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Communities of butterflies on ten spoil heaps in Ostrava Basin

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Abstract: Heaps, dumps of mining waste, metallurgical slags, and other materials are a very characteristic type of post-industrial sites in the Ostrava Basin. Many studies in the past few decades have focused on plants, fungi, spiders, and beetles inhabiting this unique habitat, revealing many rare species. Yet, comprehensive research on butterflies, an emblematic group of insects, has been surprisingly lacking. This study aimed to assess the diversity and distribution of butterflies on these heaps employing a consistent methodology and data collection approach conducted by the same team throughout the entire season. The purpose of our research was to assess whether heaps in the Ostrava Basin could serve as refuges and alternative habitats for certain rare butterfly species. Through our comprehensive study, we aimed to evaluate the potential of these heaps to support biodiversity and conserve endangered lepidopteran species within the region. Ten heaps were selected based on their accessibility, biological significance, and habitat predispositions. Butterfly surveys were conducted from May to September 2023 using nets. During the research, a total of 59 species of butterflies were recorded, of which 37 were diurnal butterflies, the main group under study. Four of these species were listed on the Red List of the Czech Republic or were subject to legal protection. In addition to diurnal butterflies, heaps provide an alternative habitat for many other notable invertebrate and vertebrate species. Emphasizing the importance of heaps as vital habitats for biodiversity, particularly for protected and endangered species, the research demonstrates that heaps in Ostrava Basin can serve as refuges and alternative habitats for various species of organisms that would otherwise be threatened, including some butterfly species.

Keywords: anthropogenic environment, biodiversity, diurnal butterflies, heaps, industrial habitats

Introduction

Post-industrial and anthropogenic habitats are often perceived negatively by the general public. This perspective persists in society despite research conducted since the end of the last century, demonstrating that these habitats significantly enhance overall diversity in the landscape. They frequently establish conditions for life that are absent in the surrounding landscape, thereby attracting rare and protected species. Since the loss of diversity is a complex problem, understanding the critical role of post-industrial habitats in ecosystems becomes increasingly important (Tropek et al. 2012).

The rapid development of industrial and mining activities in the Ostrava Basin dates back to the turn of the 18th and 19th centuries. During coal mining the leftover mining waste, known as spoil, had to be moved out of the mine areas. For this purpose, heaps began to form in the first half of the 19th century (Kroutilík 1954). A heap is thus a geomorphological feature created by human activity. The term ´halda´ is derived directly from the German word ´die Halde´, referring to the shape of a pile. In the Ostrava region, a heap is also called by synonyms "odval" or "výsypka", names derived from the description of material handling (Filipová et al. 2013, Petránek 2016).

Earlier methods of mining did not allow for the extraction of large amounts of spoil, resulting in relatively small heaps. The lower volume of tailings mined was also a consequence of operations nearer to the surface. The tailings from the early period of coal mining are no longer visible in the landscape or are almost unrecognisable. The greatest impact on society and the landscape occurred in the 20th century when most of the existing heaps or heap complexes were created. Initially, heaps were formed haphazardly next to mine shafts. This unplanned method of heap formation lasted until the first half of the 20th century (Kroutilík 1954). In the second half of the century, heaps were originally established in open spaces in or near the cities, but due to rapid urban development some of the heaps became part of cities. A key turning point occurred in the 1970s when dumping on already existing heaps ceased, and the mined material began to be dumped on devastated sites, creating so-called central heaps. Examples of central heaps include the Heřmanice and Zárubek heaps. In some cases, tailings have also been used to remediate the subsidences caused by deep coal mining appearing on the surface (Havrlant 2003).

Heaps are primarily composed of waste rock material, commonly known as mine stone. Mine stone was transported to the heaps in all sizes, from very small dust fragments to boulders. In addition, heaps also contain steelmaking and metallurgical slag. Even low-quality iron ore, often sourced from the USSR, was directly transported to the heaps without any processing. Additionally, heaps received non-metallic waste of a chemical or municipal nature. This material ended up on the heaps in a somewhat unorganized manner. In mixed heaps, where various materials were deposited, it is often not precisely known what portion is made up of a specific material (Havrlant et al. 1967, Kuthan 1991, Černý et al. 2003, Koutecká & Koutecký 2006, Skulina 2008).

At their inception, heaps are inhospitable places without signs of life. The extracted spoil, sometimes from depths of more than a kilometre, contains no organic matter or plant diaspores. Only after this material is exposed to the surface does weathering occur, releasing basic biogenic and trace elements, thus allowing the so-called primary succession to start. This unique phenomenon is observable in heaps and, for example, in volcanic activity. In these challenging conditions, only a few common species with a broad tolerance for extreme environmental conditions, which we call pioneer species, can survive. These species gradually prepare the heap for more demanding organisms. This process, known as facilitation, involves early successional species making resources more accessible and altering the habitat conditions. However, pioneer species are not competitive, and over time, they give way to a wider range of more demanding species. Species diversity becomes richer throughout this process called succession. Natural succession is a long-term process that is financially undemanding and independent of human intervention. The opposite approach to restoring nature on heaps is reclamation. Modern forestry reclamation involves technical reclamation, where the terrain is shaped, followed by biological reclamation involving the planting of ideal plants and their maintenance. Nowadays, a third, middle way is often advocated. Managed succession involves bypassing the initial stages of natural succession by planting species that would naturally settle the area later. It also includes suppressing invasive plant species (Stalmachová 1996, 2003, 2006, Řehounek et al. 2010).

