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A floristic study of the Sorkhankol Wildlife Refuge, Guilan province, Iran

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ABSTRACT

Sorkhankol Wildlife Refuge with an area of 1209 ha is located in the central part of Anzali Wetland. In total, 81 species belonging to 35 families and 68 genera were surveyed and identified on the basis of a floristic study from July 2013 through June 2014. The largest families are Poaceae (11 taxa), Asteraceae (8 taxa) Apiaceae, Brassicaceae and Cyperacae (5 taxa). The dominant life forms were cryptophyte (43.21%), followed by the therophytes (39.51%), hemicryptophytes (13.58%) and phanerophytes (3.7%). From the chorological point of view, the largest proportion of the flora belongs to the pluriregional elements (44.44%). A comparison between our study and other parts of the Anzali Wetland showed that Sorkhankol was not particularly species-rich. Currently, the major threats to the research area include eutrophication, pressure from boating and fishing activities, invasion of exotic species and other human induced disturbances.

Key words: Anzali Wetland, Chorology, Floristic richness, Life form, North of Iran, Sorkhankol.

INTRODUCTION

Wetlands are often located between land and water and have therefore been referred to as ecotones (i.e., transitional communities) (Burton & Tiner, 2009). They have been described as "nature's kidneys", because they function as the downstream receivers of the water and waste from natural and human sources; they have also been called ''ecological supermarkets'' due to the extensive food chain and rich biodiversity that they support (Mitsch & Gosselink, 2007). They are critical habitats for many plants and animals, including numerous threatened and endangered species, and provide vital and valuable ecosystem services such as flood control and the maintenance of water quality (Van der Valk, 2006).

Anzali Wetland, a coastal lagoon (37° 24' N, 49° 22' E) is one of the first certificated Ramsar sites of the world and covers a surface area of 15000 ha in the province of Guilan on the south west of the Caspian Sea. This area consists of a complex of large, shallow, eutrophic, freshwater lagoons, marshes and seasonally flooded grasslands, separated from the Caspian Sea by a sandy barrier of about 1 km wide, with open grassland, pomegranate scrub and sand dune vegetation (Evans, 1994). Furthermore, the wetland is an important ecosystem for breeding and over wintering of 77 birds species (Mansoori, 1995). It consists of four main parts: west, central (Sorkhankol), east and south (Siah-keshim); these parts have different physico-chemical, morphological, phyto-ecological and geographical characteristics (Ayati, 2003). The entire wetland is designated as Ramsar site, but some parts of the ecosystem including Siah-keshim Protected Area, Sorkhankol, Selkeh and Chokam Wildlife Refuge have been protected by the Department of Environment of Islamic Republic of Iran (JICA, 2012) (Fig. 1). The wetland size and morphology have not been stable for the last century (Kimball, 1974); it is connected to the Caspian Sea through a partly regulated, longueur channel with its surface only 2 m above the mean level of the Caspian Sea; consequently, seawater can temporarily enter into the wetland during storms or when the sea level increases (Kazanci *et al.,* 2004).

There is no previous floristic information about the flora of Sorkhankol Wildlife Refuge. Nevertheless, recent floristic and vegetation studies on the wetlands of the southern Caspian sea and its rivers have been reported (Asri & Eftekhari, 2002; Ghahreman & Attar, 2003; Asri & Moradi, 2004; Ghahreman *et al.,* 2004; Naqinezhad *et al.,* 2006; Sharifnia *et al.,* 2007; Jalili *et al.,* 2009; Khodadadi *et al.,* 2009; Zahed *et al.,* 2013; Faghir & Shafii, 2013). The objectives of this research are to identify the floristic composition, determining the life forms and chorology of each taxon and describe the threats of the study area.

MATERIALS AND METHODS

STUDY AREA

The Sorkhankol Wildlife Refuge with an area of about 1209 ha, is located in the central part of the Anzali Wetland between latitudes 37° 23′ and 37° 26′ N and longitudes 49° 24′ and 49° 27′ E (Fig. 2). Hend khale and Siah darvishan Rivers enter the Wetland from the eastern and western aspects, respectively. The average depth of water varies during seasons and it is highest during winter and spring seasons (i.e. over 2 m) as a result of more precipitation and rivers inflow and also decreases in summer due to more evaporation and more extraction rates for farming and other human activities.

