

# The Grecian anomalous blue *Polyommatus (Agrodiaetus) aroaniensis* (Brown, 1976) (Lepidoptera: Lycaenidae) discovered in Croatia, at the north-western edge of its distribution

Toni KOREN & Boris LAUŠ

Croatian Herpetological Society – Hyla, I. Lipovac 7, HR-10000 Zagreb, Croatia; E-mail: koren.toni1@gmail.com, boris.laus.pmf@gmail.com

**Abstract.** In 2014 and 2015, a survey to improve the knowledge about the distribution of butterflies of the subgenus *Polyommatus (Agrodiaetus)* was carried out in southern Croatia. The first observations of a new species for the country, *P. aroaniensis*, were made. These localities present the northwesternmost points of the species distribution, with the closest known population occurring in Bosnia and Herzegovina. New localities for the three species, *P. admetus*, *P. damon*, and *P. ripartii*, were also recorded, extending the range of the latter two species. Our findings increase the number of recorded butterfly species in Croatia to 197.

Key words: Lika, Croatia, Lepidoptera, Lycaenidae, *Polyommatus*, *Agrodiaetus*, new records

**Izvleček. Modrin *Polyommatus (Agrodiaetus) aroaniensis* (Brown, 1976) (Lepidoptera: Lycaenidae) najden na Hrvaškem, na severozahodni meji njegove razširjenosti** – V letih 2014 in 2015 smo raziskovali razširjenost metuljev podrodu *Polyommatus (Agrodiaetus)* v južnem delu Hrvaške. Prvič smo zabeležili vrsto *P. aroaniensis*. Te lokalitete ležijo na najbolj severozahodnem delu območja razširjenosti te vrste, katere naslednja najbližja populacija je znana iz Bosne in Hercegovine. Našli smo tudi nove lokalitete za tri vrste *P. admetus*, *P. damon* ter *P. ripartii* in tako povečali znano območje razširjenosti slednjih dveh vrst. Z našimi najdbami se je število zabeleženih vrst dnevnih metuljev na Hrvaškem povzdignilo na 197.

Ključne besede: Lika, Hrvaška, Lepidoptera, Lycaenidae, *Polyommatus*, *Agrodiaetus*, nove najdbe

## Introduction

So far, three species belonging to the subgenus *Polyommatus (Agrodiaetus)* have been recorded in Croatia: *Polyommatus (Agrodiaetus) damon* (Denis & Schiffermüller, 1775), *Polyommatus (Agrodiaetus) admetus* (Esper, 1783) and *Polyommatus (Agrodiaetus) ripartii* (Freyer, 1830) (Šašić & Mihoci 2011). All three species are very local, with their known range limited to the southern part of the country, mainly Dalmatia, Dalmatinska Zagora and southern Lika. They belong to the butterfly species group with dot-like distributions, and their range is discontinuous in the Balkans (Tolman & Lewington 2008, Vila et al. 2010). Generally, all the mentioned species are local and rare in Europe (Tolman & Lewington 2008).

Only a few historical records from Croatia exist prior to the 20<sup>th</sup> century for *P. admetus* (Koren 2010a) and a single record for *P. damon* (Mann 1869). In addition, *P. ripartii* had been recorded only a few years ago in Croatia (Koren 2010b). For all three species, several new records expanding their known range in Croatia have been gathered and published in the last few years (Mihoci et al. 2006, Koren et al. 2011, Tvrtković et al. 2012, Koren & Lauš 2013, Koren et al. 2015). However, their distribution in the country is far from well known. Almost every surveyed region of southern Croatia yields new records, while most of the historical studies do not contain data about these species. This is partially due to their relatively short flight period, usually from mid-July to the beginning of September. Additionally, they are usually present in the areas that are distanced from the sea or other interesting Mediterranean areas, which are more frequently visited by entomologists (e.g. Habeler 1976). It was only in the last several years that we started to survey lesser known regions of Croatia, especially Lika, the border with Bosnia and Herzegovina, and the mountains in this bordering region. More detailed surveys resulted in many new and interesting species records (e.g. Koren et al. 2011, Tvrtković et al. 2011).

