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Plant communities across a vegetation profile in Kaboodan Island of Urmia Lake (northwest of Iran)

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Abstract

In the present study, the vegetation of Kaboodan Island, the largest island of saltwater Urmia Lake (northwest of Iran) was documented, predominantly based on a vegetation profile established across the island. For this purpose, vegetation sampling was carried out along a north-south profile together with some scattered points. Vegetation data analysis was accomplished in the form of classification using TWINSPAN and ordination using DCA. The synoptic table of vegetation units and the schematic view of vegetation profile were also presented. From a total of 107 relevés, 24 plant communities were distinguished according to floristic and ecological characteristics in Kaboodan Island. They were categorized into three groups including: 1. Plant communities formed on the dried bed of Urmia Lake (on the island present-day shorelines), 2. Plant communities developed on the island former shorelines, and 3. Plant communities found on hills adjacent to shorelines, steppe areas and valleys of the island. The result of the present survey showed that, Kaboodan Island with a less-touched ecosystem and no anthropogenic activities over decades is a home to various plant species and vegetation types. Considering to unstable hydrological condition of Urmia Lake in recent years, conservation and vegetation monitoring is highly recommended for this and other islands of the lake facing the succession trend.

Keywords: Classification, Irano-Turanian region, island, ordination, salt lake

اجتماعات گیاهی در امتداد پروفیل پوشش گیاهی در جزیره کبودان دریاچه ارومیه (شمال‌غرب ایران)*

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خلاصه

در این مطالعه، پوشش گیاهی جزیره کبودان، بزرگترین جزیره دریاچه آب شور ارومیه واقع در شمال‌غرب ایران عمدتا براساس پروفیل پوشش گیاهی مستقر در عرض جزیره مورد بررسی قرار گرفت. به این منظور، نمونه‌برداری پوشش گیاهی در امتداد یک پروفیل شمالی-جنوبی و برخی نقاط پراکنده صورت گرفت. تجزیه و تحلیل داده‌های پوشش گیاهی در قالب طبقه‌بندی با استفاده از روش TWINSPAN و رسته‌بندی با به کارگیری روش DCA انجام شد. جدول خلاصه شده واحدهای رویشی و تصویر شماتیک پروفیل پوشش گیاهی ارایه شدند. از مجموع ۱۰۷ رولوه پوشش گیاهی، ۲۴ اجتماع گیاهی با در نظر گرفتن جنبه‌های فلورستیکی و بوم‌شناختی در جزیره کبودان شناسایی شدند. این اجتماعات در سه گروه جای داده شدند که عبارتند از: ۱- اجتماعات گیاهی شکل‌گرفته در بستر خشک شده دریاچه ارومیه (در ساحل کنونی جزیره کبودان)؛ ۲- اجتماعات گیاهی توسعه یافته در ساحل قبلی جزیره و ۳- اجتماعات گیاهی موجود در تپه‌ماهورهای مجاور خطوط ساحلی، مناطق استپی و دره‌های جزیره کبودان. در نتیجه بررسی حاضر مشخص گردید که جزیره کبودان با اکوسیستم کمتر دست‌خورده و بدون فعالیت‌های انسانی در طول دهه‌ها، دربردارنده گونه‌های متنوع گیاهی و تیپ‌های مختلف پوشش گیاهی است. با توجه به وضعیت آبی ناپایدار دریاچه ارومیه در سال‌های اخیر، حفاظت و نظارت بر پوشش گیاهی این جزیره و سایر جزایر دریاچه ارومیه که با روند توالی روبرو هستند، مؤکدا توصیه می‌گردد.

واژه‌های کلیدی: جزیره، دریاچه شور، رسته‌بندی، طبقه‌بندی، ناحیه ایران و تورانی

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Introduction

The geographical isolation of islands and archipelagos along with their environmental limitations has always drawn the attention of nature discoverers and scientists to investigate biodiversity issues in these areas. Islands are relatively simple ecosystems involving confined biota in comparison to the complex biota of continental areas (Cox *et al.* 2016). They are natural laboratories for answering a number of questions of biology and biogeography, as well as acting as conservative systems. The spatial restriction of islands makes endemism and evolutionary opportunities along with shaping refuge to threatened species (Greuter 2001, Whittaker & Fernández-Palacios 2007, Sciandrello *et al.* 2021). On the other hand, islands are fragile and vulnerable ecosystems due to their limited areas. Apart from climate change, they are at risk of human pressure such as overexploitation, livestock grazing and tourism. These threatening factors create conditions for habitat alteration and establishment of invasive species, which cause loss of diversity in islands (Bergmeier & Dimopoulos 2003, Fernández-Palacios *et al.* 2016, Médail 2017).

There are uninhabited islands around the world, which are highly suited to biodiversity and geobotany researches, perfectly isolated lands for monitoring. Urmia Lake is one of the largest hyper-saline lakes in the world which encompasses a comparatively virgin archipelago. There are 102 islands in this saline lake in different magnitudes, from very small to large (Ghaheri *et al.* 1999). Historically Eslami (Shahi) Island was the largest one but now it is a peninsula. Only this island/peninsula is dwelled by local people and the other islands are without inhabitants, however, there are ancient evidences of human settlement in some islands (Khanmohammadi & Kharazi 2012).

Many recent researches have quantitatively assessed the rapid shrinkage phenomenon of Urmia Lake (AghaKouchak *et al.* 2015, Alborzi *et al.* 2018, Sharifi *et al.* 2018) reflecting the fact that islands are also influenced by such worrying conditions. The flora and vegetation of Urmia Lake salt marshes (especially halophytic plant communities) have been studied both before tremendous retreating of the lake shorelines (Asri & Ghorbanli 1997) and after drastic changes of the lake water level (Ahmadi *et al.* 2018, Ghorbanalizadeh *et al.* 2020). Despite the importance of Urmia Lake as a National Park and a main wetland ecosystem in Iran and the world since 1975, there are poor investigations about flora and vegetation of the lake's islands. Zehzad (1989) carried out a floristic and general vegetation study in Ashk Island. He recorded 198 vascular plant species and recognised four vegetation types from this island (Zehzad 1989). There is a biodiversity checklist for the Lake and its islands provided by Asem *et al.* (2016). Generally, the flora of Urmia Lake islands has dispersedly been recorded by several botanists during their field works and gathered in two main floristic resources of Iran in Flora Iranica (Rechinger 1963–2015) and Flora of Iran (Assadi *et al.* 1988–2018). Recently a plant diversity research along with a preliminary study of vegetation was accomplished in Eslami Peninsula listing 417 species for the flora (Sedghipour 2017). Furthermore, a floristic study was conducted in Kaboodan, Espir and Arezoo Islands of Urmia Lake with an approach of plant diversity assessment among them. Totally 358 species of vascular plants belonging to 49 families were recorded across these islands (Gordani 2018).

Plant communities and vegetation patterns of Urmia Lake shorelines have been recently investigated by the author and her colleagues according to data sampling in diverse sites around the lake (Ghorbanalizadeh *et al.* 2020). In parallel, field work conditions were provided for sampling the vegetation of Kaboodan Island. Practically, phytosociological studies on the islands of Urmia Lake (including Kaboodan Island, as the largest island of the lake), has not been previously surveyed in the frame of vegetation types. With a less-touched ecosystem and no human inhabitancy over decades, vegetation study of this island is worthwhile. This paper is going to focus on the vegetation and plant communities occurring in Kaboodan

Island. This study develops the knowledge about biodiversity and distribution patterns of species in Urmia Lake region and it provides comparative ways to assess the vegetation and ecological differences among the islands of the lake. The results may aid for management and conservation planning in current susceptible condition of Urmia Lake.

Materials and Methods

- Study area

Geography: Urmia Lake is a shallow salt lake located between two provinces of W & E Azarbaijan in northwestern Iran. From a phytogeographical point of view, this area is placed in the Irano-Turanian region (Zohary 1973, Takhtajan 1986). The southern parts of Urmia Lake consist of four important large islands including Kaboodan, Ashk, Espir and Arezoo islands. Kaboodan Island (= Quyun Daqi Island), the largest island of the lake, is situated near the southeastern shorelines of Urmia Lake (37˚ 28’ N and 45˚ 37’ E.), has a surface area of ca. 3125 ha with a length of ca. 10 km, characterized by a mountainous topography. The highest point of the island is about 1573 m a.s.l. which is named Zarza Peak and the lowest elevation is ca. 1268 m a.s.l. on the island’s shorelines. Shorelines of the island have variable edaphic forms from muddy substrates to sandy, stony, and rocky ones. Around this island, Arezoo, Espir, and Ashk Islands are located in north, west, and southwest, respectively (Lotfi & Moser 2012) (Fig. 1). Generally, the receding of Urmia Lake water level has caused the extension of shorelines around the island.

Geology and soil: Urmia Lake basin shows an intricate and diverse geological sequence including Precambrian metamorphic complexes to Quaternary mud deposits. Sedimentary units of the lake have different types and origins (Sharifi *et al.* 2018). Based on Kelts & Shahrabi (1986), Mesozoic flysch rocks are dominant in some islands in the eastern part of the lake while many of the islands are comprised of coralline limestone of Lower Miocene. The rocky slopes are less observed in the southern archipelago of Urmia Lake, compared to Eslami peninsula, which has prominent high Rocky Mountains originating from volcanic and volcano-sedimentary formations. There are stony and shallow soils with indefinite profiles in mountainous parts of Kaboodan Island. Besides, the hills are composed of brown soils and lithosols. Alluvial and saline soils are also observed on the shorelines (Lotfi & Moser 2012).

Climate: Since Urmia Lake area belongs to the Irano-Turanian phytogeographical region (Takhtajan 1986), its climate is categorized in Mediterranean xeric-continental bioclimate (Djamali *et al.* 2011). On the basis of Orumiyeh, Naghadeh and Bonab climate diagrams (Fig. 1), as the nearest meteorological stations to the lake islands, the region receives the most precipitation in spring from March to May. The mean annual precipitation ranges between 255.7–331.8 mm. July is the warmest month and January is the coldest. The average of mean daily temperature is recorded between 11.3–15.3 °C. In the catchment of Urmia Lake, the direction of strongest winds is westerly and south-westerly (Lotfi & Moser 2012, Sharifi *et al.* 2018), mainly observed in Kaboodan Island, particularly during spring.

Fauna and flora: Urmia Lake islands provide habitats for various resident and migratory birds, many species of amphibians, reptiles, and mammals (Eimanifar & Mohebbi 2007, Asem *et al.* 2014). Habitat heterogeneity in this island provides a favorite condition for settling of different fauna. Among mammals, mouflon (*Ovis orientalis*) has considerable populations in this island. These wild sheep and Persian fallow deer (*Dama dama mesopotamica*) were released in Kaboodan and Ashk islands for conservation aims (Asem *et al.* 2014). There are fresh water springs in Kaboodan Island for water requirements of these mammals. Birds are other important fauna of the island so that, in the shorelines harbor, some breeding birds such as flamingos, shelducks, gulls, and white pelicans (Lotfi & Moser 2012) also live. The Lake’s archipelago includes different types of vegetation and is quite rich in floristic diversity. There are open Savanna-like woodlands with scattered trees and shrubs such as *Pistacia atlantica*, *Juniperus polycarpos*, and *Rhamnus pallasii* in Kaboodan and Ashk Islands (Zehzad 1989, Ghorbanalizadeh *et al.* 2020). In recent years, the life forms of archipelago are threatened due to the rapidly drying up of Urmia Lake.

Land use: The existence of several villages in Eslami Peninsula has caused many disturbances through its natural habitats arising from over-grazing and extending the arable fields (Sedghipour 2017). Fortunately, Kaboodan Island is only affected by wild fauna without anthropogenic disturbing factors. Although, there are some traces of previous inhabitancy in parts of this island related to far past (Khanmohammadi & Kharazi 2012).

