



Seasonal Dynamics of *Carabus Coriaceus* Linnaeus, 1758 “Coleoptera, Carabidae” Activity in the Areal’s Eastern Part

Sergei Alekseev¹, Alexander Ruchin^{2*}, Gennady Semishin²

¹Ecological club «Stenus», Kaluga, Kaluga region, Russia.

²Joint Directorate of the Mordovia State Nature Reserve and National Park «Smolny», Saransk, Republic of Mordovia, Russia.

ABSTRACT

Seasonal dynamics of the activity of *Carabus coriaceus* (Carabidae) imago was studied in the eastern part of the areal (in mixed and pine forests in Mordovia State Nature Reserve and National Park “Smolny”, Republic of Mordovia). Seasonal activity varied by year. It started from late April in 2018 and early May until mid-September and October. The peak number was recorded in the second half of July-August. In the warm spring of 2018, the timing of the start of activity was shifted to April, while in the cold spring of 2019, the ground beetle began activity only in early May. The catchability of *C. coriaceus* was higher within the territory of Mordovia State Nature Reserve comparing to the National Park “Smolny”. This may be due to the fact that Mordovia State Nature Reserve ecosystems have been protected for a longer time. In this protected area, anthropogenic activity ceased more than 80 years ago and the ecosystems have fully recovered.

Keywords: Carabidae, Imago, *Carabus coriaceus*, Mordovia state nature reserve, National park “Smolny”.

HOW TO CITE THIS ARTICLE: Alekseev S, Ruchin A, Semishin G. Seasonal Dynamics of *Carabus Coriaceus* Linnaeus, 1758 “Coleoptera, Carabidae” Activity in the Areal’s Eastern Part. Entomol Appl Sci Lett. 2021;8(2):26-31. <https://doi.org/10.51847/9Fb9BzKuoH>

Corresponding author: Alexander Ruchin

E-mail ✉ ruchin.alexander@gmail.com

Received: 01/04/2021

Accepted: 10/06/2021

INTRODUCTION

Coleoptera, Carabidae are widely distributed from the Arctic and alpine tundras to seacoasts, deserts, and rainforests, and they may be common in these environmental conditions [1-4]. They play a significant role in biocenoses as entomophages that regulate the number of terrestrial invertebrates, and they are considered economically useful: both imago and larvae destroy some pests of forestry and agriculture, limiting their numbers [5-8]. Carabidae is a convenient model object for ecological and faunal studies. This family is used for zoological diagnostics of soils, zoogeographic characterization of biocenoses, and assessment of anthropogenic impacts on the biocenosis [9-14].

Carabus species are large, often colorful, well-recognized, and well-studied members of the

Carabidae. They are usually polyphagous predators that consume various invertebrates [15-17]. Some of them are common for forests. But there are species that can be rare, especially in conditions of severe anthropogenic pressure [7, 18-20]. *Carabus (Procrustes) coriaceus* Linnaeus, 1758 is a very large species of ground beetle with larval or imaginal diapause. The life cycle lasts one year and it is recyclic with autumn reproduction or obligately two-year recyclic with late-summer or autumn reproduction [21]. Females lay their eggs in September. Most larvae overwinter in the first and second stages. The species has a two-year development cycle [22]. The species is widely distributed in Europe [6, 22-26]. In some places, it is considered rare and is included in the lists of protected species [27-30]. The main factors leading to a low population of the species are habitat degradation (deforestation), the use of pesticides, and the weak ability of the species to

settle. Recently, the areal has been described in detail within central Russia [31]. The eastern border of the species' areal passes through the Chuvash Republic and the Ulyanovsk region. The Republic of Mordovia is located close to the eastern border of the species' areal [32, 33]. The objective of the present study was to investigate the seasonal dynamics of *Carabus coriaceus* activity in the eastern part of its areal.

MATERIALS AND METHODS

The Republic of Mordovia is located in the center of the East European Plain between 42°11' and 46°45' East longitude and 53°38' and 55°11' North latitude. The Sura and Moksha

Rivers (tributaries of the Volga and Oka Rivers, respectively) are the main rivers in the basin where the Republic of Mordovia is located. The territory of the republic is situated in the forest and forest-steppe zone of Central Russia. There are several small steppe areas within the territory. The eastern part of Mordovia is located in the northwest of the Volga Upland, and the western part in the Oka-Don lowland (**Figure 1**). In this regard, a variety of habitats is observed in the studied area. Boreal coniferous and mixed forests are common in the west, northwest, and north of the region [34]. Deciduous forests cover the central and eastern parts of the republic [12, 35]. Forest-steppe landscapes prevail in the east and south-east.

