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ORIGINAL ARTICLE

Exploring the diversity and abundance of necrophagous flies (Diptera) in Tabriz County, northwestern Iran: Implications for medical and public health importance

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Abstract

Flies are medically and veterinary-important arthropods that not only transmit various pathogens to humans and animals, but are also the main agents of human and animal myiasis. The aim of this study was to determine the biodiversity and abundance of medically important flies in Tabriz County, northwestern Iran. Adult and larval specimens were collected monthly from July to October 2021 and subsequently were identified using valid morphological identification keys. Several biodiversity indices, including species richness, species evenness, Shannon–Wiener index, and degree of occurrence, were calculated. Totally, 17 species belonging to five families including Muscidae, Calliphoridae, Sarcophagidae, Fanniidae, and Anthomyiidae were captured. The highest rate of species richness (S = 14) was observed in August and September, and the lowest one (9) in October. The highest rates of species evenness and Shannon–Wiener indices were observed in October. *Musca domestica, Muscina stabulans, Lucilia sericata, Chrysomya albiceps, Sarcophaga africa, Sarcophaga argyrostoma, Sarcophaga aegyptica, Sarcophaga* sp., and *Fannia* sp. were constant species while *Musca autumnalis, Sarcophaga lehmanni, Sarcophaga* (*Liosarcophaga*) sp., *Anthomyia* sp., and *Phaonia* sp. were classified as accidental species in the study area. Notably, sixteen species of necrophagous flies were reported for the first time in this region. Considering the medical and veterinary importance of flies, similar studies are recommended in other parts of the country.

Keywords Biodiversity · Evenness · Fly · Necrophagous · Richness · Iran

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Introduction

Diptera, one of the largest orders of insects, accounts for approximately 10% of the world's animal species. About 125,000 species of flies have been identified worldwide, of which almost 2,500 belong to the Sarcophagidae family, 1,500 to Calliphoridae, 5,000 to Muscidae, and 285 to Fanniidae (Brown 2005; Pape 1996). Moreover, approximately 11,000 species of flies, including necrophagous species, can cause diseases in humans and animals due to their ability to mechanically and biologically transmit various pathogens such as bacteria, fungi, nematodes, and viruses, as well as by causing myiasis. Thus, flies have medical, veterinary, and economic importance (Grassberger et al. 2013; Russell et al. 2013; Dehghan et al. 2021).

Myiasis is the infestation of live humans or animals by fly larvae, which feed on the host's necrotic or even living tissue (Akbarzadeh et al. 2018). The larvae may infest host wounds or natural cavities including the mouth, ears, eyes, nose, and urogenital tract (Akbarzadeh et al. 2018). Sarcophagidae, Calliphoridae, Muscidae, and Oestridae are the most important families that cause human myiasis (Bernhardt et al. 2019; Nasser et al. 2021). Myiasis is a significant health concern in Iran, particularly in areas with traditional animal husbandry. Unfortunately, there are no recorded data on the prevalence of human myiasis in Iran. All available information is only based on the reported cases. From 2013 to 2020, 26 cases of human myiasis caused by various species of flies were reported from Iran (Jokar et al. 2022). Moreover, some families such as Sarcophagidae and Calliphoridae are particularly important in forensic studies (Fremdt and Amendt 2014; Ren et al. 2018; Fantio et al. 2022).

Among scavenger and necrophagous insects, blow flies (Diptera: Calliphoridae) and flesh flies (Diptera: Sarcophagidae) are significant in forensic entomology due to their early arrival at the corpse's location, making them helpful in solving criminal cases (Ren et al. 2018).

Studying the biodiversity of fly populations helps to better understand the ecological dynamics of an ecosystem (Motevalli Haghi et al. 2021). In addition, they are often employed as indicators of the quality of environments (pollution levels, habitat disturbance, and climate change). Moreover, some fly species act as mechanical vectors of diseases or cause myiasis, but some species are used in the treatment of patients (maggot therapy) (Mohd Zubir et al. 2020; Dehghan et al. 2021). So, studying on biodiversity indices of flies provides valuable data for scientific investigations in biology, taxonomy and ecosystem function fields and also controlling medically and veterinary health problems (Motevalli Haghi et al. 2021).

