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A new species of *Zercon* (Parasitiformes: Mesostigmata) from Norway, with notes on sexual dimorphism in Zerconidae

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Abstract

In this paper we describe and illustrate Zercon hamaricus **sp. nov.** based on all postembryonic stages obtained from soil samples and laboratory cultures. The new species belongs to a species group in which dorsal setae J1– J4 in females are short and similar in length, and J5 are considerably longer. In most species of this group opisthonotal setae J5 and Z4 are clearly displaced anteriorly. Zercon hamaricus **sp. nov.** is most similar to Z. forsslundi Sellnick, 1958 and to a less extent to Z. polonicus Błaszak, 1970. The females of Z. forsslundi, Z. polonicus and Z. hamaricus **sp. nov.** can be distinguished based on the range of J5, the length and character of the Z and S-series setae, the distance between setae Z5 and the location of gdZ3. We also include comparative information on other related species of Zercon. The new species is one of the six known species that have clearly visible sexual dimorphism in opisthonotal chaetotaxy.

Keywords: zerconid mites, laboratory culture, morphology, immature stages, species distribution

Introduction

The family Zerconidae Canestrini, 1891 currently includes more than 400 described species and 46 genera, and is widely distributed throughout the Northern Hemisphere, including high-altitudes and arctic areas (Sellnick 1958; Halašková 1970, 1977, 1979; Błaszak 1975a, b, 1976, 1978, 1979; Błaszak et al. 1997; Mašán & Fendra 2004; Lindquist et al. 2009; Beaulieu et al. 2011; Sikora 2014; Faleńczyk-Koziróg et al. 2018; Kavianpour et al. 2018; Marchenko 2018, 2019, 2021; Karaca 2019, 2021; Urhan & Karaca 2019; Kaczmarek et al. 2020). Eight species of Zerconidae have been reported from continental Norway-one of Parazercon, two of Prozercon and five of Zercon (Gwiazdowicz & Gulvik 2005a, 2007; Gwiazdowicz et al. 2013). The recently confirmed Z. lindrothi Lundqvist & Johnston, 1985 (Bolger et al. 2018) was earlier recorded from Norway (Lundqvist & Johnston 1985), but is not mentioned in checklist of Gwiazdowicz & Gulvik (2005a). Other Zercon species: Z. baloghi Sellnick, 1958; Z. curiosus Trägardh, 1910 and Z. triangularis C.L. Koch, 1836 have been earlier reported from Norway by Slomian et al. (2005) while Z. zelawaiensis Sellnick, 1944 [listed by Mehl (1979) as Zercon cf. zelawaiensis] has been confirmed by Gwiazdowicz & Gulvik (2005b). All above-mentioned records of Zercon originate from the southern part of Norway (Vestland county). Most of the Zercon species described so far belong to a group in which the opisthonotal chaetotaxy of males and females is very similar (e.g. Halašková 1970, 1977; Błaszak 1974; Sikora 2014; Urhan & Karaca 2019). However, in a few species, the males and females show clear differences in opisthonotal chaetotaxy, a phenomenon that was first described by Sellnick (1958) in Z. forsslundi. Since then some other Zercon species with clear sexual dimorphism in chaetotaxy have been described, and differences between males and females have also been found

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in cheliceral morphology, hypostomal and palpal chaetotaxy, and some morphological characters of the venter (Błaszak 1974; Halašková 1977; Błaszak & Skorupski 1992; Călugăr 2004–2006; Ujvári 2011a, b; Sikora 2014; Faleńczyk-Koziróg *et al.* 2018).

We herein describe a new species, *Zercon hamaricus* **sp. nov.**, including a full ontogenetic series, compare its morphology with the most similar congeners, and discuss the phenomenon of sexual dimorphism in Zerconidae.

Material and Methods

Specimens of Zercon hamaricus sp. nov. were collected on 25 July 2017 by S. Kaczmarek in Hamar, Norway (Innlandet county), from moderately humid moss on rocks. Mites were extracted using Tullgren funnels for 7 days and mounted in PVA mounting medium (Lactic Acid, Poly Vinyl Acetate, and Phenol Solution, BioQuip Products, Inc., CA, USA). The drawings were made using a Nikon Eclipse E200 microscope equipped with a Nikon Y-IDT drawing tube, and then edited with Corel Draw 2017. Measurements and transmitted-light photomicrographs were made using a Leica DM3000 equipped with a Leica DFC420 camera and Leica Application Suite 3.8. For scanning electron microscopy (SEM), the mites were air-dried and coated with Au/Pd in a Polaron SC502, sputter coated and placed on Al-stubs with double-sided adhesive tape. Observations and micrographs were made with a ZEISS Supra 55VP scanning electron microscope at the Department of Natural History, University Museum of Bergen, Norway. Due to lack of measurements in some previous work, some measurements were taken from the original drawings with the use of imageJ 1.50d software (Schneider et al. 2012) as clearly explained in the text. All measurements are given in micrometres (µm). The setal terminology used in the description of Z. hamaricus sp. nov. follows Lindquist & Evans (1965) and Lindquist & Moraza (1998) for idiosomal setation and Johnston & Moraza (1991) for the notation of dermal glands and lyrifissures. The setal terminology and notation of dermal glands and lyrifissures used in descriptions of other Zerconidae species discussed in this paper have been converted to the above-mentioned systems if necessary.

Taxonomy

Zercon hamaricus sp. nov.

(Figures 1-27)

Material examined

Holotype female, collected from moderately humid moss on rocks on a slope near the bank of Mjøsa Lake, in a mixed forest stand with pine (*Pinus sylvestris* L.), birch (*Betula pendula* Roth), rowan (*Sorbus aucuparia* L.) and ash (*Fraxinus excelsior* L.), in the surroundings of Domkirkeodden Museum of Medieval Culture and History in Hamar, Norway (N 60°47'33.7", E 11°2'9.2", 150 m. a.s.l.). Field collected paratypes—2 females, 1 male, 3 deutonymphs and 2 protonymphs—collection data as for holotype. Paratypes from laboratory culture—6 females, 7 males, 5 deutonymphs, 1 protonymph and 6 larvae—collected from culture founded by three females, on Plaster of Paris and charcoal substrate, fed with nematodes.

The holotype (1 female) and paratypes (5 females, 5 males, 6 deutonymphs, 2 protonymphs, 4 larvae) of *Zercon hamaricus* **sp. nov.** are deposited in the Department of Evolutionary Biology, Kazimierz Wielki University (Bydgoszcz, Poland). Other paratypes (3 females, 3 males, 2 deutonymphs, 1 protonymph, 2 larvae) are deposited in the collection of the University Museum of Bergen (Norway).

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Diagnosis (adult female)

Anterior margin of ventrianal shield with two pairs of setae (Zv1 present). Pores gv3 located posteriorly to line connecting para-anal setae close to line connecting setae Jv4. Podonotal shield with 21 pairs of setae, covered entirely with irregular tile-like sculpture. Setae j1, j2, s3 and r4-r5and s6 barbed. Seta r3 barbed, located on ventral side of idiosoma. Opisthonotal shield with 21 pairs of setae (Z2 present). All opisthonotal setae without apical hyaline endings. Setae J1-J4 and Z1-Z3and S2 short, smooth and pointed. Seta S3 clearly longer than S2, smooth and pointed. Setae S2 and S3 never reach the insertions of next setae in series and never reach beyond the edge of opisthonotum. Other opisthonotal setae long and barbed. Seta J5 never reach beyond posterior edge of opisthonotum and almost reach the posterodorsal cavities. Pores gdZ1 (Po2) close and posterior to line connecting insertions of setae Z2 and S3, closer to insertion of Z2. Pores gdZ3 (Po3) on the line connecting the insertions of setae J5 and Z4, closer to posterion of Z4. Pores gdZ3 and insertions of setae J5 and Z4 located distinctly anterior to posterodorsal cavities.

Description

Female (n=9)

Idiosoma length 505–529, width (at level of anterior edge of ventrianal shield) 403–410.

