Description of *Pseudocandona serfozoi* n. sp. (Crustacea, Ostracoda, Candonidae) from Romania

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Abstract. *Pseudocandona serfozoi* n. sp. of the *zschokkei*-group of *Pseudocandona* s. l. is described. The new species was collected from the hyporheic waters of the Târnava Mare river and from several nearby springs of the Harghita mountains in Romania. The new species has a trapezoidal carapace and second male antennae with well-developed male bristles. It differs from the other four known trapezoidal species of *Pseudocandona* by that latter character and the morphology of the hemipenis. The taxonomic position of the trapezoidal species of the *zschokkei*-group is discussed.

Key words. *Pseudocandona*, *zschokkei*-group, Ostracoda, new species, stygobiont.

1. Introduction

The genus *Pseudocandona* was established by Kaufmann (1900), who extracted it from the genus *Candona* Baird, 1845. The most recent and widely accepted redefinition of *Pseudocandona* was given by Meisch (1996, 2000). The name *Pseudocandona* was recently challenged by Karanovic (2005), who argued that *Pseudocandona* is a junior synonym of *Typhlocypris* Vejdovski, 1882. However, her revision applied only to the nomenclature, as the diagnostic characters and the composition of the genus were not changed.

The relation of the species groups within *Pseudocandona* s. l. is far less clear. Meisch (1996) divided *Pseudocandona* s. l. into 5 groups: the *caribbeana-*, *compressa-*, *rostrata-*, *eremita-*, and *zschokkei*-groups. Karanovic (1999) added a sixth group, the *prespica*-group. Later Karanovic (2005) revised the systematics of these subgroups. She divided the genus *Typhlocypris* into two sub-genera: *Typlocypris* Vejdovski, 1882 and *Pseudocandona* Kaufmann, 1900. The latter is identical with the *compressa*-group of species, while the former one should include the other four groups of species. Distinctive characters are the number of setae on the second segment of the mandibular palp, the chaetotaxy of the male antenna and the length of the short seta (h_1) on the last segment of the cleaning leg. Karanovic (2005) also incorporated the *zschokkei*-group into the *eremita*-group.

The validity of Karanovic's (2005) system, however, remains controversial. Danielopol (pers. com.) draws the attention to the importance of the ontogenetical development of the valve shape and ornamentation, which defines a system different from that of Karanovic (2005). The taxonomic importance of the valve characters was briefly stressed by Namiotko & Danielopol (2004).

Meisch (2000) defined the *zschokkei*-group on the basis of the trapezoidal shape of the valves. Four trapezoidal *Pseudocandona* species are presently known: *P. zschokkei* (Wolf, 1920), *P. rouchi* Danielopol, 1978, *P. delamarei* Danielopol 1978, and *P. pescei* (Karanovic, 2005). *P. zschokkei* is widespread in Western Europe, as it has been reported from Austria, Germany, Switzerland, France, Belgium, the Netherlands, Luxembourg and Sweden. The other three species are only known from their type localities: *P. delamarei* and *P. rouchi* each from a single (but not the same) locality from France, while *P. pescei* was recorded from Greece. Recently, a new trapezoidal *Pseudocandona* species was collected from Romania. In this paper I present a description of the new species, with comparative analysis of the distinctive characters.

2. Material and Methods

Samples were collected during 2001, 2002, 2003 and 2004 by the present author. The samples from springs were collected with a hand-plankton-net. The samples from the river interstitial habitat were collected with a hand-plankton-net from the water that had infiltrated into the small holes dug on the river banks (Karaman-Chappuis method). The samples were preserved in formaldehyde (4% final concentration) or in 70% ethanol. The ostracods were picked out under a stereo-microscope, the dissected limbs were mounted on slides in glycerol and their valves were preserved in tubes with 70% ethanol (with the exception of the holotype and allotype and a juvenile, the valves of which were stored dry in micropaleontological cells). Non-dissected animals were preserved in ethanol tubes.

The valves of the ostracods preserved in formaldehyde have decalcified strongly, so this method proved to be improper to apply for samples which would have to be kept for a longer time (several weeks) before processing.

SEM photos were taken from the valves of two adult females and were not preserved. Drawings were made under the light microscope using a camera lucida.

The chaetotaxic notation follows the model proposed by Broodbakker & Danielopol (1982), as revised for the second antenna by Martens (1987) and the thoracopods by Meisch (1996 and 2000). The terminology used for the valve ornamentation follows Sylvester-Bradley & Benson (1971).

Abbreviations used in text and figures: A, anterior; a, outer lobe of hemipenis; A1, antennule (1st antenna); A2, 2nd antenna; b, inner lobe of hemipenis; CR, caudal ramus (uropod, furca); D, distal; d, seta on Pr of L6; d_1, d_2, d_p, setae on Pr of L7; E, endopod; e, seta on EI of L6; EI-EIV, 1st to 4th podomeres of E; Ex, exterior; Exo, exopod; f, seta on EII of L6; g, setae on EIII of L6 and L7; Ga, anterior claw of CR; G_M (G_m), major (minor) claw on EIV of A2; Gp, posterior claw of CR; G_{1-3}, anterior and internal claws (or setae) on EIII of A2; H, height; h, medial lobe of hemipenis; h_{1-3}, setae (or claws) on EIV of L6 and L7; In, interior; L, length; l, large (relative L of setae or claws); L5, maxilliped (5th limb); L6, walking leg (6th limb); L7, cleaning leg (7th limb); LV, left valve; M, sclerotized internal process of hemipenis; m, medium (relative L of setae or claws); Md, mandibula (3rdlimb); Mdp, mandibular palp; Mx1, maxillula (1st maxilla, 4th limb); P, posterior; pl, plumose (seta); Pr, protopod; RV, right valve; s, small(relative L of setae or claws); s_a (s_p),anterior (posterior) seta of CR; S_{1-2}, plumed setae on the 1st podomere of Mdp; t_{1-4}, internal setae on EII of A2 (t_2 and t_3 transformed in males into sensory bristles); W, width; Y, aesthetasc on EI of A2; y_{1-3}, aesthetascs on EII, EIII and EIV of A2, respectively; y_a, aesthetasc on theterminal podomere of A1; z_{1-3}, external setae (or claws) on EIII of A2; α, ß, γ, special setae on the 1st, 2nd, and 3rd podomeres, respectively. Podomeres of a given limb used as a reference for evaluation of the relative L of setae and claws: A1, 4th podomere; A2, EI; Mdp, 3rd podomere; Mx1 palp, 2nd podomere; L6, EII; L7, EI.

