Final project report
Reporting template

Project acronym		BIOVEINS
Project title		Connectivity of green and blue infrastructures: living veins for biodiverse and healthy cities
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Project period (Start date – End date)		01/03/2017 – 31/05/2020
Project website, if applicable		www.bioveins.eu

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List of partners involved in the project (company/organization and principal investigator). Please use partner numbers to specify the tasks, work packages and inputs of each partner in sections 4.3, 5 and 6.2 to 6.4.	Partner 1: University of Antwerp, BELGIUM, Roeland Samson (coordinator) Partner 2: FCiencias.ID, Universidade de Lisboa, Lisboa, PORTUGAL, Pedro Pinho Partner 3: French National Institute for Agricultural Research (INRA), Paris, FRANCE, Muriel Tichit Partner 4: Estonian University of Life Sciences, Tartu, ESTONIA, Lauri Laanisto Partner 5: Poznan University of Life Sciences, Poznan, POLAND, Piotr Tryjanowski Partner 6: Swiss Federal Research Institute WSL , Birmensdorf, SWITZERLAND, Marco Moretti Partner 7: Université Paris Sud, Orsay, FRANCE, François Chiron

1. Short description for publicity

Figure 1. A. Insect trap nest in tree. B. Flowering Lotus corniculatus var. Leo plant on terrace in Zürich for the strawbAIRies citizen science campaign investigating air pollution distribution and plant fertilasation by insects (Foto: Joan Casanelles and Yvonne Kunz WSL).

In a hearing phase of this project municipalities highlighted their needs of guidance on the implementation, managing and restoration of green and blue infrastructures (GBI), including their multi-functionality as recreational areas and functional corridors for biodiversity. Nonetheless, while claiming that GBI should maximize the provision of ecosystem services (ESs), knowledge to support this statement was lacking. In particular we do not know the key features of GBI linking biodiversity to the provision of ESs, and how connectivity of GBI influences their ESs. Recent syntheses have highlighted that functional aspects of biodiversity and trophic interactions more often determine ecosystem functioning and ESs provision than does species richness (taxonomic diversity) per se, and that they are the basis for a sustainable GBI management. In our project, we used advanced trait-based approaches, and particularly functional diversity, to investigate the mechanisms behind the role of GBI connectivity to enhance ecological permeability across the urban matrix and to provide key ESs. This study was performed in seven European cities along a latitudinal gradient (Lisbon, Almada, Zurich, Paris, Antwerp, Poznan and Tartu). In each city we studied the biodiversity in 36 parks varying in size and connectivity. Biodiversity was assessed for a broad range of taxa from plants, insects, birds, bats to phyllosphere microorganisms. Moreover, also the major environmental ESs - and their size dependence - of urban green infrastructure were assessed. Stakeholders were engaged in various ways, including via a unique citizen science campaign strawbAIRies organised simultaneously in four of the project cities.

2. Summary

BIOVEINS aimed at using functional diversity to highlight the mechanisms underpinning the link between urban green and blue infrastructures (GBI), taxonomic diversity and ecosystem services (ESs) provisioning, and to provide, together with local stakeholders, the knowledge to identify the critical features of GBI, to guide the establishment, management and restoration of GBI, and to optimize ESs provisioning. The project was enrolled in seven European cities along a latitudinal gradient, i.e. Lisbon and Almada (Portugal), Zurich (Switzerland), Paris (France), Antwerp (Belgium), Poznan (Poland) and Tartu (Estonia). In each of the cities about 36 urban green sites, with a total of 224 sites, were selected varying in size and connectivity.

A broad and diverse range of taxa were studied in the selected urban sites. In total 523 woody species were identified in all sites, of which nearly 300 were overlapping in different cities. The highest woody species diversity was found in Paris. A total of 134 species of epiphytic lichens were recorded The average number of species per site was highest in Tartu and lowest in Poznan. 4381 insect nests were analysed containing 16 bee species, 45 wasp species and 31 species of their natural enemies. Increased urban green connectivity promoted the number of bee and wasp species and decreased their dead rates. Bats were most abundant, and had the highest diversity in Zurich, followed by Antwerp. Artificial lighting lowers bat diversity. A total of 122 bird species was observed in selected GBI. If parks are big enough, they also host birds that usually avoid cities.

Of all considered functional plant types, trees contributed most to ESs provisioning: carbon stock, air pollution mitigation, cooling of the urban microclimate and pollination due to biodiversity hosting.
Two citizen science campaigns were organized. In BirdLab French volunteers recorded birds visiting bird feeders during winter. Bird feeding makes participants more relaxed and connected to nature, so that it can be considered as an ESs provided by urban nature. StrawbAIRies, on air quality and pollination success, was organised simultaneously in Tartu, Poznan, Antwerp and Zurich. Air quality is in general better in Tartu than in Poznan or Antwerp.

All citizens should be considered stakeholders, but they should be well informed. Communication with governmental stakeholders is best organized via personal contact. Concepts, like ecosystem services, are key instruments for policy-makers but are often poorly understood. So, laymen communication is key, even with professional stakeholders.

3. Objectives of the research

The overall aim of BIOVEINS was investigating the role of functional diversity to highlight the mechanisms underpinning the link between urban green and blue infrastructures (GBI), taxonomic diversity and ecosystem services (ESs) provisioning, and to provide, together with local stakeholders, the ecological and interdisciplinary knowledge to identify the critical features of GBI, to guide the establishment, management and restoration of GBI, and to mitigate the effects of major urban global challenges, like habitat fragmentation, air pollution, and urban heat island. Specific objectives were:
1) Assessing the effect of urbanisation (in particular habitat loss and habitat fragmentation) of different taxonomic groups representative of distinct habitat types, dispersal ability, feeding requirements, nesting resources, activity times, and known to be sensitive to urbanisation processes.
2) To assess the functional diversity of various taxonomic groups in different urban green areas (with different size, connectivity, and geographic location).
3) Assessing the relative importance of green-blue spaces and urbanisation drivers in shaping taxonomic and functional aspects of biodiversity within and across cities.

4) Providing recommendations about how to design and restore urban green and blue spaces to enhance biodiversity and connectivity in densely populated cities.
5) To estimate the potential of air pollution removal and microclimate regulation in different urban green areas.
6) To evaluate the relative ecosystem service provision in different urban green areas.

4. Project activities and achievements

4.1. General description of activities over the duration of the project
For every WP, there was one lead partner, which is mentioned for each WP. However, we would like to stress out that all partners were involved in most of the WPs. Without this strong team work, we would not have been able to collect and analyse the huge amount of information and knowledge which results from this project.

WP1 (sites; P2): The European Urban Atlas was used to select possible sites, looking at all urban green spaces within the cities. Those were then classified per size (area) and connectivity (Proximity Index). A maximum of 36 sites per city were then randomly selected, which resulted in a total of 244, because some combinations of size and connectivity were not available. Sites centroid was then provided and the nearest appropriate location per taxa was sampled. A number of environmental variables based on landscape (land-cover) and satellite (Sentinel, LandSAt) data were also calculated, at multiple scales.

WP2 (biodiversity; P6): A broad and diverse range of taxa were studied in the selected urban sites, which are described separately below.

Vegetation: Vascular plants were sampled in 125 parks in 6 cities (by the groups in Tartu, Antwerp, Zürich and Poznan) using quadrats method, where in five 5m x 5m quadrats per site (near the centroid) trees and shrubs were sampled (identification of species and size measurements), and within 1m x 1m quadrats herbaceous vegetation was sampled (species richness, vegetation height and cover). In addition to quadrats, a general description of the site´s vegetation together with the list of main woody species (together with average height) was given. The focus was on woody plants as they dominate the vegetation and their ecosystem services provisioning.

Lichens: Epiphytic lichens were sampled in all cities. In each site 4 trees were sampled using the European Standard protocol, to quantify species abundance. Data analysis looked at taxonomic and functional traits, to assess the role of green spaces for biodiversity and also for air quality and microclimate regulation.

Cavity-nesting bees and wasps (CNBW): CNBW, and their enemies (like parasites and beetles), were sampled using trap-nests constructed with reeds and cardboard tubes. Trap-nests were installed in each study site in vertical structures (mainly trees and occasionally light poles or ornamental columns) at a height of 2.5-3.5m, exposed S-E and with direct sunlight. The trap-nests were installed on January-February 2018 and were exposed until October of that year. Then, the reeds were opened, and the ones containing nests were separated in vials until their emergence and were subsequently identified to the species level when possible. CNBW are used as a model system to monitor the effects of urbanisation from the individual to the community level, using both interaction networks and fitness proxies.

Bats and nocturnal insects: Bats were sampled with acoustic data loggers installed on the trunk of a suitable tree with open canopy, between 3-4 m height above ground. Bat foraging activity was measured with the autonomous ultrasound recorders Batlogger M (Elekon AG, 2018). Nocturnal insects were collected in parallel with bats with an intercept LED light-trap. They were installed in a suitable tree 10-20 m distant from the Batlogger, hung from an open foliage branch at least 4.5 m above ground. Traps were emptied daily after each sampling night. In the laboratory, insects were classified to the order level. Bats and nocturnal insects have been chosen to monitor the effects of

urbanization on nocturnal fauna, an ecological niche frequently understudied, with particular focus on light pollution and trophic interactions.

Birds: In 2018, the sampling design was built and assessed in Paris and Poznan that was later proposed to the other cities in 2019. In each city (n=7), partners hired a skilled ornithologist who sampled birds during breeding. Each ornithologist visited 36 parks twice in April and May (except for Almada and Antwerp with 14 and 16 parks, respectively), and counted all birds heard and seen during 10 min. Special attention was paid to control for potential biases in species detectability by measuring noise level at each bird count. Data analysis looked at taxonomic and functional diversities to assess the role of urban parks (size, isolation, habitat composition and configuration) for bird conservation. Often questioned by stakeholders themselves, trade-offs were assessed between park size and diversification of ecological habitats within parks.

