ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume 65 86 Number 3, 2017
https://doi.org/10.11118/actaun201765030833

ALTITUDINAL VARIABILITY IN WING PATTERNS OF *PHYLLONORYCTER SALICTELLA* (ZELLER, 1846) (LEPIDOPTERA: GRACILLARIIDAE)

František Gregor[1], Hana Šefrová[2], Zdeněk Laštůvka[3]

[1]Loosova 14, 638 00 Brno, Czech Republic
[2]Department of Crop Science, Breeding and Plant Medicine, Faculty of AgriSciences, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic
[3]Department of Zoology, Hydrobiology, Fisheries and Apiculture, Faculty of AgriSciences, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic

Abstract

GREGOR FRANTIŠEK, ŠEFROVÁ HANA, LAŠTŮVKA ZDENĚK. 2017. Altitudinal Variability in Wing Patterns of *Phyllonorycter salictella* (Zeller, 1846) (Lepidoptera: Gracillariidae). *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* 65(3): 833–838.

Individual variability of wing patterns is not frequent in European species of the genus *Phyllonorycter* Hübner, 1822. It is unusually distinct in *Phyllonorycter salictella* (Zeller, 1846) which causes some taxonomic ambiguities and oversights. We found on numerous material of adults reared from overwintering pupae collected in the Czech and Slovak Republics since 1950 that this variability is related with altitude (temperature). Adults with the distinct generotypic (plesiomorphic) wing patterns dominated in submountain populations while individuals with the strongly reduced (apomorphic) wing drawings were represented quite negligibly. This ratio was reversed in lowland populations. The observed variability is continuous between extreme variants, it is regionally and trophic unaffected, and more pronounced in males than in females. The results support the view that the questionable taxa such as *Phyllonorycter viminiella* (Sircom, 1848) and *P. heringiella* (Grønlien, 1932) represent only individual (local or regional) forms of the above species.

Keywords: altitude, *Phyllonorycter*, *Salix*, variability

INTRODUCTION

The most *Phyllonorycter* Hübner, 1822 species (about 150 species known in Europe: Buszko, 2013, De Prins and De Prins, 2016) are characterized by species specific forewing drawings, formed by longitudinal, oblique or transverse white or metalic streaks or strigulae. The individual variability or differences manifest relatively rarely, e.g. in different size of adults in various generations or in some sexually dimorphic species. The distinct sexual dimorphism is obvious e.g. in the forewing drawings of *Phyllonorycter medicaginella* (Gerasimov, 1930). The ground color is brick red in males, usually with three costal strigulae, and red rusty in females with only two costal strigulae (Šefrová, 2002a). The forewing colouration of *Phyllonorycter issikii* (Kumata, 1963) differs in summer and overwintering generations (Kumata, 1963, Šefrová, 2002b), similarly as in some other European species overwintering as adults, e.g. *Phyllonorycter sagitella* (Bjerkander, 1790), *P. comparella* (Duponchel, 1843), and *P. pastorella* (Zeller, 1846). Some variability also occurs in several species mining on Fabaceae, as *P. adenocarpi* (Staudinger, 1863), *P. genistella* (Rebel, 1900), *P. scopariella* (Zeller, 1846), *P. staintoniella* (Nicelli, 1853), and *P. triflorella* (Peyerimhof, 1872). Their forewing strigulae are sometimes unusually connected, they are indistinct or the wings are quite unicolor (cf., e.g. Laštůvka and Laštůvka, 2006).

The larvae of *Phyllonorycter salictella* (Zeller, 1846) create underside leafmines on many *Salix* species, especially on *Salix purpurea*, *S. alba,* and their hybrids (e.g. De Prins and De Prins, 2016). The species develops two generations annually, adults of the first generation are on the wing usually in May and June, the second in August (Hering, 1957). *Phyllonorycter salictella* is widespread in the Eurosiberian region, also throughout Europe with exception of the Balkan Peninsula and the Mediterranean islands (Davis and Deschka, 2001, Buszko, 2013, De Prins and De Prins, 2016). Some close related taxa were described in the past, mostly based on small differences in the wing pattern intensity, esp. *P. viminiella* (Sircom, 1848) and *P. heringiella* (Grønlien, 1932) (cf., e.g. Laasonen and Laasonen, 2000, Bengtsson, 2010, De Prins and De Prins, 2016).

