

PSEUDOCANDONA SYWULAI SP. NOV., A NEW STYGOBITIC
OSTRACODE (OSTRACODA, CANDONIDAE) FROM CROATIA

BY

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ABSTRACT

Pseudocandona sywulai sp. nov. (Ostracoda, Candonidae) collected in the cave Đuderina, Croatia, is described and illustrated. The new species belongs to the *eremita*-species group of the genus *Pseudocandona* Kaufmann and can be distinguished from its congeners belonging to this group mainly by the shape and size of the carapace as well as by the chaetotaxy of the second antenna. It resembles *P. eremita* (Vejdovský, 1880) sensu lato very closely. A comparative morphological analysis of the species belonging to this group is presented also.

RÉSUMÉ

Pseudocandona sywulai sp. nov. (Ostracoda, Candonidae) trouvée dans la grotte Đuderina, en Croatie, est décrite et illustrée. La nouvelle espèce appartient au groupe d'espèces *eremita* du genre *Pseudocandona* Kaufmann et peut être distinguée des congénères de ce groupe, principalement par la forme et la taille de la carapace ainsi que par la chétotaxie de la seconde antenne. Elle apparaît très proche de *P. eremita* (Vejdovský, 1880) sensu lato. Une analyse morphologique comparée des espèces appartenant à ce groupe est également présentée.

INTRODUCTION

The genus *Pseudocandona* Kaufmann, 1900 (Ostracoda, Candonidae) as recently redefined by Meisch (1996, 2000) can be best distinguished in the subfamily Candoninae Kaufmann, 1900 by the following characters: (a) surface of

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adult valves smooth or pitted and usually bearing stiff setae, (b) externo-distal (γ) seta on the 2nd segment of the mandibular palp smooth (not plumose), (c) rudimentary branchial plate on maxilliped with 2 setae, (d) cleaning leg with the protopodite bearing 3 setae, missing the medial seta (f seta) on the penultimate segment and with the terminal segment of this limb set with 2 long and one short setae, (e) Zenker's organ with 7 rings of spines, (f) hemipenis with flat and weakly sclerotized M-process. According to Meisch (1996), five species-groups can be recognized in *Pseudocandona*: (1) the *carribeana*-, (2) the *compressa*-, (3) the *eremita*-, (4) the *rostrata*-, and (5) the *zschokkei*-group. Recently, Karanovic (1999) introduced a sixth group: the *prespica*-group. Distinction of these groups mostly relies on the shape of the carapace and on the number of setae in the setal group situated on the 2nd segment of the mandibular palp. Based solely on the former character, the group *eremita* is reasonably well distinguished by its triangular carapace. This group was introduced and characterized by Danielopol (1978, 1982). According to this author (Danielopol, 1982), the following combination of characters is diagnostic for the *eremita*-group: (a) carapace triangular in lateral view, (b) dorsal margin of left valve with a hump that overlaps the right valve, (c) valves with shallow pits mostly in the central area, (d) carapace of medium length (0.7-1.1 mm), (e) second antennae with sexual dimorphism in apical chaetotaxy: females have two large claws G_1 and G_3 , one reduced claw G_2 (c. $1/2 \times G_1$), three external z-setae and the G_m claw equalling $2/3 \times$ claw G_M ; males have reduced claws G_1 and z_1 (indicated as G_2 and G_3 , respectively, in Danielopol, 1982) from which z_1 amounts to $1/2$ of G_2 (as G_1 in Danielopol, 1982), (f) male clasping organs asymmetrical, the right one being larger, (g) cleaning leg with 3 setae on the protopodite, undivided 2nd and 3rd endopodial podomeres, long distal seta on the penultimate podomere and with the short seta on the terminal podomere being larger than $1/2$ of the length of this segment, (h) furca with long posterior seta and with distal claws bearing two groups of fine spinules on their posterior margins, (i) Zenker's organ with seven rosettes of spikes from which the distal one is funnel-shaped, (j) female genital lobe flat in the area of the genital opening and posteriorly with a finger-like process, (k) hemipenis with well developed inner lobe and with cornet-like bursa copulatrix.

Eight stygobitic species were assigned to the *eremita*-group by Danielopol & Hartmann (1986): *P. cavicola* (Klie, 1935), *P. dispar* (Hartmann, 1964), *P. eremita* (Vejdovský, 1882), *P. pretneri* Danielopol, 1978, *P. puteana* (Klie, 1931), *P. serbani* Danielopol, 1982, *P. trigonella* (Klie, 1931), and *P. szoecsi* (Farkas, 1958), the last one with two subspecies, i.e., *P. s. szoecsi* (Farkas, 1958) and *P. s. pannonicola* (Löffler, 1960). However, as the detailed morphology of the appendages of these two subspecies (originally described as two species) remains unknown, a separation at the specific level is provisionally maintained in the present paper.

Recently, one of us (T. R.) collected, in a cave near Split (Croatia), several specimens of a triangular *Pseudocandona* that we consider a new species. In this paper we provide a description of *Pseudocandona sywulai* sp. nov., with a comparative morphological analysis of the species belonging to the *eremita*-group of the genus *Pseudocandona*. The present paper also constitutes a contribution to the knowledge of the very poorly known freshwater ostracode fauna of Croatia.

METHODS

Samples were collected with a benthos net and sorted animals were fixed in 75% ethanol. Dissected specimens were mounted in glycerine on slides, with the valves stored dry in micropalaeontological cells, whereas un-dissected material was preserved in 97% ethanol and kept in a glass tube. Carapace dimensions were measured to the nearest 0.01 mm under the microscope at 500 \times . Valves and limbs were examined and figured using a compound microscope fitted with a drawing tube at magnifications of 200 \times , 400 \times or 1000 \times (oil immersion). The chaetotaxy of the limbs was coded according to the model proposed by Broodbakker & Danielopol (1982), as revised for the second antenna by Martens (1987), and extended to include the thoracopods by Meisch (1996). Names for the limbs were used according to Meisch (2000). The nomenclature of Danielopol (1969), as reviewed by Meisch (2000), was used for hemipenis morphology.

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; d₁, d₂, 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; G_a, anterior claw of CR; G_M (G_m), major (minor) claw on EIV of A2; G_p, posterior claw of CR; G₁₋₃, anterior and internal claws (or setae) on EIII of A2; H, height; h, medial lobe of hemipenis; h₁₋₃, 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 (3rd limb); Mdp, mandibular palp; Mx1, maxillula (1st maxilla, 4th limb); P, posterior; Pr, protopod; RV, right valve; s, small (relative L of setae or claws); s_a (s_p), anterior (posterior) seta of CR; S₁₋₂, plumed setae on the 1st podomere of Mdp; t₁₋₄, internal setae on EII of A2 (t₂ and t₃ transformed in males into sensory bristles); W, width; Y, aesthetasc on EI of A2; y₁₋₃, aesthetascs on EII, EIII and EIV of A2, respectively; y_a, aesthetasc on the terminal podomere of A1; z₁₋₃, external setae (or claws) on EIII of A2; α , β , γ , special setae on the 1st,

2nd, and 3rd podomeres of Mdp, 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.

