INTRODUCTION

Understanding the rules of community assembly and species coexistence is one of the oldest and most fundamental aims of ecological research (Götzenberger et al., 2012). To date, numerous potential ecological processes have been identified as drivers of species sorting into communities. Among these, abiotic conditions and biotic interactions, as well as dispersal, are generally agreed to have an important role, beside stochastic events (Cornwell and Ackerly, 2009). Abiotic and biotic processes act as a series of filters, selecting species from a regional species pool into local communities (Zobel, 2016) based on their functional characteristics which make them suitable for the particular habitat (Díaz et al., 1998). Such characteristics, i.e. “functional traits,” are defined as “any morphological, physiological or phenological feature measurable at the individual level, which impacts fitness indirectly via its effects on growth, reproduction and survival” (Violle et al., 2007). Although, by definition, reproduction is one of the three
main pillars of fitness, some reproductive traits, and especially floral traits have only played a minor role in functional trait ecology in general, and in trait-based community assembly studies in particular.

Traits frequently used in functional ecology are principally those related to the leaf-height-seed (LHS) strategy scheme (Westoby, 1998). These traits are connected to growth and survival, i.e. canopy height determining competitive ability, seed mass affecting dispersal and establishment ability, and specific leaf area defining resource investment. Although these traits are easy to measure and are good proxies for crucial biological functions, they fail to provide information about some of the most important organs and structures involved in sexual reproduction. Floral traits, in this sense, provide a very useful and complementary tool for understanding various reproductive processes (e.g. Karron et al., 2012). Unfortunately, they are generally neglected in functional ecology research, which is also reflected by their absence from the most recent handbook of standardized protocols of plant traits (Pérez-Harguindeguy et al., 2013). However, we can expect that floral traits may vary in response to both biotic and abiotic drivers (as “response traits”), and affect ecosystem functioning (as “effect traits”; Lavorel and Garnier, 2002) through providing a connection to other trophic levels (Lavorel et al., 2013).

We use the term “floral traits” to refer to characteristics of the flower having a biological function and an ecological importance by affecting the fitness of the individual. We do not use the term “reproductive traits” to avoid confusion, since this generally includes seed and fruit characteristics, which we do not consider here. As flowers provide the setting for seed and fruit development that, when mature, replace the floral structures, there is also a temporal distinction between the two groups of traits in their general effect on plant fitness. These criteria help to distinguish floral traits (neglected in trait-based plant community studies) from traits that are frequently employed and for which data are widely available, e.g. seed size. Floral traits, in this sense, include traits involved in: (a) sexual reproduction ability (as opposed to vegetative reproduction); (b) cross-pollination vs self-fertilization potential; and (c) the physiology, morphology and phenology of flowers or inflorescences and the way they get pollinated (Klotz et al., 2002). Although the connection between fitness and floral traits might seem weak in the case of certain species or habitats, in general, during the sexual reproduction phase in the plant’s life cycle, floral traits, such as flower morphology and flowering time, become crucial for maximizing reproductive output (Larson and Funk, 2016). In fact, flowering time can have a huge impact on the fitness of several types of species irrespective of their pollination type, as flowering during a time of high resource availability has been shown to possibly have a critical benefit for viable seed production (Craine et al., 2012). It is important to mention that not all species always rely on sexual reproduction and that the importance of vegetative propagation could be predominant for certain species and in certain habitat types (Klimešová et al., 2017). However, we hypothesize that a careful selection of floral traits will be relevant for the assembly of plant communities within several vegetation types.

The main goal of this synthesis is to link evidence from studies on community-scale pollination to current species coexistence and community assembly theory to better understand mechanisms driving floral trait patterns in diverse communities. We aim to review and synthesize the general trends in floral trait patterns and related processes, in order to support and direct future developments in this field. We carried out a systematic literature search to assess existing evidence on community assembly patterns of floral traits. We specifically incorporate studies that are explicitly focusing on the community scale in a wide sense, thus including both biogeographical and local-scale findings, but that do not focus on only a limited component of the whole community (i.e. species of a particular family, tribe, or genus occurring within a community). We also aim at demonstrating that floral traits are important determinants of community assembly and that they are a vital component of the ecological strategy of plants that has so far been mostly neglected in studying the assembly of diverse plant communities.

