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A Contribution to the Pollen morphology in Tribe Paniceae (Poaceae) from Telangana state, India

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Abstract
The present paper deals with the palynological studies of 20 species belonging to 12 genera of tribe Paniceae (Poaceae) from Ananthagiri hills of Vikarabad district, Telangana state using light microscope (LM) and the detailed descriptions, including shape, exine thickness, annulus diameter, annulus width, pori diameter and ornamentation of exine were provided for every species. The study also provided clear light microscope photos of the pollen grains in addition to these descriptions. The investigation showed that pollen features can be significant in distinguishing taxa of various tribes and play an important role in the specific and generic taxonomy of grasses.

Keywords: Ananthagiri hills, Paniceae, Panicoideae, Palynological studies, Poaceae

Introduction

The tribe Paniceae R.Br. is highly diverse and second largest tribe with more than 2000 species in the subfamily Panicoideae of family Poaceae. The members of this tribe are mainly distributed in tropical and subtropical regions of both hemispheres with limited distribution in temperate and cold areas (Morrone *et al.*, 2012) [11]. Paniceae is separated from other allied tribes of subfamily Panicoideae by having solitary or paired, two flowered spikelets with unequal glumes. The lemma of the lower floret is membranous and shows similarity with the upper glume in texture, however, the lemma of the upper floret is tough and rigid. This diversity is expressed in variable floral development, inflorescence architecture, leaf anatomy, and photosynthetic physiology among species (Clayton and Renvoize, 1986; Watson and Dallwitz, 1992; GPWG - Grass Phylogeny Working Group, 2001) [4, 7]. In recent systematic treatment, Paniceae has been divided into seven subtribes *viz.* Anthephorinae, Dichantheliinae, Boivinellinae, Neurachninae, Melinidinae, Panicinae and Cenchrinae. It is estimated that tribe Paniceae includes 84 genera and ca. 1500 species of grasses (Morrone *et al.*, 2012; Soreng *et al.*, 2015) [11, 19]. In India, Hooker gave the preliminary account of Paniceae and recognized ca. 147 species, belonging to 17 genera. Thereafter, Bor (1960) [3] provided a detailed account of Paniceae with 192 species within 30 genera. In India about 155 species, belonging to 23 genera are present. In the state of Telangana, 70 species from 20 genera present (Nagaraju & Prasanna, 2023) [12]. In the tribe Paniceae, the most dominant genus is Panicum L. with maximum diversity and is represented by about 28 species followed by *Digitaria* Haller (ca. 25), *Cenchrus* L. (ca. 20), *Urochloa* P.Beauv. (ca. 20) and *Setaria* P.Beauv. (ca. 17) species. Most of the species in the tribe grows in various habitats like waste places, roadsides, forest margin, open grasslands etc.

The tribe Paniceae attains significant economic importance due to the contribution of important grains (*Panicum miliaceum* L., *Cenchrus americanus* (L.) Morrone, *Paspalum scrobiculatum* L., *Setaria italica* (L.) P. Beauv.), which is many times more nutritious than common major cereals such as wheat, rice, etc. Besides, most of the species of this tribe such as *Digitaria longiflora* (Retz.) Pers. *Digitaria wallichiana* (Wight & Arn. ex Steud.) Stapf, *Urochloa distachya* (L.) T.Q. Nguyen, etc. are available as good fodder resources for livestock. Apart from these, the grasses of this tribe are good soil binders and *Stenotaphrum secundatum* (Walter) Kuntze is an important tropical turf grass. The tribe also includes important weed species in few genera like *Echinochloa*, *Panicum* and *Setaria* as serious weeds in agricultural systems.

Several studies regarding the morphology of pollen grains done by various researchers, due to their significant role in solving the taxonomic problems of Poaceae family (Andersen & Bertelsen, 1972, Kohler & Lange, 1979, Skvarla *et al.*, 2003, Liu *et al.*, 2004, Perveen, 2006) [2, 9, 10, 15]. Palynological studies of tribe Chlorideae (Ahmad *et al.*, 2011) [1] and tribe Aveneae (Nazir *et al.*, 2013) [14] from Pakistan are important contributions of pollen morphology at tribe level. In India, in Pollen flora of Maharashtra (Nair, 1990) studied 15 grass species. In Telangana state the study of Poaceae pollen grains were made by two research works (AVB Reddy and Srihari Reddy, 2020; AVB Reddy and Ravi Raj, 2020) [21, 22] from Nalgonda and Nizamabad district studied 16 grass species. Recent studies of Palynological studies of Poaceae family from Ananthagiri hills of Vikarabad district by (Swapna *et al.*, 2023) [20] studied 24 grass species in various aspects. In the present a toal of 18 species belonging to 12 genera of tribe Paniceae collected and studied the morphological characters along with light microscopic images.

