

Numerical taxonomy and morphological delimitation of six taxa of *Euphorbia* in Iraq

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ABSTRACT:

Six taxa of *Euphorbia* L. (*E. hirta* L., *E. milii* var. *milii*, *E. milii* cv. *White*, *E. prostrata* Aiton, *E. hypericifolia* L. and *E. serpens* Kunth) have collected from different locations in Baghdad. The results morphological study showed that some morphological traits have a role in the delimitation of *Euphorbia* complex like leaf shape, phyllotaxy, dimensions, color, and indumentum moreover, petiole absence or presence, stem shape, dimensions, color, presence of stipules or absence and also hairs type of stem and branching, cyathium appendages and its glands are significant for taxonomical study. However, Thirty-two morphological traits including (quantitative and qualitative) were utilized for numerical analysis of six taxa belonging to *Euphorbia* as the Hierarchal agglomerative analysis dendrogram was generated in SPSS version 20. To construct a HCA dendrogram, numerical taxonomy have been applied by using SPSS v.20 to show the relationships between the taxa of *Euphorbia*.

Keywords: *Euphorbia* plant, numerical taxonomy, Hierarchal agglomerative analysis.

التصنيف العددي و العزل المظهري

لستة انواع من نبات ام الحليب في العراق

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مستخلص:

ستة انواع من *Euphorbia* (نبات ام الحليب) جمعت من مناطق مختلفة في مدينة بغداد (*E. hirta* L., *E. milii* var. *milii*, *E. milii* cv. *White*, *E. prostrata* Aiton, *E. hypericifolia* L., *E. serpens* Kunth) اظهرت نتائج الدراسة المظهرية بانه بعض الصفات المظهرية لعبت دور مهم في تحديد نوع الورقة من حيث التعقيد لجنس *Euphorbia*، توزيع الاوراق، الابعاد، اللون، الكساء السطحي، علاوة على ذلك عدم وجود او وجود السويقات، شكل الساق، الابعاد، اللون، عدم وجود او وجود الاذينات، وكذلك نوع الشعيرات على الساق، التركيب الكاسي والغدد الملحقة الضرورية للدراسة التصنيفية. مع ذلك، اثنان وثلاثون صفة تصنيفية (كمية و نوعية) استخدمت في التحليل العددي لستة انواع للنبات المدروس حيث تم انشاء مخطط التحليل التكتلي HA وتم تطبيق التصنيف العددي لإظهار ومعرفة العلاقات التطورية بين الانواع المدروسة. باستخدام برنامج SPSS V.20. الكلمات المفتاحية: نبات ام الحليب، التصنيف العددي، التحليل التكتلي.

Introduction:

The *Euphorbia* L. is the most diverse genus in the globe with 2100 cosmopolitan species at least and widely represented in Iraq by forty four species and the third largest genus distributed in Baghdad ranging from wild, alien and cultivated in horticultural enthusiasts (Radcliffe-Smith, 1980; Bolaji *et al.*, 2014), Euphorbiaceae have important taxa as medical and Economic genera like *Euphorbia*.

In spite of its abundant vegetative diversity, the *Euphorbia* species are characterized morphologically by having a cyathiate inflorescence and a highly reduced inflorescence that look like a single flower (Steinmann and Porter, 2002).

The *Euphorbia* has been classified into four sub-genera: *Athymalus* Neck., *Esula* Pers., *Chamaesyce* Raf. Which have about 200 species including *E. hirta*, *E. hypericifolia*, *E. serpens*, *E. prostrata* and *Euphorbia* subgenera according to habit, geographical diversity, leaves and stipules traits, inflorescence branching, seed character, morphology and number of cyathia glands (Fayed *et al.*, 2020 and Patel *et*

al., 2022).

Euphorbia is complex genus and distributed as cosmopolitan therefore it is an ideal genus to look for is useful to investigate the morphological differentiation among subgenera that their species is included it.

HCA method is used to measure similarity between two observations and then assist the observation into the cluster of observations to which it has more similarity, however, numerical taxonomy is a good to delimit species (Johnson, 1998, Fernández *et al.*, 2017 and Zhao *et al.*, 2023).

2. Materials and methods:-

2.1 Plant collection: - Fresh samples of six taxa of (*E. hirta*, *E. hypericifolia*, *E. milii* var. *milii*, *E. milii* cv. *White*, *E. prostrata* and *E. serpens*) were collected from different locations of Baghdad during the period from September 2022 to May 2023, in addition to analysis of herbarium specimens from different herbaria including (MUST) Mustansiriyah University Herbarium, BUH (Baghdad University Herbarium) and National herbarium of Baghdad (BAG) with a total of 100 specimens were examined. Digi-

tal photographs were taken by Nikon camera to document the plants in their habitats. The identification of plant samples were done by using morphological description and dichotomous key of the family Euphorbiaceae (Radcliffe-Smith, 1980). For further plant identification, an image comparison in online international herbaria were used.

2.2 Morphological description and morphometric analysis: - This analysis based on morphological characters on dissecting microscope was used to magnify the structures of both vegetative and reproductive parts from fresh and herbarium specimens representing six taxa of *Euphorbia*. Five accessions for each taxa were examined for their morphological data. Some characters were difficult to examine accurately or were missing so these data were eliminated. Quantitative morphological characters like root length and width, blade length, blade width, petiole length, petiole width, etc. were measured by using a rule and Image J software processing program. The mean values of the morphological data were calculated into Microsoft Excel spreadsheet. The morphological terminology

were based on (Radcliffe-Smith, 1980, Zokian, 2006, Bingtao *et al.*, 2008 and Sleibi, 2015).

