

Morphology and Distribution of Three Genera of *Amaranthaceae* in the South Western Area of Saudi Arabia

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(Received 12/9/1422H.; accepted for publication 14/9/1424H.)

Abstract. Four species (*Aerva javanica*, *A. lanata*, *Pupalia lappaceae* and *Achyranthes aspera*) representing three genera of the family *Amaranthaceae*, and commonly distributed in the south western part of Saudi Arabia, were investigated. The study involved the morphological characteristics and their distribution in relation to some environmental parameters (altitude, temperature and rainfall). The data indicated a great morphological similarity between the two *Aerva* species, with little differences which could be correlated to their distribution in the area. *Aerva javanica* species has a wide distribution in all habitats, while *Aerva lanata* was found to be restricted only to high altitudes and low temperature. On the other hand, considerable morphological differences were observed between *Pupalia lappaceae* and *Achyranthes aspera* and the two *Aerva* species. *Pupalia lappaceae* and *Achyranthes aspera* were found to be restricted to the presence of water with preferences to high altitudes. In conclusion, the distribution of the four *Amaranthaceae* species under study in Aseer area is associated clearly with several factors. These include in the first rank the morphological adaptation of the plant species to its habitat. In addition to the environmental parameters; e.g. altitude, temperature and rainfall which influence the distribution, establishment, growth and regeneration of the plant species.

Keywords: *Amaranthaceae*, *Aerva* species, *Pupalia*, *Achyranthes*, Aseer area, Saudi Arabia, Morphology, Environmental features.

Introduction

Amaranthaceae is a cosmopolitan family consisting of 64 genera and about 800 species, mostly abundant in tropical regions of America, Africa and India [1]. The family, represented by herbs and few shrubs, contains most of the important allergic species [2, 3].

The south western part of Saudi Arabia is a unique area due to its environment and plant life. It belongs to the greater Afro-Arabian shield, which is a part of the Precambrian crystalline plate [4]. The elevation of the area above sea level ranges from

1000 m to 3130 m [5]. It contains mountains, escarpments, deep valleys, rolling land and rocky hills [6].

The climate of the area changes drastically from hot dry in low lands to rainy cold in high mountains [7, 8]. The mountains are distinguished by moderate temperature throughout most months of the year. Although, there is a decrease in temperature in winter, it does not reach freezing point, because this area is influenced by the warm marine wind. The important characteristic of the area is that it receives high rates of rainfall. These rains are distributed throughout the year with peaks in spring and summer [9].

The area contains different plant communities and habitat types which varied in their environmental features and consequently in their vegetation composition [10]. Various studies were carried out on the flora of this area [11]. Recently, the flora of Saudi Arabia was studied by many authors [12-17].

This work describes a taxonomic study on four species belonging to three genera of the family *Amaranthaceae*, widely distributed in the south western area of Saudi Arabia. Some parameters of macromorphological and micromorphological characters were recorded and investigated, in relation to the environmental features of the studied area.

Materials and Methods

Study area and plant material

The study area in the south western part of Saudi Arabia was distinguished into three distinct locations (Al-Soudah, Abha and Gizan) which are different in their altitude and climate. Data about the average monthly temperature and rainfall were recorded from reports of climatological stations at the three above mentioned locations.

Plant materials were collected from their natural habitats of the three locations and compared with the herbarium specimens at the Biology Department, Faculty of Science, King Khalid University, Abha, Saudi Arabia. Samples representing *Aerva javanica*, *A. lanata*, *Pupalia lappacea* and *Achyranthes aspera*; were collected and identified. Identification and nomenclature of species was based on previous studies on the flora of Saudi Arabia [12, 14, 16, 17].

Morphology

Macromorphological characters were recorded and measured from both freshly collected and herbarium specimens of the studied species. These characters include: length of stem, shape, length and position of leaves; and inflorescence length and diameter. Quantitative characters were recorded from at least 10 replica of each species.