Methodology

As a part of Palynological studies of Ananthagiri hills of Vikarabad district, Telangana state the authors collected 20 grass species of tribe Paniceae. The collected specimens made into herbarium following standard methodology (Jain & Rao, 1977) [8] and preserved at Herbarium Hyderabadensis (HY), Osmania University. The identification of species done by using regional floras, e-floras and other avialbale literature (Gamble and Fischer, 1957; Bor, 1960; Pullaiah & Mahammed, 1999; Pullaiah, 2015; Reddy & Reddy, 2016; Nagaraju & Prasanna, 2023) [3, 6, 12, 16, 17, 18]. Polleniferous material was collected from mature inflorescences of the grass species and collected

samples were processed, and permanent pollen slides were prepared using the Acetolysis method (Erdtman, 1960) [5]. These slides were studied under a binocular light microscope (OLYMPIS CX31) with an attached camera and noted important pollen characters, including shape, polar axis diameter, equatorial axis diameter, annulus diameter, annulus width, pori diameter and ornamentation features (Plate 1, 2, 3, 4).

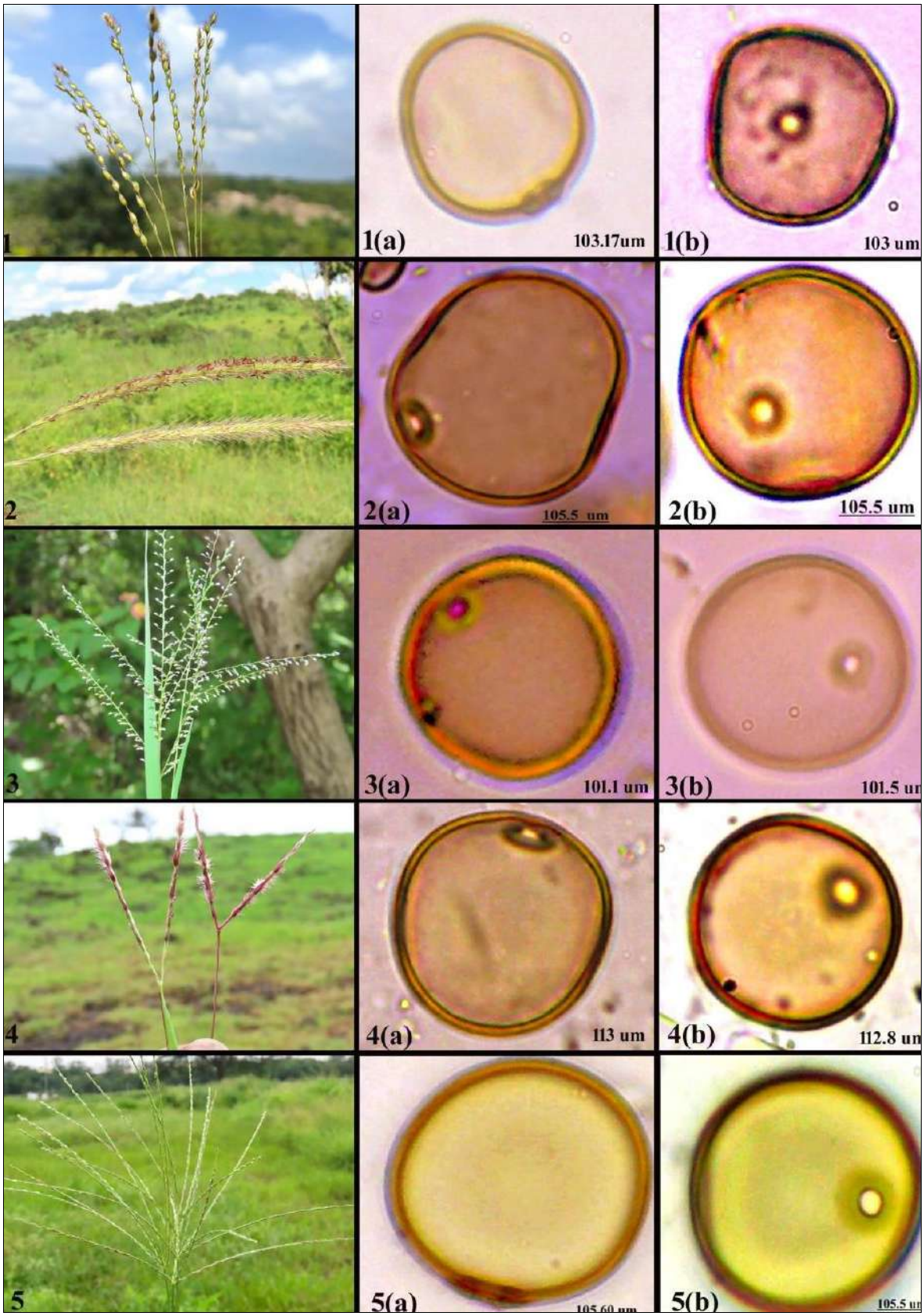

Plate 1: 1. *Alloteropsis cimicina* (L.) Stapf, 1(a). PV, 1(b). EV; 2. *Cenchrus hohenackeri* (Hochst. ex Steud.) Morrone, 2(a). PV, 2(b). EV; 3. *Digitaria abludens* (Roem. & Schult.) Veldkamp, 3(a). PV, 3(b). EV; 4. *Digitaria bicornis* (Lam.) Roem. & Schult., 4(a). PV, 4(b). EV; 5. *Digitaria ciliaris* (Retz.) Koeler, 5(a). PV, 5(b). EV (Note: PV = Polar View of Pollen Grain; EV = Equatorial View of Pollen Grain and the measurements on the pictures shows the P/E × 100 values of pollen regarding their shape)