In the review, we first summarize the different types of methodological approaches that are generally used to assess plant and pollinator communities and their interactions. In this synthesis, we then turn our attention to the particular approaches that use floral traits at the plant community level to describe assembly patterns. Based on a literature review, we synthesize reported patterns and related processes, and discuss the relevance of scale, as we incorporate studies on both biogeographical and local scales. In the succeeding section, we point out the lack of available floral trait data in most current databases as an important hindrance in advancing their involvement in community assembly studies. Finally, we provide a concise list of future steps to overcome data limitations and suggestions for research.

2 | APPROACHES USED IN COMMUNITY-LEVEL POLLINATION ECOLOGY

The field of pollination ecology has a vast array of publications focusing on evolutionary processes, population dynamics and pollination mechanisms of single species or genera. However, few studies have dealt with pollination ecology on the community scale, where the main focus is shifted towards species coexistence patterns and assembly rules of interacting communities of plants and pollinators. It is important to note here that the field of pollination ecology has rarely applied the concept of community ecology on which much of vegetation ecology relies. In pollination ecology a clade of co-occurring taxa is often considered a community. In vegetation ecology, and particularly in community assembly studies, though, communities consist of all or the majority of species co-occurring at a specific site, regardless of phylogenetic relationships or other criteria. In some cases, pollination studies on a well-defined component of the whole plant community (e.g. only animal-pollinated species in network analysis) might also represent a meaningful community-level analysis. In the following sections, we briefly introduce the most common approaches of pollination ecology studies which consider
communities (i.e. assemblages of coexisting species in a specified location) as the ecological unit of their research (Figure 1, Table 1).

In recent years the number of pollination network studies increased dramatically (Figure 1, Table 1: “A”; e.g. Junker et al., 2013; Junker et al., 2015; Bennett et al., 2018a). The interaction networks between communities of plants and pollinators (reviewed by Vázquez et al., 2009 and Knight et al., 2018) offer a perfect study system for understanding mutualistic relationships between trophic levels (Blüthgen et al., 2007) and therefore are strongly constrained by both animal and plant traits (e.g. Junker et al., 2013; Chamberlain et al., 2014; Maglianesi et al., 2014; Schleuning et al., 2015). Interaction networks combined with functional traits (Figure 1, Table 1: “AB”) can provide a deeper understanding of plant-pollinator trait matching (Sazatornil et al., 2016) and the validity of using pollination syndromes, i.e. whether a certain set of plant traits predetermine the group of potential pollinators (Lázaro et al., 2008; Ollerton et al., 2009; Rosas-Guerrero et al., 2014). Evolutionary relationships might also have the potential to explain the structure of pollination networks. On the one hand, pollinators are known to show “clade-specialization,” a preference for more closely related plant species (Vamosi et al., 2014), which can be seen as sign of niche conservatism, i.e. closely related species share similar (pollination) niches due to shared evolutionary history (Losos, 2008). On the other hand, in certain plant-pollinator networks, phylogeny might be a weak predictor (Chamberlain et al., 2014).

In this rapidly developing field, new analytical tools have been proposed for approaches combining traits, phylogeny and networks (Ibanez, 2012; Ibanez et al., 2013; Rafferty and Ives, 2013; Bastazini et al., 2017; Kantsa et al., 2018; Laigle et al., 2018). Furthermore, methods for comparing networks along environmental and resource gradients (Tinoco et al., 2017; Pellissier et al., 2018), as well as ones explaining non-random community assembly patterns based on network structure (Kemp et al., 2019), are advancing fast and have a strong potential to contribute to fully addressing the role of traits shaping species interactions and community structures (Figure 1, Table 1: “ABC”).

