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## The change of ecological composition and size groups of ground beetles in contiguous fields in central forest steppe Russia.

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### ABSTRACT

Having multifunctional effect on environment, forest shelterbelts normalize ecological conditions and form stable agroforest landscapes with high self-regulations. The researches have been carried out in the fields of Oktyabrsky district near the city of Saransk, protected by parallel oak and ash shelterbelts (the width is 23 m, the height of trees is 21 m), which were planted in 1949. Observation and analyses were carried out according to the standard techniques. The maximal species richness of ground beetles is concentrated in shelterbelts and its boundaries. Shelterbelts promote the spreading of forest and forest-swamp ground beetle species over the contiguous fields. The shelterbelts promote the spreading of large and very large sizes ground beetles over the contiguous fields.

**Keywords:** shelterbelts, forest group, swamp-forest group, meadow-waterside group, meadow-forest group of species, steppe group of species.

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## INTRODUCTION

Having multifunctional effect on environment, forest shelterbelts normalize ecological conditions and form stable agroforest landscapes with high self-regulations [1–4]. Shelterbelts give fauna an opportunity to migrate freely within such ecosystem to achieve integrity and interaction. The most numerous group of soil invertebrate agrocenosis is ground beetles (*Carabidae*). Their biotope distribution depends on soil and plant conditions and microclimate. Because of this fact, ground beetles are precise indicators of succession processes, existing in natural and anthropogenic landscapes [5-8]. High population, species diversity, and polyphagia of most ground beetles and their larvae determines the latter as a natural regulator of many soil and invertebrate insects, including agricultural and forest pests [9-11].

## OBJECTS AND METHODS

The researches have been carried out in the fields of Oktyabrsky district near the city of Saransk, protected by parallel oak and ash shelterbelts (the width is 23 m, the height of trees is 21 m), which were planted in 1949. The examined soil is leached heavy loamy black. The content of physical clay in plough layer is 36.0-44.6 %. The content of humus in top layer (0-30 centimeters or 0-12 in) is 8.70-9.27 % near the shelterbelt, and 8.21-8.65 % in open field. The sum of absorbed basis is 39.1-41.2, hydrolytic acidity is 5.11-6.62 mg-equivalent/100 g of soil. The content of available phosphorous is 93-121 mg/kg.

Observation and analyses were carried out according to the standard techniques. Ground beetles were caught by a standard method with Barber soil traps (we used half-liter glass cups 75 mm diameter with 3 cm 4% formalin solution as preservative). The traps were established in the following consecution: in the shelterbelt, on the border of the shelterbelt and field (unploughed area), and further at 10, 20, 30, 40, 50, 100, 150, 250 meters interval outwards the shelterbelt in three parallel lines.

## RESULTS AND DISCUSSION

In the time of the study of agrocenosis protected by the shelterbelts we revealed 53 species of *Carabidae* of 23 species. There are 39 species of *Carabidae* in shelterbelt, 34 species on the border of the shelterbelt and the field and 39 species in the protected field.

The meadow-field group has the highest species richness (Table 1). There are *Poecilus*, *Ophonus*, *Calathus*, *Harpalus*, *Anisodactylus*, *Amara*, *Carabus*, *Cicindella*, *Bembidion*, *Microlestes*, and *Clivina* species in this group.

The greatest number of species is in the shelterbelt and in the forest edge area. The forest group includes 3-8 species. The given group is the most diverse in the shelterbelt, on the border of the shelterbelt and in the forest edge area. The swamp-forest group of ground beetle is widely presented in the shelterbelt, while it includes only from 1 to 3 species in the group. This group spreading over the field is non-uniform; the decrease of population is observed to the center of the field. The steppe group of the contiguous field includes only 1-2 species. It is concentrated mostly in the puddle areas on the shelterbelt borders, also in the center of the field. The meadow-waterside group of ground beetle includes 1 species, i.e. *Lasiotrechus discus*, which is concentrated in the forest edge area of contiguous field. The waterside group is also represented by 1 species, i.e. *Bembidion guttula*, the only individual which has been observed at a distance of 40-150 m from the shelterbelt. The swamp group includes *Agonum filiginosum* species, which is concentrated in the shelterbelt and in the field up to 100 m from the latter.

The most abundant is meadow-forest group of species, which increases its number from shelterbelt to the field center. The forest group of species reduces its abundance from the shelterbelt to the center of the field. Its maximal abundance is observed in the shelterbelt and at a distance up to 40 m from it; further there is a decrease of this group.

