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Hoverflies (Diptera, Syrphidae) in the Danube Gorge, Carpathian Mountains, Romania: Zoogeographical, Ecological and Conservation Significance

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Abstract: Among pollinating insects, hoverflies are an important group that offers many ecosystem services; however, they are less studied in some areas of Eastern Europe. In this context, we analyzed the hoverfly fauna of a natural protected area with rich biodiversity in southwestern Romania, in the Danube Gorge area (Iron Gates Natural Park). The field work was conducted between 2021 and 2024, but we also collected hoverflies in 2007 only from a single location. We identified 111 species, of which the most common were *Sphaerophoria scripta* (Linnaeus 1758), *Episyrphus balteatus* (De Geer 1776), *Melanostoma mellinum* (Linnaeus 1758), and *Syritta pipiens* (Linnaeus 1758). In the Iron Gates Natural Park, we encountered mountainous species at relatively low altitudes (*Sericomyia silentis* (Harris 1778), *Neoascia annexa* (Müller 1776)), which populate narrow, wet valleys, situated in areas covered with beech forests. Alongside these, there are southern species with a small distribution range, which are present in the Iron Gates Natural Park at, or near, their northern distribution range limit, such as *Milesia crabroniformis* (Fabricius 1775). Thus, our data indicate that the biogeographical particularities of the Danube Gorge are also evident in hoverflies, as cold-climate and southern species at their distribution range limit meet in the region. The high number of species with saproxylic larvae is a consequence of the large area occupied by forests in the Iron Gates Natural Park. Therefore, protecting the region's forests is crucial for these insects, and confirms the value and importance of native forests in the Carpathians. Despite the high number of species, the park's wide area and our study period overlapping with pandemic restrictions make the data preliminary, confirming the precarious knowledge about this group in the region.

Key words: altitude, distribution, diversity, forests, habitats, pollinators, Iron Gates Natural Park

Introduction

The eastern part of Europe is the region with the largest gap in hoverfly studies on the continent (Reverté et al. 2023). As a result, even in areas where studies on hoverflies have been conducted for several decades, new distribution records are being reported nowadays (Tot et al. 2024). Not only is the

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knowledge in the region low, but much of the old data must also be reevaluated, and experts in this taxonomy group are few (Reverté et al. 2023).

The lack of knowledge about the distribution of hoverflies has even more negative consequences, as climate change will affect some species' distribution range, resulting in economic losses (Miličić et al. 2018a). Knowledge of these insects is important due to their multiple ecosystem services and practical importance (Dunn et al. 2020), a fact that is even more important given that pollinating insects have been declining recently (Potts et al. 2010, Goulson 2019, van Klink et al. 2024). Even in hoverflies, a significant decline was observed in recent decades, with a reduction in their abundance reaching as much as 80% in some European regions (Barendregt et al. 2022). Also, a decline in hoverfly species richness was mentioned in recent years in certain zones (Popov et al. 2017). In this context, even weeds from agricultural fields were considered useful habitats for pollinators (Milberg et al. 2025). However, conservation of forests in areas dominated by grasslands is considered vital for hoverfly populations in some regions (Ricarte et al. 2011). Generally, the conservation of forest habitats and even isolated trees is beneficial for pollinating insects (Ulyshen et al. 2023). Thus, forest quality, measured as the presence of large and old oaks, determines the success of species with saproxylic larvae (Maritano et al. 2024).

Certain hoverflies are important as bioindicators, revealing the present habitat quality and its changes over time (Popov et al. 2017). However, even in regions with natural protected areas, those areas are insufficient for hoverfly protection and conservation (Vujić et al. 2016). Nevertheless, a location where a natural protected area overlaps with an important habitat for hoverflies, is the southern slope of the Danube Gorge in Serbia (Vujić et al. 2016). Located on the Romanian shore of the Danube, is the Iron Gates Natural Park (IGNP), a protected area with a large surface, high biodiversity and numerous protected species (Rozylowicz et al. 2019). Although a hoverfly species new to Romania was recently identified in IGNP (Dumbravă & Ruicănescu 2023), data on hoverflies in the Danube Gorge are almost nonexistent compared to other protected areas in the region (Brădescu 1986, 1995). Thus, even if there is some previous information about hoverflies in south-western Romania, it covers small areas (Bălăşoiu 2007), rather than geographically and conservatively unitary areas. This fact is even more relevant, because the complementarity of the landscape, represented by the existence of areas for larval development and areas for adult survival, is necessary for the conservation of hoverflies and their ecosystem services, both at the landscape and local levels (Moquet et al. 2018). In this context, IGNP is a protected area with a highly diverse landscape (Niculae et al. 2022).

Therefore, because studies on hoverflies are important for biodiversity conservation efforts (Tot et al. 2024), and as a consequence of the biodiversity and biogeographical particularities of IGNP (Paşcovschi 1956, Covaciu-Marcov et al. 2009, 2025, Teodor et al. 2019, Petruş-Vancea et al. 2024), we hypothesized that this would shelter diverse hoverfly assemblages, with zoogeographically important species. Thus, our objectives were: 1. to establish the hoverfly species list from IGNP and neighboring areas, 2. to establish the differences determined by altitude and geographic location between hoverfly assemblages, 3. to observe any zoogeographic particularities that correspond to those observed in other groups in the region.

Materials and Methods

The hoverflies were collected over several years, mostly between 2021 and 2024. Sporadic data were available from previous years, but we also collected hoverflies in an organized manner in 2007 exclusively from the Sirinia Valley. In each study year, we spent approximately 30 days in the field dedicated to hoverflies, between March and October. The number of hours and locations investigated in the IGNP varied greatly between those days. Thus, in some cases we spent an entire day in the field collecting hoverflies, but in other cases we spent just 2 or 3 hours. Due to the IGNP's extensive surface (Rozylowicz 2008, Rozylowicz et al. 2019), it was not feasible to conduct uniform investigations; consequently, we collected hoverflies only once in some areas, made multiple field trips in others, and left certain areas unexplored. Also, because of the park's dimensions, different regions were sampled in different periods of the year. The hoverflies were collected using the direct method with hand nets. The captured individuals were preserved in test tubes with 70% ethyl alcohol and identified in the laboratory with the help of literature (Brădescu 1991, Van Veen 2004, Nedeljković et al. 2018, Vujić et al. 2020). All hoverfly individuals were personally observed and collected by the authors from the studied region.