Phyllosphere: In the first campaign (June-July 2018) samples were collected in five countries, following a detailed protocol concerning tree species selection, sample collection, preservation and transport, and in the second campaign samples were collected in five countries. Samples were send to Antwerp where they were processed in the lab for both microbial analysis and assessment of the level of air pollution at all of the sample sites. While samples are still being processed (due to the delay caused by the corona-pandemic), first results already show clear consistent similarities, but also differences over the extensive latitudinal gradient investigated.

WP3 (ecosystem services, P4): The analysis of ecosystem services provided by urban green areas involved again all the partners of the project, from spatial data of the size and fragmentation of urban green infrastructure to the diversity and abundance of different taxonomic groups assessed in this project.

Carbon stock: Based on the vegetation data collected in WP2, carbon stock estimates were calculated using species-specific models on biomass allocation on trunks, branches and leaves, and also species-specific models for calculating canopy volume based on trunk diameter and canopy width and height. This carbon stock and allocation data are also used in the ongoing analysis on air pollution mitigation and microclimate regulation (described below) as biomass proxies. Preliminary analysis showed that Antwerp has the most consistent amounts of woody biomass in green areas with different sizes, while Paris has the most variable biomass numbers. The differences in woody biomass variation in different sized green areas are driven by the amount of woody vegetation in the largest green areas (the biggest green areas in Paris have on average more than ten times more woody biomass than similar sized green areas in Antwerp). However, diversity of woody species was not overall correlated with woody biomass, so that it can be expected that urban green areas with similar size and biomass do not actually provide the same rate of ecosystem services. So, municipalities can optimize the ecosystem services provided by their urban green infrastructures without the need for structural changes in the networks (size and connectivity) of their green infrastructure.

About 500 samples (twigs, trunk bark and leaves) of 40 transects from 30 parks in Antwerp were collected. In addition, another 1285 bark samples were collected during the lichen (see before). All 1764 samples were analysed in the lab to assess the deposition of traffic related particulate matter on these surfaces. The data will allow to assess how park design influences the penetration of air pollution in these green infrastructure.

In the summer of 2019, more than 90 iButtions for temperature measurements over the city of Antwerp. Measuring locations were chosen in and around 10 parks with similar tree cover but different size. Every two and a half months, iButtons were changed so that continuous hourly data were gathered during one year. This period covered all seasons, including heat waves during summer. Data will reveal the effect of parks, and their size, on their potential for the mitigation of the urban heat island effect.

WP4 (citizen science, P1): Two citizen science campaigns were organized, i.e. Birdlab and strawbAIRies. In 2014, Birdlab was initiated (http://www.vigienature.fr/fr/vigie-manip/birdlab) which aimed at understanding bird behaviour at feeders. Anyone, skilled or not in birdwatching, could participate. BirdLab relies on an user friendly application on smartphones that has been first developed in French. After several discussions among partners for extending Birdlab to the other countries it has been decided not to do so, because translating the application in local languages would have cost more money than initially planned. Moreover, spreading the application among citizens in each studied city would have needed strong effort in communicating and meeting with local NGOs. In France, there was a strong investment in numerous media releases and broadcastings about the project. The project gave insight into bird feeding ecology, how birds interact with each other and what the effect of various cities is on these patterns.

StrawbAIRies (www.strawbAIRies.com) was enrolled in four different countries simultaneously (Estonia, Poznan, Belgium and Switzerland) building further on the extensive experience of the Belgian partner with similar campaigns (www.airbezen.be). The project aimed at mapping the local air pollution, and give insight in the fertilization efficiency by insects in relation to the availability of urban green infrastructure in the neighbourhood and the local air pollution. All necessary documents (e.g. protocols, text for surveys, text for website,...) were provided in English and subsequently translated in the local languages. A lot of attention was given to communication with the local participants. Samples were collected by the participating citizens and sent to the local partners. The local partners dried the samples and sent them to Belgium where samples were analysed. First results on local air pollution were communicated to the participants by each local partner. A more extended report on the air quality part and a report on the pollination success will be communicated soon.

4.2. Table of deliverables

Table 1. Deliverables and milestones.

Deliverable and Milestone Name			**Lead partner (country and designation)**	**Date of delivery (mm/yyyy)** Month 1 = March 2017		**Comments**
				Initially planned	**Delivered**	
Work Package	***Deliverable or Milestone***	***Full Name***				
WP7	D.01	Report of the kick-off meeting including protocols for field monitoring	Partner 1, Belgium	Month 2	Month 1	
WP7	D.02	Bi-monthly updates of WP leaders to project coordinator	All partners	Month 2	Month 1	Multiple meetings between March 2017 and February 2018
WP6	D.03	Construction and updating project website	Partner 3 (INRA France)	Month 2	Month 17	The person responsible for the website started to work in 2018. The promoter of this task passed away during the project, which made the communication with this partner very difficult.
All WPs	D.04	Reports of the (on-line) meetings of the project management committee	All partners	Month 4	Month 7	
WP2	D.05	Standardized sampling protocols	All partners	Month 6	Month 8	Protocols are available for bats, bees & wasps, birds, bacteria, lichens, and plants

WP5	D.06	Reports of the local meetings with the stakeholders	All partners	Month 12	Month 12	Every partner contacted the local stakeholders and provided the list of the meetings.
WP6	D.07	Outreach to the broader public on urban biodiversity and GBI management	Partner 6, Switzerland	Month 12	Month 12	Website was launched in July 2018 (P3).
WP1	D.08	Database on landscape configuration and connectivity	Partner 2, Portugal	Month 1	Month 5	sampling sites selection for all cities was carried out in the proper date
WP7	D.09	Mid-term report	Partner 1, Belgium	Month 18	Month 21	
All WPs	D.10	Presentation of results at scientific meetings	All partners	Month 21	During the entire project	Various contributions in a wide range of events (see list in this report part 6.2)
WP2	D.11	Database with inventory of the sampled taxa in the different cities	All partners involved in WP2	Month 24	Month 39	Excel file used internally.
WP2 and WP3	D.12	Database with local predictors of biodiversity and ecosystem service provision	All partners involved in WP2 and WP3	Month 24	Month 48	This database is still in progress as several datasets are still further analysed
All WPs	D.13	Scientific Publications	All partners	Month 24	Month 10	https://www.uantwerpen.be/en/research-groups/endemic/research/research-projects/bioveins/publications
WP2	D.14	Ecosystem service analysis on pest-control, pollination, fitness and parasitism	Partner 6	Month 24	Month 48.	Mutualistic and antagonistic networks of bees and wasps have been moved to WP2 and treated as part of biodiversity and not as

						ESs.
WP4	D.15	Layman reports on the citizen science project StrawberryCity	B, Belgium	Month 24	Month 39	The strawbAIRies report part 1 - Air quality. See https://www.uantwerpen.be/en/research-groups/endemic/research/research-projects/bioveins/
WP4	D.16	Layman reports on the citizen science project Birding Citizens	Partner 7, France	Month 24	Month 43	There is only a scientific publication about this. https://www.sciencedirect.com/science/article/pii/S0048969720327807
WP2	D.17	Database with species traits	All partners involved in WP2	Month 27	Month 48	Work in progress see https://www.uantwerpen.be/en/research-groups/endemic/research/research-projects/bioveins/
WP3 and WP4	D.18	Maps and data on urban air pollution and plant stress ecophysiology	Partner 1	Month 30	Month 48	No measurements of plant ecophysiology were taken as this was too labour intensive in comparison with the potential outcome
WP3	D.19	Report with urban case studies on the role of GBI on urban microclimate and air pollution	Partner 1 and 4	Month 30	Month 48	Data analysis still in progress

WP5	D.20	Tools and guidelines for managing GBI	All partners	Month 36	Month 48	As data-analysis is for many datasets still in progress, management suggestions will in the first place be formulated in individual publications, and later compiled on the website
All WPs	D.21	End report	All partners	Month 36	Month 45	
WP2 and WP3	D.22 (new)	Park ID cards	All partners	/	Autumn 2020	For each of the investigated parks an ID-card is established reporting on the parks' biodiversity and their relation to other parks in the city and the parks in the other countries. These ID-cards are provided to the local stakeholders
WP5	M.01	Local meetings with urban stakeholders at each city	Partner 5 (Poland)	Month 1	Month 1	Each partner was responsible for contacting and meeting with local stakeholders, based on the local conditions.
WP7	M.02	Kick-off meeting	Partner 1 (Belgium)	Month 1	Month 1	
WP6	M.03	Project website launched	Partner 3 (France)	Month 2	Month 17	http://bioveins.eu/
WP1	M.04	All sample sites selected and described	Partner 2 (Portugal)	Month 9	Month 9	
WP4	M.05	Citizen science campaign 'Birding citizens' launched	Partner 7 (France)	Month 11	Month 9, Month 21, Month 33	

WP7	M.06	First annual meeting	Partner 1 (Belgium) in collaboration with Partner 2 (Portugal)	Month 13	Month 12	The first annual meeting was held in Lisbon, Portugal.
WP4	M.07	Citizen science campaign 'StrawberryCity' launched	Partner 1 (Belgium)	Month 14	Spring 2019	Some preliminary experiments were done in 2018 and winter 2019, the campaign was held in the spring/summer of 2019.
All WPs	M.08	First scientific publication submitted	Partner 2	Month 21	Month 10 (published)	
WP5	M.09	General project meeting with stakeholders	Partner 5 (Poland)	Month 24		The assumed plan had to be changed due to financial constraints of the leading partner (P5), and English as a barrier. Each group met with their local stakeholders.
All WPs	M.10	International symposium organised by the BIOVEINS consortium	All partners.	Month 36	Not	We intended to organise a one-day session at the SURE2020 Conference which was cancelled due to the corona pandemic
All WPs	M.11	Final feedback to the local stakeholders about the results and implementation tools	All partners.	Month 36	Still has to be done	Will be delivered once the analysis of the major results is done.

4.3. Scientific outcomes

Various, and diverse taxa were selected, and were analysed in as many countries and parks as possible. Major results, or actual status is described below.