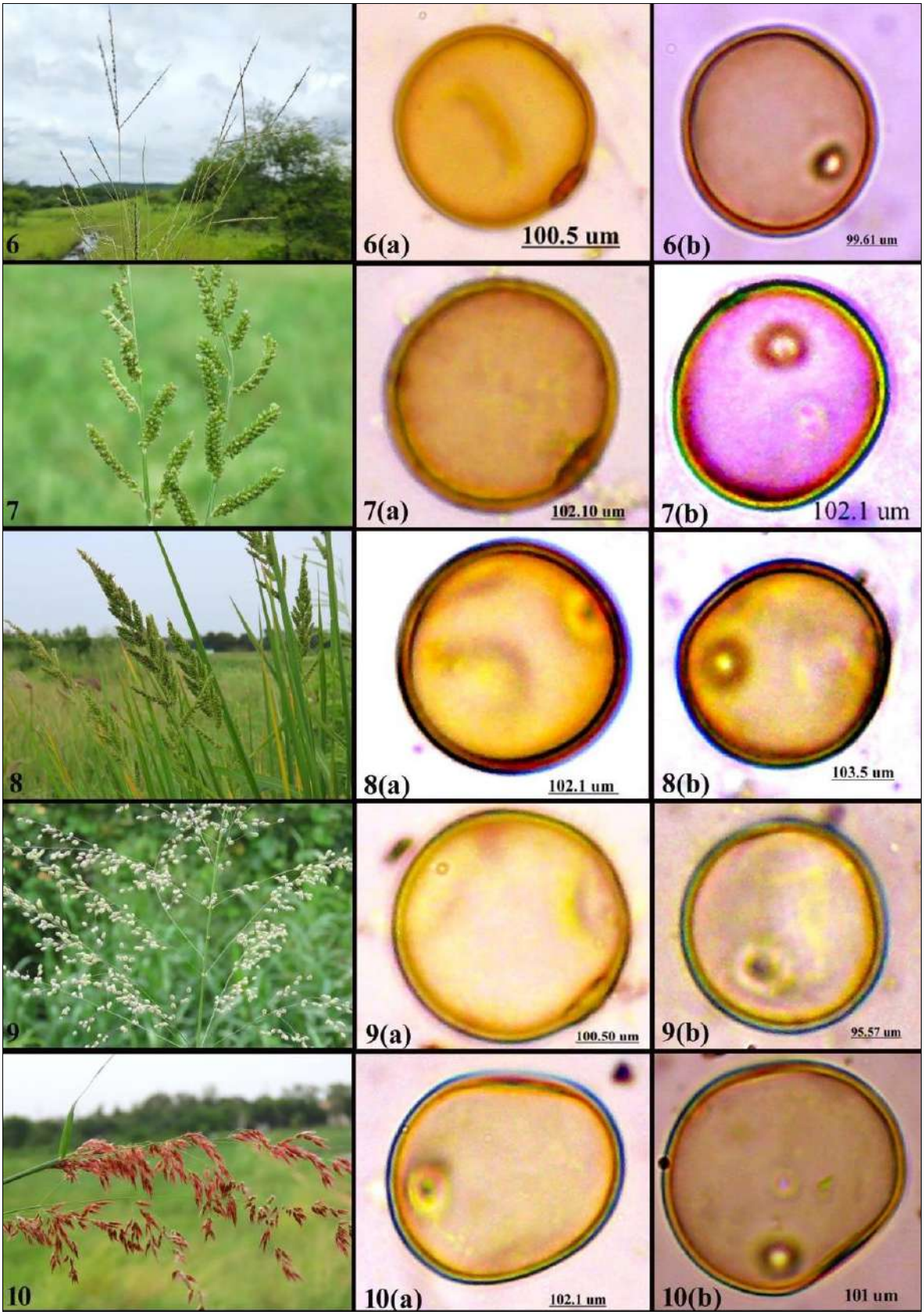

Plate 2: 6. *Digitaria longiflora* (Retz.) Pers., 6(a). PV, 6(b). EV; 7. *Echinochloa colona* (L.) Link, 7(a). PV, 7(b). EV; 8. *Echinochloa crus-galli* (L.) P. Beauv., 8(a). PV, 8(b). EV; 9. *Megathyrsus maximus* (Jacq.) B.K.Simon & S.W.L.Jacobs, 9(a). PV, 9(b). EV; 10. *Melinis repens* (Willd.) Zizka, 10(a). PV, 10(b). EV (Note: PV = Polar View of Pollen Grain; EV = Equatorial View of Pollen Grain and the measurements on the pictures shows the P/E × 100 values of pollen regarding their shape)

