

European area dynamics of *Eilicrinia cordiaria cordiaria* (HÜBNER, [1790]) (Lepidoptera: Geometridae, Ennominae) under the present climate change

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Abstract: Recent records of the geometrid moth *Eilicrinia cordiaria* (HÜBNER, [1790]) in Europe and particularly in Belarus are provided as well as summarized data about the biology of the species. The data suggest that more favorable conditions for development of *E. cordiaria* in Polesye region were formed during the last two decades. The changes observed include desiccation of floodplain ecosystems in Polesye due to quick and significant rising of annual average temperature, however, the levels of precipitation remained equal to perennial limits. Obtained data suggest that *E. cordiaria* could be significantly more widespread in Europe.

Key words: Lepidoptera, Geometridae, *Eilicrinia*, Europe, Belarus, climate change.

Arealdynamik von *Eilicrinia cordiaria cordiaria* (HÜBNER, [1790]) (Lepidoptera: Geometridae) unter den aktuellen Bedingungen des Klimawechsels

Zusammenfassung: Es werden Angaben zu aktuellen Funden des Spanners *Eilicrinia cordiaria* (HÜBNER, [1790]) in Europa und speziell in Weißrußland sowie eine Übersicht der Biologie der Art gegeben. Die Daten weisen darauf hin, daß sich die Entwicklungsbedingungen für die Art in der Region Polesien während der letzten beiden Jahrzehnte verbessert haben. Die Veränderungen umfassen die Austrocknung der dortigen Flußniederungs-Ökosysteme auf Grund des schnellen und signifikanten Anstiegs der durchschnittlichen Jahrestemperatur bei gleichbleibenden Jahresniederschlagsmengen. Die erhobenen Daten deuten an, daß *E. cordiaria* in Europa deutlich weiter verbreitet sein könnte als derzeit bekannt.

Динамика ареала *Eilicrinia cordiaria cordiaria* (HÜBNER, [1790]) (Lepidoptera: Geometridae) в условиях современных климатических изменений

Резюме: Приведены сведения о новых находках пяденицы *Eilicrinia cordiaria* в Европе, в частности, в Беларуси. Обобщены данные о биологии данного вида. Предположено, что более благоприятные условия для развития *Ei. cordiaria* в Полесском регионе возникли в течение последних двух десятилетий. Этому способствовало некоторое иссушение пойменных экосистем Полесья по причине стремительного и значительного повышения среднегодовых температур на фоне выпадения осадков в пределах многолетней нормы. Дан детальный прогноз ожидаемых находок вида в Центральной Европе. Полученные сведения позволяют предположить гораздо более широкое распространение *Ei. cordiaria* в Европе.

Introduction

The geometrid moths of the genus *Eilicrinia* HÜBNER, 1823 are mostly distributed in the Palaearctic and Oriental regions and include ten described species (SKOU

& SIHVONEN 2015). Only one species — *Eilicrinia ursula* THIERRY-MIEG, 1910 — is known from the Neotropic region (Bolivia) (SMITHSONIAN DATABASE 2017). Across Europe there are three species of the genus, *Eilicrinia cordiaria* (HÜBNER, [1790]) being the most widely distributed among them (Fig. 1).

Within the boundaries of the area which comprises the western part of the Palaearctic, a second subspecies, *E. cordiaria signigera* (BUTLER, 1889), was established. In Europe, the nominotypical subspecies is known from northeast Austria close to the border to Hungary, from the southern part of Slovakia, from Hungary, eastern, southern and western parts of Romania, virtually from the entire Balkan Peninsula (apart from the majority of countries situated near the western seaside of the Adriatic Sea), from Ukraine (mostly east of the Dnieper) and from the south of Russia (including the Crimea). Outside of Europe the nominotypical subspecies was recorded in the Southern Urals and Central Asia (Kazakhstan, Uzbekistan, western Kyrgyzstan). Along the known distribution area border or beyond it, the nominotypical subspecies was recorded in vicinity to Iasi in the northeast of Romania (MANCI et al. 2015), in the extreme Northeast (national Park Kopački Rit, HORVATÍĆ 2002) and in the extreme Southwest of Croatia (P. SKOU, personal message).

