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## The Freshwater Mite *Porolohmannella violacea* (Kramer, 1879) (Acari: Halacaridae), Description of Juveniles and Females and Notes on Development and Distribution

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**Abstract.** The description of female *Porolohmannella violacea* (Kramer, 1879) is supplemented and the development of external characters from larva to adult described. Beside an increase in size and number of setae from instar to instar, similar to that in other halacarid species, there is a marked difference in the growth in length of the palp and leg segments. Larva and protonymphs have epimeral pores. Data on geographical distribution are summarized. According to present records, *P. violacea* is restricted to the northern hemisphere, nonetheless, it is expected to be found in the south, too.

**Keywords.** Freshwater halacarid, *Porolohmannella*, development, distribution.

### 1. INTRODUCTION

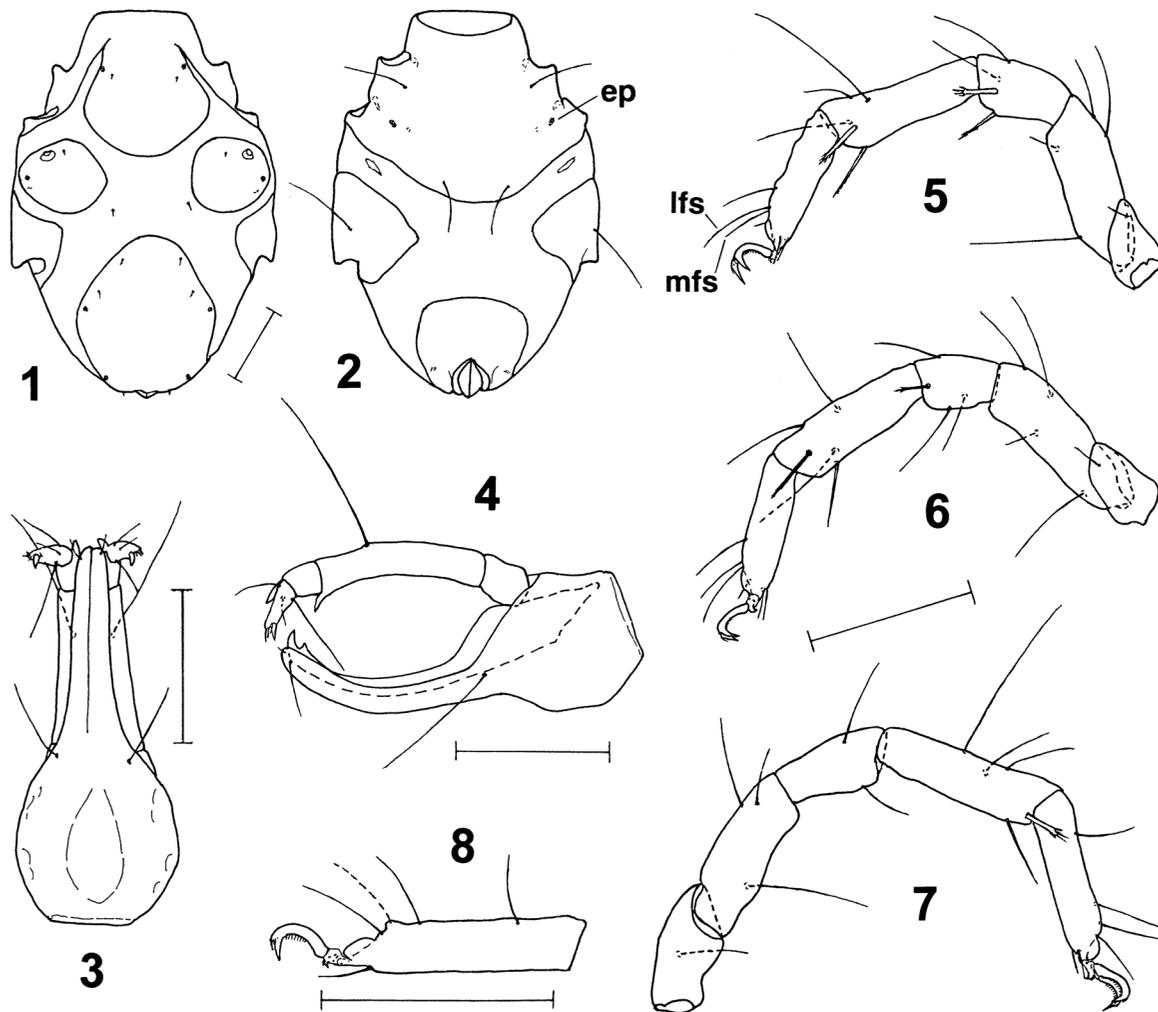
Halacarid mites are primarily marine but a few species live almost exclusively in continental freshwater. KRAMER (1879) was the first to describe a halacarid from freshwater, *Leptognathus violacea*, a rather large species characterized by a long, slightly curved rostrum and palps, in all strikingly similar to the marine genus *Leptognathus* Hodge, 1863, and a violet to pink integument, hence the name *violacea* (cf. KRAMER 1879). The species, described from Thuringia, Germany, turned out to be wide-spread in Europe, as documented by the large numbers of citations (cf. K. VIETS 1956; K. O. VIETS 1978, 1987).

The name *Leptognathus* proved to be pre-occupied and LOHMANN (1901) proposed a new name, *Trouessartella* Lohmann, 1901. This was pre-occupied, too, and thereupon TROUESSART (1901) introduced *Lohmannella* Trouessart, 1901.

In the following decades the number of both marine and freshwater halacarid species increased. Karl VIETS (1927, 1933) separated the freshwater species, all with external genital acetabula, from the marine species with internal acetabula, and distinguished between the families Halacaridae Murray, 1877 and Porohalacaridae Viets, 1933, the former including the marine taxa, the latter the freshwater taxa. Accordingly, K. VIETS (1927, 1933) distinguished between a marine genus *Lohmannella*, in the Lohmannellinae Viets, 1927, and a freshwater genus, for which he introduced the name *Porolohmannella* Viets, 1933, with the type species *P. violacea* (Kramer), and the subfamily Porolohmannellinae Viets, 1933.

The division into Halacaridae and Porohalacaridae, solely based on the position of the genital acetabula, external or internal, was abandoned by NEWELL (1947), BARTSCH (1973) and PETROVA (1974, 1981). In several species of the marine genera *Acarothrix* Bartsch, 1990, *Halacarellus* Viets, 1927, *Halacaroides* Bartsch, 1981, *Isobactrus* Newell, 1947, and *Thalassarachna* Packard, 1871 males have external but females internal acetabula (BARTSCH 2004, and in press). External genital acetabula are ion-permeable areas with osmoregulatory function (BARTSCH 1973; ALBERTI 1977, 1979). In marine halacarids one to three pairs of acetabula are present, in freshwater forms often more than three. The genital acetabula may be large, e.g., in the genera *Halacarus* Gosse, 1855 and *Thalassarachna*, or small, as in most species of *Copidognathus* Trouessart, 1888 and *Simognathus* Trouessart, 1889. In a few marine species, unusual enlargement is documented. Many, though not all halacarid mites living in freshwater have external genital acetabula.

Species of freshwater genera differ from marine ones both in the position of the genital acetabula and in their integument. The plates are thin, they show no coarse sculpturing or raised areolae, no rosette pores; they often are rather uniformly ornamented, with a reticulate or foveate pattern, and have tiny evenly spread canaliculi cross the integumental layers. The position of the genital acetabula as well as the structure of the integument and ornamentation of the plates certainly are influenced by physical and chemical environmental features, as in other meiofaunal taxa, e.g., in ostracods (MEISCH 2000).



**Figs 1–8.** *Porolohmannella violacea*, larva, **1**, idiosoma, dorsal; **2**, idiosoma, ventral; **3**, gnathosoma, ventral; **4**, gnathosoma, lateral; **5**, leg I, medial; **6**, leg II, medial; **7**, leg III, medial; **8**, tarsus III, lateral (medial parambulacral seta and claw omitted, dorso-medial fossary seta in broken line). (ep, epimeral pore; lfs, dorsolateral fossary seta; mfs, dorsomedial fossary seta) Scale = 50  $\mu$ m.

