An ecological study on the *Isoëtes* community in Istanbul, Türkiye

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Abstract

This study presents phytosociological and some ecological characteristics of the *Isoëtetum durieui* association naturally distributed in Istanbul, Türkiye. During the present study a community was characterised and compared with other communities in different regions of the world. The discussion was followed accordingly. The results obtained from the soil samples of the *I. durieui* association showed that the concentrations of boron, calcium, copper, iron, potassium, magnesium, manganese, lead and zinc were within the limit values, while those of Cd were higher.

Keywords: *Isoëtetum durieui*, ecology, plant sociology, rare species, microphyte

Introduction

The plant communities are the primary autotrophic components of terrestrial biodiversity. These contribute significantly to the continued sustainability of our biosphere, supporting the overall health, stability and productivity of ecosystems by improving soil fertility, nutrient cycling and water filtration [1-10]. Despite the ecological importance of plant diversity, it is threatened by many factors, including habitat destruction, deforestation, pollution, and climate change, with invasive species at the forefront [10-15]. In order to overcome such threats, studies on the ecological relationships between plant communities and their biotopes are important when studying different ecosystems [15-21].

The genus *Isoëtes* is a globally distributed fern genus [22,23]. Species belonging to the genus *Isoëtes* s are quite small and are known as 'grass ferns' due to their morpho-anatomical similarity to simple grasses [24,25]. Unlike many other fern genera, this genus produces two distinct spores, the species in this genus necessarily show a dependence on water at least at one stage of their development [24]. The fertile, spore-producing parts of the species usually have 2-5 lobes, named "cormus", being located underground. The leaves
show a rosette-like arrangement around the corm. Sporangial sacs at the base of the outer leaves produce macrospores, and sporangial sacs at the base of the innermost and fewer leaves produce microspores. While macrospores have an average diameter of half a millimeter, microspores generally vary in diameter between 10-20 microns [24,26].

The first floristic list for the naturally distributed genus *Isoëtes* in Turkey was presented by Jermy [27]. Many systematic studies have been undertaken lately and an updated species list of the genus has been published [23-26,28,29]. In Turkey *Isoëte* genus is represented by 6 species (*I. anatolica* Prada & Rolleri; *I. durieui* Bory; *I. histrix* Bory; *I. olympica* A. Braun; *I. gymnocarpa* (Gennari) A. Braun; and *I. vanensis* M. Keskin & G. Zare). The plant ecological niches are fixed as such, habitat characteristics are very important in their life cycle [30-37]. In view of this, knowing the habitat of a plant community makes it easier to understand its distribution and ecology [3,8-10,15, 21]. The ecological importance of the species from this genus is not well understood due to fragmentary studies. No detailed ecological study has been conducted on the current status of the naturally distributed *Isoëtes* community in Istanbul (Türkiye). Considering this, the present study was carried out to understand the phytosociological and ecological characteristics of *Isoëtes* community.

Table 1: Data on the ecological features covering the quadrats in the *Isoëtes* study area

<table>
<thead>
<tr>
<th>Quadrat number</th>
<th>Location information</th>
<th>Coordinates</th>
<th>Altitude</th>
<th>Characteristics of the habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Istanbul Province- Maltepe District: Around Süreyya Pasha Hospital</td>
<td>40.949373 Lat. 29.138577 Lon.</td>
<td>69 m</td>
<td>Degraded grassland near <em>Pinus pinea</em> and <em>P. sylvestris</em> forest</td>
</tr>
<tr>
<td>2</td>
<td>Istanbul Province- Maltepe District: Around Süreyya Pasha Hospital</td>
<td>40.948802 Lat. 29.138196 Lon.</td>
<td>73 m</td>
<td>Degraded grassland near <em>Pinus pinea</em> and <em>P. sylvestris</em> forest</td>
</tr>
<tr>
<td>3</td>
<td>Istanbul Province- Maltepe District: The Süreyya Pasha Hospital - around the pond</td>
<td>40.947184 Lat. 28.146963 Lon.</td>
<td>62 m</td>
<td>Coastal areas of the pond zone</td>
</tr>
<tr>
<td>4</td>
<td>Istanbul Province- Maltepe District: Around the village of Büyükbakkal</td>
<td>40.963726 Lat. 29.180356 Lon.</td>
<td>81 m</td>
<td>Meadows close to the road</td>
</tr>
<tr>
<td>5</td>
<td>Istanbul Province-Tuzla District: Around the neighborhood of Akfirat</td>
<td>40.950375 Lat. 29.412182 Lon.</td>
<td>152 m</td>
<td>Meadows along the road in the area around the Formula 1 race track</td>
</tr>
<tr>
<td>6</td>
<td>Istanbul Province-Tuzla District: Around the neighborhood of Akfirat, Around the Formula 1 racing area</td>
<td>40.950375 Lat. 29.412182 Lon.</td>
<td>155 m</td>
<td>Large grasslands opposite the Formula 1 race track</td>
</tr>
</tbody>
</table>
Materials and Methods

