http://dergipark.org.tr/trkjnat
Trakya University Journal of Natural Sciences, 24(2): 49-55, 2023
ISSN 2528-9691
DOI: 10.23902/trkjnat.1324756

Research Article

AN EVALUATION OF SYLVIIDAE SPECIES IN THE TRANSPORT OF POLLEN: A CASE STUDY OF İSTANBUL

Nurgül KARLIOĞLU KILIÇ[1], Ergün BACAK[2], Rüya YILMAZ DAĞDEVİREN[1], Arif Cemal ÖZSEMİR[3], Elif Ayşe YILDIRIM[1], Umut GÜNGÖR[4], Vedat BEŞKARDEŞ[5]*

[1] İstanbul University-Cerrahpaşa, Faculty of Forestry, Department of Forest Botany, İstanbul, TÜRKİYE
[2] İstanbul University-Cerrahpaşa, Vocational School of Forestry, İstanbul, TÜRKİYE
[3] Ondokuz Mayıs University, Bafra Vocational School, Samsun, TÜRKİYE
[4] İstanbul University-Cerrahpaşa, Institute of Graduate Studies, Department of Forest Engineering, İstanbul, TÜRKİYE
[5] İstanbul University-Cerrahpaşa, Faculty of Forestry, Department of Forest Entomology and Protection, İstanbul, TÜRKİYE

Cite this article as:

Karlıoğlu Kılıç N., Bacak E., Yılmaz Dağdeviren R., Özsemir AC., Yıldırım EA., Güngör U. & Beşkardeş V. 2023. An evaluation of Sylviidae species in the transport of pollen: a case study of İstanbul. *Trakya Univ J Nat Sci*, 24(2): 49-55, DOI: 10.23902/trkjnat.1324756

Received: 09 July 2023, Accepted: 19 September 2023, Published: 15 October 2023

Abstract: During pollination, pollen grains can be transported to distant distances by various factors such as wind, insects, birds, and reptiles. While there have been numerous studies on pollen transportation by birds in Europe, there is a lack of research concerning the pollen grains transported by bird species in Turkey. In this context, we explored the role of Sylviidae species in pollination and identified the plant species whose pollen is transported by these birds. The temporary ringing station located at İstanbul University-Cerrahpaşa Avcılar Campus was selected as the study area and a total of 35 feather samples were collected from individuals of *Sylvia atricapilla* (Linnaeus), *S. borin* (Boddaert), *Curruca communis* (Latham), *C. cantillans* (Pallas), *C. curruca* (Linnaeus) and *C. melanocephala* (Gmelin) captured at station. Based on the analysis of pollen found on the feather samples, it was determined that the pollen found in 18 feather samples of *Curruca curruca* and *Sylvia atricapilla* provided pollen belonging to *Pinus* (Pine), *Aesculus* (Horse chestnut), *Prunus* (Plum), *Spiraea* (Spiraea), *Quercus* (Oak), *Fraxinus* (Ash) and *Melia* (Bead tree). The most commonly determined pollen on *C. curruca* were of *Prunus* (63.5%), while the least common were of *Aesculus* (0.9%). The most commonly determined pollen on *S. atricapilla* were of *Melia* (48.1%), while the least common were of *Crocus* (0.2%). The presence of pollen among the food sources of Sylviidae species during spring, the synchronization between the arrival time of birds in the study area during migration and the pollination period of the determined plant taxa, and the prevalence of these taxa in the study area suggest that *S. atricapilla* and *C. curruca* may be contributing to pollination.

