

## New data on the taxonomic status and distribution of *Polyommatus andronicus* Coutsis & Ghavalas, 1995 (Lycaenidae)

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**Summary.** This paper details the first records of the poorly known and controversial taxon *Polyommatus andronicus* Coutsis & Ghavalas, 1995 from Southwestern Bulgaria (Mt. Alibotush, southern and central Pirin Mts.). This is a significant extension of the known range of this taxon, previously known only from NE Greece. The characters used to justify the species status of *P. andronicus* are re-evaluated. Statistical confirmation was obtained for the differences in mean wing length and male genitalia size, which support the specific distinctness of this taxon. The geographical and altitudinal range, habitat preferences, possible effects of human activity on its distribution, as well as the conservation status of *P. andronicus* are discussed.

**Key words.** Lepidoptera, Lycaenidae, *Polyommatus*, *P. icarus*, *P. andronicus*, genitalia, taxonomy, biometrics, sympatry, syntopy, distribution, endemism, Balkan Peninsula, Bulgaria.

### Introduction

The nominal taxon *Polyommatus andronicus* Coutsis & Ghavalas, 1995 was described from north-eastern Greece on the basis of several morphological, anatomical, and ecological differences from its closest relative, the widespread *Polyommatus icarus* (Rottemburg, 1775). Compared to *P. icarus*, the original description states that *P. andronicus* is larger and with slightly broader forewings; the upperside colour in males is darker, deeper violet-blue; and the male and female genitalia are constantly and disproportionately larger. In addition, *P. andronicus* was reported to be univoltine and found only higher than 1000 m, being syntopic and synchronous with second-brood *P. icarus* (Coutsis & Ghavalas 1995). Coutsis & Ghavalas (1996) reported one further difference: under UV-light the wing underside was found to have a different reflection pattern, being as a whole more reflective in *P. andronicus* than in *P. icarus*.

Ten years later, the taxonomic status of *P. andronicus* is still ambiguous. Although some recent authors listed it as such (e.g. Karsholt & Razowski 1996; Tolman & Lewington 1997; Tolman 2001), others did not recognize it as separate from *P. icarus* (Kudrna 1996, 2002; Bálint & Johnson 1997). The latter view is not difficult to understand. *P. icarus* exhibits considerable individual, seasonal and geographical variation over its vast range and, while actually noting this, Coutsis & Ghavalas (1995) stated that “superficial differentiating characters [between *P. icarus* and *P. andronicus*] are, as far as we can tell, statistical rather than absolute.” However, regrettably, they did not back their claim with the statistical analysis that such a claim invites. Moreover, a very recently published molecular study seemed to seal the fate of *P. andronicus* as just another synonym of *P. icarus*: the former was found to be exceedingly close genetically to Greek *P. icarus* and its separation from the latter was stated to have been “based on disputable evidence” (Wiemers 2003: 90). Yet the fact remains that to this day no one has specifically set out to refute or confirm the evidence presented by Coutsis & Ghavalas (1995).

Coutsis & Ghavalas (1995) stated that *P. andronicus* was only found on the closely clustered massifs of Falakró, Meníkio, and Órvilos in the district of Drama. Órvilos is a compact massif straddling the border between Greece and Bulgaria and is known in the latter country under the names Alibotush and Slavyanka. I collected on Alibotush on several occasions, most extensively during July 1993 and 1994. In 1996, after acquainting myself with the description of *P. andronicus*, I re-examined my material from Alibotush and discovered a large *Polyommatus* female corresponding closely to that description. This female, collected on 11.vii.1993 in the karst gorge of Hambar Dere, southwest of Paril village at an altitude of ca. 1400 m, markedly exceeds the maximum size reached by female *P. icarus* in Bulgaria. Its forewing measures 18.6 mm against a maximum of 17.0 mm for the Bulgarian female *P. icarus* that I examined ( $n=34\varnothing$ ), which is also exactly the maximum reported for Greek female *P. icarus* (Coutsis & Ghavalas 1995). The tentative identification of this specimen as *P. andronicus* was confirmed by John G. Coutsis who examined its genitalia in 1997 and found them to be of the large *P. andronicus* type (Coutsis, pers. comm.). This female represents the first record of *P. andronicus* from Bulgaria, which I communicated to Tom Tolman. On the basis of this information, Alibotush was listed as part of the range of *P. andronicus* (Tolman 2001: 122).

The large size of this female and its genitalia show that it conforms to the description of the nominal taxon *Polyommatus andronicus*, but this in itself does not constitute proof of specific distinctness of this taxon from *P. icarus*. Such evidence, as was said above, is sorely needed. The lack of more specimens from Alibotush and the difficult access to this border region unfortunately prevented me from gathering a more representative sample for assessing the taxonomic rank of *P. andronicus*. This discovery, however, prompted me to conduct purposeful search for *P. andronicus* in other mountains immediately adjacent to Alibotush.

