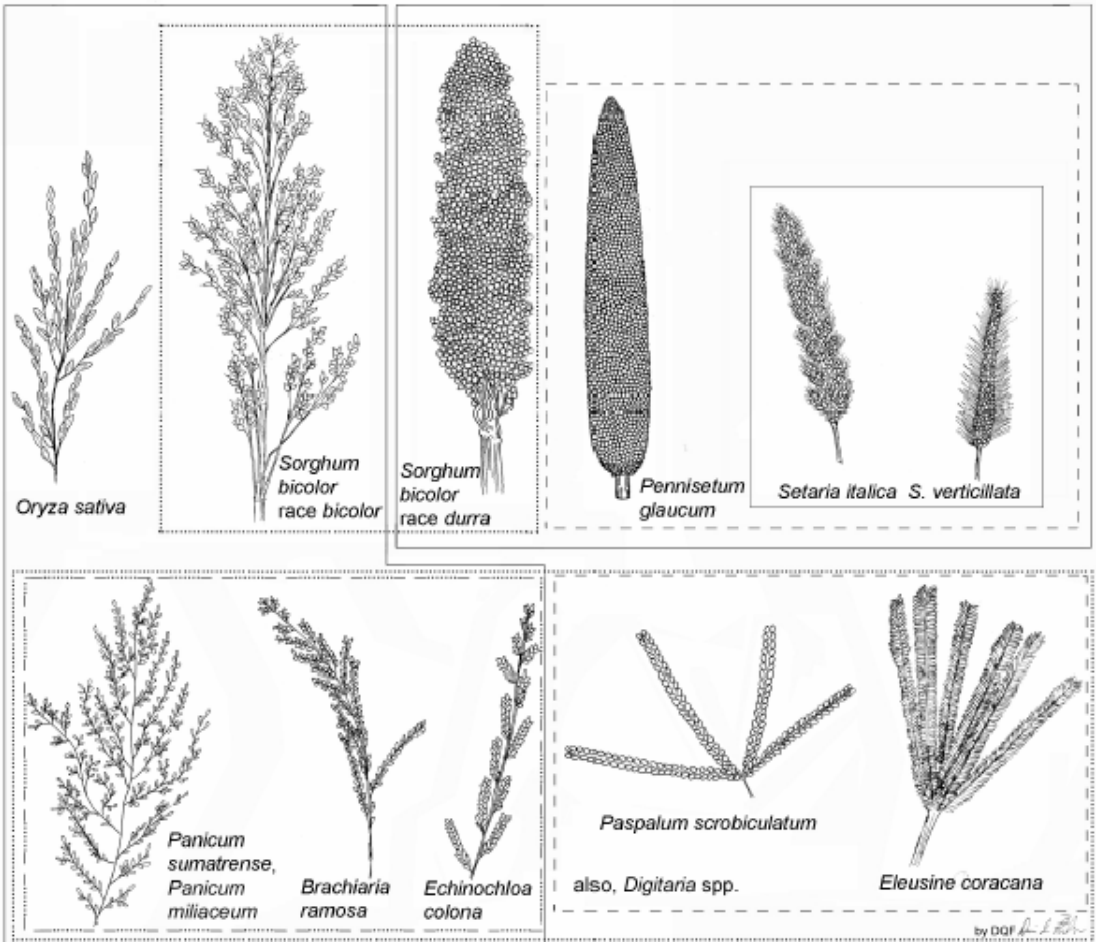
Institute of Archaeology
University College London
26 January, 2006

MG101 Archaeobotany in Practice

A MILLET ATLAS
Some Identification Guidance

Illustrations by Dorian Q Fuller



Some Millet fact tables by DQ Fuller

Table 1. Old World Cultivated 'Millets'

Species	Common Name	Region of Origin and Cultivation	References
Brachiaria ramosa (L.) Stapf. (syn. *Urochloa ramosa* (L.) R. D. Webster)	Browntop millet, pedda-sama	South India	Fuller et al. 2004; Hulse *et al.* 1980; De Wet 1995a; Kimata et al. 2000
Brachiaria deflexa (Schumach) C. E. Hubbard var. *sativa* Porteres	Guinea millet, Animal Fonio	Fouta Djalon Highlands, Guinea, W. Africa	Porteres 1976; Zeven & De Wet 1982: 127; Borlaug *et al.* 1996: 237
Digitaria cruciata (Ness) A. Camus var. *esculenta* Bor	Raishan	Khasi Hills, Assam; Hill tribes of Vietnam	Bor 1955; Singh & Arora 1972
Digitaria exilis (Kippist) Stapf.	Fonio, Acha, Fundi	West Africa	Porteres 1976; Zeven & De Wet 1982: 128; Borlaug *et al.* 1996: 59ff
Digitaria iburua Stapf.	Black Fonio, Iburu, Hungry Rice	West Africa	Porteres 1976; Zeven & De Wet 1982: 128; Borlaug *et al.* 1996: 59ff
Digitaria sangiuinalis (L.) Scop.	Harry crabgrass	Eurasian origin; cultivated in Kashmir, formerly in Europe	Porteres 1955; De Wet 1995
Echinochloa colona ssp. frumentacea (Link) De Wet, Prasada Rao, Mengesha and Brink (=*E. frumentacea* Link)	Sawa Millet	Peninsular India(?), also cultivated in Himalayas	De Wet *et al.* 1983c; Hilu 1994
Echinochloa crus-galli var. *utilis* Yabuno	Barnyard Millet	Japan	Yabuno 1987; Hilu 1994
Eleusine coaracana (L.) Gaertn.	Finger Millet, ragi	East African highlands	Hilu and De Wet 1976; Hilu and Johnson 1992
Eragrostis tef (Zucc.) Trotter	Teff	Ethiopian highlands	Zeven & De Wet 1982: 130
Panicum miliaceum L. ssp. *Miliaceum*	Proso millet	China, and SE Europe(?)/ Caucasus; cultivated throughout South Asia	Zeven and De Wet 1982; Zohary and Hopf 2000; Jones 2004
Panicum sumatrense Roth. ex Roem. & Schult. Subsp. *sumatrense* (syn. *P. miliare* auct. pl.),	Little millet, samai	India, especially peninsula	De Wet *et al.* 1983a
Paspalum scrobiculatum L.	Kodo millet	India, especially peninsula and Himalayas	De Wet *et al.* 1983b
Pennisetum glaucum (L.) R. Br (= *P. americium* (L) Leeke)	Pearl Millet	West African Savannah, cultivated through India	Tostain 1994; 1998
Setaria italica (L.) P. Beauv ssp. *italica*	Foxtail millets	China, and SE Europe(?)/ Caucasus, cultivated throughout South Asia and in parts of Southeast Asia	De Wet *et al.* 1979; Prasada Rao *et al.* 1987; Jones 2004
Setaria pumila (Poir.) Roem & Schult. (syn. *S. glauca* auct. pl.) [domesticated population reported]	Yellow foxtail millet, korali	India	Gammie 1911; De Wet 1995a
S. verticillata (L.) P. Beauv. [Domesticated populations?]	Bristley foxtail millet	South India	Fuller et al. 2004; Gammie 1911
Sorghum bicolour ssp. *bicolour*	Sorghum, jowar	African Savannahs, cultivated throughout South Asia	Harlan 1995

Table 2. New World millets

Species	Common Name	Region of Origin and Cultivation	References
Panicum sonoraum		American Southwest	De Wet 1995a
Setaria macrostachya		Mesoamerica, cultivated(?) before rise in importance of Maize	Pearsall 1995; Piperno and Pearsall 1998

Preliminary key for millet caryopsis identification (from Fuller 1999, PhD thesis)

A. 'Large millets'. Large ovate to roundish plan, with ovate or wedge-shaped section, relatively long and wide scutellum (1/2-2/3 caryopsis length). Hilum and scutellum tip often projecting (Fig. 6.7). *Sorghum, Pennisetum glaucum*
a. ovate plan, shallow scutellum, scutellum ½-2/3 caryopsis length, narrowly ovate longitudinal section. *Sorghum bicolor* subsp. *arundinaceum*
b. widely ovate to nearly round plan, shallow scutellum, generally much larger sizes (>3mm length when fresh) with width almost equal to loength (nearly circular). *Sorghum bicolor* subsp. *bicolor*
c. ovate plan, scutellum length usually 2/3-3/4 caryopsis length, total length generally <3mm (fresh) or if longer extremely narrow (<2mm when fresh), deep scutellum (approx. 1/3 total seed volume). *Pennisetum glaucum*

