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Morphological and Palynological Study of Eucalyptus Erythrocorys Grown Western Iraq

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ABSTRACT: This trial first time to describe the morphology and palynology of Eucalyptus erythrocorys (Red-cap Gum) in Iraq, a tree endemic to Western Australia. In this research study, we will examine the vegetative and reproductive organs, pollen morphology and fruit and seed, while giving descriptions that were made based on field and herbarium studies, and palynological analysis will be based on measurements made using a light microscope. Results illustrated that Eucalyptus erythrocorys is a small tree or large shrub, typically 3–8 (–14) m tall. Leaves are aromatic, lanceolate to sickle-shaped. The inflorescences are axillary and single, with peduncles measuring 1.2–3 cm. Buds are arranged in three parts, with 0.2–1 cm pedicel. The fruit is broadly campanulate, pedicellate (0–1 cm), 2.8–4 cm long, 3–5.5 cm wide, and four-lobed. The disc is ascending with 3–4 enclosed valves. Seeds are dull brown to black, obliquely pyramidal, 2–4 mm long. The pollen grains of Eucalyptus erythrocorys were characterized as oblate in shape, with a polar/equatorial (P/E) axis ratio of 0.72 (ranging from 0.70 to 0.74), referring to a broader equatorial diameter compared to the polar length. This study stands originally with SDG 15 (Life on Land) and SDG13 (Climate action) by enhancing biodiversities conservations and sustainable exploitation of Eucalyptus genotypes via morphological and palynological description.

INTRODUCTION

Myrtaceae is a medium-sized family of eudicots in the order Myrtales consisting of some 142 genera and over 5500 species (Hardstaff et al., 2022). It is most common in the southern hemisphere, especially in Australia and South America. Myrtaceae have been classically divided into two sub-families, those having dry capsular fruits with alternate leaves and those having

fleshy fruits with opposite leaves (Thornhill et al., 2015). The genus Eucalyptus L'Hér. is a dominant member of the family; there are over 800 species of which most are endemic to Australia (Rodrigues et al., 2025; Fahey et al., 2022; Staggemeier et al., 2024).

Economically, *Eucalyptus* species are important sources of timber, and of oils used as an industrial raw material, in perfumery, flavouring, paper making and in curing/ storing honey (Kirouani et al., 2025; Čmiková et al., 2023; Sniderman et al., 2018). The essential oils are high in monoterpenes and ubiquitous in the medicinal, cosmetic and food trade (Brooker and Kleinig, 2006; Barbosa et al., 2016; Collins et al., 2019). The morphology of the *Eucalyptus* is often notoriously similar from species to species (Polito et al., 2023; Al-tememmi et al., 2024; Nicolle et al., 2025) causing real problems to the taxonomist. The morphology of the leaf varies with genotype (Migacz et al., 2018), ontogenetic development and also to some degree with environmental factors (Bai et al., 2024). In *Eucalyptus*, pollen grains are found to have thickened exines and well-defined apertures (Al-Amery et al., 2024), which can sometimes be useful as a taxonomic tool. Recent revisions of the genus have been made in *Eucalyptus* subgenus *Eudesmia* (Nicolle et al., 2025; Bayly et al., 2024).

Eucalyptus erythrocorys, commonly recognized for its distinctive cap-like operculum and ornamental value, has been increasingly introduced to the semi-arid environments of Western Iraq to assess its adaptability to regional climatic stressors. Comprehensive morphological and palynological evaluations serve as essential taxonomic tools, providing critical data for species delimitation and understanding evolutionary relationships within fluctuating environmental conditions (Rudainy & Mayah, 2024; Siraj et al., 2023). By integrating both vegetative structural metrics and exine ornamentation analysis, this study aims to establish a definitive taxonomic framework for identifying E. erythrocorys variants in local botanical surveys (Xiao et al., 2023). Furthermore, investigating these characteristics is vital for elucidating how regional environmental pressures influence micro-morphological variability in introduced species, similar to recent taxonomical assessments conducted on diverse flora across Iraqi governorates (Alzawi et al., 2022; Shlash, 2026). The primary objective of this research is to document the distinct phenotypic and pollen-based attributes of E. erythrocorys, thereby enhancing our understanding of its systematic classification and phylogenetic interactions in foreign climates (KANWAL et al., 2024). Such analysis is critical, as pollen morphological features like aperture configuration and exine structure remain highly conservative, offering reliable evidence for taxonomic identification. These conservative traits are essential for differentiating taxa that may otherwise exhibit phenotypic plasticity in response to arid climate stressors (Kumar et al., 2022). By establishing a precise micro-structural profile, this research provides the necessary baseline to differentiate E. erythrocorys from other locally cultivated Myrtaceae, ultimately facilitating more accurate botanical identification and germplasm management (Aziza et al., 2024; Laallam et al., 2024).