Succession occurs not only at the level of plants but also in the development of invertebrate animal communities, including insects. In their initial stages of succession, heaps provide a habitat with xerothermophilic characteristics for many protected and endangered species (Řehounek et al. 2010, Hodeček 2016). During succession, pioneer species, being non-competitive, recede, and more demanding species, including those with reduced or even no wings, become prevalent. The entomofauna can change by up to 90% over 20 years due to succession (Vondřejc 1994, Dolný 2000a, Hodeček 2016). Therefore, it is unsurprising that heaps have become a focus for research on arthropod communities. In the 1960s, research on true bugs (Heteroptera) was conducted by Bohuslav Dobšík and Ladislav Kempný (1968). Notable arachnologist Zdeněk Majkus dedicated his work to studying spider communities on heaps, including the population ecology of *Zelotes aeneus* (Majkus 1982, 1988, 1990). Since Zdeněk Majkus was also an academic at the University of Ostrava, his work was continued by his students. Research on beetles (Coleoptera) on the Ostrava heaps was conducted by Josef Vondřejc (1994). At the beginning of the new century, research was continued by Aleš Dolný, Jiří Hodeček, Jan Šipoš, and Tomáš Kuras (Dolný 2000b, Dolný 2000c, Hodeček et al. 2015, 2016, Hodeček & Kuras 2015, Šipoš et al. 2017). Marion Mantič made many exotic discoveries (especially beetles) on the Ostrava heaps (Stanovský & Pulpán 2006, Mantič 2011). On the heaps, new species for science from the order Diptera associated with fungi were described by Jan Ševčík (Ševčík 2006).

It is surprising that, while greater attention has been paid to butterfly research on post-industrial biotopes including heaps outside the OKC and other post-industrial biotopes (Tropek et al. 2013), butterflies on Ostrava heaps have not been systematically studied. The first lepidopterological research on Ostrava heaps was conducted by Richard Wawerka in the 1920s and 1930s (Wawerka 1927, 1929, 1930, 1936), but the main period of heap formation and succession falls into later decades, rendering his findings irrelevant for today's communities. Recently, the lepidopteran communities on Ostrava heaps have only been the subject of a few university theses by students of Jiří Kupka and Barbara Stalmachová. For instance, Laryszová (2012) discussed in her thesis the characteristics of butterfly communities of the Paskov mine, and Svobodová (2015) wrote a thesis on the Lepidoptera of the heaps of Upper Silesia, dealing with the Ema heap complex, the Heřmanice heap (Ostrava), and the František mine heap. Furthermore, Matuszková (2016) discussed in her dissertation the biodiversity of butterflies in rehabilitated areas of the mining landscape, but focuses instead on the Karviná post-industrial landscape. The most recent work was written by Balonová (2023) and focused on the ecological-faunistic characteristics of the diurnal butterflies of the Doubrava heap in Orlová. These studies, dealing with individual heaps, were naturally carried out by different researchers, with different sampling efforts, and in different years. This study aimed to assess the diversity and distribution of butterflies on the heaps of Ostrava Basin employing a consistent methodology and data collection approach conducted by the same team throughout the entire season. The purpose of our research was to assess whether heaps in the Ostrava Basin could serve as refuges and alternative habitats for certain rare butterfly species. Through our comprehensive study, we aimed to evaluate the potential of these heaps to support biodiversity and conserve endangered lepidopteran species within the region.

Materials and methods

Initially, we selected suitable heaps in the Ostrava Basin that could be interesting from a lepidopterological perspective. The selection process was influenced by several factors – accessibility (some heaps have restricted access or are completely inaccessible, e.g., the Přívozská heap (Lenart 2021)) and biological interest (based on previous research and biomonitoring). Heaps in very advanced stages of succession, i.e., those that are completely forested, were excluded from our selection as they do not align with the focus of our research – for example, the Oskar (Lidice) heap. Ten heaps in the Ostrava Basin were ultimately selected (see their distribution in Fig. 1 and their characteristics in Tab. 1). For further work, we refer to them by their official names, if they exist. However, many heaps do not have official names, so we name them using one of the possible names and further in the text, we unambiguously characterize them by coordinates. We have researched the following heaps Chemická, Hedvika, Heřmanice, Hrabůvka, Jeremenko, Michálka, Oprechtice, Oskárka, Paskov, and ŽDB Bohumín.

