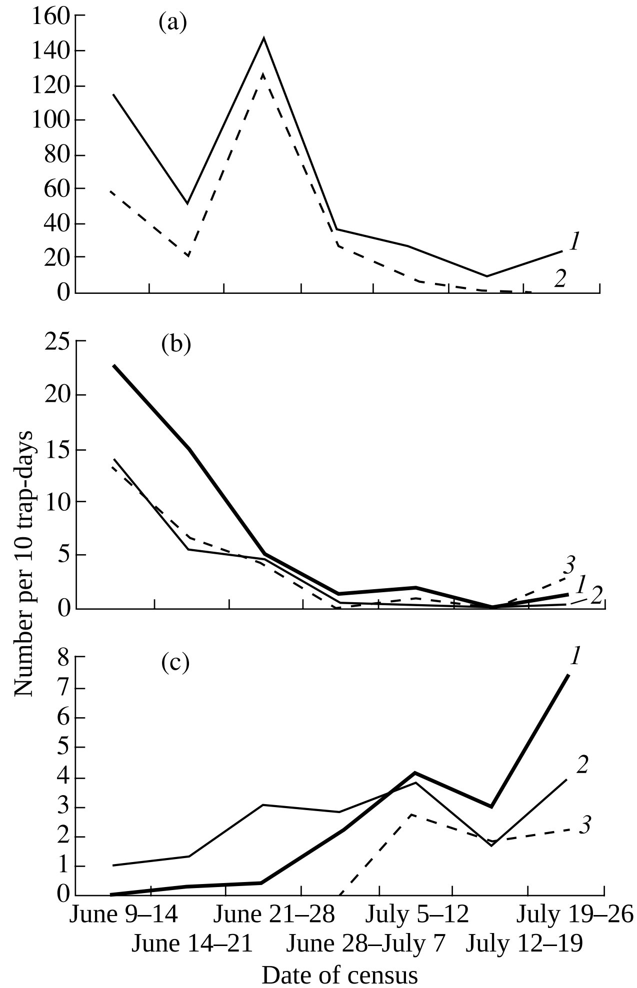

Fig. 1. Numbers of carabids trapped in the wheat field (1999): (a) (*1*) total number; (*2*) *Poecilus cupreus*; (b) (*1*) *Bembidion lampros*; (*2*) *B. properans*; (*3*) *B. quadrimaculatum*; (c) (*1*) *Harpalus rufipes*; (*2*) *H. affinis*; (*3*) *Synuchus vivalis*.

The carabid community structure changed throughout the growing period (Fig. 2). During the sprouting and tillering phases, the zoophagous *P. cupreus* and species of the genus *Bembidion* were dominant (45 and 54%, respectively). Mixophytophagous species of the genus *Harpalus* were rare: their proportion in the community was below 1%. The composition of the dominant species remained the same in the period of tillering in wheat, but the proportion of species of the genus *Bembidion* decreased to 16%, and that of *P. cupreus* increased to 78%. Species diversity increased slightly: zoophagous species *C. auropunctatum* and *C. fossor* and single individuals of some other species appeared in the field. At the heading stage, the relative abundance of *P. cupreus* was 59%, species of the genus *Harpalus* became dominant (20%), and species of the genera *Bembidion* and *C. auropunctatum* became subdominants. At the flowering phase, the proportion of mixophytophagous species of the genus *Harpalus* sharply increased (to 45%), whereas that of *P. cupreus*

Table 1. Species composition and ecological characteristics of carabids in spring wheat fields in the vicinity of Yekaterinburg