Biodiversity indices such as species richness, species evenness, Shannon –Wiener, and degree of presence or occurrence are used to diversity levels describing (Levin 2013; Fontana et al. 2020). Although many studies have been conducted on the biodiversity of medically important arthropods such as sand flies, mosquitoes, and wasps in various areas of Iran (Khoobdel et al. 2013; Jahanifard et al. 2014; Abedi-Astaneh et al. 2015; Arzamani et al. 2018; Davari et al. 2015; Yousefi et al. 2020; Paksa et al. 2023), there are few studies on the biodiversity of flies in Iran, especially in the northwestern region, which is one of the important hubs of livestock husbandry, economy, and tourism in the country.

Knowledge on the species diversity of necrophagous flies and determining their distribution is necessary to prevent transmission of the diseases caused by flies and also to use the most appropriate control methods to reduce the populations of flies. Till present, there has been no information about the fauna and biodiversity of flies in Tabriz County, northwest of Iran. Thus, the present study aimed to assess the diversity of medically and veterinary important flies in this region.

Materials and methods

Study area

Tabriz County is situated in the northwest of Iran, within East Azerbaijan Province, between the Eynali and Sahand mountains, and is traversed by two rivers: the Aji River and the Quri River. This mountainous County covers an area of 245 km^2 and is positioned at an elevation of 1,300 m above sea level in plain and 2,100 m in mountainous areas. This County is located between 38°2'N latitude and 46°25'E longitude (Fig. 1). The valley gives way to a plain that gently slopes down to the eastern shores of Lake Urmia, situated 60 km to the west. Tabriz experiences hot summers and cold winters characterized by heavy snowfall and subfreezing temperatures. The mean annual precipitation is 283 mm, with a significant portion falling as snow in winter and rain during spring and autumn. The climate of Tabriz is mild and pleasant during both spring and autumn, hot and dry in summer, and cold in winter. The average annual temperature is approximately 12 °C. Cool winds predominantly blow from east to west, particularly in summer (Statistical center of Iran 2023).

Collection and identification of flies

This cross-sectional study was done from July to October 2021 in different places of Tabriz County including residential regions, plain, mountainous and vegetation areas. Sampling of adult flies and their larvae was conducted

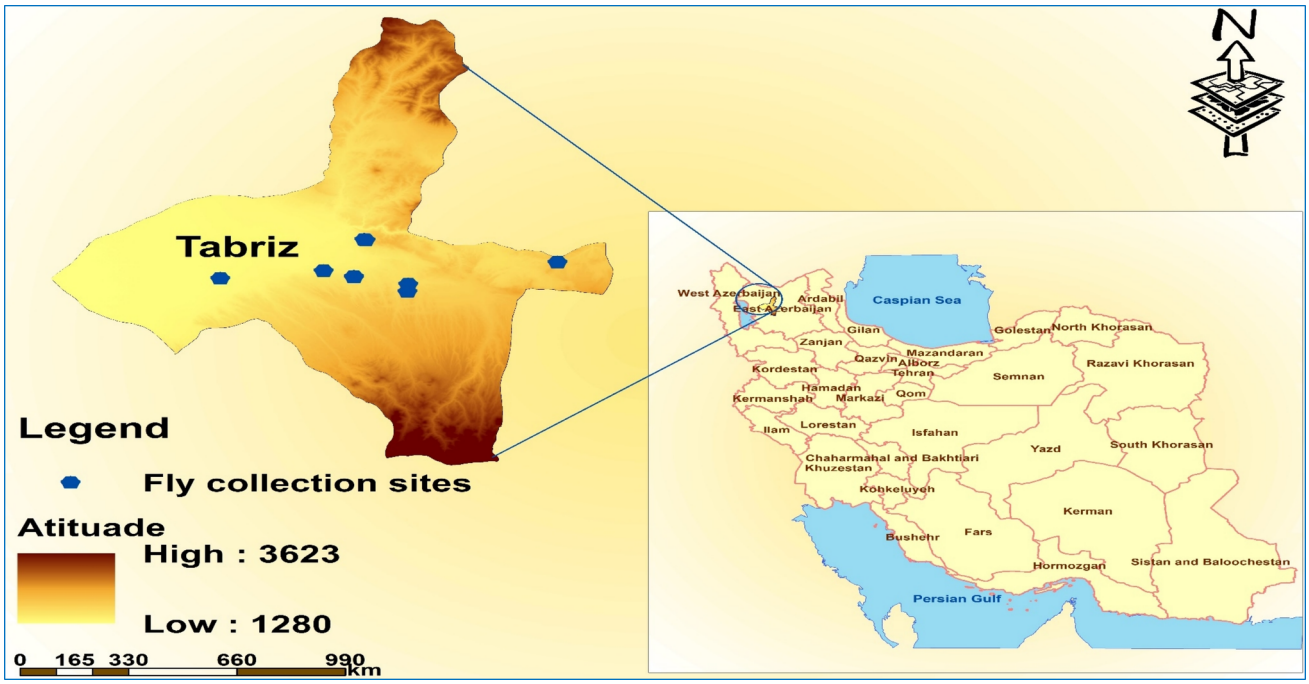

Fig. 1 Geographic location of flies sampling sites, Tabriz County, East Azerbaijan Province, Iran

