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Invading the North: Dispersal of Nearctic treehopper *Stictocephala bisonia* (*Hemiptera: Cicadomorpha: Membracidae*) in European Russia

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Abstract

In recent years, the problem of distribution and expansion of new territories by invasive species has become global. The publication analyses the current distribution of Nearctic treehopper Stictocephala bisonia *in the European part of Russia. It is a North American species which was introduced into Europe over 100 years ago, but only in the last 20-30 years has it been actively spreading in the continent. In the European part of Russia, the Nearctic treehopper has been known since 1992 from the Rostov region and since 1996 from the Krasnodar Krai. At present the species is reliably registered in 26 regions. The major part of observations (185, 82.2%) is made in the period from 2020 to 2022. Currently, the northern border of distribution is the city of Nizhny Novgorod. In the northeast, the range of the species reaches the Republic of Tatarstan, to the east of the Republic of Tatarstan and the Republic of Bashkortostan, the hopper has not yet been observed. Imagoes are observed in the southern regions beginning in the third decade of June. The maximum number of observations falls on the second and third decade of July and August.*

INTRODUCTION

In recent years, the problem of invasive species around the world has become global. The introduction and rooting of many animals and plants outside their native habitats poses a constant threat to many ecosystems of the world. In new habitats, such species often become harmful invasive pests with significant consequences for forest health, biodiversity of indigenous ecosystems, sustainability of biological resources, human health and the economy *(1–5)*.

Invasions of alien arthropods are also a widely recognized problem. Many invasive insect species pose a serious threat to biodiversity and ecosystem functioning worldwide *(6–9)*. The accelerating pace of commercial and social globalization creates significant opportunities for the movement of a wide variety of species to new areas of the world *(10–12)*. Invasive insect species are often not pests in their natural range, where they are well controlled by biotic and abiotic factors. However, in new areas they become a disaster for these places. For example, *Vespa velutina* is an invasive species introduced to Europe and several other non-native Asian countries, where it has created viable and expanding populations. In the new range, its intensive predation on *Apis mellifera* leads to losses among honey bees due to violations of the mechanisms of repelling aggression *(13,14)*. Another example of active settlement is the ladybug *Harmonia axyridis*. It is an Eastern Palearctic species found in Japan, China, Korea, Mongolia and Siberia, and has been introduced to both North America and Europe. A certain degree of impact of this species on the populations of local ladybugs has already been proven *(15)*. Since 2010, it has been actively spreading eastward, beyond the Volga River and approaching the Urals. This means that the unification of the eastern and western parts of the range will soon take place *(15–18)*. The ability of invaders to form new trophic associations may pose a threat to plants in their natural range in case of accidental introduction of a pest. Our knowledge of the biology of new pests, their invasive potential and impact, as well as possible monitoring and control methods, is generally limited *(10)*.

Among Auchenorrhyncha (Hemiptera), 30 alien species have settled in Europe, 22 of them belong to the family Cicadellidae *(19–23)*. All these species feed on plant sap and can be involved in the transmission of pathogens or significantly damage plant tissues. In addition to their economic impact on local vegetation and crops, alien species are one of the main targets when assessing threats to local biodiversity (24).

In this study, we update the available data on the distribution of an alien species of Russian entomofauna (*Stictocephala bisonia* Kopp & Yonke, 1977) with the latest field data on localities.

MATERIALS

The data of our own research conducted in 2019–2022 from several regions of Russia were analyzed. Also, to analyze the distribution of the Nearctic treehopper, information from the civilian scientific platform iNaturalist was used (www.inaturalist.org). It is a multi-taxation platform and a joint initiative of the California Academy of Sciences and the National Geographic Society. iNaturalist allows participants to make observations of any organism or its traces together with the corresponding spatio-temporal metadata. The number of observations sent to this scientific platform continues to grow. Therefore, it is becoming increasingly important that these observations can be identified at the highest taxonomic level, maximizing their value for biodiversity research *(25,26)*.

All photos uploaded by users to the iNaturalist platform have been checked and evaluated. Own collections were carried out using entomological nets in 2019-2022.