No.	Species	Life form	Ecological group	Phenological group	Number of individuals	Proportion of the total number, %
1	*Calosoma auropunctatum* Hbst.	ZEw	F	S	137	2.00
2	*Carabus cancellatus* Ill.	ZEw	FM	S	1	0.02
3	*Carabus convexus* F.	ZEw	MF	S	2	0.03
4	*Carabus granulatus* L.	ZEw	DFM	S	3	0.04
5	*Notiophilus aquaticus* L.	ZSsl	MF	A	3	0.04
6	*Elaphrus uliginosus* F.	ZEr	RT	S	1	0.02
7	*Clivina fossor* L.	ZGd	MF	S	167	2.44
8	*Epaphius secalis* Pk.	ZSl	FM	A	2	0.03
9	*Bembidion femoratum* Sturm. F.	ZSsl	RM	S	31	0.45
10	*Bembidion guttula* F.	ZSsl	RT	S	1	0.02
11	*Bembidion infuscatum* Duft.	ZSsl	F	–	1	0.02
12	*Bembidion lampros* Hbst.	ZSsl	RM	S	477	6.95
13	*Bembidion properans* Steph.	ZSsl	RM	S	330	4.81
14	*Bembidion quadrimaculatum* L.	ZSsl	RM	S	556	8.02
15	*Poecilus cupreus* L.	ZSbls	F	S–A	2471	36.03
16	*Poecilus lepidus* Leske.	ZSbls	MF	A	4	0.06
17	*Poecilus punctulatus* Schall.	ZSbls	F	S	1	0.02
18	*Poecilus versicolor* Sturm.	ZSbls	MF	S	27	0.39
19	*Pterostichus melanarius* Ill.	ZSbls	F	M	1	0.02
20	*Prerostichus niger* Schall.	ZSbls	FM	S–A	1	0.02
21	*Pterostichus oblongopunctatus* F.	ZSbls	FM	S–S	2	0.03
22	*Agonum gracilipes* Duft.	ZSl	FM	S	15	0.22
23	*Calathus ambiguus* Pk.	ZSl	F	A	18	0.26
24	*Calathus erratus* C. Sahlb.	ZSl	F	A	50	0.73
25	*Calathus melanocephalus* L.	ZSl	MF	A	94	1.37
26	*Calathus micropterus* Duft.	ZSl	F	A	1	0.02
27	*Synuchus vivalis* Pk.	ZSlc	MF	A	245	3.57
28	*Amara aenea* Deg.	MGh	MF	S	1	0.02
29	*Amara apricaria* Pk.	MGh	F	A	3	0.04
30	*Amara bifrons* Gyll.	MGh	F	A	1	0.02
31	*Amara communis* Pz.	MGh	DFM	S	1	0.02
32	*Amara consularis* Duft.	MGh	MF	A	7	0.10
33	*Amara equestris* Duft.	MGh	MF	A	7	0.10
34	*Amara familiaris* Duft.	MGh	MF	S	6	0.09
35	*Amara majuscula* Chd.	MGh	F	A	2	0.03
36	*Amara ovata* F.	MGh	MF	S	1	0.02
37	*Amara similata* Gyll.	MGh	MF	S	1	0.02
38	*Curtonotus aulicus* Pz.	MGh	MF	A	11	0.16
39	*Curtonotus convexiusculus* Marsh.	MGh	F	A	1	0.02
40	*Curtonotus gebleri* Dej.	MGh	F	A	5	0.07
41	*Ophonus stictus* Steph.	MSCh	MF	A	4	0.06
42	*Ophonus puncticollis* Pk.	MSCh	MF	S	1	0.02
43	*Harpalus affinis* Schrnk.	MGh	MF	MS	787	11.47

Table 1. (Contd.)

No.	Species	Life form	Ecological group	Phenological group	Number of individuals	Proportion of the total number, %
44	*Harpalus calceatus* Duft.	MGh	F	A	26	0.38
45	*Harpalus cistelloides* Motsch.	MGh	F	–	1	0.02
46	*Harpalus distinquendus* Duft.	MGh	MF	S	6	0.09
47	*Harpalus progrediens* Schaub.	MGh	MF	S	2	0.03
48	*Harpalus rubripes* Duft.	MGh	MF	A	1	0.02
49	*Harpalus rufipes* Deg.	MSCh	F	A	1322	19.27
50	*Harpalus xanthopus* Hemm.et Har.	MGh	MF	S	1	0.02
51	*Acupalpus meridianus* L.	MSCh	F	S	9	0.13
52	*Microlestes minutulus* Goeze	ZSlc	MF	S	9	0.13
53	*Microlestes maurus* Sturm.	ZSlc	MF	S	1	0.02
	Total				6859	