This contribution brings results of the study of the forewing patterns of this species depending on altitude.

MATERIALS AND METHODS

The evaluated adults (310 specimens) were reared from mines collected in 36 localities in the Czech and Slovak Republics during October and November in 1950–1960 and then in 2005–2015 (lgt. F. Gregor). A supplementary breeding from July 2016 provided only 15 adults, thus the material non-evaluable statistically. The mines were mostly collected on *Salix purpurea* L., S. × *rubra* Huds., *S. alba* L., *S. daphnoides* Vill., and *S. myrsinifolia* Salisb. The identification was confirmed by the examination of genitalia in less obvious cases or by the study of cremaster of pupae which differs from other salicicolous *Phyllonorycter* species (Gregor and Patočka, 2001). The material is deposited in the Entomological Department of the Moravian Museum Brno and in the private collection of the senior author.

The finding places were ordered according to altitude and divided in four altitudinal (thermal) categories I–IV (tab. I). These categories correspond more or less with the climate regions of the Czech Republic (or the former Czechoslovakia) by Quitt (1971): I. warm (including the unit 11 of the moderately warm region), II. moderately warm (units 5–10), III. moderately warm (units 1–4), and IV. cold regions. The mean October temperatures of these four areas, which could be important in the development of pupae, are approximately 7–10, 6–8, 6–7 and (4) 5–6 °C.

After intensity of the forewing drawings, four color types (with continuous variability) A, B, C, and D were defined (tab. II, fig. 1). The proportional representation of these color types A–D was evaluated for each altitudinal category. The color types were also divided after sex composition.

The nomenclature of *Salix* species follows Vašut *et al.* (2013), with minor modifications after The Plant List (2013). The codes of fields for the faunistic grid mapping system see Pruner and Míka (1996). The statistical evaluation was performed by the Pearson correlation coefficient using the Correl function in the Microsoft Excel.

RESULTS AND DISCUSSION

The variability of the forewing patterns of *Phyllonorycter salictella* is manifested by the gradual reduction until complete disappearance of the costal strigulae 2, 3, 4, and dorsal 3, by the gradual increase of dispersed brownish black scales from the apex to the base of the wing, and by the clouding of the formerly white colour (tab. II, fig. 1). The topography of the basic white drawings with the basal streak and strigulae (characteristic for the entire genus) is retained, but in varying degrees covered by colour or by dark scales (also on thorax). The same phenomenon was probably observed by Laasonen and Laasonen (2000) in *P. heringiella* (very probably synonymous with *P. salictella*).

The continuous transition was found between color types A and D and their representation is significantly dependent on altitude. In altitudes 700–900 m a.s.l. (height category IV), the plesiomorphic type A prevails (63% of adults), the "smoky" type D is represented by only 2% of adults. While in lowlands (height category I), the type D dominates (54%) and the type A is represented by only 5% (tab. III, fig. 2). The values of the Pearson correlation coefficient show a strong linear dependence of the type A on altitude (0.983886) and less distinct (but still significant) dependence of the type B (0.884085). And conversely, the types C and D are significantly inversely dependent on altitude (–0.91886 and –0.95767). Our material of adults from June 2016 suggests that the summer generation is probably variable in a similar extent as the adults from the overwintering pupae. A more accurate comparison of individuals of both generations and the statistical evaluation was not possible due to inadequate summer material (tab. IV).

The dependence on altitude is partly different between sexes, or is less pronounced in females. The color type D is represented by 42% of males and only by 23% of females. But the rule that the intraspecific variability is greater in males than in females is true for the majority of animals (Flegr, 2007).