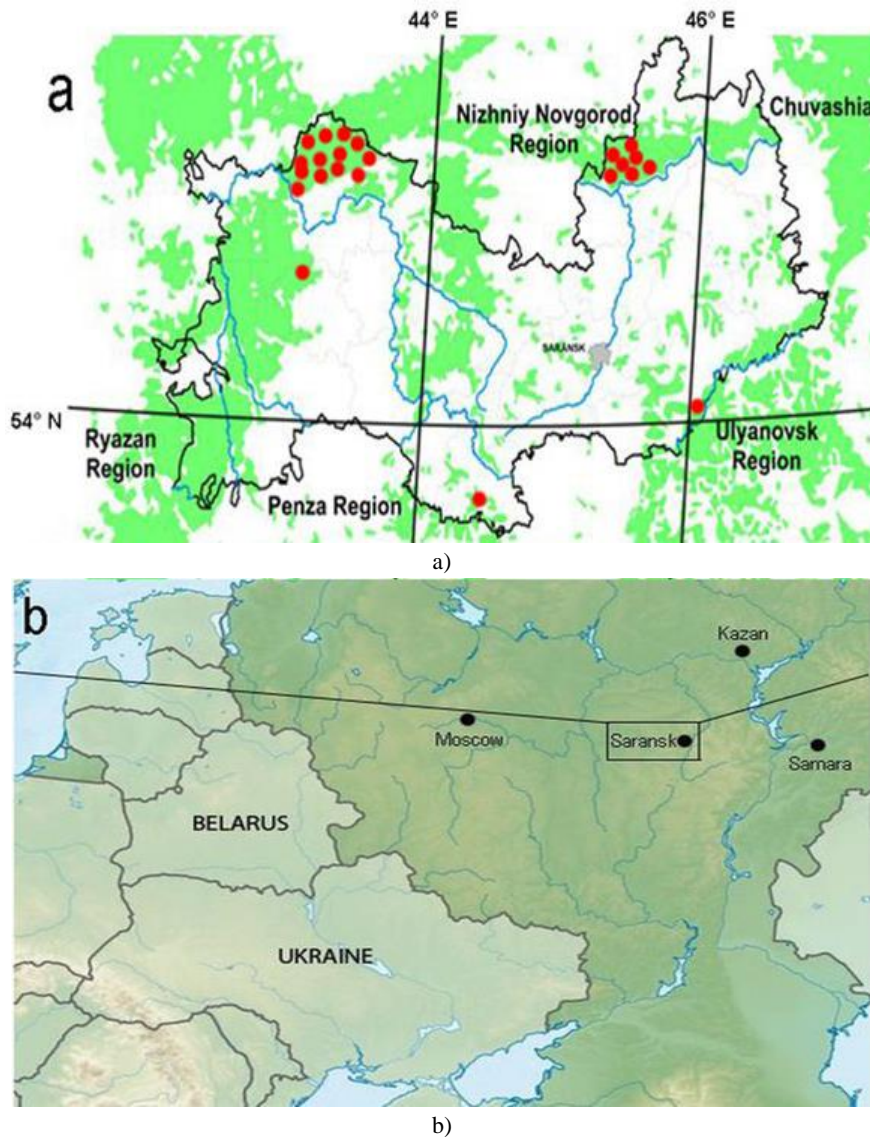


Figure 1. Study sites of *C. coriaceus* (shown with red dots).

The collection was carried out using pitfall traps in different regions of the Republic of Mordovia in 2018-2019. The distribution of ground beetles was studied during 2008-2020. The pitfall traps consisted of plastic cups with a volume of 0.5 liters with a 4% formalin solution poured into them. In order to study seasonal population dynamics, traps were placed in the forests of the Mordovia State Nature Reserve in four localities (Temnikov district of the Republic of Mordovia) and the National Park "Smolny" in three localities (Ichalki and Bolshoe Ignatovo districts of the Republic of Mordovia). In each locality, there were 10 traps (from the end of April to September), which were installed in one line with a distance between them of 2-3 m. The evaluation of accounting results was expressed in dynamic density (ex./100 trap-days).

