Breeding birds in the Munich Botanical Garden:
assessment of the 2018 populations and methods for future monitoring

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Report on an intensive research project carried out from 12 April to 21 June 2018 in the lab of
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Running title – Breeding birds of the Botanical Garden Munich

Abstract – A comprehensive census of the birds in the Munich Botanical Garden during the 2018 breeding season revealed the presence of 45 bird species, of which 26 were effectively breeding. The analysis of the birds' behaviour and territories enabled me to determine the optimal route for future monitoring. This 785-m-long route ensures the detection of all breeding species, but is insufficient to assess their density. Therefore, between-species comparisons should be avoided. Based on the birds' phenology and behaviour and published protocols for bird monitoring, I recommend two counting sessions on sunny days, one at the end of April and one at the beginning of June, each beginning fifteen minutes after sunrise.

Introduction

In a world where urban areas continuously increase and threats to wild biodiversity intensify, birds are an important part of our everyday fauna as well as indicators of habitat diversity and insect richness. A decline of breeding bird populations has been recorded in many urbanized but also agricultural areas of Europe (Knapp *et al.* 2008, Batáry *et al.* 2018). Declines of bird abundances in some urban regions, such as the striking decrease of the House sparrow (*Passer domesticus*) populations (Crick *et al.* 2002, Brichetti *et al.* 2008), are thought to be the consequence of predation pressure by domestic cats, a decrease of nesting sites and food availability, and possibly also light and noise disturbance (Beckerman *et al*. 2007, Strohbach 2009).

Located in the heart of Munich, the park of Nymphenburg Palace and the adjacent Botanical Garden constitute a 220-hectare-large semi natural area, in which small mammals, roe deer, and birds breed freely. The castle's park is regularly subject to bird monitoring and has been shown to be a refuge for more than 40 breeding bird species and 25 additional species in winter (Grüner *et al.* 2013). The 20 hectares of the Botanical Garden, which comprise a lake, two types of forests, a formal garden and an orchard, however, have never been prospected for breeding birds.

Considering that the garden is a completely protected area, equipped with numerous nest boxes and feeders, and adjacent to the palace park, a census of the birds inhabiting this area has long been a desideratum. Long term monitoring will provide information on increases or decreases of the populations of different bird species, without the influence of most of the factors suspected of leading to population declines, such as pesticides, herbicides, cats, and light pollution.

Longer-term monitoring would work best is if a standard method were applied every year. To determine the simplest possible protocol providing reliable data, I carried out a comprehensive census of the breeding birds using existing protocols (Blondel *et al.* 1977, Reynolds *et al*. 1980). My research was aimed at providing the baseline for future comparisons and is additionally useful in having tested the least time-consuming and most efficient method of assessing the breeding birds in the garden for further monitoring.

Material and methods

Between April 15th and June 20th, 2018, I tested two methods for bird counting. This period was chosen based on Blondel *et al.* (1977), who recommend centering bird sampling in Western Europe around May 8th. I first followed the method of Reynolds *et al*. (1980), using listening points. Four points were chosen in different parts of the garden. Equipped with binoculars, I stood for fifteen minutes at each point, then moved to the next point, and reported each contact with a bird (observation or hearing) on a map [Annex]. All listening sessions began at sunrise. Due to the relatively small size of the botanical garden and the activity of gardeners in the early morning, this method proved inconclusive.

I next tested an adaptation of the spot map method to measure the population density of breeding birds (Williams 1936, as cited in Franzreb 1976). Once or twice a week, again equipped with binoculars, I walked along the paths of the botanical garden. Each bird seen or heard was identified and its position marked on the map. If possible, the sex and bird's reproductive behaviour (male singing, territory defense, material gathering for the nest) were noted. Flying birds were not considered. All detected nests were localized on the map, and a list of all the contacted birds was compiled from these data. Species were considered as breeding in the botanical garden when a male was heard singing or defending a territory at least on three different days or when at least one female was seen more than twice. Birds contacted more than twice without exhibiting any reproductive behaviour were considered potential breeders. The frequency of observations was calculated for every breeding species and plotted with respect to time (Fig. 2).