2.3. Numerical (phonetic) analysis: - For this analysis, HCA was achieved to assess the degree of similarity inside data matrix by using Euclidean distances, the dendrogram was drawn using ward linkage method with the SPSS 20 software for grouping the most important diagnostic characters were selected from the morphological data and their states were defined for each trait (Tables 1).

Table.1 Characters and character states in numerical taxonomy

| No. | Characters | Character states |
|-----|--------------------------------|---|
| 1- | Root Length | Centimeters |
| 2- | Root width | Centimeters |
| 3- | Stout taproots | 0 (absent), 1 (present) |
| 4- | Swollen roots | 0 (absent), 1 (present) |
| 5- | Stem length | Centimeters |
| 6- | Stem diameter | Centimeters |
| 7- | Prostrate stems | 0 (absent), 1 (present) |
| 8- | Pilose trichomes of stems | 0 (absent), 1 (present) |
| 9- | Stem prickles | 0 (absent), 1 (present) |
| 10- | Phyllotaxy | 1 (opposite), 2 (whorled) |
| 11- | Blade length | Centimeters |
| 12- | Blade width | Centimeters |
| 13- | Blade apexes | 1 (acute), 2 (obtuse), 3 (obcordate), 4 (rounded) |
| 14- | Blade bases | 1 (oblique), 2 (truncate) |
| 15- | Blade bases | 1 (serrate), 2 (entire) |
| 16- | Petiole | 0 (sessile), 1 (petiolate) |
| 17- | Petiole Length | Millimeters |
| 18- | Petiole diameter | Millimeters |
| 19- | Stipules length | Millimeters |
| 20- | Stipules width | Millimeters |
| 21- | Spine stipules | 0 (absent), 1 (present) |
| 22- | Bract length | Centimeters |
| 23- | Bract width | Centimeters |
| 24- | Bract apex | 0 (absent), 1 (retuse), 2 (obtuse) |
| 25- | Inflorescences arrangement | 1 (branched compound raceme), 2 (Simple raceme), 3 (compound dichasium) |
| 26- | Cyathium involucre shape | 1 (cup shape), 2 (turbinate), 3 (campanulate) |
| 27- | Pedicelled cyathia | 0 (absent), 1 (present) |
| 28- | Cyathia notched with red color | 0 (absent), 1 (present) |
| 29- | Numbers of gland | Numbers |
| 30- | Stipitate appendages | 0 (absent), 1 (present) |
| 31- | 2 small, 2 large appendages | 0 (absent), 1 (present) |
| 32- | Style length | Millimeters |

3.1 Results and discussion: -**3.1.1 Morphological description and morphometric analysis: -****3.1.1.1 Roots: -**

The roots of *E. hirta* can reach 6 mm. in length and 1.2 mm. in diameter with white –yellowish white in color, cylindrical in shape and lateral roots distributed along the root. While the root of *E. hypericifolia* have a distinct taproot with swelling parts like nodes in the end of root with dimensions 5.5

× 1.5 mm. with prominent brown color, also, cylindrical in shape and numerous lateral roots arising from the tap root spreading along the root. On the hand, Both *E. serpens* and *E. prostrata* have a small taproots with brown color and many branches of lateral roots spreading on the roots. *E. milii* var. *milii* and *E. milii* cv. *White* have stout taproots, yellowish white in color with numerous lateral roots spreading from the base the primary roots (Fig.1, table.2).

Table (2): The morphological data of root of *Euphorbia* taxa

| Taxa | Root length(cm) | Root diameter(cm) | Root color |
|-----------------------------------|-----------------|-------------------|------------------------|
| <i>E. hirta</i> | 6 | 1.2 | White- yellowish white |
| <i>E. hypericifolia</i> | 5.5 | 1.5 | Brown |
| <i>E. milii</i> var. <i>milii</i> | 10 | 2.2 | Yellowish white |
| <i>E. milii</i> cv. <i>white</i> | 10 | 2.2 | Yellowish white |
| <i>E. prostrata</i> | 3.1 | 0.3 | Brown |
| <i>E. serpens</i> | 3 | 0.2 | Brown |



Fig. (1): Roots of *Euphorbia* taxa: A) *E. hirta* (B) *E. serpens* (C) *E. hypericifolia* (D) *E. milii* var. *milii*, (E) *E. milii* cv. *White* (F). *E. prostrata*, 40 x

3.1.2 Stems

The features of the stems varied in the studied taxa in terms of dimensions, habits, colors, the surface indumentum and the nature of branches with regard to the length of the stem, the average length ranged from (15-28 cm.) in the studied species. On the other hand, the average minimum diameter was 0.1cm. in *E. serpens* and *E. prostrata*, and the average maximum diameter was 0.7 cm in *E. milii* cv. *White*. All the

taxa were erect except for *E. prostrata* and *E. serpens* were prostrate. Whereas the colors of the stems differed from green, reddish green, pale green, and bluish green. However, the stems were glabrous in the species *E. prostrata*, *E. serpens* and *E. hypericifolia* and dense pubescent pilose trichome in *E. hirta* while the stems of *E. milii* var *milii* and *E. milii* cv. *White* were covered with sharp, smooth prickles (Table.3 and Fig.2).