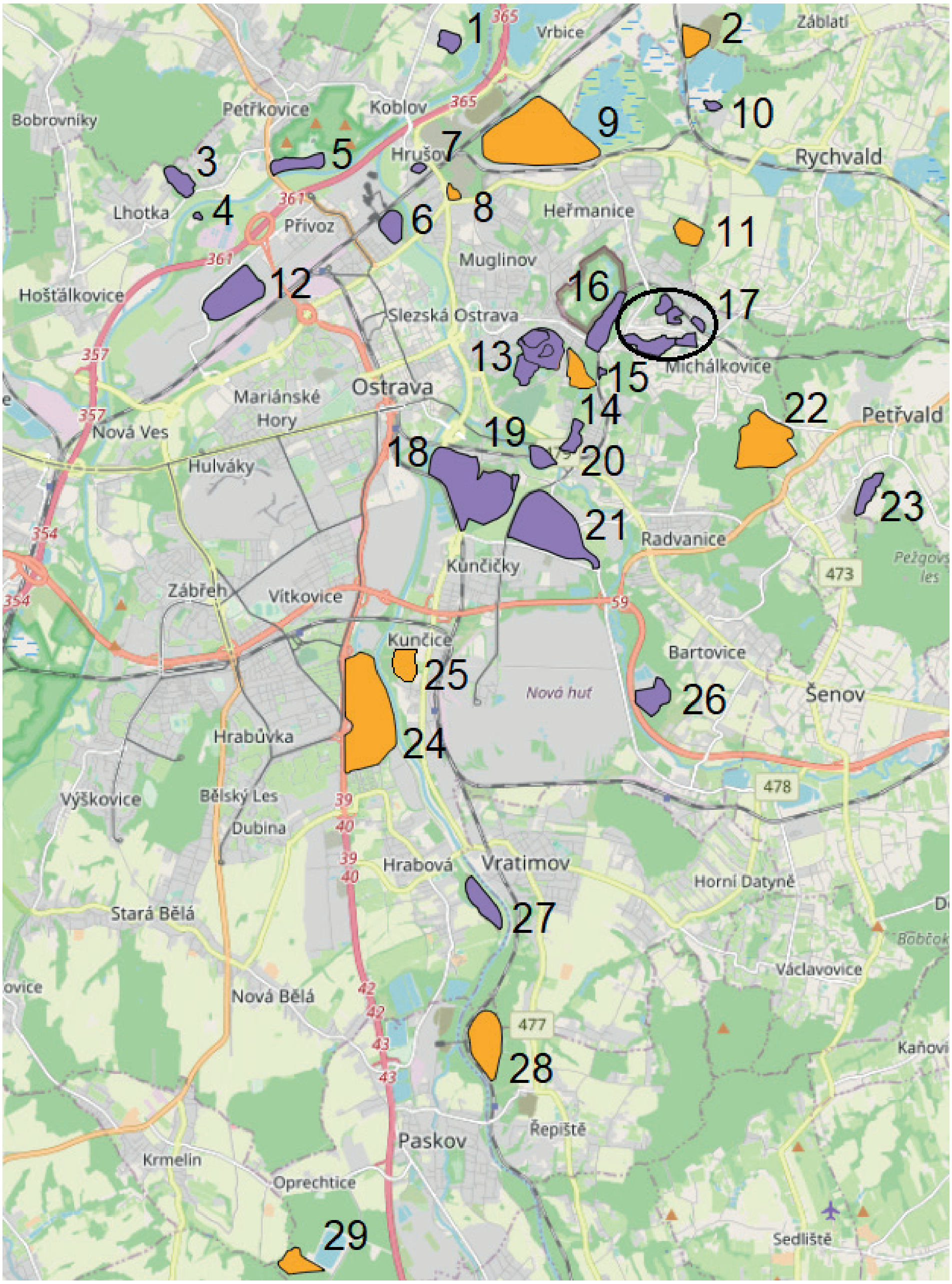

Fig. 1: A map of spoil heaps in the Ostrava Basin; the orange colour represents the studied heaps (namely – 2 – ŽDB Bohumín, 8 – Chemická, 9 – Heřmanice, 11 – Oskárka, 14 – Michálka, 22 – Hedvika, 24 – Hrabůvka, 25 – Jeremenko, 28 – Paskov, 29 – Oprechtice); the purple colour represents other heaps (namely – 1 – Koblov, 3 – Oskar (Lidice), 4 – Oderka, 5 – Anselm (Ed. Urx), 6 – Přívozská heap, 7 – Hubert (Stachanov), 10 – Rychvald, 12 – Jan Šverma, 13 – Ema heap complex, 15 – Jan, 16 – Josef, 17 – Heap complex of Michal mine (Petr a Pavel, Petr Cingr, Briketářská, Michalské náměstí), 18 – Zárubek – Central heap, 19 – Zárubek – Za Lučinou, 20 – Jan Maria, 21 – NH – Lihovarská, 23 – Pokrok, 26 – NH – Bartovická, 27 – Hrabová)

Tab. 1: Table with properties of studied heaps. Name abbreviation of heap name (**Osk** = Oskárka, **ŽDB** = ŽDB Bohumín, **Heř** = Heřmanice, **Chem** = Chemická, **Hed** = Hedvika, **Mich** = Michálka, **Hra** = Hrabůvka, **Jer** = Jeremenko, **Pas** = Paskov, **Opr** = Oprechtice); **Start of activities:** the year in which the heap began to be formed; **Year of end dumping:** the year when any material stopped being dumped on the heap; **End of activities:** the year when all activities, including reclamations, on the heap ended; **Thermal activity:** the presence of thermal activity on a specified heap; **Reclamation:** indicated whether reclamation was or was not carried out; **Year of reclamation:** the year when reclamation ended; **Total area (ha):** the total area of the heap in hectares; **Usable area (ha):** the area of the heap usable for the majority of diurnal butterflies in hectares (we calculated this from the total area and the area without tree cover); **1:** that the activity was present/was performed; **0:** absence of activity; **+:** the activity is still in progress; **?:** the probable presence of activity or uncertainty about time frame; **NA:** not available data.

Name	Start of activities	Year of end dumping	End of activities	Thermal activity	Reclamation	Year of reclamation	Total area (ha)	Usable area (ha)
Osk	1950	1980	2013	0	1	2013	10	2.5
ŽDB	1955	1990	2023+	0	0	NA	15	12.75
Heř	1970	1993	2023+	1+	0	1989	120	114
Chem	1851	1997	1997	1?	1	2010	4	0.6
Hed	1903	1979	1998	1+	1	1979	50	5
Mich	1925	1972	1972	0	1	1933	18	5.4
Hra	1914	1966	2010	1+	1	2010	110	88
Jer	1960?	2000	2000	0	1	2006	23	11.5
Pas	1960	2017	2023+	0	1	2014	40	36
Opr	NA	1998	2003	0	1	2003	13	9.1

The Oskárka heap (49°51'18"N, 18°20'42"E) underwent reclamation between 2007 and 2013. Almost the entire area of the heap is covered by forest, with the remaining southern part being sunny and having an herbaceous layer. A notable feature of this heap is the wavy relief formed by mounds of mining spoil. **The ŽDB Bohumín heap** (49°52'51.60"N, 18°20'42.00"E) is likely still active, with the area undergoing early succession and the top part still treeless. **The Heřmanice heap** (49°52'4.80"N, 18°18'46.80"E), one of the largest heaps in Ostrava, underwent forestry reclamation in 1989 but due to the later development of thermal activity, it is now still in early stage of succession. Therefore, although it is known when the heap underwent reclamation, we state in the table above that it did not undergo reclamation. A detailed entomological study, focusing on butterflies, was conducted here by Svobodová (2015), and some species were also recorded by Kočárek (2004). **The Chemická heap** (49°51'39.60"N, 18°17'42.00"E) underwent partial forestry reclamation around 2010. The heap is relatively small and almost entirely covered by trees, except for the southern part. **The Hedvika heap** (49°49'40.80"N, 18°21'32.40"E) is partially covered with trees planted as part of forestry reclamation in 1979, with a larger part covered by self-seeded trees. A detailed lepidopterological study has not been conducted here, only Rýznar recorded some species in the Nature Conservation Finding Database (2006–2020). **The Michálka heap** (49°50'6.00"N, 18°19'15.60"E) underwent forestry reclamation as early as 1933 and is now largely forested, but there are also non-forested parts with some disturbance, due to often visits of horses from nearby riding club. On **the Hrabůvka heap** (49°47'16.80"N, 18°16'37.20"E), forestry reclamation was carried out in 2010. Most of the heap is grassed, and only a minor part is covered by forest. Filipová (2012, et al. 2013) focused on the occurrence of butterflies on this heap, and Fišer (2018) also recorded butterflies here. On **the Jeremenko heap** (49°47'49.20"N, 18°17'2.40"E), forestry reclamation was carried out in 2006 but was unsuccessful. The site was then left to natural succession, and now the heap is half covered with self-seeded trees. On **the Paskov heap** (49°44'42.00"N, 18°18'7.20"E), forestry reclamation was carried out in the northern and western parts, while the central, southern, and eastern parts were grassed in 2014, while central was left to natural succession. Most of the heap is covered with an herbaceous layer, and trees constitute about a tenth of the area. Laryszová (2012) focused on the monitoring of the lepidopterofauna on this heap, and Fišer (2018) also recorded here some butterflies. **The Oprechtice heap** (49°42'54.00"N, 18°15'39.60"E) underwent forestry reclamation in 2003, with the lower parts covered with forest and the upper plateau consisting of young trees and meadow vegetation.

