

UAV-Based Land Cover Classification for Hoverfly (Diptera: Syrphidae) Habitat Condition Assessment: A Case Study on Mt. Stara Planina (Serbia)

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Supplementary Materials

Supplementary materials include:

- Tables **S1** to **S3** that provide information about sizes of the training and validation sets on three study sites with three experimental repetitions;
- Tables **S4** to **S12** that provide information about the results obtained from three study sites and three experimental repetitions evaluated by additional metrics: precision, recall, and f-score per each class k calculated with the following equations:

$$precision_k = true\ positive_k / (true\ positive_k + false\ positive_k)$$

$$recall_k = true\ positive_k / (true\ positive_k + false\ p_k)$$

$$F1 - score_k = 2 \times (precision_k \times recall_k) / (precision_k + recall_k)$$

- Table **S13** presents the list of potential richness of hoverfly species for the certain vegetation types;
- Table **S14** presents the list of recent richness of hoverfly species in three designated study sites;
- Zenodo link to raw data (orthomosaics) which enables research repeatability: <https://doi.org/10.5281/zenodo.4482248>
- Zenodo link to instruction video for recreating research results: <https://doi.org/10.5281/zenodo.4482323>

Table S1. Dojkinci1 different partitions of training and validation sets.

Dojkinci1						
class	Training	Validation	Training1	Validation1	Training2	Validation2
1	2537	744	2434	521	2552	556
2	2585	384	2453	557	2700	494
3	2837	502	2474	545	2725	516
4	2487	501	2263	505	2421	497
5	2246	571	2400	547	2330	495
6	1928	404	2418	495	2665	491

total	14620	3106	14442	3170	15393	3049
sum of all polygons	345829					

Table S2. Dojkinci2 different partitions of training and validation sets.

Dojkinci2						
class	Training	Validation	Training1	Validation1	Training2	Validation2
1	2905	500	2805	507	2573	500
2	3205	487	2816	517	2505	500
3	2900	500	2811	509	2530	500
4	2976	500	2607	507	2976	500
5	2890	500	2500	502	2890	500
total	14876	2487	13539	2542	13474	2500
sum of all polygons	340321					

Table S3. Babin zub different partitions of training and validation sets.

Babin zub						
class	Training	Validation	Training1	Validation1	Training2	Validation2
1	1204	212	1214	210	1014	204
2	1048	190	1000	200	1000	200
3	1200	200	1002	200	1000	205
4	1061	200	1000	200	1000	201
5	1016	206	1006	200	1005	200
total	5529	1008	5222	1010	5019	1010
sum of all polygons	117239					

Table S4. Precision, recall, and f-score per class for SVM, RF, and k-NN classifiers (corresponding overall accuracy, Kappa index results presented in the manuscript) for Dojkinci1 study site.

Dojkinci1				
	class	Precision	Recall	F-score
SVM	1	0.97	1.00	0.98
	2	0.74	0.62	0.68
	3	0.74	0.90	0.81
	4	0.91	0.96	0.94
	5	0.97	0.91	0.94
	6	0.94	0.81	0.87
RF	1	1.00	0.99	1.00
	2	0.84	0.93	0.88
	3	0.93	0.91	0.92
	4	0.97	0.96	0.97

	5	0.99	0.97	0.98
	6	0.97	0.96	0.97
K-NN	1	0.95	0.99	0.97
	2	0.77	0.72	0.74
	3	0.84	0.92	0.88
	4	0.96	0.92	0.94
	5	0.98	0.91	0.94
	6	0.90	0.91	0.90

Table S5. Precision, recall, and f-score per class for SVM, RF, and k-NN classifiers (corresponding overall accuracy, Kappa index results presented in the manuscript) for Dojkinci2 study site.

Dojkinci2				
	class	Precision	Recall	F-score
SVM	1	0.87	0.91	0.89
	2	0.67	0.78	0.72
	3	0.77	0.74	0.75
	4	0.89	0.80	0.84
	5	0.89	0.84	0.86
RF	1	0.80	0.98	0.88
	2	0.87	0.71	0.78
	3	0.81	0.93	0.87
	4	0.94	0.88	0.91
	5	0.98	0.86	0.91
K-NN	1	0.80	0.97	0.88
	2	0.81	0.51	0.62
	3	0.66	0.94	0.78
	4	0.93	0.83	0.88
	5	0.97	0.83	0.89

Table S6. Precision, recall, and f-score per class for SVM, RF, and k-NN classifiers (corresponding overall accuracy, Kappa index results presented in the manuscript) for Babin zub study site.

Babin zub				
	class	Precision	Recall	F-score
SVM	1	0.92	0.91	0.91
	2	0.66	0.73	0.69
	3	0.75	0.69	0.72
	4	0.98	0.98	0.98
	5	0.99	1.00	0.99
RF	1	0.93	0.94	0.93

	2	0.76	0.85	0.81
	3	0.88	0.79	0.83
	4	0.98	0.98	0.98
	5	1.00	0.99	1.00
	1	0.88	0.60	0.72
	2	0.59	0.89	0.71
K-NN	3	0.86	0.77	0.81
	4	0.93	0.94	0.93
	5	0.99	0.96	0.98

Table S7. Precision, recall, and f-score per class for SVM, RF, and k-NN classifiers for the first repetition for Dojkinci1 study site.