Dorsal idiosoma (Figures 1, 3-5). Podonotal shield with 21 pairs of setae. All podonotal setae without hyaline endings. Lengths of podonotal setae of females summarized in Table 1. Seta *j1* longest in *j*-series, other *j*-series setae of comparable length. Setae *j1* and *j2* with subapical barbs. Setae *j3–j6* smooth and pointed. All *z*-series setae of comparable length, smooth and pointed. Seta s1 shortest of the s-series. Setae s3 and s6 of comparable length and longest of s-series. Seta s3 with subapical barbs, seta s6 with one subapical barb, other s-series setae smooth and pointed. Setae r1 and r2 smooth and pointed, setae r4-r5 with one subapical barb. Seta r1 shortest and r5 longest of r-series on podonotal shield. Podonotal shield covered entirely with irregular tile-like sculpture. Location of podonotal glands: gdj2 (pol) posterior to insertion of seta sl, close and anterior to line connecting setae i3 and z2; gdi4 (po2) close and posterior to line connecting insertions of setae i4 and z4; gdz5 (po3) close and posterior to line connecting insertions of setae z5 and s4. Location of podonotal poroids: *idj1* posterior to insertion of seta *j1*; *ids4* close to lateral margin of podonotum, at the level of seta r5; idj3, idj6 and idz4 not visible. Opisthonotal shield with 21 pairs of setae. All opisthonotal setae without hyaline endings. Lengths of opisthonotal setae and longitudinal distances between insertions of setae in specific series of females summarized in Table 2. Setae J1-J4 short, smooth and pointed. Seta J5 clearly longer, with subapical barbs. Seta J5 never reach beyond posterior edge of opisthonotum, almost reach posterodorsal cavities. Setae Z1-Z3 of comparable length, short, smooth and pointed. Setae Z4 and Z5 clearly longer, with barbs located at about one third or one fourth from seta termination. Seta Z4 clearly reach beyond lateral edge of opisthonotum, and reach the insertion of Z5. Seta Z5 longer (1.2–1.3 times) than Z4. Distance between setae Z5 214– 225. Seta S2 shortest of S-series. Setae S1 and S4 with one subapical barb. Setae S2 and S3 smooth and pointed, S3 clearly longer (1.4-1.7 times) than S2. Setae S2 and S3 never reach the insertion of next seta in series. Seta S4 clearly longer (1.6-2.1 times) than S3. Seta S5 with subapical barbs, longer (1.1–1.4 times) than S4. Setae R1-R6 of similar length (30–40), pointed, with one subapical barb. Opisthonotal shield covered with tile-like structure in anterior corners from the anterior edge to ZI-Z2-S4 line. The axial part of opisthonotal shield with irregular horizontal lines to J4-J4 line. Similar lines visible also in the lateral parts of opisthonotal shield to J4–Z4 line. Remaining posterior surface of opisthonotum without sculpture, finely dotted. Posterodorsal cavities crescent-like with undulating anterior margins. Location of opisthonotal glands: gdz6 (Pol) anterolateral to Z1; gdZ1 (Po2) close and posterior to line connecting insertions of setae Z2 and S3, closer to insertion of Z2; gdZ3 (Po3) on the line connecting insertions of setae J5 and Z4, closer to insertion of Z4; gdZ4 (Po4)

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behind the insertion of seta S5; gdJ3 not visible. Location of opisthonotal poroids: idz6 on line connecting insertions of setae J1 and Z1; idJ1 close and adaxial to line connecting insertions of setae J1 and Z2; idJ2 on line connecting insertions of setae J2 and J4; idJ3 posterior to line connecting insertions of setae J4 and Z3, closer to Z3; idJ4 on line connecting insertions of setae J5 and Z4, closer to J5; idJ5 posterior and adjacent to line connecting posterior edges of inner posterodorsal cavities; idZ4 close to line connecting setae Z4 and Z5, closer to Z5; ids6 close to antero-abaxial edge of opisthonotum; idS1 posterior to ids6 at the level of seta S2; idS3 doubled, close to line connecting setae S3 and S4, closer to S4; idS4 posterior to seta S4, at the level of seta Z4; idR3 not visible.



FIGURES 1-2. Zercon hamaricus sp. nov., female. 1. Dorsal aspect; 2. Epistome.

Gnathosoma. Epistome (Figure 2) typically shaped for genus, with medial process bifurcated. One female with medial process tripartite.

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FIGURES 3–5. Zercon hamaricus **sp. nov.**, female, SEM micrographs. 3. Dorsal aspect; 4. Opisthonotum; 5. *J*-series setae and dorsal cavities.

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| | | ₽ <i>₽</i> | | | | 33 | | |
|-----------|----------------------------|------------|---------|--------|---------------------------|------|---------|--------|
| | Z. hamaricus | | Z. pole | onicus | Z. hamaricus | | Z. pole | onicus |
| | length | type | length | type | length | type | length | type |
| jl | $36 \pm 2 \ / \ 32 - 39$ | В | 35 | В | $33 \pm 3 \ / \ 30 - 37$ | В | n/a | В |
| j2 | $24\pm1\ /\ 2327$ | В | n/a | S | $20 \pm 1 \ / \ 19 - 22$ | В | n/a | S |
| j3 | $24 \pm 1 \ / \ 23 - 25$ | S | n/a | S | $20 \pm 1 \ / \ 18 - 23$ | S | n/a | S |
| j4 | $23\pm2\ /\ 20\!\!-\!\!25$ | S | n/a | S | $21 \pm 1 / 19 - 22$ | S | n/a | S |
| j5 | $22 \pm 1 \ / \ 21 - 24$ | S | n/a | S | $19 \pm 1 \; / \; 17 20$ | S | n/a | S |
| j6 | $24 \pm 1 \ / \ 23 - 26$ | S | n/a | S | $19 \pm 1 \; / \; 17 20$ | S | n/a | S |
| zl | not developed in Zercon | | | | | | | |
| z2 | $19 \pm 1 \ / \ 18 - 21$ | S | n/a | S | $19 \pm 1 \ / \ 18 - 22$ | S | n/a | S |
| z3 | $20 \pm 1 \ / \ 19 - 21$ | S | n/a | S | $22 \pm 1 \ / \ 21 23$ | S | n/a | S |
| z4 | $26\pm2\ /\ 2329$ | S | n/a | S | $23 \pm 1 \ / \ 21 25$ | S | n/a | S |
| z5 | $24\pm2 \ / \ 22 -\!26$ | S | n/a | S | $21 \pm 1 \ / \ 19 - 23$ | S | n/a | S |
| <i>z6</i> | $18 \pm 2 \ / \ 15 - 21$ | S | n/a | S | $14 \pm 1 \ / \ 13 - 17$ | S | n/a | S |
| s1 | $19 \pm 2 \ / \ 17 - 22$ | S | n/a | S | $16 \pm 1 \ / \ 15{-18}$ | S | n/a | S |
| s2 | $30 \pm 3 \ / \ 24 - 33$ | S | n/a | S | $21 \pm 2 \ / \ 19 - 23$ | S | n/a | S |
| s3 | $46\pm3\ /\ 4350$ | В | n/a | S | $42\pm2 \ / \ 39 \ -45$ | В | n/a | S |
| <i>s4</i> | $27 \pm 1 \ / \ 25 - 28$ | S | n/a | S | $21 \pm 1 \ / \ 20 - 23$ | S | n/a | S |
| s5 | $30\pm2\ /\ 2732$ | S | n/a | S | $24 \pm 1 \ / \ 22 - 26$ | S | n/a | S |
| <i>s6</i> | $43\pm3 \ / \ 40 \ -48$ | В | n/a | S | $35 \pm 2 \ / \ 32 - 37$ | В | n/a | S |
| rl | $17 \pm 1 \ / \ 17 - 19$ | S | n/a | S | $17 \pm 1 \; / \; 15 19$ | S | n/a | n/a |
| r2 | $23 \pm 2 \ / \ 21 - 26$ | S | n/a | S | $24\pm2\ /\ 2228$ | S | n/a | S |
| r3 | $49\pm1\ /\ 4852$ | В | n/a | S | $40 \pm 2 \ / \ 36 - 42$ | В | n/a | n/a |
| r4 | $33 \pm 2 \ / \ 30 - 35$ | В | n/a | S | $26\pm3\ /\ 2229$ | В | n/a | S |
| r5 | $37 \pm 2 / 33 - 40$ | В | n/a | S | $31 \pm 2 / 28 - 35$ | В | n/a | S |

TABLE 1. Length (mean \pm SD / range in μ m) and smoothness of podonotal setae in female and male of Zercon hamaricus **sp. nov.** with comparison to Z. polonicus Błaszak, 1970.

n/a-data not available.; type of seta: S-smooth; B-barbed.

