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PALYNOLOGY AND SEED DIVERSITY OF *Ludwigia* GENUS (ONAGRACEAE) IN KARNATAKA INDIA

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ABSTRACT

The Onagraceae Juss., also known as the evening primrose family in Karnataka reports two genera and eight species. *Ludwigia* reports seven species with cultivated species. Present work deliberates pollen morphometry and seed morphometry. Pollen reports different types (Prolate spheroidal, prolate, sub-prolate) with surface ornamentation and pore numbers (three or six). Seed morphometry records different types of seed shape (rectangular, oval, ellipsoid, heart, squar) with surface testa ornamentation.

Key words: Evening primrose, Heart shape seed, Pollen morphology, Pores, Seed morphology.

Introduction

The Onagraceae Juss., also known as the evening primrose family, has a rich history dating back to its classification by the French botanist Jean-Baptiste Lamarck in 1785. It includes approximately 18 genera and 650 species, found primarily in temperate and tropical regions. The family is renowned for its diverse plant forms, which range from herbs to shrubs, and for its brightly colored flowers, often adapted to specific pollinators such as moths and bees. Early botanical studies categorized Onagraceae into various genera, but it was molecular phylogenetic research in the late 20th and early 21st centuries that significantly advanced our understanding of its evolutionary history and relationships to other plant families (Levin, *et al.*, 2004). Flora of Karnataka A Checklist Vol. 2: Gymnosperms & Angiosperms have reported the 196 families contains 4853 species under 1543 genera out of which 2 genera (*Ludwigia*, *Oenothera*) and 8 species (*L. adscendens*, *L. perennis*, *L. peplodes*, *L. perennis*, *L. hyssopifolia*, *L. octovalvis*, *L. peruviana*, *O. rosea*) and 1 sub species (Sessiliflora) belongs to Onagraceae family (Sanjappa & Sringeswara, 2019).

Reproductive structures and evolution in *Ludwigia* L. (Onagraceae) Vol. I. worked by Richard. H. Eyde (1977) in the book Annals of the Missouri Botanical Garden. In part I of this book, author studied details of androecium which helps in understanding the evolution of plants. Paleotropical lineage of Indian water primrose *Ludwigia* species (Onagraceae) using pollen morphometric analysis. The late Cretaceous Corsinipollentines from central India and its nearest living fossil pollen *Ludwigia* L. species from Pleistocene karewa sediments in Kashmir shows morphometrical affinities with pollen of extant *Ludwigia* L. species (*Ludwigia octovalvis* (Jacq) P.H. Raven, *Ludwigia octovalvis* subsp. *sessiliflora* (M. Micheli) Raven, *Ludwigia adscendens* (L.) H. Hara, *Ludwigia perennis* (L.) H. Hara, *Ludwigia hyssopifolia* (G.Don) Exell and *Ludwigia peruviana* (L.) H. Hara, commonly growing in swampy ecosystem in Indian. The field Emission Scanning Electron Microscope (FESEM) and Light microscope (LM) study draws plausible lineage of extant *Ludwigia* L. species with that of fossil specimens recovered at two different time frames based on similarities in pollen morphometry. The pollen aperture

and its character along with sexine pattern were identifiable features to distinguish different species of extant fossil *Ludwigia* species pollen. The aperture varies from brevis-colporate to slit like colpi (colporate). The sexine is stenopalynous type characterized by regulate to reticulate pattern. The multivariate principal component analysis (PCA) was applied on the numerical data obtained from pollen morphometry of living and fossil *Ludwigia* species. The Pleistocene *Ludwigia* morphotype with slit-like colpi shows close proximity to *Ludwigia octovalvis* subsp. *sessiliflora* (Micheli) Raven and *Ludwigia adscendens* (L.) H. Hara. Raven, However, Late Cretaceous, *Corsiniipollenitis* characterized by brevis colpi is closer to *Ludwigia perennis* L. and *Ludwigia hyssopifolia* (G. Don) Exell with respect to primary pollen characters and inferred as primitive species having lineage to the "Old World" (Paleotropical) species. A short pollen key of *Ludwigia* species, is presented here to enable the identification of living or fossil pollen.