Note: **Life forms**: (ZS) zoophagous stratobionts–holemakers, including (l) litter, (sl) surface–litter, (b) burrowing litter–soil, and (lc) litter- and crack-dwelling forms; (ZE) zoophagous epigeobionts, (r) running and (w) walking forms; (ZGd) zoophagous geobionts, digging forms; (MSh) mixophytophagous stratobionts–holemakers; (MSCh) mixophytophagous stratochortobionts; (MGh) mixophytophagous geobionts, harpaloid forms. **Ecological groups**: (F) forest, (FM) forest-meadow, (DFM) deciduous forest-meadow, (MF) meadow-field, (R) riparian, (RF) riparian-fluvial, (RT) riparian-thicket, (F) field, (RM) riparian-meadow. **Phenological groups** (S) spring, (S–S) spring-summer, (S–A) summer-autumn, (A) autumn, (M) multiseasonal.

decreased to 16%; *C. auropunctatum* remained subdominant. Carabids of other species were rare or functioned as subdominants. During grain formation, species of the genera *Harpalus* and *Bembidion* dominated; the proportion of *P. cupreus* decreased to 1%. Thus, a seasonal change of the trophic groups of carabids took place: at the beginning of the growing period, zoophages obviously prevailed over mixophytophages (99 : 1); at the end of the growing period, this ratio changed in favor of the species with a mixed type of feeding and became 42 : 58.

The analysis of the carabid community in the agrocenosis of the spring wheat showed that trends in population dynamics and community structure described earlier for other regions of Russia (Dushenkov, 1986; Soboleva-Dokuchaeva, 1986) were characteristic of the study region as well. These trends include the dominance of field species, the increased abundance of carabids at the beginning of the growing period in wheat, and the increase of species diversity during the season. Our results confirmed that the peak of abundance at the spring–summer phenological group occurs in early summer, the abundance of the autumn group increases at the end of the growing period, and the trophic groups of carabids substitute for one another during the growing period in plants.

The treatment of wheat with Decis in the test plots resulted in a certain decrease in the numbers of adult carabids (Fig. 3). For a week after treatment, the capture rate remained below the control value (this was determined more reliably in catches of 1999). Subsequently, the abundance of adult carabids in the treated and control plots became more uniform, and after 17–21 days the capture rate in the plot treated with Decis even exceeded the control rate ($0.02 < p < 0.05$).

The capture rate of carabids differed from year to year: in 1998, the number of beetles in catches (per 10 trap days) changed from 52 in the control to 30 after treatment; in 1999, it changed from 40 to 8. Nevertheless, the trend was the same in both years: the number of carabids in catches decreased after treatment and then increased again and exceeded the control values, with the period of recovery lasting for ten days.

Figure 4 shows the response of different carabid species to Decis treatment in 1998, the year with a high abundance of carabids. The pattern of response in 1999 was the same. Decis had the strongest effect on large zoophages. The capture rate of *P. cupreus* in the first week after treatment decreased by 49% (compared to the control), its proportion in the carabid community decreased by a factor of 1.5 (Table 2), and no recovery occurred for three weeks. The capture rate of *C. auropunctatum* in the treated plot remained 30–65% lower than in the control plot for three weeks, and the proportion of this species in the community decreased by a factor of 2.7. The capture rates of small carabids (species of the genus *Bembidion* and *C. fossor*) in the treated plot proved to increase. The maximum increase—to 161% of the control rate in species of the genus *Bembidion* and 345% in *C. fossor*—was observed during the third week after treatment; the proportions of these species in the community increased by factors of 1.4 and 3, respectively ($0.01 < p < 0.05$). In carabids of the genus *Harpalus* and *S. vivalis*, capture rates changed insignificantly and returned to the control value within three weeks.