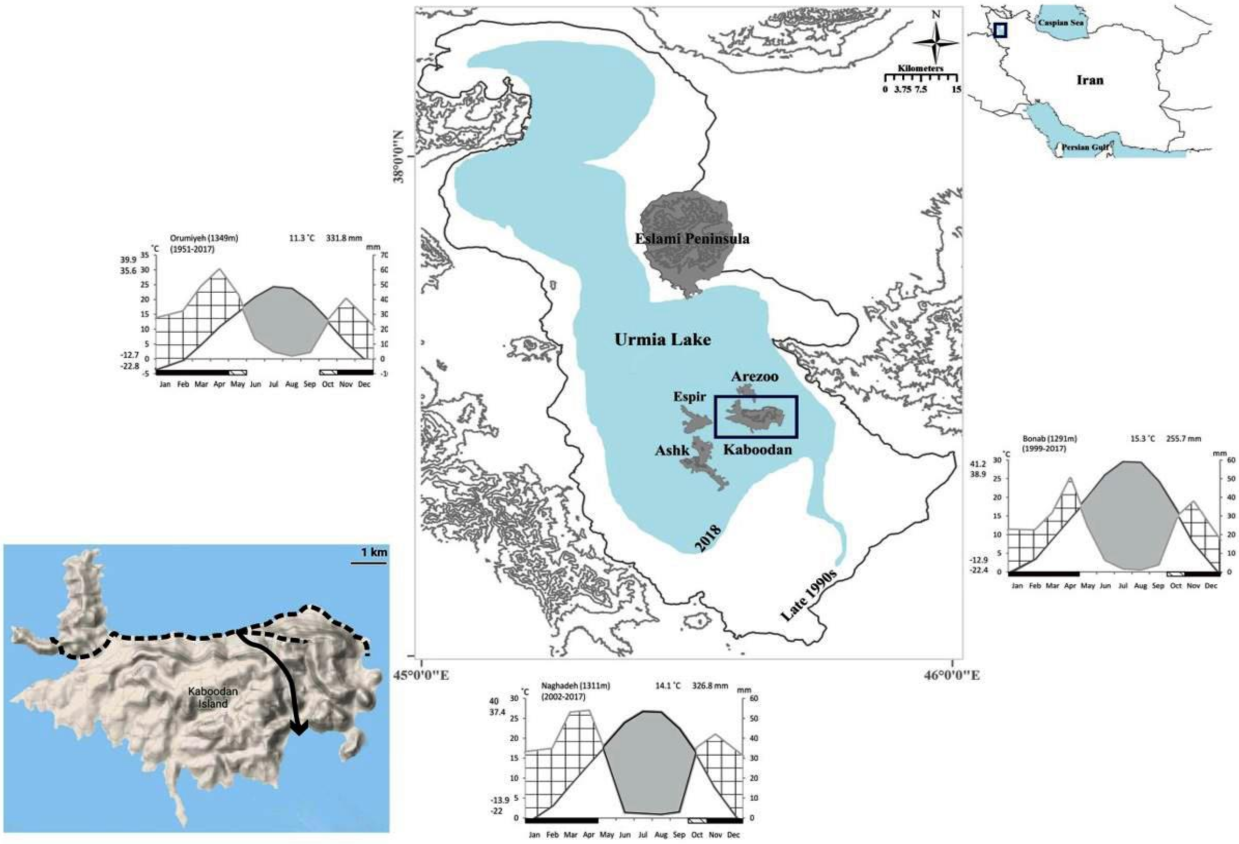

Fig. 1. Location of Kaboodan Island in Urmia Lake (NW Iran). White and blue surfaces show status of the lake in late 1990s and 2018, respectively. Climate diagrams of three cities around the southern archipelago have been illustrated including Orumiyeh (in west), Naghadeh (in south) and Bonab (in southeast) stations. Bottom left corner of the figure is the terrain map of Kaboodan Island which arrow line shows the path of vegetation profile from north side towards south side and dashed lines display the path of other sampling points.

- Vegetation survey

Vegetation data were mainly gathered along a 3-kilometer vegetation profile from north of Kaboodan Island towards its southern part during growth seasons of 2016. In addition, vegetation sampling was done in some scattered points out of the profile, in eastern and western parts of this island (Fig. 1). Totally, 107 relevés were established based on Braun-Blanquet approach (Braun-Blanquet 1964) which the size of relevés ranges between 2–400 m^2. The relevés were randomly placed along the profile and other sample points with respect to the homogeneity of vegetation structure, species composition and habitat conditions. Total cover of vegetation layers, all species with their cover-abundance values of Braun-Blanquet old scales and related information including geographic coordinates, altitude, aspect and slope were recorded for each relevé. Voucher specimens were deposited at the Herbarium of Halophytes and C_4 Plants Laboratory, School of Biology, University of Tehran

(Herbarium H. Akhani). The species were identified based on Flora Iranica (Rechinger 1963–2015), Flora of Iran (Assadi *et al.* 1988–2018), and a number of related monographs and revision papers. Nomenclature basically conforms to Flora Iranica and, in some cases, has been updated according to available papers and data bases such as Euro-Med Checklist (Euro+Med Plantbase; http://www.emplantbase.org/home.html; accessed 1 Dec. 2020) and The Plant List (2013 Version 1.1.; http://www.theplantlist.org; accessed 1 Dec. 2020).

- Data analysis

Classification: For vegetation classification, the data of relevés were sorted in a TURBUVEG database (Hennekens & Schaminée 2001) and exported for JUICE software (Tichý 2002). Sixteen relevés of this database were used in the previous study around Urmia Lake (Ghorbanalizadeh *et al.* 2020). Two-way indicator species analysis (TWINSPAN; Hill 1979) in JUICE was applied for synthetizing vegetation data. Four pseudo-species cut levels (0, 5, 25, and 50); six maximum levels of divisions and four minimum group sizes were set. In first analysis, 17 groups were emerged and then to obtain interpretable clusters, TWINSPAN was run for some groups with the above cut levels and different division levels and group sizes. Recombining of created clusters and modifying of relevé order were carried out in a few cases to amend the classification. Optimal vegetation units were distinguished according to floristic similarities, observed ecological differences and final judgment. Synoptic table indicates the results of TWINSPAN based on constancy values. All groups were standardized to equal size and as the fidelity measure, phi coefficient was used with the presence/absence data. For each proposed unit, diagnostic and dominant species were specified using the synoptic table columns analysis function of JUICE with threshold values for fidelity (50), frequency (50) and cover (40), and considering field observations. In the present study, based on the species composition, some relevé groups were assigned to phytosociological associations described in the literature according to the International Code of Phytosociological Nomenclature (ICPN; Weber *et al.* 2000). Other vegetation units were referred and described as informal plant communities. Formally introducing associations as new and determining higher syntaxa need the task of a future, more vegetation sampling in the area, as well as other islands of Urmia Lake.

Ordination: Vegetation data were visualized by means of detrended correspondence analysis (DCA) using RStudio software and R-package ‘vegan’ (Oksanen *et al.* 2017). At first, the gradient analysis was conducted with a matrix of all relevés and the species with frequency > 1. Logarithmic transformation was calculated for cover percentages of species data. The proposed vegetation units resulted from TWINSPAN were illustrated on DCA ordination graph. Besides, a matrix including all relevés and three environmental variables (altitude, aspect and slope) was entered into the analysis. With *post hoc* plotting of environmental data on DCA diagram, the correlation of vegetation data and ecological indicators was evaluated. Secondly, in another ordination analysis, author of the paper excluded 41 relevés of shoreline sample points from the vegetation and environmental matrices and then advanced the gradient analysis as mentioned above. Similarly, the pattern in species composition and the passive projecting of ecological variables along the ordination axes were interpreted. The species richness per relevé was calculated in RStudio and then box plot was prepared to show the median, quartiles and outliers of species richness for each plant community.

Results

- Vegetation communities

According to the data set including 107 relevés and 238 plant species, analyzed by TWINSPAN method and field perceiving, 24 vegetation units were recognized for the shorelines, hills, steppe areas, and the valleys of Kaboodan Island. In the following section, these units are categorized into three groups generally based on existing habitats in the island and individually described in accordance with available data. The synopsis of proposed vegetation units is represented in the synoptic table (Table 1). Moreover, for visual perspective, plant communities have been schematically illustrated along the established vegetation profile from N-side to S-side of Kaboodan Island (Fig. 2). Hereafter, the "community" term for a given plant community is abbreviated to "comm.".

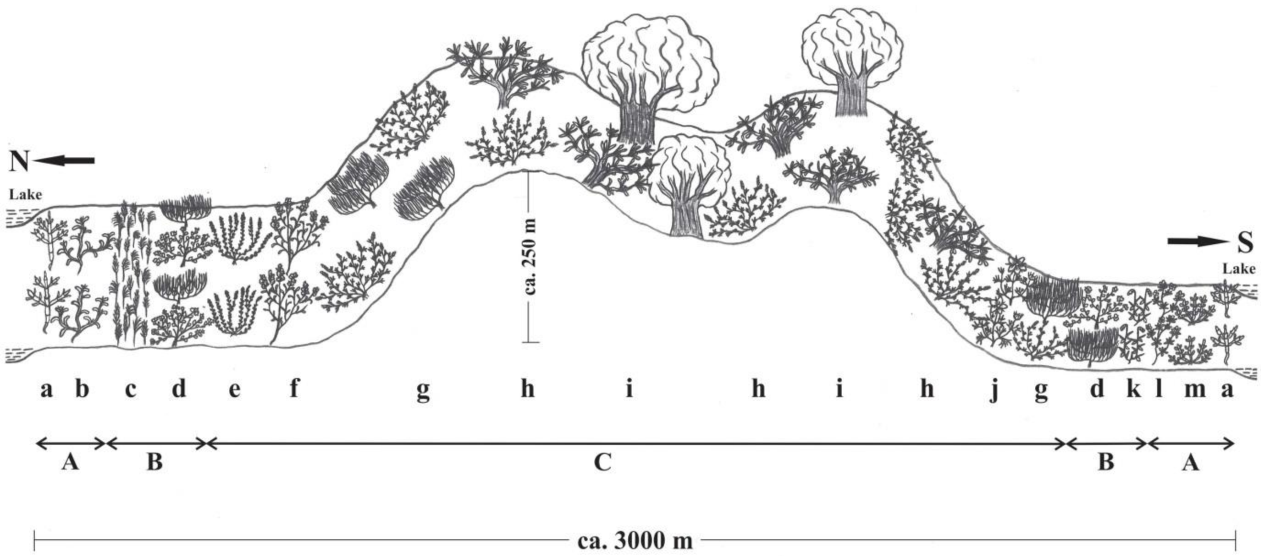

Fig. 2. Schematic representation of vegetation profile from N-side of Kaboodan Island towards S-side. The length of profile is about 3 km and the altitude difference of lowlands and highlands is about 250 m. A. Halophytic vegetation formed on the exposed salty flats, B. Successional vegetation developed on sandy-stony substrates of former shorelines, C. *Artemisia* steppes mixed with sub-shrubby or shrubby stands along with *Pistacia* woodlands (a. *Salicornietum iranicae*, b. *Halimocnemis rarifolia* comm., c. Transient zone with annuals, d. *Atraphaxis spinosa-Ephedra major* subsp. *procera* comm., e. *Caroxylon dendroides* comm., f. *Halothamnus glaucus* comm., g. *Artemisia spicigera-Ephedra major* subsp. *procera* comm., h. *Rhamnus pallasii-Artemisia spicigera* comm., i. *Pistacia atlantica* subsp. *mutica-Rhamnus pallasii* comm., j. *Peganum harmala* comm., k. *Alhagi maurorum* comm., l. *Frankenia hirsuta* comm., m. *Halocnemetum strobilacei*) (Schematic diagram drawn by author).

1. Plant communities formed on the dried bed of Urmia Lake (on Kaboodan Island present-day shorelines): These communities are mostly annual halophytic vegetation, which are gradually being appeared on the exposed lake bed around the island after receding. Such dried up salty substrates are being covered by sand in some parts.

Salicornietum iranicae Ghorbanalizadeh & Akhani (Ghorbanalizadeh *et al.* 2020) (Fig. 3a)

Diagnostic and dominant species: *Salicornia iranica*.

Habitat and ecology: An annual obligatory halophytic community on the saline exposed bed of the island present-day shorelines; with almost permanently moist soil, under periodic inundations; adjacent to the *Climacopteretum crassae* and *Halimocnemis rarifolia* comm.

Structure: Species-poor; the total cover between 20–70%.

Climacopteretum crassae Ghorbanalizadeh & Akhani (Ghorbanalizadeh *et al.* 2020)

Diagnostic species: *Climacoptera crassa*.

Habitat and ecology: An annual C_4 halophytic community on the salty temporarily wet soils of shoreline; adjacent to the *Salicornietum iranicae* and *Halimocnemis rarifolia* comm.

Structure: Relatively species-poor; the total cover between 12–35%.

Halimocnemis rarifolia comm. (Fig. 3b)

Diagnostic and dominant species: *Halimocnemis rarifolia*.

Habitat and ecology: An annual C_4 halophytic community on saline temporarily wet soils of shorelines of the island; including *Bromus tectorum* and *Hordeum murinum* subsp. *glaucum* as remarkable constant species; adjacent to the *Salicornietum iranicae*, *Climacopteretum crassae*, and *Limonium carnosum* comm.