The subspecies *E. c. signigera* lives in the Caucasus (eastern part of Georgia, Dagestan, extreme south of North Ossetia, Zakinskoye canyon), in Transcaucasus (Armenia, West Azerbaijan), in many regions in Turkey (Asia minor) and in the northern part of Iran (VIIDALEPP 1996, SKOU & SIHVONEN 2015).

On the territory of Ukraine until quite recently this species was known from all physiographic regions except for Polesye (KOSTJUK 2004). The first reports about findings of *E. cordiaria* on the territory of Ukrainian Polesye date back to the last two decades:

- Chernigov province, Nezhinsky dist., near village Vertievka, 1. VII. 2014, P. SHESHURAK (personal report);
- Chernigov province, Prilucki dist., near village Perevolchnaya, VIII. 2005, E. KONAХ (collection of Nikolay Gogol Nezhinsky State University);
- Kiev, 7. VII. 1997;
- Kiev province, Vyshgorodski dist., village Voropaev, 11. VII. 2009;
- Kiev province, Makarovski dist., village Kopylov, 9. V. 2013 and 13.–14. VII. 2016, last 3 localities V. SERGIENKO (personal report).

In 2014–2015 *E. cordiaria* was recorded from the territory of Belarus. Three places were tightly situated in the vicinity of town Mozyr, one was at some distance to southeast, two were in the south-east of town Rechica, one was to the south from Gomel and one was to the north from town Loev (Fig. 2).

Methods and material

The specimens were collected at night with help of light from different lamps with power 250 W (fluorescent-mercury lamp, mixed light lamp, metal halide lamp) which were set in front of fabric screen for insects' collection. As source of electricity a Honda generator was used.

The collected moths are stored in collection of State Scientific and Production Amalgamation "The Scientific and Practical Center for Bioresources" (Minsk, Belarus).

- Gomel province, Mozyrski dist., 14 km SO Mozyr, N 51°54'32.50" N, 29°20'16.50" E, on the border of waste ground with xerophytic plants and pine and birch stand, using light, 18. VII. 2014, 1 specimen (A. KULAK, Ye. DERZHINSKY);
- Gomel province, Mozyr, N 52°2'55" N, 29°17'2" E, flooded shrubby meadow on the left brink of river Pripyat, using light, 19. VII. 2014, 1 specimen (A. KULAK, Ye. DERZHINSKY);
- Gomel province, Kalinkovichski dist., 6,5 km W Kalinkovichi, 1,3 km W village Rudhya Gorbovichskaya, 52°7'31" N, 29°11'16" E, mosaic of shrubby (willows) dry and flooded meadows, separated forest stand with thinned flooded oak forest and dry pine forest, using light, 20. VII. 2014, 2 specimens (A. KULAK, Ye. DERZHINSKY);
- Gomel province, Loevski dist., village Pervomajsk, 52°3'33" N, 30°45'25" E, dry meadow on the edge of village, using light, 24. VII. 2014, 4 specimens (A. KULAK, Ye. DERZHINSKY);
- Gomel province, Rechicki dist., 22,5 km SO Rechica, 0,9 km O village Dvorec, 52°10'23" N, 30°37'2" E,

shrubby (willows) meadow with small groups of oaks at the left bank of Dnieper, using light, 14. v. 2015, 6 specimens (A. KULAK, Ye. DERZHINSKY);

- Gomel province, Mozyr, house doorway, using light, 16. v. 2015, 1 specimen (Ye. RUDZKO);
- Gomel province, Gomel dist., 4,5 km SW village Chenki, 52°19'9" N, 30°56'17" E, flooded oak forest on sandy ridge near Sozh, using light, 19. v. 2015, 1 specimen (Ye. DERZHINSKY).

Results and discussion

In Europe, *E. cordiaria* mostly expands through deciduous forests zones, forest-steppe and steppe. It primarily inhabits lowland meadows along rivers and woodland belts (SKOU & SIHVONEN 2015), occasionally it is characterized as mesophilous (POLTAVSKY et al. 2007). On the territory of Belarus all findings of this geometrid species were along the rivers Dnieper, Pripyat and Sozh (Fig. 2) and generally located in valleys (Figs. 3, 4) or adjacent biotopes. One exception was a specimen found 14 km SE from Mozyr in a biotope with xerophytic vegetation, 7.5 km from river Pripyat (Fig. 5).