RESULTS AND DISCUSSION

The Republic of Mordovia is part of the range and is located close to the eastern border of the distribution of this species. The main biotopes of this species are forest edges, forest meadows, forest roads, and clearings in mixed and pine forests [33, 36]. Despite the fact that there are a lot of forests in the region, the findings of *C. coriaceus* are mainly confined to protected

areas. In such conditions, the forest landscapes where *C. coriaceus* lives remain untouched.

Nevertheless, we note that the number of species in Mordovia State Nature Reserve was almost three times higher than the number of species from biotopes from the forests of National Park "Smolny". The first protected area is protected for a longer time and all the landscapes have been untouched for more than 80 years. Ecosystems in the National Park "Smolny" have been protected for only 25 years, and before that, intensive forestry activities were carried out on this territory. It is possible that anthropogenic activity has caused some damage to the populations of *C. coriaceus* and they are now in the recovery stage.

The activity of ground beetles is influenced by several factors, including temperature, humidity, microclimatic conditions, etc. [37, 38]. The temperature has long been considered the most important abiotic factor affecting the activity of Carabidae [39, 40]. The seasonal and life-history fluctuations strongly influence the observed abundances and distributions of Carabidae in certain biotopes [1, 21, 41].

Seasonal activity of *C. coriaceus* began in late April-early May and lasted until mid-September – the first half of October (**Figure 2**). Only one peak of abundance was recorded, which occurred in the second half of July – August.

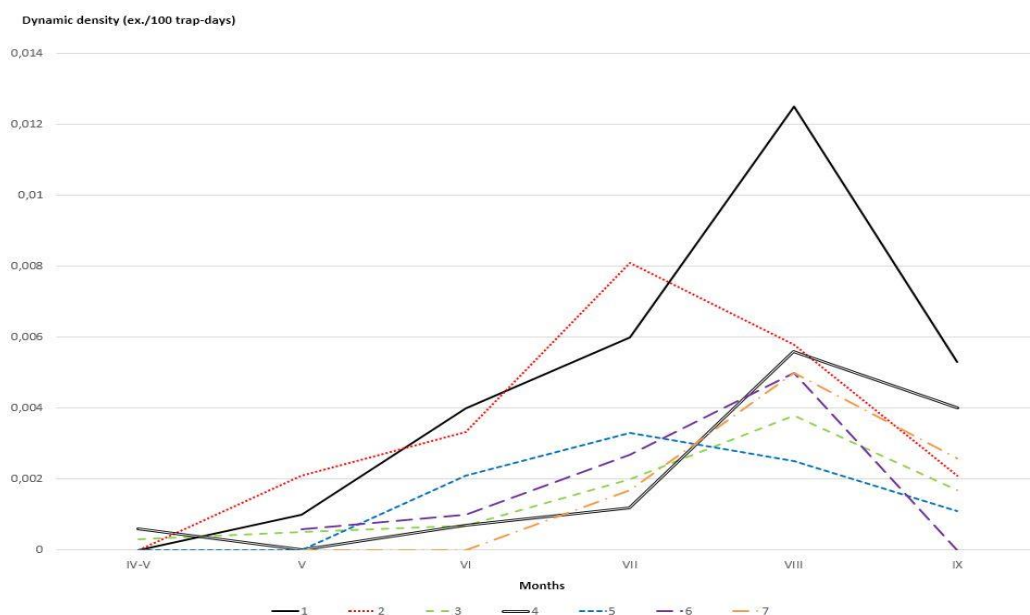


Figure 2. Dynamics of seasonal activity of *Carabus coriaceus*. The territory of Mordovia State Nature Reserve (1 – sq. 86; 2 – sq. 18; 3 – sq. 34; 4 – sq. 435) and the territory of National Park "Smolny" (5 – sq. 10; 6 – sq. 1; 7 – sq. 3). The relative abundance is indicated on the ordinate axis (ex./100 trap-days).