Structure: Species richness relatively low; the total cover between 40–88%.

Suaeda gracilis comm. (Fig. 3c)

Diagnostic and dominant species: *Suaeda gracilis*.

Habitat and ecology: An annual C_4 halophytic community on the salty exposed bed of Urmia Lake in present-day shorelines of the island, under temporary flooding; *Halimocnemis rarifolia*, one of the main constant species.

Structure: Species-poor; the total cover between 50–70%.

Halocnemetum strobilacei (Keller) E. Topa 1938 (Topa 1939)

Diagnostic species: *Halocnemum strobilaceum* and *Aeluropus littoralis*.

Habitat and ecology: A suffruticose halophytic community on the saline dried bed of the lake in present-day shorelines of the island, here covered by sand and small stones; adjacent to the *Frankenia hirsuta* comm.

Structure: Species richness very low; the total cover 8%.

Frankenia hirsuta comm. (Fig. 3d)

Diagnostic and dominant species: *Frankenia hirsuta*.

Habitat and ecology: A perennial halophytic community on the recent shorelines of the island with salty soil; adjacent to the *Halocnemetum strobilacei* and *Alhagi maurorum* comm.

Structure: Species richness low; the total cover between 30–35%.

Caroxylon nitrarium comm. (Fig. 3e)

Diagnostic species: *Caroxylon nitrarium* and *Strigosella africana*.

Dominant species: *Caroxylon nitrarium*.

Habitat and ecology: An annual C_4 halophytic community on the salty exposed flats in recent shorelines of the island.

Structure: Species richness low; the total cover between 40–65%.

Atriplicetum tataricae Ubrizsy 1949 (Ubrizsy 1949) (Fig. 3f)

Diagnostic and dominant species: *Atriplex tatarica*.

Habitat and ecology: An annual C_4 halophytic community on exposed areas of the lake bed in present-day shorelines of the island, predominantly covered by sand on the soil surface; with individuals of *Atriplex* in large sizes.

Structure: Species-poor; the total cover between 23–60%.

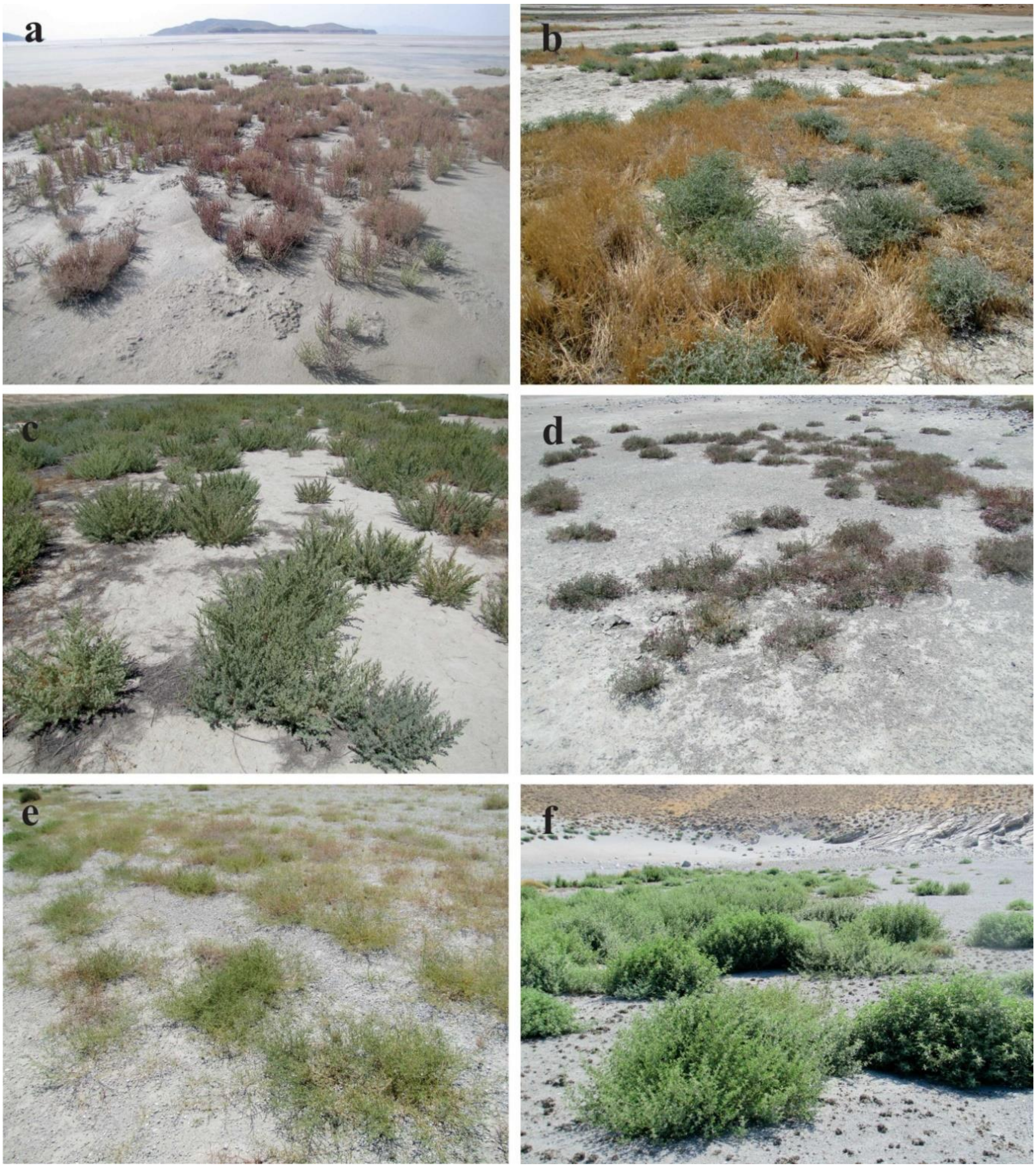

Fig. 3. Some plant communities formed on the dried bed of Urmia Lake: a. *Salicornietum iranicae*, b. *Halimocnemis rarifolia* comm., c. *Suaeda gracilis* comm., d. *Frankenia hirsuta* comm., e. *Caroxylon nitrarium* comm., f. *Atriplicetum tataricae*.

2. Plant communities developed on the former shorelines of the island (above present-day shorelines): These communities are developing on sandy low-saline substrates composed of coarse stones and white pebbles dropped from the hills and steep slopes of the island, most probably due to water and wind erosion. Their species composition often consist of both shoreline and steppe vegetation flora.

Alhagi maurorum comm. (Fig. 4a)

Diagnostic and dominant species: *Alhagi maurorum*. Habitat and ecology: A hemicryptophyte ruderal community on sandy soil including rather fine stones on the former shoreline; with *Atriplex tatarica* and *Hordeum murinum* subsp. *glaucum* as the main constant species; adjacent to the *Frankenia hirsuta* comm. and *Atraphaxis spinosa-Ephedra major* subsp. *procera* comm.

Structure: Medium species richness; the total cover between 30–50%.

- Transient zone with annuals

In some parts between the recent and the former shorelines of the island there is a transient vegetation zone including annual vernal species which the *Bromus tectorum* and *Vulpia persica* are dominant ones in it. Clearly, this zone is going through the succession and will be occupied by rather constant vegetation in the future.

Limonium carnosum comm. (Fig. 4b)

Diagnostic species: *Limonium carnosum*, *Frankenia hirsuta*, and *Halimocnemis rarifolia.*

Dominant species: *Limonium carnosum.*

Habitat and ecology: A suffruticose halophytic community on the sandy substrate of the former shoreline, considerably covered by white stones and large pebbles; adjacent to the *Halimocnemis rarifolia* comm. and *Atraphaxis spinosa-Dianthus orientalis* comm.

Structure: Medium species richness; the total cover between 25–60%.

Verbascum nudicaule comm. (Fig. 4c)

Diagnostic and dominant species: *Verbascum nudicaule.*

Habitat and ecology: An open perennial community on the sandy soil consists of white stones and pebbles, above present-day shorelines; with *Noaea mucronata,* one of the main perennial constant species.

Structure: Relatively high species richness; the total cover 10%.

Atraphaxis spinosa-Dianthus orientalis comm. (Fig. 4d)

Diagnostic species: *Dianthus orientalis* and *Atraphaxis spinosa.*

Dominant species: *Dianthus orientalis.*

Habitat and ecology: A noteworthy perennial community above recent shorelines of the island, on sandy substrate including large stones and white pebbles; adjacent to the transient zone and *Limonium carnosum* comm.

Structure: Species-rich; the total cover between 25–40%.

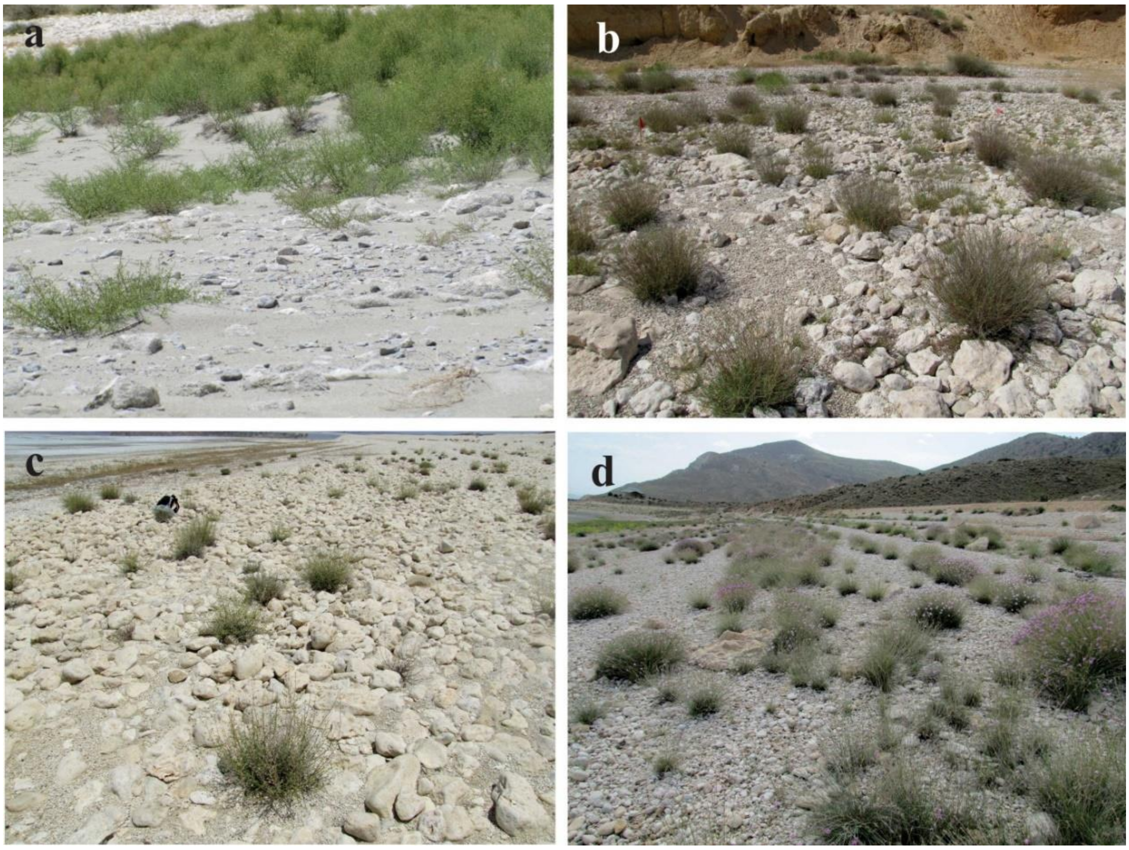

Fig. 4. Plant communities developed on the former shorelines of Kaboodan Island: a. *Alhagi maurorum* comm., b. *Limonium carnosum* comm., c. *Verbascum nudicaule* comm., d. *Atraphaxis spinosa-Dianthus orientalis* comm.

3. Plant communities found on hills adjacent to shorelines, steppe areas and valleys of the island: These communities are largely composed of perennials distributing through lowland to highland areas and valleys of Kaboodan Island in the shape of steppe-subshrub, steppe-shrub and steppe-open woodland vegetation types.

Halimionetum verruciferae (Keller 1923) Ţopa 1939 (Topa 1939)
Diagnostic and dominant species: *Halimione verrucifera.*
Habitat and ecology: A perennial halophytic community, above the former shorelines at the foot of steppe area, on sandy substrate; *Caroxylon dendroides* and *Pimpinella aurea* as two of the main constant species.
Structure: Species-rich; the total cover between 75–80%.