Floral characteristics are one of the most important diagnostic features used in classical taxonomy; thus the assumption of a connection between certain morphological patterns (i.e. number of petals, stamens etc.) and phylogeny is implicit in this study subject. However, such expected niche conservatism of floral traits along phylogenetic trees has been met with very few attempts to explore whether floral traits indeed adhere to conservatism, e.g. through estimating the phylogenetic signal of these traits. Moreover, trait conservatism has been addressed at the community scale, where the phylogeny of the co-occurring species is considered. Although these approaches could help to reveal evolutionary processes driving functional trait-based community assembly (Figure 1, Table 1: “B”), results on this topic are scarce and have hitherto been contradictory. For instance, flower colour had a strong phylogenetic signal among species of a temperate grassland (Binkenstein et al., 2013), but only a weak signal was found among species growing along an altitudinal gradient in the Himalayas (Shrestha et al., 2014). Junker et al. (2015) reported a phylogenetic signal for three out of eight different quantitative floral traits, in the most comprehensive study on the phylogenetic and functional assembly based on floral traits at the community scale to date. There is some evidence for phylogenetic clustering of floral traits in both small sets of closely related

![FIGURE 1](image-url) The most common approaches to study plant and pollinator communities. A, Pollination networks; B, phylogenetic signal of floral traits; C, species co-occurrence studies (abundance or frequency-based); and the combination of these: AB, trait matching in plants and pollinators and the testing of pollination syndromes; AC, pollination networks in plant communities taking into account the abundance and co-occurrence of species; BC, species coexistence patterns driven by floral traits and/or phylogenetic relationships (i.e. highlighted area, indicating the main focus of this synthesis). ABC, functional trait-based community assembly driven by trophic interactions. The different shades and shapes represent different functional trait values. The sizes of shapes are proportional to species abundances. In section B empty symbols with dashed branches represent species present in the habitat species pool but missing from local communities. Thus, approaches of section B generally work on the habitat species pool rather than on the plot level.
species (trait evolution within phylogenetic clades) and small local communities representing a phylogenetically "dispersed" set of species. However, explicit assessments of larger species pools covering a larger part of the phylogenetic tree and thus including "deeper" nodes (early diversification) are still scarce and conducted only for few vegetative traits (Pennell et al., 2015).

The above-mentioned approaches focus on plant–pollinator interactions by analysing patterns in functional traits and phylogenetic relationships between species. However, to date, very few published studies have reviewed this in a comprehensive way. The above questions and themes are worth exploring further in the future, to shed new light on the ecology of plant–pollinator interactions. Moreover, we must remark that these approaches completely ignore the abiotically pollinated plant species coexisting within the community (Figure 1). Species with different pollination modes might not be relevant in terms of pollination networks, but still have an effect on the abundance and/or fitness of neighbouring plants through competition for abiotic resources (Flacher et al., 2015) or through heterospecific pollen transfer (Ashman and Arceo-Gomez, 2013).

### 3 | FLORAL TRAITS IN COMMUNITY ECOLOGY

3.1 | Literature search

We carried out a systematic literature search of studies on plant community assembly and floral traits in Web of Science. Our search terms were (plant* AND (pollinat* OR flower* OR floral*)) AND trait*
AND communit∗) yielding 982 results (last accessed: 22.02.2018). While we scanned visually all titles from this list, we focussed more closely on the first 300 papers (ordered by relevance according to Web of Science) which were scanned also by abstract. Among the selected studies we skimmed all references and the context in which they were cited resulting in other potentially relevant articles. We excluded studies on: (a) populations/“communities” consisting of a limited selection of species (e.g. genera or small clades); (b) evolutionary processes without describing spatial patterns; and (c) review, viewpoint/commentary or forum papers, book chapters and theoretical frameworks. The described criteria resulted in 21 studies which were clearly related to empirical studies on community assembly in the broad sense (for a brief summary on the aims of study, floral traits used and most important findings of each paper, see Appendix S1). In the next sections, we describe and discuss the papers found in the context of current community assembly theory, in terms of processes shaping species coexistence and functional trait patterns on different spatial scales.

