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Obtrusiveness of *Argemone ochroleuca* sweet in different natural surroundings in Taif

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Abstract

This study was designed to elucidate the role of *Argemone ochroleuca* Sweet-an exotic worldwide weed-in native desert communities of various habitats (sand plains, dams and wadies) in Taif. The latter is characterized by its high diversity in local climatic and topographic conditions. The inter-relationship between the species invasibility (INV) and its biological features (such as plant size; PS, seed production; SP and seed bank; SB) and between some of community factors (such as species richness; SR and productivity) was studied. Results evinced high seed productivity of *Argemone* (85, 850 seeds). Species seed bank attained an average value of 7, 736. m^{-2}. The seed productivity plain habitat was characterized by possessing the highest values of: invasibility, diversity, *Argemone* size, seed production, seed bank and community productivity compared with the other two habitats. Correlation between invasibility (INV), species richness (SR), plant size (PS), seed productivity (SP) and seed bank (SB) and each other indicated that INV positively correlated with both plant size and seed production. Plant size positively correlated with invasibility and seed productivity. The later positively correlated with invasibility and plant size .On the other hand, there was a negative correlation between INV and SR and SB. A negative correlation was also obtained between SR and all other variables and also between SP and SR and SB. Plant size negatively correlated with species richness and seed bank.

Keywords: Reproduction, organic matter, community variables.

INTRODUCTION

Argemone ochroleuca is an invasive worldwide medicinal plant with economic potentialities. It is native of Mexico and naturalized in most warm countries of the world in sub-humid as well as semiarid regions. It is now a principal invasive common weed of many vegetable and crop fields and in various countries (Holm et al., 1977). It reduces the yield of many cereals such as wheat (Rawson and Bath, 1980) as its seed is an undesirable contaminant in stock sold food, in turn, a high level of control is required. Not only the structure of native plant communities is affected by invasiveness of this species but also the fauna is. Ownbey (2007) differentiates *A. ochroleuca* from *A. mexicana* on the basis of differences in flower bud shape and petal colour.

Invasive species are one of the most significant threats to native species diversity, and identifying the factors that make places more or less invasible has been one of the most important issues in the study of invasions (Wilcove et al., 1998; Pimentel et al., 2000). From a theoretical perspective, the reasons some communities are more invasible than others is a question intrigue ecologists (Cadotte et al., 2009) because it underlines fundamental concepts in community ecology: species coexistence and assembly (Tilman, 2004). Serpentine systems attributed this behavior to the often extreme environment within these communities. Spatial heterogeneity, spatial scale (local or regional) and productivity are critical elements in understanding the invasibility of communities. Harrison and Cornell (2008) studied species richness at either local or regional scales. Starzomski et al., (2008) found

Table 1. The studied habitats, localities and their position in Taif Governorate.

Habitat	Locality	Position
Sand plains	1-Al – Shafa	25 km Southwest of Taif
	2-Jabajeb	Northwest
	3-Al – Arafah	35 km North
Dams	1-Gadeer	7 km South
	2-Ekrima	6 km Northwest
Wadies	1-Thumalah	25 km Southwest
	2-Wadi S'ab	5 km Southwest
	3-Saysed	14 km Northwest
	4-Jaleel	28 km Northwest

that local richness did not depend on regional richness during any time of community assembly. Elton (1958) first proposed that a high richness of native species armors sites against invasion by making reasons less available to newly arriving species. Many studies supported this idea by detecting negative relationships between native and exotic diversity at small spatial scale – the scale of interaction between individuals - (Brown and Peet, 2003). Latter authors revealed that competition from resident species has strong and significant effects on both establishment and performance of invaders. Native and exotic diversity could positively be correlated only on larger spatial scale and furthermore the most diverse regions are often the most invaded, particularly for plant communities (Harrison et al., 2006). Davis et al. (2007) demonstrated that the relationship between native and exotic diversity flipped from negative to positive at scales at which spatial heterogeneity in the environment came into play.

The history of introduction of *A. mexicana,* now occupying large tracts of deteriorated rangelands in Asir region, KSA 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) essentially needed by livestock. Therefore, determining *Argemone*'s rangeland distribution and its invasion ecology are essential for planning control measures of this weed. This investigation is an extension of a previous one (Moussa et al., 2012) in Taif Governorate, KSA. They concluded the high diversity of native communities (possessing 35 associate species belonging to 25 different families). The present investigation is intended in studying the disorders resulting from introducing this troublesome weed - on a local scale- on some characters of native plant communities in different habitats in Taif. The effect of *Argemone* invasiveness on species richness – as a measure of plant diversity – as well as the community productivity – estimated by organic carbon content - was established. We sought to investigate and compare the effects of the species invasiveness - at the different habitats - on its own biological features such as: size, seed production and number of stored seeds in superficial soil layers.