Özet: Tozlaşma sırasında polenler, başta rüzgâr olmak üzere böcek, kuş, sürüngen gibi canlı veya cansız etmenlerle uzak mesafelere taşınabilmektedir. Avrupa'da kuşların polen taşıması ile ilgili pek çok çalışma olmasına rağmen, Türkiye'de kuş türlerinin taşıdıkları polenlerle ilgili herhangi bir çalışma bulunmamaktadır. Bu bağlamda, Sylviidae türlerinin tozlaşmaya katkısının araştırılması ve bu kuşların taşıdığı polenin hangi bitki türlerine ait olduğunun belirlenmesi amaçlanmıştır. Araştırma alanı olan İstanbul Üniversitesi-Cerrahpaşa Avcılar Kampüsündeki geçici halkalama istasyonunda Sylviidae familyasına ait *Sylvia atricapilla* (Linnaeus), *S. borin* (Boddaert), *Curruca communis* (Latham), *C. cantillans* (Pallas), *C. curruca* (Linnaeus) ve *C. melanocephala* (Gmelin) yakalanmış ve polen taşıdığı düşünülen kuşlardan toplam 35 tüy örneği alınmıştır. Bu tüy örneklerinde gerçekleştirilen polen analizleri sonucunda sadece *Curruca curruca* ve *Sylvia atricapilla* kuş türlerine ait 18 tüy örneğinde polenlerin hangi bitki türüne ait oldukları tespit edilmiştir. Kuşların *Pinus* (Çam), *Aesculus* (At kestanesi), *Prunus* (Erik), *Spiraea* (İspirya), *Quercus* (Meşe), *Fraxinus* (Dişbudak) ve *Melia* (Tespih ağacı) olmak üzere 8 bitki cinsine ait polenleri taşıdığı tespit edilmiştir. *Curruca curruca* tarafından en fazla taşınan polenler *Prunus* cinsine (% 63,5), en az taşınanlar ise *Aesculus* cinsine (%0,9) aittir. *Sylvia atricapilla* tarafından en fazla taşınan polenler *Melia* cinsine (%48,1) en az taşınanlar ise *Crocus* L. cinsine (%0,2) ait bulunmuştur. Sylviidae familyası türlerinin, ilkbahardaki besinlerinin arasında polenlerin olması, kuşların alana göç ile gelme zamanları ile tozlaşma zamanlarının uyumu ve taşıdıkları polenlerin ait oldukları bitki taksonlarının alanda yaygın olması *S. atricapilla* ve *C. currca*'nın tozlaşmaya yardımcı olduklarını düşündürmektedir. Bu çalışmada İstanbul ölçeğinde kuşların tozlaşmaya katkısını ortaya koyan ilk çalışma olmakla birlikte, polenler ve kuşlarla ilgili gelecekte yapılacak çalışmalara veri kaynağı olacaktır.

Edited by:
Cem Vural

****Corresponding Author:***
Vedat Beşkardeş
vkardes@iuc.edu.tr

ORCID iDs of the authors:
NKK. orcid.org/0000-0002-6255-6819
EB. orcid.org/0000-0003-0589-4288
RYD. orcid.org/0000-0003-1209-5257
ACÖ. orcid.org/0000-0002-2593-8826
EAY. orcid.org/0000-0003-2097-6863
UG. orcid.org/0000-0003-0455-6076
VB. orcid.org/0000-0002-7404-6357

Key words:
Pollen
Avian pollination
Curruca curruca
Sylvia atricapilla

Introduction

One of the most important stages in the evolution of plants is the emergence of pollen. Pollen grains form the male gametophytes of seed plants, are released from the anther and can be carried long distances by wind or animals. The transfer of pollen grains to the stigma of the female organ is called pollination. Although some flowers are self-pollinating, most plants have developed mechanisms to ensure mutual pollination. Reciprocal pollination is the transfer of pollen from the flowers of one plant to the flowers of another plant of the same species (Campbell & Reece 2002). Studies on pollen transport dates back to early 1800s, but there still exist unstudied areas (Kevan 1975). Pollination generally occurs abiotically mainly by wind, and biotically especially by insects and to some extent by birds and reptiles (Campbell & Reece 2002).

Birds have many important tasks in the ecosystem such as the distribution of seeds, pollination and control of pests (Sekercioglu 2006). Some bird species in Europe are known to feed on nectar, but data about their roles on pollination is quite limited (Ortega-Olivience *et al.* 2005). The role of birds on pollination in Europe and North Africa is considered almost insignificant compared that of insects (Faegri & Van Der Pijl 1971, Proctor & Yeo 1979). When the other continental parts of the world are considered, nectar-feeding birds (Hummingbirds - Trochilidae in North and South America), the nectar birds (Sunbirds- Nectarinidae in the Middle East, East Asia and South Africa) and Honeyeaters - Meliphagidae, known as honey-eating birds, in Australia and New Zealand contribute significantly to pollination (Ford 1985). The interest of birds in flowers is actually for obtaining nectar and pollen (Cronk & Ojeda 2008). Birds sticking their beaks on a flower usually cause a large amount of pollen to be dispersed. In this way, pollen can adhere to certain body parts of the bird and contribute to pollination when the bird visits another plant of the same species (Parker 1977). Differentiated by their pollen or nectar feeding patterns, birds have evolved to match the morphological structures of the flowers they prefer (Stiles 1981, Nicohols & Fleming 2003).

The dry weight of pollens used by birds as a food source contain in average 16-30% protein, 1-7% starch, 0-15% free sugar and 3-10% fat. They also contain a significant amount of phosphate (Proctor *et al.* 1973). These nutrients help birds to provide energy and water especially at short stopovers during migration and to complete the migration successfully (Cecere *et al.* 2011).

Although there are many studies on bird pollination in the world (Proctor *et al.* 1973, Kevan, 1975, Parker 1977, Cronk & Ojeda 2008), there is no study on pollen transferring by birds in Turkey. In this context, our objective was to explore the role of Sylviidae species in pollination and identify the specific plant species whose pollens are transported by these birds. We collected feather samples from birds captured at the temporary bird ringing station within İstanbul University-Cerrahpaşa Avcılar Campus -an important site located along one of the bird migration routes in the country. We then conducted pollen analyses on the collected feather samples to determine the plant species whose pollens are carried by birds.