In all cases the habitats include certain willow species (*Salix cinerea* L., *S. alba* L., *S. myrsinifolia* SALISB., *S. acutifolia* WILLD., *S. triandra* L.), on which larvae are likely to develop (according to available literature data plants of genus *Salix* L. without further specification are considered to be foodplants). B. MÜLLER managed to rear larvae on the Asian invasive plant *Salix matsudana* KOIDZ. (SKOU & SIHVONEN 2015).

Insufficient knowledge of larval instars of *E. cordiaria* is due to difficulties of breeding this species which was profoundly described in F. CERVA's work (CERVA 1907). Based on the obstacles observed by this experienced entomologist it could be concluded that low air humidity and additional imago feeding are crucial for this species.

E. cordiaria is a bivoltine species. In the south of Europe the first generation usually occurs as early as the middle of April (Romania, Rostov-on-Don). North of there, for example in the southern part of Slovakia and major parts of Ukraine, adults' flight starts from the first days to the middle of May. Flight of the first generation usually ends by the end of May to beginning of June. On the most part of the area the first individuals of the second generation emerge at the beginning of July and keep flying until the end of July to beginning of August.

Moreover, depending on the weather conditions, there were observed outliers, and occasional early or late individuals could be recorded, especially at places where the species occurs more frequently: for example, in the beginning of April in Bulgaria; on 9. VIII. outside Kiev ("PG18" 2008; D. BORISYUK, personal message), in the end of August in Romania (SKOU & SIHVONEN 2015) and in Hungary (SZALKAY 2017), and from the middle of April to the end of July in the European South of Russia (POLTAVSKY et al. 2007).

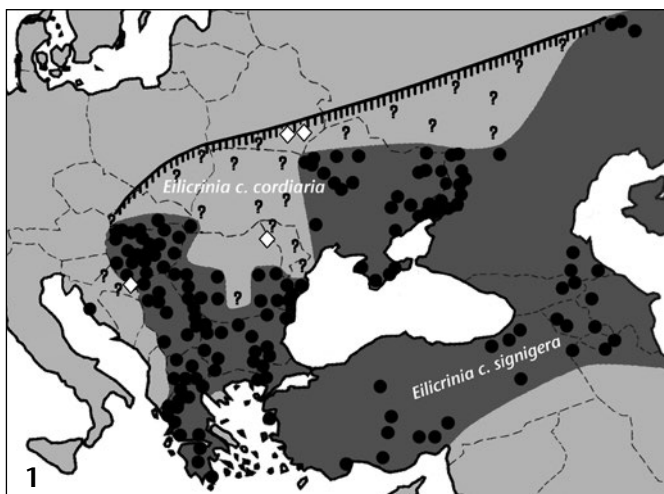


Fig. 1: Expansion of *Ellicrinia cordiaria* in Europe (dark gray filling and black dot = according to SKOU & SIHVONEN 2015; white rhombus = new findings which were not included into the mentioned monography; cogged line = the part of the predicted northern border line of the species' distribution; question marks = predicted potential record spots).

