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STUDIES ON BOREAL AGROMYZIDAE (DIPTERA).
X. PHYTOMYZA MINERS ON CRASSULACEAE

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Three species of Phytomyza are known as leaf-miners of Crassulaceae, as follows: Phytomyza rhodiolae n. sp. (type-locality Kluane Lake, Yukon Territory) on Rhodiola rosea L., P. sedi Kaltenbach (Europe) on Sedum album L., and P. sedicola Hering (Europe) on Sedum telephium L. and S. cepaea L. Descriptions and illustrations of the differences in the male genitalia and puparia are given for each species.

Trois espèces de Phytomyza sont connues comme mineuses dans les feuilles des Crassulacées, tel que: Phytomyza rhodiolae n. sp. (localité-type Lac Kluane, Territoire du Yukon) sur Rhodiola rosea L., P. sedi Kaltenbach (Europe) sur Sedum album L., et P. sedicola Hering (Europe) sur Sedum telephium L. et S. cepaea L. Des descriptions et des illustrations des différences entre les genitalia mâles et les puparia sont pourvues pour chaque espèce.

Folgende drei Arten von Phytomyza werden als Blattminierer von Crassulaceae besprochen: Phytomyza rhodiolae n. sp. (Fundort des Typus: Kluane Lake, Yukon Territorium) an Rhodiola rosea L., P. sedi Kaltenbach (Europa) an Sedum album L., und P. sedicola Hering an Sedum telephium L. und S. cepaea L. Jede Art wird durch Beschreibung und Abbildungen der unterschiedlichen männlichen Kopulationsorgane und der Puparien abgegrenzt.

The *Phytomyza* miners of Crassulaceae have been little studied, as indicated by the fact that genitalia figures have previously been published for only one species (*P. sedicola* Hering) and for that very recently (Spencer, 1972). My recent discovery of a new species in the recently declared Kluane National Park (Yukon Territory) makes it opportune for me to provide a complete review of the available information.

Spencer (in correspondence) has concluded on the basis of the structure of the aedeagus that *Phytomyza sedicola* Hering belongs to the *P. hendeli* group, containing also miners of *Clematis*, *Anemone* and *Ranunculus* (Ranunculaceae). Information on this group will be given in his work (now in press) on the Agromyzidae of Denmark and Fennoscandia. The other two Crassulaceae-miners, *P. sedi* Kaltenbach and *P. rhodiolae* n. sp., have a rather different type of aedeagus characterized by a shortened basal section and the absence of paramesophalli. They are clearly monophyletic sister-species (since at least the shortened basal section must be interpreted as a synapomorphy), but whether they also belong with *P. sedicola* to the *P. hendeli* group requires clarification. I will not speculate on this question until further information on the group has been published.

Identification of the immature stages of the species treated in this paper should not present difficulty. They all feed on different host plants, and are the only Agromyzidae known to attack these plants. The posterior spiracles are diagnostic for each species (Fig. 10-12). Identification of adults should be based on study of the male aedeagus, which is strikingly different in each species (Fig. 1-9).

I follow the botanical nomenclature of Webb (1964), who treats *Rhodiola* as a genus distinct from *Sedum* and uses the name *Sedum telephium* L. in a wide sense (including *S. maximum* L. and others as subspecies). The holotype of the new species (*Phytomyza rhodiolae*) has been deposited in the Canadian National Collection (Ottawa). My use of terms and abbreviations was explained in the first paper of this series (Griffiths, 1972).

TREATMENT OF SPECIES

Phytomyza rhodiolae new species

Adult. – Head with orbits narrowly projecting above eye in lateral view; genae in middle 0.4 - 0.5 times eye height; eyes with only sparse fine pubescence. Frons at level of front ocellus about twice width of eye; orbits very broad posteriorly, together occupying at least half of frons width. Ors normally directed posteriorly (but one or both directed anteriorly in a few specimens), ori directed inwardly; posterior ors normally fully as long as anterior ors (shorter or on one side absent in only two specimens); anterior ori variously developed, 0.3 - 0.8 times as long as posterior ori; orbital setulae more or less two-rowed posteriorly. Peristomal margin with vibrissa and 2-5 upcurved peristomal setulae. Third antennal article rounded distally, with short pubescence.