As can be inferred from the previous text, six out of these ten heaps have not yet undergone a detailed lepidopterological survey. These are the Oskárka, ŽDB Bohumín, Chemická, Michálka, Jeremenko, and Oprechtice heaps.

Mapping of butterflies was conducted from May to September 2023. The selected heaps were divided into two routes – the first circuit comprising Oskárka, ŽDB Bohumín, Heřmanice, Chemická, Hedvika, and Michálka, while the second circuit included Hrabůvka, Jeremenko, Paskov, and Oprechtice. The first circuit of heaps was visited six times on the following dates: 05.05., 12.07., 27.07., 10.08., 27.08., 08.09.; while the second circuit was visited five times on: 30.06., 21.07., 02.08., 15.08., 01.09.; except the Oprechtice heap, which was visited an additional time on 14.07. Monitoring times for each heap were varied to cover the widest part of the day. Standard monitoring started at 9 a.m. and ended at 5 p.m. The duration of the stay on each heap varied depending on the period of study, weather conditions, and butterfly abundance, but on average, 30 minutes were spent on each heap by two people, resulting in one person-hour per heap and date. The basic equipment for collecting butterflies was a 40 cm diameter entomological butterfly net. Individual species were identified using the online key (Beneš et al. 2012) and the book of Macek et al. (2015). In addition to the primary focus on butterfly collection, incidental observations of other noteworthy fauna were made in the absence of a structured methodology.

Results

A total of 59 species of the order Lepidoptera were recorded, of which 37 were diurnal butterflies (36 species in the imago stage, one species in the larval stage). Four species from this list are included on the Red List of the Czech Republic or are subject to legal protection under regulation no. 395/1992 Coll.

Tab. 2: Butterfly species recorded on the heaps from May to September 2023. Threat categories according to the Czech Red list of invertebrates (Hejda et al. 2017): **NT** – near threatened; Categories according to legal protection: **EN** – endangered. **Con:** conservation status.

Latin name	Czech name	Spoil heaps	Con
Sphingidae	**lišajovití**		
Smerinthus ocellatus (Linnaeus, 1758)	lišaj paví oko	Heř	
Macroglossum stellatarum (Linnaeus, 1758)	dlouhozobka svízelová	ŽDB, Jer, Pas	
Zygaenidae	**vřetenuškovití**		
Zygaena filipendulae (Linnaeus, 1758)	vřetenuška obecná	Osk, ŽDB, Mich, Jer, Pas, Opr	
Zygaena loti (Denis & Schiffermüller, 1775)	vřetenuška kozincová	Jer	
Noctuidae	**můrovití**		
Autographa gamma (Linnaeus, 1758)	kovolesklec gama	Osk, ŽDB, Heř, Chem, Hed, Mich, Hra, Jer, Pas, Opr	
Noctua pronuba (Linnaeus, 1758)	osenice šťovíková	Chem	
Tyta luctuosa (Denis & Schiffermüller, 1775)	tmavoskvrnka svlačcová	Heř	
Erebidae			
Diacrisia sannio (Linnaeus, 1758)	přástevník chrastavcový	Hed, Hra, Jer, Pas, Opr	
Spilosoma lubricipedum (Linnaeus, 1758)	přástevník mátový	Hra	
Euclidia glyphica (Linnaeus, 1758)	jetelovka hnědá	Osk, Opr	
Geometra papilionaria (Linnaeus, 1758)	zelenoplášťník březový	ŽDB	

Thalera fimbrialis (Scopoli, 1763)	zelenopláštník mateřídouškový	Opr	
Geometridae	**píďalkovití**		
Chiasmia clathrata (Linnaeus, 1758)	kropenatec jetelový	Osk, ŽDB, Heř, Jer, Pas	
Scotopteryx chenopodiata (Linnaeus, 1758)	vlnočárník sveřepový	Osk, Mich, Jer, Opr	
Ematurga atomaria (Linnaeus, 1758)	tmavoskvrnáč vřesový	Osk, ŽDB, Heř, Mich, Pas, Opr	
Aplocera plagiata (Linnaeus, 1758)	píďalka úhorová	Heř, Hra	
Siona lineata (Scopoli, 1763)	bělokřídlec luční	Osk	
Camptogramma bilineatum (Linnaeus, 1758)	píďalka kopřivová	Hra, Opr	
Tortricidae	**obalečovití**		
Agapeta hamana (Linnaeus, 1758)	obalečík žlutý	Opr	
Pyralidae	**zavíječovití**		
Oncocera semirubella (Scopoli, 1763)	zavíječ červenožlutý	Osk, ŽDB, Jer, Pas, Opr	
Crambidae	**travaříkovití**		
Cynaeda dentalis (Denis & Schiffermüller, 1775)	zavíječ hadincový	Opr	
Patania ruralis (Scopoli, 1763)	zavíječ kopřivový	Jer	
Hesperiidae	**soumračníkovití**		
Erynnis tages (Linnaeus, 1758)	soumračník máčkový	Osk, ŽDB, Heř, Mich, Jer, Pas, Opr	
Thymelicus lineola (Ochsenheimer, 1808)	soumračník čárečkovaný	Osk, Hra, Jer, Pas, Opr	
Thymelicus sylvestris (Poda, 1761)	soumračník metlicový	Osk	
Ochlodes sylvanus (Esper, 1777)	soumračník rezavý	Hra, Pas, Opr	
Pieridae	**běláskovití**		
Pieris napi (Linnaeus, 1758)	bělásek řepkový	Osk, ŽDB, Heř, Chem, Hed, Mich, Hra, Jer, Pas, Opr	
Pieris rapae (Linnaeus, 1758)	bělásek řepový	Osk, ŽDB, Heř, Chem, Hed, Mich, Hra, Jer, Pas, Opr	
Pieris brassicae (Linnaeus, 1758)	bělásek zelný	Osk, Heř, Hed	
Anthocharis cardamines (Linnaeus, 1758)	bělásek řeřichový	Heř, Chem, Hed, Mich	
Pontia edusa (Fabricius, 1777)	bělásek rezedkový	Heř, Hra	
Leptidea juvernica (Williams, 1946)/sinapis (Linnaeus, 1758)	bělásek luční/hrachorový	Pas, Opr	
Colias hyale (Linnaeus, 1758)	žluťásek čičorečkový	Osk, ŽDB, Pas	
Gonepteryx rhamni (Linnaeus, 1758)	žluťásek řešetlákový	ŽDB, Heř, Chem, Pas, Opr	