All mapped bird encounters were digitalized with the software QGIS. Each breeding bird's territory (or the area used by the total group in the case of non-territorial birds such as Fieldfares, Goldfinches, Ducks and Geese) was extrapolated from the groups of points obtained on the map: a heat map (Table 1) was generated from all observations made between April 15th and May 15th, and of singing males from the May 16th to June 20th (fledglings increase the number of observations and do not give any information on the defended territories). Contour lines were then computed, and territories determined as the patches delimited by the contour line which

represents half of the maximum point density. Adjustments were made manually, based on the field observations, when the birds were unequally distributed (which leads to hotspots that are hard to distinguish from each other). A grid of 10 x 10 m cells was used to visualize the density of observations and the species richness (Fig. 3).

The optimal sample path was determined as the route crossing the grid cells with values of species richness as high as possible. The minimum number of species per grid cell was chosen such that no breeding species was left out. A 50 m-wide area along each side of the route was considered the detection zone (Schieck 1997).

Table 1: Source and values of the radius used for computing the heat maps. When the territory size was not available, it was calculated from the highest value of population density.

Latin	**English**	**Source**	**Territory area (Ha)**	**Radius (m)**
Columba palumbus	Common Wood Pigeon	Aubineau & Boutin (1998)	5	126
Dendrocopos major	Great Spotted Woodpecker	Salvati (2001)	5,8	136
Picus viridis	European Green Woodpecker	Geroudet (1998)	20	252
Garrulus glandarius	Eurasian Jay	Gregory (1996)	1,3	64
Corvus corone	Carrion Crow	Gregory (1996)	1,25	63
Periparus ater	Coal Tit	Geroudet (1998)	2,5	89
Cyanistes caeruleus	Eurasian Blue Tit	Geroudet (1998)	1	56
Parus major	Great Tit	Geroudet (1998)	1,25	63
Phylloscopus collybita	Common Chiffchaff	Ferry (1981)	0,8	50
Sylvia atricapilla	Eurasian Blackcap	Ferry (1981)	1,1	59
Regulus ignicapilla	Common Firecrest	Simms (1985)	0,5	40
Regulus regulus	Goldcrest	Simms (1985)	0,5	40
Troglodytes troglodytes	Eurasian Wren	Ferry (1981)	5,1	127
Sitta europaea	Eurasian Nuthatch	Ferry (1981)	2	80
Certhia brachydactyla	Short-toed Treecreeper	Geroudet (1998)	1,5	69
Turdus merula	Common Blackbird	Geroudet (1998)	4,7	122
Turdus philomelos	Song Thrush	Geroudet (1998)	2,5	89
Muscicapa striata	Spotted Flycatcher	Wood (2010)	5	126
Erithacus rubecula	European Robin	Geroudet (1998)	2,1	82
Fringilla coelebs	Common Chaffinch	Wood (2010)	1,6	71
Pyrrhula pyrrhula	Eurasian Bullfinch	Geroudet (1998)	5	126
Chloris chloris	European Greenfinch	Wood (2010)	3	98

Results

Between 15 April and 15 May 2018, I encountered 45 bird species in the botanical garden (Table 2), of which 26

were breeding in the study area or its immediate surrounding. Eight of these were observed regularly during the breeding season and potentially also bred in the botanical garden. Two thirds of the contacted birds are passerines, and 21 of 26 urban indicator species (as defined by Tratalos et al., 2007) were recorded. Two species that are not usually found in urban areas were contacted occasionally: a male Sedge warbler and a male Grasshopper warbler (for Latin and German names, see Table 2). These species usually breed in reeds, but were heard singing in the bushes south of the Systematic Garden.