SYSTEMATIC DESCRIPTION

Pseudocandona sywulai sp. nov. (figs. 1-5)

Type locality. — Cave Đuderina near the village of Dugopolje, 10 km NE of Split, Croatia (UTM coordinates): 4 825385 N, 33 629968 E; altitude 265 m a. s. l. The site is situated in a typical karst (= polje) known as Vrtače and located under the north-facing slope of the Velika Gradina hill, a part of the Mosor Mountain.

Type material. — Holotype: a female with the limbs dissected and mounted in glycerine on a permanent slide, valves stored dry in a micropalaeontological cell. Allotype: a male dissected and stored as the holotype. Paratypes: (a) one male (without hemipenes) and two females dissected and stored as the holotype; (b) one sub-adult male and one sub-adult female (8th stage juveniles) and three juvs. of the 7th stage mounted as undissected in glycerine on slides with the valves stored dry; (c) two juvs. of the 6th stage and two of the 5th stage mounted in toto (not dissected) in glycerine on slides; (d) one empty female carapace and one empty carapace of the 7th stage juv. stored dry; (e) one female and 26 juvs. in toto preserved in ethanol and kept in a tube. All type specimens were collected by T. Rađa on 22.iv.2000 from the type locality. Deposition: the holotype, allotype, and the bulk of the undissected paratypes in ethanol are housed in the Museum of Natural Sciences, Split, Croatia (No. 1001). The remaining specimens are lodged at the University of Gdańsk (Poland) in the collection of the senior author.

Diagnosis. — Small representative of the *eremita*-species group of the genus *Pseudocandona* with triangular, nearly equally shaped left and right valve and relatively broad inner lamella at the anterior end, amounting to c. 9% of the valve length. The claws G_1 and G_3 of A2 in females $3\times$, and G_M claw at least $2.5\times$ as long as the anterior margin of EII + III. The EII and EIII of A2 in males differentiated and with male bristles; the claw G_2 equalling $4\times$, and G_M $3.5\times$ the length of the anterior margin of EII of this limb. Posterior seta on Pr of A2 longer than the anterior margin of EI of this limb. Podomeres EII and EIII of the cleaning leg not differentiated, forming one compound segment, with seta g longer than EII + III, short seta h_1 of this leg hook-like and recurved downwards.

Description of female. — Carapace viewed dorsally (fig. 1E) moderately compressed, the greatest W equalling about 40% of the L and situated at mid-length. Both ends similarly weakly pointed, LV overlaps RV at both extremities. LV (fig. 1C) triangular in lateral view with the greatest H situated just behind mid-length, at 56% of the L. Dorsal margin in front of the highest part first almost straight, then in its transition into anterior end very weakly concave. Postero-dorsal margin sloping more steeply than the antero-dorsal one and thus postero-ventral junction more narrowly rounded than the anterior end. Ventral margin slightly concave. Calcified part of the inner lamella narrow, on the anterior end

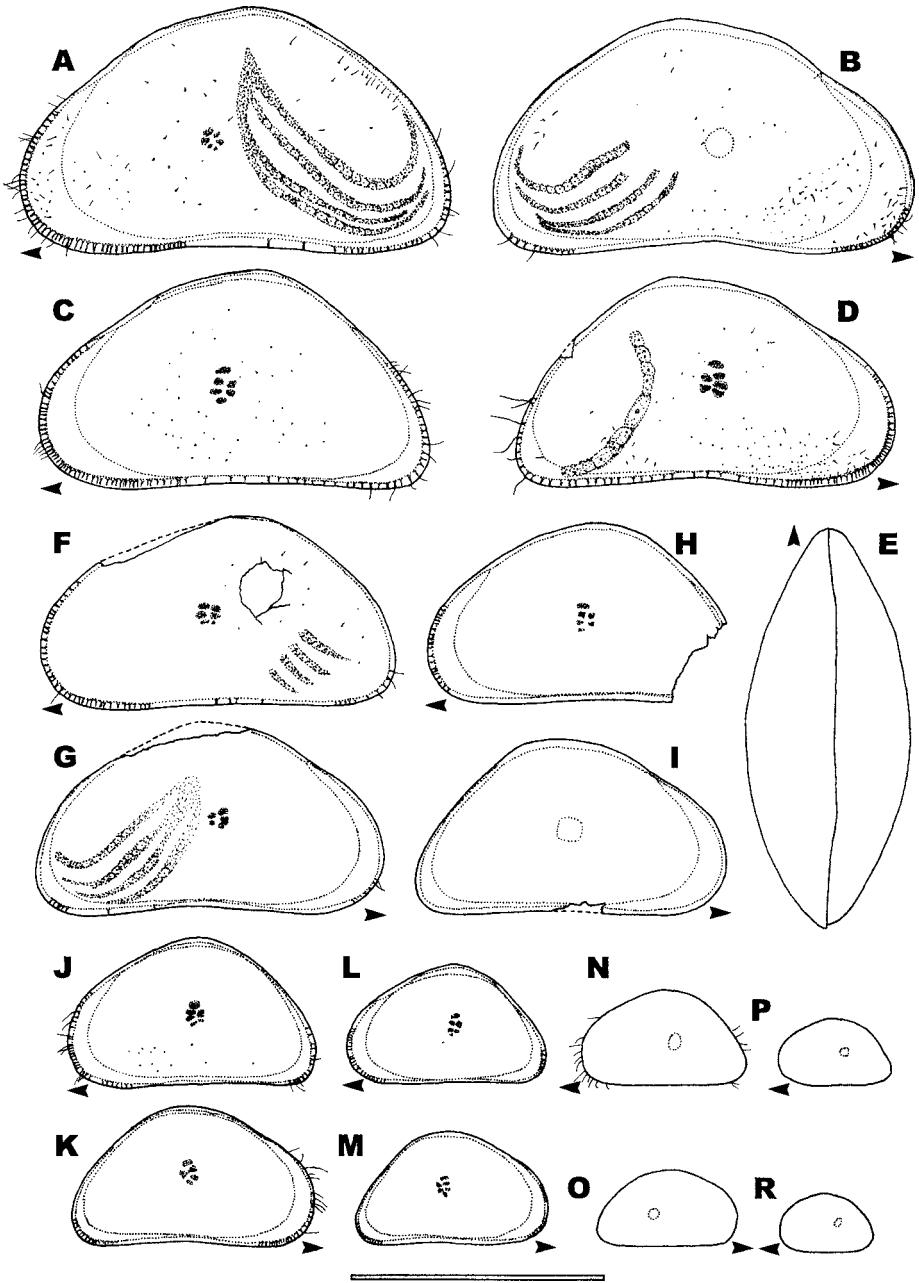


Fig. 1. *Pseudocandona sywulai* sp. nov. A-B, male allotype; C-D, female holotype; E, female paratype; F-G, subadult male (8th stage juvenile) paratype; H-I, subadult female (8th stage juvenile) paratype; J-M, 7th stage juvenile paratypes; N-O, 6th stage juvenile paratypes; P-R, 5th stage juvenile paratypes. A-D, F-M, valves viewed laterally; E, carapace in dorsal view; N-R, carapaces viewed laterally. Scale: A-R, 0.5 mm.

it represents 9% and on the posterior 5% of the LV length. RV (fig. 1D) similar in outline to LV but smaller and lower (see measurements below), and with more pronounced straight and concave parts of the antero-dorsal margin. Fused marginal zone of the valves narrow, with straight, short, and dense radial pore canals. Valves whitish, with smooth surface and a few setae on both ends. Measurements: LV: L = 0.78 mm, H = 0.44 mm, H/L = 0.56; RV: L = 0.76 mm, H = 0.42 mm, H/L = 0.55.