3.2 | Local scale

The main processes driving non-random community assembly through plant–pollinator interactions are filtering, competition and facilitation (Sargent and Ackerly, 2008), which can create non-random patterns in floral traits among the co-occurring species of a community (Figure 1, Table 1: “BC”). In the traditional sense, filtering is mainly thought to be caused by environmental (i.e. abiotic) conditions directly. However, due to the connection that floral traits enable between trophic levels, abiotic conditions might also affect plants indirectly through the available pool of pollinators. Plant adaptations to maximize reproductive output by e.g. producing easily accessible flowers (Pellissier et al., 2010), increasing biomass allocation to floral structures (Fabbro and Körner, 2004) or promoting earlier and prolonged flowering (Makrodimos et al., 2008) were found to be correlated with environmental gradients. However, correlation does not necessarily mean causation, as environmental filtering is equally likely to act on potential pollinators or directly on the plants themselves.

Plant species can also experience reduced reproductive output (pollen limitation) due to pollinator scarcity or environmental perturbations directly (reviewed by Bennett et al., 2018a). Loss in reproductive success can occur in certain environmental conditions, when plants fail to attract their potential pollinators because of e.g. poor light availability or other unsuitable abiotic conditions (Sargent and Ackerly, 2008). Therefore, small-scale habitat filtering needs to be studied in the context of plant–pollinator interactions (e.g. Burkle and Irwin, 2010; Lázaro et al., 2015), thus combining the effects of abiotic and biotic conditions as well as temporal changes in plant communities (de Deus and Oliviera, 2016; Warring et al., 2016).

Similarly, disentangling the effect of biotic interactions — competition and facilitation — on the observed community patterns is not straightforward (e.g. Hegland and Totland, 2012). In theory, pollinator sharing leads to competition that can be disadvantageous to at least one of the species involved (reviewed by Mitchell et al., 2009). On the one hand, competition for pollinators can cause reduced reproductive success when: (a) pollinators are scarce, due to decreased visitation rates (i.e., pollinators are a limiting resource); or (b) the shared pollinator is common, due to dilution by an increased amount of interspecific pollen transfer (Sargent and Ackerly, 2008). The effect on the reproductive success of competing partners is highly dependent on the density of conspecific and heterospecific individuals (Benadi and Paw, 2018) and can be modified by other factors, such as the presence of invasive super-attractive flowers (Chittka and Schürkens, 2001). Moreover, competition between insect- and wind-pollinated species for abiotic resources can also have a negative impact on insect-pollinated species in terms of resource allocation to floral traits involved in pollinator attraction (Flacher et al., 2015). On the other hand, having attractive neighbours might be beneficial, as they can increase the frequency of visitations by shared pollinators (Pellissier et al., 2012), which is most effective when the co-flowering species have similar floral traits or when they are super-generalists (e.g. alien species; Vilà et al., 2009). Another type of trait similarity is quite frequent among food-deceptive orchids (e.g. Traunsteinera globosa), which take advantage of and mimic the floral traits of other nectar-producing neighbouring plants (in this example Trifolium pratense) — often referred to as “magnet” species — thus deceiving pollinators unable to distinguish them (Juillet et al., 2007). To disentangle the two contrasting mechanisms — competition and facilitation — Mesgaran et al. (2017) proposed a model for predicting the optimal density of co-flowering species that is beneficial for a given plant in terms of pollination rate, and found that it is largely dependent on the attractiveness of the neighbours. Besides this modelling approach, in recent years there has been an increase in empirical studies on the density dependence of pollinator-mediated plant–plant interactions in natural communities (e.g. Bergamo et al., 2020).