Materials and Methods

Introduction of the Research Area

The research area, used as a temporary bird ringing station, is located within İstanbul University-Cerrahpaşa Avcılar Campus, along the shores of Küçükçekmece Lake, and on the Black Sea-Mediterranean bird migration route (Fig. 1).

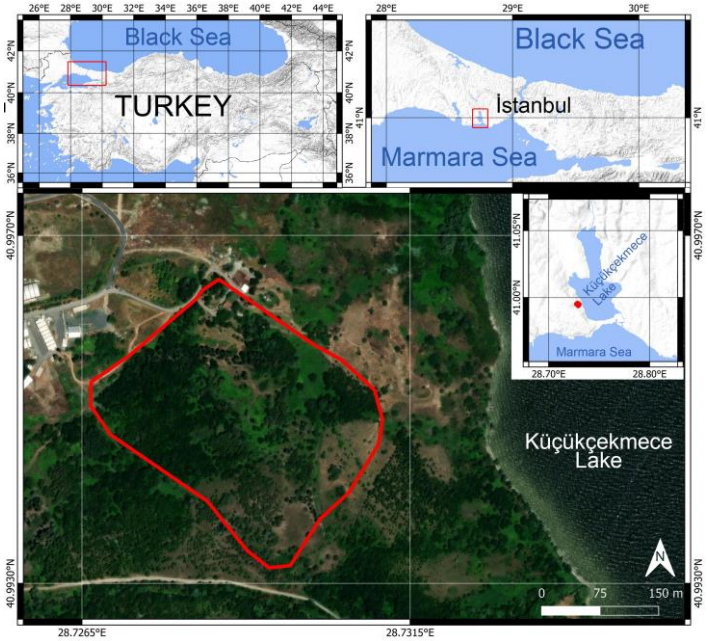

Fig. 1. The satellite view of the research area (based on GoogleEarth data) (lower figure part) and two map view of the area in country and İstanbul level (upper figure part) The red closed line corresponds to the study area borders and the red solid circle in the inset figure correspond to the location of the research area along Küçükçekmece Lake.

Among the important woody plant taxa found in the area are *Cupressus sempervirens* L., *Pinus brutia* Ten., *Pinus pinaster* Soland., *Quercus frainetto* Ten., *Fraxinus ornus* L., *Ulmus minor* Mill., *Eleagnus angustifolia* L., *Populus alba* L., *Salix alba* L., *Prunus spinosa* L., *Rosa canina* L., and *Rubus fruticosus* L. (Akşehirli 2005). The research area has a "hot-dry summer sub-climate type (Csa)" according to the Köppen classification (Öztürk *et al.* 2017). According to the Turkish State Meteorological Service (https://mgm.gov.tr), the meteorological values of the last decade in Turkish Thrace Region are as follows: the average temperatures (°C) with lowest and highest values for winter, spring, summer, and autumn are 6.1 (2.4-10.1), 13.7 (9.1-19.3), 24.8 (19.4-30.7), and 16.5 (12.5-21.7), respectively, and the average total precipitation (mm=kg÷m²) is 78.0, 48.4, 34.5, and 58.1, respectively.

Method

A bird ringing study was conducted in the research area for a period of 96 days, from 03 March 2021 to 06 June 2021. "Japanese Mist Nets" also known as mist nets were used to capture the birds. These nets were 2 meters high, either 7 or 12 meters long, black in color, and had a mesh size of 16 mm. The initial inspection of the nets began at sunrise, and subsequently, the nets were checked on an hourly basis. The final inspection of the nets was conducted one hour after sunset. Among the birds captured by the nets in the course of the ringing activity, those belonging to the Sylviidae family were included in the study. Sylviidae members play a significant role in pollen transportation (Da Silva *et al.*, 2016). During autumn migration, a substantial portion of their diet consists of fruits. During spring migration, the primary source of food for Sylviidae species is insects; however, they also consume pollen, which is easily accessible and more easily digestible (Burquez 1989). The feather with pollen around the beak can be easily distinguished by visual inspection. For this purpose, feather samples with pollen were collected around the beak of Sylviidae species were collected using forceps and the feathers with pollen were transported to the laboratory in small plastic containers for further evaluation.

