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OBSERVATIONS ON THE OPTICAL PROPERTIES OF AN EARLY SUMMER BLUE BUTTERFLY COMMUNITY IN TRANSYLVANIA, ROMANIA (LEPIDOPTERA: LYCAENIDAE, POLYOMMATINI)

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ABSTRACT: The spectral properties of eight blue butterfly species (*Cupido osiris*, *Glaucopsyche alexis*, *Lycaeides argyrognomon*, *Lysandra bellargus*, *Maculinea arion*, *Plebejides sephirus*, *Plebejus argus* and *Polyommatus icarus*) representing the tribe Polyommatini (Lepidoptera : Lycaenidae) and belonging the early summer fauna are measured. The species examined are tabulated according to their relationships, male prezygotic behaviours and larval host preferences. According to these variables the optical signal emitted by the blue male wing surfaces are grouped and analysed.

Keywords: Lycaenidae, Polyommatina, prezygotic strategy, optical signal, spectrum

INTRODUCTION:

On 25th of May 2014 in a Transylvanian xerothermophilous habitat eight Polyommatini species have been recorded as the members of a rich early summer butterfly fauna. Amongst them there were some closely related species whose taxonomic discrimination according to the lepidopterists' experience needs great expertise. The characters used to identify these species are based on minute morphological or wing pattern differences which are certainly not applied by the butterflies themselves. The application of such characters deserves much higher brain capacity than the one possessed by any butterfly imagines.

This observation has been already put into focus of our investigations. We hypothesised for nine closely related *Polyommatus* species with very similar biology inhabiting the same site that their imagines use optical signals for prezygotic discriminations. Indeed we demonstrated that the optical signals emitted by the male wings using structural colours (Márk *et al.* 2009) are finely tuned and can generate easily detectable signals for species-specific discriminations and interactions (Piszter *et al*. 2011, Bálint *et al*. 2012).

Present paper is dedicated to the same topic extending the investigations to that community of Polyommatini butterflies in western Transylvania. The members of the community do not form a closely related group as their relationships are more loose compared to the nine polyommatines we examined previously. Moreover, some species possess different imaginal prezygotic strategy and there are also stark contrasts in their biology. In this paper we address the questions (i) the optical properties of the species examined can be considered as species specific, and (ii) is there any similarity in the optical signals of the species using the same imaginal prezygotic strategy?

MATERIALS AND METHODS:

Geographical location: 2 km NW of settlement Ugruţiu (politically managed by Dragu) in Dealurile Clujului (hills of Cluj), Transylania (in judeţul Salaj, western Romania).

Coordinates: 47º00' N // 23º22' E; 350 m.

Biotope: The habitat is formed by a long chain of hillside meadows on lime depositions in south-south-western exposure. Main vegetation type in the hillsides are comprised by continental species, the dominant association is *Festuco rupicolae-Caricetum humilis* Soó 1947, the subdominant one is *Festuco rupicolae-Danthonietum alpinae* Csűrös *et al*. 1961; both associations with mosaics of *Stipetum*. The bottom regions of the hills are moderately grazed by livestock (buffalos, cows and horses), and the pastures and the hillside meadows are separated by an almost closed *Pruno spinosae-Crataegetum* Soó (1927) 1931 belt. The flat hilltops are overgrown by *Quercetum petraeae-cerris* Soó 1963.

Site

Fig.1 Geographic location of the site where the community of eight polyommatina butterflies has been recorded (coordinates: 47º00' N // 23º22' E; 350 m).

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The upper image shows the geographical location of the site in larger scale indicating human settlements and main roads; the region enclosed by the rectangle is shown in larger magnification by the lower image, where a yellow "x" indicates precisely the site where the eight polyommatina species has been recorded. In this lower image the main vegetational types are well visible:(1) pastures in the bottom region, (2) the *Prunus-Crataegus* belt between the pastures and hillside meadows, (c) the hillside xero-thermophilous meadows and (4) the *Quercus* forest on the hilltop. The settlement Ugruţiu is situated in the lower right corner (source: Google Maps, accessed: 12. XI. 2014).

The species examined are demonstrating that they are optically dimorphic: wing surfaces in males are dorsally much more reflective than in females (see Figs 2-3). In Table 1 their relationships are indicated by subtribal names, species representing the same higher category have qualitatively more similar wing pattern and genitalia morphology. Male preyzgotic strategies are indicated as patrolling (when males are searching for females in the entire habitat by restless patrolling flights, and their individual numbers are low) or perching (when males are sedentary perching on haulm ends and waiting for females, creating high density micropopulations in a small patch of the habitat). First larval stage hosts are also tabulated indicating the microhabitat where perching males congregate and females oviposit (Table 1).