MATERIALS AND METHODS

Vegetation study

During the year 2008/2009 vegetation study of *A. ochroleuca* was undertaken in nine selected localities in Taif Governorate, KSA (Table 1) that represent different habitats types. Vegetation was studied in these habits in order to cover all variations in all directions around Taif. A total of 135 lines (5 m each) were defined (15 per location) following the line transect method. Plant specimens were collected and identified following Migahid (1974) and stored in King Abdulaziz Herbarium (Branch of Girl's College). Floristic composition of the studied and associate species was prepared. From the constructed lists, the importance value of recorded species (Relative density + Relative frequency + Relative cover) was calculated (Ludwig and Reynolds, 1988). Importance values represented the invasiveness of the species. Species richness ($D = S / \log A$ where D = sp. Richness, S = total number of species per specimens, A = specimen area or line length) as a measure of the species diversity (Pielou, 1975; Magurran, 1988) was calculated for the different localities.

Biological characteristics of *Argemone*

Size *of Argemone* plants as well as its productivity tests (average number of flower buds, flowers and fruits per individual plant as well as the average number of seeds per fruit) was calculated. Finally, the average number of seeds produced per individual was estimated at all selected localities. Soil samples (five replications; 50 x 50 x 2 cm^3 each) from the underneath of the plants were superficially collected, intermixed, air dried then re-divided for homogeneity. Seed trapping activities determines the quality of invasive species arriving at each locality. So, seed bank (the number of *Argemone* seeds stored. m^{-2} soil) was evaluated using five replications of 5 g soil samples. Separation took place by the floating method using 40% $CaCl_2$ and examination took place by the aid of an electric binocular (X 20).

Community productivity

Percentage of organic matter content (Walkley and Black, 1934) as well as organic carbon content - as a measure for community productivity - (Page et al., 1982), was estimated.

Statistical analysis

The variation between community parameters (species richness; SR invisibility; INV and soil organic matter content; OM and OC), *Argemone* (plant size; PS, seed production; SP and seed bank; SB) in relation to the different localities was assessed using one-way

Table 2. Productivity tests of *Argemone ochroleuca* plants at the different localities.

Locality	Av. no. of flower buds / indiv.	Av. no. of flower / indiv.	Av. no. of fruits / indiv.	Av. no. of seeds / fruit	Av. no. of seeds / indiv.
Al-Shafa	21	12	258	472.7	122,160
Jabajeb	18	12	162	435.5	70,515
Al-Arafah	20	10	223	460.7	102,558
Gadeer	20	16	163	463.3	75,438
Ekrima	20	16	215	440.1	94,708
Thumalah	19	12	170	466.9	79,185
Wadi S'ab	22	11	164	433.0	71,188
Saysid	16	16	167	447.0	74,644
Jaleel	18	14	179	458.6	82,257
Mean value	19.3	13.2	189	453.1	85,850

analysis of variance (ANOVA). Relationships between community variables and each other were tested using simple linear correlation coefficient (*r*). The statistical package SPSS version 10.0 for windows was used for different statistical analyses.

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. The first documentation of *Argemone* 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). In the present study, nine locations in Taif representing different habitats (Table 1) were selected to detect hazardous role of *Argemone* as an invasive weed.

Vegetation study

Argemone invasiveness (INV); expressed as the importance value; varied with the variation in localities. The highest invasibility (180) was detected at Al-Arafah, followed by 150 at Al-Shafa, while the lowest value (97) was recorded at Wadi S'ab. The remaining localities attained intermediate values. Species richness attained its highest value (9.07) at Gadeer. Median values (7.93, 7.73, 7.20 and 7.13) were achieved at Jaleel, Thumalah, Saysed and Ekrima, respectively; the sites of inter-mediate importance values. Species richness showed negative correlation (Tables 3 and 4) with the invisibility; as the former decreases with increasing the latter and vice versa. To-date little is known about the impact of *Argemone* on biodiversity. Kumar and Rohatgi (1999) postulated that the species decreases biodiversity in India.

