

Supporting information

Title: Flowers of *Impatiens glandulifera* as hubs for both pollinators and pathogens

Running head: Pollinators and pathogens of *Impatiens glandulifera* flowers

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Tables

Table S1. Stem height and diameter of individuals of invasive alien *Impatiens glandulifera*. Data on profile area of flowers, length of lower sepal and width of flower entry of surveyed *I. glandulifera* individuals are also presented.

Population	N individuals	Stem height [cm]			Stem diameter [mm]		
		Minimal	Maximal	Average	Minimal	Maximal	Average
Izerian Foothills	30	55	231	133	4.8	30.5	16.2
Kraków and surrounding areas	30	48	183	115	4.5	23.5	13.0
Muszyna and surrounding areas	30	53	238	116	5.6	22.5	12.7

Population	N individuals	Flower area [mm ²]			Length of lower sepal [mm]			Width of flower entry [mm]		
		Minimal	Maximal	Average	Minimal	Maximal	Average	Minimal	Maximal	Average
Izerian Foothills	30	394	880	664	22.0	30.5	25.4	10.3	15.2	12.7
Kraków and surrounding areas	30	413	766	609	20.0	27.0	23.7	11.1	14.9	12.7
Muszyna and surrounding areas	30	429	721	577	22.2	27.5	24.1	10.8	16.0	13.2

Table S2. Base, candidate and best-fit models with the number of all recorded pollinators, bumblebees and fungal pathogen species as target variables. The selected best-fit model (bolded) had the lowest corrected Akaike information value AICc.

Model	AICc value
Pollinators:	
<u>Base model:</u>	
N pollinator records ~ Pollinator + Region + Flowering power + Flower area + Flower hue + Stem height + Temperature + Sun radiation + Wind speed + Cover area + Day time + Region*Flowering power + Region*Stem height	1937.30
<u>Candidate models:</u>	
N pollinator records ~ Pollinator + Region + Flowering power + Flower area + Flower hue + Stem height + Temperature + Sun radiation + Cover area + Region*Flowering power + Region*Stem height	1932.3
N pollinator records ~ Pollinator + Region + Flowering power + Flower area + Flower hue + Stem height + Temperature + Sun radiation + Cover area + Region*Stem height	1929.50
N pollinator records ~ Pollinator + Region + Flowering power + Flower area + Stem height + Temperature + Sun radiation + Cover area + Region*Stem height	1928.70
Bumblebees:	
<u>Base model:</u>	
N bumblebee records ~ Bumblebee + Bumblebee size + Flowering power + Flower area + Temperature + Sun radiation + Wind speed	1680.67
<u>Candidate models:</u>	
N bumblebee records ~ Bumblebee + Bumblebee size + Flowering power	2079.57
N bumblebee records ~ Bumblebee + Bumblebee size + Flowering power + Temperature + Sun radiation	1716.73
N bumblebee records ~ Bumblebee + Bumblebee size + Flowering power + Temperature + Sun radiation + Wind speed	1686.06
Fungal pathogens:	
<u>Base model:</u>	
N pathogen species records ~ N pollinator records + Region + Temperature + Sun radiation + Flowering power + Flower area + Length of lower sepal + Width of flower entry + Plant size + Flowering power*Region	214.4
<u>Candidate models:</u>	
N pathogen species records ~ Region + Flowering power + Flower area + Length of lower sepal + Flowering power*Region	201.41
N pathogen species records ~ Region + Flowering power + Length of lower sepal + Flowering power*Region	199.15
N pathogen species records ~ Region + Flowering power + Flowering power*Region	197.14

Table S3. Results of pairwise contrasts for pollinator species variable from the model created for all recorded pollinators (see Table 3 in the main text).