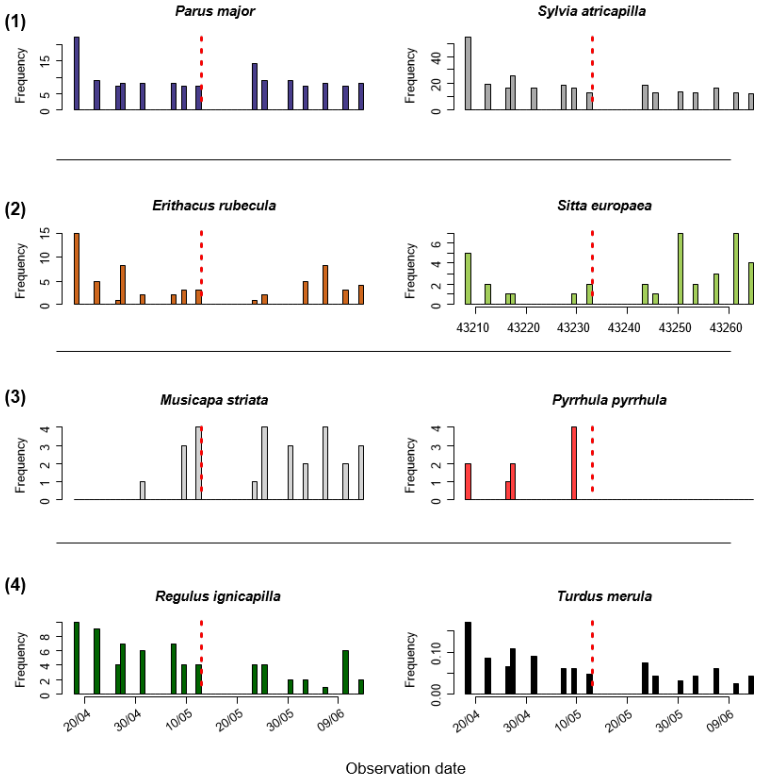

Figure 1: Observation frequency of breeding species during the study period. The red dashed line represents the date at which the first fledglings were observed. The observation frequency of most bird was constant (panel 1), but a few species were rarely or not detected during brooding (panel 2), two were absent or very quiet at the early or late dates (panel 3), and two were less frequently encountered over time (panel 4).

The contact frequency was low in the middle of the study period (25 April – 25 May) for the European robin, the Tree creeper and the Eurasian nuthatch (Fig. 1). No Spotted flycatcher were contacted at the beginning of the study period (15 - 30 April), and the European Bullfinch was not detected after the 10 May. The frequency of observation of the Firecrest and the Blackbird decreased during the sampling period (Fig.1). For the remaining breeding species, the contact rate was stable throughout the study period.

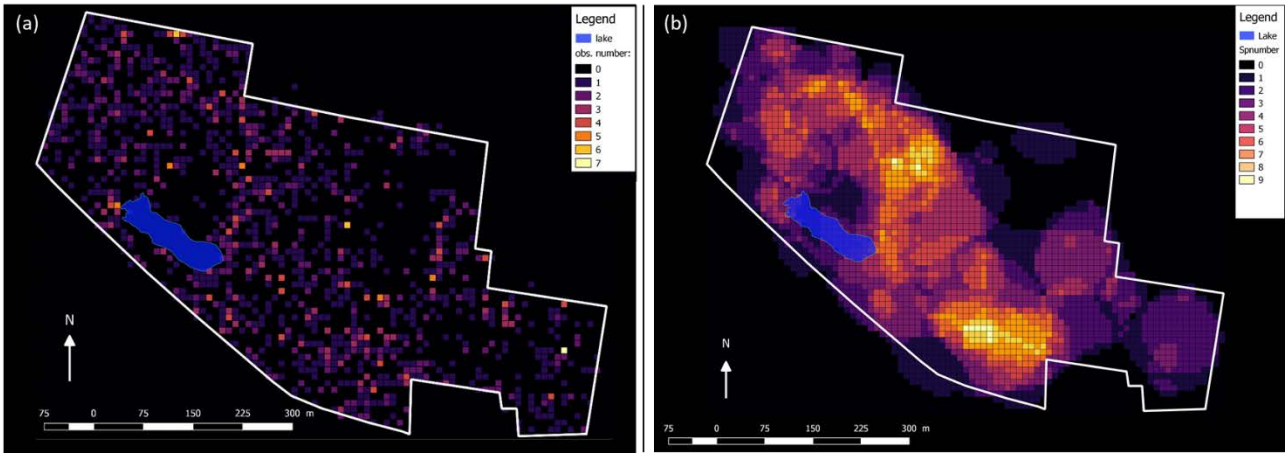

Figure 2: Observation number (a) and species number (b) in cells of 10 x10 m.

