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Full Length Research Paper

Vegetation strategies of invasive *Argemone ochroleuca* sweet in different habitats in Taif Governorate, Saudi Arabia'

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Argemone ochroleuca **is an invasive worldwide medicinal plant with economic potentialities. The species is largely distributed in Taif Governorate, KSA. Its introduction affected the flora of the area hence, the study aimed at elucidating the effects of its infestation at nine localities representing three different habitats, sand plains (such has in Al- Shafa, Jabajeb, and Al-Arafah), dams (as in Gadeer Albanat and Ekrima) and wadies (such as in Thumalah, Wadi shab, Saysed and Jaleel). The importance of the study in Taif Governorate is exemplified in high salt accumulation, scanty rains and high evapotranspiration of the studied area. The reason for studying the *Argemone* communities arises from the fact that they occupy virtually every habitat where extreme conditions keep out other forms of life. The species is characterized by its high propagation ability that affects to a large extent - the rangeland ecosystems. In this study, some of the characteristics of the natural vegetation cover in the chosen localities were examined, such as the floristic composition of species inhabiting the *Argemone* communities, their important values and the physico-chemical analysis of the inhabited soil. Also, a detailed study of the pheonological changes of *A. ochroleuca* was monitored during the year, 2008/2009. A number of 35 desert weed species, with different life forms and belonging to 25 different families were associated with *Argemone*. Among these species, *Argemone* preponderated and attained the highest importance value of 180 at Al-Arafah locality. Following the phenology of *Argemone*, results revealed that its life history is completed within eight months. Seed germination takes place in December, vegetatively grows in January, flowers in March and April and disperses seeds in May, June and July.**

Key words: Invasion, importance value, floristic composition, phenology.

INTRODUCTION

Exotic plants can disrupt ecosystem functions such as nutrient cycling. In one case involving a non-native plant in Hawaii, Vitousek and Walker (1989) determined that introducing a single noxious weed significantly altered the entire functions of an ecosystem. Weeds trigger a decline in ecosystem diversity and an overall reduction in native plant species abundance (D'Antonio and Vitousek, 1992). Invasions by weeds typically follow anthropogenically established xeric corridors along roads and trails (Brothers, 1992). Disturbance to native vegetation is likely to increase invasion susceptibility (Burke and Grime, 1996). Stohlgren et al. (1999) concluded that high resource availability in biological "hot spots," or areas of elevated diversity, increases the risk and rate of weed infestation, especially, in ecologically critical source habitats such as the riparian zones, wet meadows, and aspen groves, small weed patches may expand rapidly revealing a need for early detection and control. Spread of *Agremone* is thought to be related to human activities such as site disturbance and overgrazing. Shanmughavel

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(1995) attributed invasion of *Agremone mexicana* into a forest rangeland to heavy grazing.

The genus *Argemone* (Papaveraceae) contains almost 30 species, all with prickly stems, leaves, and capsules (Schaarzbrach and Kadereit, 1999). The two species, *A. ochroleuca* and *A. mexicana* (Mexican poppy) seem to thrive in tropical and subtropical climates. In Mexico, *A. ochroleuca* was found mostly in 47 of 378 maize fields (Vibrans, 1997) and as weeds in 240 crop fields in Eastern Ethiopia. Tamado and Millberg (2000) indicated that *A. ochroleuca* is not restricted to any of 23 environmental and crop management variables recorded for example, altitude, soil type, rainfall, or crop species. *A. mexicana* occurs in a wide range of cropping situations (sugarcane, vegetable, coffee, cacao, citrus fruit and tobacco cultivations, and in pastures) but was lacking in rice cultivation (Acuna, 1974). The first documentation of the genus in Saudi Arabia was given by Migahid (1974). Hussein et al. (1983) found *A. mexicana* in different investigated desert areas in KSA. Currently, the two species were already identified in the same country (Collenete, 1985; Chaudhary and Al-Jowaid, 1999). *A. mexicana* now occupies large tracts in deteriorated rangelands in Asir region. *A. ochroleuca* is most widespread in Taif Governorate (Shorbaji and Abidin, 1999). Both species are distributed in the western and southern parts of the Kingdom, the former being unintentionally introduced from the New World.

The economic importance of Argemone species could be concluded as sources of oil and renewable energy (Singh and Singh, 2010) and alkaloids (Singh et al., 2010). It was also reported as a medicinal plant (Deka and Deka, 2007) as an insect-host infesting the important economical crops (Gonzalez and Suris, 2008); as a weed plant having antioxidant effect (Perumal et al., 2010), against bacteria (Osho and Adetunji, 2010), against fungi (Abou-Zeid and El-Fattah, 2007) against plant virus (Tripathi and Sharma, 2007), against nematodes (Elbadri et al., 2009) and against insects (Sharma et al., 2009).