Pairwise Contrasts							
Pollinator species	Contrast Estimate	Std. Error	t	df	Adj. Sig.	95% Confidence Interval	
						Lower	Upper
<i>Syrphidae - Bombus hortorum</i>	-13.514	1.911	-7.071	197	2.607E-11	-17.282	-9.745
<i>Syrphidae - Bombus lucorum complex</i>	-0.901	1.010	-0.892	197	0.373	-2.893	1.090
<i>Syrphidae - Vesputa vulgaris</i>	-1.796	2.904	-0.618	197	0.537	-7.523	3.931
<i>Syrphidae - Bombus pascuorum</i>	-6.904	1.280	-5.394	197	1.966E-07	-9.428	-4.380
<i>Syrphidae - Apis mellifera</i>	-3.369	1.001	-3.366	197	0.001	-5.343	-1.395
<i>Syrphidae - Apoidea</i>	-1.517	2.787	-0.544	197	0.587	-7.012	3.979
<i>Syrphidae - Bombus sylvarum</i>	-1.768	2.360	-0.749	197	0.455	-6.423	2.887
<i>Syrphidae - Bombus terrestris</i>	-4.466	1.575	-2.836	197	0.005	-7.571	-1.361
<i>Bombus hortorum - Syrphidae</i>	13.514	1.911	7.071	197	2.607E-11	9.745	17.282
<i>Bombus hortorum - Bombus lucorum complex</i>	12.613	2.048	6.160	197	4.021E-09	8.575	16.650
<i>Bombus hortorum - Vesputa vulgaris</i>	11.718	3.509	3.339	197	0.001	4.797	18.639
<i>Bombus hortorum - Bombus pascuorum</i>	6.610	2.155	3.067	197	0.002	2.359	10.860
<i>Bombus hortorum - Apis mellifera</i>	10.145	1.988	5.103	197	7.840E-07	6.224	14.065
<i>Bombus hortorum - Apoidea</i>	11.997	3.380	3.549	197	0.000	5.331	18.663
<i>Bombus hortorum - Bombus sylvarum</i>	11.746	2.986	3.934	197	0.000	5.857	17.634
<i>Bombus hortorum - Bombus terrestris</i>	9.048	2.588	3.496	197	0.001	3.944	14.152
<i>Bombus lucorum complex - Syrphidae</i>	0.901	1.010	0.892	197	0.373	-1.090	2.893
<i>Bombus lucorum complex - Bombus hortorum</i>	-12.613	2.048	-6.160	197	4.021E-09	-16.650	-8.575
<i>Bombus lucorum complex - Vesputa vulgaris</i>	-0.895	2.964	-0.302	197	0.763	-6.739	4.950
<i>Bombus lucorum complex - Bombus pascuorum</i>	-6.003	1.320	-4.547	197	9.508E-06	-8.607	-3.399
<i>Bombus lucorum complex - Apis mellifera</i>	-2.468	1.209	-2.040	197	0.043	-4.853	-0.083
<i>Bombus lucorum complex - Apoidea</i>	-0.615	2.860	-0.215	197	0.830	-6.255	5.024
<i>Bombus lucorum complex - Bombus sylvarum</i>	-0.867	2.468	-0.351	197	0.726	-5.735	4.001
<i>Bombus lucorum complex - Bombus terrestris</i>	-3.565	1.700	-2.097	197	0.037	-6.917	-0.212
<i>Vesputa vulgaris - Syrphidae</i>	1.796	2.904	0.618	197	0.537	-3.931	7.523
<i>Vesputa vulgaris - Bombus hortorum</i>	-11.718	3.509	-3.339	197	0.001	-18.639	-4.797
<i>Vesputa vulgaris - Bombus lucorum complex</i>	0.895	2.964	0.302	197	0.763	-4.950	6.739
<i>Vesputa vulgaris - Bombus pascuorum</i>	-5.108	3.097	-1.649	197	0.101	-11.216	1.000
<i>Vesputa vulgaris - Apis mellifera</i>	-1.573	2.964	-0.531	197	0.596	-7.419	4.273
<i>Vesputa vulgaris - Apoidea</i>	0.279	3.933	0.071	197	0.943	-7.477	8.036
<i>Vesputa vulgaris - Bombus sylvarum</i>	0.028	3.694	0.008	197	0.994	-7.258	7.313
<i>Vesputa vulgaris - Bombus terrestris</i>	-2.670	3.136	-0.851	197	0.396	-8.855	3.515
<i>Bombus pascuorum - Syrphidae</i>	6.904	1.280	5.394	197	1.966E-07	4.380	9.428
<i>Bombus pascuorum - Bombus hortorum</i>	-6.610	2.155	-3.067	197	0.002	-10.860	-2.359
<i>Bombus pascuorum - Bombus lucorum complex</i>	6.003	1.320	4.547	197	9.508E-06	3.399	8.607
