RUSSIAN ACADEMY OF SCIENCES
SIBERIAN BRANCH

BIODIVERSITY AND DYNAMICS OF ECOSYSTEMS IN NORTH EURASIA

VOLUME 3

Section "DIVERSITY OF THE FAUNA OF NORTH EURASIA"

PART 1

Novosibirsk, Russia
August 21-26, 2000

IC&G, Novosibirsk, 2000

PHENOTYPIC VARIABILITY OF EYESPOTS AS A HOMOLOGOUS WING PATTERN OF ELEMENTS IN SATYRS (*LEPIDOPTERA: NYMPHALIDAE, SATYRINAE)*

Zakharova E.Yu.

Urals State University,
51 Lenin Str., 620083, Ekaterinburg, Russia, e-mail: elena.zakharova@usu.ru

Keywords: *phenotypic correlation structure, butterfly wing pattern, eyespots, Satyrinae.*

Abstract

This work is devoted to the elucidation of phenotypic correlation structure of wing pattern homologous elements, utilizing satyrinae eyespots as an example. The analysis was conducted on several Urals *Satyrinae* species of genera *Coenonympha, Aphantopus, Maniola, Lopinga, Lasiommata, Oeneis*. Higher correlations between neighbouring homologous pattern elements, then between phenes which vary more independently.

Introduction

The color patterns of butterflies consist of mosaics of colored scales in which each scale is an extruded lamina of a single epidermal cell. The overall pattern is a highly organized system of pigment distributions of homologous elements (spots and bands). The general scheme of *Lepidoptera* color pattern was developed by B.N.Schwanwitsch (1955, 1956) and with more details in *Nymphalidae* by Nijhout (1985, 1990; Nijhout, Wray, 1988). The nymphalid ground plan consists of two systems of bands (symmetrical and asymmetrical), border ocelli (eyespots), parafocal elements and submarginal bands. All real observed patterns are derived from the selective expression, suppression, displacement and distortion of the ground plan elements.

Each pattern element (series of homologous elements) varies independently, so that size, position and expression of one element can vary from one wing cell to another without any correlative changes with other elements (Paulsen, Nijhout, 1993).

This work is devoted to the elucidation of phenotypic correlation structure among eyespots of wing pattern of some Urals Satyrinae species (*Lepidoptera: Nymphalidae, Satyrinae*). Variability of eyespot diameters in relation to their expression is discussed.

Material and Methods

Diameters of eyespots were measured as the distance between the two points where the outer ring intersected the midline of the wing cell, in which the eyespot was centered. Forewing length was measured from the wing basis to its apex. Hindwing length was measured from the wing basis to the apex of Cu_2 vein.

Samples of ten satyrinae species were being made on the territory of Sverdlovsk, Chelyabinsk and Kurgan regions during 1994–1999 years: *Coenonympha glycerion* (890 specimens), *C. arcania* (473 specimens), *C. pamphilus* (372 specimens) *Aphantopus hyperantus* (1155 specimens), *Maniola jurtina* (170 specimens), *Minois dryas* (382 specimens), *Lasiommata maera* (95 specimens), *L. petropolitana* (112 specimens), *Lopinga achine* (790 specimens), *Oeneis tarpeia* (70 specimens).

Results

The data on phenotypic variability of wing patterns collected during several years (1994–1999) permitted us to separate all eyespots in two groups in terms of their expression: (1) the stable ones and (2) spots, which sometimes are absent and are characterized by us as phenes. All of them vary in their sizes.

Stability of eyespot expression depends on species and sex (table). It is sensible to analyse males and females separately because there are frequent sexual distinctions.