In community ecology, abiotic drivers and biotic interactions shaping species distributions are often inferred from observing functional trait patterns. Non-random trait distribution, convergent (more similar) or divergent (more dissimilar than expected by chance) trait values can indicate which mechanisms and interactions are dominant within the community. According to contemporary coexistence theory (Chesson, 2000), species coexistence depends on the stabilizing effect of niche differences when fitness differences between species are small. Although this theory has been exemplified with vegetative plant functional traits (e.g. HilleRisLambers et al., 2012), one can apply the same theory to pollinator-mediated plant–plant interactions as well. Coexisting plant species having similar fitness (e.g. similar display size) have a similarly high probability of getting pollinated (Hegland and Totland, 2012). However, a high degree of trait convergence and pollinator sharing increases the probability of receiving heterospecific pollen. Therefore, plant species need to separate their pollination niches in order to coexist in a community. We propose that niche partitioning between similar species can happen via three main mechanisms: (a) partitioning in
time by having asynchronous flowering phenology (Oleques et al., 2017); (b) partitioning in interaction partners by specialization on particular (groups of) pollinators (e.g. difference in spectral reflectance; McEwen and Vamosi, 2010; van der Kooi et al., 2016) or (c) partitioning in morphology by different pollen placement mechanisms to avoid heterospecific pollen transfer (e.g. anther position; Fantinato et al., 2017). While the above-described mechanisms were extensively studied in certain clades and specialized systems (e.g. Muchhala and Potts, 2007; de Jager et al., 2011; Muchhala et al., 2014), evidence on diverse multi-clade communities remains scarce. As such mechanisms can result in both convergent and divergent floral trait patterns, one should be cautious when inferring community assembly rules, and attempt to distinguish traits reflecting fitness differences vs niche differences.

Contrary to vegetative functional traits, floral trait patterns of coexisting species are mainly relevant when species overlap in their time of flowering to a certain extent. Although some evidence suggests that facilitation can also occur among non-co-flowering species via maintaining pollinator populations by providing high floral diversity (Braun and Lortie, 2019), these interactions are poorly studied. The interplay between co-flowering plants is widely known and well tested, but still, results remain contradictory (Jensen et al., 2019). Therefore, developing new tools for assessing the overlap in flowering period among co-occurring species within communities are highly encouraged (Fantinato et al., 2016).

### 3.3 | Biogeographical scale

Local communities are assembled from a larger, regional pool of species via abiotic and biotic filters. Therefore, exploring functional trait patterns on larger biogeographical scales is crucial for understanding these filtering processes and thus local community assembly mechanisms. In the case of floral traits, large-scale patterns were found to be driven by climatic gradients (e.g. Rech et al., 2016), which might cause turnover in pollinator communities (e.g. Devoto et al., 2009) and in biodiversity patterns (e.g. Ollerton et al., 2011), as well as by geology and/or land-use types (e.g. Kühn et al., 2006; Binkenstein et al., 2013). On the global scale, the majority of plant species are pollinated by insects and other animals (78% and 94% in temperate and tropical communities, respectively) compared to the number of wind- or water-pollinated ones (Ollerton et al., 2011), and only a small proportion are capable of obligate or facultative self-pollination. Another global trend is the increasing specialization of pollination syndromes towards the tropics (Ollerton et al., 2006). However, the driver behind these two trends is still unclear (Schemske et al., 2009), and the existence of a latitudinal gradient in specialization has recently been questioned (Moles and Ollerton, 2016).

It is generally accepted that pollination other than via animals is selected for when pollinators become scarce or unpredictable (e.g. on islands, Barrett, 1996). Therefore, under unsuitable conditions for pollinators, species with alternative reproductive strategies become more abundant. Based on a global community dataset, Rech et al. (2016) showed that the distribution of animal- and wind-pollinated species is non-random, but related to current climatic conditions. Animal pollination was more dominant in the tropics (warm habitats, closed vegetation with high precipitation), whereas a higher proportion of wind-pollinated species could be found on islands compared to continents (Rech et al., 2016). On the national scale of Germany, Kühn et al. (2006) found that the proportion of wind-pollinated species was most strongly correlated with wind speed and altitude (where, under both conditions, pollinator availability is generally lower) as well as on open vegetation and moist habitats (such as bogs and fens). Dominance of self-pollination was spatially more scattered, especially in areas that included habitats with high disturbance, areas with a high proportion of alien species (e.g. riverbanks) and a high proportion of annual species. It has also been shown that oceanic islands host a surprisingly high proportion of self-compatible species (Lord, 2015; Grossenbacher et al., 2017) which therefore suggests that securing sexual reproduction when the number of potential outcrossing partners is limited is crucial for colonization success in remote locations (Baker, 1955).

