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Research article

Floristic and ecological characteristics of biotopes in Bayrampaşa District (İstanbul)

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Abstract

In this study, the biotope types and their floristic compositions of Bayrampaşa, one of the rapidly developing and increasingly populated districts of İstanbul, were investigated. The characteristics of biotopes and an inventory of the natural and exotic taxa they contain were created, and also the ecological characteristics of the biotopes were included. Biotopes in the district were visited in different seasons of the year, and plant samples were collected in accordance with herbarium techniques, then dried and identified. The list of exotic taxa was taken from the Bayrampaşa Directorate of District Parks and Gardens. In addition, soil samples were taken and chemical analyses were made. The main biotopes identified in the district are; parks, gardens of public buildings, industrial areas, railways, roadsides and abandoned lands. Out of a total of 236 taxa identified in these biotopes, 121 of them were natural and 115 were exotic. *Asteraceae*/*Compositae* came to the fore with the number of natural taxa it contains and *Rosaceae* with the number of exotic taxa it contains. As a result of the study, the importance of urban ecological studies in such regions was emphasized by drawing attention to biotopes that are under pressure with rapid urbanization, especially in rapidly developing cities.

Keywords: Bayrampaşa; biotope types; ecological planning; urban ecology; urban flora

1. Introduction

Scientists who investigated living creatures and their interactions with their environment looked for answers in forests, tropics, and uninhabited islands, which are isolated biotopes from human communities, and thought that the fauna and flora of cities were not regular due to the human factor (Altan, 1997). However, cities can have surprising richness in terms of ecological diversity when compared with wild habitats of similar sizes. In fact, many studies have shown that cities have a richer and more diverse flora than the surrounding rural areas. (Sukopp and Werner, 1983; Pyšek and Pyšek, 1990; Kühn, et al., 2004). When the reason for this rich biodiversity was investigated, it was revealed that this was the result of high habitat diversity (Gilbert, 2012). As urban biodiversity is understood, research interest in cities has increased and urban ecology has gained a serious momentum in recent years (Sukopp, 2002). Urban ecology is a sub-branch of ecology and its main purpose is to reveal and examine the direct or indirect effects of cities and urbanization on the natural environment (Gilbert, 1989).

Today, more than 56% of the world's population lives in cities, and for the first time in 2007, the world urban population exceeded the rural population (The World Bank, 2019). With the increasing population and expanding cities, a large part of the environmental problems have been transferred to the cities, and it has become important to protect natural areas in cities and making them sustainable at the same time. Cities are the most differentiated ecosystems of the earth and resemble large laboratories allowing investigations by containing many ecological factors (Collins et al., 2000). There are remarkable differences in urbanization levels of developing and developed economies. While developed countries have completed their infrastructures, solved their urbanization problems and controlled the urban population, the situation in developing economies is the opposite and today more than 2/3 of the population in these countries live in cities. 30 of the 60 cities with a population of over 5 million

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in the world are in the developing Asian countries (United Nations, 2018).

Urban ecosystems can be damaged by floods, storms and other heavy weather events as well as human activities, rapid urbanization and similar factors. However, natural habitats can also be damaged by urbanization and face the risk of extinction, which consequently, brings great risks to wildlife (Sahin, 2002). Protecting and improving the ecological and visual values of cities, ensuring the continuity of green spaces in the city and protecting the natural balance may be possible with a plan (Ozay, 2014). In this direction, the first conservation method that comes to mind is to protect natural treasures such as water, vegetation and soil from possible damage and then to increase and develop green areas. Initially, it is necessary to determine the biotopes that have an important place in the urban ecosystem and to reveal the ecological and floristic characteristics of these biotopes to achieve the aforementioned goal (Altay et al., 2010).

A few studies examining the ecological and floristic properties of the major biotope types in İstanbul can be mentioned. Among these, studies that examine the amount of green areas in central districts of İstanbul (Aksoy, 2001) and examining seasonal flowers and bulbous plant practices in public green spaces in İstanbul (Onat, 2012) can be cited. In addition, studies that examine the urban ecology and floristic characteristics of İstanbul districts include Eminönü and Fatih (Sahin, 2002), Kadıköy (Osma et al., 2010), Kartal (Altay et al., 2010), Pendik (Eskin et al., 2012), Üsküdar (Mutlu, 2004), Ümraniye (Borekci, 2008), Sarıyer (Gullu, 2009), Beşiktaş (Kabaalioglu, 2013) and Zeytinburnu (Yapar, 2013). Two recent studies in the neighboring city of Kocaeli also reveals floristic characteristics of railways (Altay et al., 2015) and other urban transport areas along with the hemeroby degrees (Beyhan et al., 2020).

Bayrampaşa, which is one of the central and major districts of İstanbul, has experienced a rapid population growth in recent years and natural areas have been damaged and eventually different biotopes have appeared (Anonymous, 2015). A study similar to that of the abovementioned studies has not been conducted for Bayrampaşa District, and for this reason this study is aimed to reveal the district's floristic and ecological features. Thusly, it is intended to draw attention to the negative consequences of unplanned urbanization and industrialization on urban ecology and to create awareness in order to take necessary measures.

2. Materials and methods

2.1. General information of study area

2.1.1. Location

Bayrampaşa, located at 41° 01' north and 28° 55' east coordinates, is neighboring Gaziosmanpaşa District to the North, Eyüp District to the East, Zeytinburnu District to the South and Esenler District to the West. The district is located on Thrace lands, the European side of İstanbul (Fig. 1).

2.1.2. Population and demographics

As of 2020, Bayrampaşa District with a total population of 274,735 has a surface area of 9.61 km^2 and a population density of 28,588 people/km^2 (Table 1). The proportion of females and males in the population is 50.37% and 49.63% respectively. Since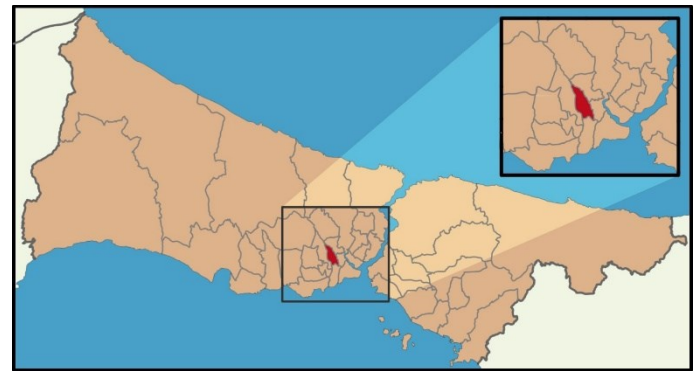 the district is centrally located in terms of culture, shopping, education and transportation, the active population can reach and even surpass 1 million during the day. In the 1970s, the agriculture-dominated district economy is now dominated by industry and trade. The Bosnian population, which increased as a result of immigration from Yugoslavia in the 1960s, forms the basis of the socio-cultural structure of the district (Endeksa, 2020).

Fig. 1. Location of Bayrampaşa District within İstanbul (Anonymous, 2009).

Neighborhood	Population
Yıldırım	53315
Kartaltepe	44022
Muratpaşa	34105
Altıntepsi	28674
Kocatepe	21549
Cevatpaşa	19243
Yenidoğan	18675
Terazidere	15791
Orta	15255

Table 1
Population of Bayrampaşa neighborhoods in descending order (Endeksa, 2020).

2.1.3. History

During the conquest of İstanbul in 1453, the district, which served as a headquarters and rallying center, gained importance in the defense of the region with the barracks, shelters and hospitals being built subsequently. Immigration from Balkan countries as a result of Ottoman Empire losing its power in the region, significantly increased the population of the district. With subsequent immigration from Yugoslavia in the 1950s and 1960s, the current sociocultural structure of the district has been shaped. The reason why Bayrampaşa is a popular destination as a residential area for the immigrants is the number factories built in those years.

The name of the district comes from Bayram Pasha, one of the grand viziers of Sultan Murad the 4th. Maltepe Military Hospital built in 1827 and Ferhat Pasha Farm, which was established at the end of the 19th century, are among important historical heritage in the region. Unfortunately, there are not many traces left from the aqueducts and water scales in Bayrampaşa that were built during the reign of Sultan Süleyman the Magnificent (Bayrampasa Bld., 2020).

2.1.4. Topography and geology

When we look at the general topographical features, İstanbul is in the form of an eroded plateau extending along Kocaeli and Çatalca Peninsulas (Fig. 2 and 3). (IBB, 2007, 2020). The research area is located in Çatalca or Trakya peneplain in the European side of İstanbul Province.
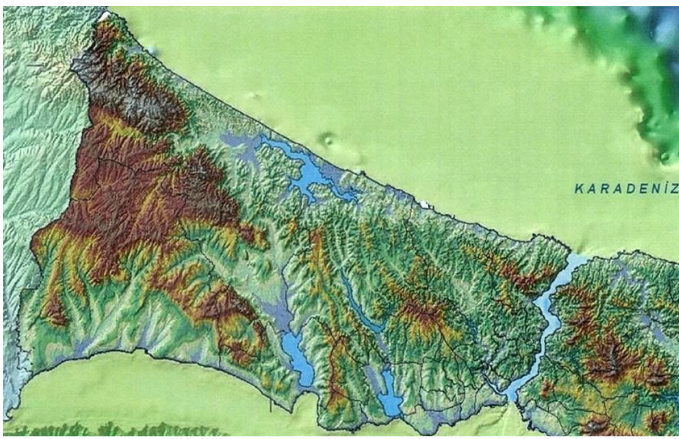
Fig. 2. Topographic map of İstanbul showing mainly the European side with Black Sea on the top (IBB, 2007).

Fig. 3. Lidar (Light Detection and Ranging) imaging of a large part of İstanbul city center, including Bayrampaşa District, comprising the historic peninsula, Bosphorus strait in the middle and Golden-Horn (IBB, 2020).
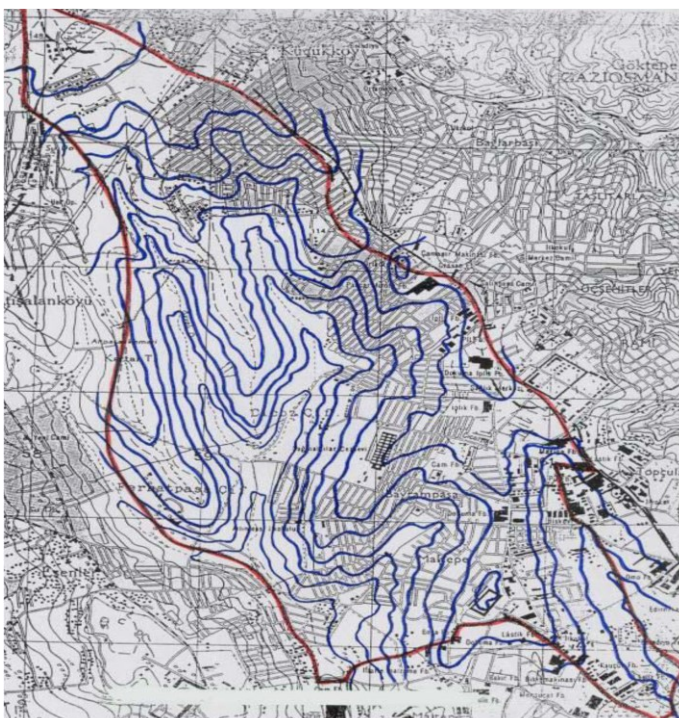

Fig. 4. Topography of Bayrampaşa District (Karabas, 2010).

This peneplain contains river valleys with broad bases, except for a few hills exceeding 200 meters on the Büyükçekmece

-Karaköy line from the Bosphorus. When we look at the topography of Bayrampaşa District, we observed an altitude of up to 145 m from sea level and decreasing towards the South. This altitude goes down to 30 m in the Northwest (Fig. 5) (Anonymous, 2015).
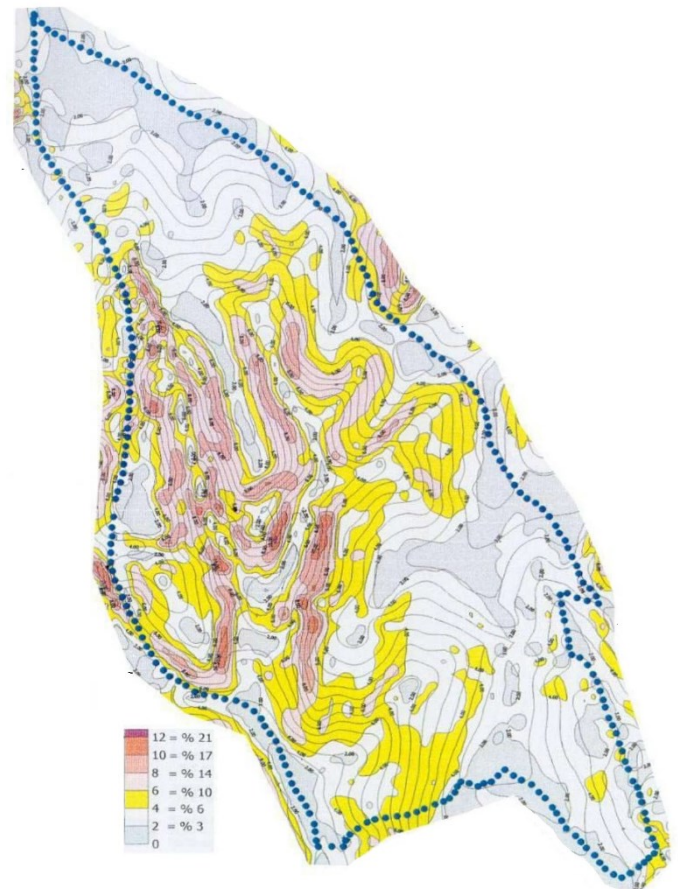

Fig. 5. The gradient map of Bayrampaşa District (Karabas, 2010).

The settlements in the district are generally established on a land with a slope of 0-15% and there are very few settlements on the land with a slope of more than 20% (Fig. 6) (Karabas, 2010).

2.1.5. Soil properties

There are lime-free brown forest and brown forest soils around Bayrampaşa District. These shallow soils contain A and C horizons. Below them is the D horizon, which is the bedrock. The B horizon, known as the accumulation zone, is not generally seen around Bayrampaşa. Some problems such as stony and rocky soils of the district and high erosion limit agricultural activities (Ozay, 2014).