The distribution of observations on the map (Fig. 2) suggests a stable spacing, except that breeding birds were less frequent directly facing the botanical institute building and in the alpine garden. By contrast, the density of species varied greatly throughout the garden, with the species hotspots being around the lake, in the rhododendron forest, the pine forest and the insect information pavilion. The cells with a species richness ≥ 6 cover the territory of every species breeding in the garden (except for the Redstart, which territory is located next to the greenhouse, outside of the study area). Thus, the most efficient path for monitoring the garden's birds is one that hits the maximum of cells with ≥ 6 species (Fig. 3). It extends for 785 m and covers six of the ten environments present in the garden (Formal garden, Forest, Humid area, Grassland, Orchard and Pine forest). The bird species which territories, located less than 50 m away from the optimal route, can be detected in this way are summarized in Table 3.

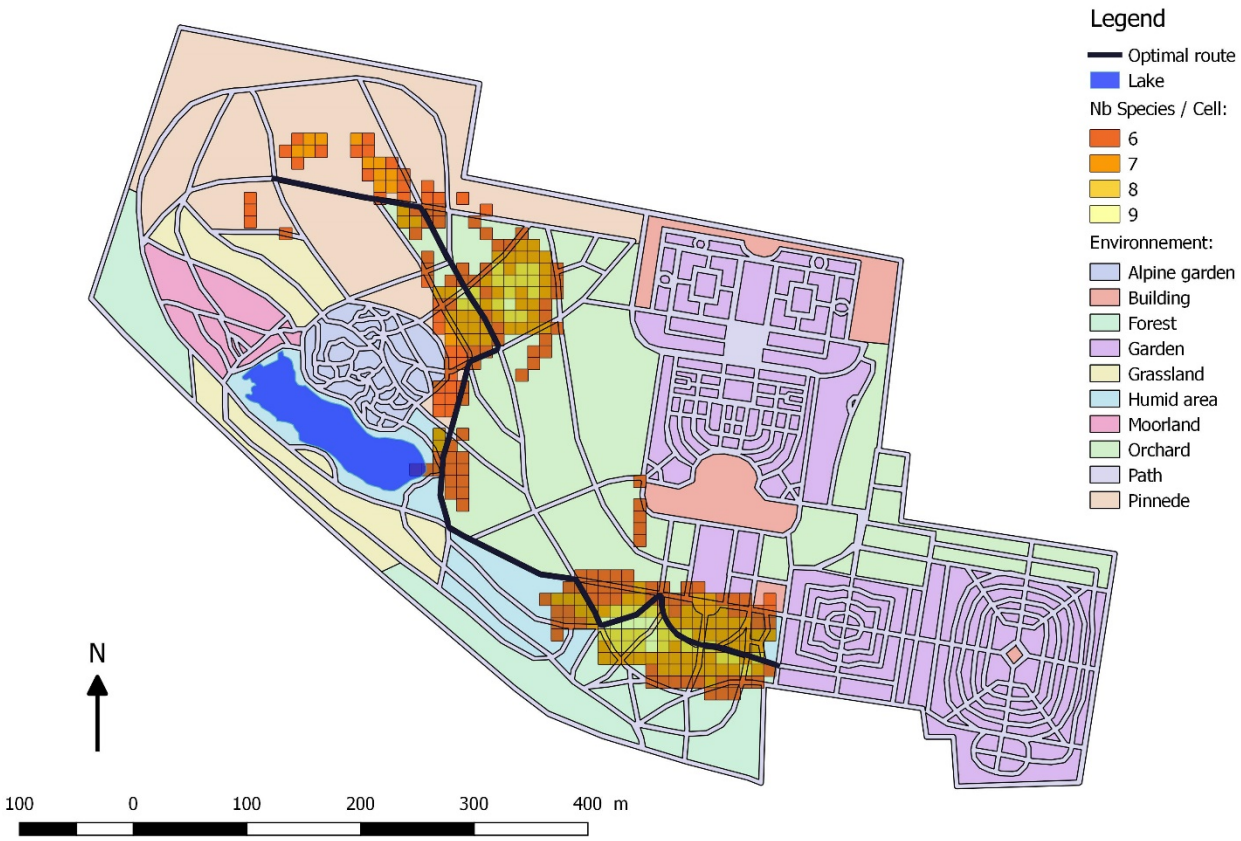

Figure 3: Optimal route for monitoring the birds of the Munich Botanical Garden shown along with the cells that allow sampling all 26 species breeding in the garden

Table 3: Comparison between the number of breeding pairs in the garden and the hypothetic number of pairs detected by monitoring along the optimal path.

Latin	**English**	**Breeding pairs**	**Detected pairs**	**Detected pairs %**
Anser anser	Greylag Goose	1	1	100
Columba palumbus	Common Wood Pigeon	3	3	100
Dendrocopos major	Great Spotted Woodpecker	4	3	75
Picus viridis	European Green Woodpecker	1	1	100
Corvus corone	Carrion Crow	1	1	100
Periparus ater	Coal Tit	1	1	100
Cyanistes caeruleus	Eurasian Blue Tit	9	4	44,4
Parus major	Great Tit	6	5	83,3
Phylloscopus collybita	Common Chiffchaff	2	1	50
Sylvia atricapilla	Eurasian Blackcap	12	6	50
Regulus ignicapilla	Common Firecrest	5	3	60
Regulus regulus	Goldcrest	2	2	100
Troglodytes troglodytes	Eurasian Wren	2	1	50
Sitta europaea	Eurasian Nuthatch	2	2	100
Certhia brachydactyla	Short-toed Treecreeper	2	1	50
Turdus merula	Common Blackbird	3	2	66,6
Turdus pilaris	Fieldfare	3	yes	100
Turdus philomelos	Song Thrush	3	2	66,6
Muscicapa striata	Spotted Flycatcher	2	1	50
Erithacus rubecula	European Robin	6	3	50
Fringilla coelebs	Common Chaffinch	4	4	100
Pyrrhula pyrrhula	Eurasian Bullfinch	1	1	100
Chloris chloris	European Greenfinch	4	1	25
