

Supplementary information for "Explaining variability in the production of seed and allergenic pollen by invasive *Ambrosia artemisiifolia* across Europe" in Biological Invasions

## Electronic Supplementary Material

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**Table S1.** Number of study sites for each of the European bioclimatic regions where *A. artemisiifolia* occurs. The Anatolian, Atlantic and Boreal region have some records of *A. artemisiifolia* but it is unknown if these include any established populations.

bioclimatic region	sites
continental	18
pannonian	11
alpine	5
mediterranean	5
blackSea	4
steppic	2
anatolian	0
atlantic	0
boreal	0

**Table S2.** Structure and fit of the linear mixed effect models of the relation between *A. artemisiifolia* reproduction and size, corresponding to Fig. 2.

response variable	fixed effects	random effects	N plants	N sites	R <sup>2</sup> marginal	R <sup>2</sup> conditional	Fig.
log(racemes)	log(biomass)	log(biomass) site	811	39	0.831	0.908	1a
log(racemes)	log(volume)	log(volume) site	811	39	0.743	0.869	1d
log(female structures)	log(biomass) + structure.type	log(biomass) site	804	39	0.754	0.903	1b-c
log(female structures)	log(volume) + structure.type	log(volume) site	804	39	0.594	0.845	1e-f

**Table S3.** Correlation coefficients of the model "TotalReduced" (see main document, Table 3)

	Intercept	altitude	fraction sand	GDD	Precipitation	Ambrosia density	bare soil	other vegetation
altitude	0.027							
fraction sand	0.047	-0.189						
GDD	-0.089	0.083	-0.012					
precipitation	0.031	-0.123	0.131	0.135				
Ambrosia density	-0.017	0.027	-0.057	0.03	0.014			
bare soil	-0.014	-0.001	-0.109	0.05	0.03	0.284		
other vegetation	-0.026	0.022	-0.078	0.015	-0.002	0.332	0.63	
GDD x precipitation	0.181	0.007	0.123	0.051	0.323	0.003	0.046	-0.023

**Table S4.** The environmental factors of the model "SiteReduced" on individual plant volume, a generalised linear mixed-effects model of environmental variables remaining after stepwise AIC-based selection of factors from the full model, and then fit by REML. Estimates represent coefficients of  $\log(\text{plant volume in cm}^3)$  with their Standard Error; the t-value is the ratio between the Estimate and its Standard Error, and the p-value the probability that this t-statistic is drawn from a standard t-distribution with "df" degrees of freedom.

Environmental factor	Estimate	Std.Error	df	t-value	p-value
Intercept (habitat type: arable)	9.533	0.626	2326	15.223	0.000
habitat type: grassland	-2.469	0.873	23	-2.829	0.010
habitat type: infrastructure	-0.835	1.711	23	-0.488	0.630
habitat type: ruderal	-1.297	0.769	23	-1.688	0.105
growing degree days	0.705	0.365	23	1.933	0.066
precipitation	0.442	0.432	23	1.024	0.317
growing degree days x precipitation	1.117	0.288	23	3.874	0.001
Ophraella	-2.372	1.152	23	-2.058	0.051
sand	-0.378	0.302	23	-1.253	0.223

**Table S5.** The correlation coefficients of the model "SiteReduced" in Table S4.

	Intercept (habitat type: arable)	habitat type: grassland	habitat type: infrastructure	habitat type: ruderal	fraction sand	Ophraella	GDD	precipitation
habitat type: grassland	-0.561							
habitat type: infrastructure	-0.638	0.316						
habitat type: ruderal	-0.857	0.431	0.569					
fraction sand	0.165	0.045	-0.276	-0.174				
Ophraella	-0.363	0.023	0.238	0.223	-0.011			
GDD	0.006	-0.007	-0.147	0.079	0.015	-0.346		
precipitation	-0.006	-0.248	0.058	0.213	-0.027	-0.369	0.305	
GDD x precipitation	-0.01	-0.056	0.139	0.17	0.032	-0.207	0.141	0.449