3. *Pseudocandona serfozoi* n. sp.

Derivation of name: This species is named after the uncle and aunt of the author, Pál and Gabriella Serfőző, who assisted him during the field work.

Type locality: The holotype, allotype and a number of paratypes were collected from the hyporheic habitat of the River Târnava Mare, in the village of Subcetate (coordinates: 46°27'12" N; 25°26'37" E, altitude: appr. 800 m), Harghita county, Romania. The samples were taken right next to the bridge crossing the river, where the latter leaves the village. The Târnava Mare at Subcetate is a cool, fast-flowing upland river. Its bottom consists of stones, fine gravel and sand.

Further paratypes were collected from several springs within the catchment area of the Izvoarele stream, a tributary of the River Târnava Mare, close to Izvoarele (approx. coordinates of the village: 46°27'20"; 25°26'53"). All these springs arise no farther than 10 kms from the village of Subcetate, at an altitude of approx. 900 m a.s. l.

The whole area (Fig. 1) is located on the western slopes of the Harghita Mountains, which form the southernmost parts of the inner, volcanic chain of the Eastern Carpathians.

Holotype: One adult male collected from the hyporheic habitat of the River Târnava Mare at Subcetate village, 2nd June, 2004. Valves preserved dry in a micropaleontological cell, and limbs mounted on a slide in glycerol.

Allotype: One adult female collected from the same site in April, 2003. Valves preserved dry in a micropaleontological cell, limbs mounted on a slide in glycerol.

Paratypes: One undissected adult male preserved in ethanol, collected together with the holotype (GZS21, 7/11).

Two juveniles preserved in ethanol, collected together with the holotype (GZS21, 7/7)

The limbs of three females (GZS40, GZS41 and GZS48) mounted on slides in glycerol. The valves of the GZS40 and GZ41 females were decalcified, thus having become improper for SEM-work. The valves of the GZS48 female were used for SEM photography and are figured in the present paper. Sampling dates and places: GZS40: 21.IV.2001, spring on the catchment area of Izvoarele stream; GZS41, GZS48: IV.2002., the River Târnava Mare at Subcetate, hyporheic habitat.

Limbs of two adult (GZS49, GZS63) and one sub-adult (GZS42) males mounted on slides in glycerol. Valves had been decalcified, so they were useless. Sampling dates and places: GZS49: V.2001., spring on the catchment area of Izvoarele stream; GZS63: IX.2002., spring on the catchment area of Izvoarele stream; GZS42: IV.2002., the River Târnava Mare at Subcetate, hyporheic habitat.

A last stage (A1) juvenile male, valves preserved dry on a micropaleontological cell, limbs mounted on a slide in glycerol. It was collected from the hyporheic habitat of the River Târnava Mare at Subcetate village, Romania 2nd June, 2004.

The limbs of 12 other juveniles mounted on slides in glycerol were collected partly from the River Târnava Mare at Subcetate, and partly from springs at the Izvoarele stream catchment area.

The limbs of another adult female (P3) were mounted on a slide; several photos were taken of them and drawings were made. Unfortunately, this slide was later broken by accident. SEM photos were also taken from the valves of this female. Date and place of the collection: IX. 2002., the River Târnava Mare at Subcetate, hyporheic habitat.

The type material is preserved in the Hungarian Natural History Museum, Budapest.

Diagnosis

Carapace rather small, distinctly trapezoidal in lateral view, with slight sexual dimorphism. Dorsal margin straight, almost

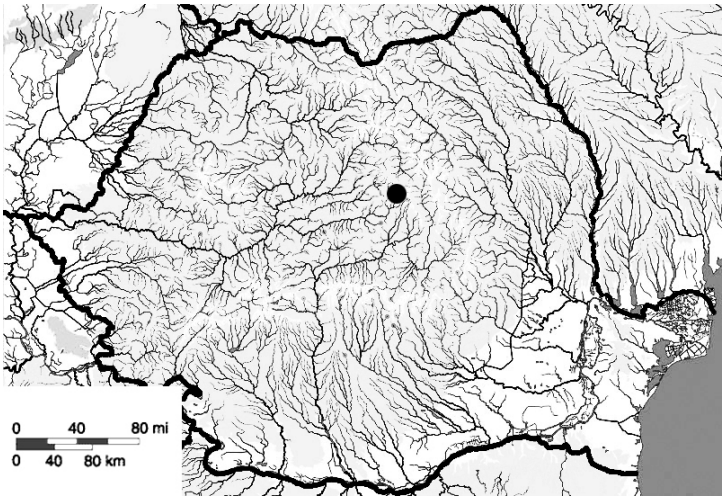


Fig. 1. Map of Romania, showing the sampling sites.

horizontal, gently sloping towards the anterior end; antero-dorsal and postero-dorsal corners of the valves are marked. There is a prominent reticular pattern of pits (foveolae) on the whole surface of the valves. Female A2 with 3 markedly long claws: G_1, G_3, and G_M. G_1 about 3x as long as the anterior margin of EII+EIII; G_2 claw only about half as long as G_1. Male A2 with well developed male bristles; G_2 and G_M claws well developed, about equally long. G_2 about 3x as long as the combined length of the EII and EIII segments; G_1 claw less than half as long as G_2, z_1 claw hardly exceeding half the length of G_2. Postero-ventral setal group of the 2nd segment of mandibular palp with 3 setae. Seta h_1 of the cleaning leg short and recurved, hook-like. Hemipenis with three lobes, a, h, and b. The medial (h) lobe high and rounded, not two-folded, inner (b) lobe with a slightly concave distal margin.

Description

Carapace: Female (Fig. 2: A, B, C; Fig. 3: C). Both valves trapezoidal in lateral view. Left valve (Fig. 2: A) slightly larger than the right one, its dorsal margin straight, slightly oblique. Antero-dorsal and postero-dorsal corners well developed. Anterior margin widely rounded, posterior margin only slightly arched, long and oblique, postero-ventral corner sharply rounded. Ventral margin slightly concave in the middle. The valve is the highest at the beginning of the posterior third, the greatest height is 53% of the valve length. Anterior vestibulum equals approx. 10% of the total valve length. Posterior vestibulum narrow, wide only at the postero-ventral corner. Right valve (Fig. 2 B) slightly smaller and more slender than the left one, its maximal height equalling 51% of the valve length; dorsal margin horizontal, the posterior margin sloping less strongly than that of the right valve, the postero-dorsal corner being ~~is~~ even sharper, its posterior end, however, being also rounded. In all other characters the right valve resembles the left one.