Lycaenidae	**modráskovití**		
Aricia agestis (Denis & Schiffermüller, 1775)	modrásek tmavohnědý	Opr	
Celastrina argiolus (Linnaeus, 1758)	modrásek krušinový	ŽDB, Hra, Jer, Pas	
Cupido argiades (Pallas, 1771)	modrásek štírovníkový	Osk, ŽDB, Heř, Mich, Hra, Jer, Pas, Opr	
Cupido decoloratus (Staudinger, 1886)	modrásek tolicový	Jer	
Plebejus argus (Linnaeus, 1758)	modrásek černolemý	Pas	NT/-
Polyommatus icarus (Rottemburg, 1775)	modrásek jehlicový	Osk, ŽDB, Heř, Chem, Mich, Hra, Jer, Pas, Opr	
Satyrium w-album (Knoch, 1782)	ostruháček jilmový	Opr	NT/-
Thecla betulae (Linnaeus, 1758)	ostruháček březový	Hra	
Papilionidae	**otakárkovití**		
Papilio machaon Linnaeus, 1758	otakárek fenyklový	Osk, ŽDB, Jer, Pas	-/EN
Nymphalidae	**babočkovití**		
Aglais urticae (Linnaeus, 1758)	babočka kopřivová	Mich, Hra	
Apatura ilia (Denis & Schiffermüller, 1775)	batolec červený	Heř, Chem, Hed, Mich, Hra, Jer	-/EN
Aphantopus hyperantus (Linnaeus, 1758)	okáč prosíčkový	Osk, ŽDB, Heř, Hed, Mich, Jer, Pas, Opr	
Araschnia levana (Linnaeus, 1758)	babočka síťkovaná	Osk, ŽDB, Heř, Hed, Mich, Hra, Jer, Pas, Opr	
Argynnis paphia (Linnaeus, 1758)	perleťovec stříbropásek	Hed, Pas, Opr	
Brintesia circe (Fabricius, 1775)	okáč voňavkový	ŽDB	
Coenonympha pamphilus (Linnaeus, 1758)	okáč poháňkový	Osk, Heř, Hed, Mich, Hra, Jer, Pas, Opr	
Inachis io (Linnaeus, 1758)	babočka paví oko	ŽDB, Heř, Chem, Hra, Pas	
Issoria lathonia (Linnaeus, 1758)	perleťovec malý	ŽDB, Heř	
Lasiommata megera (Linnaeus, 1767)	okáč zední	ŽDB, Hra	
Maniola jurtina (Linnaeus, 1758)	okáč luční	Osk, ŽDB, Heř, Chem, Hed, Mich, Hra, Jer, Pas, Opr	
Melanargia galathea (Linnaeus, 1758)	okáč bojínkový	Osk, Mich, Hra, Jer, Pas, Opr	
Pararge aegeria (Linnaeus, 1758)	okáč pýrový	Hed	
Polygonia c-album (Linnaeus, 1758)	babočka bílé C	ŽDB, Heř, Hed, Hra, Opr	
Vanessa atalanta (Linnaeus, 1758)	babočka admirál	Osk, ŽDB, Heř, Chem, Hed, Hra, Jer, Pas, Opr	
Vanessa cardui (Linnaeus, 1758)	babočka bodláková	ŽDB, Opr	

Tab. 3: Other interesting invertebrate species recorded on the heaps from May to September 2023. Threat categories according to the Czech red list of invertebrates (Hejda et al. 2017): **VU** – vulnerable, **NT** – near threatened; Categories according to legal protection: **EN** – endangered, **CR** – critically endangered.

Latin name	**Czech name**	**Spoil heaps**	**Conservation**
Hexapoda	Hmyz		
Mantodea	Kudlanky		
Mantis religiosa (Linnaeus, 1758)	kudlanka nábožná	Heř, Pas	VU/CR
Orthoptera	Rovnokřídlí		
Acheta domesticus (Linnaeus, 1758)	cvrček domácí	Heř	
Oedipoda caerulescens (Linnaeus, 1758)	saranče modrokřídlá	ŽDB, Heř, Mich, Pas	
Hymenoptera	Blanokřídlí		
Xylocopa sp. Latreille, 1802	drvodělka	Hra	
Scolia hirta (Schrank, 1781)	žahalka žlutá	Osk, Pas	NT/-
Coleoptera	Brouci		
Carabus scheidleri Panzer, 1799	střevlík Scheidlerův	Osk	-/EN
Cicindela campestris Linnaeus, 1758	svižník polní	Hed, Pas	-/EN
Cylindera germanica (Linnaeus, 1758)	svižník německý	Pas	NT/EN
Oxythyrea funesta (Poda, 1761)	zlatohlávek tmavý	Osk, Hra	-/EN

Tab. 4: Endangered vertebrate species recorded on the heaps from May to September 2023. Threat categories according to the Czech Red list of vertebrates (Chobot & Němec 2017): **CR** – critically endangered, **VU** – vulnerable, **NT** – near threatened; Categories according to legal protection: **EN** – endangered, **SE** – strongly endangered, **ES I** – Birds Directive Annex I, **ES II** – Habitats Directive Annex II, **ES IV** – Habitats Directive Annex IV, **ES V** – Habitats Directive Annex V, **BU II** – Strictly protected animal species.

