Habitual differences of *Phyllonorycter salictella* (Zeller, 1846) and *P. heringiella* (Grönlien, 1932) (Lepidoptera: Gracillariidae) in two Finnish materials; a problem pair

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From *Phyllonorycter salictella* (Zeller,1846) a sister species *P. heringiella* (Grönlien, 1932) is here extracted on the basis of the number and colour of costal strigulae at the tip of the wing and the brightness of the golden coloration of the forewing. *P. salictella* is reported from the Finnish biogeographical provinces *Al, Ab, N, Ka, Ta, Kl, Oa, Tb, Om, Oba*, and *Obb* and *P. heringiella* from *Al, Ab, N, Ka, Ta, Sa*, and *Oba*. It is assumed that the golden hue, which sometimes covers the normally white strigulae of the forewing, occurs in freshly emerged moths and disappears after first flying efforts.

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1. Introduction

Three new *Phyllonorycter* species: *P. grönlieni* (M. Hering, 1926), *P. heringiella* (Grönlien, 1932), and *P. brevilineatella* (Benander, 1944) were reported from Norway and Sweden within a short time period about 50-70 years ago. *P. grönlieni* was soon synonymised back with *P. hilarella* (Zetterstedt, 1839) and this pair will not be dealt with here. However, because of its great habitual resemblance to *P. salictella* (Zeller, 1846) suspicions of the species status of *P. heringiella* has been presented every now and then during the last 20 years (Table 1). In addition, still another problem came up recently, when Buszko (1996) suggested that *P. viminiella* (Sircom, 1848), living on the British Isles, was just a subspecies of *P. salictella*. In the following, we are going to analyse *P. salictella* and *P. heringiella* on the basis of their appearance and food plants in Finnish material. As Svensson (1997) emphasized, it is very difficult to differentiate between the genitalia of these species - so we will pay little attention to the genitalia.

2. Literature, materials and methods

We started with checking the material of *Phyllonorycter dubitella* (Herrich-Schäffer, 1855) in coll.s Laasonen and the Zoological Museum of the University of Helsinki

Table 1. Opinions of some authors of the species status on seven problematic *Phyllonorycter* spp. vimi = *P. viminiella*, sact = *P. salictella*, heri = *P. heringiella*, saco = *P. salicicolella*, brev = *P. brevilineatella*, hila = *P. hilarella*, grön = *P. grönlieni*. + = the authors do accept the species status, +? = they accept, but present suspicions, -! = they do not accept at all , - = the authors do not opine, or the species do not live in the region dealt with in the respective paper. Squares depict the pairs of moths, their species status has been disputed in the literature, as well as roughly the time how long the dispute has continued.

The authors		vimi 1848	sact 1846	heri 1932	saco 1848	brev 1944	hila 1839	grön 1926
Benander	1944	+	+	+	+	+	+	+
Hackman *et al.*	1950	+	+	-	+	+	+	+
Hering	1957	+	+	+	+	+	+	+
Krogerus *et al.*	1971	-	+	+	+	-	+	-!
Kuznetsov	1981	+	+	-!	+	-	+	-!
Opheim & Fjeldså	1983	-	+	-!	+	-	+	
Emmet *et al*	1985	+	-	-	+	-	+	
Svensson *et al.*	1987	-	+	-!	+	+?	+	
Buszko	1996	-!	+	-!	+	+?	+	
Svensson	1997	+	+	+	+	+?	+	
Karsholt & Stadel Nielsen	1998	-	+	-	+	-	+	

(ZMUH) to be sure that none of the moths with three costal strigulae would have slipped in there because of an old decision tree (cf. Benander, 1944). The moths in which the first costal and dorsal strigulae elongated peripherally to a parallel pair were included in this study (Svensson 1997), especially if their fringe line costally continued intermittently medial to the strigulae (not present at the level of a strigula). Also the distance of the dorsal fringe line from the wing should not increase posteromedially. In all, four moths were transferred to our study material.