monthly. The geographic coordinates of the sampling sites were recorded to prepare a distribution map of the fly species using the ArcMap software. Modified traps containing chicken liver inside, as bait, were used to capture the adult flies (Fig. 2) These modified traps were set up early in the morning and collected late in the evening. Furthermore, the larvae of flies were collected from the chicken liver and kept in an open plastic container under ambient conditions (Dehghan et al. 2020). Adult specimens that were attracted to the bait were caught by a standard insect net. The captured adult flies and larvae were transferred to the laboratory.

Subsequently adults were be-pinned directly through the thorax and most of the larvae were stored in 70% alcohol. To confirm larval identification, some of them were transferred in the insectarium and reared at temperature conditions of 25 ± 2 °C and a humidity of 60 ± 5% (Dehghan et al. 2020). Specimens were identified using valid morphological identification keys (Marshall et al. 2011; Richet et al. 2011; Akbarzadeh et al. 2015; Grisales et al. 2016; Grzywacz et al. 2017; Jones et al. 2019; Malaithong et al. 2019; Whitmore et al. 2020). During the identification process, some fly specimens were only classified to the genus level due to morphological similarities among species within the same genus, lack of comprehensive taxonomic keys, and inadequate specimen quality.

Data analysis

The following biodiversity indices were calculated:

Species richness (S): This index indicates the number of species present in an ecological community or a within specific period of time (Spellerberg and Fedor 2003).

Shannon–Wiener index ($H = -\sum_i^S \mathbf{Pi} \times \mathbf{ln}\ P_i$): The index represents the species biodiversity within an ecological area or a specific period of time (Magurran 2004).

Species evenness (E = H/ln S): This index describes the relative abundance of different species within a region or a period of time (Magurran 2004).

Degree of presence or occurrence (C = n/N × 100): This index shows the number of sites where a species is captured divided by the total number of studied sites. According to this index, constant species are present in 50% or more of the sites, common species in 25–49%, accidental species in 12–24%, and very accidental species in less than 12% of the studied sites (Neffar et al. 2016).

Results

The fauna of flies in Tabriz County

Totally, 2192 flies belonging to 17 species were collected from various sites of Tabriz County. The collected flies belonged to five families: Muscidae, Calliphoridae, Sarcophagidae, Fanniidae, and Anthomyiidae (for photographs of some representative species, see the Online resource). *Musca domestica* Linnaeus, 1758 was the most abundant species, followed by *Chrysomya albiceps* Wiedemann, 1819 and *Lucilia sericata*