The present study aims to describe the morphological and palynological features of *E. erythrocorys* noted for its unusual floral arrangement which makes to of significant horticultural value and also to add to the meagre information available on the taxonomy of this species. Furthermore, this trial contributes to Sustainable Development Goal 15 and climate action Goal 13 via boosting the taxonomic knowledges, biodiversities conservations, and sustainable management of tree genetic resources.

MATERIAL AND METHODS

Morphological Characterization

Morphological characteristics of Eucalyptus erythrocorys were then examined based on field observations of cultivated plants grown in western Iraq, with comparative references (Cerritos-Castro et al., 2026). Important floral characters (floral bud shape, operculum features and stamen arrangement) were described using a stereomicroscope (Leica EZ4, Germany).

Palynological Analysis

Pollen grains were treated by the normal classic acetolysis method as descriptively modified by Alrawi et al., (2023) in order to remove cytoplasmic material and see the exine features more clearly. They were mounted in glycerin jelly on glass slides before examining with a light microscope (Olympus CX23, Japan) at ×400 magnification. For each sample at least 30 grains were measured to give:

Polar axis (P, µm), Equatorial axis (E, µm), Colpus length (µm), and Shape Index (P/E), calculated using the formula (Negi et al., 2026):

Shape Index (P/E) = Length of Polar Axis (P)/Length of Equatorial Axis (E)

Environmental Data

The environmental data are from the University of Anbar site in Ramadi, western Iraq. Soil samples were analyzed for pH, electrical conductivity (EC) and texture. Climatic data such as mean annual temperature, rainfall and relative humidity (summarised in Table 1 and illustrated in Fig 1, which also has topography and Köppen climate zones using QGIS mapping tools (QGIS Development Team, 2024; IMOS Iraqi Meteorological Organization and Seismology, 2024) were also collected from here.

Table 1. Environmental parameters of the Eucalyptus erythrocorys habitat in western Iraq.

Parameter	Value	Method / Source
Soil pH	7.6 ± 0.1	Laboratory pH meter
Soil Electrical Conductivity (EC)	2.3 ± 0.2 dS/m	EC meter
Soil Texture	Sandy loam	Hydrometer method
Mean Annual Temperature	23.5 ± 1.2 °C	IMOS, 2024
Mean Annual Rainfall	135 ± 10 mm	IMOS, 2024
Relative Humidity	38% ± 5%	IMOS, 2024