Independent of the position of the genital acetabula, *Porolohmannella* and *Lohmannella* proved to differ in a number of other characters, in the number of setae on the epimeral plates and genitoanal plate, the number and arrangement of setae on the palps and gnathosoma, the shape of the pharyngeal plate, the position of the solenidion on tarsus II, and absence or presence of a carpite (cf. BARTSCH 1989). The state of these characters is expected to be independent of environmental parameters.

Recently, in a small pond near Hamburg, Germany, numerous females and juveniles of *Porolohmannella violacea* were found. The development of external characters, from instar to instar, has been studied in several ma-

rine species (BARTSCH 1998, 2003) but to date in no representative of a freshwater halacarid genus. The larva, nymphs and female of *P. violacea* are now described, the character development outlined and compared with marine halacarids.

## 2. MATERIAL AND METHODS

The material studied was collected in June, July and August 2006 in northern Germany, north of Hamburg, in a shallow pond adjacent to a helocrene swamp area. The pond is approximately 10x20 m (width x length), on the northern border there are small bushes, mainly willows

(*Salix* sp.), rarely more than 3 m in height, along the southern border most trees have been removed. In the shallow water there is a mass occurrence of the moss *Fontinalis howellii* Renaud & Cardot.

Obvious macrofaunal elements in the pond are the snails *Lymnaea stagnalis* (Linnaeus, 1758) and *Planorbium corneum* (Linnaeus, 1758). Amongst the meiofauna living between the moss mites were very abundant, viz., the halacarids *Porohalacarus alpinus* Thor, 1910 and *Porolohmannella violacea* and the oribatid mite genus *Hydrozetes* Berlese, 1902; Hydrachnidia and the halacarid mites *Soldanellonyx monardi* Walter, 1919 and *Lobohalacarus weberi* (Viets & Romijn, 1924) were rare. Other meiofaunal taxa were rotatorians, turbellarians, nematodes, oligochaetes, tardigrades, and larvae of insects (ceratopogonids and chironomids); copepods or ostracods were almost lacking.

In January, February and March 2006 the mean monthly temperature was below 1 °C (DEUTSCHER WETTERDIENST 2006). June and July 2006 were characterized by high temperature and intense, long-term sunshine. July, with several days beyond 30 °C, had higher temperature and more sunshine than ever registered since regular documentation of meteorological data (which started a century ago). The sunshine period, with up to 16 hours a day, was 50 % beyond long-term mean July values. In both June and July rain was considerably below average. August was extremely wet, with two to four times more rain than usual (DEUTSCHER WETTERDIENST 2006).

*Porolohmannella violacea* was extracted from moss samples. Ten individuals of each instar (larva, protonymph, deutonymph, female) were studied in detail. Abbreviations used in the descriptions are: AD, anterior dorsal plate; AE, anterior epimeral plate; ds-1 to ds-6, first to sixth pair of dorsal setae of idiosoma, numbered from anterior backward; EI to EIV, epimeral plate(s) I to IV; GA, genitoanal plate; GO, genital opening; GP, genital plate; OC, ocular plate(s); P-2 to P-4, second to fourth palpal segment; pas, parambulacral seta(e); PD, posterior dorsal plate; PE, posterior epimeral plate(s); pgs, perigenital setae. The epimeral plates, legs and their segments are numbered I to IV. The leg segments are trochanter, basifemur, telofemur, genu, tibia, and tarsus. The setation formula of the legs presents the number of setae from trochanter to tarsus. The given number of setae of the tarsi includes the solenidion and parambulacral setae. The position of a seta is given in a decimal system with reference to the length of the relevant structure, from its anterior to posterior or proximal to distal end. Voucher specimens of each instar are deposited in the Zoological Museum in Hamburg.

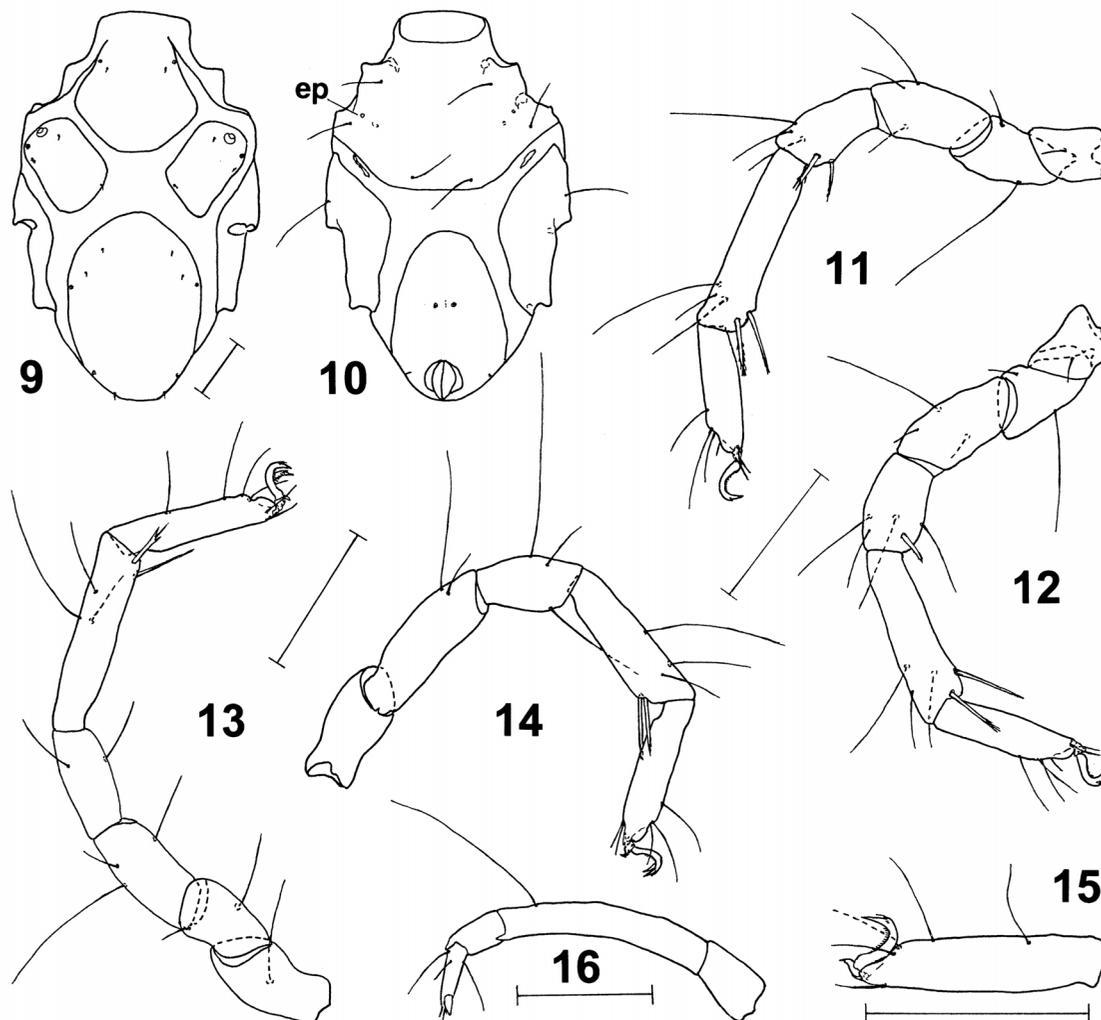
### 3. DESCRIPTION

#### 3.1. Larva (Figs 1–8)

**Idiosoma.** Length 207–277 µm. Idiosoma pale, almost transparent, with pair of small spots of black eye-pigment. Dorsal plates with delicately reticulate ornamentation, each polygon about 5–7 µm in diameter. Anterior margin of AD truncate (Fig. 1). OC rounded, slightly wider than long. PD 1.2 times longer than AD. Idiosoma with four pairs of gland pores, one pair on AD, one on OC, and two pairs on PD. Pore canaliculus immediately posterior to gland pore of OC. Dorsal setae tiny. Pair of ds-1 on AD, ds-2 on OC, ds-3 in striated integument, ds-4 and ds-5 on PD, both anterior to the level of third pair of gland pores, ds-6 in posterior margin of PD. Part of anal sclerites seen in dorsal aspect. AE with pair of epimeral pores (Fig. 2), each slightly ovate and 4–5 µm in diameter, and two pairs of long, slender ventral setae. PE short, epimeral plate IV lacking; PE with single pair of slender setae. Anus in posterior end of idiosoma.