2.1.6. Climatological properties

The province of İstanbul, which is geographically a transitional area, displays a complex structure in terms of climate. Generally, the city's climate is a combination of oceanic climate, Mediterranean climate and continental climate. A large part of the city has a mild version of the Mediterranean climate and generally has hot and dry summers (Yildizci, 1978). High relative humidity is observed in the district due to its proximity to the sea. According to the data we have obtained, the hottest months

are July (23.2 ºC) and August (23.1 ºC), the coldest months are January (5.1 ºC) and February (5.5 ºC). Average temperature is 13.8 ºC annually. The lowest and highest temperature values are seen in January (-12.6 ºC) and August (38.5 ºC) (Anonymous, 2011). Severe winds with an average speed of 2.9-4.2 m/s are seen in the district on 71 days of the year. In the district, 28.3% (181.4 mm) of the annual precipitation falls in autumn, 21.4% (136.5 mm) in spring and 39.5% (252.2 mm) in winter. Annual relative humidity average is 75%. The vegetation months are the 8 months between April and November with an average temperature of +10.0 ºC or higher temperatures. The amount of precipitation falling within the vegetation period is 293 mm (Anonymous, 2011).

2.1.7. Status of green areas and parks

There are many green areas and parks arranged for public use in the district. Many parks have basketball courts, children's playgrounds, volleyball courts and other sports fields. Istanbulites preferred to go to recreation areas and gardens until the mid-19th century (Osma et al., 2010). Today, there are 70 parks and children's playgrounds, 36 median-strips, 15 basketball courts and 28 ornamental pools in Bayrampaşa District. The amount of green space in the district, which was 124,687 m² in 1994, has been increased to 572,133 m² today as a result of the efforts and works carried out by the Parks and Gardens Directorate. While the amount of green area per person in Bayrampaşa District was 0.75 m² in 1994, today this value has been increased to 4.05 m². There is an 849% increase in the amount of green areas in the district as a result of intensive work (Anonymous, 2015). List of green areas, parks and playgrounds of the district are given in Appendix 1.

2.1.8. Natural vegetation, exotic plants and plant diversity

The dominant vegetation of the region is maquis and pseudomaquis, which in time, replaced the oak and chestnut forests that were destroyed as a result of urbanization (Avci, 2008). Since the northern parts of İstanbul are colder than the south, the number of species is fewer in these regions (Yaltirik and Uluocak, 1973). The most important of the families that make up the natural vegetation of the biotopes in the study area are *Asteraceae/Compositae* comprising 13.18% of all the species followed by *Leguminosae/Fabaceae* family with 10.85%, *Poaceae/Gramineae* with 10.08% *Brassicaceae/Cruciferae* family with 5.4%, *Rosaceae* family with 3.1%, *Lamiaceae/Labiatae* family with 2.32% and other families totaling the remaining 52.71%.

While significant changes have been observed in native plant species due to human factors in the living areas of the city, it is known that many exotic plant species that are not naturally found in the city have moved to this environment. For various reasons, some grown trees were removed from their original places and planted in different areas (Ozay, 2014). Although they do not have a natural distribution area in İstanbul, cypress trees are widely spread and have an important place in the geographical view of the city. Cypresses attracted attention not only because of the precious wood, but also because of its appearance that appeal to the people (Yaltirik et al., 1997). There are many cypress trees in Bayrampaşa District, especially Bayrampaşa City Park. Persian silk tree (*Albizzia julibrissin* Durazz.), magnolia (*Magnolia grandiflora* L.), Chinese wisteria (*Wisteria si-*

nensis DC.), horse chestnut (*Aesculus hippocastanum* L.) and palm (*Washingtonia robusta* H.Wendl.) are just some of the exotic trees located in Bayrampaşa District of İstanbul. Although there is no natural distribution area in İstanbul, one of the species that has been transported to Europe from İstanbul is the Persian silk tree. The seeds of Persian silk tree, whose scientific name is *A. julibrissin*, were transported from İstanbul to Florence by an Italian named Filippo Degli Albizzi in 1745. Scientific definition of this plant was made by botanists in 1787 (Ozay, 2014). Among the exotic species brought to İstanbul more recently are *Ginkgo* and *Robinia* species, red flowered horse chestnut, American sweetgum tree, magnolia and cypress species (Yaltirik et al., 1997).

The species that stands out as an invasive species in the city is *Acer negundo* L., known as the ash-leaf maple which has a natural distribution area in North and Central America. Among the maple species, *A. negundo* has been reported to have the most allergenic pollens (Medrzycki, 2007). *A. negundo*, having a rapid growing nature, was planted on parks, gardens and roadsides in Europe during the 17th century.

With around 2500 vascular plant species, İstanbul has a richer diversity than the Netherlands (1600 species) which has a land area 8 times larger than İstanbul, and the UK (1850 taxon) which is 47 times larger than İstanbul, whereas having almost the same level of plant diversity with Poland, which is 60 times larger. In addition, there are 23 species endemic to İstanbul flora and 40 species endemic to Turkey flora in İstanbul (Ozhatay and Keskin, 2007). 112 Important Plant Areas in Turkey is determined (Ozhatay et al., 2005) and 5 of them are located on the European side of İstanbul (Ozay, 2014). However, our study area Bayrampaşa District, does not contain any important plant areas.

2.1.9. Biotopes

The regions selected as inspection areas for our study from the biotope types within Bayrampaşa District (Table 2).

Table 2
Biotope types and inspection areas in the study area.

Biotope Type	Study Area
Parks (Recreational Areas)	Şehit Hüseyin Usluca Park, Şehit Cehar Dudayev Park, Nasrettin Hoca Park, Kıyı Sokak Park, İsmet Paşa Park, Sabri Akpınar Park, Cezaevi Yolu Park, Şehit Zafer Gürcan Işık Park, Alia İzzet Begoviç Park, Recep Tayyip Erdoğan Park, Çevre Park, Dr. Nihat Ergin Park, Avas Köyü Yolu Park, Kocatepe Metro Park, Bayrampaşa Şehir Park, Yıldırım Bayezit Park, Sevgi Park, Cumhuriyet Park, Dr. Sadık Ahmet Park, Sancak Park, Nermin Divoviç Park
Gardens of Government Buildings	Bayrampaşa State Hospital, Sabit Büyükbayrak Vocational and Technical Anatolian High School, Yıldırım Police Station
Industrial Zones	Bayrampaşa Industrial Zone
Railroad Stations	Kocatepe Metro Station, Sağmalcılar Metro Station
Roadsides	Trans European Motorway connections
Abandoned Lands	Land located across Bayrampaşa City Park, Land across Hidayet Türkoğlu Sports Complex, Land across Sabit Büyükbayrak Vocational and Technical Anatolian High School

2.2. Research methods

The research materials are the soil and plant samples collected from Bayrampaşa District along with the documents obtained from related institutions.

Plants growing in some biotope types in Bayrampaşa District are collected at vegetation period and dried by applying herbarium methods, and these collected plant samples were identified several sources but mainly by making use of "Flora of Turkey and the East Aegean Islands [Vol. 1-9 and Supp. Davis, P.H. (Ed) (1965-2001)] (Davis, 1965-1985)". Subsequently, the determination of the species was made definite by comparing the samples found in the Herbarium of Istanbul University Faculty of Science and the Marmara University Faculty of Arts and Sciences. The list of natural plants found in each biotope type is given in alphabetical order at the level of family, genus and species.

Lists of exotic species in biotope types examined in our study were obtained from Bayrampaşa Municipality Directorate of Parks and Gardens and rearranged in alphabetical order using the names from the books "Turkish Dictionary of Plant Names", (Baytop, 1997) and "Manual of Cultivated Plants", (Bailey, 1949). Photographs of the species that grow in the biotopes where our study was conducted (such as parks, road sides, industrial areas, railways, public buildings, abandoned lands) were also taken.

In addition, soil samples were taken from the studied biotope types. For this purpose, they were collected from a depth of about 10 cm with a stainless steel shovel and then labeled and packed into polyethylene bags. The analyses of soil samples were carried out in the Istanbul Municipality Parks and Gardens Directorate Quality Control Research and Development Laboratory in Anatolian side of İstanbul. In line with the reports received, it is understood that all analyses were made under $22 \pm 4^{o}C$ laboratory conditions. The methods used for each parameter in the analysis are presented in Table 3.

Table 3
Methods used in soil analyses.

Parameters	Analytical Method Used
Useful Potassium	TS 8341: 1990
Lime content	TS 8335 ISO 10693: 1996
Ph	Saturation mud
Useful Phosphorus	TS 8340: 1990
EC / Salt%	TS 8340: 1990
Soil Type	Bouyocus Hydrometry Method
Organic Matter	TS 8336: 1990
Ph	TS 8332 ISO 10390: 1995
Water Saturation	TS 8333: 1990

The theoretical data used in our study is obtained from İstanbul Metropolitan Municipality, Anatolian Side Parks and Garden Directorate Quality Control Research and Development Laboratory, İstanbul Metropolitan Municipality Parks Gardens and Green Areas Department European Side Parks and Gardens Directorate, Istanbul Metropolitan Municipality Map Directorate, Bayrampaşa Municipality Parks and Gardens Directorate, State Institute of Statistics İstanbul Regional Directorate, İstanbul Meteorology 1st Region Directorate, and also from the documents published on the official websites of the Directorates and the individuals working in these public institution as well as public and private libraries.

3. Results

The selected research areas from different types of biotopes were shown in Table 3. in materials and methods section of this article.

Biotope types chosen as study areas will be given under the related topics, separate lists of exotic and natural plant taxa determined in each biotope will be presented and additionally bioclimatic property data and soil analyses reports will be shared in Appendix 1.

A total of 6 biotopes were determined within the study area in Bayrampaşa District. A total of 236 taxa 121 of which is native and 115 exotic were identified. Total number of families within the study area was determined as 72. Ratios of native and exotic taxa in respect to the families were presented in Table 4.

Table 4
Distribution of families with the highest number of taxa in Bayrampaşa District.

Family	Number of Taxa	Ratio (%)
Native Taxa		
Asteraceae/Compositae	17	14.1
Brassicaceae/Cruciferae	7	5.79
Lamiaceae/Labiatae	3	2.48
Fabaceae/Leguminosae	14	11.57
Pinaceae	3	2.48
Poaceae/Gramineae	13	10.74
Rosaceae	4	3.31
Others	60	49.6
Exotic Taxa		
Asteraceae/Compositae	3	2.61
Brassicaceae/Cruciferae	0	0
Lamiaceae/Labiatae	3	2.61
Fabaceae/Leguminosae	5	4.35
Pinaceae	8	7
Poaceae/Gramineae	3	2.61
Rosaceae	12	10.43
Others	81	70.43

Number of taxa found in each biotope type is presented in Table 5. Also the comparison of results from studies conducted in other districts of İstanbul is presented in Table 6. The natural taxa that belong to the biotopes that our study was carried out, and the number of different biotopes that these taxa were detected in, can be seen in Appendix 2.

Table 5
Number of taxa found in each biotope type in Bayrampaşa District

Biotope Type	Number of Natural Taxa
Parks and Recreational Areas	79
Gardens of Government Buildings	21
Industrial Zones	32
Railroads	39
Roadsides	62
Abandoned Lands	25

When the soil properties of biotope types in study area were investigated, almost every biotope has high usable phosphorus and usable potassium levels. Parameters with lower values however, were encountered in soils from abandoned lands biotopes.

Table 6

Comparison of result from our study and other studies [Eminönü (Sahin, 2002), Fatih (Sahin, 2002), Kadıköy (Osma et al., 2010), Çatalca (Genc, 2003), Üsküdar (Mutlu, 2004), Kartal (Altay et al., 2010), Ümraniye (Borekci, 2008), Beşiktaş (Kabaalioglu, 2013), Zeytinburnu (Yapar, 2013)] conducted in other districts of İstanbul.

	Family Name				
(%)	*Asteraceae*	*Poaceae*	*Fabaceae*	*Rosaceae*	*Lamiaceae*
Study Area	14.1	10.74	11.57	3.31	2.48
Eminönü	3	3	1	14	2
Fatih	3	3	1	14	2
Kadıköy	15.7	5.5	6.5	6	2.6
Çatalca	13.51	4.50	11.03	5.18	5.63
Üsküdar	7.6	7.6	13.9	5.8	3.13
Kartal	12	6	10	5.4	3.93
Ümraniye	12.08	9.58	12.08	4.58	5.83
Beşiktaş	12.72	10.58	9.09	5.09	2.90
Zeytinburnu	10.22	7.66	6.20	5.85	4.74

4. Discussion

The result of our study reveals *Asteraceae* as the family with the highest number of native taxa and *Rosaceae* as the family with the highest number of exotic taxa. It can be seen that these families are represented with the highest number of taxa in Flora of Turkey as well (Davis, 1965-1985).

It can be noticed that the number of native and exotic species are higher in Parks and Recreational area biotopes which is considered natural since the soil in these biotopes is richer in organic substances and water filtration characteristic of soil is better.

The ratio of the number of species in large families and the ratio of genera with the most taxa, from comparable floristic and ecological studies in İstanbul; Eminönü-Fatih (Sahin, 2002), Kadıköy (Osma et al., 2010), Üsküdar (Mutlu, 2004), Kartal (Altay et al., 2010), Ümraniye (Borekci, 2008), Beşiktaş (Kabaalioglu, 2013) and Zeytinburnu (Yapar, 2013) is similar. We are of the opinion that the reason for this is that the study regions are close to each other and have similar ecological factors.

A total of 873 exotic plants have been identified in 52 important parks, gardens and groves of İstanbul (Yaltirik et al., 1997). If we include the species found in other green areas to this figure, we can conclude that İstanbul has an extremely rich plant species diversity.

There are 79 natural taxa in 70 parks in Bayrampaşa District. The species diversity in the study is not comparable to İstanbul in terms of species richness used in vegetation. The main reason for this situation can be attributed to the soil structure. Investigation of afforestation in the city in Bayrampaşa District was carried out by Aksoy (2002). The plants of Bayrampaşa City Park were researched by Yeler (2004), and the open and green areas of Bayrampaşa District were investigated in terms of quality and quantity by Levend (2008). Thus, important scientific data were obtained for planting the parks and green areas of Bayrampaşa District. These studies have generally been plant centered or vegetation- oriented, and natural flora and soil characteristics have not been studied. This situation is also valid for the works carried out for other parks and green areas of İstanbul.