Thereafter we went through the materials belonging to the *P. salictella* group - 63 moths in coll. Laasonen and 214 moths in the ZMUH. The criteria with which we differentiated *P. salictella* from *P. heringiella* were (Grönlien 1932, Svensson 1997):

- the number of clearly defined costal strigulae at the tip of the forewing; in *P. salictella* at the most 1° and in *P. heringiella* at least 2°. The uneven numbers here deserve an explanation. There were moths in which it was difficult to decide, if a strigula is a strigula or just a group of few diffuse white scales, as well as moths with two strigulae on one wing and three on the other. We thus slightly softened the strict criteria of one and three strigulae for *P. salictella* and *P. heringiella*, respectively (Svensson 1997).

- the shade of the golden coloration at the base of the forewing; *P. salictella* suffused, greyishgolden, *P. heringiella* bright, orange golden,

- to define better the impression of darkening at the tip of the forewing between the costal and dorsal strigulae we built up a scale; the longitudinal length of the area of dark scales at the tip of the wing in relation to the transverse width of the wing there; in *P. salictella* the length exceeded the width and in *P. heringiella* it was the other way round.

After this division, moths were extracted from *P. salictella* and *P. heringiella* in which the normally white strigulae were suffused by a golden hue; in spite of the suffusion, the eventual strigulae were clearly marked with their brown inner edgings (Emmet *et al.* 1985).

We made genital preparates from eight moths of the *P. salictella* group - from two males and two females of both species, respectively. In females the concavity of the ostium, as well as the thickening of the posterior apophyses were specially analysed (Svensson 1997). In males, we paid attention to the form and length of the spine at the tip of the broad left valva, as well as the form of the curved tip of the right thin valva.

The literature (Grönlien 1932, Benander 1944, Hering 1957, Emmet *et al.* 1985, Svensson 1997, Kuznetzov & Baryshnikova 1998) gives many *Salix* spp. as food plants for the *P. salictella* group (Table 2). To these we add the food plants of 77 reared moths in coll.s Laasonen and the ZMUH.

3. Results

The number of strigulae divided best the 277 moths of the *P. salictella* group into 129 *P. salictella* and 132 *P. heringiella*, (Fig. 1, Table 3). The term "1 - 1°" is explained by the fact that there were four moths with one strigula on one forewing and two on another; as well as nine moths in which a small group of white scales perhaps could have been diagnosed as another strigula. However, these 13 moths were included into *P. salictella*. Likewise, within the term "2°-3" there were

Table 2. *Salix* and *Populus* spp. reported in the literature (= +) and observed in Finland (= F) as food plants for three *Phyllonorycter* spp.

	P. viminiella	*P. salictella*	*P. heringiella*
S. fragilis	+	F	F
S. viminalis (=*rossica*)	+	+,F	F
S. caprea	+	F	F
S. alba	-	+,F	F
S. phylicifolia (=*bicolor*)	-	F	F
S. repens ssp. *argentea*	-	+	+
S. aurita	-	+	+
S. myrsinifolia	-	-	+,F
S. pentandra	-	-	F
S. purpurea	-	+	-
S. daphnoides	-	+	-
S. siuzewii	-	+	-
P. tremula	+	-	-

twelve freshly emerged moths, which certainly had two strigulae on both forewings, but the third strigula was represented with a few white scales only. These 12 moths were included into *P. heringiella*.

Of the other criteria, the coloration was also helpful. The suffused coloration seemed to be caused by erect scales, as if the air under the scales would diminish the brightness of the coloration. The erect scales looked also slightly broader. There were 15 moths caught with a continuous light trap and exposed to the fumes of chlorinated liquids used in them. In these 15, the colour of the forewing was never very bright and sometimes difficult to evaluate.In addition, six of them were worn and the number of strigulae could not be defined with certainty (Tables 3 and 4 : Uncertain specimens). Perhaps they all belonged to *P. heringiella*.

Our new criterium defining the darkening of the wing tip was not very good. However, attempts to modify this criterium and to divide the moths repeatedly in two did not bring a better result. In Table 4, the origin of the analysed 277 moths from Finnish biogeographical provinces is presented.

