

***Coleophora sirella* Tabell & Mutanen, sp. n. from Finland (Lepidoptera: Coleophoridae)**

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Coleophora sirella Tabell & Mutanen, **sp. n.** from Finland is described as new. The species resembles most closely *C. glitzella* O. Hofmann, 1869, *C. murinella* Tengström, 1848 and *C. juncicolella* Stainton, 1851 but has diagnostic differences in its life history, external appearance, genital morphology as well as DNA barcode. The new species feeds on *Empetrum nigrum* L. Adult male and female, their genitalia as well as larval case are illustrated, and the known distribution range is given. DNA barcodes are provided for the new species and its closest European relatives.

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1. Introduction

The species of *Coleophora* Hübner, 1822 occurring on various peatlands in Northern Europe have been well known for many decades. Since the descriptions of *C. plumbella* Kanerva, 1941 and *C. obscuripalpella* Kanerva, 1941, only one such species has been discovered. This species is *C. thulea* Johansson, 1967, which inhabits different kinds of subalpine bogs. Quite surprisingly, in 2006, the Finnish amateur lepidopterist Reijo Siloaho collected a series of a tiny coleophorid moth from a small bog in central Finland. The moths did not match externally any known Fennoscandian species. The examination of genitalia and the comparison of available DNA barcodes of Palaearctic and Nearctic *Coleophora* species revealed that the specimens represent a

previously unknown species. Later, careful examinations on the collection site showed that the new species feeds on *Empetrum nigrum* L. (Ericaceae), a plant that has not been recorded as a food plant for any previously described species of *Coleophora*. The new species is described in the present paper as *Coleophora sirella* Tabell & Mutanen, **sp. n.**

2. Materials and methods

A great majority of the specimens of the new species has been collected at dawn by netting flying male adults in early morning sunshine. Most females have been captured by sweeping *Empetrum nigrum* and *Calluna vulgaris* (L.) Hull (Ericaceae) in the afternoon. A few specimens

have also been collected at sunset by netting vegetation. One male specimen was reared from a larva.

For morphological studies of the genitalia, nine genitalia preparations were made by JT and RS (see the type material), following standard techniques (Robinson 1976). The genitalia were severed from the abdomen, and male genitalia spread out with two insect pins. After replacing the water with alcohol, the genitalia were mounted on a slide with Euparal fixative, and covered with a cover glass. The female genitalia were mounted ventral side upwards.

The photos of adult specimens and larval case were taken with Canon EOS 40D, Canon Macro Lens EF 100 mm 1:2.8 USM and Soligor Extension Tubes. The genitalia were photographed from the genitalia slides in ventral view with Leica DM 1000 Microscope and integrated Leica DF 295 digital camera. All final photos were combined of several layers of different depth of focus using CombineZP and edited with Adobe Photoshop CS4.

Five specimens were subjected to sequencing of a standard animal DNA barcode region (658 bp fragment of COI gene).

One leg of five specimens was deposited in microplate wells with 30 μ L of absolute alcohol in each well. These samples were sent to the Canadian Centre for DNA Barcoding (CCDB), Guelph, Canada, for DNA extraction, barcode amplification and sequence analysis. The laboratory protocols used are explained in deWaard *et al.* (2008). All five specimens were successfully sequenced, resulting in a full-length barcode fragment for three specimens and sequences of 640 bp and 623 bp for the remaining two specimens. Distance statistics were calculated using BOLD (Barcode of Life Data Systems) tools, accessible at <http://www.boldsystems.org>. To assess the phylogenetic position of *C. sirella* sp. n., a maximum likelihood tree including *C. sirella* sp. n. and 22 related species (142 specimens) of North European *Coleophora* was constructed with Mega 7 (Kumar *et al.* 2016). Node bootstrap supports were assessed with 500 bootstrap replications. Details of successfully sequenced voucher specimens, including voucher data, images and GenBank accession numbers, are publicly available through the dataset DS-COLSIR at

