

Expansion of *Harmonia axyridis* (Pallas, 1773) (Coleoptera: Coccinellidae) to European part of Russia in 2018 – 2020

Alexander B. Ruchin, Leonid V. Egorov, Evgeniy A. Lobachev, Sergei V. Lukiyarov, Alexey S. Sazhnev, Gennadiy B. Semishin

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The mass reproduction of *Harmonia axyridis* (Pallas, 1773) (Coleoptera: Coccinellidae) was recorded in many Russian regions in 2018–2020. The material was collected from 13 areas of the Central Russia and the Volga region, and from one area of the Caucasus. New data on the distribution in the European part of Russia of the invasive *Harmonia axyridis* is presented. The species recorded for the first time from the Republic of Tatarstan, Nizhny Novgorod, Pskov, Kursk, Tambov, Astrakhan regions and the Chechen Republic for the first time. The ratio of morphs of the species in some localities was analyzed. Red morphs (f. *succinea* and f. *spectabilis*) apparently dominated, which can be explained by their longer lifespan. The nominative morph (f. *axyridis*) was observed for populations of *H. axyridis* from the Kursk region. Probably, the expansion of the species in European Russia has two ways: the first from the side of Western and Eastern Europe, and the second from the Caucasus.

Key words: *Harmonia axyridis*, Coleoptera, fauna, new records, color morphs.

Alexander B. Ruchin, Leonid V. Egorov, Gennadiy B. Semishin. Joint Directorate of the Mordovia State Nature Reserve and National Park «Smolny», 430005 Saransk, Russia; e-mail: ruchin.alexander@gmail.com

Leonid V. Egorov. State Nature Reserve «Prisursky», 428034 Cheboksary, Russia;

Evgeniy A. Lobachev, Sergei V. Lukiyarov. National Research Mordovia State University, 430005 Saransk, Russia;

Alexey S. Sazhnev. Papanin Institute for Biology of Inland Waters, 152742 Borok, Russia;

Alexey S. Sazhnev. Severtsov Institute of Ecology and Evolution, 117071 Moscow, Russia

INTRODUCTION

These days, the invasive species problem has become global. The invasions of many animals

and plants do pose a threat to the indigenous ecosystems' biodiversity, the sustainability of biological resources and human health (McNeely et al. 2001; Raíces et al. 2017; Dubovik et al. 2019;

Zadavec et al. 2019). *Harmonia axyridis* (Pallas, 1773) is one of the most famous invasive species of ladybirds (Coleoptera: Coccinellidae). It has attracted the attention of researchers around the world during many years. In Russia and neighboring countries, the native *H. axyridis* habitat includes Southern Siberia, Primorsky territory, Kuril and Shantar islands; Northern Kazakhstan, Mongolia, China, Japan, and Korea. Further, the species was introduced in America and Europe, where mass settlement of *H. axyridis* from Far Eastern populations were carried out to suppress aphids, coccids and cicadas. The modern habitat has become almost universal (Gordon 1985; Barševskis, 2009; Brown et al. 2011; Roy et al. 2016). Invasive populations of *H. axyridis* in the European part of Russia began to form during 2005–2006 in the Krasnodar territory (Ukrainky & Shapovalov 2010; Korotyayev 2016). The mass breeding of the species was recorded in Kaliningrad (Zakharov et al. 2011) in 2010. The first acclimatized population of the species was found in Sochi. *H. axyridis* was found in various regions in 2012 (Orlova-Bienkowskaja & Bienkowski 2017). The species was recorded in the Volga region (Samara region, Chuvash Republic and the Republic of Mordovia) in 2019 by Egorov et al. (2019a).

