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Syntaxonomical Analyses of the Secondary Vegetation of Harran Plain (Sanliurfa/Turkey) Ensuing Excessive Irrigation by Using GIS and Remote Sensing

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Abstract
This study has been conducted for the purpose of determining the halophytic and ruderal vegetation located in the study area where secondary salinization occurs due to excessive irrigation and evaporation of the irrigation water leaking from surrounding lands of the agricultural territory in Akçakale region on Turkish-Syrian borders in the southern part of Harran plain and its periphery. Analysis of the vegetation has been conducted by using Braun-Blanquet method. Structures and limits of the vegetation mosaic of present associations were determined by Geographic information system (GIS) and Satellite remote sensing data. As a result of this study, the following were found: a new alliance belonging to halophytic vegetation, *Halothamno hierochunticae-Salsolion incanescentis* and two new associations, *Halothamno hierochunticae-Salsoletum incanescentis* and *Hymenolobo procumbentis-Aeluropetum lagopoidis* and two new associations belonging to ruderal vegetation, *Frankenio pulverulentae-Chenopodietum albi* and *Prosopo farctae-Alhagietum manniferae*.
Keywords: Excessive irrigation, halophyte, Harran plain, ruderal, syntaxonomy.

Harran Ovasında (Şanlıurfa/Türkiye) Aşırı Sulama Sonrası Oluşan Sekonder Vejetasyonun GIS ve Uzaktan Algılama ile Sintaksonomik Analizi
Özet
Bu çalışma, Harran Ovasının güneyinde Türkiye-Suriye sınırında yer alan Akçakale bölgesinde aşırı sulama ve çevre alanlardan sızan sulama sularının buharlaşması sonucu oluşan sekonder tuzlu alanlardaki halofitik ve ruderal vejetasyonu belirlemek amacıyla yapıldı. Mevcut vejetasyonun analizinde Braun-Blanquet metodu uygulandı. Coğrafik bilgi sistemleri (GIS) ve Uzaktan algılama uydu verileri kullanılarak vejetasyonun yapısı ve sınırları belirlendi. Bu çalışmanın sonucu olarak halofitik vejetasyona ait yeni bir alyans, *Halothamno hierochunticae-Salsolion incanescentis*; yeni iki birlik, *Halothamno hierochunticae-Salsoletum incanescentis* ve *Hymenolobo procumbentis-Aeluropetum lagopoidis*; ruderal vejetasyona ait iki yeni bitki birliği, *Frankenio pulverulentae-Chenopodietum albi* ve *Prosopo farctae-Alhagietum manniferae*, tespit edildi.
Anahtar Kelimeler: Aşırı sulama, halofit, Harran ovası, ruderal, sintaksonomi.

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INTRODUCTION

Harran plain which is located between Turkey-Syrian borders of Southeastern Anatolian region extends in the Mesopotamian sector of the West Irano-Turanian phytogeographical subregion of Irano-Turanian phytogeographical region (Zohary 1973). The Irano-Turanian phytogeographical region includes the Central, Eastern and Southeastern Anatolian geographical divisions of Turkey with a total area of approximately 38 900 000 ha. The Irano-Turanian phytogeographical region of Turkey has been a birth-place for many civilizations. Irrigation and agriculture have played an important role in the area around water basins like the Euphrates, Aras, Van and Tigris. However, as the maintenance of irrigation through drainage

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networks were neglected, the salinization of soils made the land unsuitable for agriculture. In the Fertile Crescent, the Tigris-Euphrates rivers salted up 2-5 millennia ago, resulting in the collapse of civilizations. In fact, salt accumulation in the irrigated lands led to desertification in Mesopotamia, and the lands bordering the Mediterranean more than 2000 years ago (Öztürk et al. 2008) (Fig. 1).

Recent studies in Southeastern Anatolia, particularly in the Harran plain, have shown that halophytic areas have increased considerably. After the completion of the Southeastern Anatolian Irrigation Project (GAP in Turkish), excessive irrigation has lead to an increase in the salinity levels of the soil (Atamov et al. 2006). When these cultivated areas were abandoned due to high salinization, they were occupied by the halophytes forming a secondary vegetation. Out of 225 000 ha in the Harran plain 8513 ha are classified as very highly saline areas (Özkutlu and İnce 1999). These areas are especially found around Akçakale and their total salinity level varies between 0.075 and 1.450% (Dinç and Şenol 1988).

Salinity of soils is an important problem all over the world. 10 million hectares of arable landscape is lost due to salinity every year. Some 1 518 722 ha of land in Turkey is faced with salinity and alkalinity problems. This constitutes 2% of Turkey's soil resources. Of these, 614 657 ha has a low salinity and 504 603 ha has a high salinity level. Salinity is an even greater problem in the dry or semi-dry climates due to water evaporation from the lower subsurface layers (Ağca 1999).

Saline areas are increasing in Turkey. The regions facing the problem of salinity and alkalinity in Turkey include Çarşamba and Tarsus plains in North and South Anatolia; some parts of Çukurova, Lake Tuz area, plains of Konya and Çumra in Central Anatolia; Iğdır plain in the east; Alaşehir, Salihli, Menemen plains, Bakırçay basin, Sarayköy (Denizli) and environs and Söke plain in the Great Menderes basin of Aegean region (Saatçı and Tuncay 1971). Due to improper irrigation techniques, Harran plain has been added to the abovementioned lands since 1994.