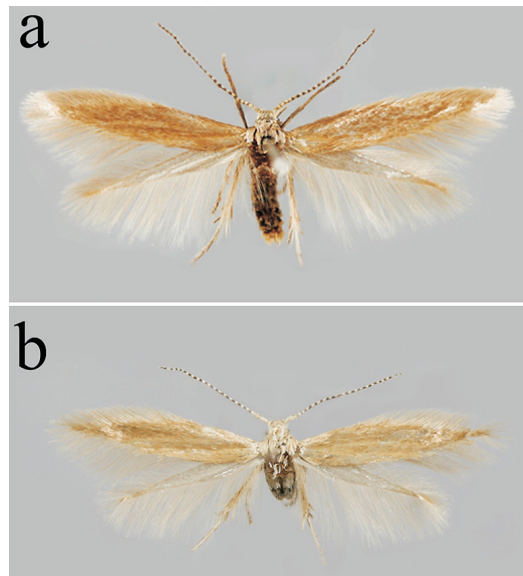


Fig. 1. Adults of *Coleophora sirella* sp. n. – a. Male. – b. Female.

www.boldsystems.org and at doi: [dx.doi.org/10.5883/DS-COLSIR](https://doi.org/10.5883/DS-COLSIR).

The type specimens are deposited in the collection of the Finnish Museum of Natural History, University of Helsinki, Finland (MZH) and the private collections of several collectors.

3. Description of *Coleophora sirella* Tabell & Mutanen, sp. n.

Type material. Holotype ♂ (GP 4739 J. Tabell): Finland, ES: Kangasniemi, YKJ 687:348, 5.VI.2006, R. Siloaho leg., coll. MZH.

Paratypes (226 ♂ 16 ♀): 167 ♂ 14 ♀ the same locality as in the holotype, but other collecting details as follows: 5.VI.2006 14 ♂ (G.p. no. 46 R. Siloaho, Gen. prep. no. 27/2006 R. Siloaho), 6.VI.2006 3 ♂, 8.VI.2006 5 ♂, 9.VI.2006 2 ♂, 10.VI.2006 2 ♂, 12.VI.2006 1 ♂, 15.VI.2006 3 ♂, 16.VI.2006 2 ♂, 2.VI.2007 2 ♂, 3.VI.2007 2 ♂, 4.VI.2007 10 ♂ 1 ♀ (G.p. no. 77 R. Siloaho), 5.VI.2007 7 ♂ 2 ♀ (GP 4679 J. Tabell), 6.VI.2007 4 ♂ 2 ♀ (GP 4731 J. Tabell, DNA sample 16581 Lepid Phyl), 8.VI.2007 4 ♀ (GP 4053 J. Tabell), 9.VI.2007 1 ♀, 4.VI.2008 2 ♂, 5.VI.2008 8 ♂ 1 ♀, 1.VI.2010 1 ♂, 15.VI.2010 17 ♂ (DNA sample 16591 Lepid Phyl), 4.VI.2011 7 ♂, 5.VI.2011 4 ♂, 6.VI.2011 6 ♂,