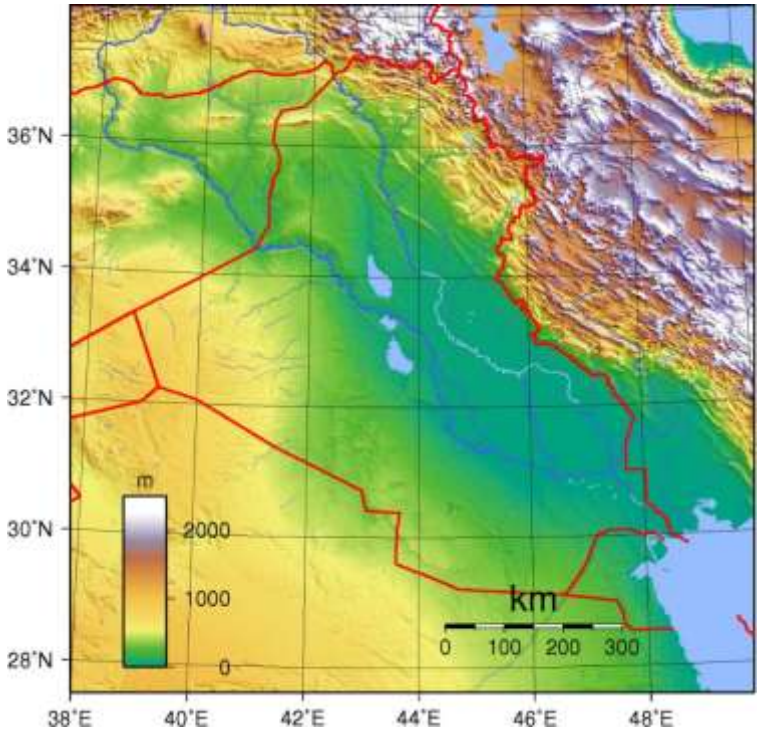


Fig. 1. Map of the study area illustrating the location of Eucalyptus erythrocorys in western Iraq, involving Köppen climate zones and topographic elevation. Base map generated using QGIS 3.34.

Statistical Analysis

Statistically, quantitative data were analyzed using SPSS software (Version 26.0). Descriptive statistics, comprising mean and standard deviation (mean ± SD), were calculated for each morphological, anatomical, and palynological parameter. Moreover, the variability in traits was assessed and data were summarized using tables and figures.

RESULTS AND DISCUSSION

Morphology of tree

Eucalyptus erythrocorys is a small tree or large shrub (Fig. 2A), typically 3–8 (–14) m tall, with smooth, creamy-white bark occasionally marked with brown (Fig. 2B). Leaves are aromatic, lanceolate to sickle-shaped, 15–25 cm long, with red petioles (Fig 2D). It thrives on limestone ridges and outcrops with sandy or alkaline soils, showing drought and heat tolerance. Branches are red (Fig. 2C).



Fig. 2. *Eucalyptus erythrocorys* tree morphology. A: Whole tree, B: tree stem, C: branch, D: leaves

The blade length was 11.1-17. (12.73) cm, and the width 1-1.5 (1.33) cm. while petiole length is 13-26 (20.6) mm with width of 1-4 (2.01) mm (Table 2).

Table 2. shows blade and petiole traits of *Eucalyptus erythrocorys*

parameter	**Blade**		**Petiole**	
	Length (cm)	Width (cm)	Length (mm)	Width (mm)
Range (mean)	11.1-17. (12.73)	1-1.5 (1.33)	13-26 (20.6)	1-4 (2.01)
SE	3.14	0.14	3.2	0.61
SD	3.93	0.17	4.27	0.94

Morphology of floral parts

The inflorescences are axillary and single, with peduncles measuring 1.2–3 cm. Buds are arranged in three parts, with 0.2–1 cm pedicel. Mature buds are obovoid, 2–2.5 cm long and 2–2.6 cm wide. The operculum is bright red, lobed, and persistent post-anthesis, which is atypical for the genus (Fig. 3).



Fig. 3. *Eucalyptus erythrocorys* tree in flowering phase. A: operculum, B: flowers opening

Stamens are bright yellow with no of 1240 (Table 3), grouped in four clusters, with versatile, dorsifixed anthers dehiscing via longitudinal slits (Fig. 3A, B, Fig. 4A, B). The ovary typically has 3–4 locules with 4–6 vertical rows of ovules. Pistil is greenish to yellowish green with length range of 11-12 mm (Table 3).

Table 3. some stamens and pistil traits of *Eucalyptus erythrocorys*

Stamen			**Pistil**	
Filament length (mm)	no	Color	Style length (mm)	color
16-19	1240	Lemon yellow	11-12	Green-yellowish green

