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Review of the genus *Hippodamia* (Coleoptera: Coccinellidae) in the Palearctic region

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ABSTRACT

Hippodamia Chevrolat, 1836 currently comprises 19 species. Four species of *Hippodamia* are native to the Palearctic region: *Hippodamia arctica* (Schneider, 1792), *H. septemmaculata* (DeGeer, 1775), *H. tredecimpunctata* (Linnaeus, 1758), and *H. variegata* (Goeze, 1777). Here, we provide an identification key to these species, along with illustrations of morphological characters.

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Coccinellidae; dichotomous key; faunistic review; ladybirds; old world

Introduction

Ladybirds in the genus *Hippodamia* Dejean, 1837 (Coleoptera, Coccinellidae) are easily recognised by their tarsal claws that are typically cleft, unlike in other genera (Gordon 1985; Nedvěd 2015). The number of currently accepted species worldwide is 19, left aside the genus *Ceratomegilla* Crotch, 1873. Seventeen species occur in the Nearctic region (Gordon 1985) and four in the Palearctic region (Iablokoff-Khnzorian 1982). A revision of the genus was proposed by Chapin (1946).

Hippodamia has a complicated taxonomic history. It was described by Chevrolat (1836) to accommodate *Coccinella mutabilis* Scriba, 1791. This name is a junior synonym of *Coccinella variegata* Goeze, 1777. Later, Mulsant (1846) erected another genus, *Adonia*, for *C. mutabilis*. Although the name *Adonia variegata* was widely used until the end of the twentieth century, *Adonia* was then abandoned as a junior synonym. The valid name should be *H. (Hippodamia) variegata*. Meanwhile, *Coccinella quinque-signata* Kirby, 1837, a North American species, was transferred to the genus *Hemisphaerica* Hope, 1840 (Hope 1840). A type species was not stated

in the original description of *Hippodamia* (Chevrolat 1836) and it was Crotch (1874) who designated *H. tredecimpunctata* as the type.

The genus *Adonia* was separated from *Hippodamia* and *Hemisphaerica* by the following characters (Brown and De Ruelle 1962): bearing a postcoxal line on the first abdominal sternite, margined base of the pronotum, and strongly dilated first tarsomeres of front and middle legs of males. Although these features were used for distinguishing among these genera, they were not relevant for species of North America. For example, the Holarctic species *Hippodamia arctica* (Schneider, 1792), which had been placed by some authors in the genus *Adonia*, possesses the postcoxal line on the first abdominal sternite, but the pronotal base is not margined and the male tarsi are only scarcely dilated.

Subsequently, Belicek (1976) considered the genus *Adonia* to be a junior synonym of the genus *Hippodamia*, which was later confirmed by Gordon (1985). However, Iablokoff-Khnzorian (1982) considered the genus *Adonia* to be a subgenus of *Hippodamia*. More recently, Kovář (2007) divided the genus *Hippodamia* into two subgenera: *Hemisphaerica* Hope, 1840 and *Hippodamia* Chevrolat, 1836 and considered the name *Adonia* as a synonym of subgenus *Hippodamia*. The biology and distribution of the Palearctic species were reviewed by Nikitsky and Ukrainsky (2016) and Nepaeva et al. (2017).

In the current paper, we update the information on the species of *Hippodamia* in the Palearctic region. Moreover, an identification key to the Palearctic species of the genus is presented. We do not discuss subgenera of *Hippodamia* sensu lato, because this requires a molecular phylogenetic study including both Palearctic and Nearctic species.

Material and methods

This article was prepared based on a literature review and samples collected in Europe (Czech Republic) and Asia (Iran, Kazakhstan, Siberia). Ladybirds were collected using a sweeping net, a mouth-operated aspirator, or by hand. Specimens were studied using a stereomicroscope (Olympus SZ-ST, Zeiss Stemi 2000-C, and Nikon SMZ 1500). Specimens were boiled in 10% KOH for up to 10 minutes depending on body colour darkness, then rinsed in distilled water for a maximum of 5 min, and mounted in Hoyer's medium. Microscopic photographs were made with a Lumenera digital camera using Quick Photo software. Processing and editing of photographs were done using the following software packages: Adobe Photoshop CS5.1, Zerene Stacker version T2019-10-07-1410, and Helicon Focus version 7.5.4.