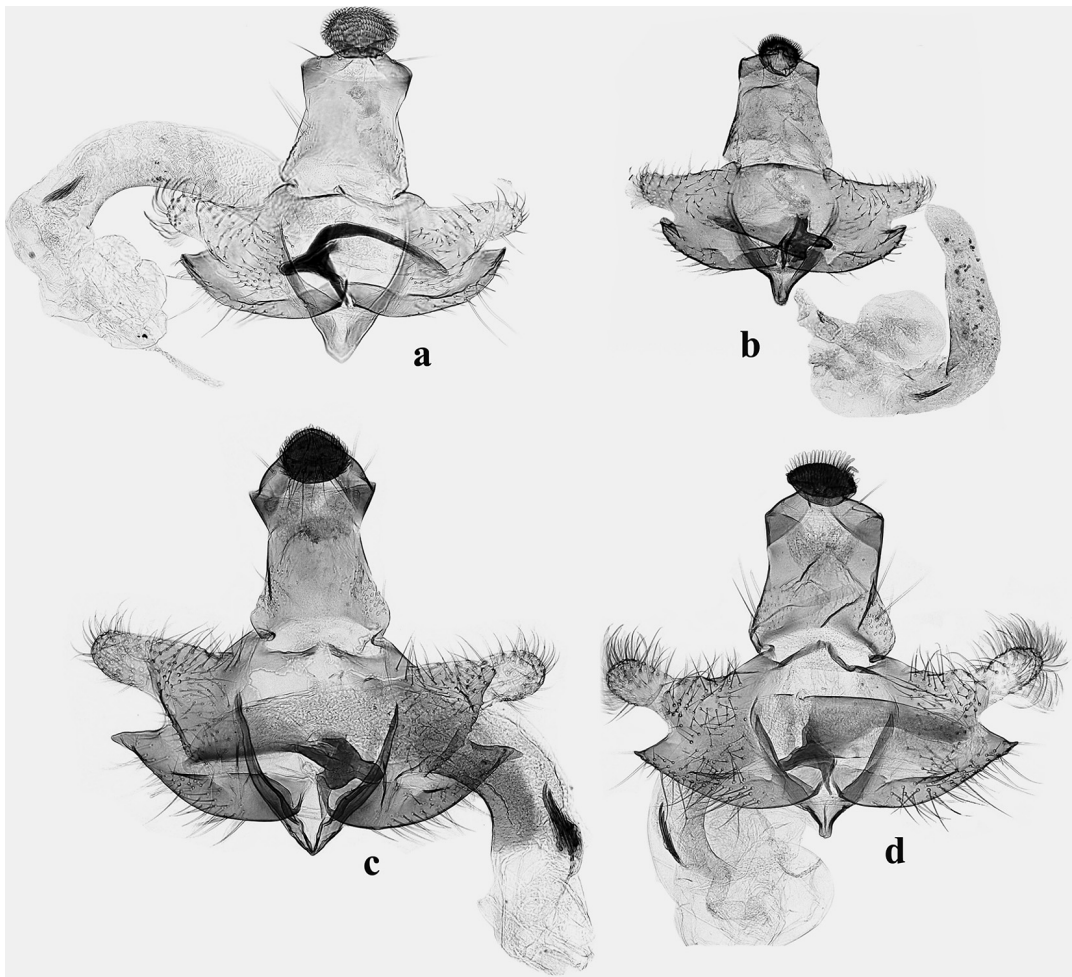


Fig. 2. Male genitalia of four related species of *Coleophora*. – a. *Coleophora sirella* sp. n., holotype (GP 4739 J. Tabell). – b. *Coleophora juncicolella*, Finland, Kangasala (GP 4019 J. Tabell). – c. *Coleophora murinella*, Finland, Hartola (GP 1529 J. Tabell). – d. *Coleophora glitzella*, Finland, Hartola (GP 4496 J. Tabell).

8.VI.2011 14 ♂ 1 ♀, 9.VI.2011 5 ♂ (DNA sample 05627 Lepid Phyl), 10.VI.2011 9 ♂, all in colls Siloaho & Tabell, 5.VI.2007 2 ♂ T. & K. Nupponen leg. & coll., 6.VI.2007 14 ♂ T. & K. Nupponen leg. & coll., 6.VI.2007 3 ♂ E. Saarela leg. & coll., 6.VI.2007 10 ♂ L. Sippola leg. & coll., 7.VI.2007 4 ♂ J. Tabell leg. & coll., 8.VI.2007 2 ♀ J. Junnilainen leg. & coll., 10.VI.2007 3 ♂ J. Junnilainen leg. & coll., e.l. 2007 1 ♂ L. Sippola leg. & coll.; Finland, *ES*: Joutsa, YKJ 684:45, 9.VI.2007 1 ♂ 1 ♀ J. Junnilainen leg. & coll.; 9.VI.2009 1 ♂ J.-P. Kaitila leg. & coll.; Finland, *ES*: Eteläinen Haukkasuo, YKJ 674:349, 13.VI.2012 6 ♂ J. Junnilainen leg. & coll.; Finland, *EK*:

Vehkaojansuo, YKJ 672:349, 9.VI.2012 14 ♂ J. Junnilainen leg. & coll.; Finland, *EH*: Hartola, YKJ 682:344, 5.VI.2008 1 ♂, 9.VI.2009 5 ♂, 6.VI.2011 at 5.40–6.20 am 13 ♂ (DNA sample 16587 Lepid Phyl), 9.VI.2012 at 6.30 3 ♂ J. Tabell leg. & coll.; Finland, *PS*: Rautavaara, YKJ 705:355, 20.VI.2013 4 ♂ J. Junnilainen leg. & coll.; Finland, *PPp*: Tervola, 26.VI.1976 1 ♂ J. Jalava leg., coll. MZH; Finland, *PPp*: Tornio, YKJ 731:38, 7.VII.1987 1 ♀ (G.p. no 66/2007 RS) E. Laasonen leg., coll. E. & L. Laasonen; Finland, *EP*: Isojoki, YKJ 689:22, Iso Rapaneva, 13.VI.2009 6 ♂ (GP 4740 J. Tabell) T. Rinta-Paavola leg. & coll.; Finland, *EP*: Kurikka, YKJ 696:25, Kalistanneva, 10.VI.2010 2 ♂ T. Rinta-



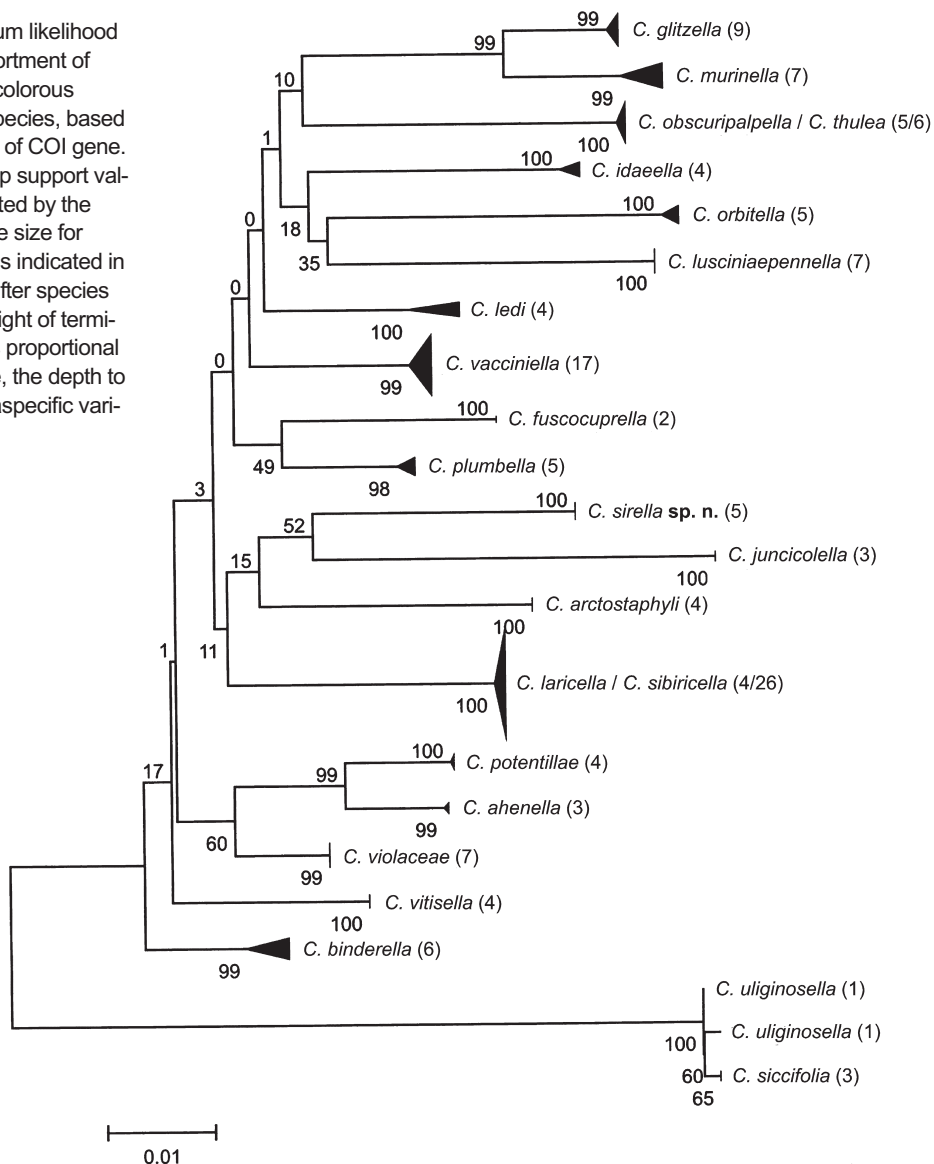
Fig. 3. Female genitalia of four related species of *Coleophora*. – a. *Coleophora sirella* **sp. n.**, paratype (GP 4679 J. Tabell). – b. *Coleophora juncicolella*, Finland, Hartola (GP 4516 J. Tabell). – c. *Coleophora murinella*, Finland, Hartola (GP 629 J. Tabell). – d. *Coleophora glitzella*, Finland, Hartola (GP 4566 J. Tabell).