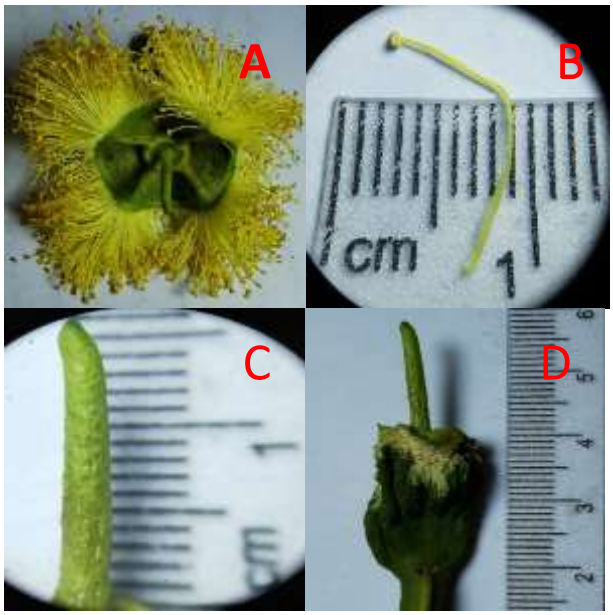


Fig. 4. Floral parts of Eucalyptus erythrocorys. A: stamens B: Filament, C, D: pistil (Stigma)

Fruit and Seed Morphology

The fruit is broadly campanulate, pedicellate is of 2-3.4 (2.85±0.35) cm, 3.1–3.7 cm (3.44±0.2) long, 3.6–4.5 cm diameter (Table 4), and four-lobed. The disc is ascending with 3–4 enclosed valves (Fig 5A). Seeds are dull brown to black, obliquely pyramidal, 4-7 mm (5.6±0.8) long (Table 4), with ribbed sides and a smooth surface; hilum terminal (Fig 5B).

Table 4. fruit and seed properties of *Eucalyptus erythrocorys*

Parameters	Fruit		Seed			
	Diameter (cm)	Height (cm)	Pedicle length (cm)	Length (mm)	Width (mm)	color
Average	4.1±0.16	3.44±0.2	2.85±0.35	5.6±0.8	1.5±0.5	brown
Range	3.6-4.5	3.1-3.7	2-3.4	4-7	1-2	



Fig. 5. *Eucalyptus erythrocorys* reproductive organs. A: Fruit, B: seeds

Palynological study

The pollen grains of *Eucalyptus erythrocorys* were characterized as oblate in shape (fig 6), with a polar/equatorial (P/E) axis ratio of 0.72 (ranging from 0.70 to 0.74), referring to a broader equatorial diameter compared to the polar length. The average polar axis measured 21.33 µm (20.23–22.45 µm), whereas the equatorial axis was notably larger, averaging 29.78 µm (28.78–31.25 µm) (table 5). The overall pollen length and width were 26.29 µm (23.96–28.64 µm) and 25.49 µm (22.16–28.77 µm), respectively. Colpus length averaged 6.11 µm (4.57–7.64 µm), accounting for approximately 23.37% (17.12–29.88%) of the total pollen length. These features reflect a typical eucalypt pollen morphology, contributing valuable data for palynological identification and taxonomic differentiation within the genus *Eucalyptus*.

Table 5. illustrates palynological traits of *Eucalyptus erythrocorys* pollen grains

	Polar view		colpus		Equatorial view			
Genus	Length **(µm)**	Width **(µm)**	Colpus Length **(µm)**	Colpus Length ratio %	polar axis **(µm)**	Equatorial axis **(µm)**	P/E	shape

Eucalyptus erythrocorys	26.29 (23.96-28.64)	25.49 (22.16-28.77)	6.11 (4.57-7.64)	23.37 (17.12-29.88)	21.33 (20.23-22.45)	29.78 (28.78-31.25)	0.72 (0.70-0.74)	Oblate
SD	1.82	2.17	1.11	4.71	0.86	0.9	0.02	

Therefore, the shape: Oblate (P/E ratio ≈ 0.72), Size: ~26.29 µm (polar) × ~25.49 µm (equatorial), Colpus: 3 elongated colpi, ~6.11 µm long, Exine: Thickened, Apertures: Distinct colpi (typical of Myrtaceae).