The collected pollen samples were brought to the Palynology Laboratory at İstanbul University-Cerrahpaşa Faculty of Forestry, where pollen preparations were made according to the Wodehouse method (Wodehouse 1935). Two pollen preparations, each covered with coverslips of size 24×50 mm, were prepared for each bird feather sample. The identification, counting, and photography of the pollen grains were performed using a Leica DM750 Light Microscope. Reference pollen preparations from the Palynology Laboratory at İstanbul University-Cerrahpaşa Faculty of Forestry and various pollen atlases (Wodehouse 1935, Erdtman 1952, Aytuğ 1965, Aytuğ *et al.* 1971, Moore & Webb 1978, Faegri & Iversen 1964, Moore *et al.* 1991, Beug 2004) were utilized for pollen identifications at genus level. Pollen counts were completed by scanning the entire surface of each preparation from top to bottom, covering a total area of 12 cm^2. These counts were converted to pollen quantity per cm^2 and the results were reported as pollen percentages. Pollen percentages were calculated for each bird feather sample, and pollen percentage diagrams were drawn using the TILIA software (Grimm 2019).

Results

Six bird species belonging to the Sylviidae family *Sylvia atricapilla, S. borin, Curruca communis, C. cantillans, C. curruca* and *C. melanocephala* were caught in the course of the ringing studies. Pollen grains were found in only 18 out of 35 feather samples. The identified pollen grains determined were found to be carried only by individuals of *C. curruca* and *S. atricapilla*. The pollen identifications showed that pollen of 8 plant taxa were carried by the two Sylvidae species. It was determined that *Curruca curruca* and *Sylvia atricapilla* carried pollen of an average of 3 (min 1 - max 5) and 4.07 (min 2 - max 6) an average of plant taxa respectively. Information on the codes given to the individuals from which feather samples were collected and the collection dates are presented in Table 1.

As a result of the pollen analysis, the Gymnosperm taxon *Pinus* and the Angiosperm woody plant taxa *Aesculus*, *Prunus*, *Spiraea*, *Quercus*, *Fraxinus*, and *Melia* were identified. Among the herbaceous plant taxa, only *Crocus* was determined. The diagnosed pollen grains from bird feathers and the corresponding pollen percentage data were calculated, and the pollen percentage diagram for samples obtained from each individual was presented in Fig. 2.

Pollen grains carried by *Curruca curruca* belong to 7 different plant genera. The total number of pollen grains transported by this bird species is 780 (minimum 10 - maximum 340 pollen grains), with an average of 195. The most commonly transported pollen by *C. curruca* belongs to the *Prunus* (total of 496 grains, 63.5%), while the least commonly transported pollen belongs to the *Aesculus* (7 grains, 0.9%) (Table 2; Fig. 3).

Table 1. Details of sampled feathers.

Sampled bird species	Sample codes	Collection dates
Curruca curruca	CUCUR-01	14.04.2021
	CUCUR-02	09.04.2021
	CUCUR-03	16.04.2021
	CUCUR-04	18.04.2021
Sylvia atricapilla	SYATR-01	25.04.2021
	SYATR-02	18.04.2021
	SYATR-03	07.04.2021
	SYATR-05	15.04.2021
	SYATR-06	17.03.2021
	SYATR-07	18.04.2021
	SYATR-08	18.04.2021
	SYATR-09	09.04.2021
	SYATR-10	18.04.2021
	SYATR-11	08.04.2021
	SYATR-12	18.04.2021
	SYATR-13	18.04.2021
	SYATR-14	18.04.2021