## Methods

**Material.** Specimens with *P. icarus*-like morphology were collected on two separate field trips to the southern and central parts of the Pirin range, situated immediately to the north of Alibotush. The study area is shown in Fig. 25. In geomorphological terms Pirin and Alibotush are really no more than parts of the same massif (Zagorchev 1995) with their flora also showing a great degree of similarity (Bondev 1991) and it was expected that their butterfly faunas would also be very similar, as indeed they turned out to be. The first trip, carried out during 25.–26.vii.1998, concentrated on the region between the Popovi Livadi pass (ca. 1400 m) and the highest summit of central Pirin, Orelek (2099 m). On my second trip, during 30.vi.–4.vii.2003, I was accompanied part of the time by Mr. Slobodan Davkov (Skopje). Together we studied more exhaustively the region which I had visited in 1998, collecting as low as ca. 700 m in southern Pirin. Following that I visited the montane and subalpine zone of southern Pirin, in the region of its highest peak, Sveshtnik (1975 m). In preparation for this comparative analysis, I also collected a comparative sample of *P. icarus* from various other localities in Bulgaria encompassing the whole resident altitudinal range of *P. icarus* from sea level

to ca. 1900 m and the whole gamut of habitats occupied by *P. icarus*, from xerothermic to subalpine.

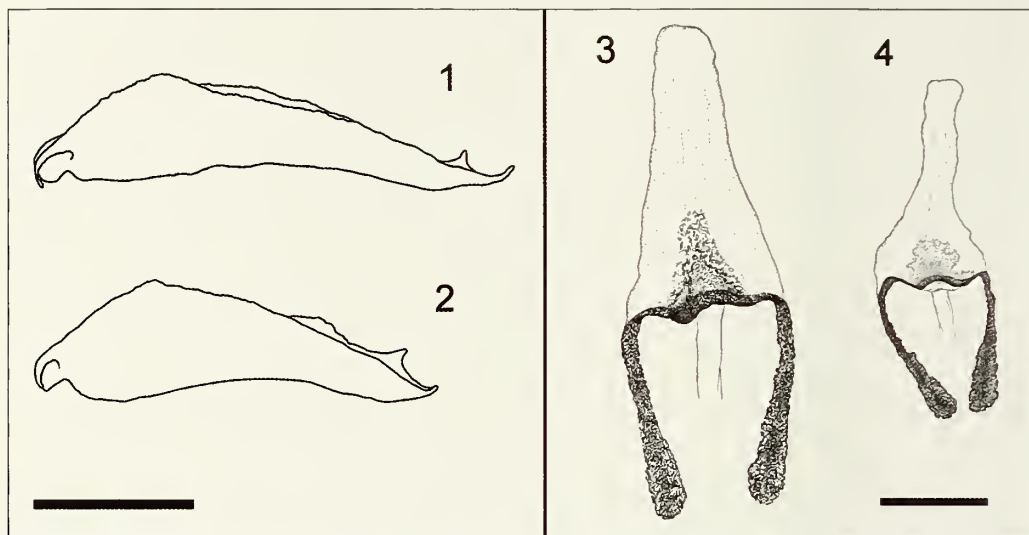
Wing and genital measurements were taken using an eyepiece-mounted scale bar on a Wild stereomicroscope. Wings of set specimens were measured from wing base to tip, including fringe, with an accuracy of 0.1 mm. Genitalia were extracted following maceration of the abdomen in a 10 % solution of KOH, cleaned of residual tissue, and measured. The length of the male genitalia was measured from the base to the tip of the valva with an accuracy of 0.01 mm. In addition, the numerical data provided by Coutsis & Ghavalas (1995) for Greek *P. icarus* and *P. andronicus* were included in the analysis. For the wing (FWL) and valva (VL) measurements a unit-less index FWL/VL was calculated to eliminate the effect of overall size variation. The means were statistically evaluated using a Student's two-tailed *t*-Test with assumed equal variances.

**Karyology.** The haploid chromosome number in *P. icarus* and all studied species of the *Peros-eroides* complex is  $n=23$  (Robinson 1971: 569). However, *P. buzulmavi* Carbonell, 1992 from the Turkish provinces of Hakkari and Van, a taxon morphologically similar to *P. icarus* and *P. andronicus*, has a very different karyotype with  $n=45$  (Puplesiene & Olivier 2000). It was therefore considered of importance to study the karyotype of specimens tentatively identified as *P. andronicus*. Testes were extracted, fixed in the field in a 3:1 solution of 96 % ethanol and glacial acetic acid, and refrigerated until further study. Preparations were made at the Department of Genetics, University of Turku, Finland following a methodology developed by Dr. Seppo Nokkala (Grozova & Nokkala 1996). Countable first-metaphase (MI) plates were photographed at a magnification of 1000 $\times$  with an Olympus DP11 microscope digital camera system mounted on an Olympus BH-2 light microscope. The brightness and contrast of the images were enhanced in Jasc Paint Shop Pro 7.04; no other post-processing was applied.