Vegetation: During the fieldwork a total of 482 woody species were identified across 215 urban green areas (UGA) in the seven studied cities. Paris showed the highest average of woody species per UGA (19.4 ± 1.2), although the most biodiverse UGAs in terms of absolute species richness were found in Tartu and Zürich. In general, large green areas host a slightly higher number of woody species. Mean species richness per UGA in the rest of the cities ranged from 6.4±0.3 in Poznan to 9.5±1 in Almada.

Lichens: City specific species represent an important share of richness, but not of abundance; more specifically of the 134 species found in seven cities, nearly only half occur in a single city; however, those rare species represent only 7% of total abundance. Opposingly, 27% of the species occur in 4 or more cities but represent 86% of total abundance. Thus, abundance-based metrics should be used to make cross-cities analyses. No obvious effect of macroclimate was found in both taxonomic and functional metrics of diversity; instead, the highest values of diversity were found in opposing sides of the climate gradient, even if different species are found there. However, urban lichen communities were dominated by tolerant species, both to pollution and aridity, suggesting the prevailing effect of urbanization-driven factors into shaping these communities. Also large β-diversity values within cities were found. The latter suggests that trait-based metrics should be used to unravel the urbanization driven effects on lichens.

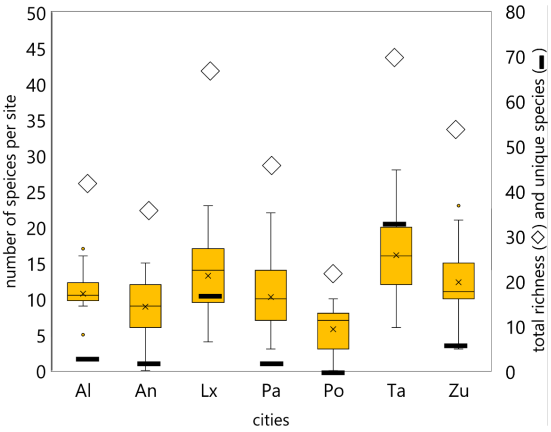

Figure 2. Lichen biodiversity in the BIOVEINS cities. Al = Almada, An = Antwerp, Lx = Lisbon, Pa = Paris, Po = Poznan, Ta = Tartu and Zu = Zurich.

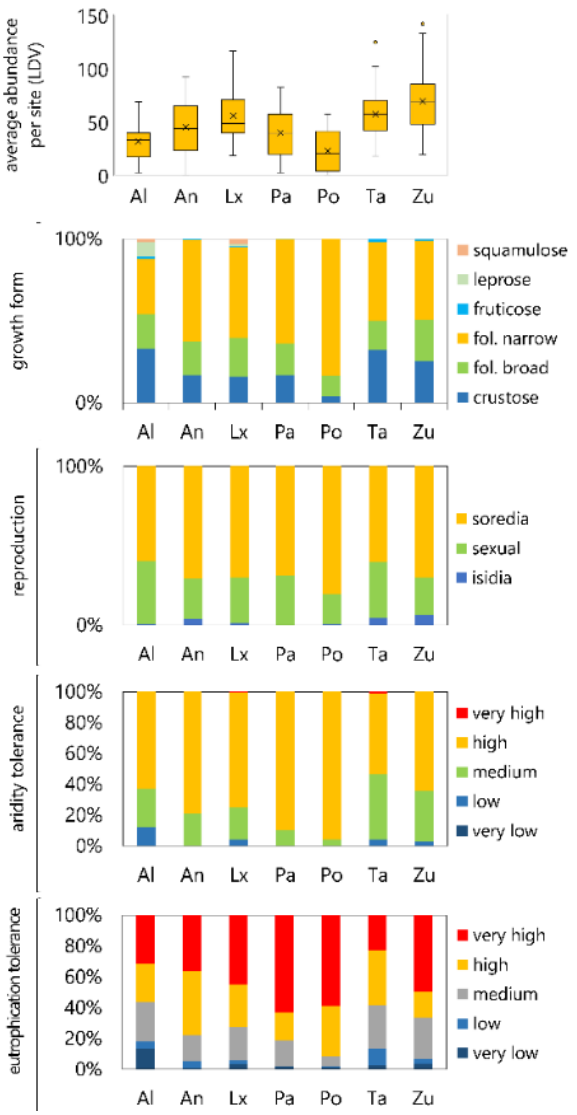

Figure 3. Lichen properties as observed in the BIOVEINS cities. Al = Almada, An = Antwerp, Lx = Lisbon, Pa = Paris, Po = Poznan, Ta = Tartu and Zu = Zurich.

Cavity-nesting bees and wasps: In total, we obtained 4500 nests of cavity-nesting bees and wasps with a total number of 16500 cells. We found 17 bee species and 46 wasp species in total considering the five cities. More cavity-nesting wasp species than bee species were found in all considered cities. Highest bee species richness and number of cells was found in Paris (15 sps., 1517 nest cells), followed by Zurich (11 sps., 1159 nest cells), Antwerp (9 sps., 760 nest cells), Poznan (8 sps., 519 nest cells) and Tartu (8 sps., 294 nest cells), while highest wasp richness was found in Zurich (41 sps., 641

nest cells), Antwerp (35 sps., 341 nest cells), Paris (33 sps., 375 nest cells), Poznan (29 sps., 319 nest cells) and Tartu (24 sps., 534 nest cells). Larger amounts of available habitat (inferred with larger park size and higher values of the proximity index) lead to higher numbers of nests, number of species and birth rates in both bees and wasps (Figure 4 and Figure 5). In addition, we found 42 species of parasites, kleptoparasites and nest destroyers belonging to the groups of flies, wasps, beetles, acari and bees. We did not find any relationship between the amount of available habitat and the parasitism rate for both of the groups in any of the cities (Figure 5).

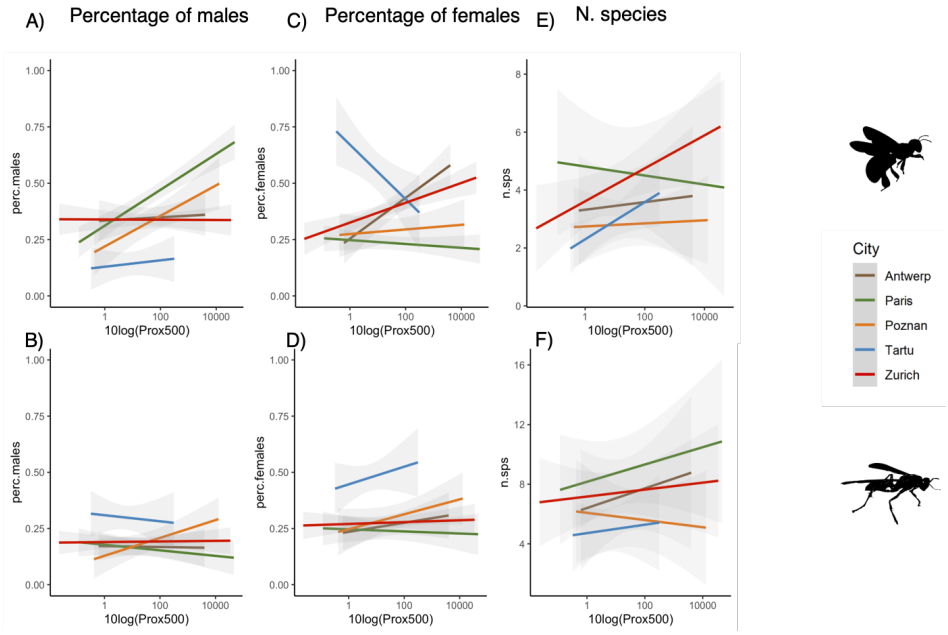

Figure 4. Reproductive success and community metrics of bees and wasps along a gradient of urban intensity in Antwerp, Paris, Poznan, Tartu and Zürich. The subpanels show the percentage of males (A, B), the percentage of females (C, D) and the number of species (E, F) for cavity-nesting bees (A,C,E) and wasps (B, D, F). The urban intensity gradient is inferred with the proximity index values calculated at each sampling location with a buffer of 500m. Note the scale of the proximity index has been log-transformed.

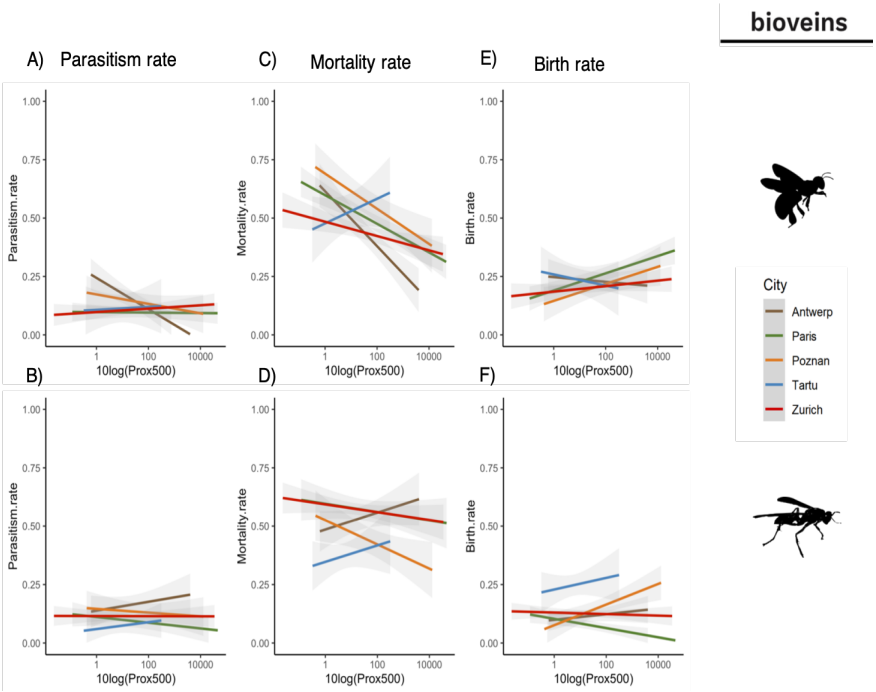

Figure 5. Reproductive success of bees and wasps along a gradient of urban intensity in Antwerp, Paris, Poznan, Tartu and Zürich. The subpanels show parasitism rate (A, B), mortality rate (C, D) and birth rate (E, F) for cavity-nesting bees (A,C,E) and wasps (B, D, F). The urban intensity gradient is inferred with the proximity index values calculated at each sampling location with a buffer of 500m. Note the scale of the proximity index has been log-transformed.