Efforts to control weed infestation are hampered by natural dispersion of seeds. Thus, determining its rangeland infestation and distribution is essential for planning control measures of this obnoxious and poisonous weed. Traditional means of weed control included the application of expensive herbicides, plowing weeds under the soil (a temporary solution at best), biological control, careful selection and reseeding of valuable grazing plant species, labor intensive pulling efforts, and animal grazing. Without any form of control, noxious weeds can rapidly make viable rangelands worthless (Medina, 1998).

Introducing species into a new environment can have devastating effects on ecosystem quality (Van Groenendael et al., 1998). *Argemone* sp. is an example of a noxious weed that has been introduced into Saudi Arabia (Migahid, 1974). This relatively newly introduced noxious weed accounts for the loss of rangeland value in valleys around Taif mountains area. *Argemone* sp. has a tendency to multiply rapidly thereby, choking the land to compete with other range plant species and reduce the land value.

The history of the introduction of *A. mexicana* now occupying large tracts of deteriorated rangelands in Asir region is not traceable. *A. ochroleuca* was most widespread in Taif area (Shorbaji and Abidin, 1999). The two species are growing in almost all types of soil and at different climatic conditions. In addition, all stages of growth can be observed in the same area at the same time of the year. Studies showed that noxious weeds also decrease wildlife forage quality (Medina, 1998). Weeds reduce the available forage for livestock. Therefore, determining rangeland distribution *of Argemone* and its invasion ecology are essential for planning control measures of this weed. The investigation aims at studying the ecology and the floristic composition of *Argemone* communities at the different localities resembling the various habitats in Taif Governorate, KSA (Figures 1 to 10). Studying the vegetation of the dominant and associated species and their important values was also undertaken. Monitoring the plant life stages (phenology) of this important invasive species may help researchers to go on studying more about its biology and means of control.

The study site

Nine localities with three different ecosystems in Taif (an important part of Saudi Arabia) were chosen (Figure 1). Dryness is a characteristic climatic feature of the area since rainfall is less than 10 inches and a maximum temperature of 37°C are reached in September (Figure 2). Taif governorate lies in the desert or semi-desert region of the world. Temperature decreases the dryness in the angle of rain and evaporation, thus, it affects the vegetation of the area (Abou-Zeid and El-Fattah, 2007). Therefore, the locations of this study were carefully selected to cover all directions around Taif city, and represent all topographic variables. Three main habitats were chosen as follows:

1. Open areas (sandy plains) such as in Al-Shafa (25 km, Southwest of Taif), Jabajeb (Northwest of Taif) and Al-Arafah (about 35 km, North of Taif).
2. Dams such as in Gadeer Albanat (7 km, South of Taif) and Ekrima (6 km Northwest of Taif).
3. Wadies as in Thumalah and Wadi shab (28 and 5 km, Southwest of Taif successively), Saysid and Wadi-Jaleel (14 and 28 km, Northeast of Taif successively).

MATERIALS AND METHODS

Nine selected locations covering most of the vegetation variations

Figure 1. The study site (Taif Governorate) in Saudi Arabia.