A1 (fig. 2A). I + II: A-2l, P-2l/III: A-1m/IV: A-1m/V: A-2l, P-1m/VI: A-2l, P-1m/VII: A-1m-2l, P-1l/VIII: D- y_a -1l(cs)-2l. The largest anterior setae on the penultimate podomere c. 2.7-2.8 times the L of the ramus (the last 5 podomeres combined). Aesthetasc y_a 2.9-3.1 times as long as terminal podomere (its sensory part representing 16% of the total L of this organ). The lengths of the posterior margins of the last 5 distal podomeres (IV-VIII) are in ratio: 1.0 : 1.2 : 1.2 : 1.5 : 1.4 and ratio L/W of these podomeres, from proximal onwards: 1.0, 1.2, 1.7, 3.0, 4.8.

A2 (fig. 2B). Pr: P-1l/Exo: D(Ex)-2s-1l/EI: P-Y, P(D)-1m-1l/E(II + III): A-1s, P- y_1 , P(In)-3s(t_2, t_3, t_4)-1m(t_1), D(A)-1m(G_2), D(P)- y_2 , D(Ex)-3s($z_1: G, z_2, z_3$), D(In)-2l(G_1, G_3)/EIV: D(A)-1l(G_M), D(P)- y_3 + 1m, D(Ex)-1l(G_m), D(In)-1l. The relative L of the anterior margin of the endopodial podomeres EI: EII + III: EIV as: 1.0 : 0.63-0.66 : 0.21-0.22. Aesthetasc Y equals 0.52 of the L of EI (sensory part of this organ represents 42% of its L). EH and EIII not differentiated (joint between these not developed). Relative lengths of the A2 claws, some setae, and the remaining aesthetascs compare with the L of EI as: $G_1 = 1.9$, $G_2 = 0.7$, $G_3 = 1.8$, $G_M = 1.6-1.7$, $G_m = 1.0-1.1$, z_1 (claw) = 0.3-0.4, $t_1 = 0.6$, $y_1 = 0.2$, $y_2 = 0.1$, $y_3 = 0.8-0.9$ (sensory part 12-15% of its L).

Md (fig. 2C) consists of the coxal plate and 4-segmented palp (Mdp). Coxa typically elongated and heavily chitinized with one lateral seta, distally (on the ventral side of the animal) with 7 strong teeth interspaced with sets of diverse setae, and ventrally with one plumed seta. Mdp: I: In-1s(α)-1s(S_2)-1m-1m(S_1)/II: Ex-2m, In-1s(β)-4m/III: Ex-3l, In-1s-1m, D-1m(γ)-1m/IV: D-2s-1m-2m(G). First podomere externally with the Exo plate. On the left Mdp three (instead of two) external setae on the 2nd podomere were seen. Setal group on the 2nd podomere with 3 setae. Externo-distal γ seta on 3rd podomere smooth. Both claws of the terminal podomere sub-equal and amounting to 1.6-1.7 of the L of 3rd palp podomere.

Rake-like organ (fig. 2E) with 10 teeth.

Mx1 (fig. 2D) with elongated branchial plate, 3 masticatory processes, and a 2-segmented palp: I: Ex-3m-1l/II: D-3s-1m-2m(cs).

L5 (fig. 3A). Pr bearing one anterior 'a' seta and two exterior setae 'b' and 'd'. Masticatory process (endite) apically with a group of 14 setae. Exo plate consisting



Fig. 2. *Pseudocandona sywulai* sp. nov., female holotype. A, A1; B, right A2 in external view; C, Md; D, Mx1; E, rake-like organ. Scale: A-E, 100 μ m.

of 2 filaments, one long and flexible and one shorter and stiff. Conical palp-shaped E, with remains of segmentation, is provided with 3 apical setae, from which dorsal one is the shortest.