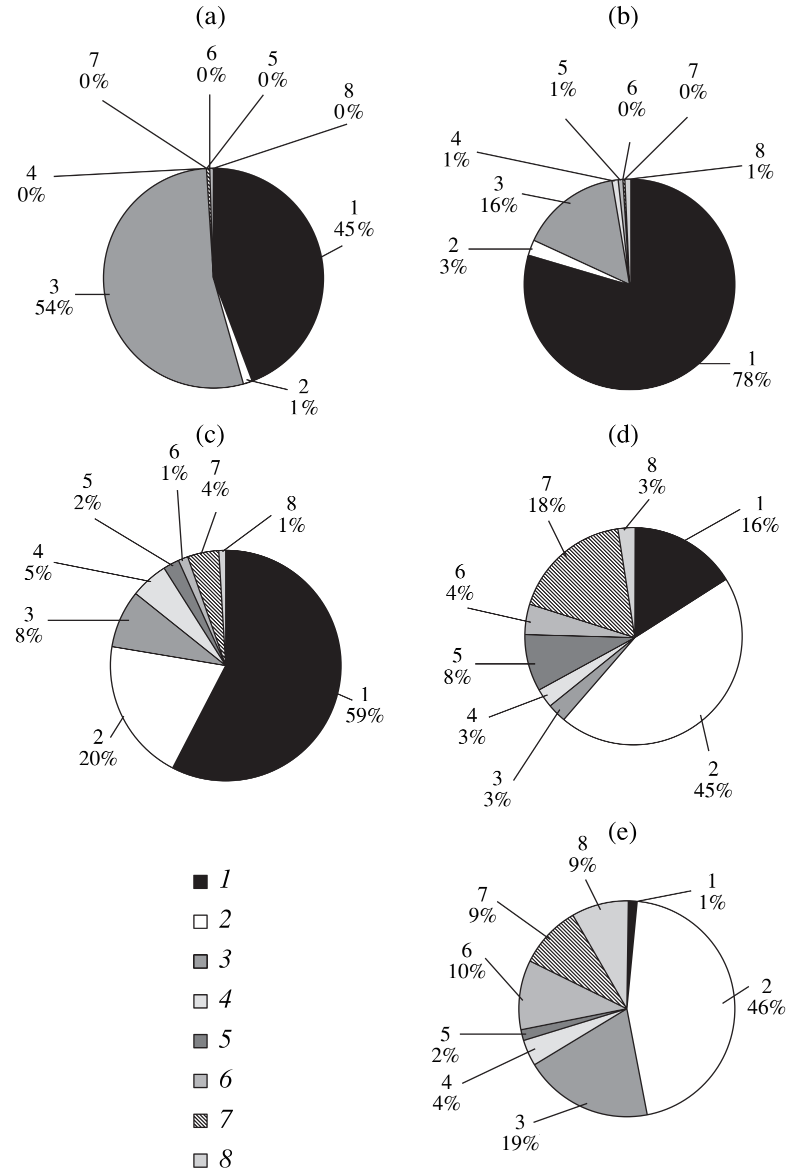

Fig. 2. Changes in the structure of the carabid community in the growing season of 1999: (*1*) *Poecilus cupreus*, (*2*) species of the genus *Harpalus*, (*3*) species of the genus *Bembidion*, (*4*) *Calosoma auropunctatum*, (*5*) *Clivina fossor*, (*6*) species of the genus *Calathus*, (*7*) *Synuchus vivalis*, and (*8*) other species. Phases of wheat development: (a) sprouting and tillering, (b) booting, (c) heading, (d) flowering, and (e) grain for mation.