Micromorphological characters involved description of the leaf surface trichomes and pollen grain morphology (i.e. polarity, shape and dimension). Leaves were softened by boiling in 30% lactic acid. Then, the upper and lower epidermis were removed and mounted in 50% glycerol for microscopic investigation and photography.

Pollen grains were removed from anthers, collected and placed in glacial acetic acid for 3 min., acetolyzed and mounted in glycerin-jell for light photography [18]. Pollen grain diameter was calculated as mean value of 10-20 replica.

Results

Environmental features of the study area

The study area of the south western part of Saudi Arabia contains different habitats; e.g. mountains, escarpments, deep valleys, rolling land and rocky hills. Three locations, Al-Souda, Abha and Gizan, having different environmental features, were selected for this study. These locations are also different in their elevation above the sea level (Al-Souda 2800 m, Abha 2200 m and Gizan 130 m) as shown in Fig. 1.

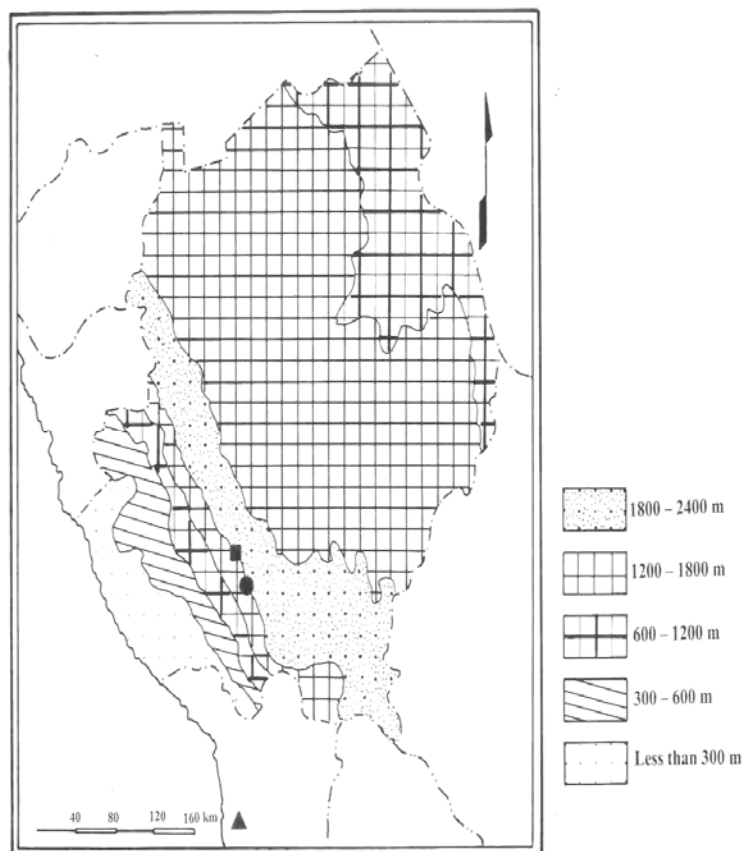


Fig. 1. Map of the south western region of Saudi Arabia showing the three studied locations; (■) Al-Souda, (●) Abha and (▲) Gizan.

Generally, the climate of the area is influenced by the southerly monsoon current associated with the intertropical front which is channelled along the Red Sea trench from which diurnally directed toward Saudi Arabia by differential heating. The average of monthly temperature and rainfalls in the three locations of the study area are shown in Fig. 2.

The climate at Al-Souda (latitude 18°15' N, longitude 42°22' E) is cool and wet with rainfall at any time of the year, with maximum (98 mm) during May and minimum (10 mm) during December and January. The temperature reached maximum degree (19°C) during June and July, and minimum (7°C) during December and January.

The mean annual temperature at Abha (latitude 17°80' N, longitude 42°46' E) reached 18.5°C, with maximum (22°C) during June, July and August; and minimum (12°C) during December and January. The rainfall is expected at any time of the year with maximum (150 mm) during May and minimum (2 mm) during December.