The study covered the entire length of Iron Gates Natural Park, which overlaps with the Romanian shore of the Danube (Figure 1). The investigated area has a length of approximately 170 km along the northern shore of the Danube, between the

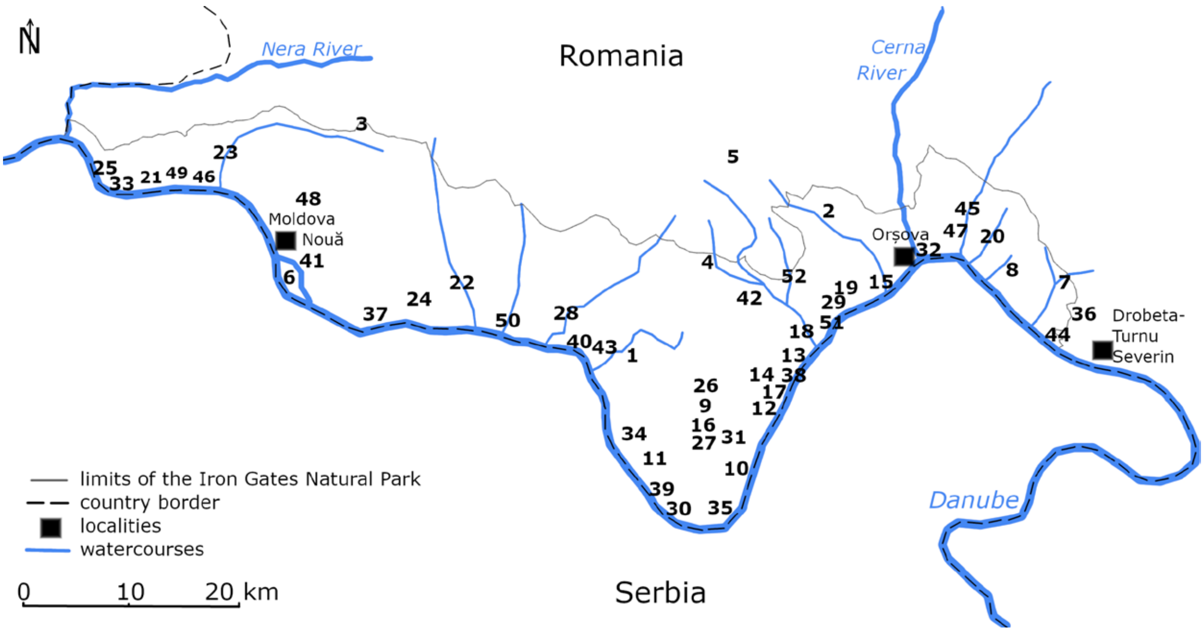

Fig. 1. Sampling points of hoverflies collected in the IGNP (1 – Valea Sirinia, 2 – Valea Eșelniței, 3 – Cărbunari, 4 – Valea Teiului, 5 – Eselnița mine, 6 – Ostrov Moldova Veche, 7 – Valea Luchiței, 8 – Slătinicul Mare, 9 – Baia Nouă mine, 10 – Valea Tișoviței, 11 – Valea Stariștei, 12 – Liubotina, 13 – Dubova, 14 – Valea Ponicovei, 15 – Eșelnița, 16 – Baia Nouă, 17 – Valea Plavișeviței, 18 – Valea Mraconiei, 19 – Valea Mala, 20 – Valea Vodiței, 21 – Divici, 22 – Sichevița, 23 – Valea Radimnei, 24 – Crușovița, 25 – Baziaș, 26 – Valea Coprivei, 27 – Eibenthal, 28 – Berzasca, 29 – Valea Ogradena, 30 – Șvinița, 31 – Cioaca Cremenească, 32 – Orșova, 33 – Valea Ribiș, 34 – Valea Elișevei, 35 – Valea Iuți, 36 – Breznița Ocol, 37 – Liborajdea, 38 – Valea Grăniceri, 39 – Greben, 40 – Drencova, 41 – Moldova Veche, 42 – Valea Morii, 43 – Valea Drestelnic, 44 – Valea Oglănicului, 45 – Ilovița, 46 – Șușca, 47 – Tarovăț, 48 – Moldova Nouă, 49 – Belobreșca, 50 – Valea Liubcovei, 51 – Ciucaru Mare, 52 – Valea Neamțului).

entrance of the river in Romania and near Drobeta-Turnu Severin city. Besides the areas near the Danube, we also went upstream the river's tributaries in the IGNP, reaching altitudes of 600-700 meters. To a small extent, we also investigated areas bordering the park, reaching altitudes between 900 and 1000 meters in the Almăj Mountains. The hoverflies were collected from various habitat types. Usually, we looked for areas with flowering plants. We also captured individuals from shady areas in forests, from mountain streams in forests, or from the edges of forest roads. Thus, we captured hoverflies from open, grassy areas with flowers, and from oak and beech forests. The flies were collected from different areas of the Danube Gorge, starting from the immediate vicinity of the Danube (between a few meters and several tens of meters from the river), as well as from different tributaries (Sirinia, Eșelnița, Mraconia, Vodița, Crușovița, etc.), even from over 15 km from the Danube. The samples were collected from altitudes between 80 to 1000 meters.

We collected 458 samples containing hoverfly individuals. The data were processed based on location in the gorge and time of year. We calculated the species percentage abundance according to these parameters and the frequency of occurrence with which the species appeared in the samples. We also calculated diversity (Shannon index), similarity (Jaccard index), and the significance of the differences between periods and different areas of IGNP, using Kruskal-Wallis and Mann-Whitney tests. Based on the literature (Brădescu 1991, Speight 2024, Krpač 2021), we classified the species from a zoogeographical and ecological perspective, as well as based on the food of the larvae. The data were processed in Microsoft Office Excel and Past programs (Hammer et al. 2001).

Results

We identified 574 hoverfly individuals, which belong to 111 species (Tables 1 and 2). Furthermore, in three instances, identification was possible only to the genus level. The most common species in the Danube Gorge area was *Sphaerophoria scripta* (Linnaeus, 1758), with a percentage abundance of 16.38%. It was followed by *Episyrphus balteatus* (De Geer, 1776) (11.5%), *Melanostoma mellinum* (Linnaeus, 1758), and *Syritta pipiens* (Linnaeus, 1758). Most

Table 1. Percentage abundance (P%) frequency of occurrence (f%) and of hoverfly species (after the IUCN Red List 2025) identified in the Iron Gates Natural Park

