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BUTTERFLY FAUNA (PAPILIONOIDEA & HESPERIOIDEA) IN THE SURROUNDING AREA OF KARLOVAC, CROATIA

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This paper represents the first systematic butterfly checklist of the surrounding area of Karlovac. The research into butterfly fauna diversity was carried out during the period 2001-2007. Sixty four butterfly species were recorded. Adding species from literature sources, the total number on checklist rises to 74, representing 37.95% of the butterfly fauna of Croatia. Forty eight butterfly species were recorded for the first time in this area, and ten species from older literature sources need to be confirmed in future surveys. Records of species are noted with sites and dates of findings. Faunistic and biogeographical analyses were made, as well as a short overview of threats, legislative protection and habitat preferences of the species.

Keywords: butterflies, fauna, biogeography, habitat, protection, Karlovac

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Ovaj rad predstavlja prvi sustavni popis vrsta danjih leptira u okolici Karlovca. Istraživanje faune danjih leptira provedeno je u razdoblju od 2001. do 2007. godine. Utvrđene su 64 vrste danjih leptira koje s dosadašnjim literaturnim podacima za Karlovac daju listu od 74 vrste, odnosno 37,95% faune danjih leptira Hrvatske. Po prvi puta za okolicu Karlovca je utvrđeno 48 vrsta, a deset vrsta iz starijih izvora će trebati potvrditi budućim istraživanjima. Nalazi su navedeni s lokalitetima i datumima opažanja vrsta. Napravljena je faunistička i biogeografska analiza, te kratki pregled ugroženosti, propisane zaštite i vezanosti vrsta za tipove staništa.

Ključne riječi: danji leptiri, fauna, biogeografija, staništa, zaštita, Karlovac

INTRODUCTION

So far, there have been very few scientific or other publications concerning the butterflies of the Karlovac area or the wider geographic region named Kordun. The only data referring to this little-researched area were given by JAKŠIĆ (1988) in the »Provisional distribution maps of butterflies of Yugoslavia« and TABORSKY (1910) who listed 21 butterfly species recorded in the western part of Karlovac. The closest locations in which butterflies were systematically studied were: the surroundings of the upper course of the Kupa River (LORKOVIĆ & MLADINOV, 1971; MLADINOV, 1978, 1983; MLADINOV & LORKOVIĆ, 1985), surroundings of Zagreb (VUKOTINOVIĆ, 1879; GRUND, 1905, 1907–08, 1913, 1916, 1918; STEINER, 1916; LORKOVIĆ, 1990; etc.), Mt. Žumberačka gora (BOJANIĆ, 2001), Klek mountain (PERKOVIĆ, 2005; MIHOCI *et al.*, 2007), Turopolje region (PAVELIĆ, 1996) and Plitvice Lakes National Park (LORKOVIĆ,

1954; KUČINIĆ, 1999; ŠAŠIĆ, 2004). All of these studied areas border on the Kordun region which has always been just a temporary stop for researchers.

Previous studies have mostly been linked to certain types of habitats (mountains, wetlands and rivers), or protected natural areas: Samoborsko i Žumberačko gorje Nature Park, Risnjak National Park, Plitvice Lakes National Park, Klek Significant Landscape. Therefore, while expecting to find many species that were never before recorded and published in this area, the main objective of this study was to explore the diversity of butterflies and to compile for the first time a checklist of butterfly fauna of the surrounding area of Karlovac.

While previous studies mostly involved natural habitats, this study focused on anthropogenic peripheral areas of the city of Karlovac (semi-natural habitats). Sampling sites were chosen because of the heterogeneity of habitats and to achieve a more complete picture of the composition of the butterfly fauna.

MATERIAL AND METHODS

The city of Karlovac is situated in the central part of Croatia, at latitude 45°, 29', 34'' N and longitude 15°, 33', 31'' E, 55 kilometres southwest of the capital city Zagreb (Fig. 1).

Research into the butterfly fauna in area surrounding Karlovac was conducted during seven vegetation seasons, and included four sites that are close to each other, and a single-day research in 2006 at one separate site (Fig. 2). The period of

Fig. 1. Researched area on the map of Croatia

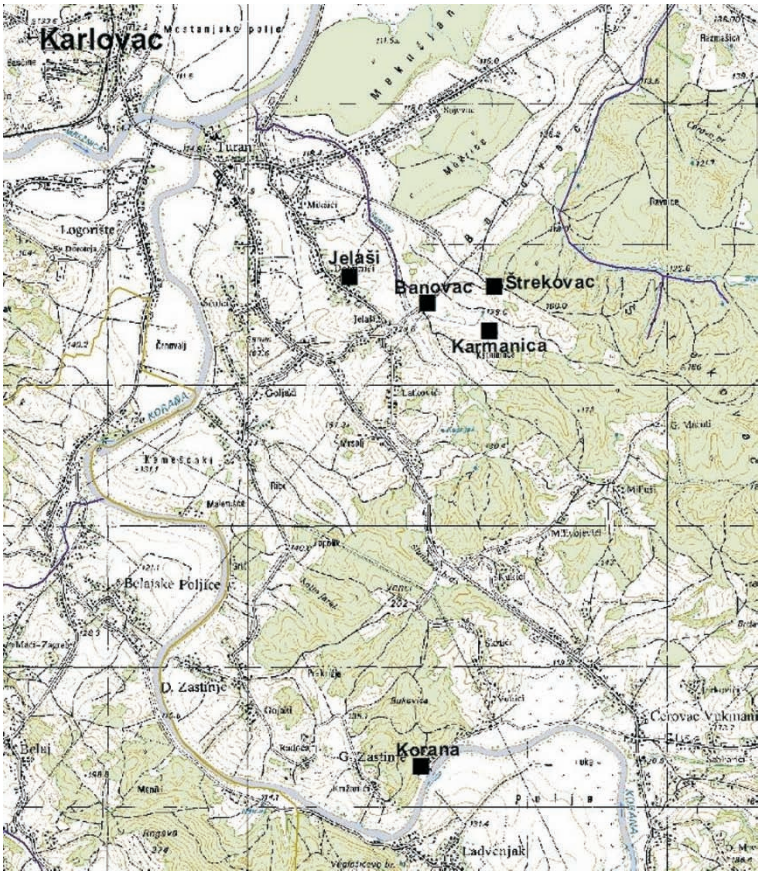

Fig. 2. Researched sites in the surroundings of Karlovac

seven years was not predefined. That means that survey lasted until there were no new butterfly species to be recorded at the sites, following the main goal of this paper – to explore the diversity of butterflies in the surrounding area of Karlovac. The research was carried out from February to October during the middle of the days with less than 50% cloud cover.