Carapace in dorsal view (Fig.3: C) rather slender, elongated. The left valve overlaps the right one at both ends. Carapace ~~is~~ widest in the middle, the greatest width equalling 35% of its length. The anterior end is pointed, the posterior one is sharply rounded.

The whole surface of the valves (Fig. 2 C) is covered with rather large and deep pits (foevolae), which form a reticular pattern. There are sparse setae on the whole surface of the valves. The arrangement of the central muscle scars is representative of the subfamily Candoninae. The fused marginal zones are narrow, with straight, regularly distributed marginal pore canals.

Measurements

Holotype. LV: L=0.83 mm, H=0.48 mm. RV: L=0.82 mm, H=0.44 mm.

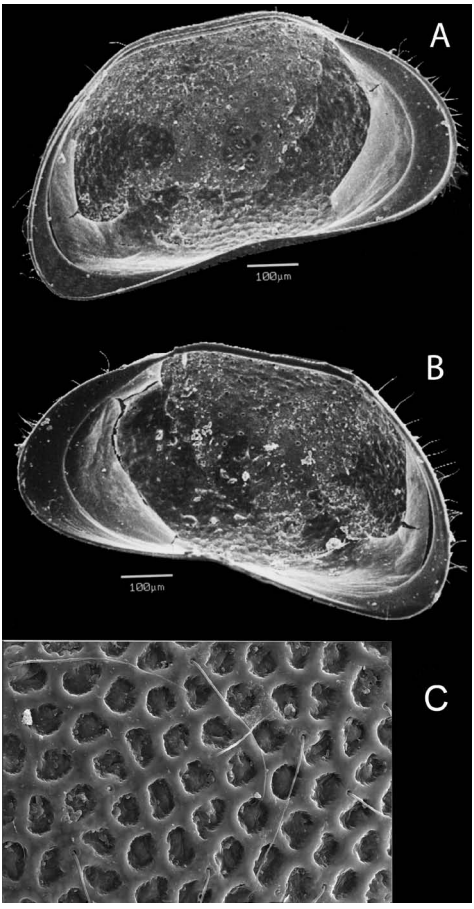


Fig. 2. A and B: Left and right valves of the female (specimen P3); C: surface ornamentation of a female valve (GZS48).

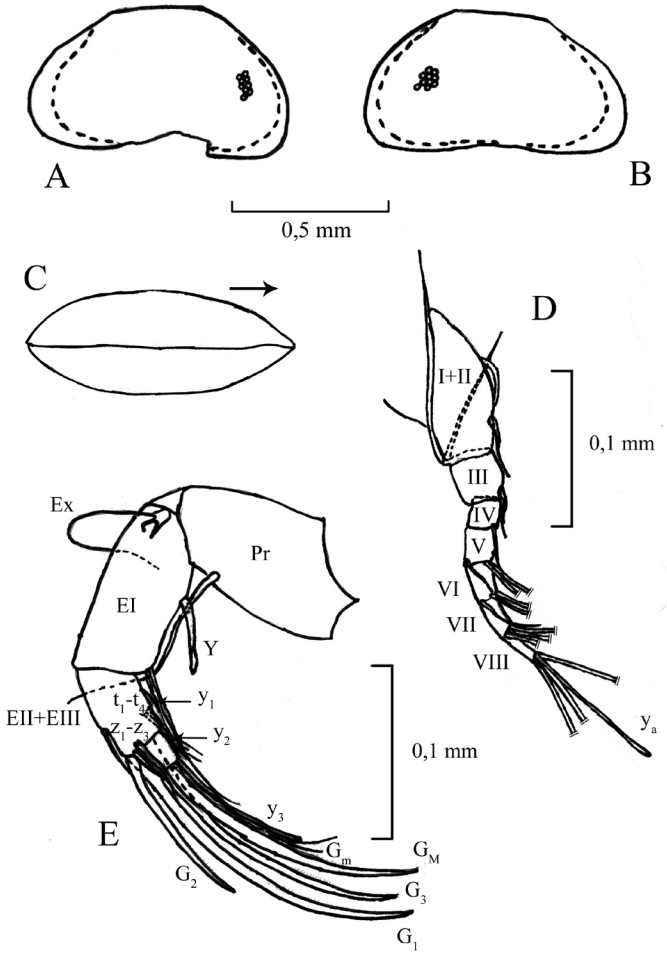


Fig. 3. A, B: Male left and right valves (holotype, outer view); C: Carapace of female (allotype, dorsal view). D: antennula (P3), E: female antenna (P3).

Specimen "P3". LV: L=0.82 mm, H=0.45 mm. RV: L=0.82 mm, H=0.43 mm. Maximal width of the carapace: 0.28 mm.

Male (Fig. 3A, B). Size, shape and ornamentation of the valves are remarkably similar to those of the female. However, the posteroventral corner of the carapace is broader and more rounded than in the female.

Antennula (Fig. 3 D): I+II: A-1l (pl)-1m, P-2l/ III: A-1m/ IV: A-1m/ V:A-2l, P-1m/ VI: A-2l, P-1s/ VII: A-3l-1s (α) /VIII: D - 3l - y_a. y_a is 3.8 as long as the distal (VIII) segment.

One male paratype (GZS42) has only 1 anterior seta on the IVth podomere and only two long anterior setae on the Vth A1 podomere.

Antenna. Female (Fig. 3 E): Pr: P-1l/ Exo: D -2s-1l/ EI: P-Y, P (D)1s-1m/ EII+III: A-1s, P-y_1, P (In) - 4s (t1-4), D (A) - 1m (G_2), D (P)-y_2, D (Ex) -1s (z_1)-2m (z_2-z_3), D (In) - 2l (G_1, G_3)/ EIV: D (A) - 1l (G_M), D (P)-y_3-1l, D (In)-1m (G_m). Most probably there should be a further seta on EIV, as is characteristic for the Cyprididae, but I did not manage to see it. Female „P3" has 2 setae instead of one on the anterior margin of the EII+III segment.