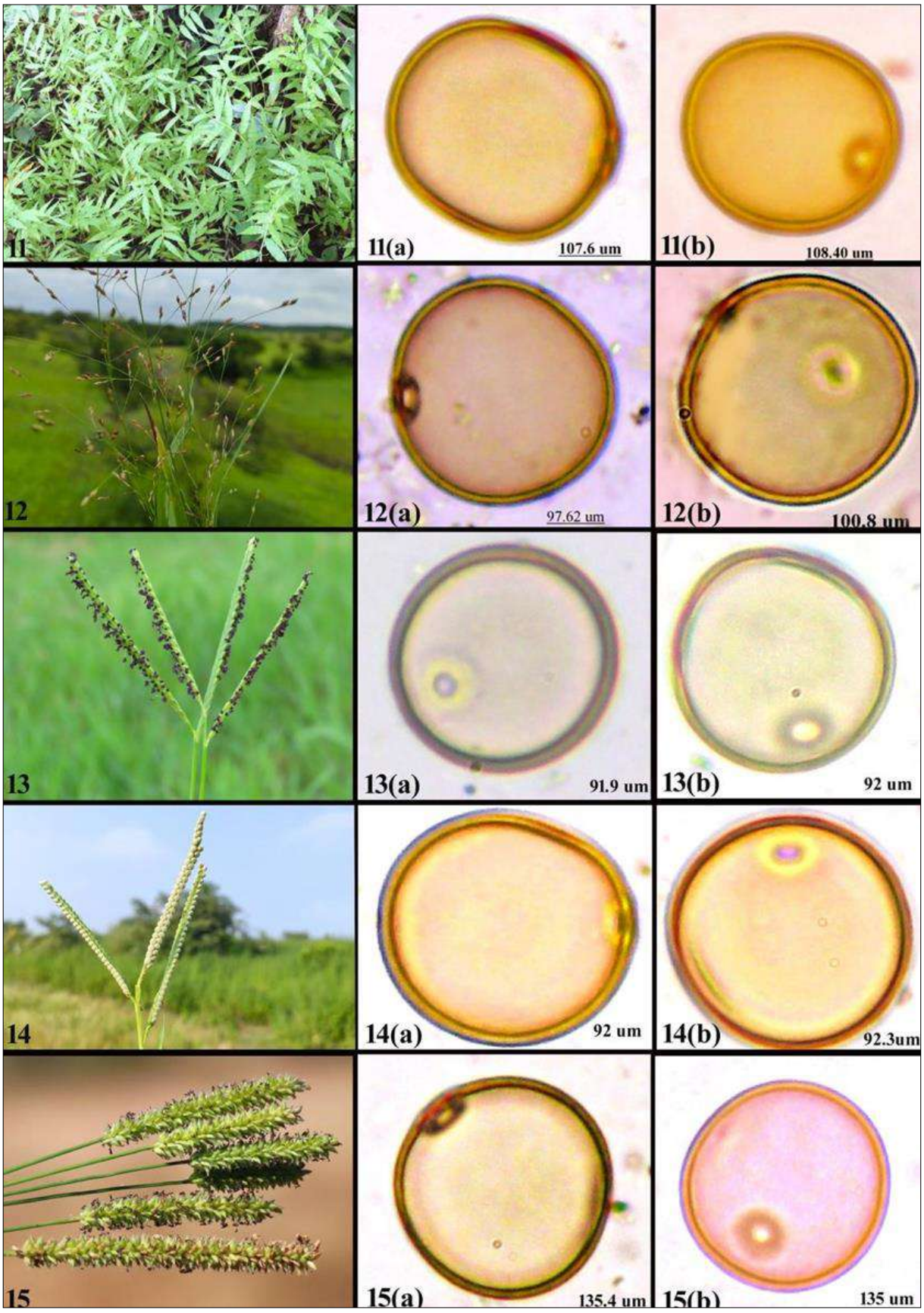

Plate 3: 11. *Oplismenus compositus* (L.) P. Beauv., 11(a). PV, 11(b). EV; 12. *Panicum curviflorum* Hornem., 12(a). PV, 12(b). EV; 13. *Paspalum distichum* L., 13(a). PV, 13(b). EV; 14. *Paspalum scrobiculatum* L., 14(a). PV, 14(b). EV; 15. *Sacciolepis indica* (L.) Chase, 15(a). PV, 15(b). EV (Note: PV = Polar View of Pollen Grain; EV = Equatorial View of Pollen Grain and the measurements on the pictures shows the P/E × 100 values of pollen regarding their shape)