Table 1.
Species examined with indications to their relationships (by subtribal names), male behaviour before mating (prezygotic strategy) and larval host preference (first larval stage host

Species name (with author name and year of description)	Subtribal name	prezygotic strategy	First larval stage host
Cupido osiris (Meigen, 1829)	Everina	Perching	*Onobrychis*
Glaucopsyche alexis (Denis & Schiffermüller, 1775)	Glaucopsychina	Patrolling	*Vicia*
Maculinea arion (Linnaeus, 1758)	Glaucopsychina	Patrolling	*Thymus*
Lysandra bellargus (Rottembrurg, 1775)	Polyommatina	Patrolling	*Hippocrepis*
Polyommatus icarus (Rottembrurg, 1775)	Polyommatina	Patrolling	*Trifolium*
Lycaeides argyrognomon (Bergsträsser, 1779)	Polyommatina	Perching	*Coronilla*
Plebejides sephirus (Frivaldszky, 1835)	Polyommatina	Perching	*Astragalus*
Plebejus argus (Linnaeus, 1758)	Polyommatina	Perching	*Lotus*

Specimens:

All specimens were taken in the site described above on 25th of May, 2014, by Zsolt Bálint, and kept in the scientifically curated Lepidoptera collection of the Hungarian Natural History Museum (Budapest, Hungary). Beside the locality and acquisition labels, an additional label has been added to specimens measured by the spectroboard (Bálint *et al.* 2010) referring to this study with the following inscription „MTM – Univ. V. Goldis, Szilágyság program, ugróci boglárka-közösség, spektroszkópia mérés: 2014. XI. 6., Bálint Zsolt és Kertész Krisztián" (= Hungarian Natural History Museum – University Vasile Goldis, program Salaj, polyommatine butterfly community of Ugruţiu, spectroscopic measurements: 6.09.2014, Zsolt Bálint and Krisztián Kertész).

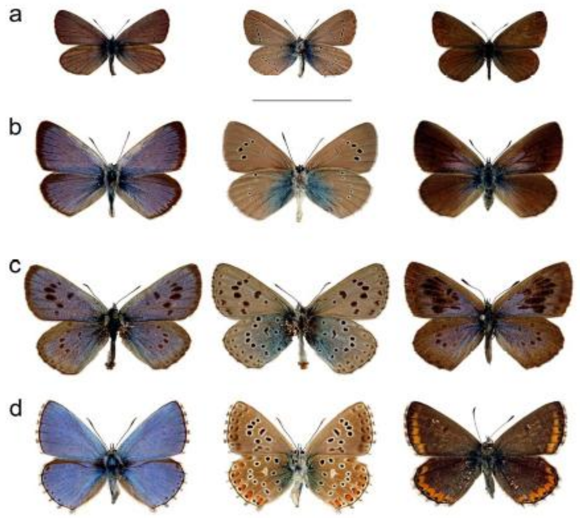

Fig. 2 Species examined. Left column: male in dorsal view, central column: same specimen in ventral view, right column: female, in dorsal view, a = *Cupido osiris*, b = *Glaucopsyche alexis*, c = *Maculinea arion*, d = *Lysandra bellargus* (scale bar: 20 mm) (© images: Hungarian Natural History Museum, Lepidoptera collection, digital archives)

Fig. 3 Species examined. Left column: male in dorsal view, central column: same specimen in ventral view, right column: female, in dorsal view, a = *Polyommatus icarus*, b = *Lycaeides argyrognomon*, c = *Plebejides sephirus*, d = *Plebejus argus* (same maginification as Figure 2) (© images: Hungarian Natural History Museum, Lepidoptera collection, digital archives)

Experimental methods:

One specimen per species has been measured. Perpendicular reflectance measurements were done using our protocol developed earlier (Bálint *et al.* 2010) for non-destructive optical analysis. The spectrophotometer was Avantes HS 1024*122TEC. The specimens were placed on the spectroboard and optical reflectance from each wings was recorded aiming the discal region. The four spectra for each butterfly specimens were filtered (moving average, 10 points) and normalized to one at the blue maxima and averaged, to obtain one single spectrum characterizing the specimen. The obtained eight curves were plot in one diagram (Figure 4) for easier comparison.