In Gizan (latitude 15°54' N, longitude 42°33' E) the climate is hot and dry all the year round with high mean annual temperature (30.3°C). The rainfall reached maximum (8 mm) during October and minimum (1 mm) during June.

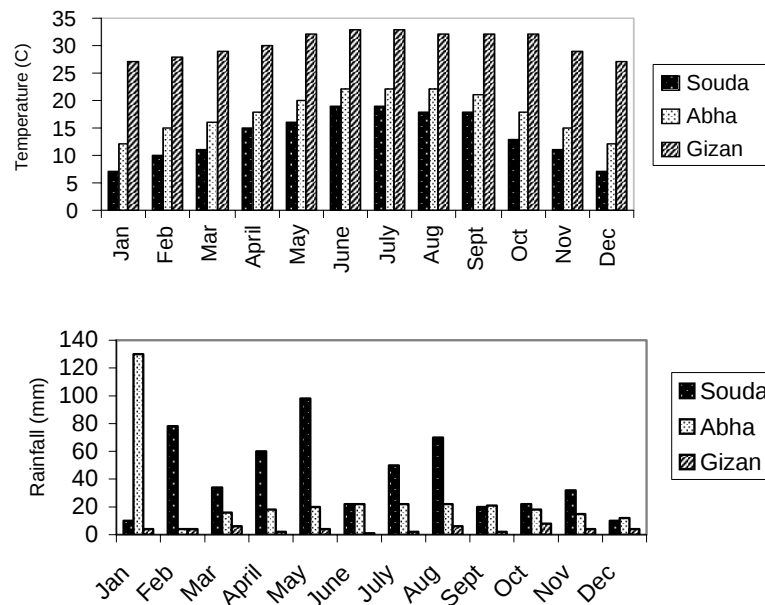


Fig. 2. Annual temperature and rainfalls of the studied locations.

Macromorphological characteristics

Species of the family *Amaranthaceae* are herbs or shrubs with alternate or opposite, simple exstipulate leaves. Flowers are bisexual or unisexual with the plants monoecious or diecious, 3-bracteate, mostly in axillary or terminal cymes. Perianth 3-5-lobed, the

segment more or less scarious. Stamens are 3-5, ovary superior, 1-celled and generally 1-ovuled. Fruit utricle or capsule. In Saudi Arabia species are all herbs, but the two *Aerva* species can appear almost woody enough to be classified as shrublets.

***Aerva javanica* (Burm. f.) Spreng.**, Erect shrublet, grey, tomentose, 30-60 cm high with erect cylindrical stems, branching from near the base (Fig. 3, A). Leaves alternate, elliptic-lanceolate, covered with densely stellate hairy, obtuse, tapering to a short petiole, 1-4 cm long, 0.5-1 cm wide. Inflorescence white, woolly, cylindrical, terminal, 2-8 cm in long and 4-6 mm in diameter, leafless, simple or branched. Flowers bisexual or unisexual with the plants monoecious or diecious; female flowers larger than the male ones which contain 5 stamens and 5 staminodes. Female flowers with a pistil, single style and 2 linear stigmas. Fruit oblong, single-seeded; seeds black, shining compressed, 1 mm in long. Species, usually found on rocky ground with shallow sandy silt and widely distributed from high altitude to sea level.



Fig. 3. Morphological characteristics of herbarium specimens of ; (A) *Aerva javanica*, (B) *A. lanata*, (C) *Pupalia lappaceae* and (D) *Achyranthes aspera*.

***Aerva lanata* (L.) Juss. ex J. A. Schultes**, Erect herb, woolly, shoots are covered with unbranched (smooth) hairs, up to 50 cm high. Leaves small alternate, obovate to obcordate, with dense hairs, up to 1.2 cm in long, 0.6 cm wide. Inflorescence, white, woolly, short spikes, 1.2-1.8 cm in long and 0.4 cm in diameter, most of them are axillary. Flowers bisexual and species restricted to high altitude only (Fig. 3, B).