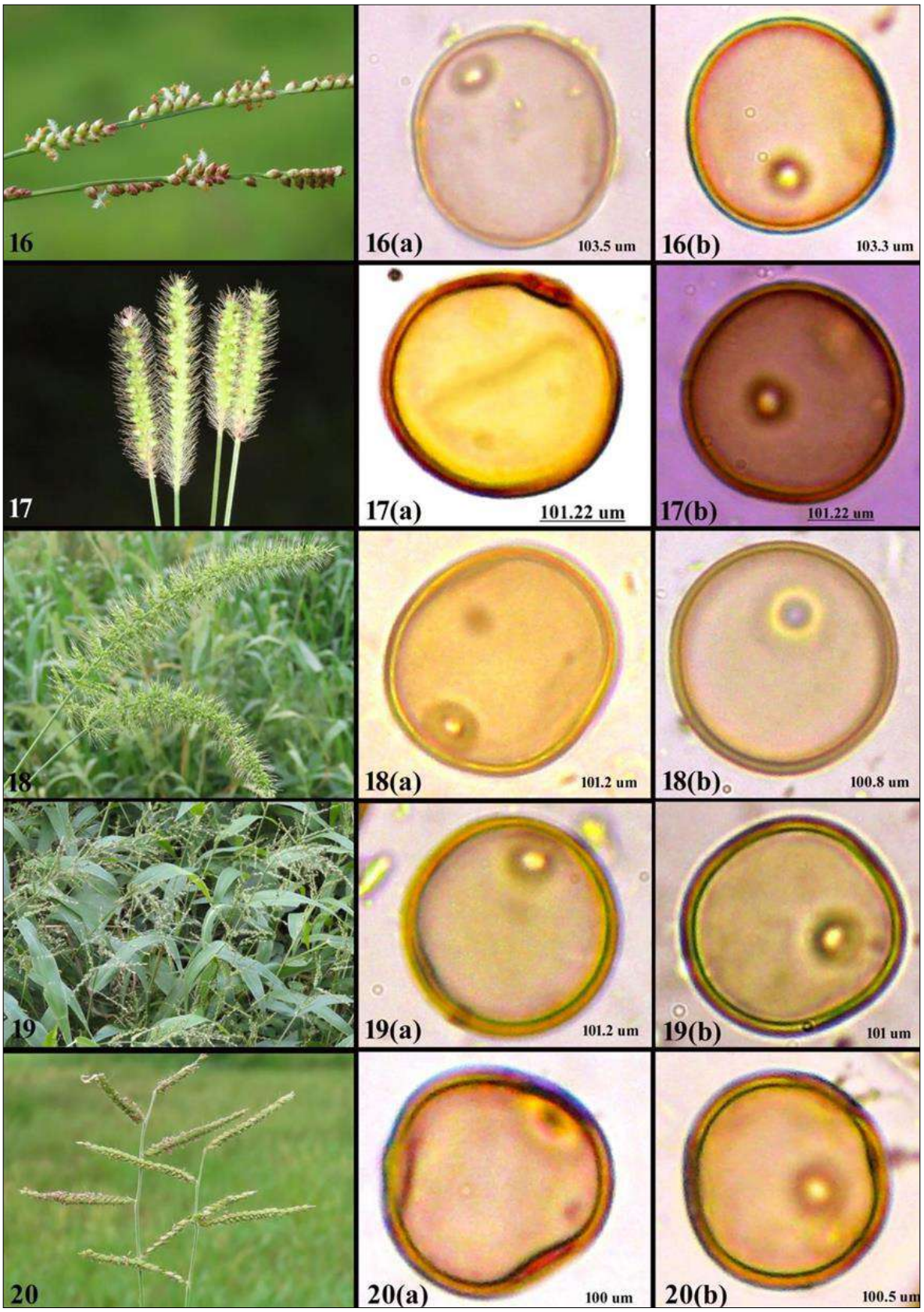

Plate 4: 16. *Setaria flavida* (Retz.) Veldkamp, 16(a). PV, 16(b). EV; 17. *Setaria pumila* Roem. & Schult., 17(a). PV, 17(b). EV; 18. *Setaria verticillata* (L.) P. Beauv., 18(a). PV, 18(b). EV; 19. *Urochloa ramosa* (L.) T.Q. Nguyen, 19(a). PV, 19(b). EV; 20. *Urochloa trichopus* Stapf, 20(a). PV, 20(b). EV (Note: PV = Polar View of Pollen Grain; EV = Equatorial View of Pollen Grain and the measurements on the pictures shows the P/E × 100 values of pollen regarding their shape)

Results and Discussion

There is no authentic research work was conducted on the pollen morphology of tribe Paniceae. A total of 20 grass belongings to 12 genera of tribe Paniceae from Poaceae family collected and studied the Palynological features. The pollen grains are stenopalynous in nature and monoporate with psilate ornamentation, but differs in shape, exine thickness, annulus diameter, annulus width and pori diameter. The detailed descriptions along with photographs, with all characters of each pollen grains are given below.