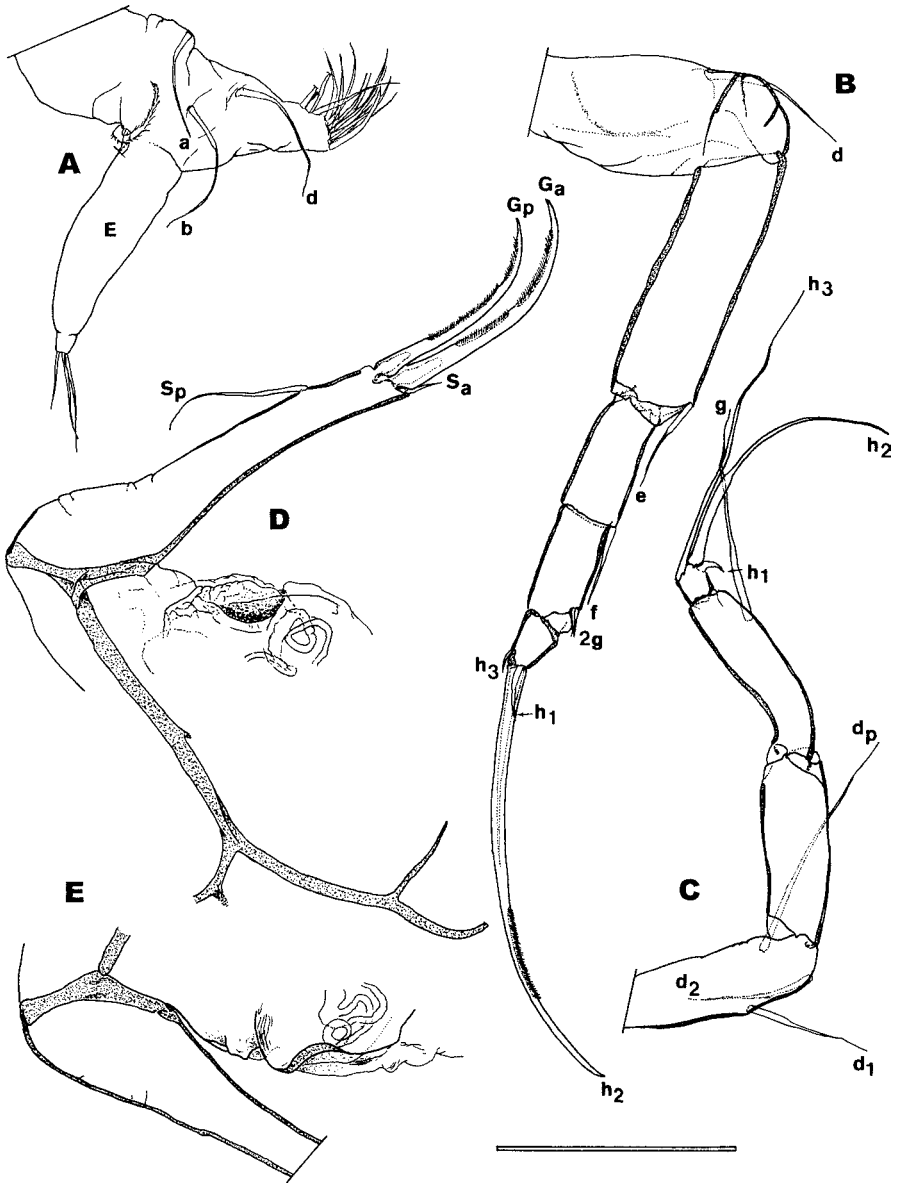


Fig. 3. *Pseudocandona sywulai* sp. nov. A-D, female holotype; E, female paratype. A, L5; B, L6; C, L7; D, CR, its attachment and genital lobe; E, genital lobe. Scale: A-E, 100 μ m.

L6 (fig. 3B): Pr: A(D)-1*m*(d)/EI: A(D)-1*s*(e)/EII: A(D)-1*s*(f)/EIII: A(D)-2*s*(g)/EIV: P-1*s*(*h*₃), D-1*s*(*h*₁)-1*l*(*h*₂: G). Terminal claw (*h*₂) serrated and equalling 3.5-3.6 of the length of EII.

L7 (fig. 3C). Pr: Ex-2*m*(*d*₁, *d*₂), In-1(*d*_p)/EII + III: P(D)-1*l*(g)/EIV: D-1*s*(*h*₁)-1*l*(*h*₂)-1*l*(*h*₃). Cleaning leg 4-segmented, EII and EIII forming compound podome-

re. Seta g as long as 1.1-1.3 of the length of EI. Relative lengths of 3 apical setae as: $h_1 = 0.1-0.2$, $h_2 = 1.3-1.4$, $h_3 = 1.7-1.8$. Seta h_1 hook-like and recurved downwards.

CR and genital lobe (fig. 3D, E). Ratio of lengths of anterior margin, s_a , G_a , G_p , s_p and the distance between the insertion points of s_p and G_p as: 100 : 13-14 : 74-79 : 69-71 : 45-49 : 21-26. Genital lobe as seen before smashing by a cover glass weakly developed, with two indistinct, fine, and somewhat laterally oriented and rounded folds (posterior one more developed) separated by a small depression with a well sclerotized margin. When compressed under pressure from the cover glass, folds not distinctly protruding beyond the margin of the central depression. Oocyte diameter c. 100-120 μm (representing c. 13-15% of the carapace L).

Description of male. — Valves in lateral view (fig. 1A, B) similar in shape to those of female, but postero-dorsal margin sloping less steeply backwards and posterior end is distinctly more broadly rounded than in female. Greatest H at 54% of the L. Calcified part of the inner lamella on the anterior end amounting to 9.5%, and on the posterior end to 4.5% of the valve L. Measurements: LV: L = 0.86 mm, H = 0.48 mm, H/L = 0.56; RV: L = 0.84 mm, H = 0.46 mm, H/L = 0.55.

A1. I + II: A-2l, P-2l/III: A-1l/IV: A-1l/V: A-2l, P-1m/VI: A-2l, P-1m/VII: A-1m-2l, P-1l/VIII: D- y_a -1l(cs)-2l. Setal equipment as in female but anterior setae on 3rd and 4th podomere relatively larger (medium in size in female). Aesthetasc y_a c. 3.5 times as long as terminal podomere. Lengths ratios of the posterior margins of the last 5 podomeres (IV-VIII) from proximal to distal: 1.0 : 1.3 : 1.3 : 1.7 : 1.4 and ratio L/W of these podomeres, from proximal onwards: 1.0, 1.3, 1.8, 3.4, 4.3. Penultimate podomere slightly more elongated than that of female.

A2 (fig. 4A, B). Pr: P-1l/Exo: D(Ex)-2s-1l/EI: P-Y, P(D)-1m-1l/EII: A(D)-1s, P- y_1 , D(In)-1s(t_4)-3m(t_1, 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)-1m(G_3)-1m(G_1)/EIV: D(A)-1l(G_M), D(P)- y_3+1m , D(In)-1m(G_m)-1m. Endopod 4-segmented, and the relative L of the anterior margin of EI : EII : EIII : EIV as: 1.0 : 0.42 : 0.25 : 0.16. Aesthetasc Y, as in female, equalling c. 0.5 of EI. Setae t_2 and t_3 transformed into male bristles and their lengths represent 0.9 and 0.8 of the length of EI, respectively; t_1 shorter (0.5-0.6), t_4 very short (0.1). Relative lengths of claws and setae on EIII and EIV as: G_1 (claw) = 0.9, G_2 (claw) = 1.8, G_3 (seta) = 0.6, z_1 (claw) = 0.9, z_2 and z_3 (setae) = c. 0.3, G_M (claw) = 1.5, G_m (claw) = 0.6. Relative L of the remaining aesthetascs similar to those in female.

Mdp and Mx1 palp without distinct sexual dimorphism.

L5 (fig. 4C, D). Pr and respiratory plate as in female. E developed into asymmetrical, prehensile palps. Right palp (fig. 4C) more developed, distally helmet-shaped; left one (fig. 4D) slender, its finger only slightly curved.

L6 and L7 as in female.