**Gnathosoma.** Length 117–123 µm, 0.44–0.50 of length of idiosoma. Rostrum slender, about 1.5 times longer than gnathosomal base. Gnathosomal base faintly ornamented. Pharyngeal plate large, extending almost to basal margin (Fig. 3). Tectum slightly concave. Basal pair of maxillary setae long, inserted near base of rostrum, apical pair of maxillary setae near tip of rostrum, adjacent to two pairs of rostral setae. Palps four-segmented. P-2 cylindrical, with conspicuously long seta at 0.68 or about 18 µm proximal to end of segment; apically with a ventromedial lamellar process (Fig. 4). P-3 with dorsomedial lamellar process. P-4 with three slender setae in a basal whorl, a short spine, two stout setae, about 7 µm long, and one setula. Chelicerae elongate; small apical claw dentate.

**Legs.** With three pairs of five-segmented legs; basi- and telofemora fused. Number of setae per segment: legs I and II, 1, 1+3 (basi- + telofemur), 4, 5, 6; leg III, 1, 1+2, 2, 5, 6. No variation in the 10 larvae studied. Tibiae I to III 1.2, 1.1 and 1.1 times longer than tarsi. Pair of ventral setae on genu and tibia I pectinate (Fig. 5). Genu II with single pectinate seta and tibiae II and III each with pair of ventral setae (Figs 6 and 7). All tarsi with pair of small fossa membranes. Tarsus I with dorsolateral papilla proximal to dorsal fossary seta. Solenidion on tarsus I and II in dorsolateral position immediately adjacent to fossa membrane, about 6 µm long. Dorsolateral fossary seta on tarsus I distinctly longer than dorsomedial seta. On tarsus II and III no such difference in length of fossary setae. On tarsus III interval between basal seta and dorsal fossary seta about 20 µm, distance from basal seta to basis of tarsus somewhat more than height of tarsus; basal seta at 0.27 relative to length tarsus (Fig. 8). All tarsi end with pair of



**Figs 9–16.** *Porolohmannella violacea*, protonymph, **9**, idiosoma, dorsal; **10**, idiosoma, ventral; **11**, leg I, medial; **12**, leg II, medial; **13**, leg III, medial; **14**, leg IV, medial; **15**, tarsus III, lateral (medial parambulacral seta and claw omitted, dorsomedial fossary seta in broken line); **16**, palp, lateral. (ep, epimeral pore) Scale = 50  $\mu\text{m}$ .

parambulacral setae. Tarsi with paired claws. Claw pecten with short tines. Central sclerite minute, on tarsus III with delicate upper tooth.

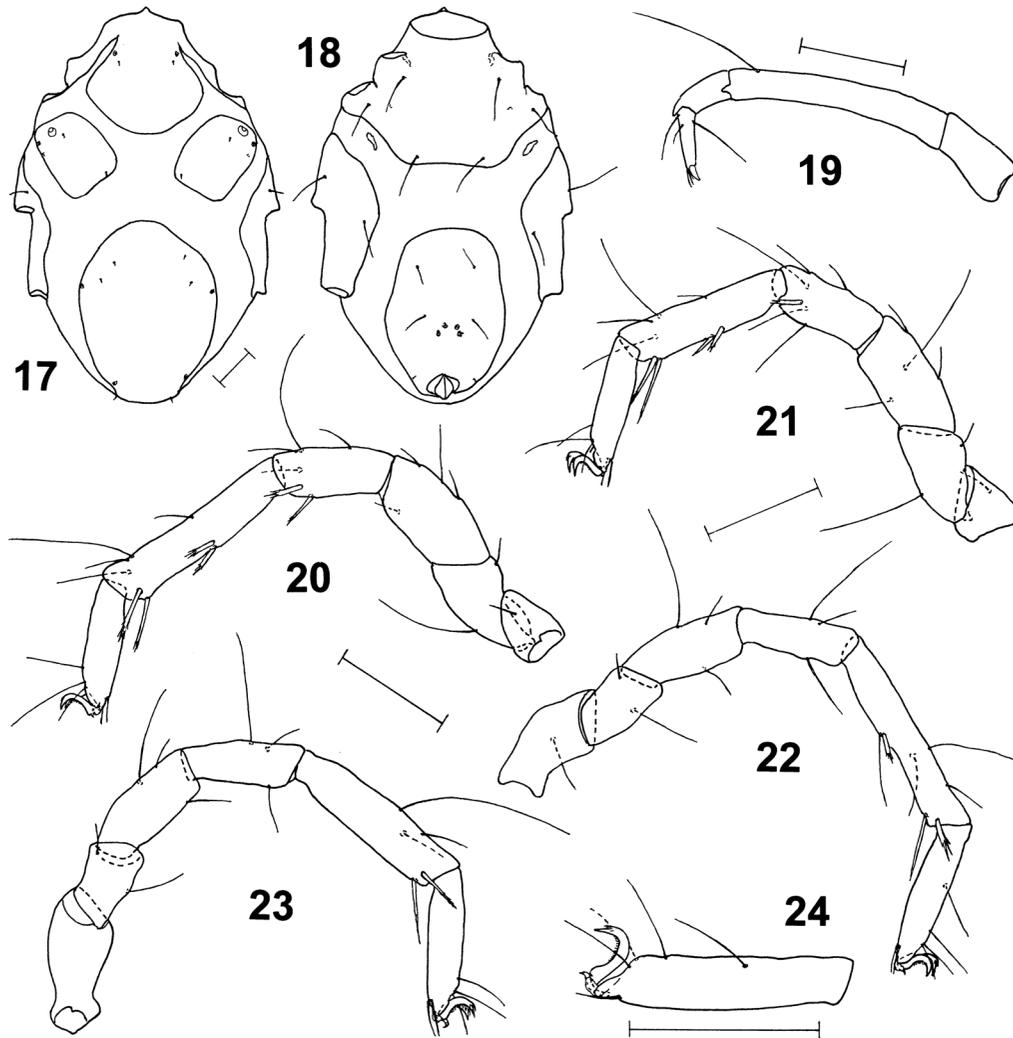
### 3. 2. Protonymph (Figs 9–16)

**Idiosoma.** Length 301–347  $\mu\text{m}$ . Idiosoma pale, translucent; gut contents with red spots. Idiosoma with two lateral and one median spot of eye pigment. Dorsal plates delicately reticulate. Anterior margin of AD truncate (Fig. 9) or with minute frontal process. OC longer than wide. PD 1.3 times longer than AD. Pair of ds-3 on OC. AE with

pair of small epimeral pores (Fig. 10), 3–4  $\mu\text{m}$  in diameter, and three pairs of slender setae. PE including epimeral plates III and IV; a single ventral (marginal) seta present. Genital plate and anal plate fused to GA; this plate with one pair of external genital acetabula which are 4  $\mu\text{m}$  in diameter.

**Gnathosoma.** Length 145–161  $\mu\text{m}$ , i.e., 0.43–0.49 of length of idiosoma. Seta on P-2 at 0.81 (Fig. 16); distance from seta to end of P-2 15  $\mu\text{m}$ .