Relative lengths of claws (compared to EI): G2: 1, G1: 2, G3: 1.9, GM: 1.6, Gm: 1

The adult female possesses 3 z-setae (z_1 short and thick, claw-like) and 4 t-setae standing close to each other.

Male (Fig. 4 A, B): Pr: P - 1l/ Exo: D -2s -1l/ EI: P-Y, P (D) - 1s - 1m/ EII: A (D) - 1s, P-y_1, D (In) - 2s (t_1, t_4) - 2m (t_2, t_3)/ EIII: D (P) - y_2, D (A) - 1l (G_2), D (Ex) - 2s (z_2, z_3) - 1m (z_1:G), D (In) -2m (G_1, G_3)/ EIV: D (A) - 1l (G_M), D (P) - y_3 -1m, D (In) -1m (G_m), D -1m.

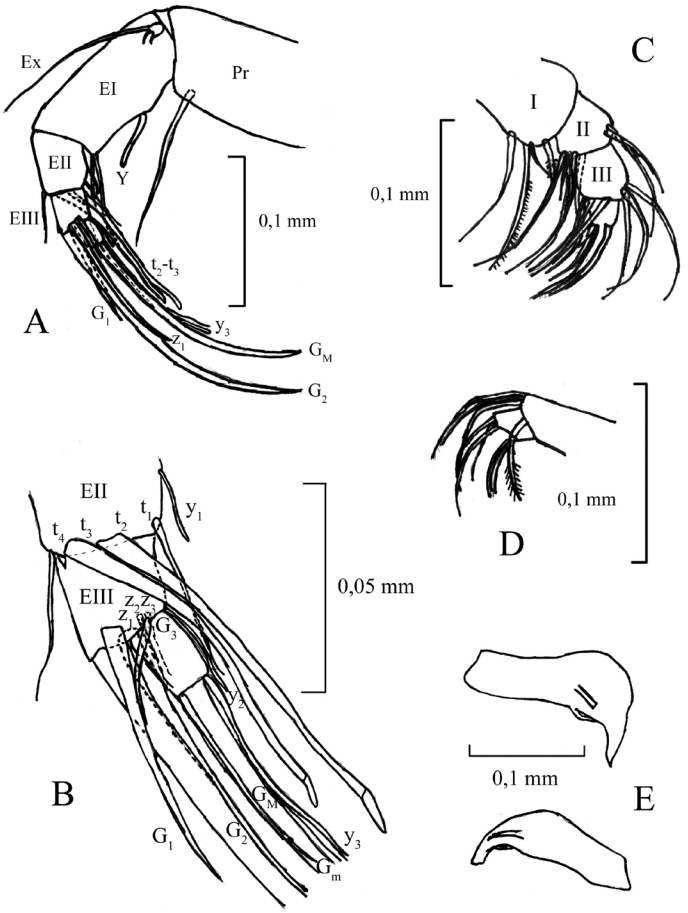


Fig. 4. A, B: male antenna (GZS49), C: mandibular palp (P3), D: maxillular palp (GZS48), E: right and left male clasping organs (GZS49).

EII and EIII separated. All 4 t-setae standing far from each other. Setae t_2 and t_3 transformed into well-developed male bristles; t_4 short, rudimentary. G_3 seta-like, reduced, z_1 transformed into a claw, which slightly exceeds half the length of G_2. Antenna with only 2 long claws (G_2 and G_M). Relative lengths of claws (compared to EI): G_1: 0.7, G_2: 1.9, z_1: 1, G_M: 1.5, G_m: 0.6.

Mandibular palp (Fig. 4 C): I: In -1l - 1l (S1, pl)-1s (α) - 1s (S2, pl)/ II: In - 1s (β) - 3l, D - 1l, Ex-1m-1l/ III: In - 1s - 1l, D - 1l - 1l (γ) / Ex-3l/IV: D -2s - 1m - 2l (G, pl).

The second segment of the mandibular palp presents internally a group of 3 long setae. This segment also presents a short, smooth seta called „β „ very close to the above mentioned setal group, a further, isolated long seta, and externally a pair of setae. Distal claws of the mandibular palp are 2.3x as long as the EIII segment.

Maxillular palp (Fig. 4 D): I: Ex-3l (pl) - 1l/ II: D - 2l - 4m.

L5 (maxilliped): Protopodite with an anterior „a" seta and two exterior setae („b" and „d"). Exopodite with two plumed setae. Female: Endopodite with 3 distal setae. Male: Endopods transformed into clasping organs (Fig. 4 E). The right palp is larger, distally strongly inflated, helmet shaped. The left one is more slender and more regularly curved.

L6 (walking leg) (Fig. 5 A): Pr: A (D) - 1m (d)/ EI: A (D) - 1s (e)/ EII: A (D)-1m (f)/ EIII: A (D) - 2s (g_1, g_2)/ EIV: P - 1s (h_3), D-1s (h_1)-1l (h_2: G). Terminal claw strongly curved, serrated, 3.8x as long as EII.

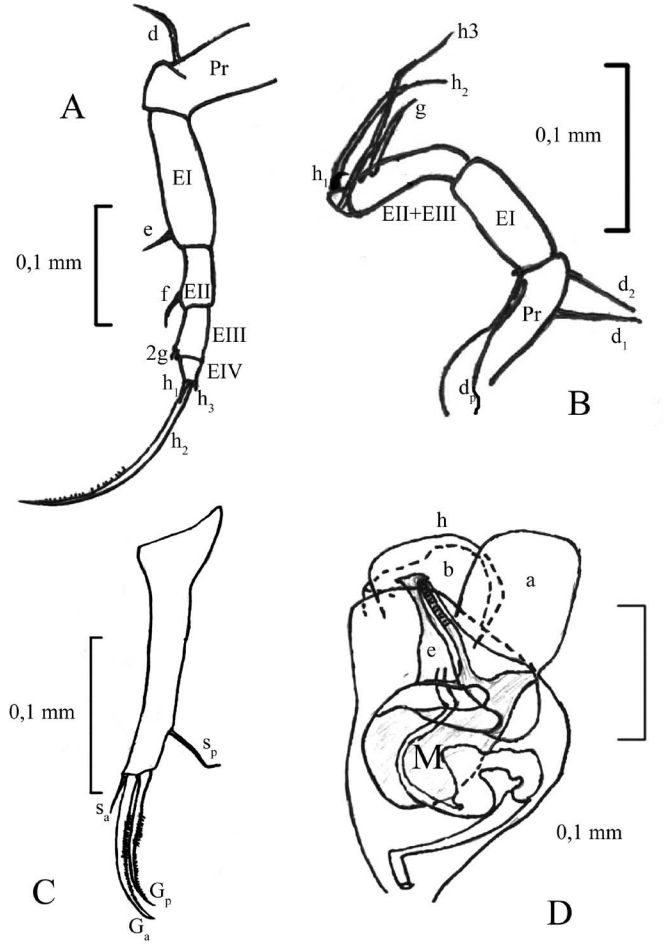


Fig. 5. A: walking leg (6th limb) (GZS48); B: cleaning leg (7th limb) (GZS48); C: caudal ramus (P3); D: hemipenis (holotype).