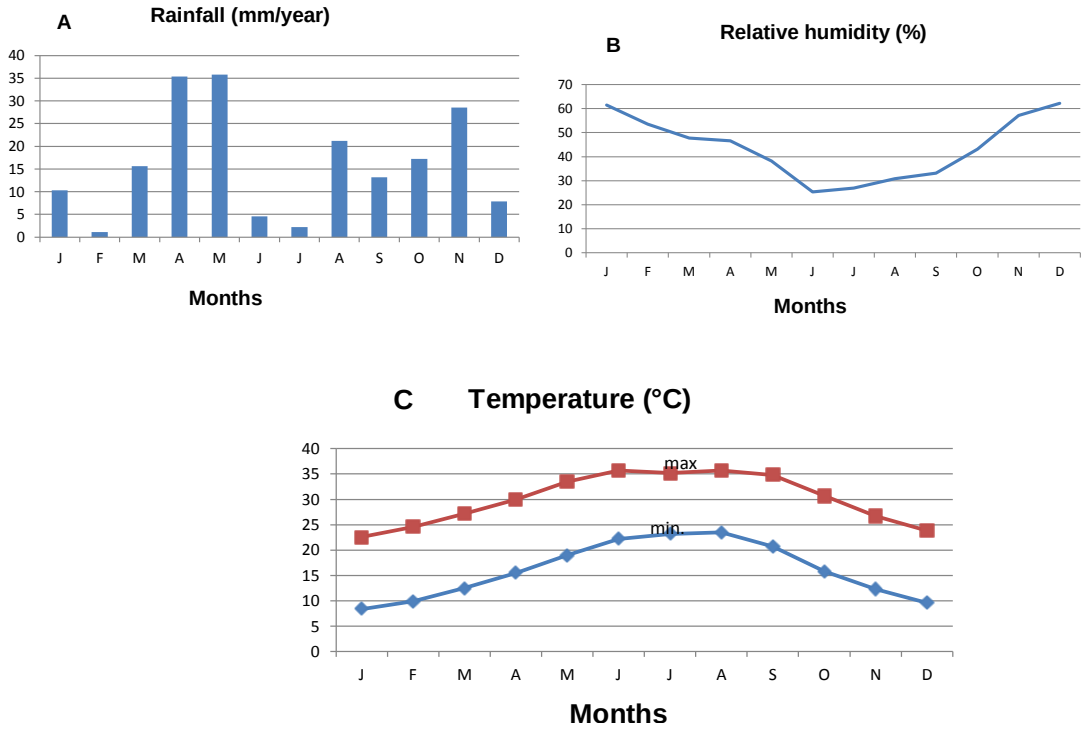

Figure 2. Average rainfall (mm), relative humidity (%), and mean temperatures during 2009 in Taif Governorate.

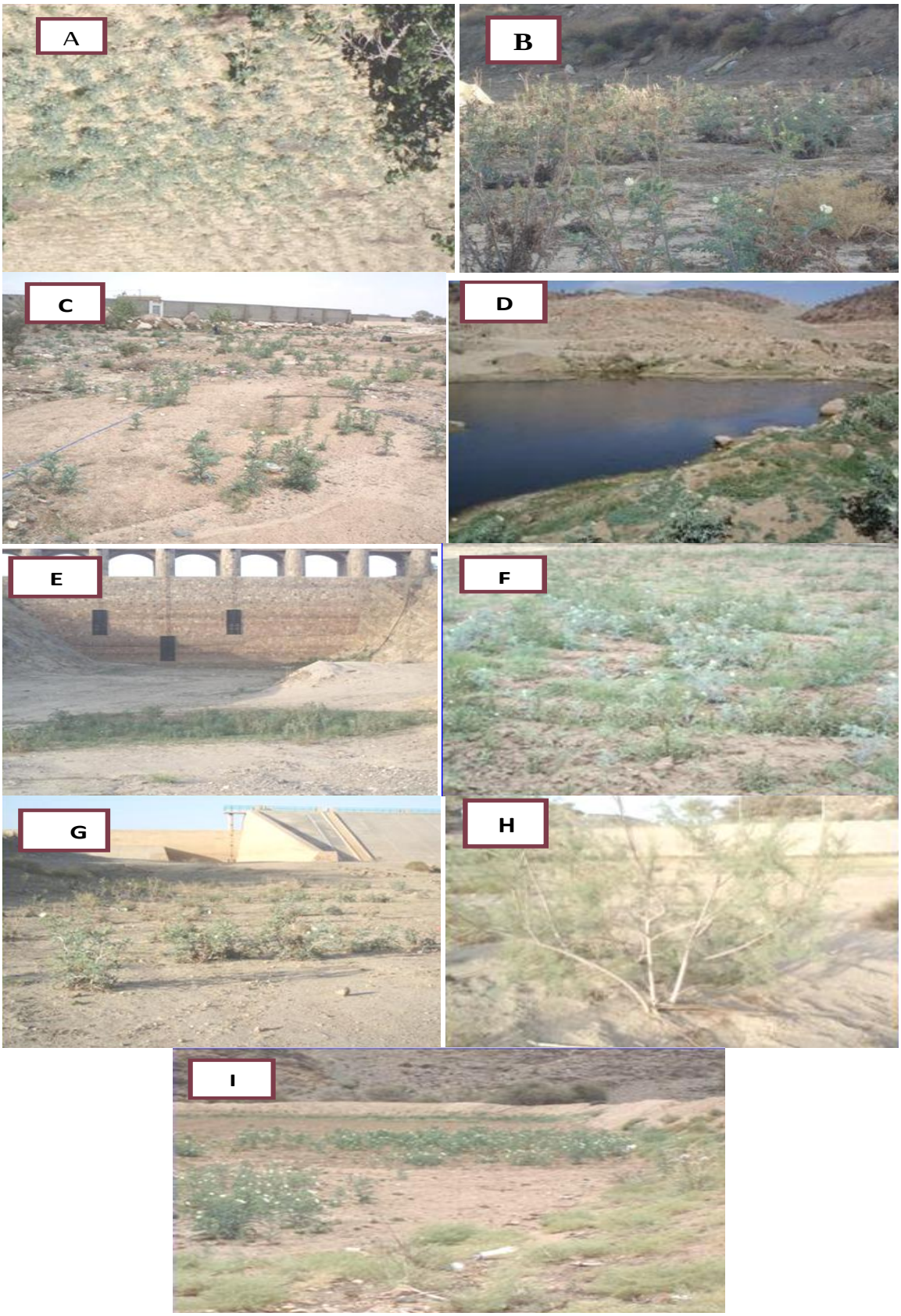

Figure 3. Over view of distribution of *Argemone* and associated species at: (A) Al-Shafa, (B) Jabajeb, (C) Al-Arafah, (D) Gadeer, (E) Ekrima, (F) Thumalah, (G) Wadi S'ab, (H) Saysid, I-Jaleel.