This species was recorded for Belgorod region by Binkovskaya (2004). In the present days, *H. axyridis* is widely distributed through the European Russia, and it is known from the Belgorod, Bryansk, Kaliningrad, Kaluga, Lipetsk, Moscow, Penza, Rostov-on-Don, Samara, Saratov, Voronezh and Ulyanovsk regions, Krasnodar and Stavropol territories, Adygea, Chuvash, Dagestan, Kabardino-Balkaria, North Ossetia, Crimea, Mordovia and the Bashkir Republics (Khabibullin et al. 2009; Ukrainky & Shapovalov 2010; Zakharov et al. 2011; Alekseev et al. 2012; Ukrainky 2013; Orlova-Bienkowskaja 2014; Ukrainky & Orlova-Bienkowskaja 2014; Kruglova et al. 2015; Orlova-Bienkowskaja & Mogilevich 2016; Emets 2018; Anikin 2019; Egorov et al. 2019a; author's data).

MATERIAL AND METHODS

The material on *H. axyridis* was collected from various regions of the European part of Russia in 2018–2020. The part of the observations was made thanks to the online project www.inaturalist.org. Names of morphs are given according to Andrianov et al. (2018). The photographs of the habitus of the species were taken by a Samsung ST96 camera and Acer Liquid Z630 smartphone with using the Open Camera program. The studied material is partially deposited in collections of Mordovia State Nature Reserve (Pushta settlement), Mordovia State University (Saransk) and Institute for Biology of Inland Waters (Borok settlement). Map was created in SimpleMappr online service (www.simplemappr.net).

RESULTS

Below, there is a list of records of *H. axyridis* with data on the locality, biotope (if possible), quantity of collected specimens, names of morphs and collectors. New records of *H. axyridis* from the European Russia in 2018–2020 are shown on the map (Fig. 1).

2018

Kaluga region: Kaluga, Vishnevskogo str., 54.5334°N, 36.1679°E, X.2018, 1 ind. (f. *succinea*), Maryutin V.G.

Penza region: Neverkinsky district, Bikmurzino vill., 52.7825°N, 46.8039°E, 5–10.VII.2018, 10 ind. (6 – f. *succinea*, 4 – f. *conspicua*), Polumordvinov O.A.

Volgograd region: Dubovskiy district, Gorny Bylykley vill., Tolstaya balka, 49.5506°N, 45.0672°E, on the UV-light, 14–15.IX.2018, 1 ind. (f. *succinea*), Anikin V.V.

2019

Astrakhan region: Astrakhan, city center, near the city Kremlin, 46.3492°N, 48.0293°E, 10.IV.2019, 1 ind., Ruchin A.B.

Kaluga region: Yukhnovskiy district, Malye Ustyia vill., 1.XI.2019, 54.8925°N,

34.9998°E, 8 ind. (6 – f. *succinea*, 2 – f. *conspicua*), Goncharova O.

Kursk region: Zheleznogorsky district, vic. Zheleznogorsk, 52.3166°N, 35.3802°E, 10.VI.2019, 1 ind. (f. *succinea*), Degtyarev N.I.; same locality, 14.VI.2019, 1 ind. (f. *succinea*), Degtyarev N.I.; same district, vic. Ostapovo vill., 52.3234°N, 35.497°E, 18.VI.2019, 1 ind. (f. *spectabilis*), Ryzhkov O.; same locality, 19.VI.2019, 3 ind.s (f. *succinea*), Ryzhkov O.; Kursky district, Selikhovy Dvory vill., 51.5758°N, 36.0838°E, 14.VII.2019, 1 ind. (f. *succinea*), Degtyarev N.I.; Gorshechensky district, Kunye vill., 51.3905°N, 37.6413°E, 21.VII.2019, 1 ind. (f. *succinea*), Sklyar E.; Oboyansky district, Bobryshevo vill., 51.1869°N, 36.3775°E, 23.VII.2019, 1 ind. (f. *succinea*) Degtyarev N.I.; Kurchatovsky district, vic. Kurchatov, Kursk Reservoir, 51.678°N, 35.6395°E, 24.VII.2019, Degtyarev N.I.; Zheleznogorsky district, vic. Mikhaylovka vill., 52.2264°N, 35.4175°E, 9.VIII.2019, 1 ind. (f. *succinea*), Ryzhkov O.; same district, Khlynino vill., 52.2420°N, 35.4777°E, 28.IX.2019, 1 ind. (f. *succinea*), Sklyar E.; Dmitrievsky district, Dmitriev-Lgovsky city, 52.1311°N, 35.0921°E, 10.VIII.2019, 1 ind. (f. *succinea*), Ivlev K.S.; Kursky district, 1st Kurasovo vill., 51.9006°N, 36.1454°E, 10.VIII.2019, 1 ind. (f. *succinea*), unknown collector; same district, vic. Zapovedny vill., 51.5683°N, 36.0853°E, 4.V.2019, 1 ind. (f. *succinea*), 16.VI.2019, 1 ind. (f. *succinea*), 29.VI.2019, 2 ind.s (f. *succinea* & f. *conspicua*), 30.VI.2019, 1 ind. (f. *axyridis*), 13.X.2019, 1 ind. (f. *succinea*), 19.X.2019, 52 ind.s (47 – f. *succinea*, 1 – f. *conspicua*, 3 – f. *spectabilis*, 1 – f. *axyridis*) Degtyarev N.I., Ryzhkov O.