In these ecosystems, halophytes are the dominant species. Halophytes have developed mechanisms to avoid salinity stress through succulency, salt secretion glands, salt dilution capacity, osmotic adaptation, protein resistance to high salt concentrations, and selectivity in absorption through the roots (Flowers et al. 1997, Ungar 1998, Ashraf 1999, Yokoi et al. 2002). Halophytes can grow by accumulating Na^+ and Cl^- ions, thus creating turgor pressure (Waisel 1972, Yeo 1983, Guray and Demir 2001).

Excessive saline accumulation in the root area, which causes partial or entire loss of soil fertility, is a common issue. Soil salinity problems are widespread in arid and semi-arid regions; however, salt affected soils are also common in humid and semi-humid regions, especially in coastal areas where especially sea water entrance is seen. In addition, ground waters also cause high level of salinization. There are approximately 1000 million hectares of salt-affected soil globally. Distribution of salt-affected soils among continents are as follows: 3.5% in Africa, 21% in Asia, 7.6% in South America, 0.9% in North America, 0.7% in Central America, 4.6% in Europe and 42.3% in Australia (Munsuz et al. 2001).

Munns (1999) categorizes salinization into two groups depending on their formation pattern:

1. Primer (natural) salinization: this is the type of soil salinization based on saline waters of seas and oceans coming to soils through natural means, such as tides and sprays, drying of saline lakes or having a bedrock with high salt rates. For example, salinization around Lake Tuz in Turkey.

2. Secondary salinization: this type of salinization occurs in soil which was not saline before the impact of anthropogenic factors (i.e. as a result of excessive irrigation). For example, salinization in Harran plain, which includes the studied area as well.

During salinization of soils, different salts accumulate in soil in inverse proportion to their solubility. In unsalted or less-salted soil, dominant ions in soil solution are Ca^{++}, Mg^{++} and HCO_3^-. Excessively soluble salts become dominant with an increase in salinization. Most of the saline soils (EC>10 dS/m) in desert, semi-desert and arid regions contain high concentrations of NaCl and Na_2SO_4. The soil with electrical conductivity higher than 4 dS/m, 25 cm below the ground level, is accepted as saline soil. A similar definition is used in World Soil Maps of FAO/UNESCO. EC of the soils in the study area is far above 4 dS/m (Munsuz et al. 2001).

Geographic Information System (GIS) makes

Fig 1. Location of the study area (•).

many vegetation applications and plannings easier through data assessments, updating, mapping and tracing. Remote sensing data provides useful information on terrain usage, crop pattern, plant development, plant productivity, plant-water requirement, evapo-transpiration calculation and salinity depending on the level of accuracy (Bayramov and Mamedov 2008). Remote sensing has many advantages in land measurements. Information obtained with remote sensing techniques is not only theoretical; they are based on measurements on the ground. Remote sensing information can be obtained systematically; they also allow for comparison of time-related changes. Satellite data which allow for instant sensing of wide areas also facilitate analysis, updating and combination with other data by transferring them to GIS media (Bastiaanssen et al. 2000, Güleryüz and Arslan 2001).

This study was conducted in an area of approximately 23 hectare (230.778 m^2s) covered with halophyte and ruderal plants which lost their agricultural characteristics in Akcakale region in the south of Harran plain where secondary salinization was seen. Cultivation still continues in other parts of Harran plain.

This is the first study to investigate the halophytic and ruderal vegetations of Southeastern Anatolian region in respect to phytoecology and phytosociology by Braun-Blanquet (1965) method and by using GIS and Satellite remote sensing.

MATERIAL AND METHODS

In the process of identifying the plant species, we refer fundamentally to Flora of Turkey (Davis 1965-1985, Davis et al. 1988, Güner et al. 2000), some other floras (Post 1932, Zohary 1966, Hedge 1997) and several surveys (Adıgüzel and Aytaç 2001, Çolak and Sorger 2004, Kaya and Ertekin 2009). In this study, Braun-Blanquet (1965) "floristic unite system" and Frey and Lösch (1998) detailed "abundance-cover" scale were used.

The size of relevés was determined as 25 m^2 for halophytic vegetations and 40 m^2 for ruderal vegetations by using minimal area method. Evaluation of the syntaxa which belong to halophytic and ruderal vegetations were made by referring to Braun-Blanquet et al. (1952), Zohary (1973), Mucina (1997) and Kropác (2006). International Code of Phytosociological Nomenclature principles were followed for naming the new syntaxa (Weber et al. 2000). The tables which belong to the associations were given together with the upper syntaxonomic units in which they were placed. The climate of the study area was evaluated

Table 1. Properties of IKONOS satellite.

Spatial Resolution		Visible sensors		
		1-meter panchromatic (1-m PAN)	4-meter multi spectral (4-m MS)	1-meter pan-sharpened (1-m PS)
Spectral Resolution (μm)	Band			
	Band 1: Blue	0.45-0.90 μm	0.445-0.516 μm	
	Band 2: Green		0.506-0.595 μm	
	Band 3: Red		0.632-0.698 μm	
	Band 4: Near IR		0.757-0.853 μm	
Temporal Resolution	The revisit rate for IKONOS is 3 to 5 days off-nadir and 144 days for true-nadir.			
Swath	11 km x 11 km (Single Scene)			
Radiometric Resolution	The sensor collects data with a 11-bit (0-2047) sensitivity and are delivered in an unsigned 16-bit (0-65565) data format. From time-to-time the data are rescaled down to 8-bit (0 - 255) to decrease file size.			
Communications	IKONOS conducts telemetry, tracking and control in the 8345.968-8346.032 MHz band (downlink) and 2025-2110 MHz band (uplink). Downlink data carrier operates in the 8025-8345 MHz band.			

by using the data of Akçakale meteorology station (Anonymous 2006). The bioclimate of the study area was determined by Emberger (1954) and Akman and Daget (1971). The soil samples were analyzed by the Soil and Fertilizer Research Institute according to Page et al. (1990).