## Results

Already on first examination in the field most of the collected specimens fell naturally into two groups: smaller, lighter blue males corresponding to *P. icarus* and larger, darker males corresponding to *P. andronicus* as described by Coutsis & Ghavalas (1995). However, external characters (size, colour, underside pattern) and condition of the individuals were found to be variable to the extent that the placement of many specimens was uncertain. For this reason, the first stage of the analysis was a morphometric study of the male genitalia, the only character that according to Coutsis & Ghavalas (1995) shows no numerical overlap between the two taxa. Rather than applying statistical analysis, these authors illustrated the forewings and valvae of eight *P. icarus* and six *P. andronicus* specimens on pls. 5–9 (pp. 154–156). While showing the existence of size differences, this form of presentation is not well suited for assessing their significance, especially as all illustrated *P. icarus* are of approximately the same large to very large size and thus do not reflect the size variation in this species as a whole.





**Figs. 1–2.** Lateral view of the left valva (setae omitted). **1.** *P. andronicus* ♂, Central Pirin, below Dobro Pole plateau, 1800–1900 m, 26.vi.1998 (forewing length 17.7 mm). **2.** *P. icarus* ♂, East Bulgaria, East Stara Planina Mts., Karandila nature park, 1000 m, 16.vi.1999 (forewing length 17.7 mm).

**Figs. 3–4.** Dorsoventral view of the female genitalia (bursa and part of ductus bursae omitted). **3.** *P. andronicus* ♀, Central Pirin, Popovi Livadi – Orelek, 1600 m, 2.vii.2003 (forewing length 17.3 mm). **4.** *P. icarus* ♀, Pirin, Popovi Livadi, 1400 m, 1.vii.2003 (forewing length 14 mm). Scale bars = 1 mm.

**Genitalia.** There is a strong dichotomy in the size of male and female genitalia in the sample from Pirin (Figs. 1–4). The valva length values fall into two clear-cut groups with no overlapping values whatsoever (Figs. 5, 6), and their means of variance differ very significantly ( $P < 0.0001$ ). Values and variance in these groups match well the numerical values given by Coutsis & Ghalvalas (1995). Given these strong similarities, for simplicity throughout this chapter I shall refer to the group with smaller male and female genitalia as the ‘(Pirin) *P. icarus*’ and to that with larger genitalia as the ‘(Pirin) *P. andronicus*’ respectively. Note however that this should not be taken as a taxonomic conclusion regarding the species status of the latter taxon at this point.

Coutsis & Ghalvalas (1995) stated that the male genitalia of *P. andronicus* are disproportionately larger than those of *P. icarus*, but this assertion was not tested in a statistically meaningful way. To do this the FWL/VL ratio is used here (Tab. 1). The mean ratio for *P. andronicus* (5.66) is significantly ( $P < 0.0001$ ) smaller than the mean ratio for *P. icarus* (6.38). This confirms that in *P. andronicus* the genitalia are on average larger relative to the individual’s size than they are in *P. icarus*.

Female genitalia in the Pirin material likewise show a clear dichotomy in the size and shape of genitalia, though this is more difficult to quantify and analyze because, on one hand, the female genitalia are largely membranous and thus susceptible to distortion, and on the other hand, the number of available *P. andronicus* females was very small. Due to this a statistical analysis was not attempted. Nevertheless, the difference observed bears out the observations of Coutsis & Ghalvalas (1995), with the genitalia being clearly longer and more massive in Pirin *P. andronicus* than in Pirin and other Bulgarian *P. icarus* (Figs. 3, 4).

**Tab. 1.** Pooled key measurements of males of *P. icarus* from the Pirin Mts., *P. andronicus* and *P. icarus* from other localities in Bulgaria, as well as of *P. icarus* and *P. andronicus* from Greece (the latter taken from Coutsis & Ghavalas 1995), with confidence levels for the differences in means (Student's two-way *t*-Test).