Ventral idiosoma (Figure 6). Epigynal and peritrematal shields shaped typically for genus. Seta r3 with subapical barbs. Sternal shield fully covered with reticulate ornamentation, setae st1-st5 similar in length, 16–27, smooth and pointed. Ventrianal shield length 221–242, width (at level of Jv2 setae) 319–333. Ventrianal shield with 21 smooth and pointed setae. Ventrianal shield covered with dotted and reticulate ornamentation in the anterior part (to level of Zv3 setae), remaining posterior surface of ventrianal shield without reticulate ornamentation, finely dotted. Setae Jv1, Jv2, Zv1-Zv4 17–24, Jv3 26–31, Jv4 and para-anal setae 35–45, Jv5 49–54 and postanal seta 45–50 long. Three parallel lines of denser dots visible posterior to postanal seta (length of each line does not exceed distance between para-anal setae). Anus length 22–27, width 17–20. Location of ventral glands: gv1 close to insertion of st3, gv2 multiple and typically located; gvi in the inguinal region; gv3 (posterior para-anal glands) posterior to line connecting para-anal setae, close to line connecting setae Jv4; gp anterior to peritreme. Location of ventral poroids: iv1 posterior to insertion of st3; iv3 at the posterior edge of sternal shield, adaxial to insertion of st3; iv5 on the genital shield, posterior to seta st5; ip1 antero-adaxial to gp; ip2 postero-adaxial to stigma; ivo1 and ivo2 located at level of Jv2–Zv2 setae; ivo3 close to lateral edge of ventrianal shield, close

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and posterior to line connecting insertions of setae Zv4; *ivo4* not visible; *ivi* in the inguinal region; *ivp* single, anterior to line connecting setae Jv5, closer to insertion of Jv5.

| | ŶŶ | | | | | | ර්ර | | | | | |
|-----------------|------------------------------------|------|----------|-------|----------|------|----------------------------|------|-----------|------|----------|------|
| - | Z. hamaricus | | Z. forss | lundi | Z. polor | icus | Z. hamaricus | | Z. forssl | undi | Z. polon | icus |
| - | length | type | length | type | length | type | length | type | length | type | length | type |
| JI | $19 \pm 1 \ / \ 17 - 20$ | S | n/a | S | 14 | S | $14 \pm 1 \ / \ 13 - 16$ | S | n/a | S | 12 | S |
| J1–J2 | $44\pm5 \ / \ 3850$ | | n/a | | 36–40 | | $38 \pm 3 \; / \; 31 41$ | | n/a | | 33-37 | |
| J2 | $19 \pm 1 \; / \; 18 20$ | S | n/a | S | 14 | S | $13 \pm 1 \ / \ 12 - 14$ | S | n/a | S | 12 | S |
| J2–J3 | $36\pm5 \ / \ 32 \ -46$ | | n/a | | 44–48 | | $28\pm4/2234$ | | n/a | | 24–29 | |
| <i>J3</i> | $14 \pm 1 \; / \; 13 15$ | S | n/a | S | 14 | S | $11 \pm 1 / 10 - 14$ | S | n/a | S | 12 | S |
| J3–J4 | $37 \pm 7 \; / \; 31 51$ | | n/a | | 22 | | $29 \pm 4 \ / \ 19 34$ | | n/a | | 18 | |
| J4 | $16 \pm 1 \ / \ 14 - 17$ | S | n/a | S | 16 | s | $10\pm1\ /\ 811$ | s | n/a | S | 14 | S |
| J4–J5 | $38\pm5 \ / \ 30 \ -47$ | | n/a | | 26 | | $30\pm8\ /\ 2448$ | | n/a | | 14 | |
| J5 | $74 \pm 4 \; / \; 70 83$ | В | 70 | В | 63–72 | В | $10\pm1~/~9{-}11$ | S | n/a | S | 30–38 | В |
| Zl | $20\pm1\ /\ 1822$ | S | n/a | S | 12 | s | $15\pm2\;/\;13\!\!-\!\!17$ | s | n/a | S | 10 | S |
| Z1–Z2 | $52\pm5 \ / \ 4562$ | | n/a | | 42–48 | | $37 \pm 4 \ / \ 32 - 44$ | | n/a | | 31-35 | |
| Z2 | $19\pm1\ /\ 1821$ | S | n/a | S | 12 | s | $13 \pm 1 \; / \; 11 15$ | s | n/a | S | 10 | S |
| Z2–Z3 | $45\pm6 \ / \ 3353$ | | n/a | | 28-32 | | $33\pm7\ /\ 2246$ | | n/a | | 20-24 | |
| Z3 | $20\pm1\ /\ 1822$ | S | n/a | S | 44–48 | В | $15 \pm 1 \ / \ 14 - 16$ | S | n/a | S | 39–43 | в |
| Z3–Z4 | $65 \pm 6 \; / \; 56 74$ | | n/a | | 44–48 | | $49\pm5 \ / \ 3757$ | | n/a | | 32-36 | |
| Z4 | $88 \pm 2 \; / \; 86 \!\!-\!\! 92$ | В | 76 | В | 68–72 | В | $77 \pm 4 \; / \; 71 82$ | В | 64 | В | 47–56 | В |
| Z4–Z5 | $84 \pm 2 \; / \; 81 88$ | | n/a | | n/a | | $64\pm2\ /\ 5866$ | | n/a | | n/a | |
| Z5 | $111 \pm 4 \ / \ 101{}115$ | В | 84 | В | 70–74 | В | $102\pm2\:/\:100104$ | В | 76 | В | 48–55 | В |
| SI | $35\pm2\;/\;32\!\!-\!\!38$ | В | n/a | S | n/a | S | $29\pm1/2730$ | В | n/a | S | n/a | S |
| S1–S2 | $66 \pm 4 \; / \; 60 71$ | | n/a | | n/a | | $50 \pm 5 \; / \; 44 57$ | | n/a | | n/a | |
| <i>S2</i> | $23\pm2\;/\;20\!\!-\!\!26$ | S | n/a | S | 13 | S | $20 \pm 1 \ / \ 18 - 21$ | S | n/a | S | 12 | s |
| S2–S3 | $50\pm4\ /\ 4455$ | | n/a | | 46–50 | | $36\pm4\ /\ 30\ -42$ | | n/a | | 29–33 | |
| <i>S3</i> | $35 \pm 2 \; / \; 33 38$ | S | n/a | S | 13 | S | $32 \pm 1 \ / \ 28 33$ | S | n/a | S | 12 | S |
| S3–S4 | $73 \pm 6 \ / \ 60 - 80$ | | n/a | | 58-62 | | $56\pm5\ /\ 4767$ | | n/a | | 38-42 | |
| <i>S4</i> | $64\pm4\ /\ 5770$ | В | 52 | В | 35–39 | s | $53 \pm 4 \: / \: 47 63$ | В | 44 | В | 27-31 | S |
| S4–S5 | $76\pm5 \ / \ 7285$ | | n/a | | 46–50 | | $56 \pm 6 \; / \; 44 61$ | | n/a | | 38-42 | |
| <i>S5</i> | $80 \pm 3 \; / \; 75 84$ | В | 64 | В | 52-57 | В | $67 \pm 3 \; / \; 61 73$ | В | 52 | В | 44-48 | В |
| Jv5 | $51 \pm 2 \; / \; 49 54$ | S | n/a | S | 24 | s | $43\pm2 \ / \ 40 \ -46$ | s | n/a | S | 16 | S |
| Z5–Z5 | 219 ± 4 / 214–22 | 25 | 176 | 5 | 120 |) | $174 \pm 6 \ / \ 165 - 18$ | 3 | 152 | | 100 | |
| idiosoma length | $518 \pm 10 \ / \ 505 - 52$ | 29 | 495 | ; | 450-4 | 90 | 412 ± 12 / 395-42 | 27 | 390 | | 350-38 | 80 |
| idiosoma width | $407 \pm 4 / 403 - 41$ | 0 | 375-4 | 405 | 320-3 | 50 | 310 ± 8 / 298–31 | 8 | 288 | | 240-20 | 65 |

TABLE 2. Length (mean \pm SD / range in μ m) and smoothness of opisthonotal setae with longitudinal distances between insertions of setae in female and male of *Zercon hamaricus* **sp. nov.** with comparison to *Z. forsslundi* Sellnick, 1958 and *Z. polonicus* Błaszak, 1970 with notes on the body length/width and *Z5–Z5* distance.

n/a-data not available; type of seta: S-smooth; B-barbed.

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FIGURE 6. Zercon hamaricus sp. nov., female, ventral aspect.

Male (n=8)

Idiosoma length 395-427, width (at level of anterior edge of ventrianal shield) 298-318.

Dorsal idiosoma (Figures 7, 9–12). Podonotal shield with 21 pairs of setae. All podonotal setae without hyaline endings. Lengths of podonotal setae of males summarized in Table 1. Seta *j1* longest of *j*-series, other *j*-series setae of comparable length. Seta *j1* with subapical barbs, *j2* with one subapical barb. Setae j3-j6 smooth and pointed. All *z*-series setae smooth and pointed, *z6* shortest, *z2–z5* longer and of comparable length. Seta *s1* shortest of the *s*-series. Setae *s3* and *s6* of comparable length and longest of *s*-series. Seta *s3* with subapical barbs, seta *s6* with one subapical barb, other *s*-series setae smooth and pointed. Setae *r1* and *r2* smooth and pointed, setae *r4–r5* with one subapical barb. Seta *r1* shortest and *r5* longest of *r*-series of podonotal glands: same as in female. Location of podonotal poroids: *idj1* abaxial to insertion of seta *j1*; *ids4* as in female; *idj3*, *idj6* and *idz4* not visible. Opisthonotal setae and longitudinal distances between insertions of setae in specific series of males summarized in Table 2. Setae *31–J5* short, smooth and pointed. Seta *J5* clearly thickened when compared to *J1–J4*. Setae of *Z*-series similar to those in female. Seta *Z4* clearly reach beyond