Effect of seed age and soil texture on germination of some *Ludwigia* L. species (Onagraceae) in Nigeria worked by Oziegbe Matthew *et al.*, (2010). Seed germination in *Ludwigia* species was greatly influenced by seed age and soil type. In *Ludwigia abyssinian* germination was not influenced by seed age and soil texture. Freshly shed seeds and six-month-old seeds of *Ludwigia* species *decurrens* variety showed a very low percentage germination on all the germination media, and six-month-old seeds germinated significantly earlier than freshly shed seeds. Some soil types could significantly reduce germination of freshly shed seeds

Ludwigia peruviana (L.) H. Hara (Onagraceae) in the Wetlands near Sydney, Australia worked by S.W.L. Jacobs, F. Perrett, G.R. Sainty, K.H. Bowmer and B.J. Jacobs (2001) *Ludwigia peruviana* (L.) H. Hara is an aquatic shrubby species introduced from the Americas and spreading to wetlands in coastal south-eastern Australia. It has become dominant, replacing much of the former vegetation in the Wetlands, a series of shallow urban swamps and lakes near Sydney, Australia. Studies of *L. peruviana* were essential to the development of a management plan for the Wetlands. Ecological studies were conducted in situ and supplemented by a series of germination and growth experiments in controlled environments. Flowering peaked in early autumn. Seed production for 1990-91 was ~ 450000 seeds m⁻² and there was also ~ 65000 seeds m⁻² in the soil seed bank and ~ 300000 seeds m⁻² in old fruits that remained on the stems over winter. The seeds are ~ 0.8 mm long, weigh ~ 0.05 mg, are hydrophobic, usually germinate while afloat, and are easily dispersed by water, machinery and birds.

Viability of fresh seed was 99% (tetrazolium dye test), and - 20% of seeds were dormant. Dormancy appeared to break down within two years.

Brown (1966) reported 21 genera and 100 species pollen diversity using illustration and reported types: Pollen in tetrads and disarticulated tetrads, Distinctly papillose projections, Pollen in which the pore structure is essentially internal, although at times the pores may be slightly aspidote, can be divided into (a) grains which are sharply triangular, (b) the obtusely angled grains 3-pored species. Tribe IV: Jussieae reports with *Ludwigia* genus:

Ludwigia pepuloides (H.B.K.) RAVEN (Louisiana, Brown 1621, LSU) Pollen grains single, 60-70 At diameter, obtusely triangular to spherical, triporate with aspidote pores, 14 At deep and 24 at wide, occasional tetraporate grains of the same size; exine smooth (hp) faintly baculate (under oil); sexine 4.7 At thick, nexine thick but Pollen in diameter. *Ludwigia decurrens* WALT. (Louisiana, Newsom I, LSU) Pollen in tetrads, arranged in strings of ten or more tetrads, 76-80 in diameter.

Paul *et al.*, (2021) reported Pollen grains of 58 wetland species of angiosperms belonging to 17 families, growing in different wetlands of Sub-Himalayan biodiversity hotspots, Northern Bengal and lower Gangetic plains, India. In this work they have reported *L. adscendens*, *L. octavilis*, *L. peruviana*. Light microscopic images of all this has been conducted but not SEM images, only *L. perennis* has been reported.

Material and Methods

Study area

Karnataka boasts over 38,575 sq. km of forest cover, accounting for roughly 20% of its geographical area, ranging from lush Western Ghats evergreen forests to arid eastern scrublands. Vegetation of Karnataka are

- i. Tropical wet Evergreen Forests,
- ii. Semi-Evergreen Forests,
- iii. Moist Deciduous Forests,
- iv. Dry Deciduous Forests,
- v. Shola Forests,
- vi. Shola Grasslands and Grassy Blanks,
- vii. Savannas, viii. Scrubs and thickets.

Collection of species is carried out in districts like Dharwad, Belgaum, Chikmanglore, Dakshina Kannada, Udupi, Kodagu (Government of Karnataka, 2026).

Pollen and seed morphometric studies

Mature anthers are collected in 70 % alcohol in Eppendorf tubes with codes for SEM studies. The dried

seeds were given for Scanning Electron Micrographs. The seeds were mounted on carbon stub. Using paint brush seeds are spread without damage. Place the sample into a gold sputtering, using a mini-gold sputter, sputter gold for 30s at ~ 70 m Torr pressure. Remove stub from gold sputtering system. Than stub is kept under electron microscope to take microphotography (Betageri & Kotresha, 2024; Deshi, *et al.*, 2025).

Results

Palynological Studies of *Ludwigia* L.