Caroxylon dendroides comm. (Fig. 5a)
Diagnostic species: *Caroxylon dendroides* and *Ferula szowitsiana*.
Dominant species: *Caroxylon dendroides*.
Habitat and ecology: A perennial salt-affected community on the hills above former shorelines, overlooking the exposed salty flats; *Artemisia spicigera*, the main perennial constant species; *Poa bulbosa* and *Aegilops tauschii*, the dominant grasses in springtime; adjacent to the *Atraphaxis spinosa-Ephedra major* subsp. *procera* comm. and *Halothamnus glaucus* comm.
Structure: High species richness; the total cover between 75–93%.

Caroxylon vermiculatum-Artemisia spicigera comm.
Diagnostic species: *Caroxylon vermiculatum* and *Aegilops crassa* var. *macranthera*.
Habitat and ecology: A perennial community mixed with *Artemisia* stands on the low-altitude steppes near the former island shoreline; dominated by *Carex pachystylis,* grasses such as *Aegilops tauschii* and *A. triuncialis* and other vernal plants in the time of spring; adjacent to the *Pistacia atlantica* subsp. *mutica-Rhamnus pallasii* comm.
Structure: Very rich in species composition; the total cover between 85–90%.

Halothamnus glaucus comm. (Fig. 5b)
Diagnostic species: *Halothamnus glaucus* and *Leptaleum filifolium.*
Dominant species: *Halothamnus glaucus.*
Habitat and ecology: A perennial C_4 halophytic stand located in *Artemisia-Ephedra* steppe-subshrubs, almost near to the former shoreline; noticeably dominated by *Carex pachystylis* and grasses such as *Bromus tectorum, Hordeum murinum* subsp. *glaucum* and *Poa bulbosa* in springtime; adjacent to the *Caroxylon dendroides* comm. and *Artemisia spicigera-Ephedra major* subsp. *procera* comm.
Structure: Rather species-rich; the total cover between 85–95%.

Atraphaxis spinosa-Ephedra major subsp. ***procera*** comm. (Fig. 5c)
Diagnostic species: *Atraphaxis spinosa.*
Dominant species: *Atraphaxis spinosa* and *Ephedra major* subsp. *procera.*
Habitat and ecology: A subshrub community on foothills above the former island's shorelines with sandy-stony substrate; adjacent to the *Caroxylon dendroides* comm., transient zone, *Alhagi maurorum* comm. and *Artemisia spicigera-Ephedra major* subsp. *procera* comm.
Structure: High species richness; the total cover between 30–50%.

Artemisia spicigera-Ephedra major subsp. ***procera*** comm. (Fig. 5d)
Dominant species: *Artemisia spicigera.*
Habitat and ecology: A vast mixed community of *Artemisia spicigera* and *Ephedra major* subshrubs occurred in many low to high-altitude steppe areas of the island; composed of *Stipa hohenackeriana, Iris barnumiae, Noaea mucronata, Poa bulbosa* and *Carex pachystylis* as the main perennial constant species; covered by annual species stands including *Aegilops*

triuncialis, *Erodium cicutarium*, *Minuartia meyeri*, *Senecio glaucus*, *Androsace maxima*, *Arenaria leptoclados*, and *Helianthemum salicifolium* in the springtime.

Structure: Species-rich; the total cover between 70–92%.

Pistacia atlantica subsp. ***mutica-Rhamnus pallasii*** comm. (Fig. 5e)

Diagnostic species: *Pistacia atlantica* subsp. *mutica* and *Rhamnus pallasii.*

Dominant species: *Pistacia atlantica* subsp. *mutica* in tree layer, *Poa bulbosa* in herb layer.

Habitat and ecology: An open woodland community occurred all over the island from low to high-altitude steppes and also in the valleys, often mixed with *Rhamnus pallasii* shrubby community; *Artemisia spicigera* and *Stipa hohenackeriana* as the main perennial constant species; *Bromus tectorum*, *Hordeum murinum* subsp. *glaucum*, *Senecio glaucus*, *Minuartia meyeri*, *Arenaria leptoclados*, *Bromus danthoniae*, *Helianthemum salicifolium*, *Androsace maxima*, and *Alyssum desertorum* as examples of common annual constant species covering these woodlands, particularly in springtime.

Structure: Noticeably species-rich; the total cover between 60–95%.

Rhamnus pallasii-Artemisia spicigera comm. (Fig. 5f)

Diagnostic species: *Rhamnus pallasii*, *Teucrium polium*, *Centaurea virgata* subsp. *squarrosa*, and *Asperula rezaiyensis.*

Habitat and ecology: A steppe-shrubby community mainly distributed on highlands of the island, also found in the valleys, sometimes mixed with *Pistacia atlantica* woodlands; associated with a number of sub-shrubby and perennial constant species such as *Ephedra major* subsp. *procera*, *Prunus microcarpa*, *Atraphaxis spinosa*, *Stipa hohenackeriana*, *Noaea mucronata*, and *Poa bulbosa*; occupied by common annual species and grasses in the springtime.

Structure: With very high species richness; the total cover between 55–80%.

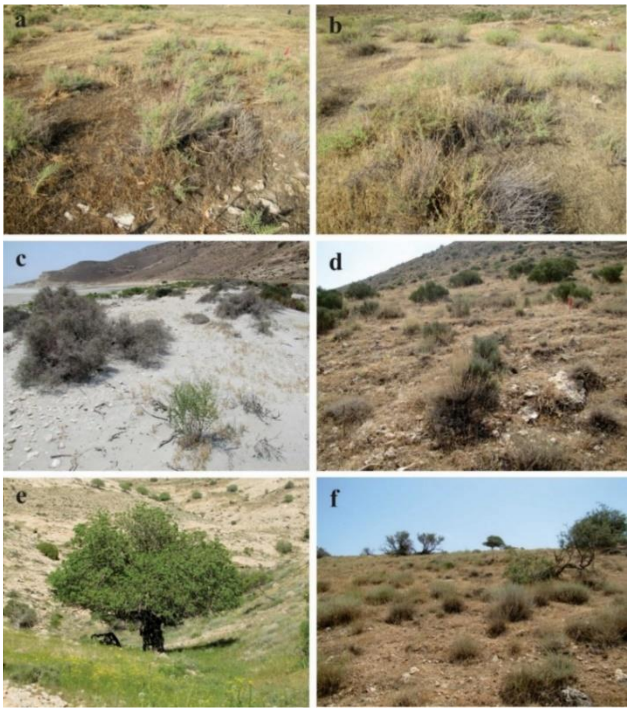

Fig. 5. Some plant communities found on hills adjacent to shorelines, steppe areas and valleys of Kaboodan Island: a. *Caroxylon dendroides* comm., b. *Halothamnus glaucus* comm., c. *Atraphaxis spinosa-Ephedra major* subsp. *procera* comm., d. *Artemisia spicigera-Ephedra major* subsp. *procera* comm., e. *Pistacia atlantica* subsp. *mutica-Rhamnus pallasii* comm., f. *Rhamnus pallasii-Artemisia spicigera* comm.

Hymenocrater bituminosus-Ephedra major subsp. ***procera*** comm. (Fig. 6a)

Diagnostic species: *Hymenocrater bituminosus*.

Habitat and ecology: A subshrub community embedded in mid-altitude *Artemisia* steppes of the island, on the stony substrate; including *Pimpinella aurea*, *Poa bulbosa*, *Atraphaxis spinosa*, *Artemisia spicigera*, and *Noaea mucronata* as the main perennial constant species; covered by *Scandix stellata*, *Galium spurium*, *Holosteum glutinosum*, and other vernal plants at the first of growing season.

Structure: Relatively species-rich; the total cover between 40–75%.

Juniperus polycarpos comm. (Fig. 6b)

Diagnostic and dominant species: *Juniperus polycarpos.*

Habitat and ecology: Juniper woodland found on the steep slopes of the island or as scattered stands along valleys of the area; including sporadic *Pistacia* trees and a number of subshrubs such as *Ephedra major* subsp. *procera*, *Prunus microcarpa*, *Cotoneaster nummularius*, *Daphne mucronata*, *Hymenocrater bituminosus*, *Rubia rigidifolia*, and *Atraphaxis spinosa.*

Structure: Quite rich in species; the total cover 70%.

Agropyron cristatum subsp. ***pectinatum-Noaea mucronata*** comm.

Diagnostic species: *Agropyron cristatum* subsp*. pectinatum*, *Tanacetum canescens*, and *Viola occulta.*

Habitat and ecology: A perennial community embedded in high-altitude *Artemisia* steppes of the island; comprising *Artemisia spicigera* and *Pimpinella aurea* as the considerable constant perennials, and *Scandix stellata*, *Cerastium perfoliatum*, *Lamium amplexicaule*, and *Noccaea perfoliata* as the constant annuals, especially in springtime.

Structure: Rather species-rich; the total cover between 60–75%.

Peganum harmala comm. (Fig. 6c)

Diagnostic and dominant species: *Peganum harmala.*

Habitat and ecology: A ruderal community found on the highest point of the island (also observed near the shoreline), seemingly on degraded soil; occupied by patches of *Carex pachystylis, Poa bulbosa* and annuals such as *Erodium cicutarium* and *Helianthemum salicifolium* during springtime.

Structure: High species richness; the total cover between 70–94%.

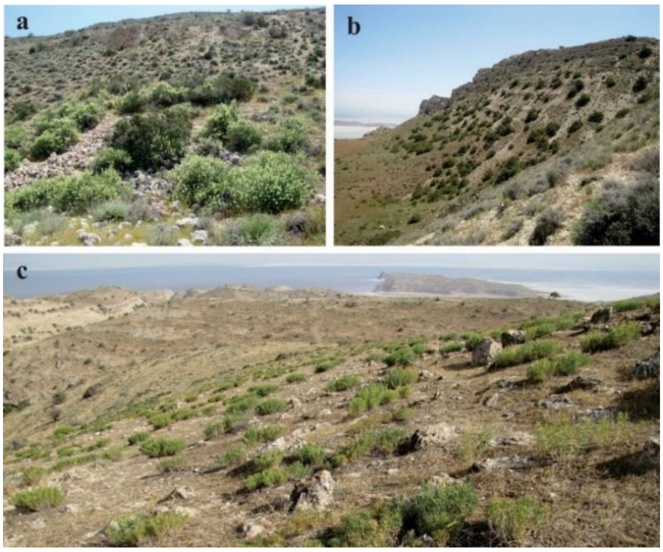

Fig. 6. Some plant communities found on hills adjacent to shorelines, steppe areas and valleys of the Kaboodan Island: a. *Hymenocrater bituminosus-Ephedra major* subsp. *procera* comm., b. *Juniperus polycarpos* comm., c. *Peganum harmala* comm.

- Gradient analysis

DCA ordination diagram of proposed vegetation units (Fig. 7A) revealed an almost clear differentiation between the halophytic plant communities formed on present-day shorelines of the island (blue circle), the communities developed on sandy-stony substrates of former shorelines (red circle) and the communities of gently sloping hills, steppe areas and valleys of the island (yellow circle). First axis (DCA1) displayed a floristic variation with the length of 5.93 and the second axis (DCA2) with the length of 6.20. Superimposing of environmental data to the ordination discovered the negative correlation of altitude and aspect with DCA first axis and the positive correlation of slope with DCA second axis (Fig. 7a). The arrow position of these three environmental indicators represent-days a positive correlation among them, as a group, influencing the floristic gradient. As a result, the plant communities in right side of the graph are often coastal halophytic vegetation established on low-altitude flat areas of the island's shorelines with no aspect and slope. Gradually with increasing altitude and slope and appearance of aspect other communities are illustrated (Fig. 7A, a). On the other hand, plant communities of shoreline areas (blue and red circles) are rather well separated on the diagram while the communities of inland areas (yellow circle) overlap profoundly. This overlapping may be related to similar floristic composition and habitat condition of inland plant communities. Removal of the relevés of shoreline communities from the data set caused better visualizing in steppe and valley vegetation of the island along ordination axes (Fig. 7B). Accordingly, DCA analysis clearly indicated the floristic differentiation of non-shoreline plant communities with 3.10 for the length of first axis and 2.57 for the length of second axis. Then, projecting of the ecological factors on the ordination diagram showed the positive correlation of slope and aspect with the first axis and the negative associating of altitudinal gradient with the second axis (Fig. 7b).