Table (3): The morphological data of stem of *Euphorbia* taxa

| Taxa | Length (cm) | Diameter (cm) | Stem color | Stem habit | Indumentum |
|-----------------------------------|-------------|---------------|-----------------------|-----------------|------------|
| <i>E. hirta</i> | 17 | 0.3 | Bluish green | Erect | Pilose |
| <i>E. hypericifolia</i> | 18 | 0.2 | Pale green | Erect-Ascending | Glabrous |
| <i>E. milii</i> var. <i>milli</i> | 28 | 0.7 | Bluish green | Erect | Glabrous |
| <i>E. milii</i> cv. <i>White</i> | 28 | 0.7 | Pale green | Erect | Glabrous |
| <i>E. serpens</i> | 20 | 0.1 | Bluish green | Prostrate | Glabrous |
| <i>E. prostrata</i> | 15 | 0.1 | Dark to reddish green | Prostrate | Glabrous |



Fig. (2): Stems of *Euphorbia* taxa (A) *E. serpens* (B) *E. prostrata*, (C) *E. hirta* (D) *E. milii* var. *milii* (E) *E. hypericifolia* (F) *E. milii* cv. *White*, 40 x

3.1.3 Leaves: -

The leaves showed diversity in the characters as phyllotaxy, colors and other foliar features as blade shapes, apexes, bases, margins, dimensions and indumentum as well as petiole traits. The leaves are usually simple and arranged oppositely except for *E. milii* which is whorled, the color is light green in *E. hirta*, *E. milii* var. *milii* and *E. milii* cv. *White*, while olive green is noticed in *E. prostrata* and dark green in *E. hypericifolia*. On the other hand, bluish green is found in *E. serpens*. Regarding the shape of blade leaves differed among

the studied taxa: oblong-Elliptic (*E. hirta*, *E. milii* var. *milii* and *E. milii* cv. *White*), rounded (*E. serpens*), ovate (*E. prostrata*) and lanceolate (*E. hypericifolia*), however, the apexes are acute in *E. hirta* and *E. hypericifolia*, obtuse in *E. milii* var. *milii* and *E. milii* cv. *White*, obcordate in *E. serpens* and rounded in *E. prostrata*. Nevertheless, the bases are truncate in all studied taxa except for (*E. serpens*, *E. hypericifolia* and *E. hirta*) which are oblique. The margins are either entire (*E. milii* var. *milii*, *E. milii* cv. *White*) or serrate (*E. hypericifolia*, *E. hirta* and *E. serpens* (with red

margin and *E. prostrate*). The average lengths and widths are varied which the maximum average length was 3 cm in *E. milii* taxa and the minimum was 0.3 cm in *E. serpens*, on the other hand, the smallest average width was 0.2 cm in *E. serpens* and the largest width value was 1.4 in *E. milii* cv. *White*. The pilose trichomes are distributed in the

surface of *E. hirta* while puberulent hairs are found in *E. hypericifolia* and *E. serpens* and *E. prostrata*, the remaining taxa are glabrous. The leaves of *E. milii* taxa fall during hot seasons. Petioles are absent in *E. milii* taxa and very short in the remaining species (Table.4 and Fig. 3).

Table (4): The morphological data of blade leaves of *Euphorbia* Spp.

| Taxa | Blade Shape | Blade Color | Blade apex | Blade base | Blade margin | Length (cm) | Width (cm) |
|-----------------------------------|------------------|--------------|------------|------------|-------------------------------------|-------------|------------|
| <i>E. hirta</i> | Oblong-Elliptic | Light green | Acute | Oblique | Serrate | 2.4 | 1.2 |
| <i>E. hypericifolia</i> | Lanceolate | Dark green | Acute | Oblique | Serrate | 1.7 | 0.7 |
| <i>E. milii</i> var. <i>milli</i> | Oblong-Elliptic | Light green | Obtuse | Truncate | Entire | 3 | 1.3 |
| <i>E. milii</i> cv. <i>White</i> | Oblong-spatulate | Light green | Obtuse | Truncate | Entire | 3 | 1.4 |
| <i>E. serpens</i> | Rounded | Bluish green | Obcordate | Oblique | Entire | 0.3 | 0.2 |
| <i>E. prostrata</i> | Ovate | Olive green | Rounded | Truncate | Serrate in the end half of the leaf | 0.4 | 0.2 |