Normally 3 + 1 dc (but 4 + 1 in one male); acr in 2-4 irregular rows anteriorly; 4-8 presutural ia; 2-6 postsutural ia; inner pa short, at most 1/3 as long as outer pa.

Second cross-vein (m-m) absent. Costal ratio mg_2/mg_4 1.5-1.8 (means: ♂, 1.65; ♀, 1.7). Wing length: ♂, 1.45-1.95 mm (mean 1.8 mm); ♀, 1.9-2.1 mm (mean 2.0 mm).

Colour almost entirely dark. Centre of frons dark brown, scarcely paler than black ocellar plate and vertex; anterior part of orbits slightly paler (brownish) along eye margins in some specimens; genae brown. Labella dull yellow to yellow-brown. Thorax finely grey-dusted over black ground-colour, weakly shining; seams of notopleural and mesopleural sutures greyish white; wing base and squamae infuscated (largely grey or grey-brown), latter with blackish fringe. Legs largely black, with tips of femora yellow-brown to dark brown (scarcely contrasting). Abdomen largely dark brown. Basal cone of ovipositor (♀) entirely grey-dusted.

Eighth sternum of male postabdomen more or less fused with 6th tergum along distinct suture line, with narrow lateral extensions to sides of venter. Telomeres represented by densely setulose apical lobes of perianthrium, not delimited by suture. Pregonites not extending ventrally. Aedeagus as Fig. 1-2; basal sclerites short, strongly asymmetrical, the left with long curved basal process extending below phallosome; medial lobe large but inconspicuous, unpigmented except for a few small marks; distal section with pair of slender divergent sinuate tubules (distiphallus) arising from cylindrical area of sclerotization about ejaculatory duct (mesophallus), without paramesophalli. Ejaculatory apodeme as Fig. 3; lateral angles of ejaculatory bulb pigmented.

Puparium and third instar larva. – Mandibles with two alternating teeth, right mandible longer than left. Anterior and posterior spiracles of similar structure but latter much larger, each with two long horns of about equal length with bulbs mostly near apices of horns; anterior spiracles with 6-8 bulbs on each horn (12-15 bulbs in total); posterior spiracles (Fig. 10) on large conical projections, with 9-12 bulbs on each (very long and slender) horn (19-24 bulbs in total). Puparium dark brown, shining, with conspicuous transverse wrinkles on all segments, 1.9 - 2.3 mm long.

Mine. – Larvae solitary leaf-miners on *Rhodiola rosea* L. Mine (Fig. 13) basically linear-blotch (linear initially), occupying whole or greater part of leaf in most cases, with channels visible both on upper and lower surfaces (partly full-depth), appearing whitish green in reflected light when fresh; faeces deposited as discrete particles. Pupation site varying; the majority of the larvae in the original sample left their mines (through slits on the upper or lower surface of the leaf) before puparium formation, but others remained in their exit slits so that the hind end of the puparium became anchored in the leaf by the posterior spiracles and a few formed puparia completely inside the leaf without an exit slit.

Types. – Holotype ♂, 10 ♂♂ 18 ♀♀ paratypes from larvae 24.vii.72 on *Rhodiola rosea* L. subsp. *integrifolia* (Raf.), near S end Kluane Lake (rock ledge at 4000 feet elevation on Sheep Mountain; 61° 2'N, 138° 32'W), Yukon Territory, emerged 3-13.v.73, leg D. E. & G. C. D. Griffiths.

Remarks. – An interesting anomaly of the abdominal structure is shown by two males of this species. In one the 4th and 5th terga are divided in the centre of the dorsum, and the anterior margin of the 6th tergum projects forward between the halves of the 5th tergum. A second male shows the same anomaly to a lesser degree; only its 5th tergum is divided, and the 6th tergum is less projected anteriorly. This modification may have functional significance in allowing lengthening of the muscles attached to the 6th tergum.