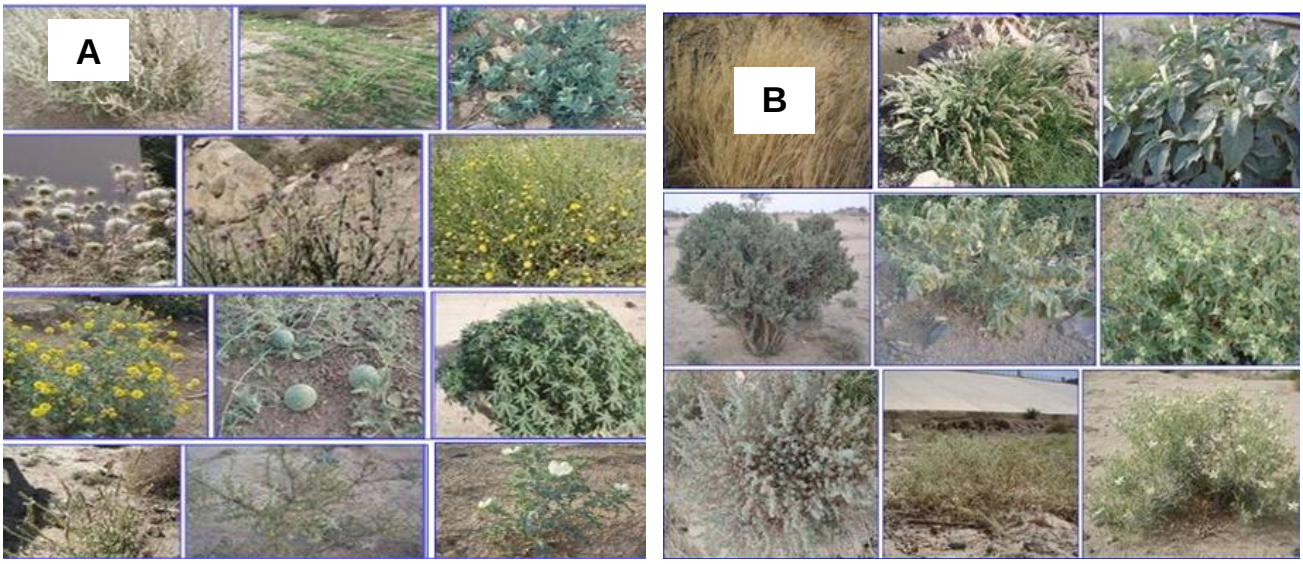

Figure 4. The plant species associated with *Argemone* at the studied location.

Figure 5. Germination stage of *Argemone* species.

Figure 6. Seedling stage of *Argemone* species.

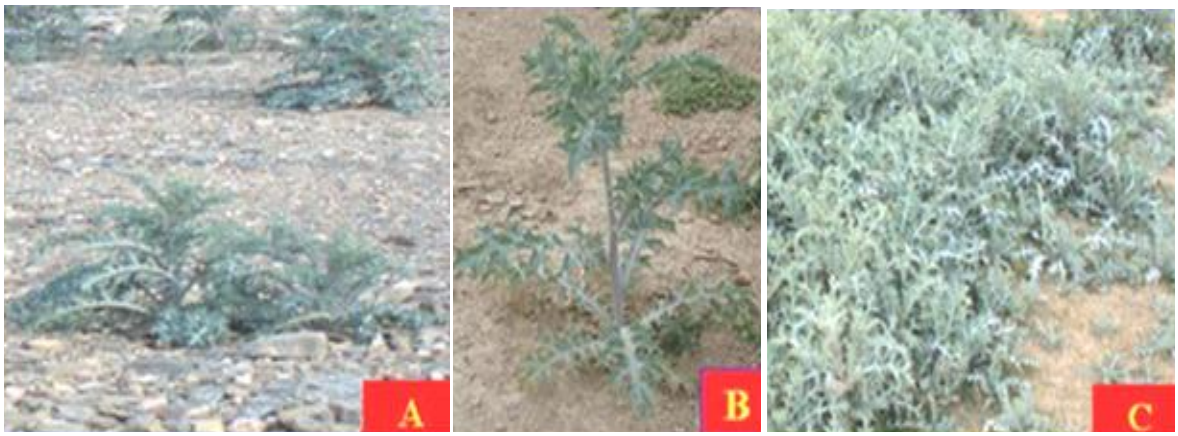

Figure 7. Vegetative stage of *Argemone* species.

Figure 8. Flowering stage of *Argemone* species.