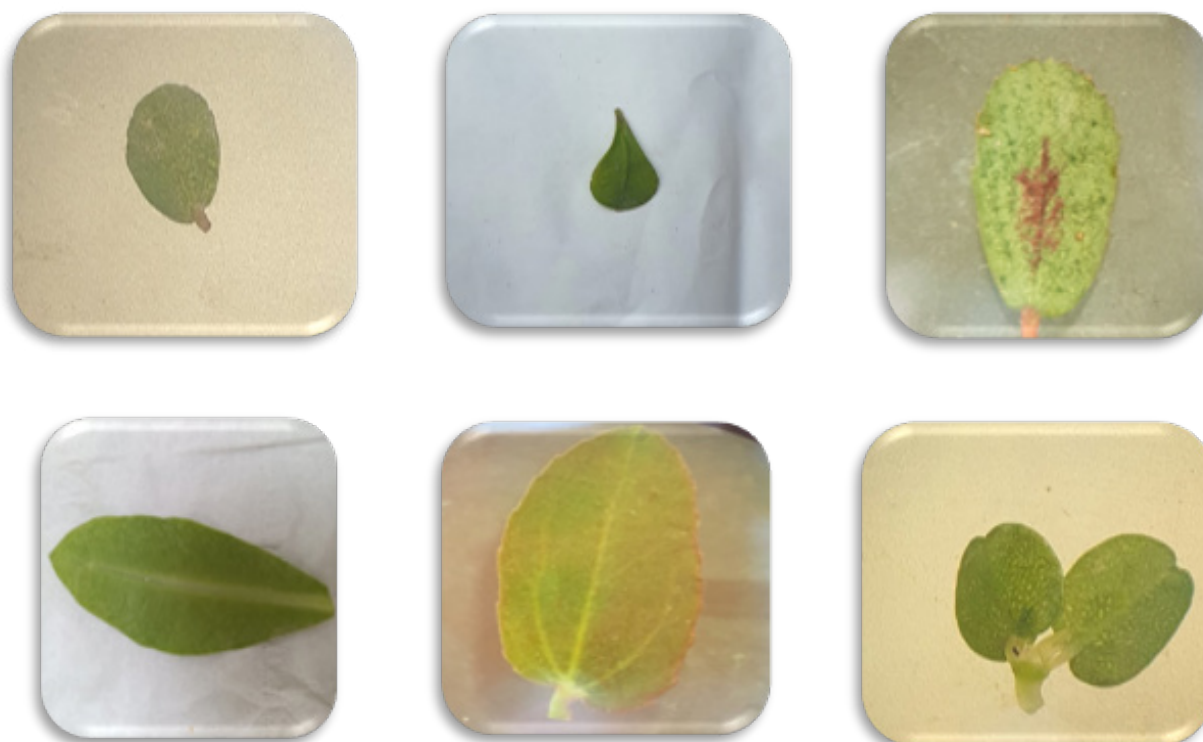


Fig. (3): Leaves of *Euphorbia* taxa (A) *E. hirta* (B) *E. prostrata* (C) *E. serpens* (D) *E. milii* cv. *White*, (E) *E. milii* var. *milii*, (F) *E. hypericifolia*, 40 x

Table (5): The morphological data of petioles of *Euphorbia* Spp.

| Taxa | Length (mm) | Diameter (mm) | Color | Indumentum |
|----------------------------------|-------------|---------------|-----------------|------------|
| <i>E. hirta</i> | 0.5 | 1 | Yellowish green | Pilose |
| <i>E. hypericifolia</i> | 0.8 | 0.4 | Bluish green | Glabrous |
| <i>E. milii</i> var <i>milli</i> | / | / | / | / |
| <i>E. milii</i> cv. <i>White</i> | / | / | / | / |
| <i>E. serpens</i> | 0.6 | 0.3 | Green | Glabrous |
| <i>E. prostrate</i> | 0.7 | 0.3 | Yellowish green | Glabrous |

3.1.3.1 Stipules: -

Stipules usually occur on the lateral sides of petiole, *E. hirta* stipules are small about 1.3 mm. in length and linear in shape and white while *E. hypericifolia*, stipules are deltoid in shape, red, and wide at the base with acuminate apex, ciliated margins and trichomes distributed on the surface. The stipules of *E. prostrata* resemble of *E. hypericifolia* in shape but vary in color which is

dark green, dimensions and glabrous, entire margin and mucronate apex. On the other hand, stipules of *E. serpens* are broadly triangular, white membranous, 1 × 1.5 mm. with fringed margins and glabrous. The stipules of *E. milii* taxa are modified to long brown spine with smooth surface with different dimension and mucronate apex (Table.6 and Fig.4).

Table (6): The morphological data of stipules of *Euphorbia* taxa

| Taxa | Length (mm) | Diameter (mm) | Color | Indumentum |
|-----------------------------------|-------------|---------------|-------------------------------|------------|
| <i>E. hirta</i> | 1.3 | 0.1 | White | Glabrous |
| <i>E. hypericifolia</i> | 4 | 4.5 | Green blotched with red color | Pilose |
| <i>E. milii</i> var. <i>milli</i> | 150 | 0.2 | Yellow-Light brown | Glabrous |
| <i>E. milii</i> cv. <i>White</i> | 200 | 0.3 | Dark brown | |
| <i>E. serpens</i> | 1 | 1.5 | Light green | Glabrous |
| <i>E. prostrata</i> | 2.5 | 2 | Light green | Glabrous |



Fig.(4) Stipules of *Euphorbia* taxa (A) *E.hirta* (B) *E.hypericifolia*, (C) *E.prostrata* (D) *E.serpens* , (E) *E.milii* var. *milli*, 40 x.

3.1.4 Bracts:-

Bracts are observed in *E. milii* taxa which are broad ovate in shape, red, glabrous, entire margin, retuse apex

and truncate base in *E. milii* var. *milii* while *E. milii* cv. *White* have ovate, white, glabrous, entire margin, obtuse apex and truncate base (Table.7)

Table (7): The morphological data of bracts of Euphorbia taxa

| Taxa | Bract shape | Bract length(cm) | Bract width(cm) | Bract apex | Bract base |
|-----------------------------------|-------------|------------------|-----------------|------------|------------|
| <i>E. hirta</i> | / | / | / | / | / |
| <i>E. hypericifolia</i> | / | / | / | / | / |
| <i>E. milii</i> var. <i>milii</i> | Broad ovate | 3.5 | 5 | Retuse | Truncate |
| <i>E. milii</i> cv. <i>White</i> | Ovate | 2 | 3.5 | Obtuse | Truncate |
| <i>E. serpens</i> | / | / | / | / | / |
| <i>E. prostrata</i> | | / | / | / | / |

3.1.5 Inflorescences: -

They are arranged in compound raceme which were clustered and branched as in the species *E. hirta* and *E. hypericifolia* or organized in a simple raceme so that they are axillary and single solitary as in these species. *E. prostrata* and *E. serpens* as well as compound dichasium inflorescences is observed in *E. milii* taxa. The inflorescences are usually terminated with cyathium.