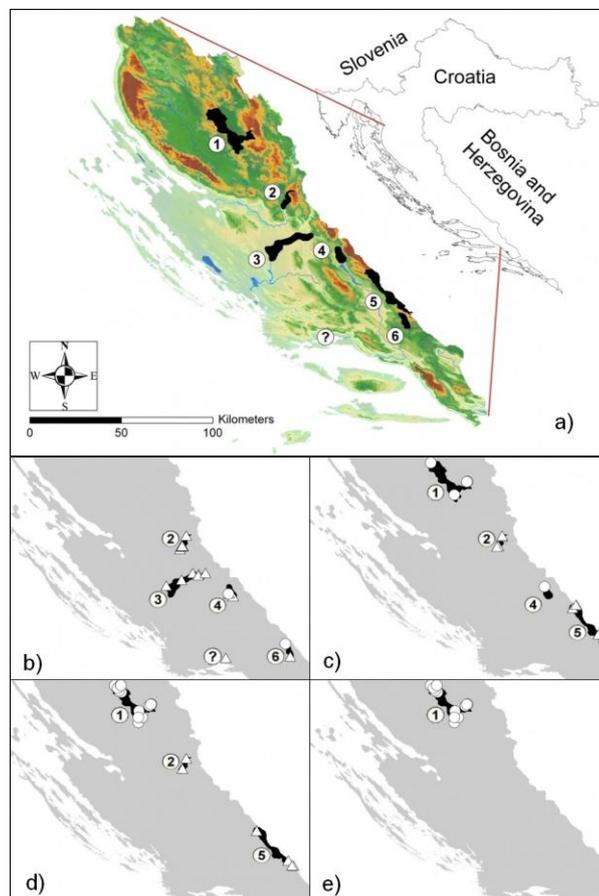
Here we present new records of the three species belonging to the subgenus *Polyommatus (Agrodiaetus)* from Croatia, and the first records of the fourth species of the subgenus, *Polyommatus aroaniensis* (Brown, 1976).

## Materials and methods

Butterflies belonging to the subgenus *Polyommatus (Agrodiaetus)* were observed and/or collected during 2014 and 2015 in Croatia, ranging from Lika in the northern part of the survey area to southern Dalmatia in the south. Several specimens per locality were collected and placed into the first author's collection. For each specimen, basic habitat description, altitude and coordinates were taken. On all localities, the habitat type was registered and later cross-checked with the Republic of Croatia Database of Habitat Types (Državni zavod za zaštitu prirode 2008). The altitude was measured in the field using Garmin GPS devices, or later using Google Earth software. Specimens were identified to the species rank in accordance with the descriptions given by Tolman & Lewington (2008). Nomenclature follows the Fauna Europaea list of European butterflies (Fauna Europaea 2015). For each species, known altitudinal ranges were also calculated, based on the species-locality records.

## Results

According to the literature and newly collected records, the butterflies of the subgenus *Polyommatus (Agrodiaetus)* are known from six regions in Croatia, stretching from the Lika region to Dalmatinska Zagora (Dalmatia) (Fig. 1a). An additional region, where we did not confirm any of the four species, but historical records for *P. admetus* exist, is marked with the question mark (Kozjak Mountain in the vicinity of Split, according to Stauder 1923).



**Figure 1.** Map of the surveyed regions of the four species of the subgenus *Polyommatus (Agrodiaetus)* in Croatia (a), with all records of the four species in Croatia on maps below: *P. admetus* (b), *P. damon* (c), *P. ripartii* (d) and *P. aroaniensis* (e). Numbers and black silhouettes refer to regions: 1 - Ličko sredogorje, 2 - Poštak Mountain and Zrmanja spring, 3 - Upper part of the Krka River, 4 - Cetina spring, 5 - Mountains Troglav and Kamešnica, 6 - Voštane - Tijarica, ? - unconfirmed record from Kozjak Mt. Literature records are presented with white triangles, while new records gathered in 2014 and 2015 are presented with white circles.