Identification of specimens was done using available keys (Chapin 1946; Gordon 1985; Nedvěd 2015). The taxonomy at the genus and species level agrees with Kovář (2007). Morphological terminology follows Ślipiński

(2007). Iranian ladybirds are deposited at the Plant Protection Department, Agricultural Faculty, Lorestan University (Khorramabad, Iran); specimens of *H. tredecimpunctata* in the entomological collection of the University of South Bohemia (České Budějovice, Czech Republic), *H. septemmaculata* in the entomological department of the National Museum (Prague, Czech Republic); and *H. arctica* in the Laboratory of Fundamental and Applied Zoology, Altai State University (Barnaul, Siberia, Russia).

Results

Hippodamia Chevrolat, 1836

Diagnosis

Body length 3–7 mm. Body elongate-oval, elytra moderately convex, glabrous, femora visible beyond lateral margins of elytra. Elytral colour orange or red with black pattern, variable number of spots or without a pattern. Anterior clypeal border straight between lateral projections. Antenna 11-segmented; slightly shorter than head capsule with a moderately compact 3-segmented club. Terminal maxillary palpomere strongly securiform. Prothoracic hypomeron without fovea near anterior angles; prosternal process very narrow without distinct carinae. Metaventrite with or without postcoxal lines. Apex of middle and hind tibiae each with two spurs. Tarsal claw cleft, with inner tips shorter than outer tips. Postcoxal line on first abdominal ventrite complete or absent.

Ecology

Predatory, mainly feeding on aphids on herbaceous vegetation.

Identification key to the Palearctic species in the genus *Hippodamia*

1. First abdominal ventrite and metaventrite without postcoxal lines (Fig. 4B); pronotum widest in the middle of length (Fig. 1B, C); the base of pronotum not bordered (Fig. 4C); abdominal ventrites black with orange spots in lateral margins (Fig. 3B, C); body size 6–7 mm..... 2
- First abdominal ventrite and metaventrite with complete postcoxal lines; line not extending beyond half of the length of the abdominal ventrite (Fig. 4A); pronotum widest after the middle (Fig. 1A, D); the base of pronotum bordered (Fig. 4D); abdominal ventrites black with (Fig. 3A) or without (Fig. 3D) orange spots in lateral margins; body size 3–5.5 mm..... 3
2. Pronotum yellowish-white with a large black median square-shaped spot (Fig. 2D, E), in populations outside Iran usually also with separate rounded lateral spots (Fig. 2C); elytra usually orange, with 13 black