Republic of Mordovia: Saransk, 12–15.X.2019, 17.X.2019, 18.X.2019, 21.X.2019, 112 ind.; environs of Saransk, Yalga, 54.1265°N, 45.1240°E, 16.X.2019, 24 ind.s; Zubovo Polyana district, Zhukovka vill., 53.8771°N, 42.7207°E, 27.X.2019, 1 ind., Lobachev E.A.; Ichalki district, National Park «Smolny», Kemlaynskoe forestry, quarter 93, 54.7394°N, 45.3831°E, 21–22.VIII.2019, at the sanatorium «Alatyr», at the light, 3 ind., Semishin G.B.; Temnikov district, Mordovia State Nature Reserve, Pushta settlement, 54.7193°N, 43.2243°E, 15.VIII.2019, 16.VIII.2019, at the light,

2 ind., Semishin G.B.; same data, Pushta settlement, 28.X.2019, 5.XI.2019, 2 ind., Ruchin A.B.

Nizhny Novgorod region: Pochinki district, Baikovo vill., 54.7767°N, 44.8549°E, 20.X.2019, 18 ind., Lobachev E.A.

Pskov region: Pustoshkinsky district, Pustoshka vill., 56.3388°N, 29.3563°E, 1 ind. (f. *succinea*), unknown collector.

Samara region: Stavropolsky district, Togliatti, 53.5092°N, 49.4503°E, 8.X.2019, 2 ind. (f. *spectabilis*), Tretyakova D.V.

Saratov region: Saratov, B. Sadovaya, str., 51.5217°N, 45.9837°E, apartment, on the UV-light, 6–13.VIII.2019 3 ind.s (f. *succinea*), Anikin V.V.; same locality, 2–6.IX.2019, 5 ind.s (3 – f. *succinea*, 2 – f. *conspicua*), Anikin V.V.; Lysogorsky district, Beloye Ozero vill., flood plain of Medveditsa R., 51.2469°N, 45.0077°E, h=139 m, UV-light, 15–18.VII.2019, 7 ind.s (3 – f. *succinea*, 4 – f. *conspicua*), Anikin V.V.; Saratovsky district, Raslovka-2 vill., 51.7777°N, 46.2339°E, holiday village, in the garden, at day, 13.IX.2019, 4 ind.s (f. *succinea*), Sinichkina O.V.; same district, Pristannoe vill., 51.5967°N, 46.1980°E, 13.IX.2019, 1 ind. (f. *conspicua*), unknown collector. Saratov, 51.5821°N, 45.9397°E, 13.IX.2019, 1 ind. (f. *succinea*), unknown collector. Tatishchevsky district, vic. Shirokoye vill., 51.7254°N, 45.7380°E, 6.X.2019, 1 ind. (f. *succinea*), unknown collector; Khvalynsky district, Khvalynsk vic., facility of Saratov State University, 52.4861°N, 48.0439°E, UV-light, 19.X.019, 25 ind.s (13 – f. *succinea*, 10 – f. *conspicua*, 2 – f. *spectabilis*), Anikin V.V.