Bats and nocturnal insects: We sampled a total of 12,714 insects and recorded 283,126 bat passes containing 5 million echolocation calls. Small Diptera and Trichoptera represented 56% of the sampled individuals, while medium-sized Lepidoptera and small-sized Coleoptera represented 20%. The remaining groups accounted for less than 10% of total abundance each. Around 91% of the bat calls belonged to *Pipistrellus pipistrellus,* while Long-range echolocators (LRE) and Short-range echolocators (SRE) accounted for 5% and 4% of the bat calls. Thus, Mid-range echolocators (MRE) were significantly more present than the remaining guilds (Figure 6).

We found a greater abundance and diversity of bats and nocturnal insects in the city of Zurich, followed by Antwerp and Paris. We identified artificial lighting in the UGA to lower bat diversity by probably filtering out light-sensitive species. We also found a negative correlation between both bat activity and diversity and insect abundance, suggesting a top-down control. An in- depth analysis of the Zurich data revealed divergent responses of the nocturnal fauna to landscape variables, while still showing top-down control of bats on insect abundance. Thus, to effectively preserve biodiversity in urban environments, UGA management decisions should take into account the combined ecological needs of bats and nocturnal insects and consider the specific spatial topology of UGA in each city.

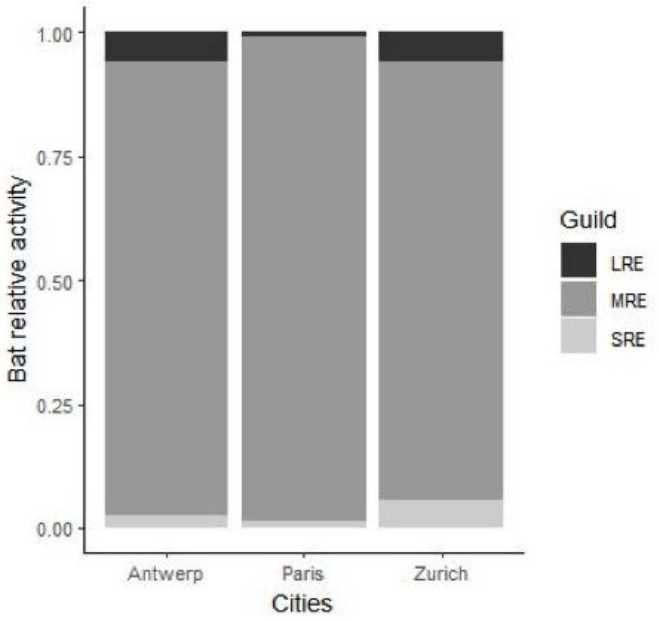

Figure 6. Composition of the three guilds of bats in the Antwerp, Paris and Zurich. The proportional composition of the guilds is based on the number of calls recorded by the bat-loggers. LRE= Long-range echolocators; MRE= Mid-range echolocators; SRE= Short-rang

Birds: In all cities together, we detected 122 bird species representing almost one fourth of the breeding avifauna in Europe. Mean species number per city ranged from 38 to 69 (mean = 52 sp.). We found higher species richness in Eastern and Central European cities like Poznan, Tartu and Zurich compared with the Western European ones. Although relatively rich, studied cities showed an important taxonomic and functional overlapping in community composition (75% share of species and 90% of functional traits between cities). Lisbon in Portugal and Tartu in Estonia hosted the most dissimilar bird communities, likely reflecting contrasted biogeographic regions but also the occurrence of sensitive species to urbanization that makes these bird communities more original.

Although these sensitive species usually avoid urban areas (hereafter called “urban avoiders”), they can maintain populations in green parks that are large enough and well connected with each other. In cities, they often are specialized species to woody and aquatic habitats, and of conservation concerns (threatened species). To better understand the role of green spaces in the persistence of urban avoiders within cities, we assessed the effects of park size, park isolation, heterogeneity and configuration of habitat patches within parks and habitat diversity in the landscape on local communities. As expected, we found an overall effect of habitat diversity at park and landscape levels on bird richness. Park area

as well as patch size (or contiguous patches of the same habitat) increased the proportion of urban avoiders within park, indicating that patch area also matters when conserving those species.
These results have important implications for urban stakeholders and park managers. In our study 10 hectares parks were considered sufficient, if the objective is to maintain urban-adapter bird species (synanthropic and generalist species). By contrast, larger parks of 50 hectares minimum were found necessary if the conservation of urban avoider and threatened species is the objective. We also found a trade-off between increasing habitat patch heterogeneity and patch size within parks. Urban avoider species were best conserved in parks with a large habitat patch. Diversifying types of habitat for increasing bird species richness within parks should thus consider habitat patch size in order to preserve both specialized and generalist species.

Phyllosphere: Two campaigns were organised in the summer of 2018 to collect phyllosphere samples (first campaign: 15 June to 27 July 2018 and second campaign 18 to 28 September 2018). The phyllosphere is the aerial region of the plant colonized by microbes and in this research we focus on the leaves, also called the phylloplane. In both campaigns samples were collected according to a strict protocol in Antwerp, Poznan, Tartu. Paris and Zurich collected samples only during the first campaign and Lisbon only in the second campaign. Sampling was done by collecting healthy, undamaged *Platanus x acerifolia* or *Acer platanoides* leaves in 12 parks in each of the different cities mentioned above. For these samples the phyllosphere composition (through miseq sequencing) and the leaf deposition of magnetisable particulate matter (expressed as SIRM and obtained through magnetic analysis) was determined. Magnetisable particulate matter is a good indicator of traffic derived PM in the urban area. This resulted in a total of 256 samples that were successful analysed in the lab. Statistical analysis demonstrated a significant effect of city, campaign and the log value of SIRM. The latter suggests an effect of air pollution on the observed communities. However, further analysis is required – and is ongoing -to draw indefinite conclusions.

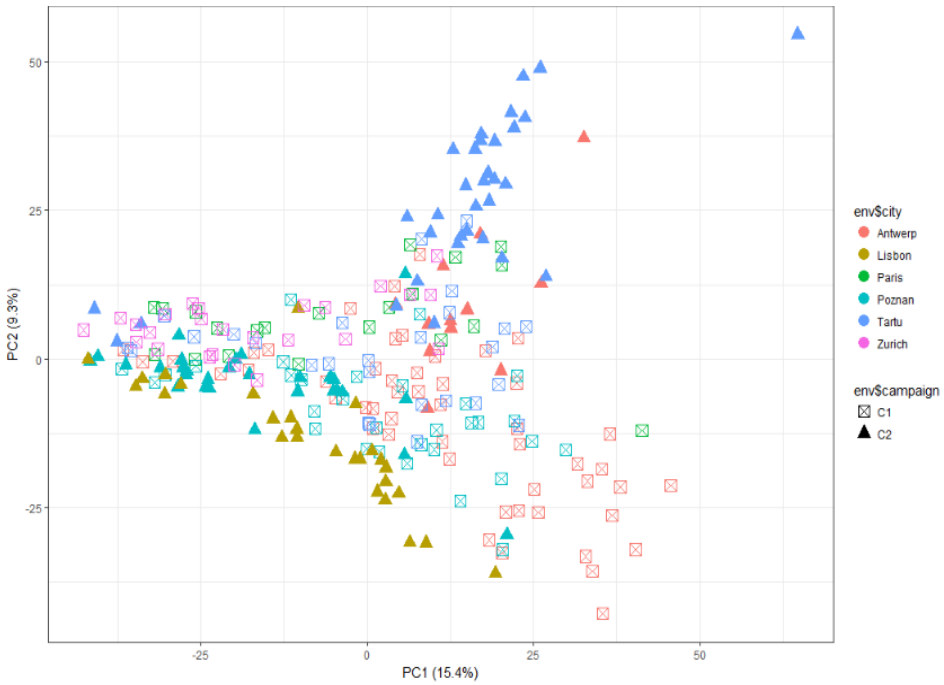

Figure 7. Biplot of the PCA on the composition of the whole phyllosphere bacterial communities of each tree (n = 256), marked according to the city and campaign they were sampled in.

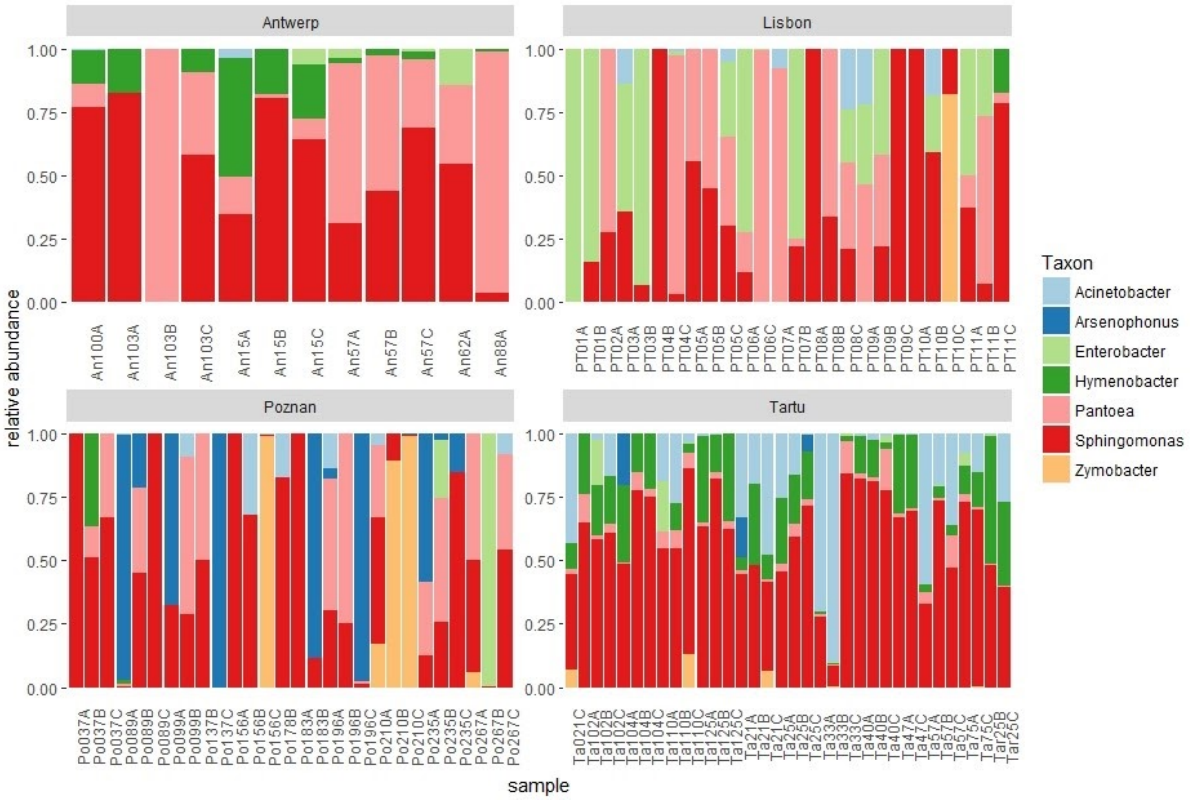

Figure 8. Relative abundance of the ten most occurring taxa in the different samples, grouped by city, for campaign 2.