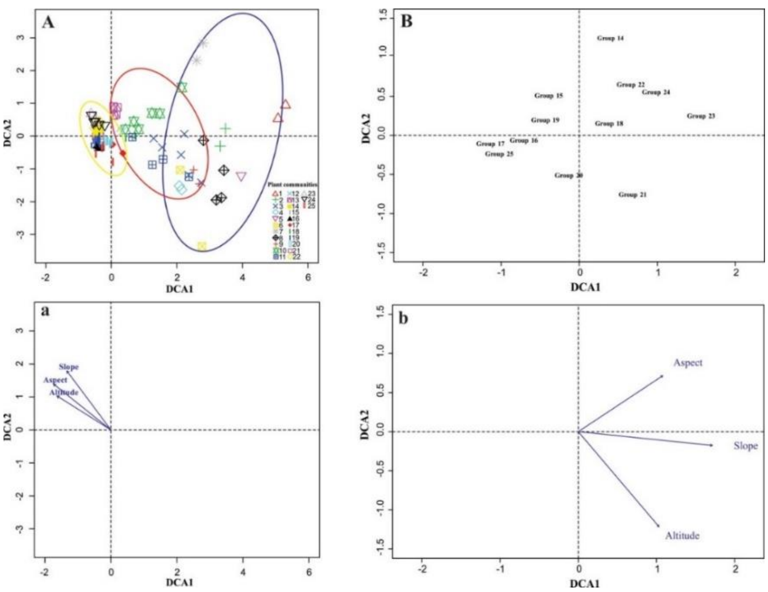

Fig. 7. A. DCA ordination diagram of TWINSPAN units with a. projecting of three environmental variables, B. DCA diagram after removing of shoreline vegetation units with b. superimposing of environmental variables: 1. *Salicornietum iranicae*, 2. *Climacopteretum crassae*, 3. *Halimocnemis rarifolia* comm., 4. *Suaeda gracilis* comm., 5. *Halocnemetum strobilacei*, 6. *Frankenia hirsuta* comm., 7. *Caroxylon nitrarium* comm., 8. *Atriplicetum tataricae*, 9. *Alhagi maurorum* comm., 10. Transient zone with annuals, 11. *Limonium carnosum* comm., 12. *Verbascum nudicaule* comm., 13. *Atraphaxis spinosa-Dianthus orientalis* comm., 14. *Halimionetum verruciferae*, 15. *Caroxylon dendroides* comm., 16. *Caroxylon vermiculatum-Artemisia spicigera* comm., 17. *Halothamnus glaucus* comm., 18. *Atraphaxis spinosa-Ephedra major* subsp. *procera* comm., 19. *Artemisia spicigera-Ephedra major* subsp. *procera* comm., 20. *Pistacia atlantica* subsp. *mutica-Rhamnus pallasii* comm., 21. *Rhamnus pallasii-Artemisia spicigera* comm., 22. *Hymenocrater bituminosus-Ephedra major* subsp. *procera* comm., 23. *Juniperus polycarpos* comm., 24. *Agropyron cristatum* subsp. *pectinatum-Noaea mucronata* comm., 25. *Peganum harmala* comm. (The group number in diagram B is the same as plant community number in diagram A).

Table 1. Synoptic table of the proposed vegetation units of Kaboodan Island with percentage frequencies (percentage constancies). Frequency values of diagnostic species are grey-highlighted in the relevant column than in others.

Vegetation category	**Plant community formed on the dried bed of Urmia Lake (on Kaboodan Island present-day shorelines)**								**Plant community developed on the former shorelines of the island (above present-day shorelines)**					**Plant community found on hills adjacent to shoreline, steppe area and valley of the island**											
Plant communities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Number of relevés	4	2	6	2	1	2	2	4	2	6	4	2	4	2	4	2	2	4	19	10	7	5	1	6	4
DS. *Salicornietum iranicae*																									
Salicornia iranica	100	100	.	.	.	.	.	.	50	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DS. *Climacopteretum crassae*																									
Climacoptera crassa	50	100	33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DS. *Halimocnemis rarifolia* comm.																									
Halimocnemis rarifolia	.	.	100	100	.	.	.	50	50	.	75	.	.	.	.	.	.	25	.	.	.	.	.	.	.
DS. *Suaeda gracilis* comm.																									
Suaeda gracilis	.	.	33	100	.	.	.	25	100	.	25	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DS. *Halocnemetum strobilacei*																									
Halocnemum strobilaceum	.	.	.	.	100	50	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aeluropus littoralis	.	.	.	.	100	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DS. *Frankenia hirsuta* comm.																									
Frankenia hirsuta	.	.	17	.	.	100	.	.	100	.	100	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DS. *Caroxylon nitrarium* comm.																									
Caroxylon nitrarium	.	.	.	.	.	.	100	.	.	.	.	.	25	.	.	.	.	.	.	.	.	.	.	.	.
Strigosella africana	.	.	17	.	.	.	100	.	.	17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DS. *Atriplicetum tataricae*																									
Atriplex tatarica	.	.	17	.	.	.	.	100	100	33	.	.	.	.	.	.	.	50	.	.	.	.	.	.	.
DS. *Alhagi maurorum* comm.																									
Alhagi maurorum	.	.	.	.	.	.	.	.	100	.	.	.	.	.	.	.	.	25	.	.	.	.	.	.	25
Transient zone with annuals																									
DS. *Limonium carnosum* comm.																									
Limonium carnosum	.	.	.	.	.	.	50	.	.	.	100	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DS. *Verbascum nudicaule* comm.																									
Verbascum nudicaule	.	.	.	.	.	.	.	.	.	.	.	100	.	.	.	.	.	.	.	.	.	.	.	.	.
DS. *Atraphaxis spinosa-Dianthus orientalis* comm.																									
Dianthus orientalis	.	.	.	.	.	.	.	.	.	33	50	.	100	.	.	.	.	50	.	.	71	.	100	17	.

Vegetation category	**Plant community formed on the dried bed of Urmia Lake (on Kaboodan Island present-day shorelines)**								**Plant community developed on the former shorelines of the island (above present-day shorelines)**					**Plant community found on hills adjacent to shoreline, steppe area and valley of the island**											
Plant communities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Number of relevés	4	2	6	2	1	2	2	4	2	6	4	2	4	2	4	2	2	4	19	10	7	5	1	6	4
DS. *Halimionetum verruciferae*																									
Halimione verrucifera	.	.	.	.	.	.	.	.	.	.	.	.	.	100	.	.	.	.	.	.	.	.	.	.	.
DS. *Caroxylon dendroides* comm.																									
Caroxylon dendroides	.	.	.	.	.	.	.	.	.	.	.	.	.	100	100	.	50	50	.	.	.	.	.	.	.
Ferula szowitsiana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	50	.	.	.	.	.	.	.	.	.	.
DS. *Caroxylon vermiculatum-Artemisia spicigera* comm.																									
Caroxylon vermiculatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100	.	.	.	10	.	.	.	.	.
Aegilops crassa var. *macranthera*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100	.	.	.	10	.	.	.	.	.
DS. *Halothamnus glaucus* comm.																									
Halothamnus glaucus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100	.	.	.	.	.	.	.	.
Leptaleum filifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	50	.	.	.	.	.	.	.	.
DS. *Atraphaxis spinosa-Ephedra major* subsp. *procera* comm.																									
Atraphaxis spinosa	.	.	.	.	.	.	.	.	50	17	.	.	50	.	25	.	.	100	.	10	71	80	100	33	25
Artemisia spicigera-Ephedra major subsp. *procera* comm.																									
Ephedra major subsp. *procera*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	.	50	100	68	50	100	100	100	67	50
Artemisia spicigera	.	.	.	.	.	.	.	.	.	.	25	50	.	50	100	100	50	50	100	100	100	80	.	100	75
Carex pachystylis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	100	100	.	42	10	.	20	.	.	100
Stipa hohenackeriana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	50	58	80	86	40	.	67	25
Noaea mucronata	.	.	.	.	.	.	.	.	.	.	.	100	75	.	25	.	.	25	42	40	86	60	100	83	50
Iris barnumiae	.	.	.	.	.	.	.	.	.	.	.	.	.	50	25	.	.	.	89	40	43	60	.	67	.
Pimpinella aurea	.	.	.	.	.	.	.	.	.	.	.	.	.	100	25	.	.	50	11	.	14	100	100	100	.
Prunus microcarpa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100	60	100	.	.
DS. *Pistacia atlantica* subsp. *mutica-Rhamnus pallasii* comm.																									
Pistacia atlantica subsp. *mutica*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	90	43	.	100	.	.
DS. *Rhamnus pallasii-Artemisia spicigera* comm.																									
Rhamnus pallasii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	90	100	.	.	17	.
Teucrium polium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	71	.	.	.	.

Vegetation category	**Plant community formed on the dried bed of Urmia Lake (on Kaboodan Island present-day shorelines)**								**Plant community developed on the former shorelines of the island (above present-day shorelines)**					**Plant community found on hills adjacent to shoreline, steppe area and valley of the island**											
Plant communities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Number of relevés	4	2	6	2	1	2	2	4	2	6	4	2	4	2	4	2	2	4	19	10	7	5	1	6	4
Centaurea virgata subsp. *squarrosa*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	71	.	.	.	.
Asperula rezaiyensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	57	.	.	.	.
Bufonia parviflora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	43	.	.	.	.
DS. *Hymenocrater bituminosus-Ephedra major* subsp. *procera* comm.																									
Hymenocrater bituminosus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100	100	.	.
Vicia anatolica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	40	.	.	.
Lactuca tuberosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	40	.	.	.
DS. *Juniperus polycarpos* comm.																									
Juniperus polycarpos	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100	.	.
DS. *Agropyron cristatum* subsp. *pectinatum-Noaea mucronata* comm.																									
Agropyron cristatum subsp. *pectinatum*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100	67	.
Tanacetum canescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100	50	.
Viola occulta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	50	.
DS. *Peganum harmala* comm.																									
Peganum harmala	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	50	.	.	.	.	.	.	.	75
Common species																									
Bromus tectorum	.	50	100	.	.	50	100	25	100	100	75	100	100	.	50	.	100	75	53	90	100	20	100	50	50
Vulpia persica	.	.	33	.	.	50	.	.	100	100	25	100	100	50	50	.	.	100	5	70	86	80	.	83	25
Senecio glaucus	.	50	83	100	.	.	.	.	.	83	75	50	100	100	100	100	100	100	89	100	100	100	100	100	100
Roemeria hybrida	.	100	50	.	.	.	.	.	.	83	50	100	75	50	50	100	.	100	84	40	43	60	.	83	.
Holosteum glutinosum	.	100	50	100	.	.	.	.	.	17	50	100	75	100	50	100	.	.	47	80	86	80	100	83	.
Hordeum murinum subsp. *glaucum*	.	100	83	.	.	50	50	75	100	33	.	.	.	.	25	.	100	50	5	80	29	.	.	.	25
Bromus danthoniae	.	.	33	50	.	50	.	.	.	17	100	50	25	.	50	100	.	.	79	90	86	40	100	33	.
Minuartia meyeri	.	.	33	.	.	.	.	.	.	67	25	100	50	50	75	50	100	50	100	100	71	80	100	33	100
Arenaria leptoclados	.	.	.	.	.	50	.	.	.	17	25	100	.	.	100	100	50	.	79	90	86	40	.	17	75