Dojkinci1				
	class	Precision	Recall	F-score
SVM	1	1.00	1.00	1.00
	2	0.88	0.51	0.65
	3	0.65	0.91	0.76
	4	0.99	0.74	0.85
	5	0.71	0.97	0.82
	6	0.82	0.73	0.77
RF	1	1.00	1.00	1.00
	2	0.93	0.86	0.89
	3	0.86	0.86	0.86
	4	0.98	0.95	0.96
	5	0.92	0.97	0.95
	6	0.82	0.86	0.84
K-NN	1	0.98	0.99	0.98
	2	0.86	0.64	0.74
	3	0.71	0.93	0.81
	4	0.98	0.92	0.95
	5	0.84	0.95	0.89
	6	0.80	0.68	0.74

Table S8. Precision, recall, and f-score per class for SVM, RF, and k-NN classifiers for the first repetition for Dojkinci2 study site.

Dojkinci2				
	class	Precision	Recall	F-score
SVM	1	0.86	0.81	0.84
	2	0.61	0.66	0.63

	3	0.66	0.82	0.73
	4	0.87	0.74	0.80
	5	0.82	0.72	0.77
RF	1	0.90	0.83	0.86
	2	0.72	0.82	0.77
	3	0.86	0.90	0.88
	4	0.93	0.89	0.91
	5	0.94	0.87	0.91
K-NN	1	0.88	0.86	0.87
	2	0.70	0.50	0.58
	3	0.61	0.94	0.74
	4	0.89	0.85	0.87
	5	0.95	0.79	0.87

Table S9. Precision, recall, and f-score per class for SVM, RF, and k-NN classifiers for the first repetition for Babin zub study site.

Babin zub				
	class	Precision	Recall	F-score
SVM	1	0.98	0.78	0.87
	2	0.66	0.77	0.71
	3	0.71	0.79	0.75
	4	0.97	0.92	0.95
	5	1.00	1.00	1.00
RF	1	0.97	0.92	0.94
	2	0.77	0.83	0.80
	3	0.81	0.80	0.81
	4	0.98	0.97	0.98
	5	1.00	1.00	1.00
K-NN	1	0.89	0.57	0.69
	2	0.59	0.80	0.68
	3	0.73	0.79	0.76
	4	0.95	0.93	0.94
	5	1.00	0.99	0.99

Table S10. Precision, recall, and f-score per class for SVM, RF, and k-NN classifiers for the second repetition for Dojkinci1 study site.

Dojkinci1				
	class	Precision	Recall	F-score
SVM	1	0.94	1.00	0.97

	2	0.81	0.73	0.77
	3	0.84	0.92	0.88
	4	0.98	0.96	0.97
	5	0.86	0.96	0.91
	6	0.90	0.77	0.83
RF	1	0.98	0.99	0.98
	2	0.91	0.96	0.93
	3	0.98	0.95	0.97
	4	0.97	0.98	0.97
	5	0.99	0.97	0.99
	6	0.98	0.96	0.97
K-NN	1	0.94	0.99	0.97
	2	0.87	0.91	0.89
	3	0.97	0.97	0.97
	4	0.98	0.95	0.96
	5	0.98	0.94	0.96
	6	0.93	0.87	0.90

Table S11. Precision, recall, and f-score per class for SVM, RF, and k-NN classifiers for the second repetition for Dojkinci2 study site.

Dojkinci2				
	class	Precision	Recall	F-score
SVM	1	0.93	0.78	0.85
	2	0.67	0.72	0.69
	3	0.83	0.91	0.87
	4	0.89	0.84	0.86
	5	0.84	0.89	0.87
RF	1	0.89	0.82	0.85
	2	0.73	0.81	0.77
	3	0.92	0.85	0.89
	4	0.93	0.93	0.93
	5	0.90	0.93	0.92
K-NN	1	0.86	0.84	0.85
	2	0.66	0.62	0.64
	3	0.80	0.85	0.83
	4	0.91	0.88	0.89
	5	0.84	0.90	0.87

Table S12. Precision, recall, and f-score per class for SVM, RF, and k-NN classifiers for the second repetition for Babin zub study site.

Babin zub				
	class	Precision	Recall	F-score
SVM	1	0.94	0.84	0.89
	2	0.71	0.75	0.73
	3	0.78	0.78	0.78
	4	0.90	0.95	0.92
	5	1.00	1.00	1.00
RF	1	0.96	0.94	0.95
	2	0.78	0.85	0.81
	3	0.86	0.76	0.81
	4	0.92	0.98	0.95
	5	1.00	1.00	1.00
K-NN	1	0.88	0.52	0.66
	2	0.56	0.79	0.66
	3	0.75	0.76	0.76
	4	0.94	0.93	0.93
	5	0.99	0.99	0.99

Table 13. The list of potential richness of hoverfly species for the certain vegetation types: A, vegetation type of alpine, subalpine, and oro-Mediterranean vegetation; B, montane spruce and mixed spruce forests; and E, the vegetation type of beech and mixed beech forests. 0 indicates the absence of the species, 1 indicates the presence of the species.