The Jelaši site is a suburb of Karlovac with agricultural areas and mowing meadows that phytocoenologically belong to *Molinio-Arrhenatheretea* R. Tüxen 1937 class. The Banovac site includes a transitional landscape between a suburb and woodland. It consists of former agricultural areas recently overgrown by shrubs belonging to *Prunetalia spinosae* R. Tüxen 1952 order. The Karmanica site stretches over a damp boscage area along the stream, overgrown by vegetation belonging to associations of *Equiseto-Scirpetum sylvaticae* Šegulja, 1974 and *Alnetum glutinoso-incanae* BR.-BL., 1915. The Štrekovac site represents the edge of the forest. The forest in the higher places of this hilly area is out of the reach of flood waters and belongs to the association *Carpino betuli-Quercetum roboris fagetosum* Rauš, 1971. The fifth site was visited just once, in 2006, on the bank of Korana River, next to the village of Vukmanički Cerovac, south of Karlovac.

Butterflies were collected with an entomological net, identified and released. One or a few individuals of each species identified in this study were caught and prepared for a private collection. In the period 2001–2005 sites were visited at irregular intervals. In 2006 four sites were visited in a more detailed way: Jelaši 13, Banovac 10, Štrekovac 9 and Karmanica 9 times, and in 2007 one site was visited 8 times (Štrekovac). These surveys were done on average once every two weeks, with variations in the intervals for any period with bad weather conditions.

Determination of species regarding wing morphology was done according to TOLMAN & LEWINGTON (1997), STILL (1996), BENTON & BERNHARD (2006) and STERRY & MACKAY (2004). Individuals from the *Leptidea* genus were identified from genital morphology according to JAKŠIĆ (1998) and LELO (2002, 2003).

Systematics follows KARSHOLT & RAZOWSKI (1996). Concerning the biogeographical analysis the faunal types of each species (Tab. 1) are noted according to VARGA *et al*. (2005). The percentage proportions of particular faunal types of butterflies were calculated (Tab. 3).

Conservation and protection statuses of recorded species at the national level are evaluated using the Red List of Butterflies of Croatia (ŠAŠIĆ & KUČINIĆ, 2004) and the Ordinance on the proclamation of protected and strictly protected wild taxa, Official Gazette 99/09 (ANON., 2009). At the European and global level, conserva-

Tab. 1. List of butterfly fauna with all records of sites and dates of species findings during researched period 2001–2007, following the systematics of KARSHOLT & RAZOWSKI (1996)

Sites and dates of species findings	FC[1]	FT[2]
HESPERIOIDEA **Hesperiidae**		
Erynnis tages (Linnaeus, 1758) – Banovac: *May 4 th, May 11th, July 20th (2006);* Karmanica*: May 11th, July 31th (2006);* Štrekovac: *April 27th (2005); April 20th, May 4th, May 11th, July 20th (2006); April 6th, June 27th (2007)*	2	2c
Pyrgus malvae (Linnaeus, 1758) – Jelaši: *July 30th, (2006);* Banovac: *April 27th (2005); May 4th, July 20th (2006);* Karmanica: *May 11th (2006);* Štrekovac: *July 27th (2005); May 11th, July 20th (2006); April 6th, May 12th (2007)*	2	2c
Heteropterus morpheus (Pallas, 1771) – Karmanica: *July 6th (2006);* Štrekovac: *June 27th (2007)*	24	4b
Carterocephalus palaemon (Pallas, 1771) – Jelaši: *May 18th (2007)*	16	3a
Thymelicus lineola (Ochsenheimer, 1808) – Banovac: *June 20th (2006);* Karmanica: *June 22th (2006)*	2	2c
Thymelicus sylvestris (Poda, 1761) – Karmanica: *July 6th (2006);* Štrekovac: *June 20th (2006); June 11th (2007)*	2	2c
Ochlodes venata (Bremer & Grey, 1853) – Jelaši: *July 20th (2006);* Karmanica: *July 27th, July 31th (2006);* Štrekovac: *May 18th th, July 7th (2006); May 25th (2007);* Korana: *July 1th (2006)*	2	2b
PAPILIONOIDEA **Papilionidae**		
Iphiclides podalirius (Linnaeus, 1758) – Jelaši: *June 29th (2003); June 26th, July 24th (2004); May 1th th, July 16th (2005); July 7th, July 15th (2006); April 23th (2007);* Karmanica: *July 6th, July 27th (2006);* Štrekovac: *July 7th, July 20th (2006); August 14th (2007)*	3	5d
Papilio machaon Linnaeus, 1758 – Jelaši: *June 21th (2005); May 6th, June 22th, July 30th (2006);* Banovac: *April 20th, April 22th, May 11th (2006);* Karmanica: August 17th (2006); Štrekovac: *April 20th, May 4th, May 11th (2006); April 6th, April 20th, May 12th, June 11th, July 21th (2007)*	7	2a