Besides the dependence on altitude, we did not detect the influence of other factors, such as trophic, regional or local effect on the forewing colouring.

The impetus for the development of a certain phenotype (in the overwintering generation) is very probably temperature that may cause both by the altitude difference of at least 5 °C (mean October temperatures) and by the microclimatic conditions. The mines are dispersed on host plants and the tree and bush willows themselves grow on various, sunlit and shaded places. The continuous intraspecific variability in the wing patterns of *P. salictella* excludes the possibility that there is a selection of hereditary ecotypes or a group of closely related young species. It seems that the individual phenotypes of *P. salictella* (occasionally considered for more species) are a direct response to the current

I: *Altitudinal categories of finding places of Phyllonorycter salictella; ordered according to altitude*

Category	Locality	Altitude (m a.s.l.)	Faunistic field	Year of collection	Number of specimens
I (160–300 m)	Tvrdonice	170	7267	1953	5
	Brno Ráječek	190	6865	1950, 1960, 1961	5
	Praha-Stromovka	190	5852	1955	2
	Kolín	200	5957	1955	5
	Černovír u Olomouce	210	6369	1950	5
	Veverská Bítýška	220	6764	1958	11
	Sv. Jan pod Skalou	230	6050	1954	3
	Zdounky	230	6769	1955	5
	Adamov	250	6766	1958	10
	Brno-Černá Pole	250	6765	1960–68, 2005–15	48
	Mikulov	250	7165	1950,1958	6
	Jestřebí	260	5353	1956	4
	Mokrá Hora	260	6764	2014	4
	Brno-Bystrc	280	6765	1958	3
	Morkovice	290	6769	1960	3
II (301–500 m)	Frýdek	308	6376	1959	10
	Průhonice	310	6053	1952, 1956	2
	Bytča	310	6777	1955	4
	Ochoz-Hádek	360	6766	2015, 2016	11
	Horní Poříčí	400	6464	1955	5
	Křtiny	420	6666	1958–1962, 2010	51
	Pribovce	420	6884	1955	3
	Svitavy	440	6264	1955	6
	Opatov	450	6164	1955	10
III (501–700 m)	Horní Bečva	505	6575	1960	4
	Chotěboř	520	6260	1955	6
	Milešovka	580	5449	1955	3
	Rýmařov	590	6069	1960	4
	Gaderská dolina	600	7081	1957, 1960	15
	Žďárná	650	6566	2010	18
	Poprad	700	6987	1957	3
IV (701–900 m)	Makov	750	6576	1955	2
	Pribylina	780	6885	1954	12
	Dedošová dolina	850	7081	1957	1
	Štrba	900	6886	1954	2
	Telgart	900	7187	1953	19
Total specimens					310

temperature in the critical period of transformation of a larva to pupa. Greater or smaller differences in the representation of various color types also in localities of the same altitude may be explicable by the effect of microclimate and by individual responses of each specimen on the temperature (males more susceptible than females). It is possible that humidity may also interact with temperature.

It is not known if the less contrasty or monotonous individuals may be ecologically more successful.

II: *Color types of Phyllonorycter salictella; cf. also fig. 1*

Type	Costal strigulae 2, 3, 4	Dorsal strigula 3	Strigulae color
A	distinct, broad	distinct, broad	white, shiny
B	reduced	reduced	white
C	strongly reduced	strongly reduced	off-white
D	absent	absent	smoky

III: *Representation (number of specimens) of color types of P. salictella in altitudinal categories, overwintering generation*

Specimens	Category/altitude	A	B	C	D
119	I/160–300	6	16	33	64
102	II/301–500	16	14	33	39
53	III/501–700	26	18	6	3
36	IV/701–900	23	11	1	1
310		71	59	73	107

IV: *Representation (number of specimens) of color types of P. salictella in altitudinal categories, summer generation 2016*