When some natural taxa determined in our study are evaluated on the basis of species; it is noteworthy that although some taxa are found in almost every biotope, some species are encountered only in certain biotope types. The main reason for this situation may be different ecological tolerances of taxa. While ecologically tolerant species (these are generally invasive taxa) are encountered in different biotope types, species with low ecological tolerance are generally found in a limited number of biotopes.

The hemeroby degrees of some of the biotopes in our area of study are compatible with the hemeroby degrees determined by Sukopp and Weiler (1988). If we evaluate our work area according to the hemeroby scale; we see that H0, H1, H2, H3, H4 and H8 degrees are not present. We can find H5 degree in ruderal areas, H6 degree in small meadows seen between the neighborhoods, H7 degree of hemeroby in lands used in agriculture, and H9 degree in train stations, in all highway arteries and garbage collection areas.

Acidic fertilizers should be preferred for fertilizing in parks. Since nutrient intake will be difficult in soils with pH between 7 and 8, the pH will be lowered with acidic fertilizers to facilitate the nutrient intake of the plants (Fageria & Zimmermann, 1998). The change of soil characteristics and pollution should be checked regularly by taking soil samples. Factors causing soil, water and air pollution should be determined and solutions should be developed. With the pollution map and inventories created, the localities and how to intervene these areas should be determined. Industrial environments should be afforested for natural air treatment and facilities should be established for the disposal of wastes. Bad weather, soil and water conditions reduces the biological diversity and cause disruption of the natural balance. This ultimately affects humans, who are the most important and topmost element of the pyramid of living beings.

Appendix 1

1. *Natural Taxa Found in Biotopes of Bayrampaşa*

1.1. *Natural taxa found in parks and recreational lands biotopes*

SPERMATOPHYTA

A. GYMNOSPERMAE

CUPRESSACEAE
Cupressus sempervirens L.
Juniperus communis L.

PINACEAE

Cedrus libani A. Rich
Pinus pinea L.
TAXACEAE
Taxus baccata L.

B. ANGIOSPERMAE
a. MAGNOLIOPSIDA / DICOTYLEDONEAE

APIACEAE / UMBELLIFERAE
Berula erecta (Huds.) Coville

APOCYNACEAE
Nerium oleander L.
Vinca major L.

ASTERACEAE / COMPOSITAE
Anthemis arvensis L.
Bellis perennis L.
Cichorium pumilum Jacq.
Cota altissima (L.) *J.Gay*
Erigeron canadensis L.
Matricaria chamomilla L.
Senecio leucanthemifolius subsp. *vernalis* (Waldst. & Kit.) Greuter
Sonchus oleraceus L.
Taraxacum campylodes G.E.Haglund

BORAGINACEAE
Anchusa azurea Miller
Echium plantagineum L.
E. vulgare L.
Heliotropium europaeum L.

BRASSICACEAE / CRUCIFERAE
Capsella bursa-pastoris (L.) Medik.
Descurainia sophia (L.) Webb Ex Prantl
Draba muralis L.
Raphanus raphanistrum L.

CARYOPHYLLACEAE
Stellaria media (L.) Vill.

CONVOLVULACEAE
Convolvulus arvensis L.

CUCURBITACEAE
Ecballium elaterium (L.) A. Rich.

ELAEAGNACEAE
Elaeagnus angustifolia L.

EUPHORBIACEAE
Euphorbia helioscopia L.

GERANIACEAE
Erodium gruinum (L.) L'Hér.
Geranium molle L.
G. rotundifolium L.

JUGLANDACEAE
Juglans regia L.

LAMIACEAE / LABIATAE

Ballota nigra L. subsp. *anatolica* P. H. Davis
Lamium purpureum L.
Mentha spicata L.

LAURACEAE
Laurus nobilis L.

LEGUMINOSAE / FABACEAE
Cercis siliquastrum L.
Gleditsia triacanthos L.
Lotus tenuis Waldst. & Kit.
Medicago polymorpha var. *vulgaris* (Benth.) Shinners
Melilotus indicus (L.) All.
M. officinalis (L.) Pall.
Robinia pseudoacacia L.
Trifolium campestre Schreb.
T. repens L. var. *repens* L.

MALVACEAE
Malva nicaeensis All.
M. sylvestris L.

MORACEAE
Ficus carica L. subsp. *carica* (All.) Schinz et Thell.
Morus alba L.

OLEACEAE
Jasminum fruticans L.
Ligustrum vulgare L.
Olea europaea L.

OXALIDACEAE
Oxalis articulata Savigny
O. corniculata L.

PLATANACEAE
Platanus orientalis L.

POLYGONACEAE
Rumex acetosella L.

PRIMULACEAE
Anagallis arvensis L.

RANUNCULACEAE
Helleborus orientalis Lam.
Ranunculus marginatus D'Urv.

ROSACEAE
Crataegus monogyna Jacq.
Prunus avium (L.) L.
Rosa canina L.
Rubus sanctus Schreb.

SALICACEAE
Salix alba L.

PLANTAGINACEAE
Cymbalaria muralis Gaertn., B. Mey. & Scherb.
Veronica cymbalaria Bodard
V. persica Poir.

TILIACEAE

Tilia argentea Desf. ex DC.
URTICACEAE
Urtica dioica L.

VIOLACEAE
Viola sieheana W.Becker

VITACEAE
Vitis vinifera L.

b. LILIOPSIDA / MONOCOTYLEDONEAE
ASPARAGACEAE
Muscari neglectum Guss. ex Ten.

POACEAE / GRAMINEAE
Dactylis glomerata L.
Hordeum murinum L.
Lagurus ovatus L.
Phalaris minor Retz.
Setaria italica (L.) P. Beauv.

Appendix 2

1. Taxa that can be found in multiple biotopes

Hordeum murinum L. (*Poaceae/Gramineae*) 6 biotopes
Lamium purpureum L. (*Lamiaceae/Labiatae*) 5 biotopes
Cupressus sempervirens L. (*Cupressaceae*) 5 biotopes
Bellis perennis L. (*Asteraceae/Compositae*) 4 biotopes
Capsella bursa-pastoris (L.) Medik. (*Brassicaceae/Cruciferae*) 4 biotopes
Sinapis arvensis L. (*Brassicaceae/Cruciferae*) 4 biotopes
Convolvulus arvensis L. (*Convolvulaceae*) 4 biotopes
Euphorbia helioscopia L. (*Euphorbiaceae)* 4 biotopes
Malva sylvestris L. (*Malvaceae*) 4 biotopes
Rumex acetosella L. (*Polygonaceae*) 4 biotopes
Ranunculus marginatus D'Urv. (*Ranunculaceae*) 4 biotopes
Veronica persica Poir. (*Plantaginaceae)* 4 biotopes
Festuca heterophylla Lam. (*Poaceae/Gramineae)* 4 biotopes
Juniperus communis L. (*Cupressaceae*) 3 biotopes
Cedrus libani A. Rich (*Pinaceae*) 3 biotopes
Nerium oleander L. (*Apocynaceae*) 3 biotopes
Carduus pycnocephalus L. (*Asteraceae/Compositae*) 3 biotopes
Dittrichia viscosa (L.) *Greuter* (*Asteraceae/Compositae*) 3 biotopes
Raphanus raphanistrum L. (*Brassicaceae/Cruciferae*) 3 biotopes
Elaeagnus angustifolia L. (*Elaeagnaceae*) 3 biotopes
Lotus tenuis Waldst. & Kit. (*Leguminosae/Fabaceae*) 3 biotopes
Muscari neglectum Guss (*Asparagaceae*) 3 biotopes
Dactylis glomerata L. (*Poaceae/Gramineae*) 3 biotopes
Echinochloa cruss-galli (L.) P. Beauv. (*Poaceae/Gramineae*) 3 biotopes
Poa annua L. (*Poaceae/Gramineae*) 3 biotopes
Setaria viridis (L.) P. Beauv. (*Poaceae/Gramineae*) 3 biotopes
Pinus nigra J. F. subsp. *pallasiana* (Lamb.) Holmboe (*Pinaceae*) 3 biotopes

Pinus pinea L. (*Pinaceae*) 3 biotopes

2. Taxa found in only one type of biotope

Ammi visnaga (L.) Lam. (*Apiaceae/Umbelliferae*)
Berula erecta (Huds.) Coville (*Apiaceae/Umbelliferae*)
Daucus carota L. (*Apiaceae/Umbelliferae)*
Vinca major L. subsp. *major* (*Apocynaceae*)
Cardamine hirsuta L. (*Brassicaceae/Cruciferae*)
Descurainia sophia (L.) Webb Ex Prantl (*Brassicaceae/Cruciferae*)
Draba muralis L. (*Brassicaceae/Cruciferae*)
Stellaria media (L.) Vill. (*Caryophyllaceae*)
Chenopodium album L. (*Chenopodiaceae*)
Centaurium erythraea Rafn. (*Gentianaceae*)
Geranium molle L. (*Geraniaceae*)
Geranium rotundifolium L. (*Geraniaceae*)
Juglans regia L. (*Juglandaceae*)
Lythrum salicaria L. (*Lythraceae*)
Jasminum fruticans L. (*Oleaceae*)
Olea europaea L. (*Oleaceae*)
Oxalis articulata Savigny (*Oxalidaceae*)
Ranunculus arvensis L. (*Ranunculaceae*)
Prunus avium (L.) L. (*Rosaceae*)
Rosa canina L. (*Rosaceae*)
Rubus sanctus Schreber (*Rosaceae*)
Populus alba L. (*Salicaceae*)
Veronica cymbalaria Bodard (*Scrophulariaceae*)
Solanum angustifolium Mill. (*Solanaceae*)
Tilia argentea Desf. ex DC. (*Tiliaceae*)
Verbena officinalis L. (*Verbenaceae*)
Viola sieheana Becker (*Violaceae*)
Vitis vinifera L. (*Vitaceae*)
Cyperus longus L. (*Cyperaceae*)
Lagurus ovatus L. (*Poaceae/Gramineae*)
Panicum miliaceum L. (*Poaceae/Gramineae*)

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Research article

Standing of biotechnology subjects found in biology courses of higher education and profiling of prospective teachers for their interests on biotechnology

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Abstract

In this study, profiling of prospective teachers for their interests on biotechnology in higher education institutions has been conducted and in conjunction with this, the extent of biotechnology subjects in the textbooks of higher education institutions has been investigated. A questionnaire has been prepared to reveal the educational level on biotechnology in higher education institutions and the interest whom prospective teachers have in biotechnology. The prepared questionnaire has been applied to 100 prospective teachers receiving education in the Departments of Physics, Chemistry, Biology, and Applied Sciences Education in Kazim Karabekir Faculty of Education at Ataturk University. As a result of the questionnaire applied to prospective teachers, it has been determined that 54% of the prospective teachers are fond of the subjects related to biotechnology. Also, the assessment carried out for showed that most of the prospective teachers (65%) recognize the importance of biotechnology but also they believe that the subjects of biotechnology in higher education are not covered enough and the information given is not sufficient and the necessary explanations are not made about its importance.

Keywords: Ataturk University; biotechnology subjects; higher education; prospective teachers; questionnaire

1. Introduction

Applied sciences, namely biology, chemistry and physics, are disciplines that utilize existing scientific knowledge to develop more practical applications, technology, or inventions (Ozyigit, 2020a). Therefore, any advances in these disciplines directly affect people's futures. This puts forth the importance of the education of applied sciences students. Application of modern science and technology in education depends on the removal of conservative and dogmatic thoughts (Klimenko, 2017; Chowdhury, 2018; Bakholskaya et al., 2020). Nowadays, science and technology, along with molecular biology and biotechnology within life sciences are progressing rapidly (Arvas and Kaya, 2019).

While nature is being destroyed by humans unconsciously, natural resources are being depleted, environmental pollution

occurred (Turan et al., 2020; Yalcin et al., 2020). Natural environments are influenced by industrial and human activities and contaminated with harmful organic contaminants such as polycyclic aromatic hydrocarbons (PAHs), insecticides, herbicides and both organic (i.e. hydrocarbons, different solvents, petroleum products, pesticides, herbicides, polychlorinated biphenyls, phthalate esters, phenols, and their derivatives) and inorganic contaminants include heavy metals and metalloids such as arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), mercury (Hg), nickel (Ni), manganese (Mn), molybdenum (Mo) and zinc (Zn) (Gupta et al., 2020; Hocaoglu-Ozyigit and Genc, 2020). Having said that, an alternative eco-friendly perspective must be established so as biological control can be effectively used for organisms (Akcay and Kaya, 2019; Bahaman et al., 2020; Oyewusi et al., 2020).

The dramatic changes mentioned above made it a necessity to increase the researches in applied sciences branches and for well-educated scientists to focus on the solutions for these problems. In recent years, advances in biotechnology have shown promise in finding solutions to these problems via biotechnological methods and thus, training knowledgeable and sufficient people, who will work in problem solving using biotechnological applications, became a requirement. Also, improvement in observation, experimentation, analysis, synthesis and decision-making skills of candidate teachers is needed. The best way for this is to emphasize laboratory studies in the curriculum of physics, chemistry, biology and applied sciences education departments (Jeronen et al., 2017; Kumandas et al., 2019). Biology and consequentially biology education both including biotechnology, has priority among these science branches.

The word biology consists of two words; bios (living) and logos (science) and refers to the "science of life". Although the term "biology" was used by Roos in 1797, Burdach in 1800, and Lamarck and Trevianus in 1802, scientific researches in the field literally started 25-30 years later. The progress was amazing in a short period of 150-200 years, after the discovery of cell (Gardner, 1965; Serafini, 2013; Ozyigit, 2020a; Urry et al., 2020).

Today, biology has many branches such as anatomy, astrobiology, biotechnology, biochemistry, bioinformatics, biolinguistics, biological anthropology, biological oceanography, biomechanics, biophysics, botany, cell biology, developmental biology, ecology, ethology, evolutionary biology, genetics, histology, immunology, microbiology, molecular biology, neuroscience, paleontology, physiology, population biology, quantum biology, structural biology, synthetic biology, systems biology, theoretical biology, toxicology and virology (Ozyigit, 2020a).

Biotechnology is defined as the science that uses biological systems, living organisms, or parts of these to improve or create diverse products (Fári and Kralovánszky, 2006). With another definition, "Study of combination of both the living organism or their parts and a group of technologies to develop or make different products to improve the quality of human life" (Ozyigit, 2020a). Currently, biotechnology has a wide field of application and has many benefits for human life and all living organisms. Briefly, biotechnology covers the use of various biochemical and physiologic properties of microorganisms, cells and tissues mostly in cultured forms for practical purposes, gene recombination for obtaining desired features, remediation with organisms, in fields like agriculture, forestry, food industry, medicine, pharmacy, and even military (Ozyigit, 2012, Ozyigit et al., 2013; Arvas and Kaya, 2019; Bahaman et al., 2020; Muslem et al., 2020; Wahhab et al., 2020).