Pieridae		
Leptidea sinapis (Linnaeus, 1758) – Jelaši: *June 20th, August 29th (2001); July 13th, July 24th (2004); April 21th, May 6th, May 13th, June 20th, June 22th, June 25th, July 7th, July 20th, July 30th, August 19th (2006);* Banovac: *April 20th, April 22th, May 4th, May 11th, May 18th, June 20th, July 7th, August 18th (2006);* Karmanica: *August 9th (2004); May 11th, May 18th, June 22th, July 6th, July 27th, July 31th, August 17th (2006);* Štrekovac: *August 4th (2004); April 27th (2005); April 20th, May 4th, May 11th, May 18th, June 20th, July 7th, July 20th, August 18th, September 11th (2006); April 6th, April 20th, May 12th, May 25th, June 11th, June 27th, July 21th, August 14th (2007)*	2	5a
Anthocharis cardamines (Linnaeus, 1758) – Štrekovac: *April 20th, May 4th, May 11th, May 18th, July 20th (2006); April 6th (2007)*	15	2c
Pieris brassicae (Linnaeus, 1758) – Jelaši: *August 3th (2004);* Karmanica: *July 6th (2006)*	2	2a
Pieris mannii (Mayer, 1851) – Jelaši: *August 6th (2004); July 30th (2006);* Štrekovac: *May 4th (2006)*	19	5d
Pieris rapae (Linnaeus, 1758) – Jelaši: *July 30th, August 19th (2006)*	2	2c
Pieris napi (Linnaeus, 1758) – Jelaši: *June 29th (2003); June 17th, July 15th, August 19th (2006);* Štrekovac: *May 4th, June 20th (2006);* Banovac: *June 20th (2006)*	2	2a
Colias croceus (Fourcroy, 1785) – Jelaši: *July 20th, August 4th (2004); July 15th, July 20th, July 30th, August 19th, September 11th (2006);* Banovac: *July 20th, August 18th (2006);* Karmanica: *August 9th (2004); June 22th, July 6th, July 27th, July 31th, August 17th, September 7th (2006);* Štrekovac: *July 20th, August 18th, September 11th (2006); June 27th, July 21th, August 14th (2007)*	13	1a
Gonepteryx rhamni (Linnaeus, 1758) – Jelaši: *July 19th, August 6th (2004); Mart 22th, April 2th, May 1th, June 22th (2005); Mart 22th, April 9th, April 17th, May 6th, May 13th, June 17th, June 20th, June 22th, July 7th, July 20th, July 30th (2006); February 24th, Mart 3th, Mart 13th (2007);* Banovac: *April 20th, April 22th, May 4th, May 11th, May 18th, June 20th, June 25th (2006); February 24th (2007);* Karmanica: *April, 14th, May 11th, May 18th, June 22th, July 6th, August 17th (2006);* Štrekovac: *April 27th (2005); April 20th, May 4th, May 11th, May 18th, June 20th, July 7th, August 18th (2006); Mart 8th, Mart 16th, April 6th, April 20th, May 12th, July 21th, August 14th (2007)*	15	2c
Lycaenidae		
Hamearis lucina (Linnaeus, 1758) – Štrekovac: *July 27th (2005); April 20th, July 20th (2006); April 6th (2007)*	9	5b
Lycaena phlaeas (Linnaeus, 1761) – Štrekovac: *July 20th (2005); May 18th, July 20th (2006); June 27th, August 14th (2007)*	2	2a
Lycaena dispar (Haworth, 1802) – Jelaši: *July 20th (2003); June 25th, July 20th, July 30th, August 19th (2006);* Banovac: *August 18th (2006);* Karmanica: *July 27th, July 31th, August 17th, September 7th (2006);* Štrekovac: *July 20th, August 18th (2006); August 14th (2007)*	8	2c
Lycaena tityrus (Poda, 1761) – Jelaši: *July 20th, July 30th (2006);* Banovac: *May 11th (2006);* Karmanica: *May 18th, July 27th, July 31th, August 17th (2006);* Štrekovac: *May 11th, May 18th, July 20th, August 18th (2006); May 12th (2007)*	6	5a
Lycaena alciphron (Rottemburg, 1775) – Štrekovac: *June 20th (2006)*	12	5a
Thecla betulae (Linnaeus, 1758) – Jelaši: *September 11th (2006)*	22	2c
Callophrys rubi (Linnaeus, 1758) – Štrekovac: *May 12th, May 25th (2007)*	6	2b
Satyrium spini (Denis & Schiffermüller, 1775) – Korana: *July 1th (2006)*	9	5b
faauto***Satyrium ilicis*** (Esper, 1779) – Štrekovac: *June 11th (2007)*	20	5b
Cupido argiades (Pallas, 1771) – Jelaši: *July 20th (2006);* Banovac: *May 18th (2006);* Karmanica: *August 17th (2006);* Štrekovac: *April 27th (2005); May 18th (2006); June 11th (2007)*	2	2c
Celastrina argiolus (Linnaeus, 1758) – Jelaši: *September 11th (2006);* Karmanica: *July 31th (2006);* Štrekovac: *May 4th (2006); June 11th (2007);* Korana: *July 1th (2006*	2	2a
Plebeius argus (Linnaeus, 1758) – Štrekovac: *July 20th (2006)*	7	2c
Plebeius idas (Linnaeus, 1761) – Jelaši: *July 20th, September 11th (2006);* Karmanica: *July 31th, August 17th (2006)*	23	2a