A homogeneous material of 22 moths was reared in 1996 out of 58 mines taken from three *Salix fragilis* trees at *Ta*: Nokia (682:31) Pitkäniemi in 1995. The tree with most of the mines was about 30 years old and of round form, f. *bullata* and the two others, 30–200 m away, at least 150 years old, not so good looking, with partially decayed and amputated trunks and branches, and of normal tree form. The reared moths were killed with cyanide shortly after emergence and had virtually no flight activity. Among this Pitkäniemi material there were eleven moths belonging to *P. salictella* and eleven moths belonging to *P. heringiella*. Among the latter moths we found three specimens with a golden suffusion which covered all the normally white strigulae - forma *"aurea"*. Three other moths had the suffusion on the strigulae at the tip of the wing, as well as a partial suffusion of the lateral edge of few other strigulae - an intermediate form. In addition, in coll. ZMUH there was one reared *P. salictella* with a total golden suffusion - *P. salictella* f. *viminiella* - and another with a partial suffusion. As an explanation for these golden forms, we suggest that freshly emerged moths with no flight activity before they are killed, may have this hue, which soon wears off by flying.

The distribution of males and females was very even within both species. Among *P. salictella* there were 55 males and 74 females and among *P. heringiella* 56 males and 76 females. Neither was there any bias between the sexes in the strigulae, in the hue of the golden coloration, nor in the darkening with one exception. There were 18 moths, in which the large darkening was exceptionally long and wide, and 16 of them were females.