Biological characteristics of *Argemone*

Estimates of the species productivity Table 2, revealed that the number of flower buds produced per individual ranged from a lowest value of 16 (at Saysid) to a highest of 22 (at Wadi S'ab). Meantime, the number of produced flowers ranged from 10 (as a lowest value at Al-Arafah) to 16 (a highest value, simultaneously monitored at Gadeer, Ekrima and Saysid, successively). The species produced huge numbers of fruits that ranged from a decreased value of 162 of (at Jabajeb) to a highest of 258 per individual (at Al-Shafa). The latter locality was also distinguished by giving a maximized number of 473 seeds per fruit whereas a minimal value of 433 seeds was given at Wadi S'ab. So an overall maximal number of 122,160 seeds per individual *Argemone* plant were rained at Al-Shafa while a minimal overall number of 70,515 seeds were detected at Jabajeb. It was observed that 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 disperse seeds. The immense numbers of produced seeds evinces the high propagation of the species. Seed production of *Argemone* varies throughout the world. Mauritius reports the greatest seed production with an average of 60 to 90 capsules per plant with 300 to 400 seeds in each capsule (Holm et al., 1977). They added that most seeds fall around the base of the parent plant where they form a carpet of seedlings. Dispersal occurs in surface water and in mud adhering to farm machinery and the feet of man and livestock. Seeds are readily eaten by a number of bird species in Puerto Rico as indicated by the presence of many seeds of the

Table 3. Means of *Argemone* variables (±S.D) at the nine studied localities; INV, Invasibility; SR , Species Richness; PS , (Plant 1,Al-Shafa; 2, Jabajeb; 3, Al-Arafah; 4, Gadeer ; 5, Ekrima; 6, Thumalah; 7, Wadi S'ab; 8, Saysid; 9, Jaleel;), SP , Seed Productivity ; SB , Seed Bank ; OM, organic matter content; OC, organic carbon content; SD , Standard Deviation (**), significant at 1%.

Argemone variable	Locations									Total ± SD	F-ratio	Sig.
	1	2	3	4	5	6	7	8	9			
INV (Invasibility)	150±32.37	120±17.13	180±26.07	101±15.64	138±17.16	110±22.23	97±36.63	109 ± 20.64	120 ± 10.61	125.0±33.13	6.51	0.00**
SR (species richness)	3.07±0.96	2.60±2.31	4.07±1.28	9.07±2.12	7.13±2.23	7.73±1.87	6.20±2.51	7.20 ± 2.08	7.93 ± 1.39	6.11±2.86	22.09	0.00**
PS (m^3) (Plant Size)	5.72±0.76	3.88±0.68	4.18±0.28	3.66±0.54	3.95±0.49	4.63±0.75	3.70±0.73	4.10 ± 0.64	4.25 ± 0.41	4.23±0.82	5.38	0.00**
SP (seed/indiv.) (seed productivity)	122,160±11,258	70,516±19,935	102,558±13,540	75,439±11,585	94,708±17,184	79,185±17,228	71,189 ±14,887	74,644 ± 17,105	82,257 ± 36,720	85,851±41,108.	0.87	0.55n.s
SB (seed.m^{-2}) (seed bank)	7,100±1,387	13,600±2,219	6,700±908	10,120±756	3,000±353	7,200±1,095	8,600 ± 1,025	5,700 ± 570	7,600 ± 418	7,736±2,978	34.99	0.00**
OM (%)	0.55	3.75	2.41	2.00	0.78	0.73	3.44	1.56	0.94	1.79		
OC (%)	0.24	1.67	1.07	0.89	0.35	0.33	1.53	0.70	0.42	0.80		

Table 4. Pearson's - product moment correlation coefficient (*r*) between the estimated community variables. For variable abbreviations and units, see Table 2.

Variable	INV	SR	PS	SP	SB
INV.		-0.590	0.420	0.801**	-0.324
SR	-0.590		-0.404	-0.479	-0.274
PS	0.420	-0.404		0.778*	-0.225
SP	0.801**	-0.479	0.778*		-0.447
SB	-0.324	-0.274	-0.225	-0.447	

**Correlation is significant at the 0.01 level (2-tailed), * correlation is significant at the 0.05 level.

species in birds' stomachs (Barnés, 1946). In Ethiopia, most seeds do not normally germinate the year after shedding. Instead they enter the seed bank and seedlings establish, even in well-maintained field, probably for many years (Karlsson et al., 2003). Number of *Argemone* seeds buried in superficial soil layer (seed bank; SB) attained a mean value of 7, 7 36. m^{-2} that ranged from a minimal of 3,000 at Ekrima (dam topographic habitat) to a maximal value of 13,600 at Jabajeb (an open sand plain habitat). An intermediate value of 7, 275 seeds was recorded in wadies of Thumalah, S'ab, Saysid and Jaleel. On raining, water is stored behind the dams that help in loosing most of seeds on flooding, thus attaining the lowest seed bank values. The intermediate values found in wadi habitats might be a result of water runoff that carries seeds from the surrounding higher terraces and settles them down the wadies.