<u>'Small millets'</u>
B. scutellum length definitely less than 1/2 length, generally closer to 1/3. *Eleusine* spp, *Paspalum* spp
a. round or nearly so in plan (i.e. L:W approx. 1): cultivars
1. linear hilum: *Paspalum scrbiculatum*
2. angular/irregular-globose in transverse section: *Eleusine coracana*
b. elliptical (-ovate) in plan (L:W ratio generally 1.5-2): mainly wild spp.
3. linear hilum, depressed ovate or semi-circular in transverse section: *Paspalum* spp, e.g. *P. costatum, P. vaginatum*
4. hilum more or less round, located at the basal end of the seed on an edge distance from the ventral surface (separated by either a disentangle or else a smooth curve). some Eragrostidae
4i. striate, rugose or pusticulate surface of testa, generally trigonous in transverse section: *Eleusine* spp, e.g. *E. indica.* Some other Eragrostid genera fall here, e.g. *Dactyloctinum aegptiaca*
4ii. smooth: *Eragrostis* spp., e.g. *E. tef.* (Ethiopian crop)

C. scutellum length around 1/2, but ranging upto 2/3: *Digitaria, Panicum,* some *Pennisetum* spp.
a. elliptical and elongate (with l:w ratio of 1.5-2+): *Digitara,* some *Panicum* spp., some *Pennisetum* spp.
5. caryopsis apex (abaxial end) usually acute, scutellum apex acute-slightly rounded: some *Panicum* spp., e.g. *P. antidotale, P. repens,* some *Digitaria* spp., e.g. *D. exilis* (Fonio millet of West Africa), some *Pennisetum* spp., e.g. *P. polystachion* .
Additional criteria: scutellum cavity "shallow," thin and convex in *Panicum* spp., scutellum cavity 'deep' with concave to straight longitudinal section in *Pennisetum* and *Digitaria.*
6. caryopsis apex well-rounded, scutellum apex well-rounded. Possible additional criteria: distinct size difference (insufficient comparative material to confirm).

6i. *Pennisetum alopecuroides*

6ii. *Digitaria cruciata*

b. widely ovate (with L:W generally 1-1.5); apex (abscutellumnal) end of seed usually somewhat acute (i.e. pointed): *Panicum* crops *P.sumatrense, P. miliaceum*), some *Digitaria* spp.

Additional criteria: scutellum "shallow," thin and convex to straight in lengthwise section.

7. L:W ratio closer to 1.5, smaller, L usually <2mm fresh, <1.4mm mm charred [1], *P. sumatrense*

8. L:W ratio closer to 1, larger, L usually >2mm fresh, 1.3-2 mm charred [2], *P. miliaceum*

9. *Digitaria* spp., e.g. *D. longiflora*

D. scutellum length markedly longer than 1/2 usualy exceeding 2/3; scutellum "deep," thick and straight to concave in lengthwise section: *Setaria* spp., *Echinochloa* spp., *Brachiaria ramosa*

a. plan ellipsoidal, with maximum width near center; hilum obovate, small, usually 15-20% caryopsis length

10. apex of scutellum acute or obtuse, sides of scutellum diverging;

10i. *Setaria italica*, larger, scutellum generally narrower with acute apex

10ii. *Brachiaria ramosa* , somewhat smaller and flatter, scutellum general wider with rounded apex

11. apex of scutellum rounded, sides of scutellum parallel, nearly semi-circular in cross-section: *Setaria pumila*, sometimes *S. verticillata* (which is smaller than *S. pumila*). Other *Setaria* spp. fall out here, e.g. *S. sphaceleata* (which is usually smaller than *S. verticillata*)

a. maximum width displaced towards scutellum end

12. parallel sided scutellum, seed narrowly ovate (L:W ratio ca. 1.5), caryopsis apex sometimes pointed: small *Setaria*, e.g *S. verticillata* (also 11, above).

13. apex of scutellum rounded; hilum widely ovate (L:W ratio ca. 1), caryopsis apex never with point: *Echinochloa*

13i. Sides of scutellum always(?) parallel sided[?] *E. crus-galli*

13ii. Side of scutellum always (?) diverging; hilum long, approx. 1/3 length of caryopsis: *E. colona*

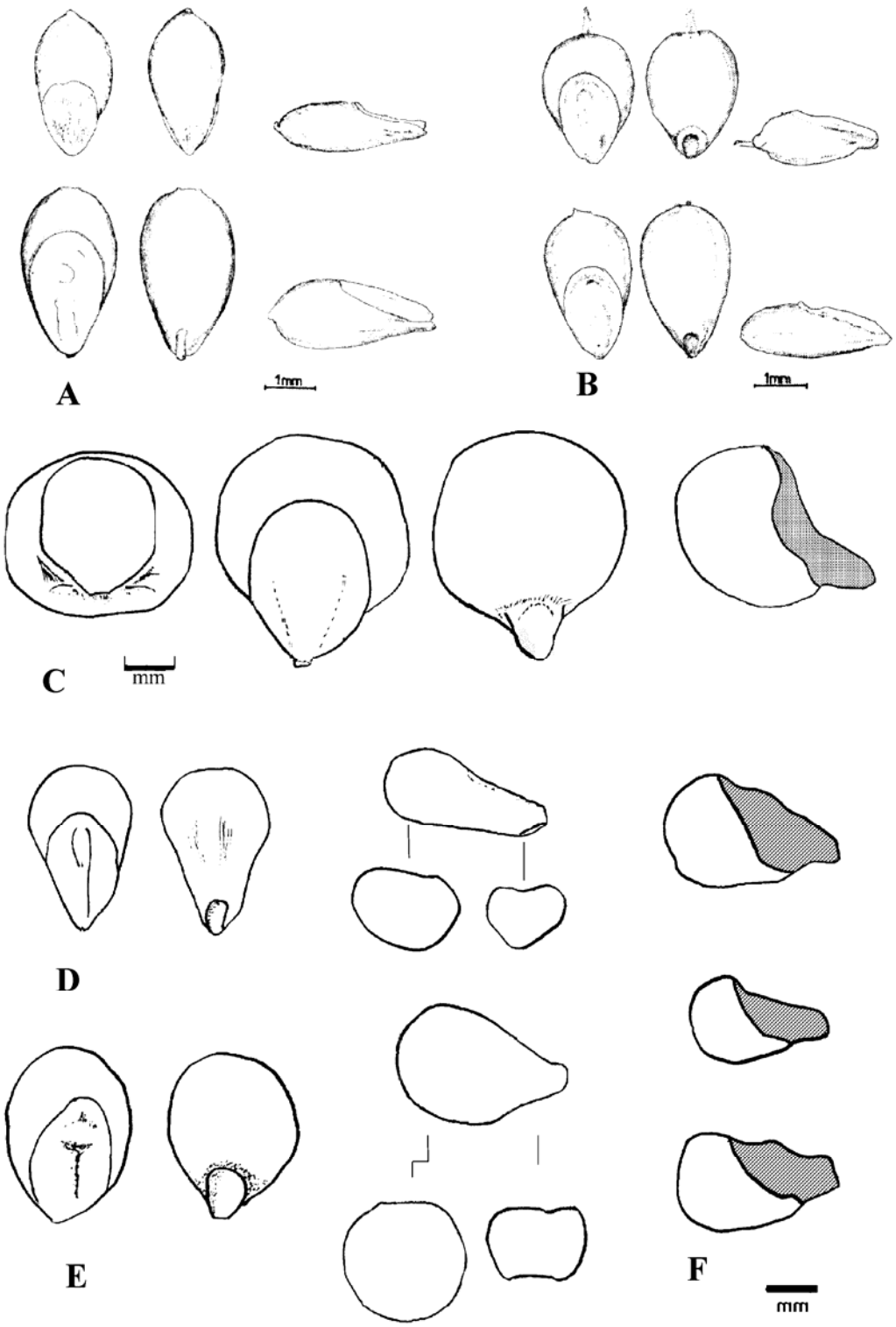


Figure 6.7. The large millets. A. Two examples of *Sorghum bicolor* subsp. *arundinaceum* race virgatum (after Wasylikowa and Kubiak-Martens 1995). B. Two examples of *S. bicolor* subsp. *arundinaceum* race verticiliflorum (after Wasylikowa and Kubiak-Martens 1995). C. *S. bicolor* subsp. *bicolor* race durra, from Dharwad, Karnataka. Note cross-section showing embryo thickness. D. *Pennisetum glaucum*, narrow grain typical of two-seeded spikelets, from Dharwad, Karnataka. E. *P. glaucum*, plump grain typical of one-seeded spikelets, from Dharwad, Karnataka. F. Longitudinal sections of *P. glaucum* examples showing embryo thickness, from Dharwad, Karnataka.