No. crt.	Species	IUCN	P%	f%	No. crt.	Species	IUCN	P%	f%
1	*Baccha elongata*	LC	0.87	2.76	58	*Melangyna quadrimaculata*	LC	0.52	2.07
2	*Brachypalpus laphriformis*	LC	0.35	1.38	59	*Melanostoma mellinum*	LC	3.66	8.97
3	*Brachypalpus valgus*	LC	0.52	2.07	60	*Melanostoma scalare*	LC	2.79	7.59
4	*Capliprobola speciosa*	LC	0.17	0.69	61	*Meligramma cincta*	LC	0.17	0.69
5	*Ceriana conopsoides*	LC	0.7	2.76	62	*Merodon aberrans*	LC	0.35	1.38
6	*Ceriana vespiformis*	LC	0.17	0.69	63	*Merodon analis*	LC	0.35	1.38
7	*Chalcosyrphus eunotus*	VU	0.17	0.69	64	*Merodon armipes*	LC	0.17	0.69
8	*Cheilosia albitarsis*	LC	0.17	0.69	65	*Merodon avidus*	LC	0.7	1.38
9	*Cheilosia canicularis*	LC	0.17	0.69	66	*Merodon calidus*	LC	1.05	3.45
10	*Cheilosia hercyniae*	LC	0.17	0.69	67	*Merodon clavipes*	LC	0.17	0.69
11	*Cheilosia impressa*	LC	0.17	0.69	68	*Merodon equestris*	LC	0.7	1.38
12	*Cheilosia laticornis*	LC	0.17	0.69	69	*Merodon funestus*	LC	0.52	0.69
13	*Cheilosia latifrons*	LC	1.05	1.38	70	*Merodon pruni*	LC	0.17	0.69
14	*Cheilosia nigripes*	LC	0.17	0.69	71	*Merodon rufus*	LC	0.17	0.69
15	*Cheilosia pagana*	LC	0.87	2.07	72	*Merodon serrulatus*	LC	0.17	0.69
16	*Cheilosia proxima*	LC	1.05	2.07	73	*Milesia crabroniformis*	LC	0.52	2.07
17	*Cheilosia urbana*	LC	0.17	0.69	74	*Milesia semiluctifera*	LC	0.17	0.69
18	*Cheilosia scutellata*	LC	0.17	0.69	75	*Myathropa florea*	LC	2.79	6.9
19	*Cheilosia semifasciata*	LC	0.17	0.69	76	*Neoascia annexa*	LC	0.17	0.69
20	*Cheilosia ruffipes*	LC	0.7	2.07	77	*Neoascia meticulosa*	LC	0.17	0.69
21	*Cheilosia vicina*	LC	0.17	0.69	78	*Neoascia obliqua*	LC	0.17	0.69
22	*Cheilosia vulpina*	LC	0.35	0.69	79	*Paragus bicolor*	LC	0.52	1.38
23	*Chrysogaster basalis*	VU	0.35	0.69	80	*Paragus bradescui*	EN	0.17	0.69
24	*Chrysogaster solstitialis*	LC	0.7	2.07	81	*Paragus haemorrhous*	LC	0.52	2.07
25	*Chrysotoxum bicinctum*	LC	0.35	1.38	82	*Paragus punctulatus*	LC	0.17	0.69
26	*Chrysotoxum cautum*	LC	1.05	2.07	83	*Paragus* sp.	-	1.22	3.45
27	*Chrysotoxum festivum*	LC	1.05	4.14	84	*Paragus tibialis*	LC	0.35	1.38
28	*Chrysotoxum octomaculatum*	NT	0.17	0.69	85	*Parasyrphus punctulatus*	LC	0.35	1.38
29	*Chrysotoxum verralli*	LC	0.52	2.07	86	*Philhelius laetum*	LC	0.17	0.69
30	*Chrysotoxum vernale*	LC	0.87	2.76	87	*Philhelius pedissequus*	LC	0.7	2.76
31	*Dasysyrphus albostriatus*	LC	1.39	4.83	88	*Pipiza lugubris*	LC	0.17	0.69
32	*Dasysyrphus tricinctus*	LC	0.35	1.38	89	*Pipizella annulata*	NT	0.52	0.69
33	*Didea fasciata*	LC	0.52	1.38	90	*Pipizella maculipennis*	LC	0.17	0.69
34	*Epistrophe eligans*	LC	0.35	1.38	91	*Platycheirus scutatus*	LC	0.17	0.69
35	*Epistrophe nitidicollis*	LC	0.17	0.69	92	*Scaeva pyrastri*	LC	0.35	1.38
36	*Episyrphus balteatus*	LC	11.5	17.9	93	*Scaeva selenitica*	LC	0.17	0.69
37	*Eristalinus aeneus*	LC	0.17	0.69	94	*Sericomyia silentis*	LC	0.17	0.69
38	*Eristalis abusiva*	LC	1.05	2.07	95	*Sphaerophoria scripta*	LC	16.4	22.1
39	*Eristalis anthophorina*	LC	0.17	0.69	96	*Sphaerophoria* sp.	-	4.18	9.66
40	*Eristalis arbustorum*	LC	1.05	2.76	97	*Sphegina clunipes*	LC	0.17	0.69
41	*Eristalis pertinax*	LC	0.7	2.07	98	*Sphiximorpha subsessilis*	LC	0.17	0.69
42	*Eristalis rupium*	LC	0.17	0.69	99	*Spilomyia manicata*	LC	0.35	0.69
43	*Eristalis similis*	LC	0.87	2.76	100	*Spilomyia saltuum*	LC	0.52	2.07
44	*Eristalis tenax*	LC	3.14	11	101	*Syritta pipiens*	LC	3.31	11.7
45	*Eumerus amoenus*	LC	0.35	1.38	102	*Syrphus ribesii*	LC	1.74	6.9
46	*Eumerus flavitarsis*	LC	0.17	0.69	103	*Syrphus torvus*	LC	0.17	0.69
47	*Eumerus pulchellus*	LC	0.52	1.38	104	*Syrphus vitripennis*	LC	2.26	4.14
48	*Eumerus sabulonum*	LC	0.17	0.69	105	*Tropidia scita*	LC	0.17	0.69
49	*Eumerus* sp.	-	0.17	0.69	106	*Volucella bombylans*	LC	0.17	0.69
50	*Eupeodes corollae*	LC	1.39	4.83	107	*Volucella inanis*	LC	0.87	2.76
51	*Eupeodes luniger*	LC	0.7	2.76	108	*Volucella inflata*	LC	0.35	1.38
52	*Ferdinandea cuprea*	LC	1.05	4.14	109	*Volucella pellucens*	LC	1.22	4.83
53	*Helophilus hybridus*	LC	0.17	0.69	110	*Volucella zonaria*	LC	1.74	5.52
54	*Helophilus pendulus*	LC	0.35	1.38	111	*Xanthandrus comtus*	LC	1.22	4.14
55	*Helophilus trivittatus*	LC	0.7	2.76	112	*Xylota segnis*	LC	0.87	2.76
56	*Mallota cimbiciformis*	LC	0.17	0.69	113	*Xylota sylvarum*	LC	0.35	1.38
57	*Mallota fuciformis*	LC	0.35	1.38	114	*Xylota tarda*	LC	0.52	2.07

