Measuring the quality of pollinator habitats and the effectiveness of measures to increase feed availability

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PROBLEM

The qualitative decrease of habitats has been identified as a main driver of the decline in insect abundance.[1] Due to a lack of instruments, it is difficult to determine how well the living conditions for pollinators are in an area and whether measures taken to improve them were effective.[2] A sufficient, continuous and diverse feed supply are key indicators of habitat quality.

Can we assess pollinator habitat quality using computer vision technology on honey bee hives, to measure (A) pollen availability and (B) pollen diversity?

METHODS & TECHNOLOGY

Data on both questions was collected at five locations from Aug. to Sept. 2021.

(A) Pollen availability through hive monitoring
- Two hives per site were equipped with the apic.ai monitoring systems
- Algorithms counted bees entering with pollen (assumed to carry 15 mg [3])
- Data collected was compared to the BEEHAVE colony simulation model (weather data 2006-2009, data from third year of simulation was chosen)

(B) Pollen diversity through color assessment and laboratory analysis
- Pollen samples of two days per hive were collected using pollen traps
- Samples were photographed with a reflex camera using good lighting
- Subsequent analysis of samples in a specialized laboratory
- Use of Simpson´s Biodiversity Index to measure diversity of lab data

Data of Hive 6 on Aug. 24th - color profile and lab analysis.

18% Rest* 14% Plantain 14% Mustard 40% Clematis 6% Dandelion 7% Buddleja davidii
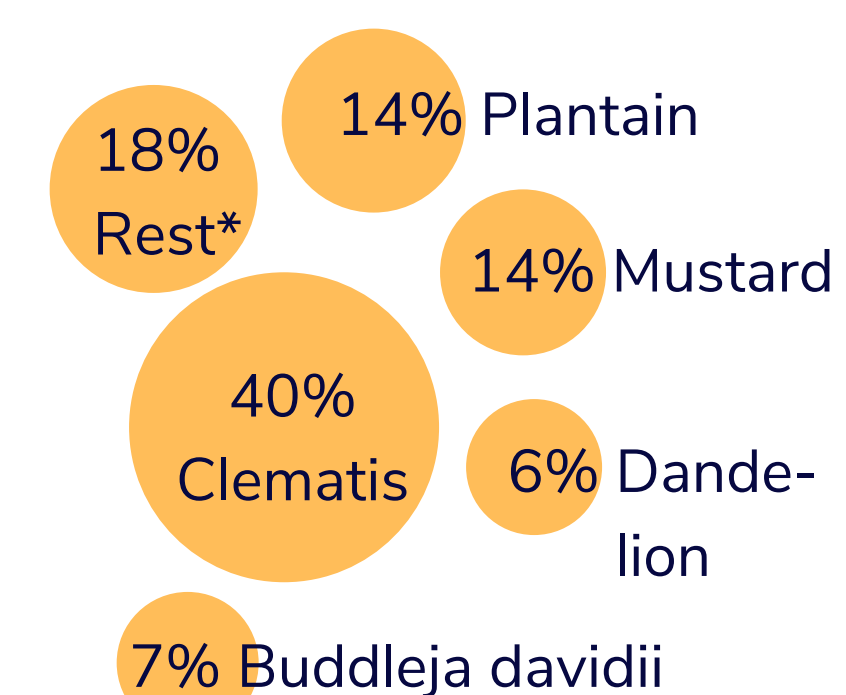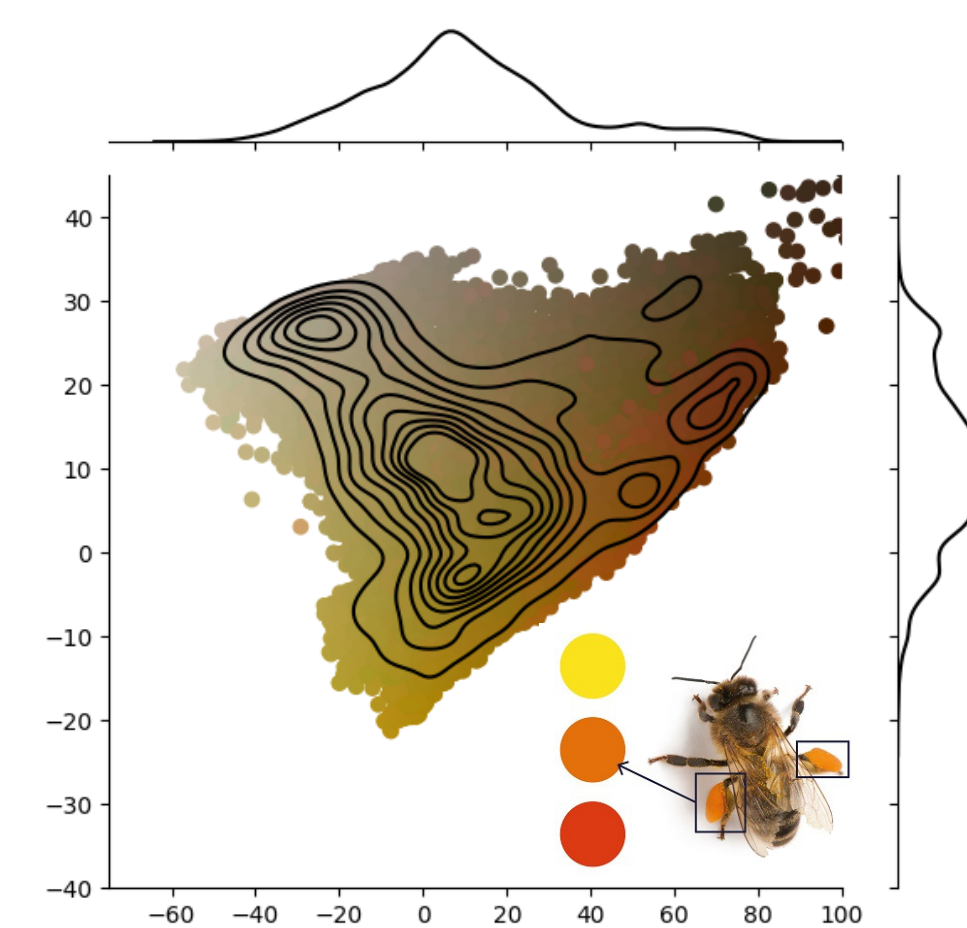
* Aster, bryony, hedge bindweed, Oenothera, St. John's wort, Virginia creeper, snow berries, ivy