The pollen grains were used for light and scanning electronic microscope and detail information are given below in Table 1. The study shows that pollen can be broadly divided in several groups based on size, shape and surface structure. There are different kind of pollen

grain shape based on amb, polar and equatorial view they are in circular, prolate, oblate, equiaxial, polar shapes, and apolar. Stratification as tectum types like tectate, semitectate, atectate, and as three different layers ectexine, intine, endexine and there are different kind of surface ornamentation also known as sculpturing they are echinate, reticulate, striate, psilate & verrucate. Pores number on an average range from three to six on each pollen grain

Key to *Ludwigia* genus using pollen morphometry:

1	obtusely triangular	2
1	Other shapes	3
2	Length and breadth $56.85 \pm 0.040 \mu\text{m}$	
	<i>Ludwigia adscendens</i> (L.) H. Hara	
2	Length and breadth $56.85 \pm 0.040 \mu\text{m}$	
	<i>Ludwigia peploides</i> (Kunth) P. H. Raven	
3	Sub-prolate	
	<i>Ludwigia hyssopifolia</i> (G. Don)	
3	Other shapes	4
4	Prolate	5
4	Prolate spheroidal	6
5	Pollen notches are blunt without pore	
	<i>Ludwigia octovalvis</i> (Jacq.) P.H. Raven	
5	Pollen notches are slightly pointed with pore	
	<i>Ludwigia octovalvis</i> subsp. <i>sessiliflora</i> (Micheli) P.H. Raven	
6	Pores 6 in number with cerebellar surface	
	<i>Ludwigia peruviana</i> (L.) H. Hara	
6	Pores 3 in number with smooth surface	
	<i>Ludwigia perennis</i> L.	

Ludwigia adscendens (L.) H. Hara:

The pollen grains of exhibit obtusely triangular shape which has a tricolpate shape and sculpturing psilate and as double layer on the surface. The average length of the pollen grains is $59.85 \pm 0.0152 \mu\text{m}$, while the average breadth is $56.85 \pm 0.040 \mu\text{m}$. Each pollen grain possesses three pores. The pores themselves have an average length of $13.81 \pm 0.032 \mu\text{m}$ and a breadth of $15.17 \pm 0.057 \mu\text{m}$.

Ludwigia hyssopifolia (G. Don) Exell:

The pollen grains are sub-prolate in shape and sculpturing echinate. The average length of the pollen grains is $59.85 \pm 0.0152 \mu\text{m}$, and the breadth is $56.85 \pm 0.040 \mu\text{m}$. Each pollen grain contains three pores. The pores are $7.47 \pm 0.003 \mu\text{m}$ length and $12.57 \pm 0.000 \mu\text{m}$ breadth