Hoverfly species	A	B	E
<i>Brachyopa_dorsata</i>	0	0	1
<i>Brachyopa_insensilis</i>	0	0	1
<i>Brachyopa_plena</i>	0	0	1
<i>Callicera_aurata</i>	0	0	1
<i>Callicera_fagesii</i>	0	0	1
<i>Callicera_spinolae</i>	0	0	1
<i>Ceriana_conopsoides</i>	0	0	1
<i>Cheilosia_pascuorum</i>	0	0	1
<i>Cheilosia_redi</i>	0	0	1
<i>Chrysotoxum_festivum</i>	0	0	1
<i>Criorhina_asilica</i>	0	0	1
<i>Criorhina_floccosa</i>	0	0	1
<i>Doros_destillatorius</i>	0	0	1
<i>Epistrophella_euchroma</i>	0	0	1
<i>Eristalis_tecta</i>	0	0	1
<i>Eumerus_clavatus</i>	0	0	1

<i>Eumerus flavitarsis</i>	0	0	1
<i>Eupeodes goeldlini</i>	0	0	1
<i>Eupeodes lucasi</i>	0	0	1
<i>Ferdinandea aurea</i>	0	0	1
<i>Heringia heringi</i>	0	0	1
<i>Mallota cimbiciformis</i>	0	0	1
<i>Mallota fuciformis</i>	0	0	1
<i>Melanogaster curvistylus</i>	0	0	1
<i>Meligramma guttata</i>	0	0	1
<i>Meligramma triangulifera</i>	0	0	1
<i>Merodon auripes</i>	0	0	1
<i>Merodon kozufensis in litt.</i>	0	0	1
<i>Merodon loewi</i>	0	0	1
<i>Merodon olympi</i>	0	0	1
<i>Merodon orjeniesis in litt.</i>	0	0	1
<i>Merodon rufus</i>	0	0	1
<i>Milesia crabroniformis</i>	0	0	1
<i>Milesia semiluctifera</i>	0	0	1
<i>Myolepta dubia</i>	0	0	1
<i>Myolepta obscura</i>	0	0	1
<i>Myolepta potens</i>	0	0	1
<i>Myolepta vara</i>	0	0	1
<i>Orthonевра nobilis</i>	0	0	1
<i>Paragus tibialis</i>	0	0	1
<i>Pipiza austriaca</i>	0	0	1
<i>Pipiza carbonaria</i>	0	0	1
<i>Pipiza festiva</i>	0	0	1
<i>Pipiza luteitarsis</i>	0	0	1
<i>Sphiximorpha subsessilis</i>	0	0	1
<i>Spilomyia manicata</i>	0	0	1
<i>Spilomyia saltuum</i>	0	0	1
<i>Temnostoma meridionale</i>	0	0	1
<i>Temnostoma vespiforme</i>	0	0	1
<i>Volucella inflata</i>	0	0	1
<i>Xanthogramma stackelbergi</i>	0	0	1
<i>Xylota florum</i>	0	0	1
<i>Xylota tarda</i>	0	0	1
<i>Cheilosia herculana</i>	1	0	0
<i>Cheilosia melanura rubra</i>	0	0	0
<i>Eumerus montanum</i>	0	0	0
<i>Merodon rasicus</i>	1	0	0

<i>Paragus_kopdagensis</i>	1	0	0
<i>Callicera_macquarti</i>	0	0	1
<i>Chalcosyrphus_nemorum</i>	0	0	1
<i>Chalcosyrphus_rufipes</i>	0	0	1
<i>Cheilosia_kerteszi</i>	0	0	1
<i>Cheilosia_laticornis</i>	1	0	1
<i>Cheilosia_psilophthalma</i>	0	0	1
<i>Chrysogaster_basalis</i>	0	0	1
<i>Criorhina_pachymera</i>	1	0	1
<i>Epistrophe_melanostoma</i>	0	0	1
<i>Eumerus_ornatus</i>	1	0	1
<i>Merodon_calidus</i>	1	0	1
<i>Merodon_omediterraneus_in_litt.</i>	1	0	1
<i>Paragus_bradesi</i>	1	0	1
<i>Chamaesyrphus_lusitanicus</i>	0	0	0
<i>Psilota_atra</i>	0	0	0
<i>Brachyopa_bicolor</i>	0	0	1
<i>Brachyopa_maculipennis</i>	0	0	1
<i>Brachyopa_panzeri</i>	0	0	1
<i>Brachyopa_pilosa</i>	0	0	1
<i>Brachyopa_testacea</i>	0	0	1
<i>Brachyopa_vittata</i>	0	0	1
<i>Cheilosia_aerea</i>	0	1	1
<i>Cheilosia_cynocephala</i>	0	0	1
<i>Cheilosia_lenta</i>	0	0	1
<i>Cheilosia_soror</i>	0	1	1
<i>Dasysyrphus_eggeri</i>	0	0	1
<i>Eupeodes_bucculatus</i>	0	1	1
<i>Ferdinanda_cuprea</i>	0	0	1
<i>Lejogaster_tarsata</i>	0	0	1
<i>Merodon_nigritarsis</i>	0	1	1
<i>Merodon_ruficornis</i>	0	1	1
<i>Neocnemodon_vitripennis</i>	0	0	1
<i>Orthonevra_frontalis</i>	0	0	1
<i>Paragus_albifrons</i>	0	1	1
<i>Pipiza_fasciata</i>	0	0	1
<i>Platycheirus_scutatus</i>	0	1	1
<i>Temnostoma_bombylans</i>	0	0	1
<i>Volucella_zonaria</i>	0	1	1
<i>Callicera_rufa</i>	0	0	0
<i>Cheilosia_ahenea</i>	0	0	0