Carduelis carduelis	European Goldfinch	8	yes	100

Discussion

The diversity of 45 bird species of which 26 were breeding in the study area or its immediate surrounding reflect the high-quality habitats in the botanical garden. Nevertheless, the garden is located in an urban environment, with constant high car traffic along at least one of its borders. Its bird diversity is therefore influenced by the surrounding urban environment, matching the relatively high proportion of urban indicator species (Tratalos et al., 2007), namely 21 of the 45 total (47 %). Despite the small lake in the garden, few wetland species were recorded (no species of Scolopacidae, only one species of Laridae, only two wetland passerines, and no breeding aquatic species). This is probably due to the small surface area of the lake and the lack of surrounding riparian forest. The formal garden is the least bird-friendly environment (fewer observations and fewer species) than the remaining habitats. The most favorable habitats were the two forests and the orchard (Fig. 2). This is explained by the formal garden offering fewer hiding and foraging possibilities than a forest or an orchard.

The breeding phenology of the recorded species matches information in the literature: Flycatchers were first recorded at the beginning of May, after they came back from their wintering area in Africa. Numerous passerines are quiet during the incubation period as attracting females is not necessary, and singing resumes after the fledglings' first flight, as observed for the Robin and the Nuthatch (Géroudet 1998, Svensson *et al.* 2009). This implies that at least two monitoring periods are necessary to have a complete census of the breeding birds, as recommended by Blondel *et al.* (1970), namely once before the early breeders start to brood (end of April) and once when the activity increases again (beginning of June). The monitoring should begin fifteen minutes after sunrise to avoid the dawn chorus (before sunrise), when the number of birds singing at once is confusing, and the following calm period (during fifteen minutes after sunrise) when birds are foraging and sing only occasionally. Singing activity then resumes, increasing the probability of detection. These observations are only valuable for sunny days, and I performed all my counts during good weather as recommended by Blondel *et al.* (1970).