Table 2.Numbers of observed species in one park (minimum and maximum) per taxon and per city. Mean number of species is the mean of all parks within one city.

City	Taxa	Mean number of species	Maximum number of species	Minimum number of species
Antwerp	Bacteria (OTUs)	263	298	235
Paris	Bacteria (OTUs)	249	275	204
Poznan	Bacteria (OTUs)	238	252	225
Tartu	Bacteria (OTUs)	230	262	165
Zurich	Bacteria (OTUs)	224	262	181
Antwerp	Bats	12	19	5
Paris	Bats	11	13	7
Zurich	Bats	14	19	9
Antwerp	Bees	3	7	1
Paris	Bees	5	10	1
Poznan	Bees	3	5	1
Tartu	Bees	3	4	1

Zurich	Bees	4	8	1
Almada	Birds	15	22	9
Antwerp	Birds	9	14	3
Lisbon	Birds	15	22	4
Paris	Birds	13	19	6
Poznan	Birds	18	28	7
Tartu	Birds	15	23	8
Zurich	Birds	13	18	6
Antwerp	Entomophilous plants	69	108	37
Paris	Entomophilous plants	208	1179	55
Poznan	Entomophilous plants	51	77	12
Tartu	Entomophilous plants	65	102	41
Zurich	Entomophilous plants	179	688	90
Antwerp	Fungi (OTUs)	357	428	288
Paris	Fungi (OTUs)	330	427	252
Poznan	Fungi (OTUs)	415	478	359
Tartu	Fungi (OTUs)	316	367	258
Zurich	Fungi (OTUs)	354	408	203
Almada	Lichens	11	17	5
Antwerp	Lichens	9	15	1
Lisbon	Lichens	13	23	4
Paris	Lichens	10	22	3
Poznan	Lichens	6	10	1
Tartu	Lichens	16	28	6
Zurich	Lichens	13	24	4
Antwerp	Nocturnal insects	9	11	1
Paris	Nocturnal insects	8	11	7
Zurich	Nocturnal insects	10	13	6
Antwerp	Wasps	6	14	1

Paris	Wasps	9	13	2
Poznan	Wasps	5	9	1
Tartu	Wasps	4	10	1
Zurich	Wasps	6	15	1
Almada	Woody vegetation	8	16	3
Antwerp	Woody vegetation	9	18	1
Lisbon	Woody vegetation	6	14	2
Paris	Woody vegetation	27	101	3
Tartu	Woody vegetation	15	48	4
Zurich	Woody vegetation	12	27	2

Air pollution (WP3 + WP4): Vegetation samples were collected to assess the amount of magnetizable particulate matter – expressed as nSIRM, and being majorly caused by motorized traffic and industry – being deposited on their surface. Trunk bark was collected in all parks except in Almada, with up to eight samples per park. Figure 9 illustrates the distribution of normalised SIRM values in the different cities. More detailed datasets were gathered in selected parks in Antwerp, where samples were taken along transects towards the park's centroid. These data will be further analysed to assess the mitigating effect of urban parks for atmospheric particulate matter. Furthermore, leave samples were collected during the strawbAIRies citizen science campaign. These data visualise local variation in air quality within the cities as well as between cities (Figure 10).

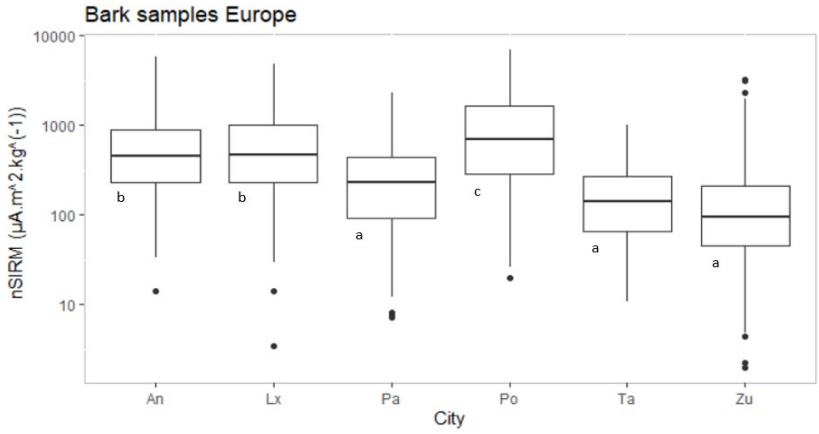

Figure 9. Distribution of normalised SIRM (nSIRM) values for bark samples from Antwerp (An), Lisbon (Lx), Paris (Pa), Poznan (Po), Tartu (Ta) and Zurich (Zu). Significant differences ($p < 0.05$) between cities are indicated by different letters. Pay attention to the log-transformed y-axis.

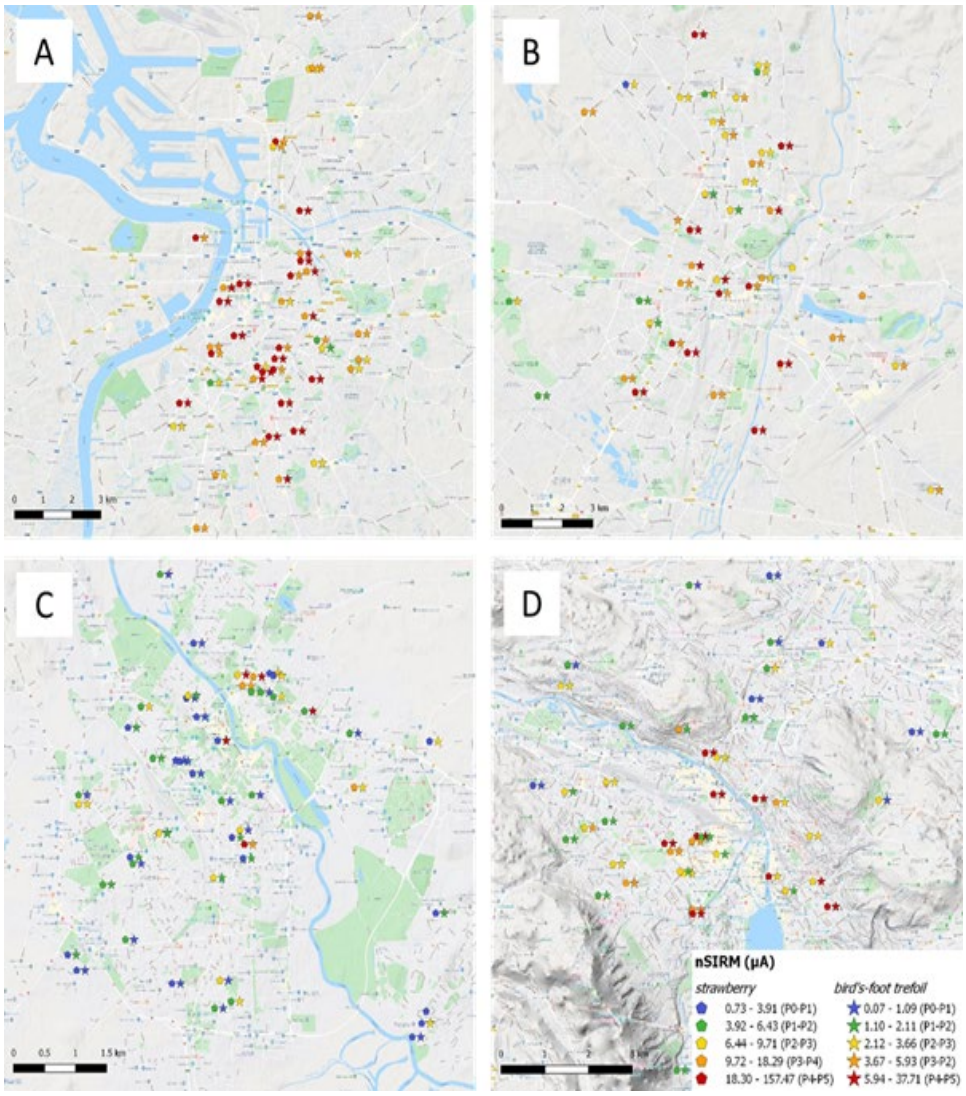

Figure 10. Maps with results from the strawbAIRies Europe citizen science campaign. Values are divided in bins of equal amount of values. Values for each location are compared with all the values in Europe. A = Antwerp, B = Poznan, C = Tartu and D = Zürich.