Simpson's index

$$D = \sum_{i=1}^{s} 1 - \frac{n_i(n_i - 1)}{n\,(n - 1)}$$

n_i = Number of individuals of a species i
n = Total number of individuals

RESULTS

Location	Landscape description	ID	Date	(A) Pollen availability						(B) Pollen diversity			
				Pollen foraged (g)	SD (g)	Pollen demand (g)	Delta	Delta location		Species richness	Simpson's Index	Species richness location	Simpson's index location
Karlsruhe	Urban, industrial park in the city, next to an allotment club	1	09.Aug.	79	0,07	123	-36%	-12%		23	0,74	37	0,85
		2	09.Aug.	118	0,09	123	-4%			19	0,74		
		1	10.Aug.	98	0,08	120	-18%			17	0,74		
		2	10.Aug.	132	0,10	120	9%			17	0,82		
Obersulm	Rural, surrounded by fields, hills and vineyards	3	24.Aug.	70	0,06	81	-13%	-18%		22	0,73	44	0,79
		4	24.Aug.	*						16	0,68		
		3	27.Aug.	56	0,06	73	-23%			23	0,74		
		4	27.Aug.	*						25	0,78		
Düsseldorf	Urban, industrial park inside the city, next to the Rhein river	5	24.Aug.	**				**		12	0,60	23	0,70
		6	24.Aug.	**						13	0,79		
		5	25.Aug.	**						16	0,56		
		6	25.Aug.	**						13	0,77		
Schuttertal	Rural, small community surrounded by the Black forest	7	25.Aug.	*				-51%		9	0,31	16	0,35
		8	25.Aug.	43	0,06	79	-46%			11	0,34		
		7	26.Aug.	29	0,05	78	-62%			6	0,51		
		8	26.Aug.	43	0,06	78	-44%			4	0,14		
Lindau	Suburban, apple plantation, surrounded by fields and houses	9	07.Sept.	62	0,06	55	12%	28%		3	0,27	3	0,38
		10	07.Sept.	**						***			
		9	08.Sept.	74	0,07	51	44%			2	0,46		
		8	08.Sept.	***						***			