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lateral edge of opisthonotum, and reach beyond insertion of Z5. Seta Z5 longer (1.2–1.4 times) than Z4. In most of studied males the length of Z3 seta ranged from 14 to 16. In two males we found unusual length of Z3 setae. In one male the left Z3 seta was short (13) while the right one was clearly longer (34) (Figures 9–10). In another male both Z3 setae were longer than usual (34 and 37) (Figures 11–12). Distance between setae Z5 165–183. Setae of S-series similar to those in female. Seta S3 clearly longer (1.3–1.8 times) than S2. Seta S4 clearly longer (1.4–2.0 times) than S3. Setae R1–R6 23-35, pointed, with one subapical barb. Opisthonotal shield covered with tile-like structure in anterior corners between shield margin and Z1-Z2-Z3-S4 line and further with net-like pattern to J4-Z4 line. Remaining posterior surface of opisthonotum without sculpture, finely dotted. Posterodorsal cavities crescent-like with undulated anterior margins. Location of opisthonotal glands: same as in female. Location of opisthonotal poroids: idz6 posterior to line connecting insertions of setae J1 and Z1, closer to Z1; idJ1 on the line connecting insertions of setae J1 and J2; idJ2 close and adaxial to line connecting insertions of setae J2 and J3; idJ3 posterior to line connecting insertions of setae J4 and Z3, closer to Z3; idJ4 posterior to line connecting insertions of setae J5 and Z4; idJ5 posterior and adjacent to line connecting posterior edges of inner posterodorsal cavities; idZ4 close to line connecting setae Z4 and Z5, closer to Z5; ids6 close to antero-abaxial edge of opisthonotum; *idS1* equidistant from seta S2 and lateral edge of opisthonotum; *idS3* doubled, close to line connecting setae S3 and S4, closer to S4; idS4 posterior to setae S4, at the level of setae Z4; idR3 not visible.



FIGURES 7-8. Zercon hamaricus sp. nov., male. 7. Dorsal aspect; 8. Epistome.



FIGURES 9–12. Zercon hamaricus **sp. nov.**, unusual chaetotaxy in male. 9–10. Male with one seta Z3 short and the other clearly longer; 11–12. Male with both setae Z3 longer than usual.



FIGURE 13. Zercon hamaricus sp. nov., male, ventral aspect.

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Gnathosoma. Epistome (Figure 8) typically shaped for genus with medial process bifurcated. One male with medial process tripartite.

Ventral idiosoma (Figure 13). Genital and peritrematal shields shaped typically for genus. Seta r3 with subapical barbs. Sternal shield anteriorly covered with reticulate ornamentation. Sternal setae smooth and pointed, st1-st2 17–23, and st3-st5 12–15 long. Ventrianal shield length 177–200, width (at level of Jv2 setae) 254–271. Ventrianal shield with 21 smooth and pointed setae. Ventrianal shield covered with dotted and reticulate ornamentation in the anterior part (to level of Zv3 setae), remaining posterior surface of shield without reticulate ornamentation and finely dotted. Setae Jv1, Jv2, Zv1-Zv4 14–21, Jv3 20–25, Jv4 and para-anal setae 28–34, Jv5 40–46 and postanal seta 37–41 long. Three parallel lines of denser dots visible posterior to postanal seta (length of each line does not exceed distance between para-anal setae). Anus length 17–20, width 10–16. Location of ventral glands: gv1 adaxial to line connecting insertions of setae st3 and st4; location of other glands same as in female. Location of ventral poroids: iv3 posterior to insertion of st3; iv5 on the sternal shield, posterior to insertion of seta st5; location of other poroids same as in female.



FIGURES 14-15. Zercon hamaricus sp. nov., deutonymph. 14. Dorsal aspect; 15. Epistome.

Deutonymph (n=8)

Idiosoma length 414–436, width (at level of anterior edge of ventrianal shield) 311–344.

Dorsal idiosoma (Figure 14). Podonotal shield with 21 pairs of setae. All podonotal setae without hyaline endings. Lengths of podonotal setae of deutonymphs summarized in Table 3. Seta *j1* longest of *j*-series, other *j*-series setae of comparable length. Seta *j1* with subapical barbs, other *j*series setae smooth and pointed. All z-series setae smooth and pointed, z6 shortest and z4 longest. Seta s1 shortest of s-series. Setae s2, s4 and s5 of comparable length. Setae s3 and s6 of comparable length and longest of s-series. Seta s3 with subapical barbs, seta s6 with one subapical barb, other sseries setae smooth and pointed. Setae r1 and r2 smooth and pointed, setae r4-r5 with one subapical barb. Seta rl shortest and r5 longest of r-series. Podonotal shield partly covered with irregular netlike sculpture and laterally with tile-like pattern with some more densely corrugated pattern between *j*-series and *z*-series. Location of podonotal glands and poroids: same as in male. Opisthonotal shield with 21 pairs of setae. All opisthonotal setae without hyaline endings. Lengths of opisthonotal setae and longitudinal distances between insertions of setae in specific series of deutonymphs summarized in Table 4. Setae JI-J5 as in male: short, smooth and pointed; seta J5 clearly thickened when compared to J1-J4. Setae of Z-series similar to those in female. Seta Z4 clearly reach beyond lateral edge of opisthonotum, and reach beyond insertion of Z5. Seta Z5 longer (1.2-1.3 times) than Z4. Distance between setae Z5 155-161. Seta S1 with one subapical barb. Seta S2 shortest of S-series, smooth and pointed. Setae S3-S5 with subapical barbs. Seta S3 clearly longer (2.1–3.0 times) than S2. Seta S2 never reach and S3 almost reach the insertion of next seta in series. Setae S3 and S4 of comparable length. Seta S5 longer (1.2–1.4 times) than S4. Seta R1 always slightly longer (24–30) than other setae of R-series (17–24). All R-setae with one subapical barb. Opisthonotal shield covered with tile-like pattern in antero-lateral corners and net-like pattern to line J4-Z3-S4. Remaining posterior surface of opisthonotum without sculpture, finely dotted. Posterodorsal cavities with undulated anterior margin; outer cavities crescent-like, inner ones more rounded. Location of opisthonotal glands: gdz6 (Po1) anterolateral to Z1; gdZ1 (Po2) on the line connecting insertions of setae Z2 and S3, closer to insertion of Z2; gdZ3 (Po3) anterior to line connecting insertions of setae J5 and Z4, closer to insertion of Z4; gdZ4 (Po4) on the line connecting insertions of setae Z5 and S5; gdJ3 not visible. Location of opisthonotal poroids: idz6 posterior to line connecting insertions of setae J1 and Z1; idJ1 close and adaxial to line connecting insertions of setae J1 and J2; idJ2 close and abaxial to line connecting insertions of setae J2 and J4, closer to J2; idJ3 posterior to line connecting insertions of setae J4 and Z3; idJ4 posterior to line connecting insertions of setae J5 and Z4; idJ5 posterior to line connecting posterior edges of inner posterodorsal cavities; idZ4 close to line connecting setae Z4 and Z5, closer to Z5; ids6 close to antero-abaxial edge of opisthonotum; idS1 on the line connecting insertions of setae S1 and S2, closer to S1; idS3 doubled, close to line connecting setae S3 and S4; idS4 posterior to seta S4, at the level of gdZ3; idR3 not visible.

Gnathosoma. Epistome (Figure 15) typically shaped for genus.

Ventral idiosoma (Figure 16). Seta *r3* with subapical barbs. Sternal shield in anterior part with delicate reticulate ornamentation, posterior part dotted (barely visible). Setae *st1-st5* 12–21, smooth and pointed (*st5* off the shield). Ventrianal shield length 152–165, width (at level of *Jv3* setae) 248–263. Ventrianal shield with 17 smooth and pointed setae (*Jv1* and *Zv1* off the shield). Ventrianal shield covered with dotted and reticulate ornamentation in the anterior part (to level of *Jv3–Zv4* setae), remaining posterior surface of ventrianal shield without reticulate ornamentation and finely dotted. Setae *Jv1*, *Jv2* and *Zv1* 12–20, *Jv3* and *Jv4* 19–25, *Zv2* 9–13, *Zv3* and *Zv4* 13–19, *Jv5* 52–59, para-anal setae 27–30 and postanal seta 44–46 long. Three parallel lines of denser dots visible posterior to postanal seta (length of each line does not exceed distance between para-anal setae). Anus length 17–23, width 15–16. Location of ventral glands: *gv1* between insertions of setae *st3* and *st4*; *gv2* multiple and typically located; *gv3* (posterior para-anal glands) posterior to line connecting

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para-anal setae, close to line connecting setae Jv4; gp close to peritreme, at the level of coxa III; gvi close to posterior edge of coxa IV. Location of ventral poroids: iv1-iv3 similar to those in male; iv5 posterior to insertion of seta st5, at the level of gv2; ip1 at the level of coxa II; ip2 similar to those in adults; ivo1 and ivo2 located at level of Jv2-Zv2 setae; ivo3 close to lateral edge of ventrianal shield, close to line adjacent to anterior edge of anus; ivo4 not visible; ivp single, anterior to line connecting setae Jv5, closer to insertion of Jv5; ivi close to posterior edge of coxa IV.