**Table S6.** The environmental factors of the model "PlotReduced" on individual plant size. See legend of Table S4.

<b>Environmental factor</b>	<b>Estimate</b>	<b>Std.Error</b>	<b>df</b>	<b>t-value</b>	<b>p-value</b>
(Intercept)	7.605	0.285	2609	26.661	0.000
Ambrosia density	-0.280	0.071	379	-3.968	0.000
bare soil	-0.572	0.135	379	-4.229	0.000
other vegetation	-0.357	0.120	379	-2.973	0.003

**Table S7.** The correlation coefficients of the model "PlotReduced" in Table S6.

	(Intr)	Ambrosia density	bare soil
Ambrosia density	-0.011		
bare soil	-0.011	0.29	
other vegetation	-0.015	0.34	0.637

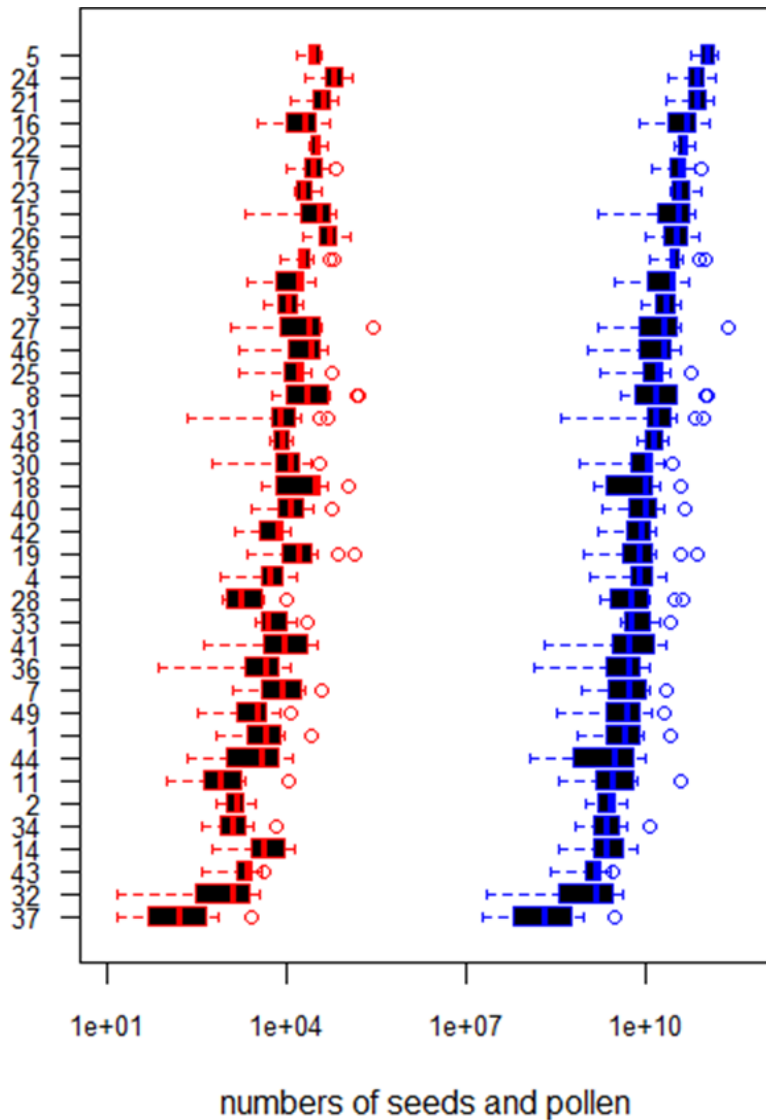
**Table S8.** The environmental factors of the model "RegionalReduced" on individual plant size. See legend of Table S4.