This area is located in the Caspian coastal lowland, or Guilan - Mazandaran coastal plain that lies between the Talesh Mountains and the Caspian Sea shoreline (Kazanci *et al.,* 2004). Geologically, this lagoon has been separated from the Caspian Sea by the Anzali sand spit during the late Holocene (Lahijani *et al.,* 2009).

The climate is strongly seasonal, with hot wet summers and cool to cold damp winters (Bird, 2010); and based on the recent bioclimatic classification of Iran it is thought to have a temperate oceanic climate (sub-Mediteranean variant) (Djamali *et al.,* 2011). The average temperature and precipitation for the last eleven years (2001 – 2012) was 16.71 °C, and 1764.76 mm, respectively. The maximum and minimum mean temperatures were 29.6º C, and 2.7º C, respectively. Maximum precipitation occurs in late summer and autumn (Aug. to Dec.) (Fig. 3).

Data collection

Data collection was performed from July 2013 to June 2014. The voucher specimens were deposited in the Herbarium University of Guilan (GUH). Plant nomenclature was according to (Rechinger, 1963 − 2010; Davis, 1965 − 1988; Tutin *et al.,* 1964 − 1980; Komarov, 1934 − 1954; Ghahreman, 1975 − 2005). Classification of flowering plants was based on the APG III (2009) and the name of taxon authors was coordinated using IPNI (2014). Life forms of species were determined depending upon the location of the regenerative buds and the shed parts during the unfavorable season (Raunkiaer, 1934). Geographical distribution of species were determined on the basis of classification of vegetation zones (Zohary, 1973; Thakhtajan, 1986; Léonard, 1988). The phytogeographical regions in the study are Pl (Pluriregional elements, referring to plants that are ranging over three phytogeographical regions), Cos (Cosmopolitan elements, refering to plants that have a broad worldwide distribution), Scos (Subcosmopolitan elements, refering to plants ranging in distribution over most continents, but not all of them), IT (Irano-Turanian elements), M (Mediterranean elements), and ES (Euro - Siberian elements). For the habitats of aquatic species, we used the classification of Cook (1996). Delimitation of the habitats was performed with physiognomical approaches and based on the field observation in each habitat (Kent & Coker, 1992).

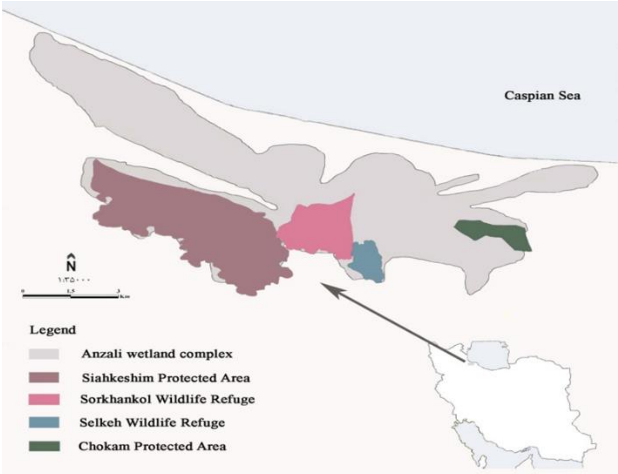

Fig. 1. Location and divisions of the Anzali International Wetland In Northern Iran.

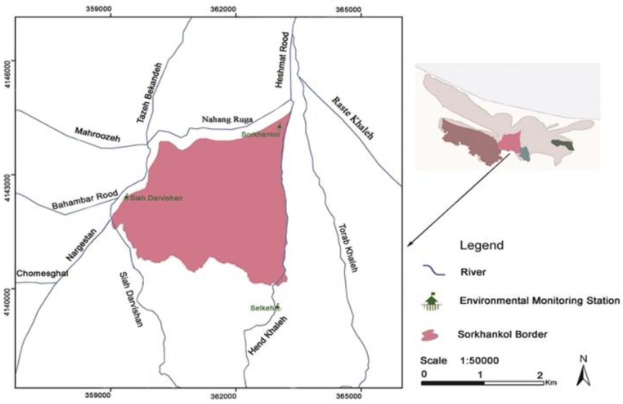

Fig. 2. Map of Sorkhankol Wildlife Refuge in central part of Anzali Wetland.