IKONOS, satellite used in this study, is a commercial earth observation satellite, and was the first to collect publicly available high-resolution imagery at 1 and 4 m resolution. It offers multispectral (MS) and panchromatic (PAN) imagery. In this study, IKONOS 1 m x 1 m and 2.5 RMSE belonging to 2006 were used as satellite images. These images were acquired in 37 N zone, by using UTM as a projection and WGS 84 as datum. The properties of the satellite IKONOS were given in Table 1 (Anonymous 2002).

Brief Description of the Study Area

Harran plain, covering the study area, is one of the most important agricultural areas of Turkey and located between 36º47' and 39º15' east longitude and 36º40' and 37º41' north latitude within the borders of the province of Şanlıurfa in Southeastern Anatolian region. It is bordered to Germuş and Susuz mountains in the north, Turkey-Syria state border in the south, the Tek Tek plateau in the east and the Fatik plateau in the west. Within these borders, the widest area of the Harran plain is 60 km in the south, and its narrowest area is 30 km in the centre of the Tek Tek and the Fatik plateaus. Its length is 65 km in south-north direction. Its altitude is about 400 m, which makes it one of the lowest areas in the region. The area of Harran plain is 225 000 ha (Anonymous 1980).

Harran plain is a landslide basin, resembling to a bathtub topographically. General slope varies between 0% and 2%. Northern parts of the plain are relatively sloping, but in southern parts slope is close to zero. Halophytic area where the study was conducted is located among the villages of Öncül, Altıntepe, Pınarcık and Arıcan of Akçakale district, which is the lowest part of Harran plain and Syrian border. The altitude of this area changes between 334 and 343 m (Fig. 2).

Harran plain was formed in Pliocene-Quaternary, with sloping of young techno-technic movements created during the elevation of Toros Mountains and volcanic areas which took place from time to time and calcareous deposits formed in Eocene and Neocene eras. These movements were quite effective in the south of Gaziantep-Şanlıurfa-Mardin plateau (Tunçdilek 1985, Ardos 1992).

Epeirogenic movements accompanying the tectonic movements in Quaternary, in particular, gave Harran plain its final shape. Harran plain descended and gained the characteristics of a graben compared to its environment, whereas Tek Tek plateau in its east and Fatik plateau in its west became horsts (Ardos 1992). Alluvium layer covering the surface of the plains is created by accumulation of the materials eroded by rivers from nearby calcareous areas which were members of Euphrates limestone formation (Anonymous 1972, Tardu et al. 1987). The geological formations detected in Harran plain are below:

Paleocene marl: Eocene forms non-porous base rock under limestone. Its thickness is about 800 m.

Eocene limestone: Consists of crystallized limestones. As carstic structures are well developed, it plays the role of an important aquifer of the region. It is about 300 m thick.

Miocene limestone: Consists of argillaceous limestones. As carstic structures are partially developed, it shows the characteristics of an aquifer. It is about 100 m thick.

Pliocene clay: Consists of clays which include gypseous levels sporadically. Its thickness is about 200 m.

Pleistocene clay, sand and pebbles: This unit, which is in the form of layers of clay, sand and pebbles on Pliocene clays, forms the free aquifer on the surface. Its thickness is almost 60 m.

The facts that Harran plain is covered with alluvium soil, which is the most favorable type of soil for agriculture, that its average altitude is almost 400 m and that it has negligible slope play an important role on the agricultural potential of this plain. Alluvium soil covering the plain is relatively a thick coating, whose thickness changes from 60 to 200 cm. There are also colluvial soils with pebbles and sand especially in the eastern and western parts. Although these soils are not as fertile as alluvium soils, they are still arable. Plain soil is usually deep and rich in clay. Dominant clay mineral is smectite group clays. They have high lime content (Doğanay 1994).

RESULTS

From the analysis of the results of soil samples taken from syntaxa containing areas detected in the study area, when the soils are assessed in terms of pH, it can be seen that *Halothamno hierochunticae-Salsoletum incanescentis*, *Hymenolobo procumbentis-Aeluropetum lagopoidis* and *Prosopo farctae-Alhagietum manniferae* diffuse in low-alkali soil conditions (pH 7.5-8.5), and that *Frankenio pulverulentae-Chenopodietum albi* can adapt to high alkali (pH>8.5) pH conditions (Table 2).