In fact, people used biotechnology for their daily activities

such as bread yeasting, vinegar and yogurt production, as well as making clothes and shelters since ancient times. However, with the advancement of biological techniques together with other science branches, microbiology, biochemistry, genetics, molecular biology, omics technologies, bioinformatics became the base of biotechnology today (Kaya et al., 2013; Filiz et al., 2017; Arvas and Kaya, 2019; Ozyigit, 2020a; Samsulrizal et al., 2020).

A special and remarkable field of application in biotechnology, recombinant DNA technology, is broadening peoples' horizon in sciences such as medicine, food technology, pharmacology and agricultural biotechnology, and providing large amount of benefits, as well (Johnson, 1983; Akalin, 2020; Gul, 2020; Plavec and Berlec, 2020; Tomic et al., 2021).

Recombinant DNA techniques and modern biotechnology can be applied to form proteins and genes that are not normally produced in a cell. Also, bacteria and living organisms carrying recombinant DNA can be released to the natural world to increase the fertility of the soil, can serve as an insecticide, used for molecular farming, biopharming or relieving pollution (Abdul et al., 2019; Hasan and Manan, 2020; Subramaniam et al., 2020). Microorganism research is now in the field of interest of food biotechnology, medicine, agriculture etc. (Cetinkaya et al., 2020; Ozyigit, 2020b; Ozyigit et al., 2020).

Some scientific works that have already been done using biotechnological methods and some possible future studies are; (1) obtaining plants resistant to biotic and abiotic stress and containing more nutritious products, (2) obtaining and raising healthier, productive, disease-resistant livestock, (3) transferring edible vaccines in food products, (4) environmental cleaning with transgenic organisms, (5) research and development of new drug formulations, especially obtaining delayed-release type formulation development, (6) obtaining recombinant therapeutic agents, diagnostics for infectious and genetic diseases and artificial organs and tissues, (7) development of specific gene delivery vectors and DNA vaccines and gene therapy, (8) identification of drug candidates with the help of the bioinformatics and genetic applications and (9) utilization of biotechnology in preclinical research and development (Arvas and Kaya, 2019; Akalin, 2020; Carvalho et al., 2020; Gul, 2020; Ozyigit, 2020b; Ozyigit et al., 2020; Plavec and Berlec, 2020).

Nowadays, keeping up with advancements in biotechnological fields has become a necessity. Turkey is rich in biotechnological raw materials and these should be used in the best way by entrepreneurs and institutions. This situation shows us that related branches of universities such as biology and life sciences should be supported in terms of knowledge and finances.

This work aims to determine the levels of biotechnology knowledge in lessons of higher education branches and the interest of prospective teachers in biotechnology.

2. Materials and methods

In order to determine the extents to which biotechnology subjects are included in the courses, the textbooks of which used in departments of Physics, Chemistry, Biology, and Applied Sciences Education in higher education were examined. Also, a surveillance research as a questionnaire was prepared to reveal the interest prospective teachers have on biotechnology subjects. The questions of the survey used to inquire about the interest of prospective teachers having can be seen in the results section.

2.1. Evaluation questionnaire

The questionnaire prepared was applied to the 100 prospective teachers receiving education from the four departments in Kazim Karabekir Faculty of Education at Ataturk University, Erzurum, Turkey. The departments and the number of students that survey performed were presented in Table 1. Due to considering as of an interfering factor, prospective teachers were chosen as half and half regarding with sex.

Table 1
Distribution of prospective teachers in the departments.

Department	Number of students (n)	Percentage (%)
Biology Teaching	34	34
Physics Teaching	22	22
Chemistry Teaching	24	24
Applied Sci. Teaching	20	20
Total	100	100

3. Results and discussion

3.1. Standing of where biotechnology subjects found in biology courses in the programs of higher education

The textbooks used in the programs of higher education were examined in this work. As a result of the examination, the subjects related with biotechnology were found to be in the contexts of these textbooks (in some extents) taught in the courses.

3.2. Evaluation of the prospective teachers receiving education in terms of their interests in biotechnology

The following questions below were asked to find out what extent the prospective teachers were interested in biotechnology subjects. The obtained results were evaluated and presented below.

3.2.1. Do the prospective teachers receiving education find the subjects of biotechnology in the programs of higher education interesting and current?

The opinions of the prospective teachers about whether they find the subjects related to biotechnology included in the curriculum of higher education up-to-date and interesting or not were given in Table 2. Of the prospective teachers who answered the question, 21% said that I find it definitely up-to-date and interesting, 35% said that I would be very interested, and 23% would be moderately interested. On the other hand, the rate of the prospective teachers who said "I have little interest on biotechnological subjects" was 13% while 8% of the prospective teachers answered as "I don't care".

Table 2
The interest of prospective teachers having on biotechnology subjects.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	21	21
Agree	35	35
Partly agree	23	23
Don't agree	13	13
Definitely don't agree	8	8
Total	100	100

3.2.2. Questions about inviting qualified persons for providing attraction on biotechnology issues to prospective teachers receiving education

The question about whether qualified persons to be invited for a seminar in order to provide attraction on biotechnology issues to prospective teachers and the answer that given for the question were given in Table 3. 87% of the prospective teachers' thought asked for inviting a qualified person for a seminar in order to provide attraction on biotechnology issues were positive as the answer, while 16% was moderately (partly) agree. Whereas, the rest of them gave negative answer for the proposal.

Table 3
Invitation of a qualified person for a seminar in order to provide attraction on biotechnology issues.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	28	28
Agree	43	43
Partly agree	16	16
Don't agree	8	8
Definitely don't agree	5	5
Total	100	100

3.2.3. When prospective teachers were asked for, should biotechnology issues be comprised in greater extent in the relevant textbooks?

In Table 4, the answers from prospective teachers were presented for the proposal related with whether biotechnology issues should be comprised in greater extent in the relevant textbooks. 86% of the prospective teachers participating in the questionnaire was agree about comprising biotechnology issues in greater extent in the relevant textbooks. Among them, 29% was partly agree. On the contrary, 14% stated that the information given was sufficient on biotechnology subjects.

Table 4
The percentages of the answers given related with whether biotechnology issues should be comprised in greater extent in the relevant textbooks.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	17	17
Agree	40	40
Partly agree	29	29
Don't agree	11	11
Definitely don't agree	3	3
Total	100	100

3.2.4. Biotechnology related subjects present in the curriculums

The answers given by the prospective teachers to the question of whether they care of the subjects related to biotechnology in the curriculum or not were presented in Table 5. The results showed that 12% of the prospective teachers states of having care for very much, 42% of them states of having care for fairly well and 25% of them states of having care for little interest. And, 21% of them states of having no care.

3.3. The opinions of prospective teachers about whether wishing to participate in laboratory exercises in biotechnology related subjects

The answers given by the prospective teachers to the question of whether they care of whether wishing to participate in laboratory exercises in biotechnology related subjects were pre-

sented in Table 6. While 17% of the prospective teachers said that they would participate in the laboratory exercises with pleasure, 32% of them said that they could participate, and 37% of them said that caring to participate in some sense. And, 14% of them said that do not wishing to participate.

Table 5
The percentages of whether caring of biotechnology subjects in the relevant textbooks or not being in the curriculums.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	12	12
Agree	42	42
Partly agree	25	25
Don't agree	10	10
Definitely don't agree	11	11
Total	100	100

Table 6
The opinions of prospective teachers about whether wishing to participate in laboratory exercises in biotechnology related subjects.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	17	17
Agree	32	32
Partly agree	37	37
Don't agree	9	9
Definitely don't agree	5	5
Total	100	100

3.3.1. Interest of the prospective teachers having about whether willing to participate on the research related with milk and cheese production using microorganisms

The information collected on the interest of the prospective teachers participating in the questionnaire in investigating milk and cheese making using microorganisms was presented in Table 7. 18% of the prospective teachers stated that they are definitely interested to involve in such a research. 38% of them was agree and 27% was partly agree. The rate of prospective teachers who are not very interested in this issue was 17%.

Table 7
Interest of prospective teachers in research related with milk and cheese production using microorganisms.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	18	18
Agree	38	38
Partly agree	27	27
Don't agree	11	11
Definitely don't agree	6	6
Total	100	100

3.3.2. Interest of the prospective teachers having about whether willing to participate on the research related with altering dangerous microorganisms into non-dangerous states

In Table 8, it is stated whether the prospective teachers take care of participating in a research related with altering hazardous microorganisms into non-hazardous states. While 26% of the prospective teachers who wants to participate in such research as saying definitely yes, 31% of them stated that they would like to participate, and 19% of the stated that they did not want to participate.

Table 8
Interest of prospective teachers in research related with altering dangerous microorganisms into nondestructive forms.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	26	26
Agree	31	31
Partly agree	29	29
Don't agree	9	9
Definitely don't agree	10	10
Total	100	100

3.3.3. Prospective teachers' opinions on the use of microorganisms in medical research

The opinions of the prospective teachers having whether interest to participate in the research related with the use of microorganisms in medical research was presented in Table 9. While 18% of the prospective teachers who absolutely wants to participate in such research, 35% of them stated that they could participate, 24% was moderately agree and 23% of them stated that they would not participate.

Table 9
The information taken as the prospective teachers' opinions on the use of microorganisms in medical research.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	18	18
Agree	35	35
Partly agree	24	24
Don't agree	17	17
Definitely don't agree	6	6
Total	100	100

3.3.4. Whether the prospective teachers are willing to participate in the research about converting hazardous wastes into non-hazardous forms using microorganisms.

The answers given by the prospective teachers to the questions about the research of converting hazardous wastes into non-hazardous forms were given in Table 10. 79% of the prospective teachers stated that they wanted to participate in such a study and 23% of them stated that they could participate in part. 8% of them stated that they could never participate.

Table 10
Interest of prospective teachers in research related with converting hazardous wastes into non-hazardous forms using microorganisms.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	21	21
Agree	35	35
Partly agree	23	23
Don't agree	13	13
Definitely don't agree	8	8
Total	100	100

3.3.5. Prospective teachers' opinions on employing microorganisms in establishing of bio-gas facilities

The answers given by the prospective teachers to the question about possibility of their involvement in researches in establishing of biogas facilities were given in Table 11. 32% of the prospective teachers says yes as they could definitely participate

in such works, 21% of them stated that they could participate, 20% of them says yes in part, and 27% of them says no.

Table 11
Possibility of prospective teachers to participate in a study related with using microorganisms in the establishment of biogas facilities.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	32	32
Agree	21	21
Partly agree	20	20
Don't agree	15	15
Definitely don't agree	12	12
Total	100	100

3.3.6. Prospective teachers' opinions on the gene therapy related issues including modifications of genes that cause hereditary diseases in humans

The answers given by the prospective teachers to the question about possibility of their involvement in researches on the gene therapy related issues including modifications of genes were given in Table 12. 52% of the prospective teachers stated that they can willingly participate in such a research, 26% of them stated that they can participate in part, and 22% of them stated that they are not interested at all.

Table 12
Prospective teachers' opinions whether want to involve or not in gene therapy oriented researches.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	16	16
Agree	36	36
Partly agree	26	26
Don't agree	13	13
Definitely don't agree	9	9
Total	100	100

3.3.7. Prospective teachers' opinions on the issues related to the use of biotechnology in plant breeding researches

The answers given by the prospective teachers participating in the survey to the question about the use of biotechnology in plant breeding studies were presented in Table 13. 29% of the prospective teachers stated that they prefer to participate in such a research, 28% of them stated that they could join to such a research in part, and 43% of them stated that they do not want to involve.

Table 13
Possibility of prospective teachers to participate in a research related to the use of biotechnology in plant breeding researches.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	11	11
Agree	18	18
Partly agree	28	28
Don't agree	28	28
Definitely don't agree	15	15
Total	100	100

3.4. Prospective teachers' opinions regarding whether they were gained competent knowledge about biotechnology during the secondary and high school education years

The prospective teachers' opinions on the question of

whether they had gained competent knowledge about biotechnology during the secondary and high school education years were given in Table 14. 10% of the prospective teachers participating in the survey stated that they definitely gained adequate knowledge about biotechnology during the secondary and high school education years, 42% of them said that they gained rather less, and 18% of them said that definitely did not gained.

Table 14
Consideration of whether prospective teachers were gained competent knowledge or not about biotechnology during the secondary and high school education years.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	10	10
Agree	23	23
Partly agree	19	19
Don't agree	30	30
Definitely don't agree	18	18
Total	100	100

In this study, the standing of where biotechnology subjects found in biology courses in higher education was investigated. For this purpose, general biology 1, 2, 3, and 4, environmental health, microbiology, genetics, mathematics, general physics, general chemistry and environmental chemistry textbooks were examined in terms of whether covering biotechnology related subjects.

As a result of the examination, it was found that there are some subjects related to biotechnology in the books that are read in the higher education curriculums in our country. The courses that include the subjects related to biotechnology (applications of molecules play roles in biotechnology, tools used in biotechnology, wastewater treatment strategies, recombinant DNA technology etc.) were found to be general biology, microbiology, genetics, and environmental health.

Achieving progress in biotechnology as in every field depends on the studies included in higher education programs. According to the results of the survey conducted to determine prospective teachers' interest in biotechnology, 79% (23% in part) of the prospective teachers find biotechnology-related subjects interesting and up-to-date. In the study, as definitely and/or fairly well, 71% of the prospective teachers agreed on inviting qualified persons to give seminars and providing up-to-date information on biotechnology. According to our results, 57% of prospective teachers want biotechnology subjects extensively to be included in the textbooks of higher education that indicates the need for covering more information on biotechnology subjects. Besides, 54% of the prospective teachers said that they enjoy with the subjects related to biotechnology in the curriculums.

When the prospective teachers were asked whether they would like to participate in laboratory researches with having different goals, 49% of them wants to participate as definitely and/or fairly well and 37% of them wants to participate in part. The results show that as definitely and/or fairly well; 56% of them wants to participate in researches involving in productions of milk and cheese using microorganisms; 57% of them stated their willingness to participate in researches involving modification of dangerous microorganisms into non-destructive forms; 53% of them wants to participate in researches involving in productions of vaccine, antibiotics, vitamins and enzymes using microorganisms; 56% of them prefer to join into researches regarding with converting hazardous wastes into non-hazardous forms using microorganisms; 53% of them care about involving

in researches related with obtaining gases such as methane and ethane using microorganisms.

