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Geographical variation in wing pattern of *Micropterix maschukella* Alphéraky, 1876 (Lepidoptera : Micropterigidae)

Michail V. Kozlov

Laboratory of Ecological Zoology, Department of Biology, University of Turku, FIN-20500 Turku, Finland

Summary

Five discrete types of forewing pattern can be found within populations of *Micropterix maschukella* Alphéraky. In Lagodekhi, Eastern Georgia, frequencies of wing pattern types were the same for males and females ; no differences were found between the two study years. The frequency of wing pattern type was therefore considered to be a population specific character and was used to study geographical variation. Phenetic resemblances of 15 samples from the Crimea and Caucasus correspond in general to the spatial proximities of the sampling sites. Three geographically consistent units were distinguished : northern (Crimea and Krasnodar district), south-western and eastern. A clear allopatric differentiation within the species was found, but there was no corresponding variation in the male genitalia.

Résumé

Parmi les populations de *Micropterix maschukella* Alphéraky, on trouve cinq types discrets de dessin des ailes antérieures. A Lagodekhi, Georgie orientale, la fréquence des types de dessins des ailes est la même pour les mâles et les femelles ; on n'a pas trouvé de différences entre les deux années de l'étude. La fréquence des types de dessin des ailes a donc été considérée comme caractéristique des populations et utilisée pour étudier la variation géographique. Les ressemblances phénétiques de 15 échantillons de Crimée et du Caucase correspondent en général aux proximités spatiales des sites des échantillons. Trois unités géographiques consistantes ont été distinguées : nord (Crimée et région de Krasnodar), sud-ouest et est. On a constaté une nette différenciation allopatrique dans cette espèce, mais pas de variation correspondante dans les genitalia mâles.

Zusammenfassung

In Populationen von *Micropterix maschukella* Alphéraky lassen sich fünf Typen der Vorderflügelzeichnung unterscheiden. In Lagodekhi, Ost-Georgien, werden diese Zeichnungsmuster-Typen bei Männchen und Weibchen mit gleicher relativer Häufigkeit beobachtet ; zwischen den beiden Untersuchungsjahren gab es hierbei keine Unterschiede. Die relativen Häufigkeiten der Zeichnungsmuster-Typen wurden daher als populationsspezifisch betrachtet und als Maß für geographische Variabilität verwendet. Das Erscheinungsbild von 15 Sammelproben von der Krim und aus dem Kaukasus läßt sich im allgemeinem mit den räumlichen Abstand der Fundpunkte in Beziehung setzen. Drei geographische Bereiche lassen sich unterscheiden : ein nördlicher (die Krim und die Gegend von Krasnodar), ein südwestlicher und ein östlicher. Innerhalb der Art wurde eine deutliche allopatrische Differenzierung festgestellt, die aber nicht mit einer entsprechenden Variation der männlichen Genitalien verbunden ist.

Introduction

The contrasting wing pattern is typical for almost all of the approx. 70 species of the Palaearctic genus *Micropterix* Hübner [1825] (Heath, 1987). Wing pattern characteristics are widely used in determination keys (Razowski, 1975 ; Zagulajev, 1978 ; Kozlov, 1988 ; 1989 ; 1990a ; Whitebread, 1992), and they are of critical importance for the identification of females, whose genitalia are very poor in specific characters. However, variation of wing pattern characteristics has not been studied in this genus and the absence of knowledge of the extent of interpopulation and geographical variation has sometimes caused taxonomic problems.

The small (about 8-10 mm wing expanse) day-active irridescent moth *Micropterix maschukella* Alphéraky is widely distributed and very abundant in the Crimea and Caucasus. In Eastern Georgia the moths emerge at the beginning of May in the valleys ; at the altitudes 1500-1700 m the last specimens were observed in late July. The moths feed on the pollen of several plant species, usually on elder (*Sambucus nigra* L.) and *Philadelphus caucasicus* Koehne. Sometimes they also visit flowers of *Rubus* spp. and *Rosa* spp. (pers. obs.). The investigation of wing pattern variation has been prompted by the description of a new species, *Micropterix maritimella* (Zagulajev, 1983) based on females originating from the population of *M. maschukella* in Gantiadi, Abkhasia, which I had studied for some years.

