

# CONTRIBUTION TO THE KNOWLEDGE OF THE BUTTERFLY FAUNA (LEPIDOPTERA: PAPILIONOIDEA) OF MT KOZJAK, SPLIT, CROATIA

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**Koren, T., Burić, I., Glavan, G. & Verovnik, R.: Contribution to the knowledge of the butterfly fauna (Lepidoptera: Papilionoidea) of Mt Kozjak, Split, Croatia. Nat. Croat. Vol. 28, No. 1., 21-33, 2019, Zagreb.**

Mt Kozjak is an elongated mountain ridge situated in central Dalmatia, just above the Riviera of Kaštela near Split. It was well surveyed a century ago by Hermann Stauder who recorded 38 butterfly species. Among these, *Papilio alexanor* was the most prominent discovery. During our surveys from 2007 to 2018, we recorded 82 butterfly species at 19 localities bringing the total of observed species to 87. We managed to confirm the presence of *Papilio alexanor* more than hundred years after the first observation in the area. The occurrence of some additional rare and interesting species like *Carcharodus orientalis*, *Pyrgus sidae*, *Pyrgus serratulae*, *Parnassius mnemosyne*, *Euchloe ausonia*, *Cupido osiris*, *Polyommatus admetus* and *Hyponphele lycaon* is discussed in more detail. The butterfly fauna of Mt Kozjak is very diverse given its geographic position, low habitat diversity and size. Abandonment of pasturing and subsequent overgrowing of calcareous grasslands is the most important factor causing long term butterfly decline on Mt Kozjak.

**Key words:** distribution, diversity, Kaštela, Dalmatia, *Papilio alexanor*, *Cupido osiris*

**Koren, T., Burić, I., Glavan, G. & Verovnik, R.: Prilog fauni danjih leptira (Lepidoptera: Papilionoidea) planine Kozjak, Split, Hrvatska. Nat. Croat. Vol. 28, No. 1., 21-33, 2019, Zagreb.**

Planina Kozjak izduženi je planinski greben smješten u središnjoj Dalmaciji, iznad Kaštela u blizini Splita. Prije jednog stoljeća to je područje dobro istražio Herman Stauder te je zabilježio 38 vrsta danjih leptira. Među njima, najistaknutiji je nalaz vrste *Papilio alexanor*. Tijekom našeg istraživanja koje je trajalo od 2007. do 2018. zabilježili smo 82 vrsta leptira na 19 lokaliteta, povećavajući broj poznatih vrsta na 87. Uspjeli smo potvrditi i prisutnost vrste *Papilio alexanor*, preko 100 godina nakon prvih opažanja na tome području. Dodatno raspravljamo o nalazima rijetkih ili zanimljivih vrsta poput *Carcharodus orientalis*, *Pyrgus sidae*, *Pyrgus serratulae*, *Parnassius mnemosyne*, *Euchloe ausonia*, *Cupido osiris*, *Polyommatus admetus* i *Hyponphele lycaon*. Fauna leptira planine Kozjak vrlo je raznolika s obzirom na svoj geografski položaj, nisku raznolikost staništa i veličinu. Napuštanje ispaše i zarastanje vapnenačkih travnjaka najvažniji su čimbenici koji uzrokuju dugoročno opadanje raznolikosti leptira na Kozjaku.

**Ključne riječi:** rasprostranjenost, raznolikost, Kaštela, Dalmacija, *Papilio alexanor*, *Cupido osiris*

## INTRODUCTION

Kozjak, also known as Mali Kozjak or Primorski Kozjak, is a mountain located above the seven different villages/settlements that are part of Kaštela town, near Split. It is part of the Dinaric Alps, and it stretches from the pass of Klis in the southeast, to the pass of Malačka in the west (POLJAK, 2007). The highest peak of the mountain is Veli vrj (779 m) located above Kaštel Gomilica (POLJAK, 2007).

Kozjak is one of the longest contiguous ridges in Croatia. Its southern slopes are very steep, and mostly difficult to access. The northern slopes are less steep and create a plateau which gradually declines towards Dalmatian Zagora. The western part of the ridge is called Malačka, and is a well-known recreation area for the inhabitants of the surrounding cities. In the past, the area of Mt Kozjak was used for grazing mostly by sheep, but recently grazing has been almost entirely abandoned. On the ridge of Mt Kozjak from Malačka to Sveti Jure, the most important grassland community is *Carici-Centtaureetum rupestris* (TRINAJSTIĆ *et al.*, 1993). On the southern slopes the prevailing forest communities are *Pistacio-Pinetum halepensis* De Marco, Veri et Caneva 1984 and *Fraxino orni-Quercetum ilicis* Horvatić /1956/ 1958, while on the northern slopes the most common communities are *Carpino orientalis-Quercetum virgilianae* Trinajstić 1987 and *Ostryo-Quercetum virgilianae* Trinajstić 1987 (TRINAJSTIĆ & KAMENJARIN, 1998).