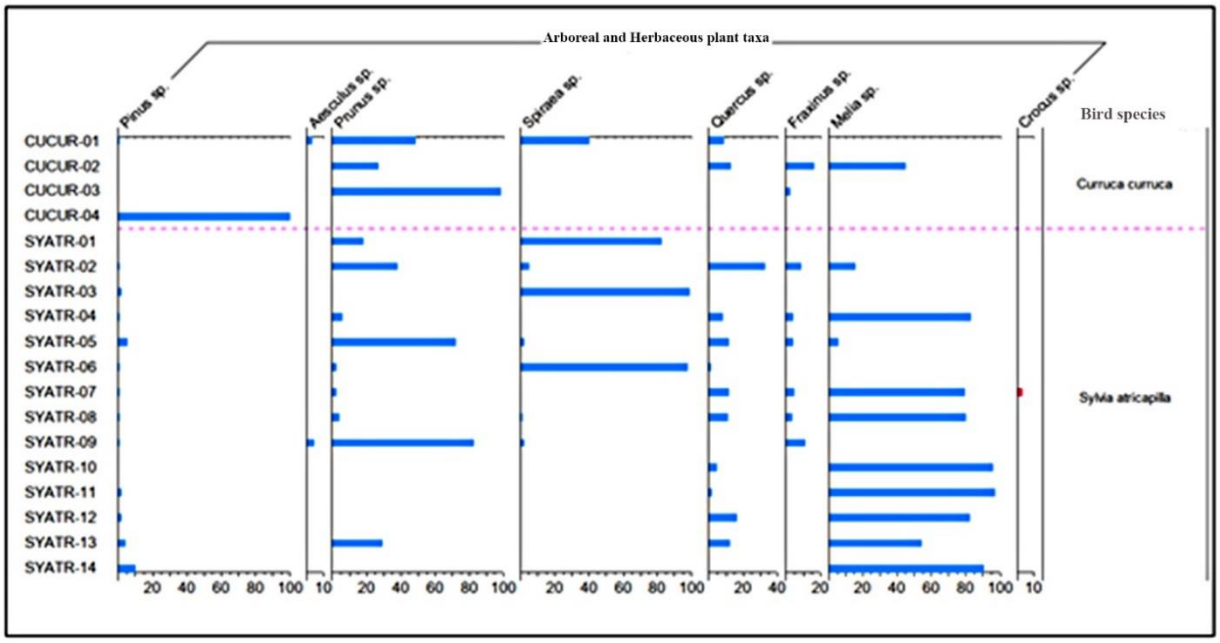

Fig. 2. Pollen percentage diagram of gymnosperm, angiosperm and herbaceous plant taxa identified in bird feather samples.

Table 2. Types and quantities of pollen carried by *C. curruca* with respect to the identified taxa.

Sample codes	Identified taxa							
	Aesculus	***Fraxinus***	***Melia***	***Pinus***	***Prunus***	***Quercus***	***Spiraea***	**Total**
CUCUR-01	7			1	107	19	88	222
CUCUR-02		33	93		55	27		208
CUCUR-03		6			334			340
CUCUR-04				10				10
Total Overall	**7**	**39**	**93**	**11**	**496**	**46**	**88**	**780**

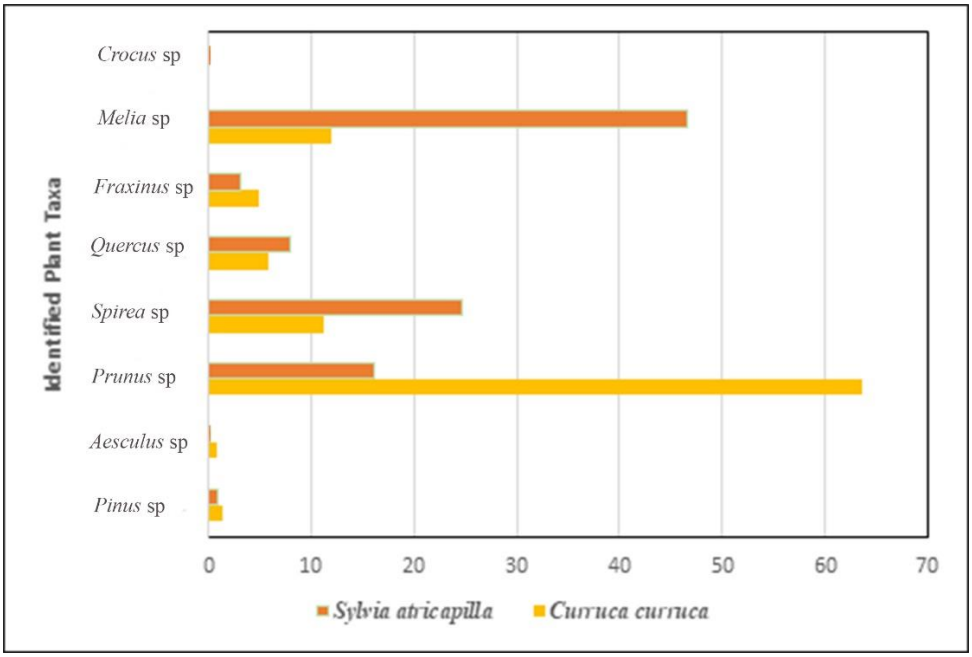

Fig. 3. The percentage diagram of the identified and counted pollen grains in the species *C. curruca* and *S. atricapilla*.

Table 3. Types and quantities of pollen carried by *S. atricapilla* with respect to the identified taxa.

Sample codes	Identified taxa								
	Aesculus	***Crocus***	***Fraxinus***	***Melia***	***Pinus***	***Prunus***	***Quercus***	***Spiraea***	**Total**
SYATR-01						35		162	197
SYATR-02			19	32	1	79	68	11	210
SYATR-03					3			202	205
SYATR-04			15	340	1	22	32		410
SYATR-05			9	11	10	151	24	4	209
SYATR-06			1		1	7	3	374	386
SYATR-07		6	11	192	1	5	28		243
SYATR-08			21	485	3	25	67	4	605
SYATR-09	8		22		1	166		4	201
SYATR-10				150			7		157
SYATR-11				126	2		2		130
SYATR-12				70	1		14		85
SYATR-13				13	1	7	3		24
SYATR-14				19	2				21
Total Overall	**8**	**6**	**98**	**1438**	**27**	**497**	**248**	**761**	**3083**