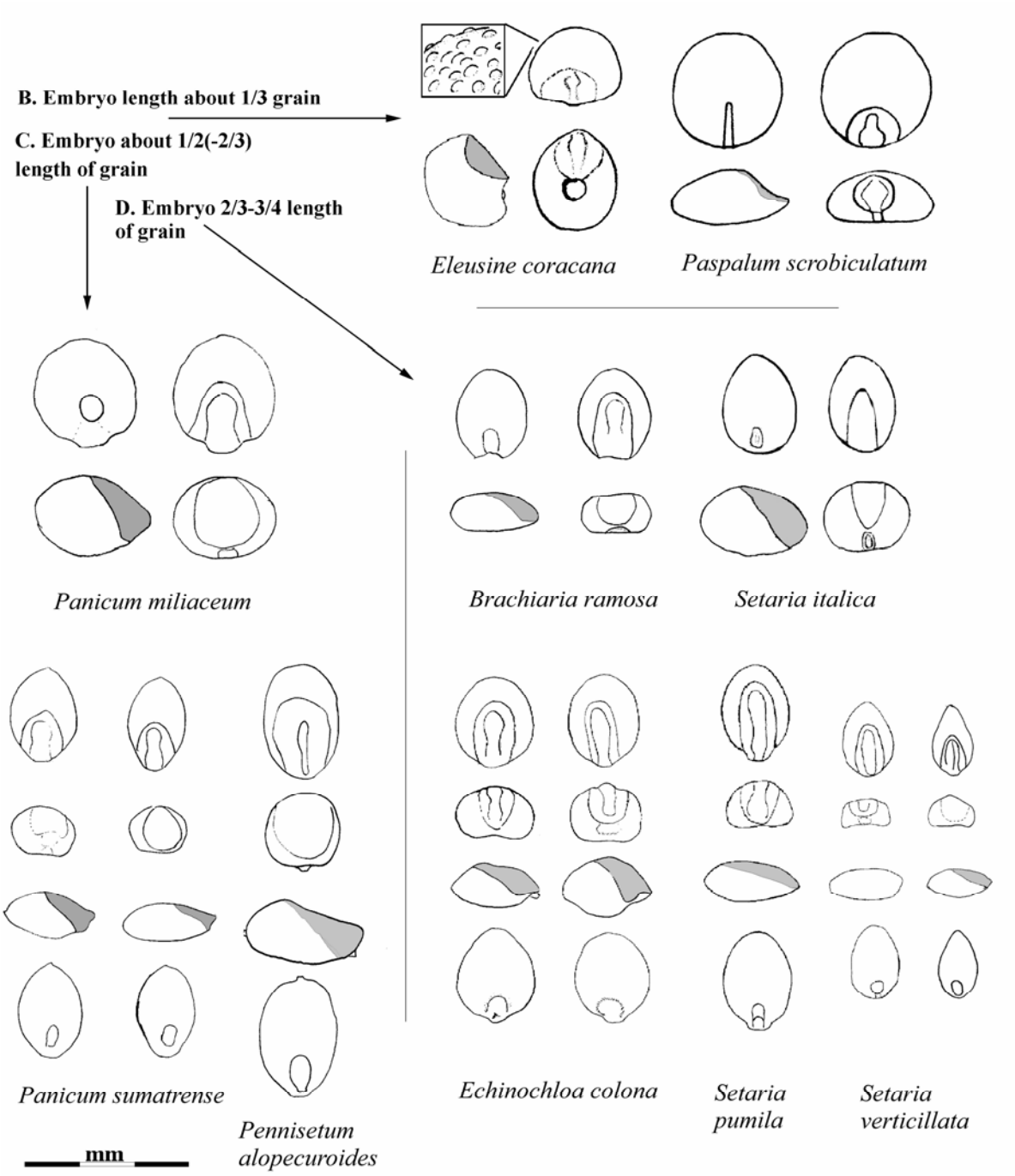
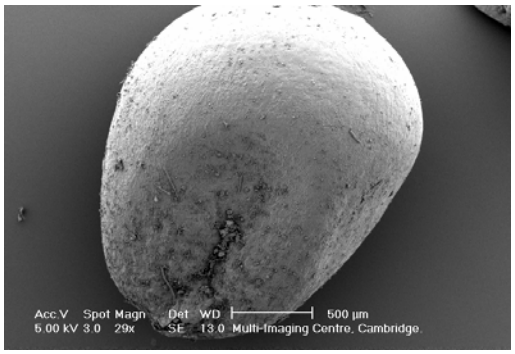
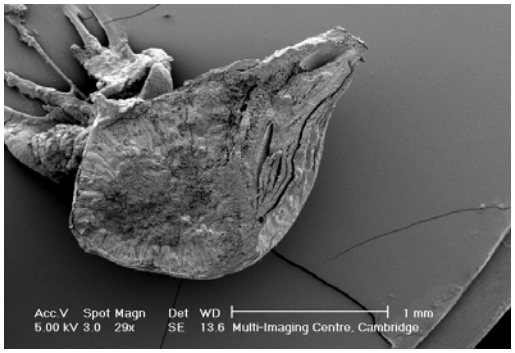
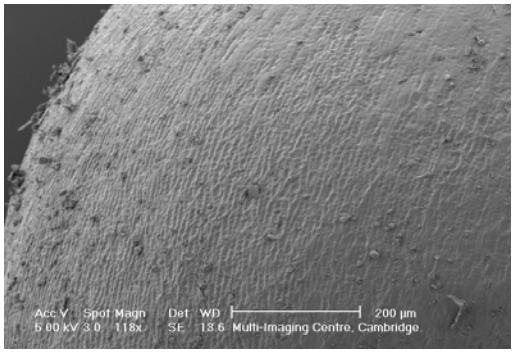


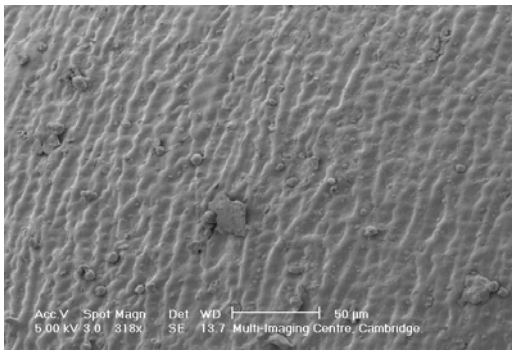
Figure 6.8. The small millets. Divided into basic groups on the basis of proportion of embryo length to length. Illustrations based on a variety of modern comparative material. For descriptive key see Table 6.3.