The probability of detection of a species along the optimal route depends on the number of territories encountered but also on the birds' shyness. Nevertheless, all breeding species are theoretically detectable from the optimal route proposed here (Fig. 3). The estimate of the number of breeding pairs, however, will depend on the species, and I suggest that future monitoring should focus on the density of breeding pairs within the detection area of 50 m away from the path so as to have comparable results.

Conclusion

A comprehensive census of the birds in the Munich Botanical Garden during the 2018 breeding season revealed the presence of 45 bird species, of which 26 were effectively breeding. The analysis of the birds' behaviour and territories enabled me to determine the optimal route for future monitoring. This 785-m-long route ensures the detection of all breeding species, but is insufficient to assess their density. Therefore, between-species comparisons should be avoided. Based on the birds' phenology and behaviour and published protocols for bird monitoring, I recommend two counting sessions on sunny days, one at the end of April and one at the beginning of June, each beginning fifteen minutes after sunrise.

Further comparison with my 2018 base line data will reveal changes in the breeding birds' community and population density in a protected area within the city of Munich. In the context of increasing urbanization, this will contribute to a better understanding of the population dynamics of the urban fauna under favorable conditions, where the effect of climate change *per se* can be detected.

Acknowledgements

I am grateful to Professor Susanne Renner for letting me conduct this project, her help in defining its aims and writing the present report. I also thank the ornithologist Dr. Manfred Siering for checking the Latin names and for discussion and advice, Natalie Cornish for her help with the software QGIS, and all the gardeners for their sympathy and interest in my project.

Table 2: List of the birds contacted during 20 monitoring walks in the botanical garden between 15 April and 15 June 2018. The breeding species are indicated in bold. The number of birds is indicated when it differs from the number of breeding birds (number of contacts in brackets). Birds were considered as breeding if reproductive behaviour was observed regularly or a pair was seen at least twice. Bracketed asterisks (*) refer to observed reproductive behavior, but an abandoned nest (*Garrulus glandarius*, *Picus viridis*), or a territory located at the border of the study area (*Phoenicurus ochruros*). Birds were considered as potentially breeding if they were regularly present during the breeding period, but neither reproductive behavior nor juvenile birds were observed. Birds seen or heard fewer than three times were considered as non-breeders.

Order	Family		*Latin*	English	German		Number of birds	Breeding pairs
Anseriformes	**Anatidae**	***1***	*Anser anser*	Greylag Goose	Graugans	**Breeding**	1-9	1
		2	*Anas platyrhynchos*	Mallard	Stockente	Potentially breeding	1-5	
		3	*Aythya fuligula*	Tufted Duck	Reiherente	Potentially breeding	1-3	
Pélécaniformes	**Ardéidae**	*4*	*Ardea cinerea*	Grey Heron	Graureiher	Contact	1 (2x)	
Accipitriformes	**Accipitridae**	*5*	*Pernis apivorus*	European Honey Buzzard	Wespenbussard	Contact	1 (1x)	
		6	*Accipiter nisus*	Eurasian Sparrowhawk	Sperber	Contact	1 (1x)	
		7	*Buteo buteo*	Common Buzzard	Mäusebussard	Contact	1-2 (2x)	
Gruiformes	**Rallidae**	*8*	*Fulica atra*	Eurasian Coot	Blässhuhn	Potentially breeding	1-3	
Charadriiformes	**Laridae**	*9*	*Larus michahellis*	Yellow-legged Gull	Mittelmeermöwe	Contact	1 (2x)	
Columbiformes	**Columbidae**	***10***	*Columba palumbus*	Common Wood Pigeon	Ringeltaube	**Breeding**		3
Apodiformes	**Apodidae**	*11*	*Apus apus*	Common Swift	Mauersegler	Potentially breeding	4-6	
Piciformes	**Picidae**	***12***	*Dendrocopos major*	Great Spotted Woodpecker	Buntspecht	**Breeding**		4
		13	*Picus viridis*	European Green Woodpecker	Grünspecht	**Breeding (*)**		1
Falconiformes	**Falconidae**	*14*	*Falco tinnunculus*	Common Kestrel	Turmfalke	Contact	1 (2x)	
Passériformes	**Corvidae**	***15***	*Garrulus glandarius*	Eurasian Jay	Eichelhäher	**Breeding (*)**		1
		16	*Corvus corone*	Carrion Crow	Rabenkrähe	**Breeding**		1
	Paridae	***17***	*Periparus ater*	Coal Tit	Tannenmeise	**Breeding**		1
		18	*Lophophanes cristatus*	European Crested Tit	Haubenmeise	Contact	1 (1x)	
		19	*Cyanistes caeruleus*	Eurasian Blue Tit	Blaumeise	**Breeding**		9
		20	*Parus major*	Great Tit	Kohlmeise	**Breeding**		6
	Hirundinidae	*21*	*Hirundo rustica*	Barn Swallow	Rauchschwalbe	Potentially breeding	1-5	
	Phylloscopidae	*22*	*Phylloscopus trochilus*	Willow Warbler	Fitis	Contact	1 (1x)	