The possession of maximized seed bank value by the sand plain topographic habitat ensures the intensive receive of seeds arriving by different dispersal means. Plant size (PS) varied at the studied localities; the largest of which (5.8 m^3) was detected at Al-Shafa, while extensively minimized (3.7 m^3) at Gadeer. An intermediate value (4.2 m^3) was recorded at Al-Arafah.

Community productivity

Along with spatial scale, site productivity likely affected the invasibility of communities and thus the relationship between native and exotic diversity, (Davis et al., 2007) especially at small scales, where competitive exclusion potentially varied with site productivity. Authors continued that productive sites had a common positive relationship between native and exotic diversity, whereas unproductive sites had a common nega-tive relationship. Generally, in Taif, *Argemone* tends to inhabit the less fertile (less productive) soils, having low organic matter and organic carbon content (Table 3). Former parameter varied from a least value of 0.55 (at Al-Shafa) to a highest of 3.75% (at Jabajeb) while the latter one ranged between 0.24 (also at Jabajeb) and 1.67% (at Al-Shafa). This comes in concordance with Parsons and Cuthbertson (1992) who mentioned that the species tends to grow best in soils of low fertility. They added that in Australia, it is peculiarly adapted to colonize derelict areas low in phosphorus. *A. mexicana* is better suited to grow at sites deficient in nitrogen whereas the closely related *A. ochroleuca* does better where phosphorus is limiting (Ramakrishnan and Gupta, 1972). Moussa et al. (2012) reported that slight alkalinities as well as complete lacking of carbonates are characteristic features for the studied localities. They added that high EC is expressed at Jaleel and owed that trend to the possession of higher contents of Ca^{+2}, Cl^{-} and SO_4^{+2}. They continued that highest Mg^{+2}content is detected at Ekrima, while Na^{+} is exceedingly measured at Thumalah. Neither species appear to have obvious restriction to particular agronomic or environmental situations (Karlsson et al., 2003). In southern India it occurs up to an altitude of 800 m a.s.l. and when growing in undisturbed land, it can produce fresh weights of 6 to 9 t/ha but, in cultivated land, it is generally not an aggressive competitor (Holm et al., 1977).

It is to be noted that the species richness was inversely proportional to the community productivity; expressed as organic matter and organic carbon content (Table 3). Hodgson et al. (2002) found a positive relationship between diversity and productivity and a negative diversity – invisibility, productivity – invisibility relationship among bacterial colonies.

One way ANOVA test showed significant differences (F-ratio = 0.00; sign. =6.51, 22.09, 5.38 and 34.99) between invasibility (INV), species richness (SR), plant size (PS) and seed bank (SB) values of the nine localities (Table 3). The highest value of invasibility (180 ± 26.07) was found at Al-Arafah locality, while that of species richness (9.07 ± 2.12) was attained at Gadeer. Al-Shafa was distinguished by possessing the largest plant size (5.72 ± 0.76) as well as the highest seed productivity (122,160 ± 11,258). Higher organic matter and organic carbon (3.75; 1.67%, respectively) were detected at Jabajeb.

The calculation of correlation coefficient (*r*) between the different community variables (Table 4) indicated that invasiveness (INV), plant size (PS) and seed productivity (SP) had the highest number of correlations with high significant positive correlations between each other. Correlation between INV, SR, PS, SP and SB and each other (Table 4) indicated that INV positively correlated with both plant size (PS) and seed production (SP). Plant size (PS) positively correlated with invasibility (INV) and seed productivity (SP). The later (SP) positively correlated with invisibility (INV) and plant size (PS). On the other hand, there was a negative correlation between INV and SR and SB. A negative correlation was also obtained between SR and all other variables and also between SP and SR and SB. Plant size (PS) also negatively correlated with species richness (SR) and seed bank (SB).

Conclusion

We might come to a conclusion that *A. ochroleuca* is one of the most hazardous invasive wild weeds, flourishing nearly in all drastic habitats in arid and semi-arid regions of the world, especially in Taif; as a wide less fertile Governorate in Saudi Arabia. The sand plain habitat is characterized by possessing the highest values of invasibility, diversity of native communities, *Argemone* size *Argemone* seed production, number of seeds contained in superficial soil layer and community productivity (organic matter content) if compared with the other two habitats. Invasiveness is positively correlated with either plant size and species production. The latter is positively correlated with invasiveness and plant size, while negatively correlated with species richness and seed bank.

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