Latin name	**Czech name**	**Spoil heaps**	**Conservation**
Chordata	Strunatci		
Amphibia	Obojživelníci		
Bombina variegata (Linnaeus, 1758)	kuňka žlutobřichá	Pas, Opr	CR/SE/ES II & IV/BU II
Bombina sp. Oken, 1816	kuňka	Jer	-/EN/-/-
Bufo bufo (Linnaeus, 1758)	ropucha obecná	Heř, Hra, Opr	VU/EN/-/-
Pelophylax esculentus (Linnaeus, 1758)	skokan zelený	ŽDB	NT/SE/ES V/-
Rana dalmatina Fitzinger, 1839	skokan štíhlý	Opr	NT/SE/ES IV/BU II
Reptilia	Plazi		
Lacerta agilis Linnaeus, 1758	ještěrka obecná	Osk, ŽDB, Heř, Chem, Hed, Opr	VU/SE/ES IV/BU II
Natrix natrix (Linnaeus, 1758)	užovka obojková	Heř	NT/EN/-/-
Aves	Ptáci		
Lanius collurio Linnaeus, 1758	ťuhýk obecný	Hra	NT/EN/ES I/-
Mammalia	Savci		
Lepus europaeus Pallas, 1778	zajíc polní	Heř, Hra, Pas	NT/-/-/-

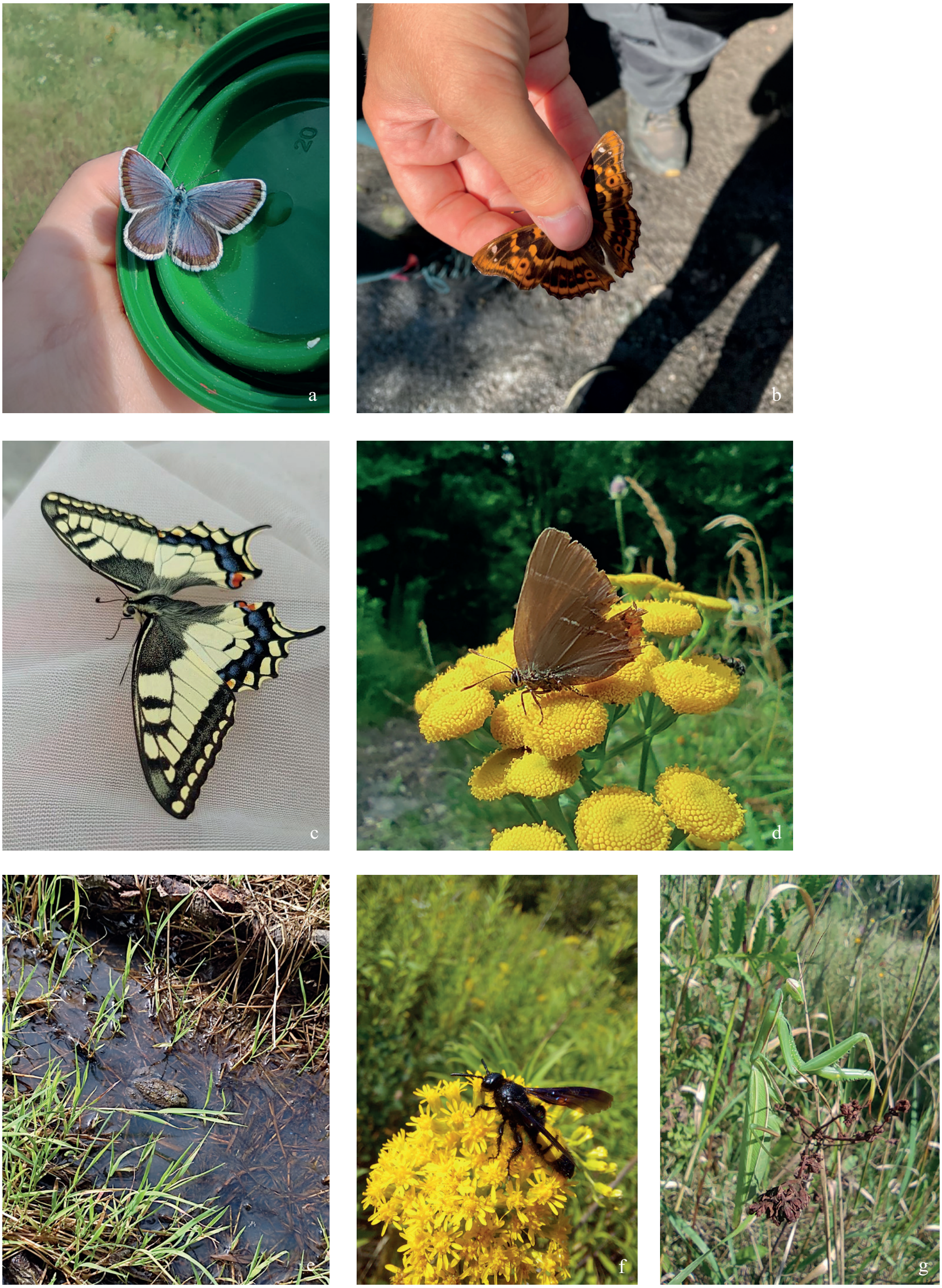

Fig. 2: Valuable species on the heaps: a) *Plebejus argus*, Paskov (photo by Adam Mikunda), b) *Apatura ilia*, Heřmanice (photo by Veronika Ohainková), c) *Papilio machaon,* Jeremenko (photo by Vojtěch Polák), d) *Satyrium w-album*, Oprechtice (photo by Adam Mikunda), e) *Bombina variegata*, Oprechtice (photo by Adam Mikunda), f) *Scolia hirta*, Oskárka (photo by Vojtěch Polák), g) *Mantis religiosa*, Paskov (photo by Adam Mikunda)

Discussion

To date, lepidopterological research has been conducted on five of the heaps and heap complexes in the Ostrava Basin. These include the Heřmanice, Hrabůvka, the Ema heap complex, Paskov, and Oprechtice heaps. Nonetheless, the research attributed to the Oprechtice heap actually focused on the adjacent settling pond located beneath the heap. Therefore, including this heap in the list of studied heaps is debatable, but it is relevant from the perspective of comparing the found species (see below). From the heaps studied before, we included Heřmanice, Hrabůvka, Paskov, and Oprechtice in our research, and we also added heaps not previously studied from a lepidopterological perspective, namely, Oskárka, ŽDB Bohumín, Chemická, Hedvika, Michálka, and Jeremenko heaps.