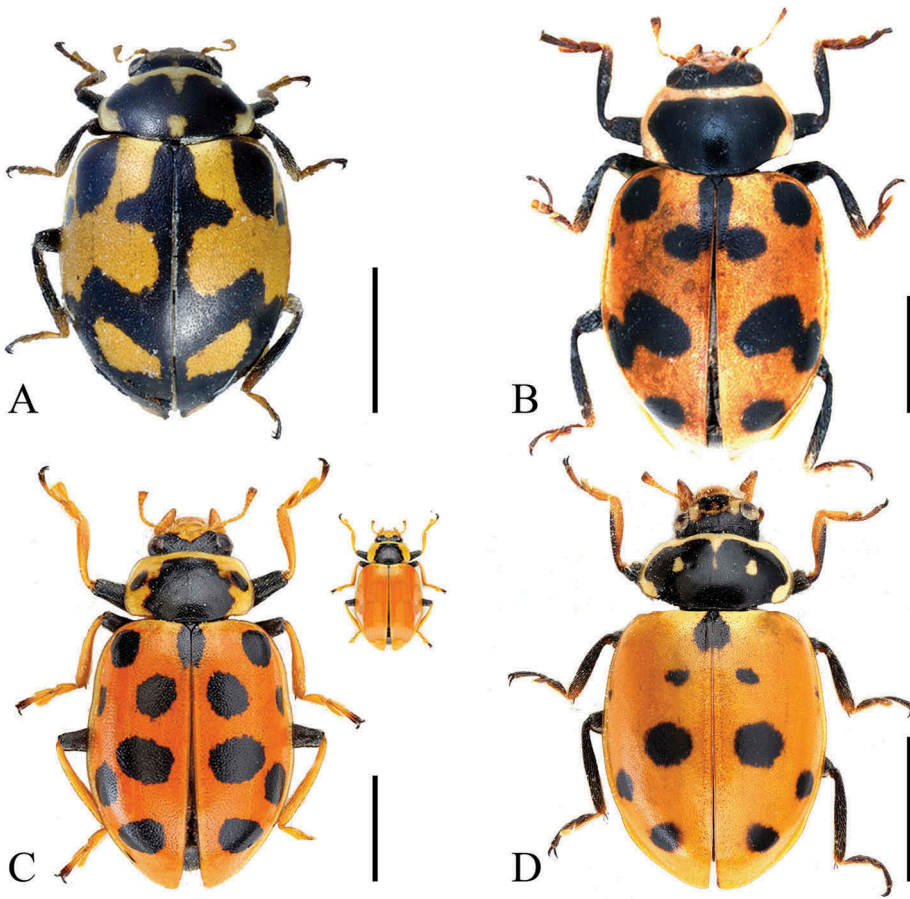


Figure 1A–D. Dorsal view of Palearctic species of *Hippodamia*. A, *Hippodamia arctica*; B, *H. septemmaculata*; C, *H. tredecimpunctata* with 13 black spots; insert, without spots; D, *H. variegata*. Scale bars – 2.0 mm.

- spots (Fig. 1C) or without any spots (Fig. 1C, small illustration); femora black, tibiae orange; male genitalia as in Fig. 5C, G.....
 *H. tredecimpunctata*
 – Pronotum mostly black with yellowish-white lateral and anterior margins (Fig. 2B); elytra usually orange, with 11 black spots (Fig. 1B); femora black, tibiae black, except small distal orange part; male genitalia as in Fig. 5B, F.
 *H. septemmaculata*
 3. Elytra red to orange, with a variable number of black spots (0–15; 11 on Fig. 1D); pronotum yellowish-white, with a large black median crown-shaped spot (Fig. 2F) or two white eye spots in the black area (Fig. 2G); fore femora brown, distal half of mid femora black, hind femora black, tibiae orange (Iran) to mostly black with orange tip (Central Europe); abdominal ventrites black; male genitalia as in Fig. 5D, H..... *H. variegata*