The genitalia were not helpful in differentiat-

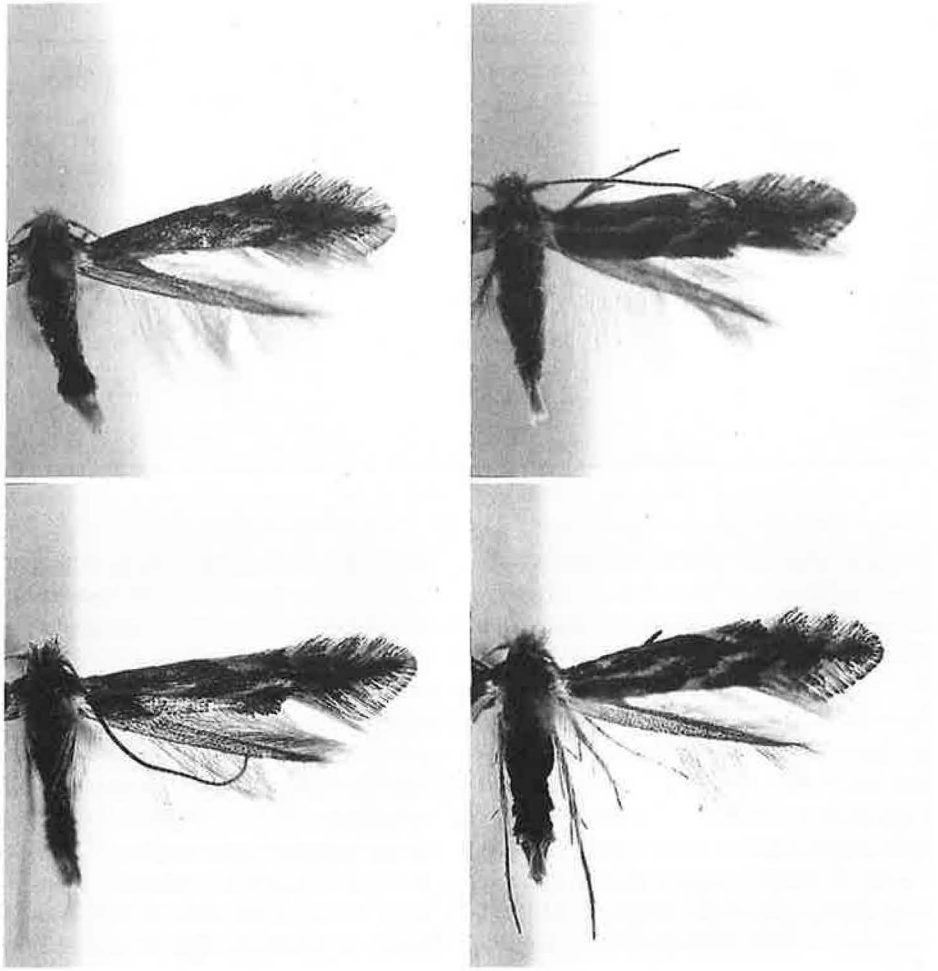

Fig.1. Enlargement 13x. Upper row, a pair of *Phyllonorycter salictella* (Zeller, 1846) from Finland, EH: Nokia 682:31. To the left a male reared 1996 of a mine taken from *Salix fragilis* at Pitkäniemi and to the right a female reared 15.1.1995 from *Salix alba* at Vihnusjärvi. Lower row, a pair of *P. heringiella* (Grönlien,1932) from Finland, EH: Nokia 682:31 Pitkäniemi, reared of mines from *Salix fragilis*. To the left a male reared 27.1.1994 and to the right a female reared 1996. All moths were collected and reared by E.M.&L.Laasonen. On these black-and-white pairs of figures, the number of strigulae can be seen, but not the shade of the coloration.

Table 3. The distribution of other criteria in 277 moths of the *P. salictella* group, if the number of clearly visible strigulae at the tip of the wing was taken as a decisive criterium.

	Strigulae	Coloration		Darkening		Total
		suffused	bright	large	small	
P. salictella f. *viminiella*	1	1	-	1	-	1
Intermediate form	1	1	-	1		1
P. salictella	1- 1°	116	13	100	29	129
Uncertain specimens	2?	6	-	5	1	6
P. heringiella	2°-3	12	110	80	52	132
Intermediate form	3	-	4	1	3	4
P. heringiella f. *"aurea"*	3	-	4	1	3	4

Table 4. The origin of the 277 moths of the *P. salictella* group from Finnish biogeographical provinces (males/females).

	Al	*Ab*	*N*	*Ka*	*Ta*	*Sa*	*Kl*	*Oa*	*Tb*	*Om*	*Oba*	*Obb*	Total
P. salictella f. *viminiella*	-	-	0/1	-	-	-	-	-	-	-	-	-	1
Intermediate form	-	-	1/0	-	-	-	-	-	-	-	-	-	1
P. salictella	1/1	1/2	30/39	7/4	9/12	-	0/1	4/6	1/4	1/3	1/1	0/1	129
Uncertain specimens	-	1/0	1/1	2/0	0/1	-	-	-	-	-	-	-	6
P. heringiella	4/8	3/4	36/48	5/2	7/12	1/0	-	-	-	-	0/2	-	132
Intermediate form	0/1	-	-	-	2/1	-	-	-	-	-	-	-	4
P. heringiella f. *"aurea"*	-	-	-	-	4/0	-	-	-	-	-	-	-	4

ing the moths of the *P. salictella* group, neither by using the criteria suggested in the literature nor using those made up by us. The food plants were also not helpful (Table 2), as with many other *Phyllonorycter* spp. living on *Salix* spp. We studied especially the food trees *S. fragilis, S. alba*, and *phylicifolia*, but this did not clear up the problem. The observed flying times were for *P. salictella* 28.5 to 18.6, 31.7 to 11.8 and 6.10, and for *P. heringiella* 16.5 to 3.7 and 25.7 to 13.8. Once again a feature with no help in the differentiation. The eventual third generation of *P. salictella* is certainly a great exception at least in Finland.

4. Discussion

Our study was initiated by the seesawing discussion of the species status of some *Phyllonorycter* spp. (Table 1). However, we have to point out that there are several authors from Finland and neighbouring countries, who do not express an opinion in their lists (Varis *et al.* 1987, Martin 1991, Ivinskis 1993, Kerppola *et al.* 1995, Luig & Keskula 1995, Savenkov *et al.* 1996). We showed that the *P. salictella* group can be divided in two on the basis of habitual differences, but our work is not meant as a revision of the problem pair. Today, two species are officially accepted and we thus report *P. heringiella* as a new species to Finland and to many biogeographical provinces here. To the discussions over the species status of *P. viminiella* we can just add a small piece of information and the final solution has to be made elsewhere. Perhaps also a study dealing with *P. salicicolella* (Sircom, 1848) and *P. brevilineatella* (Benander, 1944) would be worth of an effort, as there seem to be different food plants - *Salix* spp. - and living habits of the populations in the south and in the north.