**Slika 1.** Karta raziskovanih regij štirih vrst podrođu *Polyommatus (Agrodiaetus)* na Hrvaškem (a), z vsemi znanimi podatki za štiri vrste na kartah spodaj: *P. admetus* (b), *P. damon* (c), *P. ripartii* (d) in *P. aroaniensis* (e). Označe in črna področja se nanašajo na regije: 1. Ličko sredogorje, 2. Poštak in izvir reke Zrmanje, 3. gornji del reke Krke, 4. izvir reke Cetine, 5. hribovi Troglav in Kamešnica, 6. Voštane - Tijarica, ? - nepotrjena najdba s hriba Kozjak. Literaturni podatki so predstavljeni z belimi trikotniki, novi podatki zbrani v 2014 in 2015 pa z belimi krogi.

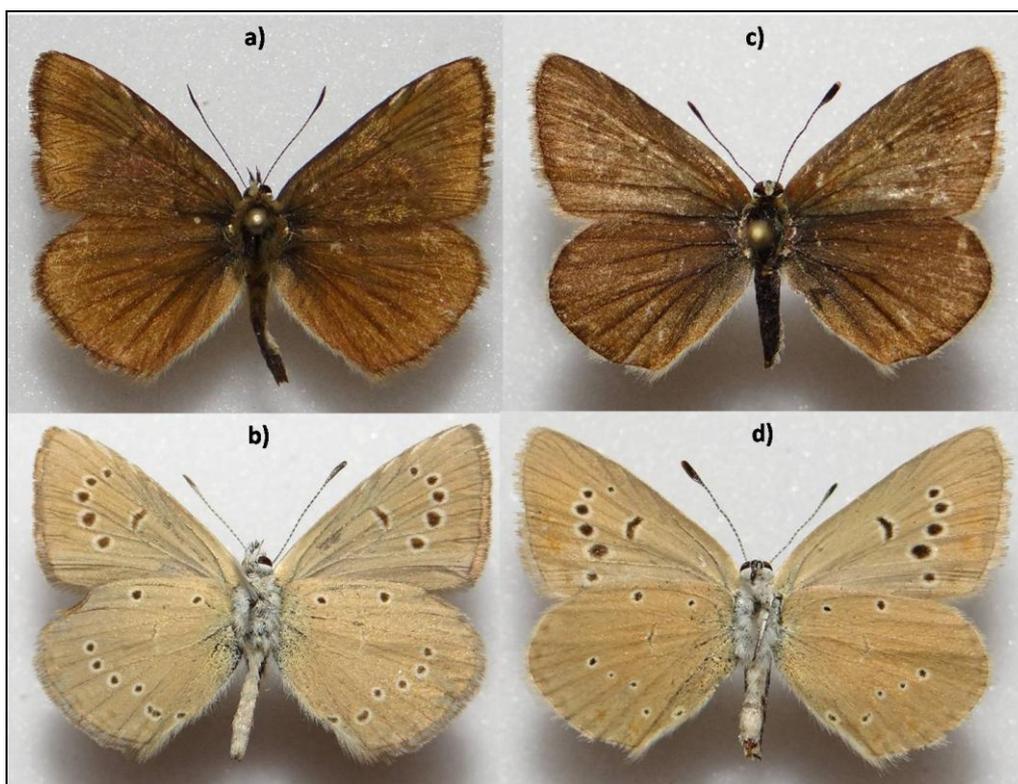
Within these six regions, we visited several localities in order to confirm the presence of the *Polyommatus (Agrodiaetus)* butterflies (Tab. 1, Fig. 1a). *Polyommatus admetus* was recorded on two new localities (Fig. 1b), *P. damon* on five new localities, and in two new regions (Ličko sredogorje and Cetina spring, Fig. 1c), and *P. ripartii* on 13 new localities and one new region (Ličko sredogorje, Fig. 1d). *P. damon* was confirmed on each studied locality within Ličko sredogorje and Cetina spring also being new for this species. Aside from the species already known from the country, we recorded an additional new species – *P. aroaniensis*, on 12 localities within one region (Ličko sredogorje) (Fig. 1e, Fig. 2).

**Table 1.** List of new records of the four species of the subgenus *Polyommatus (Agrodiaetus)* in Croatia, with description of locality, region number (according to the map in Fig. 1a), dates of visit, number of observed specimens (N), coordinates (X and Y in WGS84 decimal degrees) and altitude (Z).