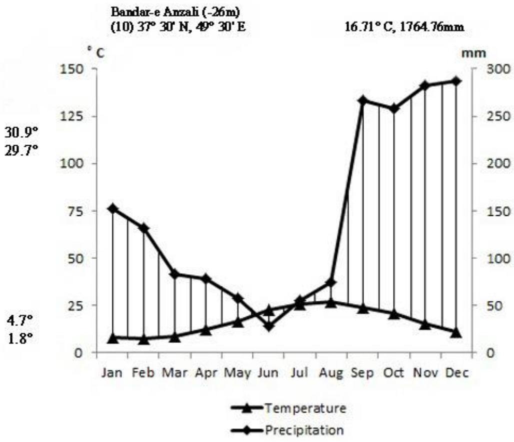

Fig. 3. Climatic diagram of Bandar-e Anzali (2001 − 2012).

RESULTS AND DISCUSSION

Flora

The wetland is not particularly species rich; a total of 81 species belonging to 35 families and 68 genera were recorded in Sorkhankol Wildlife Refuge (Appendix 1). Two families of Monilophytes (Pteridophytes) and 33 families of Angiosperms (27 eudicots and 6 monocot families) constitute the studied flora (Table 1). The richest families in terms of species composition were Poaceae with 11 species, Asteraceae with 8 species, Apiaceae, Brassicaceae and Cyperaceae all with 5 species.

Eighteen families (51.43%) were represented by only a single species.

The uniformity of the aquatic environment (e.g., Sculthorpe, 1967; Cook, 1985; Les, 1988; Titus & Urban, 2009) due to the moderating effect of water, allows aquatic plant species to occupy very large ranges (Santamaría, 2002); it is clear that in this way, plant species and consequently, genetic diversity is relatively low. Numerous lines of evidence indicate that aquatic angiosperms originated on land. The richness of plant species in aquatic and wetland habitats is relatively low compared with most terrestrial communities (Richardson & Vymazal, 2001). A comparison between the total species in the research area and the other parts of Anzali wetland complex include Selkeh Wildlife Refuge and Siah-keshim Protected Area shows that our studied area has the lowest species richness. (Asri & Eftekhari, 2002; Zahed *et al.,* 2013) (Table 2). The rising sea level is expected to result in a greater frequency and duration of inundation and in some cases, higher salinities in coastal wetlands (Titus, 1988; Boesch *et al.,* 1994). The effective connection of Sorkhankol to the salt water of the Caspian sea, may explain the low richness of species; while there is no such connection in Selkeh and Siah-Keshim Wetlands. Moreover, the area of open water in the present study is more than other mentioned wetlands and consequently open water vegetation shows the least species diversity.

Life forms

Life-form refers rather to the vegetative form of the plant body which is assumed by many ecologists to be a result of morphological adjustments to the environment (Cain, 1950). It is shown usually that growth form of plants displays an obvious relationship to key environmental factors (Mueller-Dombois & Ellenberg, 1974). Raunkiaer's system is still the simplest and, in many ways, the most satisfying classification system for plant life-forms (Begon *et al.,* 1996). In the present study, cryptophytes were the dominant life-forms, accounting for 43.21 % of all species in the studied area, followed by therophytes (32 species, 39.51%), hemicryptophytes (11 species, 13.58%) and phanerophytes (3 species, 3.70%). Detailed classification of cryptophytes shows that they consist of helophytes (with 13 species, 16.04%), geophytes and hydrophytes (each 11 species and 13.58%). In addition, floating hydrophytes with 8 species (9.87%) and submerged hydrophytes with 3 species (3.11%) were found in the research area.

In Raunkiaer's terminology, most aquatic macrophytes are cryptophytes, i.e. plants in which the dormant buds survive periods unfavourable for active growth either under the ground or in the water (Denny, 1985). Therophytes and hemicryptophytes are the most prominent life form after cryptophytes. The predominance of cryptophytes and therophytes has been previously observed in other studied aquatic ecosystems (Tabosa *et al.,* 2012; Zahed *et al.,* 2013). A high proportion of therophytes has been previously reported in other studied wetlands in northern Iran by other authors (Ghahreman *et al.,* 2004; Naqinezhad *et al.,* 2006; Khodadadi *et al.,* 2009; Naqinezhad & Hosseinzadeh, 2014). Therophytes are particularly abundant in desert climates and communities with disturbed vegetation (Cain, 1950); Moreover, therophyte species typically represent a large number of the invasive plants in the world (Quézel *et al.,* 1990).