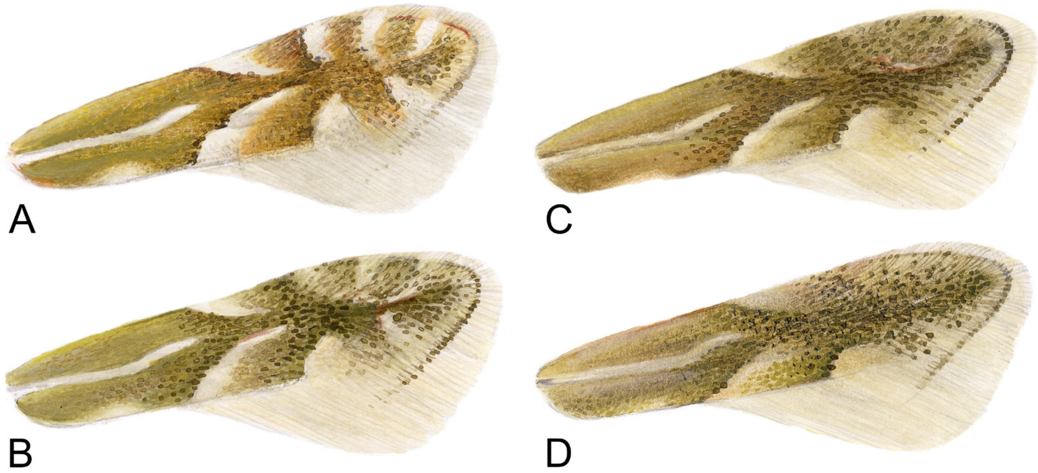
Specimens	category/altitude	A	B	C	D
3	I/160–300	1	0	2	0
9	II/301–500	4	2	2	1
3	III/501–700	2	0	1	0
15		7	2	5	1

It is clear e.g. in the darker and inconspicuous overwintering adults of the above mentioned species who easily escape the attention of predators in their winter shelters.

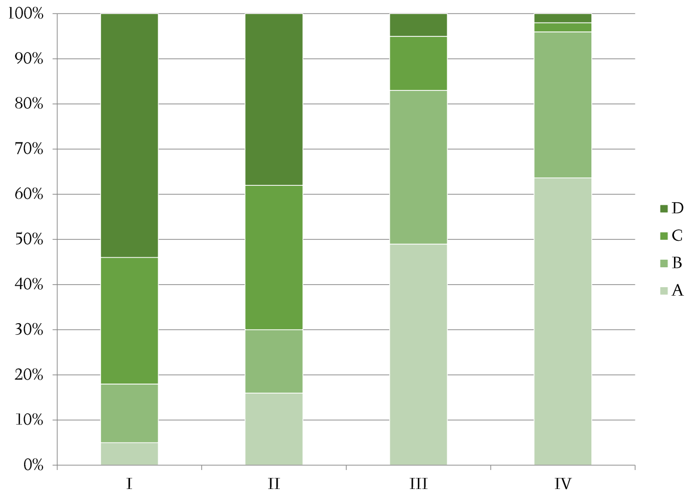
Phyllonorycter salictella belongs within the salicicolous species of this genus in the subgroup "*hilarella*" (Davis and Deschka, 2001), a monophyletic group with very uniform genitalia morphology where the length of saccus can be the only reliable discriminative character. In Europe, *P. dubitella* (Herrich-Schäffer, 1855), *P. hilarella* (Zetterstedt, 1839), *P. salicicolella* (Sircom, 1848), *P. salictella* (Zeller, 1846), *P. viminetorum* (Stainton, 1854), and the inconclusive *P. rolandi* (Svensson, 1966) occur from this group. Only *P. salictella* is significantly variable among these species. This variability led some authors to descriptions of other species whose taxonomic status is currently being evaluated inconsistently: *P. heringiella* (Grønlien, 1932), *P. jaeckhi* (Hering, 1934), and *P. viminiella* (Sircom, 1848) (cf. Laasonen and Laasonen, 2000, Davis and Deschka, 2001, Bengtsson, 2010, De Prins and De Prins, 2016). *Phyllonorycter pseuditeina* (Kumata, 1973) belongs very probably also to these problematic taxa.