<i>Bombus pascuorum - Vesputa vulgaris</i>	5.108	3.097	1.649	197	0.101	-1.000	11.216
<i>Bombus pascuorum - Apis mellifera</i>	3.535	1.451	2.437	197	0.016	0.674	6.396
<i>Bombus pascuorum - Apoidea</i>	5.387	2.983	1.806	197	0.072	-0.495	11.269
<i>Bombus pascuorum - Bombus sylvarum</i>	5.136	2.574	1.995	197	0.047	0.059	10.213
<i>Bombus pascuorum - Bombus terrestris</i>	2.438	1.907	1.279	197	0.203	-1.322	6.198
<i>Apis mellifera - Syrphidae</i>	3.369	1.001	3.366	197	0.001	1.395	5.343
<i>Apis mellifera - Bombus hortorum</i>	-10.145	1.988	-5.103	197	7.840E-07	-14.065	-6.224
<i>Apis mellifera - Bombus lucorum complex</i>	2.468	1.209	2.040	197	0.043	0.083	4.853
<i>Apis mellifera - Vesputa vulgaris</i>	1.573	2.964	0.531	197	0.596	-4.273	7.419
<i>Apis mellifera - Bombus pascuorum</i>	-3.535	1.451	-2.437	197	0.016	-6.396	-0.674
<i>Apis mellifera - Apoidea</i>	1.852	2.870	0.645	197	0.519	-3.808	7.513
<i>Apis mellifera - Bombus sylvarum</i>	1.601	2.455	0.652	197	0.515	-3.241	6.443
<i>Apis mellifera - Bombus terrestris</i>	-1.097	1.690	-0.649	197	0.517	-4.430	2.236
<i>Apoidea - Syrphidae</i>	1.517	2.787	0.544	197	0.587	-3.979	7.012
<i>Apoidea - Bombus hortorum</i>	-11.997	3.380	-3.549	197	0.000	-18.663	-5.331
<i>Apoidea - Bombus lucorum complex</i>	0.615	2.860	0.215	197	0.830	-5.024	6.255
<i>Apoidea - Vesputa vulgaris</i>	-0.279	3.933	-0.071	197	0.943	-8.036	7.477
<i>Apoidea - Bombus pascuorum</i>	-5.387	2.983	-1.806	197	0.072	-11.269	0.495
<i>Apoidea - Apis mellifera</i>	-1.852	2.870	-0.645	197	0.519	-7.513	3.808
<i>Apoidea - Bombus sylvarum</i>	-0.251	3.578	-0.070	197	0.944	-7.308	6.805
<i>Apoidea - Bombus terrestris</i>	-2.949	3.080	-0.958	197	0.339	-9.024	3.125
<i>Bombus sylvarum - Syrphidae</i>	1.768	2.360	0.749	197	0.455	-2.887	6.423
<i>Bombus sylvarum - Bombus hortorum</i>	-11.746	2.986	-3.934	197	0.000	-17.634	-5.857
<i>Bombus sylvarum - Bombus lucorum complex</i>	0.867	2.468	0.351	197	0.726	-4.001	5.735
<i>Bombus sylvarum - Vesputa vulgaris</i>	-0.028	3.694	-0.008	197	0.994	-7.313	7.258
<i>Bombus sylvarum - Bombus pascuorum</i>	-5.136	2.574	-1.995	197	0.047	-10.213	-0.059
<i>Bombus sylvarum - Apis mellifera</i>	-1.601	2.455	-0.652	197	0.515	-6.443	3.241
<i>Bombus sylvarum - Apoidea</i>	0.251	3.578	0.070	197	0.944	-6.805	7.308
<i>Bombus sylvarum - Bombus terrestris</i>	-2.698	2.742	-0.984	197	0.326	-8.105	2.709
<i>Bombus terrestris - Syrphidae</i>	4.466	1.575	2.836	197	0.005	1.361	7.571
<i>Bombus terrestris - Bombus hortorum</i>	-9.048	2.588	-3.496	197	0.001	-14.152	-3.944
<i>Bombus terrestris - Bombus lucorum complex</i>	3.565	1.700	2.097	197	0.037	0.212	6.917
<i>Bombus terrestris - Vesputa vulgaris</i>	2.670	3.136	0.851	197	0.396	-3.515	8.855
<i>Bombus terrestris - Bombus pascuorum</i>	-2.438	1.907	-1.279	197	0.203	-6.198	1.322
<i>Bombus terrestris - Apis mellifera</i>	1.097	1.690	0.649	197	0.517	-2.236	4.430
<i>Bombus terrestris - Apoidea</i>	2.949	3.080	0.958	197	0.339	-3.125	9.024
<i>Bombus terrestris - Bombus sylvarum</i>	2.698	2.742	0.984	197	0.326	-2.709	8.105