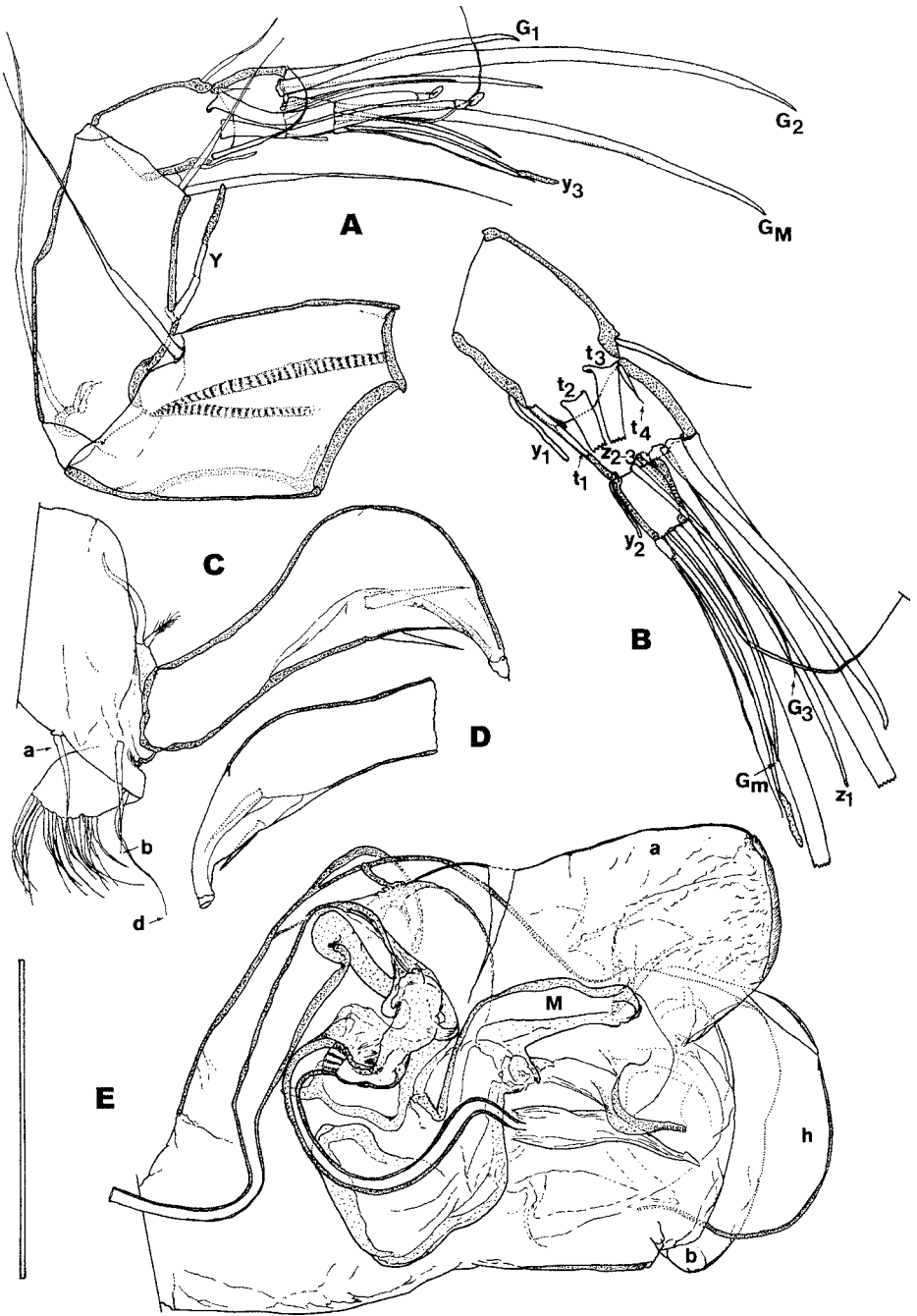


Fig. 4. *Pseudocandona sywulai* sp. nov., male allotype. A, left A2 in internal view; B, left A2, details of apical chaetotaxy; C, right L5 with prehensile palp; D, left prehensile palp; E, left hemipenis in external view. Scales: A, 100 μm ; B, 144 μm ; C-E, 78 μm .

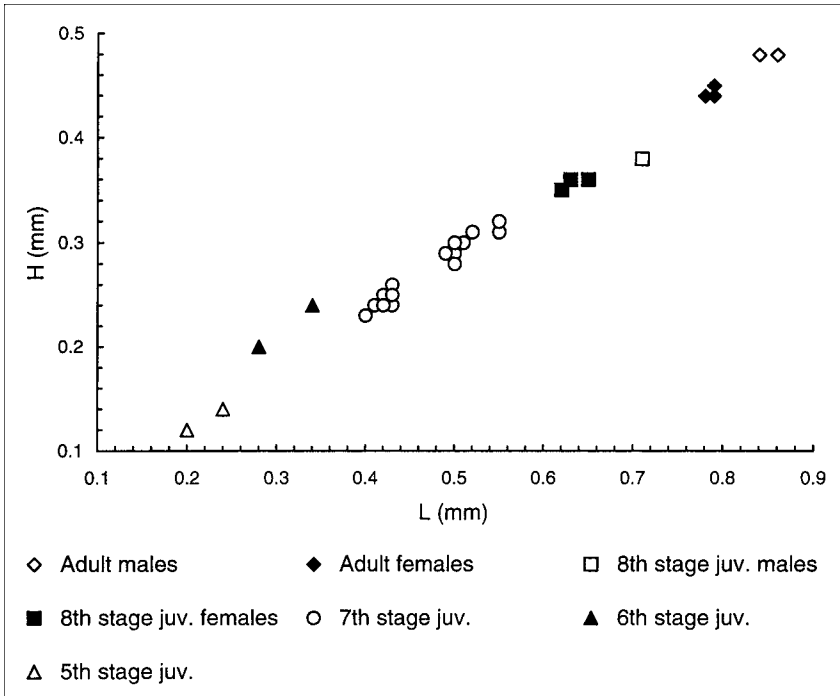


Fig. 5. *Pseudocandona sywulai* sp. nov. Scatter plot of length (L) versus height (H) of adult and juvenile carapaces.

CR. Claws relatively shorter and anterior seta relatively longer than those in female. Ratio of lengths of anterior margin, s_a , G_a , G_p , s_p , and the distance between s_p and G_p as: 100 : 18 : 61-63 : 56-58 : 38-43 : 22-24.

Hemipenis (fig. 4E). Outer lobe (a) well developed, sub-rectangular; inner and shortest lobe (b) wide with slightly concave distal margin; medial lobe (h) widely rounded and reaching beyond lobes a and b. M-process proximally with a broad plate, contracted central part, and the distal plate with a characteristic, well sclerotized, curved and posteriorly oriented (to the posterior end of the animal) appendix, which is distally crenulated. Bursa copulatrix elongated, conical with thunderbolt-shaped distal part.

Zenker's organ with 7 internal rings of spines, its length represents 27-28% of the carapace L.

Further descriptions. — As an addition to the description of the new species, the carapace size variability of the last four juvenile stages and the adults is shown in fig. 5, while the valve shapes of the juveniles are presented in fig. 1F-R. It has to be stressed here that, at least in the 7th juvenile stage, for which there was the richest material available, one can distinguish two distinct clusters of individuals: smaller juveniles with a range of $L = 0.40-0.43$ mm (possibly females), and

larger ones (? males) with the L amounting to 0.50-0.55 mm. It could well be that the sexual dimorphism in carapace length in *P. sywulai* sp. nov. appears to be significant early in post-embryonic development, and is retained until the adult stage. This phenomenon has already been documented for species in other genera of Candoninae, e.g., for the last two juvenile stages of *Candona neglecta* G. O. Sars, 1887) (vide Danielopol & Casale, 1988).