<i>Cheilosia_faucis</i>	0	0	0
<i>Cheilosia_laeviseta</i>	1	1	0
<i>Cheilosia_laeviventris</i>	0	0	0
<i>Cheilosia_loewi</i>	0	0	0
<i>Cheilosia_pictipennis</i>	1	1	0
<i>Cheilosia_sahlbergi</i>	0	0	0
<i>Cheilosia_vujici</i>	1	1	0
<i>Chrysogaster_coemiteriorum</i>	0	0	0
<i>Chrysotoxum_orthostylum</i>	1	1	0
<i>Eupeodes_tiroiensis</i>	1	1	0
<i>Melanogaster_aerosa</i>	0	0	0
<i>Merodon_aureus</i>	1	1	0
<i>Paragus_absidatus</i>	1	1	0
<i>Paragus_finitimus</i>	1	1	0
<i>Paragus_punctulatus</i>	1	1	0
<i>Pelecocera_tricincta</i>	1	1	0
<i>Pipizella_bispina</i>	1	1	0
<i>Platycheirus_angustatus</i>	0	0	0
<i>Platycheirus_angustipes</i>	0	0	0
<i>Platycheirus_manicatus</i>	1	1	0
<i>Platycheirus_melanopsis</i>	1	1	0
<i>Platycheirus_meridimontanus</i>	1	1	0
<i>Platycheirus_tatricus</i>	0	0	0
<i>Sphaerophoria_laurae</i>	1	1	0
<i>Spilomyia_triangularata</i>	0	0	0
<i>Arctophila_bombiformis</i>	0	0	1
<i>Arctophila_superbiens</i>	0	0	1
<i>Baccha_elongata</i>	1	1	1
<i>Blera_fallax</i>	0	0	1
<i>Brachypalpoides_lentus</i>	0	0	1
<i>Brachypalpus_chrysites</i>	0	0	1
<i>Brachypalpus_laphriformis</i>	0	0	1
<i>Brachypalpus_valgus</i>	1	1	1
<i>Caliprobola_speciosa</i>	0	0	1
<i>Callicera_aenea</i>	0	0	1
<i>Chalcosyrphus_eunotus</i>	0	0	1
<i>Chalcosyrphus_piger</i>	0	0	1
<i>Chalcosyrphus_valgus</i>	0	0	1
<i>Chamaesyrphus_caledonicus</i>	0	0	1
<i>Chamaesyrphus_scaevoides</i>	0	0	1
<i>Cheilosia_alba</i>	0	0	1

<i>Cheilosia_albipila</i>	0	0	1
<i>Cheilosia_albitarsis</i>	1	1	1
<i>Cheilosia_antiqua</i>	1	1	1
<i>Cheilosia_balkana</i>	0	0	1
<i>Cheilosia_barbafacies</i>	0	0	1
<i>Cheilosia_barbata</i>	1	1	1
<i>Cheilosia_bergenstammi</i>	0	0	1
<i>Cheilosia_bracusi</i>	0	0	1
<i>Cheilosia_caerulescens</i>	1	1	1
<i>Cheilosia_canicularis</i>	0	0	1
<i>Cheilosia_carbonaria</i>	0	0	1
<i>Cheilosia_chloris</i>	0	0	1
<i>Cheilosia_chrysocoma</i>	0	0	1
<i>Cheilosia_clama</i>	0	0	1
<i>Cheilosia_derasa</i>	1	1	1
<i>Cheilosia_fasciata</i>	0	0	1
<i>Cheilosia_flavipes</i>	1	1	1
<i>Cheilosia_fraterna</i>	0	0	1
<i>Cheilosia_frontalis</i>	1	1	1
<i>Cheilosia_gagatea</i>	1	1	1
<i>Cheilosia_gigantea</i>	1	1	1
<i>Cheilosia_grisella</i>	1	1	1
<i>Cheilosia_grossa</i>	0	0	1
<i>Cheilosia_hercyniae</i>	1	1	1
<i>Cheilosia_himantopus</i>	0	0	1
<i>Cheilosia_illustrata</i>	1	1	1
<i>Cheilosia_impressa</i>	1	1	1
<i>Cheilosia_insignis</i>	1	1	1
<i>Cheilosia_lasiopa</i>	0	0	1
<i>Cheilosia_lenis</i>	0	0	1
<i>Cheilosia_longula</i>	0	0	1
<i>Cheilosia_melanopa</i>	1	1	1
<i>Cheilosia_melanura</i>	1	1	1
<i>Cheilosia_morio</i>	0	0	1
<i>Cheilosia_mutabilis</i>	1	1	1
<i>Cheilosia_nebulosa</i>	0	0	1
<i>Cheilosia_nigripes</i>	1	1	1
<i>Cheilosia_orthotricha</i>	0	0	1
<i>Cheilosia_pagana</i>	0	0	1
<i>Cheilosia_personata</i>	1	1	1
<i>Cheilosia_pini</i>	0	0	1