For the previously studied heaps, we can compare the butterfly species composition from previous research with our results. Svobodová (2015) and Kočárek (2004) list these species on the Heřmanice heap – *A. urticae*, *A. levana*, *I. io*, *P. c-album*, *V. atalanta*, *V. cardui*, *C. pamphilus*, *I. lathonia*, *G. rhamni*, *P. napi*, *P. rapae*, *P. edusa*, *P. icarus*, *Lycaena phlaeas*, *Lycaena dispar*, and *P. machaon*. To some extent, the species composition we recorded was similar. Our research revealed the presence of additional diurnal species for this heap – *A. cardamines*, *C. argiades*, *M. jurtina*, *A. hyperantus*, *A. ilia*, *E. tages*, and *P. brassicae*. In the 2023 season, Copper butterflies of the species *L. phlaeas* and *L. dispar* were observed very infrequently not only on heaps (but Fišer et al. 2023, Kuras et al. 2023), so their presence is certainly not ruled out. *P. machaon*, being very mobile and having an open population structure, is very likely to have been not observed on the heap, yet present in the surrounding landscape. Filipová (2012) and Fišer (2018) recorded these species on the Hrabůvka heap – *I. io*, *A. urticae*, *V. cardui*, *V. atalanta*, *P. icarus*, *C. argiades*, *P. brassicae*, *P. napi*, *P. rapae*, *G. rhamni*, *O. sylvanus*, *C. pamphilus*, *M. jurtina*, *P. machaon*, *A. ilia*, *L. dispar*, and *Z. filipendulae.* We recorded additional species for this heap – *T. lineola*, *C. argiolus*, *P. edusa*, *L. megera*, *A. levana*, *P. c-album*, and *M. galathea*. However, we did not record previously observed *V. cardui*, *P. brassicae*, *G. rhamni*, *P. machaon*, *L. dispar*, and *Z. filipendulae*. The situation with the Copper butterflies and *P. machaon* is the same as that with the previous heap. *Z. filipendulae*, being the most common species of burnet in the Czech Republic, is very likely to have been recorded on this heap, considering we found this species on other heaps. Laryszová (2012) and Fišer (2018) researched the Paskov heap. They recorded these species – *P. machaon*, *Apatura Iris*, *P. icarus*, *C. argiolus*, *C. decoloratus*, *Favonius quercus*, *A. hyperantus*, *C. pamphilus*, *M. galathea*, *M. jurtina*, *I. lathonia*, *A. levana*, *V. atalanta*, *V. cardui*, *I. io*, *L. juvernica*, *C. hyale*, *Colias crocea*, *A. cardamines*, *P. napi*, *P. brassicae*, *P. rapae*, and *T. lineola*. Our research revealed the presence of these additional species for this heap – *O. sylvanus*, *E. tages*, *A. paphia*, *P. argus*, *C. argiades*, *L. juvernica/sinapis*, *Z. filipendulae*, and *M. stellatarum*. We did not confirm the presence of previously reported *A. iris*, *C. decoloratus*, *F. quercus*, *I. lathonia*, *V. cardui*, *C. hyale*, *C. crocea*, *A. cardamines*, and *P. brassicae*. The presence of *L. juvernica*, recorded in previous research on the heap, is possible, but it can only be distinguished from *L. sinapis* by the morphology of the genitals. We also recorded one of these two species, but it is safer to list it as *L. juvernica/sinapis*. The endangered *A. iris* occupies very similar habitats as *A. ilia*, so the persistence of this species cannot be ruled out. Our research discovered a very interesting species *P. argus* (see below). In Oprechtice, Valušák (2020) recorded these species – *I. io*, *P. c-album*, *A. urticae*, *Nymphalis antiopa*, *M. galathea*, *C. pamphilus*, *A. paphia*, *C. argiolus*, *P. icarus*, *M. stellatarum*, and *Z. filipendulae*. We recorded additional species for this heap – *T. lineola*, *E. tages*, *O. sylvanus*, *M. jurtina*, *A. hyperantus*, *A. levana*, *V. cardui*, *S. w-album*, *A. agestis*, *C. argiades*, *P. napi*, *P. rapae*, *G. rhamni*, and *L. juvernica/sinapis*. It can be noted that Valušák did not focus on diurnal butterflies in his research, and therefore we recorded many more species, including the discovery of the presence of the inconspicuous butterfly *S. w-album* (see below).

Across all the heaps in the Ostrava Basin, a total of seven species of conservation interest were found, namely *P. argus*, *Polyommatus bellargus* (Vicherek 2018), *P. machaon*, *A. ilia*, *A. iris*, *L. dispar*, *S. w-album*. The first half of these species are characteristic of early successional stages of steppes to forest-steppes and often occur in anthropogenic locations. The second half of the species is associated with forest edges, paths, or valleys along rivers. The figurative mosaic of these habitats can often be found on heaps, thanks to the various stages of succession present on a single heap, making heaps an ideal location for the occurrence of these endangered species.

In addition to previous research, two of these species were newly associated with heaps by our research. The near threatened *P. argus* was recorded on the Paskov heap. It was once widespread, but now its main occurrence is primarily restricted to the west of the Czech Republic and South Moravia. In the Moravian-Silesian region, a known population of this species exists around Starý and Nový Jičín. Last year, it expanded into the Poodří Protected Landscape Area, into a former sand quarry in Kunín (Ožana et al. 2022). This is the first record from the Ostrava region since 2010. This species requires areas with sparse vegetation and a sufficient degree of disturbance, created for example, by bulldozers, military vehicles, or explosives. For this reason, it fares relatively well in the west of the Czech Republic, particularly in the Most and Sokolov basins. To protect this species, succession should be blocked to maintain it in an early stage (Beneš et al. 2002). *S. w-album* is also nearly threatened and is reported to be relatively abundant in the Czech Republic but often escapes attention due to its very secretive life. It was recorded on the Oprechtice heap. This species is not very selective in terms of habitat, but the presence of the host plant *Ulmus* spp. is crucial. All species of the genus *Ulmus* are struggling with Dutch elm disease, caused by the fungus *Ophiostoma novo-ulmi*. This fungus has decimated up to 95% of elm populations (Beneš et al. 2002, Černý 2016). The endangered *P. machaon* was recorded during monitoring on several heaps – Oskárka, ŽDB Bohumín, Jeremenko, and Paskov. It prefers early successional stages with the presence of host plants from the Apiaceae family. It is known that males and females meet at the tops of hills (so-called hill-topping), in this case, at the tops of heaps that are higher than the surrounding terrain. *A. ilia*, another endangered species, was recorded on the Heřmanice, Chemická, Hedvika, Michálka, Hrabůvka, and Jeremenko heaps. This species is associated with forest paths, road edges, or river valleys with stands of *Populus tremula*. It often seeks food on the ground in mud, in puddles, on excrement, etc. (Beneš et al. 2002).