Mt Kozjak, at least its southern slopes, was known to lepidopterists by the beginning of the 20<sup>th</sup> century when Hermann STAUDER made several visits to the area (1911, 1913, 1921-1923). His most prominent observation was of *Papilio alexanor* Esper, 1800 on screes above the Kaštel Stari railway station, a record that has not been confirmed in recent surveys (VEROVNIK & ŠVARA, 2016). Altogether, STAUDER recorded 38 butterfly species, among which *Hylonephele lupina* (Costa, 1836), *Brenthis daphne* (Bergsträsser, 1780), *Pyrgus sidae* (Esper, 1784) and *Gegenes nostradamus* (Fabricius, 1793) should be mentioned (STAUDER, 1921-1923). The latter probably refers to the more widespread species *Gegenes pumilio* (Hoffmannsegg, 1804) as there are no confirmed records of *G. nostradamus* so far north in Dalmatia (LORKOVIĆ, 1971). We must mention that most of STAUDER's observations come from lower altitudes around Kaštel Stari, and the coastal part of Kaštel Riviera, which were not targeted in our surveys. RADOVANOVIĆ (1976) mentions the observations of two migratory species from Mt Kozjak, *Vanessa atalanta* and *Vanessa cardui*. Apart from a few records of *Proterebia phegea* (Borkhausen, 1788) (KOREN *et al.*, 2010) no additional information has been published from the study area in recent years.

The goal of our paper is to discuss the butterfly diversity of Mt Kozjak, with the addition of notes for some rare and interesting species recorded during the survey, and to compare it to the neighbouring regions and historical records.

## MATERIALS AND METHODS

Field surveys were carried out during the last decade, from 2007 to 2018, with the majority of field work in the last two years. Topography and habitat diversity as visible from Google Earth images were used to select potentially butterfly-diverse localities in the region. In all, 19 localities (Fig. 1) were visited during this survey, some of them on several occasions to cover the entire butterfly field season. The spatial processing and visualisation of data was made in the program ARC GIS desktop. Butterflies were identified using standard field guides (LAFRANCHIS, 2004; TOLMAN & LEWINGTON, 2008). Additionally, specimens of the genera *Leptidea*, *Melitaea* and *Plebejus* were collected and their genitalia were examined for correct

identification. The identification of the *Hipparchia fagisyrriaca* complex was done on the basis of the male Jullien organ in the field (LORKOVIĆ, 1976; LAFRANCHIS, 2004). The exact records of *P. alexanor* were omitted from this paper due to conservation concerns. The nomenclature follows WIEMERS *et al.* (2018).

#### List of localities

The list of localities contains the relevant toponyms, a short description of the habitat, altitude, coordinates, dates of the visits and observers. Localities are arranged in geographical order from west towards east (Fig. 1).

1. Kozjak, Malačka, war monument, calcareous pastures overgrown with bushes and trees, 520 a.s.l, 43,5812N, 16,3204E, 24.6.2018, Koren, Burić
2. Kozjak, on small side road westwards to spring Češmenovac, maquis, rocky and bushy slopes, 270 a.s.l, 43,576972N, 16,324042E, 28.4.2007, Verovnik, 5.6.2014, Burić, 1.5.2018, 20.7.2018, Verovnik, Glavan
3. Kozjak, E of Malačka pass, rocky pastures partially overgrown with bushes, 495 a.s.l, 43,581811N, 16,327353E, 28.4.2007, Verovnik, 29.5.2017, 1.5.2018, 24.6.2018, Koren, Burić
4. Kozjak, E of Malačka pass at peak Birnjač, rocky slopes and scrubs, 560 a.s.l, 43,580269N, 16,337931E, 1.5.2018, Verovnik, Glavan
5. Kozjak, Biranj, rocky slopes and scrubs, 490 a.s.l, 43,5788317N, 16,3433669E, 29.5.2017, Koren, Burić
6. Kozjak, on a small side road eastwards below Biranj, maquis and pine plantations, 315 a.s.l, 43,575122N, 16,349311E, 28.4.2007, Verovnik, 20.7.2018, 1.5.2018, Verovnik, Glavan
7. Kozjak, Balavan, rocky pastures partially overgrown with bushes, maquis edges, 115 a.s.l, 43,5663N, 16,36755E, 29.4.2013, Koren, 9.3.2014, Burić
8. Kozjak, fireway road from Kaštel Stari to Kaštel Gomilica, eastern part, maquis, karstic pastures, 325 a.s.l, 43,572951N, 16,369455E, 2.5.2013, Burić, Lauš
9. Kozjak, fireway road from Kaštel Stari to Kaštel Gomilica, western part, maquis, karstic pastures, 355 a.s.l, 43,571737N, 16,379939E, 2.5.2013, 9.3.2014, Burić, Lauš
10. Kozjak, Sibovica, edge of a gravel road, maquis, rocky pastures, 295 a.s.l, 43,565035N, 16,400081E, 1.5.2018, Koren, Burić, Štih
11. Kozjak, Putalj, crossroad at the turn for Putalj, below Malačka, maquis, rocky pastures, 360 a.s.l, 43,566403N, 16,400165E, 30.4.2018, 1.5.2018, Koren, Burić
12. Kozjak, Putalj, above the church St. Luka, rocky pastures, 735 a.s.l, 43,571522N, 16,411005E, 30.4.2018, Koren, Burić
13. Kozjak, Putalj, road below the church St. Luka, maquis and small crop fields, 375 a.s.l, 43,566977N, 16,416305E, 30.4.2018, Koren, Burić
14. Kozjak, Putalj, ridge and slopes E of Sveti Luka peak, rocky pastures, edges of oak woods, 620 a.s.l, 43,569931N, 16,423889E, 24.6.2018, 30.4.2018, 29.5.2017, Koren, Burić, 20.5.2018, 20.7.2018, Verovnik, Glavan
15. Kozjak, Blaca, humid meadows near the temporary stream, 405 a.s.l, 43,573588N, 16,45862E, 30.4.2018, 24.6.2018, Koren, Burić