**Legs.** With four pairs of legs, legs I to III six-segmented (Figs 11–13), leg IV five-segmented (Fig. 14). Leg chaetotaxy: legs I and II, 1, 2, 3, 5, 5, 6; leg III, 1, 2, 3, 2, 5, 6;



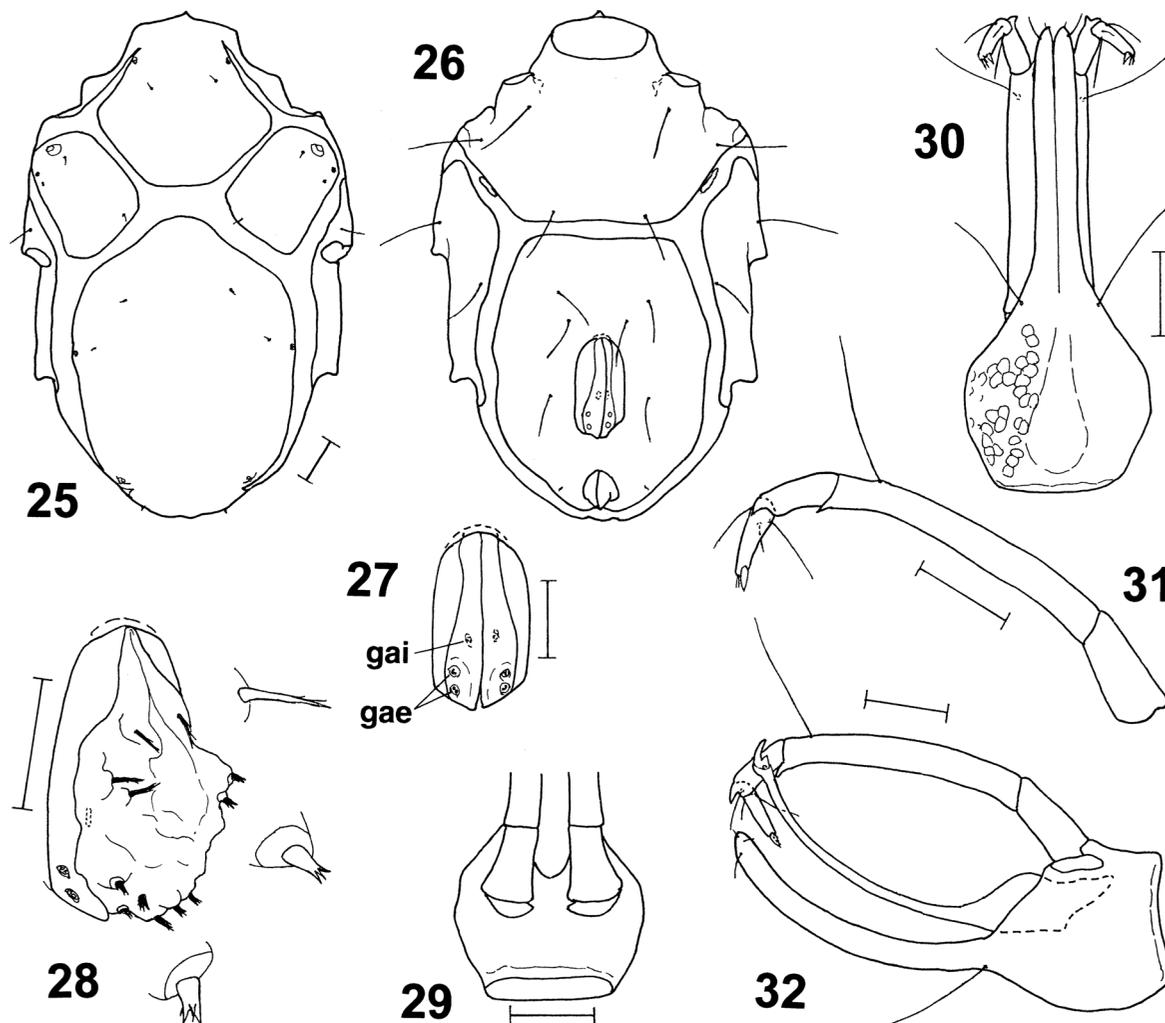
**Figs 17–24.** *Porolohmannella violacea*, deutonymph, 17, idiosoma, dorsal; 18, idiosoma, ventral; 19, palp, lateral; 20, leg I, medial; 21, leg II, medial; 22, leg III, medial; 23, leg IV, medial; 24, tarsus III, lateral (medial parambulacral seta and claw omitted, dorsomedial fossary seta in broken line). Scale = 50  $\mu\text{m}$ .

### 3. 3. Deutonymph (Figs 17–24)

leg IV, 0, 0+2 (basi- + telofemur), 3, 5, 5. Tibiae I to IV 1.5, 1.3, 1.2 and 1.1 times longer than tarsi; telofemora I to III 1.1–1.2 times longer than genua. Genu and tibia I each with pair of bipectinate setae (Fig. 11). Genu II with single pectinate seta. Tibiae II to IV each with pair of ventral setae; on tibia III ventromedial seta coarsely pectinate and somewhat shorter than ventrolateral seta; on tibia IV both setae similar in size and not markedly pectinate. Paired fossary setae on tarsus I dissimilar in length, on tarsi II to IV almost equal in length. Basal seta on tarsus III at 0.38 relative to length of tarsus (Fig. 15), or 1.5 times height of tarsus; interval between basal seta and dorsal fossary seta 20  $\mu\text{m}$ .

**Idiosoma.** Length 440–487  $\mu\text{m}$ . Idiosoma with three spots of eye pigment. Dorsal and ventral plates reticulate. AD with small frontal spine (Fig. 17); AD about as long as wide. OC with cornea, two pairs of minute setae, gland pore and pore canaliculus. Length of PD about 1.4 times that of AD. AE with three pairs of ventral setae; epimeral pores lacking. PE with short dorsal seta and two long ventral setae. GA with two pairs of setae, situated anterior to two pairs of genital acetabula (Fig. 18). Acetabula 3–4  $\mu\text{m}$  in diameter.

**Gnathosoma.** Length 195–204  $\mu\text{m}$ , i.e., 0.41–0.45 of length of idiosoma. Seta on P-2 at 0.85 (Fig. 19), or 15  $\mu\text{m}$  removed from apical end.



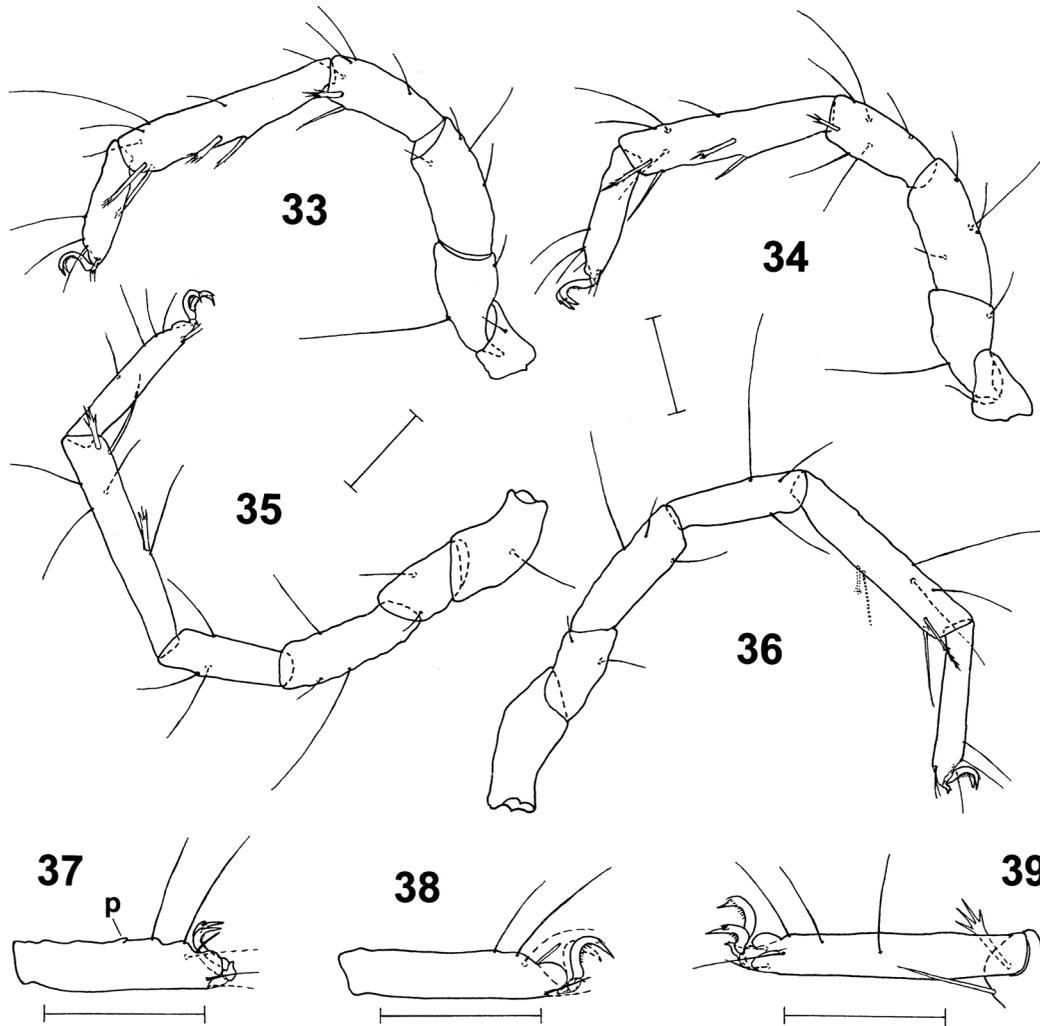
**Figs 25–32.** *Porolohmannella violacea*, female, **25**, idiosoma, dorsal; **26**, idiosoma, ventral; **27**, genital sclerites; **28**, ovipositor with genital spines; **29**, gnathosomal base, dorsal; **30**, gnathosoma, ventral; **31**, palp, lateral; **32**, gnathosoma, lateral. (gae, external genital acetabula; gai, internal genital acetabulum) Scale = 50  $\mu$ m.