Table 1: Pollen characters of different species in tribe Paniceae

S. No	Name of the Taxon	PAD (µm)	EAD (µm)	P/E ratio (µm)	ET (µm)	PD (µm)	AD (µm)	AW (µm)
1	*Alloteropsis cimicina* (L.) Stapf	25.68	24.89	1.03	1.51	2.49	5.2	0.8
2	*Cenchrus hohenackeri* (Hochst. ex Steud.) Morrone	36.33	33.95	1.07	2.02	1.58	6.84	1.15
3	*Digitaria abludens* (Roem. & Schult.) Veldkamp	24.02	23.73	1.01	2.52	2.16	4.92	1.6
4	*Digitaria bicornis* (Lam.) Roem. & Schult.	25.72	22.67	1.13	1.63	1.8	4.27	1.25
5	*Digitaria ciliaris* (Retz.) Koeler	27.76	27.03	1.03	2.21	2.88	6.17	1.59
6	*Digitaria longiflora* (Retz.) Pers.	25.56	25.66	1	2.28	1.6	6.47	1.36
7	*Echinochloa colona* (L.) Link	44.57	38.86	1.15	2.9	1.78	6.94	2.27
8	*Echinochloa crus-galli* (L.) P. Beauv.	28.24	27.65	1.02	2.32	1.71	5.71	1.8
9	*Megathyrsus maximus* (Jacq.) B.K.Simon & S.W.L.Jacobs	28.17	28.87	0.98	1.58	1.92	5.46	2.05
10	*Melinis repens* (Willd.) Zizka	33.67	31.9	1.06	2.56	2.03	6.97	1.25
11	*Oplismenus compositus* (L.) P. Beauv.	27.44	26.86	1.02	2.07	1.6	4.7	2.07
12	*Panicum curviflorum* Hornem.	30.81	31.56	0.98	2.87	1.94	7.08	1.09
13	*Paspalum distichum* L.	25.47	27.69	0.92	1.32	2.41	5.58	2.02
14	*Paspalum scrobiculatum* L.	26.86	29.19	0.92	1.74	1.74	3.93	1.52
15	*Sacciolepis indica* (L.) Chase	34.11	25.18	1.35	1.65	2.03	5.23	1.32
16	*Setaria flavida* (Retz.) Veldkamp	30.99	29.92	1.04	1.77	2.52	6.3	1.4
17	*Setaria pumila* Roem. & Schult.	28.09	27.75	1.01	2.09	2.03	6.66	0.85
18	*Setaria verticillata* (L.) P. Beauv.	30.75	30.36	1.01	1.8	4.65	8.45	0.9
19	*Urochloa ramosa* (L.) T.Q. Nguyen	29.92	29.75	1.01	2	1.39	4.7	1.07
20	*Urochloa trichopus* Stapf	25.07	25.19	1	1.88	2.04	5.49	1.35

(Note: **PAD –** Polar Axis Diameter; **EAD –** Equatorial Axis Diameter; **P/E** – PAD/EAD; **ET –** Exine Thickness; **PD** – Pore Diameter; **AD** – Annulus Diameter; **AW** – Annulus Width)

1. *Alloteropsis cimicina* (L.) Stapf

Pollen grains are monads, prolate spheroidal, spherical in shape. The polar axis is ± 25.68 µm and equatorial axis diameter is ± 24.89 µm. P/E ratio is ± 1.03 µm. Exine thickness is ± 1.51 µm, sexine as thick as nexine. Pollen is monoporate, pori circular, ± 2.49 µm, annulus ± 5.20 µm in diameter, annulus width ± 0.80 µm and ornamentation is psilate.

2. *Cenchrus hohenackeri* (Hochst. ex Steud.) Morrone

Pollen grains are monads, prolate spheroidal in shape. The polar axis is ± 36.33 µm and equatorial axis diameter is ± 33.95 µm. P/E ratio is ± 1.07 µm. Exine thickness is ± 2.02 µm, sexine and nexine equal in thickness. Pollen is monoporate, pori circular, ± 1.58 µm, annulus ± 6.84 µm in diameter, annulus width ± 1.15 µm and ornamentation is psilate.

3. *Digitaria abludens* (Roem. & Schult.) Veldkamp

Pollen grains are monads, prolate spheroidal in shape. The polar axis is ±24.02 µm and equatorial axis diameter is ±23.73µm. P/E ratio is ±1.01 µm. Exine thickness is ± 2.52 µm, sexine (1.57µm) thicker than nexine (± 0.95µm). Pollen is monoporate, pori circular, ±2.16µm, annulus ± 4.92µm in diameter, annulus width ± 1.60 µm and ornamentation is psilate.

4. *Digitaria bicornis* (Lam.) Roem. & Schult.