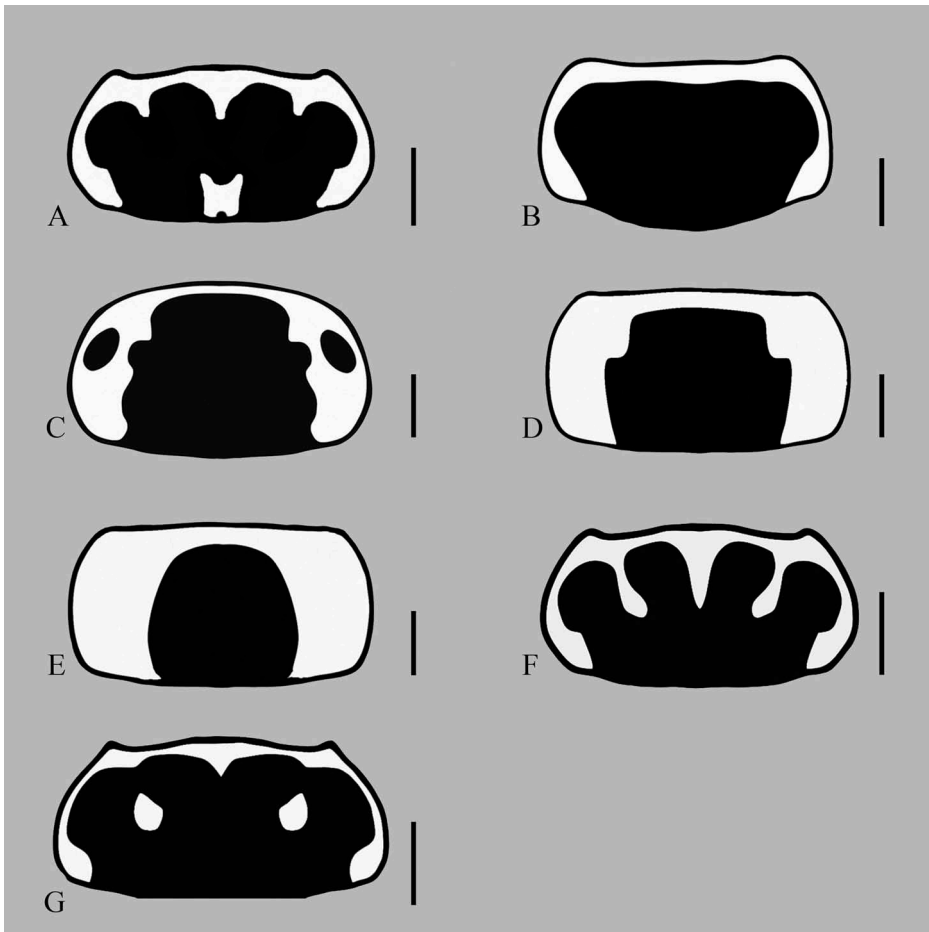


Figure 2A–G. Variability of pronotal patterns of Palearctic species of *Hippodamia*. A, *Hippodamia arctica*; B, *H. septemmaculata*; C–E, *H. tredecimpunctata*; F–G, *H. variegata*. Scale bars – 0.5 mm.

- Elytra yellow, with black pattern or elytra black with yellow pattern (Fig. 1A); pronotum yellowish-white, with a large black median crown-shaped spot and yellowish spot on the base of pronotum (Fig. 2A); femora black, proximal half of tibiae black; abdominal ventrites black with orange spots in lateral margins; male genitalia as in Fig. 5A, E..... *H. arctica*

Checklist of the species of the genus *Hippodamia* of Palearctic region

Hippodamia arctica (Schneider, 1792)

Material examined

KAZAKHSTAN, East Kazakhstan Region, South-Western Altai, Listvyaga Mountain Range, 10 August 2009, 1 m, leg. A.S. Kusekova, det. E.A.