16. Kozjak, Bobani, below the road at the village, rocky pastures overgrown with junipers, near the wet meadows along the temporary stream, 430 a.s.l, 43,571392N, 16,473031E, 20.5.2018, 20.7.2018, Verovnik, Glavan
17. Kozjak, Blaca SE, rocky pastures overgrown with junipers, 445 a.s.l, 43,570237N, 16,477441E, 30.4.2018, Koren, Burić
18. Kozjak, Bobani, hiking path below Bobanova greda, steep rocky and bushy slopes, 465 a.s.l, 43,569315N, 16,492602E, 30.4.2018, 24.6.2018, Koren, Burić
19. Kozjak, Bobani, hiking path below Bobanova greda, maquis and steep rocky slopes, 370 a.s.l, 43,568211N, 16,499436E, 30.4.2018, 24.6.2018, Koren, Burić

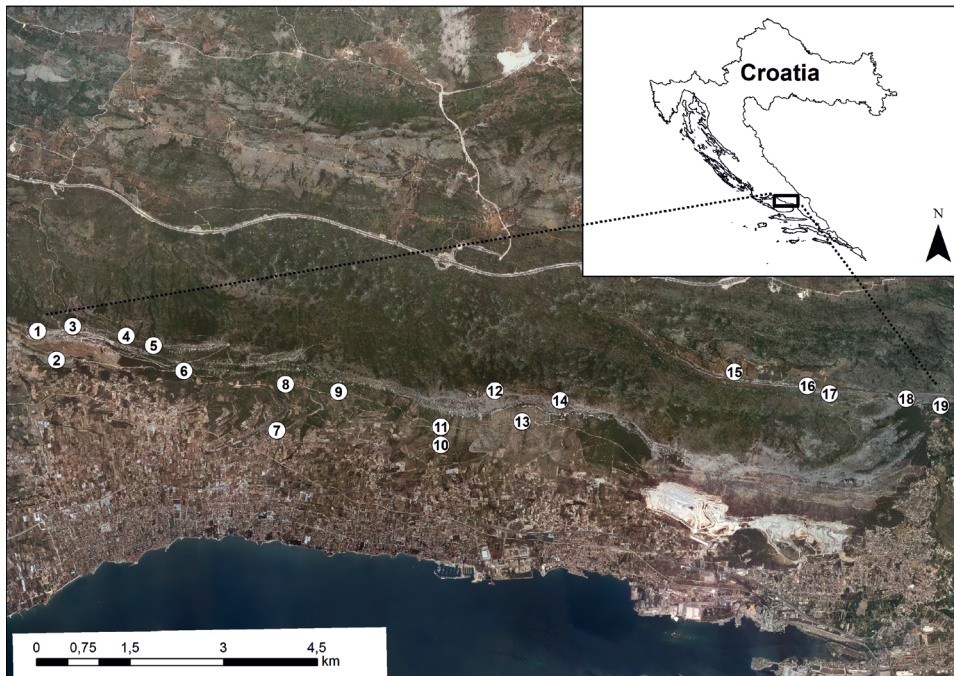


Fig. 1. Map of butterfly sampling localities on Mt Kozjak above Kaštel in Dalmatia.

## RESULTS AND DISCUSSION

Despite its prominent position near largest city (Split) in Dalmatia, Mt Kozjak has received very little attention from lepidopterologists in recent decades. This is even more surprising given the recent prolific publishing of local butterfly faunas for Dalmatia and its hinterland (WITHRINGTON & VEROVNIK, 2008; KOREN *et al.*, 2011; MIHOCI *et al.*, 2011; VEROVNIK, 2011; KOREN *et al.*, 2015a; VEROVNIK *et al.*, 2015; KAČÍREK, 2017). Mt Kozjak was first visited by the author RV in 2007 specifically to survey the southern slopes and the ridge for *Papilio alexanor*, however without success. But the observation at that time of several rare species and large diversity initiated more intensive surveys in recent years, resulting in both good phenological and geographical coverage of the studied area.