**Tabela 1.** Seznam novih najdb štirih vrst podrodu *Polyommatus (Agrodiaetus)* na Hrvaškem, z navedeno lokaliteto, številko regije (v skladu z zemljevidom na Sl. 1a), datumi obiskov, številom opaženih osebkov (N), koordinatami (X in Y v WGS84 decimalnih stopinjah) in nadmorsko višino (Z).

| Locality   | Region No. | Date      | N   | Y        | X        | Z [m] |
|--|------------|-----------|-----|----------|----------|-------|
| <b><i>Polyommatus damon</i></b>                          |            |           |     |          |          |       |
| Cetina village, Cetina River spring                      | 4          | 6.8.2015  | >5  | 43,97678 | 16,43013 | 392   |
| crossroad toward Srednja gora, about 5 km SW from Udbina | 1          | 4.8.2014  | >5  | 44,48584 | 15,73214 | 759   |
| Kozja Draga, locality 1, NW from Udbina                  | 1          | 2.8.2014  | >10 | 44,55868 | 15,82837 | 884   |
| Kozja Draga, locality 2, NW from Udbina                  | 1          | 29.7.2015 | >10 | 44,56016 | 15,83255 | 987   |
| Kneževići village  | 1          | 28.7.2015 | 1   | 44,66228 | 15,54793 | 926   |
| <b><i>Polyommatus ripartii</i></b>                       |            |           |     |          |          |       |
| Komić, Balić-bunar, Udbina                               | 1          | 27.7.2014 | >10 | 44,45777 | 15,73282 | 834   |
| turnoff toward Srednja gora, about 5 km SW from Udbina   | 1          | 4.8.2014  | 2   | 44,48584 | 15,73214 | 759   |
| grasslands 4.5 km S from Udbina                          | 1          | 3.8.2014  | >5  | 44,48637 | 15,76173 | 700   |
| grasslands towards Čojluk, 3.5 km SW from Udbina         | 1          | 3.8.2014  | 3   | 44,52165 | 15,73645 | 722   |
| Kozja Draga, locality 3, NW from Udbina                  | 1          | 2.8.2014  | >5  | 44,55063 | 15,8165  | 834   |
| Kozja Draga, locality 1, NW from Udbina                  | 1          | 2.8.2014  | >5  | 44,55868 | 15,82837 | 884   |
| Kozja Draga, locality 2, NW from Udbina                  | 1          | 29.7.2015 | >5  | 44,56016 | 15,83255 | 958   |
| Svračkovo selo   | 1          | 27.7.2015 | 10  | 44,62524 | 15,59953 | 718   |
| Ljubovo, locality 1, NW from Svračkovo Selo              | 1          | 28.7.2015 | 15  | 44,63319 | 15,58182 | 856   |
| Ljubovo, locality 2, NW from Svračkovo Selo              | 1          | 28.7.2015 | 5   | 44,64771 | 15,56841 | 928   |
| Kneževići village  | 1          | 28.7.2015 | 3   | 44,66228 | 15,54793 | 926   |
| Brestovača meadow, W from Bunić                          | 1          | 29.7.2015 | 5   | 44,66302 | 15,59378 | 916   |
| towards Brestovača meadow, W from Bunić                  | 1          | 29.7.2015 | 4   | 44,66523 | 15,59152 | 919   |
| <b><i>Polyommatus admetus</i></b>                        |            |           |     |          |          |       |
| Rože -Voštane, slopes near the rode                      | 6          | 5.8.2015  | 1   | 43,6578  | 16,86279 | 923   |
| Kosore, Cetina river bank                                | 4          | 6.8.2015  | 1   | 43,93645 | 16,42894 | 383   |
| <b><i>Polyommatus aroaniensis</i></b>                    |            |           |     |          |          |       |
| Komić, Balić-bunar, Udbina                               | 1          | 27.7.2014 | 5   | 44,45777 | 15,73282 | 671   |
| turnoff toward Srednja gora, about 5 km SW from Udbina   | 1          | 4.8.2014  | 1   | 44,48584 | 15,73214 | 759   |
| grasslands 4.5 km S from Udbina                          | 1          | 3.8.2014  | >5  | 44,48637 | 15,76173 | 700   |