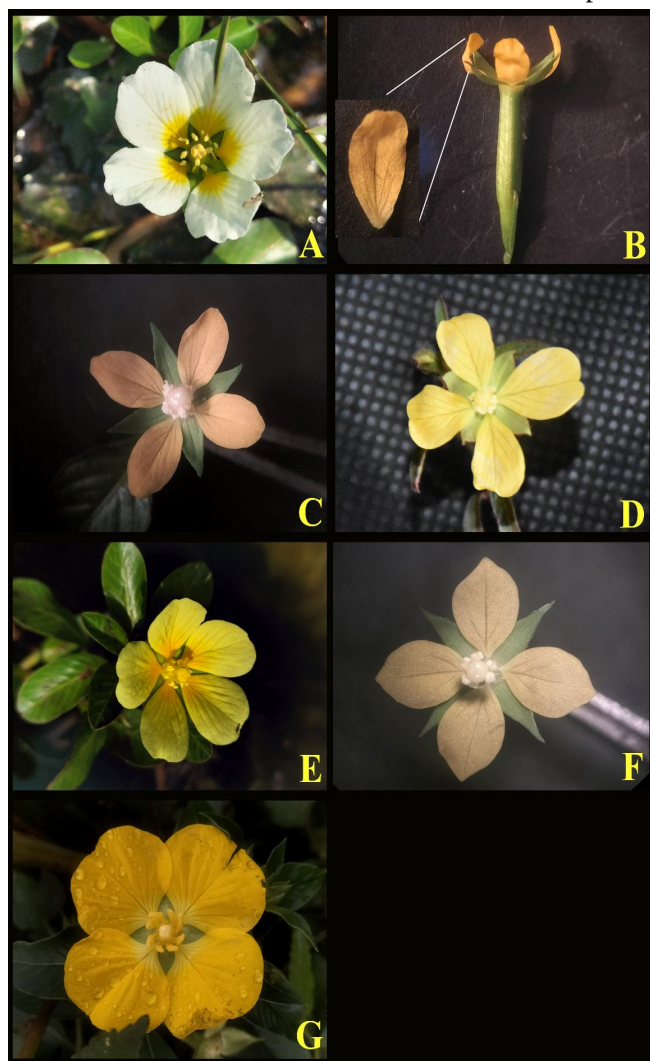


Fig. 1: A. *Ludwigia adscendens* (L.) H. Hara B. *Ludwigia hyssopifolia* (G. Don) C. *Ludwigia octovalvis* (Jacq.) P.H. Raven D. *Ludwigia octovalvis* subsp. *Sessiliflora* (Micheli) P.H. Raven E. *Ludwigia peploides* (Kunth) P.H. Raven F. *Ludwigia perennis* L G. *Ludwigia peruviana* (L.) H. Hara.

Table 1: Pollen studies of Onagraceae family in Karnataka.

Species name	Pollen Shape	Length (Mean)±S. E	Breadth (Mean)±S. E	Pores count	Length (Mean)±S.E	Breadth (Mean)±S. E
<i>Ludwigia adscendens</i> (L.) H. Hara	obtusely triangular	59.85±0.0152	56.85±0.040	3	13.81±0.032	15.17±0.057
<i>Ludwigia hyssopifolia</i> (G. Don)	Sub-prolate	38.86±0.003	38.43±0.223	3	7.47±0.003	12.57±0.000
<i>Ludwigia octovalvis</i> (Jacq.). P.H. Raven	prolate	72.82±0.373	66.85±0.087	6	14.28±0.184	7.07±0.863
<i>Ludwigia octovalvis</i> subsp. <i>Sessiliflora</i> (Micheli) P.H. Raven	prolate	35.95±0.058	40.34±0.122	6	11.84±0.215	6.63±0.0352
<i>Ludwigia peploides</i> (Kunth) P.H. Raveen	obtusely triangular	70.59±0.307	76.14±0.228	3	14.62±0.073	13.25±0.050
<i>Ludwigia perennis</i> L	Prolate spheroidal	34.44±0.091	38.24±0.121	3	×	×
<i>Ludwigia peruviana</i> (L.) H. Hara	Prolate spheroidal	64.41±0.220	84.54±0.13	6	×	×
• SE.- Standard Error						

***Ludwigia octovalvis* (Jacq). P.H. Raven:**

The pollen grains are prolate in shape and sculpturing verrucate. The average length of pollen grain is 72.82 ± 0.373 µm and the breadth is 66.85 ± 0.087 µm. Each pollen grains contain six pores. The pores are 14.28 ±

0.184 µm length and 7.07 ± 0.863 µm breadth.

***Ludwigia octovalvis* subsp. *sessiliflora* (Micheli) P.H. Raven:**

The pollen grains are polarate tricolpate shape and sculpturing echinate. With the average length of 35.95 ± 0.058 µm and breadth of 40.34 ± 0.122 µm. They have six pores, each measuring 11.84 ± 0.215 µm in length and 6.63 ± 0.0352 µm in breadth.