**Legs.** All four pairs of legs six-segmented. Tibiae of legs I to IV 1.7, 1.5, 1.4 and 1.3 times longer than corresponding tarsi. Telofemora of all legs about 1.1 times length of genua. Leg chaetotaxy as summarized in Table 1. Genua I and II with two and one pectinate setae, respectively. Tibia I in general with four ventral pectinate setae (Fig. 20), rarely with three such setae and one of mid-segmental setae being absent. Tibia II mostly with three, rarely with four ventral setae (Fig. 21). Tibia III with four ventral setae, two of them short and pectinate, one seta slender and smooth and one rather stout but without distinct pectination (Fig. 22). Tibia IV with single pair of generally long ventral setae (Fig. 23). On tarsi I and II dorso-lateral fossary seta longer than dorsomedial one, on following tarsi these fossary setae similar in size. On tarsus

III distance between basal seta and dorsal fossary seta 20  $\mu$ m; this basal seta at 0.46 relative to length of tarsus (Fig. 24); distance between basal seta and basal edge of tarsus slightly more than height of tarsus.

### 3. 4. Female (Figs 25–39)

**Idiosoma.** Length 525–590  $\mu$ m. Integument of idiosoma, gnathosoma and legs pink to violet, gut contents red-brown. With three spots of eye pigment, a pair on OC and a single one on AD. Dorsal and ventral plates distinctly reticulate, mesh size 5–8  $\mu$ m. AD slightly wider than long (Fig. 25). OC longer than wide. Length of PD about 1.7 times that of AD. AE wider than long, with three pairs of ventral setae. PE with short dorsal seta and two long ven-

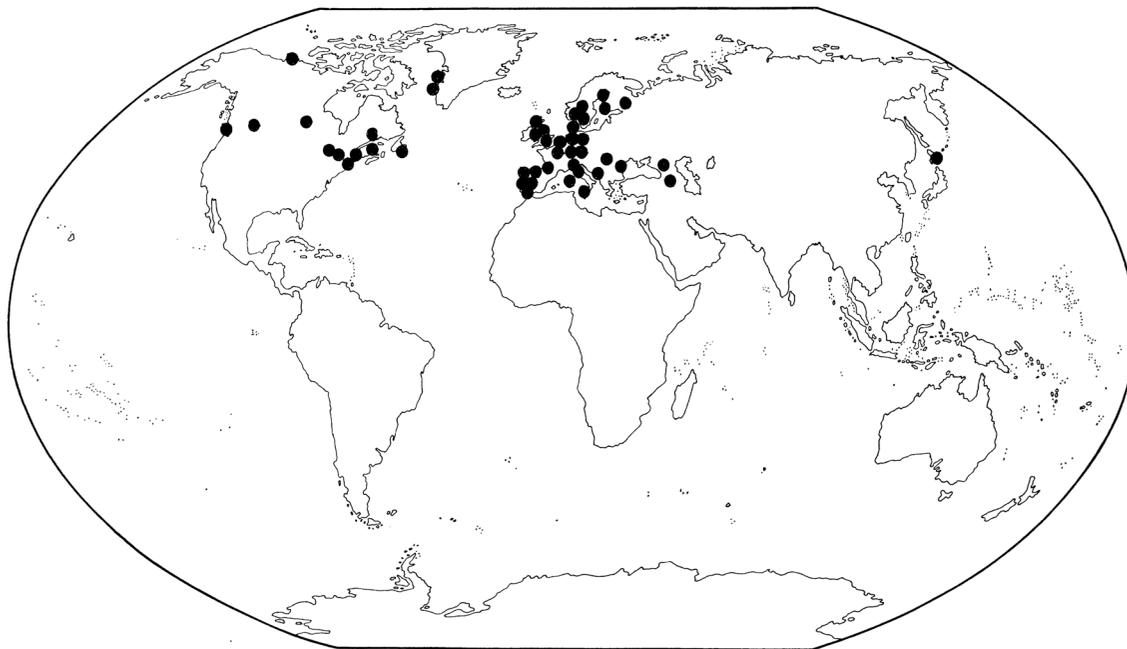


**Figs 33–39.** *Porolohmannella violacea*, female, **33**, leg I, medial; **34**, leg II, medial; **35**, leg III, medial; **36**, leg IV, medial; **37**, tarsus I, lateral (medial parambulacral seta and dorsomedial fossary seta in broken line); **38**, tarsus II, lateral (medial parambulacral seta, claw and dorsomedial fossary seta in broken line); **39**, end of tibia and tarsus III, dorsolateral. (p, papilla) Scale = 50  $\mu$ m.

tral setae (Figs. 25 and 26). GA large, dominating ventral aspect; plate with three pairs of slender perigenital setae, two pairs anterior to GO, one pair lateral to GO. GO almost in middle of GA. Genital sclerites with two pairs of external genital acetabula, each acetabulum about 5  $\mu$ m in diameter. A third pair of similar-sized genital acetabula in internal position, on inner flank of genital sclerites (Fig. 27). Ovipositor short, with basal pair of bristle-like setae and five pairs of short apical spines (Fig. 28). Basal pair 15  $\mu$ m long and delicately pennate. Apical pairs of genital spines 7–9  $\mu$ m long and tri- or quadrifid; two anterior pairs somewhat longer (9  $\mu$ m) than three posterior pairs of apical genital spines. Anus in ventral position. Females with zero to three eggs.

Gnathosoma. Length 252–275  $\mu$ m, 0.45–0.48 of length of idiosoma. Gnathosomal base coarsely foveate (Fig. 30). Arrangement of maxillary setae as in larva (Fig. 30). Tectum concave (Fig. 29). P-2 and P-3 with ventromedial and dorsomedial spiniform process, respectively (Fig. 32). Seta on P-2 at 0.86 (Figs 31 and 32), 20  $\mu$ m proximal to end of that segment.

Legs. Tibiae of legs I to IV 1.9, 1.6, 1.5 and 1.3 times longer than their tarsi; telofemora 1.1–1.2 times longer than genua. Chaetotaxy as summarized in Table 2. Genu and tibia I with one and two pairs of ventral setae, respectively, ventromedial setae distinctly pectinate (Fig. 33), ventrolateral setae weakly pectinate. Genu and tibia II with one and three to four pectinate setae, respectively (Fig. 34).