3.1.5.1 Cyathia: - They are aggregation of flowers inflorescences resemble

a single flower which the outer structure of the cyathium is called the involucre, they are usually accompanied by petaloid appendages and glands (Table.8 and Fig. 5). Taxonomically cyathia diversity and complexity are significant features for the delimitation the species of Euphorbia species. In *E. hirta*, the cyathium is pedicelled about 1 mm., cup-shaped involucre, green usually notched with reddish color at the top, frequently a pilose trichomes are distributed on its surface, composing of about six clusters in the axial. In

addition, four glandular structures with a white discoid petal-like appendage is presenting in the edges of the involucre. However, the cyathia of *E. hypericifolia* cyathia are almost sub-sessile about 1 mm long, glabrous with a cup-shaped involucre with four glands 4, tiny, almost round, stipitate, with white to pink appendage variable (Two small round to two big somewhat elliptical) about 2 clusters in the axial, while *E. serpens* is characterized by turbinate like structure involucre, axillary inflorescence cyathium, sessile, gradually expanded into base of involucre with two small clusters in the axial; cyathium involucre, 1×0.7 mm, green, glabrous, internally hairy below glands, the bracts of involucre fused most of length, with three toothed at free apex with white margins, four dark pinkish, fleshy, glands are alternate with bracts. On the other hand, the cyathium of *E. prostrata* is axillary, peduncle less than 0.5 mm long; 2 clusters in the axial, turbinate cyathium involucre less than 1 mm long, green, pubescent, with four glands, the five bracts of involucre have acute apex, green tips with whitish fimbriated margin the glands alternate with bracts which are red reniform-rounded,

the petal-like appendage are whitish to pale pinkish, entire or weakly scalloped on outer margin. The cyathia of *E. milii* var. *milii* are glabrous, united in terminal cymes on a 5 cm peduncle about 0.5×1.1 cm, a campanulate involucre 3.5×4 mm, fused with 5 red orbicular to reniform nectariferous glands, no appendages have been observed. Nevertheless, the cyathia of *E. milli* cv. *White* are resemble of red *milii* but differs in dimensions as the campanulate involucre are 4×5 mm, 5 cm. peduncle with five orbicular-reniform yellow glands alternating with five glabrous white bracts with ciliated apex, 1×2 mm.



Fig.(5):Inflorescence of *Euphorbia* taxa (A) *E. serpens* (B) *E. hypericifolia* (C) *E. prostrata* (D) *E.milii* var. *milii* (E) *E. hypericifolia* (F) *E. milii* cv. *White*, 40x.

Table (8): The morphological data of cyathia of *Euphorbia* taxa

| Taxa | Cyathium pedicel length mm. | Cyathium Indumentum | Gland shape | Gland color |
|----------------------------------|-----------------------------|---------------------|--------------------|-------------|
| <i>E.hirta</i> | 1 | Pilose | Elliptic | Green |
| <i>E. hypericifolia</i> | 1 | Pubescent | Elliptic | Green |
| <i>E.milii</i> var. <i>milii</i> | 3.5 | Glabrous | Reniform-orbicular | Red |
| <i>E.milii</i> cv. <i>White</i> | 4 | Glabrous | Reniform-orbicular | Yellow |
| <i>E.prostrata</i> | 0.4 | Pilose | Reniform-round-ed | Red |
| <i>E.serpens</i> | 0.7 | Glabrous | Reniform | Red |

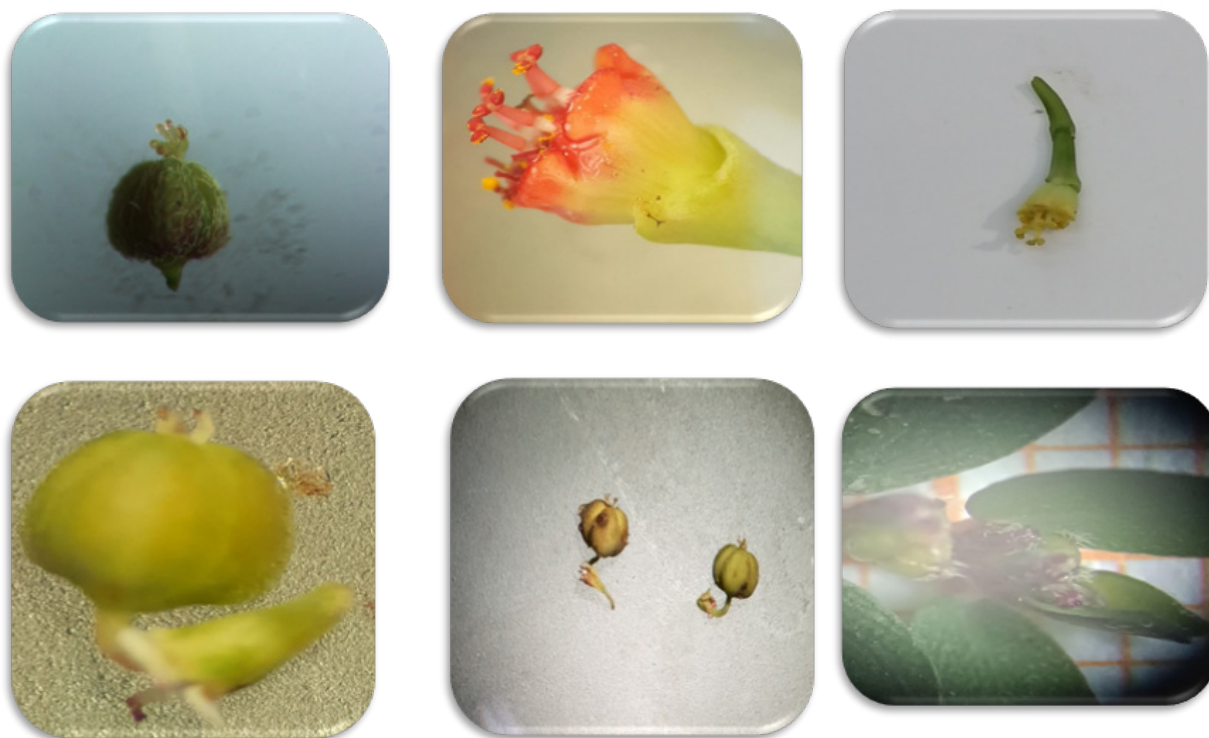


Fig.(6): Cyathia of *Euphorbia* taxa (A) *E.hirta* (B) *E.milii* var.*milii* (C) *E.prostrata* (D) *E.milii* cv. *White* (E) *E.hypericifolia* (F) *E.serrpens*, 40x

3.1.6 Flowers:-

Euphorbia hirta have staminate flowers inside and surrounded the cluster of inflorescences. These flowers are sessile with glabrous pedicles, each one has stamen consisted from anther and filament, the filament is light green, glabrous, hollow and cylindrical shape, 0.2 mm. in length. Also, the anthers are subglabrous, yellow with extrose dehiscence. A pistillate flower is exerted in the involucre, the ovary is superior has three green angular lobes punched with

red color pilose trichomes. The styles are three free from the base, extremely bifid and the stigma is capitated.