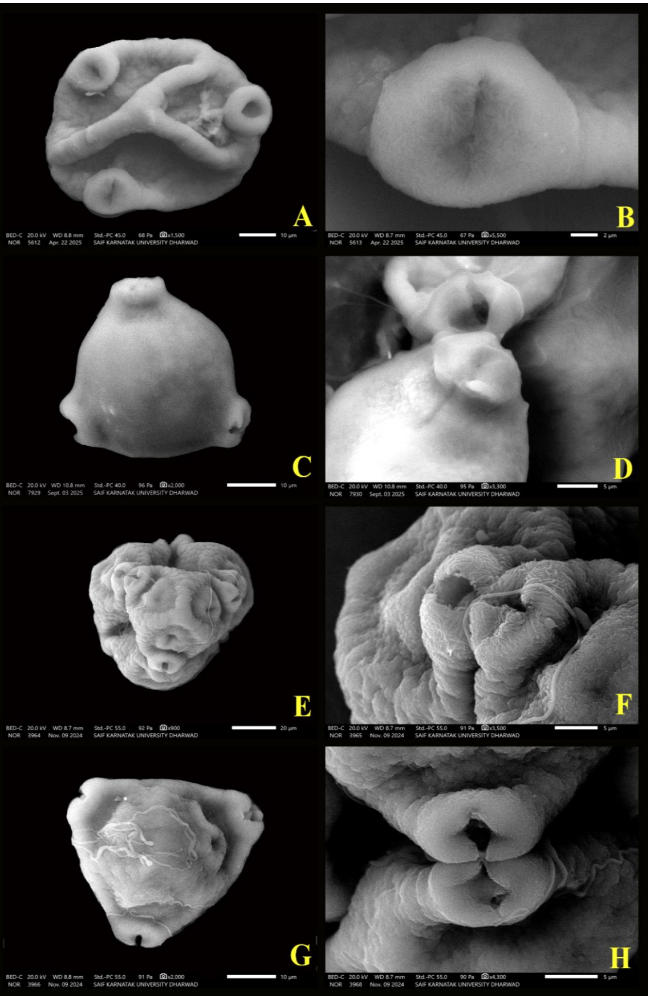


Fig. 2: Pollen morphology of A. *Ludwigia adscendens* (L.) H. Hara B. *Ludwigia hyssopifolia* (G. Don) C. *Ludwigia octovalvis* (Jacq.). P.H. Raven D. *Ludwigia octovalvis* subsp. *Sessiliflora* (Micheli) P.H. Raven.

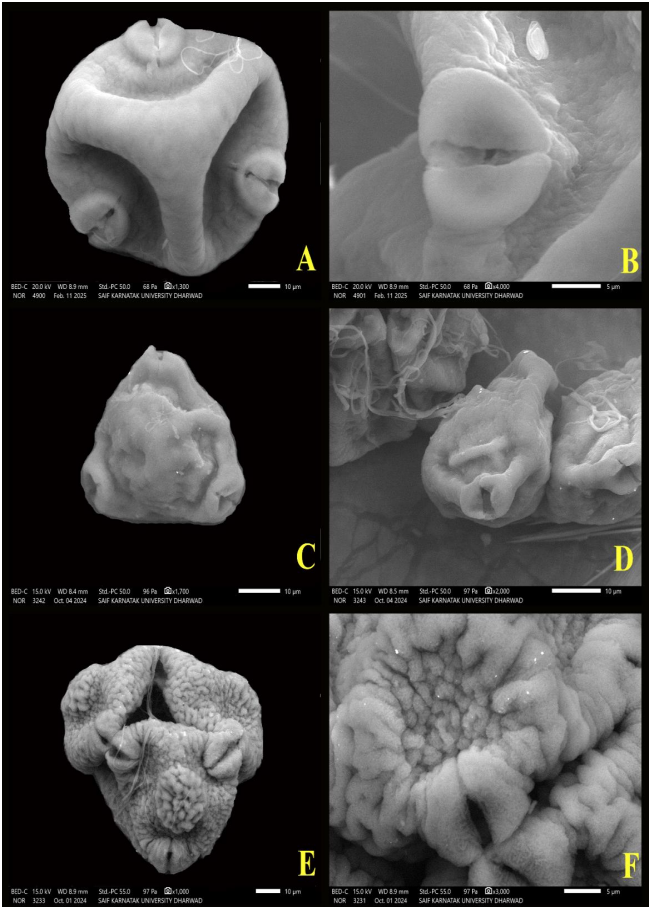


Fig. 3: Pollen morphology of E. *Ludwigia peploides* (Kunth) P.H. Raveen F. *Ludwigia perennis* L G. *Ludwigia peruviana* (L.) H. Hara.

Table 2: Showing variation among seed in Onagraceae family of Karnataka.

Name of species	Shape	Surface	Length (Mean)± S. E	Breadth (Mean)± S. E	testa cell shape	L (M)±SD	B (M)±SD
<i>Ludwigia adscendens</i> (L.) H. Hara	rectangular shape	Net like	2.106±0.008	2.106±0.000	polygonal	×	-
<i>Ludwigia hyssopifolia</i> (G. Don) Excell	Oval shape	Parallel ridges	356.4±3.744	606±9.710	Rod	78.64±4.11	7.259±0.554
<i>Ludwigia octovalvis</i> Raven (Jacq.) P.H. Raven	Oval shape	Textured	467.4±0.578	679.1±20.790	polygonal	85.91±3.95	0.742±0.428
<i>Ludwigia</i> subsp. <i>sessiliflora</i> (Micheli) P.H. Raven.	Heart shape	Net like	876.2±50.296	868.2±51.618	Irregular	51.40±2.17	25.41±2.00
<i>Ludwigia peploides</i> (Kunth) P.H. Raven	rectangular shape	Net like	107.6±0.088	164.3±0.133	polygonal	-	-
<i>Ludwigia perennis</i> L.	square shape	Net like	551.0±22.027	628.5±3.608	irregular	27.55±2.708	32.91±6.27
<i>Ludwigia peruviana</i> (L.) H. Hara	Ellipsoid shape	Ridges	623.1±8.014	276.8±6.974	rectangular	29.41±2.278	46.91±3.02