**Tab. 1.** List of species observed or listed from Mt Kozjak with locality numbers corresponding to the List of localities. Literature sources are added.

List of species		Locality number	Literature records
<b>Hesperiidae</b>			
1.	<i>Erynnis tages</i> (Linnaeus, 1758)	15, 16	STAUDER (1921-1923)
2.	<i>Carcharodus alceae</i> (Esper, 1780)	1, 2, 3, 7, 14, 16	
3.	<i>Carcharodus orientalis</i> Reverdin, 1913	2, 6	
4.	<i>Spialia orbifer</i> (Hübner, 1823)	2, 6	STAUDER (1921-1923)
5.	<i>Pyrgus alveus</i> (Hübner, 1803)	3, 5	
6.	<i>Pyrgus armoricanus</i> (Oberthür, 1910)	16	
7.	<i>Pyrgus malvae</i> (Linnaeus, 1758)	1	
8.	<i>Pyrgus serratulae</i> (Rambur, 1839)	15	
9.	<i>Pyrgus sidae</i> (Esper, 1784)	3	STAUDER (1911, 1921-1923)
10.	<i>Thymelicus acteon</i> (Rottemburg, 1775)	1, 15, 19	STAUDER (1913, 1921-1923)
11.	<i>Thymelicus lineola</i> (Ochsenheimer, 1808)	3, 15	STAUDER (1921-1923)
12.	<i>Thymelicus sylvestris</i> (Poda, 1761)	15	
13.	<i>Ochlodes sylvanus</i> (Esper, 1777)	6, 14	
14.	<i>Gegenes nostrodamus</i> (Fabricius, 1793)	/	STAUDER (1921-1923)
<b>Papilionidae</b>			
15.	<i>Parnassius mnemosyne</i> (Linnaeus, 1758)	14	
16.	<i>Iphiclides podalirius</i> (Linnaeus, 1758)	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19	STAUDER (1921-1923)
17.	<i>Papilio alexanor</i> Esper, 1800	*	STAUDER (1911, 1921-1923)
18.	<i>Papilio machaon</i> Linnaeus, 1758	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 13, 14, 15	STAUDER (1911, 1921-1923)
<b>Pieridae</b>			
19.	<i>Leptidea sinapis</i> (Linnaeus, 1758)	1, 2, 3, 5, 13, 15, 16	
20.	<i>Anthocharis cardamines</i> (Linnaeus, 1758)	2, 3, 4, 6, 7, 8, 10, 11, 13, 14, 15, 17, 18, 19	
21.	<i>Euchloe ausonia</i> (Hübner, 1804)	2, 3, 4, 5, 10, 14	STAUDER (1921-1923)
22.	<i>Aporia crataegi</i> (Linnaeus, 1758)	14, 15, 16	
23.	<i>Pieris brassicae</i> (Linnaeus, 1758)	2, 6, 7, 8, 10, 11, 14, 15, 18, 19	
24.	<i>Pieris ergane</i> (Geyer, 1828)	1, 2, 3, 5, 6, 10, 14, 15, 16	STAUDER (1911, 1921-1923)
25.	<i>Pieris manni</i> (Mayer, 1851)	1, 2, 3, 5, 6, 7, 8, 10, 14, 19	STAUDER (1911, 1913, 1921-1923)
26.	<i>Pieris rapae</i> (Linnaeus, 1758)	1, 2, 3, 6, 7, 8, 10, 11, 14, 15, 16, 17, 18, 19	STAUDER (1921-1923)
27.	<i>Pieris napi</i> (Linnaeus, 1758)	/	STAUDER (1921-1923)
28.	<i>Pontia edusa</i> (Fabricius, 1777)	1, 2, 3, 6, 7, 8, 10, 11, 13, 14, 15, 16, 18	