Temperature (WP3): In Antwerp, 94 temperature sensors (Thermochron iButton DS1921G-F5) were hung spread over 10 parks in Antwerp. Parks were chosen to cover a range of park dimensions between less than one hectare to almost 40 hectares. In eight of the parks two transects were selected and in two parks one transect was selected. On these transects ideally 5 temperature sensors were hung. One between the centroïd of the park and the border, one at the border and three outside the park at 20 m, 50 m and 100 m from the park border. In addition, one temperature sensor was hung at the centroïd of every park. Air temperature was measured every hour from July 2019 until October 2020. During the measurement period, some temperature sensors disappeared due to theft, leading to a loss of data. We will use this data to investigate the effect of urban park size on the regulation of the microclimate during heatwaves and on the year round temperature variation in general. It is expected to see a larger temperature buffering effect for larger parks than smaller parks, especially during heatwaves.

Pollination success (WP4): To assess pollination success *Lotus corniculatus* var. Leo flowers and pods and *Fragaria sp.* flowers and strawberries were counted during the strawbAIRies citizen science campaign which took place from May to July 2019. There was a lot of interest in this campaign so there were more candidates then the number of participants we initially had in mind. The difficulty was, however, to receive all samples and all information from all the participants. There was a clear

difference in *Lotus* "first flower date" between the cities. Mean first flower date in Poznan and Tartu was one week earlier than in Antwerp and Zürich. Pods from 259 participants were counted with a minimum of zero pods and a maximum of 435 pods. The total number of pods counted was 7526. When comparing numbers of flowers with numbers of pods, we can conclude that most flowers and pods are formed in July. Next to this, strawberry shape was investigated since this also is a measure for pollination success. More uniform strawberries are expected to have been better pollinated. In every city, more than half (55 – 82%) of the strawberries are registered with shape A (this is the most uniform shape). With a notable 82% in Poznan. This data will be connected with the data from WP1, so we can see if pollination success is dependent on proximity to green areas for example and we plan to write a publication about this.

4.4. List of project meetings

Table 3. List of project meetings.

Date	Place	Participating partners	Meeting title and object
07/03/2017	Antwerp (B)	All project partners	Project kick-off meeting
03/04/2017	Brussels (B)	Pedro Pinho	Kick-off BiodivERsA projects
05/09/201	e-meeting	All project partner	Follow-up meeting
14/09/2017	e-meeting	All project partner	Follow-up meeting
09/10/2017	e-meeting	All project partner	Follow-up meeting
20/11/2017	e-meeting	All project partner	Follow-up meeting
11/12/2017	e-meeting	All project partner	Follow-up meeting
08/01/2018	e-meeting	All project partner	Follow-up meeting
29/01/2018	e-meeting	All project partner	Follow-up meeting
21-22/2/2018	Lisbon, Portugal	1, 2, 3, 4, 5, 6, 7	annual meeting Lisbon
23/2-31/12/2018	e-meetings	All project partners	multiple bi-lateral or multi-lateral meetings to discuss and fine tune sampling protocols
18-21/2/2019	Poznan, Poland	1, 4, 5, 6, 7	annual meeting Poznan
22/2-31/12/2019	e-meetings	All project partners	multiple bi-lateral or multi-lateral meetings to discuss and fine tune sampling protocols and data-analyses
6/11/2019	Skype	1, 2, 4	follow-up and planning final event
27/11/2019	Skype	1, 2, 4	follow-up and planning final event
21/01/2020	Skype	1, 2, 4	follow-up and planning final event
16-19/2/2020	Tartu, Estonia	1,2,4,5,6,7	annual meeting Tartu
20/2-30/11/2020	e-meetings	All project partners	multiple bi-lateral or multi-lateral meetings to discuss data analyses and publications
13/3/2020	Skype	1, 2, 4,5	follow-up, final report and planning final event
24/3/2020	Skype	1, 2, 4	follow-up, final report and outreach
23/4/2020	Skype	1, 2, 4,5	follow-up, final report and outreach
12/5/2020	Skype	1, 2, 4, 5, 6	follow-up, final report and co-authorship
26/5/2020	Skype	1, 4, 6	follow-up, final report
5/6/2020	Skype	1, 4, 6	follow-up, final report
19/10/2020	Skype	1, 4, 6	follow-up, final report
29/10/2020	Skype	1 & 4	discussion collaboration for paper
9/11/2020	Skype	1, 4, 6	follow-up, final report

4.5 Follow up activities and plans for further exploitation of the results

As a huge amount of data was collected within the framework of the BIOVEINS-project, all project partners plan to further analyse their data after the end of the project. All project partners agreed to continue their collaborations, to achieve multi-partner publications. A list of planned publications and a timing is available for all partners in a common map, together with a meta-database of the available data. The partners will organise regular teleconferencing meetings, and collaborate on drafts of manuscripts via a commonly accessible map.

Although the planned end-event - a one-day session on the SURE2020 Conference in Poznan - was cancelled due to the corona-pandemic. There is the overall plan and willingness to still present our work to the public on an international event, when time is due.
As data are continuously further analysed, and new or fine-tuned findings come up regularly, we will publish and spread these new findings via peer-reviewed articles, contributions at symposia, but also - and very importantly - also via our website (www.uantwerpen.be/bioveins). Also the parks' ID-cards (reporting on their biodiversity), and the updates, will be placed on the website (access restricted to stakeholders).

Various partners also will participate in various local initiatives advising local stakeholders on urban green management. So, will e.g. the Swiss partner participate in working groups on Zurich Green office (Grün Stadt Zürich, GSZ) on urban trees in Zurich and other Swiss cities. Furthermore, they also will participate in specific grant programs oriented in disseminating scientific activities and enhancing participatory events with citizens and local authorities, such as the third Millennium foundation and in the Swiss National Science Foundation outreach program Agora.

5. Stakeholder engagement in the project

5.1 Before the project's start

Before the project started, the partners had contacted local stakeholders to obtain permissions required for carrying out the research in public green areas, according to the local law, such as installing trap nests, collecting leaf, lichen and soil samples. This also involved contacting park managers and municipalities to obtain the information about beehives on the area of the park, frequency of mowing and other relevant information for our study. Also contacts were made for collaboration in other fields, and for data exchange, wherever relevant.

5.2 During the project

All of the project's activities in parks had been allowed by the local municipality, and we didn't encounter any difficulties, nor with obtaining the permissions before the start of the project, neither during the course of our project. During our discussions we all agreed that we should consider every person who benefits from our research or shows interest in it, as a stakeholder. It enabled us to reach a broader public, and broaden our field of activity.

The engagement activities for stakeholders were divided into two types: (a) activities taking place independently in each team, and (b) the same activities taking place simultaneously by all partners. The division of activities has been caused by the fact that the organization structure of stakeholders differs between countries/cities. Therefore, the means of contact with stakeholders were tailored by each partner, to fit the local conditions. Another important reason for this stakeholder tailoring, is that stakeholder interactions best happen in the local language as English is for many stakeholders too difficult, or not even possible, for subtle communications.

In order to improve our understanding of the needs and expectations of governmental and non-governmental institutions, and to facilitate a two-way knowledge transfer between researchers and

stakeholders, a survey had been created by Partner 5. The questionnaire was then translated by most partners into their native languages and sent to relevant stakeholders in terms of utilizing the project's results and implementation of the project's conclusions on a local/national level. Answers were received from 24 stakeholders working for governmental and non-governmental institutions (3 from Tartu, 6 from Poznań and 15 from Zurich, stakeholders from Antwerp did not reply to the questionnaire), which showed that (a) the stakeholders that had answered had been moderately familiar with the term "ecosystem services", (b) written contact might not be the best form of communicating the stakeholders, and (c) seminars and workshops are perceived as the best form of stakeholder engagement. As the questionnaires were sent out before the corona-pandemic, conference interviews were not as common as they are now, which might also make this tool a familiar and easy way to communicate with the stakeholders.

Another action, undertaken simultaneously by most partners(1, 2, 4, 5, 6), was the citizen science project strawbAIRies, already described above. In order to draw public attention, information about the project was spread around the internet (Twitter, Facebook, Instagram, dedicated webpage) and mass media (TV, radio stations, newspapers). The interest of the media exceeded our expectations in most cities, and the project was joined also by city and urban district council members.

The last activity that took place simultaneously in each city, was an online survey (*Maptionnaire*) about urban public green areas, which was led by Partner 2. The main objectives of this survey were (1) to identify the spatial patterns of preferences for green areas within BIOVEINS cities, (2) to identify which parks are avoided and why, and (3) to get to know how citizens would like to see green spaces in the future. A total of 330 citizens replied to the survey, having selected a total of 850 green spaces, including places that are prefered, avoided and with a high amount of perceived cultural services and biodiversity.As a result of our activities, we have concluded citizens being a very valuable, committed and active group of stakeholders which might not be forgotten when discussing the implementation and management of urban green infrastructures.

Table 4. Contacted stakeholder.

Partner	Who?	When?	How?	Topic
1	Jiska Verbouw	fieldwerk at the Zoo of Antwerp until July 2018	e-mail, phone	admission for field work
1	Linda Vanelacker and Vera Cuypers	fieldwerk at the Zoo of Antwerp from July 2018	e-mail	admission for field work , stakeholder questionnaire
1	Patrick Dictus	fieldwork in the city of Antwerp from April 2018 until March 2020	e-mail	admission for field work, stakeholder questionnaire, communication of first results
1	Jan Swings	fieldwork in the city of Antwerp from March 2020 until the end of the project	e-mail	admission for field work, communication of first results
1	Karel Olbrechts	fieldwork in the city of Antwerp from July 2019 until the end of the project	e-mail, phone	information about field work, stakeholder questionnaire, communication of first results
1	Wim Mertens	fieldwork at nature reserve of Natuurpunt from 2018 until 2020	e-mail	admission for field work, stakeholder questionnaire, communication of first results
5	City municipality, public green management	Before the start of fieldwork, multiple times	e-mail, post, telephone	Permission to access and sample the parks, to inform about our project
5	Iwona Zajączek - Department of Environmental Protection	June 2020	e-mail	stakeholders questionnaire
5	Tomasz Lisiecki - Municipal Green Management	June 2020	e-mail	stakeholders questionnaire
5	Wiesław Rygielski - Anti-smog coalition	June 2020	e-mail	stakeholders questionnaire