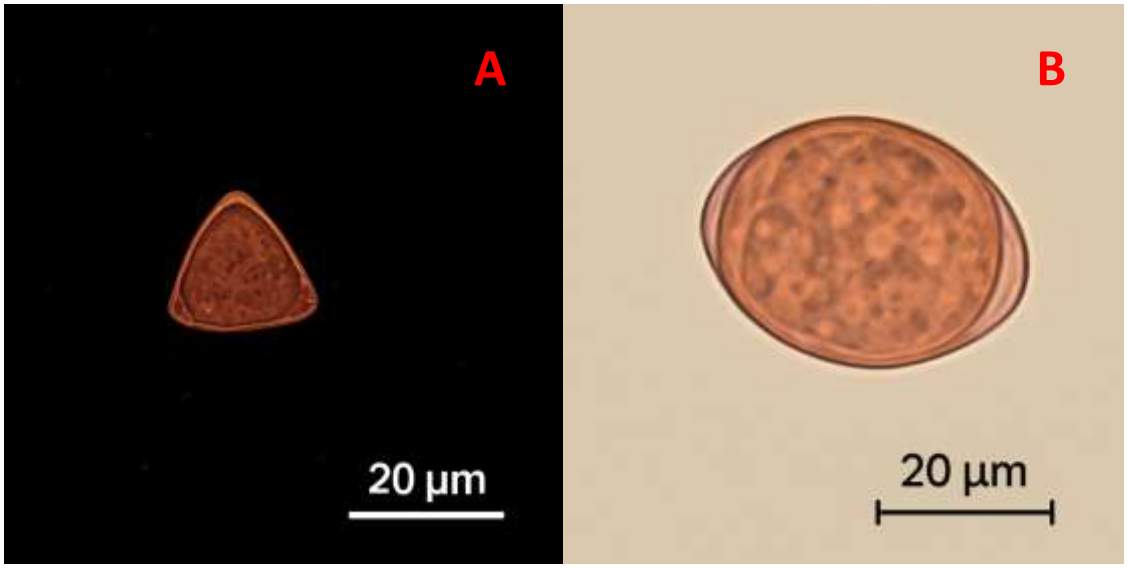


Fig. 6. the equatorial and polar prospect of pollen grains. A: Polar axes, B; Equatorial axes.

Comparative Distribution and Adaptability of Selected Eucalyptus Species in Iraq

The genus *Eucalyptus* includes several species introduced into Iraq for afforestation, timber production, and environmental rehabilitation (Table 6). Among the most common or experimentally introduced species are *Eucalyptus camaldulensis* (River red gum), *Eucalyptus globulus* (Blue gum), *Eucalyptus robusta* (Black eucalyptus), *Eucalyptus alba* (White gum), *Eucalyptus grandis* (Flooded gum), *Eucalyptus melliodora* (Honey eucalyptus), *Eucalyptus resinifera*, Red cassia eucalyptus, (Al-Tememmi et al., 2023), and *Eucalyptus sideroxylon* (Red ironbark / Yellow eucalyptus). Contrariwise, *Eucalyptus erythrocorys* has recently been described and assessed for potential use in similar roles. *Eucalyptus camaldulensis* is our most widely established member of the genus; it occurs throughout Iraq, notably on riverbanks and among irrigation systems, in all of which situations its high tolerance to drought and salinity renders it suitable for use in arid and semi-arid zones (Abd et al., 2015). *Eucalyptus globulus* is the most widely used species where climatic conditions permit its cultivation (in Central and Northern Iraq) but it can find no place in the hot Southern provinces (Al-Tememmi et al., 2025). Other species of Eucalypt, such as *E. robusta*, *E. alba* and *E. grandis*, are restricted to nurseries and experimental or reservation sites under controlled irrigation (Amin et al., 2015). *Eucalyptus erythrocorys* is of comparatively recent introduction; its floral morphology is interesting, though its adaptability is moderate; at present it is confined to a few trial plantations in the north of the country. Although of moderate drought-resistance, it cannot grow well in the summer heat and dry conditions of most of the country, and cannot therefore be expected to compete successfully in its naturalisation with *E. camaldulensis* and *E. globulus*. It does not share the sensitive drought-resistance of *E. sideroxylon*, but the timber is appreciated, the tree having other merits as an ornament (Youkhana et al., 1987). Recent field surveys indicate that the situation obtaining with these species is: that *E. camaldulensis* and *E. globulus* are over-represented both in large scale afforestation and in the planting of streets, gardens, parks etc. and that *E. erythrocorys* is considerably less widely grown or is still under trial and is still confined to the experimental plots. fairly little of the *E. erythrocorys*, though distributed in such small blocks as are shown in earlier maps for use and trial purposes in locations in these areas.

