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CORRIGENDUM

Temporal cycles and spatial asynchrony in the reproduction and growth of a rare nectarless orchid, *Cypripedium calceolus*

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The authors apologize for errors and missing values in the Finnish climate data used in the analyses. The corrected results from the Finnish climate models are given in the edited Table 4 below, together with corrected versions of the relevant sections of the Results and Discussion.

There were also some minor typographical errors in plant ID indices. Therefore, some clump pairs were missing from Supporting Information Table S1 and some pairs were included twice in the models of within-population correlations of clump size, results of which are shown in Table 5. However, this did not affect the model results until the third decimal point. Corrected Tables 5 and S1 are also given below.

RESULTS

Climate models

In general, variation in flowering intensity was best explained by the temperature of the previous summer and clump size during the previous growing season, although the best variables for summer temperatures differed between countries, as did the effects of temperature (Table 4). In Finland, the most-parsimonious model for flowering intensity also included mean winter snow depth, which was negatively correlated with subsequent flowering (Table 4). For clump size, the best single predictor was clump size in the previous year, which was positively correlated with current size (Table 4). Current clump size was also positively associated with spring snow depth in both countries (Table 4). In Estonia, clump size increased with increasing cumulative temperature sum of the previous growing season. The strongest effect of this was seen in the smallest clumps (Table 4, Fig. 2), indicating that the smallest plants were the most sensitive to temperature. Moreover, clump size in Estonia was associated with spring weather conditions, with the precipitation sum having a positive effect and the cumulative temperature sum having a negative effect on size (Table 4).

DISCUSSION

Climate, reproduction and growth

In addition to clump size, weather conditions of the previous year and of the current spring affected the performance of clumps of *C. calceolus*, with temperature of the previous growing season and snow depth being the most influential weather aspects for flowering intensity and clump size. However, the effects of weather conditions varied between countries (Table 4). The negative effect of high summer temperatures on flowering in Estonia may be due to the costs of increased respiration. Instead, warm summers had a positive effect on flowering intensity in Finland, possibly because, in general, the average summer temperatures there are lower than in Estonia, and the clumps are, on average, smaller and therefore do not suffer from excess respiration. In this respect, the differences observed here between countries are not particularly surprising, as other studies have also reported that the effects of summer temperatures on orchids may vary by species, study location or the measure used to describe plant performance (Hutchings, 2010; Sletvold *et al.*, 2013; Shefferson, Warren & Pulliam, 2014). Spring snow cover seemed to have a protective effect on plant growth. In addition, melting snow also provides moisture. In Estonia, where the climate is not as humid as in Finland and the plants are more likely to experience drought, clump size was further increased by high spring precipitation (Table 4), which ensured favourable water conditions for growth. This finding suggests that the growth of *C. calceolus* will benefit from the predicted increase in precipitation at high latitudes (IPCC, 2014). However, spring snow cover has continued to decrease in the Northern Hemisphere during the past two decades (IPCC, 2014), and this could lead to more frequent bud damage from freezing in spring, as has already been observed in subalpine wild flowers (Inouye, 2008). In contrast to spring snow cover, deep winter snow had a negative effect on flowering. This effect was seen only in Finland, probably because snow cover is thicker there than in Estonia. Overall, decreasing snow cover could result in smaller, but more intensively flowering plants.

Table 4. Results from linear mixed-effects models that were used to explore associations between selected climatic variables and the flowering intensity (proportion of flowering ramets) and clump size (number of ramets) of *Cypripedium calceolus* populations in Finland and Estonia

Dependent variable	Finland	Estimate ± SE	Estonia	Estimate ± SE
	Parameter		Parameter	
Flowering intensity	Intercept	0.2707 ± 0.1027***	Intercept	0.6276 ± 0.5899
	Cumulative temperature of the previous growing season	0.0032 ± 0.0005***	Cumulative temperature of the previous growing season	–0.0016 ± 0.0003***
	Log(clump size of the previous growing season)	0.3730 ± 0.1060***	Log(clump size of the previous growing season)	0.5606 ± 0.0981***
	Minimum temperature of the previous growing season	0.1303 ± 0.0293***		
	Mean winter snow depth	–0.0552 ± 0.0076***		
Clump size	Intercept	0.4063 ± 0.0929***	Intercept	2.0531 ± 0.1285***
	Log(clump size of the previous growing season)	0.6929 ± 0.0760***	Log(clump size of the previous growing season)	0.2572 ± 0.0029***
	Mean spring snow depth	0.0149 ± 0.0028***	Maximum spring snow depth	0.0040 ± 0.0009***
			Cumulative temperature of the previous growing season	0.0007 ± 0.0001***
			Spring precipitation sum	0.0017 ± 0.0003***
			Cumulative spring temperature	–0.0011 ± 0.0002***
			Log(clump size of the previous growing season) × Cumulative temperature of the previous growing season	–0.0006 ± 0.0001***

All predictors are centred, and the models include clump nested within population as a random factor.
Parameter estimates are on logit (flowering intensity) and log (clump size) scales.
$^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$ based on Wald tests.

Table 5. Pairwise correlations in flowering intensity (proportion of flowering ramets) and clump size (number of ramets) among clumps within Finnish and Estonian populations of *Cypripedium calceolus*.

Dependent variable	Average correlation		% positive correlations		% negative correlations	
	Country	Estimate ± SE	Country	Estimate – SE–Estimate + SE	Country	Estimate – SE–Estimate + SE
Flowering intensity within population	Estonia	0.1944 ± 0.0446*	Estonia	0.1761–0.2886***	Estonia	0.0049–0.0155***
	Finland	0.0567 ± 0.0325	Finland	0.0740–0.1152***	Finland	0.0467–0.0556***
Clump size within population	Estonia	0.2287 ± 0.0637*	Estonia	0.2748–0.3921**	Estonia	0.0065–0.0189***
	Finland	0.0222 ± 0.0500	Finland	0.0625–0.0915***	Finland	0.0373–0.0523***
Flowering intensity between population	Estonia	0.1229 ± 0.050*	Estonia	0.1135–0.1788***	Estonia	0.0070–0.0235***
	Finland	0.0417 ± 0.0263	Finland	0.0839–0.1054***	Finland	0.0545–0.0807***
	Between countries	0.0202 ± 0.0192	Between countries	0.0516–0.0630***	Between countries	0.0514–0.0691***
Clump size between populations	Estonia	0.0031 ± 0.0355	Estonia	0.0343–0.0620***	Estonia	0.0472–0.0736***
	Finland	−0.0013 ± 0.0178	Finland	0.0495–0.0609***	Finland	0.0440–0.049 ***
	Between countries	0.0121 ± 0.0132	Between countries	0.0536–0.0637***	Between countries	0.0400–0.0451***

Average correlation is the mean of correlations over all pairwise comparisons between clumps, and % negative and positive correlations are the numbers of significant negative and positive correlations, respectively, divided by the total number of pairwise correlations. Note that the proportions are back-transformed from logit, and therefore *P*-values indicate whether the estimates significantly differ from 0.5.
***: $P < 0$ .001, **: $P < 0.01$, **: $P < 0.05$ based on Satterthwaite's approximation (average correlations) or Wald tests (% correlations).

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1.