Polyommatus icarus (Rottemburg, 1775) – Jelaši: *July 5th (2003); July 20th (2006); May 18th (2007);* Banovac: *June 20th (2006);* Karmanica: *July 27th, August 17th (2006);* Štrekovac: *August 16th (2003); July 25th, July 27th (2005); June 20th, July 20th, August 18th (2006); May 25th (2007)*	2	2c
Nymphalidae		
Argynnis paphia (Linnaeus, 1758) – Štrekovac: *August 18th (2006)*	15	2c
Argynnis adippe (Denis & Schiffermüller, 1775) – Karmanica: *June 22th (2006);* Štrekovac: *August 7th (2003); July 25th (2005)*	7	2c
Issoria lathonia (Linnaeus, 1758) – Štrekovac: *August 9th (2004)*	2	2c
Brenthis ino (Rottemburg, 1775) – Jelaši: *June 17th (2006)*	6	3b
Brenthis daphne (Denis & Schiffermüller, 1775) – Štrekovac: *June 20th (2006); May 12th, May 25th, June 11th (2007)*	1	4a
Boloria selene (Denis & Schiffermüller, 1775) – Karmanica: *July 31th, August 17th (2006)*	6	3b
Boloria dia (Linnaeus, 1767) – Karmanica: *July 31th, August 17th (2006)*	2	2c
Vanessa atalanta (Linnaeus, 1758) – Jelaši: *August 15th (2003); July 1th, July 22th, August 3th (2004); June 22th (2005); July 7th, July 15th, July 30th, August 19th, September 11th, October 24th (2006);* Banovac: *August 18th, October 22th (2006);* Karmanica: *August 9th (2004); July 6th, July 27th, July 31th (2006);* Štrekovac: *July 24th (2005); July 7th, July 20th, August 18th, September 11th (2006)*	13	5a
Vanessa cardui (Linnaeus, 1758) – Jelaši: *August 15th (2003); June 25th, July 15th, July 20th (2006);* Banovac: *July 7th, July 20th, August 18th (2006);* Karmanica: *July 6th (2006)*	13	1b
Inachis io (Linnaeus, 1758) – Jelaši: *July 23th (2003); May 3th, July 10th (2005); July 20th, August 19th (2006); Mart 13th (2007);* Banovac: *April 22th, May 4th, May 11th, June 25th, July 20th, August 18th (2006); Mart 16th (2007);* Karmanica: *July 6th, August 17th, September 7 th (2006);* Štrekovac: *April 27th (2005); April 20th, May 4th, July 7th, July 20th (2006); Mart 8th, April 6th, April 20th, June 11th (2007);* Korana: *July 1th (2006)*	15	2c
Polygonia c-album (Linnaeus, 1758) – Jelaši: *August 10th (2001); June 20th, July 30th (2006);* Banovac: *May 11th, June 20th, July 20th, August 18th (2006);* Karmanica: *August 4th (2004); August 17th (2006);* Štrekovac: *August 9th (2004); July 24th (2005); June 20th, July 20th, August 18th, September 11th (2006); April 6th, May 25th, June 11th, July 21th (2007)*	15	2c
Araschnia levana (Linnaeus, 1758) – Jelaši: *July 6th (2005); June 20th, June 22th, June 25th, July 30th (2006);* Banovac: *April 22th, May 4th, May 11th, June 20th, June 25th (2006);* Karmanica: *June 22th, July 27th, July 31th, August 17th (2006);* Štrekovac: *August 6th (2002); April 27th (2005); May 4th, May 11th, June 20th, July 20th, August 18th (2006); April 6th, April 20th, June 11th, July 21th, August 14th (2007)*	15	2c
Nymphalis antiopa (Linnaeus, 1758) – Jelaši: *July 7th (2006);* Banovac: *April 26th (2005); May 4th (2006);* Karmanica: *July 6th (2006)*	14	2a
Nymphalis polychloros (Linnaeus, 1758) – Jelaši: *August 20th (2001); June 20th (2006);* Štrekovac: *April 20th, June 20th (2006); April 6th (2007)*	15	5e
1020407 ***Euphydryas aurinia*** (Rottemburg, 1775) – Karmanica: *May 11th, May 18th (2006)*	6	2c
Melitaea cinxia (Linnaeus, 1758) – Jelaši: *July 21th (2003); May 18th (2007);* Štrekovac: *July 21th (2001)*	6	5a
Melitaea phoebe (Denis & Schiffermüller, 1775) – Karmanica: *August 17th (2006);* Štrekovac: *May 11th (2006)*	11	4a
Melitaea didyma (Esper, 1778) – Karmanica: *July 6th (2006);* Štrekovac: *July 25th (2005); July 20th (2006)*	10	5a
Melitaea diamina (Lang, 1789) – Štrekovac: *June 20th (2006)*	6	4a
Melitaea athalia (Rottemburg, 1775) – Jelaši: *June 17th, June 25th, July 30th, August 19th (2006); May 18th (2007);* Banovac: *June 20th (2006);* Karmanica: *May 18th, June 22th, July 21th, July 31th, August 17th (2006);* Štrekovac: *May 11th, May 18th, June 20th, July 20th, August 18th (2006); May 12th, May 25th (2007)*	7	2c

Neptis sappho (Pallas, 1771) – Jelaši: *July 7th, July 20th (2006);* Banovac: *May 18th, July 7th (2006);* Karmanica: *July 6th, July 27th, July 31th, August 17th, September 7th (2006);* Štrekovac: *July 25th (2005); May 4th, May 11th, May 18th, July 7th, July 20th, August 18th, September 11th (2006); April 20th, May 12th, May 25th, June 11th, June 27th, July 21th, August 14th (2007)*	17	4a
Neptis rivularis (Scopoli, 1763) – Korana: *July 1th (2006)*	5	4a
Apatura ilia (Denis & Schiffermüller, 1775) – Banovac: *June 20th (2006);* Štrekovac: *June 11th (2007)*	18	2d
Pararge aegeria (Linnaeus, 1758) – Banovac: *August 18th (2006);* Karmanica: *August 17th (2006);* Štrekovac: *July 5th (2003); August 18th, September 11th (2006); May 12th, May 25th, August 14th (2007)*	21	5b
Lasiommata megera (Linnaeus, 1767) – Jelaši: *August 16th (2001); August 16th (2002); July 7th (2006);* Štrekovac: *April 20th, July 21th, August 14th (2007)*	2	5b
Coenonympha arcania (Linnaeus, 1761) – Karmanica*: July 6th (2006);* Štrekovac: *June 20th (2006); May 12th, June 11th, June 27th (2007)*	4	5b
Coenonympha pamphilus (Linnaeus, 1758) – Jelaši: *June 17th, June 22th, July 7th, July 20th, August 19th, September 11th (2006);* Banovac: *May 11th, May 18th, June 20th, June 25th, July 20th (2006);* Karmanica: *May 11th, May 18th, June 22th, July 6th, July 27th, July 31th, August 17th (2006);* Štrekovac: *May 11th, May 18th, June 20th, July 20th, August 18th (2006); May 25th, June 11th, June 27th, July 21th, August 14th (2007)*	2	2c
Pyronia tithonus (Linnaeus, 1767) – Karmanica: *July 27th (2006);* Štrekovac: *July 25th (2005); July 20th (2006); July 21th (2007)*	6	5b
Aphantopus hyperantus (Linnaeus, 1758) – Banovac: *June 20th (2006);* Karmanica: *June 22th, July 6th (2006);* Štrekovac: *June 20th, July 7th (2006)*	7	2c
Maniola jurtina (Linnaeus, 1758) – Jelaši: *July 17th (2001); August 7th (2003); August 4th, June 24th, July 1th, August 12th (2004); June 17th, June 20th, June 22th, June 25th, July 15th, July 20th (2006);* Banovac: *June 20th, July 7th, July 20th, August 18th (2006);* Karmanica: *August 9th (2004); June 22th, July 6th, July 27th, July 31th, August 17th, September 7th (2006);* Štrekovac: *June 20th, July 7th, July 20th, August 18th, September 11th (2006); May 12th, May 25th, June 11th, June 27th, July 21th, August 14th (2007);* Korana: *July 1th (2006)*	2	5b
Melanargia galathea (Linnaeus, 1758) Jelaši: *August 12th (2004); July 15th (2005); June 22th (2006);* Banovac: *June 20th, July 7th, July 20th (2006);* Karmanica: *June 22th, July 6th (2006);* Štrekovac: *June 29th, August 7th, August 15th (2003); July 25th (2005); June 20th, July 7th, July 20th (2006); June 11th, June 27th, July 21th (2007);* Korana: *July 1th (2006)*	11	5c
Minois dryas (Scopoli, 1763) – Karmanica: *August 4th (2004); July 27th, July 31th (2006);* Štrekovac: *August 7th (2003); August 9th (2004); July 25th (2005); July 20th (2006); July 21th (2007)*	6	4a
Brintesia circe (Fabricius, 1775) – Karmanica: *July 6th, September 7th (2006);* Štrekovac: *July 7th, July 20th, August 18th (2006); June 11th, June 27th (2007);* Korana: *July 1th (2006)*	4	5b