Table S4. Results of pairwise contrasts for bumblebee species variable from the model created for bumblebees solely (see Table 4 in the main text).

Bumblebee species	Contrast Estimate	Std. Error	t	df	Adj. Sig.	95% Confidence Interval	
						Lower	Upper
<i>Bombus hortorum</i> - <i>Bombus lucorum</i> complex	3.557	0.527	6.750	229	1.200E-10	2.519	4.596
<i>Bombus hortorum</i> - <i>Bombus pascuorum</i>	1.405	0.507	2.768	229	0.006	0.405	2.405
<i>Bombus hortorum</i> - <i>Bombus sylvarum</i>	2.986	0.956	3.123	229	0.002	1.102	4.870
<i>Bombus hortorum</i> - <i>Bombus terrestris</i>	2.278	0.659	3.459	229	0.001	0.980	3.575
<i>Bombus lucorum</i> complex - <i>Bombus hortorum</i>	-3.557	0.527	-6.750	229	1.200E-10	-4.596	-2.519
<i>Bombus lucorum</i> complex - <i>Bombus pascuorum</i>	-2.153	0.390	-5.518	229	9.231E-08	-2.921	-1.384
<i>Bombus lucorum</i> complex - <i>Bombus sylvarum</i>	-0.571	0.840	-0.680	229	0.497	-2.226	1.083
<i>Bombus lucorum</i> complex - <i>Bombus terrestris</i>	-1.280	0.471	-2.719	229	0.007	-2.208	-0.352
<i>Bombus pascuorum</i> - <i>Bombus hortorum</i>	-1.405	0.507	-2.768	229	0.006	-2.405	-0.405
<i>Bombus pascuorum</i> - <i>Bombus lucorum</i> complex	2.153	0.390	5.518	229	9.231E-08	1.384	2.921
<i>Bombus pascuorum</i> - <i>Bombus sylvarum</i>	1.581	0.872	1.814	229	0.071	-0.137	3.299
<i>Bombus pascuorum</i> - <i>Bombus terrestris</i>	0.873	0.512	1.705	229	0.090	-0.136	1.881
<i>Bombus sylvarum</i> - <i>Bombus hortorum</i>	-2.986	0.956	-3.123	229	0.002	-4.870	-1.102
<i>Bombus sylvarum</i> - <i>Bombus lucorum</i> complex	0.571	0.840	0.680	229	0.497	-1.083	2.226
<i>Bombus sylvarum</i> - <i>Bombus pascuorum</i>	-1.581	0.872	-1.814	229	0.071	-3.299	0.137
<i>Bombus sylvarum</i> - <i>Bombus terrestris</i>	-0.709	0.901	-0.787	229	0.432	-2.483	1.066
<i>Bombus terrestris</i> - <i>Bombus hortorum</i>	-2.278	0.659	-3.459	229	0.001	-3.575	-0.980
<i>Bombus terrestris</i> - <i>Bombus lucorum</i> complex	1.280	0.471	2.719	229	0.007	0.352	2.208
<i>Bombus terrestris</i> - <i>Bombus pascuorum</i>	-0.873	0.512	-1.705	229	0.090	-1.881	0.136
<i>Bombus terrestris</i> - <i>Bombus sylvarum</i>	0.709	0.901	0.787	229	0.432	-1.066	2.483