The host-plant, *Rhodiola rosea* L., is widely distributed in Eurasia, as well as in North America. There is one previous record of *Phytomyza* mines on it, by Hartig (1939) for Alto Adige (Italy). As far as I am aware, no flies were obtained from Hartig's samples. His ascription of the mines to *P. sedicola* Hering therefore needs confirmation, and we should bear in mind the alternative possibility that he had the present species before him.

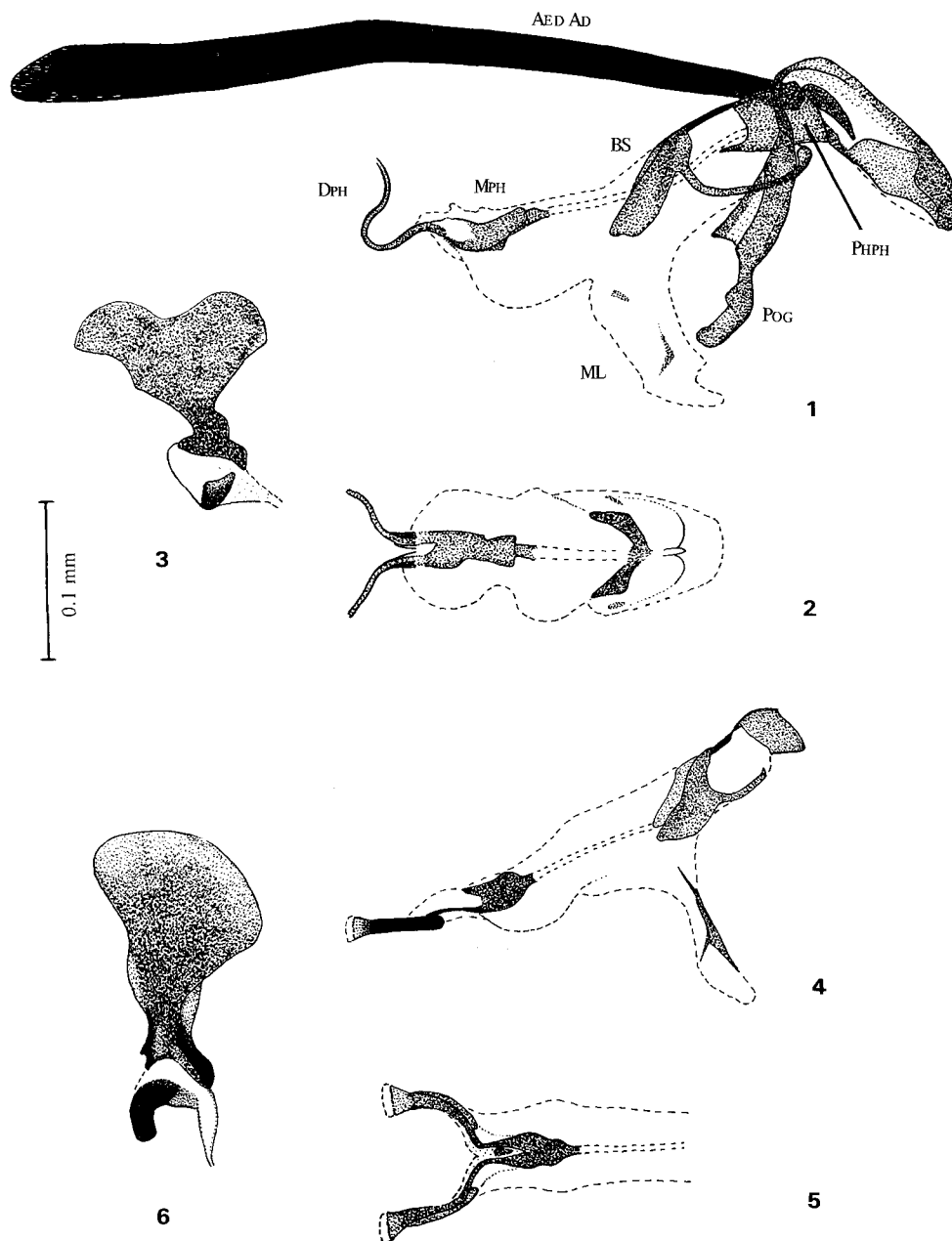


Fig. 1-3. *Phytomyza rhodiolae* n. sp., holotype ♂: 1, aedeagus and associated structures in left lateral view (AED AD aedeagal