	"Bye-bye smog" and Commision for civil dialogue			
5	Tomasz Knioła - Naturalists' Club	June 2020	e-mail	stakeholders questionnaire
5	Arkadiusz Zacharzewski - Center for Promotion of Sustainable Development	June 2020	e-mail	stakeholders questionnaire
5	Andrzej Kepel & Ewa Olejnik - Polish Society for Nature Conservation "Salamandra"	June 2020	e-mail	stakeholders questionnaire
5	Adam Mojżeszewicz - Housing Association "Osiedle Młodych"	June 2020	e-mail	stakeholders questionnaire
5	Aneta Mikołajczak - Coalition "Zazieleń Poznań"	June 2020	e-mail	stakeholders questionnaire
5	Urszula Chłystun - The Voivodeship Fund for Environmental Protection and Water Management	June 2020	e-mail	stakeholders questionnaire
5	Piotr Klawiter - Greenery Urban Management CEDRUS	June 2020	e-mail	stakeholders questionnaire
5	Andrzej Łuczak - Environmental Support Company ENINA	June 2020	e-mail	stakeholders questionnaire
5	Adam Gatniewski - APUS Lovers	June 2020	telephone	stakeholders questionnaire
5	Tadeusz Mizera - Society of Eagle Protection KOO	June 2020	e-mail	stakeholders questionnaire
5	Monika Nawrotna - Ławica Airport, Environment Section	June 2020	e-mail	stakeholders questionnaire

5	Michał Beim - Urban Cyclist Group	June 2020	e-mail	stakeholders questionnaire
6	City, regional and cantonal authorities of Zurich	At the beginning of the project (several contacts)	e-mai, in person and telephone	Presentation of the goals and design of the project
6	Public green managers of 32 parks in the city of Zurich under the coordination of Ms Bettina Tschander, Grün Stadt Zürich, GSZ	At the beginning of the project (several contacts)	e-mai, in person and telephone	Selection and permission to access the public green areas. Selection of trees and preliminary discussion about green management.
6	Regional and cantonal authorities of all Swiss cantons	Two years after the project starting	e-mail and telephone	Request of data on honeybees in different regions and cities
6	Federal Office for the Environment in Bern (Mrs Debora Zaugg)	March-April 2020	Telephone	Wild bee in cities. Potential threat by beekeepers. Mandate to study this aspect in synergy with BIOVEINS and other similar projects.
6	Public green authorities in Zurich	Several meetings from September 2019 to May 2020	In person and zoom (corona period)	State of the art of urban trees, knowledge gaps, future research directions
7	The Urban Ecology Agency of Paris municipality	During the application for funding	e-mail, in person and telephone	Presenting the goals and getting support from them
7	Urban green managers of 14 other cities around Paris where biodiversity monitoring was displayed	At the beginning of the project (one or two contacts per city)	e-mail, in person and telephone	Selection and permission to access the public green areas. Selection of trees and preliminary discussion about green management.
7	Managers of the urban parks in Paris	During the biodiversity monitoring	e-mail, in person and telephone	Selection and permission to access the public green areas. Selection of trees and preliminary discussion about green management.

5.3 Foreseen after the project's end

Local meetings with governmental and non-governmental stakeholders, as well as with citizens interested in the subject (open meeting), will be organised by each partner. Depending on the (local) situation in regard to the corona-pandemic, meetings will be organised via teleconferencing or as a more traditional meeting. As mentioned above, for all selected parks an ID-card - reporting on the biodiversity of the investigated taxa in relation to the intra- and interurban biodiversity observed within the BIOVEINS-parks - is created. These ID-cards will be (or are already) distributed over all relevant stakeholders. The distribution of these ID-cards will be accompanied with a workshop to explain these ID-cards, and the other findings of the BIOVEINS-project.

6. Dissemination of results

6.1 List of scientific publications

An Excel-list of all scientific (submitted) publications is added to this report, just as an Excel-overview of all planned publications (find the extra tab "Planned" in the enclosed Excel-file, link below).
Scientific output in terms of peer-reviewed publications is still limited, due to the time needed to prepare, collect and analyse the extensive field data, and due to the interconnection between the various datasets.

The latest version of this document is available on the Google Drive.
https://drive.google.com/file/d/1labtQ-EgFoYSB1rj5MEekmS-rqllrxNx/view?usp=sharing

All published papers can be found on the website. https://www.uantwerpen.be/en/research-groups/endemic/research/research-projects/bioveins/publications/

6.2. Dissemination of results to scientists and scientific organisations

Poster presentations

- BIOVEINS: How does nature circulate through cities? An investigation of biodiversity and ecosystem services provided by green areas in European cities. Anskje Van Mensel, Babette Muyshondt, Laure-Anne Franck and Roeland Samson. National Symposium for Applied Biological Sciences (NSABS), Ghent, 4/2/2019.
- Phyllopshere bacteria in urban green. Babette Muyshondt, Karen Wuyts, Wenke Smets, Anskje Van Mensel, Roeland Samson en Sarah Lebeer. National Symposium for Applied Biological Sciences (NSABS), Ghent, 4/2/2019.
- Responses of bees and wasps to urbanization. Joan Casanelles-Abella, Loïc Pellissier & Marco Moretti. Biology18, Nêuchatel February/2020
- Preliminary results on the effect of urbanization on biodiversity in 5 European cities. Joan Casanelles-Abella, Lucia Villarroya, Martin K. Obrist, Loïc Pellissier & Marco Moretti. 1st Iberian Ecological Society Meeting (SIBECOL 2019). Barcelona February/2020
- Responses of bats and nocturnal insects to urbanization in 3 European cities. Lucia Villarroya, Joan Casanelles Abella, Marco Moretti & Martin K. Obrist. Biology19, Zürich February/2019
- Feeding behaviour of urban bees. Stephania Müller, Joan Casanelles Abella, Alexander Keller, Jordi Bascompte & Marco Moretti. Connectivity: Plant Interactions Reloaded. The Plant Science Center Symposium 2020. 02/12/2020
- Estimation of regulating ecosystem services in urban areas. Marta Maria Alos Orti, Lauri Laanisto. 15th European Ecological Federation (EEF) Congress and 18th National SPECO Meeting: „Ecology accross borders; Embedding Ecology in Sustainable Development Goals". Lisbon (Portugal), 29.07.2019 - 02.08.2019.

- The role of urban vegetation in air quality improvement. Marta Maria Alos Orti, Lauri Laanisto. 49th Annual Meeting of the Ecological Society: „Science meets practice“. Münster (Germany), 09.9.2019 - 13.09.2019.

Oral presentations:

- BIOVEINS: How does nature circulate through cities. Connectivity of green and blue infrastructures: living veins for biodiverse and healthy cities. Anskje Van Mensel. PhD seminar at the Department of Bioscience Engineering, University of Antwerp, 18/12/2018
- Phyllosphere bacterial communities in urban green: ecology & application. Babette muyshondt. PhD seminar at the Department of Bioscience Engineering, University of Antwerp, 17/01/2019.
- Strawberries and particulate matter: a tasteful combination? Roeland Samson. BiodivERsA-symposium, Brussels, 02/04/2019
- Pinho P, et al., 2019. Managing cities green infrastructure to enhance the provision of ecosystem services to create more liveable and resilient cities. IUFRO - International Union of Forest Research Organizations: Interconnecting forests, science and people. Curitiba, Brazil 29 Set- 5 Oct 2019.
- Pinho P, et al., 2019. Metrics to quantify Biodiversity-ES relationships over spatial scales. 15th European Ecological Federation (EEF) Congress. July 29 to August 2 2019, FCUL, Portugal).
- Pinho P., Luz A., Grilo F., Vieira J., Mexia T., Aleixo & Branquinho C. 2018. Nature Based Solutions to optimize the provision of Ecosystem Services to create more liveable and resilient cities. CAPERmed 2018 - III Meeting (20-21 June 2018, Pamplona, Spain)
- Lorrillière R, Bessa-Gomes C, Chiron F Bird feeder attendance during winter investigated with a new and original citizen sciences scheme. Bird Numbers 2019, Evora, Portugal (Oral).
- Deguines N., Lorrillière R., Dozières A., Bessa-Gomes C. & Chiron F. Any despot at my table? Assessing competition in wintering bird communities at garden birdfeeders. BES Annual Meeting 2019, Belfast, Ireland (Oral).
- Lorrillière R, Chiron F, Duffaut C, Bessa-Gomes C Common birds during winter in the face of urbanization, foraging ecology questioned thanks to an original citizen science scheme (BirdLab), European Congress of Conservation Biology, Jyväskylä, Finland, Juin 2018 (Oral).

6.3 List of dissemination activities with stakeholders

www.strawbAIRies.com - Website and information provided by partner 1 (WP4 - citizen science) and translated to local languages by partners 1, 2, 4, 5 and 6.

Information to Lisbon Municipality data managers (LxDataLab) about biological data collection within the municipality within the BioVeins project.
Park IDs - For all selected parks an ID-card - reporting on the biodiversity of the investigated taxa in relation to the intra- and interurban biodiversity observed within the BIOVEINS-parks - is created. These ID-cards will be (or are already) distributed over all relevant stakeholders. The distribution of these ID-cards will be accompanied with a workshop to explain these ID-cards, and the other findings of the BIOVEINS-project.

A transdisciplinary symposium was organised (“Greening cities”, Jan. 2019) in Paris with local decision-makers and stakeholders working on the project, landscape designers, architects, and social entrepreneurs which aimed at presenting Bioveins results and working on urban and nature issues in cities. We also organised annual meetings gathering all municipalities involved in the project in the Paris region.

6.4 Dissemination of results to stakeholders

Dissemination of results to stakeholders:

- The results of the strawbAIRies project were communicated to each participant individually vie-mail. Partner 1 provided the results with an accompanying letter and each participating partner (partners 1, 4, 5 and 6) translated the latter to their local language and sent around the results to the local participants.
- Park IDs: for all selected parks an ID-card - reporting on the biodiversity of the investigated taxa in relation to the intra- and interurban biodiversity observed within the BIOVEINS-parks - is created. These ID-cards will be (or are already) distributed over all relevant stakeholders. The distribution of these ID-cards will be accompanied with a workshop to explain these ID-cards, and the other findings of the BIOVEINS-project.
- Swiss partners have been discussing the current state of the art of urban green and urban trees and knowledge gaps with the green managers of the city of Zurich. Such dialogue between science and society will continue also with social scientists and psychologists in the view of future interdisciplinary collaborations. Similar discussions have been organised (but temporarily adjourned due to the coronavirus) on follow-up topics related to BIOVEINS, and in particular the potential problem of beekeeping in urban environments as potential threat for the local wild bees.