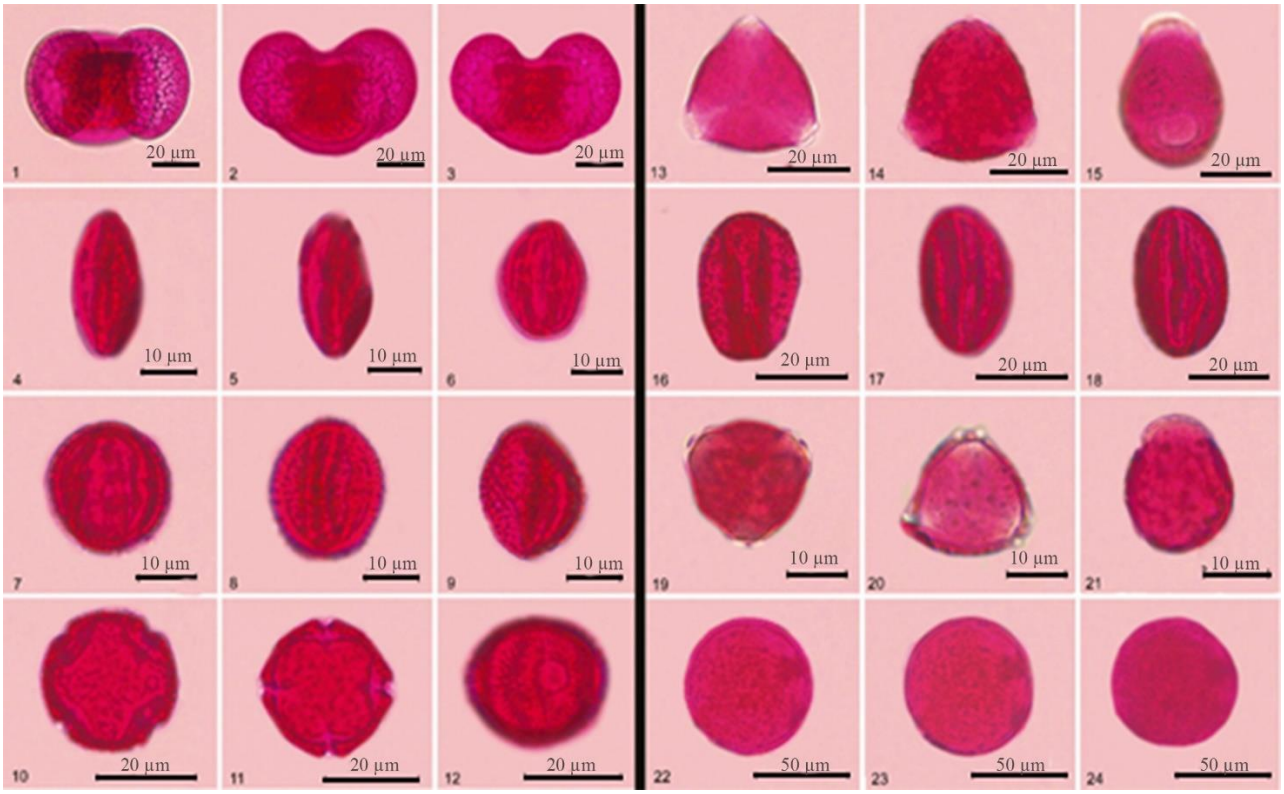

Fig. 4. The photographs of the pollen grains identified in the pollen preparations under a light microscope. (1-3 *Pinus*; 4-6 *Aesculus*; 7-9 *Fraxinus*; 10-12 *Melia* 13-15 *Prunus*; 16-18 *Quercus*; 19-21 *Spiraea*; 22-24 *Crocus*).

The pollen carried by *Sylvia atricapilla* belongs to 8 different plant genera. The total number of pollen carried by this bird species is 3083 (minimum 21 - maximum 605 pollen), with an average of 220.2. The pollen carried by *S. atricapilla* is predominantly from the *Melia* (a total of 1438 pollen, 48.1%), while the least carried pollen belongs to the *Crocus* (6 grains, 0.2%) (Table 3, Fig. 3).

The percentage diagram of the identified and counted pollen grains found on the feathers of both bird species is presented in (Fig. 3).

Light microscopy photographs of the pollen identified during the study are presented in Fig. 4.