**TABLE 1: Ecological composition of ground beetle fauna of shelterbelt and contiguous fields**

| Ecological group of species         | Number of species   |       |       |       |       |       |       |       |             |       |       |       |       |       |       |       |       |
|-------------------------------------|---------------------|-------|-------|-------|-------|-------|-------|-------|-------------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                     | Windward (m)        |       |       |       |       |       |       |       | Leeward (m) |       |       |       |       |       |       |       |       |
|                                     | 250                 | 150   | 100   | 50    | 40    | 30    | 20    | 10    | Shelterbelt | 10    | 20    | 30    | 40    | 50    | 100   | 150   | 250   |
| Forest                              | 3                   | 7     | 4     | 6     | 6     | 5     | 6     | 5     | 8           | 5     | 4     | 3     | 4     | 4     | 4     | 5     | 3     |
| Forest-swamp                        | 2                   | 2     | 1     | 2     | 3     | 1     | 4     | 2     | 6           | 2     | 2     | 2     | 3     | 2     | 2     | 3     | 1     |
| Meadow, meadow-field, field         | 17                  | 17    | 21    | 20    | 17    | 19    | 18    | 17    | 22          | 19    | 17    | 17    | 18    | 16    | 17    | 17    | 14    |
| Steppe, meadow-steppe, steppe-field | 3                   | 1     | 3     | 2     | 2     | 3     | 2     | 1     | 1           | 1     | 1     |       |       | 1     | 1     | 2     | 2     |
| Meadow-waterside                    | 1                   | 1     |       |       |       |       |       |       | 1           |       | 1     | 1     | 1     | 1     |       |       |       |
| Waterside                           |                     |       |       |       | 1     | 1     |       |       |             |       |       |       | 2     | 2     | 1     | 1     |       |
| Meadow-swamp                        |                     |       |       | 1     |       |       |       |       |             |       |       |       |       |       |       |       |       |
| Swamp                               |                     | 1     | 1     | 1     | 1     |       | 1     | 1     | 1           | 1     | 1     | 1     | 1     | 1     | 1     |       |       |
|                                     | Species richness, % |       |       |       |       |       |       |       |             |       |       |       |       |       |       |       |       |
| Forest                              | 11.11               | 24.14 | 13.33 | 18.75 | 20    | 17.24 | 19.35 | 19.23 | 20.51       | 17.86 | 15.38 | 12.5  | 13.79 | 14.81 | 15.38 | 17.86 | 15    |
| Forest-swamp                        | 7.41                | 6.9   | 33.33 | 6.25  | 10    | 3.45  | 12.90 | 7.69  | 15.38       | 7.14  | 7.69  | 8.33  | 10.34 | 7.41  | 7.69  | 10.71 | 5     |
| Meadow, meadow-field, field         | 62.96               | 58.62 | 70.00 | 62.50 | 56.67 | 85.52 | 58.06 | 65.08 | 56.41       | 67.86 | 65.38 | 70.83 | 62.07 | 59.26 | 65.38 | 60.71 | 70    |
| Steppe, meadow-steppe, steppe-field | 11.11               | 3.45  | 10.00 | 6.25  | 6.67  | 10.34 | 6.45  | 3.85  | 2.56        | 3.57  | 3.85  |       | 0.00  | 3.70  | 3.85  | 7.14  | 10    |
| Meadow-waterside                    | 3.70                | 3.45  |       |       |       |       |       |       | 2.56        |       | 3.85  | 4.17  | 3.45  | 3.70  |       |       |       |
| Waterside                           |                     |       |       |       | 3.33  | 3.45  |       |       |             |       |       |       | 6.90  | 7.41  | 3.85  | 3.57  |       |
| Meadow-swamp                        |                     |       |       | 3.13  |       |       |       |       |             |       |       |       |       |       |       |       |       |
| Swamp                               |                     | 3.45  | 3.33  | 3.13  | 3.33  |       | 3.23  | 3.85  | 2.56        | 3.57  | 3.85  | 4.17  | 3.45  | 3.70  | 3.85  |       |       |
|                                     | Abundance, %        |       |       |       |       |       |       |       |             |       |       |       |       |       |       |       |       |
| Forest                              | 29.07               | 1.10  | 1.73  | 2.13  | 2.40  | 1.83  | 1.86  | 3.26  | 11.54       | 8.25  | 12.51 | 11.86 | 8.12  | 4.50  | 8.98  | 6.36  | 3.76  |
| Forest-swamp                        | 15.12               | 0.36  | 0.40  | 0.56  | 0.52  | 0.22  | 0.56  | 0.53  | 1.00        | 0.22  | 0.26  | 0.29  | 0.18  | 0.16  | 0.12  | 0.28  | 0.26  |
| Meadow, meadow-field, field         | 41.88               | 98.42 | 97.71 | 97.12 | 96.98 | 97.78 | 97.47 | 96.03 | 87.39       | 91.51 | 87.15 | 87.74 | 91.56 | 95.15 | 90.83 | 93.33 | 95.92 |
| Steppe, meadow-steppe, steppe-field | 10.47               | 0.03  | 0.08  | 0.06  | 0.05  | 0.14  | 0.05  | 0.04  | 0.01        | 0.01  | 0.01  | 0.00  |       | 0.01  | 0.02  | 0.01  | 0.05  |
| Meadow-waterside                    | 1.16                | 0.03  |       |       |       |       |       |       | 0.01        |       | 0.03  | 0.03  | 0.04  | 0.02  | 0.00  |       |       |
| Waterside                           | 2.33                |       |       |       | 0.03  | 0.03  |       |       |             |       |       |       | 0.05  | 0.07  | 0.04  | 0.01  |       |
| Meadow-swamp                        |                     |       |       | 0.09  |       |       |       |       |             |       |       |       |       |       |       |       |       |
| Swamp                               |                     | 0.06  | 0.08  | 0.03  | 0.03  |       | 0.05  | 0.14  | 0.05        | 0.30  | 0.01  | 0.04  | 0.07  | 0.05  | 0.08  | 0.01  |       |