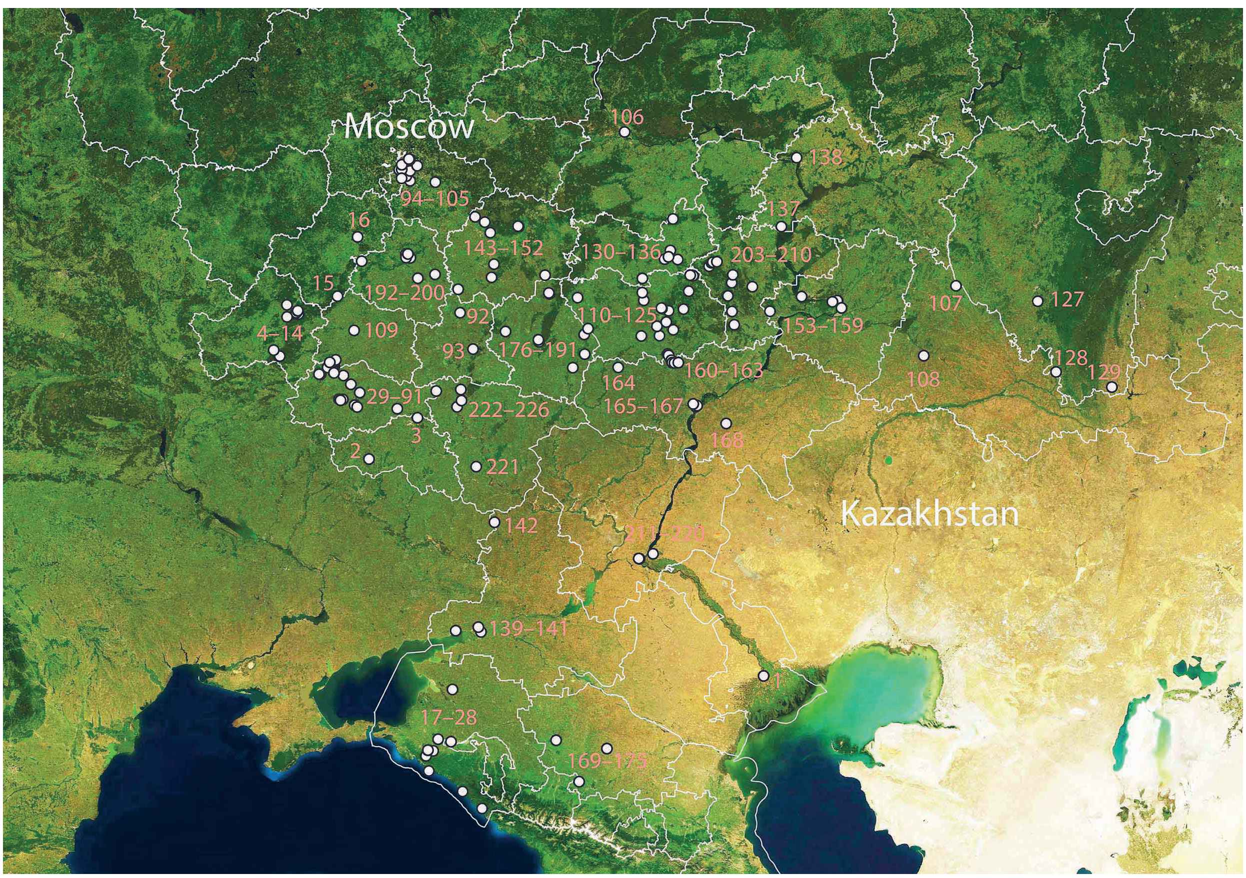

Figure 1. *A map of the distribution of Stictocephala bisonia in the European part of Russia (according to the platform users and the authors' own observations). See Appendix for a list of localities.*

The seasonal activity of imagines is determined on the basis of all these observations and all references related to the European part of Russia (excluding the Caucasus). The distribution and biology of this species in the Caucasus region was described earlier *(27,28)*.

RESULTS

Currently, the new range of the Nearctic treehopper *Stictocephala bisonia* in the European part of Russia occupies a huge area. Based on observations of volunteers from civil science and literature data *(28–30)*, the species was reliably registered in 26 regions (Figure 1 and Appendix). The main part of the observations (185, 82.2%) was made in the period from 2020 to 2022.

In the European part of Russia, the Nearctic treehopper has been known at least since 1992 from the Rostov Region *(31)* and since 1996 from the Krasnodar Territory *(29)*. Previously, the northernmost reliably documented find of the species dated back to 1998 in the Voronezh Region *(32)*.

The first imagos are observed already in the third decade of June (Volgograd region and Krasnodar Krai) (Figure 2). However, most of the observations were made in the second and third decades of July and August. In September, the number of observations of imago Nearctic treehopper decreases. However, the Nearctic treehopper is registered until the second decade of October (Bryansk region, Kursk region, Krasnodar Krai).

DISCUSSION

The original range of *Stictocephala bisonia* in the past was limited to the eastern and middle parts of North America. However, with the growth of trade in shrubs and fruit trees for nurseries, this species was accidentally introduced to the Western part of the USA, to the Hawaii *(33)*. It first appeared in Europe in 1912 (the town of Kevevára, former Hungary, now part of Serbia, *(34)*), was discovered in France little later (35) and since then the species has gradually spread throughout the continent, with the exception of the northernmost areas *(19)*. In Europe, it is currently known from 23 countries in the southeastern, western and central parts *(19)*. It also reached North Africa, Transcaucasia, the Middle East and Central Asia *(36)*.

However, earlier the rate of spread of *Stictocephala bisonia* was insignificant. For example, in the Czech Republic it was discovered only in 1994 in southeastern Moravia. But then it spread relatively quickly in southern and northeastern Moravia, Bohemia *(37)*. In Germany, this species was first recorded in 1966 in the far southwestern part of the country and has since spread to the southwest and northeast *(38)*. *Stictocephala bisonia* first appeared in Slovakia in 1972, in the southwestern part of the country, and for more than 15 years it has colonized mainly the lowlands of Western and Eastern Slovakia *(39)*. *Stictocephala bisonia* was first observed in southern Poland in 2007, then near Warsaw in 2010 and on the Baltic coast in 2015, with additional observations totalling more than 80 cases in Poland. It is assumed that *Stictocephala bisonia* reached Lithuania some time after 2015 *(39)*.

It is highly likely that *Stictocephala bisonia* appeared in Belarus around the same time. For the first time in the territory of Grodno (Western Belarus) during the growing season of 2020, 13 individuals of this species were found. Previously, it was registered only in the south of the country, spreading from the south and south-west direction *(40)*.

Stictocephala bisonia was first observed as a pest in 1954 in Moldavia, in 1963 in Ukraine, in 1959 in Armenia, in 1960 in Azerbaijan and Georgia, in 1963 in Transcarpathia *(27,41)*. Now in these countries, the species is considered a pest of agricultural crops. Another example of the recent rapid spread of the species is China, where it was discovered in 2020 *(42)*.