apodeme, BS basal section of aedeagus, DPH distiphallus, ML medial lobe of aedeagus, MPH mesophallus, PHPH phallophore, POG postgonite); 2, distal section and medial lobe of aedeagus in ventral view; 3, ejaculatory bulb and apodeme. Fig. 4-6. *Phytomyza sedi* Kaltenbach (♂), Hvar, Yugoslavia: 4, aedeagus in left lateral view; 5, distal section of aedeagus in ventral view; 6, ejaculatory bulb and apodeme.

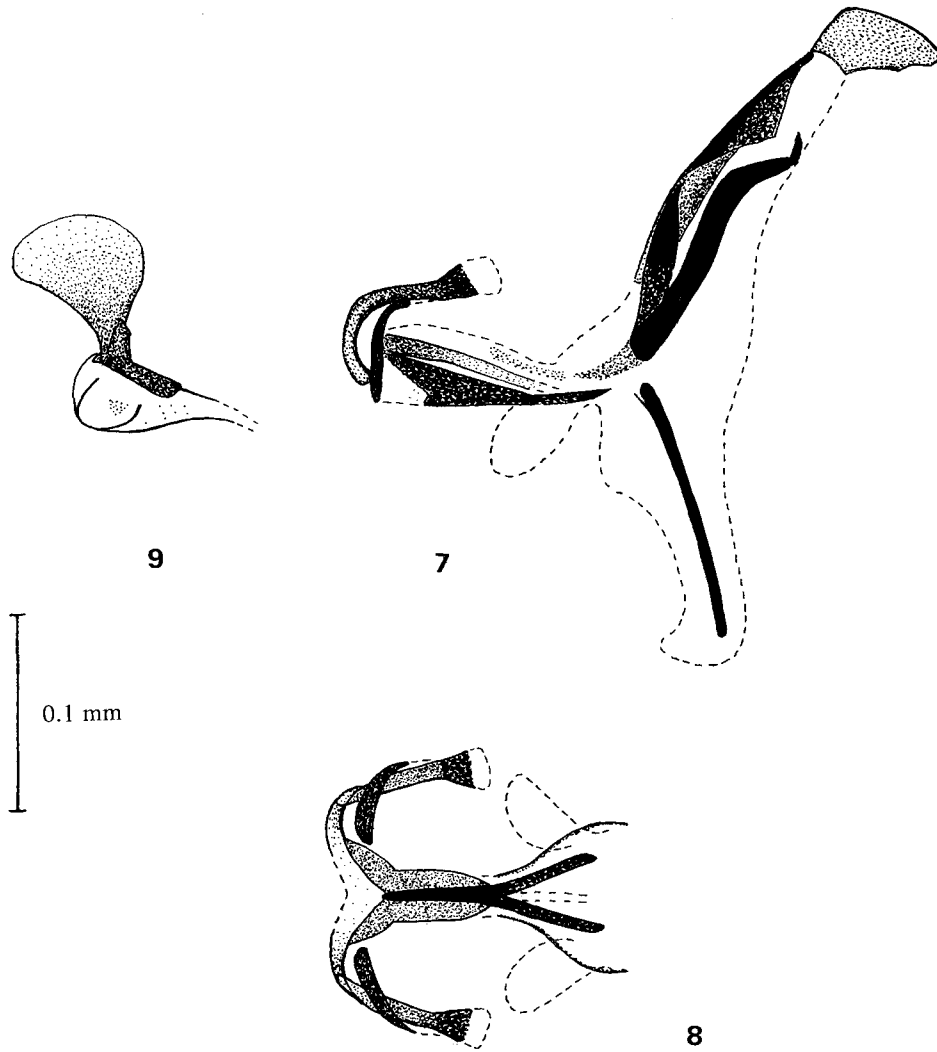


Fig. 7-9. *Phytomyza sedicola* Hering (♂), Sinaia, Roumania: 7, aedeagus in left lateral view; 8, distal section of aedeagus in ventral view; 9, ejaculatory bulb and apodeme.