When soils are assessed in terms of EC (electrical conductivity), it can be seen that all associations grow in highly saline soil (EC>15) and that associations were differently resistant to salt. Analysis results show that the association with best resistance against soil salinity is *Hymenolobo procumbentis-Aeluropetum lagopoidis*, the ones with medium-resistance to highly saline environments are *Halothamno hierochunticae-Salsoletum incanescentis* and *Frankenio pulverulentae-Chenopodietum albi*, and *Prosopo farctae-Alhagietum manniferae* is the association with lowest tolerance. In addition, from observing

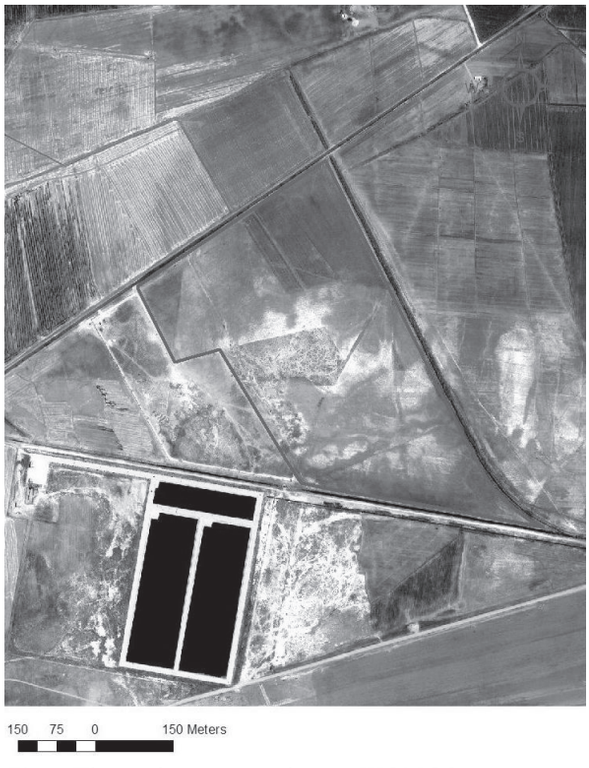

Fig 2. The study area according to IKONOS.

Table 2. Chemical analysis of the soils in the study area.

Associations	pH	EC(ds/m)	Cations (me/100 g)				Anions (me/100 g)			
			Na	K	Ca	Mg	CO_3	HCO_3	Cl	SO_4
No plant cover	8.7	125.4	30.0	1.8	6.37	77.7	1.4	63.2	38.0	13.27
Halothamno hierochunticae-Salsoletum incanescentis	8.4	74	19.0	2.92	11.88	15.44	0.3	24.5	19.7	14.74
Halothamno hierochunticae-Salsoletum incanescentis	7.9	58	5.5	0.21	10.0	26.88	-	16.5	14.15	11.94
Hymenolobo procumbentis-Aeluropetum lagopoidis	8.5	109.6	15.0	0.58	8.88	76.40	1.2	52.2	32.6	14.86
Frankenio pulverulentae-Chenopodietum albi	8.6	75	10.5	1.0	7.25	62.12	0.4	42.7	26.7	11.07
Prosopo farctae-Alhagietum manniferae	8.3	47.2	23.0	0.1	4.59	4.5	0.1	12.7	10.7	8.69
Prosopo farctae-Alhagietum manniferae	7.6	17.4	5.0	0.08	1.15	6.08	-	6.1	3.8	2.41

the salt concentrations in soils, it can be concluded that *Hymenolobo procumbentis-Aeluropetum lagopoidis* can grow in highly saline areas. Soil with no plant cover has extremely high EC rates (Fig. 3).

When the soils are assessed in terms of cations, it can be seen that Na^+ is dominant at locations where *Prosopo farctae-Alhagietum manniferae* grows; whereas for *Halothamno hierochunticae-Salsoletum incanescentis*, *Frankenio pulverulentae-Chenopodietum albi* and *Hymenolobo procumbentis-Aeluropetum*, dominant cation is Mg^{++}. When values from these analyses are examined, it can be stated that salt types in the soils where all associations grow are Mg^{++}, Na^+, Ca^{++} and K^+, in the order of cation concentration. In addition, it can be said that the most abundant salt compound in the environment are Mg^{++} salts. When soils are examined for their anionic content, presence of bicarbonate, chloride, sulfate and carbonate is detected in the order of cation concentration. Generally speaking, bicarbonate and chloride anions are more dominant in the environment.

As a result, all plant associations defined in the study area can grow in highly saline soil. It can be said that magnesium bicarbonate, magnesium chloride and sodium chloride salts are dominant in the soils where associations grow.

The climate of the study area is characterized as semi-arid cool Mediterranean climate. First type of the East Mediterranean precipitation regime (W.Sp.A.Sm.) is seen in the study area. As seen in the ombrothermic diagram, arid period lasts from the middle of April to October. July is the driest and hottest month in Akçakale (Table 3, Fig. 4).

Halophytic Vegetation

Halothamno hierochunticae-Salsolion incanescentis all. nov.

(Holotypus: *Halothamno hierochunticae-Salsoletum incanescentis*)

This alliance spreads on salty hydromorphic soils in Harran plain. This alliance characterizes the salty plain formation surrounding Harran plain in the Southeastern Anatolia. The alliance is present at 334-341 m in Harran plain. The general coverage ranges between 65% and 85%. The pH of the soil fluctuates between 7.9 and 8.5. The characteristic species of the alliance are *Salsola incanescens* C.A.Mey., *Halothamnus hierochunticus* (Bornm.) Botsch., *Atriplex leucoclada* Boiss., *Gypsophila antari* Post & Beauverd,

Atriplex leucoclada Boiss., which is a characteristic species of the new alliance, is a new record for the flora of Turkey and occurs on salted areas between Akçakale and Ceylanpınar in Turkey-Syria border. This taxon naturally spreads in Palestine, Jordan, Iraq, Sinai, Kuwait, Bahrein, United Arab Emirates, Saudi Arabia, Yemen, Qatar, Caucasus, Persia, Turcomania, Afghanistan, and Pakistan (Hedge 1997).