Vegetation category	**Plant community formed on the dried bed of Urmia Lake (on Kaboodan Island present-day shorelines)**								**Plant community developed on the former shorelines of the island (above present-day shorelines)**					**Plant community found on hills adjacent to shoreline, steppe area and valley of the island**											
Plant communities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Number of relevés	4	2	6	2	1	2	2	4	2	6	4	2	4	2	4	2	2	4	19	10	7	5	1	6	4
Poa bulbosa	.	.	17	.	.	.	.	.	.	17	25	50	75	100	100	100	100	100	100	90	100	100	100	83	100
Helianthemum salicifolium	.	.	.	.	.	.	.	.	.	17	.	.	.	.	50	.	100	50	74	90	71	40	.	17	100
Androsace maxima	.	.	17	.	.	.	.	.	.	17	.	.	.	.	100	100	50	100	95	90	86	20	.	33	.
Erodium cicutarium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	100	.	25	79	80	86	60	.	.	100
Aegilops triuncialis	.	.	.	.	.	.	.	.	50	17	.	.	.	50	50	100	50	100	74	50	57	.	.	33	.
Aegilops tauschii	.	.	.	50	.	.	.	.	50	.	25	.	.	100	50	100	.	25	42	60	14	40	.	.	25
Ziziphora tenuior	.	.	.	.	.	.	.	.	.	.	25	.	.	50	50	100	.	.	79	70	86	60	.	33	.
Galium verticillatum	.	.	.	.	.	.	.	.	.	17	50	100	75	100	25	50	50	50	68	50	71	60	100	17	25
Cerastium inflatum	.	.	.	.	.	.	.	.	.	50	50	.	100	100	.	.	.	75	42	90	86	80	100	83	.
Scandix stellata	.	.	.	.	.	.	.	.	.	.	75	50	100	100	75	50	50	50	32	50	100	100	100	100	.
Alyssum desertorum	.	.	.	.	.	.	.	.	.	.	.	.	25	50	100	100	.	25	42	100	29	60	100	50	50
Lamium amplexicaule	.	.	.	.	.	.	.	.	.	.	.	.	.	50	50	100	50	.	26	60	86	60	.	100	25
Helianthemum ledifolium	.	.	.	.	.	.	.	.	.	.	.	.	50	.	25	50	.	.	58	30	43	20	.	67	25
Gagea reticulata	.	.	.	.	.	.	.	.	.	.	.	.	.	100	100	50	.	.	74	30	29	80	100	100	25
Tragopogon caricifolius	.	.	.	.	.	.	.	.	.	17	.	50	.	100	25	.	100	50	63	.	.	100	.	83	.
Galium spurium	.	.	.	.	.	.	.	.	.	17	50	.	100	100	25	.	.	50	.	20	86	100	.	67	25
Noccaea perfoliata	.	.	.	.	.	.	.	.	.	17	.	.	75	100	25	.	.	25	5	20	29	40	100	100	.
Linaria simplex	.	.	33	.	.	.	.	.	.	67	25	100	50	50	25	50	.	50	42	20	14	.	.	.	.
Papaver argemone	.	.	33	.	.	.	.	.	.	33	25	50	25	.	25	100	.	75	21	30	71	.	.	67	.
Cymbolaena griffithii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	100	.	.	26	20	71	.	.	.	.
Ceratocephala falcata	.	.	.	.	.	.	.	.	.	.	.	.	.	50	50	100	.	.	26	10	14	.	.	33	25
Crupina crupinastrum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	50	100	.	.	47	30	43	20	.	17	.
Descurainia sophia	.	.	33	.	.	.	.	.	.	17	.	.	.	50	25	.	100	.	5	30	29	.	.	17	25
Holosteum umbellatum	.	.	50	.	.	.	.	.	.	50	50	.	.	.	50	.	50	25	37	.	.	.	.	17	25
Camelina rumelica	.	.	.	.	.	.	.	.	.	33	25	.	50	.	25	50	.	50	11	50	57	20	.	50	.
Roemeria refracta	.	.	.	.	.	.	50	.	.	.	.	50	.	50	25	.	50	.	11	.	29	100	100	67	.
Silene coniflora	.	.	17	.	.	.	.	.	.	83	.	.	.	.	.	.	50	25	26	30	.	.	.	.	50

Vegetation category	Plant community formed on the dried bed of Urmia Lake (on Kaboodan Island present-day shorelines)								Plant community developed on the former shorelines of the island (above present-day shorelines)					Plant community found on hills adjacent to shoreline, steppe area and valley of the island											
Plant communities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Number of relevés	4	2	6	2	1	2	2	4	2	6	4	2	4	2	4	2	2	4	19	10	7	5	1	6	4
Diptychocarpus strictus	.	.	.	.	.	.	.	.	.	.	.	100	50	50	50	.	.	.	11	20	14	60	100	17	.
Buglossoides tenuiflora	.	.	.	.	.	.	.	.	.	33	.	.	.	50	50	100	.	50	16	10	14	20	.	.	.
Rochelia disperma	.	.	.	.	.	.	.	.	.	.	.	.	.	50	.	50	.	.	58	20	.	20	.	.	.
Koelpinia linearis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	100	.	.	26	20	.	40	.	.	.
Chardinia orientalis	.	.	.	.	.	.	.	.	.	.	.	.	25	50	50	100	.	.	53	20	14	.	.	.	.
Bellevalia glauca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	50	50	.	53	.	14	40	.	.	.
Nonea caspica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	50	100	.	.	53	20	29	20	.	17	.
Leopoldia caucasica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	.	.	.	58	.	29	20	100	33	.
Allium stamineum	.	.	.	.	.	.	.	.	.	.	.	.	.	50	50	50	.	25	26	.	.	.	.	17	.
Callipeltis cucullaris	.	.	.	.	.	.	.	.	.	17	.	.	.	.	50	.	.	.	5	30	71	20	.	.	.
Torilis leptophylla	.	.	.	.	.	.	.	.	.	.	.	.	.	50	50	.	.	.	.	20	71	.	.	.	.
Minuartia hamata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	16	20	29	20	.	33	.
Loliolum subulatum	.	.	17	.	.	.	.	.	.	.	.	.	.	.	.	50	.	.	.	50	57	.	.	17	.
Valerianella oxyrrhyncha	.	.	.	.	.	.	.	.	.	.	.	.	25	.	50	100	.	.	26	20	29	20	.	17	.
Sisymbrium septulatum	.	.	17	.	.	.	.	.	.	.	.	.	.	.	50	.	.	.	16	.	14	20	.	.	.
Alyssum linifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11	.	14	20	100	83	.
Centaurea ustulata	.	.	.	.	.	.	.	.	.	.	.	.	.	50	25	.	.	.	16	20	43	20	100	33	.
Silene spergulifolia	.	.	.	.	.	.	.	.	.	.	.	.	25	.	.	.	.	50	5	20	71	20	.	67	.

Vegetation category	Plant community formed on the dried bed of Urmia Lake (on Kaboodan Island present-day shorelines)								Plant community developed on the former shorelines of the island (above present-day shorelines)						Plant community found on hills adjacent to shoreline, steppe area and valley of the island											
Plant communities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Number of relevés	4	2	6	2	1	2	2	4	2	6	4	2	4	2	4	2	2	4	19	10	7	5	1	6	4

Other species (species name community number: constancy value): *Acantholimon scorpius* 18: 50, 21: 57, 22: 20, 23: 100, 24: 17; *Gaudinopsis macra* 10:17, 11:50, 21: 57; *Thymus fedtschenkoi* 20: 10, 21: 86, 23: 100; *Cousinia seidlitzii* 19: 11, 20: 30, 21: 71, 24: 17; *Crucianella gilanica* 21: 71, 22: 20, 23: 100, 24: 67; *Rosularia sempervivum* 18: 25, 21: 71, 22: 20, 23: 100, 24: 17; *Pimpinella tragium* subsp. *lithophila* 14: 50, 18: 50, 21: 57, 22: 20; *Litwinowia tenuissima* 20: 10, 21: 29, 22: 20, 24: 67; *Eryngium billardieri* 18: 50, 20: 10, 21: 43, 22: 40, 24: 17; *Milium vernale* 21: 29, 22: 40, 23: 100, 24: 83; *Geranium tuberosum* 14: 100, 15: 50, 19: 11, 24: 67; *Papaver decaisnei* 10: 33, 11: 25, 12: 100, 18: 25, 21: 29, 23: 100, 24: 33; *Avena eriantha* 20: 50, 21: 57; *Bupleurum gerardii* 20: 30, 21: 71; *Cerastium perfoliatum* 13: 25, 23: 100, 24: 100; *Heterocaryum rigidum* 10: 17, 14: 50, 15: 50, 16: 50, 19: 16; *Allium akaka* 16: 50, 19: 21, 24: 33; *Eremopyrum distans* 2: 100, 3: 50, 7: 100, 8: 50, 9: 100, 10: 67, 18: 25; *Crucianella chlorostachys* 16: 100, 19: 37, 20: 10; *Heliotropium* sp. 9: 100, 12: 100, 18: 50; *Delphinium quercetorum* 15: 50, 19: 16, 24: 33; *Medicago radiata* 19: 26, 21: 14; *Taeniatherum caput-medusae* 10: 17, 11: 50, 16: 50, 18: 25, 19: 5, 25: 50; *Tripleurospermum parviflorum* 3: 17, 6: 50, 10: 50, 11: 25, 19: 5; *Ziziphora rotundifolia* 20: 20, 21: 57; *Paronychia kurdica* 12: 50, 18: 25, 21: 57; *Velezia rigida* 16: 100, 21: 57; *Astragalus guttatus* 15: 50, 16: 50, 17: 100, 22: 20; *Lomelosia olivieri* 19: 16, 21: 43; *Daphne mucronata* 21: 57, 23: 100; *Kali tragus* 6: 50, 7: 50, 9: 50, 18: 50; *Jurinea pulchella* 21: 14, 23: 100, 24: 50; *Polygonum aviculare* 2: 50, 7: 50, 10: 17, 11: 25, 18: 25; *Allium rubellum* 16: 50, 19: 21; *Capparis spinosa* 13: 50, 18: 50, 22: 20; *Papaver dubium* 13: 100; *Tulipa montana* var. *chrysantha* 22: 20, 23: 100, 24: 33; *Arabis nova* 15: 25, 23: 100, 24: 33; *Astragalus* sp. 21: 57; *Scutellaria theobromina* 21: 29, 22: 20, 23: 100; *Habrosia spinuliflora* 11: 25, 21: 43; *Hornungia procumbens* 2: 50, 3: 17, 11: 50; *Minuartia hybrida* 18: 50, 20: 10, 21: 14; *Medicago monantha*17: 50, 21: 14, 22: 20, 25: 25; *Cirsium* sp. 21: 29, 24: 33; *Trigonella coerulescens*15: 25, 18: 25, 19: 5, 25: 25; *Trigonella spruneriana* 16: 50, 19: 5, 20: 10, 21: 14; *Echinops orientalis* 20: 10, 21: 29, 22: 20; *Astragalus camptoceras*16: 100, 19: 5, 22: 20; *Astragalus* sp. 14: 50, 19: 11, 23: 100; *Euphorbia heteradena* 19: 11, 20: 10, 21: 14; *Melica jacquemontii* 18: 25, 21: 43; *Picnomon acarna* 15: 25, 21: 29, 22: 20; *Leontice armeniaca* 19: 21; *Medicago rigidula* 19: 16; *Astragalus dieterii* 21: 14, 24: 33; *Ceratocephala testiculata* 14: 50, 21: 14, 23: 100; *Cerastium dichotomum*18: 25, 21: 29; *Helichrysum rubicundum* 21: 29, 23: 100; *Astragalus safavii* 22: 20, 23: 100, 24: 17; *Valerianella discoidea* 19: 11, 21: 14; *Valerianella vesicaria* 14: 50, 21: 29; *Crepis sancta*18: 25, 19: 5, 21: 14; *Garhadiolus hedypnois* 16: 50, 20: 10, 21: 14; *Henrardia persica* 20: 20, 21: 14; *Vicia michauxii* 14: 50, 17: 50, 21: 14; *Cotoneaster nummularius* 21: 43, 23: 100; *Verbascum orientale* 13: 25, 21: 29; *Rubia rigidifolia* 21: 29, 23: 100; *Hypecoum pendulum* 22: 40, 25: 25; *Thalictrum sultanabadense* 21: 14, 22: 20, 23: 100; *Asperuginoides axillaris* 21: 14, 23: 100; *Centaurea urvillei* subsp. *deinacantha* 21: 29; *Acantholimon bracteatum* 21: 29; *Trigonella strangulata* 21: 29; *Valerianella amblyotis* 21: 29; *Ziziphora capitata* 21: 29; *Geranium rotundifolium* 21: 29; *Sedum nanum* 21: 29; *Pistacia atlantica* subsp. *mutica* 21: 29; *Phragmites australis* 2: 50, 8: 25; *Bolboschoenus affinis* 8: 50; *Pterocephalus canus* 22: 20, 24: 17; *Eremopyrum bonaepartis* 7: 50, 18: 25; *Holosteum* sp. 7: 50, 18: 25; *Olimarabidopsis pumila* 13: 25, 19: 5; *Lycium ruthenicum* 18: 25, 22: 20; *Sedum tetramerum* 20: 10, 21: 14; *Veronica hederifolia* 22: 20, 23: 100; *Lactuca orientalis* 18: 25, 21: 14; *Geranium* sp. 21: 14, 22: 20; *Moltkia coerulea* 19: 5, 24: 17; *Chondrilla juncea* 18: 25, 21: 14; *Valerianella* sp. 21: 29; *Alyssum szovitsianum* 21: 29; *Isatis buschiana* 10:33; *Silene marschallii* 21: 14, 23: 100; *Lepidium perfoliatum* 3: 17; *Lactuca glaucifolia* 3: 17; *Camphorosma monspeliaca* 15: 25; *Spergularia diandra* 6: 50; *Scrophularia azerbaijanica* 21: 14; *Bromus sterilis* 21: 14; *Onopordum acanthium* 21: 14; *Scrophularia variegata* subsp. *rupestris* 21: 14; *Lappula spinocarpos* 21: 14; *Ziziphora clinopodioides* 21: 14; *Sideritis montana* 21: 14; *Valerianella cymbicarpa* 21: 14; *Herniaria hirsuta* subsp. *cinerea* 20: 10; *Centaurea benedicta* 20: 10; *Sedum kotschyanum* 10: 17; *Amberboa nana* 12: 50; *Cleome iberica* 12: 50; *Atriplex leucoclada* 18: 25; *Astragalus* sp. 21: 14; *Stipa* sp. 23: 100; *Astragalus jacobsii* 19: 5; *Erodium ciconium* 19: 5; *Arenaria serpyllifolia* 12: 50; *Salvia spinosa* 18: 25; *Astragalus campylorrhynchus* 19: 5; *Allium* sp. 18: 25; *Xeranthemum squarrosum* 24: 17; *Cotoneaster* sp. 23: 100; *Ranunculus oxyspermus* 22: 20; *Muscari* sp. 21: 14; *Cousinia grandis* 23: 100; *Carduus pycnocephalus* subsp. *marmoratus* 22: 20; *Galium azerbayjanicum* 21: 14; *Gladiolus italicus* 22: 20; *Aegilops kotschyi* 19: 5; *Glaucium corniculatum* 22: 20; *Alyssum* sp. 15: 25; *Euphorbia aserbajdzhanica* 24: 17; *Poa pratensis* 24: 17; *Tragopogon* sp.25: 25; *Stipa arabica* 25: 25; *Clypeola jonthlaspi* 22: 20; *Lathyrus inconspicuus* 22: 20.