Each involucre of *E. hypericifolia* containing one female flower surrounded by male flowers. Flowers are unisexual; male flowers are sessile, stamen consisted from anther and filament, the filament is greenish yellow, glabrous, hollow and cylindrical shape, 0.4 mm. in length. Anthers are reniforms, dark pink-white and extrose dehiscence. Pistillate flowers have

short pedicel, ovary superior, glabrous, 3-locules, and three bifid near the end of the styles.

The involucre of *Euphorbia serpens* have one female flower surrounded by male flowers. Flowers are unisexual; male flowers have stamens consisted from anther and filament, the filament is white, glabrous, hollow and cylindrical shape, 0.3 mm. in length. Anthers are reniforms, light yellow- light pink and extrose dehiscence. Pistillate flowers have short pedicel, ovary superior, glabrous, 3-celled, and branched styles from the base with 5 stigmas.

The involucre of *E. prostrata* consist of female flower surrounded by staminate, flowers are unisexual, never be in clusters, male flowers have stamens consisted from anther and filament,

the filament is white, glabrous, hollow and cylindrical shape, 0.2 mm. in length. Anthers are connated from the base, spheroids, white and extrose dehiscence. Pistillate flowers have short pedicel, ovary superior, dark green, pilose trichome, ovoid, 3-celled, and short branched styles from the base with 5 stigmas.

E. milii var. *milii* 1 x 2 mm, with, at the center, a female flower without calyx and corolla, surrounded by male flowers also without calyx and corolla. Male flowers many; bracteoles linear, apex pilose. Female flower: ovary smooth and glabrous, usually included with involucre; styles connate below middle; stigma 2-lobed. Table.9 summarize the morphological features of ovary of six taxa of *Euphorbia*.

Table (9): The quantitative data of Gynoecium of *Euphorbia* taxa

| Taxa | Ovary shape | Ovary dimensions (mm) | Style length (mm) |
|-----------------------------------|-------------|-----------------------|-------------------|
| <i>E.hirta</i> | Ovate | 0.9×1.1 | 0.3 |
| <i>E.hypericifolia</i> | Ellipsoid | 0.8×1.2 | 0.4 |
| <i>E. milii</i> var. <i>milii</i> | Globose | 1×1.3 | 1.5 |
| <i>E.milii</i> cv. <i>white</i> | Globose | 1×1.2 | 1.4 |
| <i>E.serpens</i> | Globose | 0.5×0.4 | 0.2 |
| <i>E.prostrata</i> | Ovate | 0.3×0.4 | 0.1 |

3.1.7 Fruits:-

The fruits of studied species are schizocarp fruits. The fruits of *E. hirta* are light green to yellowish green, ovoid to spheroid in shape, pilose trichome, 1.2 length and 1.5 in width, three lobed capsules. However; the fruits of *E. hypericifolia* are 3-lobed capsule, 1.3×1.5 mm, light green, glabrous, spheroid

and three mericarps with three seeds. The fruits of *E. prostrata* are light green, ovoid, glabrous, 3 lobed, 0.7mm in length and 1.2 in width. The *E. milii* taxa failed to produce fruits may be due to failing in fertilization. In addition, there is no fruits have been detected in *E. serpens*.

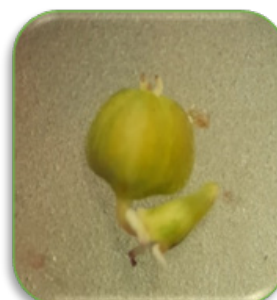


Fig. (7): Fruits of *Euphorbia* taxa (A) *E. hirta* (B) *E. hypericifolia* (C) *E. prostrata*, 40 x

3.1.8 Seeds

The significant value of the seeds of Euphorbiaceae had long been noticed such as absence or presence of caruncle, shape, size and testa ornamentation as illustrated in (Fig.8). The seeds of *E. hirta* are ovoid, 0.6×0.4 mm, caruncle absent, deeply grooved configuration and light brown in color. The seeds of *E. hypericifolia* are ovoid, 0.9×0.6 mm, regular grooved, light brown without caruncle. While the seeds of *E. prostrata* are ovoid, light brown, 0.7×0.9

mm, regular grooved without caruncle. However, according to Zokian, 2006, Bingtao *et al.*, 2008 and Sleibi, 2015, some qualitative morphological characters in this study as shape of blade leaves, petiole, stems, cyathia, ovaries etc. agreed with several studies as mentioned above and several quantitative morphological features were different because the variety of habitats and different environmental conditions that live in as dimensions of leaves, stems and etc.