Two associations that can be included in this

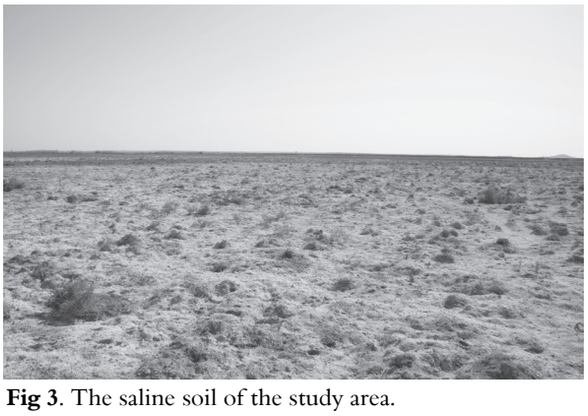

Fig 3. The saline soil of the study area.

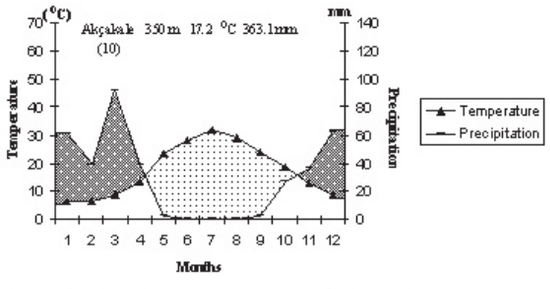

Fig 4. Ombrothermic diagram of Akçakale.

Table 3. Climatic data of the Akçakale meteorological station.

Stations	Altitude (m)	P (mm)	PE	S	M (°C)	m (°C)	Q	Precipitation regime	Bioclimate
Akçakale	350	363.1	0.2	0.005	31.8	6.2	48.5	W.Sp.A.Sm.	Semiarid mild medit.

P: mean annual precipitation in mm; M: mean maximum temperature (°C) for the hottest month; m: mean minimum temperature (°C) for the coldest month; Q: Emberger's pluviothermic quotient: 2000 P/M^2-m^2; PE: summer rainfall; S=PE/M: Emberger's index of xericity; Sp: spring; W: winter; A: autumn; Sm: summer, medit.: Mediterranean.

alliance are as fallows:

Halothamno hierochunticae-Salsoletum incanescentis ass. nov. (type) (Table 4) (Fig. 5)

Holotypus: relevé 2, 340 m, cover 80%, 25 m^2,

This association is holotypus of the alliance. Therefore, the characteristic species and ecological preference are similar. The physiognomy is dominated by Salsola incanescens C.A.Mey. The association spreads in halophytic area of Harran

Fig 5. *Halothamno hierochunticae-Salsoletum incanescentis*.

Table 4. *Halothamno hierochunticae-Salsolion incanescentis* and *Halothamno hierochunticae-Salsoletum incanescentis* (type ass.)

Relevé no	1	2	3	4	5	6	7	8	Presence
Size of plot (m^2)	25	25	25	25	25	25	25	25	
Soil	SHyd	SHyd	SHyd	SHyd	SHyd	SHyd	SHyd	SHyd	
Altitude (m)	341	340	340	339	334	335	336	337	
Coverage (%)	80	80	85	80	80	85	85	80	
Differential and Characteristic species of alliance and association									
Salsola incanescens C.A.Mey.	4	4	4	3	4	4	3	4	V
Halothamnus hierochuntica (Bornm.) Botsch.	1	1		1	1		1	1	IV
Atriplex leucoclada Boiss.	1	2a		1m		1m	1m	1	IV
Gypsophila antari Post & Beauverd			+		+	+			II
Characteristic species of Frankenietalia pulverulentae									
Frankenia pulverulenta L.		+			+	+	+		III
Characteristic species of Saginetea maritimae									
Hymenolobus procumbens (L.) Schinz & Thell.		+		+				+	II
Companions									
Alhagi mannifera Desv.		1	+		1		1	1	IV
Fumaria parviflora Lam.			+	+		+	+		III
Polypogon maritimus Willd. subsp. *maritimus*	+	+			+			+	III
Adonis aestivalis L. subsp. *aestivalis*	+	+		+			+		III
Podospermum laciniatum (L.) DC.	+		+		+			+	III
Polygonum equisetiforme Sibth. & Sm.	+		+			+	+		III
Prosopis farcta (Banks & Sol.) J.F.Macbr.	1			1	+				II
Sonchus asper (L.) Hill subsp. *glaucescens* (Jord.) Ball	+	+						+	II
Peganum harmala L.		+					+	+	II
Polygonum aviculare L.		+			+			+	II
Polygonum salicifolium Brouss. ex Willd.		+			+			+	II
Ceratocephala falcata (L.) Pers.		+	+				+		II
Lepidium perfoliatum L.		+	+					+	II
Chenopodium foliosum (Moench) Asch.	+					+	+		II
Epilobium hirsutum L.		+		+	+				II
Valerianella vesicaria (L.) Moench	+			+		+			II
Centaurea solstitialis L. subsp. *solstitialis*		+	+				+		II
Koelpinia linearis Pall.	+				+		+		II
Phleum exaratum Griseb. subsp. *exaratum*		+	+			+			II
Hypecoum pendulum L.			+						I
Cressa cretica L.				+					I
Bupleurum croceum Fenzl			+						I
Polypogon monspeliensis (L.) Desf.		+							I

plain. The pH of the soil changes between 7.9 and 8.4. The general coverage ranges between 80% and 85%. The association occupies an altitudinal range of 334-341 m.