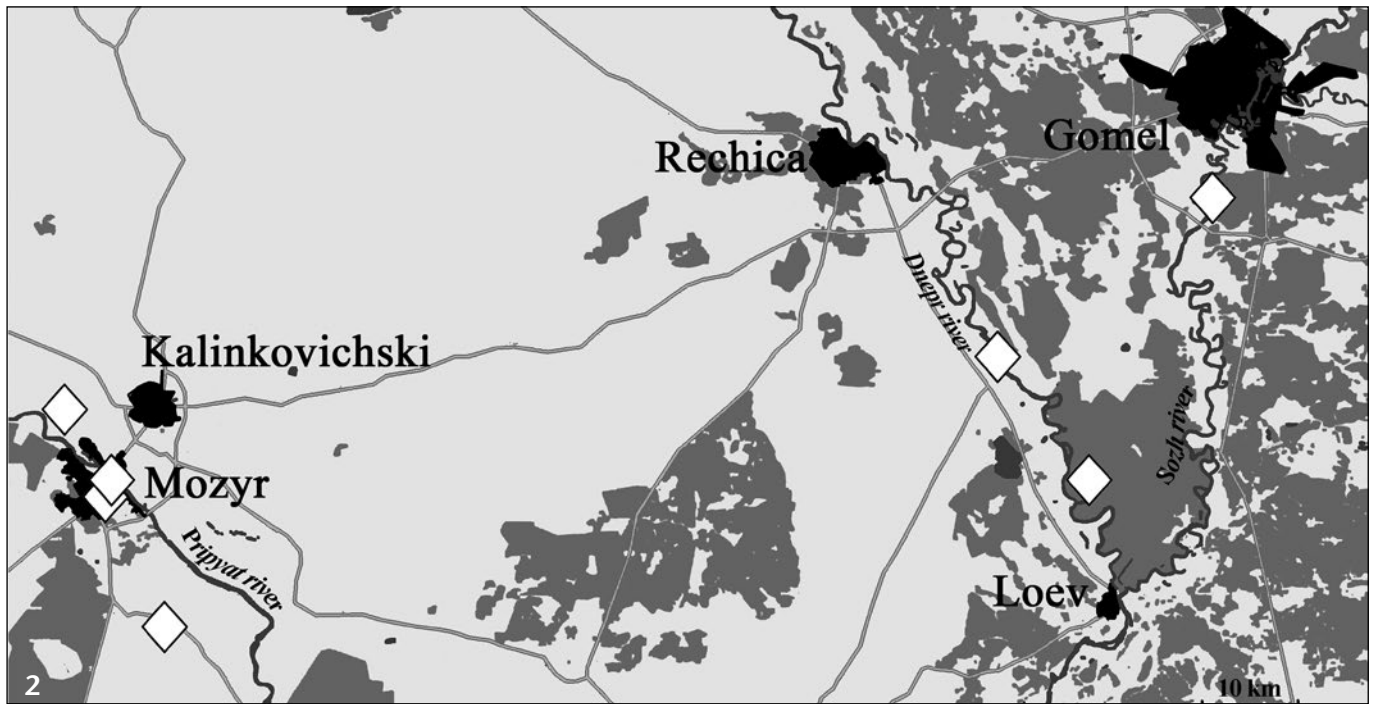


Fig. 2: Collection sites of *Ellicrinia cordiaria* on the territory of Belarus.

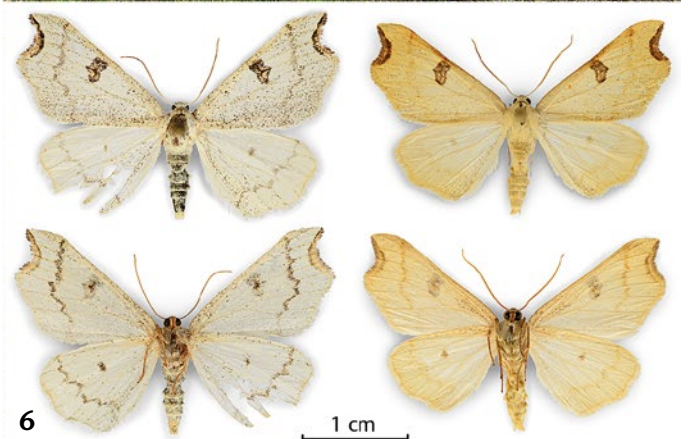


Fig. 3: The habitat of *Ellicrinia cordiaria* in Kalinkovichski district (52°3'11" N, 29°16'14" E). Fig. 4: The habitat of *Ellicrinia cordiaria* in Rechicki district (52°10'23" N, 30°37'2" E). Fig. 5: The habitat of *Ellicrinia cordiaria* in Mozyrski district (51°54'32.50" N, 29°20'16.50" E). Fig. 6: Imago *Ellicrinia c. cordiaria* from spring (left) and summer (right) generations (top upperside, bottom underside) in Belarus.

Larvae of *E. cordiaria* develop very fast (approximately 3 weeks according to CERVA 1907). Thus, it could be expected that specimens found in August may belong to a 3rd generation. The outlying records of *E. cordiaria* from the Urals stating that it flies in June to beginning of July ([URAL MOTHS] 2017) and therefore was considered as monovoltine species, are more likely based on singular findings and do not accurately reflect the species' phe-

nology. Recent findings in the end of July in vicinity of Mugodzhzar Hills confirm this statement ("PG18" 2008).