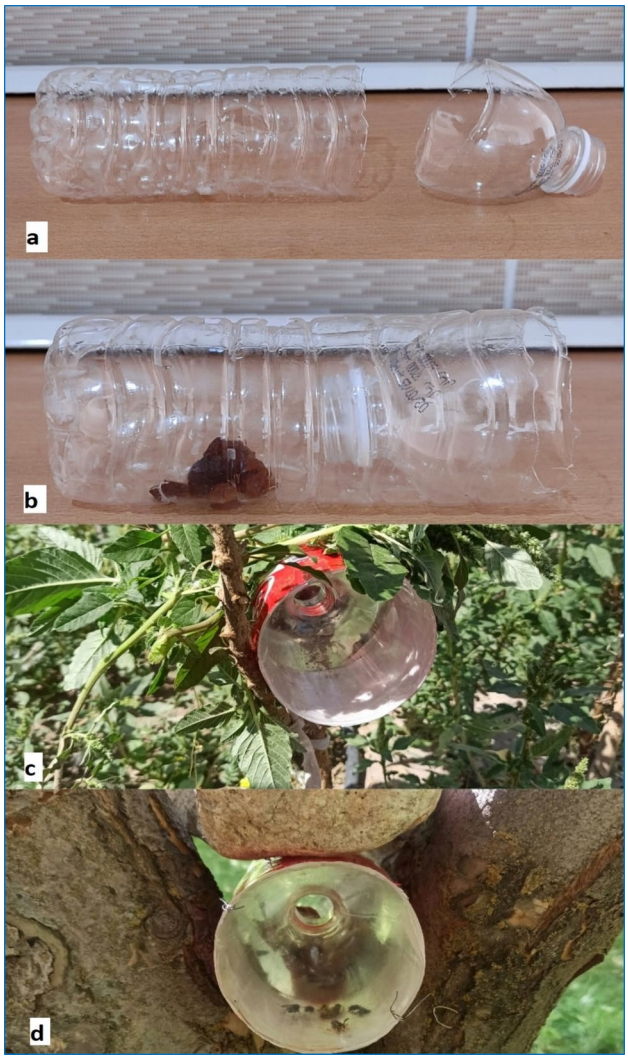

Fig. 2 Collection of flies using a modified trap. **a** Cutting a plastic bottle to create a fly trap. **b** A trap containing bait. **c** Trap deployed in the field. **d** Flies attracted to the bait within the trap

Meigen, 1826. The largest number of flies were observed in August. Generally, 711 (32.4%) specimens were captured in residential areas, while the remaining 1,481 (67.6%) were found in mountainous and plain areas. Eleven species were collected in the County residential areas: *L. sericata* (37.8%), *M. domestica* (18.6%), *Ch. albiceps* (15.3%), *Sarcophaga* sp. (6.5%), *Sarcophaga argyrostoma* Robineau-Desvoidy, 1830 (5.3%), *Sarcophaga africa* Wiedemann, 1819 (4.6%), *Muscina stabulans* Meigen, 1826 (4.5%), *Calliphora vicina* Robineau-Desvoidy, 1830 (3%), *Sarcophaga variegata* Scopoli, 1763 (2.5%), *Fannia* sp. (1.8%), and *Sarcophaga lehmanni* Dahlbom, 1850 (0.1%). Sixteen species were caught in the mountainous and plain areas including *M. domestica* (33.5%), *Ch. albiceps* (28.8%), *L. sericata* (16.6%), *Sarcophaga* sp. (8.7%), *S. argyrostoma* (2.9%), *M. stabulans* (2.8%), *Sarcophaga aegyptica* Robineau-Desvoidy, 1830 (2.1%), *S. africa* (2%), *C. vicina* (0.9%), *Fannia* spp. (0.5%), *Hydrotaea* sp. (0.4%), *S. variegata* (0.3%), *Phaonia* sp. (0.2%), *Musca autumnalis* De Geer, 1776 (0.07%), *Sarcophaga* (*Liosarcophaga*) sp. (0.07%), and *Anthomyia* sp. (0.07%).

Diversity indices

The highest species richness was observed in August and September, while the lowest occurred in October. The highest and the lowest rates of species evenness and Shannon–Wiener indices were found in October and September, respectively (Table 1).

According to degree of presence or occurrence, *M. autumnalis, S. lehmanni, Sarcophaga* (*Liosarcophaga*) sp., *Anthomyia* sp., and *Phaonia* sp. were classifies as accidental species. *Calliphora vicina, S. variegata,* and *Hydrotaea* sp. were common species while the other captured fly species were classified as constant species in the study area.

Discussion

Despite the medical and veterinary importance of flies, few studies have been conducted on their fauna, frequency, and biodiversity in Iran, particularly in East Azerbaijan Province. Before the present study, six fly species including *Bellardia pandia* Walker, 1849, *Bellardia viarum* Robineau-Desvoidy, 1830, *Bellardia vulgaris* Robineau-Desvoidy, 1830, *C. vicina*, *Calliphora vomitoria* Linnaeus, 1758, and *Cynomya mortuorum* Linnaeus, 1761 were reported from different areas of East and West Azerbaijan Provinces in the northwest of Iran (Modarresi et al. 2019). From the above mentioned species, only *C. vicina* was caught in the current study, thus 16 species of flies were reported for the first time from this area.

In Ankara, which has a similar climate to Tabriz, *C. vicina*, *C. vomitoria*, *L. sericata*, *Lucilia richardsi* Collin, 1933, *M. domestica*, *M. stabulans*, and the family Sarcophagidae have been reported with *C. vicina* as the dominant species, which was active throughout all the studied months (Halide et al. 2017). Some species were found as common in both Iran and Turkey. Similar to the study from Ankara, *C. vicina* was captured in all investigated months in Tabriz.