<i>Cheilosia_proxima</i>	1	1	1
<i>Cheilosia_pubera</i>	1	1	1
<i>Cheilosia_ranunculi</i>	0	0	1
<i>Cheilosia_rhynchops</i>	1	1	1
<i>Cheilosia_rufimana</i>	0	0	1
<i>Cheilosia_scanica</i>	0	0	1
<i>Cheilosia_scutellata</i>	1	1	1
<i>Cheilosia_semifasciata</i>	0	0	1
<i>Cheilosia_subpictipennis</i>	1	1	1
<i>Cheilosia_urbana</i>	0	0	1
<i>Cheilosia_uviformis</i>	0	0	1
<i>Cheilosia_variabilis</i>	0	0	1
<i>Cheilosia_velutina</i>	0	0	1
<i>Cheilosia_vernalis</i>	1	1	1
<i>Cheilosia_vicina</i>	1	1	1
<i>Cheilosia_vulpina</i>	0	0	1
<i>Chrysogaster_solstitialis</i>	0	0	1
<i>Chrysotoxum_bicinctum</i>	1	1	1
<i>Chrysotoxum_cautum</i>	1	1	1
<i>Chrysotoxum_elegans</i>	1	1	1
<i>Chrysotoxum_fasciatum</i>	1	1	1
<i>Chrysotoxum_fasciolatum</i>	1	1	1
<i>Chrysotoxum_montanum</i>	1	1	1
<i>Chrysotoxum_octomaculatum</i>	1	1	1
<i>Chrysotoxum_tomentosum</i>	1	1	1
<i>Chrysotoxum_vernale</i>	1	1	1
<i>Chrysotoxum_verralli</i>	1	1	1
<i>Criorhina_berberina</i>	1	1	1
<i>Criorhina_ranunculi</i>	1	1	1
<i>Dasysyrphus_albostriatus</i>	1	1	1
<i>Dasysyrphus_friuliensis</i>	0	0	1
<i>Dasysyrphus_hilaris</i>	0	0	1
<i>Dasysyrphus_lenensis</i>	0	0	1
<i>Dasysyrphus_pauxillus</i>	0	0	1
<i>Dasysyrphus_pinastri</i>	0	0	1
<i>Dasysyrphus_postclaviger</i>	0	1	1
<i>Dasysyrphus_tricinctus</i>	1	1	1
<i>Dasysyrphus_venustus</i>	0	0	1
<i>Didea_alneti</i>	0	0	1
<i>Didea_fasciata</i>	1	1	1
<i>Didea_intermedia</i>	0	0	1

<i>Doros_profuges</i>	0	0	1
<i>Epistrophe_diaphana</i>	0	0	1
<i>Epistrophe_eligans</i>	0	0	1
<i>Epistrophe_flava</i>	0	0	1
<i>Epistrophe_grossulariae</i>	0	0	1
<i>Epistrophe_leiophthalma</i>	1	1	1
<i>Epistrophe_nitidicollis</i>	1	1	1
<i>Episyrrhus_balteatus</i>	1	1	1
<i>Eriozona_syrphoides</i>	1	1	1
<i>Eristalinus_aeneus</i>	0	0	1
<i>Eristalinus_sepulchralis</i>	0	0	1
<i>Eristalis_alpina</i>	1	1	1
<i>Eristalis_arbustorum</i>	1	1	1
<i>Eristalis_horticola</i>	1	1	1
<i>Eristalis_intricaria</i>	1	1	1
<i>Eristalis_jugorum</i>	1	1	1
<i>Eristalis_nemorum</i>	0	0	1
<i>Eristalis_pertinax</i>	1	1	1
<i>Eristalis_picea</i>	0	0	1
<i>Eristalis_rupium</i>	1	1	1
<i>Eristalis_similis</i>	1	1	1
<i>Eristalis_tenax</i>	1	1	1
<i>Eumerus_alpinus</i>	0	0	1
<i>Eumerus_grandis</i>	1	1	1
<i>Eumerus_tarsalis</i>	1	1	1
<i>Eumerus_tricolor</i>	1	1	1
<i>Eupeodes_corollae</i>	1	1	1
<i>Eupeodes_luniger</i>	1	1	1
<i>Eupeodes_nielseni</i>	1	1	1
<i>Eupeodes_nitens</i>	1	1	1
<i>Hammerschmidtia_ferruginea</i>	0	0	1
<i>Helophilus_pendulus</i>	0	0	1
<i>Helophilus_trivittatus</i>	0	0	1
<i>Lapposyrphus_lapponicus</i>	1	1	1
<i>Lejota_ruficornis</i>	0	0	1
<i>Leucozona_inopinata</i>	1	1	1
<i>Leucozona_laternaria</i>	1	1	1
<i>Leucozona_lucorum</i>	1	1	1
<i>Megasyrphus_erraticus</i>	0	0	1
<i>Melangyna_barbifrons</i>	1	1	1
<i>Melangyna_compositarum</i>	0	0	1