Considering biomes on the global scale, the ratio of outcrossing compared to selfing declines as increasing latitude and is — in some cases — significantly different among major biomes (Moeller et al., 2017). However, these patterns are most likely due to the distribution of life forms rather than a consequence of actual plant–pollinator interactions, as there is a strong correlation between the rate of outcrossing and life form, as expected in general (Michalski and Durka, 2009).

Although certain life forms have a higher proportion of certain pollination types (Michalski and Durka, 2009; but see Ollerton et al., 2011) and mating systems (Moeller et al., 2017), it is less known how floral traits relate to other functional traits. Within communities, the proportion of pollination types was found to be correlated to certain optical spectral signals detected by remote sensing (Feilhauer et al., 2016). Based on models predicting leaf traits from spectral data, a number of strong correlations were detected between the community-weighted mean (CWM) values of leaf traits and pollination types. The CWM of specific leaf area (SLA) and leaf dry mass were positively related to the proportion of insect pollination and negatively to wind pollination, whereas for leaf dry matter content (LDMC) the relationship was reversed, and none of the traits were related to selfing. However, as CWM values were used throughout this study, the correlation between vegetative and reproductive traits at the species level remains unexplored. Assessments whether pollination-related traits form an independent axis of plant strategy are still lacking (but see Salguero-Gómez et al., 2016 for an assessment using reproduction-related parameters calculated from population matrices).

During our literature survey, we have found studies predominantly covering small scales with both small extents (i.e. samples cover small geographical areas) and grain sizes (each sample or plot is small, e.g. several square meters; for more on ‘extent’ and ‘grain size’ see Wiens, 1989). In contrast to this, among studies on the biogeographical scale (large extent in general), the majority was...
sampled at a very coarse grain, while studies with high resolution (i.e. fine-grained) samples are limited in number, and often not evenly distributed along the studied gradient(s). Studies that investigate patterns at grid cell level (i.e. evenly distributed) or have small grain size but high extent are virtually missing (but see Kühn et al., 2006).

4 | AVAILABILITY OF FLORAL TRAITS

Although there are a growing number of studies using pollination-related traits in community ecology, the amount of publicly available floral trait data is not increasing nearly as rapidly. As a part of TRY (Kattge et al., 2020), the largest collection of trait databases to date, predominantly categorical traits related to floral and reproductive ecology can be found sourced from BiolFlor (Kühn et al., 2004), Ecoflora (Fitter and Peat, 1994) or PLANTSdata (Green, 2009). Although there is a general gap for continuous traits (but see FReD; Arnold et al., 2010), these are often more variable within than among species.

Floral traits are known to have considerable intraspecific variability (e.g. floral tube length: Anderson et al., 2014; floral scent: Delle-Vedove et al., 2017). This variability should be kept in mind when using database data especially on a small spatial scale. For leaf traits, there is evidence that database data can be a sufficient proxy for on-site measurements of moderately plastic traits such as LDMC, but not always for highly plastic ones, such as canopy height or SLA (Cordlandwehr et al., 2013). Although this has not been studied for the majority of floral traits, flowering phenology (measured as onset of flowering in Julian days) was shown to generally have higher interspecific than intraspecific variability (Kazakou et al., 2014), and therefore can be considered a “stable” trait, even when used as a continuous variable. However, besides trait plasticity, the suitability of database data might also depend on the strength of the environmental gradient (Cordlandwehr et al., 2013) and the spatial scale of the study, therefore calling for even more precautions.