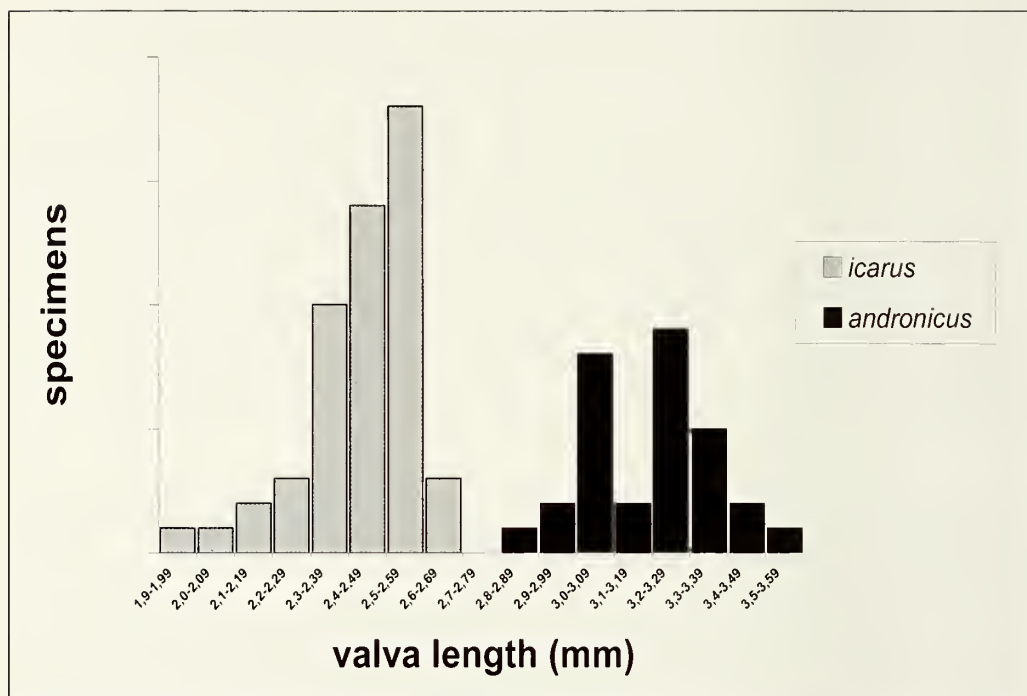
Character	<i>P. icarus</i> (52 ♂)			<i>P. andronicus</i> (29 ♂)			confidence level (P)
	min	max	mean	min	max	mean	
Forewing length FWL (mm)	11.3	17.7	15.42	16.10	19.50	18.07	<0.0001
Valva length VL (mm)	1.96	2.62	2.42	2.84	3.50	3.19	<0.0001
Index FWL/VL	5.59	7.06	6.38	5.21	6.16	5.66	<0.0001

**Morphology.** Having established the marked dichotomy of the Pirin sample in terms of genital characters, it has to be seen if and how these differences in genital morphology correlate with differences in external morphology.

**Size.** The Pirin *P. icarus* correspond well to other Bulgarian *P. icarus* from similar altitudes (700–1850 m) while the Pirin *P. andronicus*, collected between 1600 and 1950 m, are on average larger. The female from Alibotush clearly falls inside this latter group. As was said above, the forewing length variance of the Pirin *P. andronicus* partially overlaps that of Bulgarian *P. icarus* (see Tab. 1 and Figs. 7–22). Nevertheless, the difference between the means is statistically very significant ( $P < 0.0001$ ) in the males (Tab. 1), and whereas an insufficient number of females of Pirin *P. andronicus* was available for analysis, there appears to be a similar degree of difference in female wing length too.

**Wing shape.** Coutsis & Ghavalas (1995) stated that the forewing in male *P. andronicus* is broader than in *P. icarus*, and illustrated this with drawings of forewings to scale (pp. 154–156) but, again, provided no numerical values. Examination of my material does not support this character, which shows no clear correlation with the two distinct valva types. Many Pirin *P. andronicus* (e.g. Fig. 13) have markedly narrow and pointed forewings while many Pirin (and other Bulgarian) *P. icarus* have very broad wings. Variation in this character is so considerable in both groups that further analysis was not considered necessary.

**Upperside colour in males.** Coutsis & Ghavalas (1995) noted that on average male *P. andronicus* have a deeper, darker blue upperside colour than *P. icarus*. Such difference however is difficult to see in colour plate 10 of the original description, where in addition the blue of both *P. icarus* and *P. andronicus* specimens has an unnatural, silvery cast when compared to actual specimens. The Pirin *P. andronicus* do have a remarkably uniform darker blue corresponding well to the description of *P. andronicus*, while fresh *P. icarus* from Pirin are generally lighter, as in most other Bulgarian *P. icarus*. However, this difference, if at all real, is clearly visible only in fresh or almost fresh specimens. In older males of both series the upperside colour is more difficult to determine due to loss of wing scales and membrane. Furthermore,



**Fig. 5.** Distribution of valva length values in male *P. icarus* and *P. andronicus*. Original data from Bulgaria are combined with numerical data from Coutsis & Ghavalas (1995).

the tone of the male upperside colour exhibits great seasonal and individual variability in *P. icarus*, even in fresh specimens. Likewise, occasionally, *P. andronicus* males have a lighter blue shine similar to that of *P. icarus* (Coutsis & Ghavalas 1995: pl. 10 fig. 4). The female upperside ground colour and the development and colour of the submarginal lunules are identical in the Pirin *P. icarus* and *P. andronicus*. Compared to the former, as well as other Bulgarian *P. icarus*, the only difference appears to be that Pirin *P. andronicus* females either lack completely (as does the Alibotush female) or have very limited blue basal suffusion. This suffusion is much more variable and often very extensive in other Bulgarian *P. icarus*. This upholds the stated difference between females of Greek *P. andronicus* and *P. icarus* (Coutsis & Ghavalas 1995).