| | | | Р | | | | L | | | |
|-----------|----------------------------|-------|---------|-------|--------------------------------------|--------------|--------|-------|----------------------------|------|
| | Z. hamaricu | ıs | Z. polo | nicus | Z. hamarici | Z. hamaricus | | nicus | Z. hamaricus | |
| | length | type | length | type | length | type | length | type | length | type |
| jl | $30 \pm 2 / 27 32$ | В | n/a | В | $24 \pm 1 \ / \ 23 - 24$ | В | n/a | В | $22 \pm 2 / 20 - 24$ | S |
| j2 | $21 \pm 1 \ / \ 19 - 23$ | S | n/a | S | $17\pm1\ /\ 1518$ | S | n/a | S | nds | - |
| j3 | $22\pm3\ /\ 19 – 25$ | S | n/a | S | $22\pm1\ /\ 2122$ | S | n/a | S | $19\pm1\ /\ 1819$ | S |
| j4 | $22\pm2\ /\ 1824$ | S | n/a | S | $22\pm1\ /\ 2023$ | S | n/a | S | $20 \pm 1 \; / \; 19 {}21$ | S |
| j5 | $21\pm1/20\!\!-\!\!23$ | S | n/a | S | $20\pm1 \ / \ 18 – 21$ | S | n/a | S | $19\pm1\:/\:1820$ | S |
| j6 | $20\pm1\:/\:19\!\!-\!\!22$ | S | n/a | В | $19\pm1 \ / \ 1821$ | S | n/a | S | $20\pm1\:/\:1920$ | S |
| z1 | not developed in Ze | ercon | | | | | | | | |
| z2 | $17\pm2\ /\ 1421$ | S | n/a | S | $20\pm1 \ / \ 18 – 20$ | S | n/a | S | $17 \pm 1 \; / \; 16 17$ | S |
| z3 | $22\pm2\ /\ 20\!-\!25$ | S | n/a | S | nds | - | nds | - | nds | - |
| z4 | $28\pm2\:/\:25\!\!-\!\!31$ | S | n/a | S | $31\pm1\ /\ 2933$ | В | n/a | S | $34\pm2 \ / \ 3237$ | В |
| z5 | $23 \pm 1 \ / \ 21 25$ | S | n/a | S | $20 \pm 1 \; / \; 19 \!\! - \!\! 21$ | S | n/a | S | $20 \pm 1 \; / \; 18 21$ | S |
| <i>z6</i> | $12\pm 1 \; / \; 11 15$ | S | n/a | S | nds | - | nds | - | nds | - |
| s1 | $15 \pm 1 \; / \; 13 16$ | S | n/a | S | nds | - | nds | - | nds | - |
| s2 | $20\pm1\:/\:1921$ | S | n/a | S | nds | - | nds | - | nds | - |
| s3 | $49\pm4/4355$ | В | n/a | В | nds | - | nds | - | nds | - |
| s4 | $25\pm2\ /\ 2129$ | S | n/a | S | $30\pm1\:/\:2832$ | В | n/a | S | $49\pm1\:/\:4851$ | В |
| s5 | $27\pm2\ /\ 2329$ | S | n/a | S | $30\pm1\:/\:2931$ | S | n/a | S | nds | - |
| s6 | $40\pm3\ /\ 36\!-\!44$ | В | n/a | S | $28\pm1\ /\ 2729$ | В | n/a | S | $6\pm0.5~/~5\!-\!6$ | S |
| rl | $14 \pm 1 \; / \; 13 16$ | S | n/a | S | nds | - | nds | - | nds | - |
| r2 | $22\pm1\ /\ 20\!-\!24$ | S | n/a | S | $42\pm3 \ / \ 38 \ -46$ | В | 32 | В | nds | - |
| r3 | $41\pm2\ /\ 39\!-\!45$ | В | n/a | n/a | $27\pm1/2627$ | В | n/a | n/a | nds | - |
| r4 | $20 \pm 2 \ / \ 17 - 23$ | В | n/a | S | nds | - | nds | - | nds | - |
| r5 | $29\pm2/2331$ | В | n/a | S | $14\pm1\ /\ 1316$ | S | n/a | S | nds | - |

TABLE 3. Length (mean \pm SD / range in μ m) and smoothness of podonotal setae in deutonymphs (D), protonymphs (P) and larvae (L) of *Zercon hamaricus* **sp. nov.** with comparison to *Z. polonicus* Błaszak, 1970.

n/a-data not available; nds-not developed in stage; type of seta: S-smooth; B-barbed.

Protonymph (n=3)

Idiosoma length 329-340, width (at level of anterior edge of opisthonotal shield) 235-252.

Dorsal idiosoma (Figure 17). Podonotal shield with 12 pairs of setae. All podonotal setae without hyaline endings. Lengths of podonotal setae of protonymphs summarized in Table 3. Seta j1 longest of *j*-series, other *j*-series setae of comparable length. Seta j1 with subapical barbs, other *j*-series setae smooth and pointed. Seta z4 longest of *z*-series, with subapical barbs, other *z*-series setae of comparable length, smooth and pointed. Setae of *s*-series of comparable length. Setae s4 and s6 with one subapical barbs. Seta s6 off the podonotal shield. Seta r2 on the podonotal shield, clearly

longer, with subapical barbs. Seta r5 off the podonotal shield, short, smooth and pointed. Podonotal shield covered entirely with irregular lines (delicately corrugated). Location of podonotal glands: gdj2 (pol) posterior to insertion of seta j2, anterior to line connecting insertions of setae j3; gdj4(po2) and gdz5 (po3) as in female and male. Location of podonotal poroids: ids4 antero-abaxial to insertion of seta s4; other poroids as in female. Opisthonotal shield with 14 pairs of setae. All opisthonotal setae without hyaline endings. Lengths of opisthonotal setae and longitudinal distances between insertions of setae in specific series of protonymphs summarized in Table 4. Setae J_{I} -J5 short, smooth and pointed. Setae Z1-Z3 short, smooth and pointed. Setae Z4 and Z5 clearly longer, with barbs located at about one third or one fourth from seta termination. Seta Z4 clearly reach beyond lateral edge of opisthonotum, and reach beyond insertion of Z5. Seta Z5 longer (1.1-1.4 times) than Z4. Distance between Z5 setae 97–99. Seta S2 shortest of S-series, smooth and pointed. Setae S3–S5 longer with subapical barbs. Seta S3 clearly longer (1.5–1.8 times) than S2. Setae S2– S4 clearly reach the insertions of next setae in series. Setae S3 and S4 of comparable length (S4 1.1-1.2 times longer than S3). Seta S5 longer (1.2–1.3 times) than S4. Seta R1 off the opisthonotal shield, short (14–16), smooth and pointed. Opisthonotal shield covered with similar pattern to line J4–S4. Remaining posterior surface of opisthonotum finely dotted. Posterodorsal cavities with undulated anterior margin; outer cavities crescent-like, inner ones more rounded. Location of opisthonotal glands: gdz6 (Po1) anterior to insertion of Z1; gdZ1 (Po2) anterior to line connecting insertions of setae Z2 and S3; gdZ3 (Po3) close to line connecting insertions of setae Z3 and Z4, close to insertion of Z4; gdZ4 (Po4) on the line connecting insertions of setae Z5 and S5, close to insertion of Jv5; gdJ3not visible. Location of opisthonotal poroids: *idz6* posterior to line connecting insertions of setae J1 and Z1, equidistant; idJ1 close and adaxial to line connecting insertions of setae J1 and J2; idJ2 on line connecting insertions of setae J2 and J4, closer to J2; idJ3 posterior to line connecting insertions of setae J4 and Z3; idJ4 anterior to line connecting insertions of setae J5 and Z4, closer to J5; idJ5 on the line connecting Z5 setae, closer to insertion of Z5; idZ4 close and anterior to insertion of seta Z5; ids6 close to antero-abaxial edge of opisthonotum, anterior to insertion of seta S2; idS1 anterior to insertion of seta S3, at the level of seta S2; *idS3* doubled, close to line connecting setae S3 and S4, at the level of seta Z3; *idS4* posterior to seta S4, at the level of seta Z4; *idR3* not visible.

Gnathosoma. Epistome (Figure 18) typically shaped for genus.

Ventral idiosoma (Figure 19). Setae r3 with subapical barbs. Sternal shield without ornamentation. Setae st1–st3 12–16, st5 off the sternal shield and shorter 6–7. Ventrianal shield with 9 smooth and pointed setae (Jv1 off the shield). Ventrianal shield without visible sculpture, with some corrugations. Setae Jv1, Jv2 and Zv2 of comparable length (14–17), para-anal setae longer 19–22, postanal seta 42–45 and Jv5 48–53 long. Two parallel lines of denser dots visible posterior to postanal seta (length of each line does not exceed distance between para-anal setae). Anus length 17–19, width 13–14. Location of ventral glands: gv2 abaxial to Jv1 setae, on the line connecting insertions of these setae; gv3 (posterior para-anal glands) posterior to line connecting para-anal setae; gp anterior to short peritreme, at the level of coxa III. Location of st1; iv2 posterior to insertion of st2; ivo1 and ivo2 located at level of Jv2–Zv2 setae, ivo1 close to anterior edge of ventrianal shield; ivo3 close to lateral edge of ventrianal shield, at the level of para-anal setae; ivo4 not visible; ivp single, antero-abaxial to insertion of seta Jv5.