Table 2. Distribution of the hoverfly species in the Iron Gates Natural Park (1 – Valea Sirinia, 2 – Valea Eşelniţei, 3 – Cărbunari, 4 – Valea Teiului, 5 – Eselniţa mine, 6 – Ostrov Moldova Veche, 7 – Valea Luchiţei, 8 – Slătinicul Mare, 9 – Baia Nouă mine, 10 – Valea Tişoviţei, 11 – Valea Stariştei, 12 – Liubotina, 13 – Dubova, 14 – Valea Ponicovei, 15 – Eşelniţa, 16 – Baia Nouă, 17 – Valea Plavişeviţei, 18 – Valea Mraconiei, 19 – Valea Mala, 20 – Valea Vodiţei, 21 – Divici, 22 – Sicheviţa, 23 – Valea Radimnei, 24 – Cruşoviţa, 25 – Baziaş, 26 – Valea Coprivei, 27 – Eibenthal, 28 – Berzasca, 29 – Valea Ogradena, 30 – Şviniţa, 31 – Cioaca Cremenească, 32 – Orşova, 33 – Valea Ribiş, 34 – Valea Elişevei, 35 – Valea Iuţi, 36 – Brezniţa Ocol, 37 – Liborajdea, 38 – Valea Grăniceri, 39 – Greben, 40 – Drencova, 41 – Moldova Veche, 42 – Valea Morii, 43 – Valea Drestelnic, 44 – Valea Oglănicului, 45 – Iloviţa, 46 – Şuşca, 47 – Tarovăţ, 48 – Moldova Nouă, 49 – Belobreşca, 50 – Valea Liubcovei, 51 – Ciucaru Mare, 52 – Valea Neamţului).

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**
Baccha elongata	**X**	**X**							X																																											**X**
Brachypalpus laphriformis				X				X																																												
Brachypalpus valgus				X				X																										X																		
Capliprobola speciosa																																													X							
Ceriana conopsoides	**X**															X																					X							X								
Ceriana vespiformis																											X																									
Chalcosyrphus eunotus							X																																													
Cheilosia albitarsis		X																																																		
Cheilosia canicularis																																	X																			
Cheilosia hercyniae			X																																																	
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Cheilosia latifrons			X		X																																															
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Cheilosia pagana	**X**			X		X																																														
Cheilosia proxima	**X**									X																X																										
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Table 2. Continuation.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	**49**	**50**	**51**	**52**
Cheilosia scutellata								X																																												
Cheilosia semi-fasciata			X																																																	
Cheilosia ruffipes	X							X																			X																									
Cheilosia vicina		X																																																		
Cheilosia vul-pina			X																																																	
Chrysogaster basalis																										X																										
Chrysogaster solstitialis	**X**																										X																								X	
Chrysotoxum bicinctum	**X**												X																																							
Chrysotoxum cautum														X										X	X																											
Chrysotoxum festivum	**X**											X			X						X	X			X																											
Chrysotoxum octomaculatum		X																																																		
Chrysotoxum verralli														X	X									X																												
Chrysotoxum vernale																					X				X								X																			
Dasysyrphus albostriatus	**X**	**X**			X																		X		X							X																				
Dasysyrphus tricinctus		X			X																																															
Didea fasciata					X		X																																													
Epistrophe eligans													X																																							
Epistrophe nitidicollis																																X																				
Episyrphus balteatus	**X**	**X**	**X**	**X**				X	X		X					X			X	X		X		X								X											X		X					X		

Table 2. Continuation.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	**49**	**50**	**51**	**52**
Eristalinus aeneus						X																																														
Eristalis abusiva																X										X																X										
Eristalis anthophorina			X																																																	
Eristalis arbustorum	**X**					X	X																																													
Eristalis pertinax				X					X									X																																		
Eristalis rupium					X																																															
Eristalis similis			X																							X				X	X																					
Eristalis tenax	X			X	X	X		X								X						X				X			X							X																
Eumerus amoenus	**X**											X																																								
Eumerus flavitarsis													X																																							
Eumerus pulchellus	**X**												X																																							
Eumerus sabulonum																							X																													
Eumerus sp.													X																																							
Eupeodes corollae	**X**		X													X					X						X														XX											
Eupeodes luniger	**X**							X													X										X-																					
Ferdinandea cuprea	**X**						X						X																X	X													X									
Helophilus hybridus						X																																														
Helophilus pendulus														X		X																																				
Helophilus trivittatus	**X**					X														X		X																														

Table 2. Continuation.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	**49**	**50**	**51**	**52**
Mallota cimbiciformis	**X**																																																			
Mallota fuciformis													X																																				X			
Melangyna quadrimaculata				X									X																																							
Melanostoma mellinum	**X**		X	X				X									X	X	X	X	X		X	X																												
Melanostoma scalare	**X**	**X**					X		X		X				X				X																					X												
Meligramma cincta		X																																																		
Merodon aberrans												X				X																																				
Merodon analis	**X**					X																																														
Merodon armi-pes		X																																																		
Merodon avidus	**X**																																																			
Merodon calidus							X				X																							X										X								
Merodon clavipes																									X																											
Merodon eques-tris							X																				X																									
Merodon fu-nestus							X																																													
Merodon pruni												X																																								
Merodon rufus																				X																																
Merodon serrulatus																				X																																
Milesia crabroniformis																																			X		X		X													
Milesia semiluctifera																												X																								

Table 2. Continuation.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	**46**	**47**	**48**	**49**	**50**	**51**	**52**
Myathropa florea	**X**				X	X				X	X					X										X																										
Neoascia annexa				X																																																
Neoascia meticulosa			X																																																	
Neoascia obliqua										X																																										
Paragus bicolor	**X**											X																																								
Paragus bradescui																														X																						
Paragus haemorrhous			X				X																X																													
Paragus punctulatus	**X**																																																			
Paragus sp.																			X											X		X						X										X				
Paragus tibialis			X														X																																			
Parasyrphus punctulatus		X				X																																														
Philhelius laetum																								X																												
Philhelius pedissequus	**X**	X	X																	X																																
Pipiza lugubris	**X**																																																			
Pipizella annulata					X																																															
Pipizella maculipennis																																															X					
Platycheirus scutatus	**X**																																																			
Scaeva pyrastri	**X**														X																																					
Scaeva selenitica	X																																																			