**Underside pattern.** There is considerable variation both in terms of ground colour and development of maculation in both series. The Pirin *P. andronicus* are on average slightly more boldly marked with larger black spots. The wedge-shaped distal extensions of the white ring surrounding the discal spot on the fore- and hindwings are on average longer, wider at the base, and altogether more prominent than in Pirin or other Bulgarian *P. icarus*. However, there is some variation in this character in *P. icarus*, with these wedge-like markings being sometimes well developed. The metallic blue-green basal suffusion on the underside of the hindwing is extensive in Pirin *P. andronicus* males while on average much more restricted or nearly absent in the summer brood male Pirin (and other Bulgarian) *P. icarus*. A few very worn *P. icarus*

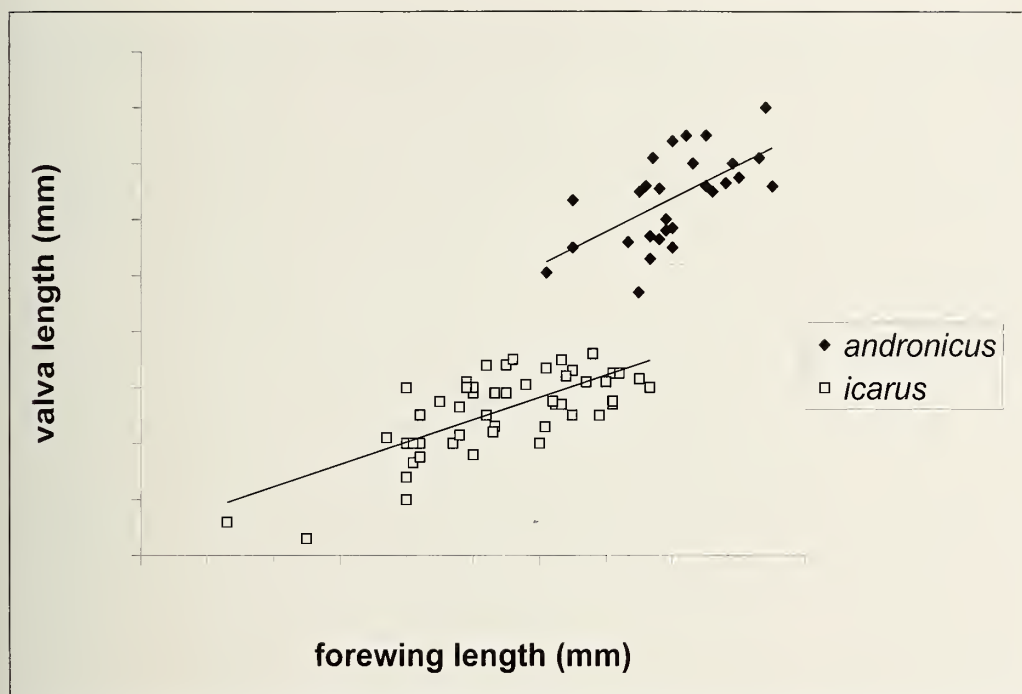


Fig. 6. Correlation of valva and forewing lengths of male *P. andronicus* and *P. icarus*, with trend lines. Original data from Bulgaria are combined with numerical data from Coutsis & Ghavalas (1995).

of the spring brood collected at higher altitudes in Pirin show extensive basal suffusion similar to that of the Pirin *P. andronicus*. All of these traits correspond to those observed in Greek *P. andronicus* and *P. icarus* (Coutsis & Ghavalas 1995).

**Karyotype.** More than 20 countable first-metaphase (MI) plates with a stable haploid number of  $n=23$  (Fig. 23) were found in preparations of testes from two males of Pirin *P. andronicus* (No ZK0303 and No ZK0304). The karyotype of *P. andronicus* is thus identical to that of *P. icarus*.

**Altitudinal range, sympatry and syntopy.** The Pirin *P. icarus* were found in flowery open places in the deciduous and coniferous forest zones from the lowest foothills to the tree line at 1800–1850 m. This corresponds well to the upper limit of the resident range of *P. icarus* on other high mountains in Bulgaria (pers. observ.) and Greece (Coutsis & Ghavalas 1995). In contrast, Pirin *P. andronicus* were not found lower than 1500 m, but as high as ca. 1950 m. However, my observations at the latter altitude, on the slopes below the summit of Orelek, indicate that *P. andronicus* may range freely as high as Orelek itself (2099 m); there is certainly no physical barrier to prevent them from doing so and the habitats close to the summit are basically the same as at 1950 m.

In Pirin *P. icarus* and *P. andronicus* were found syntopically in flowery open habitats (roadsides, forest glades, and subalpine meadows) between ca. 1500–1850 m; no habitat segregation was apparent between the two there. This situation closely corresponds to