List of species	Locality number	Literature records
29. <i>Colias crocea</i> (Geoffroy, 1785)	1, 2, 3, 4, 7, 8, 10, 11, 13, 14, 15, 16, 17, 18, 19	STAUDER (1921-1923)
30. <i>Gonepteryx rhamni</i> (Linnaeus, 1758)	3, 7, 8, 11, 13, 14, 15	
<b>Lycaenidae</b>		
31. <i>Lycaena phlaeas</i> (Linnaeus, 1760)	2, 3, 5, 8, 14, 15, 16	STAUDER (1921-1923)
32. <i>Favonius quercus</i> (Linnaeus, 1758)	13	
33. <i>Callophrys rubi</i> (Linnaeus, 1758)	2, 3, 5, 6, 7, 8, 10, 11, 15, 17, 18, 19	
34. <i>Satyrrium acaciae</i> (Fabricius, 1787)	15	
35. <i>Satyrrium ilicis</i> (Esper, 1779)	1, 2, 3, 5, 14, 15	STAUDER (1921-1923)
36. <i>Satyrrium spini</i> ([Denis & Schiffermüller], 1775)	1, 3, 5, 13, 14, 15, 18	STAUDER (1921-1923)
37. <i>Lampides boeticus</i> (Linnaeus, 1767)	1	
38. <i>Leptotes pirithous</i> (Linnaeus, 1767)	2, 16	
39. <i>Cupido minimus</i> (Fuessly, 1775)	1, 3, 4, 8, 11, 13, 14, 15, 16, 17, 19	STAUDER (1921-1923)
40. <i>Cupido osiris</i> (Meigen, 1829)	16	
41. <i>Cupido argiades</i> (Pallas, 1771)	16	
42. <i>Celastrina argiolus</i> (Linnaeus, 1758)	3, 5, 6, 8	STAUDER (1921-1923)
43. <i>Scolitantides orion</i> (Pallas, 1771)	2, 3, 4, 5, 6, 8, 10, 11, 13, 14, 15, 16, 17, 18, 19	
44. <i>Glaucopsyche alexis</i> (Poda, 1761)	2, 3, 6, 7, 8, 10, 11, 13, 14, 15, 17, 18, 19	STAUDER (1921-1923)
45. <i>Iolana iolas</i> (Ochsenheimer, 1816)	6, 9	STAUDER (1921-1923)
46. <i>Plebejus argus</i> (Linnaeus, 1758)	3, 14, 16	
47. <i>Plebejus idas</i> (Linnaeus, 1761)	3, 5, 14, 16	
48. <i>Aricia agestis</i> ([Denis & Schiffermüller], 1775)	1, 2, 3, 4, 6, 7, 8, 10, 11, 13, 14, 15, 16, 18, 19	
49. <i>Lysandra bellargus</i> (Rottemburg, 1775)	2, 3, 6, 11, 15, 16	STAUDER (1921-1923)
50. <i>Lysandra coridon</i> (Poda, 1761)	14, 16	
51. <i>Polyommatus escheri</i> (Hübner, 1823)	3, 15	STAUDER (1921-1923)
52. <i>Polyommatus icarus</i> (Rottemburg, 1775)	2, 3, 5, 6, 8, 10, 11, 13, 14, 15, 16, 18, 19	
53. <i>Polyommatus thersites</i> (Cantener, 1835)	15, 16	
54. <i>Polyommatus admetus</i> (Esper, 1783)	14	STAUDER (1921-1923)
<b>Nymphalidae</b>		
55. <i>Libythea celtis</i> (Laicharting, 1782)	2, 3, 5	
56. <i>Brenthis daphne</i> (Bergsträsser, 1780)	/	STAUDER (1921-1923)
57. <i>Argynnis pandora</i> ([Denis & Schiffermüller], 1775)	2, 3, 6, 14	STAUDER (1911, 1913)
58. <i>Fabriciana adippe</i> ([Denis & Schiffermüller], 1775)	15	

List of species	Locality number	Literature records
59. <i>Speyeria aglaja</i> (Linnaeus, 1758)	14, 15	
60. <i>Issoria lathonia</i> (Linnaeus, 1758)	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17	
61. <i>Vanessa atalanta</i> (Linnaeus, 1758)	2, 3, 16	RADANOVIĆ (1976)
62. <i>Vanessa cardui</i> (Linnaeus, 1758)	1, 3, 6, 8, 13, 14, 16	RADANOVIĆ (1976)
63. <i>Aglais io</i> (Linnaeus, 1758)	3	
64. <i>Polygonia egea</i> (Cramer, 1775)	14	STAUDER (1921-1923)
65. <i>Nymphalis polychloros</i> (Linnaeus, 1758)	3, 9, 14	
66. <i>Nymphalis antiopa</i> (Linnaeus, 1758)	/	STAUDER (1921-1923)
67. <i>Melitaea cinxia</i> (Linnaeus, 1758)	2, 3, 5, 6, 8, 10, 11, 13, 16	
68. <i>Melitaea didyma</i> (Esper, 1778)	2, 6, 14, 16	STAUDER (1911, 1913, 1921-1923)
69. <i>Melitaea phoebe</i> ([Denis & Schiffermüller], 1775)	16	STAUDER (1921-1923)
70. <i>Limenitis reducta</i> Staudinger, 1901	1, 2, 3, 5, 6, 7, 8, 10, 11, 13, 14, 15, 16, 18, 19	STAUDER (1921-1923)
71. <i>Charaxes jasius</i> (Linnaeus, 1767)	5	STAUDER (1921-1923)
72. <i>Pararge aegeria</i> (Linnaeus, 1758)	14	
73. <i>Lasiommata maera</i> (Linnaeus, 1758)	3, 4, 5, 11, 13, 14, 15, 18	STAUDER (1921-1923)
74. <i>Lasiommata megera</i> (Linnaeus, 1767)	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19	
75. <i>Coenonympha arcania</i> (Linnaeus, 1760)	3, 5	
76. <i>Coenonympha pamphilus</i> (Linnaeus, 1758)	2, 3, 5, 8, 14, 15, 16	STAUDER (1911, 1913, 1921-1923)
77. <i>Maniola jurtina</i> (Linnaeus, 1758)	1, 3, 5, 14	
78. <i>Hyponephele lycaon</i> (Kühn, 1774)	14	
79. <i>Hyponephele lupina</i> (Costa, 1836)	/	STAUDER (1921-1923)
80. <i>Proterebia phegea</i> (Borkhausen, 1788)	2, 3, 4, 9, 10, 12, 14, 17	STAUDER et al., (2010)
81. <i>Melanargia galathea</i> (Linnaeus, 1758)	1, 3, 13, 16, 19	
82. <i>Melanargia larissa</i> (Geyer, 1828)	2, 3, 5, 14, 15	STAUDER (1911, 1913, 1921-1923)
83. <i>Satyrus ferula</i> (Fabricius, 1793)	2, 3, 13, 14, 15, 18	
84. <i>Hipparchia fagi</i> (Scopoli, 1763)	1, 3, 13, 14, 15, 16, 18, 19	
85. <i>Hipparchia statilinus</i> (Hufnagel, 1766)	2, 6, 14	
86. <i>Hipparchia semele</i> (Linnaeus, 1758)	1, 3, 13, 14, 15	STAUDER (1921-1923)
87. <i>Brintesia circe</i> (Fabricius, 1775)	1, 3, 13, 14, 15	