***Pupalia lappaceae* (L.) A. Juss. var. *velutina* (Moq.) Hook. f.**, Perennial herb, up to 50 cm in long. Leaves, opposite, short petiolate, ovate, silky in young stages, 1-5 cm long, 0.9 - 5 cm wide. Inflorescence spherical heads, 1 cm in diameter, interrupted especially in their lower parts. Flowers in clusters, each with 3 hermaphrodite florets subtended by

2 bracts and 4 bracteoles, covered with white woolly hairs and broad spines which modified from 2 sterile flowers. Fruit berry-like shaped (Fig. 3, C). Common, creeping through shade places and rocky hill side at high altitude.

***Achyranthes aspera* L.**, Erect annual herb, up to 1.5 m high. Leaves opposite, with short petiolate, lanceolate, silky beneath when young, 1-5 cm long, 0.4-2 cm wide. Inflorescence long terminal and short axillary spikes, up to 30 cm long, 0.6-1.0 cm diameter. Flowers bisexual, the lower ones retroflexed. The bracts glossy which enable the fruit to stick on clothes and woolly skin of animals; small spiny tips, whitish or purplish (Fig. 3, D). Species distributed in vallies and shadow places at high altitude. However, the macromorphological characters are summerized in Table 1.

Micromorphological characteristics

***Aerva javanica* (Burm. f.) Spreng.**, pollen grains are apolar, spheroidal - polyhedral with obtuse angles. Diameter ranged between 15-18 μm . Pollen grains polypantoporate (16 pores) each about 3-4 μm in diameter and rounded. Exine 1.5-2 μm thick. Sexine as thick as nexine, minutely granulate. Tectum thin supported by densely spaced bacula (Fig. 4, A).

Trichomes are uniseriate, tapered at the end, multiarticulated with stellate base cell (Fig. 5, A and E).

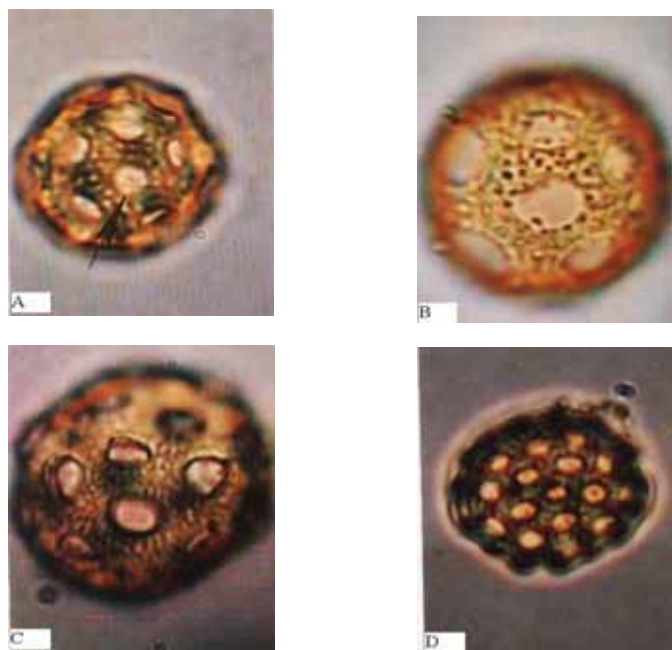


Fig. 4. Pollen grain morphology of; (A) *Aerva javanica*, (B) *A. lanata*, (C) *Pupalia lappaceae* and (D) *Achyranthes aspera*, (X 1500).