It is worth noting that in the relatively warm spring of 2018, the timing of the start of activity was shifted to April, while in the cold spring of 2019, the ground beetle began activity only in early May. However, subsequently, due to changes in the temperatures and cooling in the summer of 2018, the peak population was shifted to the beginning of August (**Figure 2 and Graphs 1, 3, 4, 6, and 7**). And vice versa, in 2019 (**Figure 2 and Graphs 2 and 5**) the peak population was recorded in the second half of July.

In contrast to our studies in Hungary, two peaks of the seasonal activity of *C. coriaceus* were recorded: in late June-July and late August-early September [3, 42]. Slovakia also had two peaks of activity that were weather-dependent [43]. In the forests of Slovenia, the first specimens were caught in late April, and the last – in early November. The species becomes abundant in late May, mid-July, and especially between late August and late October [44]. In Croatia, this species was most active in late summer and autumn, but a small peak of activity was also observed in spring [45]. Since activity, in addition to the features of the life cycle, is associated with the weather conditions, it is obvious that the corresponding changes in the catch rate over the years and during the season will always be ambiguous.

CONCLUSION

The seasonal activity of *C. coriaceus* in the eastern part of the range varied by year. It began in late April or early May and lasted till mid-September and October. At the same time, the peak number fell in the second half of July – August. The beginning of activity was influenced by the ambient temperature. Thus, in the warm spring of 2018, the start dates of activity were shifted to April, and in the cold spring of 2019, *C. coriaceus* began its activity only in early May. At the same time, the catchability of *C. coriaceus* was higher in the Mordovia State Nature Reserve, in contrast to the National Park "Smolny". This may probably be due to the longer duration of the Mordovia State Nature Reserve ecosystem protection. In this protected area, anthropogenic activity ceased more than 80 years ago and the ecosystems have fully recovered.

ACKNOWLEDGMENTS: None

CONFLICT OF INTEREST: None

FINANCIAL SUPPORT: None

ETHICS STATEMENT: None

REFERENCES

1. Lövei GL, Sunderland KD. Ecology and behavior of ground beetles (Coleoptera: Carabidae). Annu Rev Entomol. 1996;41(1):231-56. doi:10.1146/annurev.en.41.010196.001311
2. Bondarenko AS, Zamotajlov AS, Belyi AI, Khomitskiy EE. Fauna and ecological characteristics of ground beetles (Coleoptera, Carabidae) of the Nature Sanctuaries «Prichernomorskiy» and «Tuapsinskiy» (Russia). Nat Conserv Res. 2020;5(3):66-85. doi:10.24189/ncr.2020.032
3. Fülöp D, Bérces S, Szabó P, Samu F. Effects of abiotic factors on co-occurring *Carabus* (Coleoptera: Carabidae) species. Biologia. 2021;76(2):663-71. doi:10.2478/s11756-020-00593-w
4. Ludwiczak E, Nietupski M, Kosewska A. Ground beetles (Coleoptera; Carabidae) as an indicator of ongoing changes in forest habitats due to increased water retention. PeerJ. 2020;8:e9815. doi:10.7717/peerj.9815
5. Pearce JL, Venier LA. The use of ground beetles (Coleoptera: Carabidae) and spiders (Araneae) as bioindicators of sustainable forest management: a review. Ecol Indic. 2006;6(4):780-93.
6. Vladić ŽJ, Jelaska LŠ. Long term changes (1990–2016) in carabid beetle assemblages (Coleoptera: Carabidae) in protected forests on Dinaric Karst on Mountain Risnjak, Croatia. Eur J Entomol. 2020;117:56-67. doi:10.14411/eje.2020.006
7. Bondarenko AS, Zamotajlov AS, Shchurov VI. Contribution to biology and distribution studies on some ground beetles species (Coleoptera, Carabidae) registered in the Red Data Book of Krasnodarsky Krai. Nat Conserv Res. 2017;2(Suppl. 1):70-80. doi:10.24189/ncr.2017.005 [In Russian]