Compared to neighbouring regions of Dalmatia, the butterfly fauna of Mt Kozjak with 87 species (Tab. 1) is relatively depauperated, however the nearby Biokovo mountains with 116 species (KAČIREK, 2017) covers a much larger area and a 1000 m larger altitudinal span. When compared with mountains in the Dalmatia hinterland (TVRTKOVIĆ *et al.*, 2012; KOREN & LAUŠ, 2013; KOREN *et al.*, 2015b) and the Velebit mountains (MIHOČI *et al.*, 2007; TVRTKOVIĆ *et al.*, 2015) the lower butterfly diversity becomes even more evident (Tab. 2). Lack of habitat diversity, permanent water flows, and the geographical position of Mt Kozjak, closer to the coast, are probably the main reasons for the reduction in diversity. When compared to the much larger, but entirely lowland area of northern Dalmatia, the diversity of Mt Kozjak is somewhat higher, due to several montane or mesophilous species present at higher altitudes that were not recorded there. The montane character of the Mt Kozjak fauna is evident in the presence of *Pyrgus serratulae* (Rambur, 1839), *Parnassius mnemosyne* (Linnaeus, 1758), *Hyponephele lycaon* (Rottemburg, 1775), *Hipparchia fagi* (Scopoli, 1763) and *Aglais io* (Linnaeus, 1758). While the latter might be an irregular migrant to the area, given its general scarcity in Dalmatia (STAUDER, 1921-1923), the other species are likely residents at higher altitudes of Mt Kozjak.

**Tab. 2.** Comparison of butterfly diversity among different mainland regions of Dalmatia and Croatian mountain ranges in the area surrounding Mt Kozjak. Altitudinal span of sampling localities in each region is added.

Region/Mountain	No. of species	Altitudinal span (m)
Mt Kozjak	87	110 - 740
Biokovo range	116	90 - 1760
Mt Dinara	128	250 - 1910
Mt Poštak	108	600 - 1430
Velebit Mts.	153	30 - 1760
Northern Dalmatia	81	0 - 120

The region of Mt Kozjak is of no considerable significance for the conservation of threatened species in Croatia. According to Red Data Book of Croatian Butterflies (ŠAŠIĆ *et al.*, 2013) six of the observed species are listed as near threatened (NT): *Papilio machaon* Linnaeus, 1758, *Parnassius mnemosyne*, *Glaucopteryx alexis* (Poda, 1761), *Polyommatus thersites* (Cantener, 1835), *Scolitantides orion* (Pallas, 1771), and *Proterebia phegea*, while *Thymelicus acteon* (Rottemburg, 1775), *Papilio alexanor*, and *Pieris brassicae* (Linnaeus, 1758) are considered data deficient species (DD). At the European level (VAN SWAAY *et al.*, 2010) there are six species considered near threatened (NT): *Thymelicus acteon*, *Pyrgus serratulae*, *Parnassius mnemosyne*, *Iolana iolas* (Ochsenheimer, 1816), *Hipparchia statilinus* (Hufnagel, 1766), and *H. fagi*. *Papilio alexanor* and *Parnassius mnemosyne* are listed on Habitat Directive Annex IV (ANONYMUS, 1992). These two species should be considered of high conservation priority for the studied region.