L7 (cleaning leg) (Fig. 5 B): Pr: Ex - 2m (d_1, d_2: pl), In - 1l (d_p:pl)/ EII+III: P -1m (g:pl)/ EIV: D -1s (h_1) - 2l (h_2, h_3:pl). Distal seta „h_1" on EIV is short, strongly curved. EII and EIII segments are fused.

Caudal ramus (Fig. 5 C) slightly curved; claws strongly curved, serrated. S_a- and S_p-setae present.

Zenker`s organ with 7 spinous whorls.

Hemipenis (Fig. 5 D) with 3 distal lobes. The outer lobe (a) is distinctly protruding, square-shaped, with rounded corners. The medial lobe (h) is also protruding, its distal margin is rounded. Inner lobe (b) with a slightly concave distal margin. The bursa copulatrix (e) is cornet shaped. Distal part of the M-process only partially sclerotized, its end being characteristically crenulated.

Genital lobe of the female: Moderately convex, with a very short and blunt protrusion.

Distribution and ecology

Pseudocandona serfozoi n. sp. is presently only known from a very restricted area and is possibly endemic to the Harghita Mountains in Romania. But as the European stygofauna is rather poorly known, the real distribution of the species cannot be assumed with certainty.

The new species is probably a stygobiont, as it was found living in the hyporheic habitat of an upland river. Its repeated occurrence in springs probably means that *P. serfozoi* n. sp. lives also in phreatic waters, and that specimens accidentally washed out to the surface can survive at least for some time in

springs. From the many samples taken from the springs of the region, I conclude that *P. serfozoi* n. sp. does not form large, self-sustaining populations in springs.

Although the sample number is not large, the sex ratio of *P. serfozoi* n. sp. populations approaches 1:1 (see "Type material"), which means that the reproduction of the known populations is most probably fully bisexual.

In the hyporheic samples taken from the River Târnava Mare, the new species co-occurs with the stygophilous-stygobiont ostracods *Nannocandona faba* Ekman, 1914, *Nannocandona stygia* Sywula, 1976, *Cryptocandona vavrai* Kaufmann 1900, and *Kovalevskiella* aff. *phreaticola* (Danielopol, 1965) and with the ubiquist ostracod *Pseudocandona albicans* (Brady, 1984). Co-occuring harpaticoid species, as identified by the present author, are the following ones: *Attheyella crassa* (Sars, 1863), *Attheyella wierzejvskii* (Mrazek, 1893), *Bryocamptus echinatus* (Mrazek, 1893), *Bryocamptus typhlops* (Mrazek, 1893), *Bryocamptus zschokkei* (Schmeil, 1893), *Elaphoidella elaphoides* (Chappuis, 1923) and *Paracamptus schmeili* (Mrazek, 1893).

The springs from which the new species was collected have a rather rich ostracod fauna, characterized by crenophilic-crenobiont species like *Candona neglecta* Sars, 1987, *Candona sanociensis* Sywula, 1971, *Cryptocandona vavrai* Kaufmann, 1900, *Cypria ophtalmica* (Jurine, 1820), *Cyclocypris laevis* (O. F. Müller, 1776), *Cyclocypris helocrenica* Fuhrmann & Pietrzeniuk, 1990, *Eucypris pigra* (Fischer, 1851), *Psychrodromus olivaceus* (Brady & Norman, 1889) and *Cavernocypris subterranea* (Wolf, 1920).

Taxonomic discussion

Applying the species-group definition given by Meisch (1996, 2000), the new species belongs to the *zschokkei*-group of *Pseudocandona*, a group which is characterised by having trapezoidally shaped and distinctly ornamented valves. The zschokkei-group includes the following species, all of which are stygobionts: *P. zschokkei* (Wolf, 1920); *P. delamarei* Danielopol, 1978; *P. dichtliae* (Brehm, 1953); *P. rouchi* Danielopol, 1978; *P. pescei* (Karanovic, 2005) and *P. serfozoi* n. sp.

P. delamarei Danielopol, 1978 has an almost rectangular, more elongated carapace, which is larger (0.97-1.1 mm vs. 0.82 -0.83 mm in *P. serfozoi* n. sp.), and its valve surface ornamentation is finer (Danielopol, 1978b).

The carapaces of *P. zschokkei* (Wolf, 1920), *P. rouchi* Danielopol, 1978 and *P. pescei* (Karanovic, 2005) are similar in size, ornamentation, and shape (in lateral view) to *P. serfozoi* n. sp. (Danielopol 1978b, Meisch 2000, Karanovic 2005). However, there are small differences, which allow the distinction of *P. zschokkei* and *P. pescei* from *P. serfozoi* n. sp. even on the base of the valve morphology alone. *P. zschokkei* has a considerably wider carapace in dorsal view than *P. serfozoi* n. sp. *P. pescei* has a straight, but oblique dorsal valve margin, and the posterior part of both valves is shorter; the posterior margin is steeper than in *P. serfozoi* n. sp.

The valves of *P. rouchi* and *P. serfozoi* n. sp. appear very similar in the stereomicroscope, making the distinction of the two species on the base of valve characters alone at least uneasy.

The SEM-photo in Danielopol (1978b) shows the valve surface ornamentation of *P. rouchi* to be finer than that of the new species. However, the validity of this character needs further confirmation.