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Table 6. distribution of eucalypts species in Iraq and their uses

Species	Distribution in Iraq	Climatic/Soil Adaptability	Primary Uses	Notes	References
Eucalyptus camaldulensis	Widespread, riverine & irrigated zones	High drought and salinity tolerance	Afforestation, timber, reforestation	Most dominant species	(Abd et al., 2015)
Eucalyptus globulus	Central and northern Iraq	Prefers moderate temperature & adequate moisture	Timber, essential oils, afforestation	Limited in hot southern zones	(Al-Tememmi et al., 2025)
Eucalyptus robusta	Experimental plantations	Moderate drought & heat tolerance	Timber, experimental use	Adaptability under evaluation	(Amin et al., 2015)
Eucalyptus alba	Experimental plantations	Moderate drought & heat tolerance	Timber, experimental use	Adaptability under evaluation	(Amin et al., 2015)
Eucalyptus grandis	Irrigated agricultural zones	Requires well-drained soils and water	Timber	Restricted distribution	(Amin et al., 2015)
Eucalyptus melliodora	Localized, limited	Moderate drought resistance	Honey production, timber	Limited presence	(Al-Tememmi et al., 2023)
Eucalyptus resinifera	Localized, limited	Moderate drought resistance	Honey production, timber	Limited presence	(Al-Tememmi et al., 2023)
Eucalyptus sideroxylon	Limited trials	Sensitive to extreme heat & drought	Hardwood, ornamental	Sensitive to harsh Iraqi climate	(Youkhana et al., 1987)
Eucalyptus erythrocorys	Limited, experimental trials in north	Moderate drought tolerance, sensitive to heat	Afforestation, ornamental	Recently introduced, localized	Present study/2022-24

Eucalyptus erythrocorys (Red-cap Gum) is a small to medium-sized evergreen tree to 3–8 meters tall native to Western Australia (Migacz et al., 2018; Ghnaya et al., 2015). It generally found in well-drained terrain, growing on limestone ridges in sandy alkaline soils (Brooker and Kleinig, 2006). This species of tree is tolerant of coastal conditions, desert heat and brief periods of temperatures down to around -5 ºC (Orel et al., 2025; Brooker, 2000). Its red operculum (from Greek erythro = red; korys = helmet) covers yellow flowers that flower in between February and April (Lughadha et al., 1990). The flowers are somewhat showy, making the species attractive in gardens and also attracting hummingbirds, which feed upon the nectar (Brooker and Kleinig, 2006). Its smooth creamy-white bark and rough patches are complemented by leaves that are aromatic (on crushing), lanceolate and red on their petioles (Ghnaya et al., 2015). It is noted that the tree branches can break through heavy fruiting, so that some kind of pruning is desirable (NVIS Technical Working Group, 2017; de Salas, and Baker, 2025) reflecting in seeds set (Sbais et al., 2022). Culturally important by association as the Noongar Aboriginal name is given as Illyarrie (Ghnaya et al., 2015).

Generally speaking, *E. erythrocorys* stands for a resilient and visually striking species perfectly suited for cultivation in a range of difficult environments, combining ecological, aesthetic and cultural value. While the broad morphological features conform to the general *Eucalyptus* model, *E. erythrocorys* exhibits clear and unique combinations of characters which support its taxonomic status and range of distribution. Its persistent colourful operculum and close-spaced yellowish stamens are elements of the flower matched in general terms in the diagnostics offered by Brooker (2000) but here more prominent than otherwise

comparable species such as *E. baueriana*. Such distinctive elements assist in species identification and also in their attractiveness to pollinators, especially of nectar-feeding birds, and in particular humming-bird types, indicative of important ecological characteristics of Australian Eucalyptus species (Stephens et al., 2025; Brundrett et al., 2024). The result of pollen palynological treatment in characterising the *E. erythrocorys* as possessing oblate forms with a respective P/E ratio of 0.72 indicates a compressed structure. These appear consistent with results from studies of the other species of Myrtaceae, including applications of home Eucalyptus species, *E. globulus* and *E. camaldulensis*. Particular mention is made in the work of regarding the overall particular characteristics of the *Eucalyptus* pollen; particularly thickened with their distinctive colpi (De Souza Neto et al., 2022; Zamaloa et al., 2020).