<b>Environmental factor</b>	<b>Estimate</b>	<b>Std.Error</b>	<b>df</b>	<b>t-value</b>	<b>p-value</b>
(Intercept)	7.555	0.303	2609	24.924	0.000
altitude	-0.749	0.295	34	-2.540	0.016

**Table S9.** The correlation coefficient of the model "RegionalReduced" in Table S8.

	(Intr)
altitude	0.04

**Fig. S1.** Estimated numbers of *A. artemisiifolia* seeds (left) and pollen (right) produced per m<sup>2</sup> per site (numbers presented on a log scale, ordered according to median amounts of pollen, and ID of the sites corresponding to Table 1). Boxplots represent the variation across plots within sites, with the thick line as the median, the boxes representing the quartiles, and the whiskers 1.5 times the interquartile range, and dots data points outside the whiskers.



**Table S10.** The environmental factors of the model of the density of pollen production (expressed as log-transformed pollen numbers). See legend of Table S4.

Environmental factor	Estimate	Std.Error	df	t-value	p-value
Intercept (habitat type: arable)	23.900	0.419	381	57.101	0.000
longitude	0.496	0.323	26	1.533	0.137
altitude	-0.662	0.269	26	-2.457	0.021
habitat type: grassland	-1.026	0.602	26	-1.704	0.100
habitat type: infrastructure	-0.473	0.833	26	-0.568	0.575
habitat type: ruderal	-1.303	0.511	26	-2.548	0.017
Ophraella presence	-0.469	0.249	26	-1.883	0.071
GDD	-0.154	0.259	26	-0.594	0.558
precipitation	0.288	0.261	26	1.105	0.280
GDD x precipitation	0.627	0.270	26	2.324	0.028

**Table S11.** Pairwise differences in the density of pollen production between habitat types (AR=arable, GR=grassland, IN=infrastructure, RU=ruderal), according to a post-hoc Tukey test of the model in Table 10. An asterisk indicates significance at the p=0.05 level.

	Estimate	Std. Error	z value	Pr(> z )
GR - AR == 0	-1.0258	0.5947	-1.725	0.2991
IN - AR == 0	-0.4726	0.8226	-0.575	0.9367
RU - AR == 0	-1.3031	0.5052	-2.579	0.0459 *
IN - GR == 0	0.5532	0.8519	0.649	0.9117
RU - GR == 0	-0.2773	0.5781	-0.480	0.9617
RU - IN == 0	-0.8305	0.6984	-1.189	0.6217

(Adjusted p values reported -- single-step method)

**Table S12.** The environmental factors of the model of the density of seed production (expressed as log-transformed seed numbers). See legend of Table S4.

Environmental factor	Estimate	Std.Error	df	t-value	p-value
Intercept (habitat type: arable)	9.684	0.357	381	27.114	0.000
latitude	-0.807	0.271	26	-2.976	0.006
altitude	-1.058	0.271	26	-3.901	0.001
habitat type: grassland	-0.396	0.522	26	-0.759	0.455
habitat type: infrastructure	0.565	0.715	26	0.790	0.437
habitat type: ruderal	-1.103	0.444	26	-2.485	0.020
Ophraella presence	-0.432	0.189	26	-2.287	0.031
GDD	-0.485	0.241	26	-2.016	0.054
precipitation	0.134	0.224	26	0.597	0.556
GDD x precipitation	0.666	0.235	26	2.837	0.009

**Table S13.** Pairwise differences in the density of seed production between habitat types (AR=arable, GR=grassland, IN=infrastructure, RU=ruderal), according to a post-hoc Tukey test of the model in Table 10. An asterisk indicates significance at the p=0.05 level.

GR - AR == 0	-0.3964	0.5159	-0.768	0.8640
IN - AR == 0	0.5651	0.7064	0.800	0.8493
RU - AR == 0	-1.1033	0.4386	-2.516	0.0548
IN - GR == 0	0.9615	0.7377	1.303	0.5505
RU - GR == 0	-0.7069	0.5236	-1.350	0.5206
RU - IN == 0	-1.6684	0.6300	-2.648	0.0382 *

(Adjusted p values reported -- single-step method)

**Fig. S2.** Variation in a) bare soil cover, b) *Ambrosia* density, and c) cover by vegetation other than *Ambrosia* across habitat types (AR=arable, GR=grassland, IN=infrastructure, RU=ruderal). Boxplots represent variation across all plots of all sites per habitat type.