***Ludwigia peploides* (Kunth) P. H. Raveen:**

2 Small seed, 1 × 1.5 mm

These pollen grains are obtusely triangular to spherical in shape and sculpturing verrucate. The average length of pollen grain is $70.59 \pm 0.307 \mu\text{m}$ and breadth is $76.14 \pm 0.228 \mu\text{m}$. Each grain contains three pores, which are $14.62 \pm 0.073 \mu\text{m}$ in length and $13.25 \pm 0.050 \mu\text{m}$ in breadth.

***Ludwigia perennis* L.:**

The pollen grains are prolate spheroidal in shape and sculpturing psilate surface. The average pollen grain length measuring $34.44 \pm 0.091 \mu\text{m}$ and $38.24 \pm 0.121 \mu\text{m}$ in breadth. Each grain has three pores (Pore measurements not provided.)

***Ludwigia peruviana* (L) H. Hara:**

Pollen grains are prolate spheroidal in shape and ornamentation (surface is covered by two layers in sculpturing cerebriform), upper view of the pollen we can observe a globular shape mass of cell arranged in cluster. Pollen with an average length of $64.41 \pm 0.220 \mu\text{m}$ and breadth of $84.54 \pm 0.13 \mu\text{m}$. They possess six pores. (Pore dimensions not provided.)

Seed Morphometric Studies

Seed morphometry and testa cell analysis presented for the first time in this level of detail for the selected taxa, offering insights into reproductive morphology and identification.

Key to *Ludwigia* genus using seed morphometry:

1 Rectangular shape	2
1 Other shapes	3
2 Large seed, $2 \times 1 \text{ mm}$	
<i>Ludwigia adscendens</i>	

Ludwigia peploides

3 Oval shape

4

3 Other shape

5

4 Surface with thick walls having streaks at centre

Ludwigia hyssopifolia

4 Surface with thin walls having ridge at centre

Ludwigia octovalvis

5 Heart shape

Ludwigia octovalvis* subsp. *Sessiliflora

5 Other shape

6

6 Elliposide shape long without beak

Ludwigia peruviana

6 Square shape with beak

Ludwigia perennis***Ludwigia adscendens* (L) H. Hara:**

The seeds are characterized by a rectangular shape and a net-like surface texture. They are relatively uniform in size, with both the mean length and breadth measuring with standard deviation $2.106 \pm 0.008 \text{ mm}$ and $2.106 \pm 0.000 \text{ mm}$, respectively. The testa cells are polygonal in shape, although no specific measurements for testa cell dimensions (L and B) are provided for this species.

***Ludwigia hyssopifolia* (G. Don) Excell:**

The produces seeds with a oval shape and a surface marked by parallel ridges. The seeds have a mean length and standard deviation of $356.4 \pm 3.744 \mu\text{m}$ and a mean breadth and standard deviation of $606 \pm 9.710 \mu\text{m}$. The testa cells are rod-shaped. Under microscopic examination, the length of the testa cells is 78.64 ± 4.11

μm and the breadth is $7.259 \pm 0.554 \mu\text{m}$, indicating elongated and narrow cell structures.

***Ludwigia octovalvis* (Jacq) P.H. Raven:**

The seeds are oval in shape and have a textured surface. The mean seed length and standard deviation is $467.4 \pm 0.578 \mu\text{m}$, the breadth and standard deviation is $679.1 \pm 20.790 \mu\text{m}$. The testa cells are polygonal in form. Microscopically, the length of the testa cells measures $85.91 \pm 3.95 \mu\text{m}$, and the breadth is $0.742 \pm 0.428 \mu\text{m}$, suggesting narrow and elongated cell features. Notches are blunt without pore.