Material and methods

The study consisted of two parts : intrapopulation variation was investigated in Lagodekhi Natural Reserve (Georgia, formerly the U.S.S.R. ; 41°50′ N, 46°20′ E) ; geographical variation was studied from specimens collected by the author and those kept in the Zoological Institute, St. Petersburg, Russia.

Moths were sampled from inflorescences of host plants by net and immediately anaesthetised by chloroform. Each sample was characterized by frequencies of moths with different wing pattern (see Figs 1-5) ; males and females were recorded separately. In total, about 5,500 moths were thus investigated. Samples were compared by chi-square test or, if the sample size was very small, by the non-parametric lambda criterion. Diversity (μ) was calculated according to Zhivotovsky (1982) :

$$\mu = (\Sigma_i \sqrt{p_i})^2,$$

where p_i is the frequency of the *i*th type of wing pattern (i = 1...5). The presence of geographical variation was tested by **G**-statistic for heterogeneity of proportions (Gabriel & Sokal, 1969). Pairwise similarity

$$\mathbf{R}_{k,l} = \Sigma_i \sqrt{p_{ik} p_{il}}$$

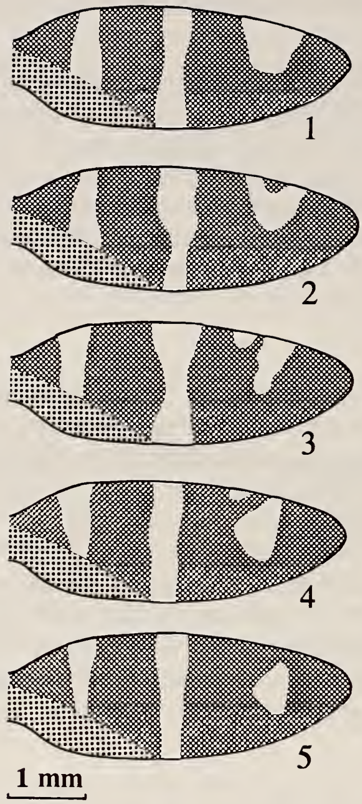
based on the ratio of frequencies (p_i) of all the wing pattern types (i) in populations under comparison (k and l) (Zhivotovsky, 1982) was calculated for all samples involved in the study ; similarity matrix was clustered on the base of mean arithmetic unweighed estimations of the similarity between clades.

Results

Wing pattern variation

The general appearance of the golden pattern in *M. maschukella* includes two bands (basal and medial) and a subapical spot, sharply distinguished from the cupreous-brownish background.

Five discrete types of forewing pattern were found. The first type has a large, almost rectangular subapical gold spot laying along the costal margin of the wing (Fig. 1). The second type differs from the first by having a small dark spot within this gold spot (Fig. 2). In both the third and fourth type there are two spots (small costal and large subapical) on the costal edge. These two types differ in the form of the subapical spot, which has its maximum width either at the costal margin (type 3, Fig. 3), or towards the centre of the wing (type 4, Fig. 4). The 5th type differs from the 4th due to the absence of the costal spot ; the large subapical spot is usually not connected to the costal edge of the wing (Fig. 5), although there are some exceptions.



Figs 1-5. The five types (numbers 1-5) of forewing pattern of *M. maschukella*.

The two bands, although variable in form and width, did not show any clearly recognizable types.

The right and left wings of the moth usually have the same type of wing pattern. However, 30.6% of specimens collected in Lagodekhi 1989 and 28.7% in 1990 were asymmetrical. But if the pattern of the right and left wing varies independently, the expected number of asymmetrical moths would be significantly (about 2 times) higher than observed (in 1989 : expected 64.0%, $G = 799.1$, $df = 1$, $P < 0.0001$; in 1990 : expected 56.9%, $G = 291.9$, $df = 1$, $P < 0.0001$). In spite of the high percentage of asymmetrical specimens, some genetic background of wing pattern types is assumed. But even if the variation is phenotypic only, it does not affect the conclusions of the present study.