It is not known if the altitudinal variability phenomenon of *P. salictella* described in this contribution could be applied in the whole distributional range of this species, but it may help to clarify taxonomic position of the above problematic taxa. *Phyllonorycter jaeckhi* (Hering, 1934) and *P. viminiella* (Sircom, 1848) are currently mostly considered synonyms of *P. salictella*, but the taxonomic position of *P. heringiella* is different by various authors. Laasonen and Laasonen (2000) and Bengtsson (2010) unlike Davis & Deschka (2001) consider *P. heringiella* a separate species (a sibling species of *P. salictella*). Photos of *P. heringiella* in the work by Bengtsson (l. c., p. 201) very probably represent four males (his fig. 10 and 11 a, b, c) and one female of *P. salictella* (fig. 13, our very distinct type A); fig. 12 seems to be *P. dubitella* (Herrich-Schäffer, 1855).

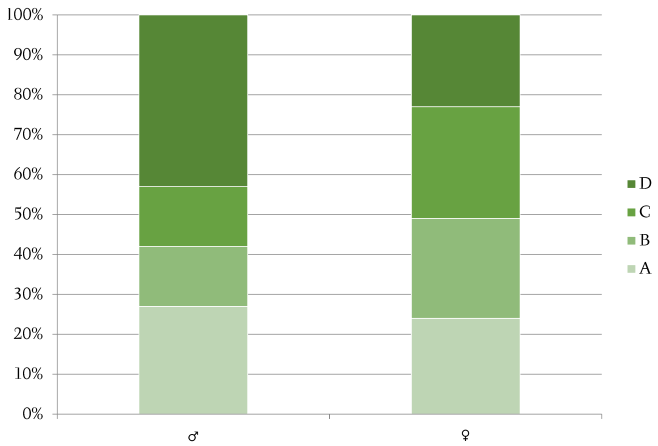
The European species of the "*hilarella*" subgroup are relatively easily distinguishable. The patterns in the middle of the forewing are only slightly unstable in *P. hilarella*, *P. salicicolella,* and *P. viminetorum*. The American representative *P. apicinigrella* (Braun, 1908) is habitually out of this relatively "conservative" state of the "*hilarella*" subgroup. Its monotonously coloured forewing is entirely without drawings, with only black roots of hind ciliae. It is exceptional within the genus because the colorful habitus and forewings with sharp drawings, sometimes metalic, is considered an ancestral type of the genus. The formation of the indistinct forewing drawings in *P. salictella* may arise similarly as in *P. apicinigrella*, and may be related to the ability to create inconspicuous cryptic coloration, as in some of the above species which adults hibernate.



1: *Wing pattern variability of Phyllonorycter salictella (orig. F. Gregor), cf. Tab. II*



2: *Representation (number of specimens) of color types of Phyllonorycter salictella in altitudinal categories, overwintering generation; A–D – four color types of the forewing drawings, see Fig. 1 and Methods, I–IV – altitudinal (thermal) categories from the warmest to coldest, see Methods*



3: *Representation (number of specimens) of color types of Phyllonorycter salictella in both sexes, overwintering generation; others as in Fig. 2*

CONCLUSION

Dependence of the forewing patterns on altitude was registered in *Phyllonorycter salictella* (Zeller, 1846). The wing drawings are sharper and more contrast with the increasing altitude. Adults with the distinct wing patterns dominate in submountain populations, and conversely the unclear until disappearing drawings prevail in lowlands. The altitudinal variability is very probably caused by the current temperature acting on early pupae in autumn, but the effect of other factors is also possible. Revealing this variability may help to resolve uncertainties regarding taxonomic position of some obscure taxa, esp. *Phyllonorycter viminiella* (Sircom, 1848) and *P. heringiella* (Grønlien, 1932).