The prospective teachers were asked whether they would like to take part in a research involving gene therapy related issues including modifications of genes that cause hereditary diseases in humans, 52% of them stated their agreement as definitely on the subject. Additionally, 29% of them wants to join into researches involving carrying out plant breeding activities.

In the study, 33% of the prospective teachers stated that biotechnology related subjects were not being covered enough in the time period of their secondary and high school; therefore, they stated that they do not have comprehensive knowledge on biotechnology subjects. This showed that biotechnology related subjects should be covered in a more way in secondary and high school education. Additionally, 2% of the prospective teachers stated that they are at least a member of a current academic and biotechnology journal. This reveals the fact that the level of biotechnological researches being performed is not quite enough and the students receiving education at universities do not have consciousness about the importance of biotechnology.

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Research article

Crossability and inheritance of seed coat colour in cowpea at F_1 generation

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Abstract

A study on crossability and inheritance of seed coat colour in cowpea was conducted between October, 2017 and August, 2018. Two accessions of cowpea: IT98K-205-8 (white seeded) and IT98K-555-1 (brown seeded) were used for the study. Plants were raised in plastic pots in the screen house, and as flowers mature, crosses were performed manually, early in the morning between 7.00 and 9:30 AM. Significant level of differences were detected between the crosses for all traits observed except for number of seeds per pod. Overall, 19 successful pods were generated from 67 crosses representing 28.36% success rate, and indicating a low level of compatibility between accessions. All seeds of F_1 plants were black, contradicting the model that maternal parents determine the phenotypes of F_1s. However, the two parents bred true for seed coat colour indicating their pure line status. It was shown that maternal effect played significant role regarding crossability, but did not influence the seed coat colour inheritance of the crop. These results indicated epistasis, and it is suggested that the inheritance of seed coat colour in cowpea is polygenic.

Keywords: Cowpea; epistasis; maternal effect; polygenic; seed coat color

1. Introduction

Cowpea (*Vigna unguiculata* L. Walp) is crop of significant importance in Africa; it serves as a source of proteins in the tropical and subtropical countries (Lelou et al., 2011; Stoilova and Pereira, 2013), where Nigeria is ranked the highest in terms of production (FAOSTAT, 2020). It is a source of income for the people of Africa where it is widely cultivated for different purposes (Ogunkanmi and Adekoya, 2013; Rangkham and Khanna, 2018). Despite the good attributes of cowpea, one of the major constraints hampering its productivity in Nigeria is drought (Fatokun et al., 2009). Breeding of genotypes with high level of tolerance to drought stress for all stages of growth and development are desirable to sustain yield. Nevertheless, breeding for drought must be done with consumer acceptability considerations to prevent drawbacks that might arise from rejection of improved varieties; as utilization of the crop in Africa is heavily dependent on consumer preference (Egbadzor et al., 2014).

One of the most important attributes of cowpea influencing its acceptability and its introduction to markets is the seed coat colour which has been a subject of study for ages, with the genetic factors underlying their expression elucidated (Herniter et al., 2019). There are various patterns of seed coat displayed by cowpea seeds and the preferred colours and pigmentations are region specific (Herniter et al., 2019). According to Egbadzor et al. (2014), the seed coat colour and pigmentation in crop plants are influenced by anthocyanin syntheses and controlled by some anthocyanin genes (like *pac 1* gene) which are abundant in plants and important to plants in signaling abiotic stress such as drought (Carvalho et al., 2019). Seed coat colour and pigmentation inheritance in cowpea has been reported to be quantitative in nature involving several genes (Oluwatosin, 2000; Mustapha, 2009), contrary to the findings of Yilwa (2012). These number of genes involved have been attributed to the seed coat colour combinations of the parental lines involved in specific crosses (Egbadzor et al., 2014).

Development of improved cultivars for any constraint requires combination of genotypes of diverse origins as parental stocks. Adapted individuals in terms of specific constraints in a particular ecology are normally the best sources of genes for breeding improved varieties. A larger genetic variability in existence in the tropics among cowpea genotypes serves as source of information for developing hybrids for specific constraints. However, proper choice of parents is critical to a successful breeding program of cowpea because of limitations resulting from hybridization for inheritance of polygenic traits (Aremu et al., 2007). Therefore, information on genetic compatibility and inheritance of seed coat colour and their relationship with drought tolerance in cowpea would contribute positively to the improvement of the crop through hybridization.

This research aimed at studying the level of crossability between two cowpea accessions and inheritance of seed coat colour in F_1 generation.

2. Materials and methods

The experiment was carried out at the screen house of the Department of Plant Science and Biotechnology (PSB), Adekunle Ajasin University, Akungba-Akoko (AAUA), Nigeria between October, 2017 and January, 2018 for the crosses, while evaluation of F_1 was done in the Plant Breeding Field, PSB, AAUA between April and August, 2018. Two accessions of cowpea: IT98K-205-8 and IT98K-555-1 received from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria were used for this experiment and were tagged A and B respectively. These accessions were chosen based on the following attributes: Both accessions were erect types and of Nigerian origin, while A is early maturing and moderate yielding, B is high yielding (Ajayi and Gbadamosi, 2020). Accession A had sub-hastate leaflet shape, straight pods, dark green leaves, dark green immature flowers, yellow-white mature flowers, dark green immature pod colour and white seed coat colour. Accession B on the other hand had hastate leaflet shape, slightly curved pods, pale green leaves, pale green immature flowers, purple-white mature flowers, pale green immature pods and brown seed coat colour. Accession A was drought tolerant, while B was drought susceptible and these attributes have been confirmed at seedling (Ajayi et al., 2018), vegetative (Ajayi et al., 2020) and flowering stages (data yet to be published). In addition, accession A combines *Striga* and *Alectra* resistance with early maturity and high yield (Singh et al., 2006; Ajeigbe et al., 2008; Noubissie Tchiagam et al., 2010; Hayatu et al., 2016).

Seeds were planted in plastic pots filled with 7.5 kg sandy loam soil without fertilizer application. Five seeds were planted

per pot per accession and later thinned to one plant per pot after two weeks of emergence.

Eight pots were used for each accession arranged in two rows for direct crosses and their reciprocals. Four pots from each cross held the plants which served as the pollen receptors, while the remaining four held the pollen donors. As the flowers begin to mature, crosses between accessions were performed manually very early in the morning between 7 AM and 9:30 AM (Singh et al., 1999) (with modifications). After the pollinations have been done, all pollinated flowers were tagged. The date of pollination and the type (direct/reciprocal) were written on the tags and harvesting of pods was done as they mature. Twenty seeds from each of the parents and crosses were grown in the field in non-replicated plots to produce seeds by natural self-pollination to observe the inheritance patterns of seed coat colour among individuals at pod maturity. Spacing of plants in the field was maintained at 30 cm intra row and 50 cm inter row spacing. Visual observation of seed coat colour was done and recorded for each plant at pod maturity.

The following data were collected for pollinated flowers: number of flowers pollinated, number of pods set, percentage of pods set, average pod length, average number of seeds per pod and average number of days to pod maturity. Percentage of plants emerged, percentage of plants survived, and percentage of plants expressing certain seed coat colours were also recorded for parents and the F_1 hybrids at pod maturity. Data were subjected to one way analysis of variance (ANOVA) with the cross regarded as fixed factor in SPSS program version 20.

3. Results and discussion

The results of the crosses are presented in Table 1. Significant level of differences were detected between the crosses for all traits observed except for number of seeds per pod. Differences in number of flowers pollinated resulted from the high number of flowers produced by accession B which resulted in several of its flowers receiving pollens from one flower of accession A in the direct crosses (AxB). However, the reciprocal crosses (BxA) had lower number of flowers crossed due to fewer flower production by accession A. Number of flowers crossed per plant ranged between 10 and 14 in AxB; it had the highest number of pods set per plant (ranging between 2 and 4), highest pod length (ranging between 10.20 cm and 13.50 cm) and the least number of days to pod maturity (19.00 and 20.00 days). However, number of seeds per pod was highest in BxA, ranging between 3 and 8 seeds per pod per plant and the highest percentage pod set per plant (ranging between 25 and 50 percent). Lower number of seeds per pod observed in AxB despite its

Table 1
Analysis of the reciprocal crosses of two accessions (A and B) of cowpea.

Trait	Cross	Mean	SE	Min	Max	MS (Df=1)	MSE (Df=6)
Number of flowers pollinated/plant	AxB	11.50	0.96	10.00	14.00	78.13**	4.29
	BxA	5.25	1.11	3.00	8.00		
Number of pods set/plant	AxB	3.00	0.41	2.00	4.00	3.13**	0.79
	BxA	1.75	0.48	1.00	3.00		
Percentage pod set/plant	AxB	26.19	3.25	20.00	33.33	102.03**	90.52
	BxA	33.33	5.89	25.00	50.00		
Pod length	AxB	11.49	0.79	10.20	13.50	17.94**	4.38
	BxA	8.50	1.25	7.10	12.23		
Number of seeds/pod	AxB	3.50	0.50	2.00	4.00	1.13[ns]	3.63
	BxA	4.25	1.25	3.00	8.00		
Number of days to pod maturity	AxB	10.50	0.29	19.00	20.00	0.50**	0.17
	BxA	20.00	0.00	20.00	20.00		

: Significant. **SE: Standard error; **MS:** Mean square value; **MSE:** Mean square error; **DF:** Degree of freedom.

longer pod length must have been as a result of bigger seeds obtained from the cross compared to the seed size of the reciprocal.

Overall 19 successful pods were generated from a total of 67 crosses representing 28.36% success rate indicating a low level of cross-compatibility between the accessions. Generally, percentage pod set of both direct (26.19%) and reciprocals (33.33%) were low, indicating a considerable level of incompatibility between the parents. Similar findings were reported (Lelou and Van Damme, 2006; Lelou et al., 2011) in intraspecific crosses of cultivated and wild accessions of cowpea. Different success rates of direct and reciprocal crosses have been reported in crosses of cowpea (Ogunkanmi and Adekoya, 2013), interspecific crosses between cowpea and mung bean (Win et al., 2015) and sesame (Laurentin and Benitez, 2014), an attribute linked to maternal influence. Failure of majority of the crosses may be attributed to lack of fertilisation as described by Lelou and Van Damme (2006), genetic variation, environmental factor, fertilisation barriers, embryo abortion and hybrid failure could have also contributed to the low success rate (Ogunkanmi and Adekoya, 2013). However, contrary findings were reported by Mohammed et al. (2010) and Rangkham and Khanna (2018). In crosses between cultivated cowpea and wild relatives, successful crosses ranging between 54 and 63.9% were observed (Mohammed et al., 2010), while the range fell between 60 and 76.19% in crosses among accessions of cowpea of different locations of India (Rangkham and Khanna, 2018).

The results for seed coat colour inheritance among the parents and the F_1 direct and reciprocals crosses are presented in Table 2.

Table 2
Inheritance of seed coat colours in parents and F_1 hybrids of cowpea.

Genotype	NSP	EM (%)	SU (%)	WS (%)	BRS (%)	BLS (%)
A	20	50	100	100	0	0
B	20	80	100	0	100	0
AxB	20	90	100	0	0	100
BxA	20	50	100	0	0	100

NSP: Number of seeds planted; **EM:** Percentage emerged; **SU:** Percentage survived; **WS:** Percentage of plants with white seed coat colour; **BRS:** Percentage of plants with brown seed coat colour; **BLS:** Percentage of plants with black seed coat colour.

Germination was good for F_1 hybrids just as for the parental lines and the plants were vigorous in growth till maturity producing viable seeds. A sufficient level of reproductive potential was indicated in the crosses by the successful advancement of the seeds of the crosses to F_1 generation. The parents were true breeders for seed coat colours, however, what was observed among the F_1 was different from what was expected. Despite the fact that both parents had white (accession A) and brown seeds (accession B), all F_1s had black seeds (Figure). When crosses between white and brown seeded parents result in black F_1s, it implies heterosis of seed coat colour (Egbadzor et al., 2014). Black colour is found to be dominant over brown colour, and also, black eye region of white is dominant over the brown, therefore the crosses resulted in the solid black seed coat colour. It would be important if the pattern of inheritance of the seed coat colour is studied in F_2 and subsequent generation to observe if the black seeds would segregate into different groups of seed coat colour. The findings of the present study are similar to what was reported by Egbadzor et al. (2014) among crosses of white and brown seeded cowpea. In their own case, the F_2 segregated

into three and ten seed coat groups suggesting involvement of many genes as described by Drabo et al. (1988) in cowpea and by Chandler et al. (1989) in maize. The complex nature of these crosses could be linked to epistasis or quantitative inheritance in which heterosis was involved in inheritance of seed coat colour as suggested by Mustapha (2009) and Egbadzor et al. (2014).
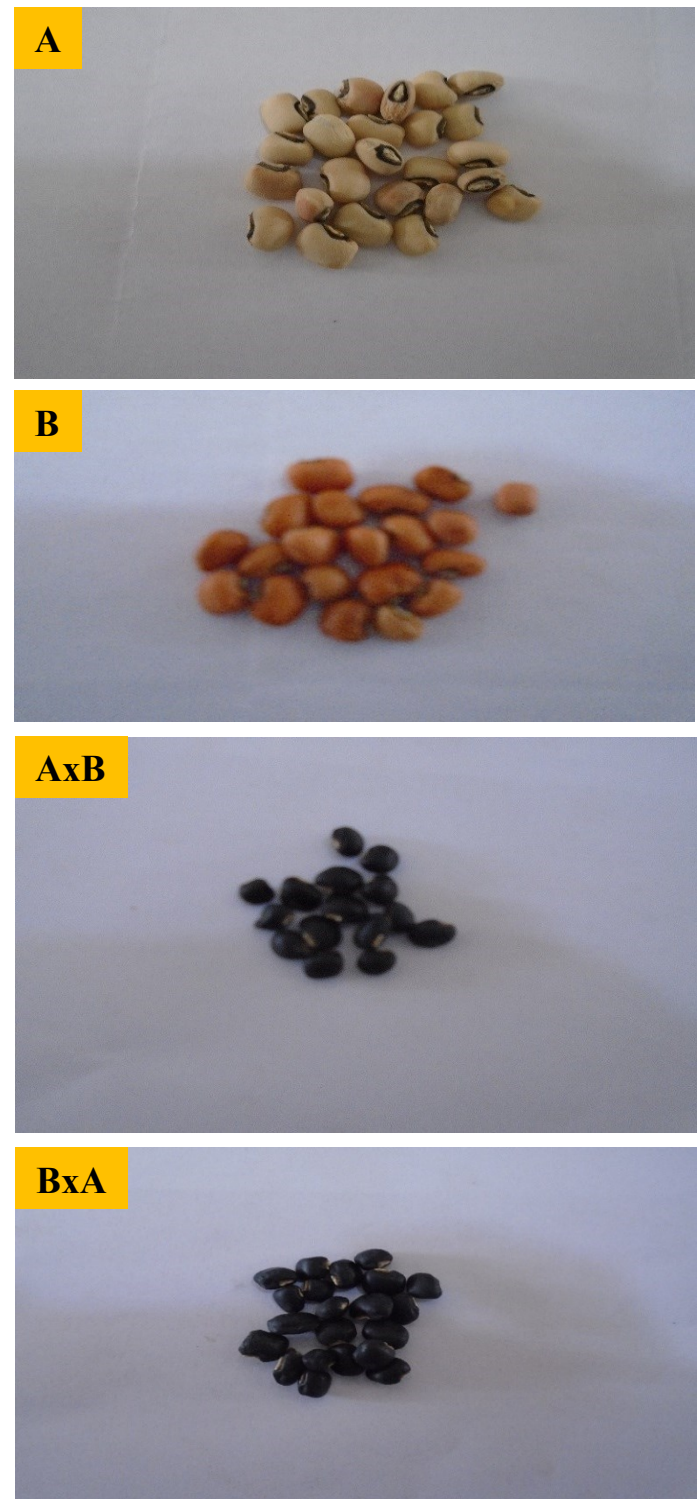

Fig. Inheritance of seed coat colour in parents (A and B) and F_1 hybrids (AxB and BxA) of cowpea.