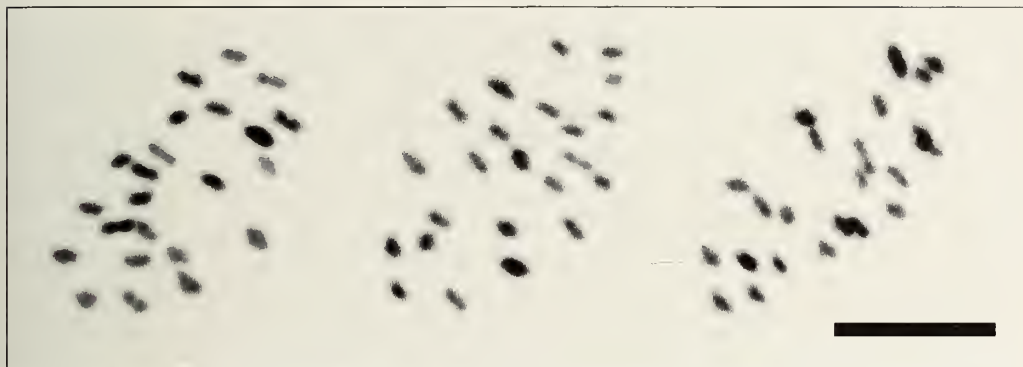


Fig. 23. Karyotype (MI) of *Polyommatus andronicus* ♂, Central Pirin, Popovi Livadi – Orelek, 1600 m, 2.vii.2003, fixation No ZK0303. Scale bar = 10  $\mu$ m.

either already begun or was just beginning in early July 2003. The emergence of Pirin *P. andronicus* begins clearly earlier than most of the above species excluding *P. escheri dalmatica*. Thus, although for now I assume that the Pirin *P. andronicus* develop in a single generation, as concluded by Coutsis & Ghalvalas (1995), I cannot exclude the possibility that a second, perhaps only partial, generation can develop in particularly favourable years at lower altitudes (1500–1600 m). I have found such partial second generation for *P. artaxerxes* and *P. escheri dalmatica* in the second half of August at lower altitudes in Rhodopi (unpublished data).

Most specimens of *P. icarus* collected by myself on Pirin, as mentioned above, are second-generation specimens though their condition is variable. On average, however, these are in better condition than the Pirin *P. andronicus*, which shows that their emergence begins somewhat later than the latter. This situation matches well the one outlined by Coutsis & Ghalvalas (1995) for sympatric Greek *P. icarus* and *P. andronicus*.

## Discussion

**Taxonomy.** To summarize the above findings, the analyzed sample from central and southern Pirin can be divided into two groups. The butterflies of the ‘*P. icarus*-like’ group occur from 700 m (the lowest studied altitude) to ca. 1850 m, have constantly smaller male and female genitalia, two generations annually, and identical size and external characters than other Bulgarian *P. icarus*. The individuals of the ‘*P. andronicus*-like’ group occur from ca. 1400–1500 m to at least 1950 m (and probably higher), are on average larger than both the former group and other Bulgarian *P. icarus*, have on average a darker male upperside colour and heavier underside spotting, and their male and female genitalia are constantly larger irrespective of the individual’s size. These two groups occur syntopically and synchronously between 1500 and 1850 m. The correlated differences in external and genital morphology, voltinism and altitudinal range displacement with partial syntopy and synchrony between the ‘Pirin *P. icarus*’ and ‘Pirin *P. andronicus*’ represent exactly the same situation as that



Fig. 24. Habitat of *Polyommatus andronicus* and *P. icarus* above the tree line at ca. 1850 m in South Pirin (in the background is Sveshtnik peak, 1975 m), 3.vii.2003.

described for Greek *P. icarus* and *P. andronicus* by Coutsis & Ghalvalas (1995). The only explanation for the observed phenomenon is that the two groups of butterflies up till now referred to as 'Pirin *P. icarus*' and 'Pirin *P. andronicus*' do indeed represent two specifically distinct entities: respectively, the ubiquitous *P. icarus* and the montane *P. andronicus*. Hence, the results presented here confirm the conclusions of Coutsis & Ghalvalas (1995). On the other hand, it is found that differences stated by Coutsis & Ghalvalas (1995) in external characters such as forewing shape, upperside colour in males, and underside pattern are too variable to be reliable identification markers. In addition, there are no differences between the karyotypes of the two species.

In reality, what is traditionally known as the widespread Palearctic species *P. icarus* is a complex of an unknown number of specifically distinct taxa, of which *P. andronicus* is only one. Another possibly distinct species is the taxon *P. tumangeusis* Im, 1988 from North Korea and the Russian Primorye. This taxon is larger than *P. icarus* (forewing length up to 19 mm) and is univoltine (Gorbunov 2001: 142–143), thus representing, in a very superficial sense, an 'equivalent' of *P. andronicus*. From a European perspective a recent molecular study (Wiemers 2003) revealed that "while populations [of *P. icarus*] from Spain to Iran appear as a monophyletic group (including the Greek *Polyommatus andronicus* Coutsis & Ghalvalas, 1995 which has been separated only recently from *P. icarus* based on disputable evidence), the Moroccan specimen of *P. icarus* is placed outside this clade. This result came as a surprise because Northwest African populations of *P. icarus* are thought to represent the same subspecies as in Europe [...]. The COI and ITS-2 p-distances between the Moroccan and Eurasian populations of *P. icarus* differ to