| Locality  | Region No. | Date      | N   | Y        | X        | Z [m] |
|---|------------|-----------|-----|----------|----------|-------|
| grasslands toward Čojluk, 3.5 km SW from Udbine | 1          | 3.8.2014  | 1   | 44,52165 | 15,73645 | 722   |
| Kozja Draga, locality 3, NW from Udbina         | 1          | 2.8.2014  | 3   | 44,55063 | 15,8165  | 834   |
| Kozja Draga, locality 1, NW from Udbina         | 1          | 2.8.2014  | 4   | 44,55868 | 15,82837 | 884   |
| Kozja Draga, locality 2, NW from Udbina         | 1          | 29.7.2015 | >50 | 44,56016 | 15,83255 | 958   |
| Svračkovo Selo                                  | 1          | 27.7.2015 | 5   | 44,62524 | 15,59953 | 718   |
| Ljubovo, locality 1, NW from Svračkovo Selo     | 1          | 28.7.2015 | 6   | 44,63395 | 15,58049 | 858   |
| Ljubovo, locality 2, NW from Svračkovo Selo     | 1          | 28.7.2015 | 3   | 44,64771 | 15,56841 | 928   |
| Kneževići village                               | 1          | 28.7.2015 | 2   | 44,66228 | 15,54793 | 926   |
| Brestovača meadow, W from Bunić                 | 1          | 29.7.2015 | 2   | 44,66302 | 15,59378 | 916   |

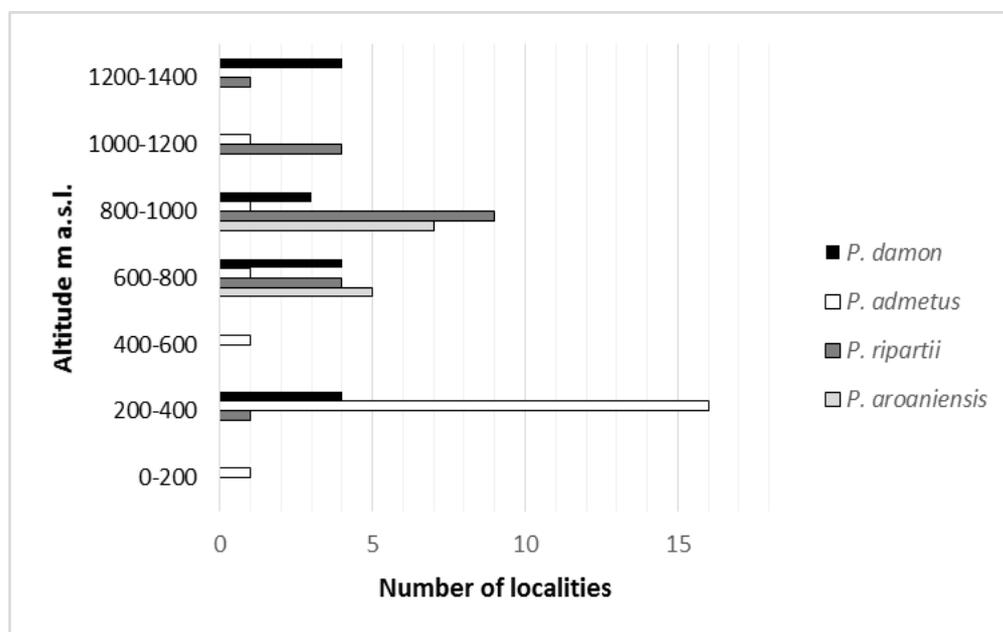


**Figure 2.** Male (a, b) and female (c, d) specimens of *P. aroaniensis* from Kozja Draga locality in Croatia (photo: Toni Koren).

**Slika 2.** Samec (a, b) in samica (c, d) vrste *P. aroaniensis* z lokalitete Kozja Draga na Hrvaškem (foto: Toni Koren).