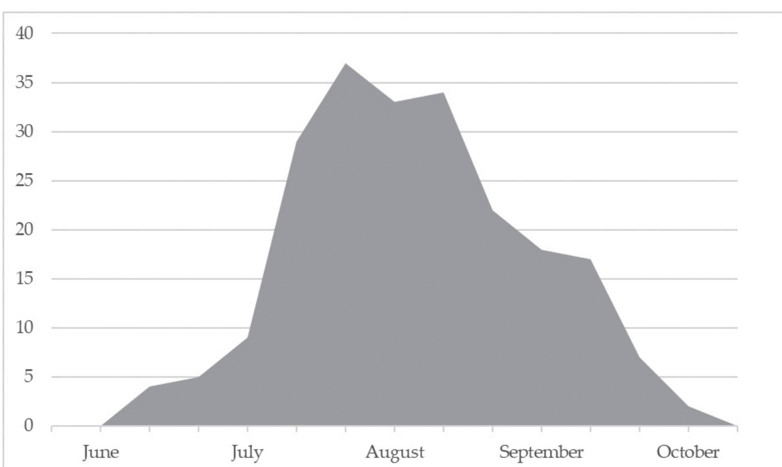

Figure 2. *Seasonal dynamics of Stictocephala bisonia activity in the European part of Russia (ordinate axis – number of observations).*

Thus, in all these countries, the finds of the Nearctic treehopper have increased tenfold over the past decade. It is clearly seen that during this time *Stictocephala bisonia* actively spread to the north and northeast.

It is possible that *Stictocephala bisonia* had two distribution directions on the territory of the European part of Russia. The first direction is from the west from Ukraine to the east. In Kursk, Belgorod, Moscow, the first documented finds date back to 2015 and 2017, in the Voronezh region the first find was made in 1998. The second direction is from the south (from the Rostov region and Krasnodar Krai) to the north and north-east. In Central Russia (Tambov region) it has been observe since 2013. Similar trends and distribution directions were also observed in other insect species *(43–45)*. It can also be assumed that there have been repeated drifts of this species to cities with different ground transportation. This is evidenced by observations of the species in the cities of central Russia: Moscow (2015), Tambov (2013, 2014).

Currently, the northern border of distribution is the city of Nizhny Novgorod. In the northeast, the range of the species covers the Republic of Tatarstan. Further to the east of the Republic of Tatarstan and the Republic of Bashkortostan, civil science did not mark the species.

In the Volga region, the main data have been obtained since 2019. Usually, civil science volunteers manage to mark a species when it becomes more numerous. Therefore, we do not exclude that *Stictocephala bisonia* already inhabited these regions 2-3 years before these finds.

According to many observations, the number of *Stictocephala bisonia* has increased significantly in recent years. Since 2004, there has been an increase in the number of *Stictocephala bisonia* in the Rostov region and an increase in the proportion of plantings damaged by it in young and perennial grape plantings. A massive outbreak of activity was observed in 2008, when more than 50% of plantings were damaged *(46)*. The main factors of the mass reproduction of *Stictocephala bisonia* in Kabardino-Balkaria are climate warming, the presence of forage plants that are not removed from the gardens, as well as the absence of natural enemies in the climatic conditions of the republic *(27)*.

Stictocephala bisonia is found in various habitats, both natural and artificially created by man. It can be found on well-lit forest edges and clearings, dry and moderately moist meadows, in high ruderal grassy vegetation along streams and reservoirs. The species was also found in places located deep in the forest (clearings, as well as small forest settlements). It often lives on the roadsides of highways and railways, park areas in cities, gardens, vegetable gardens, in abandoned quarries. The seasonal dynamics of the number of *Stictocephala bisonia* is similar to the dynamics in other parts of the newly acquired area.

Climate has a dominant influence on the behavior, abundance and distribution of insects, with temperature being the most dominant variable *(47)*. Seasonal changes in climatic variables in different geographical areas change the behavior of insects in different ways. In temperate and continental climates, many species have physiologically adapted to extreme temperatures through diapause, hibernation, or migration. While some tropical insect species have the potential to take root and survive in cooler climates, their successful rooting depends on having long periods of optimal temperature conditions to complete their development *(48)*.

Stictocephala bisonia is recognized as one of the most dangerous pests among the Membracidae. For several decades, it has led to crop loss in orchards and vineyards in the southern part of Europe *(39)*. It is an extremely polphagous pest of cultivated and wild trees that damages young twigs. With their ovipositor the females cut deep paired incisions on the bark of trees and lay eggs there. Wood-destroying fungi and some forms of cancer penetrate through the cuts, which exacerbates the harmfulness of this species. As a result of tissue damage, the sap movement and the supply of nutrients to the tops of shoots stops, which disrupts the normal development of growth, weakening and reducing its growth. Severely damaged branches die off. The bark at the site of damage lags behind and dies. With severe damage, young plants stop growing, then die *(27,40)*.

CONCLUSIONS

In the European part of Russia, the Nearctic treehopper has been known at least since 1992. Already in 1998, it was discovered in the Voronezh region. However, most of the observations were made in 2020-2022, which indicates mass reproduction in the newly acquired area and accelerated rates of settlement in the last 5-7 years. Presumably, *Stictocephala bisonia* had two vectors of distribution across the territory of the European part of Russia – from the west and from the south. The seasonal dynamics of the number of *Stictocephala bisonia* is similar to the dynamics in other parts of the newly acquired area. The first imago individuals are observed in the southern regions in the third decade of June. The maximum of observations falls on the second and third decade of July and August. The treehopper is registered until the second decade of October. Taking into account all aspects of the harmfulness of *Stictocephala bisonia*, it is necessary to pay more attention to the possible further spread of this species across the territory of Russia. In addition, the volunteers' observations highlight the importance of natural history databases, such as iNaturalist, which allow users to upload photos for expert identification, and we encourage conservationists to use the data in these repositories.

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APPENDIX

A list of localities of *Stictocephala bisonia* in the European part of Russia (data from the authors and data from the iNaturalist platform). The list of regions of Russia is given in alphabetical order.