In Turkey, the highest rate of flies' frequency was observed in June while the lowest one was in January. Alpha diversity indices were different in various months, the highest rate of richness was observed in June and the lowest rate in January and also the highest rate of evenness and Shannon–Wiener indices were observed in September and June, respectively (Halide et al. 2017). In July, August, September, and October, which corresponds to collection months in our study, the biodiversity indices were different

Table 1 Frequency and diversity indices of necrophagous flies in Tabriz County, northwestern Iran, 2021

Fly species	July						August						September						October					
	Frequency	Proportion (Pi)	Pi $\log_e$ pi	Richness	Evenness	Shannon–Wiener	Frequency	Proportion (Pi)	Pi $\log_e$ pi	Richness	Evenness	Shannon–Wiener	Frequency	Proportion (Pi)	Pi $\log_e$ pi	Richness	Evenness	Shannon–Wiener	Frequency	Proportion (Pi)	Pi $\log_e$ pi	Richness	Evenness	Shannon–Wiener
Musca domestica	82	0.468	0.355	10	0.703	1.619	125	0.123	0.257	14	0.654	1.728	402	0.5	0.346	14	0.58	1.53	20	0.106	0.237	9	0.809	1.78
Muscina stabulans	7	0.04	0.128				26	0.025	0.092				24	0.029	0.102				16	0.085	0.209			
Phaonia sp.	0	-	-				0	-	-				3	0.003	0.017				0	-	-			
Hydrotaea sp.	0	-	-				3	0.002	0.012				3	0.003	0.017				0	-	-			
Musca autumnalis	0	-	-				1	0	-				0	-	-				0	-	-			
Lucilia sericata	28	0.16	0.293				347	0.342	0.366				58	0.071	0.187				82	0.436	0.361			
Chrysomya albiceps	25	0.148	0.282				295	0.290	0.358				197	0.241	0.342				18	0.1	0.230			
Calliphora vicina	2	0.01	0.046				21	0.020	0.078				7	0.008	0.038				4	0.021	0.081			
Sarcophaga africa	11	0.062	0.172				18	0.017	0.069				27	0.033	0.112				7	0.037	0.121			
Sarcophaga variegata	3	0.017	0.069				1	0	-				12	0.014	0.059				5	0.026	0.094			
Sarcophaga argyrostoma	0	-	-				53	0.06	0.168				14	0.017	0.069				15	0.08	0.202			
Sarcophaga aegyptica	0	-	-				29	0.028	0.100				2	0.002	0.012				0	-	-			
Sarcophaga sp.	2	0.01	0.046				91	0.09	0.216				62	0.08	0.202				21	0.111	0.243			
Sarcophaga lehmanni	1	0.005	0.026				0	-	-				0	-	-				0	-	-			
Sarcophaga (Liosarcophaga) sp.	0	-	-				1	0	-				0	-	-				0	-	-			
Fannia sp.	14	0.08	0.202				3	0.002	0.012				3	0.003	0.017				0	-	-			
Anthomyia sp.	0	-	-				0	-	-				1	0.001	0.006				0	-	-			
Total	175	-	-				1014	-	-				815	-	-				188	-	-			

between Tabriz and Ankara cities. Although, species richness was higher in Tabriz (S = 9–14) than Ankara (S = 6–8), the evenness and Shannon–Wiener indices were higher in Ankara (E = 0.873–0.981, H = 2.454–2.618) than in Tabriz (E = 0.578–0.809, H = 1.526–1.778). The Shannon–Wiener index is influenced by species richness and species evenness indices (Zouirech et al. 2015). The distribution of species in a population (species evenness) was higher in Turkey thus the biodiversity of flies was higher in Turkey than in Iran.

The results of our study showed that the highest rate of flies' frequency was observed in August and the lowest in July. Considering that our sampling was done only in four months, it is not possible to compare the seasonal activity of flies between Iran and Turkey.

In the south of Iran, in three Islands located in the Persian Gulf with tropical climate, ten species (S = 10) of flies were captured, seven of which were also collected in our study area. In the south of the country, the highest flies frequency was observed in early spring and fall (Khoobdel et al. 2013). In Tabriz, characterized by mild weather, the highest species frequency was observed in summer (August). In other studies, conducted on flies populations in north, center, and southwestern Iran including Mazandaran (S = 7 and H'= 1.005), Qom (S = 13 and H'= 1.87), and Khuzestan (S = 3 and H'= 0.67) Provinces, the alpha diversity indices varied, the highest rates of biodiversity indices were observed in the central part and the lowest ones were in the southwest. The species richness in East Azerbaijan Province was higher than in the mentioned three provinces and the mean value of Shannon–Wiener in our study area was higher than in the north and southwest areas (Davari et al. 2015; Mozaffari et al. 2020; Motevalli Haghi et al. 2021).