Paavola leg. & coll.; Finland, *EP*: Seinäjoki Karvasuo YKJ 6954:292, 15.VI.2012 2 ♂ (DNA sample 23201 Lepid Phyl) Marko, Nestori & Anttoni Mutanen leg., coll. M. & T. Mutanen.

Diagnosis. *Coleophora sirella* Tabell & Mutanen, **sp. n.** is a small species with unicolorous pale brown forewings. It is slightly larger than the smallest North European *Coleophora* species, *C. juncicolella*, that feeds on *Calluna vulgaris* and *Erica* (Ericaceae), but markedly smaller than the other externally similar species *C. glitzella* and *C. murinella*, which feed on *Vaccinium vitis-idaea* L. (Ericaceae). The new taxon may also be confused with *C. sibiricella* Falkovitsh, 1972, a species living on *Larix*

(Pinaceae), and worn specimens of *C. antennariella* Herrich-Schäffer, 1861, living on *Luzula pilosa* (L.) Willd. (Juncaceae). The forewing of *C. sirella* **sp. n.** (Fig. 1) is lanceolate with long costal apical fringes. In fresh specimens, a few orange-brown scales are present at fold, unlike in the allied species (colour drawings are presented in Emmet 1996). The male genitalia of *C. sirella* **sp. n.** (Fig. 2a) are easy to separate from those of the other coleophorids with unstriped forewings by its dorsally narrow and extremely strongly sclerotized phallosome. In *C. juncicolella* (Fig. 2b), it is more wedge-shaped and more or less evenly chitinized. In both *C. murinella* (Fig. 2c) and *C. glitzella* (Fig. 2d), the

Fig. 4. Maximum likelihood tree of an assortment of European unicolorous *Coleophora* species, based on sequences of COI gene. Node bootstrap support values are indicated by the nodes. Sample size for each species is indicated in parentheses after species name. The height of terminal triangles is proportional to sample size, the depth to degree of intraspecific variation.



phalotheca is arched too, but it is dorsally weakly sclerotized. In *C. sibiricella* and *C. antennariella*, the phalotheca consists of two strongly chitinized rods. The female genitalia of *C. sirella* sp. n. (Fig. 3a) are characterized by chalcid antrum, shape and position of ostium in the distal margin of the sterigma, and by a long spinulate section of ductus bursae. In *C. juncicolella* (Fig. 3b) and *C. murinella* (Fig. 3c), the spinulate section is much shorter, and ostium is situated at the anterior margin of sterigma, as also in *C. glitzella* (Fig. 3d). In *C. sibiricella*, the shape of sterigma and a large

signum are separating details from *C. sirella* sp. n. For comparison of the genitalia, see also Razowski (1990) and Emmet (1996).