P. serfozoi n. sp. clearly differs from all other known trapezoidal *Pseudocandona* species in the morphology of the male antenna. Indeed, each of the other four species of the *zschokkei*-group, i.e. *P. zschokkei*, *P. delamarei*, *P. rouchi* and *P. pescei*, has simple (untransformed) t-setae (Meisch 2000, Danielopol 1978b, Karanovic 2005), while in *P. serfozoi* n. sp. these setae are transformed into fully developed so-called "male bristles".

In the males of both *P. rouchi* and *P. delamarei* the z1-setae on the antenna is transformed into a claw which is almost as long as G_2 and G_M; the antenna therefore carries 3 long claws. The males of *P. pescei* have 4 long antennal claws, the G_1-claw being as long as G_2 and G_M, and z_1 being only slightly shorter. The males of *P. serfozoi* n. sp. (like those of *P. zschokkei*) have only two long claws on the

antenna, as the z_1-claw is much shorter than G_2 and G_M.

The males of *P. serfozoi* n. sp. also differ in the morphology of the hemipenis. The males of *P. zschokkei*, *P. rouchi* and *P. delamarei* have a two-folded medial (h) lobe, these folds being designated as h_1 and h_2, respectively (Meisch 2000, D.L. Danielopol pers. com.), while *P. serfozoi* n . sp. has a simple, rounded medial (h) lobe, and also a simple, slightly concave inner (b) lobe. According to Karanovic (2005), *P. pescei* has a two folded inner (b) lobe, although the two figures of the hemipenis in her article appear somewhat contradictory, the medial (h) lobe being high on her first, and very low on her second figure.

The females of *P. rouchi* and *P. serfozoi* n . sp. are not easyly distinguished in practice. Both sexes of *P. rouchi* have a single t-seta on the antenna, while the females of *P. serfozoi* n . sp. exhibit the usual 4 t-setae. However, this character needs high magnification to be seen. The co-occurrence of these two species is very improbable, anyway, and the presence of a single male is enough for an easy identification.

Brehm (1953) described *Pseudocandona dichtliae* as a new trapezoidal ostracod species, with both a subdivided male antenna and male bristles (as *P. serfozoi* n. sp.). However, according to the original description, *P. dichtliae* is distinctly larger (1.15-1.2 mm), and the central part of the valves is smooth, without any ornamentation. This excludes the synonym with *P. serfozoi* n. sp. *P. dichtliae* is an uncertain species, and according to Meisch (2000) it is probably a junior synonym of *Pseudocandona sarsi* (Hartwig, 1899), a species belonging to the *rostrata*-group. It is therefore excluded from the following discussion about the taxonomy of *zschokkei*-group of species.

4. Taxonomy of the *zschokkei*- and *eremita*-species groups of *Pseudocandona* s. l.

4.1. The *zschokkei*- and *eremita* -groups share the following characters.

(a) The right valves of the adults are trapezoidal with an always straight - but not always horizontal - dorsal margin (right valve reniform, elongated or at least sub-trapezoidal in the other species-groups of *Pseudocandona*). In some species, the dorsal margin of the right valve is so strongly oblique (see Namiotko et al. 2004 for the description of *P. sywulai* and Namiotko & Danielopol 2004 for the description of *P. marmonieri*) that the valve appears triangular in lateral view, but even in that case, the antero-dorsal angle is always well developed.

(b) The ornamentation of the adult valves appears very similar in the *eremita*- and *zschokkei* -groups of species (Namiotko & Danielopol, 2004), although the species of the *eremita*-group exhibit only small foveae that are restricted to the central part of the valves. By contrast, the adults of the *rostrata*- and *compressa*-species groups have entirely smooth valves, with the remarkable exception of *P. insculpta* (G.W. Müller, 1900): the latter species, which belongs to the *compressa*-group, has strongly ornamented valves. Ornamentation of adult valves may be considered ~~is~~ a paedomorphic character in *Pseudocandona,* as juveniles of all species have ornamented (pitted) valves. The species of the *rostrata*- and *compressa* -groups lose their valve foveae during the last moult, while the adults of the species of the *eremita*- and *zschokkei* -groups have the same ornamentation than that of the juveniles (Danielopol 1978b, Namiotko & Danielopol 2004).

(c) The carapace shape of the A-3 juveniles as well as that of the younger juveniles is triangular in some species of the *zschokkei*-group, this being due to the fact that the arched dorsal margin of the left valve overgrows the right valve. The trapezoidal carapace shape of *P. rouchi* and *P. serfozoi* n. sp. appears only in the A-2 stage. The juveniles of *P. delamarei* (and possibly *P. zschokkei*) are distinctly trapezoidal even in the A-3 stage (Danielopol, pers. comm.). The carapace shape of the juveniles *P. pescei* are unknown. The A-3 juveniles of the other species groups of *Pseudocandona* s. l. are never triangular. The carapaces of the A-3 juveniles of the *eremita*-group are also triangular (Namiotko & Danielopol 2004), resembling those of the A-3 juveniles of the *zschokkei*-group.

(d) According to Namiotko & Danielopol (2004), in the *eremita*-group, the width of the anterior vestibulum in relation to the valve size does not increase notably during the last moult, this in contrast to the species of the remaining groups of species of the genus *Pseudocandona* s. l. Arrested growth is also seen in the *zschokkei*-group, with, however, one remarkable exception: the adult males of *P. delamarei* possess a relatively much wider anterior vestibulum than both the adult females and juveniles of both sexes (Danielopol 1978b).

(e) The long terminal claws of the female and male antennas are long or very long in both groups (at least 2x as long as the combined EII+EIII segments, but in most cases 2.5-3 x as long), with the exception of *P. puteana* (Klie, 1931). In the other groups of *Pseudocandona* s. l., the long claws are almost always shorter than the double length of EII+EIII (Namiotko & Danielopol, 2004).

(f) All species of the *eremita*- and *zschokkei*-groups are stygobionts, while all the other species of *Pseudocandona* s. l. are epigeic or, at the utmost, stygophilic, as for instance *P. sarsi* (Hartwig, 1899) and *P. albicans* (Brady, 1864).

4.2. The *eremita*- and *zschokkei*-groups share the following characters with some of the other species-groups of *Pseudocandona*:

(a) the setal group of the 2nd segment of the mandibular palp carries 3 setae in the species of the *eremita*-, *zschokkei*-, *rostrata*-, and *caribbeana* -groups (there are 4 and 5 setae in that setal group in the *prespica*- and *compressa*-groups, respectively);

(b) the male antenna has only the seta z_1 transformed intto a claw; z_2 remains a seta in all groups, except the *compressa*-group;

(c) the very short and strongly recurved, hook-like h_1-seta on the distal segment of the cleaning leg characterises the *zschokkei*-, *eremita*- and *rostrata*-groups of *Pseudocandona* (Karanovic 2005).