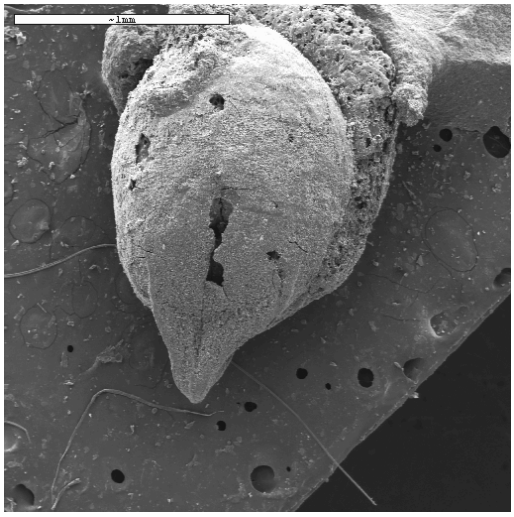
Pennisetum glaucum



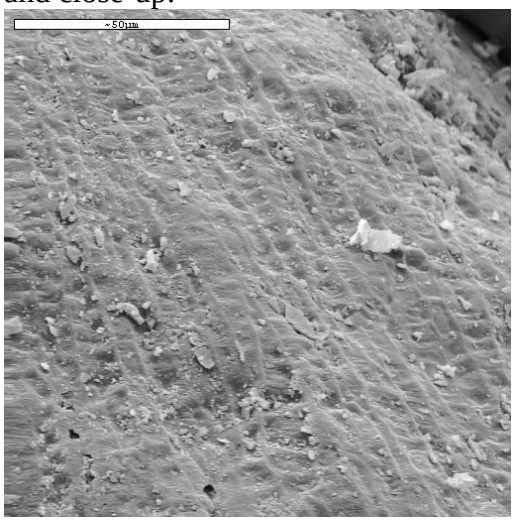


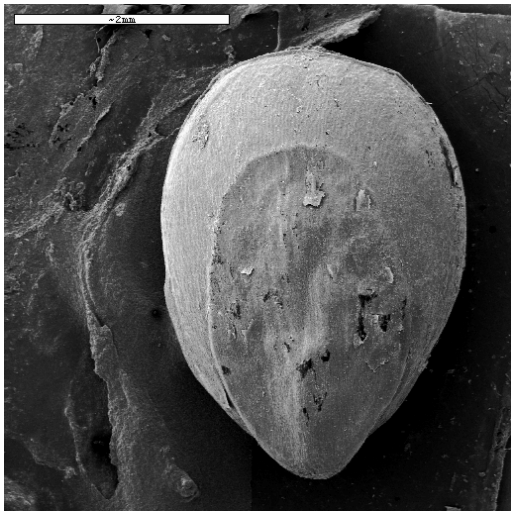




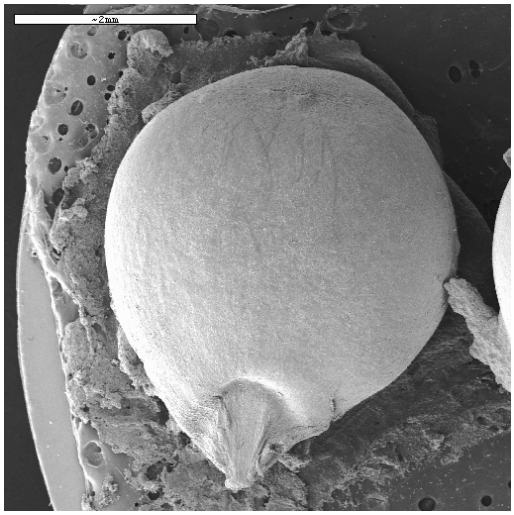


archaeological, Senegal
and close-up:

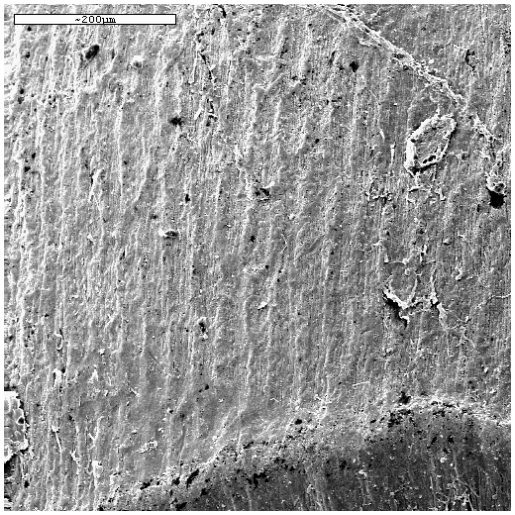




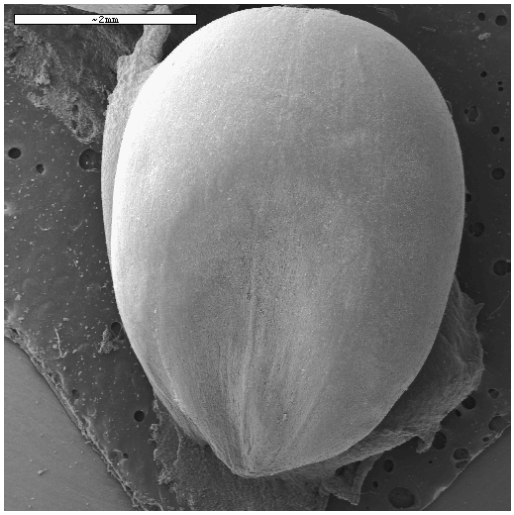
ssp. Arundinaceum



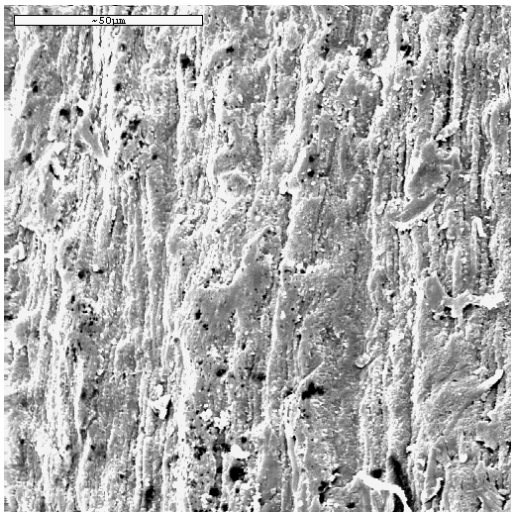
race bicolor



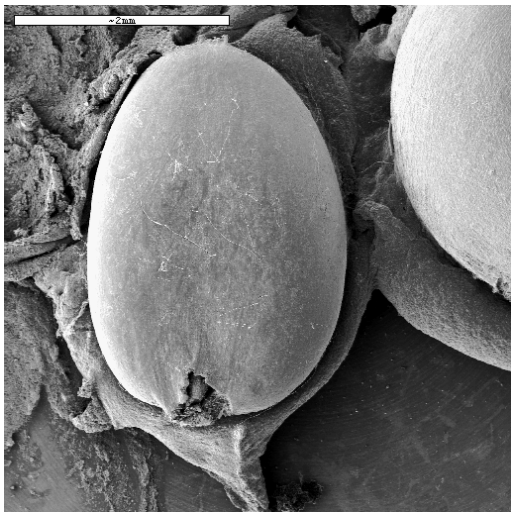
ssp. arundinaceum



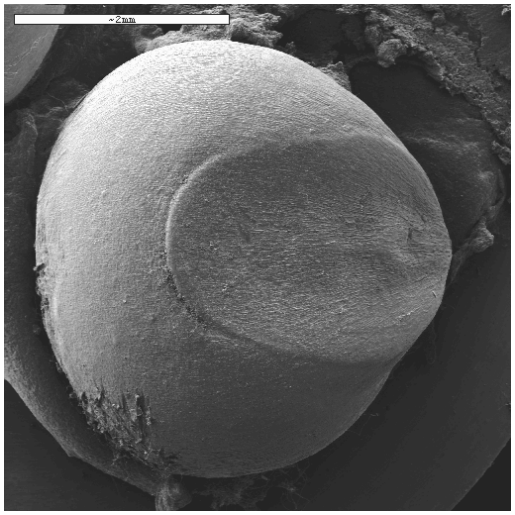
race bicolor



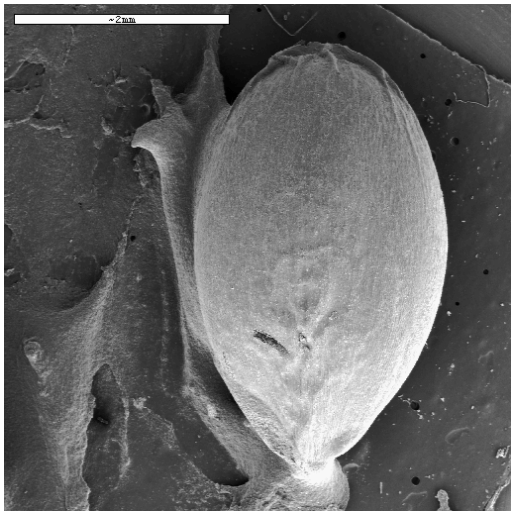
ssp. arundinaceum



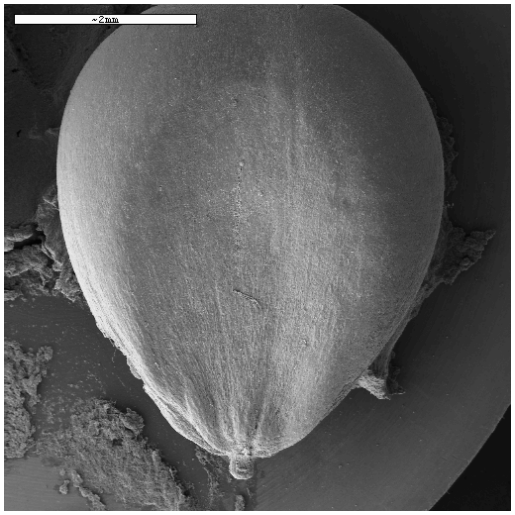
race guinea



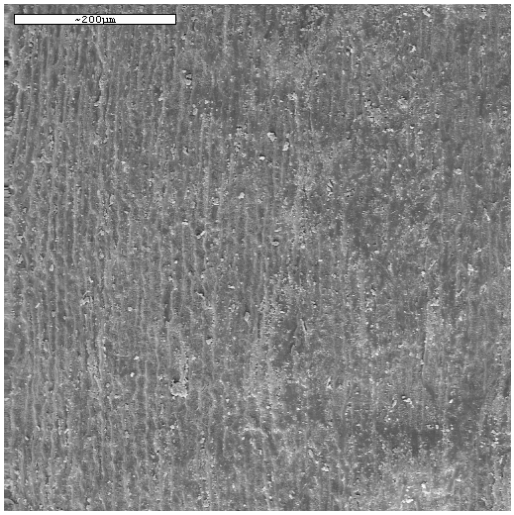
race caudatum



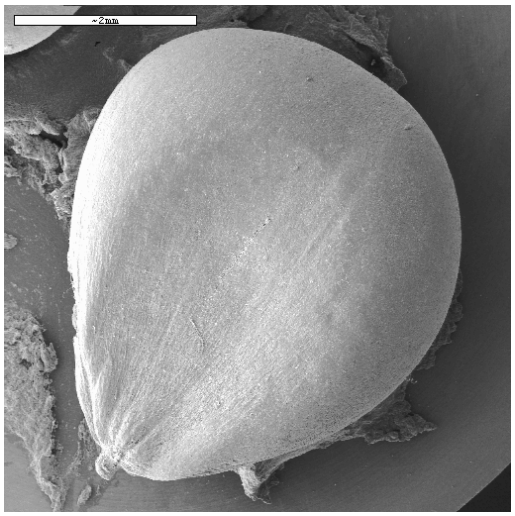
Sorghum halpense



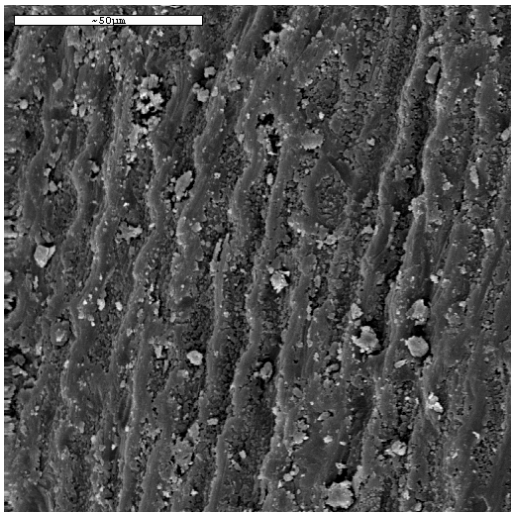
race durra



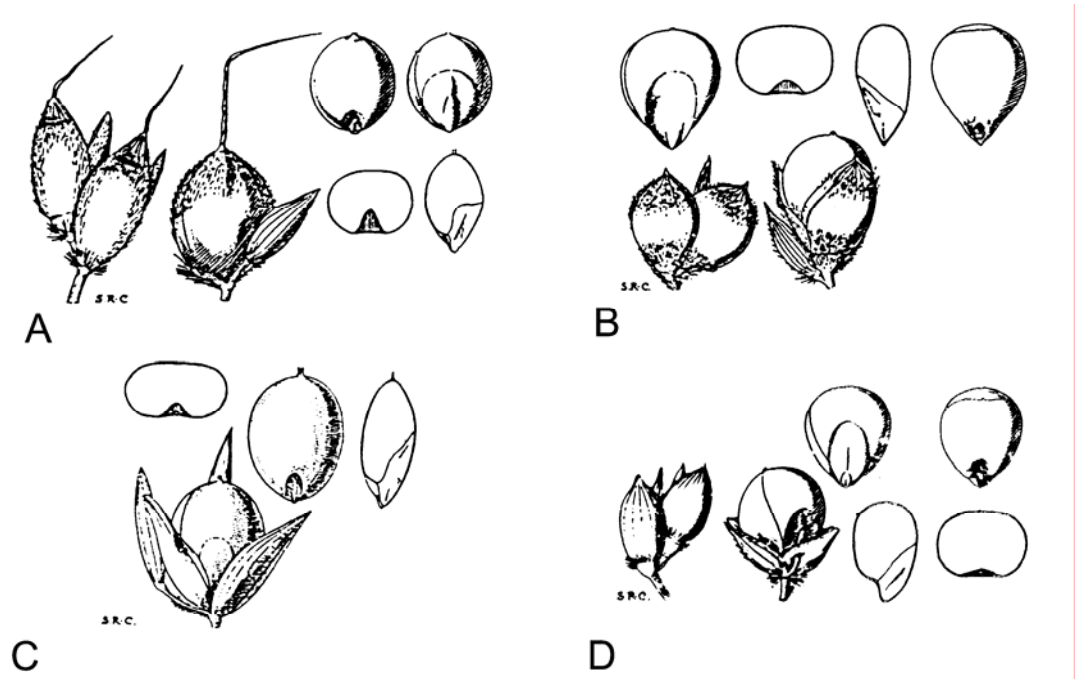
S. halpense



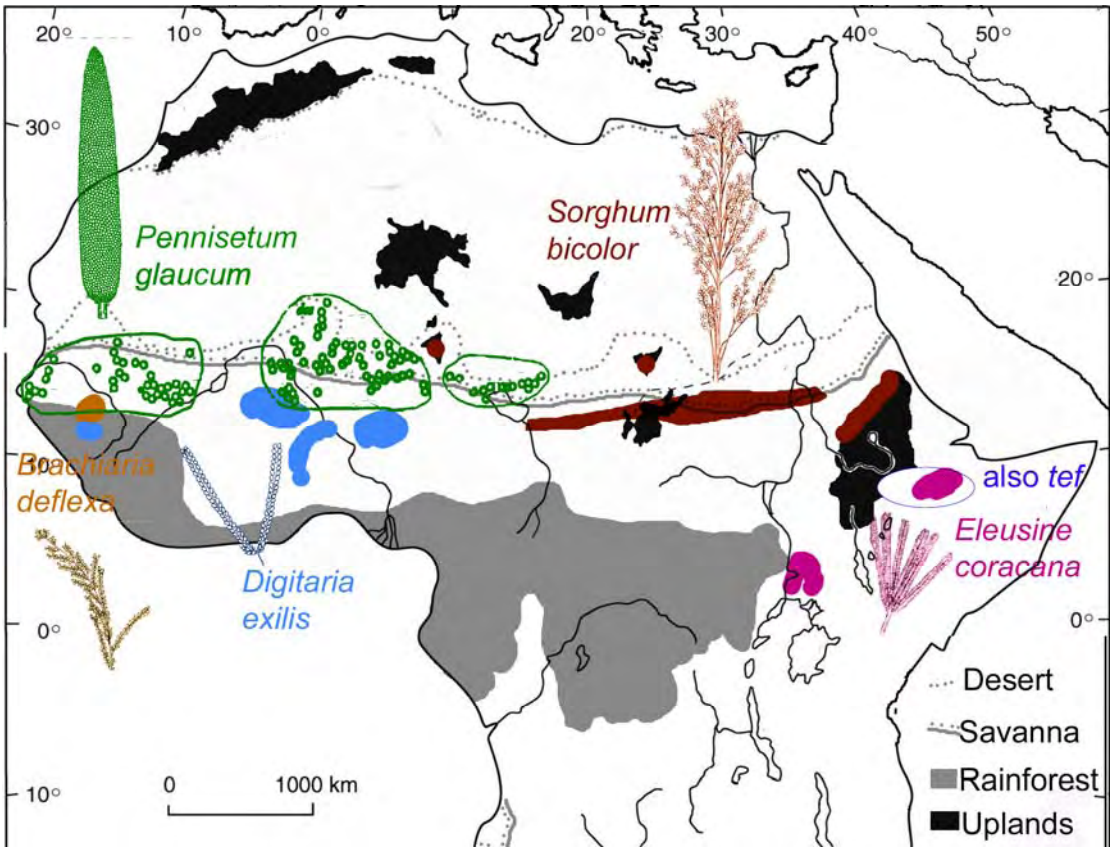
race durra



S. halpense

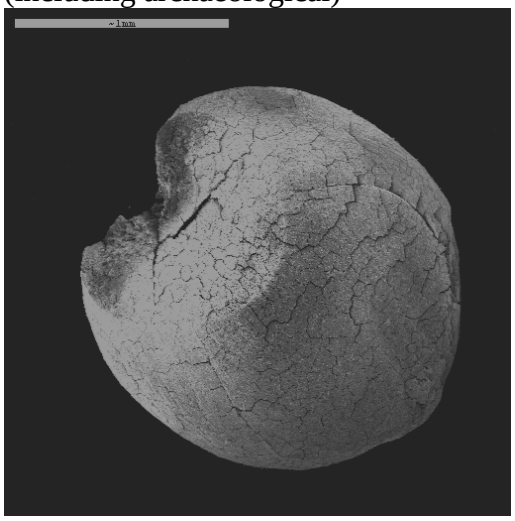


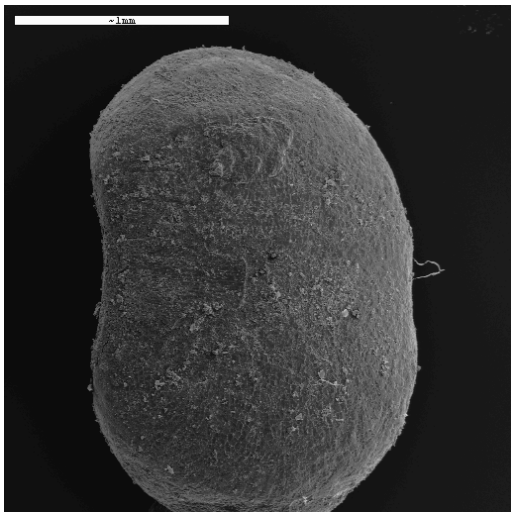