8. Rozhnov VV, Lavrinenko IA, Razzhivin VY, Makarova OL, Lavrinenko OV, Anufriev VV, et al. Biodiversity revision of a large arctic region as a basis for its monitoring and protection under conditions of active economic development (Nenetsky Autonomous Okrug, Russia). *Nat Conserv Res.* 2019;4(2):1-28. doi:10.24189/ncr.2019.015 [In Russian]
9. Magura T, Lövei GL. Consequences of urban living: urbanization and ground beetles. *Curr Landsc Ecol Rep.* 2021;6:9-21. doi:10.1007/s40823-020-00060-x
10. Koivula M. Useful model organisms, indicators, or both? Ground beetles (Coleoptera, Carabidae) reflecting environmental conditions. *ZooKeys* 2011;100:287-317. doi:10.3897/zookeys.100.1533
11. Kirichenko-Babko M, Danko Y, Musz-Pomorksa A, Widomski MK, Babko R. The impact of climate variations on the structure of ground beetle (Coleoptera: Carabidae) assemblage in forests and wetlands. *Forests.* 2020;11(10):1074. doi:10.3390/f11101074
12. Ruchin AB, Alekseev SK, Khapugin AA. Post-fire fauna of carabid beetles (Coleoptera, Carabidae) in forests of the Mordovia State Nature Reserve (Russia). *Nat Conserv Res.* 2019;4(Suppl.1):11-20. doi:10.24189/ncr.2019.009
13. Zamotajlov AS, Serdyuk VY, Khomitskiy EE, Belyi AI. New data on distribution and biology of some rare ground beetles (Coleoptera, Carabidae) in South Russia. *Nat Conserv Res.* 2019;4(4):81-90. doi:10.24189/ncr.2019.066 [In Russian].
14. Khobrakova LT, Rudykh SG, Ulzii T, Gantigmaa Ch. Life cycle of ground beetle *Chlaenius tristis reticulatus* Motschulsky, 1844 (Coleoptera: Carabidae) in the condition of Western Transbaikalia. *Far East Entomol.* 2020;418:19-24. doi:10.25221/fee.418.4
15. Carbonne B, Bohan DA, Petit S. Key carabid species drive spring weed seed predation of *Viola arvensis*. *Biol Control.* 2020;141:104148. doi:10.1016/j.biocontrol.2019.10414
16. Eötvös CB, Lövei GL, Magura T. Predation pressure on sentinel insect prey along a riverside urbanization gradient in Hungary. *Insects.* 2020;11(2):97. doi:10.3390/insects11020097
17. Knapp M, Seidl M, Knappová J, Macek M, Saska P. Temporal changes in the spatial distribution of carabid beetles around arable field-woodlot boundaries. *Sci Rep.* 2019;9:8967. doi:10.1038/s41598-019-45378-7
18. Ruchin AB, Egorov LV. Overview of insect species included in the Red Data Book of Russian Federation in the Mordovia State Nature Reserve. *Nat Conserv Res.* 2017;2(Suppl.1):2-9. doi:10.24189/ncr.2017.016
19. Ruchin AB, Khapugin AA. Red data book invertebrates in a protected area of European Russia. *Acta Zool Academ Sci Hung.* 2019;65(4):349-70. doi:10.17109/AZH.65.4.349.2019
20. Cicort-Lucaciu AŞ. Road-killed ground beetles prove the presence of *Carabus hungaricus* (Coleoptera: Carabidae) in North-Western Romania. *Nat Conserv Res.* 2020;5(3):134-8. doi:10.24189/ncr.2020.035
21. Matalin AV. Life cycles of ground beetles (Coleoptera, Carabidae) of the Western Palearctic: abstract. *dis. Doctors biol. Sciences Moscow;* 2011. 46 p. [In Russian]
22. Minets ML. Seasonal activity dynamics of ground beetles of the genus *Carabus* L. (Coleoptera, Carabidae) in the coniferous forests of Belarus. *Vestn BGU.* 2007;2(3):71-7. [In Russian]
23. Riecken U, Raths U. Use of radio telemetry for studying dispersal and habitat use of *Carabus coriaceus* L. *Ann Zool Fennici.* 1996;33(1):109-16.
24. Turin H, Penev L, Casale A. (eds.) The genus *Carabus* L. in Europe. A synthesis. *Pensoft Publ., Sofia–Moscow–Leiden;* 2003. 536 p.
25. Andorko R, Kadar F. Carabid beetle (Coleoptera: Carabidae) communities in a woodland habitat in Hungary. *Entomol Fenn.* 2006;17(3):221-8.
26. Teofilova T. Ground beetles (Coleoptera: Carabidae) from the region of Cape Emine (central Bulgarian Black Sea coast). Part II. Ecological parameters and community structure. *ZooNotes.* 2015;71:1-12.
27. Red Data Book of Chuvashia Republic. Vol. 1. P. 2. Rare and endangered species of