Phytomyza sedi Kaltenbach 1869

Phytomyza sedi Kaltenbach. Kaltenbach, 1869: 172. — 1874: 258. Hering, 1957: 24. — 1967: 72. Types lost; type-locality Boppard (Germany).

Adult. — As described for *P. rhodiolae*, except as follows.

Genae in middle about 0.3 times eye height. Only one strong ori (anterior ori very short or absent); orbital setulae one-rowed. Costal ratio mg_2/mg_4 1.8 - 1.9. Wing length 1.4 - 1.75 mm (♂).

Aedeagus as Fig. 4-5; basal process of left basal sclerite shorter; medial lobe with well differentiated sclerites; wide unpigmented gap between mesophallus and basal sclerites; tubules of distiphallus appearing more or less straight (not sinuate) in lateral view. Ejaculatory apodeme very large (Fig. 6); ejaculatory bulb with pair of strongly projecting pigmented lateral tubercles.

Puparium and third instar larva. — Mandibles of about equal length, with only single (upper) clearly differentiated tooth, this relatively large and hook-shaped. Posterior spiracles on short conical projections, with two short horns, crescentic in caudal view (Fig. 11), with 12-14 bulbs. Puparium white, 1.6 mm long. (Anterior spiracles lost).

Mine. — Larvae solitary leaf-miners on *Sedum album* L. Mine described by Hering (1967) as follows.

“Brownish blotch-mines on the underside of the cylindrical leaves expanding into their interior and hollowing them out. Eventually the attacked leaf is whitish, revealing in its interior irregularly distributed black faecal particles and finally near its tip the puparium within the leaf, which soon withers and falls”.

Material examined. — 1 ♂ from larva 1.vii.38 on *Sedum album* L., Le Puy, Haute-Loire, France, emerged 8.viii.38, leg. H. Maneval (from Hering collection). 1 ♂ from larva 21.iv.63 on *Sedum album* L., Hvar Island, Yugoslavia, emerged 26.iv.63, leg. E. M. Hering (no. 7006).

Remarks. — I have no doubt that Hering (1957) was correct in concluding that he had rediscovered Kaltenbach's species. The size difference between the puparia of this species and those of *P. sedicola* on *Sedum telephium* L. noted by Kaltenbach has been confirmed.

Certain corrections of Hering's (1957) redescription should be noted. His estimate of the wing length as 1 mm is too low; and the squamal fringe is not white, but brown. More seriously misleading is his supposed description of the larva (Hering, 1954). Some confusion must have arisen, since the described larva is clearly that of a *Hydrellia* species (Ephydriidae); it is quite unlike that of any agromyzid, since it lacks anterior spiracles and has closed thorn-shaped posterior spiracles. Fortunately I was able to find a puparium inside a mined leaf mounted with Maneval's specimen. This is the basis of the above description. It has nothing to do with the larva described by Hering.

In his key Hering (1957: 967) also lists *Sedum acre* L. as a host of this species, thus contradicting the statement in his redescription (1957, vol. 3: 25) that it had not been found on species other than *Sedum album* L. There are no flies bred from *S. acre*, nor pressed mines on this plant in Hering's collections. In the circumstances the record for *S. acre* seems best discounted.

Phytomyza sedicola Hering 1924

Phytomyza sedicola Hering. Hering, 1924: 40. — 1927: 150. De Meijere, 1926: 290. Hendel, 1935: 476. Spencer, 1972: 90. Syntypes ♂ ♀, Herculesbad (Roumania), in the Zoologisches Museum, Humboldt Universität, Berlin.