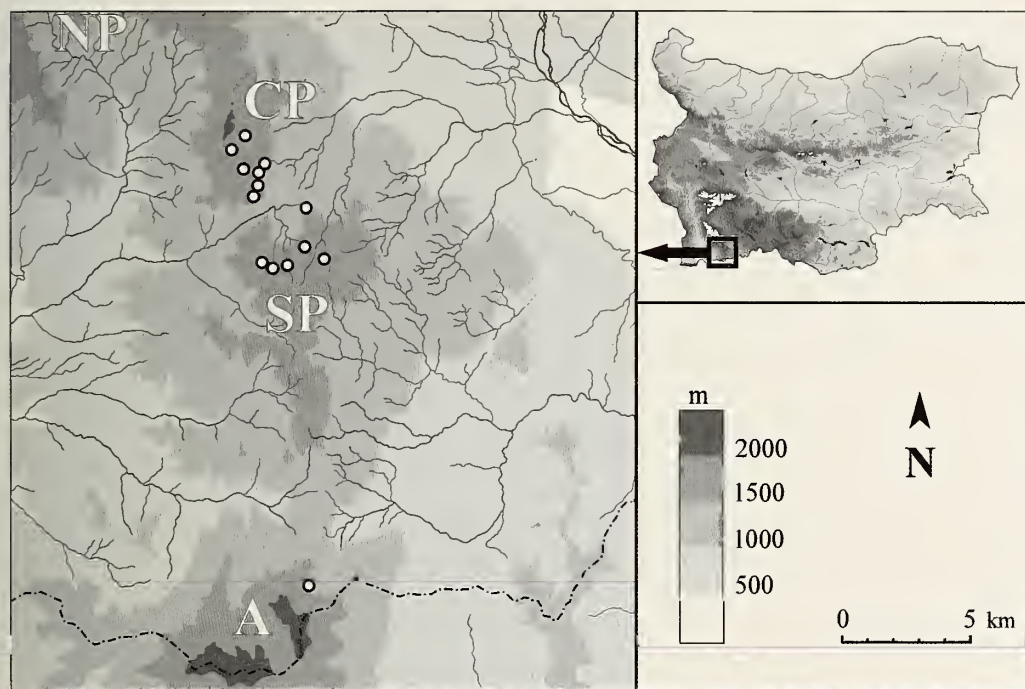


Fig. 25. Known localities (white-centered circles) of *Polyommatus andronicus* in Bulgaria. A. Alibotush. SP. Southern Pirin. CP. Central Pirin. NP. Northern Pirin.

a much higher degree than in other species [...], including those with well differentiated subspecies in Northwest Africa (like *Polyommatus amandus*), and are on the level of well differentiated species. The Moroccan specimen also differs in phenotype from the other *P. icarus* (f. *celina* Austaut), but *P. icarus* is an extremely variable species throughout its vast, trans-Palaeartic distributional range. Without further material it cannot be decided if Northwest African populations of *P. icarus* are so divergent from Eurasian ones that they should better be seen as representing a distinct *Polyommatus* species.”

It would seem that the molecular data obtained by Wiemers disprove conclusively the taxonomic distinctness of *P. andronicus*. However, I do not see this to be the case. The observed morphological and genital differences between partly sympatric and syntopic *P. icarus* and *P. andronicus* in both Greece and Bulgaria agree entirely, and it is impossible to explain these in any other way than by accepting the existence of two biological species – no matter how closely related genetically. There is little doubt that the species status of *P. andronicus* is justified. This situation is a good reminder that genetic distances provide a measure on relatedness, not a straightforward indication of taxonomic status, and also exposes the risks inherent in basing taxonomic decisions on results from limited DNA sequences. If anything, then, the DNA data available so far should make taxonomists scrutinize more closely what is currently known as ‘*P. icarus* s. str.’ (excluding *P. andronicus*), as several good species can be expected to exist within this taxon, even inside the western Palearctic. Further DNA studies on this complex, involving COII sequences as well, are most desirable. It is worth



remembering that, beside *P. andronicus*, three other species-level taxa very similar to *P. icarus* were described from Europe in recent years: *P. abdon* Aistleitner & Aistleitner, 1994 from Southern Spain, and *P. elena* Stradomsky & Arzanov, 1999 and *P. neglectus* Stradomsky & Arzanov, 1999 from the steppes of easternmost Europe. All of these are presently considered synonyms of *P. icarus* (Kudrna 1996; Tshikolovets 2003), and due to lack of material it has not been possible to reassess their status here. However, several circumstances of interest must be noted with respect to the latter two taxa. Stradomsky & Arzanov (1999) reported that *P. elena* and *P. neglectus* are sympatric and syntopic with *P. icarus* while showing differences in genital structure. Particularly remarkable is the sclerotization pattern in the female genitalia which differ drastically from what I have myself observed in females of Bulgarian *P. icarus* and *P. andronicus*.