Because of agricultural and fish pond activities, detrimental environmental pressures are particularly more significant in the southern part of our studied area.

Phytogeographical affinities

Phytogeographical elements of the studied area include Pl (36 species, 44.44%), Cos (13 species, 16.05%), Scos (12 species, 14.81%), ES-IT-M (7 species, 8.64%), ES-IT (6 species, 7.42%), ES (4 species, 4.94%), ES-M (2 species, 2.47%) and IT-M (1 species, 1.23%) (Fig. 4). It is obvious that most of the plant species are widespread elements (75.3%).

The highest proportion of pluriregional plants is related to the humid and wet conditions. Also, human activities increases this phytogeographical element by increasing ruderal plants.

Table 1. Number of families, genera and species in main plant groups in Sorkhankol Wildlife Refuge.

Plant Groups	Families	Genera	Species
Eudicots	27	47	55
Monocots	6	19	24
Monilophytes	2	2	2
Total	35	68	81

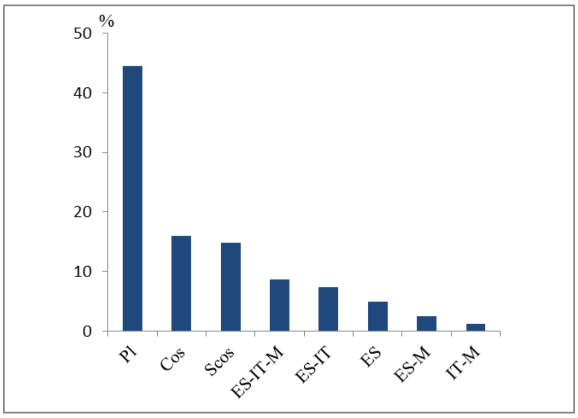

Fig. 4. Proportion of different chorotypes in Sorkhankol Wildlife Refuge. Abbreviation (ES = Euro-Sibirian, Pl = Pluriregional, Cos = Cosmopolitan, Scos = Subcosmopolitan, M = Mediterranean, IT = Irano - Turanian).

Table 2. Comparative floristic richness. Siah-keshim (Eftekhari & Asri, 2002); Selkeh (Zahed *et al.*, 2013).

	Sorkhankol	Siah-keshim	Selkeh
Species	81	103	102
Genus	68	78	84
Family	35	47	46
Area (ha)	1209	4500	360

Aquatic habitats and ecology

In this study, four habitat types were recognized based on water requirement and life forms as determined by the physiognomical (Raunkiaer, 1937) (Fig. 5). Hygrophytes (Hyg in Appendix 1): This habitat represented the most diversity of species in the studied region. Plants of this habitat are adapted to wet or water logged soil near wetland e.g.: *Alternanthera sessilis, Bidens tripartita, Cardamine hirsuta, Echinochloa crus-galli, Eclipta prostrata, Plantago major, Solanum nigrum* and *Urtica dioica*. Emergent plants (Em in Appendix 1): These parts cover the peripheral margin of open water areas and are characterized by emergent helophytic plants, Such as *Phragmites australis* and *Typha latifolia*. *Phragmites australis* as the predominant species occupies large parts of this habitat. This plant creates a suitable shelter for wintering and migrant birds; however, community structure changes with the development of *Phragmites* monocultures, causing a decrease in other plant species and reduction in biodiversity (Chambers *et al.*, 1999). *Typha latifolia* constituted only a small patch in the northwestern of our studied area. Some elements of this habitat are *Hydrocotyle ranunculoides, Ranunculus scleratus, Schoenoplectus lacustris, Nasturtium officinale, Bolboschoenus affinis, Berula angustifolia* and *Sparganium neglectum*.

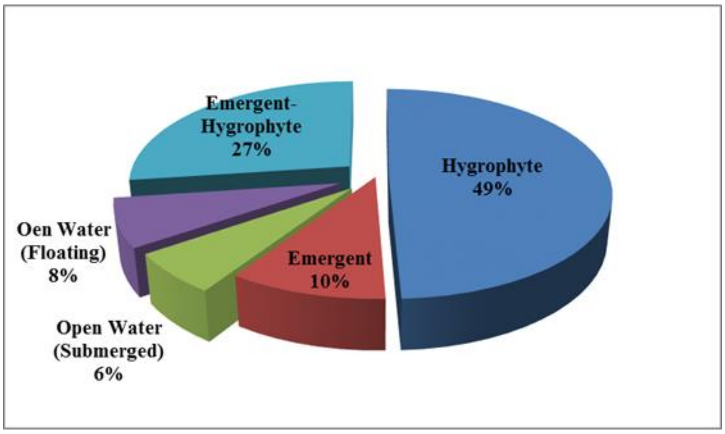

Fig. 5. Habitat relative spectrum of plants studied.