[1] – marks of faunal component according to Varga *et al*. (2005) listed in Tab. 3.
[2] – marks of faunal types according to Varga *et al*. (2005) listed in Tab. 4.

tion and protection statuses of recorded species are evaluated in the Red Data Book of European Butterflies (VAN SWAAY *et al*., 2010), IUCN Red List of Threatened Species (IUCN, 2011), Appendices of the Bern Convention (ANON., 1979) and Annexes of the Habitat Directive 92/43/EEC (ANON., 1992).

RESULTS AND DISCUSSION

Faunistic analysis

In the surrounding area of Karlovac a total of 64 species of butterflies were recorded from 2001 until 2007. Dates and sites where the species were recorded are noted in Tab. 1. At four researched sites during the seven years, 62 species of

Tab. 2. Comparison of butterfly fauna of the environs of Karlovac currently recorded with former research into the butterflies of Karlovac, listed by the systematic of KARSHOLT & RAZOWSKI (1996)

Species	TABORSKY, 1910	JAKŠIĆ, 1988	This work
HESPERIOIDEA			
Hesperiidae			
Erynnis tages (Linnaeus, 1758)			+
Pyrgus malvae (Linnaeus, 1758)			+
Heteropterus morpheus (Pallas, 1771)			+
Carterocephalus palaemon (Pallas, 1771)			+
Thymelicus lineola (Ochsenheimer, 1808)			+
Thymelicus sylvestris (Poda, 1761)			+
Ochlodes venata (Bremer & Grey, 1853)			+
PAPILIONOIDEA			
Papilionidae			
Parnassius mnemosyne (Linnaeus, 1758)[1]			
Iphiclides podalirius (Linnaeus, 1758)	+		+
Papilio machaon Linnaeus, 1758			+
Pieridae			
Leptidea sinapis (Linnaeus, 1758)			+
Anthocharis cardamines (Linnaeus, 1758)			+
Aporia crataegi (Linnaeus, 1758)	+	+	
Pieris brassicae (Linnaeus, 1758)			+
Pieris mannii (Mayer, 1851)			+
Pieris rapae (Linnaeus, 1758)			+
Pieris napi (Linnaeus, 1758)	+		+
Pontia daplidice (Linnaeus, 1758)	+		
Colias croceus (Fourcroy, 1785)			+
Colias hyale (Linnaeus, 1758)	+		
Gonepteryx rhamni (Linnaeus, 1758)		+	+
Lycaenidae			
Hamearis lucina (Linnaeus, 1758)			+
Lycaena phlaeas (Linnaeus, 1761)			+
Lycaena dispar (Haworth, 1802)	+		+
Lycaena virgaureae (Linnaeus, 1758)		+	
Lycaena tityrus (Poda, 1761)	+	+	+
Lycaena alciphron (Rottemburg, 1775)			+
Lycaena thersamon (Esper, 1784)	+	+	
Thecla betulae (Linnaeus, 1758)			+
Callophrys rubi (Linnaeus, 1758)			+
Satyrium spini (Denis & Schiffermüller, 1775)			+
Satyrium ilicis (Esper, 1779)			+
Cupido argiades (Pallas, 1771)			+
Celastrina argiolus (Linnaeus, 1758)			+
Pseudophilotes vicrama (Moore, 1865)	+	+	
Plebeius argus (Linnaeus, 1758)	+		+
Plebeius idas (Linnaeus, 1761)			+
Polyommatus icarus (Rottemburg, 1775)	+	+	+
Polyommatus bellargus (Rottemburg, 1775)	+	+	