Molecular diagnosis (Fig. 4). A full length of 658 bp barcode fragments of COI gene was obtained from three *C. sirella* sp. n. specimens. They were compared to all available corresponding sequences of the Palaearctic and Nearctic *Coleophora* species. Concerning European species, the DNA barcode analysis (only specimens with full barcode sequence considered) shows that the K2P distance to the nearest neighbour,

Table 1. Interspecific divergences (658 bp) of *Coleophora sirella* sp. n. and related species, based on the analysis of COI gene. The maximum intraspecific variations are marked in bold.

	<i>C. sirella</i> sp. n.	<i>C. glitzella</i>	<i>C. juncicolella</i>	<i>C. murinella</i>
<i>C. sirella</i> sp. n. (<i>n</i> = 3)	0	5.91	6.24	6.25
<i>C. glitzella</i> (<i>n</i> = 9)		0.31	6.93	2.19
<i>C. juncicolella</i> (<i>n</i> = 3)			0	7.10
<i>C. murinella</i> (<i>n</i> = 7)				0.77

morphologically nonsimilar *C. fuscocuprella* Herrich-Schäffer, 1854, is 4.69%. The nearest neighbour to *C. sirella* sp. n. is, however, the Nearctic *C. glaucella* Walsingham, 1882 (feeds on *Arctostaphylos glauca* Lindl (Ericaceae)), with the minimum divergence of 4.59% to *C. sirella* sp. n. The divergences between *C. sirella* sp. n. and three morphologically similar species, namely *C. juncicolella*, *C. glitzella* and *C. murinella*, are 5.91%–6.25% (Table 1). Each taxon displays a low to moderate intraspecific variation, the maximum distance being 0.0% in *C. juncicolella* (*n* = 3) and *C. sirella* sp. n. (*n* = 3), 0.31% in *C. glitzella* (*n* = 9) and 0.77% in *C. murinella* (*n* = 7). The results indicate that *C. sirella* sp. n. can unambiguously be distinguished from the other species also by the DNA barcodes.

Description. Imago (Fig. 1): Wingspan ♂ 9.0–10.5 mm, ♀ 7.8–8.3 mm. Head and thorax pale brown, postocular scales whitish. Antenna pale grey, annulated with brown, scape concolorous with head. Labial palpus pale brown, darker apically. Forewing pale brown, suffused with light ochre scales, especially along fold, fringe concolorous with ground colour, costal

fringe long, basally paler. Hindwing and fringe pale greyish brown. Abdomen pale greyish brown, tergal patches (Fig. 5a–b, 3rd segment) 2 × longer than wide, covered with about 30 small conical spines.

Male genitalia (Fig. 2a): Gnathos knob transversely oval, arms rather long. Tegumen broad, almost parallel-sided, pedunculi very short. Cucullus short, distal half extended beyond sacculus. Valvula twice as broad as cucullus, ventral margin broadly rounded, surface covered with short bristles. Transtilla straight, narrow, gradually tapered towards apex. Sacculus well sclerotized; ventral margin rounded, ending in sharp angle; dorsal margin straight or lightly convex. Phallosome dorsally narrowly and darkly sclerotized, arched tube. In vesica one cluster of several small, spiniform cornuti.

Female genitalia (Fig. 3a): Papillae anales broad, outer margins rounded. Anterior apophyses as long as sterigma, posterior apophyses twice longer than anterior apophyses. Sterigma transverse, 3.5 × as wide as long, caudal margin slightly rounded, with a row of 6–7 long bristles on each side of ostium. Ostium broadly U-