Other authors also noted that the number of carabids falling into soil traps decreased after the treatment of crops with Decis, but the observed effect lasted for a longer period of time (Kaczmarek, 1991; Bogdanov, 1997). In our experiments, carabids restored their abundance within 10 days after treatment. This may be attributed to the fact that the area of treated plots was relatively small, which facilitated their colonization by beetles migrating from the neighboring biotopes. It is unclear, however, why the numbers of carabids falling into soil traps in the experimental plots exceeded those in the control plots. A similar phenomenon was observed (Sokolowsky, 1997) upon the treatment of winter rape crops with the pyrethroid Fastak. Carabids might accumulate in the treated areas owing to the abundance of easily accessible prey (dead and paralyzed insects). Another possible explanation is the change in the behavior of adult carabids in these areas. Sublethal doses of pyrethroids cause the increased activity of insects, which is manifested in overexcitation, frequent grooming, escape from shelters, migrations, and coordination disturbances (Bradbury and Coates, 1993; Wiles and Jepson, 1994). This may lead to an increase in the capture rate.

The effects of pyrethroid treatment on the carabid community manifests itself in the change of indices

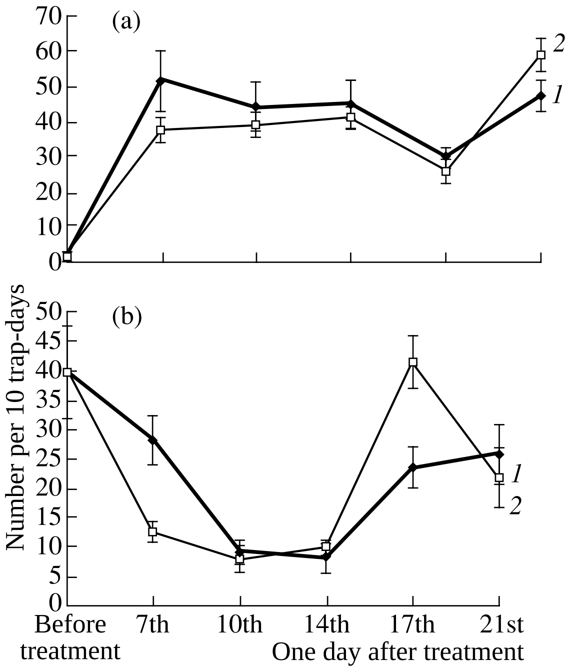

Fig. 3. Numbers of carabids trapped in the wheat field after treatment with Decis in (a) 1998 and (b) 1999: *1* – control, *2* – Decis.

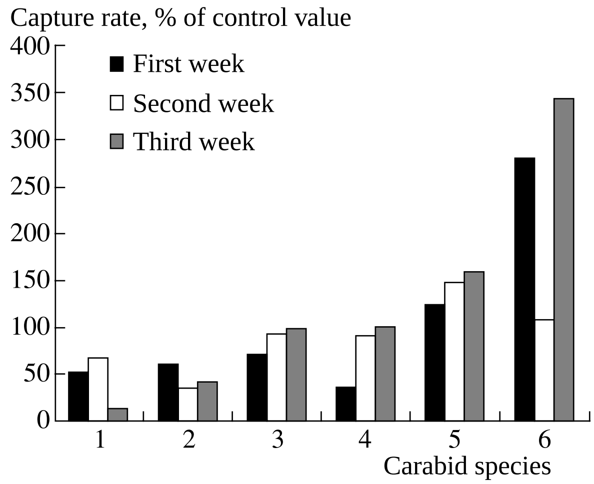

Fig. 4. Changes in the numbers of carabids in soil traps one, two, and three weeks after treatment with Decis (1998): (1) *Poecilus cupreus*, (2) *Calosoma auropunctatum*, (3) *Harpalus rufipes*, *H. affinis*, (4) *Synuchus vivalis*, (5) species of the genus *Bembidion (B. lampros, B. properans, B. quadrimaculatum)*, (6) *Clivina fossor.*

characterizing dominance of individual species. Moreover, the anthropogenic impact, irrespective of its type, leads to rearrangements in the functional structure of the carabid community, which are aimed at decreasing the proportion of large zoophages and increasing the proportions of small zoophages and mixophytophages (Khot'ko *et al.*, 1993). Thus, Vlasenko and Shtundyuk (1994) noted a decrease in the proportion of *P. cupreus* in the carabid community upon the Decis treatment of winter rape crops. A similar phenomenon was observed in our experiments. This can be explained by the fact