Tambov region: Kirsanovsky district, Ilyinka vill., 52.4917°N, 42.8072°E, 24.VIII.2019, 3 ind. (f. *conspicua*), Yarova E.

Republic of Tatarstan: Kazan, 55.85554°N, 49.075767°E, 30.IX.2019, 1 ind. (larva), Kutuzova N.; Zelenodolsk district, Volzhskokamsky State Biosphere Reserve, Sadovyi settlement, 55.9076°N, 48.7446°E, 25.X.2019, 1 ind., Ruchin A.B.

Ulyanovsk region: Nikolaevsky district, chalk carrier by Kuroedovo vill., 53.0833°N, 47.3833°E, 25.VII.2019, 3 ind. (f. *succinea*), Volkova Ju.V., Zolotuhin V.V.

Volgograd region: Volgograd, 48.8197°N, 44.6446°E, 10.VIII.2019, 1 ind. (f.

succinea), Ivanov D.

2020

Kursk region: Zheleznogorsky district, vic. Zheleznogorsk, 52.3341°N, 35.3492°E, 21.II.2020, 1 ind. (f. *succinea*), Degtyarev N.I.; same locality, 12.III.2020, 1 ind. (f. *succinea*), Degtyarev N.I.; Kursky district, vic. Zapovedny vill., 51.5683°N, 36.0853°E, 16.II.2020, 1 ind. (f. *spectabilis*), 20.II.2020, 1 ind. (f. *spectabilis*), Degtyarev N.I., Ryzhkov O.

Republic of Mordovia: Temnikov district, Mordovia State Nature Reserve, Pushta settlement, 54.7193°N, 43.2243°E, 3.III.2020, one overwintered ind. in the apartment (f. *succinea*), Ruchin A.B.

Additional material

Chechen Republic: Groznensky district, Raduzhnoe vill., 43.4061°N, 45.4321°E, 9.XI.2019, 1 ind. (f. *succinea*), Saparbaeva L. (www.inaturalist.org).

DISCUSSION

In the present study, *H. axyridis* is recorded from the Astrakhan, Pskov, Kursk, Tambov, Nizhny Novgorod regions, Republic of Tatarstan and Chechen Republic for the first time. Tatarstan is the most eastern point of the species detection in the European part of Russia. This species was not found in Saratov, Samara, Ulyanovsk, Penza regions, and Republic of Mordovia until 2019 (Egorov et al. 2019b; Ruchin et al. 2019, present data). A significant amount of material was registered for Saransk (Republic of Mordovia). In 2019, this species was collected not only within boundaries of cities and other settlements, but also far beyond of them. We indicated it for three protected natural territories of federal significance: Mordovia State Nature Reserve, Volzhsko-Kamsky State Biosphere Reserve and National