Figure 9. Fruiting stage of *Argemone* species.

around Taif city were selected. Periodic field visits of fifteen days break were connected during the year, 2008/2009. The floristic composition of the associated species was recorded. Collection, identification, and classification were carried out following Migahid

Figure 10. Seed dispersal stage of *Argemone* species.

Table 1. Variations in physical and chemical analysis of the studied nine locations.

Locality	EC (mmhos)	PH (1:2.5)	Cation (ml equiv./L)				Anion (ml equiv./L)			
			K^+	Na^+	Mg^{++}	Ca^{++}	SO_4^-	Cl^-	HCO_3^-	CO_3^-
Al-Shafa	0.11	7.7	0.21	0.13	0.96	0.42	0.38	0.38	0.96	-
Jabajeb	0.19	7.7	0.25	0.25	1.06	1.42	1.64	0.38	0.96	-
Al-Arafah	0.09	7.7	0.23	0.05	0.40	0.73	0.11	0.48	0.82	-
Gadeer	0.40	7.8	0.06	2.06	1.35	2.90	5.44	0.38	0.55	-
Ekrima	0.55	7.7	0.13	2.25	1.98	3.95	7.52	0.38	0.41	-
Thumalah	0.38	7.7	0.04	2.77	1.54	1.95	5.41	0.48	0.41	-
Wadi Sab	0.11	7.7	0.21	0.14	0.76	0.69	0.36	0.48	0.96	-
Saysid	0.07	7.7	0.13	0.06	0.29	0.69	0.40	0.38	0.39	-
Jaleel	0.61	7.7	0.22	1.15	1.50	5.70	8.38	0.48	0.41	-

(1974). A total of 135 lines (5 m each) were defined (15 per location) following the line transect method (Ludwig and Reynolds, 1988) and the importance value of recorded species was calculated. Phenological changes of *Argemone* plants were regularly monitored during its growing season (December to June, 2008/2009). Surface soil samples (area of 0.25 m^2, 5 replications) from the natural habitats were collected, air dried, then physico-chemically analyzed according to Page et al. (1982).

RESULTS AND DISCUSSION

Taif is the largest city in KSA distinguishing by a strategic site. It lies between East and Southwest of KSA. It is also characterized by its mountainous topography and mild climate. In this study, nine locations representing sand plains (open areas), dams and wadies were selected to determine the spread of *Argemone* plant and its dominant associated plant species during the year, 2008/2009. These aforementioned localities were chosen for many reasons namely, wide distribution and large cover of *Argemone* plants and associated weed species, especially, in the valleys, shortage in studying plant cover generally in valleys of KSA and not much is known about the ecology of *Argemone*.

Argemone species was recognized as a common weed in some countries (Holm et al., 1979; Walsh and Norton, 2007). The first documentation of the genus *Argemone* in KSA was by Migahid (1974). Two species of *Argemone* (*A. mexicana* L. and *A. ochroleuca* Sweet) were identified in the Western and Southern parts of KSA (Collenete, 1985; Chaudhary and Al-Jowaid, 1999). These two species are growing in almost all types of soil and at different climatic conditions. *A. ochroleuca* sweet was most widespread in Taif area (Shorbaji and Abidin, 1999).

This study was conducted to determine the spread of *Argemone* plant species in dams and valleys at Taif Governorate, KSA. Soil physical and chemical analysis (Table 1) of superficial layers evinced the slight alkalinity of soils at all localities and all soil samples lacking carbonates. The highest EC value was clear at Jaleel. This is explained by possessing the highest values of Ca^{++}, Cl^- and $SO4^-$ content. Ekrima recorded the highest Mg^{++} content while the highest Na^+ content was found in

Thumalah locality. Ramakrishnan and Gupta (1972) reported that *A. ochroleuca* and *A. mexicana* are better suited to grow in deficiency of phosphorus and nitrogen when growing as weeds at Chandigarh, India.

Data in Table 2 showed that the major plant species in the nine districts were belonging to 25 families namely; Acanthaceae, Amaranthaceae, Asclepiadaceae, Boraginaceae, Cactaceae, Chenopodiaceae, Compositae, Cucurbitaceae, Cupressaceae, Euphorbiaceae, Labiatae, Leguminosae, Lemneaceae, Liliaceae, Moraceae, Myrtacea, Papaveraceae, Poaceae, Resedaceae, Rhamnaceae, Solanaceae, Tamaricaceae, Typhaceae, Urticacea and Zygophyllaceae.