As shown on the maps, *P. admetus* is most widespread in Dalmatia, with the northernmost record in Lika, on the Poštak Mountain (Fig. 1b). *P. damon* (Fig. 1c) and *P. ripartii* (Fig. 1d) share localities and habitats, with the exception of the spring of the Cetina River, where only *P. damon* was recorded. Records of these two species in Ličko sredogorje are 36 km away from the closest known population on Poštak Mountain, and present the northernmost distribution for these species in Croatia. *P. aroaniensis* is only found in the northernmost region (Ličko sredogorje) (Fig. 1e).

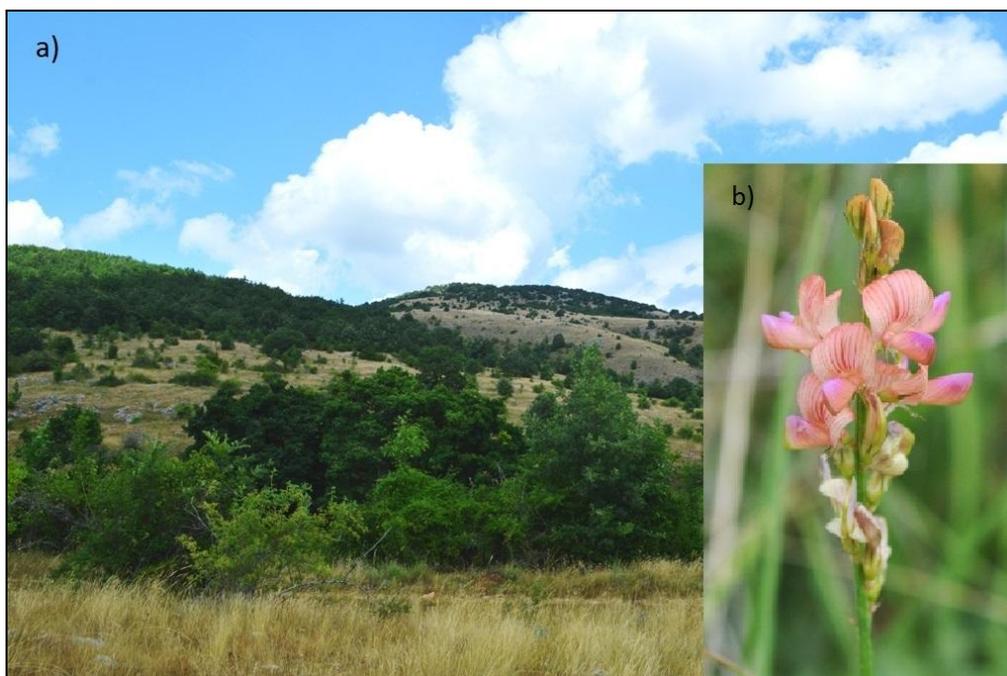
Altitudinal ranges of the four species greatly overlap (Fig. 3). *P. admetus* records range from 235 to 1089 m a.s.l., with most records from between 200 and 400 m a.s.l. The highest record is on Poštak Mountain (1,089 m a.s.l.). The altitudinal ranges for *P. damon* and *P. ripartii* show similar patterns, and extend from 200 to 1,400 m, with a gap in records for altitudes between 400 and 700 m a.s.l. Records of these two species at lower altitudes (200-400 m a.s.l.) are connected with river spring areas (the Zrmanja and Cetina Rivers), and need to be clarified further. Most of the records for *P. ripartii* range from 700 to 1,100 m a.s.l., and for *P. damon* from 700 to 1,400 m a.s.l. Records of *P. aroaniensis* have all been made between 600 and 1,000 m a.s.l., showing preferences for moderate altitudes.



**Figure 3.** Altitudes at which the four species of the subgenus *Polyommatus (Agrodiaetus)* were recorded, including all the literature records and the records presented in this study.

**Slika 3.** Nadmorske višine, na katerih so bile najdene štiri vrste podrodu *Polyommatus (Agrodiaetus)* na Hrvaškem, upoštevajoč vse literaturne podatke in nove podatke iz te raziskave.