According to Flora of Turkey, a natural spread of *Salsola incanescens* C.A.Mey., which is the characteristic type of its association, was known previously only in Van province in Turkey. Meyer described the species as a subshrub, later authors as an annual herb. Our Specimens in the study area are also subshrub. This species is an Irano-Turanian element and habitat prefers saline soils, favourably in drier salt-marshes, in many types of normal semi desert vegetation, on ruderal places, along roads, in and at the edge of cultivation etc. The other characteristic species of the association is *Halothamnus hierochuntica* (Bornm.) Botsch. and is a new floristic record for Turkey (Freitag et al. 2009).

Hymenolobo procumbentis-Aeluropetum lagopoidis ass. nov. (Table 5) (Fig. 6)

Holotypus: relevé 24, 336 m, cover 70 %, 25 m^2

It resembles the *Halothamno hierochunticae-Salsoletum incanescentis* with regard to habitat. *Aeluropus lagopoides* (L.) Trin. ex Thwaites var. *lagopoides* determines the physiognomy of the association. The other characteristic species of the association is *Hymenolobus procumbens* (L.) Schinz & Thell. The general coverage ranges between 65% and 70%. The association prefers altitudes of 334-337 m. The pH of the soil is 8.5.

A. lagopoides (L.) Trin. ex *Thwaites* var. *lagopoides*, which characterizes *Hymenolobo procumbentis-Aeluropetum lagopoidis*, found in saline desert and coastal habitats, are local in two places in Turkey, namely East (Kars) and South (Amanos mountains).

Ruderal Vegetation

Frankenio pulverulentae-Chenopodietum albi ass. nov. (Table 6) (Fig. 7)

Holotypus: relevé 16, 337 m, cover 70 %, 40 m^2

The association was identified at the altitudes of 337 to 338 m. General coverage changes between 60% and 75%. The reaction of its soil is alkaline (pH 8.6). *Chenopodium album* L. subsp. *album* var. *album* determines the physiognomy of the association and has a wide spread in Turkey except West Anatolia. The other characteristic species of the association are *Frankenia pulverulenta* L. and *Oligochaeta divaricata* (Fisch. & C.A.Mey.) K.Koch.

Prosopo farctae-Alhagietum manniferae ass. nov. (Table 7) (Fig. 8)

Fig 6. *Hymenolobo procumbentis-Aeluropetum lagopoidis*.

Fig 7. *Frankenio pulverulentae-Chenopodietum albi*.

Fig 8. *Prosopo farctae-Alhagietum manniferae*.

Holotypus: relevé 12, 341 m, cover 80%, 40 m^2

The association was identified at the altitudes between 339 to 343 m. The reaction of the soil is slightly neutral and alkaline (pH 7.6-8.3). General coverage is between 80% and 85%.

The characteristic species of the association are *Alhagi mannifera* Desv., *Prosopis farcta* (Banks & Sol.) J.F.Macbr. and *Taraxacum sintenisii* Dahlst. *A. mannifera* Desv. determining the physiognomy of the association is a ruderal species and spreads South and East Anatolia in Turkey.

DISCUSSION

First phytosociological researches on halophytic communities in Turkey were conducted in Lake Tuz and Konya basin in Central Anatolia (Birand 1961,

Table 5. *Hymenolobo procumbentis-Aeluropetum lagopoidis* ass. nov.

Relevé no	21	22	23	24	25	Presence
Size of plot (m²)	25	25	25	25	25	
Soil	SHyd	SHyd	SHyd	SHyd	SHyd	
Altitude (m)	334	337	337	336	337	
Coverage (%)	65	65	70	70	65	
Differential and Characteristic species of the association						
Aeluropus lagopoides (L.) Trin. ex Thwaites var. *lagopoides*	4	4	4	4	4	V
Hymenolobus procumbens (L.) Schinz & Thell.		+	+	+		III
Characteristic species of Halothamno hierochunticae-Salsolion incanescentis						
Atriplex leucoclada Boiss.		+		+		II
Characteristic species of Frankenietalia pulverulentae						
Frankenia pulverulenta L.	+			+		II
Characteristic species of Saginetea maritimae						
Hymenolobus procumbens (L.) Schinz & Thell.			+	+		II
Companions						
Lepidium perfoliatum L.		+		+		II
Ceratocephala falcata (L.) Pers.	+			+		II
Hypecoum pendulum L.	+				+	II
Polypogon maritimus Willd. subsp. *maritimus*	+			+		II
Alhagi mannifera Desv.	+	+				II
Valerianella vesicaria (L.) Moench		+			+	II
Adonis aestivalis L. subsp. *aestivalis*			+	+		II
Polygonum aviculare L.		+			+	II
Chenopodium foliosum (Moench) Asch.	+			+		II
Fumaria parviflora Lam.	+			+		II
Peganum harmala L.		+			+	II
Phleum exaratum Griseb. subsp. *exaratum*				+	+	II
Sonchus asper (L.) Hill subsp. *glaucescens* (Jord.) Ball		+			+	II
Bupleurum croceum Fenzl				+		I
Epilobium hirsutum L.				+		I
Centaurea solstitialis L. subsp. *solstitialis*				+		I
Koelpinia linearis Pall.		+				I
Podospermum laciniatum (L.) DC.				+		I
Chenopodium album L. subsp. *album* var. *album*	+					I