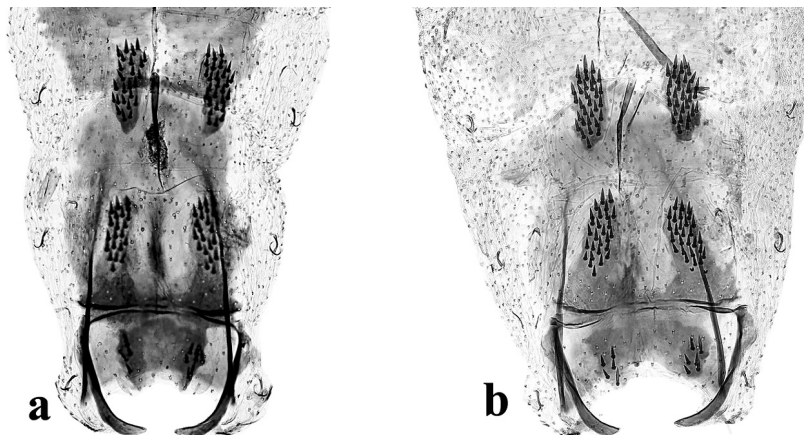


Fig. 5. Abdomens of *Coleophora sirella* sp. n. – a. Male. – b. Female.



Fig. 6. Larval case of *Coleophora sirella* sp. n.

shaped, situated in posterior third of sterigma, without marginal setae. Posterior part of colliculum chalcid, strongly chitinized, anterior part swollen, almost transparent. Spinulate section of ductus bursae about $7 \times$ longer than sterigma, twisted at posterior quarter, anterior section with one coil. Corpus bursae oval. Signum relatively large, base broad, spine slender, almost straight.

Biology. The life cycle of *C. sirella* sp. n. is incompletely known. The larva probably feeds exclusively on the leaves of *Empetrum nigrum* and makes the case (Fig. 6) from an empty mined leaf, which it cuts off from the host plant. Subsequently it widens the case by adding another piece of a hollow leaf to the anterior part of its case. The larva supposedly overwinters twice, the latter time as mature. Despite industrious searching of larvae by several collectors, only a few larvae have been found so far, the rearing resulting in one adult and one parasite. Males are active in the morning, at sunrise between 05.00 and 07.30 (summer time), flying above twigs of *Empetrum* and *Calluna*. The female adults appear less mobile and prefer to sit at tips of bog shrubs making only small spurts instead of flying longer distances. Most females have been caught in the afternoon, between 16.00–18.00 (summer time). The flight period is about one week, from the beginning of June (southern Finland) to the beginning of July (northern Finland). The habitats are open *Empetrum* bogs and sandy moors surrounded by bogs.

Distribution. The species is so far known only from Finland, where it is widely but locally distributed over most of the country, excluding northernmost regions. Probably *C. sirella* sp. n. has a wider, at least Palaearctic, distribution

range, judging from the wide distribution and prevalence of its host plant, *E. nigrum*. Supposedly, the short flying period, early flying time and inconspicuous appearance of the adult have hampered the discovery of the species until now.

Etymology. The species name is derived from the first letters of the name Reijo Siloaho, the Finnish lepidopterist who has collected the majority of the type material.

4. Discussion

As we have sequence data from only a single mitochondrial gene, the phylogenetic position of *C. sirella* sp. n. remains uncertain. Based on the DNA barcode based phylogeny, its sister species is *C. juncicolella*. This appears a likely scenario, because these species also share similar external morphology, relatively similar genitalia, and both feed on Ericaceae. A sister species to them, although poorly supported, is *C. arctostaphyli* Meder, 1934 that also feeds on Ericaceae and is morphologically similar. The monophyly of *Coleophora* feeding on Ericaceae appears possible, although in our tree, a few species were nested within the complex. Our result is largely consistent with the phylogeny of Bauer *et al.* (2012), which is based on COI and wingless genes. However, their analysis lacked *C. sirella* sp. n. and *C. arctostaphyli*. They found strong support for the monophyly of the *C. vacciniella* complex, but consistent with our results, they did not recover Ericaceae feeding species within it forming a monophylum. Interestingly, *C. vacciniella* Herrich-Schäffer, 1861, a species usually living on Ericaceae, has unusually broad diet and

is known to feed also e.g. on *Salix* (Salicaceae), *Spiraea* and *Rubus chamaemorus* L. (Rosaceae), *Myrica gale* L. (Myricaceae) and *Betula* (Betulaceae).

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