Information / technology transfer:

The information transfer was done via scientific and stakeholder dissemination and communication activities as described above.
There was no substantial technology transfer outside of the project team.

Outreach to the general public and Education project:

- A general report on the air quality part of strawbAIRies campaign was provided in English by partner 1. This report was translated by the local partners (partners 1, 4, 5 and 6) and communicated directly to the stakeholders via e-mail and to the general public via the project website (www.strawbAIRies.com and https://www.uantwerpen.be/en/research-groups/endemic/research/research-projects/bioveins/publications/).
- Knowledge gathered within BIOVEINS was used by Partner 1 within their 'AIRbezen@School'-project (www.airbezen.be), to raise awareness on the importance of urban green infrastructure and air quality. For the same purpose Partner 1 will also use this knowledge in the running B@seball-project (Biodiversity at School Environments Benefits for ALL.)
- Partner 1 will also use this knowledge on urban biodiversity into running project and PhD applications.
- Interview on European Researchers' Night,on which project results were disseminated (https://www.youtube.com/watch?v=fT8OXhnehSo).

7 Global Impact assessment indicators

7.1 Impact statement

BIOVEINS has allowed to obtain data of 10 groups of organisms across 5 European cities (plants, lichens, birds, bats, nocturnal insects, bees, wasps, leaf bacteria, soil bacteria and fungi). It is one of the most diverse datasets of organisms collected in urban environments in Europe. These data have allowed (and will continue to do so) to test hypotheses related to biodiversity changes along urban intensity gradients and biotic homogenization of cities. These data also enables to estimate the link between biodiversity, ecosystem functioning and associated services. The potential of these data does not end with the present project. They offer opportunities for advanced analyses in future years as well as collaborations and exchanges with other projects and researchers around the World.

From the profile of academic education, BIOVEINS has allowed to employ four PhD students, of which three women and one man. They have been given the opportunity to access to a big European project, to interact with stakeholders and to confront themselves with other countries and different realities. The interaction between senior scientists and PhD students has been very enriching for both sides. BIOVEINS was also mentioned in seminars for students, and topics and research from BIOVEINS could serve as examples during lectures.

At the research group of partner 1, a lot of new Master thesis project have started with topics building further on the topics of BIOVEINS. For example there is a running topic where a student is investigating bee biodiversity in Antwerp. Next to this there is a students who is investigating the effect of urban green in street canyons on the air temperature in Antwerp. Next year a new student will start who will investigate bat biodiversity in Antwerp in more detail. Also for the research group of partner 2, BIOVEINS created a lot of new possibilities. The BIOVEINS project allowed the development of Cristiana Aleixo PhD thesis on the topic of "Using Remote Sensing to measure the provision of Ecosystem service and increase cities resilience" at Lisbon University, and also contributed to the creation of a new research thematic line on Urban Ecology in cE3c research centre, materialized by the UrbanLab (http://urbanlab.campus.ciencias.ulisboa.pt/)

From an outreach perspective, BIOVEINS has had wide visibility. In some countries more than others. Certainly the activities around the Citizen Science projects have been very well received. For example, 266 people participated in the strawbAIRies project. In Poznan, BIOVEINS was really visible on local television and radio with more than 10 TV and 15 radio interviews, where the strawbAIRies project was especially popular. The project was also regularly mentioned in social media (Twitter and Facebook). Also in Estonia there was a big interest in the project from the media. They had several clips in Estonian national broadcasting about the strawbAiries project during the prime time news, raising the awareness of air pollution. The feedback from the media has been important. This has raised the awareness of the authorities and the city dwellers towards environmental and biodiversity issues in the city. Aditionally, in Poznan three dedicated city walks were organised to show the importance of city parks to local fauna and flora. Next to this, numerous talks to local governements and local people on green and blue infrastructures took place.

Some (preliminary) results were already used by local authorithies for urban planning. For example, the initial data from strawbAiries (pollution numbers extracted from the leaves of Fragaria and Lotus) were used by some city district communities in Estonia for developing better traffic arrangement in collaboration with the city municipality.

7.2 Synthetic figures for the project publications (including interactions with stakeholders)

5 published papers, 1 submitted or in review and 5 in preparation (listed in the publication list template, but not taken into account in the following table). 4 published papers with impact factor >5, including *Environmental research* (2), Science of the Total Environment (1) and Chemosphere (1).

Analysis of the project publications:

Table 5. Analysis of BIOVEINS publications

Scientific Journal	*Number*	*Impact Factor*
Environmental research	**2**	**5.026 (2018)**
Science of the Total Environment	**1**	**6.551 (2019)**
Chemosphere	**1**	**5.778 (2019)**
Zoomorphology	**1**	**1.120 (2019)**

International dimension and multi-partnership for publications

Table 6. Publications and communications resulting directly from the BIOVEINS project.

		Number of publications
Multi-partner publications (at least 2 partners)	**Peer-reviewed journals**	1
	Books or chapters in books	NA
	Communications (conferences)	NA
Single-partner publications	**Peer-reviewed journals**	3
	Books or chapters in books	NA
	Communications (conferences)	12
Outreach initiatives including interactions with stakeholders	**Popularization articles**	NA
	Popularization conferences	NA
	Others	NA

7.3. Other scientific outputs

Table 7. Other scientific outputs.

	Number, years and comments (Actual or likely outputs)
International patents obtained	NA
International patents pending	NA
National patents obtained	NA
National patents pending	NA
Operating licences (obtained / transferred)	NA
Software and any other prototype	NA
Company creations or spin-offs	NA
New collaborative projects	NA
Scientific symposiums	cancelled/postponed due to corona-crisis
Others (please specify)	NA

7.4. Assessment and follow-up of personnel recruited on fixed-term contracts (excluding interns)

Table 8. Information about BIOVEINS personnel during the course of the project.

Identification			Before recruitment for the project			Recruitment for the project				After the project			
Surname and first name	Sex M/F	E-mail address	Last diploma obtained at time of recruitment	Country of studies	Prior professional experience, including post-docs (years)	Partner who hired the person (Organisation and Country)	Position in the project (1)	Duration of missions (months) (2)	End date of mission on project	Professional future (3)	Type of employer (4)	Type of employment (5)	Promotion of professional experience (6)
Van Mensel Anskje	F	anskje.vanmensel@uantwerpen.be	MSc in Biology	Belgium	2	1	Doctoral student	26	31/5/2020 (paid) but working until end of project	Fixed-term contract	University	Doctoral student	
Muyshondt Babette	F	babette.muyshondt@uantwerpen.be	MSc in Biology	Belgium	0	1	Doctoral student	9	31/12/2018	Fixed-term contract	FWO Flanders	Doctoral student	
Ana Castanheiro	F	ana.castanheiro@uantwerpen.be	PhD in Bioscience Engineering	Belgium	5 years PhD	1	Post-doctoral	3.5	31/5/2020 (paid)	/	/	/	
Hanne Hendrickx	F	hanne.hendrickx@uantwerpen.be	MSc in Biomedical sciences	Belgium	0	1	employee	3.5	31/5/2020 (paid)	Fixed-term contract	University	Doctoral student	
Pedro Pinho	M	ppinho@fc.ul.pt	PhD	Portugal	6	2	Postdoc	26	31/3/2020	Fixed-term contract	research public institution	researcher	yes (fostering a research line dedicated to urban ecology)
Casanelles Abella Joan	M	jona.cassanelles@wsl.ch	MSc degree	Catalonia, Spain	0	6	Doctoral student	36	31/5/2020	Fixed-term contract			

Stefanie Müller	F	stefanie.mueller@wsl.ch	BSc degree	Switzerland	0.5	6	MSc student	12	2/3/2020	Fixed-term contract			
Lucía Villarroya Villalba	F	lucia.villarroya@wsl.ch	BSc degree	Switzerland	0	6	MSc student	12	11/10/2018	Fixed-term contract			
Lauri Laanisto	M	laanisto@ut.ee	PhD in ecology	Estonia	10	4	Researcher	24	01/03/20	Permanent position	Public university	researcher	
Romain Lorrillière	M	romain.lorrilliere@mnhn.fr	PhD in ecology	France	7	7	Post-doctoral	12	31/08/2018	Fixed-term contract	research public institution	researcher	
Nicolas Deguines	M	nicolas.deguines@univ-poitiers.fr	PhD in ecology	France	5	7	Post-doctoral	18	30/11/2019	Permanent position	research public institution	researcher	
Meredith Root_Bernstein	F	*mrootbernstein@gmail.com*	PhD in ecology	France	6	3	Post-doctoral	24	31/12/2018	Permanent position	research public institution	researcher	
Anna Maria Kubicka	F	*amkkubicka@gmail.com*	PhD in biology	Poland	0	8	Post-doc	36	31/5/2020	Fixed-term contract in the department		researcher	move more to human ecology
Patrycja K. Kwiatkowska	F	*pkf.kwiatkowska@gmail.com*	DVD (veterinarian)	Poland	6	8	PhD student	36	31/5/2020	PhD defence		probably veterinary practice	

7.5. Data Management and timeline for open access

During the project Switchdrive was used as a communication platform where all data and documents were stored.
The meta-database will be kept updated by all partners, and more detailed data, e.g. needed for data analysis and common publications, will be sent upon request to partners.
Internally: a metadatabase will be put on the Google Drive (https://docs.google.com/spreadsheets/d/1DTfBe2kib564mucy5DxePEx7AgeaTnigmFciS_pyctw/edit?usp=sharing).
Data will be made available to other stakeholders, but only after publication of these data in the scientific peer-reviewed literature.
An overview of the collected data will be made available on the website (https://www.uantwerpen.be/en/research-groups/endemic/research/research-projects/bioveins/).