The least significant difference adjusted significance level is .05.

Table S5. The BLAST match sequence and GenBank numbers of recorded fungal species.

No	Fungal taxa	BLAST match sequence			GenBank no.
		accession No.	coverage (%)	similarity (%)	
1	<i>Alternaria alternata</i>	MN589684	99	99.3	OR245528
2	<i>Alternaria tenuissima</i>	MN593335	99	99.3	OR245529
3	<i>Boeremia exigua</i>	ON599328	99	99.1	OR245530
4	<i>Botrytis cinerea</i>	MT704558	100	98.9	OR245531
5	<i>Cladosporium cladosporioides</i>	MT466517	99	99.5	OR245532
6	<i>Epicoccum nigrum</i>	MW580410	100	99.1	OR245533
7	<i>Epicoccum tritici</i>	KX965725	99	99.3	OR245534
8	<i>Fusarium acuminatum</i>	MW580411	99	99.2	OR245535
9	<i>Fusarium avenaceum</i>	KT963799	99	99.7	OR245536
10	<i>Fusarium boothii</i>	MK910046	100	99.8	OR245537
11	<i>Fusarium equiseti</i>	MK733980	98	98.8	OR245538
12	<i>Fusarium graminearum</i>	KF624778	99	98.1	OR245539
13	<i>Fusarium sporotrichioides</i>	MT732817	99	99.8	OR245540
14	<i>Mucor hiemalis</i>	MT514370	98	100.0	OR245541
15	<i>Nigrospora oryzae</i>	MG603657	100	99	OR245542
16	<i>Stagonosporopsis ligulicola</i>	KJ868166	98	99.6	OR245543