Representatives of sorghum cultivated races (after Snowden 1936): A. bicolor, B. durra, C. guinea, D. caudatum. [not shown, southern African *kafir* race]



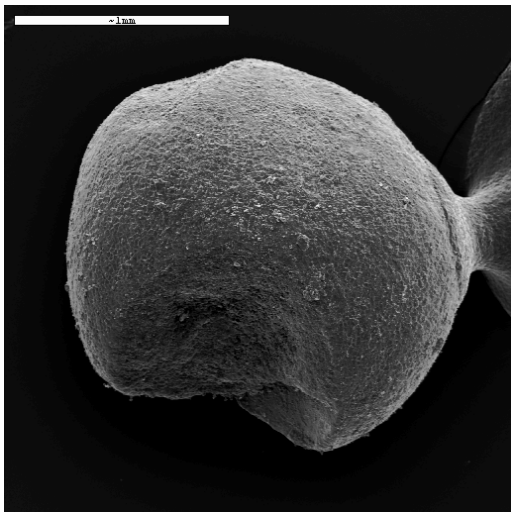
Current best inference of regions of origin for African Millets.

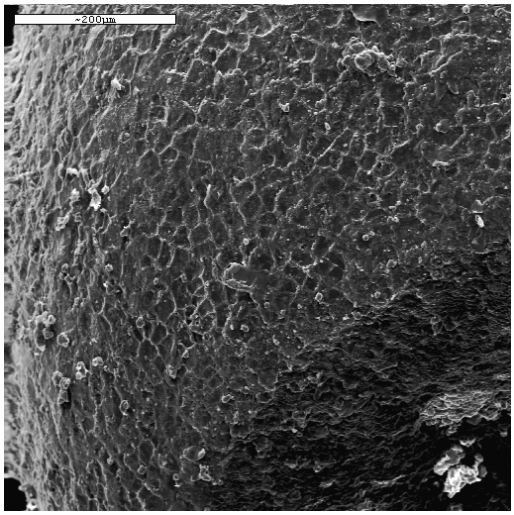
Paspalum scrobiculatum
(including archaeological)





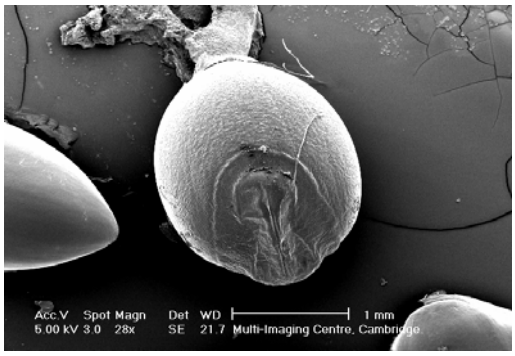
ventral surface, linear hilum

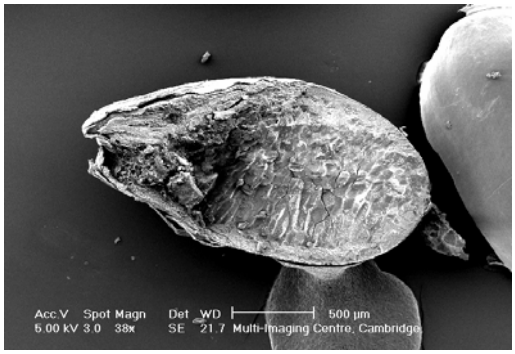


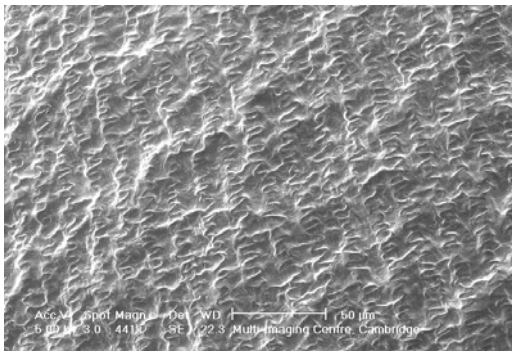


close-up of dorsal pericarp
(archaeological)

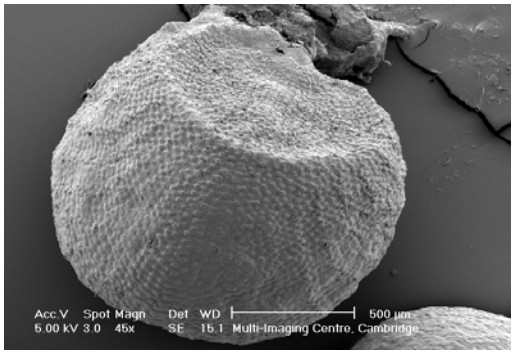
Panicum miliaceum



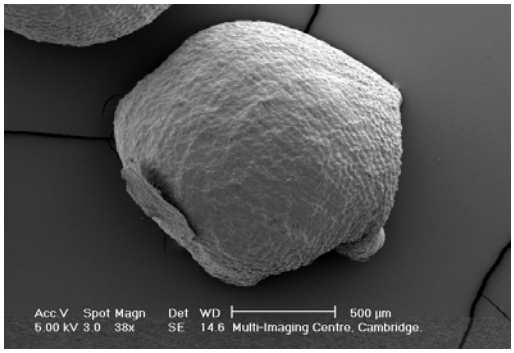




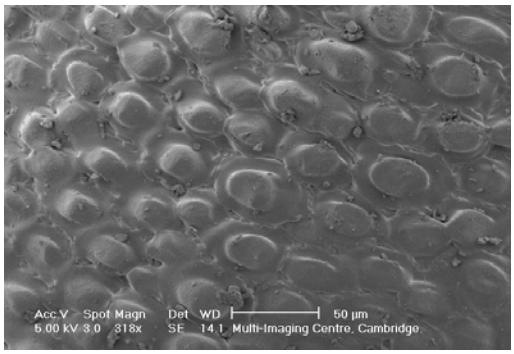
Eleusine coracana



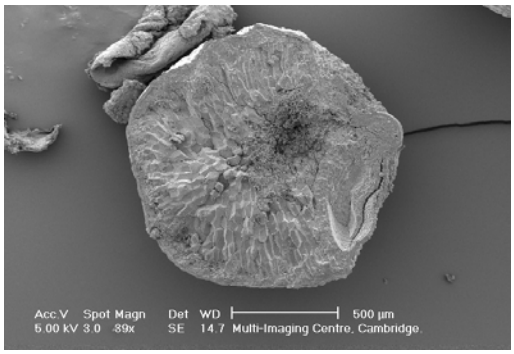
dorsal view



side view, scutellum to right.