Discussion

- Vegetation communities

This study shows that, Kaboodan Island in Urmia Lake comprising varied less-touched habitats is highly significant for documentation of its flora and vegetation. Floristically, it is quite rich in the Irano-Turanian elements occurring in steppes, steppe-shrubby communities and woodlands (Zohary 1973, Djamali *et al.* 2011). Diverse habitats of this island are derived from the interaction of different factors of geology, soil, slope, aspect, altitude, and macro/microclimatic condition, which allows it to house a variety of vegetation types. Following is the island vegetation discussed according to the three aforementioned groups in the results, respectively:

1. Shrinkage of Urmia Lake water caused the formation of seasonally inundated exposed salty flats adjacent to the former shorelines of Kaboodan Island. These saline habitats are in successional initials and became prone to harbor annual halophytic vegetation communities in some parts of the island present-day shorelines (Fig. 2). Such halophytic plant communities have been shaped according to the rate of soil salinity and humidity, similar to other shorelines of hyper-saline Urmia Lake (Asri 1999, Ahmadi *et al.* 2018, Ghorbanalizadeh *et al.* 2020). These communities are floristically very poor, often dominated by one halophyte species (Fig. 8). Similarly, halophilous vegetation was recorded on the salt marshy and sandy shorelines of Ashk Island, the second largest islands of Urmia Lake and Eslami Peninsula (Zehzad 1989, Sedghipour 2017).

Spatially and temporally establishment of annual halophytic vegetation on the island's shoreline is affected by variability of climate regime and edaphic factors during the years. In contrast to the salt marshes of Urmia Lake which have distinct vegetation zonal patterns (Ghorbanalizadeh *et al.* 2020), the zonation patterns of Kaboodan exposed salty areas are in early stages, mainly with one or two zones. Interestingly, the highly saline habitats in some points of the island present-day shorelines are gradually being covered by sand (see Fig. 3f). Degraded soils washed out from the island's highlands, blowing of sand and dust storms in the Urmia Lake region and erosion of varied rock formations in the catchment basin (Sharifi *et al.* 2018) may be the source of these sands.

2. Along with retreating of Urmia Lake water during the drought in the past decades (Alborzi *et al.* 2018), former shorelines of Kaboodan Island faced to substantial changes, geologically and floristically. Many visited parts of these shorelines across the island have been covered by sand, fine and big pebbles or large stones in white color (Fig. 4). Apart from the source of sandy substrates noted above, seemingly in some areas, rock fragments have gradually fallen down from steep slopes of the island towards the former shorelines creating new stony layer on them. In spite of vicinity to the salty present-day shorelines, the occurrence of sandy-stony layer has decreased the soil salinity of former shorelines providing new habitats. Since the latter shorelines are subject to the succession trends, one can distinguish transient zones dominated by annual species close to the exposed saline flats. On the other hand, towards the island interiors, vegetation stands mostly with perennial steppe species are developing (Fig. 2). These stands are variable in species composition and compared to the halophytic communities support higher number of species, due to low soil salinity and passing succession stages (Fig. 8).

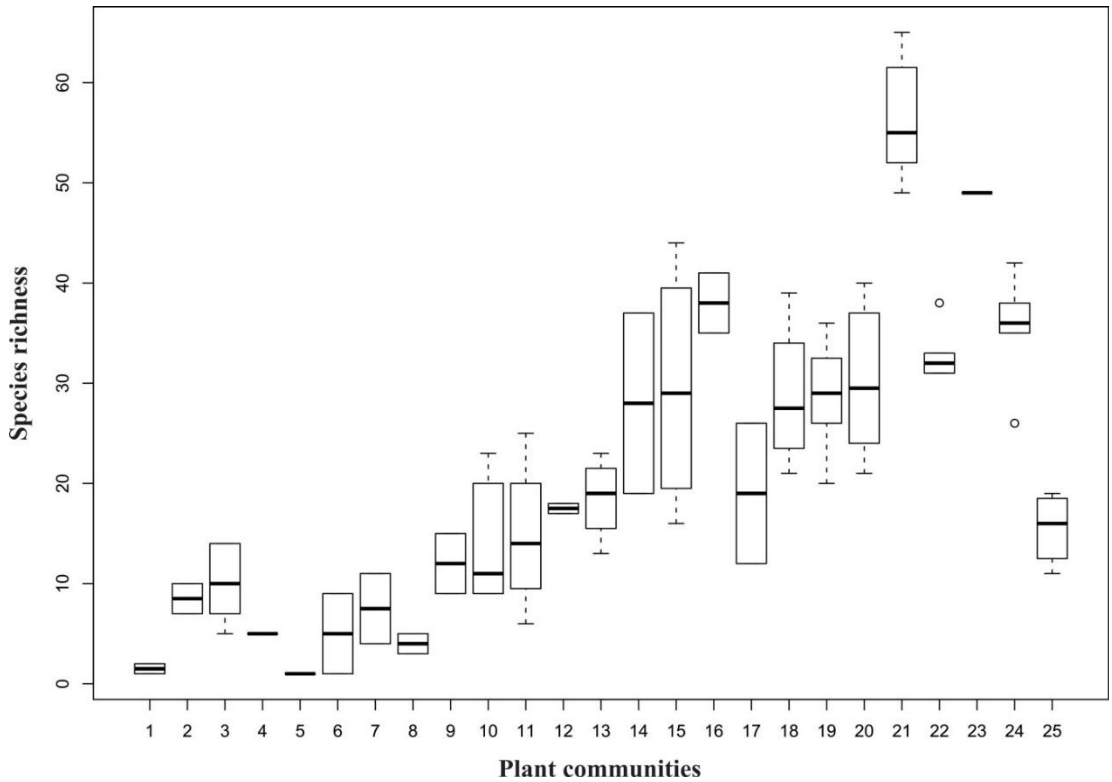

Fig. 8. The box plot of species richness and plant communities: 1. *Salicornietum iranicae*, 2. *Climacopteretum crassae*, 3. *Halimocnemis rarifolia* comm., 4. *Suaeda gracilis* comm., 5. *Halocnemetum strobilacei*, 6. *Frankenia hirsuta* comm., 7. *Caroxylon nitrarium* comm., 8. *Atriplicetum tataricae*, 9. *Alhagi maurorum* comm., 10. Transient zone with annuals, 11. *Limonium carnosum* comm., 12. *Verbascum nudicaule* comm., 13. *Atraphaxis spinosa-Dianthus orientalis* comm., 14. *Halimionetum verruciferae*, 15. *Caroxylon dendroides* comm., 16. *Caroxylon vermiculatum-Artemisia spicigera* comm., 17. *Halothamnus glaucus* comm., 18. *Atraphaxis spinosa-Ephedra major* subsp. *procera* comm., 19. *Artemisia spicigera-Ephedra major* subsp. *procera* comm., 20. *Pistacia atlantica* subsp. *mutica-Rhamnus pallasii* comm., 21. *Rhamnus pallasii-Artemisia spicigera* comm., 22. *Hymenocrater bituminosus-Ephedra major* subsp. *procera* comm., 23. *Juniperus polycarpos* comm., 24. *Agropyron cristatum* subsp. *pectinatum-Noaea mucronata* comm., 25. *Peganum harmala* comm.

3. Geo-morphologically, the main body of Kaboodan Island is composed of gently sloping hills, rocky uplands with steep slopes, non-rocky highlands and shallow to partly deep valleys across the island. Such areas of the island house different kinds of habitats with unique ecological conditions. They are usually typified by xeromorphic steppe vegetation (Takhtajan 1986), in particular *Artemisia* steppes (Zohary 1973), similar to documented results in Ashk Island (Zehzad 1989) and Eslami Peninsula (Sedghipour 2017), as nearby islands. Results of current study discovered that *Artemisia* steppes are mostly mixed with sub-shrubby or shrubby vegetation on low to high hilly lands and the valleys of Kaboodan Island (Fig. 2). The example communities are *Artemisia spicigera-Ephedra major* subsp. *procera* comm. (Fig. 5d) and *Rhamnus pallasii-Artemisia spicigera* comm. (Fig. 5f, Table 1). In the same way, Zehzad (1989) recorded *Artemisia* communities accompanied by shrub or tree species (*Rhamnus* and/or *Pistacia*) occupying the majority of Ashk Island.

Rhamnus pallasii shrublands and *Pistacia atlantica* subsp. *mutica* woodlands are openly settled on gentle slopes of lowlands, highlands and rocky outcrops of valleys throughout the island (Fig. 9a). This is the typical scrub and woodland vegetation of Atropatanian Province of Irano-Turanian floristic region (Takhtajan 1986). The plant communities comprising these phanerophyte species capture the highest species richness in the ground flora and also amongst other communities of the island (Fig. 8). Based on Zehzad (1989) there is similar tree-shrub vegetation classified in several types containing different perennial forbs and grasses in Ashk Island.

Apart from small patches of *Juniperus polycarpos* found in the valleys associated with *Ephedra major* subsp. *procera*, *Rhamnus pallasii* and *Pistacia atlantica* subsp. *mutica*, there is a considerable stand of juniper woodland occurred on the steep slopes in northeastern uplands of Kaboodan Island (Fig. 6b). Juniper trees are more abundant in Kaboodan than in Ashk Island and Eslami Peninsula (Zehzad 1989, Sedghipour 2017). There is no record of this juniper species from Espir and Arezoo islands (Gordani 2018). Beside *Pistacia* woodland, junipers are also the characteristics of Atropatanian Province (Zohary 1973, Takhtajan 1986).

Annual and perennial grasses such as *Aegilops* spp. and *Poa bulbosa* dominate over the *Artemisia* steppes with notable coverage during springtime (Fig. 9b). Zehzad (1989) also documented dense grassy patches on the non-rocky highlands of Ashk Island.

Peganum harmala community (Fig. 6c), dominated by *Peganum* as an indicator of grazed area and degraded soil (Louhaichi *et al.* 2012), was documented from lowlands and highlands of the island which its occurrence can be related to the human settlement and livestock disturbances in the far past (Khanmohammadi & Kharazi 2012). Such ruderal community was recorded from central uplands of Ashk Island (Zehzad 1989) and remarkably from many degraded steppe areas of Eslami Peninsula (Sedghipour 2017).

Atraphaxis spinosa is one of the important sub-shrub species scattered across the island which recently is developing and forming community on the new sandy-stony habitats of the former shorelines together with *Dianthus orientalis* and *Ephedra major* subsp. *procera* (Figs 4d & 5c).