**TABLE 2: Size groups of ground beetles of shelterbelt and contiguous fields**

| Size groups of ground beetles | Number of species   |       |       |       |       |       |       |       |             |       |       |       |       |       |       |       |       |
|-------------------------------|---------------------|-------|-------|-------|-------|-------|-------|-------|-------------|-------|-------|-------|-------|-------|-------|-------|-------|
|                               | Windward (m)        |       |       |       |       |       |       |       | Leeward (m) |       |       |       |       |       |       |       |       |
|                               | 250                 | 150   | 100   | 50    | 40    | 30    | 20    | 10    | Shelterbelt | 10    | 20    | 30    | 40    | 50    | 100   | 150   | 250   |
| Very small size (3-6 mm)      | 5                   | 7     | 5     | 5     | 6     | 5     | 5     | 5     | 5           | 5     | 5     | 5     | 7     | 7     | 6     | 6     | 5     |
| Small size (6-9 mm)           | 8                   | 8     | 10    | 10    | 10    | 7     | 9     | 8     | 14          | 8     | 7     | 7     | 7     | 6     | 8     | 8     | 3     |
| Average size (9-11 mm)        | 6                   | 6     | 7     | 7     | 6     | 7     | 7     | 6     | 11          | 6     | 7     | 5     | 7     | 5     | 5     | 7     | 5     |
| Large size (11-17 mm)         | 7                   | 7     | 7     | 9     | 8     | 8     | 8     | 6     | 6           | 7     | 6     | 6     | 7     | 7     | 5     | 5     | 6     |
| Very large size (17-23 mm)    | 1                   | 1     | 1     | 1     |       | 2     | 2     | 1     | 3           | 2     | 1     | 1     | 1     | 2     | 2     | 2     | 1     |
|                               | Species richness, % |       |       |       |       |       |       |       |             |       |       |       |       |       |       |       |       |
| Very small size (3-6 mm)      | 18.52               | 24.14 | 16.67 | 15.63 | 20    | 17.24 | 16.13 | 9.23  | 12.82       | 17.86 | 19.23 | 20.83 | 24.14 | 25.93 | 23.08 | 21.43 | 25    |
| Small size (6-9 mm)           | 29.63               | 27.59 | 33.33 | 31.25 | 33.33 | 24.14 | 29.03 | 30.77 | 35.90       | 28.57 | 26.92 | 29.17 | 24.14 | 22.22 | 30.77 | 28.57 | 15    |
| Average size (9-11 mm)        | 22.22               | 20.69 | 23.33 | 21.88 | 20    | 24.14 | 22.58 | 23.08 | 28.21       | 21.43 | 26.92 | 20.83 | 24.14 | 18.52 | 19.23 | 25.00 | 25    |
| Large size (11-17 mm)         | 25.93               | 24.14 | 23.33 | 28.13 | 26.67 | 27.59 | 25.81 | 23.08 | 15.38       | 25.00 | 23.08 | 25.00 | 24.14 | 25.93 | 19.23 | 17.86 | 30    |
| Very large size (17-23 mm)    | 3.70                | 3.45  | 3.33  | 3.13  |       | 6.90  | 6.45  | 3.85  | 7.69        | 7.14  | 3.85  | 4.17  | 3.45  | 7.41  | 7.69  | 7.14  | 5     |
|                               | Abundance, %        |       |       |       |       |       |       |       |             |       |       |       |       |       |       |       |       |
| Very small size (3-6 mm)      | 2.62                | 4.35  | 2.73  | 5.10  | 4.64  | 4.02  | 3.19  | 4.15  | 0.54        | 3.71  | 3.12  | 7.42  | 6.53  | 4.81  | 5.41  | 3.23  | 3.80  |
| Small size (6-9 mm)           | 1.09                | 1.01  | 1.05  | 1.47  | 1.15  | 0.72  | 1.34  | 1.03  | 1.18        | 0.29  | 0.54  | 0.95  | 0.74  | 0.45  | 0.25  | 0.45  | 0.45  |
| Average size (9-11 mm)        | 64.78               | 70.89 | 70.24 | 64.65 | 59.26 | 48.45 | 58.74 | 43.96 | 15.73       | 52.40 | 55.49 | 28.93 | 42.54 | 49.43 | 66.22 | 65.45 | 55.91 |
| Large size (11-17 mm)         | 31.32               | 23.71 | 25.96 | 28.73 | 34.96 | 46.73 | 36.65 | 50.83 | 82.10       | 43.48 | 40.78 | 62.63 | 50.14 | 45.28 | 28.02 | 30.83 | 39.80 |
| Very large size (17-23 mm)    | 0.20                | 0.03  | 0.02  | 0.06  |       | 0.08  | 0.08  | 0.04  | 0.45        | 0.11  | 0.08  | 0.07  | 0.05  | 0.04  | 0.10  | 0.04  | 0.04  |