4.3. The morphology of the new species provides further arguments pointing towards the close phylogenetic relationhip between the *eremita*- and *zschokkei*-groups.

Presently, *P. serfozoi* n. sp. is the only species of the *zschokkei*-group with fully developed male antennas (EII and EIII segments separated, male bristles present). Indeed, the remaining species of the *zschokkei*-group lack the male bristles and retain the fused EII+EIII segments.

By contrast, *P. pretneri* Danielopol, 1982 is the only species of the *eremita*-group which has a male antenna without male bristles and fused EII+EIII segments. All the other 10 species of the *eremita*-group of which males are known, have fully developed male antennae. Moreover, the size and proportions of the male antennal claws of *P. serfozoi* n. sp. meet the form which characterizes the males of the *eremita*-group. The relatively short z_1-claw that characteristizes *P. serfozoi* n. sp. was considered a diagnostic character of the *eremita*-group (Namiotko & Danielopol, 2004), present also in *P. zschokkei*, but not so in *P. delamarei*, *P. rouchi*, and *P. pescei*, nor so in the species of the other groups of *Pseudocandona* s. l.

Furthermore, the hemipenis of *P. serfozoi* n. sp., although it has its own specific shape, has the same general structure than that of the males of the *eremita*-group.

5. Is the *zschokkei*-group a monophyletic lineage?

Karanovic (2005), mainly relying on the limb morphology, incorporated the *zschokkei*-group into the *eremita*-group, arguing that neither the shape of the valves nor the arrested development of the male antenna have a systematic value.

However, the following characters suggest that the trapezoidal species of the *zschokkei*-group might form an independent lineage, which, however, is closely related to the *eremita*-lineage.

(a) The left valves of the species of the *zschokkei*-group all have straight dorsal margins, and the antero-and postero-dorsal corners of the left valve are always well developed. The left and right valves are only very slightly asymmetrical in all 5 species. On the contrary, in the *eremita*-group, the dorsal margin of the left valve is at least

gently arched, or highly peaked, while antero- and postero-dorsal corners do not exist. The asymmetry between the arched or prominently triangular left valve and the trapezoidal right valve varies from the moderately expressed ("subtriangular" forms) to the very prominent (high triangular forms) in the *eremita* -group.

(b) In 4 of the 5 species of the *zschokkei*-group (nothing has been published about the ontogeny of *P. pescei*), the last two juvenile stages (A-1 and A-2) are trapezoidal, similarly to those of the adults. In contrast, the A-1 and A-2 juveniles of the *eremita*-group have triangular carapaces, this even in the the populations where the adults possess 'only' subtriangular carapaces (Iepure et al. 2007).

(c) In the *zschokkei*-group, valve surface ornamentation of the adults varies from distinctly (*P. serfozoi* n. sp. and *P. pescei*) to moderately expressed (*P. delamarei)*, while the valve ornamentation is finer (but also considerably variable) in the *eremita*-group. Unlike the species of the *eremita* -group, none of the five known trapezoidal species of the *zschokkei*-group has a valve ornamentation that is restricted to the central parts of the valves.

The taxonomic validity of the two following characters has been somewhat challenged by the description of *P. serfozoi* n. sp.

(d) Only *P. serfozoi* n. sp. has fully developed male antennae (A2), while the four other species of the zschokkei-group have 'arrested' male antennae (penultimate segment undivided and without male bristles). It is widely recognised that the arrested development of the male antenna has no systematic value, as it sporadically also occurs in other candonine lineages (e.g., *Pseudocandona insculpta* of the *compressa*-group, *Pseudocandona illiesi* (McKenzie, 1971), the genus *Baicalocandona* Mazepova, 1976), and also so in the *eremita*-group (*P. pretneri*). However, the unusually frequent occurrence of the arrested male antennal development among the trapezoidal *Pseudocandona* species remains unexplained, except if it is assumed that they represent a independent lineage. The hypogeic life form is not a satisfactory explanation in itself: the *eremita*-group species are also exclusively hypogeic, and still the majority of them have fully developed male antenna. Moreover, all species of the following, mostly or exclusively hypogeic genera - *Cryptocandona* Kaufmann, 1900, *Schellencandona* Meisch, 1996 and the majority of *Mixtacandona* Klie, 1938 species - have fully developed male antennas. (*Mixtacandona juberthiae* Danielopol (1978a) has no male bristles, but the EII and EIII A2-segments are separated in the males (Danielopol, 1978a)). However, it is important to notice that the "arrested" male antennas of *P. zschokkei, P. delamarei, P. rouchi* and *P. pescei* do not share a common A2-chaetotaxy and claw ratios, but each have their own peculiarities.

(e) As the two-folded medial lobe (h) of the hemipenis is not present in *P. serfozoi* n. sp., and its presence is uncertain in *P. pescei*, while it is seen in *P. delamarei*, *P. rouchi* and *P. zschokkei*, it is here suggested that the taxonomic value of this character needs to be checked through future investigations. It could be argued that the trapezoidal versus triangular carapace form (in fact, this concerns only the form of the left valve, ~~as~~ the right valve being basically trapezoidal in both the *eremita*- and *zschokkei*-groups) has no taxonomic importance, as the trapezoidal and triangular valve shapes occur repeatedly in a number of candonine lineages, so for instance in the genera *Mixtacadona, Schellencandona, Baicalocandona*. The triangular carapace shape obviously evolved independently through convergent evolution in those three lineages.

(f) The vast majority of the trapezoidal and triangular candonine species are known from underground waters or ancient lakes, which also corroborates the hypothesis of convergent evolution.

However, a character which is certainly the product of convergence on a higher systematic level could be a valid character at a lower systematic level. The trapezoidal versus triangular carapace (left valve) shape is a useful character for species identification. Some species of the *eremita*-group (Iepure et al. 2007) show remarkable variability even within a single population, but they never have trapezoidal left valves, as the

dorsal margin remains always at least gently arched, and the antero-dorsal and postero-dorsal corners are inconspicuous. The question arises whether the trapezoidal versus triangular carapace shape might point out the existence of two closely related lineages just above the species level.