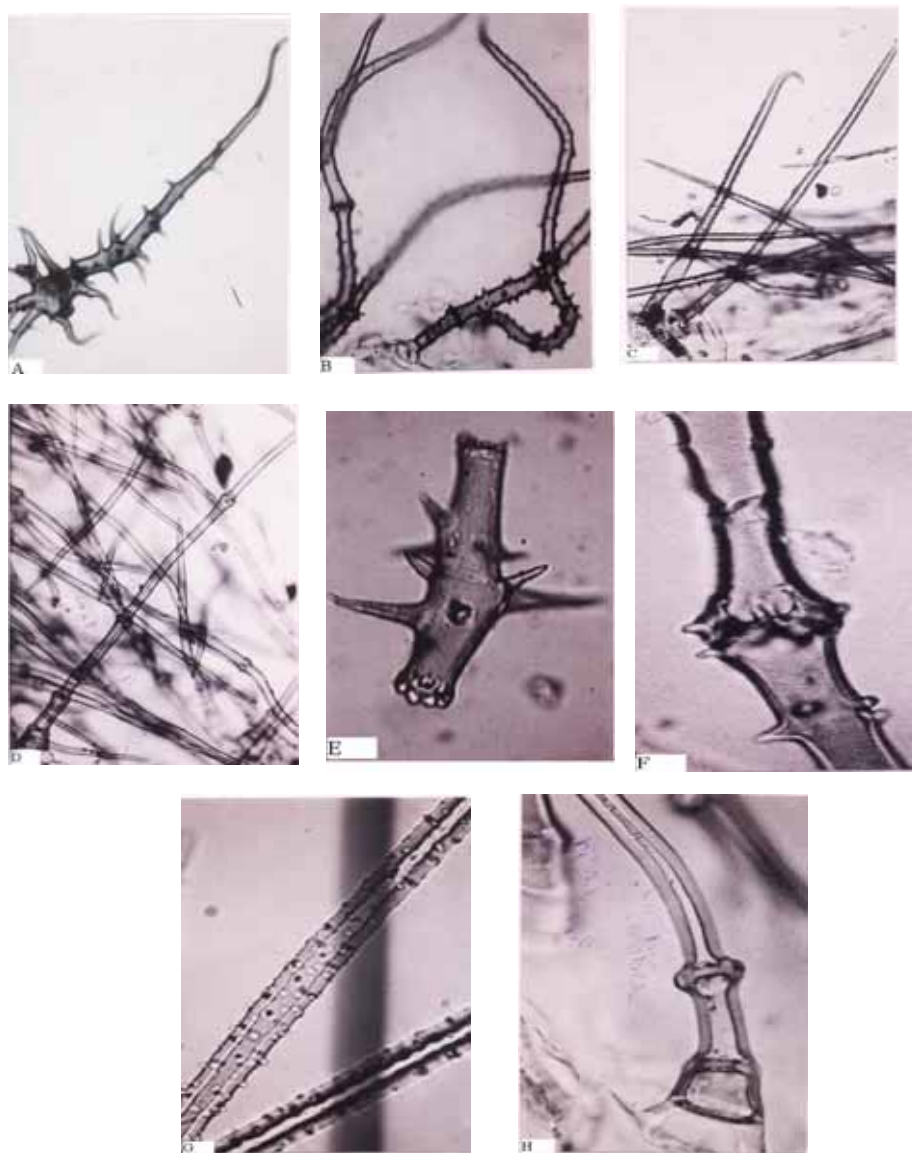


Fig. 5. Epidermal trichomes of; *Aerva javanica* (A and E), *A. lanata* (B and F), *Pupalia lappaceae* (C and G) and *Achyranthes aspera* (D and H). Magnification power for A, B, C and D is X 40, and for E, F, G and H is X 400.

***Aerva lanata* (L.) Juss. ex J. A. Schultes**, pollen grains apolar, spheroidal - polyhedral with obtuse angles. Diameter ranged from 18-20 μm . Pollen grain polypantoporate (16 pores), each pore of about 5-6 μm in diameter and round-shaped. Exine 1.5-2 μm thick, sexine as thick as nexine, minutely granulate. Tectum thin, supported by densely spaced bacula (Fig. 4, B).

Trichomes with spinulated surface, uniseriate, tapered at the end, multiarticulate (Fig. 5, B and F).