**Fig. 40.** Geographical distribution of *Porolohmannella violacea*.

**Table 1.** *Porolohmannella violacea*, deutonymph. Leg segments and their number of setae (number of cases of a given variant in brackets).

segment	1	2	3	4	5	6
<b>leg I</b>	1(20)	2(20)	3(2),4(17),5(1)	6(20)	7(7),8(13)	6(20)
<b>leg II</b>	1(20)	2(20)	3(1),4(19)	6(20)	7(18),8(2)	6(20)
<b>leg III</b>	1(20)	2(20)	3(20)	3(20)	7(20)	6(20)
<b>leg IV</b>	0(20)	2(20)	3(20)	3(20)	5(20)	5(20)

**Table 2.** *Porolohmannella violacea*, female. Leg segments and their number of setae (number of cases of a given variant in brackets).

segment	1	2	3	4	5	6
<b>leg I</b>	1(20)	2(20)	4(20)	6(20)	7(1),8(19)	6(20)
<b>leg II</b>	1(20)	2(20)	4(20)	6(20)	7(3),8(17)	6(20)
<b>leg III</b>	1(20)	1(1),2(17),3(2)	3(20)	3(20)	7(20)	6(20)
<b>leg IV</b>	0(19),1(1)	2(20)	2(1),3(19)	3(20)	5(3),6(12),7(5)	5(20)

**Table 3.** *Porolohmannella violacea*. Number of idiosomal setae, epimeral pores, epimeral plates, and genital acetabula (internal and external) in each instar. (–, GP absent in larva. Changes from one instar to the other underlined and in bold).

	L	PN	DN	Ad
AE, pairs of setae	2	<u>3</u>	3	3
AE, pairs of epimeral pores	1	1	<u>0</u>	0
PE including epimeral plates	EIII	EIII, <u>EIV</u>	EIII,EIV	EIII,EIV
PE, number of setae	1	1	<u>3</u>	3
GP, pairs of setae	–	0	<u>2</u>	<u>3</u>
GP, pairs of acetabula	–	1	<u>2</u>	<u>3</u>

**Table 4.** *Porolohmannella violacea*. Leg chaetotaxy of larva\protonymph\deutonymph\female.

(–, leg IV absent in larva. Single cases omitted, rare variants in parentheses. Changes from one instar to the other underlined and in bold).

	leg I	leg II	leg III	leg IV
	L\PN\DN\Ad	L\PN\DN\Ad	L\PN\DN\Ad	L\PN\DN\Ad
trochanter	1\1\1\1	1\1\1\1	1\1\1\1	–\0\0\0
basifemur	1 <u>2</u> \2\2	1 <u>2</u> \2\2	1 <u>2</u> \2\2(-3)	–\0\2\2
telofemur	3\3\3- <u>4</u> \4	3\3\4\4	2\3\3\3	–\2\3\3
genu	4\5\6\6	4\5\6\6	2\2\3\3	–\3\3\3
tibia	5\5\7- <u>8</u> \8	5\5\7(-8)\(7-) <u>8</u>	5\5\7\7	–\5\5\5- <u>6</u> \(-7)
tarsus	6\6\6\6	6\6\6\6	6\6\6\6	–\5\5\5

Tibia III with four ventral setae, ventromedial setae short and pectinate (Fig. 35). Tibia IV with three dorsal and two to four ventral setae (Fig. 36); pair of apical ventral setae always present; number of mid-segmental setae, one pectinate, one slender, variable, often different on right and left leg. Solenidia on tarsi I and II (Figs 37 and 38) in dorsolateral position, adjacent to fossa membrane, 10 and 9 µm in length, respectively. On these tarsi dorsomedial fossary seta distinctly shorter than dorsolateral seta. Tarsus I with papilliform process proximal to dorsal fossary seta (Fig. 37). Basal seta of tarsus III almost in middle of segment, at 0.57 relative to length of tarsus (Fig. 39), interval between basal seta and base of tarsus 1.3 times that of height of tarsus, distance from basal seta to dorsal fossary seta 20–22 µm. All tarsi with pair of parambulacral setae and pair of claws.

**Male unknown.**

**Remarks.** In the females, the number and shape of the ventral setae on tibia IV proved to vary from two to four. The apical pair of setae always is present, the two mid-

segmental setae, one bipectinate, one slender, may be lacking on either one or both legs. Unilateral differences are very common. In ten females studied the most common combination of setae on tibia IV was, presence of the slender ventral mid-segmental seta but absence of the pectinate seta (11 legs, 55 %). On five tibiae IV (25 %) both a pectinate and a slender mid-segmental seta were present, whereas on three tibiae (15 %) both mid-segmental setae were absent. A single tibia IV (5 %) had a pectinate but no slender mid-segmental seta. In material (53 females) from North America (unpublished data), the presence of three ventral setae on tibia IV was the most common state (63 %), without any concentration on the one or other variant in a given locality (population). The four females collected on Hokkaido, Japan, had three ventral setae on tibiae IV, all pectinate (ABÉ 1990).

All instars have a small dorsolateral papilla on tarsus I (cf. Fig. 37), although in dorsomedial aspect the papilla may be obscured. ABÉ (1990) emphasized the similarity with a chemosensory organ. There is a very delicate afferent canal through the integument, so this papilla is not mere-

ly a part of the reticulum that covers the surface; it may represent a famulus.

### 3. 5. Development

The larva has a short idiosoma with three pairs of five-segmented legs. The dorsal plates AD, OC and PD are present, the PD is short (relative to length of the AD), the ornamentation of the plates is weak. The larva already has the final number of dorsal idiosomatic setae and gland pores. The AE has a pair of epimeral pores and two pairs of setae. The PE is short and bears a single seta. The anal sclerites are partly visible in dorsal aspect. The gnathosoma is characterized by its slender palps and rostrum.

In the protonymphs the epimeral plate IV and leg IV have been added. The OC and PD have increased in size, the OC in the medial and posterior portion, the PD both anterior to the pair of ds-4 and between the gland pores. The PE that now includes epimeral plate IV is much longer than in the larva but the PE still bears a single seta. On the AE a pair of setae on epimeral plate II has been added. The epimeral pores are still present though less conspicuous than in the larva. A genital plate, fused with the anal plate, and a pair of genital acetabula have been added. The shape of the gnathosoma resembles that of the larva but the position of the seta on P-2 has changed in this and the following instars. The femora of the three larval pairs of legs are divided, hence the legs are six-segmented, leg IV is five-segmented. The tibiae have increased in length, relative to the tarsi. Setae have been added to the basifemora I to III, telofemur III and genua I and II.

The deutonymph differs from the protonymph in that the epimeral pores of the AE are reduced, on the PE a short dorsal and long ventral seta are added and the GA bears two pairs of genital acetabula and two pairs of pgs. Both pairs of setae are anterior to the genital acetabula. All legs are six-segmented. Changes in the number of setae are summarized in Table. 4. Setae have been added on basifemur IV, telofemora I, II and IV, and genua and tibiae I to III.

In the female both the dorsal and ventral plates are longer and wider and their reticulate ornamentation is much more prominent than in the nymphs, and the areas of striated integument between the plates are narrow. On the large GA a posterior pair of pgs has been added and in the middle of the plate is the large genital opening. Two pairs of genital acetabula have moved onto the genital sclerites, a third pair is on the inner flank of the sclerites. The anal sclerites are in a ventral position. The shape, number of setae and the ratio of gnathosoma to idiosoma is similar to that of the other instars, P-2 has grown in length and

the seta, in almost mid-segmental position in the larva, is now in an apical position. All legs, especially their tibiae, have increased in length; tibia I is 1.7 times longer than tarsus I (instead of 1.1–1.2 times as in the larva). The tarsi are more slender (length:height ratio) than in the larva, extended in length primarily at their bases, as demonstrated on tarsus III. The basal seta of tarsus III is positioned at 0.56 in the female, but at 0.46, 0.38 and 0.27 in the preceding instars, respectively. The setation of the tibiae often differs from that in the deutonymph, that of the other leg segments is the same in both instars.