The only character that could not be evaluated in the present study is the difference between *P. icarus* and *P. andronicus* in the UV-reflective pattern of the wing underside reported by Coutsis & Ghavalas (1996). Such differences are perhaps of little taxonomic significance. The quantity of UV-reflected pigments stored in the wings of *P. icarus* is heavily dependent on the flavonoid content of the legume plant parts eaten by the larvae; inflorescences are richer in flavonoids than leaves of the same plant, and in laboratory rearings it is possible to vary the UV-reflectivity of *P. icarus* individuals by varying the larval diet (Burghardt et al. 1997). Thus, the differences observed by Coutsis & Ghavalas (1996) could have been induced by differing larval diets of syntopic *P. icarus* and *P. andronicus*, the latter feeding predominantly on inflorescences. This might indicate that in conditions of syntopy these two taxa prefer different parts of the same plants, thereby reducing competition for a common food resource.

**Ecological preferences of *P. andronicus*.** This is a xeromontane species that prefers flowery rocky habitats between 1000 and 1950 m (Fig. 24), possibly reaching up to ca. 2100 m (see above). All known localities are on partly karstified Proterozoic marble of the Dobrostan formation (Zagortchev 1995). The larval host plant remains unknown.

My detailed observations in Pirin show that there is an altitudinal displacement between the two species. While *P. icarus* barely reaches above the tree line (just as in other Bulgarian mountains), *P. andronicus* inhabits also higher, subalpine habitats considerably above the tree line, including barren karst terrain. In Pirin the two species occur together over most of the altitudinal range of *P. andronicus*, 1500–1850 m. This, however, may be a relatively recent development brought about by human interference with the natural succession of the vegetation. I observed the highest density of *P. andronicus* (including all females seen and a pair in copula) in southern Pirin on the slopes of Sveshtnik peak above the tree line (between 1800 and 1950 m). Only a few males were recorded below that altitude, invariably flying rapidly along narrow dirt roads in otherwise contiguous dense coniferous forest. In central Pirin most butterflies were found in sheltered, sunny flower-rich roadsides along the road leading to Orelek, at altitudes of 1500–1600 m. In both central and southern Pirin all habitats currently utilized by *P. andronicus* between 1500 and 1750 m owe their existence to human activities that have led to disruptions in the forest cover.

Therefore the primary post-glacial habitat of *P. andronicus* under a natural vegetational succession appears to have been flowery subalpine grassland on stony calcareous ground at and above the natural tree line, i.e. higher than 1700–1800 m (Fig. 24). This

is supported by the difference in the lowest altitude at which *P. andronicus* occurs in Greece (1000 m: Coutsis & Ghavalas 1995) and Bulgaria (central and southern Pirin: 1500 m, Alibotush: ca. 1400 m, but based on only one specimen). From these numbers it appears that in Bulgaria *P. andronicus* does not reach as low as in Greek mountains. A possible reason for this can be fact that in Greece *P. andronicus* finds even more favourable conditions for downward dispersal on account of Greek mountains being on the whole much more deforested than Bulgarian mountains (Coutsis & Ghavalas 1991; Polunin 1997). My observations in southern Pirin suggest that males of *P. andronicus* in particular can fly long distances down into the forest using man-made ‘corridors’ such as roads. It is also certain that these human activities must have also facilitated the simultaneous upward dispersal of *P. icarus*, thereby enhancing the contact between the two species.

**Range and conservation status of *P. andronicus*.** The newly discovered Bulgarian localities (Fig. 25) significantly expand the total distribution of *P. andronicus*. This Balkan endemic is now known to be restricted to several massifs clustered in a small area between the valleys of Struma/ Strimon and Mesta/ Nestos. In my opinion there is little chance of any further significant additions to the known range of this species. One further region deserves attention in this regard, namely the karst section of northern Pirin below Vihren peak. At ca. 1800–2000 m in the vicinity of ‘Vihren’ chalet there are karstified marble slopes with xerophyllous plant communities dominated by sparse *Pinus heldreichii* stands that are similar to the communities found at that altitude on Alibotush (pers. observ.). As was said above, *P. andronicus* has successfully adapted to secondary, man-made habitats and has thus managed to considerably expand its altitudinal range in the historical past. That having been said, this species does nevertheless have a very limited range and should probably be regarded as ‘Vulnerable’ and of high conservation interest on a European scale.

## Conclusion

The present study provides independent and full support to the conclusions of Coutsis & Ghavalas (1995) regarding the specific distinctness of *P. andronicus*. This is so far the only known sibling species of *P. icarus* in Europe and, what is especially interesting, the two occur in partial syntopy and synchrony. This offers good opportunities for research on the ecology of both species.

The significance of the morphological characters of *P. andronicus* was re-assessed and the conclusions of Coutsis & Ghavalas (1995) are largely confirmed. However, I found that the male upperside colour and forewing shape are too variable in both *P. andronicus* and *P. icarus* to present reliable differences. *P. andronicus* is found to be an even larger species than originally described, with the forewing of the largest Bulgarian specimens measuring 19.5 mm (male) and 18.6 mm (female).

The Bulgarian localities reported here expand considerably the known distribution of this Balkan endemic. My observations on its habitat preferences and altitude range in Bulgaria lead me to conclude that in the historical past this species has apparently benefited considerably from human activity (deforestation, road building) allowing it to expand its range to lower, previously heavily forested, regions. A ‘Vulnerable’ status is nevertheless considered justified in the light of its very limited total range.

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