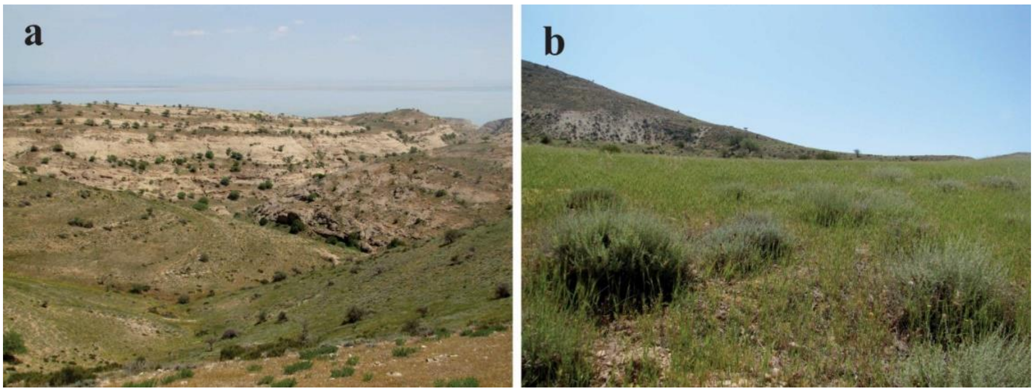

Fig. 9. a. *Rhamnus pallasii* shrublands and *Pistacia atlantica* subsp. *mutica* woodlands, b. Domination of grasses in *Artemisia* steppes during the springtime.

- Conservation and monitoring points

Fortunately, the southern archipelago in Urmia Lake National Park is lack of both human habitation and animal husbandry. Therefore, from the floristic and faunistic points of views it is a proper ecosystem, less-touched and un-grazed by domestic animals, whereas Eslami Peninsula (historically as an island) intensely suffers from human and livestock destructions. Due to developing of arable fields, fruit gardens and anthropogenic effects of local residents, natural communities of trees and shrubs have been degraded in many parts of this peninsula. There are only scattered patches of such vegetation remaining on its highlands (Sedghipour 2017). Palynological studies have shown massive changes in vegetation around the Urmia Lake through glacial-interglacial cycles based on climate oscillation and they have reconstructed the history of vegetation (van Zeist & Bottema 1991, Djamali *et al.* 2008). According to these studies, xerophytic woodlands and shrublands were common in surrounding areas of the lake. Such woodlands have been destroyed by overgrazing and long-term land use and replaced by *Artemisia* steppes (Djamali *et al.* 2011). If destructive pressures are prevented or decreased in the Urmia Lake catchment, revival of such open xerophytic scrubs may be practical. *Salicornietum iranicae* and *Climacopteretum crassae*, as examples of water-dependent annual halophytic plant communities on Kaboodan shoreline, are affected by current impermanent condition of Urmia Lake water level. Apart from planning effective strategies to restore the lake's ecological level, to evaluate the effect of water stress, determining a buffer zone around the lake comprising the island's shorelines and monitoring of this zone is essential for vegetation protection and restoration. Establishment of permanent vegetation plots on former shorelines of Kaboodan Island is strongly needed to follow the succession trend and changes in plant communities such as *Limonium carnosum* comm. and *Atraphaxis spinosa*-*Dianthus orientalis* comm. The present study displayed that, Kaboodan Island contains a considerable floristic diversity and shelters various plant communities, in particular tree and shrub vegetation. The occurrence of *Juniperus polycarpos*, *Pistacia atlantica* subsp. *mutica* and *Rhamnus pallasii* in the form of different plant communities all over the island is very noticeable. These phanerophytic vegetation units are well preserved in Urmia Lake National Park; however, conservation plans are required to protect them against climate change and growth of wild sheep population in the island. Considering to habitat heterogeneity in Kaboodan Island, more vegetation surveys could be result in more information. Vegetation monitoring is pivotal in exposed present-day and former shorelines of the island and other islands of Urmia Lake which are being faced with succession during recent unstable hydrological condition of this lake.

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References

AghaKouchak, A., Norouzi, H., Madani, K., Mirchi, A., Azarderakhsh, M., Nazemi, A., Nasrollahi, N., Farahmand, A., Mehran, A. & Hasanzadeh, E. 2015. Aral Sea syndrome desiccates Lake Urmia: call for action. Journal of Great Lakes Research 41(1): 307–311.

Ahmadi, A., Asri, Y., Tatian, M.R., Tamartash, R. & Yeganeh, H. 2018. The effect of Urmia Lake drying in plant communities changes of saline lands around it. Journal of Rangeland (Iranian Society for Range Management) 12(2): 138–153 (In Persian).

Alborzi, A., Mirchi, A., Moftakhari, H., Mallakpour, I., Alian, S., Nazemi, A., Hassanzadeh, E., Mazdiyasni, O., Ashraf, S., Madani, K., Norouzi, H., Azarderakhsh, M., Mehran, A., Sadegh, M., Castelletti, A. & AghaKouchak, A. 2018. Climate-informed environmental inflows to revive a drying lake facing meteorological and anthropogenic droughts. Environmental Research Letters 13(8): 084010.

Asem, A., Eimanifar, A., Djamali, M., De los Rios, P. & Wink, M. 2014. Biodiversity of the Hypersaline Urmia Lake National Park. Diversity 6: 102–132.

Asem, A., Eimanifar, A. & Wink, M. 2016. Update of "Biodiversity of the Hypersaline Urmia Lake National Park (NW Iran)". Diversity 8(1): 6. https://doi.org/10.3390/d8010006.

Asri, Y. 1999. Vegetation of the Orumieh lake salt marshes. Publication of Research Institute of

Forests and Rangelands, Tehran. 222 pp. (In Persian).

Asri, Y. & Ghorbanli, M. 1997. The halophilous vegetation of the Orumieh lake salt marshes, NW. Iran. Plant Ecology 132(2): 155–170.

Assadi, M., Maassoumi, A.A., Khatamsaz, M. & Mozaffarian, V. (eds). 1988–2018. Flora of Iran. Vol. 1–149. Research Institute of Forests and Rangelands, Tehran (In Persian).

Bergmeier, E. & Dimopoulos, P. 2003. The vegetation of islets in the Aegean and the relation between the occurrence of islet specialists, island size, and grazing. Phytocoenologia 33(2–3): 447–474.

Braun-Blanquet, J. 1964. Pflanzensoziologie, Grundzüge der Vegetationskunde. 3rd ed. Springer Verlag, Vienna.

Cox, C.B., Moore, P.D. & Ladle, R.J. 2016. Biogeography: an ecological and evolutionary approach. John Wiley & Sons, Chichester. 512 pp.

Djamali, M., de Beaulieu, J.-L., Shah-Hosseini, M., Andrieu-Ponel, V., Ponel, P., Amini, A., Akhani, H., Leroy, S.A.G., Stevens, L., Lahijani, H. & Brewer, S. 2008. A late Pleistocene long pollen record from Lake Urmia, NW Iran. Quaternary Research 69(3): 413–420.

Djamali, M., Akhani, H., Khoshravesh, R., Andrieu-Ponel, V., Ponel, P. & Brewer, S. 2011. Application of the Global Bioclimatic Classification to Iran: implications for understanding the modern vegetation and biogeography. Ecologia Mediterranea 37(1): 91–114.

Eimanifar, A. & Mohebbi, F. 2007. Urmia Lake (northwest Iran): a brief review. Saline Systems 3(5): 1–8.

Fernández-Palacios, J.M., Nogué, S., Criado Hernández, C., Connor, S., Góis-Marques, C.A., Menezes de Sequeira, M. & Nascimento Reyes, L.D. 2016. Climate change and human impact in Macaronesia. Past Global Changes Magazine 24(2): 68–69.

Ghaheri, M., Baghal-Vayjooee, M. & Naziri, J. 1999. Lake Urmia, Iran: a summary review. International Journal of Salt Lake Research 8(1): 19–22.

Ghorbanalizadeh, A., Akhani, H. & Bergmeier, E. 2020. Vegetation patterns of a rapidly drying up salt lake ecosystem: Lake Urmia, NW Iran. Phytocoenologia 50(1): 1–46.

Gordani, S. 2018. Comparison of the flora of Lake Urmia islands (Kaboodan, Arezu, Espir, Ashk and Eslami). MSc thesis, Department of Plant Sciences, University of Tehran, Iran (In Persian).

Greuter, W. 2001. Diversity of Mediterranean island floras. Bocconea 13: 55–64.

Hennekens, S.M. & Schaminée, J.H. 2001. TURBOVEG, a comprehensive data base management system for vegetation data. Journal of Vegetation Science 12(4): 589–591.

Hill, M.O. 1979. TWINSPAN – a FORTRAN Program for Arranging Multivariate Data in an Ordered Two-way Table by Classification of the Individuals and Attributes. Cornell University, Ithaca. 48 pp.

Kelts, K. & Shahrabi, M. 1986. Holocene sedimentology of hypersaline Lake Urmia, northwestern Iran. Palaeogeography, Palaeoclimatology, Palaeoecology 54(1–4): 105–130.

Khanmohammadi, B. & Kharazi, E. 2012. Discovery of Ilkhanid historical monuments in Kaboodan Island of Lake Urmia. Conference of consultation of the Iranian city, the historical, cultural and religious city of Urmia, Iran. 12 pp. (In Persian).

Lotfi, A. & Moser, M. 2012. A concise baseline report: Lake Uromiyeh. Conservation of Iranian Wetlands Project, IRI Department of Environment, United Nations Development Program. 113 pp.

Louhaichi, M., Ghassali, F., Salkini, A. & Petersen, S. 2012. Effect of sheep grazing on rangeland plant communities: case study of landscape depressions within Syrian arid steppes. Journal of arid Environments 79: 101–106.

Médail, F. 2017. The specific vulnerability of plant biodiversity and vegetation on Mediterranean islands in the face of global change. Regional Environmental Change 17(6): 1775–1790.

Oksanen, J., Blanchet, F.G., Friendly, M., Kindt, R., Legendre, P., McGlinn, D., Minchin, P.R., O'Hara, R.B., Simpson, G.L., Solymos, P., Stevens, M.H.H., Szoecs, E. & Wagner, H. 2017. vegan: Community Ecology Package. R package version 2.4-3. https://CRAN.R-project.org/package=vegan.

Rechinger, K.H. (ed.). 1963-2015. Flora Iranica. Vol. 1–181. Akademische Druck- und Verlagsanstalt, Graz.

Sciandrello, S., Cambria, S., Giusso del Galdo, G., Guarino, R., Minissale, P., Pasta, S., Tavilla, G. & Cristaudo, A. 2021. Floristic and vegetation changes on a small Mediterranean Island over the last century. Plants 10(4): 680.

Sedghipour, V. 2017. Plant diversity of Eslami Peninsula (Urmia Lake, East Azerbaijan). MSc thesis, Department of Plant Sciences, University of Tehran, Iran (In Persian).

Sharifi, A., Shah-Hosseini, M., Pourmand, A., Esfahaninejad, M. & Haeri-Ardakani, O. 2018. The Vanishing of Urmia Lake: A Geolimnological Perspective on the Hydrological Imbalance of the World's Second Largest Hypersaline Lake. *In*: Nooran, P.G. *et al*. (eds). Lake Urmia: A Hypersaline Waterbody in a Drying Climate [The Handbook of Environmental Chemistry]. Springer, Berlin, Heidelberg.

Takhtajan, A. 1986. Floristic Regions of the World [English translation from Russian]. University of California Press, California. 544 pp.

Tichý, L. 2002. JUICE, software for vegetation classification. Journal of Vegetation Science 13(3): 451–453.

Topa, E. 1939. La Végétation des halophytes du Nord de la Roumanie. Bulletin Faculty Stünte din Cernauti 13: 58–80.

Ubrizsy, G. 1949. Magyarország ruderális gyomnövény-szövetkezetei, tekintettel a mezőgazdasági vonatkozásokra. [Agricultural Aspects of the Hungarian Ruderal Weed Plant Communities]. Mezőgazdasági Tudományos Közleményekből 1: 87–123 (In Hungarian).

van Zeist, W. & Bottema, S. 1991. Late Quaternary vegetation of the Near East (Tubinger Atlas des Vorderen Orients (TAVO), Series A). Dr. Ludwig Reichert Verlag, Wiesbaden. 156 pp.

Weber, H.E., Moravec, J. & Theurillat, J.-P. 2000. International code of phytosociological nomenclature. 3rd edition. Journal of Vegetation Science 11(5): 739– 768.

Whittaker, R.J. & Fernández-Palacios, J.M. 2007. Island biogeography: ecology, evolution, and conservation. Oxford University Press, Oxford. 401 pp.

Zehzad, B. 1989. Flora and vegetation of Ashk Island (Urmia Lake National Park). Journal of Science, University of Tehran 18: 57–64 (In Persian).

Zohary, M. 1973. Geobotanical Foundations of the Middle East. Gustav Fischer Verlag, Stuttgart. 765 pp.