Study area

The commanding feature of Istanbul is that it is located on two continents (Europe and Asia), between two seas (Marmara and Black Sea) and in two phytogeographical regions (Euro-Siberian and Mediterranean) [15]. The climate is a typical four-season continental Mediterranean climate with warm summers (above 30 °C) and mild winters (rarely below 0 °C). The average temperature is 14.1 °C and the average rainfall is 820 mm [15]. It is part of the Euro-Siberian region represented by the Euxine sub-region, while the Mediterranean region belongs to the East Mediterranean province [15,38-40]. This position is reflected in the great diversity of flora and vegetation in Istanbul [15].

Floristic data

The floristic composition of the Isoëtes community has been done recently by Keskin et al. [41]. For the identification of Isoëtes species and other fern species, the studies of Bolin et al. [23], Keskin and Musselman [24], Keskin [25,42] and Keskin et al. [43] were considered. The species identification was done for the moss species following the studies of Spence and Ramsay [44], Elharech et al. [45], Ozturk et al. [46] and Sjölander [47].

Ecological data

Ecological data was collected using the random homogeneous square sampling method. Each sample area was taken as 1 m² and a total of 6 quadrats were taken in the study area. (Table 1). All plants in each quadrat were recorded. The Braun-Blanquet approach [48] was used to classify the floristic composition found in each quadrant in terms of plant sociology. For syntaxonomie nomenclature and synonyms of higher levels of classification, Brullo et al. [49] was followed, in the light of most recent data.

Soil analysis

After drying for 48 hours at 80 °C, soil samples are sieved through a 2 mm steel mesh to obtain a uniform particle size distribution suitable for subsequent analysis. Samples weighing 0.200-0.250 g were transferred to Teflon containers for further processing. For soil samples, a solution containing 6 ml of 65 percent Merck's HNO₃, 3 ml of 37 percent Merck's HCl and 2 ml of 48 percent HF was prepared and added to the vessels. The samples were subjected to a dissolution process using a Berghof-MSW2 microwave apparatus to optimise efficiency and precision. At the end of dissolution, the samples were filtered through Whatman blue-banded filter paper into sterile 50 ml Falcon tubes using ultrapure water, total volume of the filtrate was adjusted to 50 ml to ensure uniformity and consistency in subsequent analyses. The samples prepared as such were used to determine elemental concentrations using inductively coupled plasma optical emission spectroscopy (ICP-OES), a PerkinElmer - Optima 7000DV instrument. The contents of B, Ca, Cd, Cu, Fe, K, Mg, Mn, Pb and Zn, expressed in mg/kg dry weight were determined [12, 36,37,50,51].

Results and Discussion

Looking at the floristic composition of the Isoëtetum durieui association distributed in the study area, we recorded that it develops in early spring and is characterised by the dominance of Juncus capitatus and Isoëtes durieui, growing together with hygrophilous microphytes (Table 2). The association is also characterized by pioneer ephemeral vegetation. Considering the structure and ecology of the association in terms of plant sociology, it is compatible with the
characteristic species of the Isoëto-Nanojuncetea class, Isoëtalia order and Isoëtion alliance [49]. In all the quadrats of the Isoëtetum durieui association identified by us, the moss species Ptychostomum pseudotriquetrum, had high ecological tolerance, and Ophioglossum lusitanicum fern-a microphyte, always accompanied this association. A similar report has been recorded by other researchers [24, 42, 52].