Discussion

Approximately 289.166 plant species are pollinated by insects and 923 plant species are pollinated by birds throughout the world. When insect and bird pollinations are compared, the number of plant species pollinated by all birds is considered very low (Inouye 2007). In Europe, 61 bird species are known to visit plants and assist in the transport of pollen (Da Silva *et al.* 2016). Birds actually help pollen transport by attaching pollen to their feathers as they visit flowers for nectar and predation on insects (Ford 1985). Ford (1985) states that especially Sylviidae species of the songbirds (Passerine) in Europe carry pollen and are likely pollinators. The only study in Europe that proved bird pollination was the experimental study by Ortega-Olivencia *et al.* (2005) who revealed that birds belonging to the order Passeriformes pollinated the flowers of *Anagyris foetida* L. In our study, we have determined that *Curruca curruca* transports the pollens of 7 woody plant taxa, while *Sylvia atricapilla* carries the pollens of 7 woody plant taxa along with one herbaceous taxon (*Crocus* sp). The prevalence of plant species in the area and the harmony between the pollination time of these plants, and the migration and arrival times of Sylviidae species suggest that the two bird species may help pollination. During the autumn migration, Sylviidae species consume mainly fruits (Jordano 1988, Schaefer *et al.* 2014). However, in the spring migration, the main food source of Sylviidae change to insects, and also they consume easily accessible nectar and pollen, which is much easier to digest (Da Silva *et al.* 2014). Pollen helps birds to provide energy and water, especially at short stopovers during migration, and to successfully complete the migration (Schwilch *et al.* 2001, Cecere *et al.* 2011). In Europe, the majority of plants whose pollen is carried by birds do not require bird pollination as they are predominantly pollinated by insects. It has been reported that birds receive the main benefit from this mutualistic relationship, as birds visit the plant to eat nectar or insects (Da Silva *et al.* 2014).

Two of the plant taxa that birds carry their pollen are exotic (*Aesculus* and *Spiraea*), while the others (remaining 6 genera) are natural species. Da Silva *et al.* (2014) stated in their study that bird species in Europe interact with the flowers of 66 natural and 29 exotic plant species. In this study, it was determined that in addition to Da Silva *et al.* (2014) and Da Silva *et al.* (2016), Sylviidae species helped pollen transport from *Melia, Aesculus, Spiraea* and *Crocus* species.

As a result, although we do not have conclusive evidence that Sylviidae family species provide pollination in our study the fact that the birds have pollen among their food in the spring, the harmony between the migration and arrival times of the birds and the pollination times, and the fact that the plant taxa to which the pollen they carry are common in the area suggest that *S. atricapilla* and *C. curruca* help pollination.

Acknowledgement

The study was carried out with the approval of the Republic of Türkiye Ministry of Agriculture and Forestry, General Directorate of Nature Conservation and National Parks (26137614-280.01.01-E.2141100 12.07.2019). We would like to thank Ceren Gezik (İstanbul-Türkiye), Emre Taha Demir (İstanbul-Türkiye), Mehmet Ali Balcı (İstanbul-Türkiye), Nalan Karaca (İstanbul-Türkiye) and Yasir Sevil (İstanbul-Türkiye), who helped in the ringing works, and the Nature-loving Volunteers who contributed and ORCUVAM (Forestry Studies, Applications and Research Center) for their support.

Ethics Committee Approval: Since the article does not contain any studies with human or animal subject, its approval to the ethics committee was not required.

Data Sharing Statement: All data are available within the study.

Author Contributions: Concept: E.B., V.B., Design: N.K.K, V.B., Execution: N.K.K., E.B., R.Y.D., A.C.Ö., E.A.Y., U.G., Material supplying: E.B., A.C.Ö., U.G., Data analysis/interpretation: N.K.K., V.B., Writing: N.K.K., V.B., Critical review: N.K.K., E.B., R.Y.D., A.C.Ö., E.A.Y., U.G., V.B.

Conflict of Interest: The authors have no conflicts of interest to declare.

Funding: The authors declared that this study has received no financial support.

Editor-in-Chief note: Vedat Beşkardeş is a member of Editorial Board of Trakya University Journal of Natural Sciences. However, he was't involved in the decision process during manucript evaluation.

References

1. Akşehirli, İ. 2005. *A landscape analysis of Küçükçekmece lake and its surroundings for ecological planning.* Master's thesis, Institute of Science, İstanbul University, 247 pp.
2. Aytuğ, B. 1965. Polen Moroflojisi ve Türkiye'nin Önemli Gymnosperm'leri Üzerinde Palinolojik Araştırmalar. *Journal of the Faculty of Forestry İstanbul University,* 15(3): 58-96.
3. Aytuğ, B., Aykut, S., Merev, S. & Edis, G. 1971. İstanbul Çevresi Bitkilerinin Polen Atlasi, *İstanbul Üniversitesi Orman Fakültesi Yayınları*, İstanbul, 174 pp.