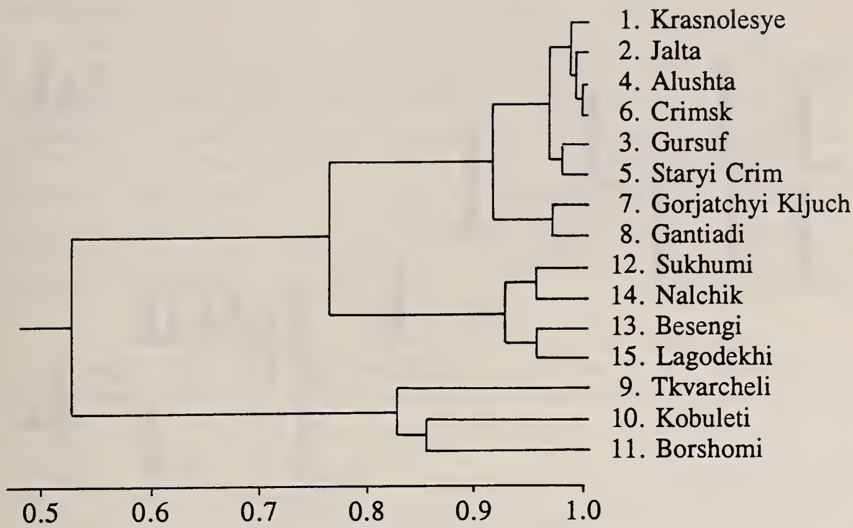


Fig. 6. Dendrogram based on the similarity between samples of *M. maschukella* in wing pattern frequency.

In spite of the very low (about 10%) proportion of males in samples obtained from the inflorescences of elder in Lagodekhi, I succeeded in obtaining samples of 15-25 males from six local populations ; differences between sexes appeared to be non-significant (lambda = 0.04-1.10). Differences between samples obtained in Lagodekhi in 1989 and 1990 from the same local populations were also not significant. Thus, I concluded that the frequencies of wing pattern types are relatively stable in time, and therefore the samples collected in different years can be compared when studying geographical variation. To increase the sample size, males and females were pooled when counting wing pattern frequencies.

Geographical variation

The 15 localities in the Crimea and Caucasus, significantly heterogeneous in wing pattern frequencies ($n = 5242$, $G = 1383.6$, $df = 52$, $P < 0.0001$), were included in the analysis. Clustering of the similarity matrix showed that the phenetic resemblances of samples correspond in general to their spatial proximities (Fig. 6). Three geographically consistent units were distinguished : northern (Crimea and Krasnodar district), south-western and eastern (Fig. 7).