All records of *E. cordiaria* in Belarus entirely follow the standard phenology for this species in Europe. We recorded the first generation in three sites in May 14.–19. It is worth mentioning that 6 individuals were collected in Rechicki dist. during 1.5 hours at night of 14. v. 2015 under

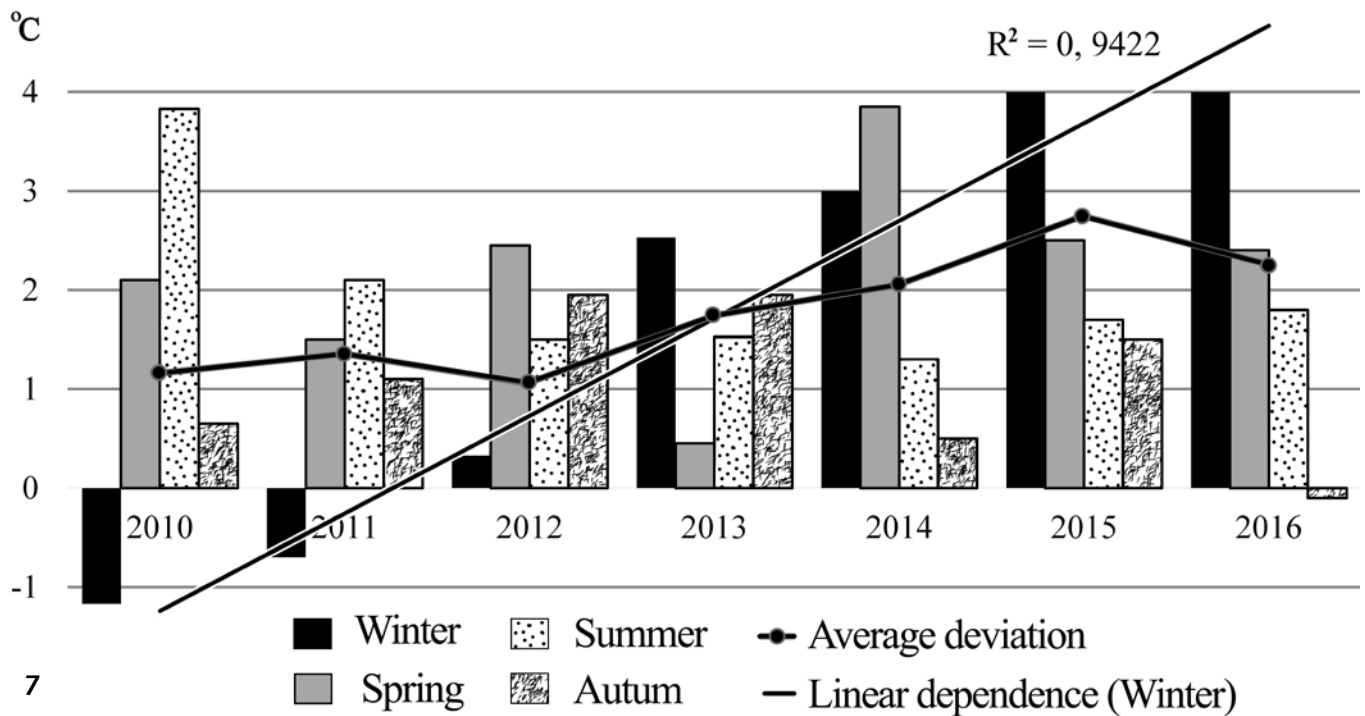


Fig. 7: Annual average air temperature deviations from long-term averages for the four seasons during 2010–2016 in Belarus.

extremely unfavorable conditions (cold night, strong wind and rain). By that moment, all of them had wings with varying degree of damage. Therefore, *E. cordiaria* is a common species for this territory and more likely starts its flight during the first decade of May. Second generation was found in 4 sites 18.–24. VII. (max 4 specimens per night). Moths collected at the end of the second decade of July were in ideal state and occur at a frequency of only 1–2 individuals per night. Thus, the beginning of flight of the second generation in Belarus starts approximately in the middle of July or some days earlier.