<i>Melangyna_lasiophthalma</i>	0	0	1
<i>Melangyna_lucifera</i>	1	1	1
<i>Melangyna_quadrimaculata</i>	0	0	1
<i>Melangyna_umbellatarum</i>	0	0	1
<i>Melanogaster_nuda</i>	0	0	1
<i>Melanogaster_parumplicata</i>	0	0	1
<i>Melanostoma_mellinum</i>	1	1	1
<i>Melanostoma_scalare</i>	1	1	1
<i>Meligramma_cincta</i>	1	1	1
<i>Meligramma_cingulata</i>	0	0	1
<i>Meliscaeva_auricollis</i>	1	1	1
<i>Meliscaeva_cinctella</i>	1	1	1
<i>Merodon_aberrans</i>	0	0	1
<i>Merodon_aerarius</i>	1	1	1
<i>Merodon_armipes</i>	1	1	1
<i>Merodon_balkanicus</i>	1	1	1
<i>Merodon_bessarabicus</i>	1	1	1
<i>Merodon_constans</i>	0	0	1
<i>Merodon_desuturinus</i>	1	1	1
<i>Merodon_equestris</i>	0	0	1
<i>Merodon_flavus</i>	0	0	1
<i>Merodon_moenium</i>	1	1	1
<i>Merodon_moesiacus_in_litt.</i>	1	1	1
<i>Merodon_obscuritarsis</i>	1	1	1
<i>Merodon_trebevicensis</i>	0	0	1
<i>Merodon_virgatus</i>	1	1	1
<i>Microdon_analis</i>	1	1	1
<i>Microdon_devius</i>	1	1	1
<i>Microdon_mutabilis</i>	1	1	1
<i>Myathropa_florea</i>	1	1	1
<i>Neoascia_annexa</i>	0	0	1
<i>Neoascia_interrupta</i>	0	0	1
<i>Neoascia_meticulosa</i>	0	0	1
<i>Neoascia_obliqua</i>	0	0	1
<i>Neoascia_podagrica</i>	0	0	1
<i>Neoascia_tenur</i>	0	0	1
<i>Neoascia_unifasciata</i>	0	0	1
<i>Neocnemodon_brevidens</i>	0	0	1
<i>Neocnemodon_larusi</i>	0	0	1
<i>Neocnemodon_latitarsis</i>	0	0	1
<i>Neocnemodon_pubescens</i>	0	0	1

<i>Orthonevra_montana</i>	0	0	1
<i>Paragus_constrictus</i>	0	0	1
<i>Paragus_haemorrhous</i>	1	1	1
<i>Paragus_majoranae</i>	1	1	1
<i>Paragus_pecchiolii</i>	1	1	1
<i>Paragus_testaceus</i>	1	1	1
<i>Parasyrphus_annulatus</i>	1	1	1
<i>Parasyrphus_lineolus</i>	1	1	1
<i>Parasyrphus_macularis</i>	1	1	1
<i>Parasyrphus_mallineus</i>	1	1	1
<i>Parasyrphus_nigritarsis</i>	1	1	1
<i>Parasyrphus_punctulatus</i>	1	1	1
<i>Parasyrphus_vittiger</i>	1	1	1
<i>Pipiza_noctiluca</i>	0	0	1
<i>Pipiza_notata</i>	0	0	1
<i>Pipiza_quadrimaculata</i>	1	1	1
<i>Pipizella_annulata</i>	1	1	1
<i>Pipizella_divicoi</i>	1	1	1
<i>Pipizella_pennina</i>	1	1	1
<i>Pipizella_viduata</i>	1	1	1
<i>Pipizella_virens</i>	1	1	1
<i>Platycheirus_albimanus</i>	1	1	1
<i>Platycheirus_ambiguus</i>	0	0	1
<i>Platycheirus_aurolateralis</i>	0	0	1
<i>Platycheirus_brunnifrons</i>	0	0	1
<i>Platycheirus_clypeatus</i>	0	0	1
<i>Platycheirus_complicatus</i>	0	0	1
<i>Platycheirus_discimanus</i>	1	1	1
<i>Platycheirus_europaeus</i>	0	0	1
<i>Platycheirus_fulviventris</i>	0	0	1
<i>Platycheirus_immaculatus</i>	0	0	1
<i>Platycheirus_muelleri</i>	0	0	1
<i>Platycheirus_nielsenii</i>	1	1	1
<i>Platycheirus_occultus</i>	0	1	1
<i>Platycheirus_parmatus</i>	1	1	1
<i>Platycheirus_peltatus</i>	0	0	1
<i>Platycheirus_splendidus</i>	1	1	1
<i>Platycheirus_sticticus</i>	0	0	1
<i>Platycheirus_tarsalis</i>	1	1	1
<i>Platycheirus_transfugus</i>	0	0	1
<i>Pocota_personata</i>	0	0	1