Table 2. Effects of treatment with Decis on the structure of the carabid community (1998)

Species	Control		Treatment with Decis	
	number of individuals	%	number of individuals	%
First week after treatment				
Poecilus cupreus	288	41.7 ± 1.9	148	27.8 ± 1.7*
Species of the genus *Harpalus*	236	34.2 ± 1.8	167	31.4 ± 1.8
Species of the genus *Bembidion*	105	15.2 ± 1.4	131	24.6 ± 1.6*
Calosoma auropunctatum	20	2.9 ± 0.6	12	2.2 ± 0.6
Clivina fossor	11	1.6 ± 3.1	31	5.8 ± 0.9*
Synuchus vivalis	14	2.0 ± 0.6	5	0.9 ± 1.0
Other species	16	2.3 ± 0.6	38	7.1 ± 1.0*
Total	665		532	
Third week after treatment				
Poecilus cupreus	32	5.7 ± 1.0	4	0.6 ± 0.3*
Species of the genus *Harpalus*	344	61.1 ± 2.0	342	54.3 ± 2.1*
Species of the genus *Bembidion*	100	17.8 ± 1.6	161	25.6 ± 1.8*
Calosoma auropunctatum	17	3.0 ± 0.7	7	1.1 ± 0.4*
Clivina fossor	11	2.0 ± 0.6	38	6.0 ± 1.0*
Synuchus vivalis	28	5.0 ± 0.9	28	4.4 ± 0.9
Other species	31	5.5 ± 1.0	50	7.9 ± 1.1
Total	563		630	

* Differences are significant at $p < 0.05$.

that adult *P. cupreus* are sensitive to pyrethroids to such a high degree that this species is used as an indicator of pesticide toxicity for the carabid fauna in agrocenoses (Brown, 1998; cited from Zakharenko, 1999). Upon the treatment of wheat crops with Decis, the capture rates of *P. cupreus* and *C. auropunctatum* decreased for three weeks; simultaneously, the capture rates of small predators of the genus *Bembidion* and *C. fossor* increased.

CONCLUSIONS

(1) In spring wheat fields in the vicinity of Yekaterinburg, 53 species of carabids were recorded; ten of them were not included in the previous lists of carabid species found in the agrocenoses of grain crops in the Middle Urals. Field species proved to be dominant in the carabid community, which is characteristic of open sites exposed to anthropogenic impact.

(2) The seasonal population dynamics of carabids in the study area follows the pattern characteristic of other regions of the Russian nonchernozem zone. It is confirmed that the peaks of abundance in carabids of the spring and autumn phenological groups occur in early and late summer, respectively. The species diversity of carabids increases during the season simultaneously with the decrease in their total numbers.

(3) The trophic structure of the carabid community changes during the growing season, with zoophagous forms (*Poecilus cupreus* and species of the genus *Bembidion*) prevailing in the beginning and species with a mixed type of feeding (the genus *Harpalus*) prevailing in the end of the season.

(4) The treatment of small areas (less than 1 ha) with the pyrethroid insecticide Decis in the period of booting in wheat causes a short-term decrease in the total abundance of carabids (for 7 days); subsequently, this parameter in the treated areas increases and exceeds the control values.

(5) In the treated areas, the numbers of large zoophages *P. cupreus* and *Calosoma auropunctatatum* decreased by 49 and 65% (compared to the control values), and the numbers of small predatory carabids of the genus *Bembidion* and *Clivina fossor* increased by 61 and 245%, respectively. These changes reflected structural rearrangements in the carabid community.

REFERENCES

Bogdanov, M.R., The Degree of Hazard Presented by Pyrethroids to Soil Invertebrates of the Potato Agrocenosis, *Cand. Sci. (Biol.) Dissertation*, St. Petersburg, 1997.