However, biodiversity indices are influenced by some factors including climatic and topographic condition, type of vegetation, etc. (Feliciangeli 1987; Kassem et al. 2012). These factors differ between various areas of Iran. The vast area with suitable climatic conditions and topography has a positive effect on the establishment and increase of the populations of different species of flies, and as a result, biodiversity naturally increases (Mozaffari et al. 2020; Motevalli Haghi et al. 2021).

Flies play a crucial role in estimating the Post-Mortem Interval (PMI) and can provide valuable evidence in forensic studies (Verma and Paul 2013; Sharma et al. 2015). The present study confirmed that forensically important species including *C. vicina*, *L. sericata, Ch. albiceps, S. africa*, *S. variegata,* and *S. argyrostoma* (Fremdt and Amendt 2014; Grisales et al. 2016; Ren et al. 2018) are present in Tabriz County. The geographic zone has the main influence on the species diversity of arthropods and on the sequence of their appearance on a corpse. For example, forensically important species of Sarcophagidae were commonly seen on indoor corpses, which could be due to their special biological characters (Fremdt and Amendt 2014; Baz et al. 2015; Szpila et al. 2015; Matuszewski et al. 2016). *Sarcophaga africa*, *C. vicina* and *S. variegata* that were captured in our study area, live in human dwellings and are known as indicators of urban habitats in summer. While *Sarcophaga albiceps* Meigen, 1826 is considered as an indicator of rural habitats (Fremdt and Amendt 2014). Some species of flesh flies such as *S. africa* and *S. argyrostoma* usually were found on indoor corpses(Ren et al. 2018). So, it can be argued that the diversity and abundance of flies in a region is strongly related to their biological characters and habitat preferences.

It is important to note that six species, including *L. sericata, Ch. albiceps, S. africa,* and *S. argyrostoma*, as constant species, and *S. variegata,* as accidental species, were collected from the Specialized Dermatological and Infectious Hospital. The presence of these species in the vicinity of this hospital in the northwest region of the country could lead to various issues, including the occurrence of myiasis in open wounds resulting from burns, bedsores, or any other inadequately covered wounds (Azarmi et al. 2024). Several cases of nosocomial myiasis due to *L. sericata* and *Ch. albiceps* were reported from hospitals (Delwar et al. 2021; Zobairy et al. 2023). Skin injuries or wounds are not only infested with fly larvae, but flies are able to transfer antibiotic-resistant bacteria to patient's wounds (Ranjbar et al. 2016; Schaumburg et al. 2016). So the pattern of arthropods-borne diseases is directly related to the biodiversity of arthropods in each region and it is necessary to design vector control programs according to this basic information.

Conclusions

This study reports 16 species from five families of necrophagous flies for the first time in East Azerbaijan Province, including several medically and forensically important species. Given the highest species richness was observed in August and September, these months are recommended for capturing fly species for ecological, biological, and systematic surveys. The highest frequency of *L. sericata*, as the main candidate for maggot therapy, was observed in August, therefore, this month is recommended for catching and rearing this species for use in maggot therapy. The high diversity of medically important flies in the Tabriz County can cause health problems for people. Therefore, it is recommended to use measures to prevent the epidemic of diseases transmitted by flies as well as myiasis, especially around the studied hospital.

Supplementary Information The online version of this article (https://doi.org/10.1007/s11756-025-01951-2) contains peer-reviewed but unedited supplementary material.

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Authors'contributions Sara Doosti and Madineh Abbasi conceived the original idea for this study. Behrooz Naghili Hokmabad, Ahad Bazmani and Kamran Akbarzadeh helped supervise the project. Sahar Azarmi wrote the manuscript with support and revisions from Saideh Yousefi and Madineh Abbasi. Mostafa Farmani carried out the implementation. Saideh Yousefi and Omid Dehghan performed the species diversity analytics. All authors discussed the results and contributed to the final manuscript.

Data availability All data on which this article is based are included within the text.

Declarations

Ethical consideration The ethics committee at Tabriz University of Medical Sciences approved this protocol (Ethics Code: IR.TBZMED.VCR.REC.1399.405).

Consent for publication Not applicable.

Competing interests The authors declare that they have no competing interests.

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