In addition to *P. dubitella*, we also went through the material of *P. corylifoliella* (Hübner, 1796) and *P. salicicolella* in coll Laasonen to make sure that no moths of interest had been slipped in to these very nearby species (Svensson 1997). Thereafter, the 63 moths of the *P. salictella* group in coll. Laasonen formed a pilot material, and were screened more than five times, when the criteria were worked up to divide this group in two. After this the much bigger coll. at the ZMUH was gone through in a standardized way. In other words, we strongly recommend to everyone who is taking up this problem, to gain expertise and skills with long series of moths and not just analyse them one by one.

Both collections had some potential handicaps. There were almost 50 find localities of these moths and longer series - like Pitkäniemi - were rare. The material in coll. ZMUH was relatively old, from 1920–50, and sometimes with very limited find data. The material in coll. Laasonen was younger and included more precise rearing data.

The two dividing criteria - the number of wing tip strigulae and the brightness of the basal wing coloration - worked very well in dividing the group into *P. salictella* and *P. heringiella*, especially when we had softened up the criteria presented in the literature (Svensson 1997). With gained experience the division went rapidly. However, a word of warning is needed. *Phyllonorycter* specimens killed with chlorinated liquids in a continuous light trap may loose the brightness of their golden colour even when they are not worn,

and become difficult to determine. On the other hand, these moths seem not to suffer from the long preservation in the darkness of museum boxes - the brightness of the wings in *P. heringiella* is perfect even after 80 years. We failed in forming an objective criterion on the subjective darkness of the wing tip (Svensson 1997). Perhaps it is still necessary to add to the length of the dark blotch some estimate of the blotch area or of the darkness of the scales in the blotch.

According to Emmet *et al.* (1985) *P. viminiella* is nearer to *P. salictella* than to *P. heringiella*. This is a bit surprising, but we have not studied any British material. However, our suggestion for the origin of the golden suffusion of the white strigulae in the forms observed here apply in both combinations. This suggestion can only be verified by a large material of reared moths, in which some have had an opportunity to fly and some others not.

Svensson (1997) elevated *P. heringiella* as a good species in Sweden from a status of a northern ssp. of *P. salictella*. The original description of the former comes from the south of Norway, VE:Larvik, and Svensson (1997) himself presents provinces from the southwest of Sweden, VG to coastal north, NB. In Finland *P. heringiella* has its main distribution in six of the eight southern provinces. But, two females come from *Oba*, almost opposite to Swedish NB, at the northern end of the Gulf of Bothnia. The eventual northern finds from Finland are obviously insufficiently studied and reported.

There are means to study the problem pair in the future succesfully. A sufficient number of genital preparates - perhaps hundreds - would bring light to the eventual minimal differences in them. Maybe also an electrophoresis of deoxyribonucleic acids (DNA) extracted from the chromosomes of living or fresh moths would bring solutions. More expertly diagnosed museum material would also help, as well as use of several specialists to recheck the wing patterns presented here. However, all these require strong laboratories with experienced staff and were, unfortunately, out of reach of our resources.

5. Conclusions

By examining the appearance of more than 650 moths from the *P. salictella* group, as well as from some nearby species, we came up with the following conclusions:

1. The Finnish moths of the *P. salictella* group can be divided into *P. salictella* and *P. heringiella* on the basis of the number of tip strigulae and the brightness of the golden coloration in the forewing.

2. In Finland both *P. salictella* and *P. heringiella* occur in the provinces *Al, Ab, N, Ka, Ta,* and *Oba*. In addition, the former has been found in *Kl, Oa, Tb, Om* and *Obb* and the latter in *Sa*. A further study may reveal that both moths live in all provinces up to *Obb*.

3. Both moths have in Finland specimens with strigulae totally (or partially) suffused with gold - here called *P. salictella* f. *viminiella* and *P. heringiella* f. *aurea*. Such forms occur among reared, freshly emerged specimens, which have been immediately killed with cyanide. This fact adds a small piece of information to the discussion of the species status of *P. viminiella*, but further research is recommended.

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