Large amounts of floral trait data do exist, but these are mostly scattered or difficult to access. Old monographs (e.g. Müller, 1881; Knuth, 1898; Kugler, 1970; Faegri and van der Pijl, 1979), regional and national floras and other sources of “grey” literature can provide an extensive base for further syntheses of the current knowledge. However, empirical results for quantitative traits, e.g. nectar properties (Baude et al., 2016), will likely need to be collected to achieve consistent data. Despite the potential of these resources, there has been no initiative so far to pull these data together in a standardised way on a common platform, like has been achieved for other trait groups, such as clonal traits (CLO-PLA; Klimešová and de Bello, 2009), fine root traits (FRED; Iversen et al., 2017) or seed traits (SID: Royal Botanic Gardens Kew, 2018). Therefore, establishing standards in the measurement of floral traits as well as compiling existing and comparable data for a larger species pool and biogeographical extent (e.g. GloPL; Bennett et al., 2018b) is one of the upcoming challenges of this field.

5 | CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

In this synthesis, we reviewed predominantly recent studies using floral and pollination-related functional traits at the community scale. We summarised the most common themes and methodological approaches, and pointed to knowledge gaps that could be explored in the future. In general, we find evidence on community-level floral trait patterns to be inconsistent, mainly due to the scarcity and heterogeneity (context specificity) of empirical studies, which do not allow general conclusions, neither on the directionality of trait patterns nor on their relative importance compared to other functional traits. We therefore provide here a concise “catalogue” of future directions in exploring floral trait-based community ecology to improve our understanding of these patterns and processes.

First, the necessary steps to overcome current limitations due to lack of data are:

1. Establishment of floral and pollination trait standards
2. Compilation and organization of floral and pollination trait data into a dedicated database specifically recognizing, among others, grey literature, non-English literature and recent empirical studies
3. Making available more trait data for larger pools of species from larger biographical extents, to enable studies beyond local scales
4. More observational vegetation data including phenological status, focusing especially on co-flowering and not only co-occurrence of species

Secondly, based on our current knowledge of ecological function and importance for plant community assembly we propose the following groups of floral traits to be considered for future compilation and sampling efforts:

1. Flower colour, including reflectance and UV patterns (expanding already existing database: FReD; Arnold et al., 2010)
2. Display size, including flower/inflorescence size, number of flowers in inflorescence, number of flowers/inflorescences per square meter
3. Floral morphology, including nectar tube length and floral symmetry
4. Positioning of reproductive organs inside the flower in relation to pollen placement on the pollinator’s body
5. Floral reward production, sugar content and chemical profile
6. Floral scent chemical profile
7. Flowering phenology
8. Pollination syndrome based on or supplemented by observed pollinator species

Finally, we think that the following research directions and prospects are of particular interest:

1. Phylogenetic signal for floral traits within and across communities (encompassing large species pools) thus enabling the assessment
of floral trait clustering/overdispersion in communities and their relation to phylogenetic relationships
2. Assessment of whether floral and sexual reproduction traits form an independent axis of plant strategy
3. More comprehensive large-scale studies encompassing both larger biogeographical extent and higher resolution data
4. Pollinator-mediated plant–plant interactions — such as competition and facilitation — and how these are governed by abiotic conditions in natural communities
5. Experiments on the role of floral traits in trait-based plant community assembly testing hypotheses generated in observational studies. This may necessitate experiments distributed in areas with different pollinator communities in which plant communities with various flower trait combinations are experimentally established and monitored

ACKNOWLEDGEMENTS
We thank Zoltán Botta-Dukát and one anonymous reviewer for their constructive comments on the manuscript.

AUTHOR CONTRIBUTIONS
The study was conceived by LG and AE-V AE-V with major contributions from LG took leadership in writing the manuscript and the remaining authors contributed substantially to the different versions. All co-authors have read and approved the final version of the manuscript.

DATA AVAILABILITY STATEMENT
This synthesis article does not contain original data.

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**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section.

**Appendix S1.** Research articles on floral trait patterns driven by biotic or abiotic factors in plant communities

**How to cite this article:** E-Vojtkó A, de Bello F, Durka W, Kühn I, Götzengerber L. The neglected importance of floral traits in trait-based plant community assembly. *J Veg Sci*. 2020;00:1–11. https://doi.org/10.1111/jvs.12877.