The fact that black seeded F_1s were produced from crosses between white seeded and brown seeded parents proved that dominance of black over brown and other colours might not be

universal, therefore, epistasis may be responsible for the expression of the black colour at F_1 and it could not have been simple dominance and recessive. Similar epistasis interactions in seed coat colour of cowpea have also been reported by other workers (Lachyan and Dalvi, 2015; Amusa et al., 2019). While the results of the present study correspond to that of Egbadzor et al. (2014) and agrees with Mustapha (2009), they contradict that of Yilwa (2012) in which similar crosses between white seeded and brown seeded cowpea gave brown in F_1. Although, the presence of white and brown in F_2 and their ratios suggested involvement of two genes governing the seed coat colour trait. The present findings also contradict the ones reported in cowpea crosses (Nwofia, 2014; Lachyan et al., 2016) and sesame (Laurentin and Benitez, 2014). However, in the study done by Amusa et al. (2019), maternal effect was observed for seed coat colour in F_1 generation, while the presence of intermediary seed coat colour in F_2 which completely deviated from the Mendelian patterns of monogenic inheritance suggested the involvement of multiple genes in control of the trait.

Seed coat colours and patterns in cowpea have been successfully mapped into three loci namely *C*, *W* and *H*, respectively linked to genes *Vigun07g110700*, *Vigun09g139900* and *Vigun10g163900* involved in flavonoid biosynthesis pathway. Segregation ratios and dominance data of another tested populations were found to be consistent with the three loci (*C*, *W* and *H*). The primary locus controlling the seed coat pattern is the *C* locus, *W* (Watson) and *H* (Holstein) majorly controlling the distribution of pigment throughout the seeds (Herniter et al., 2019). When pigmentation is invisible, restricted to the eye and or distributed across the seed coat (full coat), it is tagged no colour (C_0), Eye1 (C_1) and Eye2 (C_2), respectively. Individual with Holstein (H_1) which lacks Watson (W_1) genotype expresses Holstein; conversely individual without Holstein but having Watson genotype expresses Watson.

However, individual combining the two (Holstein and Watson) expresses the full coat phenotype. Hence, individual having C_0C_0 will express no colour phenotype regardless of the status at *W* and *H* loci, C_1C_1 genotype will express the Eye1 regardless of *W* and *H* loci. However, C_2-$W_0W_0H_1$ and C_2-$W_1H_0H_0$, respectively will express the Holstein and Watson pattern. In the present study, the crossing of the parent A with the Eye 2 genotype ($C_2C_2W_0W_0H_0H_0$) with parent B with full coat ($C_2C_2W_1W_1H_1H_1$) brown resulted in F_1 full coat ($C_2C_2W_1W_0H_1H_0$) black, which agrees with the findings of Herniter et al. (2019). Examples of flavonoids in plants are anthocyanins which determine seed coat colour and pigmentation in plants (Herniter et al., 2018). They perform the key role of stress signaling and tolerance in plants and have been found to be effected by environmental factors just as it occurs for quantitative traits, hence, suggesting that seed coat colour in cowpea may be under the influence of environment making it a quantitative trait (Egbadzor et al., 2014). The black seed coat colour in cowpea has been successfully mapped to the *Bl* genes controlling enzymes in the pathway of anthocyanin biosynthesis, and a PCR marker developed for trait based on the candidate gene *Vigun05g039500* (Herniter et al., 2018).

4. Conclusion

Conclusively, it has been shown in the present study that crosses between the accessions of cowpea involved were possible, and that maternal effect also play a significant role in the expression of traits such as number of pods set, percentage pod set, pod length and number of days to pod maturity. The results of the study also suggest that seed coat colour trait in cowpea is a polygenic trait. Further studies into the F_2 and subsequent generations are required for better understanding of the patterns of inheritance of seed coat colour in the crop. Also, the relationships between seed coat colour and pattern and drought stress tolerance is one of the future tasks of the study. Knowledge of the seed coat characteristics and other desirable traits such as drought stress tolerance can aid breeders in breeding programs of cowpea for improved yield for environments with moisture deficit as well as consumer preference in terms of seed coat colour.

Acknowledgements

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Review article

Medicinal values of a Saiva ritual plant-*Bauhinia tomentosa* L.

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Abstract

Bauhinia tomentosa L. is a small tree that belongs to the *Fabaceae* family and it is distributed in Asia, Africa, North America, and Oceania. *B. tomentosa* is used to treat some diseases including liver inflammation, abscess, tumors, wounds, and hyperlipidemia in ethnomedicines in Asia and Africa. Compounds like phytone, β-cubebene, β-caryophyllene, 3-O-methyl-d-glucose, and phthalic acid have been isolated from leaves of this plant species. This review article aims to analyze, document, and summarize the reported bioactivities of this plant species. A literature review was conducted using electronic databases like the Web of Science, Scopus, PubMed, and Science Direct to identify the relevant published studies from the year 1900 to November 2020. Various parts of *B. tomentosa* exhibited bioactivities such as analgesic, anti-anxiety, antibacterial, anticatatonic, anticonvulsant, antidepressant, antidiabetic, antifungal, anthelminthic, antihyperlipidemic, antinociceptive, antioxidant, antipyretic, anti-ulcerative colitis, motor coordination, nephroprotective, nootropic, and wound healing activities in various assays and animal models. However, no bioactive compound has been isolated from this plant species. It was observed that a daily dose of 3000 mg/kg was safe in animal models. Hence, further phytochemical and bioactivity studies should be conducted to explore more about this plant species. This work analyzed, documented, and summarized the reported bioactivities of *B. tomentosa* that will be very useful for further phytochemical and bioactivities related researches.

Keywords: Bauhinia tomentosa; bioactivity; cancer; *Fabaceae*; microbiota; Sri Lanka

1. Introduction

Bauhinia tomentosa L. is a small tree that grows from 1 to 8 m in height belongs to the *Fabaceae* family (Fig. 1). It is called Thiruvaaththi in Tamil. This plant species is native to Asia (Sri Lanka, Yemen, and India) and Africa (Angola, Burundi, Ethiopia, Kenya, Malawi, Mozambique, Somalia, Sudan, Swaziland, South Africa, Tanzania, Zambia, Zaïre, and Zimbabwe). Anyway, it has been introduced into Asia (Andaman Islands, China, Malaysia, Taiwan, Thailand, and Vietnam), Africa (Cameroon, Gambia, Ghana, Guinea, Nigeria, and Sierra Leone), North

America (Cuba, Dominican Republic, Haiti, Puerto Rico, and Trinidad and Tobago), and Oceania (Australia) (Royal Botanic Gardens, Kew, 2020) (Fig. 2). *B. tomentosa* is utilized to treat liver inflammation, abscess, tumors, wounds, hyperlipidemia, bleeding, diabetes, diarrhea, animal bites, helminthiasis, infections, fever, and abdominal, skin, and urinary tract illnesses in ethnomedicines in Asia and Africa (Chopra et al., 1992; Sastri, 1995; Kirtikar and Basu, 2005; Orwa et al., 2009). This plant species is also grown as an ornamental plant in gardens and also used as a hedge. Fiber obtained from the trees are employed to make baskets and timber is utilized as beams for sheds. Further,

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leaves are used to prepare a yellow dye and flowers are used in Saiva rituals in Sri Lanka (Orwa et al., 2009). Compounds like Phytone, β-cubebene, β-caryophyllene, 3-O-methyl-d-glucose, phthalic acid, ethyl pentyl ester, 2-butanone, 3-methoxy-3-methyl, 2,2-dimethylpropionic acid, cyclopentyl ester, 2-hexen-1-ol, 2-ethyl, 5-hydroxy-2,2-dimethylhexan-3-one, pentanoic acid, 2-methyl, butane, and 1-bromo-2-methyl have been isolated from leaves of *B. tomentosa* (Vasudevan et al., 2014; Panda et al., 2019).

Fig. 1. *B. tomentosa* in a home garden in Batticaloa, Sri Lanka.

Until now, there is no comprehensive systematic review of bioactivities of *B. tomentosa*. Therefore, this review article aims to analyze, document, and summarize the reported bioactivities of this plant species. This work would be useful for further phytochemical and bioactivities related researches.

For this aim, a literature review was conducted using electronic databases namely the Web of Science, Scopus, PubMed, and Science Direct to identify the relevant published studies from 1900 to November 2020. The scientific name (*Bauhinia tomentosa*) was applied as a search term.

2. Bioactivities of *B. tomentosa*

Details of the level of scientific evidence, bioactivity, part used, extract/compound, assay/model, dose/concentration, duration, and reference are presented in Table. So far, only *in vitro* and *in vivo* reported studies are available and the majority of the

studies have been conducted in *in vivo* models. Antioxidant activities have both *in vitro* and *in vivo* scientific evidence.

A greater number of researches were carried out to study the antioxidant activities of this plant species (Kannan et al., 2010; Krishnaswamy et al., 2013; Tiwari and Singh, 2013; Banerjee and De, 2014). Leaves unveiled several bioactivities including antibacterial (Mythreyi et al., 2005; Dugasani et al., 2010), anticonvulsant (Risa et al., 2004), anti-anxiety, anticatatonic, antidepressant (Sathya et al., 2011), antidiabetic (Mannangatti et al., 2010a; Devaki et al., 2011; Kaur et al., 2011; Tiwari and Singh, 2013), anti-ulcerative colitis (Kannan and Guruvayoorappan, 2013), motor coordination (Sathya et al., 2011), nephroprotective (Kannan et al., 2016), and nootropic (Sathya et al., 2011) activities in both *in vitro* and *in vivo* levels.

Further, ethanol extract was used in the majority of the reviewed studies. Anyway, no bioactive compound has been isolated from this plant species. As stated earlier, *B. tomentosa* has a range of uses in ethnomedicines. On the other hand, only ethnomedicinal treatments for inflammation, infections, diabetes, helminthiasis, hyperlipidemia, and would healing activities have scientific evidence currently. Only higher scientific level (*in vivo*) studies according to the lower dose and duration of treatment are deliberated below.

3. Reported *in vivo* studies

3.1. *Analgesic activity*

In a study carried out by Tiwari and Singh (2013), aqueous and methanol extracts of the root (200 mg/kg) were orally administered to mice. After 300 minutes, in eddy's hot plate method significant analgesic activity was observed.

3.2. *Anti-anxiety activity*

The anti-anxiety property was noticed in the elevated plus-maze model, hole board test, and light-dark models after administering 200 mg/kg of leaf ethanol extract (Sathya et al., 2011).

3.3. *Anticatatonic activity*

Leaf ethanol extract of dose 200 mg/kg administered to haloperidol-induced catalepsy animal models showed anticatatonic activity (Sathya et al., 2011).

3.4. *Antidepressant activity*

In an investigation conducted by Sathya et al. (2011), an extract prepared using leaves and ethanol (200 mg/kg) was administered revealed antidepressant activity and improved the depressant conditions in forced swim tests and diazepam-induced sleeping time models.

3.5. *Antidiabetic activity*

A dose of 100 mg/kg of flower ethanol extract was orally administered to Streptozotocin-induced diabetic animals reduced elevated blood glucose concentrations (Mannangatti et al., 2010a).

3.6. *Antihyperlipidemic activity*

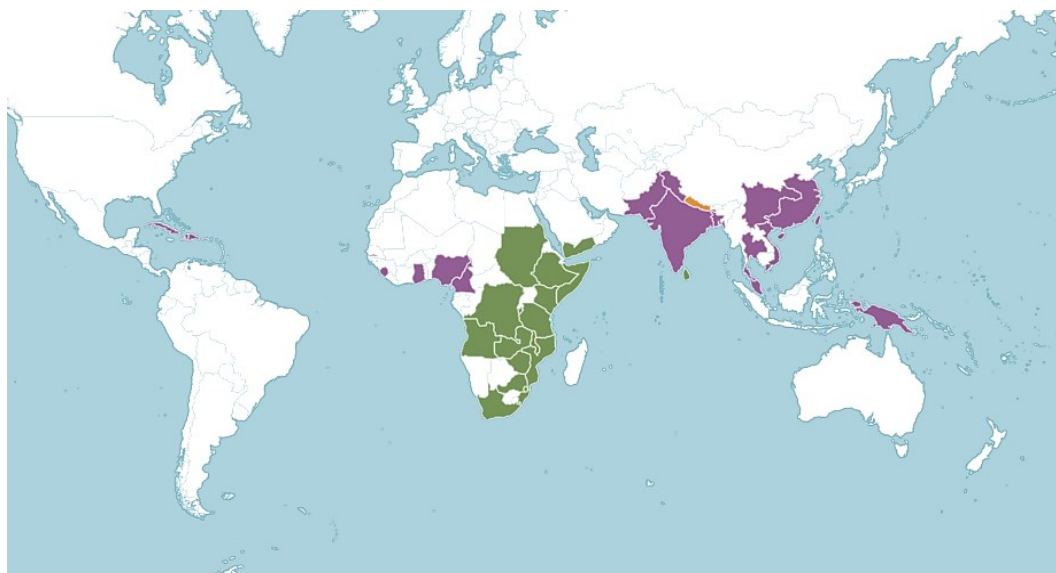Mannangatti et al. (2010a) observed significant antihyper-

Fig. 2. Distribution map of *B. tomentosa* (**Source:** Plants of the World Online: Royal Botanic Gardens, Kew. Available at http://plantsofthe-worldonline.org/taxon/urn:lsid:ipni.org:names:30193-2). **Keys:** Orange: Doubtful; Green: Native and Purple: Introduced

lipidemic properties in Streptozotocin-induced diabetic animals after orally administrating 100 mg/kg of flower ethanol extract for 7 days.