The most dominant family was compositae followed by Solanaceae, Poaceae and Zygophyllaceae, as they were represented by five, four, three and two species, respectively. The other 21 families were represented only by a sole species each. The commonly noticed weeds at the nine locations were *Blepharis ciliaris*, *Aerva javanica*, *Calotropis procera*, *Heliotropium digynum*, *Opuntiaficus indica*, *Atriplex dimorphostegia*, *Echinops spinosissimus*, *Onopordon heteracanthum*, *Psiadia arabica*, *Pulicaria crispa*, *Verbesina encelioides*, *Citrullus colocynthis*, *Juniperus excelsa*, *Ricinus communis*, *Lavandula dentate*, Acacia seyal, *Lemna gebba*, *Aloe vera*, *Ficus carica*, *Eucalyptus globules*, *A. ochroleuca*, *Eleusine compressa*, *Poa annua*, *Polypogon monspeliensis*, *Ochradenus baccatus*, *Zizphus spina-christi*, *Datura metel*, *Lycium shawii*, *Solnum incanum*, *Withania somnifera*, *Tamarix arabica*, *Typha elephantica*, *Forsskalea tenacissima*, *Fagonia indica* and *Peganum harmala*.

At the level of life form, these species were categorized as eleven perennial shrubs, seven perennial herbs, four perennial trees, three perennial grasses and only one for each of annual shrubs, perennial succulents and very small pond weed (Table 2). *Argemone*; the main subject of the study was found to be categorized as a perennial herb while Smith (2002) mentioned it as an annual herb, usually stout and about 30 to 100 cm tall.

In KSA, Mosallam (2007) showed that three main communities are dominating in Taif Governorate, Saudi Arabia, one of which is *A. mexicana*, depending on their degree of protection. Several investigators reported that the species associated with *Argemone* plant are belonging to different families. Kumar and Rohatgi (1999) reported that some weed species dominate fields including *A. mexicana* occupying almost the whole area, with little or no growth of any other species. Girma et al. (2000) showed that *A. mexicana* was selected to be a new problem weed. It exhibited the highest mean field densities, out of nineteen associated plant species. Paradkar et al. (2002) reported that in semi-irrigated and irrigated fields of Satpura zone, Madhya Pradesh, India, during spring, 1990/1991 and 1991/1992 fifteen plant species were associated with *Argemone*. Bai and Nanjappa (2003) reported that seven plant species were associated with *Argemone* plant in an experiment conducted in Bangalore, Karnataka, India while Kumara et al. (2003) showed that a number of eleven species were associated with *Argemone* in another field experiment conducted in the same town in India, during autumn, 1999. Pawar et al. (2003) showed that fourteen plant species were associated with *Argemone* in field experiments conducted in Padegaon, Maharashtra, India, during 2001/2002 and 2002/2003. Singh et al. (2004) showed a number of eleven plant species associated with *Argemone* plant. Saadabi (2006) showed that ten plant species were associated with *Argemone* in folklore. Shapaka et al. (2008) reported the presence of *D. innoxia* associated with *Argemone*.

Data (Table 2) indicated that the invasive studied species; *Argemone* had high occurrence at all studied nine localities, with a highest importance value of 180 at Al-Arafah locality. This was followed by *E. spinosissimus* that was distributed at all localities, except for Al-Arafah and attained its highest IV of 40 at Al-Shafa. *A. javanica*, *V. encelioides* and *P. harmala* were recorded in seven of the studied localities except at Al-Shafa and Al-Arafah for the first two species and Al-Shafa and Saysid for the third one. Maximal important values of 26, 31 and 56 were achieved by the three species, respectively. The composite *P. crispa* had less distribution, occurring only at six localities namely; Jabajeb, Gadeer, Ekrima, Thumalah, Wadi shab and Saysid. The highest importance value of 34 was given at Ekrima. Either *D. metel* or *F. indica* were present only at five localities with a highest IV of 14 and 35, consequently in Thumalah and Wadi shab. *R. communis*, *L. shawii* and *S. incanum* were only recorded at four localities and attained important values of 8, 27 and 25, respectively. *J. excelsa* and *A. seyal* were found only at three localities and recorded their highest importance values of 27 and 24 consequently at Jaleel and Wadi shab. Low occurrence of each of *C. colocynthis*, *L. dentate*, *P. monspeliensis* and *F. tenacissima* was recorded occurring only at two localities. Five species namely, *H. digynum*, *A. dimorphostegia*, *O. heteracanthum*, *E. compressa* and *W. somnifera* were only present at a sole locality. It is to be mentioned that *E. compressa* realized a high importance value of 90 at Al-Shafa locality. Table 2 clarifies that some species were recorded at certain localities and in the meantime, they were not passed by the robe of line transects. Those species were namely, *Blephasis ciliaris*, *C. procera*, *O. indica*, *P. arabica*, *L. gebba*, *A. vera*, *F. carica*, *E. globules*, *P. annua*, *O. baccatus*, *Z. spina-christi*, *T. arabica* and *T. elephantica*. *B. ciliaris*, P. annua and *T. elephantica* recorded high existence at all localities. The differences in geographical distribution of species, as well as, their important values may be attributed to the differences in soil salinity, soil humidity and soil topography. Figures 2 to 4 present natural overviews for the studied *Argemone* species and its associated wild species at the chosen localities.

Table 2. Recorded species inhabiting *Argemone* communities at the nine studied locations.