Pollen grains are monads, prolate spheroidal and sub prolate in shape. The polar axis is ± 25.72 µm and equatorial axis diameter is ± 22.67 µm. P/E ratio is ± 1.13 µm. Exine thickness is ± 1.63 µm, sexine thicker (± 0.95 µm) than nexine (± 0.68 µm). Pollen is monoporate, pori circular, ± 1.80 µm, annulus ± 4.27 µm in diameter, annulus width ± 1.25 µm and ornamentation is psilate.

5. *Digitaria ciliaris* (Retz.) Koeler

Pollen grains are monads, prolate spheroidal in shape. The polar axis is ± 27.76 µm and equatorial axis diameter is ± 27.03µm. P/E ratio is ± 1.02 µm. Exine thickness is ± 2.21 µm, sexine (± 1.14 µm) and nexine (± 1.07 µm) almost equal. Pollen is monoporate, pori circular, ± 2.88 µm, annulus ± 6.17 um in diameter, annulus width ± 1.59 µm and ornamentation is psilate.

6. *Digitaria longiflora* (Retz.) Pers.

Pollen grains are monads, oblate spheroidal and few prolate spheroidal in shape. The polar axis is ± 25.56 µm and equatorial axis diameter is ± 25.66 µm. P/E ratio is ± 0.99 µm. Exine thickness is ± 2.28 µm, sexine (± 1.22 µm) slightly thicker than nexine (± 1.06 µm). Pollen is monoporate, pori circular, ± 1.60 µm, annulus ± 6.47 µm in diameter, annulus width ±1.36 µm and ornamentation is psilate.

7. *Echinochloa colona* (L.) Link

Pollen grains are monads, prolate spheroidal and sub prolate in shape. The polar axis is ± 44.57 µm and equatorial axis diameter is ± 38.86 µm. P/E ratio is ± 1.14 µm. Exine thickness is ± 2.9 µm, sexine (± 1.35 µm) slightly thicker than nexine (± 1.55 µm). Pollen is monoporate, pori circular, ± 1.78 µm, annulus ± 6.94 um in diameter, annulus width ± 2.27 µm and ornamentation is psilate.

8. *Echinochloa crus-galli* (L.) P. Beauv.

Pollen grains are monads, prolate spheroidal in shape. The polar axis is ± 28.24 µm and equatorial axis diameter is ± 27.65 µm. P/E ratio is ± 1.03µm. Exine thickness is ± 2.32 µm, sexine (± 1.24 µm) slightly thicker than nexine (± 1.08 µm). Pollen is monoporate, pori circular, ± 1.71µm, annulus ± 5.71 um in diameter, annulus width ± 1.80 µm and ornamentation is psilate.

9. *Megathyrsus maximus* (Jacq.) B.K.Simon & S.W.L. Jacobs

Pollen grains are monads, oblate spheroidal and prolate spheroidal in shape. The polar axis is ± 28.17 µm and equatorial axis diameter is ± 28.87 µm. P/E ratio is ± 0.97

µm. Exine thickness is ± 1.58 µm, sexine (± 0.91 µm) thicker than nexine (± 0.67 µm). Pollen is monoporate, pori circular, ± 1.92 µm, annulus ± 5.46 µm in diameter, annulus width ± 2.05 µm and ornamentation is psilate.

10. ***Melinis repens*** (Willd.) Zizka
Pollen grains are monads, prolate spheroidal in shape. The polar axis is ± 33.67 µm and equatorial axis diameter is ± 31.90 µm. P/E ratio is ± 1.05 µm. Exine thickness is ± 2.56 µm, sexine (± 1.31 µm) almost as thick as nexine (± 1.25 µm). Pollen is monoporate, pori circular, ± 2.03µm, annulus ± 6.97 um in diameter, annulus width ± 1.25 µm and ornamentation is psilate.

11. ***Oplismenus compositus*** (L.) P. Beauv.
Pollen grains are monads, prolate spherodial in shape. The polar axis is ± 27.44 µm and equatorial axis diameter is ± 26.86 µm. P/E ratio is ± 1.03 µm. Exine thickness is ± 2.07 µm, sexine (± 1.04 µm) as thick as nexine (± 1.03 µm). Pollen is monoporate, pori circular, ± 1.60 µm, annulus ± 4.70 um in diameter, annulus width ± 2.07 µm and ornamentation is psilate.

12. ***Panicum curviflorum*** Hornem.
Pollen grains are monads, oblate spheroidal and prolate spheroidal in shape. The polar axis is ± 30.81 µm and equatorial axis diameter is ± 31.56 µm. P/E ratio is ± 0.97 µm to 100.5 µm. Exine thickness is ± 2.87 µm, sexine (± 1.35 µm) thinner than nexine (±1.52 µm). Pollen is monoporate, pori circular, ± 1.94 µm, annulus thick, ± 7.08 µm in diameter, annulus width ± 1.09 µm and ornamentation is psilate.