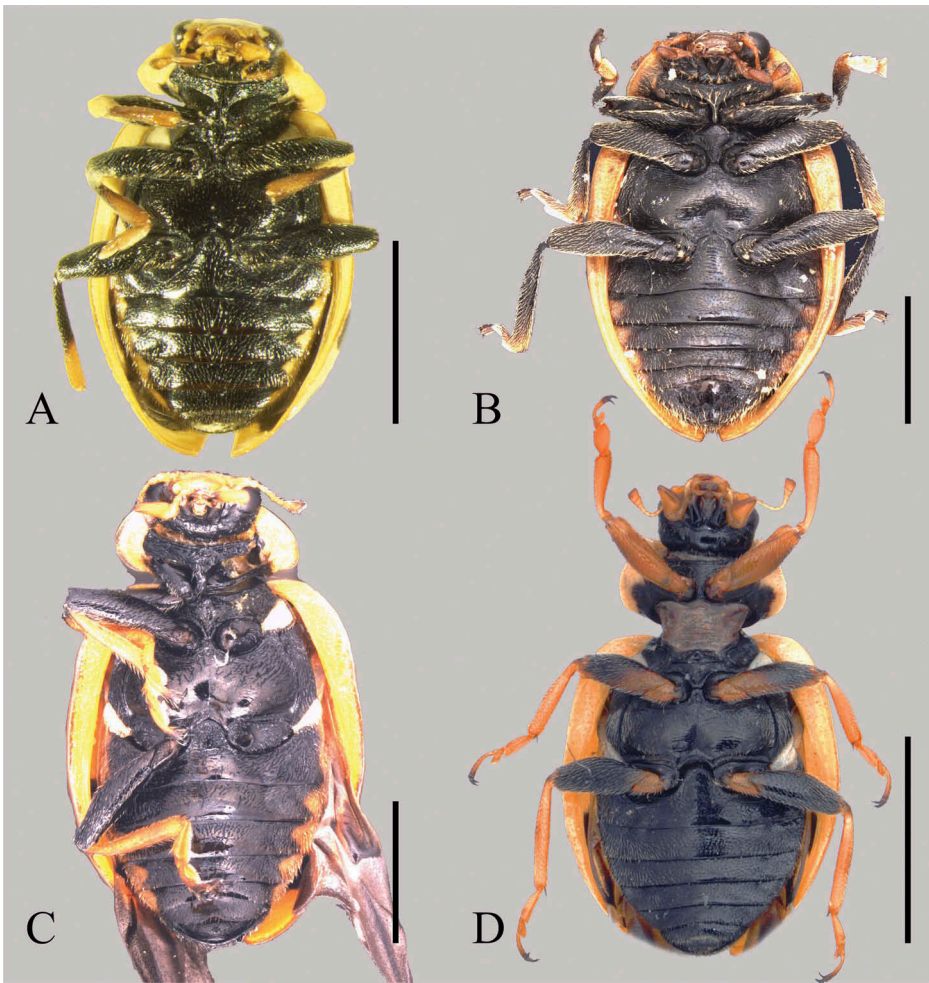


Figure 3A–D. Ventral view of Palearctic species of *Hippodamia*. A, *Hippodamia arctica*; B, *H. septemmaculata*; C, *H. tredecimpunctata*; D, *H. variegata*. Scale bars – 2.0 mm.

Nepaeva. RUSSIA, Siberia, Tigirek Nature Reserve, 26 September 2012, 1 f, leg. T.M. Krugova, det. E.A. Nepaeva; Siberia, Lena Delta, Research Station ‘Samoylov Island’, 1 September 2002, 1 f, leg. S. Kuzmina, det. A.S. Ukrainsky.

General distribution

Canada, USA (Alaska), northern Scandinavia, China (Dzungaria), India (Kashmir), Kazakhstan, Kyrgyzstan, Mongolia, Nepal, Russia (North European part, Siberia, Far East) (Canepari 1997; Kovář 2007; Nepaeva et al. 2017).

Type

Deposited in Saint Petersburg, Russia (Iablokoff-Khnzorian 1982).