Table 2. Continuation.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	**46**	**47**	**48**	**49**	**50**	**51**	**52**
Sericomyia silentis				X																																																
Sphaerophoria scripta	**X**	**X**	**X**								X	X		X	X		X	X	X	X	X	X	X	X			X	X	X		X				X	X		X			X					X						
Sphaerophoria sp.	**X**		X							X	X				X		X		X			X							X		X			X	X																	
Sphegina clunipes									X																																											
Sphiximorpha subsessilis																																		X																		
Spilomyia manicata					X																																															
Spilomyia saltuum															X							X						X																								
Syritta pipiens	**X**			X		X	X	X		X		X		X	X			X	X				X					X	X		X	X				X																
Syrphus ribesii	**X**	**X**			X				X												X												X																			
Syrphus torvus		X																																																		
Syrphus vitripennis	**X**				X				X			X					X																																			
Tropidia scita	X																																																			
Volucella bombylans	**X**																																																			
Volucella inanis		X		X																								X														X										
Volucella inflata									X																					X																						
Volucella pellucens	**X**			X					X	X							X	X																																		
Volucella zonaria				X		X					X														X								X				X		X	X												
Xanthandrus comtus	**X**									X	X			X				X																																		
Xylota segnis							X			X				X				X																																		
Xylota sylvarum								X									X																																			
Xylota tarda				X	X																																															

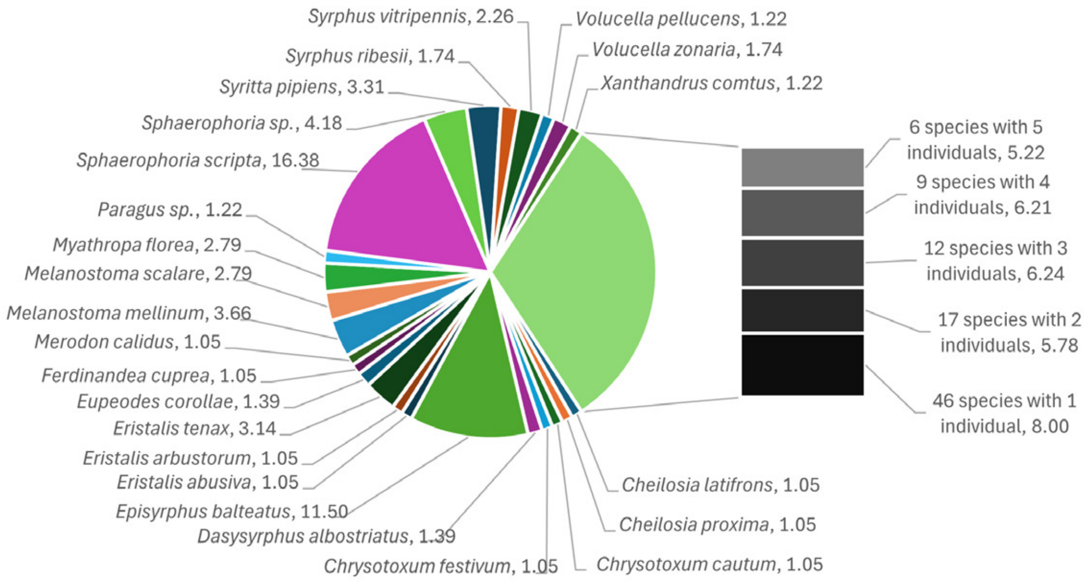

Fig. 2. Percentage abundance of hoverfly species in IGNP (species with more than 1% mentioned)

of the species had a reduced percentage abundance (Figure 2), as 46 species were represented by only one individual. The highest frequency of occurrence was also registered by *S. scripta* (46.15%), followed by *S. pipiens* and *E. balteatus* (Figure 3). Most hoverfly species (53) had a frequency of 1.92%, as they were present in only one location (Figure 3).

The number of species varied between different points of the gorge. The highest number (40) was identified in the Sirinia Valley, followed by the Eșelnița Valley (17 species), the area near the Cărbunari locality, and the Teiului Valley in the Mraconia basin (Figure 4). However, combining all the points from the Eșelnița Valley area, the number of species was 32. The differences between hoverfly assemblages from different areas of the IGNP were significant according to the Kruskal-Wallis index ($p<0.0001$). The differences were also significant when analyzing different areas of the gorge in pairs using the Mann-Whitney test ($p < 0.05$). Firstly, the assemblages in the Sirinia Valley differed significantly from those in any of the other areas, as determined by the Mann-Whitney test ($p<0.05$). The Sirinia Valley also recorded the highest diversity of hoverfly assemblages, according to the Shannon index ($H = 3.35$). This was followed by the Eșelnița Valley, with a diversity of $H = 2.79$. Combining all points from the Eșelnița Valley area, the assemblage's diversity had a value of $H = 3.26$, almost equal to that from Sirinia, which reflects the cumulative effect of multiple habitats sampled within the valley. The overall diversity of hoverfly assemblages across all sampled areas in IGNP was $H = 3.85$.

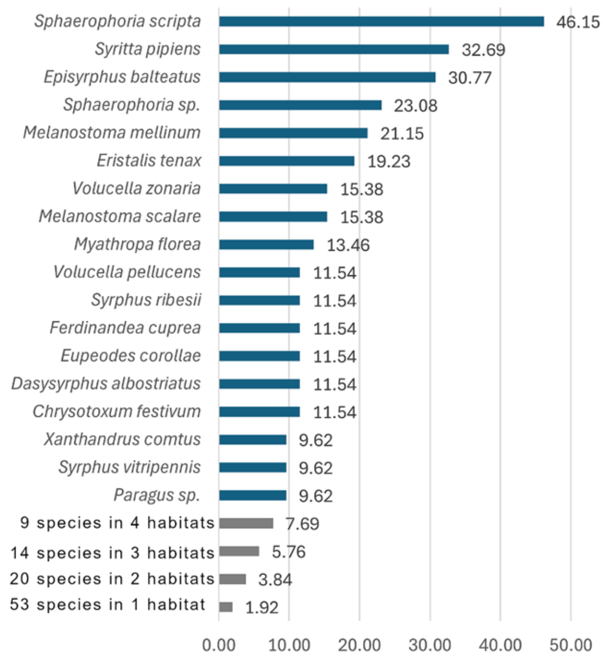

Fig. 3. Frequency of species in the sampling points in IGNP.