Pollen grains of *Eucalyptus erythrocorys* are oblate, displaying a polar/equatorial (P/E) ratio of 0.72 (0.70–0.74), consistent with a wider diameter in the equatorial than polar plane. The polar axis averaged 21.33 µm with the equatorial axis larger (28.00–31.00 µm, mean = 29.78 µm). This morphology is similar to other Eucalyptus species such as *E. camaldulensis* and *E. globulus*, which also have oblate to sub-oblate pollen with P/E ratios of between 0.70 and 0.85 (De Souza Neto et al., 2022; Colhoun ad Shimeld, 2012; Quamar and Banerji, 2025). The average colpus length (6.11 µm, 23.37% of total grain length) is also within the range reported for the genus (Singh et al., 2022; Bakour et al., 2022). The notably larger equatorial diameter compared to the polar diameter may be diagnostic among the Eucalyptus taxa, although pollen grains of *E. marginata* are also on average smaller with less expansion of the equatorial aspect than some closely related species (de Oliveira et al., 2023; Ijatuyi et al., 2025). Palynological features such as these may thus be important for taxonomic resolution within the genus but may also indicate important ecological features relating to reproductive biology and/or habitat specificity (Cooley et al., 2024).

These results permit the inclusion of palynological data in the systematics of *Eucalyptus*, particularly cases where minimal morphological variation in vegetative characters is found. Although the presence of environmental pressures such as aridity and high levels of limestone should be taken into consideration, a moderate degree of variation in size of pollen grains can be interpreted to reflect a degree of genetic stasis, comparable to that found in a relatively isolated population of *E. marginata* (Al-Tememmi et al., 2023; Butler et al., 2022). Other comparative taxonomic studies have emphasised the shortcomings of a total reliance of macromorphological characters because of the high degree of phenotypic plasticity encountered in Eucalyptus species (Nicolle et al., 2023; Nicolle and French, 2023). These notes were interpreted by the correlation among tribes individuals as recorded by Kania and Metrosidereae tribes that were documented a highly correlation relations (Wilson et al., 2022).

The inclusion of floral, fruit and palynological characters in our study appears to embrace the use of a multi-character-based identification, and follows the successful working recommendations of adopting such a policy for improved species recognition (Lukawiecki et al., 2026; Lukawiecki et al., 2024). The ecological-adaptive physiological traits in terms of drought, and salinity and alkaline soils as discussed by Keighery (2013) and their potential role in xeriscaping and soil stabilisation all auger well for its place in a sustainable landscape and urban reforestations in particularly dryish or degraded locations.

CONCLUSION

This study has covered the morphology, unique pollen and floral features of Eucalyptus erythrocorys for the first time in Iraq, especially in western Iraq. Its identity within the genus is plain and clear cut. The vegetative, floral and pollen aspects, taken together, provide an insight into its true taxonomic position and information that can be applied in hitherto undelivered horticultural selections, conservation plans and continued taxonomic work in Eucalyptus. Furthermore, the shape of floral cambium, the inflorescence, fruit and the stigma residue were very various and distinguished. This genus could increase the plant biodiversity and the pharmaceutical values. This study stands originally with SDG 15 (Life on Land) and SDG13 (Climate action) by enhancing biodiversities conservations and sustainable exploitation of *Eucalyptus* genotypes via morphological and palynological description.

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Authors' declaration

- Conflicts of Interest: None.

- I/We hereby confirm that all the Figures and Tables in the manuscript are mine/ours. Furthermore, any Figures and images that are not mine/ours have been included with the necessary permission for re-publication, which is attached to the manuscript.
- No animal studies are present in the manuscript .
- No human studies are present in the manuscript.

-Ethical Clearance: The project was approved by the local ethical committee at University of Anbar, Center of Desert Studies.

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Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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