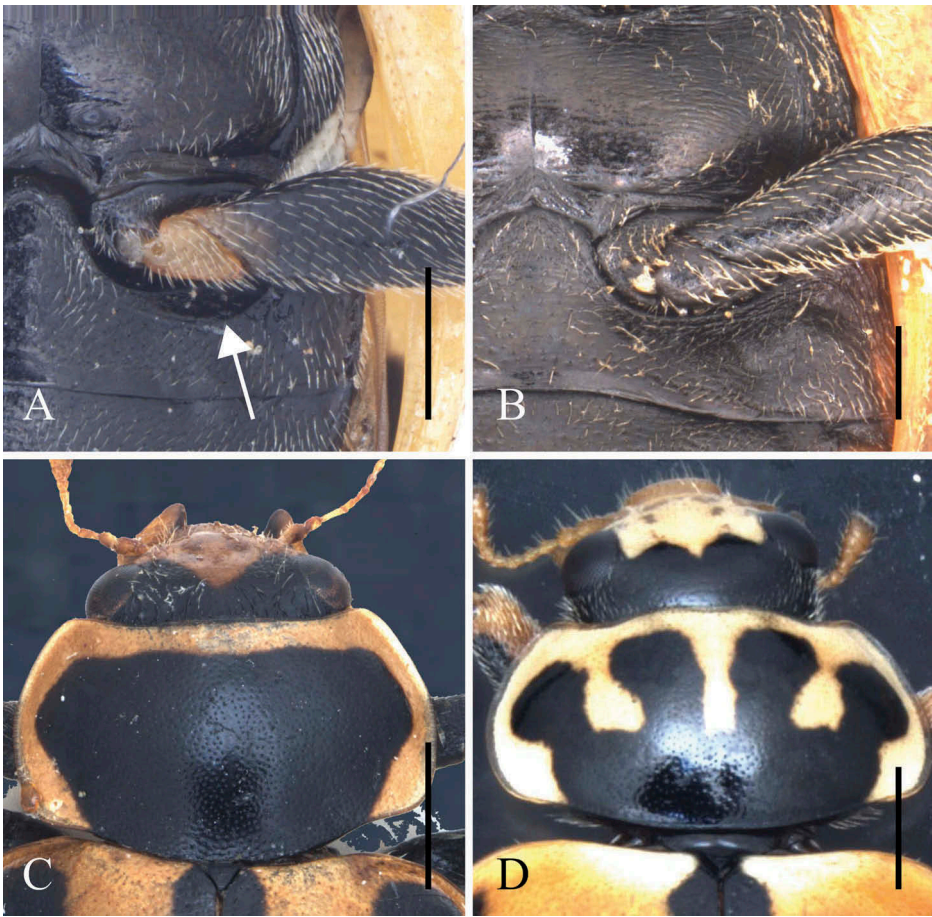


Figure 4A–D. Diagnostic characters of Palearctic species of *Hippodamia*. A, *H. variegata*, abdominal sternite with postcoxal lines (arrow); B, *H. septemmaculata*, without postcoxal lines; C, *H. septemmaculata*, the base of pronotum not bordered; D, *H. variegata*, bordered. Scale bars A, B, D – 0.5 mm, C – 1.0 mm.

Hippodamia septemmaculata (DeGeer, 1775)

Material examined

CZECH REPUBLIC, Liberec Region, Mříčná, 23 August 1993, 1 m, leg. J. Dlabola; Šumava Mountains, 1920, 1 f, leg. J. Obenberger. SLOVAKIA, Prešov Region, Tatranská Lomnica, 5 July 1947, 1 f, leg. J. Pospíšil.

General distribution

Europe, Russia (European part, Siberia, Far East), Central Asia (Kazakhstan) and East Asia (Korean Peninsula, Mongolia, northern China) (Kovář 2007; Nikitsky and Ukrainsky 2016).

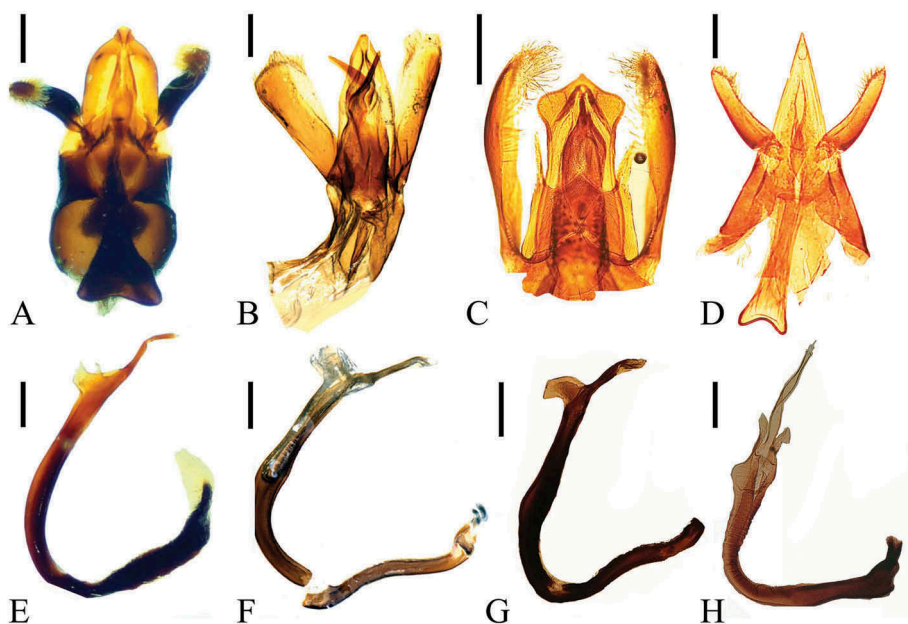


Figure 5A–H. Male copulatory organs of Palearctic species of *Hippodamia*; A–D, tegmen; E–H, penis. A, E, *Hippodamia arctica*; B, F, H, *H. septemmaculata*; C, G, *H. tredecimpunctata*; D, H, *H. variegata*. Scale bars – 0.2 mm.

Type

Deposited in Sweden (Iablokoff-Khnzorian 1982).

Hippodamia tredecimpunctata (Linnaeus, 1758)

Material examined

CZECH REPUBLIC, South Bohemian Region, České Budějovice District, Hranice, Trpnouze, 5 July 2019, 3 ff, leg & det. O. Nedvěd; Pilsen Region, Železná Ruda, 2008, 1 m, leg & det. S. Krejčík. IRAN, Isfahan Province, 1 m, leg. M. Zare Khormizi, det. A. Biranvand.