The ontogenetical trajectory of the carapace shape corroborates the importance of the valve shape, as A-2 and A-1 juveniles are triangular in the *eremita*-group, but trapezoidal in the *zschokkei*-group. However, A-3 juveniles are sub-triangular in *P. rouchi* and *P. serfozoi* n. sp., but very conspicuously trapezoidal in *P. delamarei* (and possibly also in *P. zschokkei*). This could indicate that different ontogenetical trajectories, and therefore also a number of 'cryptic' phylogenetic lineages might exist in the *zschokkei*-group. More investigations, mainly involving the early juvenile stages, are needed to clarify this point.

(g) Schäfer (2005) recently described *Cornucandona fischeri* from lower Miocene sediments in Switzerland. Its distinctive characters are two large, horn-like expansions on the left valve, the right valve being trapezoidal. A-3 juveniles are sub-triangular in shape. The species has a trapezoidal carapace, its size and ornamentation are also similar to the species of the *zschokkei*-group. According to the author, *Cornucandona fischeri* lived in a lacustrine environment, together with species of two ostracod genera which in the present-day faunas comprise hypogeic representatives, i.e. *Microdarwinula* Danielopol, 1968 (known also from semi-terrestrial habitats) and *Mixtacandona* Klie 1938 (all extant representatives are true stygobionts). These data point towards a close relationship of *Cornucandona fischeri* with the *zschokkei*-group of *Pseudocandona* s. l.

6. Conclusion

It is here suggested that the *eremita*- and *zschokkei*-groups are phylogenetically closely related. Moreover, the ontogeny of the valve shape, the stronger valve ornamentation, and the very high frequency of arrested development of the male antennae tend to indicate that the *zschokkei*-group of species possibly forms an independent evolutionary lineage.

At the present state of knowledge, I see two possibilities worth to be considered for the systematics of the *zschokkei*-group and the genus *Pseudocandona* (sensu Meisch 2000) in general.

(a) To extract the closely related *eremita*- and *zschokkei*-groups from the rest of *Pseudocandona* s. l. under the name *Typhlocypris* Vejdovski, 1882. (Similarly, a number of the remaining species-groups of *Pseudocandona* s. l. might be raised to the genus level).

(b) If the here suggested monophyly of the *zschokkei*-group will obtain further support in the future, then the erection of a separate genus for those trapezoidal species will also be an option.

However, the resolution of this complex problem is beyond the scope of the present paper. So I decided to provisionally assign *P. serfozoi* n. sp. to *Pseudocandona* sensu lato.

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References

Brehm, V., 1953. *Candona dichtliae* nov. sp., eine neue Ostracodenspezies. *Anzeiger der Österreichischen Akademie der Wissenschaften, mathematisch-naturwissenschaftliche Klasse* 90 (2): 21-22.

Broodbakker, N. W. & Danielopol, D. L. 1982. The chaetotaxy of Cypridacea (Crustacea, Ostracoda) limbs: proposals for a descriptive model. *Bijdragen tot de Dierkunde* 52: 103-120.

Danielopol, D. L., 1978a. Ostracodes hypogés du Sud de la France. 1. *Mixtacandona juberthieae* n. sp. *International Journal of Speleology* 9: 235-249.

Danielopol, D. L., 1978b. Über Herkunft und Morphologie der Süsswasser-hypogäischen Candoninae (Crustacea, Ostracoda). *Sitzungsberichte. der österreichischen Akademie der Wissenschaften, mathematisch-naturwissenschaftliche Klasse, Wien, Abt. 1*, 187: 1-162.

Danielopol, D. L., 1982. Nouvelles données sur les Candonidae (Ostracoda) hypogées de Romanie et Yugoslavie. *Bulletin du Musée national d'histoire naturelle de Paris* 4: 369-396.

Iepure, S., Namiotko, T. & Danielopol, D. L., 2007. Evolutionary and taxonomic aspects within species group *Pseudocandona eremita* (Vejdovski) (Ostracoda, Candonidae). *Hydrobiologia.* 585: 159-180.

Karanovic, I., 1999. Two interesting species of Candoninae (Crustacea, Ostracoda) from Montenegro (SE Europe). *Bulletin de l'Institut Royal des Sciences naturelles de Belgique (Biol.)* 69: 47-56.

Karanovic, I., 2005. On the genus *Typhlocypris* Vejdovski, 1882 (Crustacea: Ostracoda: Candonidae), with description of two new species. *Systematics & Biodiversity* 3: 375-406.

Kaufmann, A., 1900. Cypriden und Darwinuliden aus Schweitz. *Revue Suisse de Zoologie* 8: 209-423.

Martens, K., 1987. Homology and functional morphology of the sexual dimorphism in the antenna of *Sclerocypris* Sars, 1924 (Crustacea, Ostracoda, Megalocypridinae). *Bijdrag tot de Dierkunde* 57: 183-190.

Meisch, C., 1996. Contribution to the taxonomy of *Pseudocandona* and four related genera, with the description of *Schellencandona* nov. gen., a list of the Candoninae genera, and a key to the European genera of the subfamily (Crustacea, Ostracoda). *Bulletin de la Socété des naturalistes luxembourgeois* 97: 211-237.

Meisch, C., 2000. Freshwater Ostracoda of Western and Central Europe. In: Süsswasserfauna von Mitteleuropa 8/3, Spektrum Akademischer Verlag Gustav Fischer. 522 pp.

Namiotko, T. & Danielopol, D. L., 2004. Review of the *eremita*-species group of *Pseudocandona* Kaufmann (Ostracoda, Crustacea) with the description of a new species. *Revista Española de Micropaleontologia* 36: 109-125.

Namiotko, T. & Danielopol, D. L. & Rada, T., 2004. *Pseudocandona sywulai* sp. nov. a new stygobitic ostracode (Ostracoda, Candonidae) from Croatia. *Crustaceana* 77: 311-331.

Schäfer, P., 2005. Beiträge zur Ostracoden- und Foraminiferen-Fauna der Unteren Süßwassermolasse in der Schweiz und in Savoyen (Frankreich). 2*. La Chaux (Kanton Waadt, Schweiz. *Senkenbergiana lethaea* 85: 95-117.

Sylvester-Bradley, P. C & Benson, R. H., 1971. Terminology for surface features in ornate ostracodes. *Lethaia* 4: 249-286.