***Pupalia lappaceae* (L.) A. Juss. var. *velotina* (Moq.) Hook. f.**, pollen grains apolar, spheroidal - polyhyderal with obtuse angles (Fig. 4, C). Diameter ranged between 21-24 μm . Pollen grains polypantoporate (16 pores) each of about 5 μm diameter and round. Exine 1.5-2 μm thick. Sexine as thick as nexine, minutely granulate. Tectum supported by densely spaced bacula.

Trichomes uniseriate, with densely papillate surface, biciliate, the basal cell is small and the terminal one is long (Fig. 5, C and G).

***Achyranthes aspera* L.**, pollen grains apolar, spherical - polyhyderal with obtuse angles. Diameter 13-16 μm . Pollen grains polypantoporate (32 pores), each of about 2 μm diameter and round. Exine 0.7-1 μm thick. Sexine as thick as nexine, minutely granulate (Fig. 4, D). Tectum thin, supported by densely spaced bacula.

Trichomes unirow, multiarticulated cells with smooth surface (Fig. 5, D and H). The micromorphological characters are summarized in Table 1.

Discussion

The family *Amaranthaceae* comprises herbs and few shrubs and contains most of the important allergic species distributed in the tropical regions of America, Africa and India [1, 2]. Thus, many studies were carried out on the pollinosis caused by the pollens of this family [19, 20]. Other studies were focused on the presence of phytochemicals (e.g. betacyanin) in colored plants of the family [21, 22]. These pigments representing a potential new source of natural colourants.

On the other hand, taxonomy of *Amaranthaceae* received very low number of investigations, particularly in Saudi Arabia. The south western part of Saudi Arabia is a unique area in its environment and plant life [4]. It contains mountains, escarpments, deep valleys, rolling land and rocky hills [6]. The area contains different plant communities and habitat types which varied in their environmental features and consequently in their vegetation composition [10].

The four studied species of *Amranthaceae* are very common in Aseer area. They constitute the major part of the wild germplasm of this area. The two *Aerva* species (*A.*

javanica and *A. lanata*) showed a great similarity in their morphological characteristics. Some differences were recorded in the shape and length of leaf. The leaf trichomes are stellate at the base in *A. javanica*, while *A. lanata* has spinulate ones. The flowers of *A. javanica* are unisexual and bisexual. This could be correlated with its wide distribution in the area, and not restricted to certain altitude or temperature. This species was recorded in all habitats in Saudi Arabia by many authors [12, 14, 16, 17]. While the distribution of *A. lanata* is restricted only to high altitudes (2800 m over the sea level) and low temperatures (less than 20°C). This species was recorded only in Aseer area and not anywhere in Saudi Arabia [12, 14, 16, 17].

Table 1. Summary of the morphological characters of the four studied species

Species	<i>A. javanica</i>	<i>A. lanata</i>	<i>P. lappaceae</i>	<i>A. aspera</i>
Macrocharacters				
Stem length	30- 60 cm	30- 50 cm	30- 50 cm	90-150 cm
Leaf				
Shape	ellipt-lanceolate	obov-obcordate	ovate	lanceolate
Length	1.0-4.0 cm	1.0-2.0 cm	1.0-5.0 cm	1.0-5.0 cm
Width	0.5-1.0 cm	0.4 - 0.8 cm	0.9-5.0 cm	0.4-2.0 cm
Arrangement	alternate	alternate	opposite	opposite
Inflorescence				
Shape	spike	spike	spherical	spike
Length	2.0-8.0 cm	1.2-1.8 cm	0.9-1.1 cm	20-30 cm
Diameter	0.4-0.6 cm	0.3-0.5 cm	0.9-1.1 cm	0.8-1.2 cm
Flower				
Sex	uni- & bisexual	bisexual	bisexual	bisexual
Anther no.	5+5	5+5	5	3
Anther fert.	5 sterile	5 sterile	all fertile	all fertile
Microcharacters				
Leaf trichomes	uniseriate multiarticulate stellate base	uniseriate multiarticulate spinulate	uniseriate biciliate papillate	uniseriate articulate smooth
Pollen grains				
Polarity	apolar	apolar	apolar	apolar
Shape	spheroidal	spheroidal	spheroidal	spheroidal
Diameter	15-18 µm	18-20 µm	21-24 µm	13-16 µm
Pore no.	16	16	16	32
Pore diam.	3-4 µm	5-6 µm	5 µm	2 µm
Exine thick.	1.5-2.0 µm	1.5-2.0 µm	1.5-2.0 µm	0.7-1.0 µm