3.7. Antinociceptive activity

An extract prepared using roots and ethanol (200mg/kg) was orally administered to mice unveiled antinociceptive potentials (Tiwari and Singh, 2013).

3.8. Antioxidant activity

Streptozotocin-induced diabetic animal models were orally administered 100 mg/kg of flower ethanol extract for 15 days showed antioxidant activity (Mannangatti et al., 2010b).

3.9. Antipyretic activity

In research performed by Tiwari and Singh (2015), root and stem 70% methanol extracts (200 mg/kg) were separately orally directed to yeast-induced hyperthermia models. After 300 min.s it was noticed that the hypothermia condition was reduced.

3.10. Anti-ulcerative colitis activity

An extract was made using leaves and 70% methanol and it was orally administered to colonic inflammation animals at a dose of 20 mg/kg. After 5 days, it was spotted significant anti-ulcerative colitis activity (Kannan and Guruvayoorappan, 2013).

3.11. Motor coordination activity

Ethanol extract of leaves (200 mg/kg) administered to animals showed motor coordination activity after 30 minutes in the Rotarod test (Sathya et al., 2011).

3.12. Nephroprotective activity

Kannan et al. (2016) administered 250 mg/kg leaf methanol extract to cisplatin-induced renal damaged models. After 5 days, it was observed that an elevation in antioxidant enzymes

such as glutathione, catalase, and superoxide dismutase. Also, the bodyweight rose and reduced creatinine, serum urea, and lipid peroxidation. This study explains that this plant species has nephroprotective effects.

3.13. Nootropic activity

In a study carried out by Sathya et al. (2011), leaf methanol extract at a dose of 400 mg/kg was orally administered to the elevated plus-maze models exhibited nootropic properties.

3.14. Wound healing activity

The methanol extract was applied to both incision and excision wound models healed the wounds after 14 days (Panda et al., 2018).

4. Toxicity study

A study was carried out to observe the toxic and identify the safest dose (ED) of stem and root 70% methanol extracts separately. A dose of 3000 mg/kg orally administered to mice for 1 week showed no toxic effects and it is considered to be safe (Tiwari and Singh, 2015).

5. Conclusion

This review work revealed that *B. tomentosa* has a range of ethnomedicinal uses and scientific evidence is available for some of the ethnomedicinal utilizations. Hence, further bioactivities and phytochemical studies should be conducted to produce more scientific evidence to confirm the ethnomedicinal uses for standardization, safety, and efficacy purposes.

Also, the bioactive compounds should be discovered from this plant species, and they might be a candidate as a lead compound in future researches to combat diseases like cancer. Then these useful bioactive compounds could be synthesized in the laboratory to produce a large scale.

So far, an enormous number of bioactive phytochemicals have been isolated from several plant species. Anyway, not all the compounds or extracts have *in vivo* and clinical trial eviden-

ce and mechanisms of action for their bioactivities. Therefore, there is an urgent requirement to conduct these studies to find more effective drugs with few or no side effects than currently available drugs.

This work analyzed, documented, and summarized the reported bioactivities of *B. tomentosa*. Further, this work will be very useful for the researchers who are interested to study further bioactivity and phytochemical studies using this plant species.

Table
Reported bioactivities of *B. tomentosa*.

Level of scientific evidence	Bioactivity	Part used	Extract/Compound	Assay/Model	Dose/Concentration	Duration	Reference
In vitro	Antibacterial	Leaf	Chloroform, Methanol, Ethanol, Petroleum ether, Ethyl acetate, Aqueous	*Bacillus cereus, Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus*	100 µg/ml (MIC)	NA	Mythreyi et al. (2005)
		Leaf	Chloroform, Methanol, Ethanol, Petroleum ether, Ethyl acetate, Aqueous	*Candida albicans, Aspergillus niger*	100 µg/ml (MIC)	NA	
In vitro	Antibacterial	Root	Ethyl acetate	*Proteus vulgaris* (ATCC 12454)	7 µg/ml (MIC)	NA	Dugasani et al. (2010)
		Root	Ethyl acetate	*Pseudomonas aeruginosa* (ATCC 27853), *Enterococcus faecalis* (ATCC 2912), *Bacillus subtilis* (ATCC 10774), *Bacillus pumilus* (ATCC 14884), *Escherichia coli* (ATCC 25922)	15 µg/ml (MIC)	NA	
		Root	Ethyl acetate	*Staphylococcus aureus* (ATCC 25923)	31 µg/ml (MIC)	NA	
		Root	Hexane	*Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 27853), *Proteus vulgaris* (ATCC 12454), *Bacillus subtilis* (ATCC 10774), *Bacillus pumilus* (ATCC 14884), *Enterococcus faecalis* (ATCC 2912), *Staphylococcus aureus* (ATCC 25923)	250 µg/ml (MIC)	NA	
		Root	Methanol	*Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 27853), *Proteus vulgaris* (ATCC 12454), *Bacillus subtilis* (ATCC 10774), *Bacillus pumilus* (ATCC 14884), *Enterococcus faecalis* (ATCC 2912)	31 µg/ml (MIC)	NA	
		Root	Methanol	*Staphylococcus aureus* (ATCC 25923)	62 µg/ml (MIC)	NA	
In vitro	Anticonvulsant	Leaf	Aqueous, Ethanol	GABA A-benzodiazepine receptor binding assay	1 mg/ml	NA	Risa et al. (2004)
In vitro	Antifungal	Root	Aqueous, Ethanol Ethyl acetate	*Candida krusei* (ATCC 6258), *Candida albicans* (ATCC 10231)	15 µg/ml (MIC)	NA	Dugasani et al. (2010)
		Root	Hexane	*Candida krusei* (ATCC 6258), *Candida albicans* (ATCC 10231)	250 µg/ml (MIC)	NA	
		Root	Methanol	*Candida krusei* (ATCC 6258), *Candida albicans* (ATCC 10231)	31 µg/ml (MIC)	NA	
In vitro	Antihelminthic	Root	Ethanol, aqueous	*Pheritema postuma, Ascaris lumbricoides*	10% solution	NA	Aditya et al. (2013)
In vitro	Antioxidant	NS	NS	Mouse liver microsomes	90 µg/ml (IC$_{50}$)	NA	Kannan et al. (2010)
		NS	NS	NO radical scavenging	65 µg/ml (IC$_{50}$)	NA	
In vitro	Antioxidant	Pod, seed	NS	DPPH radical scavenging, NO radical scavenging, OH radical scavenging, ABTS radical scavenging, metal iron chelating, β-carotene-linoleate model system	NS	NA	Krishnaswamy et al. (2013)

In vitro	Antioxidant	Flower	Aqueous	DPPH radical scavenging	74 µg/ml (IC$_{50}$)	NA	Banerjee and De (2014)
		Flower	Aqueous	Total antioxidant capacity	265 µg/ml (IC$_{50}$)	NA	
In vitro	Antioxidant	NS	Aqueous	DPPH radical scavenging	85 µg/ml	NA	Tiwari and Singh (2013)
		NS	Aqueous	NO radical scavenging	310 µg/ml	NA	
		NS	Ethanol	DPPH radical scavenging	167 µg/ml (IC$_{50}$)	NA	
		NS	Ethanol	NO radical scavenging	220 µg/ml	NA	
		NS	Methanol	DPPH radical scavenging	65 µg/ml (IC$_{50}$)	NA	
		NS	Methanol	NO radical scavenging	150 µg/ml	NA	
In vivo	Analgesic	Root	Aqueous, methanol	Eddy's hot plate method in mouse	200 mg/kg	300 min	Tiwari and Singh (2013)
		Root	Ethanol	Eddy's hot plate method in mouse	400 mg/kg	300 min	
		Root	Ethanol, Aqueous, Methanol	Acetic acid-induced writhing test in mouse	400 mg/kg	300 min	
In vivo	Anti-anxiety	Leaf	Ethanol	Elevated plus maze model, hole board test, light dark model	200 mg/kg	NS	Sathya et al. (2011)
	Anticatatonic	Leaf	Ethanol	Haloperidol-induced catalepsy	200 mg/kg	NS	
	Antidepressant	Leaf	Ethanol	Forced swim test, diazepam-induced sleeping time	200 mg/kg	NS	
In vivo	Antidiabetic	Flower	Ethanol	Streptozotocin-induced diabetic	100 mg/kg	7 d	Mannangatti et al. (2010a)
In vivo	Antidiabetic	Leaf	Aqueous	Alloxan-induced diabetic	300 mg/kg	180 min	Devaki et al. (2011)
In vivo	Antidiabetic	Root	Petroleum ether	Alloxan-induced diabetic	250 mg/kg	14 d	Kaur et al. (2011)
In vivo	Antidiabetic	Stem	Aqueous, Ethanol	Streptozotocin-induced diabetic	250 mg/kg	21 d	Tiwari and Singh (2014)
In vivo	Antihyper-lipidemic	Flower	Ethanol	Streptozotocin-induced diabetic	100 mg/kg	7 d	Mannangatti et al. (2010a)
In vivo	Antinociceptive	Root	Ethanol	Mouse	200 mg/kg	NS	Tiwari and Singh (2013)
In vivo	Antinociceptive	Root, Stem	Methanol (70%)	Mouse (Acetic acid-induced writhing test)	250 mg/kg	30 min	Tiwari and Singh (2015)
		Root, Stem	Methanol (70%)	Mouse (Eddy's hot plate method)	250 mg/kg	120 min	
In vivo	Antioxidant	Flower	Ethanol	Streptozotocin-induced diabetic	100 mg/kg	15 d	Mannangatti et al. (2010b)
In vivo	Antipyretic	Root, Stem	Methanol (70%)	Yeast-induced hyperthermia	200 mg/kg	300 min	Tiwari and Singh (2015)
In vivo	Anti-ulcerative colitis	Leaf	Methanol (70%)	Colonic inflammation	20 mg/kg	5 d	Kannan and Guruvayoorappan (2013)
In vivo	Motor coordination	Leaf	Ethanol	Rota rod test	200 mg/kg	30 min	Sathya et al. (2011)
In vivo	Nephroprotective	Leaf	Methanol	Cisplatin-induced renal damage	250 mg/kg	5 d	Kannan et al. (2016)
In vivo	Nootropic	Leaf	Ethanol	Elevated plus maze model	400 mg/kg	NS	Sathya et al. (2011)
In vivo	Wound healing	NS	Methanol	Incision wound, excision wound	NS	14 d	Panda et al. (2018)

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Review article

Critical management of COVID-19 pandemic in Turkey

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Abstract

In Early December 2019, a novel coronavirus (CoV), severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has emerged in Wuhan city, Hubei province in China. SARS-CoV-2 was identified to be in betacoronavirus group as the Middle East respiratory syndrome coronavirus (MERS-CoV) and severe acute respiratory syndrome coronavirus (SARS-CoV-1). The disease caused by this virus termed coronavirus disease 2019 (COVID-19) by World Health Organization (WHO), has a wide clinical spectrum from asymptomatic to pneumonia, respiratory failure and even death. COVID-19 is highly contagious and human to human transmission was confirmed. As of December 28th 2020, there are globally 79 515 525 people infected with SARS-CoV-2. So far SARS-CoV-2 has spread to 220 countries including Turkey. Numerous measures implemented such as face mask usage, temperature measuring, social distancing, closure of workplaces and schools for the physical protection. Although almost a year has passed since the pandemic first emerged, the number of cases in the country has reached its peak. Therefore, new measures and restrictions have begun to be taken. Many vaccines have been released on the world market and a 91% effective Chinese coronavirus vaccine is expected to arrive in Turkey within the next few days.

Keywords: measures; SARS-CoV-2; social distancing; Umrah; vaccine

1. Epidemiology and clinical characteristics

In Early December 2019, the world met SARS-CoV-2 that emerged in Wuhan city, Hubei province in China. On January 7, 2020, SARS-CoV-2 was identified to be in betacoronavirus group as MERS-CoV and SARS-CoV-1 by metagenomic RNA sequencing and isolation of the virus from pneumonia patients (Hu et al., 2020). The first known cases were found to be related to the Huanan South China Seafood Market (Chen et al., 2020). Although there was a decreasing trend in the number of cases in China, the number of cases increased rapidly around the world towards the end of February due to international travel. The disease caused by this virus termed COVID-19 by World Health Organization (WHO) and declared the outbreak a pandemic on March 11, 2020 (Cucinotta and Vaneli, 2020). COVID-19 has a wide clinical spectrum including asymptomatic infection, mild upper respiratory tract illness, severe viral pneumonia and death (Garcia, 2020). Research data suggest that the virus could be transmitted through droplets scattered around while talking or coughing (Jayaweera et al., 2020). Prolonged exposure to symptomatic individuals also increases the risk of transmission. In addition, COVID-19 appears to be severe in people with underlying diseases such as diabetes, cardiovascular or lung diseases (Wu et al., 2020). Symptoms can be seen in infected people from 5 to 11.5 days (Wiersinga et al., 2020). The most common symptoms are fever, cough, fatigue and sputum production, dyspnea, headache, hemoptysis and diarrhea (Jiang et al., 2020). It is known that 89% of patients have at least one of these symptoms or signs. SARS-CoV-2 can be diagnosed by using reverse transcription polymerase chain reaction (RT-PCR) or Chest Computer Tomography (CT), as a routine imaging tool for pneumonia diagnosis is preferable. CT demonstrates typically in almost

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all COVID-19 patients, ground-glass opacities, multifocal patchy consolidation and interstitial changes with a peripheral distribution (Del Rio and Malani, 2020; Kilic et al. 2020 Wu and McGoogan, 2020). So far, drugs such as chloroquine and hydroxychloroquine which have been used in malaria treatment for many years, remdesivir, lopinavir/ritonavir and azithromycin have been used for COVID-19 treatment (Ali et al., 2020; Lu et al., 2020). Although the symptoms disappear within the recovery, it is not known what deficiencies and effects will be seen in the patient in the following years, which is a matter of concern.