Fig. (8): Seeds of *Euphorbia* taxa (A) *E. hirta* (B) *E. hypericifolia* (C) *E. prostrata*, 40x

3.2 Numerical taxonomy:-

Thirty-two morphological traits including (quantitative and qualitative) were utilized for numerical analysis of six taxa belonging to *Euphorbia*. The characters and character states are listed in (Table.10). The Hierarchical agglomerative analysis dendrogram was generated in SPSS version 20. Because of different variables traits were measured in different scales so, the data were converted to standardized scores to make variables comparable into a computer as a principal of SPSS running to construct a HCA dendrogram. To study the relationship of six taxa of *Euphorbia*, two trees were obtained from HCA, which were gained by SPSS 20 version, utilizing Ward's method and complete linkage (furthest neighbor method), respectively. It was apparent that the results of the two trees

exhibit remarkable consistency with each other (Fig. 9 and 10). In additions, the trees illustrate significant agreements with morphological findings and as the first cluster comprises *E. milii* var. *milii* and *E. milii* cv. *White* which are close together and separated from other species while the second cluster has *E. hirta* and *E. hypericifolia* which show close relationship with each other. However, the species *E. serpens* are located at the base of the cluster and supported as sister taxon to *E. serpens*. In addition, this analysis supported the separation of *E. milii* taxa in the subgenus (*Euphorbia*) from the other subgenus *Chamaesyce* Raf. which included *E. hirta*, *E. hypericifolia*, *E. serpens* and *E. prostrata*. Lately, molecular studies have confirmed four infrageneric clades were recognized in *Euphorbia* (Steinmann and Porter 2002).

After that, these clades were named subgenus: *Athymalus* Neck. ex Rchb. Peirson, *Chamaesyce* Raf., *Euphorbia* and *Esula* Pers. (Bruyns *et al.*, 2006). Furthermore investigations by (Bruyns *et al.*, 2011 and Park and Jansen 2007) confirmed the previous classification of subgenera. The phenetic taxonomy has proven to be helpful in delimitation of the studied taxa. Each cluster was

classified to form a clade that are related based on morphological traits. This highly conformity between the classification results of the complete lineage methods and Ward's methods suggests that both approaches are yielding similar outcomes. This similarity implies that the classification obtained is more reliable and appropriate.

Table.10 Matrix of morphological trait states of six taxa of *Euphorbia*

| Taxa Morphological data | <i>E. hirta</i> | <i>E.hyper- icifolia</i> | <i>E. milii var. milii</i> | <i>E. milii</i> cv. <i>White</i> | <i>E. serpens</i> | <i>E. pros- trata</i> |
|--------------------------------|---------------------|------------------------------|--------------------------------|-------------------------------------|-----------------------|---------------------------|
| 1-Root Length cm | 6 | 5.5 | 10 | 10 | 3.1 | 3 |
| 2- Root width cm | 1.2 | 1.5 | 2.2 | 2.2 | 0.3 | 0.2 |
| 3-Stout taproots | 0 | 0 | 1 | 1 | 0 | 0 |
| 4-Swalloen roots | 0 | 1 | 0 | 0 | 0 | 0 |
| 5-Stem length cm | 17 | 18 | 28 | 28 | 20 | 15 |
| 6-Stem diameter cm | 0.3 | 0.2 | 0.7 | 0.7 | 0.1 | 0.1 |
| 7-Prostrate stems | 0 | 0 | 0 | 0 | 1 | 1 |
| 8-Pilose trichomes of stems | 1 | 0 | 0 | 0 | 0 | 0 |
| 9-Stem prickles | 0 | 0 | 1 | 1 | 0 | 0 |
| 10-Phyllotaxy | 1 | 1 | 2 | 2 | 1 | 1 |
| 11-Blade length cm. | 2.4 | 1.7 | 3 | 3 | 0.3 | 0.4 |
| 12-Blade width cm. | 1.2 | 0.7 | 1.3 | 1.4 | 0.2 | 0.2 |
| 13-Blade apexes | 1 | 1 | 2 | 2 | 3 | 4 |
| 14-Blade bases | 1 | 1 | 2 | 2 | 2 | 1 |
| 15-Blade margins | 1 | 1 | 2 | 2 | 2 | 1 |
| 16-Petiole | 1 | 1 | 0 | 0 | 1 | 1 |
| 17-Petiole Length (mm) | 0.5 | 0.8 | 0 | 0 | 0.6 | 0.7 |
| 18-Petiole diameter (mm) | 1 | 0.4 | 0 | 0 | 0.3 | 0.3 |
| 19-Stipules length mm | 1.3 | 4 | 150 | 200 | 1 | 2.5 |
| 20-Stipules width mm. | 0.1 | 4.5 | 0.2 | 0.3 | 1.5 | 2 |

| Taxa Morphological data | <i>E. hirta</i> | <i>E. hypericifolia</i> | <i>E. milii</i> var. <i>milii</i> | <i>E. milii</i> cv. <i>White</i> | <i>E. serpens</i> | <i>E. prostrata</i> |
|------------------------------------|-----------------|-------------------------|--------------------------------------|-------------------------------------|-------------------|---------------------|
| 21-Spine stipules | 0 | 0 | 1 | 1 | 0 | 0 |
| 22-Bract length cm. | 0 | 0 | 3.5 | 2 | 0 | 0 |
| 23-Bract width cm. | 0 | 0 | 5 | 3.5 | 0 | 0 |
| 24-Bract apex | 0 | 0 | 1 | 2 | 0 | 0 |
| 25-Inflorescences arrangement | 1 | 1 | 2 | 2 | 3 | 3 |
| 26-Cyathium involucre shape | 1 | 1 | 2 | 2 | 3 | 3 |
| 27-Pedicelled cyathia | 1 | 1 | 0 | 0 | 1 | 1 |
| 28- Cyathia notched with red color | 1 | 0 | 0 | 0 | 0 | 0 |
| 29-Numbers of gland | 4 | 4 | 5 | 5 | 4 | 4 |
| 30-Stipitate appendages | 0 | 1 | 0 | 0 | 0 | 0 |
| 31-2 small, 2 large appendages | 0 | 1 | 0 | 0 | 0 | 0 |
| 32-Style length (mm) | 0.3 | 0.4 | 2.2 | 1.5 | 0.2 | 0.1 |