General distribution

Europe, Russia (European part, Caucasus, Siberia, Far East), Middle East (Iran, Iraq), Central Asia (Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan), East Asia (China, Japan, Korea, Mongolia), North Africa (Poorani 2002; Kovář 2007), Nearctic region (subspecies *H. tredecimpunctata tibialis*, Gordon 1985).

Type

Deposited in London, UK (Iablokoff-Khnzorian 1982).

Hippodamia variegata (Goeze, 1777)

Material examined

CZECH REPUBLIC, Pilsen Region, Železná Ruda, 2008, 1 f, leg. & det. S. Krejčík. IRAN, Lorestan Province, spring and summer 2013–2017, 648 mm, 600 ff, leg & det. A. Biranvand.

General distribution

Most of Palearctic, Afrotropical, and Oriental (northern India) regions; introduced populations in Australia, Nearctic region, and Neotropics (Franzmannb 2002; Kovář 2007; Ślipiński 2007).

Type

Deposited in Paris, France (Iablokoff-Khnzorian 1982).

Discussion

Hippodamia arctica is a rare species that can be found in the arctic, subarctic, and alpine tundra on plants infested with aphids (Belicek 1976). Abdolahi Mesbah et al. (2016) reported *H. septemmaculata* from Iran referencing Borumand (2000) although this species was not listed by Borumand. Because of this, *H. septemmaculata* should be excluded from the Iranian list of Coccinellidae. *Hippodamia septemmaculata* can be found in marshes, peat bogs, and mountains (Nedvěd 2015). The ladybird *H. tredecimpunctata* is more commonly distributed in the Palearctic region compared to *H. arctica* and *H. septemmaculata*, with reports in most of the Palearctic and Nearctic regions (Chapin 1946). It lives in cultivated fields (alfalfa), wet grassland, and parkland (Belicek 1976). In Central Europe, this species overwinters on dry grasses and leaves at forest margins (Nedvěd 2015).

Hippodamia variegata has been introduced to all continents except Antarctica, often as a result of deliberate introductions for the control of pests but also accidentally. For example, in North America, despite multiple releases between the 1950s and 1980s, *H. variegata* failed to establish (Gordon 1985; Ellis et al. 1999). The first collection of *H. variegata* in nature was near Montreal, Quebec in 1984 (Gordon 1987), as a result of accidental introduction through transoceanic shipping (Day et al. 1994; Gardiner and Parsons 2005). *Hippodamia variegata* is currently known in North and South America (Araya et al. 1997; Wheeler 1993; Finlayson et al. 2008; Williams and Young 2009; Hesler and Lundgren 2011), Europe (Nedvěd 2015), Africa (Aalbersberg et al. 1988; Ogenga-Latigo 1994), Asia (Fan and Zhao 1988; Singh et al. 1991), and Australia (Franzmannb 2002). It can be found in pastures, cultivated fields, and gardens. In Central Europe, large

overwintering groups of specimens are found in dry grass on hills (Nedvěd 2015). The enormous variability of pronotal and elytral patterns observed for this species has been the subject of several studies (e.g., in Central Europe, Honěk et al. 2012; in Iran, Zare Khormizi et al. 2013). As a result, identification keys that are mainly based on colour patterns (e.g., Abdolahi et al. 2017) are insufficient for species identification in this genus.

Currently, seven ladybird species are alternately named either *Ceratomegilla* (Kovář 2007) or *Hippodamia* (various authors): *C. alpina* (Villa & Villa, 1835), *C. apicalis* (Casey, 1899), *C. notata* (Laicharting, 1781), *C. schneideri* (Weise, 1878), *C. shelkovnikovi* (Dobzhansky, 1927), *C. ulkei* Crotch, 1873, and *C. undecimnotata* (Schneider, 1792). These taxa may represent several clades that should be included in the genus *Hippodamia* in a wider sense (*sensu lato*). Delimitation of subgenera and species of *Hippodamia* will be done using molecular phylogenetic data and published elsewhere.

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Disclosure statement

No conflict of interest was reported by the authors.

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