So far SARS-CoV-2 has spread to 220 countries worldwide. According to WHO, as of December 28th, there are 79 515 525 confirmed cases and 1 757 947 deaths globally, and the USA has become the epicenter of the epidemic with 14 191 298 total cases followed by India, Brazil and Russia (WHO, 2020).

2. The first meeting of Turkey with SARS-CoV-2

In Turkey, all the developments since the first case reported in China were followed carefully. As a first step, the Coronavirus Scientific Advisory Board in Ankara consisting of academicians was set up by the Ministry of Health, General Directorate of Public Health (GDPH) in order to make the necessary decisions by evaluating the status of the pandemic (Yaman, 2020; Zahariadis et al., 2020). The board included 21 university professors, 4 medical experts and a legal advisor (COVID19TURKEY, 2020). Assessments were made on the basis of the national pandemic plan, which was published for the influenza pandemic in 2006 and subsequently revised with the experience gained in the influenza A pandemic in 2009. Board members made frequent statements and informed the public about SARS-CoV-2 and COVID-19, and explained the measures to be taken such as frequent hand washing, social isolation, wearing face masks and gloves if it is necessary and staying home as much as possible. The meetings continued for 24/7. As of mid-February, flights were stopped primarily to China and Iran, followed by Italy, South Korea and Iraq in order to control the spread of the virus (Khan and Karatas, 2020). The first case in Turkey was detected on March 10th 2020, who was a 44 years old businessman travelled back to Turkey from Europe (Demirbilek et al., 2020; Kilic et al., 2020).

3. Quarantine implementation for those returning from Umrah

Every year more than 2 million pilgrims candidates for Hajj worship at the same time; for the worship of Umrah, more than 8 million people travel to Saudi Arabia at different times of the year. Visitors from all over the world come together in the cities of Mecca and Medina. This poses an important risk in Muslim countries as the risk of infectious diseases is high in crowded environments. In the previous years, the GDPH provided information about MERS-CoV, which appeared in the Arabian Peninsula in 2012, by warning the citizens going to Umrah and Hajj. On March 15, 2200 people returned from Umrah were brought to Konya and Kayseri and settled in dormitories. Everyone was taken to separate rooms, except for couples, who had undergone health checks at the airport and in the dormitory. During the 14-day quarantine period, approximately 500 police took security measures in the dormitory and guarded the floors and the environment inside the building (Dursun et al., 2020; Hurriyet, 2020). In this process, those who were found to be positive were treated and the quarantine duration of their contacts

was extended (Republic of Turkey Ministry of Health, 2020a). Meanwhile, with the detection of more than 100 positive cases in the group of approximately 3 thousand people who were placed in private student dormitories in Ankara on the return of Umrah, the quarantine periods were extended to 3 weeks. A sufficient number of doctors and nurses were assigned to each block where these people stayed, and especially those with chronic diseases were followed carefully. However, it is estimated that the virus has spread due to those who visit the rooms during their stay in the dormitory (BBC News, 2020a). However, the exact number of people returning from Umrah has not been officially announced. Moreover, by April, the kingdom of Saudi Arabia has banned Hajj and Umrah visits and they are expected to be resumed as of November after 7 months through serious measurements (Aljazeera, 2020a). In our country, it is expected that various quarantine applications will be applied to people returning from Hajj or Umrah visits.

4. Measures taken against COVID-19 pandemic

Just a day after the first confirmed case, schools were closed to stop the spread between children. Over the next few days, public gatherings, social events and sport games were cancelled (Erturan-Ogut and Demirhan, 2020). In the meantime, measures at airports and borders have been increased, health checks were performed and early warning systems are activated in all borders of the country since Istanbul's airports serve over 104 million passengers in a year. Destinations such as Istanbul, Dubai, Frankfurt and Atlanta are frequently used by transit passengers from all over the world (Demirbilek et al., 2020; Kilic et al., 2020; Petersen and Gokengin, 2020). Efforts were made to prepare the health system and health workers ready for a possible pandemic. A guideline was published containing the information about the transmission and the clinical characteristics of COVID-19. Guideline also provided information about how to approach patients. According to guideline; Criteria in possible case definition; people with unknown severe acute respiratory tract infections; traveling to China in the last 14 days before the onset of symptoms and healthcare personnel working in an environment with SARS-CoV-2 positive patients, close contact with the confirmed case of SARS-CoV-2 infection. People who have recently traveled abroad and have symptoms of the disease and their contacts have been identified and taken to the hospital when necessary or 14-day quarantine was applied. According to Health Ministry data, a total of 38 098 intensive care beds found in Turkey, and there were 46.5 beds per 100 000 people. In the beginning of April, it was declared that as soon as the outbreak started, the treatments of patients who could be treated later were delayed. Moreover, in this period, the bed occupancy rates were reduced from 70% to 30%. The rates of the intensive care bed occupancy had also reduced which were around 80% to 60%. It was also declared by GDPH, that Turkey was among the countries with the lowest death rate by 2.3% (Republic of Turkey Ministry of Health, 2020a). On the other hand, as of April 25, there were a total of 107 773 patients, 2706 deaths and 25 582 recovered patients (Republic of Turkey Ministry of Health, 2020b). Therefore, weekend curfews were imposed in 31 provinces including the 3 most populous cities; Istanbul, Ankara and Izmir. In order to keep people over age 65 and under 20 at home, a curfew was imposed (Simsek et al., 2020). It seems that the measures did work well since according to the Ministry of Health, as of May 1st, daily number of the recovered patients was more than double the number of the new cases. Thanks to
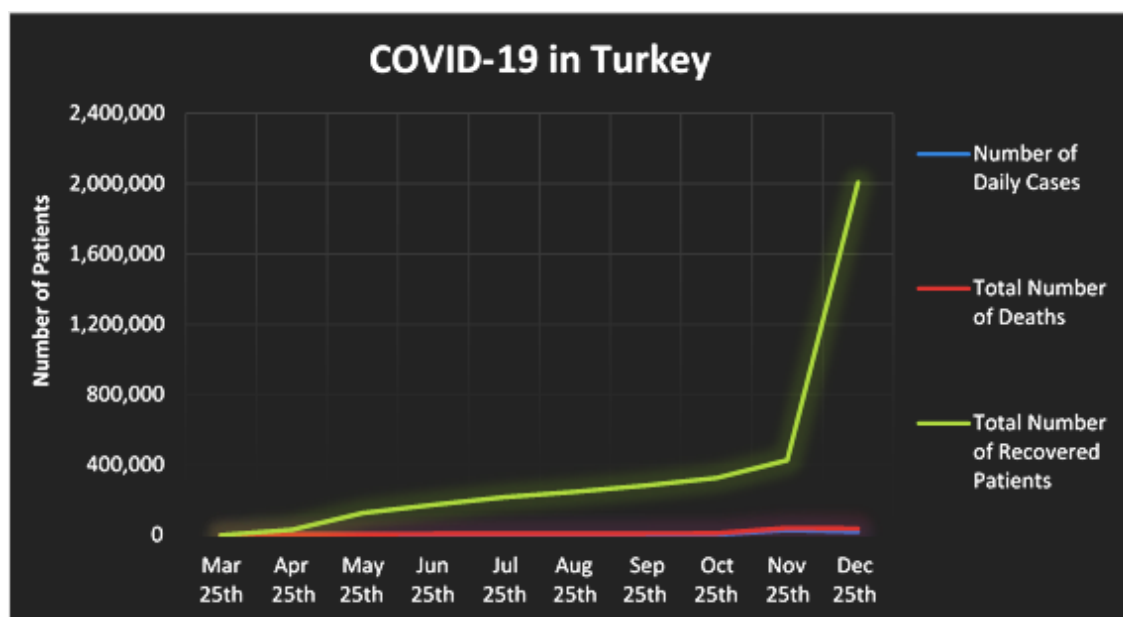
Fig. Total numbers of recovered patients, deaths and the number of daily cases from March 25th to December 25th in Turkey.

the strict measures and intensive studies, it was seen that the number of people recovering as of May 14th was approximately 3 times the number of new cases per day. By May 25th, the number of patients was 157 814 as 4369 people died and 120 015 patients recovered (Republic of Turkey Ministry of Health, 2020b). Considering the number of the city population, the number of people who had lost their lives due to COVID-19 was less compared to many European countries. On May 12th, a plan on the normalization process was issued by the Turkish Government. Applications such as curfews covering the weekends and the restriction of domestic travel would continue until June 1st. Hairdressers, shopping malls, shops and restaurants could be opened on condition that the hygiene rules were followed (Petersen and Gokengin, 2020; Republic of Turkey Ministry of Health, 2020a).

In May, with the 'Life Fits into Home' application created by the Ministry of Health, it became mandatory to obtain and use a code on this application for all trips. Thus, the health status and activities of individuals in social life and domestic transportation can be followed instantly (Koca, 2020). People who must quarantine at home since they have been in close contact with someone who has COVID-19, are followed up through this application and monitored by filiation teams (Hayat Eve Sigar, 2020). Meanwhile, an increase in the number of cases was also observed. By June 25th, the total number of cases reached 193 115 and 5046 people died as 165 706 patients recovered. A month after that, as of July 25, there were 225 173 patients, 5596 deaths and 208 477 recovered patients (Republic of Turkey Ministry of Health, 2020b). In addition, weekly status reports started to be published by the Ministry of Health as of August, and updated information about the number of new as well as total cases and deaths started to be shared weekly and daily. According to the situation report published by the Ministry of Health, as of August 25, more than 7 million tests were performed across the country and there were 261 194 laboratory confirmed patients, 6163 deaths and 238 795 recovered patients since March 11th (Republic of Turkey Ministry of Health, 2020b). The city with the highest number of cases was Istanbul, followed by the South Eastern Anatolia and Western Anatolia regions. 51% of the de-

tected cases were male patients, 49.4% of the total cases belonging to the age group from 25 to 49 and 18.7% were patients belonging to the age group from 50 to 64. Additionally, the number of children under the age of 15- infected with virus is 6.9% of the total number of cases (Republic of Turkey Ministry of Health, 2020c). As expected, in summer when normalization steps were taken, increased social activities brought along an increase in the number of cases. Thus, wed-dings and similar gatherings were banned as of August 30. However, the increase in the number of patients continued in September as the total number of patients reached 311 455, 7858 people died and 273 282 patients recovered (Republic of Turkey Ministry of Health, 2020b).

The increase in the number of cases in October-November has reached a higher level than when the pandemic first appeared. As of October 25, the number of tests performed across the country has almost doubled and exceeded 13 million as the total number of patients reached 361 801 and the number of recovered patients rose up to 314 390 (Republic of Turkey Ministry of Health, 2020b). The highest increase in the number of cases was detected in Istanbul, Eastern Marmara and Western Anatolia Regions. While the incidence of cases in men and women remained the same, the number of cases in the Western Anatolia region increased and surpassed Southeastern Anatolia (Republic of Turkey Ministry of Health, 2020d). Therefore, it was not surprising that new measures and restrictions were taken especially in major cities such as residents who are 65 and older would be allowed to go out at only certain hours, a weekend curfew had been declared from 8 pm to 10 am, restaurants and cafes were closed and only take-away services were allowed (Daily News, 2020). It was also announced that schools and universities would also be closed until the first semester. The Turkish government, which introduced online education during the pandemic period, provides tablet and free internet access services to thousands of students across the country (Ozer, 2020). Thus, the students had the opportunity to conduct lessons in accordance with the previously planned course schedules. It carries out very successful educational activities in digital environment, especially in medical faculties (Sensu et al., 2020).

According to the last published daily COVID-19 report, the number of new cases detected only on November 16 was 3316. The increase in the number of cases is the highest in the city of Istanbul, followed by the Eastern Marmara and Aegean Regions. However, there was a significant increase (33%) in the number of new hospitalizations in the Northeastern Anatolia region. Moreover, in the age group of 50-79 and 80+, more cases were detected in women compared to men (Republic of Turkey Ministry of Health, 2020e).

Interestingly, when the number of cases was expressed in hundreds at the beginning of the pandemic, the strict measures were taken with great sensitivity and then they were replaced by normalization steps in the summer as the tourism season started. Even though the number of cases had risen nearly tenfold, the restrictions applied were a lot less stringent than the beginning of the pandemic. From the statement made on November 25th, the number of daily cases was announced for the first time since July 29 as only the number of patients showing symptoms was announced in previous months which was criticized by many authorities. According to this statement, the number of daily confirmed cases in Turkey was found to be up to 28 351 and the total numbers of deaths and recovered patients reached 12 840 and 385 480 respectively (Figure 1). Thus, Turkey moved up to first place among European countries in the number of daily cases (BBC, 2020b). In the following days, new restrictions were imposed with the increasing public pressure. As of November 30, social distancing rules were tightened and lockdowns were announced to be on weekends and between 9 pm and 5 am on weekdays. Moreover, people older than 65 and younger than 20 would not be allowed to use public transport without the

Hayat Eve Sığar (HES) code. Many more restrictions are expected to be announced in the following days (Aljazeera, 2020b).

5. What is next?

Measures such as continuous informing of healthcare professionals and the public about the disease and measures to be taken, canceling travel and collective organizations, closing the workplaces and switching to the home office working were implemented in a short time. The absence of shortage in medical equipment and especially the number of beds indicates that the health system is well prepared for this process. Many workshops and vocational high schools in the country produce masks thus there was no mask shortage. However, due to the low number of tests performed at the beginning of the pandemic, some patients may be late for diagnosis. In addition, the fact that more than 7000 health personnel are infected with SARS-CoV-2 especially at the beginning of the pandemic indicates that the working environment of the health personnel is not safe enough. The measures taken by countries such as South Korea, Italy and China, which have seriously fought against the pandemic, the right and wrong steps they take should be evaluated and the same mistakes should not be made.. Countries such as Germany, the USA, England and Russia have revealed that the phase 3 trials were done successfully and some of the vaccines have already been released on markets. Among these vaccines, the first batch of 3 million doses of the Chinese vaccine which found to be 91% effective, has been expected to arrive in Turkey in the next coming days.

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