The number of setae on trochanters and tarsi is unchanged throughout all instars.

### 4. BIOLOGY AND DISTRIBUTION

The majority of records of *Porolohmannella violacea* are from standing surface waters, swamps, ponds and lakes, though the species also has been extracted from the groundwater (GLEDHILL, 1973, 1982; STRAYER, 1988). *Porolohmannella violacea* inhabits altitudes from the sea level (coastal waters) to mountain lakes in almost 2000 m, e.g., the Lacs de Estibère in the Pyrenees (ANGELIER 1965) and the Statzer See in the Alps (WALTER 1922), and a variety of substrata, sand, flocculent ooze, vascular plants, mosses, algae and also gill chambers of crayfish. Details on the life cycle are not known, other than that females are ovigerous most time of the year, carrying one to six eggs each. The presence of a large number of larvae in spring 2006 (beginning of June), as well as deutonymphs and females, and the appearance of protonymphs in the sample from July, seems to be an evidence for intense reproduction in spring.

All present records are from the northern hemisphere (Fig. 40), from Europe, Greenland, North America, and Japan (K. VIETS 1956; K.O. VIETS 1978, 1987; GREEN & MACQUITTY, 1987; PEÑIC 2004; BARTSCH 2006). The data summarized in Fig. 40 include unpublished records from Spain, Portugal and Canada (Northwest Territories, British Columbia, Alberta, Manitoba, Ontario, Quebec, Newfoundland). Several of the collecting sites (e.g., in Greenland and Northwest Territories (lake near Tuktoyaktuk)) are ice-covered for most of the year. In contrast, the small pond near Hamburg, hardly shaded by trees, was exposed for several weeks to unusual long-term solar radiation, high temperatures and deteriorating oxygen supply. The pond was rapidly evaporating in July. Beneath a cover of dried remnants of a former vegetation, in a moist mixture of sediment, debris and mosses, specimens of *P. violacea* still were alive. At a visit to the pond at the end of August, after repeatedly heavy rainfall and distinctly lowered temperature, the moss was found to be regener-

ating. In the sample examined *Porohalacarus alpinus* and *Hydrozetes* sp. were still present in moderate numbers, adults as well as juveniles. The number of specimens of *Porolohmannella violacea* had decreased considerably, but still, larvae, nymphs and females were found.

## 5. DISCUSSION

In several descriptions of the freshwater halacarids *Lobohalacarus weberi*, *Porohalacarus alpinus*, *Soldanellonyx monardi* and *S. chappuisi* Walter, 1917, the external characters of the one or other juvenile have been briefly outlined (WALTER 1919b; WALTER & BADER 1952; BARTSCH 1973, 1975, 1982); unfortunately some species are described exclusively on the basis of nymphs (WALTER 1919a; VIETS 1931; JANKOVSKAJA 1967). Now, the development of external characters from larva to adult of *Porolohmannella* has been examined. The marine genera best studied in respect to their development are *Copidognathus*, *Isobacrus*, *Rhombognathides* Viets, 1927, *Metarhombognathus* Newell, 1947 and *Rhombognathus* Trouessart, 1888 (BARTSCH 1998, 2003).

In contrast to many other aquatic mite taxa, e.g., Hydrachnidia and Oribatida, the juvenile instars of halacarid mites do not differ markedly from adults, though of course they are of smaller size. Halacarids have no apparent change in habitat or life-style.

Freshwater halacarids progress through one larval and two nymphal instars until they moult into the adult. A single exception, *Astacopsiphagus parasiticus* Viets, 1931, a mite found on freshwater crayfish in Australia, has three nymphal instars in its life cycle (VIETS 1931). Marine halacarids have one to three nymphal instars.

The character development in *P. violacea* is similar to that known in other halacarid species (cf. BARTSCH 1998, 2003). Minor differences are:

(a) In *P. violacea* epimeral pores are present in the larva but also in the protonymph; they are absent in the deutonymph and female. In most marine species in which adults lack epimeral pores, these pores are restricted to the larva.

(b) There is a striking change in the length ratio of tibia to tarsus, with a marked growth of the tibiae compared with that of the tarsi. Such a difference in length has not been described before. Adults of *P. violacea* are long-legged, but marine species studied so far are short-legged. Long-legged marine species may show a similar shift in the length relation.

(c) From instar to instar, the basal seta on tarsus III and the seta on P-2 are moved to a more apical position. The segments obviously grow in length near their bases. In marine genera, a similar but much less marked growth near the base of the tarsi has been documented. The marine species studied to date are short-legged whereas the nymphs and females of *P. violacea* have long and slender legs and palps.

Karl VIETS (1927, 1933) once distinguished between halacarid species of marine and freshwater, between Halacaridae and Porohalacaridae, respectively. That distinction has been abandoned (NEWELL 1947, 1959; BARTSCH 1973, 1989; PETROVA 1974, 1981) because it was not supported by synapomorphies. The ontogeny of *Porolohmannella violacea* is similar to the development of characters in marine halacarid species, and hence does not support a taxonomic separation into marine and freshwater families.

According to Fig. 40, *P. violacea* is wide-spread throughout the northern hemisphere. These data do not imply that *P. violacea* is restricted to the holarctic. *Porolohmannella violacea* is euryvalent and thrives in a variety of habitats, in standing as well as in running water, in brackish coastal as well as humic inland waters, it can withstand long-term solar radiation with rising water temperature, but also ice-covering for more than six months. One may speculate that high temperature prevents a colonization of the tropics, but the *P. violacea* population in northern Germany proved to withstand the hot summer in 2006. Hence, the temperature in the tropics should not hamper a distribution. According to TESCHNER (1963) and SIEMER (1996), in the freshwater halacarid *Lobohalacarus weberi* and the marine *Metarhombognathus armatus* (Lohmann, 1893) a cold season is needed in the course of development. Does the higher and more uniform annual temperature cycle in warm-temperate and tropic areas prevent *P. violacea* from colonization? Presumably not. *Lobohalacarus weberi* has been collected in the southern hemisphere, in Australia (Queensland, near Brisbane) (unpublished), in an area with an annual surface water temperature range between 16 °C and 29 °C (DAVIE 2004). Similarly, *P. violacea* may thrive in the tropics and southern hemisphere. The present geographic distribution, restricted to the holarctic, is merely the result of the extraordinarily low number of samples taken in the south compared to that in the north. *Porolohmannella violacea* may be Mesozoic, or even Pre-Mesozoic, in origin (BARTSCH 1996). The species is expected to be found in South America, Africa and Australia, either being a remnant of a Pangaean fauna or introduced by means of birds, mammals, insects, extreme floods and storms.