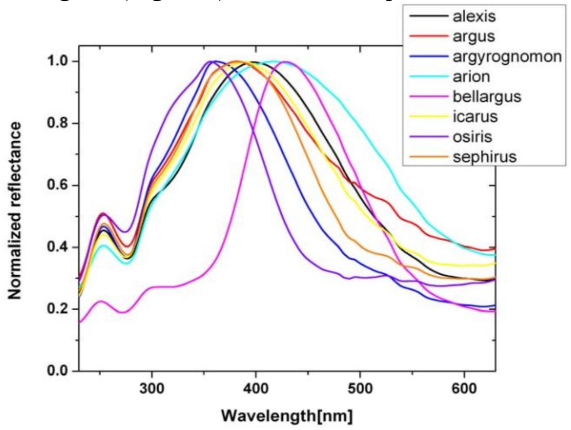

Fig. 4 Reflectance spectra of the species measured. Species (names listed in alphabetic order) and the correlated colours showing their spectral properties are indicated in the box right to the diagram.

RESULTS AND DISCUSSION:

Are there any optical properties of the species examined which can be considered as species specific?

All the species examined display characteristic spectrum. When they are shown in the same diagram they reveal that their maxima are generally positioned in different points. The most (deepest) violet species is *Cupido osiris* with the spectral maximum at 358 nm. *Lycaeides argyrognomon* is also violet but the peak is about 10 nm higher (= 368 nm).

The matching spectra of two species (*Plebejides sephirus* and *Plebejus argus*) are interesting with their maxima at 382 nm but they show characteristic difference when they are compared as *Plebejus argus* spectrum descend more smoothly after its maximum. This indicates higher degree of melanin in the scales compared to *Plebejides sephirus*. Indeed even human eyes can detect that the violet colour of *Plebejides sephirus* looks lighter (see Figure 3).

The proximity of *Glaucopsyche alexis* and *Polyommatus icarus* spectra and their maxima situated very close to each other (*P. icarus* = 391 nm; *G. alexis* = 397 nm) are also interesting. This phenomenon, with the similarity of *Plebejides sephirus* and *Plebejus argus* spectra will be explained below.

The very different blue of *Maculinea arion* is revealed by its very broad spectrum and its maximum at 418 nm. The bluest species we found is *Lysandra bellargus* with the peak at 428 nm.

Is there any shared feature in the optical signals of the species using the same imaginal prezygotic strategy?

The first observation what can be made examining Figure 4. is that the four perching species use colours closer to the UV side of the spectrum than the patrolling ones. Their maxima fall between 358 and 382 nm. The other four species with male patrolling strategy display colours with reflectance maxima shifted towards the red side of the spectrum. The probable explanation of this phenomenon is that the perching species are sitting with their wings in a fixed position, the most effective way of being observed is associated with having high reflectance in the UV side of the spectrum where the reflectance of the average vegetation is low. Therefore their colour can be restricted to a narrower spectral range. Moreover their similarity in colour neither effects the prezygotic strategy as the perching species divide the space they inhabit according to their larval host plant interest and create there high density micropopulations (Table 1).According to the shape and position of the reflectance maxima, the four perching species can be grouped in two groups: *L. argyrognomon* and *C. osiris*, and *Plebejus argus* and *Plebejides sephirus*. The species in the second group overlap almost completely till 425 nm, there the normalized reflectance of the *argus* surpasses slightly that of the *sephirus*.

The somewhat broader reflectance maxima of the patrolling species may be associated with the fact that these individuals should make themselves visible in flight, when their wings flap. In flight the position of the wing plane with respect to the sun and the potential observers changes continuously giving a “pulsating” aspect to the colour. It is interesting to note that the patrolling *Glaucopsyche alexis* and *Polyommatus icarus* possess very similar spectra. Taking into account their habitat preference we can remark that these two species do not share the same microhabitat. The former species prefers mesophilous meadows with high grasses or forest edges where *Vicia* stems can grow luxuriantly. The latter species prefer open and drier habitats with short grasses where larger stocks of *Trifolium* can be found. Because of this kind of habitat division amongst the two species *Glaucopsyche alexis* and *Polyommatus icarus* females most probably very seldom meet the males of the opposite species, hence they are not exposed to the problem to meet nonspecific polyommatine individuals with colour similar to their mates.

CONCLUSION:

Measuring the spectral properties of eight loosely related (paraphyletic) blue butterflies we demonstrated that the optical signals emitted by the male dorsal wing surfaces are species specific. This is in full correlation with our previous results based on the study of nine very closely related (monophyletic) polyommatina species. Moreover we discovered that the four species which utilize perching male prezygotic strategy display colours closer to the UV side of the visible spectrum than the other four species which have patrolling males. This observation needs to be confirmed via more experimental works both in field and in laboratory.

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