Astrakhan Region:

1. Astrakhan, 46.369421° N, 48.032087° E, 02.IX.2022, Author ID: mio_meow; Belgorod Region:

2. Belgorod, 50.580517° N, 36.504745° E, 07.VII.2019, D. Litvinov;

3. Stary Oskol, 51.341784° N, 37.920052° E, 15.VII.2021, Author ID: okasana;

Bryansk Region:

4. Bryansk Forest State Natural Biosphere Reserve, Nerussa River, 52.460455° N, 33.859778° E, 31.VII.2021, A. M. Nikolaeva;

5. Bryansk, 53.199446° N, 34.443592° E, 30.VII.2021, Author ID: urij777;

6. Bryansk, 53.214449° N, 34.361713° E, 05.X.2022, Author ID: urij777;

7. Bryansk, 53.223783° N, 34.378683° E, 18.X.2022, Author ID: natbarsova;

8. Bryansk, 53.256044° N, 34.420296° E, 14.VIII.2021, A. Zubarev;

9. Bryansk, 53.260551° N, 34.425189° E, 18.VIII.2021, A. Zubarev;

10. Seltso, 53.361915° N, 34.107338° E, 15.VIII.2022, K. Marchenkova;

11. Suzemka district, Chukhrai, 52.453088° N, 33.8871094° E, 01.VIII.2021, A. M. Nikolaeva

12. Suzemka district, Chukhrai, 52.455832° N, 33.900223° E, 27.VII.2019, Y. P. Sokolov;

13. Trubchevsk district, 1 km E of Krasnoe, 52.563717° N, 33.720278° E, 31.VII.2021, Y. Medvedko;

14. Vygonichi district, Scriabino, 53.150323° N, 34.111239° E, 25.IX.2020, D. Makhnovsky;

Kaluga Region:

15. Ulyanovo district, Shvanovo, 53.513418° N, 35.585186° E, 22.IX.2020, M. Garkunov;

16. Kaluga, 54.5326° N, 36.1711° E, 12.VIII.2022, A. Aleksandrov;

Krasnodar Region:

17. Abinsk district, 1 km W of Erivanskaya, 44.726397° N, 38.167623° E, 30.IX.2014, Author ID: macrohunter_ls;

18. Abinsk district, 1 km W of Erivanskaya, 44.727049° N, 38.169469° E, 14.X.2014, Author ID: macrohunter_ls;

19. Abinsk district, 1 km W of Erivanskaya, 44.727059° N, 38.169746° E, 24.IX.2015, Author ID: macrohunter_ls;

20. Abinsk district, Kholmskaya, 44.83228° N, 38.380695° E, 29.IX.2019, G. Okatov;

21. Abinsk district, Sverdlovsky, 45.074689° N, 38.523394° E, 09.X.2021, Author ID: kate_and_bugs;

22. Abinsk district, Svetlogorsky surroundings, 44.844896° N, 38.225298° E, 22.VII.2020, Author ID: macrohunter_ls;

23. Abinsk district, Svetlogorsky surroundings, 44.848400° N, 38.226128° E, 15.VIII.2020, Author ID: macrohunter_ls;

24. Gelendzhik district, 8 km W of Beregovoe, 44.41356° N, 38.252763° E, 22.VIII.2022, Author ID: kat_rin;

25. Kanevskaya, 46.094993° N, 38.943871° E, 13.VII.2019, E. Petutina;

26. Krasnodar, 45.023353° N, 38.901103° E, 26.VI.2018, Author ID: lugachev_vitaly;

27. Sochi urban district, Golubaya Dacha, 43.980569° N, 39.238318° E, 24.IX.2021, Author ID: dartzirus;

28. Sochi urban district, Verkhovskoye, 43.621298° N, 39.808255° E, 15.IX.2019, Author ID: andreas-73;

Kursk Region:

29. Central Black Earth State Natural Biosphere Reserve, 51.562683° N, 36.111667° E, 12.VIII.2022, K. S. Ivlev;

30. Central Black Earth State Natural Biosphere Reserve, 51.56802° N, 36.088863° E, 13.VIII.2020, O. Ryzhkov;

31. Central Black Earth State Natural Biosphere Reserve, 51.568218° N, 36.087722° E, 14.VIII.2021, O. Ryzhkov;

32. Central Black Earth State Natural Biosphere Reserve, 51.568715° N, 36.087353° E, 12.IX.2020, O. Ryzhkov;

33. Central Black Earth State Natural Biosphere Reserve, 51.570152° N, 36.098175° E, 17.VIII.2022, K. S. Ivlev;

34. Central Black Earth State Natural Biosphere Reserve, 51.57103° N, 36.085207° E, 12.IX.2020, O. Ryzhkov;

35. Central Black Earth State Natural Biosphere Reserve, 51.567763° N, 36.088835° E, 13.VIII.2020, O. Ryzhkov;

36. Central Black Earth State Natural Biosphere Reserve, 51.569° N, 36.08688° E, 14.VIII.2021, O. Ryzhkov;

37. Central Black Earth State Natural Biosphere Reserve, 51.569518° N, 36.086003° E, 23.VIII.2020, O. Ryzhkov;

38. Central Black Earth State Natural Biosphere Reserve, 51.569679° N, 36.086863° E, 03.VII.2021, O. Ryzhkov;

39. Central Black Earth State Natural Biosphere Reserve, 51.569863° N, 36.08686° E, 14.VIII.2021, O. Ryzhkov;

40. Central Black Earth State Natural Biosphere Reserve, 51.570247° N, 36.08667° E, 23.VIII.2020, O. Ryzhkov;

41. Dmitriev district, Ladygino, 52.131453° N, 35.092873° E, 13.VIII.2019, K. S. Ivlev;

42. Dmitriev surroundings, 52.132846° N, 35.046578° E, 08.VIII.2020, K. S. Ivlev;

43. Fatezh district, 5 km W of Fatezh, 52.10882° N, 35.757887° E, 06.VIII.2022, N. I. Degtyarev;

44. Fatezh district, Bolshoe Zhirovo, 51.950226° N, 35.975689° E, 06.VIII.2022, K. S. Ivlev;

45. Kurchatov district, 1 km N of Dichnya, 51.67616° N, 35.738852° E, 19.VII.2022, N. I. Degtyarev;

46. Kurchatov surroundings, 51.678677° N, 35.634734° E, 24.VII.2019, N. I. Degtyarev;

47. Kurchatov surroundings, 51.679073° N, 35.631163° E, 16.VII.2021, O. Ryzhkov;

48. Kurchatov, 51.660585° N, 35.672437° E, 05.IX.2022, N. I. Degtyarev;

49. Kursk surroundings, 51.799681° N, 36.236251° E, 28.IX.2020, D. Polyakov;

50. Kursk surroundings, 51.799888° N, 36.235992° E, 29.VIII.2022, D. Polyakov;

51. Manturovo district, 4 km S of Zarechye, 51.507062° N, 37.331533° E, 06.IX.2022, N. I. Degtyarev;

52. Medvenka district, Osinovy, 51.538862° N, 36.160311° E, 26.VIII.2022, K. S. Ivlev;

53. Zheleznogorsk district, 1 km E of Veretenino, 52.292788° N, 35.412232° E, 23.VII.2021, N. I. Degtyarev;

54. Zheleznogorsk district, 1 km E of Veretenino, 52.292288° N, 35.413242° E, 23.VII.2021, N. I. Degtyarev;

55. Zheleznogorsk district, 1 km E of Veretenino, 52.292637° N, 35.412473° E, 23.VII.2021, N. I. Degtyarev;

56. Zheleznogorsk district, 1 km E of Zolotoy, 52.258922° N, 35.370084° E, 24.VIII.2020, K. S. Ivlev;

57. Zheleznogorsk district, 1 km NE of Soldaty, 52.275155° N, 35.489747° E, 23.VIII.2019, O. Ryzhkov;

58. Zheleznogorsk district, 1 km NE of Soldaty, 52.27588° N, 35.490283° E, 23.VIII.2019, O. Ryzhkov;

59. Zheleznogorsk district, 1 km NE of Soldaty, 52.276125° N, 35.491958° E, 23.VIII.2019, O. Ryzhkov;

60. Zheleznogorsk district, 1 km NE of Soldaty, 52.280015° N, 35.475205° E, 30.VII.2021, O. Ryzhkov;

61. Zheleznogorsk district, 1 km NW of Androsovsky selsovet, 52.296172° N, 35.487778° E, 22.VIII.2019, O. Ryzhkov;

62. Zheleznogorsk district, 1 km NW of Androsovsky selsovet, 52.3047° N, 35.489837° E, 21.VIII.2021, O. Ryzhkov;

63. Zheleznogorsk district, 1 km NW of Gnan, 52.259305° N, 35.38158° E, 06.IX.2019, O. Ryzhkov;

64. Zheleznogorsk district, 1 km S of Veretenino, 52.280645° N, 35.387838° E, 14.VIII.2021, N. I. Degtyarev;

65. Zheleznogorsk district, 1 km S of Veretenino, 52.281015° N, 35.386182° E, 14.VIII.2021, N. I. Degtyarev;

66. Zheleznogorsk district, 1 km S of Veretenino, 52.281688° N, 35.382135° E, 14.VIII.2021, N. I. Degtyarev;

67. Zheleznogorsk district, 1 km S of Veretenino, 52.282032° N, 35.396528° E, 16.VII.2021, N. I. Degtyarev;

68. Zheleznogorsk district, 1 km S of Veretenino, 52.282808° N, 35.390715° E, 14.VIII.2021, N. I. Degtyarev;

69. Zheleznogorsk district, 1 km S of Veretenino, 52.283224° N, 35.386954° E, 10.X.2021, K. S. Ivlev;

70. Zheleznogorsk district, 1 km W of Ostapovo, 52.266907° N, 35.399445° E, 29.VII.2021, N. I. Degtyarev;

71. Zheleznogorsk district, 1 km W of Ostapovo, 52.269978° N, 35.401827° E, 29.VII.2021, N. I. Degtyarev;

72. Zheleznogorsk district, 1,5 km W of Ostapovo, 52.26691° N, 35.399437° E, 29.VII.2021, N. I. Degtyarev;

73. Zheleznogorsk district, 1,5 km W of Ostapovo, 52.268885° N, 35.401326° E, 29.VII.2021, K. S. Ivlev;

74. Zheleznogorsk district, 1,5 km W of Ostapovo, 52.269972° N, 35.401762° E, 29.VII.2021, K. S. Ivlev;