13. ***Paspalum distichum*** L.
Pollen grains are monads, oblate spheroidal in shape. The polar axis is ± 25.47 µm and equatorial axis diameter is ± 27.69 µm. P/E ratio is ± 0.91 µm. Exine thickness is ± 1.32 µm, sexine (± 0.70 µm) and nexine (± 0.62 µm) almost same in thickness. Pollen is monoporate, pori circular, ± 2.41 µm, annulus ± 5.58 µm in diameter, annulus width ± 2.02 µm and ornamentation is psilate.

14. ***Paspalum scrobiculatum*** **L.**
Pollen grains are monads, oblate spheroidal in shape. The polar axis is ± 26.86 µm and equatorial axis diameter is ± 29.19 µm. P/E ratio is ± 0.92 µm. Exine thickness is ± 1.74 µm, sexine (± 0.93 µm) slightly thicker than nexine (± 0.81 µm). Pollen is monoporate, pori circular, ± 1.74 µm, annulus ± 3.93 µm in diameter, annulus width ±1.52 µm and ornamentation is psilate.

15. ***Sacciolepis indica*** **(L.) Chase**
Pollen grains are monads, prolate spheroidal and sub prolate in shape. The polar axis is ± 34.11 µm and equatorial axis diameter is ± 25.18 µm. P/E ratio is ± 1.35 to 1.40 µm. Exine thickness is ± 1.65 µm, sexine (± 0.86 µm) and nexine (± 0.79 µm) almost same in thickeness. Pollen is monoporate, pori circular, ± 2.03 µm, annulus ± 5.23µm in diameter, annulus width ± 1.32 µm and ornamentation is psilate.

16. ***Setaria flavida*** (Retz.) Veldkamp
Pollen grains are monads, prolate spheroidal in shape. The polar axis is ± 30.99 µm and equatorial axis diameter is ± 29.92 µm. P/E ratio is ± 1.03 µm. Exine thickness is ± 1.77 µm, sexine (± 0.94 µm) slightly thicker than nexine (± 0.83 µm). Pollen is monoporate, pori circular, ± 2.52 µm, annulus ± 6.30 µm in diameter, annulus width ± 1.40 µm and ornamentation is psilate.

17. ***Setaria pumila*** **Roem. & Schult.**
Pollen grains are monads, prolate spheroidal and sub prolate in shape. The polar axis is ± 28.09 µm and equatorial axis diameter is ± 27.75 µm. P/E ratio ranges ± 1.01 µm to 1.17 µm. Exine thickness is ± 2.09 µm, sexine (± 1.36 µm) double compare to nexine (± 0.73 µm) in thickness. Pollen is monoporate, pori circular, ± 2.03 µm, annulus ± 6.66 µm in diameter, annulus width ± 0.85 µm and ornamentation is psilate.

18. ***Setaria verticillata*** **(L.) P. Beauv.**
Pollen grains are monads, prolate spheroidal in shape. The polar axis is ± 30.75 µm and equatorial axis diameter is ± 30.36 µm. P/E ratio is ± 1.01 µm. Exine thickness is ± 1.8 µm, sexine (± 0.92 µm) slightly thicker than nexine (± 0.88 µm). Pollen is monoporate, pori circular, ± 4.65 µm, annulus ± 8.45 µm in diameter, annulus width ± 0.90 µm and ornamentation is psilate.

19. ***Urochloa ramosa*** **(L.) T.Q. Nguyen**
Pollen grains are monads, prolate spheroidal in shape. The polar axis is ± 29.92 µm and equatorial axis diameter is ± 29.75 µm. P/E ratio is ± 1.00 µm. Exine thickness is ± 2 µm, sexine (± 1.08 µm) slightly thicker than nexine (± 0.92 µm). Pollen is monoporate, pori circular, ± 1.39 µm, annulus ± 4.70 µm in diameter, annulus width ± 1.07 µm and ornamentation is psilate.

20. ***Urochloa trichopus*** **Stapf**
Pollen grains are monads, oblate spheroidal and prolate spheroidal in shape. The polar axis is ± 25.07µm and equatorial axis diameter is ± 25.19 µm. P/E ratio is ± 0.99 µm. Exine thickness is 1.88, sexine (± 0.95 µm) and nexine (± 0.93 µm) equal in thickness. Pollen is monoporate, pori circular, ± 2.04 µm, annulus ± 5.49 µm in diameter, annulus width ± 1.35 µm and ornamentation is psilate.

Conclusion
This study examined a diverse collection of 20 grass species from the tribe Paniceae of Poaceae family, representing 12 different genera from Ananthagiri hills. This study shows that all the species present in tribe Paniceae are stenopalynous and monoporate. The ornamentation is psilate in each pollen grain in light microscopic studies. The comprehensive data presented in this study will serve as a valuable reference for future research in the field of palynology. From this study, it has been observed that there are variations in pollen grains qualitative and quantitative characteristics, in various species of the same tribe in its shape, polar and equatorial axis diameter, exine thickness, annulus diameter and width, pori size and diameter. These variations are useful for generic and specific identification, differentiation and delimitation in the tribe.

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