Yurdakulol 1974, Ocakverdi 1984, Yurdakulol and Ercoşkun 1990). Detailed studies conducted in recent years bear special importance to make it possible to determine the halophytic vegetations in Central Anatolia in phytosociological terms (Aydoğdu et al. 2002, 2004, Hamzaoğlu and Aksoy 2006, 2009, Tuğ 2006). There are also some studies conducted in saline areas outside Central Anatolia (Tatlı and İstanbulluoğlu 1986, Yurdakulol et al. 1996, İstanbulluoğlu 2004). There is another study conducted on a saline area which covers Southeastern Anatolian region, lacking a natural halophytic area (Atamov et al. 2006). However, no studies have been conducted on ruderal vegetation in the region. In this study, one alliance and two associations belonging to halophytic vegetation and two associations belonging to ruderal vegetation were detected. These syntaxa determined are new for science (Fig. 9).

The halophytic syntaxa mentioned in this study are all assignable to the class *Saginetea maritimae* Westhoff, Van Leeuwen & Adriani 1962, order *Frankenietalia pulverulentae* Rivas-Martínez ex Castroviejo & Porta 1976, alliance *Halothamno hierochunticae-Salsolion incanescentis*.

The class *Saginetea maritimae* generally includes

Table 6. *Frankenio pulverulentae-Chenopodietum albi* ass. nov.

Relevé no	15	16	17	18	19	20	Presence
Size of plot (m²)	40	40	40	40	40	40	
Soil	SHyd	SHyd	SHyd	SHyd	SHyd	SHyd	
Altitude (m)	338	337	338	338	338	338	
Coverage (%)	60	70	70	75	60	75	
Differential and Characteristic species of the association							
Chenopodium album L. subsp. *album* var. *album*	3	4	4	3	4	3	V
Frankenia pulverulenta L.		1		1	1		III
Oligochaeta divaricata (Fisch. & C.A.Mey.) K.Koch	+	+	+				III
Characteristic species of Roemerion hybridae							
Hypecoum pendulum L.		+	+	+			III
Characteristic species of Centaureetalia cyani							
Scandix pecten-veneris L.		+			+	+	III
Characteristic species of Stellarietea mediae							
Anisantha tectorum (L.) Nevski	+	+				+	III
Filago pyramidata L.	+	+			+		III
Senecio leucanthemifolius Poir. subsp. *vernalis* (Waldst. & Kit.) Greuter	+	+		+			III
Capsella bursa-pastoris (L.) Medik.		+			+		II
Ceratocephala falcata (L.) Pers.		+		+			II
Companions							
Adonis aestivalis L. subsp. *aestivalis*	+	+	+			+	IV
Sonchus asper (L.) Hill subsp. *glaucescens* (Jord.) Ball		+	+		+		III
Polygonum aviculare L.		+		+	+		III
Alhagi mannifera Desv.	+	+				+	III
Polygonum equisetiforme Sibth. & Sm.	+			+	+		III
Polypogon maritimus Willd. subsp. *maritimus*	+	+			+		III
Polygonum salicifolium Brouss. ex Willd.	+		+			+	III
Fumaria parviflora Lam.	+					1	II
Carduus pycnocephalus L. subsp. *cinereus* (M.Bieb.) P.H.Davis		+	+				II
Bupleurum croceum Fenzl	+				+		II
Phleum exaratum Griseb. subsp. *exaratum*		+		+			II
Chenopodium foliosum (Moench) Asch.		+			+		II
Koelpinia linearis Pall.			+			+	II
Valerianella vesicaria (L.) Moench		+		+			II
Centaurea solstitialis L. subsp. *solstitialis*			+				I
Epilobium hirsutum L.			r				I
Peganum harmala L.		+					I
Podospermum laciniatum (L.) DC.				+			I
Cressa cretica L.			+				I

syntaxa that diffuse in dwarf pioneer vegetation populating loamy and sandy soils in habitats under salt-spray influence. *Halothamno hierochunticae-Salsoletum incanescentis* and *Hymenolobo procumbentis-Aeluropetum lagopoidis* detected in the study area are connected to the order *Frankenietalia pulverulentae* Rivas-Martínez ex Castroviejo & Porta 1976 representing Mediterranean littoral or inland halophilous habitats which is included in this class. *Halothamno hierochunticae-Salsolion incanescentis* was formed under this order.

Another association representing halophytic vegetation, *Hymenolobo procumbentis-Aeluropetum lagopoidis*, was detected for the first time here, and its

Table 7. Prosopo farctae-Alhagietum manniferae ass. nov.