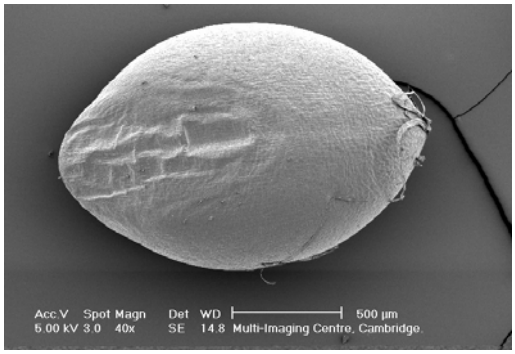


pericarp: pusticulate surface

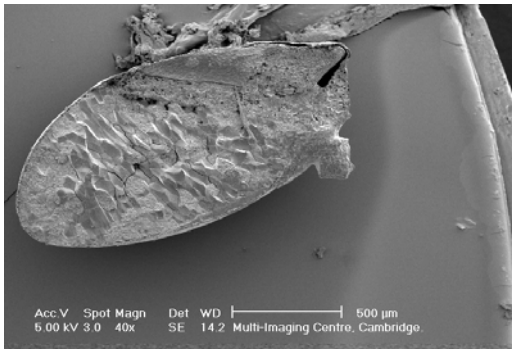


longitudinal cross-section

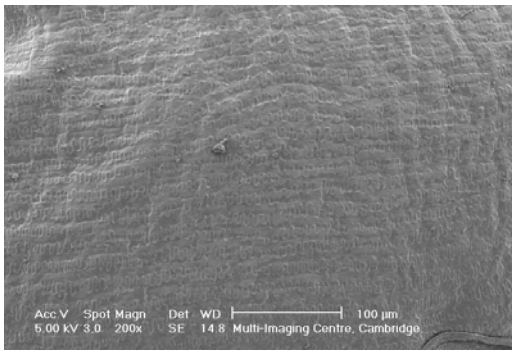
Panicum sumatrense



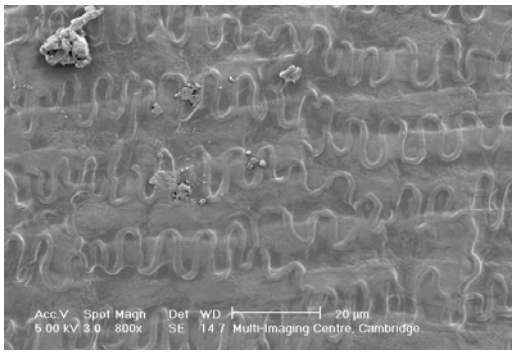
dorsal view



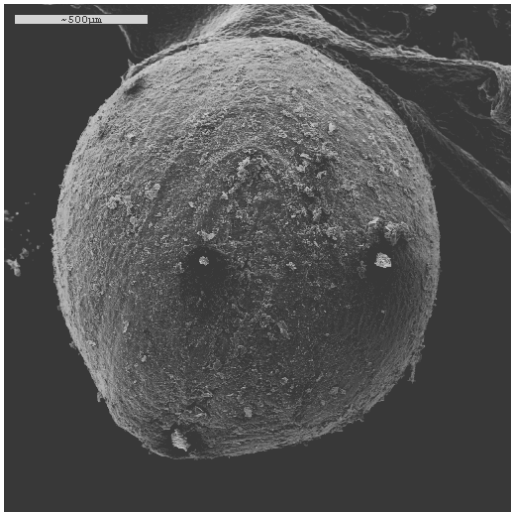
longitudinal cross-section

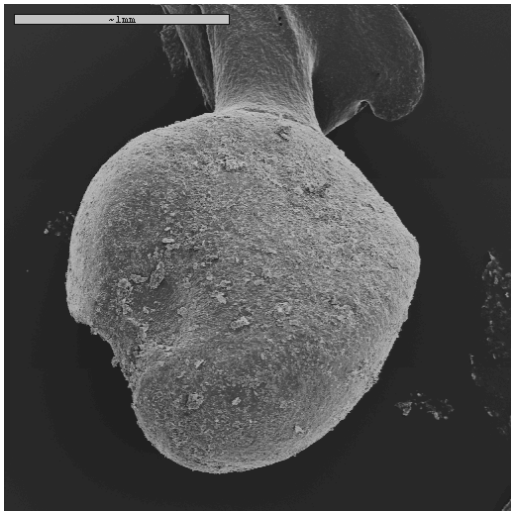


pericarp surface, dorsal

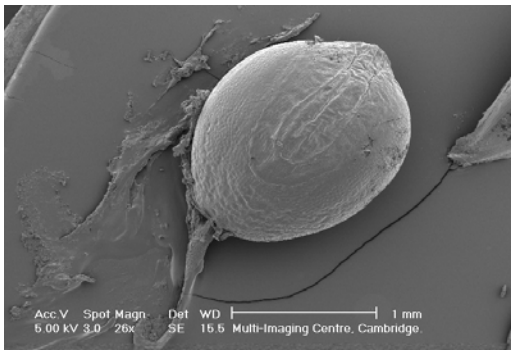


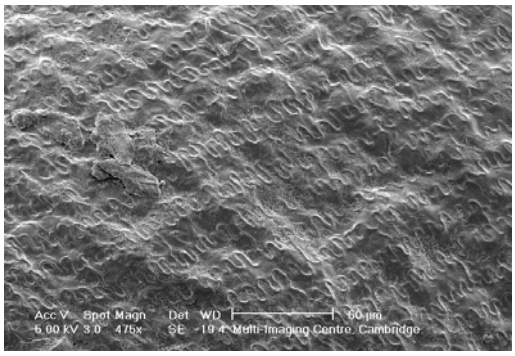
Echinochloa colona



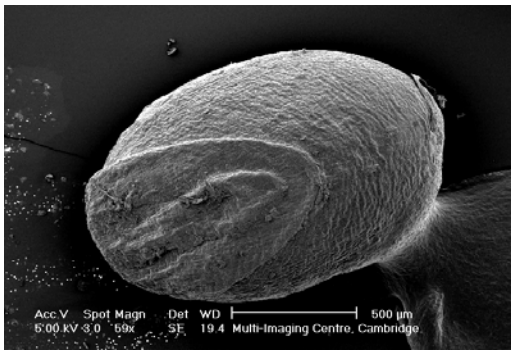


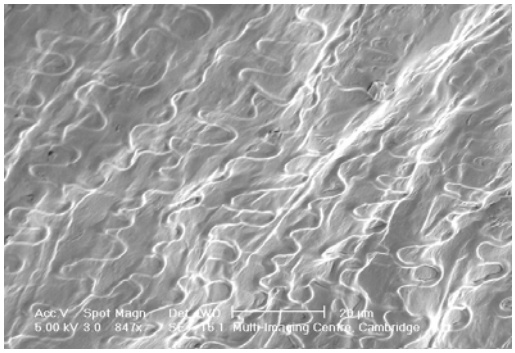
ventral surface, wide hilum

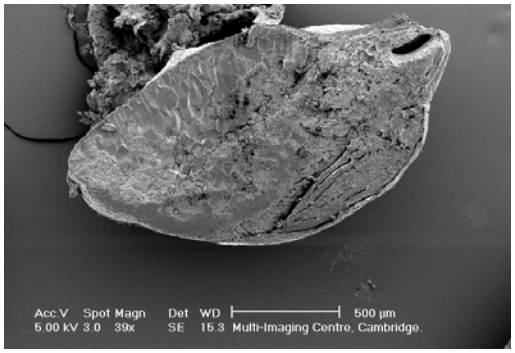


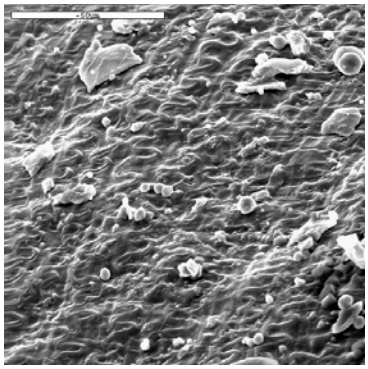