As it turns out, all four species are dependent on one habitat type: dry grasslands (Fig. 4a). On all visited localities, these grasslands combine a mixture of European dry heaths and grasslands with mat grass (*Nardus stricta*), sub-Mediterranean and epi-Mediterranean dry grasslands with bushes, rocky pastures on dry grasslands. The only exception is the region of Ličko sredogorje with presence of an additional grassland type of subatlantic mesic grasslands and highland meadows on carbonate soils. The mixture of grasslands types on all localities is always bordered by thermophilous oak forests at lower altitudes or with beech forests at higher altitudes. The locality Kozja Draga was the only place where we recorded the larvae host plant of *P. aroaniensis*, *Onobrychis arenaria* (Kit.) DC. (Fig. 4b).



**Figure 4.** Landscape in Ličko sredogorje, with sub-Mediterranean and epi-Mediterranean dry grasslands with bushes, bordering on thermophilous oak forest (a), and *Onobrychis arenaria* (b), larval host plant of *Polyommatus aroaniensis*, found in Ličko sredogorje (photo: Boris Lauš).

**Slika 4.** Pokrajina v Ličkem sredogorju, s sub-mediteranskimi in epi-mediteranskimi travniki z grmovjem, ki mejijo na termofilni hrastov gozd (a), ter *Onobrychis arenaria* (b), hranilna rastlina modrina *P. aroaniensis*, zabeležena na območju Liškega sredogorja (foto: Boris Lauš).

## Discussion

According to literature and recent data, *P. admetus* is distributed from the Kamešnica Mountain, following the Cetina spring area, Krka River, Zrmanja spring area and Poštak Mt. in the north of Croatia (Koren 2010a, Koren & Lauš 2013, Koren et al. 2015). Several literature records exist for this species, but during our survey we provided only two new records, which are clustered within the known species distribution (Koren 2010a). The literature record from Kozjak Mt. was not confirmed during our surveys. This species is widely distributed in Dalmatia, but is still local. The altitudinal range indicates that it has an affinity towards lower altitudes, and in most parts of southern Croatia it has indeed been found between 0 and 300 m a.s.l. This may be the reason for the wider distribution of *P. admetus*. Additional records for the species are expected, especially from other micro-localities in the same distribution range.

Historically, *P. damon* was first mentioned for Dalmatia by Mann (1869), but without stating the exact locality. The first recent record is from Mt. Kamešnica (Mihoci et al. 2006) where it was confirmed again, as well as at Troglav Mt. (Koren & Lauš 2013). Also, it was recorded on Poštak Mt. (Koren et al. 2015) and at the spring of the Zrmanja River (Koren et al. 2011). Our new records greatly increase its known distribution toward the north-west. However, the species is also very local in this region, but the butterflies can be locally very common where the habitat is suitable.

The third species, *P. ripartii*, was recorded near the Zrmanja River spring for the first time in Croatia in 2010 (Koren 2010b), and was soon after recorded on the Mts. Troglav, Kamešnica (Koren & Lauš 2013) and Poštak (Koren et al. 2015). Like *P. damon*, the new records from Lika greatly increase its known range of distribution to the north-west.

So far, no records of these species exist from the neighbouring Velebit Mt. (Mihoci et al. 2007), but with our records being fairly close, it is possible that some of these species could be recorded also on the northeastern side of this mountain.

The most surprising record was that of *P. aroaniensis*. The distribution of the species is restricted to the southern Balkans, and includes Bosnia & Herzegovina (Verovnik et al. 2015), Macedonia (Kolev & van der Poorten 1997, Melovski & Božinovska 2014), Bulgaria (Kolev & van der Poorten 1997, Abadjiev & Beshkov 2007), and Greece (Kolev & van der Poorten 1997, Tolman & Lewington 2008, Pamperis 2009). The recently discovered population from Bosnia and Herzegovina is located approximately 270 km to the south-east from the population in Croatia (Verovnik et al. 2015). It is considered to be rare in Bulgaria, reported from several localities in the mountains in the south-western part of the country (Pirin and Slavyanka) and around Sliven (Stara Planina) (Abadjiev & Beshkov 2007). In Greece, it is considered to be widespread but generally local. Up to now it has been recorded from the Phalakron massif, Vernon Mts., Smolikas massif, Timphristos Mt., Parnassos massif, Panakon Mts., Chelmos massif; Menalon Mts. and Taygetos Mts. (Tolman & Lewington 2008).