Examination of morphological characteristics of the two other species, *Pupalia lappaceae* and *Achyranthes aspera*, showed great differences between each other and also between the two *Aerva* species. These differences were recorded in the length of stem, shape and arrangement of leaves. The inflorescence of *Pupalia lappaceae* is spherical heads. The leaf trichomes of *Achyranthes aspera* are smooth and pollen grains are very small in diameter (13-16 µm) and have a high number (32) of pores. The two

species were restricted only to rainy locations with preference to high altitudes such as Aseer area where cold climate and water are available [12, 14]. Meanwhile, they were also recorded in cultivated fields of low lands with high content of water and high temperature [17]. Moreover, they are not recorded in dry hot areas [16].

In conclusion, it emerges that the distribution of the four *Amaranthaceae* species under study in Aseer area is associated clearly with several factors. These include in the first rank, the morphological adaptation of the plant species to its habitat. In addition to the environmental factors; e.g. altitude, temperature and rainfall which influence the distribution, establishment, growth and regeneration of the plant species.

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(قدم للنشر في ١٢/٩/١٤٢٢هـ؛ وقبل للنشر في ١٤/٩/١٤٢٤هـ)

ملخص البحث. تمت الدراسة على أربعة أنواع: أيرفا جافانكا (*Aerva javanica*). أيرفا لاناتا (*Aerva lanata*). بوباليا لاباسيا (*Pupalia lappaceae*) وأكارانسييس أسبيرا (*Achyranthes aspera*) تنتمي إلى ثلاثة أجناس من العائلة الأمارانتيسية (*Amaranthaceae*) والتي تنتشر بكثرة في منطقة جنوب غرب المملكة العربية السعودية. تضمنت الدراسة الصفات المورفولوجية وارتباط توزيع النباتات ببعض العوامل المناخية (الارتفاع عن سطح البحر، الحرارة وكمية المطر). أظهرت النتائج تشابه مورفولوجي كبير بين النوعين من جنس أيرفا (*Aerva*) مع وجود بعض الاختلافات القليلة المرتبطة بانتشارهما في المنطقة. أيرفا جافانكا (*Aerva javanica*) له انتشار كبير في كل البيئات في المنطقة بينما ينحسر تواجد أيرفا لاناتا (*Aerva lanata*) على الأماكن المرتفعة عن سطح البحر ذات الحرارة المنخفضة فقط.

من ناحية أخرى، لوحظ وجود اختلافات مورفولوجية بين النباتات من نوع بوباليا لاباسيا (*Pupalia lappaceae*) ونوع أكارانسييس أسبيرا (*Achyranthes aspera*) وكذلك النباتات من جنس أيرفا (*Aerva*). أظهرت النتائج ارتباط انتشار النباتات من نوع بوباليا لاباسيا (*Pupalia lappaceae*) ونوع أكارانسييس أسبيرا (*Achyranthes aspera*) بتواجد المياه مع أفضلية للأماكن المرتفعة عن سطح البحر.

من الدراسة يمكن أن نستخلص أن انتشار الأنواع النباتية الأربعة تحت الدراسة من العائلة الأمارانتيسية (*Amaranthaceae*) في منطقة عسير يرتبط بوضوح بالعديد من العوامل التي تشتمل في المقام الأول على

التكيف المورفولوجي للنوع النباتي للبيئة التي يعيش فيها، بالإضافة إلى العوامل المناخية مثل الارتفاع عن سطح البحر. الحرارة وكمية المطر والتي تؤثر على انتشار، نمو وثباتية النوع النباتي.