Table

Stability of eyespot expression in several satyrinae species

Cells of forewing	R5-M1	P1		1,0		0,7	1,2								92,6	100,0	93,3	87,5	100,0	100,0	2,7	
	M1-M2	P2	20,4	86,7	96,9	99,7	100,0	100,0	99,8	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
	M2-M3	P3	0,9	11,9	3,8	20,2	2,6						4,2	82,5		21,6	33,3	28,1	100,0	100,0	100,0	100,0
	M3-Cu1	P4		12,4		7,0			91,0	100,0			2,5	81,7			10,0	6,3	100,0	100,0	100,0	100,0
	Cu1-Cu2	P5		2,9		0,7	3,8		44,5	94,0			100,0	100,0					100,0	100,0	100,0	100,0
Cells of hindwing	Rs-M1	G1	98,7	100,0	100,0	100,0	7,2	17,2	98,2	99,5	20,3	18,2			100,0	100,0	100,0	100,0	100,0	100,0	31,1	33,3
	M1-M2	G2	74,3	99,5	91,7	99,3	7,5	17,2	100,0	100,0	97,0	27,3			100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
	M2-M3	G3	100,0	100,0	100,0	100,0	36,1	41,4							96,3	100,0	100,0	100,0	89,7	79,4	89,2	5,6
	M3-Cu1	G4	100,0	100,0	100,0	100,0	50,8	50,0	100,0	100,0	9,1				100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
	Cu1-Cu2	G5	97,4	100,0	99,7	100,0	57,7	60,3	100,0	100,0	99,7	36,4	86,9	85,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
	Cu2-2A	G6	96,5	98,6	63,8	72,8	26,4	37,9	99,8	100,0	29,1	4,6			100,0	97,7	100,0	100,0	100,0	100,0		1,9
	Cu2-2A	G7	1,8	5,7	0,7	1,7			0,5	1,3					77,8	81,8	96,7	87,5				
			males	fe-males	males	fe-males	males	fe-males	males	fe-males	males	fe-males	males	fe-males	males	fe-males	males	fe-males	males	fe-males	males	fe-males
		Spots marks	Coenonympha glycerion		Coenonympha arcania		Coenonympha pamphilus		Aphantopus hyperanthus		Maniola jurtina		Minois dryas		Lasiommata maera		Lasiommata petropolitana		Lopinga achine		Oeneis tarpeia	

As it was found, more significantly correlated spots were those that (1) possessed 100% stability of expression, (2) spaced into the neighbouring wing cells and (3) belonged to homologous cells of fore – and hindwings. As an example we give similarity tree-diagram of spots diameters for *Coenonympha glycerion* (females) (fig.). Co-relations were calculated on the indices of spots sizes (diameter of spot, divided on the corresponding wing length).