Adult. — Head with orbits narrowly projecting above eye in lateral view; genae in middle 0.3-0.4 times eye height; eyes with only sparse fine pubescence. Frons at level of front ocellus about twice width of eye; orbits very broad posteriorly, together occupying about half of frons width. Ors directed posteriorly, ori directed inwardly; posterior ors as long as or only slightly shorter than anterior ors; anterior ori 0.5 - 0.8 times as long as posterior ori; orbital setulae more or less two-rowed posteriorly. Peristomal margin with vibrissa and 3-5 upcurved peristomal setulae. Third antennal article rounded distally, with short pubescence.

3 + 1 dc; acr in 4-5 rows anteriorly; 5 presutural ia; 2-6 postsutural ia; inner pa about 1/3 as long as outer pa.

Second cross-vein (m-m) absent. Costal ratio mg_2/mg_4 2.1 - 2.3. Wing length 2.1 mm (♂♀).

Colour almost entirely dark. Frons dark brown anteriorly, becoming ochreous yellow posteriorly on either side of ocellar plate; inner margins of orbits also ochreous yellow; genae brown. Labella dull yellow. Thorax finely grey-dusted over dark ground-colour, weakly shining; seams of notopleural and mesopleural sutures yellowish white; wing base and squamae yellowish

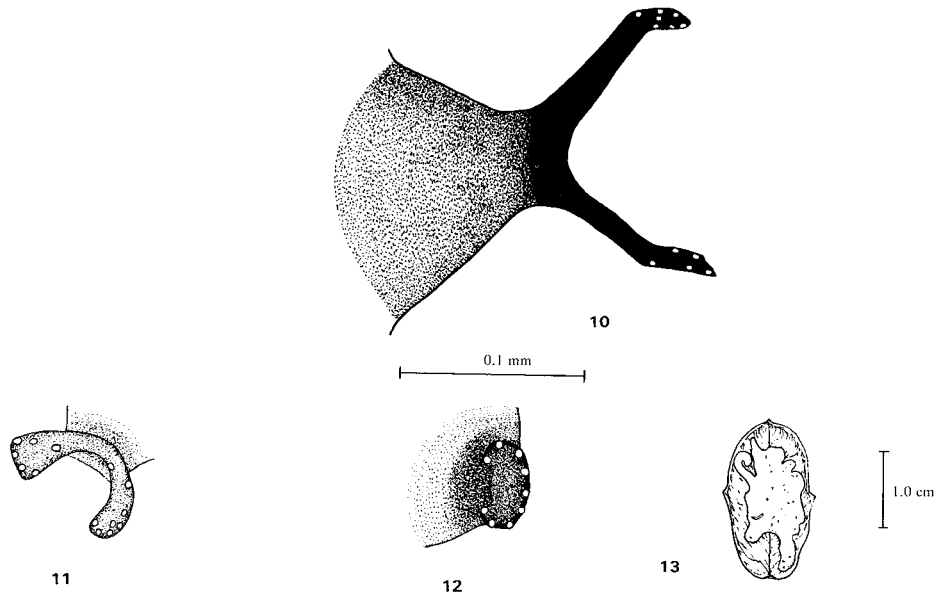


Fig. 10. *Phytomyza rhodiolae* n. sp., right posterior spiracle of puparium viewed laterally from inside. Fig. 11. *Phytomyza sedi* Kaltenbach, right posterior spiracle of puparium in caudal view. Fig. 12. *Phytomyza sedicola* Hering, right posterior spiracle of puparium in caudal view. Fig. 13. Leaf of *Rhodiola rosea* L. with mine of *Phytomyza rhodiolae* n. sp.

white, latter with dark margin and fringe. Legs largely dark, with tips of front femora contrastingly yellow; tips of other femora yellow to yellow brown. Abdomen largely brown. Basal cone of ovipositor (♀) entirely grey-dusted.