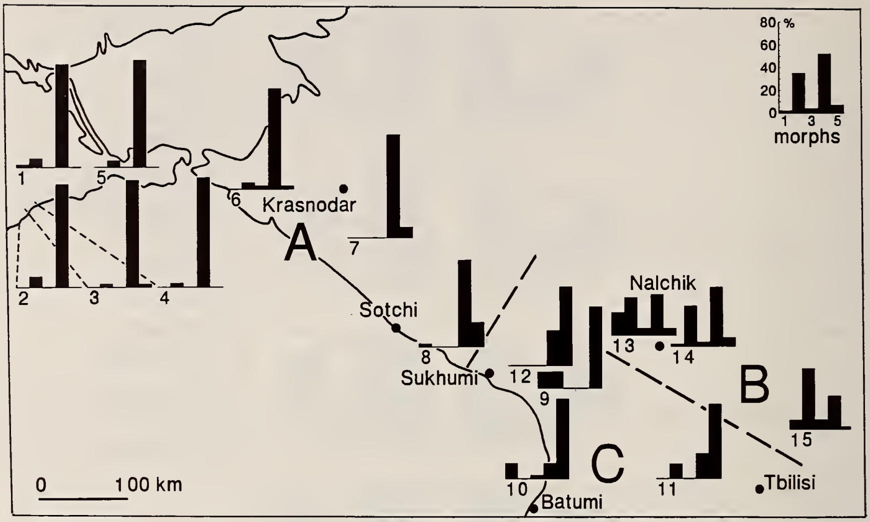


Fig. 7. Geographical variation in wing pattern frequencies of *M. maschukella* Alph. in the Crimea and Caucasus. Localities : 1 — Krasnolesye (sample size n = 94, moths collected in 1984) ; 2 — Jalta (n = 54, 1983) ; 3 — Gursuf (n = 60, 1985) ; 4 — Alushta (n = 72, 1983) ; 5 — Staryi Crim (n = 36, 1913) ; 6 — Crimsk (n = 36, 1990) ; 7 — Gorjatchyi Kljuch (n = 22, 1988) ; 8 — Gantiadi (n = 42, 1978) ; 9 — Tkvarcheli (n = 14, 1980) ; 10 — Kobuleti (n = 66, 1973) ; 11 — Borshomi (n = 46, 1898) ; 12 — Sukhumi (n = 26, 1980) ; 13 — Besengi (n = 70, 1989) ; 14 — Nalchik (n = 54, 1989) ; 15 — Lagodekhi (n = 4550, 1990). Contours correspond to the clusters identified in Fig. 6. Groups of population : A — northern ; B — eastern ; C — south-western.

Samples from the northern group demonstrated the lowest observed intrapopulation diversity (coefficient of diversity $\mu < 2.5$) ; about 90% of individuals belonged to the fourth type of wing pattern. This group was heterogeneous ($n = 416$, $G = 59.4$, $df = 28$, $P < 0.0005$) because of the most southern sample (from Gantiadi), which had an intermediate ratio of wing pattern types. If this sample is excluded from the consideration, the northern group becomes homogeneous in relation to wing pattern frequencies ($n = 374$, $G = 28.3$, $df = 24$, $P < 0.251$).

Both the south-western and eastern groups are significantly heterogeneous ($n = 126$, $G = 30.1$, $df = 8$, $P < 0.0005$, and $n = 4700$, $G = 168.2$, $df = 12$, $P < 0.0001$, respectively), and more diverse than the northern one ($\mu = 3.5$-4.5). In the south-western group the pattern number five was most abundant, in contrast to the eastern group where the second and fourth types had highest frequencies. The small number of localities being compared did not allow investigation of the geographical variation of wing pattern within these groups.

Discussion

Like leaf miners of the family Nepticulidae (Menken, 1990), *M. maschukella* bear characteristics which appear to facilitate rapid speciation : they occur in small isolated populations, the detritophagous caterpillars and pollen-eating adults have only a few (if any) competitors, and their food resources are highly predictable. But, in contrast to sympatric speciation in Nepticulidae and Yponomeutidae (Menken, 1990 ; Menken *et al.*, 1992), Micropterigidae demonstrate mostly geographical (allopatric) differentiation.

No differences in genitalic structure were found between males of *M. maschukella* with different wing patterns, or between local populations in Lagodekhi area and between populations from different geographical groups (Kozlov, 1990b and unpublished data). According to the recognition concept of species argued by Paterson (1985), this may be due to visual recognition of the opposite sex in this moth species. In this respect *M. maschukella* is similar to butterflies, which often demonstrate strict interspecific differentiation in wing pattern features, while male genitalia are quite similar, i.e. in the genus *Erebia* Dalm. (Warren, 1936).

Thus, the data obtained showed clear allopatric differentiation within the species, which, however, demonstrated no corresponding variation in male genitalia structure. It is possible that a complex of subspecies or even sibling species may exist under the name *Micropterix maschukella*, but at the present level of knowledge the differentiation in wing pattern is not sufficient to ascribe a taxonomic rank to geographically separated populations.

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