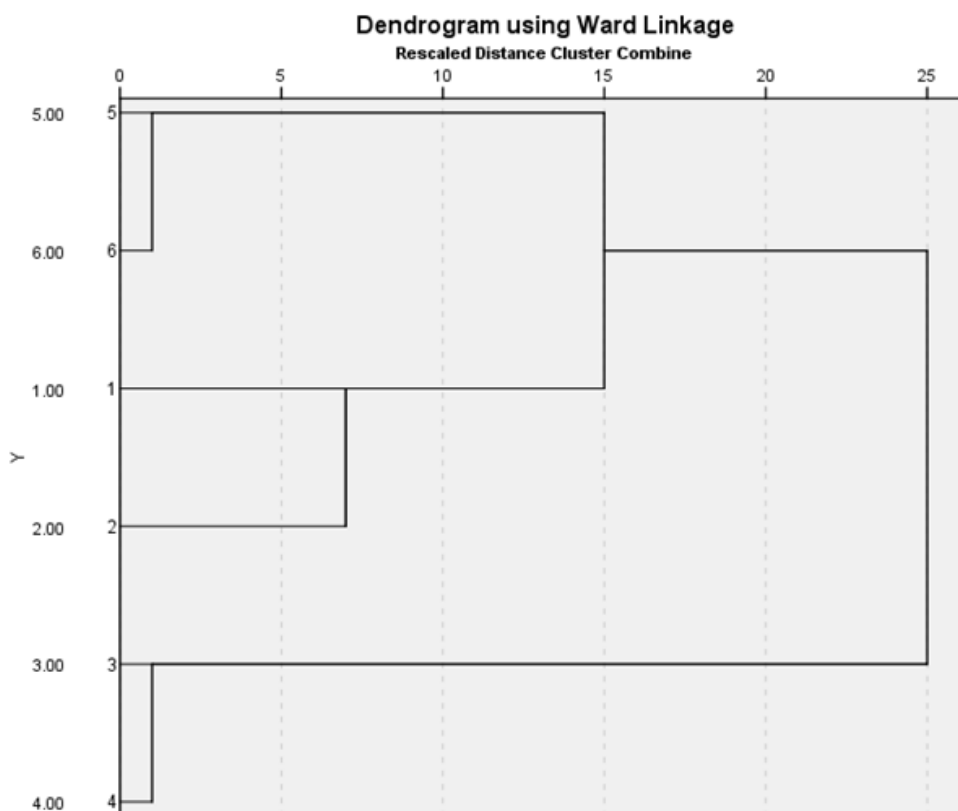


Fig. (9): Dendrogram of six taxa of *Euphorbia* by using ward method

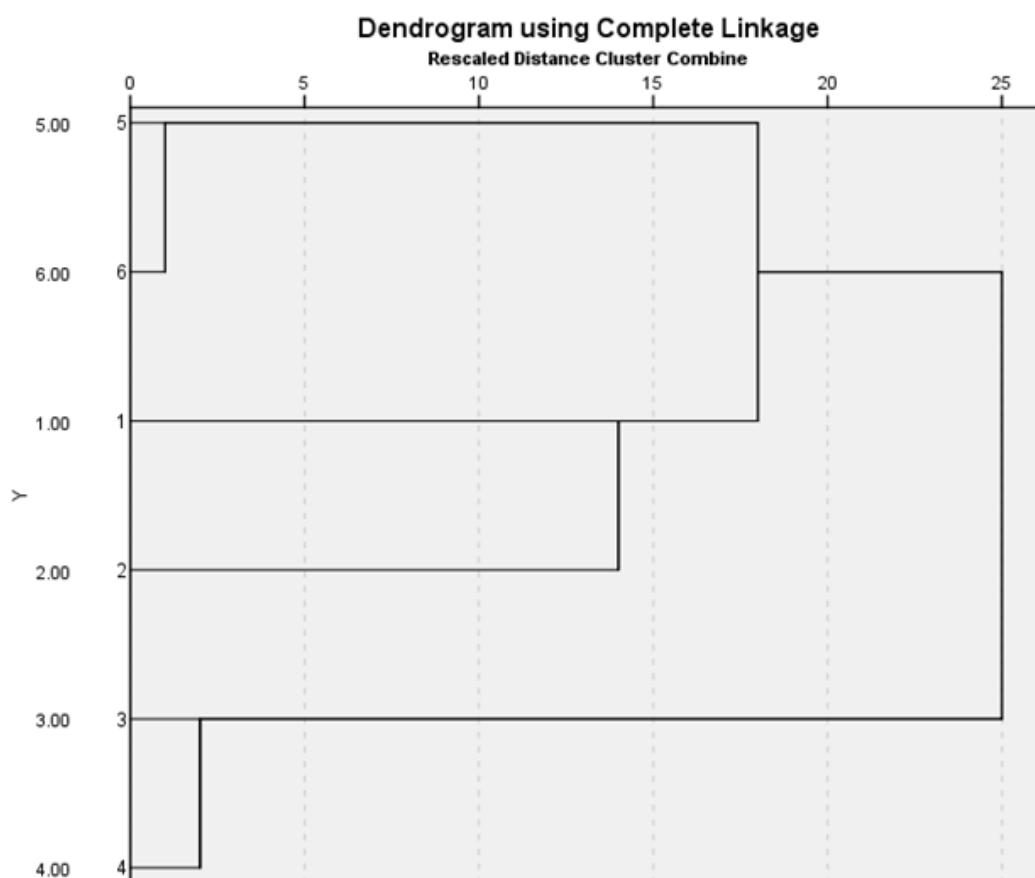


Fig. (10): Dendrogram of six taxa of *Euphorbia* by using complete linkage method

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