4. Beug, H.J. 2004. Leitfaden der Pollenbestimmungfür Mitteleuropa und Angrenzende Gebiete. Dr Friedrich Pfeil, München, 542 pp.
5. Burquez, A. 1989. Blue tits (*Parus caeruleus*) as pollinators of the crown imperial (*Fritillaria imperialis*) in Britain, *Oikos* 55: 335-340.
6. Campbell, N.A. & Reece, J.B. 2002. *Biology*, Benjamin Cummings – Pearson Education, VI. Edition, 1247 pp.
7. Cecere, J.G. Spina F., Jenni-Eirmann, S. & Boitani, L. 2011. Nectar: an energy drink used by European songbirds during spring migration, *Journal of Ornithology*, 152: 923-931. https://doi.org/10.1007/s10336-011-0675-4
8. Cronk, Q. & Ojeda, I. 2008. Bird-pollinated flowers in an evolutionary and molecular context, *Journal of Experimental Botany*, 59(4): 715-727.
9. Da Silva, L.P., Ramos, J.A., Olesen, J.M., Coutinho, A.P, Tenreiro, P.Q. & Heleno, R.H. 2016. Flower visitation by European birds offers the first evidence of interaction release in continents. *Journal of Biogeography*, 44(3): 687-695, https://doi.org/10.1111/jbi.12915
10. Da Silva, L.P., Ramos, J.A., Olesen, J.M., Traveset, A. & Heleno, R.H. 2014. Flower visitation by birds in Europe, *Oikos*, 123(11): 1377-1383.
11. Erdtman, G. 1952. *Pollen morphology and plant taxonomy*, The Choronica Botanic Company, Waltham, Mass, USA, 539 pp.
12. Faegri, K. & Iversen, J. 1964. *Textbook of Pollen Analysis, II Edition*. Denmark: Munksgaard, Copenhagen, 237 pp.
13. Faegri, K. & Van Der Pijl, L. 1971. *The principles of pollination ecology*. Pergamon press, Oxford, XII+291 pp.
14. Ford, H.A. 1985. Nectarivory and polination by birds in southern Australia and Europe. *Oikos* 44: 127-131.
15. Grimm, E. 2019. *TILIA* Software Programme Version 3.0.1.
16. Inouye, D.W. 2007. *Pollinators, Role of, Encyclopedia of Biodiversity*. Elsevier, Amsterdam, 140-146.
17. Jordano, P. 1988. Diet, fruit choice and variation in body condition of frugivorous warblers in Mediterranean scrubland. *Ardea*, 76: 193-209.
18. Kevan, P.G. 1975. Pollination and Environmental Conservation. *Environmental Conservation*, 2(4): 293-298.
19. Moore, P. & Webb, J.A. 1978. *An Illustrated Guide to Pollen Analysis*, Hodder and Stoughton Educational Division, 192 pp.
20. Moore, P., Webb, J.A. & Collinson, M.E. 1991. *Pollen Analysis, 2nd Edition*, Blackwell, Oxford, 216 pp.
21. Nicolson, S. & Fleming, P. 2003. Nectar as food for birds: the physiological consequences of drinking dilute sugar solutions. *Plant Systematics and Evolution.* 238. 139-153. https://doi.org/10.1007/s00606-003-0276-7
22. Ortega-Olivencia, A., Rodriguez-Riaño, T., Valtueña, F.J., Lopez, J. & Devesa, J.A. 2005. First confirmation of a native bird-pollinated plant in Europe, *Oikos*, 110: 578-590.
23. Öztürk, M.Z., Çetinkaya, G. & Aydın, S. 2017. Köppen-Geiger İklim Sınıflandırmasına Göre Türkiye'nin İklim Tipleri. *Coğrafya Dergisi*, (35): 17-27. https://doi.org/10.26650/JGEOG295515
24. Parker, S.A. 1977. Bird as Pollinators. https://www.birdlife.org.au/afo/index.php/afo/article/download/1360/1885 (data accessed: 15.10.2022).
25. Pellmyr, O. 2002. *Pollination by animals*, pp. 157-184. In: Herrera, C. M. and Pellmyr, O. (eds), *Plant/animal interactions. An evolutionary approach.* Blackwell Science, 332 pp.
26. Proctor, M. & Yeo, P. 1979. *The Pollination of Flowers*. Collins, London, 418 pp.
27. Proctor, M., Yeo, P. & Lack, A. 1973. *The Natural History of Pollination.* Harper Collins, London, 220 pp.
28. Schaefer, H.M., Valido, A. & Jordano, P. 2014. Birds see the true colours of fruits to live off the fat of the land. *Proceedings of the Royal Society B*, 281: 20132516. http://dx.doi.org/10.1098/rspb.2013.2516
29. Schwilch R., Mantovani R., Spina F. & Jenni L. 2001. Nectar consumption of warblers after long-distance flights during spring migration. *Ibis*, 143: 24-32.
30. Sekercioglu, C.H. 2006. Increasing awareness of avian ecological function. *Trends in Ecology & Evolution*, 21: 464-471. https://doi.org/10.1016/j.tree.2006.05.007
31. Stiles, F.G. 1981. Geographical aspects of birdflower coevolution with particular reference to Central America. *Annals of the Missouri Botanical Garden,* 68: 323-352.
32. Wodehouse, R.P. 1935. *Pollen Grains*, Hafner Publishing Company, New York: 574 pp.