Derivatio nominis. — The new species is named after Prof. Tadeusz Sywula (University of Gdańsk, Poland), in honour of his great contribution to our knowledge of non-marine ostracodes and in acknowledgement for the inestimable help in ostracode taxonomy he has given to T. N.

Distribution and ecology. — The new species is considered here a stygobite as it is known only from the type locality, where it was collected from a small pool of leaked-through water (dimensions: 35 × 45 cm), situated between the entrance gallery and the dry channel of the Cave Đuderina. This part of the cave is in complete darkness, although not more than 5.5 m deep. The pool is constantly filled with water, trickling down the cave walls in a barely noticeable way. The pool is always 8 cm deep and its bottom is covered with a layer of fine detritus, 2-3 mm thick (Rađa, 1980).

Physical and chemical characteristics of the water are as follows: pH = 7.71, temperature = 9°C, dissolved O₂ = 9.6 mg dm⁻³, saturation = 86%, hardness 163 mg dm⁻³.

The new ostracode co-occurs in the pool with three other stygobites: *Speocyclops* cf. *gallicus* Chappuis & Kiefer, 1952 (Copepoda, Cyclopoida, Cyclopidae), *Bryocamptus pygmaeus* (G. O. Sars, 1863) (Copepoda, Harpacticoida, Canthocamptidae), and *Soldanellonyx chappuisi* Walter, 1917 (Acarina, Limnohalacaridae).

COMPARATIVE MORPHOLOGICAL ANALYSIS OF THE SPECIES BELONGING TO THE EREMITA-SPECIES GROUP OF THE GENUS PSEUDOCANDONA

Pseudocandona dispar, *P. pretneri*, and *P. trigonella* differ from the new species by the conspicuously triangular shape of their carapaces when viewed laterally. The height to length ratio in these species is in the range of 0.62-0.67 (0.54-0.57 in *P. sywulai* sp. nov.).

Pseudocandona dispar, originally described from Erekli cave in Turkey (Hartmann, 1964), is larger than the new species (L of females = 0.84-0.94 mm, L of males = 0.95-0.97 mm) and has distinctly unequally shaped LV and RV as seen laterally (nearly symmetrically shaped in the new species). The shape of the RV resembles that of the new species, except for the relatively wide inner lamella at the anterior end, which amounts to c. 12% of the valve length (c. 9% in the new

species), and the position of the greatest H, which is situated distinctly behind mid-length at c. $2/3$ of the RV length (at 59% in *P. sywulai* sp. nov.). The triangular LV is distinctly higher than the RV, with the greatest H almost at mid-length and with a gentle concavity in the middle of the ventral margin. Furthermore, aesthetasc Y in this species is relatively short, not reaching the base of the two distal setae of the corresponding A2-podomere (this aesthetasc extends beyond this point in the new species), and these setae are also short: the shorter, inserted more internally, amounts in the female to c. $0.5\times$, and the longer seta to c. $0.9\times$ the L of the anterior margin of the penultimate podomere ($0.9\times$ and $1.7-1.8\times$ in *P. sywulai* sp. nov., respectively). According to Petkovski (1969), the female genital lobe of *P. dispar* displays posteriorly a distinctively, long, finger-like process (not visible in the new species).

Pseudocandona trigonella was described from a single and remarkably small ($L = 0.55$ mm) female individual collected in the cave Postojna (named Adelsberger Cave at the time of collecting), in Slovenia (Klie, 1931). Except for the conspicuous valve outline and size, which precludes confusion with any of the related species, *P. trigonella* differs from the new species also in some of the morphological features of the limbs: (a) the terminal claw (h_2) of L6 as long as 4 endopodial podomeres combined (this claw slightly shorter than 3 distal podomeres in the new species); (b) the shortest seta (h_1) of L7 straight, not-hook-like and c. $2\times$ the L of EIV (short and hook-like in *P. sywulai* sp. nov.); (c) a very long anterior claw (G_a) on CR, equalling the L of the anterior margin of the ramus (this claw $<80\%$ of the L of this margin in *P. sywulai* sp. nov.).

Pseudocandona pretneri, described also from only one living specimen, although male, was found in a karstic spring at Rak in Slovenia, close to the type locality of *P. trigonella* (cf. Danielopol, 1982). This remarkable male lacks male bristles and differentiation between the 2nd and 3rd endopodial podomeres of A2, and thus cannot be confused with *P. sywulai* sp. nov. It has to be stressed here that the chaetotaxy of L7 of both *P. trigonella* and *P. pretneri* remain unknown, hence these two species are tentatively retained in the *eremita*-group of the genus *Pseudocandona*.

In the remaining species, including the new one, the H/L ratio of the carapace is ≤ 0.6 .

Pseudocandona puteana, known only from wells at Skopje in Macedonia, is the largest (L of females = 1.02 mm, L of males = 1.05 mm) and also the most elongate species. Apart from the size and shape of the carapace, it differs from the new species mainly in: (a) subdivision of EII and EIII of L7; (b) gently arched and sideward directed (not hook-like) short terminal seta (h_1) of L7; (c) shape of the right male clasping organ: distal part markedly inflated versus evenly rounded and helmet-shaped in *P. sywulai* sp. nov.; and (d) the structure of the hemipenis:

the ventro-distal part of the inner lobe b angular (an almost right angle, vide Klie, 1931, and Danielopol, 1982) versus rounded in *P. sywulai* sp. nov.

Pseudocandona cavicola, thus far endemic to the Krška cave in Slovenia (Klie, 1935), can be readily distinguished from the new species mainly by: (a) unequally shaped valves as seen laterally (LV triangular, RV trapezoidal); (b) the greatest W of the carapace, seen dorsally, situated distinctly behind mid-length, at c. 56% of the carapace L (at mid-length in *P. sywulai* sp. nov.); (c) subdivided EII and EIII of L7; and (d) gently arched, not hook-like seta h_1 of L7. Males of this species remain unknown.

It appears that *P. eremita*, *P. pannonicola*, *P. serbani*, and *P. szoecsi*, and probably also *P. dispar*, can be considered to form the core of the *eremita*-species group that is here referred to as *P. eremita* sensu lato. *Pseudocandona pannonicola*, *P. serbani*, and *P. szoecsi* appear very similar to *P. eremita* and slight differences between them could well represent the variability of one species, therefore, these three former taxa probably deserve only infraspecific names, if any, but this needs further investigation. The new species comes very close to *P. eremita* s. 1. The most important differences between these five species are summarized in table I. As males are not known for some of these species (as for *P. pannonicola*) or have been found only sporadically (as for *P. eremita* and *P. szoecsi*), table I is based mainly on female traits. From these data it becomes apparent that there are only a few relevant characters that distinguish *P. sywulai* sp. nov. from the remaining species and the major differences are displayed by the carapace shape and size, and, especially, by the chaetotaxy of the second antenna.