Important differences also existed between periods. The highest number of species (65) was recorded in July, while the lowest number (3) was recorded in October. The number of hoverfly species reached two peaks, in July and September (Figure 5), with an approximately uniform upward trend from March to summer. Furthermore, the number of individuals was also different between the study periods, as the majority of hov-

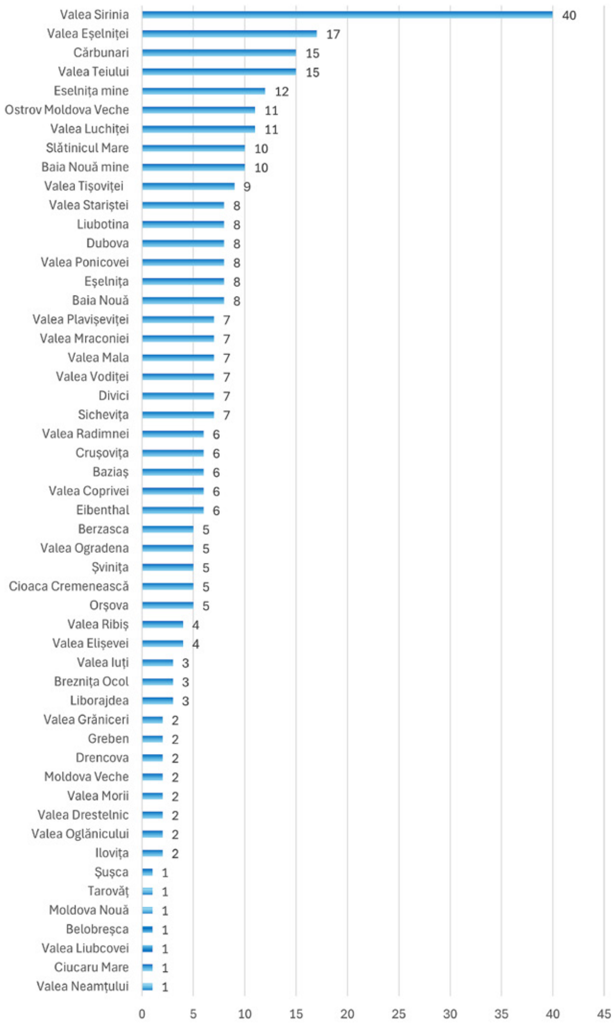

Fig. 4. Number of species registered in the sampling points in IGNP.

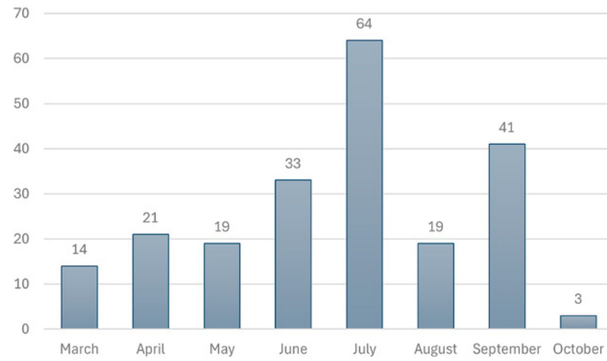

Fig. 5. Seasonal variation of species number in IGNP.

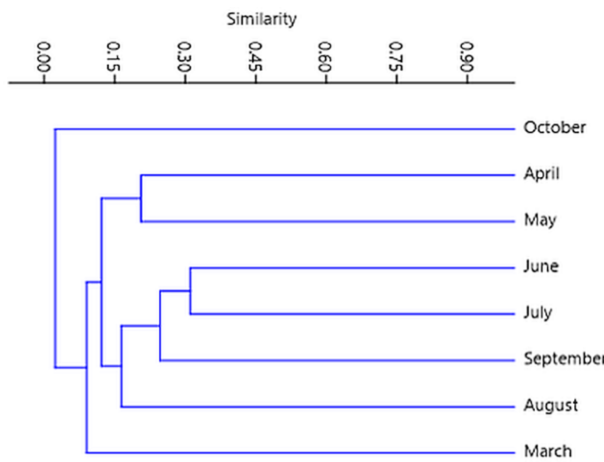

Fig. 6. Similarity between species registered in different seasons in IGNP (according to the Jaccard index).

erflies were collected in July. According to the Jaccard similarity index, the closest months, from the perspective of hoverfly assemblages, were, on one hand, June, July, and September (J=0.21 and 0.28), and, on the other hand, April and September with May (J=0.20). The most distinct hoverfly assemblage was in October (Figure 6), a month that shared species with June, July, and September (J varying between 0 and 0,07).

According to the Kruskal-Wallis test, the differences between the periods were significant ($p<0.0001$). The results were in most cases significant when analyzing the differences between months two by two using the Mann-Whitney test ($p<0.05$). However, there were no significant differences between the spring months and between August and the spring months (p varying between 0.24 and 0.97). Regarding the food of the larvae, most hoverfly species from IGNP had zoophagous larvae (36.28%). They were followed by saproxylic (34.51%) and phytophagous larvae (29.20%). From a biogeographical perspective, the majority of hoverfly species were Palaearctic (54.05%), followed by Holarctic (19.82%) and European species (17.12%), as the other categories were poorly represented.

Discussion

The 111 hoverfly species identified in IGNP represent 26.49% of the species present in Romania, which is a total of 419 species (Reverté et al. 2023). The real number of species is likely higher, as we identified some individuals that could be determined only to a genus level. Therefore, IGNP hosts many of the hoverfly species found in Romania, despite covering a relatively small area. However, the number of species is lower (less than half) compared to other natural protected areas in southwestern Romania, such as Domogled-Valea Cernei National Park

(Brădescu 1986, 1995), although studies there covered a longer period and the park has higher altitude differences. The number of species in IGNP is higher than in other high-biodiversity regions, such as Piatra Craiului National Park, where only 20 species were identified (Brădescu 2001).

The most common hoverfly in IGNP, *S. scripta*, is generally a common species, highly migratory, present in Europe, northern Africa, and parts of Asia (Speight 2024). It is common in Romania, present from the Danube Delta to the subalpine area (Brădescu 1991). Despite ecological differences, *S. scripta* also exhibits high abundance in other regions (Naderloo & Rad 2014, Hussain et al. 2018, Madureira et al. 2023, Plume et al. 2024). Thus, its high abundance in IGNP is not surprising, as *S. scripta* was identified on its entire range, from the Danube shores up to an altitude of 500-600 m. *S. scripta* inhabits both natural, forested areas and human-modified areas, including constructions, agricultural lands, and roadsides. It appears, however, near flowering plants in all cases. Both the number of distribution records and individuals were high, as the ones collected represented just a small fraction of those observed. The second species in terms of abundance, *E. balteatus*, is also widespread in Europe, considered anthropophilic and ubiquitous (Speight 2024). Thus, it occupies numerous localities in IGNP, on a wide altitudinal range. The case is also valid for *M. mellinum*, an anthropophilic species common in Europe (Speight 2024); it is also common in IGNP and widely distributed across different altitudes.