***Ludwigia octovalvis* (Jacq) P.H. Raven subsp. *sessiliflora* (Micheli) P.H. Raven:**

The seeds are heart-shaped and have a net-like surface. They are among the largest in the genus, with a mean length of $876.2 \pm 50.296 \mu\text{m}$ and a mean breadth

of $868.2 \pm 51.618 \mu\text{m}$. The testa cells are irregular in shape. Their microscopic length is measured at $51.40 \pm 2.17 \mu\text{m}$, and the breadth is $25.41 \pm 2.00 \mu\text{m}$, indicating large and variably shaped cells. Notches are slightly pointed with pore.

***Ludwigia peploides* (Kunth) P.H. Raven:**

The seeds are rectangular shape and exhibit a net-like surface pattern. The mean seed length and standard deviation is $107.6 \pm 0.088 \mu\text{m}$ and the breadth is and standard deviation $164.3 \pm 0.133 \mu\text{m}$. The testa cells in this species are polygonal. Microscopic examination reveals a testa cell length of $27.55 \pm 2.708 \mu\text{m}$ and a breadth of $32.91 \pm 6.27 \mu\text{m}$.

***Ludwigia perennis* L.:**

The seeds are square-shaped and have a net-like surface. Their mean length and standard deviation are $551.0 \pm 22.027 \mu\text{m}$ and the breadth and standard deviation is $628.5 \pm 3.608 \mu\text{m}$. The testa cells are irregular in shape, with a microscopic length of $27.55 \pm 2.708 \mu\text{m}$ and a breadth and standard deviation of $32.91 \pm 6.27 \mu\text{m}$.

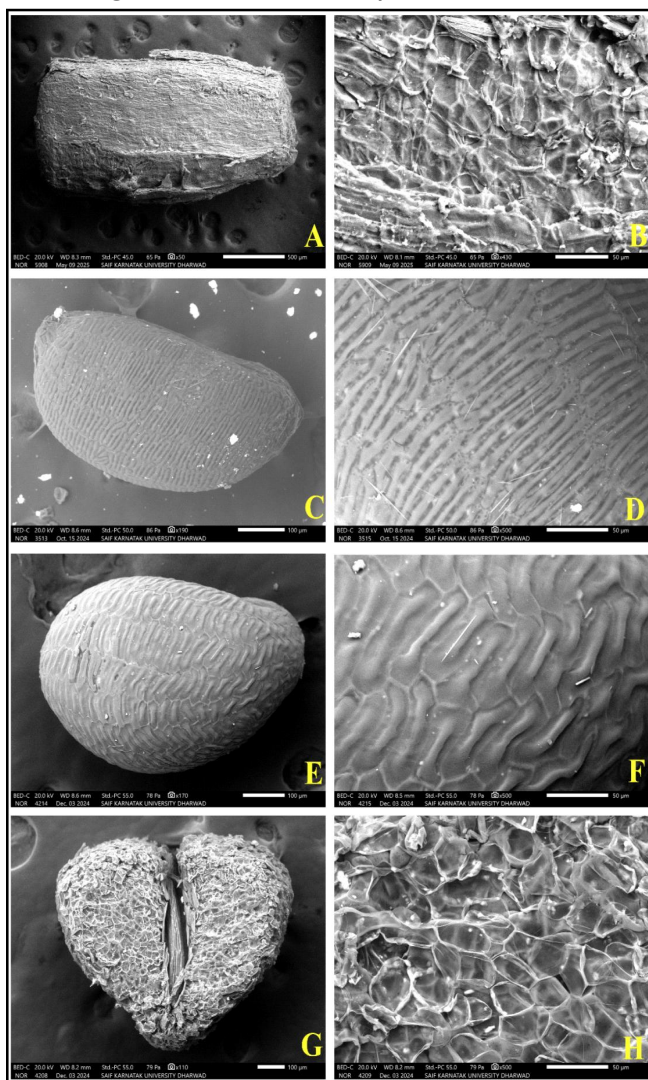


Fig. 4: Pollen morphology of A. *Ludwigia adscendens* (L) H. Hara B. *Ludwigia hyssopifolia* (G. Don) C. *Ludwigia octovalvis* (Jacq.) P.H. Raven D. *Ludwigia octovalvis* subsp. *Sessiliflora* (Micheli) P.H. Raven.