Data quality: *data excluded because of gaps in the data between sunrise and sunset; ** data excluded because colonies were only just created from swarms and their demand was expected to be different from what BEEHAVE estimated; *** data excluded because not all bees entered through the monitoring device, respectively the pollen trap.
Pollen samples were taken over approximately 24h durations. The collection may start or end one day before or after the date indicated, pollen samples in Schuttertal from August 26th were collected on August 28th and 29th).

Overview: Colors of photographed pollen.

	Düsseldorf	Lindau	Karlsruhe	Schuttertal	Obersulm
Plantaginaceae					
Taraxacum					
Aster					
Buddlejaceae					
Sinapis					
Clematis					
Balsaminaceae					
Hedera					
Achillea					
Parthenocissus					
Zea mays					
Trifolium rep.					
Heliant. annuus					
Calluna					
Chenopodiac.					

KEY RESULTS

The data indicates that pollen diversity and quantity are useful for assessing pollinator habitat quality and could be used to determine the effect of habitat quality improvement measures.

(A) The amount of pollen foraged could be determined precisely. On average, it was 17% below the demand suggested by the BEEHAVE model. The delta ranged from -62% to +44%.

(B) Laboratory analysis display a broad spectrum of species, indicating a good usefulness of the approach for measuring the species richness of a location. The average rating of biodiversity was 0.6, with values ranging from 0.14 to 0.82. The diversity of pollen collected based on colour did not provide the same level of detail, yet, colour analysis on the photographs taken of the samples resulted in a similar number of main feed sources (abundance >5%) as the lab analysis .

OUTLOOK

Further research is required to gain a better understanding of the following:

- How well does the pollen collected by the honey bees represent the floral diversity of a location. How many days and hives have to be assessed for the best results? This will be further investigated in 2022.
- How well does the BEEHAVE model represent reality regarding pollen demand? In 2022 a study will be conducted to generate long-term data for training the BEEHAVE model. This will include the monitoring of pollen collected and regular manual assessments of brood and food reserves.
- How well does the assessment of individual days represent the habitat quality over longer periods of time? This will also be investigated.
- Can the data on pollen colour also be collected in real time as the bees enter the hives with pollen on their legs? Would this colour data be sufficient for an assessment of pollen diversity?

SOURCES

1 Bundesamt für Naturschutz (BFN), Agrarreport 2017 - Biologische Vielfalt in der Agrarlandschaft, S. 36, Abgerufen von https://www.bfn.de/sites/default/files/2021-04/BfN-Agrar-Report_2017%20%281%29.pdf
2 Wix, Nana: Blühstreifen als Naturschutzmaßnahme zur Förderung der Avifauna und Tagfalterfauna in der Agrarlandschaft. Hannover: Gottfried Wilhelm Leibniz Universität, Diss., 2019, XV, S. 62.
3 Bayerische Landesanstalt für Weinbau und Gartenbau. Pollen und seine Bedeutung für Bienen. Online verfügbar: https://www.lwg.bayern.de/mam/cms06/bienen/dateien/bedeutung_pollen_internet_f%C3%BCr_internet.pdf. Abgerufen 02.02.22.