Acknowledgements

We are grateful to Richard Šefr (Brno) for statistical evaluation of results.

REFERENCES

BENGTSSON, B. Å. 2010. Notes on some Nordic species of Phyllonorycter Hübner, 1822 (Lepidoptera, Gracillariidae). *Entomologisk Tidskrift*, 131(3): 195–204.

BUSZKO, J. 2013. Fauna Europaea: Lithocolletinae. In: KARSHOLT, O. and NIEUKERKEN, E. J. (Eds.). *Fauna Europaea: Lepidoptera, Moths*. Fauna Europaea version 2.6. Available at: http://www.fauna-eu.org [Accessed: 20 March 2017].

DAVIS, D. R. and DESCHKA, G. 2001. Biology and systematics of the North American Phyllonorycter leafminers on Salicaceae, with a synoptic catalog of the Palearctic species (Lepidoptera: Gracillariidae). *Smithsonian Contributions to Zoology*, 614: 1-89.

DE PRINS, J. and DE PRINS, W. 2016. *Global taxonomic database of Gracillariidae (Lepidoptera)*. Available at: http://www.gracillariidae.net [Accessed: 20 March 2017].

FLEGR, J. 2007. *Introduction to evolutionary biology* [In Czech: Úvod do evoluční biologie]. Praha: Academia.

GREGOR, F. and PATOČKA, J. 2001. Puppen der mitteleuropäischen Lithocolletinae (Insecta: Lepidoptera: Gracillariidae). *Mitteilungen des Internationalen Entomologischen Vereins, Frankfurt a. M., Suppl.*, 8: 1–176.

HERING, E. M. 1957. *Bestimmungstabellen der Blattminen von Europa einschließlich des Mittelmeerbeckens und der Kanarischen Inseln*. The Hague: W. Junk.

KUMATA, P. 1963. Taxonomic studies on the Lithocolletinae of Japan (Lepidoptera: Gracillariidae). Part I. *Insecta Matsumurana*, 25(2): 53–90.

LAASONEN, E. M. and LAASONEN, L. 2000. Habitual differences of Phyllonorycter salictella (Zeller, 1846) and P. heringiella (Gronlien, 1932) (Lepidotera: Gracillariidae) in two Finnish materials, a problem pair. *Entomologica Fennica*, 11(3): 175–181.

LAŠTŮVKA, Z. and LAŠTŮVKA, A. 2006. The European Phyllonorycter species feeding on the plants of the tribe Genisteae (Fabaceae) with descriptions of twelve new species (Lepidoptera: Gracillariidae). *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 54(5): 65–84.

PRUNER, L. and MÍKA, P. 1996. List of settlements in the Czech Republic with associated map field codes for faunistic grid mapping system. [In Czech: Seznam obcí a jejich částí v České republice s čísly mapových polí pro síťové mapování]. *Klapalekiana*, 32(Suppl.): 1–175.

QUITT, E. 1971. *Climate regions of Czechoslovakia* [In Czech: *Klimatické oblasti Československa*]. Praha: Academia.

ŠEFROVÁ, H. 2002a. Phyllonorycter medicaginella (Gerasimov, 1930) – larval morphology, bionomics and spread in Europe (Lepidoptera, Gracillariidae). *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 50 (3): 85–90.

ŠEFROVÁ, H. 2002b. Phyllonorycter issikii (Kumata, 1963) – bionomics, ecological impact and spread in Europe (Lepidoptera, Gracillariidae). *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 50(3): 99–104.

THE PLANT LIST c2013. *The plant list. A working list of all plant species*. Version 1.1. Available at: http://www.theplantlist.org/ [Accessed: 20 March 2017].

VAŠUT, R. J., SOCHOR, M. and HRONEŠ, M. 2013. *Salix species of the Czech Republic* [In Czech: *Vrby České* republiky]. Olomouc: Univerzita Palackého.

Contact information

Hana Šefrová: sefrova@mendelu.cz
Zdeněk Laštůvka: last@mendelu.cz