Several species with restricted ranges or considered rare in Croatia are discussed in more detail:

*Carcharodus orientalis* Reverdin, 1913

This species was already recorded from the surroundings of Split by STAUDER (1921-1923) as *Carcharodus baeticus* (Rambur, 1842). Currently the records for Croatia are still relatively sparse with a single island record for Vis (WITHRINGTON & VEROVNIK, 2008), few records from northern Dalmatia (VEROVNIK *et al.*, 2015), and for Biokovo (KAČIREK, 2017). Its presence on Mt Kozjak corresponds well geographically with these records by linking the records from northern Dalmatia and Biokovo. The butterflies were observed along gravel roads where they visited wet soil patches for minerals in April 2007. No additional observations were made in the last two years.

*Pyrgus serratulae* (Rambur, 1839)

This is a typical montane species distributed mainly in the coastal part of Croatia from Velebit in the north to Biokovo in the south. It must be noted, that there are no recent records for the species from Velebit (MIHOČI *et al.*, 2007), however it has been recorded recently from nearby Poštak (KOREN *et al.*, 2015b) and Dinara (TVRKOVIĆ *et al.*, 2012). KAČIREK (2017) reports only a single specimen observed in 1990 for Biokovo, but a numerous population was observed there in 2018 on Sveti Jure at an altitude of approximately 1500 m (Koren, pers. observ.). Thus, it came as a big surprise to find the species on humid meadows near Blaca at an altitude of only 400 m. Only a single specimen was observed at the locality, even after an exhaustive search.

*Pyrgus sidae* (Esper, 1784)

This is another local skipper in Croatia with distribution extending from the Mt Poštak in the north (KOREN *et al.*, 2015b) to southern Dalmatia (KOREN, pers. observ.). It is usually sporadic and occurs in low densities, so it is hard to detect. It is reported as being widespread in the environs of Split and Kaštela by STAUDER (1911) and was recorded also from northern slopes of Biokovo (MIHOČI *et al.*, 2011), therefore its rediscovery on Kozjak was expected. Only a single specimen was observed along the ridge E of Malačka pass.

*Parnassius mnemosyne* (Linnaeus, 1758)

As a mesophilous species linked to large stands of its host plant *Corydalis* spp. it is very rare in Dalmatia, reported only from higher altitudes on Mt Dinara and Mt Troglav (TVRKOVIĆ *et al.*, 2012), Mt Kamešnica (KOREN & LAUŠ, 2013), and from Biokovo (KAČIREK, 2017). As Mt Kozjak does not reach high altitudes and is entirely covered by thermophilic vegetation its discovery on the ridge E of Sveti Luka peak was entirely unexpected. Several specimens were observed feeding on flowers on partially overgrown pastures. This indicates the species is possibly resident here, despite the fact that no host plants were observed.

*Papilio alexanor* Esper, 1800

Despite its prominence and an active search the species remained hidden for several decades and was therefore considered as a data deficient species for Croatia (ŠAŠIĆ *et al.*, 2013). Only recently has it been observed at several localities in central and southern Dalmatia (see review by VEROVNIK & ŠVARA, 2016). The southern slope of Mt Kozjak is one of the few precise historical localities for the species (STAUDER, 1911; 1921-1923), therefore most of our spring surveys were directed towards the rediscovery of *P. alexanor*. We succeeded only in 2017 when several specimens were observed along the ridge E of Malačka pass, at Biranj, and E of Sveti Luka peak. The larval host plant *Opopanax chironium* (L.) Koch. was found in low densities at all above mentioned localities. The species is more widespread in southern Dalmatia (KOREN pers. observ.) but it is generally hard to detect due to its remote and inaccessible habitats on steep rocky slopes and its short flight period.

*Euchloe ausonia* (Hübner, 1804)

First noted for Kaštel Stari below Mt Kozjak by STAUDER (1921-1923). This Mediterranean species reaches its northern border in Croatia on Pag Island (ZAKŠEK, 2005) and has also been observed at a few sites in northern Dalmatia (KOREN *et al.*, 2011; VEROVNIK *et al.*, 2015). It is more widespread further south in Dalmatia including Biokovo (MIHOČI *et al.*, 2011) and the surroundings of Dubrovnik (BURGERMEISTER, 1964). We found the species to be relatively widespread on southern slopes and along the ridge, but never abundant, especially in the second generation.

*Cupido osiris* (Meigen, 1829)

Not much is known about the distribution of this little blue in Croatia with published records only from the wider surroundings of Knin (HAFNER, 1994), Poštak (KOREN *et al.*, 2015b), Makarska (HABELER, 1976) and Dubrovnik surroundings (BURGERMEISTER, 1964). Additional unpublished records (VEROVNIK pers. observ.) are also from that region (Zrmanja spring, S slopes of Mt Dinara), therefore the discovery of a new population near Blace north of the main ridge of Mt Kozjak is of great significance. Although the site is characterised by an abundance of the larval host plant *Onobrychis* spp., only a few adult individuals were observed.