Nymphalidae			
Argynnis paphia (Linnaeus, 1758)			+
Argynnis adippe (Denis & Schiffermüller, 1775)	+		+
Issoria lathonia (Linnaeus, 1758)			+
Brenthis ino (Rottemburg, 1775)			+
Brenthis daphne (Denis & Schiffermüller, 1775)	+		+
Boloria euphrosyne (Linnaeus, 1758)		+	
Boloria selene (Denis & Schiffermüller, 1775)			+
Boloria dia (Linnaeus, 1767)			+
Vanessa atalanta (Linnaeus, 1758)			+
Vanessa cardui (Linnaeus, 1758)			+
Inachis io (Linnaeus, 1758)			+
Aglais urticae (Linnaeus, 1758)	+		
Polygonia c-album (Linnaeus, 1758)			+
Araschnia levana (Linnaeus, 1758)			+
Nymphalis antiopa (Linnaeus, 1758)		+	+
Nymphalis polychloros (Linnaeus, 1758)			+
Euphydryas aurinia (Rottemburg, 1775)			+
Melitaea cinxia (Linnaeus, 1758)	+		+
Melitaea phoebe (Denis & Schiffermüller, 1775)	+		+
Melitaea didyma (Esper, 1778)			+
Melitaea diamina (Lang, 1789)			+
Melitaea athalia (Rottemburg, 1775)	+		+
Neptis sappho (Pallas, 1771)			+
Neptis rivularis (Scopoli, 1763)	+		+
Apatura ilia (Denis & Schiffermüller, 1775)			+
Pararge aegeria (Linnaeus, 1758)			+
Lasiommata megera (Linnaeus, 1767)			+
Coenonympha arcania (Linnaeus, 1761)	+		+
Coenonympha pamphilus (Linnaeus, 1758)			+
Pyronia tithonus (Linnaeus, 1767)			+
Aphantopus hyperantus (Linnaeus, 1758)			+
Maniola jurtina (Linnaeus, 1758)	+		+
Melanargia galathea (Linnaeus, 1758)			+
Minois dryas (Scopoli, 1763)			+
Brintesia circe (Fabricius, 1775)			+

[1] – deposited in the Croatian Natural History Museum in Zagreb (MLADINOV, 1973)

butterflies were found, and two butterfly species (*Satyrium spini* (Denis & Schiffermüller, 1775) and *Neptis rivularis* (Scopoli, 1763)) were caught 3 km away from selected sites (on a bank of the Korana River next to the village of Vukmanički Cerovac). This shows that a very little distance from the city area can lead to a new species if the research is done in a heterogeneous environment. Accordingly, it is necessary to explore other areas around the city of Karlovac in order to determine the total number of species of the surrounding region, especially the river banks of four rivers in and around Karlovac.

The butterfly fauna of Croatia consists of 195 species of butterflies (TVRTKOVIĆ *et al.*, 2010). The butterfly fauna of the surroundings of Karlovac recorded in this survey counts 64 species, which represents 32.82% of Croatian fauna. All five but-

Tab. 3. Proportions of individual faunal components according to VARGA *et al*. (2005)

#	Faunal component of species	Number proportion	Percentage proportion (%)
1	Altoherbosa-nemoral (tall-forb forest habitat) species	1	1,5625
2	Euryoecious species	18	28,1250
3	Euryoecious forest edge species	1	1,5625
4	Forest edge – forest steppe (silvo-steppicolous) species	2	3,1250
5	Forest edge (rupicolous scrubland) species	1	1,5625
6	Mesophilous species	9	14,0625
7	Mesophilous (euryoecious) species	5	7,8125
8	Mesophilous meadow and marshland species	1	1,5625
9	Mesophilous silvicolous (forest edge) species	2	3,1250
10	Mesophilous steppe species	1	1,5625
11	Mesophilous-steppe (euryoecious) species	2	3,1250
12	Meso-xerophilous (euryoecious) species	1	1,5625
13	Migrant species	3	4,6875
14	Nemoral species	1	1,5625
15	Nemoral (euryoecious) species	7	10,9375
16	Nemoral (forest edge) species	1	1,5625
17	Nemoral (mesic/humid forest) species	1	1,5625
18	Poplar-willow feeding (softwood) species	1	1,5625
19	Rocky steppe species	1	1,5625
20	Quercetal (forest edge) species	1	1,5625
21	Silvicolous (euryoecious) species	1	1,5625
22	Silvicolous (forest edge) species	1	1,5625
23	Steppicolous species	1	1,5625
24	Stepposilvicolous species	1	1,5625
	TOTAL	64	100,0000

terfly families are present and species belong to 45 genera following systematics by KARSHOLT & RAZOWSKI (1996). The majority of species (51.56%) belong to Nymphalidae, 21.88% to Lycaenidae, 12.50% to Pieridae, 10.94% to Hesperiidae and 3,13% to the Papilionidae family.

Based on data on the fauna of adjacent regions, the available distribution maps and habitat types inhabited by butterflies of Croatia, the diversity of butterflies in this area is estimated to about 50% of species known for Croatia. Out of the approximately 5,000 specimens observed in this work belonging to 64 butterfly species, 61 species (95.31%) were recorded by the year 2007, and in this year only three new species were found. They were locally quite rare species at the researched sites: *Carterocephalus palaemon* (Pallas, 1771), *Callophrys rubi* (Linnaeus, 1758) and *Satyrium ilicis* (Esper, 1779). Therefore, in this narrow area of the surroundings of Karlovac, not many new species can be expected to be identified in the future.

Considering the fact that the researched area is on the very border of an urban area under intensive anthropogenic influence for at least 80 years, that the locality was greatly affected by the hostilities of 1991–1995 and is still mined, with shrubs overgrowing the meadows, it can be affirmed that the number of recorded species is quite high. On the other hand, considering the geographical position, relief and

heterogeneity of habitat types in the wider surroundings of Karlovac, a significant number of new species in this checklist could be expected. Therefore, new research should be done in some other areas around Karlovac, especially in the Kordun region. This is confirmed by the maps of the distribution of butterflies (JAKŠIĆ, 1988). According to these maps several dozen more species should dwell in the wider area of research.