<i>Portevinia_maculata</i>	0	0	1
<i>Psilota_anthracina</i>	0	0	1
<i>Rhingia_borealis</i>	1	1	1
<i>Rhingia_campestris</i>	1	1	1
<i>Rhingia_rostrata</i>	0	0	1
<i>Scaeva_dignota</i>	1	1	1
<i>Scaeva_pyrastri</i>	1	1	1
<i>Scaeva_selenitica</i>	1	1	1
<i>Sericomyia_lappona</i>	0	0	1
<i>Sericomyia_silentis</i>	0	0	1
<i>Spazigaster_ambulans</i>	0	0	1
<i>Sphaerophoria_bankowskiae</i>	1	1	1
<i>Sphaerophoria_batava</i>	1	1	1
<i>Sphaerophoria_interrupta</i>	1	1	1
<i>Sphaerophoria_rueppelli</i>	1	1	1
<i>Sphaerophoria_scripta</i>	1	1	1
<i>Sphaerophoria_taeiniata</i>	1	1	1
<i>Sphaerophoria_virgata</i>	1	1	1
<i>Sphegina_clavata</i>	0	0	1
<i>Sphegina_clunipes</i>	0	0	1
<i>Sphegina_elegans</i>	0	0	1
<i>Sphegina_latifrons</i>	0	0	1
<i>Sphegina_sibirica</i>	0	0	1
<i>Sphegina_sublatifrons</i>	0	0	1
<i>Spilomyia_diopthalma</i>	0	0	1
<i>Syrpitta_pipiens</i>	1	1	1
<i>Syrphus_nitidifrons</i>	1	1	1
<i>Syrphus_ribesii</i>	1	1	1
<i>Syrphus_torvus</i>	1	1	1
<i>Syrphus_vitripennis</i>	1	1	1
<i>Trichopsomyia_flavitaris</i>	0	0	1
<i>Trichopsomyia_joratensis</i>	0	0	1
<i>Volucella_bombylans</i>	1	1	1
<i>Volucella_inanis</i>	1	1	1
<i>Volucella_pellucens</i>	1	1	1
<i>Xanthandrus_comtus</i>	1	1	1
<i>Xanthogramma_citrofasiatum</i>	0	0	1
<i>Xanthogramma_dives</i>	1	1	1
<i>Xanthogramma_laetum</i>	1	1	1
<i>Xanthogramma_pedissequum</i>	1	1	1
<i>Xylota_ignava</i>	0	0	1

<i>Xylota_jakutorum</i>	0	0	1
<i>Xylota_segnis</i>	1	1	1
<i>Xylota_sylvarum</i>	0	0	1
<i>Xylota_xanthocnema</i>	0	0	1
<i>Sum of hoverfly species</i>	A+B=336*-170=166		E = 355

*Number of hoverfly species from Miličić et al (2020).

Table S14. The list of recent richness of hoverfly species in three designated study sites. 0 indicates the absence of the species, 1 indicates the presence of the species. * - protected hoverfly species, ** strictly protected hoverfly species.

Hoverfly species	Dojkinci1	Dojkinci2	Babin zub
<i>Baccha elongata</i>	0	1	0
<i>Brachyopa bicolor</i>	0	1	0
<i>Brachyopa maculipennis</i>	1	1	0
<i>Brachypalpus laphriformis</i>	0	1	0
<i>Brachypalpus valgus</i>	0	0	1
<i>Cheilosia aerea</i>	1	1	0
<i>Cheilosia albipila</i>	1	0	0
<i>Cheilosia albitarsis</i>	1	1	0
<i>Cheilosia antiqua</i>	0	1	0
<i>Cheilosia barbata</i>	0	1	0
<i>Cheilosia bracus</i>	1	1	0
<i>Cheilosia fasciata</i>	0	1	0
<i>Cheilosia flavipes</i>	0	1	0
<i>Cheilosia frontalis</i>	0	1	0
<i>Cheilosia gigantea</i>	0	1	1
<i>Cheilosia himantopa</i>	1	1	0
<i>Cheilosia himantopus</i>	1	0	0
<i>Cheilosia illustrata</i>	0	1	0
<i>Cheilosia impressa</i>	1	1	1
<i>Cheilosia laticornis</i>	0	0	1
<i>Cheilosia lenis</i>	0	1	0
<i>Cheilosia lenta</i>	0	1	0
<i>Cheilosia melanura</i>	0	1	0
<i>Cheilosia mutabilis</i>	1	1	0
<i>Cheilosia nebulosa</i>	0	1	0
<i>Cheilosia nigripes</i>	1	1	1
<i>Cheilosia orthotricha</i>	0	1	0
<i>Cheilosia pagana</i>	1	1	0
<i>Cheilosia personata</i> *	0	1	0
<i>Cheilosia proxima</i>	1	1	0
<i>Cheilosia ranunculi</i>	1	1	0
<i>Cheilosia rhynchops</i>	0	1	0
<i>Cheilosia scutellata</i>	1	1	0
<i>Cheilosia soror</i>	0	1	0
<i>Cheilosia subpictipennis</i>	1	0	0
<i>Cheilosia urbana</i>	1	1	0
<i>Cheilosia variabilis</i>	1	1	0
<i>Cheilosia vernalis</i>	1	1	0