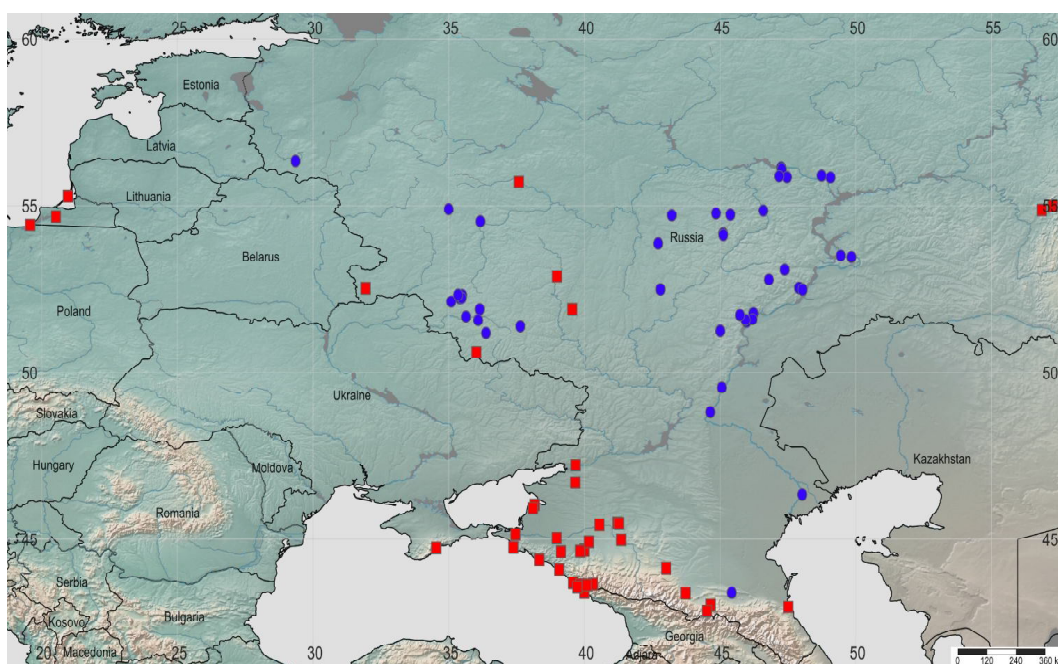


Fig. 1. Records of *Harmonia axyridis* from European Russia in 2018–2020. Red squares: new records from European part of Russia (f. *succinea*, f. *conspicua* and f. *spectabilis*). Blue squares: populations from Kursk region (f. *axyridis*). Dotted line: the species range until 2019.

Park «Smolny». These places are far from large settlements.

The temperature conditions of the Central Europe allow *H. axyridis* to multiply thrice during the growing season. The adult population consists mainly of overwintered individuals. The warm spring allows overwintered adults to start breeding in late April, the first generation then breeds in late June, the second breeds in late

July, and the third in early September (Adriaens et al., 2008; Honik et al. 2018a). We found the mass aggregation of *H. axyridis* in late summer and autumn. However, imagines was registered for Astrakhan in mid-April. Apparently, adults overwinter in the southern regions of Russia, as well as in the central Europe. However, we cannot say what exact number of generation of this species in 2019. This is because life of adults of *H. axyridis* is long, beetles of all generations born

Table 1. The ratio of morphs of *Harmonia axyridis* in abundance (in %) in the studied localities according to 2019 research data

Morph name	Nizhny Novgorod Region (Baikovo)	Republic of Mordovia (environs of Saransk, Yalga)	Republic of Mordovia (Saransk)	Average
<i>f. succinea</i>	88,9	95,8	94,6	93,1
<i>f. conspicua</i>	0	0	0,9	0,3
<i>f. spectabilis</i>	11,1	4,2	4,5	6,6
Number of samples	18	24	112	154