Bradbury, S.P. and Coates, D.R., Comparative Toxicology of Pyrethroid Insecticides, in *Problemy zagryazneniya okruzhayushchei sredy i toksikologii* (Problems of Environmental Pollution and Toxicology), Moscow: Mir, 1993, pp. 146–189.

Dushenkov, V.M., The Structure of Ground Beetle Population in a Wheat Field, in *Biotsenoz pshenichnogo polya* (The Biocenosis of a Wheat Field), Moscow: Nauka, 1986, pp. 102–107.

Kaczmarek, S., Wpliw preparatu “Decis 2.5 EC” na Carabidae w upraure ziemniaka, *Pol. Pismo Entomol.*, 1992, vol. 61, no. 3–4, pp. 125–129.

Khot’ko, E.I., Chumakov, L.S., and Selyavko, T.M., The Functional Structure of the Ground Beetle Fauna as an Index of Anthropogenic Load on Ecosystems, in *Uspekhi entomologii v SSSR: ekologiya i faunistika, nebol’shie otryady nasekomykh* (Advances in Entomology in the Soviet Union: Ecology and Faunistics, Small Orders of Insects), St. Petersburg, 1993, pp. 72–74.

Kozyrev, A.V. and Koz’minykh, V.O., Comparative Data on the Composition of Field Complexes of Ground Beetles (Coleoptera, Carabidae) in the Agrocenoses of Western and Eastern Slopes of the Middle Urals, in *80 let farmatsevticheskomu obrazovaniyu i nauke na Urale: itogi i perspektivy* (80 Years of Pharmaceutical Education and Science in the Urals: Results and Prospects), Perm, 1998, pp. 173–175.

Kryzhanovskii, O.L., Beetles of the Suborder Adephaga: Families Rhysodidae, Trachypachidae, and Carabidae (Introduction and Review of the USSR Fauna), *Fauna SSSR. Zhestkokrylye* (Fauna of the USSR: Coleoptera), Leningrad: Nauka, 1983, vol. 1, part 2.

Sharova, I.Kh. and Denisova, M.I., Ecological Differentiation of Some Forest Species of Ground Beetles of the Genus *Pterostichus* Bonelli (Coleoptera, Carabidae) in the Central Russian Forest–Steppe), *Dokl. Ross. Akad. Nauk*, 1997, vol. 356, no. 4, pp. 572–574.

Soboleva-Dokuchaeva, I.I., Dynamics of Species Composition and Activity of Ground Beetles (Coleoptera, Carabidae) in Winter Wheat Fields of the Nonchernozem Zone, in *Biotsenoz pshenichnogo polya* (The Biocenosis of a Wheat Field), Moscow: Nauka, 1986, pp. 93–102.

Sokolowsky, A., Chemiczne srodki ochrony roslin a fauna epigeicznych stawonogow agrocenoz, *Pestycydy*, 1997, no. 3–4, pp. 55–62.

Vlasenko, N.G. and Shtundyuk, D.A., The Effect of Pesticides on the Communities of Ground Beetles in Spring Rape Fields, *Agrokhimiya*, 1994, no. 2, pp. 89–94.

Voronin, A.G., *Fauna i kompleksy zhuzhelits (Coleoptera, Trachypachidae, Carabidae) lesnoi zony Srednego Urala (ekologo-zoogeograficheskii analiz)* [The Fauna and Complexes of Ground Beetles (Coleoptera, Trachypachidae, Carabidae) in the Forest Zone of the Middle Urals (Ecological–Zoogeographic Analysis)], Perm: Perm. Gos. Univ., 1999.

Wiles, J.A. and Jepson, P.C., Sublethal Effects of Deltamethrin Residues on the Within-Crop Behaviour and Distribution of *Coccinella septempunctata*, *Entomol. Exp. Appl.*, 1994, vol. 72, no. 1, pp. 33–45.

Zakharenko, V.A., Plant Protection from Pests and Diseases (by the Materials of Brighton Conference), *Agrokhimiya*, 1999, no. 12, pp. 54–68.