Larva (n=6)

Idiosoma length 230–271, width (at level of setae S3) 191–243.

Dorsal idiosoma (Figure 20). Podonotal shield with nine pairs of setae. All podonotal setae without hyaline endings. Lengths of podonotal setae of larvae summarized in Table 3. All *j*-series setae of comparable length, smooth and pointed. Setae *z2* and *z5* short, smooth and of comparable

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length, seta z4 clearly longer, with one subapical barb. Seta s4 longest of podonotal shield, with one subapical barb. Seta s6 off the shield, diminutive. Location of podonotal glands: gdj4 and gdz5 not visible. Location of podonotal poroids: idj3, idj6, idz4 and ids4 not visible. Opisthonotal shield with 6 pairs of setae. All opisthonotal setae without hyaline endings. Lengths of opisthonotal setae in larvae summarized in Table 4. Setae J2 and S3 off shield, diminutive. Setae J3, J4 and S4 similar in length, diminutive, smooth and pointed. Setae Z3, Z4 and J5 with subapical barbs and curved terminations. Seta Z4 longer (1.3–1.4 times) than Z3. Seta J5 longest of opisthonotal shield, longer (1.3–1.5 times) than Z4. Location of opisthonotal glands: gdJ3 not visible; gdZ3 (Po3) anterior to line connecting insertions of setae S3, abaxial to insertion of J2; idJ3 adaxial to insertion of J2; idJ3 adaxial to insertion sof setae Z3, on the line connecting insertions of these setae; idJ5 between anterior and posterior pair of dorsal cavities; idR3 not visible. Podonotal and opisthonotal shields with irregular pattern, delicately corrugated. Soft cuticular area between dorsal shields with visible parallel corrugations. Posterodorsal cavities circular with smooth edges, arranged typically for the genus.



FIGURE 16. Zercon hamaricus sp. nov., deutonymph, ventral aspect.

| | | Р | | | | L | | | | |
|--------------------|-------------------------------|------|---------|-------|----------------------------|---------------------------|--------|------|-----------------------------|------|
| | Z. hamaricus | | Z. polo | nicus | Z. hamaricu | Z. hamaricus Z. polonicus | | | Z. hamaricus | |
| | length | type | length | type | length | type | length | type | length | type |
| Jl | $12 \pm 2 \ / \ 10 - 14$ | S | 8 | S | $11 \pm 1 / 9 - 13$ | S | 9 | S | nds | - |
| J1–J2 | $41\pm4\ /\ 3546$ | | 36–40 | | $31 \pm 1 \ / \ 29 \ -32$ | | 28 | | n/a | |
| J2 | $11 \pm 1 \; / \; 10 {-} 14$ | S | 8 | S | $8\pm1\ /\ 6\!-\!9$ | S | 9 | S | 7 ± 1 / 6–8 | S |
| J2–J3 | $32\pm4/2536$ | | 26–30 | | $24\pm3\ /\ 20 – 29$ | | 30 | | n/m | |
| J3 | $10\pm1~/~911$ | S | 8 | S | 6 ± 1 / 5–7 | S | 9 | S | $7\pm0.5\ /\ 67$ | S |
| J3–J4 | $31\pm5\ /\ 2541$ | | 22 | | $33\pm3\:/\:27\!\!-\!\!36$ | | 20 | | n/m | |
| J4 | $9\pm1 \ / \ 810$ | S | 11–14 | S | 6 ± 1 / 5–8 | S | 10 | S | $5\pm1\ /\ 5\!-\!6$ | S |
| J4–J5 | $27\pm3\ /\ 2334$ | | 18 | | $28\pm2\:/\:2529$ | | 20 | | n/m | |
| J5 | $10 \pm 1 \ / \ 8 - 13$ | S | 12–16 | S | $6 \pm 1 / 5 - 7$ | S | 10 | S | $106 \pm 3 \ / \ 102 - 110$ | В |
| Z1 | $13\pm 3 \; / \; 10 18$ | S | 8 | S | $12\pm1\;/\;10\!\!-\!\!13$ | S | 8 | S | nds | - |
| Z1–Z2 | $43\pm5 \ / \ 35{-}53$ | | 34–38 | | $30\pm2\ /\ 2734$ | | 30 | | n/a | |
| Z2 | $12\pm2\;/\;10\!\!-\!\!15$ | S | 8 | S | $9\pm1\ /\ 8\!-\!9$ | S | 8 | S | nds | - |
| Z2–Z3 | $32\pm4\ /\ 2840$ | | 24–28 | | $27\pm3 \ / \ 2432$ | | 24 | | n/a | |
| <i>Z3</i> | $11 \pm 1 / 10 - 13$ | S | 44–50 | В | 8 ± 1 / 7–9 | S | 38 | S | $58 \pm 1 \ / \ 58{-}61$ | В |
| Z3–Z4 | 52 ± 3 / $48-58$ | | 38-42 | | $40\pm1/40\!\!-\!\!41$ | | 36 | | n/m | |
| Z4 | $94 \pm 3 \; / \; 90 {-} 100$ | В | 56-62 | В | $80 \pm 4 \; / \; 75 86$ | В | 48 | В | $77\pm3\;/\;73{-}80$ | В |
| Z4–Z5 | $67 \pm 4 \ / \ 62 - 73$ | | n/a | | $51 \pm 1 \ / \ 50 - 52$ | | n/a | | n/m | |
| Z5 | $118 \pm 4 \ / \ 113 - 124$ | В | 64–68 | В | $100 \pm 5 / 94 - 108$ | В | 70 | В | 7 ± 1 / 6–7 | S |
| S1 | $25\pm1\ /\ 2327$ | В | n/a | n/a | nds | - | nds | - | nds | - |
| S1–S2 | $44\pm5\ /\ 36\!-\!50$ | | n/a | | n/a | | n/a | | n/a | |
| <i>S2</i> | $22\pm2\ /\ 20\ -26$ | S | 9 | S | $29 \pm 3 \ / \ 25 - 31$ | S | 30 | S | nds | - |
| S2–S3 | $45\pm4\ /\ 3952$ | | 36–40 | | $34\pm4\ /\ 30\!-\!40$ | | 30 | | n/a | |
| <i>S3</i> | $58\pm4\ /\ 50\!-\!64$ | В | 19–23 | S | $46 \pm 3 \ / \ 44 - 51$ | В | 41 | В | $6\pm0.5\ /\ 5\!-\!6$ | S |
| S3–S4 | $59\pm4\ /\ 5566$ | | 46–50 | | $39 \pm 1 / 38 41$ | | 30 | | n/m | |
| <i>S4</i> | $64\pm5 \ / \ 5472$ | В | 46–50 | В | $53 \pm 1 \; / \; 51 54$ | В | 46 | В | 5 ± 0.0 | S |
| S4–S5 | $57\pm2 \ / \ 54\!\!-\!\!61$ | | 46–50 | | $43\pm1/41\!-\!\!44$ | | 34 | | n/m | |
| <i>S5</i> | $85 \pm 3 \; / \; 81 88$ | В | 54–58 | В | $67 \pm 1 \ / \ 65 - 69$ | В | 52 | В | $7\pm0.4\ /\ 67$ | S |
| Jv5 | $56\pm2 \ / \ 5259$ | S | 26 | S | $50\pm2/4853$ | S | 34 | S | 7 ± 0.4 / 6–7 | S |
| Z5–Z5 | 157 ± 2 / 155–1 | 61 | 112 | 2 | 98±1/97–99 78 | | | n/m | | |
| idiosoma length | $427 \pm 8 / 414 - 414$ | 36 | 385-4 | 405 | $335 \pm 6 / 329 -$ | 340 | 30 | 2 | 252 ± 18 / 230-2 | 271 |
| idiosoma width | $323 \pm 13 / 311 - 3$ | 44 | 270-2 | 290 | 246 ± 9 / 235-2 | 252p | 17 | 2 | 222 ± 22 / 191-2 | :43 |

TABLE 4. Length (mean \pm SD / range in μ m) and smoothness of opisthonotal setae with longitudinal distances between insertions of setae in deutonymphs (D), protonymphs (P) and larvae (L) of *Zercon hamaricus* **sp. nov.** with comparison to *Z. polonicus* Błaszak, 1970 and notes on the body length/width and *Z5–Z5* distance.

nds-not developed in stage; n/m-not measured; n/a-not applicable or data not available; type of seta: S-smooth; B-barbed.

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Gnathosoma. Epistome (Figure 21) typically shaped for genus.