Eighth sternum of male postabdomen more or less fused with 6th tergum along distinct suture line, with narrow lateral extensions to sides of venter. Telomeres not delimited from perianthrium, bearing dense group of setulae. Pregonites with inconspicuous, more or less unpigmented ventral extensions. Aedeagus as Fig. 7-8; basal sclerites rather long; sclerites of medial lobe long and slender, narrowly separated apically; paramesophalli well developed, fused anteriorly below mesophallus; terminal tubules of distal section (distiphallus) curved upwards and backwards so that their apices are posteriorly directed. Ejaculatory apodeme as Fig. 9; lateral angles of ejaculatory bulb scarcely pigmented.

The aedeagus has been previously figured by Spencer (1972).

Puparium and third instar larva. — Described by de Meijere (1926). Mandibles with two alternating teeth; right mandible longer than left. Anterior spiracles knob-shaped, with 9-12 bulbs in narrow ellipse; posterior spiracles (Fig. 12) on short conical projections, with two short horns, with 9-12 bulbs in partly open ellipse. Puparium brown, weakly shining, about 2.5 mm long.

Mine. — Larvae leaf-miners on *Sedum cepaea* L. and *S. telephium* L. (usually communal on the latter). Mine described by Hering (1957) as follows.

“Channel mostly strongly convolute, interlaced. Convolutions commonly coalescing to a secondary blotch. Faeces in a few widely separated particles. Puparium in the leaf, not in an enclosed cradle but before a preformed semicircular slit, rarely outside. The mine is very shallow, whitish, scarcely contrasting in transmitted light”.

Beiger (1960) presents a figure of the mine.

Material examined. — 1 ♀ paratype from larva 28.v.22 on *Sedum telephium* L. subsp. *maximum* (L.), Herculesbad, Banat, Roumania, emerged 18.vi.22, leg. M. Hering (no. 1986). 1 ♂ from larva 27.vii.68 on *Sedum telephium*, Sinaia, Roumania, emerged 16.viii.68, leg. K. A. Spencer. 1 ♂ from puparium 6.viii.26 on *Sedum cepaea* L., Lugano, Switzerland, emerged 10.viii.26, leg. W. Hopp (no. 3004).

Other records. -- Additional records, all based on mines, or flies bred from mines, on *Sedum telephium* L., are as follows.

- England -- Single record for Keswick, Westmorland (Spencer, 1972).
 Germany -- Widespread but local; locality records given by Hering (1924, 1927, 1955),
 Buhr (1932, 1964) and Starke (1942).
 Austria -- Sheets in Hering's mine herbarium for Dürnstein (Niederösterreich) and
 Waldaist-Tal (Mühlviertel).
 Czechoslovakia -- Widespread; locality records given by Starý (1930), Skala & Zavřel (1945 and
 Zavřel (1953, 1960).
 Poland -- Widespread; locality records given by Seidel (1924), Beiger (1960, 1965, 1970)
 and Griffiths (1966: 849).
 Denmark -- Bornholm (Buhr, 1932).
 Norway -- Vaage, Norrbotten (Rydén, 1955).
 Sweden -- Reported by Rydén (1940, 1948, 1949, 1951) from Bohuslän, Halland, Dalsland and
 Uppland.

Remarks. -- Hering (1930) also ascribed to this species mines observed by his wife Olga on *Umbilicus rupestris* (Salisb.) (= *pendulinus* DC.) at Cherbourg (France). This identification must be set aside as conjectural. No flies have yet been bred from *Umbilicus*, nor were the mines collected.

The above description is based on the specimens bred from the original host, *Sedum telephium* L. The Lugano male bred from *Sedum cepaea* L., here tentatively referred to *P. sedicola*, differs as follows: additional short third pair of ori present; 2 upcurved peristomal setulae; costal ratio mg_2/mg_4 2.0; wing length 1.8 mm; terminal tubules of aedeagus less curved, with their apices more or less dorsally (rather than posteriorly) directed. It is impossible to decide on the basis of a single specimen whether these minor differences signify anything more than individual variation. The identification should be reviewed when more material is available.

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