Besides common species, there are also rare, zoogeographically, ecologically and conservatively important species in IGNP. Of these, mountain and cold-climate hoverfly species, such as *Sericomyia silentis* (Harris, 1778), are present in IGNP at low altitudes. Although it is relatively widespread in Europe, being a Palaearctic species, it is considered a mountain species in central Europe (Speight 2024). In Romania, it was previously mentioned only in mountain areas, up to 1800 m (Brădescu 1991). According to GBIF, it is very rare in the country, being recorded in only two high areas of the Southern Carpathians, whereas in northern Europe, it is common (GBIF Secretariat 2023). It was recently reported in Montenegro at altitudes above 1450 m, near a stream in the forest (van Steenis et al. 2015). At similar altitudes, it was also present in southwestern Serbia (Miličić et al. 2018b). In the Tatra Mountains, it occurs at altitudes over 900 m, in humid zones (Klasa & Palaczyk 2010). Regarding the habitats, these data match the conditions from IGNP, as the species was found on the shore of a small stream, within an area covered with tens of kilometers of mainly beech forest. The stream is followed by a forest road, bordered by various flowering plants, wet areas and numerous vertical rocky slopes, thus classifying it as a mountain landscape. However, what does not match are the altitude and location, as the species was identified in the Mraconia valley basin, at approximately 400 m altitude, in a warm, southern area of Romania (Drugescu & Geacu 2004, Mândruț 2006). The fact is in agreement with biogeographical peculiarities of the Danube Gorge, where mountain species descend at low altitudes (Pașcovschi 1956, Iftime 2005, Covaciu-Marcov et al. 2009, Teodor et al. 2019, 2025, Petruș-Vancea et al. 2024). In the Mraconia Valley, even some mountainous species and plant communities descend to the lowest altitudes in the Carpathians (Schneider-Binder 2016). In Western Europe, *S. silentis* was observed on *Calluna vulgaris* (L.) Hull flowers (Stuke 1995, Mahy et al. 1998, Descamps et al. 2015), a plant present in IGNP on a parallel valley (Eșelnița), alongside blueberry (Petruș-Vancea et al. 2024).

Milesia crabroniformis (Fabricius, 1775) was recently reported for the first time in Romania, as IGNP is its northern distribution range limit (Dumbravă & Ruicănescu 2023). We identified and captured individuals in two new distribution points and observed individuals in other two locations. Thus, the four new distribution records prove that the species is well distributed throughout approximately the entire IGNP, particularly in its lower and warmer areas. Usually, individuals were observed near *Sambucus ebulus* L. 1753 flowering plants, flying fast on hot and sunny days. *M. crabroniformis* seems to be attracted by *S. ebulus* in Italy as well, where it is considered relatively rare (Burgio & Magagnoli 2024).

Neoascia annexa (Muller, 1776) is rare in Romania, where it is present in mountain areas from the western and northern parts of the country (Brădescu 1991, Jessat 1998). It is also rare in northern Europe (van Steenis et al. 2001, Reemer 2009). It appears to be a northern European species, rarely found in the south, as it was not mentioned in some parts of the Balkan Peninsula (Speight 2024), although it is present in Serbia (Nedeljković et al. 2009, Miličić et al. 2018b). Thus, *N. annexa* is added to northern and mountain species present at low altitudes on the Danube Gorge (Pașcovschi 1956, Iftime 2005, Covaciu-Marcov et al. 2009, Teodor et al. 2019, Petruș-Vancea et al. 2024). We identified an individual at 400 m altitude, in the Mraconia

Valley Basin, in the Almăj Mountains, within a vast beech forest, crossed by narrow, mountainous, humid, and cold valleys. It was present near springs in beech forests (Speight 2024) or in alluvial forests (Andrási et al. 2025). It was encountered on the edge of a forest road bordered, among others, by butterbur, as in other regions it was mentioned only on this plant (Andrási et al. 2025). Recently, in Mraconia Valley, another mountain insect was recorded on butterbur (Teodor et al. 2025), highlighting the valley as a shelter for species related to a cold and humid climate, usually associated with mountain areas. Thus, the habitat corresponds to its requirements, even if it is present rather in the south and at lower altitudes. The individual was identified at the beginning of August, which is relatively late compared to other cases (Speight 2024, Tóth 2011), although the flight period is considered later in higher altitudes (Speight 2024). South of Romania, in Bulgaria, it was identified in the mountains, at much higher altitudes (Tóth 2014). *N. meticulosa*, a Palaearctic species (Tóth 2011), related to humid zones (Tóth 2011, Speight 2024), was also present in IGNP. It was previously mentioned in Romania in the Romanian Plain and southern Dobruja (Brădescu 1991), Oltenia and Transylvania (Jessat 1998). It is also rare in other regions, such as North Macedonia, where it is found on river shores near *Petasites* sp. (Krpač et al. 2011), a plant also present in the IGNP.

Eristalis anthophorina (Fallèn, 1817) is rare in Romania, where it was previously identified only in the north-eastern region (Brădescu 1991). It is a Holarctic species, present in northern and central Europe (Speight 2024), in some regions being in decline (van Aartsen 2001). It does not seem to be well represented in northern Europe either, as it is rare in Sweden (van Steenis 2016) and Poland, where it is found only in the northern regions, in humid areas of primeval forests (Żóralski et al. 2018). It is rare in IGNP, where it was identified at Cărbunari (Locvei Mountains) at approximately 500 meters altitude, in an area with beech forests and mountain streams. Other mountain species, such as the Carpathian newt, have also been recently reported in the area (Covaciu-Marcov et al. 2025). *Xylota tarda* Meigen, 1822, although reported in the majority of Europe and Asia (Speight 2024), was only recently mentioned in some regions of Europe, such as the Iberian Peninsula (Ricarte et al. 2021). In Romania, it is considered very rare (Brădescu 2001), as it was generally mentioned in mountain and eastern areas, but also near IGNP, in Cernei Mountains (Brădescu 1991). It is also rare in IGNP, where it was identified only in two points, both in the high areas of the Almăj Mountains, at 400-500 m, in beech forest-dominated areas, even if it seems rather related to warm oak forests (Speight 2024). Another rare species in Romania is *Tropidia scita* (Harris, 1780); it was previously reported only in the Romanian Plain and the Danube Delta (Brădescu 1991), although it has a wide distribution range in Europe and Asia (Speight 2024). However, it is also rare in other regions of southern Europe, as it was only recently identified in Slovenia (Schwartz & de Groot 2024), and is present in Vojvodina, Serbia (Nedeljković et al. 2009). In IGNP, it was identified only in the Sirinia Valley, a heavily forested area with beech forests, as well as a watercourse and an artificial wetland, habitats like those where it was previously identified (Speight 2024, Schwartz & de Groot 2024). It was found at an altitude of 320 m, although in Central Europe it is considered uncommon and is mainly found in lowlands (Barták & Roháček 2011).