For the present, *P. sywulai* sp. nov. can best be distinguished from *P. eremita* s. 1. by the following combination of characters (see table I): (a) its small size; (b) wide inner lamella of female LV at the anterior end; (c) relatively large A2-claws: G_M , G_1 , G_2 ; (d) aesthetasc Y distinctly larger than the L of the intero-distal margin of EI; (e) larger of two postero-distal setae on EI of A2 almost twice as long as the shorter seta of this pair (this character is shared with *P. pannonicola*): (f) posterior seta on Pr of A2 larger than the anterior margin of EI; (g) large A2-exopodial seta distinctly longer than anterior margin of EI (the relative length of this seta is similar in *P. eremita*): (h) seta g on EII + III of L7 longer than this penultimate podomere.

The relatively large width of the calcified inner lamella can also be calculated from photographs provided by Petkovski (1969) for specimens considered by this author to belong to *P. szoecsi* and collected from wells at Nin and Pridraga, situated close to the Adriatic coast in Croatia (some 120-140 km from the type locality of the new species). From these photographs and also from a figure of the female genital lobe, one can see that Petkovski's (1969) material differs from the females of *P. szoecsi* originally described by Farkas (1958) from a well in environs of Budapest, in almost equally shaped LV and RV. Contrary to this, the female RV

TABLE I

Differential comparison between four closely related species of the *Pseudocandona* group "*eremita*" and the new species (abbreviations as in Methods). Data from: A, Absolon (1973, 1978); B, Daday (1900); C, Danielopol (1982); D, Farkas (1958); E, Jančařík (1952); F, Klie (1940); G, Kovalenko (1988); H, Löffler (1960, 1964); I, Petkovski (1969); K, Vávra (1891); L, Vejdovský (1882) (* = mean value)

Character	<i>P. eremita</i> (A, B, C, E, F, G, K, L)	<i>P. panno- nicola</i> (H)	<i>P. serbani</i> (C)	<i>P. szoecsi</i> (D, I)	<i>P. sywulai</i> sp. nov. (this paper)
Carapace					
Female L (mm)	0.83-0.90	0.86-0.90	0.81-0.83*	0.83-0.90	0.78-0.79
Male L (mm)	1.00	—	0.89*	?	0.84-0.86
Female W/L	0.41-0.50	0.30-0.35	?	0.37-0.38	0.40
Male W/L	0.38	—	0.31	0.39	?
W of inner lamella of female LV/L of LV (%)	<7.5	<7.0	<7.5	<6.0 (D) ~8-9 (I)	9.0-10.0
Location of the greatest H of female RV (% of L of RV)	55	55	56	61 (D) 54 (I)	56
Female A2 (L of podomeres measured along their anterior margin)					
G _M /EII + III	2.0	2.0	2.2	2.0	2.5-2.7
G ₁ /EII + III	2.5-2.7	2.3-2.6	2.5	2.2	3.0-3.1
G ₂ /EIV	3.0-3.1	2.5-2.8	2.6	?	3.3-3.4
Y/intero-distal margin EI	0.9-1.0	1.1	1.0	?	1.3
Postero-distal setae on EI, larger/smaller	1.2-1.3	2.1	1.4	?	1.9
Posterior seta on Pr/EI	0.9	?	0.9	?	1.2-1.3
Large Exo seta/EI	1.1	?	0.8	?	1.3
EII + III/EIV	3.0	2.3	2.5	?	2.8-3.1
Cleaning leg					
Seta g/EII + III	1.0-1.1	0.9	0.9	0.7	1.1-1.2
Seta d _p /seta d ₂	1.0-1.4	2.5	2.0	1.4-1.5	1.8

of this species illustrated by Farkas (1958) is distinctly more elongate than the LV ($H/L = 0.51$ on Farkas' illustration) with the greatest H situated distinctly behind mid-length, at 61% of its L (as can be calculated from Farkas' (1958) fig. 2). The genital lobe figured by Petkovski (1969) has two closely situated (slightly overlapping) folds versus a flat and weakly developed lobe as described by Farkas (1958). In his paper, Petkovski (1969) also briefly described and illustrated male individuals assigned to *P. szoecsi* (thus far the only known sites of males of this species). Thorough comparison of this description with males of the new species allowed us to find only a few differential characters. The postero-dorsal margin of the male LV and RV of the new species is steeper than that of *P. szoecsi*. The G_M claw of A2 is slightly longer in *P. sywulai* sp. nov., equalling 1.7-1.8× the L of the anterior margins of EII + EIII + EIV (in *P. szoecsi* this claw 1.6× the L

of these three distal podomeres). The shape of the clasping organs is also slightly different. The finger of the left organ in *P. sywulai* sp. nov. is less curved and dorsally almost straight (slightly concave in *P. szoecsi*), and the right organ in the new species is evenly rounded distally, whereas in *P. szoecsi* it is markedly inflated. The three corresponding lobes of the hemipenis are almost identically shaped in both species, and the absence of an illustration of the internal structures of the *P. szoecsi*-hemipenis precludes detailed comparison with the new species. Further investigation is needed to confirm if Petkovski's (1969) material ranks within the variability range of one species or deserves a separate taxonomic status.

Judging from the original and subsequent descriptions given by Löffler (1960, 1964), females of *P. pannonicola* collected from several wells in Burgenland (Austria), differ from the females of *P. sywulai* sp. nov. also in: (a) more rounded dorsal and dorso-posterior margin of both valves seen laterally (dorsal margin more or less angularly curved and sloping more steeply backwards in *P. sywulai* sp. nov.); (b) more elongated carapace as seen dorsally ($W/L = 0.3$) versus being more compact in the new species ($W/L = 0.4$); and (c) relatively long G_m claw of A2 comparing with G_M : $G_M/G_m = 1.2$ ($G_M/G_m = 1.6$ in *P. sywulai* sp. nov.).

Pseudocandona serbani, known from various alluvial aquifers in southern and central Romania (Danielopol, 1982), is represented by both amphigonous and parthenogenetic populations. The detailed description of *P. serbani* males provided by Danielopol (1982) enables comparison with those of the new species. Considering clasping organs, the dorsal margin of the finger of the left organ in *P. serbani* is conspicuous by a small but distinct concavity (this margin almost straight in *P. sywulai* sp. nov.), whereas the right clasping organs do not show differences between these two species. The distal part of the M-process of the hemipenis is remarkably similar in both species, bearing a well-sclerotized and curved appendix, which is usually bifurcated proximally and conspicuously crenulated at the distal end. In *P. sywulai* sp. nov., however, the distal part of this appendix is oriented posteriorly, whereas in *P. serbani* this part is directed more or less ventrally. Males of *P. serbani* differ from those of the new species also in the chaetotaxy of the A2. Having as a reference the L of the anterior margin of EII of this limb, the relative L of some claws and setae in *P. serbani* are as: G_2 (indicated as G_1 in Danielopol, 1982) = $3\times$; $G_M = 2.4\times$, $t_1 = 0.6\times$, whereas these claws and seta in *P. sywulai* sp. nov. equal: $G_2 = 4.1\times$; $G_M = 3.5\times$, $t_1 = 1.2\times$ the L of the reference podomere. Furthermore, the largest Exo seta of the A2 in *P. serbani* does not reach beyond the distal margin of EI (this seta in *P. sywulai* sp. nov. distinctly reaching beyond the distal margin of EI), and the L of y_3 in *P. serbani* is inferior to 0.5 of the L of EI (this aesthetasc distinctly larger than half of the L of EI in *P. sywulai* sp. nov.).