- animals. Cheboksary: State Unitary Enterprise "IPC "Chuvashia"; 2010. 372 p. [In Russian]
28. Red Data Book of Ryazan Region. Ryazan: Golos gubernii Publ; 2011. 626 p. [In Russian]
29. Red Data Book of Nizhny Novgorod Region. Nizhny Novgorod: DEKOM Publ; 2014. 448 p. [In Russian]
30. Red Data Book of Penza Region. Vol. 2. Animals. Penza; 2019. 264 p. [In Russian]
31. Egorov LV, Podshivalina VN. Revisiting the area boundaries of *Carabus coriaceus* Linnaeus, 1758 in the European part of Russia. Acta Biol Univ Daugavp. 2020;20(1):39-45.
32. Ruchin AB, Egorov LV, Aleksiev SK. Ground beetles (Coleoptera, Carabidae) of the Mordovia State Nature Reserve. Proc Mordov State Nat Reserve. 2015;14:157-91. [In Russian]
33. Aleksiev SK, Ruchin AB, Semishin GB. Ground beetles (Coleoptera, Carabidae) of the marginal biotopes of National Park «Smolny». Proc Mordov State Nat Reserve. 2018;21:260-3. [In Russian]
34. Ruchin AB, Egorov LV, Semishin GB. Fauna of click beetles (Coleoptera: Elateridae) in the interfluvium of Rivers Moksha and Sura, Republic of Mordovia, Russia. Biodiversitas. 2018;19(4):1352-65. doi:10.13057/biodiv/d190423
35. Chursina MA, Ruchin AB. A checklist of Syrphidae (Diptera) from Mordovia, Russia. Halteres. 2018;9:57-73. doi:10.5281/zenodo.1255874
36. Aleksiev SK, Ruchin AB. Fauna and abundance of ground beetle (Coleoptera, Carabidae) in pine forests. Entomol Appl Sci Lett. 2020;7(1):1-9.
37. Kosewska A, Nijak K, Nietupski M, Kędzior R, Ludwiczak E. Effect of plant protection on assemblages of ground beetles (Coleoptera, Carabidae) in sugar beet crops in four-year rotation. Acta Zool Academ Sci Hung. 2020;66(Suppl.):49-68. doi:10.17109/AZH.66.Suppl.49.2020
38. Perry KI, Herms DA. Dynamic Responses of ground-dwelling invertebrate communities to disturbance in forest ecosystems. Insects. 2019;10(3):61. doi:10.3390/insects10030061
39. Skarbek CJ, Kobel-Lamparski A, Dormann CF. Trends in monthly abundance and species richness of carabids over 33 years at the Kaiserstuhl, southwest Germany. Basic Appl Ecol. 2021;50:107-18.
40. Růžičková J, Veselý M. Movement activity and habitat use of *Carabus ullrichii* (Coleoptera: Carabidae): the forest edge as a mating site? Entomol Sci. 2018;21(1):76-83.
41. Rainio J, Niemelä J. Ground beetles (Coleoptera: Carabidae) as bioindicators. Biodivers Conserv. 2003;12(3):487-506.
42. Kádár F, Fazekas JP, Sárospataki M, Lövei GL. Seasonal dynamics, age structure and reproduction of four *Carabus* species (Coleoptera: Carabidae) living in forested landscapes in Hungary. Acta Zool Academ Sci Hung. 2015;61(1):57-72. doi:10.17109/AZH.61.1.57.2015
43. Šiška B, Eliašová M, Kollár J. *Carabus* population response to drought in lowland oak hornbeam forest. Water. 2020;12(11):3284. doi:10.3390/w12113284
44. Polak S. Cenoses and species phenology of carabid beetles (Coleoptera: Carabidae) in three stages of vegetational succession in Upper Pivka Karst (Sw Slovenia). Acta Entomol Slovenica. 2004;12(1):57-72.
45. Vujčič-Karlo S, Durbešič P. Ground beetle (Coleoptera: Carabidae) fauna of two oak woods with two different water balances. Acta Entomol Sloven. 2004;12(1):139-50.