Species	Family	Life form	Locality									I.V								
			1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
Blepharis ciliaris (Burm.f.) Spreng	Acanthaceae	Perennial herb	+	+	+	+	+	+	+	+	+	*	*	*	*	*	*	*	*	*
Aerva javanica (L.)B.L.Burtt	Amaranthaceae	Perennial herb	-	+	-	+	+	+	+	+	+	-	*	-	1	2	19	4	26	8
Calotropis procera (Ait.)Ait.f.	Asclepiadaceae	Perennial shrub	-	+	+	+	+	-	+	+	+	-	*	*	*	*	-	*	*	*
Heliotropium Digynum (Forssk.)Asch.ex. C.Christens	Boraginaceae	Annual herb	-	-	-	+	-	-	-	-	-	-	-	-	62	-	-	-	-	-
Opuntiaficus indica	Cactaceae	Perennial shrub	+	-	-	-	-	+	-	-	-	*	-	-	-	-	*	-	-	-
Atriplex dimorphostegia Kar. & Kir	Chenopodiaceae	Annual herb	-	-	-	+	-	-	-	-	-	-	-	-	69	-	-	-	-	-
Echinops spinosissimus Turra	Compositae	Perennial herb	+	+	-	+	+	+	+	+	+	40	23	-	6	9	22	14	21	8
Onopordon heteracanthum C.A.Mey.		Perennial herb	+	-	-	-	-	-	-	-	-	14	-	-	-	-	-	-	-	-
Psiadia arabica Jaub. Et Sp.		Perennial shrub	+	-	-	-	-	+	-	-	-	*	-	-	-	-	*	-	-	-
Pulicaria crispa (Forssk.) Benth.and Hook.f.		Perennial shrub	-	+	-	+	+	+	+	+	+	-	13	-	14	34	26	26	28	-
Verbesina encelioides (Cav.) Benth. Et Hook.f.ex A. Gray		Annual herb	-	+	-	+	+	+	+	+	+	-	17	-	11	12	12	31	13	18
Citrillus colocynthis (L.) schrad.	Cucurbitaceae	Perennial herb	-	-	-	-	+	-	-	-	+	-	-	-	-	6	-	-	-	*
Juniperus excelsa M.B.	Cupressaceae	Perennial tree	+	-	-	-	-	+	-	-	+	*	-	-	-	-	*	-	-	27
Ricinus communis L	Euphorbiaceae	Perennial shrub	-	-	-	+	+	+	-	+	-	-	-	-	2	3	17	-	21	-
Lavandula dentate L.	Labiatae	Annual herb	-	-	-	+	-	-	+	-	-	-	-	-	14	-	-	11	-	-
Acacia seyal Del.	Leguminosae	Perennial tree	-	-	+	-	-	-	+	-	+	-	-	9	-	-	-	24	-	14
Lemna gebba L.	Lemnaceae	Very small pond weed	-	-	-	+	-	-	-	-	-	-	-	-	*	-	-	-	-	-
Aloe vera L..	Liliaceae	Perennial succulent	-	-	-	-	+	+	+	-	-	-	-	-	-	*	*	*	-	-
Ficus carica L	Moraceae	Perennial shrub	+	-	-	-	-	+	-	-	-	*	-	-	-	-	*	-	-	-
Eucalyptus globules	Myrtaceae	Perennial tree	+	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-
Argemone orchroleuca Sweet	Papaveraceae	Perennial herb	+	+	+	+	+	+	+	+	+	155	120	180	101	138	110	97	109	139
Eleusine compressa Forssk.)Asch.& Schweinf.Ex Christen	Poaceae	Perennial grass	+	-	-	-	-	-	-	-	-	90	-	-	-	-	-	-	-	-
Poa annua L.		Perennial grass	+	+	+	+	+	+	+	+	+	*	*	*	*	*	*	*	*	*
Polypogon monspeliesis (L.) Desf.		Perennial grass	-	-	-	+	-	-	-	+	-	-	-	-	13	-	-	-	41	-
Ochradenus baccatus Del.	Resedaceae	Perennial shrub	-	+	+	+	+	+	+	+	-	-	*	*	*	*	*	*	*	-
Ziziphus spina-christi (L.) Willd.	Rhamnaceae	Perennial tree	-	-	-	-	-	+	+	-	-	-	-	-	-	-	*	*	-	-
Datura metel L.	Solanaceae	Annual shrub	-	-	-	+	+	+	+	+	-	-	-	-	7	3	14	2	8	-
Lycium shawii Roem. et Sch.		Perennial shrub	-	+	+	-	-	+	-	-	+	-	25	27	-	-	15	-	-	14
Solnum incanum L.		Perennial shrub	-	+	-	+	+	-	-	-	+	-	24	-	17	25	-	-	-	13
Withania somnifera (L.) Dun.in DC.		Perennial shrub	-	-	-	-	+	-	-	-	-		-	-	-	-	12	-	-	-
Tamarix arabica Bge.	Tamaricaceae	Perennial shrub	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	*	*
Typha elephantica Roxb.	Typhaceae	Perennial herb	+	+	+	+	+	+	+	+	+	*	*	*	*	*	*	*	*	*
Forsskalea tenacissima L.	Urticaceae	Annual herb	-	-	-	-	-	+	-	+	-	-	-	-	-	-	14	-	31	-
Fagonia indica Burm.f.	Zygophyllaceae	Annual herb	-	+	-	-	+	+	+	-	+	-	14	-	-	12	18	35	-	9
Peganum harmala L.		Annual herb	-	+	+	+	+	+	+	-	+	-	56	84	3	44	34	55	-	50