75. Zheleznogorsk district, 2 km E of Zolotoy, 52.264812° N, 35.390562° E, 30.VII.2021, N. I. Degtyarev;

76. Zheleznogorsk district, 2 km NW of Gnan, 52.259553° N, 35.376987° E, 22.VII.2021, N. I. Degtyarev;

77. Zheleznogorsk district, 2 km W of Ostapovo, 52.266312° N, 35.390708° E, 30.VII.2021, O. Ryzhkov;

78. Zheleznogorsk district, 2 km W of Ostapovo, 52.266712° N, 35.394368° E, 29.VII.2021, N. I. Degtyarev;

79. Zheleznogorsk district, 2 km W of Ostapovo, 52.271527° N, 35.38104° E, 20.VII.2021, N. I. Degtyarev;

80. Zheleznogorsk district, 2 km W of Ostapovo, 52.271552° N, 35.381042° E, 20.VII.2021, N. I. Degtyarev;

81. Zheleznogorsk district, 2 km W of Ostapovo, 52.271578° N, 35.38109° E, 20.VII.2021, N. I. Degtyarev;

82. Zheleznogorsk district, 2 km W of Ostapovo, 52.273852° N, 35.380058° E, 27.VIII.2020, O. Ryzhkov;

83. Zheleznogorsk district, 4 km NE of Veretenino, 52.321538° N, 35.445007° E, 24.VII.2021, O. Ryzhkov;

84. Zheleznogorsk district, 4 km NW of Mikhailovka, 52.252187° N, 35.291316° E, 31.VIII.2017, N. I. Degtyarev;

85. Zheleznogorsk district, 4 km NW of Mikhailovka, 52.252637° N, 35.298319° E, 23.IX.2020, Y. I. Sokolov;

86. Zheleznogorsk district, Ryshkovo, 52.155031° N, 35.483291° E, 22.VIII.2021, K. Kalagina;

87. Zheleznogorsk district, Zheleznogorsk reservoir, 52.345025° N, 35.48368° E, 19.VIII.2021, N. I. Degtyarev;

88. Zheleznogorsk district, Zheleznogorsk reservoir, 52.351448° N, 35.509693° E, 20.VIII.2021, O. Ryzhkov;

89. Zheleznogorsk district, Zheleznogorsk reservoir, 52.373843° N, 35.525968° E, 26.VIII.2021, N. I. Degtyarev;

90. Zheleznogorsk district, Zheleznogorsk reservoir, 52.388737° N, 35.532857° E, 26.VIII.2020, O. Ryzhkov;

91. Zheleznogorsk, 52.346083° N, 35.35776° E, 06.X.2020, N. I. Degtyarev;

Lipetsk Region:

92. Dankov district, 1 km S of Dankov, 53.223868° N, 39.166722° E, 02.X.2022, I. Matershev;

93. Lipetsk, 52.582012° N, 39.544492° E, 16.VIII.2022, Author ID: grossalin;

Moscow Region:

94. Domodedovo, 55.475295° N, 37.705685° E, 27.VIII.2020, L. Bulgakova;

95. Moscow, 55.553295° N, 37.595574° E, 05.VIII.2019, K. Tomkovich;

96. Moscow, 55.639681° N, 37.705685° E, 31.VIII.2021, M. Bogomolov;

97. Moscow, 55.659143° N, 37.386854° E, 21.VIII.2021, R. Providukhin;

98. Moscow, 55.663285° N, 37.460127° E, 14.IX.2015, R. Providukhin;

99. Moscow, 55.724463° N, 37.914893° E, 19.VIII.2022, S. Savelyev;

100. Moscow, 55.741867° N, 37.463488° E, 18.VIII.2022, N. Semenova;

101. Moscow, 55.829369° N, 37.704071° E, 07.VIII.2020, Y. P. Sokolov;

102. Moscow, 55.831558° N, 37.699363° E, 31.VII.2022, Y. P. Sokolov;

103. Moscow, 55.835261° N, 37.670686° E, 16.VIII.2021, Y. P. Sokolov;

104. Voskresensk district, Yurasovo, 55.452931° N, 38.442378° E, 13.VIII.2022, Author ID: kisl_mega;

105. Voskresenskoe, 55.516861° N, 37.456328° E, 05.VIII.2021, Author ID: n2morelog;

Nizhny Novgorod Region:

106. Nizhny Novgorod, 56.277565° N, 43.972091° E, 13.IX.2020, A. Surovenkov;

Orenburg Region:

107. Abdulino, 53.69313° N, 53.650311° E, 25.VII.2021, Author ID: elizaveta_zey;

108. Totskoe district, 3 km S of Totskoe, 52.463252° N, 52.710252° E, 31.VII.2022, Author ID: naturalist72304;

Oryol Region:

109. Oryol, 52.912882° N, 36.070387° E, 01.IX.2018, S. Milyakhin;

Penza Region:

110. Bessonovka district, Chemodanovka, 53.258947° N, 45.256158° E, 15.IX.2022, S. Sergatskov;

111. Bessonovka, 53.297706° N, 45.05951° E, 15.VIII.2022, T. Ivankina;

112. Bessonovka, 53.306206° N, 45.045638° E, 08.VIII.2021, T. Ivankina;

113. Gorodishche district, Gorodishche, 53.2872° N, 45.6916° E, 1.IX.2020, A.B. Ruchin;

114. Kolyshley district, Cherkassk, 52.814988° N, 44.459539° E, 20.VIII.2020, L. A. Neymark;

115. Kondol, 52.8198° N, 44.9891° E, 7.VIII.2020, A.B. Ruchin;

116. Maloserdobinsk district, Chunaki, 52.4951° N, 45.2288° E, 20.VIII.2020, A.B. Ruchin;

117. Maloserdobinsk district, Komarovka, 52.4693° N, 45.2564° E, 20.VIII.2020, A.B. Ruchin;

118. Mokshan district, Bogorodskoye, 53.439828° N, 44.53178° E, 27.VIII.2022, Author ID: hellen87;

119. Mokshan district, Pichuevka, 53.5753° N, 44.4878° E, 24.VIII.2019, A.B. Ruchin;

120. Nikolsk district, Kazarka, 53.6003° N, 45.8456° E, 1.IX.2020, A.B. Ruchin;

121. Nikolsk district, Mais, 53.8684° N, 45.9690° E, 19.VIII.2020, A.B. Ruchin;

122. Nikolsk district, Pavlovka, 53.8772° N, 45.8861° E, 6.VIII.2020, A.B. Ruchin;

123. Penza district, 1 km E of Olenevka, 52.985183° N, 44.917001° E, 13.IX.2020, D. Polikanin;

124. Penza district, 6 km SE of Penza, 53.060782° N, 45.189508° E, 14.VIII.2022, E. Frolova;

125. Shemysheyka, 52.9230° N, 45.3937° E, 24. VII.2020, A.B. Ruchin;

126. Zemetchino, 53.488393° N, 42.597702° E, 28.VIII.2022, Author ID: mma696;

Republic of Bashkortostan:

127. Ishimbai, 53.424977° N, 56.039734° E, 11. IX.2021, Author ID: evgenypodshivalov;

128. Isyangulovo district, Novopavlovka, 52.173707° N, 56.574299° E, 10.VIII.2022, Author ID: m_yumalina;

129. Akyar district, Sadovy, 51.900223° N, 58.204454° E, 29.VII.2021, K. Milyausha;

Republic of Mordovia:

130. Bolshie Berezniki district, Ekaterinovka, 54.1465° N, 45.5221° E, 27.VIII.2022, A.B. Ruchin;

131. Insar district, Nizhnyaya Vyazera, 53.8220° N, 44.4903° E, 5.VIII.2022, A.B. Ruchin;

132. Lyambir district, Malaya Elkhovka, 54.3023° N, 45.3072° E, 1.VIII.2021, A.B. Ruchin;

133. Mordovia State Nature Reserve, cordon Novenkiy, 54.709°N, 43.213°E, 20–24.VIII.2022, K. Tomkovich; cordon Inorskiy, 15–18.VIII.2021, 18–23.VIII.2021, 4 spec., M.N. Esin;;

134. National Park «Smolny», cordon Obrezki, 54.8368° N, 45.3840° E, 26.VIII.2022, G.B. Semishin;

135. Saransk urban district, Nikolaevka, 54.1534° N, 45.1407° E, 12.VIII.2022, A.B. Ruchin;

136. Saransk, 54.192954° N, 45.252653° E, 01. VIII.2022, Author ID: nastyakalinkina;

Republic of Tatarstan:

137. Tetyushi district, Bolshye Tarkhany, 54.708138° N, 48.550103° E, 09.IX.2022, Author ID: gulina;

138. Kazan, 55.857559° N, 48.996881° E, 29.IX.2020, D. Ivanov;

Rostov Region:

139. Pokrovskoe district, Primorka, 47.276365° N, 39.037864° E, 21.VII.2022, Author ID: sergen;

140. Rostov-on-Don, 47.252116° N, 39.776143° E, 28.VII.2022, Author ID: i_am_julias;

141. Rostov-on-Don, 47.348453° N, 39.698339° E, 03.VIII.2022, I. Kovtun;

142. Chertkovo, 49.389588° N, 40.171661° E, 25. VII.2020, D. Zhbir;

Ryazan Region:

143. Korablino district, Semion, 54.067195° N, 40.156838° E, 15.VIII.2022, M. Gorbunova;

144. Miloslavskoye district, 1 km NW of Chernava, 53.633499° N, 39.113891° E, 22.IX.2020, A. M. Nikolaeva;

145. Miloslavskoye district, 1 km NW of Chernava, 53.633765° N, 39.108518° E, 22.IX.2020, A. M. Nikolaeva;

146. Murmino, 54.604375° N, 40.049008° E, 17. IX.2022, E. Kitova;

147. Ryazan district, Polkovo, 54.784202° N, 39.886446° E, 26.IX.2020, Author ID: eleramo;

148. Ryazhsk district, Podvislovo, 53.83992° N, 40.085879° E, 19.IX.2020, A. M. Nikolaeva;

149. Rybnoye district, 1 km N of Konstantinovo, 54.872476° N, 39.603583° E, 28.VII.2022, A. M. Nikolaeva;

150. Shatsky district, Krivaya Luka, 53.8780° N, 41.6481° E, 10.VIII.2022, A.B. Ruchin;

151. Spassk-Ryazansky district, Brykin Bor, 54.708017° N, 40.880050° E, 10.VIII.2017 г. A. M. Nikolaeva;

152. Spassk-Ryazansky district, Brykin Bor, 54.715083° N, 40.858409° E, 06.VIII.2017 г. A. M. Nikolaeva;

Samara Region:

153. Krasny Yar district, Malaya Tsarevshchyna, 53.434449° N, 50.194146° E, 01.X.2020, Author ID: ludmila-17;

154. Krasny Yar district, Malaya Tsarevshchyna, 53.436225° N, 50.182702° E, 29.VIII.2020, Author ID: ludmila-17;

155. Samara urban district, Kozelki, 53.307553° N, 50.306608° E, 09.VIII.2022, Author ID: microecobus;

156. Samara urban district, Kozelki, 53.307729° N, 50.306807° E, 06.VIII.2022, Author ID: microecobus;

157. Syzran district, Zaborovka, 53.2499° N, 48.2173° E, 16.VII.2022, A.B. Ruchin;

158. Togliatti district, Podstepki, 53.506735° N, 49.141704° E, 18.VIII.2021, Author ID: captainpierce;

159. Zhigulevsk urban district, 1 km E of Shiryaevo, 53.415482° N, 50.041091° E, 04.X.2020, Author ID: natanikol;

Saratov Region:

160. Petrovsk district, Krutets, 52.3818° N, 45.3365° E, 20.VIII.2020, A.B. Ruchin;

161. Petrovsk, 52.3396° N, 45.3658° E, 20.VIII.2020, A.B. Ruchin;

162. Petrovsk district, Ruzaevka, 52.3344° N, 45.4290° E, 20.VIII.2020, A.B. Ruchin;

163. Petrovsk district, Sinenkie, 52.3401° N, 45.5404° E, 20.VIII.2020, A.B. Ruchin;

164. Rtishchevo, 52.254885° N, 43.784268° E, 07. IX.2022, A. Sdobnikov;

165. Saratov, 51.543462° N, 46.049769° E, 29. IX.2021, Author ID: zikade;

166. Saratov, 51.563251° N, 46.090298° E, 08. VIII.2020, Author ID: sergejseleznev;

167. Saratov, 51.593754° N, 45.975542° E, 24.IX.2019, Author ID: dari3;

168. Stepnoye district, Pushkino, 51.23711° N, 46.938822° E, 13.VII.2019, A. Stukalina;

Stavropol Region:

169. Stavropol, 45.051484° N, 41.97065° E, 23. VIII.2020, Author ID: alexeevadi;

170. Essentukskaya district, Suvorovskaya, 44.187911° N, 42.642739° E, 15.VIII.2020, N. Gerasin;

171. Essentukskaya district, Suvorovskaya, 44.18798° N, 42.642887° E, 13.IX.2020, N. Gerasin;

172. Essentukskaya district, Suvorovskaya, 44.188019° N, 42.642871° E, 05.IX.2021, N. Gerasin;

173. Novoselitskoe district, Shchelkan, 44.879103° N, 43.454389° E, 12.VIII.2020, T. Ilyina;

174. Novoselitskoe district, Shchelkan, 44.879103° N, 43.454389° E, 14.VIII.2020, T. Ilyina;

175. Novoselitskoe district, Shchelkan, 44.879103° N, 43.454389° E, 29.VIII.2020, T. Ilyina;

Tambov Region:

176. Gavrilovka 2 district, Bessonovka, 52.840502° N, 42.78685° E, 17.VIII.2022, M. Vasilyeva;

177. Gavrilovka 2 district, Bessonovka, 52.840827° N, 42.791444° E, 28.VIII.2022, M. Vasilyeva;

178. Gavrilovka district, Peresypkino-1, 52.9453° N, 42.9043° E, 29.VII.2020, A.B. Ruchin;

179. Inzhavino district, Khoroshavka, 52.249702° N, 42.458652° E, 05.IX.2022, D. Eremenko;

180. Inzhavino district, Khoroshavka, 52.250085° N, 42.458999° E, 07.IX.2022, D. Eremenko;

181. Michurinsk, 52.893659° N, 40.49164° E, 05. VIII.2022, A. Petrov;

182. Morshansk district, Maloe Pichaevo, 53.5534° N, 41.7789° E, 10.VIII.2022, A.B. Ruchin;

183. Morshansk district, Penki, 53.5700° N, 41.7576° E, 10.VIII.2022, A.B. Ruchin;

184. Tambov, 52.712644° N, 41.472283° E, 28. VIII.2013, R. Providukhin;

185. Tambov, 52.712973° N, 41.471933° E, 02. IX.2014, R. Providukhin;

186. Tambov, 52.746621° N, 41.452687° E, 11. VIII.2021, Author ID: nadezhda_murygina;

187. Umet district, Ilyinka, 52.490889° N, 42.806846° E, 16.VIII.2021, H. Yarova;

188. Umet district, Ilyinka, 52.490956° N, 42.805427° E, 28.VIII.2021, H. Yarova;

189. Umet district, Ilyinka, 52.490989° N, 42.805411° E, 16.VIII.2021, H. Yarova;

190. Umet district, Ilyinka, 52.491066° N, 42.804967° E, 26.VIII.2021, H. Yarova;

191. Umet district, Ilyinka, 52.492439° N, 42.804352° E, 23.VIII.2019, H. Yarova;

Tula Region:

192. Kireevsk district, 1 km SE of Mostovaya, 53.824085° N, 37.931258° E, 20.IX.2022, M. Privalova;

193. Uzlovaya district, Verkhovye-Lyutorichi, 53.891282° N, 38.433268° E, 17.VIII.2021, E. Benikhanov;

194. Tula, 54.237571° N, 37.581913° E, 27.VIII.2022, M. Kharkov;

195. Tula, 54.242192° N, 37.641995° E, 01.X.2022, E. Benikhanov;

196. Tula surroundings, 54.181067° N, 37.673678° E, 23.IX.2021, I. Shcherbakov;

197. Suvorov district, Zapadnoye, 54.117958° N, 36.291522° E, 03.IX.2022, V. Romanov;

198. Tula, 54.175163° N, 37.712638° E, 25.IX.2022, E. Soldatova;

199. Tula, 54.179699° N, 37.5882° E, 01.VIII.2022, A. Evsyunin;

200. Tula, 54.242187° N, 37.642153° E, 30.VIII.2021, E. Benikhanov;

Ulyanovsk Region:

201. Barysh district, Popova Melnitsa, 53.7464° N, 47.1007° E, 29.VII.2022, A.B. Ruchin;

202. Barysh district, Rumyantsevo, 53.5185° N, 46.9887° E, 4.IX.2021, A.B. Ruchin;

203. Inza district, Chamzinka, 54.0313° N, 46.4394° E, 12.VIII.2022, A.B. Ruchin;

204. Inza district, Konoplyanka, 54.0911° N, 46.5105° E, 12.VIII.2022, A.B. Ruchin;

205. Karsun district, Ermaki, 54.1026° N, 46.5489° E, 12.VIII.2022, A.B. Ruchin;

206. Karsun district, Sosnovka, 54.1091° N, 46.6674° E, 12.VIII.2022, A.B. Ruchin;

207. Kuzovatovo district, Uvarovka, 53.6779° N, 47.7031° E, 29.VII.2022, A.B. Ruchin;

208. Nikolaevka district, Baranovka, 53.0122° N, 47.1733° E, 4.IX.2021, A.B. Ruchin;

209. Nikolaevka district, Tatarsky Saiman, 53.2470° N, 47.1097° E, 4.IX.2021, A.B. Ruchin;

210. Veshkayma district, Kargino, 53.8843° N, 47.1321° E, 29.VII.2022, A.B. Ruchin;

Volgograd Region:

211. Volgograd, 48.687705° N, 44.409392° E, 25. VII.2014, I. Pristrem;

212. Volgograd, 48.687794° N, 44.407590° E, 15. VIII.2015, I. Pristrem;

213. Volgograd, 48.692162° N, 44.385198° E, 22. VII.2014, I. Pristrem;

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Voronezh Region:

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