Helophyte-Hygrophytes (Hel - Hyg): Species such as *Paspalum distichum*, *Cyperus glomeratus, Epilobium hirsutum* and *Berula angustifolia* occur in both the marginal part and wet places.

Open water: These areas are characterized with floating [OW (Fl) in Appendix 1] and submerged plants [OW (Su) in Appendix 1]. Floating plants are classified into free floating (e.g. *Lemna minor* and *Spirodela polyrhiza*) and rooted floating leaved (*Nelumbo nucifera*, *Trapa natans* and *Nymphoides cristata).*

Our observations show that *Trapa natans* is distributed mainly in the west of the studied area. In addition, Sorkhankol is characterized from other parts of the Anzali wetland complex by the wide distribution of dominant species of *Nelumbo nucifera* that typically inhabit intermediate depth in the southwest of this habitat. Submerged plant species are permanently submerged, produce floating, aerial, or submerged reproductive organs and occur at all depths of water (Wetzel, 2001; Bowden *et al*., 2006); for example *Potamogeton crispus, Myriophyllum spicatum, Ceratophyllum demersum* and *Zannichellia palustris*. The two latter species flowers are exposed to the atmosphere.

Myriophyllum spicatum was very limited in distribution in the studied area in contrast to *Ceratophyllum demersum* which occurs all around the habitat.

Ecosystem threats and management

Sorkhankol Wildlife Refuge is threatened by eutrophication (as a result of excessive waste discharge and agricultural runoff), pressure from boating and fishing activities, invasion of exotic species and other human induced disturbances. Eutrophication promotes the growth of plants in aquatic ecosystems where they were previously absent, or only present in small numbers.

Azolla filiculoides is a good example of an invasive species whose abundance is due to nutrient enrichment of the area.

In the last few years, many aquatic ecosystems in Iran have been polluted by this fern, particularly in the northern part. The invasion of this species can alter the water quality which may negatively affect the distribution of other plant communities and the habitats of waterfowl (Sadeghi *et al.,* 2013); for example, native free floating plants of this wetland like *Lemna minor* and *Spirodela polyrhiza* have seen a significant reduction as a result of the *Azolla* invasion. These threats have degraded species diversity and the productivity of the wetland.

In addition, there is grave concern about the decrease in the wetland water depth which is occurring due to the accumulation of huge amounts of sediments from rivers. Furthermore, unregulated tourist activities can cause serious damages to wetland.

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Appendix 1

Floristic list of Sorkhankol Wildlife Refuge. Symbols and abbreviation used: 1. Habitat: Em (emergent plant), OW (open water), Hyg (wet places); 2. Life form: Geo (geophyte), Hem (hemicryptophyte), Hyd (hydrophyte), Ph (phanerophyte), Thr (therophyte); 3. Chorotype: Cos (cosmopolitan), ES (Euro-Sibirian), Fl (floating plant), IT (Irano-Turanian), M (Mediterranean), Pl (pluriregional), Scos (subcosmopolitan), Su (submerged plant). GUH = Guilan University Herbarium.