The steppe group of species is concentrated on the borders of the shelterbelts and in open field.

According to the evolutionary-ecological system of the vital forms of ground beetles imago, 10 groups of the vital forms are singled out in the shelterbelts and in the protected field. Seven of them belong to the class of zoophagous, including 31 species. Three of them belong to the class of mixophytophagous, including 15 species.

All the five beetle-size groups of ground beetles have been found (Table 2). All of the groups are closely connected with the structure of the soil and vegetative conditions. The first group unites very small size ground beetles of 3-6 mm (such species as *Trochocellus*, *Notiophilus*, *Bembidion*, *Trechus*, and *Lasiotrechus*). The second group is small size ground beetles of 6-9 mm (such species as *Patrobus*, *Agonum*, *Stomis*, *Badister*, *Loricera*, *Clivina*, and some species of *Pterostichus*, *Calathus*, *Ophonus*, and *Amara* species). The third group is average size ground beetles of 9-11 mm (*Poecilus*, *Cicindella*, *Harapalus*, *Agonum*, and *Amara* species). The fourth group is large size ground beetles of 11-17 mm (*Pterostichus melanarius*, *Pseudoophonus rufipes*, *Calathus halensis*, *Pterostichus macer*, *Anisodactulus binotatus*, *Amara aulica* species). The fifth group is very large size ground beetles of 17-23 mm and more (*Carabidae* and *Calosoma* species).

Ground beetles of small size are represented by maximal species number. The maximum quantity of species is represented in shelterbelts and their border; their spreading over the field is irregular. Ground beetles of large size are widely represented. Their variety is maximum in outer shelterbelt area and up to 50 m from it. Ground beetles of average size unite include from 18.52 to 28.21% of all species. Their spreading over the field is irregular. Ground beetles of very small size prefer open fields and areas with well-cultivated ground. Their species number is rather high. The greatest number of species is represented at a distance of 40-150 m from the shelterbelt. The least number of species is ground beetles of very large size, which are largely concentrated in the shelterbelts and its outer areas.

Ground beetles of average size are the most numerous. The change of the given group abundance is connected with the number of changes of such a dominant species as *Poecilus cupreus*. Ground beetles of large size are also represented by large population. It includes such dominant species as *Pterostichus melanarius* and *Pseudoophonus rufipes*. The maximal abundance of the given group is concentrated in the shelterbelt and in its outer area up to 50 m from it. Large population of small size *Carabidae* also has maximum concentration in the shelterbelt and in its outer area up to 40 m from it. Very small *Carabidae* spread irregularly; they are most numerous at the distance of 30-100 m from the shelterbelt. Very large ground beetles are not numerous. They are concentrated in the shelterbelt and in outer area.

## CONCLUSIONS

- The maximal species richness of ground beetles is concentrated in shelterbelts and their boundaries. In shelterbelts, the number of species of ground beetles is almost twice more in comparison with the open field; and this number is 1.1-1.5 times more in areas with shelterbelts effect. The maximal ground beetles abundance in contiguous field is concentrated in areas with shelterbelts effect.
- Shelterbelts promote the spreading of forest and forest-swamp ground beetle species over the contiguous fields. The number of the forest species in the shelterbelts is more than twice more in comparison with the open field. In areas with shelterbelts effect, this number is 1.33-1.66 times more. The number of the forest-swamp species in shelterbelts is 6 times more in comparison with the open field. In the contiguous fields, their number is 2-4 times more. Abundance of forest species in shelterbelts is three times more in comparison with the open field, and it is 1.5-3 times more in areas with shelterbelts effect.
- The shelterbelts promote the spreading of large and very large sizes ground beetles over the contiguous fields. The majority of such species is obliging predators or potential zoophagues. Their maximal abundance and species richness is concentrated in shelterbelts and in areas with shelterbelts effect.



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