In 1910 TABORSKY published a list of Lepidoptera that contains 21 species of butterflies in Karlovac. Species were recorded in the western, rural part of Karlovac. In the southern surroundings of Karlovac JAKŠIĆ (1988) lists 10 species of butterflies: *Aporia crataegi* (Linnaeus, 1758), *Gonepteryx rhamni* (Linnaeus, 1758), *Lycaena virgaureae* (Linnaeus, 1758), *L. tityrus* (Poda, 1761), *L. thersamon* (Esper, 1784), *Pseudophilotes vicrama* (Moore, 1865), *Polyommatus icarus* (Rottemburg, 1775), *P. bellargus* (Rottemburg, 1775), *Nymphalis antiopa* (Linnaeus, 1758) and *Boloria euphrosyne* (Linnaeus, 1758). The individual findings of endangered and rare species of *Parnassius mnemosyne* (Linnaeus, 1758) of Karlovac are deposited in the Croatian Natural History Museum in Zagreb (MLADINOV, 1973) (Tab. 2). One record of the rare species *Brenthis ino* (Rottemburg, 1775) from this survey was published by permission of the authors in KOREN & ZADRAVEC (2010). It was published in form of map and referred to Karlovac, but was not accompanied by a locality/date type of record (Jelaši, June 17th 2006) as used in this paper.

This new research confirmed the findings of 16 species published by JAKŠIĆ (1988) and TABORSKY (1910): *Iplichides podalirius* (Linnaeus, 1758), *Pieris napi* (Linnaeus, 1758), *Gonepteryx rhamni* (Linnaeus, 1758), *Lycaena dispar* (Haworth, 1802), *L. tityrus* (Poda, 1761), *Plebejus argus* (Linnaeus, 1758), *Polyommatus icarus* (Rottemburg, 1775), *Argynnis adippe* (Denis & Schiffermüller, 1775), *Brenthis daphne* (Denis & Schiffermüller, 1775), *Neptis rivularis* (Scopoli, 1763), *Melitaea cinxia* (Linnaeus, 1758), *M. phoebe* (Denis & Schiffermüller, 1775), *M. athalia* (Rottemburg, 1775), *Coenonympha arcania* (Linnaeus, 1761), *Maniola jurtina* (Linnaeus, 1758) and *Nymphalis antiopa* (Linnaeus, 1758). We can expect some of the other 10 species to be found and confirmed in a future research in wider area of the surroundings of Karlovac. Especially it would be interesting to confirm some of rare species recorded by TABORSKY (1910), e. g. *Pontia daplidice* (Linnaeus, 1758) and *Colias hyale* (Linnaeus, 1758). At present, the new checklist of butterfly fauna of the surroundings of Karlovac consisting of all known records of butterfly species counts 74 species, representing 37.95% of the Croatian butterfly fauna. This paper publishes 48 butterfly species recorded for the first time in this area. Ten species from older literature sources need to be confirmed in future surveys (Tab. 2).

HABITAT PREFERENCES OF SPECIES

The number of recorded species is a result of habitat heterogeneity in the surroundings of Karlovac. Due to the relatively close distances of the studied sites (all within a diameter of 1 km) it is assumed that most of species come to all these sites. Accordingly, the paper dues not include a comparison of sites in terms of species composition. Although close to each other, the sites ecologically represent the majority of habitat types represented in the Karlovac surrounding area.

However, the research has revealed that forest edges, as well as sites close to them, have a higher number of species (richer biodiversity) than the suburban site

or site with agricultural fields and shrubs. Furthermore, many species specific for one habitat were not found in any other habitat type in this area. For example, *Lycaena dispar* (Haworth, 1802) was the most numerous on damp sites and poorly present on the other sites. There were many other relations between species and habitat. According to TOLMAN & LEWINGTON (1997), *Heteropterus morpheus* (Pallas, 1771) and *Carterocephalus palaemon* also indicate damp sites, where they were actually found in this research. *Apatura ilia* (Denis & Schiffermüller, 1775) can be found on forest edges near rivers, *Ochlodes venata* (Bremer & Grey, 1853) in damp woodland with ferns, *Satyrium ilicis* in dry or damp shrubberies or thinned out oak forests (TOLMAN, 2001). The species specific for woodland and forest edges were found exactly in such places: *Brintesia circe* (Fabricius, 1775), *Minois dryas* (Scopoli, 1763), *Apatura ilia*, *Neptis sappho* (Pallas, 1771), *N. rivularis*, *Argynnis paphia* (Linnaeus, 1758), *A. adippe* (Denis & Schiffermüller, 1775), *Callophrys rubi*, *Thecla betulae* (Linnaeus, 1758), etc. If they were found further than 100 meters away from the forest, they were always very rare individual specimens. *Pararge aegeria* (Linnaeus, 1758) was the only species that was found solely inside the forest, but only if significant penetration of sunlight to the ground was present.

Faunal component (Tab. 3) according to VARGA *et al*. (2005) is primarily determined by the life history of the caterpillars, and represents a certain type of habitat. In the surroundings of Karlovac about 28% of recorded species are euryoecious, about 14% are mesophilous, about 11% are nemoral (euryoecious) species, and the rest of about 47% belong to 21 other faunal components.

BIOGEOGRAPHICAL ANALYSIS

Analysis of proportions of faunal types according to VARGA *et al*. (2005) are calculated in Tab. 4. Faunal type is an assemblage or aggregation of groups of spe-

Tab. 4. Percentage proportions of faunal types according to VARGA *et al*. (2005)

#	Faunal type (biogeographical class)	Percentage proportion (%)
1a	Extra-Palaearctic: Palaeotropical-subtropical	1,56
1b	Extra-Palaearctic: Cosmopolite	1,56
2a	Transpalaeartic: Holarctic	1,12
2b	Transpalaeartic: Holopalaearctic	1,56
2c	Transpalaeartic: Eurosibirean	35,94
2d	Transpalaeartic: European-eastern Asian disjunct, »Sybilla«	1,56
3a	Boreo-continental »Siberian«: Circum-boreal, Holarctic	1,56
3b	Boreo-continental »Siberian«: Boreo-continental	3,12
4a	Southern continental: Southwestern Siberian	9,37
4b	Southern continental: Manchurian / southern Siberian / Ponto-Panonian disjunct	1,56
	Western Palaearctic: Mediterranean / Holo-mediterranean / Western Asiatic	9,38
5a	Western Palaearctic: Holo-Mediterranean	14,06
5b	Western Palaearctic: Adriato-Mediterranean	1,56
5c	Western Palaearctic: Ponto-Mediterranean	3,13
5d	Western Palaearctic: Ponto-Mediterranean / Turkestanian, Iranian	1,56
5e	TOTAL	100,00