	23	*Phylloscopus collybita*	Common Chiffchaff	Zilpzalp	**Breeding**		2
Acrocephalidae	*24*	*Acrocephalus schoenobaenus*	Sedge Warbler	Schilfrohrsänger	Contact	1 (1x)	
Locustellidae	*25*	*Locustella naevia*	Common Grasshopper Warbler	Feldschwirl	Contact	1 (1x)	
Sylviidae	***26***	*Sylvia atricapilla*	Eurasian Blackcap	Mönchsgrasmücke	**Breeding**		12
Regulidae	***27***	*Regulus ignicapilla*	Common Firecrest	Sommergoldhähnchen	**Breeding**		5
	28	*Regulus regulus*	Goldcrest	Wintergoldhähnchen	**Breeding**		2
Troglodytidae	***29***	*Troglodytes troglodytes*	Eurasian Wren	Zaunkönig	**Breeding**		2
Sittidae	***30***	*Sitta europaea*	Eurasian Nuthatch	Kleiber	**Breeding**		2
Certhiidae	***31***	*Certhia brachydactyla*	Short-toed Treecreeper	Gartenbaumläufer	**Breeding**		2
Sturnidae	*32*	*Sturnus vulgaris*	Common Starling	Star	Potentially breeding	1-35	
Turdidae	***33***	*Turdus merula*	Common Blackbird	Amsel	**Breeding**		3
	34	*Turdus pilaris*	Fieldfare	Wacholderdrossel	**Breeding**		3
	35	*Turdus philomelos*	Song Thrush	Singdrossel	**Breeding**		3
Muscicapidae	***36***	*Muscicapa striata*	Spotted Flycatcher	Grauschnäpper	**Breeding**		2
	37	*Erithacus rubecula*	European Robin	Rotkehlchen	**Breeding**		6
	38	*Phoenicurus ochruros*	Black Redstart	Hausrotschwanz	**Breeding (*)**		1
Passeridae	*39*	*Passer domesticus*	House Sparrow	Haussperling	Potentially breeding	2-4	
Motacillidae	*40*	*Motacilla alba*	White Wagtail	Bachstelze	Potentially breeding	1	
Fringillidae	***41***	*Fringilla coelebs*	Common Chaffinch	Buchfink	**Breeding**		4
	42	*Pyrrhula pyrrhula*	Eurasian Bullfinch	Gimpel	**Breeding**		1
	43	*Chloris chloris*	European Greenfinch	Grünfink	**Breeding**		4
	44	*Carduelis carduelis*	European Goldfinch	Stieglitz	**Breeding**		8
	45	*Spinus spinus*	Eurasian Siskin	Erlenzeisig	Contact	1 (1x)	

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Annexes

Annex 1: Map of the Botanical Garden Used for the Monitoring.