Figures

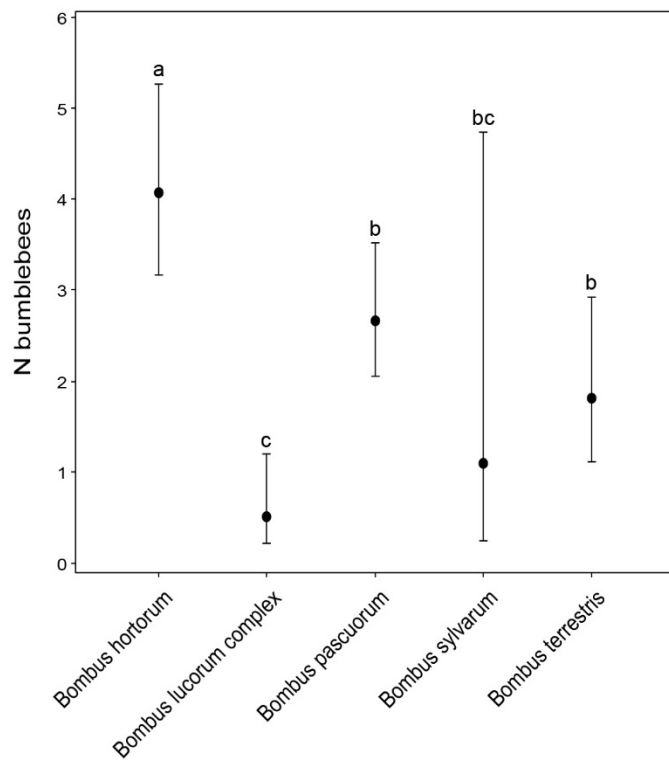


Fig. S1. Estimated mean number of bumblebees (\pm confidence intervals) recorded from *Impatiens glandulifera* in the three study regions (Izerian Foothills, Kraków and Muszyna) in southern Poland; groups with the same letter above the T-bars are not significantly different at $p < 0.05$; single records of *Bombus lapidarius* and *Psithyrus vestalis* were excluded from the analysis (see Methods).

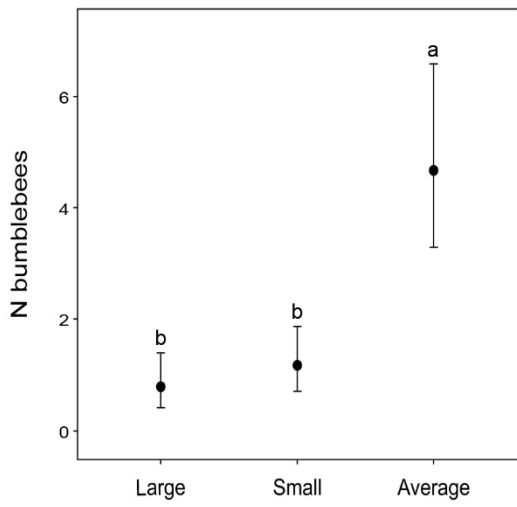


Fig. S2. Estimated mean number of bumblebee sizes (\pm confidence intervals); groups with the same letter above the T-bars are not significantly different at $p < 0.05$.

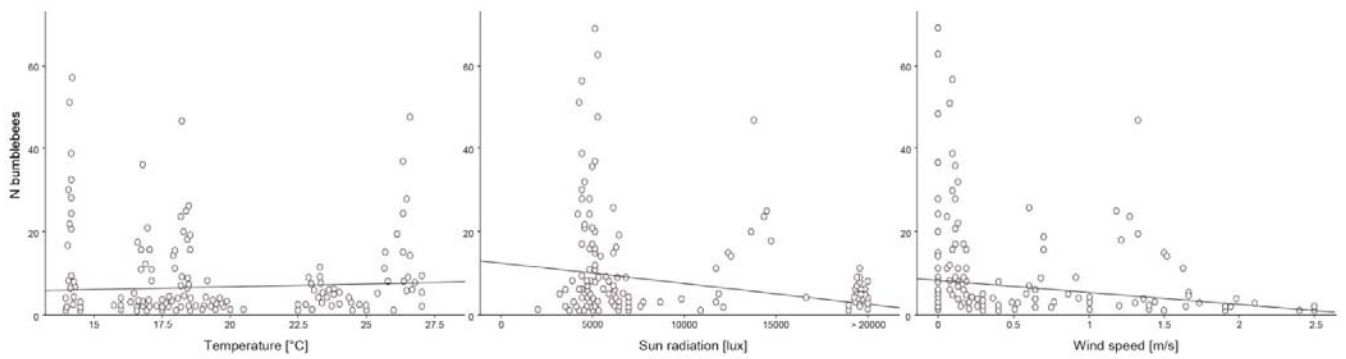


Fig. S3. Effects of air temperature, sun radiation and wind speed on the number of pollinators (see Table 4 in the main text).