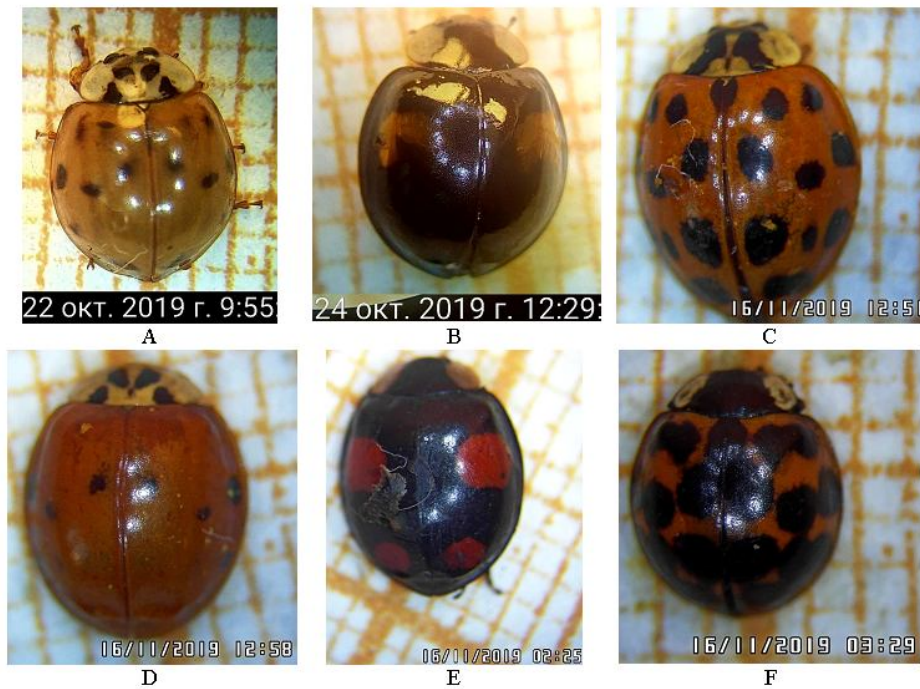


Fig. 2. The main color morphs: A – *f. succinea* (Saransk); B – *f. conspicua* (Saransk); C – *f. succinea* (Baikovo); D – *f. succinea* (Baikovo); E – *f. spectabilis* (Yalga); F – *f. succinea* (Yalga).

during the growing season and can survive until autumn and overwinter (Honik et al. 2019). Records in spring 2020 confirm that beetles can wintered in the central part of Russia.

Factors affecting the local distribution of *H. axyridis* are not reliably known. It is suggested that the urbanization degree, the number of predators and potential victims may have a certain effect (Honik et al. 2018b). There are several reasons for the mass appearance of *H. axyridis* in various regions of the Volga region, such as an abnormally warm spring in 2019 in the Middle Volga region and a long growing season with a warm first two months of autumn. Mass reproduction was recorded earlier in Russia in some years (Zakharov et al. 2011; Orlova-Benkovskaya 2014; Korotyaev, 2015).

Harmonia axyridis is a very polymorphic species with variations in the coloration patterns within a fairly broad range. It has long been an object of geneticists' study (Balueva 2010; Brown et al. 2011; Andrianov et al. 2018). We managed to collect data on the ratio of morphs of the species in some localities (Table 1, Fig. 2).

The table 1 shows that *f. succinea* dominates in all localities. *H. axyridis f. succinea* were recorded (1 ind.) for Tatarstan (Volga-Kama Reserve) and Astrakhan Region (1 ind.); in the Mordovia Nature State Reserve – *f. spectabilis* (4 ind.), in National Park «Smolny» – *f. spectabilis* (3 ind.). It is known that non-melanic morphs have higher food plasticity and more competitive (Berkvens et al., 2008). Several authors observed differences in the life expectancy of adults between some morphs of this species (Serpa et al. 2003). It was found that the red morph (*f. aulica*) has longer lifespan compared to the black morph. There are several explanations, one of them is thermal melanism. It suggests that dark insects heat up faster during insolation and reach a higher equilibrium temperature. This leads to a higher level of activity and reproductive advantage, but at the same time to a lower life expectancy (Serpa et al. 2003). Our results showed the possible domi-

nation of the red morph, which can be explained by their longer lifespan.

Apparently, the settlement of the European part of Russia is a spontaneous expansion of the species' range both from the West, which is confirmed by the findings of *f. axyridis* in the Kursk region, such morphs were previously known only from Western Europe (Brown et al. 2008), and from the south of Russia, where the «strong point» represented by local populations of *H. axyridis* introduced to the Caucasus (Ukrainsky 2013) play a significant role in the colonization of the species (primarily in the Volga region) (Orlova-Bienkowskaja 2014). Thus, the populations of *H. axyridis* that participate in the expansion of the species in the European part of Russia are probably of a mixed nature and originate from the Western and Eastern native clusters (Lombaert et al. 2014), however, finds in Republic of Bashkiria (Khabibullin et al., 2009; authors data) and in the West Kazakhstan (Aksay) indicate that native and invasive subareals may soon merge.

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