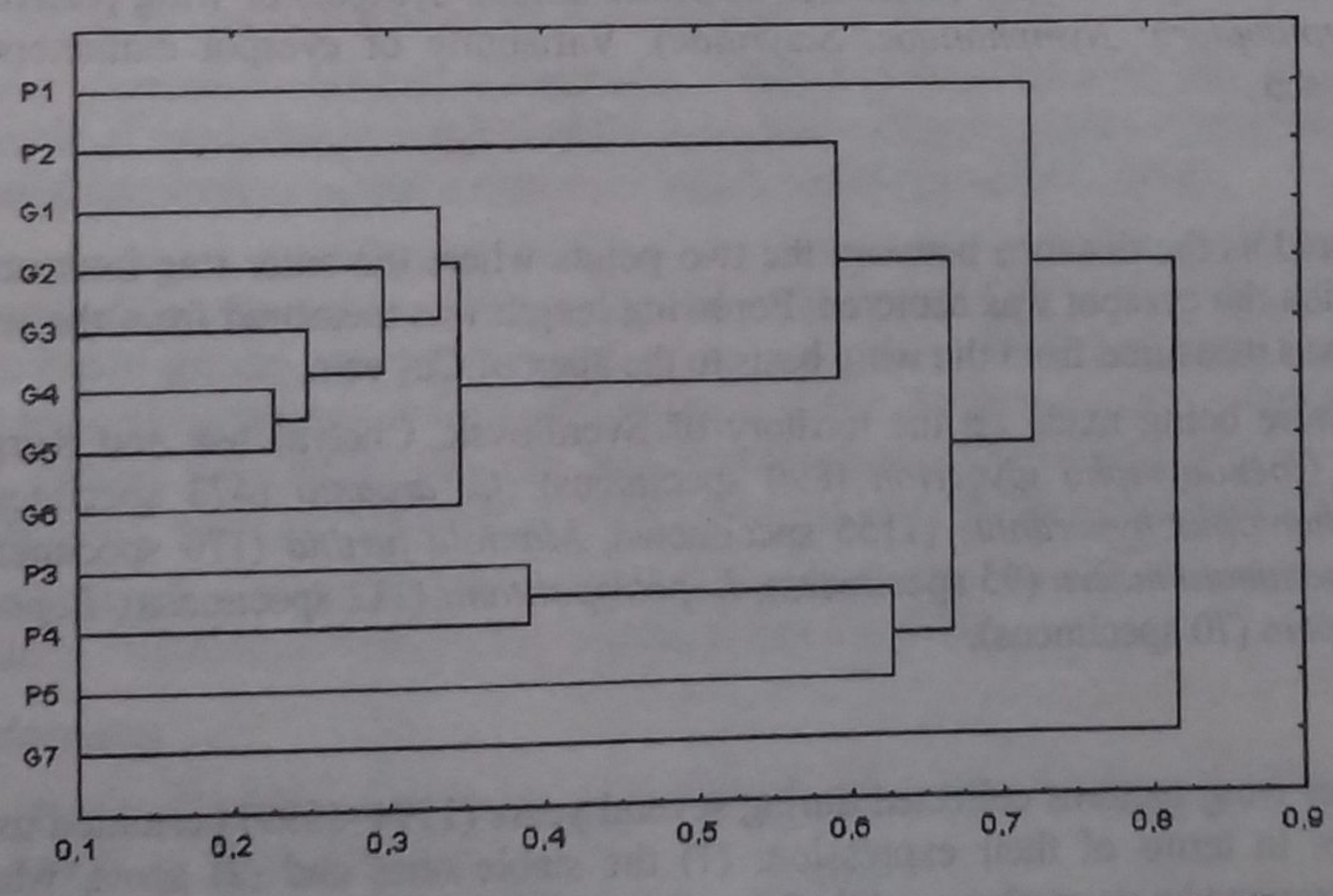

Fig. Similarity tree-diagram for eyespots of *Coenonympha glycerion* females. By X – axis is 1-R (Pearson correlation). Spots are marked as in table.

There is a compact cluster of all spots hindwing except the rare phenetical character G_7, which do not have a significant co-relation with other spots. Forewing spots do not demonstrate considerable correlations neither between each other, nor between hindwing spots. Neighbour-cell spots P3, P4, P5 are characterized higher r, then rare phenes P1, P2.

Observed phenotypic co-relation structure confirms some results of other researches (Paulsen, Nijhout, 1993) about high co-relations between neighbouring homologous pattern elements. Moreover, phenes vary more independently than other homologous elements.

References

1. Nijhout H.F. Independent development of homologous pattern elements in the wing patterns of butterflies // Dev. Biol. 1985. 108, 151.
2. Nijhout H.F. A comprehensive model for color pattern formation in butterflies // Proc. R. Soc. Lond. 1990. B 239, 81–113.
3. Nijhout H.F., Wray G.A. Homologies in the colour patterns of the genus *Heliconius* (Lepidoptera: Nymphalidae) // Biol. J. Linn. Soc. 1988. 33, 345–365.
4. Paulsen S.M., Nijhout H.F. Phenotypic correlation structure among elements of the color pattern in *Precis coenia* (*Lepidoptera: Nymphalidae*) // Evolution. 1993. 47(2), 593–618.
5. Schwanwitsch B.N. Color-pattern in *Lepidoptera* // Entomol. Obozr. 1956. XXXV, 3, 530–546. (In Russian).
6. Schwanwitsch B.N. On changing of the outer drawing of the scaly – winged. // Zool. Zh. 1955. XXXIV, 6, 1283–1291. (In Russian).