Ventral idiosoma (Figure 22). Sternal shield without ornamentation. Setae st1-st3 12–16. Ventrianal shield with three setae (Jv1, Jv2, Jv5 and Zv2 off the shield). Setae Zv2 and Jv5 6–9, Jv1 11–12, Jv2 18–19, para-anal setae 29–30 and postanal seta 50 long. Ventrianal shield subtriangular, bell-shaped (not measured). Anal opening poorly visible (not measured). Setae Z5 and S5 diminutive, abaxial to ventrianal shield, on the level of postanal seta. Location of ventral glands: gdZ4 (Po4) anterior to line connecting insertions of para-anal setae, abaxial to line connecting insertions of setae Jv5 and S5; gp close to lateral edge of the idiosoma, at the level of setae Jv1 and Zv2; gv3 not visible. Location of ventral poroids: ivo4 and ivp not visible.



FIGURES 17-18. Zercon hamaricus sp. nov., protonymph. 17. Dorsal aspect; 18. Epistome.

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The new species is named after the place of collection, Hamar-city, municipality and administrative center of Innlandet county in Norway.



FIGURE 19. Zercon hamaricus sp. nov., protonymph, ventral aspect.

Differential diagnosis

Zercon hamaricus **sp. nov.** belongs to a group of species with short JI-J4 setae and long J5 setae in females. Other species in this group are Z. forsslundi, Z. polonicus, Z. lindquisti, Z. columbianus, Z. fenestralis, Z. canadensis, Z. carolinensis, Z. lucidus and Z. mexicanus. Two subgroups of species can be distinguished with regard to SI-S3, r4-r5-s6 and RI-R6 setae (Table 5). The new species, Z. hamaricus, Z. forsslundi and Z. polonicus (the first subgroup) have the S3 setae smooth, and podonotal r4-r5-s6 setae similar to opisthonotal SI-RI-R6 setae. In the other species (the second subgroup) seta S3 is barbed, and r4-r5-s6 differ at least from some of R-series setae. Setae S2 and S3 are equal in length in Z. polonicus, S3 is slightly longer than S2 in Z. forsslundi, while in Z. hamaricus, S3 is at most 1.8 times longer than S2. In other species the S3/S2 range from 2.46 (Z. carolinensis) to 3.5 (Z. mexicanus). Therefore, we conclude that Z. hamaricus is most similar to Z. forsslundi and Z. polonicus.

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The females of Z. forsslundi, Z. polonicus and Z. hamaricus can be distinguished based on J5 range, the length and shape of the Z-series and S-series setae, the distance between setae Z5, and the location of gdZ3 (Table 6). In Z. forsslundi setae J1, J2 and J3 are generally located at the levels of corresponding Z-series setae and Z3 setae are at level of S4. The J-series and Z-series setae are displaced anteriorly in Z. polonicus and Z. hamaricus when compared with Z. forsslundi. The line connecting Z4 setae in Z. forsslundi is posterior to line connecting R5 setae, while in Z. polonicus and Z. hamaricus it is anterior to this line. The line connecting the insertions of J5 setae in Z. polonicus and Z4 are almost on the same line. Therefore, although the J5 setae are in general similar in length in these three species, these setae clearly reach the posterior edge of the opisthonotum in Z. forsslundi, which is not true in the other two species.



FIGURES 20-21. Zercon hamaricus sp. nov., larva. 20. Dorsal aspect; 21. Epistome.

Apart from Z. hamaricus, the immature stages are known in Z. canadensis (larvae and both nymphs), Z. polonicus (nymphs) and Z. columbianus (deutonymph). The characters useful to distinguish larvae and nymphs of these species are summarized in Table 7.

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TABLE 5. Distinguishing characters (females) of two subgroups of species including *Z. hamaricus* **sp. nov.**, *Z. forsslundi, Z. polonicus, Z. lindquisti, Z. columbianus, Z. fenestralis, Z. canadensis, Z. carolinensis, Z. lucidus* and *Z. mexicanus*.

| | Z. hamaricus, Z. forsslundi, Z. polonicus | Z. lindquisti, Z. columbianus, Z. fenestralis, Z. canadensis, Z. carolinensis, Z. lucidus, Z. mexicanus |
|---|--|--|
| S3 | smooth | barbed |
| S3: S2 | 1.3–1.8: 1 (Z. hamaricus) S3 slightly longer than S2 (Z. forsslundi acc. to Sellnick's description) 1: 1 (Z. polonicus) | 2.4: 1 (Z. carolinensis) 2.4–2.6: 1 (Z. fenestralis acc. to Evans' drawing) 2.5: 1 (Z. columbianus, Z. canadensis) 3.4: 1 (Z. lindquisti, Z. lucidus) 3.5: 1 (Z. mexicanus) |
| <i>SI–R1–R6</i> and <i>r4–r5–</i> <i>s6</i> | SI–RI–R6 similar to r4–r5–s6, smooth (Z. forsslundi, Z. polonicus) SI–RI–R6 similar to r4–r5–s6, barbed (Z. hamaricus) | SI-RI-R6 smooth, r4-r5-s6 barbed (Z. columbianus, Z. fenestralis, Z. canadensis, Z. carolinensis) RI-R6 smooth, SI and r4-r5-s6 barbed (Z. lindquisti) R2-R6 smooth, SI-R1 and r4-r5-s6 barbed (Z. mexicanus) R3-R6 smooth, SI-RI-R2 and r4-r5-s6 barbed (Z. lucidus) |



FIGURE 22. Zercon hamaricus sp. nov., larva, ventral aspect.

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| | Z. hamaricus | Z. forsslundi | Z. polonicus |
|--|---|--|---|
| J5 | does not reach beyond posterior edge of opisthonotum, almost reach inner dorsal cavities | reach far beyond beyond inner dorsal cavities and reach to or beyond posterior edge of opisthonotum | does not reach beyond posterior edge of opisthonotum, clearly rich inner dorsal cavities |
| <i>J5</i> and <i>Z4</i> | insertions of <i>J5</i> anterior to line connecting insertions of <i>Z4</i> | insertions of J5 on the line connecting insertions of Z4 | insertions of J5 anterior to line connecting insertions of Z4 |
| Z-series setae | Z1–Z3 of comparable length and clearly shorter than Z4–Z5 | <i>Z1–Z3</i> of comparable length and clearly shorter than <i>Z4–Z5</i> | Z1–Z2 of comparable length, Z3 clearly longer, Z4–Z5 longest |
| Z3 | smooth | smooth | barbed |
| Z5 length | 101–115 | 84 | 70–74 |
| distance between Z5 setae, location of Z5 insertions | 214–225, insertions abaxial to outer posterodorsal cavities | 176, insertions abaxial to outer posterodorsal cavities | 120, insertions adaxial to outer posterodorsal cavities |
| S-series | S2 shortest, S3 longer (1.3–1.8 times) than S2 | S2 and S3 short and of similar length | S2 and S3 short and of similar length |
| gdZ3 pores | abaxial to outer posterodorsal cavities, distant from cavities, on the line J5–Z4, clearly closer to Z4 | in front of outer posterodorsal cavities, close to cavities, slightly anterior to the line J5–Z4, slightly closer to Z4 | in front of outer posterodorsal cavities, close to cavities, behind the line J5–Z4, evenly spaced between J5 and Z4 |

TABLE 6. Distinguishing characters of females of Z. hamaricus **sp. nov.**, Z. forsslundi and Z. polonicus. Measurements in μ m.



FIGURES 23-24. Zercon hamaricus sp. nov., comparison of J-series setae. 23. Females; 24. Males.

| | Z. hamaricus | Z. polonicus | Z. canadensis | Z. columbianus |
|------------|-----------------------------------|-------------------------|----------------------------|--------------------------|
| larva | S3 and s6 short and of comparable | n/a | s6(15) clearly longer than | n/a |
| | length (5–6) | | <i>S3</i> (6) | |
| | Z3 58–61 | | Z3 - 31 | |
| | Z4 73–80 | | Z4 - 38 | |
| | J5 102–110 | | J5-50 | |
| protonymph | Z2 and Z3 short and of comparable | Z3 smooth and clearly | Z3 barbed and clearly | n/a |
| | length (7–9) | longer (38) than Z2 (8) | longer (31) than Z2 (6) | |
| | <i>S2</i> (25–31) | S2 (30) | S2 (6) | |
| deutonymph | Z3 smooth and short $(10-13)$ | Z3 barbed and long (44- | Z3 barbed and long (42) | Z3 smooth and short (12) |
| | gdZ1 on line $Z2-S3$ | 50) | gdZ1 on line S2–S3 | gdZ1 on line S2–S3 |
| | r4-r5-s6 similar to $S1-R1-R6$ | gdZ1 on line Z3–S3 | s6 differ from r4-r5 and | r4-r5-s6 differ from S1- |
| | | r4–r5–s6 similar to S1– | <i>S1–R1–R6</i> | <i>R1–R6</i> |
| | | <i>R1–R6</i> | | |

TABLE 7. Distinguishing characters of immature stages of *Z. hamaricus* **sp. nov.**, *Z. polonicus*, *Z. canadensis* and *Z. columbianus*. Measurements in μm.

n/a-stage description not available.