The syntaxonomic structure of the Isoëtetum durieui association is given below:

Table 2: Isoëtetum durieui association in the study area

<table>
<thead>
<tr>
<th>Quadrature number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitude (m)</td>
<td>69</td>
<td>73</td>
<td>62</td>
<td>81</td>
<td>152</td>
<td>155</td>
</tr>
<tr>
<td>Quadrate samples width (m²)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Direction (°)</td>
<td>E</td>
<td>SE</td>
<td>E</td>
<td>E</td>
<td>-</td>
<td>SE</td>
</tr>
<tr>
<td>Slope (%)</td>
<td>5</td>
<td>15</td>
<td>20</td>
<td>30</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Plant cover (%)</td>
<td>60</td>
<td>95</td>
<td>75</td>
<td>90</td>
<td>95</td>
<td>85</td>
</tr>
</tbody>
</table>

| Isoëtes durieui   | 33| 44| 33| 33| 44   | 33 |

**Isoetto-Nanojuncetea Class**

| Juncus capitatus | 12| 12| 12| 12| 12   | 12 |

| Juncus hybridus  | +2| +2| +1| +1| +2   | +1 |
| Poa infirma      | +1| - | +2| +2| +2   | +2 |

**Isoëtion Alliance and Isoëtalia Order**

| Isoëthes histrix | 12| 12| +2| 12| +2   | +2 |
| Lotus conimbricensis | +1| +1| +1| +1| +1   | +1 |

**Companions**

| Ptychostomum pseudotriquetrum | 22| 33| 12| 12| 12  | 12 |
| Ophioglossum lusitanicum      | +2| +2| +1| +2| +1  | +2 |
| Sagina apetala               | +2| - | +2| +2| +2  | +2 |
| Plantago coronopus            | 12| - | 12| 11| -   | 12 |
| Calendula arvensis            | 12| 12| 11| 11| -   | - |
| Ornithogalum sigmoideum       | 12| - | 11| 12| 11  | - |
| Plantago lanceolata           | - | 12| - | - | 12  | 12 |
| Erodium cicutarium            | - | - | 11| 12| +1  | - |
| Poa bulbosa                   | +1| - | - | - | -   | +1 |
| Hypericum triquetrifolium     | - | +1| +1| - | -   | - |
| Sedum hispanicum             | - | 11| - | 12| -   | - |
| Montia minor                  | - | - | - | +2| +2  | - |
| Polygonum istanbulicum        | 11| - | - | - | -   | - |
| Prospera autumnalis           | +1| - | - | - | -   | - |
| Euphorbia helioscopa          | +1| - | - | - | -   | - |
| Cynodon dactylon             | - | - | - | +2| -   | - |
| Lotus corniculatus            | - | - | - | - | +2  | - |

This plant association was first introduced to the scientific world by Braun-Blanquet [53] in the south of France. The phytosociological studies carried out by various researchers in subsequent year have shown that the association is
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*Isoëtes* community is widespread in the south of France, in Catalonia and Corse in Spain, and in Italy (particularly in Sicily) [49,54-62].

In contrast to the *Isoëtetum durieui* association, another study has been reported on the occurrence of *Isoëtes histrix* community in Turkiye [63].

Regarding the habitat preferences of this community, it has been reported that it has a limited distribution in acidophytic, seasonally dry and winter submerged areas in the Mediterranean zone of the Menderes massif in the western part of Turkiye [63].

The association found in our study area varies in terms of ecological preferences being generally distributed at an altitude of 62-155 m, on slopes varying between 5-30 percent of the land facing south and southeast.

In the light of its habitat preferences, *I. durieui* community is generally found in small depressions on land, along the banks intermittent streams and in other areas where water is available for most of the year, if not during the summer [64]. All terrestrial *Isoëtes* species distributed in Turkiye are similar in their habitat preferences. These species are prominent habitat types in small green areas in pine forest clearings, open and wide meadows, small seasonal water bodies, around volcanic rocks and paths formed by water currents in meadows [25]. It was determined that *I. durieui* association distributed in the study area had similar habitat preferences.

The elemental concentrations present in the soil samples were in the following decreasing order K > Fe > Ca > Mg > Mn > Zn > Cu > B > Pb > Cd. We can say that K values are the highest while Cd values are the lowest. The values of K, Fe, Ca, Mg, Mn, Zn, Cu, B and Pb are within the limits, but those of Cd are above the limits (Table 3). According to the elemental

Table 3: Elemental analysis (mg kg\(^{-1}\)) in the soil samples of *Isoëtetum durieui* and limit values (mg kg\(^{-1}\)) of analyzed elements