*P. aroaniensis* was first recorded in 2014 on several localities, but only a single specimen was collected. In 2015, we continued with the survey and recorded it on 11 new localities, all scattered on the outer edge of Krbavsko polje karst field. The habitat mostly consisted of thermophilous dry calcareous grasslands, partially covered with bushes.

*P. aroaniensis* usually lacks the white line on the underside of the hind-wings, therefore it can be easily separated from *P. damon* and *P. ripartii*. It also differs from *P. admetus* by the lack of two lines of dots on the edge of the hind-wing underside. Also, *P. admetus* always lacks the white line on the outer side of the hind-wings. As *P. aroaniensis* flies syntopic with *P. damon* and *P. ripartii*, careful examination of the specimens is needed in order to distinguish them. But even this could prove to be not 100% correct, and further studies on the differences in the genetics between these species would be needed.

Our records from Croatia represent the northwestern distribution limit of *P. aroaniensis* in Europe, with the closest known populations recorded from Gacko, in Bosnia & Herzegovina (Verovnik et al. 2015) and Macedonia (Kolev & van der Poorten 1997, Melovski & Bozhinovsk 2014).

With the recent discoveries of this species in Bosnia & Herzegovina and Macedonia, the range of *P. aroaniensis* in Europe has been greatly expanded in the last few years. As with other species of the subgenus *Polyommatus (Agrodiaetus)* mentioned in this paper, their distribution in Croatia was discovered only in the last decade. *P. aroaniensis* flies in a single generation from July to August (Tolman & Lewington 2008). Its larval host plant is exclusively *Onobrychis arenaria* (Kit.) DC. (Tolman & Lewington 2008), which was recorded on this locality.

It seems that, at least in Croatia, *P. aroaniensis* and *P. admetus* could be mutually exclusive, as these two species do not occur together. On the other hand, *P. damon* and *P. admetus* usually share many localities with either of the two species.

In the recent overview of Croatian butterflies, 195 species were recorded (Šašić & Mihoci 2011). However, *Hipparchia senthes* (Fruhstorfer 1908) was excluded from the list as it was based on an erroneous record (Koren et al. 2013a), while two additional species were recorded: *Pyrgus malvoides* (Elwes & Edwards, 1897) (Koren et al. 2013b) and *Melitaea ornata* (Christoph, 1893) (Koren & Štih 2013). Since no previous records of *P. aroaniensis* existed for Croatia, we add it as the 197<sup>th</sup> species on the butterfly list of Croatia.

Our surveys during the recent years greatly increased the knowledge about the distribution of species from the subgenus *Polyommatus (Agrodiaetus)* in Croatia. However, nothing about their ecology, conservation status and phylogenetics is known. Many of these species were described in the last few decades (e.g. Brown 1976, Coutsis & De Prins 2005) and their species status is mostly confirmed (Vila et al. 2010), but a genetic study of the newly recorded populations from Croatia would be necessary for taxonomical as well as conservation purposes.

## Povzetek

Doslej so bile na Hrvaškem zabeležene tri vrste metuljev, ki pripadajo podrodu *Polyommatus (Agrodiaetus)*: *P. damon*, *P. admetus* in *P. ripartii*. Vse tri so zelo lokalno razširjene v južnem delu države, predvsem v Dalmaciji, dalmatinski Zagori in južni Liki. V letih 2014 in 2015 smo raziskali južni del Hrvaške z namenom zbrati dodatne lokacije metuljev teh vrst. *Polyommatus admetus*, *P. damon* in *P. ripartii* smo našli na več novih lokalitetah in s tem slednjima dvema razširili prej znano območje razširjenosti. Poleg teh treh smo prvič na območju Hrvaške zabeležili še vrsto *P. aroaniensis*, doslej znano le iz južnega dela Bosne in Hercegovine. Naše najdbe ponazarjajo novo severozahodno mejo razširjenosti te vrste, tako da se je z njenim odkritjem število dnevnih metuljev na Hrvaškem povečalo na 197.

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