Discussion

Apart from the characteristic setation of the *J*-series in this species group, in most species there is a clearly visible anterior displacement of the insertions of some opisthonotal setae, especially *J5* and *Z4*, which is unusual in the Zerconidae. Setae *J5* clearly reach to or beyond the posterior edge of the idiosoma only in *Z. fenestralis* and *Z. forsslundi*, in which setae *J5* and *Z4* are at the same level and posterior to (*Z. forsslundi*) or on the line (*Z. fenestralis*) connecting *R5*. In all other species in this species group, setae *J5* do not reach the posterior edge of the idiosoma. In *Z. lindquisti* the *Z4* setae are on the level of *R5* with *J5* clearly anterior (at the level of *R3*). In *Z. carolinensis* the insertions of *Z4* and *J5* setae are at the same level but anterior to a line connecting *R5*. In all other species the insertions of *Z4* are more or less anterior to the line connecting *R5*, while the insertions of *J5* are more or less anterior to the line connecting *R5* and the level of *R3* in *Z. lindquisti*). The anterior displacement of opisthonotal setae described above creates a large area between setae *J5* and the dorsal cavities, which is also found in *Z. ostovani* Javan et al., 2018 (Javan *et al.* 2018). In most of the above-mentioned species (except *Z. polonicus* and *Z. forsslundi*), pore *gdZ3* is distant from the dorsal cavities.

Błaszak (1970) pointed out the close relationship of *Z. polonicus*, *Z. forsslundi* and *Z. fenestralis*, described from Poland (Tatra Mountains, Pieniny Mountains), Sweden (northern provinces Ångermanland and Lapland) and Alaska (Point Barrow) respectively, apparently because setae *J1–J4* are short and *J5* is clearly longer in these species (Evans 1955; Sellnick 1958). Sellnick (1958) separated *Z. forsslundi* and *Z. fenestralis* in his key because of the location of *gdZ3 (Po3)*. However, females of these species are the only ones in Sellnick's paper in which setae *J5* are long and *J1–J4* are similar in length and clearly shorter than *J5*. In the description of *Zercon rafalianus* Błaszak & Łaniecka, 2007 collected in Delaware (US) the authors indicated its similarity to *Z. canadensis* (found in Quebec and Ontario, Canada) and *Z. fenestralis*. The main difference between these species is that seta *J5* is considerably longer than *J4* in *Z. canadensis* and *Z. fenestralis* and short and similar to *J4* in *Z. rafalianus*. Halašková (1969, 1977) described several species with the *J5* considerably longer than *J1–J4*: the above-mentioned *Z. canadensis*, *Z. lindquisti* (found in Quebec) and *Z. carolinensis* (North Carolina, US). Using material collected in Canada (Harrington, S Quebec), Halašková (1977) supplemented the description of *Z. columbianus* by Berlese (1910) from Columbia (Missouri, according to Halašková 1977). This species also has *J1–J4* of similar

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length and considerably shorter than J5. Two other recently described species with similar J-series setation, Z. mexicanus Ujvári, 2011 and Z. lucidus Sikora, 2014, were found in the alpine zone of Central Mexico (on the volcano Popocatepetl) and Georgia (US, Appalachian Mountains, Tesnatee Gap) respectively. At these localities, supplemented by Sikora (2014), most of the species in which females have short J1–J4 and clearly longer J5 setae were found along the Atlantic Coast of US (Great Appalachian Valley) and Eastern Canada. One species (Z. fenestralis) was found in Alaska. Zercon forsslundi and Z. hamaricus were found in northern Europe, while at lower latitudes, the Central European Z. polonicus and the Mexican Z. mexicanus inhabit mountainous areas.

The other interesting aspect of Zerconidae morphology in the species group that we discuss here is the sexual dimorphism. It is generally known that in Zerconidae the intraspecific differences between males and females are expressed in the size of idiosoma and the morphology of the venter. In Z. forsslundi, Z. hamaricus and Z. polonicus males are in general similar to females with regard to opisthonotal chaetotaxy with one exception-the length of setae J5. In Z. polonicus the difference is not as great as in the other two species. Sellnick (1958) drew attention to differences between the length of J5 in males and females of Z. forsslundi, and claimed it as the first observation of clear sexual dimorphism in dorsal chaetotaxy in Zercon. In Z. hamaricus the situation is the same-setae J5 are short and similar to JI-J4 in males, while in females the J5 are clearly longer (4.2–5.1 times, 4.6 on average) than J1–J4 (Figures 23–24). According to Sellnick's (1958) drawing, seta J5 in the Z. forsslundi female is about five times as long as JI-J4. Błaszak (1974) pointed out differences between the relative length of $J_1 - J_4$ and J_5 in males and females of Z. polonicus. In this species setae J5 in females are 4–5 times longer than J_1 –J4, while in males J5 is only 2–3 times longer than J_1 – J4. Differences between sexes with regard to opisthonotal chaetotaxy have also been found in Z. mexicanus, Z. wisniewskii and Z. shevtchenkoi (Błaszak & Skorupski 1992; Ujvári 2011a; Faleńczyk-Koziróg et al. 2018). In the latter two species, however, all J-setae are short in males, while in females setae $J_1 - J_3$ are short and $J_4 - J_5$ are considerably longer. Ujvári (2011a) in addition predicted dimorphism in J-series setae in Z. quetzalcoatl (only male described, same locus typicus as in Z. mexicanus).

Differences between males and females of Zercon can be also expressed in the setation of the anterior edge of the ventrianal shield. The presence or absence of seta Zv1 is one of the first alternatives in dichotomous keys for Zerconidae (e.g. Halašková 1970, 1977; Błaszak 1974; Sikora 2014; Urhan & Karaca 2019). Interestingly, in males of Z. canadensis, Z. columbianus and Z. michaeli Halašková, 1977 there is only one pair of setae (Zv1 absent) on the anterior edge of ventrianal shield, while in females there are two pairs—therefore Halašková (1977) pointed out that this character can only be used for females in key to Canadian species of Zercon, which was confirmed by Sikora (2014). Moreover, in Z. quetzalcoatl the intraspecific variation was found in males, which often lacked Zv1, while in some individuals both Jv1 and Zv1 were present and normally positioned (Ujvári 2011a).

In their observations on Coprozerconidae, Moraza & Lindquist (1998) commented that differences between the fixed digit of the chelicera in the males and females of Zerconidae and Epicriidae had earlier gone unnoticed, which inspired Călugăr (2004–2006) to study this in the Zerconidae. In five studied species of *Zercon* and one of *Prozercon*, Călugăr (2004–2006) found that the fixed digit of the chelicera in males is straighter than that in females, and it is bifurcated. As in *Coprozercon scopaeus* Moraza & Lindquist, 1998 this can be regarded as adaptation to architocospermous semen transfer (Alberti 1988, 2002). Ujvári (2011b) found similar differences between the fixed digit in males and females in other species of *Zercon* as well as other genera of Zerconidae, and stated that it seems to be a general feature in the family. In *Z. hamaricus* we also found that chelicerae of males differ from those of females—in the male, the fixed digit is straighter than in female and is bifurcated, while in the female the chelicera has both digits curved distally.

Ujvári (2011b) found sexual dimorphism in the shape of some hypostomal and palp-trochantral setae in some species of Zerconidae. In some other genera of Nearctic Zerconidae, Sikora (2014) noted that posterolateral parts of the peritrematal shields are fused with the ventrianal shield at the level of R1/R2 setae in males, but are separated in females, and added some other remarks on morphological differences between sexes in e.g. *Amerozercon*, *Bakeras*, *Blaszakiella*, *Blaszakzercon*, *Bledas*, *Boreozercon*, *Macrozercon*, *Microzercon*, *Neomicrozercon*, *Paramixozercon* and *Parhozercon*.



FIGURE 25. Zercon hamaricus **sp. nov.**, opisthonotum of deutonymph moulting to female. D in subscript – deutonymph characters, F in subscript – female characters, white arrows – female's posterodorsal cavities, gray arrows – deutonymph's posterodorsal cavities.

Our knowledge of intraspecific morphology of both sexes in Zerconidae is limited as in relatively few taxa males and females have been described. Fortunately, both sexes are known in *Z. forsslundi* and *Z. polonicus*, which makes it possible to compare them with *Z. hamaricus*. However, the immature stages are known only in *Z. polonicus* (except larvae) and newly described species (full ontogeny), making broad comparison of these closely related species impossible. It is worth mentioning that all larvae of *Z. hamaricus* were obtained from our laboratory cultures, making the full ontogeny description possible. The developing fourth pair of legs was visible inside two of our prepared larvae, and in three of our deutonymphs the adult female chaetotaxy is visible (Figure 25). It is interesting that in *Z. hamaricus* and *Z. polonicus* the *J*-setae in deutonymphs are more similar to those of the male than those of the female. Therefore, the next step should be a study of the full ontogeny of *Z. forsslundi* and supplementing the description of *Z. polonicus* with the larva.

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