Taxa	Habitat	Life form	Chorotype	Hb. No. (GUH)
Monilophytes				
Dennstaedtiaceae				
Pteridium aquilinum (L.) Kuhn.	Em-Hyg	Geo	Cos	4997
Salviniaceae				
Azolla filiculoides Lam.	OW (Fl)	Hyd	Pl	4998
Angiosperms				
Eudicots				
Adoxaceae				
Sambucus ebulus L.	Hyg	Geo	ES-IT-M	4999
Amaranthaceae				
Alternanthera sessilis R.Br.	Hyg	Thr	Pl	5000
Amaranthus retroflexus L.	Hyg	Thr	Pl	5001
Chenopodium album L.	Hyg	Thr	Cos	5002
Apiaceae				
Berula angustifolia Mert. & W.D.J.Koch	Em-Hyg	Hel	Pl	5003
Eryngium caucasicum Fisch. Ex Steud.	Hyg	Hem	ES-IT-M	5004
Hydrocotyle ranunculoides L.F.	Em	Hel	Pl	5005
Hydrocotyle vulgaris L.	Hyg	Geo	ES	5006
Torilis leptophylla Rchb.f.	Hyg	Thr	Pl	5007
Asteraceae				
Artemisia annua L.	Hyg	Thr	ES-IT-M	5008
Bidens tripartita L.	Hyg	Thr	Pl	5009
Conyza canadensis (L.) Cronquist	Hyg	Thr	Cos	5010
Conyzanthus squamatus (Spreng.) Tamamsch.	Hyg	Hem	Scos	5011
Eclipta prostrata (L.) L.	Hyg	Thr	Pl	5012
Sonchus asper (L.) Hill. subsp. *glaucescens* (Jordan) Ball	Hyg	Hem	Pl	5013
Sonchus oleraceus L.	Hyg	Thr	Cos	5014
Xanthium strumarium L.	Hyg	Thr	Pl	5015
Brassicaceae				
Capsella bursa-pastoris (L.) Medik.	Hyg	Hem	Pl	5016
Cardamine hirsuta L.	Hyg	Thr	Cos	5017
Nasturtium officinale W.T.Aiton	Em	Hel	Pl	5018

Rorippa islandica (Oeder) Borbás	Em-Hyg	Hel	Pl	5019
Sisymbrium officinale (L.) Scop.	Hyg	Thr	ES-IT-M	5020
Caryophyllaceae				
Cerastium glomeratum Thuill.	Hyg	Thr	Scos	5021
Myosoton aquaticum Moench	Em-Hyg	Hem	ES-M	5022
Stellaria media Cirillo	Hyg	Thr	Scos	5023
Ceratophyllaceae				
Ceratophyllum demersum L.	OW (Su)	Hyd	Scos	5024
Convolvulaceae.				
Calystegia sepium (L.) R.Br.	Em-Hyg	Geo	Scos	5025
Fabaceae				
Melilotus indicus (L.) All.	Hyg	Thr	Pl	5026
Vicia sativa L.	Hyg	Thr	ES-IT-M	5027
Haloragaceae				
Myriophyllum spicatum L.	OW (Su)	Hyd	Scos	5028
Lamiaceae				
Lycopus europaeus L.	Em-Hyg	Hel	Pl	5029
Mentha aquatica L.	Em-Hyg	Hel	ES	5030
Malvaceae				
Kosteletzkya pentacarpos (L.) Ledeb.	Em-Hyg	Hel	ES	5031
Menyanthaceae				
Nymphoides cristata **(**Roxb.) Kuntze	OW (Fl)	Hyd	Pl	5032
Nelumbonaceae				
Nelumbo nucifera Gaertn.	OW (Fl)	Hyd	Pl	5033
Onagraceae				
Epilobium hirsutum L.	Em-Hyg	Geo	Pl	5034
Phytolaccaceae				
Phytolacca americana L.	Hyg	Hem	Scos	5035
Plantaginaceae				
Plantago major L.	Hyg	Hem	Scos	5036
Polygonaceae				
Polygonum hydropiper L.	Hyg	Thr	ES-IT	5037
Polygonum lapathifolium L. subsp. *Lapathifolium*	Em-Hyg	Thr	ES-IT	5038
Rumex palustris Sm.	Em-Hyg	Hem	ES-IT	5039
Rumex Pulcher L.	Em-Hyg	Hem	ES-IT-M	5040
Primulaceae				
Anagallis arvensis L. subsp. *arvensis* var. *arvensis*.	Hyg	Thr	Cos	5041
Ranunculaceae				
Ranunculus scleratus L.	Em	Thr	Pl	5042