N.B. (+) =present, (-) =absent, (*) =present at locality and not on the robe of line transects, (IV) =importance value, 1=Al-Shafa, 2=Jabajeb, 3= Al-Arafah 4=Gadeer, 5= Ekrima, 6= Thumalah, 7= Wadi Sab, 8= Saysid, 9= Jaleel.

Table 3. *Argemone* phenological stages during the year, 2008/2009.

Plant stage	Month							
	December	January	February	March	April	May	June	July
Germination	↔							
Seedlings		↔						
Vegetative			↔					
Flowering				↔	↔			
Fruiting and seed raining						↔	↔	

Argemone sp. has a tendency to multiply rapidly, choking the land, competing with other range plant species and reducing the land value particularly around Taif mountainous area (Migahid, 1974).

Rawson and Bath (1980) after large scale sampling of transects in wheat fields came to a conclusion that *A. mexicana* mainly colonizes areas where wheat stands are poor or where there are gaps in wheat seeding. The Saudi Arabian *Argemone* weed problem did not seem to have received any serious attention (Hussein et al., 1983). The higher important values of *Argemone* reflects its rapid propagation and for this reason, Al-Mutlaq (2005) paid an attention on applying herbicidal activity of plant extracts on rangelands invested with *Argemone* sp. in KSA.

Studying the phenology of *Argemone* as one of the invasive species grown and naturalized in Saudi Arabia that took place during the year, 2008/2009 (Table 3 and Figures 4 to 10) is of immense importance for the forthcoming biological studies of this species. The genus *Argemone* consists of many species; three of which are naturalized in Australia. *A. ochroleuca* is an annual prickly herb of about 100 cm height with yellow latex. The leaves are simple, sessile, spiny, sinuate-pinnatified, variegated with white dots, spiny on margins and veins. Flowers are bright yellow-white, solitary terminal on short leafy branches. Fruits are erect prickly capsules, 2 to 5 cm long, opening at the apex. Seeds are brown or black, globose, 1.5 mm in diameter prominently veined (Smith, 2002). Seeds produced in large quantities tend to fall near the parent plant producing dense stands. The plant is known to break off at the base and be windblown for long distances helping to spread seeds. Seed has also been dispersed as a contaminant in hay and pasture seed. Seeds are known to be poisonous but the other parts of the plant are used in medicinal purposes. In fact, berberine and sanguinarine, two main alkaloids isolated from *Argemone* tissues, display significant cytotoxic and antimicrobial properties (Beuria et al., 2005). These properties categorized the *Argemone* plant as a widely cultivated plant which has become a naturalized weed in many parts of the world, particularly, in subtropical region. The plant usually flowers during June and January while it fruits in January and February. It is naturalized in all Australian states, native to Mexico, naturalized in New Zealand. The species is well distinguished by its white petals which were early considered as a mutant of the yellow flower of *A. mexicana*. Following the phenological sequence (Table 3) explicated that the growth stages (germinating, seedlings, vegetative, flowering, fruiting and seed raining) consumed time periods of 30, 30, 40, 60 and 75 days, respectively, starting from December, 2008 up to mid-July, 2009. Seed germination and seedling growth occurred in winter and during the raining season that plays an important role in leaching and diluting the salts of superficial soil layers, thus, encouraging seed germination of the species. This is in agreement with several authors (Packham and Willis, 1997; Al-Huqail and Al-Turki, 2006). Lengthening of the fruiting and seed raining stage reflects the huge seed producing ability of the species.

All stages of growth could be observed in the same area at the same time of the year. These results are in agreement with Medina (1998) and Trammell and Butler (1995). Ownby (2007) mentioned that the plant flowers during June and January while fruiting occurs in January and February. Karllsson et al. (2003) indicated that the majority of the seeds normally do not germinate directly after shedding. Vohra et al. (2004) studied the periods of flowering and fruit dehiscence of *A. mexicana*. They reported that the species starts flowering in February and fruiting during March, followed by the dehiscence of capsules. The seeds were not dispersed over large distances, and fell vertically to the ground. This is in concordance with the results of the present investigation.

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