Two species from the *Mallota* genus (*Mallota cimbiciformis* (Fallèn, 1817) and *Mallota fuciformis* (Fabricius, 1794)) were identified in IGNP. Both are associated with forested areas containing old-growth trees (Speight 2024) and are rare in IGNP, with the first species recorded in a single location and the second in two locations. All distribution records are situated in forested areas (usually beech forests) with mature trees, crossed by small water courses. Their rarity is not surprising, as *M. cimbiciformis* is very rare and threatened in the Balkan Peninsula, as it was recorded only in two regions in Serbia (Vujić et al. 2002). Its presence in IGNP is a result of the large surface covered by mature forests, as it is considered an enigmatic species indicating old-growth trees (van de Meutter et al. 2023). Its rarity is also possibly a consequence of its mostly arboreal lifestyle (Speight 2024), while *M. fuciformis* has a short activity period (Speight 2024, Maritano et al. 2024). This species is selective for the size of forests, the presence of wet areas and mature oak trees (Maritano et al. 2024), which are well represented in IGNP.

IGNP is situated in a warm region of Romania, characterized by sub-Mediterranean climate influences (Drugescu & Geacu 2004, Mândruț 2006). Thus, it shelters southern, sub-Mediterranean species, both plants (Pașcovschi 1956, Imbrea et al. 2013, Schneider-Binder 2014) and animals (Fuhn 1975, Covaciu-Marcov et al. 2009, Tăușan & Teodorescu 2017). However, we identified only a few Mediterranean hoverfly species. Probably, their high mobility, as some are migratory (Speight 2024), caused a uniformity in the fauna, as some initially Mediterranean species could have expanded outside their original range. Thus, some species, although they are not actually Mediterranean, as they extend beyond that area, clearly have an affinity towards this region, but are widely distributed. However, even in groups with clear zoogeographical affinities, not in all cases does the Danube Gorge shelter southern species, a fact visible in amphibians compared with reptiles (Fuhn 1975). However, in the case of hoverflies, in IGNP there are also southern species at their distribution range limit, such as *M. crabroniformis*. In hoverflies, it seems that a high diversity is not so obvious in the Mediterranean area, as the countries from temperate Europe are somehow uniform in terms of species richness, and the endemic ones are more related to high mountain areas (see Reverté et al. 2023). At the same time, the region serves as a contact point between groups with different origins (see Paşcovschi 1956), a fact that is also true for hoverflies, which are represented by both mountain species at low altitudes and southern species at their distribution limit.

There were clear differences between hoverfly assemblages in different IGNP areas. The highest species richness and diversity were observed in the Sirinia valley, an area with high biodiversity, which was also evident in road mortality (Cupşa et al. 2024). The valleys on the eastern part of the gorge (Eşelniţa and Mraconia) are also important for hoverflies. Thus, Eşelniţa is really similar to Sirinia in diversity, and in the higher areas of the Mraconia basin, there were some rare, even mountain species, at lower altitudes, thus a corollary to the biogeographical particularities of this region (Paşcovschi 1956, Covaciu-Marcov et al. 2009, Teodor et al. 2019, 2025, Petruş-Vancea et al. 2024). Despite the species richness, Sirinia is somewhat an artifact, as we possess rigorous data from 2007, not just sporadic observations, like in other valleys. Furthermore, the high species richness was obtained from a large number of individuals, whereas in the other valleys, relatively many species were identified from a much smaller number of individuals (17 species on Eşelniţa from 19 individuals). The Sirinia valley is more accessible, as it is followed by an asphalted road, whereas the other valleys are only accessible by forest roads, and so are difficult to travel. Typically, the more developed valleys have had a higher number of species compared to smaller valleys.

In the case of larvae, species from different trophic categories were well-balanced. Many larvae were saproxylic due to the extensive forests in the area, which occupy most of IGNP (Rozylowicz 2008, Niculae et al. 2022). They shelter a relict fauna with conservation importance, as species strictly related to forests are present only in the most heterogeneous forests (Larrieu et al. 2015). Although these forests shelter fewer species, they are native and characteristic of the primary habitats of the region. In areas with a higher number of species many are migratory. Thus, in the Mraconia basin, although there are few species, they are of great biogeographic importance. At the same time, the fact that numerous larvae are saproxylic indicates that the adults, which fly in the sun above the flowers, originated from the middle of the forest (larvae), confirming the importance of landscape complementarity for hoverflies (Moquet et al. 2018). Beyond the flies themselves, this fact highlights once more the importance of natural forests for invertebrate fauna (Cicort-Lucaciu et al. 2020), in this case even with flying adults. Regarding the conservative status, most species are considered Least Concern by IUCN (95.49%). Only one species is considered endangered (*Paragus bradescui* Stănescu, 1981), two are considered vulnerable (*Chalcosyrphus eunotus* (Loew, 1873) and *Chrysogaster basalis* Loew, 1857), and two more are considered near threatened (*Chrysotoxum octomaculatum* Curtis, 1837 and *Pipizella annulata* (Macquart, 1829)) (4.50%) (IUCN Red List 2025). This situation could indicate that hoverflies are not as threatened as other groups, although they seem to be declining nowadays (Popov et al. 2017, Barendregt et al. 2022). Thus, the fact that most hoverfly species identified in IGNP are considered Least Concern is more a consequence of the insufficient amount of data about this insect, a fact clearly true for Eastern Europe (Reverté et al. 2023).

Despite the richness and biogeographical importance of the hoverfly fauna, our study has several limitations. The field activity was disrupted by the COVID-19 pandemic, which imposed travel restrictions in Romania (Dascălu 2020). Afterward, the main road in IGNP was closed for a long time in 2023 due to landslides, which also impacted other studies (Covaciu-Marcov et al. 2025). In addition, the large surface of IGNP (Rozylowicz 2008, Rozylowicz et al. 2019) prevents the investigation of its entire habitat diversity. Last but not least, meteorological conditions, including very hot and arid years (Ionita & Nagavciuc 2025), also affected the activity of hoverflies. Therefore, our data must be considered preliminary, as research should continue in areas that are difficult to reach and serve as shelters for important species.

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