cies-group level taxa that can be attributed to given core areas (VARGA *et al*., 2005). Euro-Siberian species in this research have a great dominance with a proportion of about 35.9%. That is caused by the strong influence of the continental climate typical of central Europe. These species are widely distributed through almost the whole of Eurasia (Palaeartic) (VARGA *et al*., 2005). In total, transpalaeartic species account for about 40.6% of the total in this area. Boreo-continental species that expand into the Pannonian region from the north-east account for about 4.7%. Southern continental species which expand into this region from the east-southeast account for about 10.9%. Western Palaearctic species (about 29.7%) indicate the influence of the Mediterranean climate that affects this area over the Dinarides mountain chain (Mt Velebit) and manifests itself through local modification of climate and vegetation. The only cosmopolitan species is *Vanessa cardui* (Linnaeus, 1758), also a well-known migrant. The tropical species *Colias croceus* (Fourcroy, 1785) migrates and also inhabits parts of Europe with continental and mountainous climates, but its climate optimum is in southern parts of Europe (STERRY & MACKAY, 2004). The third migrant is *V. atalanta* (Linnaeus, 1758).

CONSERVATION AND PROTECTION STATUSES OF SPECIES

In Croatia, the following species recorded in this study are listed: *Pieris brassicae* (Linnaeus, 1758), *Heteropterus morpheus* and *Apatura ilia*. Further, *Lycaena dispar, Euphydryas aurinia* (Rottemburg, 1775) and *Papilio machaon* Linnaeus, 1758 are strictly protected in Croatia (ANON., 2009). *P. brassicae, L. dispar* and *P. machaon* are represented in quite a high number of individuals at the researched sites, *E. aurinia* was recorded a few times, while *H. morpheus* and *A. ilia* are locally extremely rare. In fact, both species (*H. morpheus* and *A. ilia*) were seen only once in seven years of research.

On the Red List of Butterflies of Croatia, 38 species have threatened status (ŠAŠIĆ & KUČINIĆ, 2004). Among them, four were recorded in this research: *H. morpheus* (Near Threatened), *L. dispar* (Near Threatened), *E. aurinia* (Data Deficient) and *A. ilia* (Near Threatened). *E. aurinia* has vulnerable status in the Red Data Book of European Butterflies (VAN SWAAY *et al*., 2010).

L. dispar and *E. aurinia* are listed in the Annex II of the Habitats Directive and their conservation requires the designation of special areas of conservation (ANON., 1992). Both species are strictly protected by Appendix II of the Bern Convention (ANON., 1979). Also, *L. dispar* is listed on the IUCN Red List of Threatened Species with near threatened status (IUCN, 2011) and in the Annex IV of the Habitats Directive, which signifies strict protection (ANON., 1992). Although *L. dispar* is generally threatened because of the loss of swamps (CARTER, 1992), during this research it was one of the 20 most abundant species in the area.

Numerous scientific studies show that biodiversity in Europe has been declining rapidly for some time during periods of expansion and intensification of land use (VAN SWAAY et al., 2010). The main threats for the diversity of butterflies in this area are: loss, destruction and changes of suitable habitats, caused by air, soil and water pollution, use of pesticides and discontinuance and abandonment of mowing of the grasslands and meadows. The natural vegetation succession of grasslands is primarily caused by political, rapid economical, agricultural and social changes in

last 20 years in Croatia (including the impact of the war, with numerous suspected minefields still remaining) and represents the biggest cause of changes in the butterfly habitats of this area.

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SAŽETAK

Fauna danjih leptira (Papilionoidea & Hesperioidea) okolice Karlovca, Hrvatska

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Ovaj rad predstavlja prvi sustavni popis vrsta danjih leptira u okolici Karlovca. Istraživanje njihove faune na području okolice Karlovca trajalo je od 2001. do 2007. g. Utvrđene su 64 vrste što predstavlja 32,82% faune danjih leptira Hrvatske. Istraživanje je utvrdilo 48 vrsta prvi put zabilježenih za okolicu Karlovca, a potvrdilo 16 vrsta poznatih iz literature. Deset vrsta koje su utvrdili TABORSKY (1910), MLADINOV (1973) i JAKŠIĆ (1988) nije potvrđeno ovim istraživanjem. Broj utvrđenih vrsta manji je od broja kojeg bismo mogli očekivati na ovom području. Razlog ovako malom broju vrsta je blizina grada te veliki antropogeni utjecaj i devastacija staništa. Kada se sagledaju opsezi izmjene izvorne prirode područja i činjenica da je istraživanje vršeno gotovo u predgrađu grada, može se konstatirati da je broj vrsta dosta velik. Daljnja istraživanja šire okolice Karlovca dala bi potpuniju sliku faune leptira okolice Karlovca. Stoga bi buduća istraživanja trebalo obaviti na većim udaljenostima od naseljene zone grada.

Zastupljeno je svih pet porodica danjih leptira prema KARSHOLT & RAZOWSKI (1996), a vrste dolaze u 44 roda. Na istraživanom području od 64 utvrđene vrste 51,56% pripada porodici Nymphalidae, 21,88% porodici Lycaenidae, 12,50% porodici Pieridae, 10,94% porodici Hesperiidae i 3,13% porodici Papilionidae.

Većinu vrsta okolice Karlovca čine eurosibirske vrste (35,9%) što upućuje na klimatske, geološke i vegetacijske karakteristike kontinentalnih područja Europe, dok mediteranske (29,7%) ukazuju na utjecaj mediteranske klime.

U Hrvatskoj je zaštićeno pet vrsta utvrđenih ovim istraživanjem, a na Crvenom popisu ugroženih biljaka i životinja Hrvatske nalazimo četiri od pet spomenutih zaštićenih vrsta: *Heteropterus morpheus* (niskorizična), *Lycaena dispar* (niskorizična), *Euphydryas aurinia* (nedovoljno poznata), *Apatura ilia* (niskorizična).