Ranunculus muricatus L.	Em-Hyg	Thr	IT-M	5043
Rosaceae				
Rubus sanctus Schreb.	Hyg	Pha	Pl	5044
Rubiaceae				
Galium aparine L.	Hyg	Thr	Cos	5045
Galium elongatum C.persl	Em-Hyg	Hel	ES	5046
Salixaceae				
Salix alba L.	Hyg	Pha	ES-IT-M	5047
Scrophulariaceae				
Veronica persica Poir.	Hyg	Thr	Scos	5048
Veronica anagalloides Guss. subsp. Anagalloides	Hyg	Hem	Pl	5049
Solanaceae				
Solanum nigrum L.	Hyg	Hem	Scos	5050
Solanum dulcamara L.	Em-Hyg	Pha	ES-IT	5051
Trapaceae				
Trapa natans L.	OW (Fl)	Hyd	Cos	5052
Urticaceae				
Urtica dioica L.	Hyg	Hem	Pl	5053
Monocots				
Araceae				
Lemna minor L.	OW (Fl)	Hyd	Pl	5054
Spirodela polyrhiza (L.) Schleid.	OW (Fl)	Hyd	Pl	5055
Cyperaceae				
Bolboschoenus affinis Drobow	Em	Hel	Pl	5056
Cyperus glomeratus L.	Em-Hyg	Geo	Pl	5057
Cyperus odoratus L. subsp. *transcaucasicus* (Kuk.) Kukkonen	Em-Hyg	Geo	ES-IT	5058
Cyperus rotundus L.	Em-Hyg	Geo	Cos	5059
Schoenoplectus lacustris (L.) Palla	Em	Hel	ES-IT	5060
Juncaceae				
Juncus effusus L.	Em-Hyg	Geo	Cos	5061
Poaceae				
Avena sativa L.	Hyg	Thr	Pl	5062
Digitaria sanguinalis (L.) Scop. subsp. *pectiniformis* Henrard	Hyg	Thr	Pl	5063
Echinochloa crus-galli (L.) P.Beauv. var. *crus-galli*	Hyg	Thr	Scos	5064
Echinochloa oryzoides (Ard.) Fritsch	Em-Hyg	Thr	Scos	5065
Eleusine indica (L.) Gaertn.	Hyg	Thr	Pl	5066
Paspalum dilatatum Poir.	Em-Hyg	Geo	Pl	5067

Paspalum distichum L.	Em-Hyg	Geo	Pl	5068
Phragmites australis (Cav.) Trin. Ex Steud. var. *australis*	Em	Hel	Pl	5069
Poa annua L.	Hyg	Thr	Pl	5070
Polypogon monspeliensis (L.) Desf.	Hyg	Thr	Pl	5071
Setaria glauca (L.) P.Beauv.	Hyg	Thr	Pl	5072
Potamogetonaceae				
Potamogeton crispus L.	OW (Su)	Hyd	Pl	5073
Potamogeton pectinatus L.	OW (Su)	Hyd	Cos	5074
Zannichellia palustris L.	OW (Su)	Hyd	Cos	5075
Typhaceae				
Sparganium neglectum Beeby	Em	Hel	ES-M	5076
Typha latifolia L.	Em	Hel	Cos	5077

مطالعه ی فلوریستیک پناهگاه حیات وحش تالاب سرخانکل (استان گیلان)

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چکیده

پناهگاه حیات وحش سرخانکل با وسعت تقریبی ۱۲۰۹ هکتار، در بخش مرکزی مجموعه تالاب انزلی واقع شده است. در مجموع، طی مطالعه‌ی فلوریستیک منطقه از تیر ۱۳۹۲ تا خرداد ۱۳۹۳، تعداد ۸۱ گونه گیاهی متعلق به ۶۸ جنس و ۳۵ تیره شناسایی شد. تیره‌های Poaceae (۱۱ گونه)، Asteraceae (۸ گونه)، Apiaceae، Brassicaceae و Cyperaceae (۵ گونه) بزرگترین تیره‌های گیاهی هستند. شکل زیستی غالب منطقه کریپتوفیت ها (۴۳/۲۱٪) و پس از آن تروفیت ها ۳۹/۵۱٪)، همی کریپتوفیت ها (۱۳/۵۸٪) و فانروفیت ها (۳/۷٪) هستند. از لحاظ پراکنش جغرافیایی بیشترین سهم، متعلق به عناصر چند ناحیه ای (۴۵/۶۸٪) است. مقایسه ی انجام گرفته بین مطالعه ما و دیگر بخش‌های تالاب انزلی نشان داد که سرخانکل از لحاظ گونه ای غنی نبود. در حال حاضر، تهدیدهای اصلی در منطقه ی مورد مطالعه شامل یوتریفیکاسیون، فشار ناشی از فعالیت های مربوط به ماهی‌گیری و قایق رانی، هجوم گونه های بیگانه و دیگر فعالیت های مخرب انسانی است.

*مولف مسئول