From the data available in the literature, *P. eremita* should be considered a widely distributed species. Living populations (collected mainly from porous groundwater reached through wells and from caves) have been recorded in Austria, Bulgaria, Croatia, the Czech Republic, Germany, Macedonia, Poland, Romania, Slovakia, and Slovenia (for a review of the distribution of this species, see Meisch, 2000), as well as from Hungary (Gido & Lakatos, 2001), the European part of Turkey (Gülen, 1985), and the former Soviet Union: Ukraine (Jaworowski, 1893) and Moldova (Kovalenko, 1988). Males assigned to *P. eremita* are very rare and so far have been reported only from Romania (Danielopol, 1982), and from Slovenia and the Kosovo Region in Yugoslavia (Klie, 1940). Two males identified as *P. eremita* and reported by Wolf (1920) from Switzerland belong to a different species (for discussion see Meisch, 2000), while the presence of males in the northernmost population in Poland (Namiotko, 1990) was erroneously indicated therein. As only a few of the above-mentioned reports provide data on carapace and/or limb morphology, and so far particular studies devoted to the variability of this species have not been undertaken, a precise characterization of the geographic distribution of *P. eremita* is difficult at the moment. It is not unlikely that specific allocation of at least some of these populations could be doubtful. It could also be suggested that *P. eremita* is a species complex, actually comprising several geographical subspecies or even separate species with slightly divergent carapaces and very similar limbs.

Pseudocandona eremita (sensu Vejdovský, 1880; Vávra, 1891; Absolon, 1978) and *P. sywulai* sp. nov. differ in the shape of the female valves as seen in lateral view. The LV of *P. eremita* is triangular, usually with a more or less distinct dorsal protuberance that overlaps the RV, the dorsal margin of which is almost straight or weakly rounded in front of its highest portion. On the contrary, both valves of *P. sywulai* sp. nov. are triangular and almost equally shaped. The female genital lobe of *P. eremita* bears a posterior, finger-like protrusion of variable length (see Klie, 1940; Danielopol, 1982). In *P. sywulai* sp. nov., only a weakly protruding fold with a relatively wide base can be seen in the posterior part of the genital lobe. Other differences between the females of these two species are shown in table I. Vávra (1891) estimated that the L of the largest claws (G_1 and G_3) of A2 is 3 times that of EII + III, thus is most similar to that in the new species. This statement is true when the length of EII + III is measured between the centres of the lines of articulation. However, if the L of the anterior margin of this penultimate podomere is selected as a basis for comparison (as was done for all species in table I), the relative L of G_1 in *P. eremita* amounts to 2.7, as can be calculated from Vávra's (1891) fig. 15. Klie (1940) also estimates the relative L of this claw in this species as being less than 3 times (actually 2.5 times) the L of the anterior margin of EII + III.

Males assigned to *P. eremita* were described only by Klie (1940) and Danielopol (1982). The brief description of the former author did not allow us to find any reliable diagnostic characters distinguishing the males of this species from those of *P. sywulai* sp. nov., with the exception of the carapace L (see table I). The same carapace L (i.e., 1.00 mm) for males collected from a well at Suncuius (Romania) and assigned to *P. eremita*, was given by Danielopol (1982). Relying on the description of the latter author, males of *P. eremita* and those of *P. sywulai* sp. nov. differ in the structure of the hemipenis. The inner lobe (b) of *P. eremita* is more pointed ventrally (rounded in *P. sywulai* sp. nov.), and the distal part of the M-process of *P. eremita* has a different appearance, without the rod-shaped appendix that is characteristic for *P. sywulai* sp. nov. (and also for *P. serbani*). However, in *P. eremita* this part of the M-process displays crenulations like those in the new species and in *P. serbani* (as was already mentioned above). It is not unlikely that the crenulation of the distal part of the M-process of the hemipenis is a common and unique character for *P. eremita* s. 1.

Relatively numerous fossils were also assigned to *P. eremita* (some of these as *P. aff. eremita* or *P. cf. eremita*). These valves were recorded mainly in Quaternary sediments (for the review of the Quaternary distribution of this species, see Griffiths, 1995) but also from Upper Miocene deposits of Turiec Basin in Slovakia, as was recently reported (as *P. aff. eremita*) by Pipik (2001). However, as it is difficult to identify remains with any precision without soft parts being available, specific assignment of some of this fossil material may be questionable.

An interesting record comes from the Croatian Upper Pleistocene, by Sokač (1978). This author provides three photographs (his pl. XIV figs. 6, 8, 10) of valves found in one borehole near Vinkovci and assigned to *Typhlocypris eremita* Vejdovský, 1880. The RV extracted from a depth of 7.0-7.5 m has a rounded dorsal margin and is distinctly smaller ($L = c. 0.78$ mm) and relatively lower ($H/L = 0.56$) than the LVs taken from a depth of 22.0-22.1 m and presented on two other photographs (the L of these valves can be calculated as 0.91-0.92 mm, whereas the ratio $H/L = 0.58$). The outlines of these larger LV fit well the outline of the adult male valve of the new species, whereas the smaller fossil RV corresponds to the sub-adult male (the last juvenile stage) valve of *P. sywulai* sp. nov. The fossil valves differ from those of the new species in larger absolute size and in relatively being somewhat higher. It could well be that these differences express the variability of a single species, but this needs confirmation through direct comparison, using original material.

Final remarks. — At the present state of our knowledge, we tentatively suggest to consider the *eremita*-species group of the genus *Pseudocandona* to form a cluster of closely related ostracode taxa, where some of the species display a high

degree of local endemism, while others show wider geographical distributions. All together, they represent a reasonably distinct lineage within the genus *Pseudocandona*. Future studies (based on traditional morphology as well as, possibly, on molecular descriptors) should pay close attention to interspecific and intraspecific (inter- and intrapopulational) variation (especially to divergences in genital morphology) in order to determine the range of already accumulated differences of isolated population (before speciation is completed and after speciation), so as to distinguish alternative hypotheses concerning the mode of evolution of this group, and eventually to document if this lineage deserves a separate generic status. If so, the name *Typhlocypris* Vejdovský, 1882 has to be reactivated for that genus, a name that is still in use by some neontologists (e.g., Sywula, 1974; Kovalenko, 1988) and palaeontologists (e.g., Sokač, 1978; Krstić, 1993).

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