<table>
<thead>
<tr>
<th>Locality</th>
<th>Locality 2</th>
<th>Locality 3</th>
<th>Locality 4</th>
<th>Locality 5</th>
<th>Locality 6</th>
<th>Limit values</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>26,475±0 .527</td>
<td>26,835±0 .516</td>
<td>25,596±0 .500</td>
<td>24,655±0 .470</td>
<td>25,949±0 .493</td>
<td>27,045±0 .554</td>
</tr>
<tr>
<td>Ca</td>
<td>3176,381 ±58,649</td>
<td>3214,945±0 ,356</td>
<td>3061,034±0 ,650</td>
<td>2945,107±0 ,405</td>
<td>3098,666±0 ,719</td>
<td>3136,267±57 ,893</td>
</tr>
<tr>
<td>Cd</td>
<td>2,814±0 ,095</td>
<td>2,896±0 ,082</td>
<td>2,783±0 ,077</td>
<td>2,682±0 ,098</td>
<td>2,832±0 ,074</td>
<td>2,877±0 ,102</td>
</tr>
<tr>
<td>Cu</td>
<td>29,344±0 ,554</td>
<td>29,744±0 ,595</td>
<td>28,362±0 ,526</td>
<td>27,333±0 ,508</td>
<td>28,788±0 ,558</td>
<td>29,157±0 ,595</td>
</tr>
<tr>
<td>Fe</td>
<td>3814,286 ±70,427</td>
<td>3860,567±0 ,71,265</td>
<td>3675,758±0 ,7,829</td>
<td>3536,558±0 ,65,278</td>
<td>3720,945±0 ,68,692</td>
<td>3766,083±69 ,519</td>
</tr>
<tr>
<td>K</td>
<td>4976,371 ±91,882</td>
<td>5036,752±0 ,92,989</td>
<td>4795,625±0 ,8,492</td>
<td>4614,010±0 ,85,155</td>
<td>4854,551±0 ,89,617</td>
<td>4913,459±90 ,697</td>
</tr>
<tr>
<td>Mg</td>
<td>2105,577 ±38,858</td>
<td>2131,112±0 ,39,335</td>
<td>2029,09±0 ,37,460</td>
<td>1952,278±0 ,36,049</td>
<td>2054,042±0 ,37,958</td>
<td>2078,988±38 ,376</td>
</tr>
<tr>
<td>Mn</td>
<td>106,769±2 ,011</td>
<td>108,084±0 ,051</td>
<td>102,953±1,9</td>
<td>99,054±1,8</td>
<td>104,234±1 .980</td>
<td>105,498±1,96</td>
</tr>
<tr>
<td>Pb</td>
<td>11,991±0 .232</td>
<td>12,159±0 ,236</td>
<td>11,595±0 ,259</td>
<td>11,172±0 ,233</td>
<td>11,768±0 ,218</td>
<td>11,959±0 ,252</td>
</tr>
<tr>
<td>Zn</td>
<td>72,308±1 .370</td>
<td>73,216±1 ,386</td>
<td>69,72±1,331</td>
<td>67,125±1,282</td>
<td>70,658±1 ,337</td>
<td>71,519±1,325</td>
</tr>
</tbody>
</table>
analysis results of the soil samples, the study area shows potential contamination in terms of Cd, which is readily absorbed by plants, having toxic effects, potentially inhibiting plant growth and metabolic functions, especially in aquatic and terrestrial ecosystems [65].

Among macrophytes, *Isoëtes* species are particularly sensitive and are distributed in very limited geographical areas. The plants of this genus are seriously threatened [69]. The factors contributing to the decline and/or extinction of *Isoëtes* species include habitat degradation or loss, pollution, competitive exclusion by related plants, and intense disturbance due to anthropogenic impacts [36,51,70].

*Isoëtes* species are included within a spore-bearing group of plants, requiring water in the life cycle, especially to reach their ripening stage. As a result of climate change and drought, the distribution of these plants is narrowing. In addition, locally observed anomalies in seasonal rainfall put ecological pressures on their populations. In addition to tense pressures these plants must also struggle with the invasive species. *Isoëtes* generally prefers sunny and open grasslands due to their ecological requirements. They are unable to compete in these habitats due to pressure from invasive flowering plants that are taller, and intense anthropogenic impacts, especially activities such as construction and road building, disrupt the ecological adaptation of sensitive *Isoëtes* species.

**Conclusion**

Understanding *Isoëtes* species and their habitats from an ecological and synecological perspective on a global scale will contribute to their conservation. The results presented here include ecological findings on the *Isoëtetum durieui* association distributed in Istanbul (Turkiye). This study partially contributes to the elucidation of the ecological requirements, floristic composition and phytosociological structure of the *Isoëtetum durieui* association. Moreover, as with endemic, relict and rare plants, these species need more detailed ecological, eco-physiological and molecular studies to reveal the eco-genetic diversity of *Isoëtes* species [36,51].

**References**

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