Relevé no	9	10	11	12	13	14	Presence
Size of plot (m²)	40	40	40	40	40	40	
Soil	SHyd	SHyd	SHyd	SHyd	SHyd	SHyd	
Altitude (m)	339	342	343	341	341	340	
Coverage (%)	80	85	80	80	85	85	
Differential and Characteristic species of the association							
Alhagi mannifera Desv.	4	4	4	4	4	4	V
Prosopis farcta (Banks & Sol.) J.F.Macbr.	2b	2b	2a	2b	2b	2a	V
Taraxacum sintenisii Dahlst.	+		+		+		III
Characteristic species of Roemerion hybridae							
Hypecoum pendulum L.	+		+	+			III
Roemeria hybrida (L.) DC. subsp. *hybrida*		+		+			II
Characteristic species of Centaureetalia cyani							
Scandix pecten-veneris L.	+			+		+	III
Asperula arvensis L.			+	+			II
Buglossoides arvensis (L.) I.M.Johnst.		+			+		II
Neslia apiculata Fisch., C.A.Mey. & Avé-Lall.		+		+			II
Characteristic species of Stellarietea mediae							
Cardaria draba (L.) Desv. var. *draba*	1	1		1		1	IV
Capsella bursa-pastoris (L.) Medik.	+			+	+		III
Erigeron canadensis L.		+		+	+		III
Stellaria media (L.) Vill. subsp. *media*		1		1	1		III
Erodium cicutarium (L.) L' Her. subsp. *cicutarium*		+		+		+	III
Senecio leucanthemifolius Poir. subsp. *vernalis* (Waldst. & Kit.) Greuter			+	+		+	III
Ceratocephala falcata (L.) Pers.	+		+				II
Anisantha tectorum (L.) Nevski	+					+	II
Filago pyramidata L.	+			+			II
Solanum nigrum L. subsp. *nigrum*			+		+		II
Companions							
Geranium tuberosum L. subsp. deserti-syriacum P.H.Davis	1	1		1		1	IV
Adonis dentata Delile	+	+		+		+	IV
Fumaria parviflora Lam.	+	+		+	+		IV
Carduus pycnocephalus L. subsp. *cinereus* (M.Bieb.) P.H.Davis			+	+		+	III
Malva neglecta Wallr.	+			+	+		III
Convolvulus arvensis L.		+	+			+	III
Cynodon dactylon (L.) Pers. var. *dactylon*	+		+			+	III
Sonchus asper (L.) Hill subsp. *glaucescens* (Jord.) Ball	+		+		+		III
Sisymbrium officinale (L.) Scop.	+				+	+	III
Lathyrus sativus L.		+		+		+	III
Lactuca saligna L.	+	+				+	III
Trigonella coerulescens (M.Bieb.) Halácsy	+	+			+		III
Cichorium glandulosum Boiss. & A.Huet	+		+			+	III
Hordeum murinum L. subsp. *glaucum* (Steud.) Tzvelev			+	+		+	III
Setaria glauca (L.) P.Beauv.	+		+				II
Achillea oligocephala DC.		+		+			II
Amaranthus blitoides S.Watson	+				+		II
Amaranthus viridis L.		+		+			II
Trifolium tomentosum L.		+		+			II
Erodium botrys (Cav.) Bertol.	+					+	II
Lepidium perfoliatum L.		+		+			II
Trigonella monspeliaca L.			+			+	II
Vicia narbonensis L. var. *narbonensis*		+			+		II
Plantago lanceolata L.		+	+				II
Trigonella foenum-graceum L.				+			I

Fig 9. Distribution of the associations in the study area according to IKONOS.

tolerance was good for high saline ratio in the soil. Characteristic taxon of the association, *Aeluropus lagopoides* (L.) Trin. ex Thwaites var. *lagopoides*, is included in the type composition of many associations detected in salt deserts and coastal saline areas by Zohary (1973).

The rudeal syntaxa were connected to *Roemerion hybridae* Br.-Bl. ex Rivas-Martínez, Fernandez Gonzalez & Loidi 1999, alliance of *Centaureetalia cyani* Tx., Lohmeyer & Preising in Tx. ex von Rochow 1951, order which belongs to *Stellarietea mediae* Tx., Lohmeyer & Preising in Tx. ex von Rochow 1951 class.

The class *Stellarietea mediae*; annual ephemeral weed, ruderal, nitrophilous and semi-nitrophilous communities spread all over the world except warm tropical regions. The order *Centaureetalia cyani* spreads cereal (wheat, barley, oat, rye) weeds on rich or poor soils loamy or clayey rich soils. *Roemerion hybridae* occurs in areas of thermo-mesomediterranean.

The syntaxa identified in the study area are as stated below:

Halophytic vegetation

Class: *Saginetea maritimae* Westhoff, Van Leeuwen & Adriani 1962

Order: *Frankenietalia pulverulentae* Rivas-Martínez ex Castroviejo & Porta 1976

Alliance: *Halothamno hierochunticae-Salsolion incanescentis* all. nov.

Association: *Halothamno hierochunticae-Salsoletum incanescentis* ass. nov.

Association: *Hymenolobo procumbentis-Aeluropetum lagopoidis* ass. nov.

Ruderal vegetation

Class: *Stellarietea mediae* Tx., Lohmeyer & Preising in Tx. ex von Rochow 1951

Order: *Centaureetalia cyani* Tx., Lohmeyer & Preising in Tx. ex von Rochow 1951

Alliance: *Roemerion hybridae* Br.-Bl. ex Rivas-Martínez, Fernandez Gonzalez & Loidi 1999

Association: *Frankenio pulverulentae-Chenopodietum albi* ass. nov.

Association: *Prosopo farctae-Alhagietum manniferae* ass. nov.

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