In addition to butterflies, interesting species of other insects were also recorded. All species share a common association with steppe and forest-steppe habitats in an early successional stage, except for *A. domesticus*, which is synanthropic. The thermophilic, nearly threatened Mediterranean species *S. hirta*, extending into Central Europe, was recorded on the Oskárka and Paskov heaps. The centre of occurrence of this species in the Czech Republic is South Moravia, from where it spreads to the rest of the country. From the Moravian-Silesian region, there are only four records, all of them directly from urban areas except for one record from a quarry (Mikunda 2023). Heaps as post-industrial sites are an ideal habitat and are preferred over city outskirts, industrial zones, sand quarries, and urban developments (Twerd et al. 2019). The expansion of the vulnerable *M. religiosa*, which has massively colonized territories north of South Moravia, includes the Ostrava heaps (Heřmanice, Paskov). The successful expansion may also be attributed to parthenogenesis. In temperate zones, species prefers open xerothermic locations but is also capable of living at higher altitudes, such as on Radhošť in the Beskydy Mountains (Vitáček & Janšta 2016). The largest solitary bee in the Czech Republic, *Xylocopa* sp., was recorded on the Hrabůvka heap. Currently, there are three species of this genus in the Czech Republic – *X. iris*, *X. valga*, and *X. violacea*, with the most likely recorded being the latter, the most widespread in the Czech Republic and having the most records in the Moravian-Silesian region in the Nature Conservation Finding Database (NDOP). Until recently, South Moravia was the northernmost boundary of their occurrence. After 2010, this genus of bees underwent a significant increase in abundance and began to colonize the rest of the country. The locations of their occurrence are characterized by a large number of dead trees and natural cavities for nesting. Cavities in wood also create suitable conditions for the development of other insect species and nesting birds (Marco & Coelho 2003, Bogusch 2007). The endangered species *C. germanica*, associated with early successional open habitats, such as loess soils, pastures, or fields currently seeks post-industrial sites (Hodeček et al. 2016, Kašák & Spitzer 2022). This species was recorded on the Paskov heap. On the Heřmanice heap, the house cricket (*A. domesticus*) was recorded, illustrating the possibility of using the heap as a secondary habitat. This species probably prefers the spots with heat emitted by the heap due to its thermal activity. It is also observed on other thermally active heaps in Ostrava, namely Hedvika and Ema (Kočárek 2006, Kočárek et al. 2013). The blue-winged grasshopper (*O. caerulescens*) was recorded on the ŽDB Bohumín, Heřmanice, Michálka, and Paskov heaps. This species belongs to pioneer species and seeks dry and warm habitats; thus, the early successional stage on the heaps is an ideal refuge (Kočárek 2013).

Although the research focused on insects, with the greatest emphasis on butterflies, vertebrates were also recorded during regular monitoring of the heaps. On the Hrabůvka heap, the endangered bird *L. collurio*, which inhabits bushy slopes near steppes and forest-steppes, was observed. This species thrives in the heterogeneous vegetation of the heaps (using low vegetation for hunting food, and higher vegetation for a view of the landscape). The main components of its diet are arthropods (spiders, beetles, Hymenoptera) and smaller vertebrates, which the bird impales on nearby bushes beside its nest when food is abundant (Svendsen et al. 2015, Fišer et al. 2023, Kuras et al. 2023). The critically endangered *L. agilis* was recorded on most of the studied heaps (Oskárka, ŽDB Bohumín, Heřmanice, Chemická, Hedvika, Oprechtice). This species primarily inhabits open habitats with herbaceous vegetation, occasionally scattered shrubs, and plenty of sunny areas for basking. It can colonize newly emerging habitats such as dumps, quarries, sand pits, and even reclaimed sites (Moravec 2019). Within the heaps, amphibian species, particularly those belonging to the genus *Bombina*, have been frequently recorded. Notably, the species *Bombina variegata* has been documented on the Oprechtice and Paskov spoil heaps. Additionally, observations on the Jeremenko spoil heap have confirmed the presence of a *Bombina* species, which, due to identification challenges, could not be definitively classified to a specific species level. This genus is characterized by its aposematic colouring on the ventral side of the body. It seeks temporary pools, often found in waterlogged furrows, for example, after a tractor passes. Its habitat preference with anthropogenic interventions (heaps, gravel pits, mines, etc.) leads to a shorter lifespan and thus increased mortality. However, this is offset by the overproduction of offspring and its higher success in the early stages, due to minimal competition in the pools. These areas, despite not appearing as suitable environments for many other species of organisms due to human activity, host large and strong populations of the yellow-bellied toad, comparable to populations in natural habitats, which have been rather on the decline in recent years (Cayela et al. 2022).

Conclusion

Heaps have become a refuge and alternative habitats for a diversity of rare and endangered organisms. Owing to the various stages of ongoing succession found on the heaps, they form unique mosaic-like habitats. Both early and more advanced stages of succession can be found on the same heap. As the heaps cover nearly a tenth of the area of Ostrava, they can have an impact not only on supporting biodiversity of organisms with proper management but can also be a tourist attraction improving the well-being of human society.

Biomonitoring on these heaps was chosen so that the collected data could be used for further research. We aim to focus on whether the characteristics of the heaps influence butterfly communities and to determine which characteristics have the greatest impact on community composition and diversity. Another aspect of our research will involve studying the functional traits of species within diurnal butterfly communities in relation to anthropogenic habitats.

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