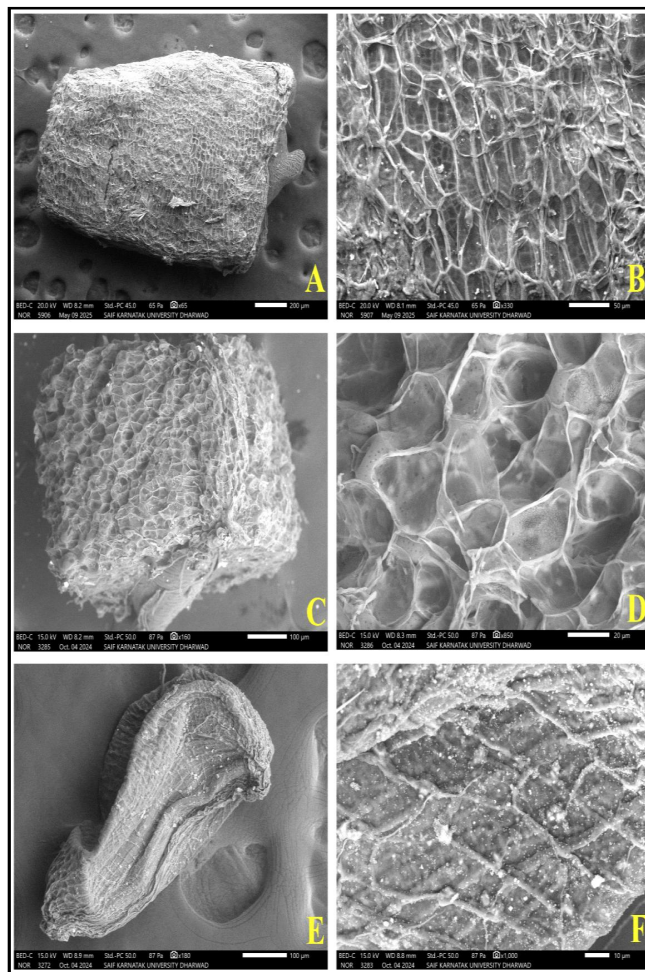


Fig. 5: Pollen morphology of E. *Ludwigia peploides* (Kunth) P.H. Raven F. *Ludwigia perennis* L. G. *Ludwigia peruviana* (L.) H. Hara.

***Ludwigia peruviana* (L) H. Hara:**

The seeds are ellipsoide in shape and have a surface covered with ridges. These seeds have a mean length and standard deviation of $623.1 \pm 8.014 \mu\text{m}$ and a mean breadth and standard deviation of $276.8 \pm 6.974 \mu\text{m}$. The testa cells are rectangular, and their microscopic dimensions are $29.41 \pm 2.278 \mu\text{m}$ in length and $46.91 \pm 3.02 \mu\text{m}$ in breadth.

References

- Betageri, S. and Kotresha K. (2024). Seed morphometric with embryo diversity of wild orchids in North Karnataka. *Journal of Diversity Studies* **3(1)**, 1–12.
- Brown, A.C. (1966). Pollen Morphology Of The Onagraceae. Review of Palaeobotany and Palynology. *Elsevier Publishing Company, Amsterdam - Printed in The Netherlands*. **3**, 163-180.
- Deshi, S., Betageri S., Patagar G.V. and Kotresha K. (2025). *Cyperus melanostachyus* Kunth. Cyperaceae. a new report to Indian flora. *Journal of Diversity Studies*, **4**, 73–77.
- Government of Karnataka (2026). Biodiversity of Karnataka, At a Glance. Karnataka Biodiversity Board. 1-78. <https://kbb.karnataka.gov.in/storage/pdf-files/Biodiversity-of-Karnataka-at-a-Glance>. (Accessed on 10-03-2026)
- Paul, P., Sayantan D., Das D. and Chowdhury M. (2022). Light and scanning electron microscopic characterization of pollen grains of some wetland angiosperms from India. *Microscopic Research Techniques*. **85**, 2628–2650.
- Rachel, A. Levin, Warren L, Wanger, Peter C. Hock, William L, Hohn, Aaron Rodriguez, David A. Baum, Liliana Katinas, Elizabeth A, Zimmer and Kenneth J, Sytsma (2004). Paraphyly in tribe Onagraceae: Insight into phylogenetic relationships of Onagraceae based on nuclear and chloroplast sequence data. *Systematic botany*, **29(1)**, 14.7-164.
- Richard, H. Eyder (1977). Reproductive structure and evolution in *Ludwiga* (Onagraceae)., Androecium, placentation, merism. *Annals of the Missouri Botanical Garden (I)*. 644-655.
- Sanjappa, M. and Sringseshwara A.N. (2019). Flora of Karnataka a checklist. Vol II Gymnosperms and Angiosperms, Karnataka Biodiversity Board. Bangalore.