<i>Cheilosia vicina</i>	0	1	0
<i>Cheilosia vulpina</i>	1	1	0
<i>Chrysogaster solstitialis</i>	0	1	0
<i>Chrysotoxum arcuatum</i>	0	0	1
<i>Chrysotoxum bicinctum</i>	1	1	0
<i>Chrysotoxum elegans</i>	1	1	1
<i>Chrysotoxum fasciatum</i>	0	0	1
<i>Chrysotoxum festivum</i>	1	1	1
<i>Chrysotoxum octomaculatum</i>	1	0	0
<i>Chrysotoxum tomentosum</i>	0	0	1
<i>Criorhina asilica</i>	1	1	0
<i>Dasysyrphus albostratus</i>	0	1	0
<i>Dasysyrphus friuliensis</i>	0	1	0
<i>Dasysyrphus postclaviger</i>	1	1	0
<i>Dasysyrphus tricinctus</i>	0	1	0
<i>Dasysyrphus venustus</i>	0	1	0
<i>Epistrophe diaphana</i>	1	1	0
<i>Epistrophe eligans</i>	0	1	0
<i>Epistrophe flava</i>	0	1	0
<i>Epistrophe grossulariae</i>	0	1	0
<i>Epistrophe melanostoma</i>	1	1	0
<i>Epistrophe nitidicollis</i>	0	1	0
<i>Epistrophella euchroma</i>	0	1	0
<i>Episyrphus balteatus</i>	0	1	1
<i>Eristalis interrupta</i>	0	1	0
<i>Eristalis jugorum</i>	0	1	0
<i>Eristalis rupium</i>	0	1	0
<i>Eristalis similis</i>	0	1	0
<i>Eristalis tenax</i>	0	1	1
<i>Eumerus ornatus</i>	0	0	1
<i>Eumerus sogdianus</i>	0	1	0
<i>Eupeodes corollae</i>	1	1	1
<i>Eupeodes flaviceps</i>	0	0	1
<i>Eupeodes lapponicus</i>	1	1	1
<i>Eupeodes latifasciatus</i>	0	1	0
<i>Eupeodes luniger</i>	1	1	1
<i>Eupeodes nielsenii</i>	0	1	0
<i>Eupeodes nitens</i>	1	1	0
<i>Heringia pubescens</i>	0	1	0
<i>Leucozona lucorum</i>	0	0	1
<i>Melangyna compositarum</i>	0	1	0
<i>Melangyna lasiophthalma</i>	1	1	0
<i>Melanostoma mellinum</i>	1	1	1
<i>Melanostoma scalare</i>	1	1	0
<i>Meligramma cincta</i>	0	1	0
<i>Meligramma guttata</i>	0	1	0
<i>Meliscaeva auricollis</i>	0	1	1
<i>Merodon aerarius</i>	0	1	1
<i>Merodon armipes</i>	0	1	1

<i>Merodon aureus</i>	0	0	1
<i>Merodon balkanicus</i>	0	0	1
<i>Merodon bessarabicus</i>	0	1	0
<i>Merodon calidus</i>	0	0	1
<i>Merodon cinereus</i>	0	0	1
<i>Merodon desuturinus</i> **	0	1	0
<i>Merodon moenium</i>	1	1	1
<i>Merodon obscuritarsis</i>	0	1	1
<i>Microdon devius</i>	0	1	0
<i>Microdon mutabilis</i>	1	1	1
<i>Myathropa florea</i>	1	0	0
<i>Myolepta potens</i> *	1	0	0
<i>Neoascia meticulosa</i>	0	1	0
<i>Neoascia obliqua</i>	0	1	0
<i>Neoascia unifasciata</i>	0	1	0
<i>Neocnemodon larusi</i>	1	1	0
<i>Paragus haemorrhous</i>	0	1	0
<i>Parasyrphus annulatus</i>	0	0	1
<i>Parasyrphus lineolus</i>	0	1	1
<i>Parasyrphus macularis</i>	0	1	0
<i>Parasyrphus punctulatus</i>	0	1	0
<i>Pipizella divicoi</i>	0	1	0
<i>Pipizella viduata</i>	1	1	0
<i>Platycheirus albimanus</i>	0	1	1
<i>Platycheirus melanopsis</i>	0	0	1
<i>Platycheirus scutatus</i>	1	1	0
<i>Platycheirus splendidus</i>	0	1	0
<i>Rhingia campestris</i>	0	1	0
<i>Scaeva pyrastris</i>	0	0	1
<i>Scaeva selenitica</i>	0	1	0
<i>Sphaerophoria scripta</i>	0	1	1
<i>Sphegina latifrons</i>	0	1	0
<i>Sphegina sublatifrons</i>	0	1	0
<i>Syrpitta pipiens</i>	1	0	0
<i>Syrphus ribesii</i>	0	1	1
<i>Syrphus torvus</i>	1	1	1
<i>Syrphus vitripennis</i>	0	1	0
<i>Temnostoma bombylans</i>	1	0	0
<i>Volucella bombylans</i>	1	1	1
<i>Volucella inflata</i>	0	1	0
<i>Xanthandrus comtus</i>	0	1	0
<i>Xanthogramma citrofasciatum</i>	0	1	0