*Polyommatus admetus* (Esper, 1783)

The first reliable records for this blue in Croatia come from the surroundings of Knin at the beginning of the 20<sup>th</sup> century (HAFNER, 1994), however its presence in Croatia long remained doubtful (LORKOVIĆ, 2009). During more intensive surveys in recent years several new populations of this local species have been discovered mainly from Lika (TVRTKOVIĆ *et al.*, 2015) and the northern Dalmatia hinterland (KOREN, 2010; KOREN *et al.*, 2011) including Mt Poštak (KOREN *et al.*, 2015b) and Mt

Dinara and its foothills along the Cetina River (KOREN, 2010). An unconfirmed record from the higher altitudes of Mt Kozjak is mentioned by STAUDER (1921-1923) but elsewhere in central and southern Dalmatia the species was not yet recorded. Several fresh males were observed on overgrown pastures in the vicinity of oak wood patches E of Sveti Luka peak, confirming its presence on the mountain. Interestingly, we have not found the species near Blaca, despite large stands of the potential larval host plant *Onobrychis* spp.

*Hyponephele lycaon* (Rottenburg, 1775)

The distribution of *H. lycaon* in Dalmatia is not well understood due to the presence of the very similar *Hyponephele lupine* (Costa, 1836) with which it can be syntopic (VEROVNIK pers. observ.). Both species are however very rare in Croatia and *H. lycaon* seems to be limited to higher altitudes. So far it has been recorded from higher altitudes on Mt Učka (REBEL, 1913), Mt Poštak (KOREN *et al.*, 2015b), Mt Dinara (TVRTKOVIĆ *et al.*, 2012) and Biokovo (MIHOČI *et al.*, 2011). We found the species together with *Polyommatus admetus* along oak wood margins E of Sveti Luka peak, but in greater numbers. STAUDER (1921-1923) mentions *H. lupine* for Kaštel Stari, but this record was not confirmed by our surveys.

Given the small size of the studied area and the lack of habitat diversity the number of observed butterfly species is unexpectedly high. That said there are still some species that will likely be discovered in the future. Among these *Tarucus balkanicus* (Freyer, 1844) is the most prominent example, as its habitat including larval host plant *Paliurus spina-christi* Mill. is dominant in the lower parts of the southern slopes of the mountain. Contiguous abandonment of pasturing, on the other hand, could pose the threat of local extinction for many rare grassland species that we were still able to detect. Restoring of light grazing, as was traditionally applied in many regions of Dalmatia, would help maintaining open grassland habitats which host the largest butterfly diversity on Mt Kozjak.

### Acknowledgements

We are grateful to Boris Lauš and Ana Štih for company during field trips. This survey was conducted within research permits from Croatian Ministry of Environment and Energy (KLASA: UP/I-612-07/16-48/66, URBROJ: 517-07-1-1-1-16-4; KLASA: UP/I-612-07/17-48/79, URBROJ: 517-07-1-1-1-17-4; KLASA: UP/I-612-07/18-48/55, URBROJ: 517-07-1-1-1-18-4).

Received December 5, 2018

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## Sažetak

### Prilog fauni danjih leptira (Lepidoptera: Papilionoidea) planine Kozjak, Split, Hrvatska

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Planina Kozjak izduženi je planinski greben smješten u središnjoj Dalmaciji, iznad Kaštela u blizini Splita. Južne su padine Kozjaka vrlo strme i nepristupačne dok su sjeverne padine manje strme i otvaraju se u visoravan koji se postupno spušta prema Dalmatinskoj zagori. Jedini istraživač leptira Kozjaka bio je i jedan od naj eminentnijih lepidopterologa početka 20. stoljeća, Hermann Stauder. On je istraživao područje Kozjaka prije više od 100 godina te tamo zabilježio 38 vrsta danjih leptira. Područje Kozjaka obilazili smo od 2007. do 2018. godine te smo ukupno zabilježili 82 vrste danjih leptira, a zajedno s nalazima iz literature za područje Kozjaka poznato je ukupno 87 vrsta danjih leptira. Najzanimljiviji nalaz je i potvrda Stauderovog nalaza južnog lastinog repa, *Papilio alexanor*, na nekoliko lokacija na Kozjaku. Osim južnog lastinog repa, na području Kozjaka zabilježili smo i druge rijetke ili zanimljive vrste o kojima dodatno raspravljamo u radu: *Carcharodus orientalis*, *Pyrgus sidae*, *Pyrgus serrataluae*, *Parnassius mnemosyne*, *Euchloe ausonia*, *Cupido osiris*, *Polyommatus admetus* i *Hyponephele lycaon*. Fauna leptira planine Kozjak vrlo je raznolika s obzirom na njen geografski položaj, nisku raznolikost staništa i veličinu. Nakon ovog istraživanja područje Kozjaka možemo svrstati u najistraženije dijelove središnje Dalmacije.