E. cordiaria is characterized by seasonal dimorphism, so, in general, individuals of first and second generations could be easily distinguished (Fig. 6). The wings' background of summer generation individuals is light yellow, the external band is barely visible. Spring generation is characterized by off-white background with plenty of dark scales. In comparison to summer generation, the bands are more pronounced. Hibernation of the species is at pupal stage. The imago flies at night and can be easily attracted by light.

It is worth mentioning that the Belarusian part of Polesye region was one of the best-studied regions in terms of lepidopterans. Highly extensive studies, including Geometridae, were conducted there during 1960s and later (KULAK 2000, 2015, DERZHINSKY & KULAK 2015 etc.). Several collecting expeditions were organized close to our *E. cordiaria* record sites near Mozyr. Therefore, it is possible that during recent decades the favorable environment was formed for expansion of this species to the north and/or for increasing in its numbers.

Expansion of *E. cordiaria* is promoted not only by average annual temperature increase but also by dessication

of swampy parts of floodlands that are hardly suitable for this species. Primarily this happens because of lesser flooding of floodplains by spring overflow water due to poor snow accumulation by springtime. It is very common for Polesye nowadays. According to the data of The Center of Hydrometeorology, Radioactive Contamination Control and Environmental Monitoring of the Republic of Belarus the peak levels of spring flood decreased on average by 17–148 cm for rivers of Dnieper basin and by 7–60 cm for rivers of Pripet basin during the warming period (i.e. since 1989, POGODA.BY 2016). Considering rising of average annual temperature during this period by 22.4% (from 5.8°C to 7.1°C), in particular during the last years this index increased by 29.3% in 2013, 34.5% in 2014, 46.6% in 2015 and 37.9% in 2016 (Fig. 7) while average annual precipitation almost did not change, that gradual dessication for the whole territory of the country is obvious which promotes improvement of conditions for developing of this species in the floodplains of Polesye.

Distribution of known habitats in Europe with regards to findings in Belarus suggested that *E. cordiaria* should also occur almost throughout all northern, central and southern Ukraine, in Moldova (along rivers Dnestr and Prut), over considerably greater part of Russia (Bryansk, Kursky, Belgorod and other regions of the northwest Ukraine). It is quite possible that absence of the data from the aforementioned territories is due to insufficient amount of studies devoted to nocturnal species of lepidopterans. Along the Danube and its tributaries, the species is likely to spread into the utmost Southeast of the Czech Republic and even the utmost Northeast of Austria. Considering recent findings of the species in Croatia it could be more widespread in this country, as

well as along the valley of river Sava in Bosnia and Herzegovina.

However, it should be taken into account that according to published data (SKOU & SIHVONEN 2015), the subspecies *E. c. cordiaria* in contrast to *E. c. signigera* does not spread to the mountains higher than 800 m. This fact explains the absence of the species in the West Carpathians and the Tatra in northern parts of Slovakia, its distribution area goes around (from the south) the mountains in the southeast of Poland as well as the West and East Carpathians in Romania.

It is likely that Polesye district will be actively inhabited by this species. Back in 1966 S. BŁESZYŃSKI suggested that *E. cordiaria* could be found in steppe biotopes in the south of Poland (BŁESZYŃSKI 1966), but it still has not been detected there. Based upon numerous findings of the species in Europe its spreading is not determined by the presence of xerophytic vegetation characteristic for steppe or forest-steppe but it is rather bound to river valleys. Taking into account the new findings of the species from Belarus, which also were located along river valleys, it could be expected that this species will appear in the southeast of Poland along valleys of Bug and Dniester tributaries.

According to data summary (SKOU & SIHVONEN 2015), *E. cordiaria* occurs locally in Europe and in many collecting sites it was recorded only occasionally. For example, this species is rare in the vicinity of Bucharest (Romania) (SZEKELY 2011), in Southern Urals ([URAL MOTHS] 2017) and even included into the red book of the Dnipropetrovsk region of Ukraine (GODLEVSKA et al. 2010). Simultaneously in many other places, for instance in Kiev region in Ukraine ("PG18" 2008, V. SERGIENKO – personal message) or in the Rostov region in Russia (POLTAVSKY et al. 2007) it is a very common species which sometimes could be found even in cities (for example, in Galați, Romania (CRISTESCU 2016), in Mozyr, etc.

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