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## REFERENCES

- ABÉ, H. 1990. New record of *Porolohmannella violacea* (KRAMER, 1879) (Acari, Halacaridae). *Acarologia* **31**: 241–246.
- ALBERTI, G. 1977. Zur Feinstruktur und Funktion der Genitalnöpfe von *Hydrodroma descipiens* (Hydrachnellae, Acari). *Zoomorphologie* **87**: 155–164.
- ALBERTI, G. 1979. Fine structure and probable function of genital papillae and Claparède organs of Actinotrichida. Pp. 501–507 in: RODRIGUEZ, J. (ed.) *Recent Advances in Acarology*. II. Academic Press, New York.
- ANGELIER, E. 1965. Les Porohalacaridae de la faune française. *Annales de Limnologie* **1**: 213–220.
- BARTSCH, I. 1973. *Porohalacarus alpinus* (Thor) (Halacaridae, Acari), ein morphologischer Vergleich mit marinen Halacariden nebst Bemerkungen zur Biologie dieser Art. *Entomologisk Tidskrift* **74**: 116–123.
- BARTSCH, I. 1975. Zur Kenntnis der Halacaridenfauna (Acari) der Quellenregion. I. Ein Beitrag zur Morphologie und Biologie dreier Arten aus dem Sphagnetum. *Gewässer und Abwasser* **57/58**: 27–42.
- BARTSCH, I. 1982. Halacaridae (Acari) im Süßwasser von Rhode Island, USA, mit einer Diskussion über Verbreitung und Abstammung der Halacaridae. *Gewässer und Abwasser* **68/69**: 41–58.
- BARTSCH, I. 1989. Süßwasserbewohnende Halacariden und ihre Einordnung in das System der Halacaroidea (Acari). *Acarologia* **30**: 217–239.
- BARTSCH, I. 1996. Halacarids (Halacaroidea, Acari) in freshwater. Multiple invasions from the Paleozoic onwards? *Journal of Natural History* **30**: 67–99.
- BARTSCH, I. 1998. A new species of the *Copidognathus pulcher* group (Acari: Halacaridae) from Western Australia. Description of adults and juveniles and notes on developmental pattern. *Species Diversity* **3**: 187–200.
- BARTSCH, I. 2003. The subfamily Rhombognathinae: developmental patterns and re-evaluation of the phylogeny (Arachnida, Acari, Halacaridae). *Senckenbergiana biologica* **82**: 15–57.
- BARTSCH, I. 2004. *Acarothrix ampliata* (Acari: Halacaridae: Copidognathinae), a new halacarid mite from Florida, with notes on external genital acetabula. *Species Diversity* **9**: 259–267.
- BARTSCH, I. 2006. 5. Acari: Halacaroidea. Pp. 113–157 in: GERECKE, R. (ed.), *Chelicerata Araneae, Acari I. Süßwasserfauna Mitteleuropas 7/2–1*: Spektrum Elsevier, Heidelberg. [2007].
- BARTSCH, I. Halacarid mites (Acari) in a freshwater influenced beach of North Stradbroke Island, Moreton Bay: Queensland. *Memoirs of the Queensland Museum* (in press).
- DAVIE, P. 2004. *Wild Guide to Moreton Bay: wildlife and habitats of a beautiful Australian coast – Noosa to the Tweed*. Queensland Museum, Brisbane.
- DEUTSCHER WETTERDIENST 2006. *Witterungsbericht für Januar–August 2006*. (<http://www.dwd.de>).
- GLEDHILL, T. 1973. Observations on the numbers of water-mites (Hydrachnellae, Porohalacaridae) in Karaman/Chappuis samples from the interstitial habitat of riverine gravels in Britain. Pp. 249–257 in: ORGHIDAN, T. *Livre du cinquantenaire de l'Institute de Spéologie 'Emile Racovitza'*.
- GLEDHILL, T. 1982. Water-mites (Hydrachnellae, Limnohalacaridae) from the interstitial habitat of riverine deposits in Scotland. *Polskie Archiwum Hydrobiologii* **29**: 439–451.
- GREEN, J. & MACQUITTY, M. 1987. Halacarid mites. Synopsis of the British Fauna (New Series) **36**: 1–178.
- JANKOVSKAJA, A.I. 1967. K faune gruntovich vod srednej Asii. I. Predstaviteli vodnich klešcej iz gruppi Porohalacaridae (Acari) v gruntovich vodach kolodcev kizilkumov. *Trudy zoologiceskogo Instituta, Akademija Nauk SSSR, Leningrad* **43**: 109–117.
- KRAMER, P. 1879. Ueber die Milbengattungen *Leptognathus* Hodge, *Raphignathus* Dug., *Caligonus* Koch und die neue Gattung *Cryptognathus*. *Archiv für Naturgeschichte* **45**: 142–157.
- LOHMANN, H. 1901. Fam. Halacaridae. *Das Tierreich* **13**: 273–305.
- MEISCH, C. 2000. Crustacea; Ostracoda. 522 pp in: SCHWOERBEL, J. & ZWICK, P. (eds.) *Süßwasserfauna von Mitteleuropa* **8/3**. Spektrum Verlag, Heidelberg.
- NEWELL, I. M. 1947. A systematic and ecological study of the Halacaridae of eastern North America. *Bulletin of the Bingham oceanographic Collection* **10**: 1–232.
- NEWELL, I. M. 1959. 42. Acari. Pp. 1080–1116 in: WHARD, H. B. & WHIPPLE, G.C. (eds) *Fresh-water Biology*. 2nd edition. John Wiley & Sons, New York.
- PEŠIĆ, V. 2004. New records of halacarid mites (Acari, Halacaroidea) from Monte Negro. *Biodiversity of the Biogradska Gora National Park* **1**: 113–120.
- PETROVA, A. 1974. Sur la migration des halacariens dans les eaux douces et la position systématique des halacariens et limnohalacariens. *Vie et Milieu (C)* **24**: 87–96.
- PETROVA, A. 1981. Sur le système des Halacaridae MURRAY, 1877 (Acari, Prostygmatata). *Acta zoologica Bulgarica* **17**: 58–62.
- SIEMER, F. 1996. Untersuchungen zur Verteilung, zur Biologie und zum Lebenszyklus mariner Halacaridae (Prostigmata: Acari) im ästuarinen Felslitoral. 165 pp. Dissertation der Universität Bremen, Bremen.
- STRAYER, D. 1988. Crustaceans and mites (Acari) from hyporheic and other underground waters in southeastern New York. *Stygologia* **4**: 192–207.
- TESCHNER, D. 1963. Die Biologie, Verbreitung und Ökologie der Grundwassermilbe *Lobohalacarus weberi quadriporus* (WALTER, 1947), Limnohalacaridae Acari. *Archiv für Hydrobiologie* **59**: 71–102.
- TROUËSSART, E. 1901. Note sur les Acariens marins (Halacaridae) récoltés par M. Henri de Gadeau de Kerville dans la région d'Omonville-la-Rogue (Manche) et dans la fosse de la Hague. *Bulletin de la Société amis des sciences naturelles, Rouen (série 4)* **14**: 247–266.
- VIETS, K. 1927. Die Halacaridae der Nordsee. *Zeitschrift für wissenschaftliche Zoologie* **130**: 83–173.
- VIETS, K. 1931. Über eine an Krebskiemen parasitierende Halacaride aus Australien. *Zoologischer Anzeiger* **96**: 115–120.
- VIETS, K. 1933. Vierte Mitteilung über Wassermilben aus unterirdischen Gewässern (Hydrachnellae et Halacaridae, Acari). *Zoologischer Anzeiger* **102**: 277–288.
- VIETS, K. 1956. Die Milben des Süßwassers und des Meeres. Katalog der Halacaridae. Meeresmilben. II. Abschnitt. Pp. 641–

- 870 in: VIETS, K. (ed.) Die Milben des Süßwassers und des Meeres. Hydrachnellae et Halacaridae, Acari. VEB Fischer Verlag, Jena.
- VIETS, K. O. 1978. Hydracarina. Pp. 154–181 in: ILLIES, J. (ed.) Limnofauna Europaea. Eine Zusammenstellung aller die europäischen Binnengewässer bewohnenden mehrzelligen Tierarten mit Angaben über ihre Verbreitung und Ökologie. 2te Auflage, Gustav Fischer Verlag, Stuttgart.
- VIETS, K. O. 1987. II. Halacaridae des Süßwasser. Pp. 829–857 in: VIETS, K. O. (ed.) Die Milben des Süßwassers (Hydrachnellae und Halacaridae [part.], Acari). 2: Katalog. Sonderbände des naturwissenschaftlichen Vereins zu Hamburg 8. Paul Parey, Hamburg.
- WALTER, C. 1919a. Hydracarinae aus den peruanischen Anden und aus Brasilien. *Revue Suisse de Zoologie* **27**: 19–59.
- WALTER, C. 1919b. Schweizerische Süßwasserformen der Halacariden. II. *Revue Suisse de Zoologie* **27**: 236–242.
- WALTER, C. 1922. Die Hydracarinae der Alpengewässer. *Denkschriften der schweizerischen naturforschenden Gesellschaft* **58**: 61–252.
- WALTER, C. & BADER, C. 1952. Mission scientifique de l’Omo – Hydracarina. *Mémoires du Muséum nationale histoire naturelle, Série A*, **4**: 87–236.
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