pericarp surface, dorsal surface; close-ups below

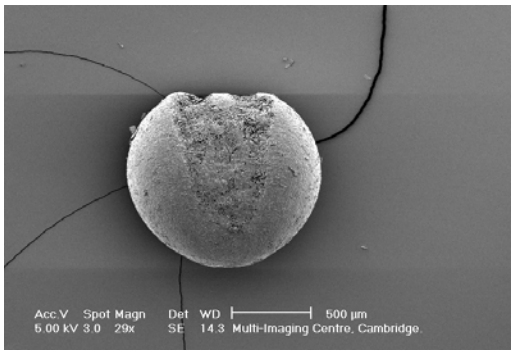


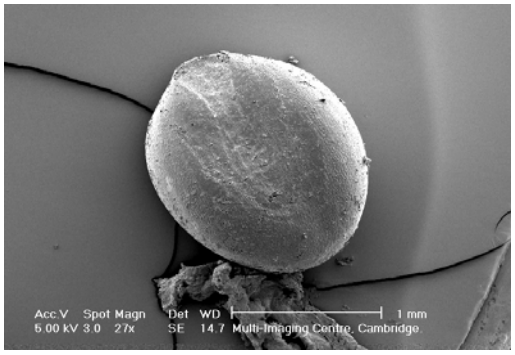


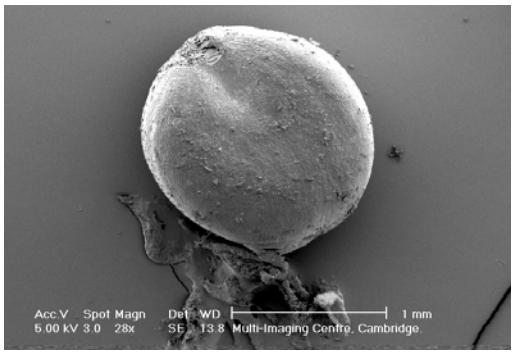


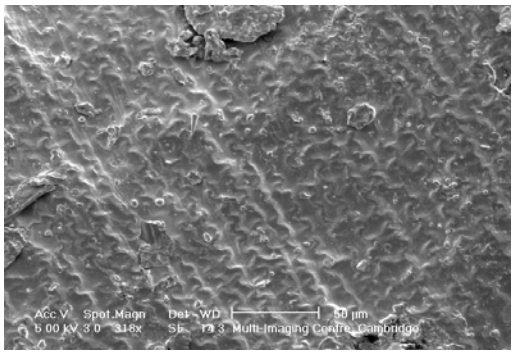


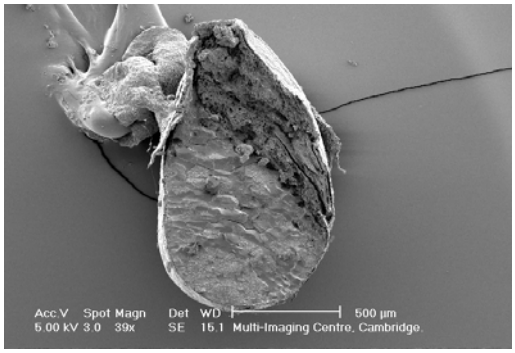
Brachiaria ramosa



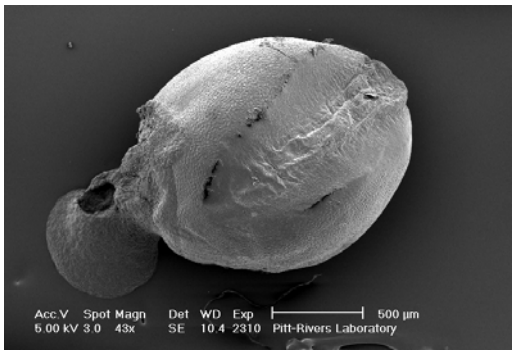




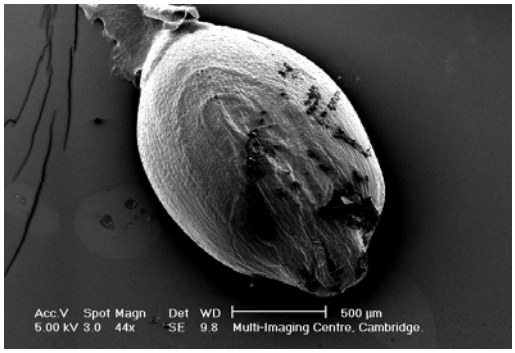


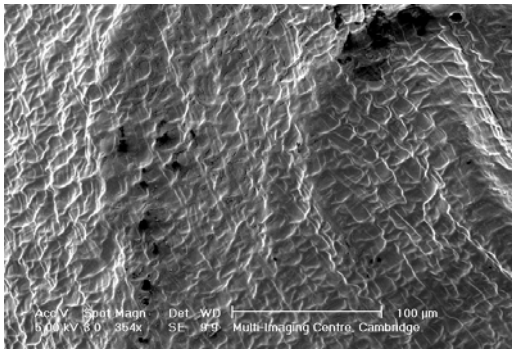


Setaria italica

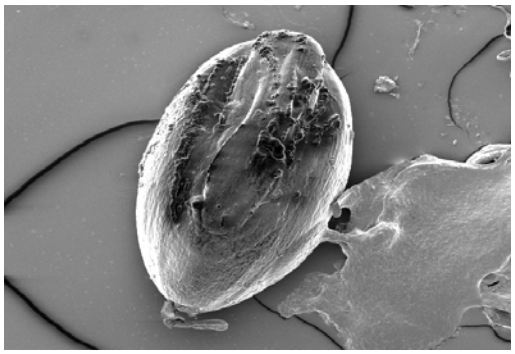


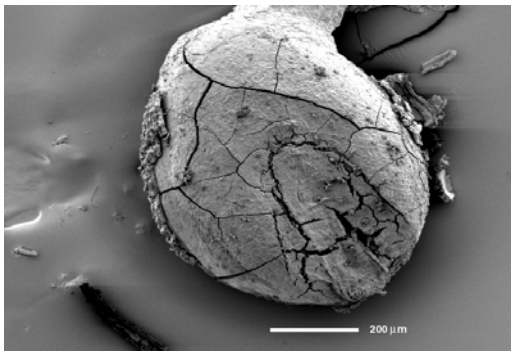
Setaria pumila



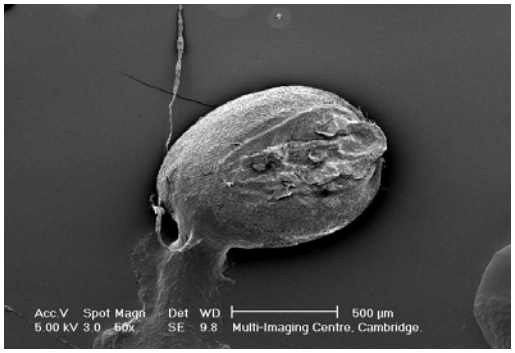


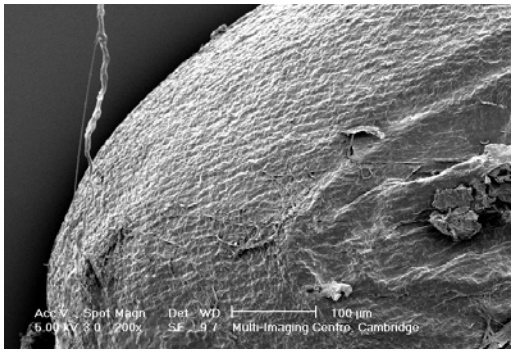
Setaria verticillata

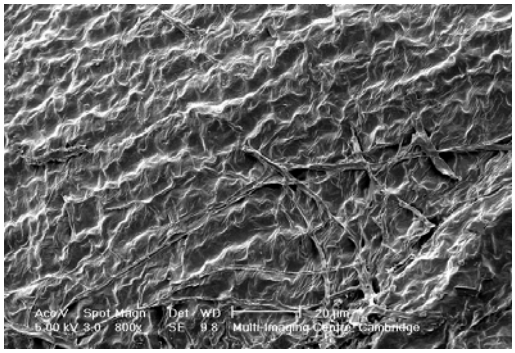




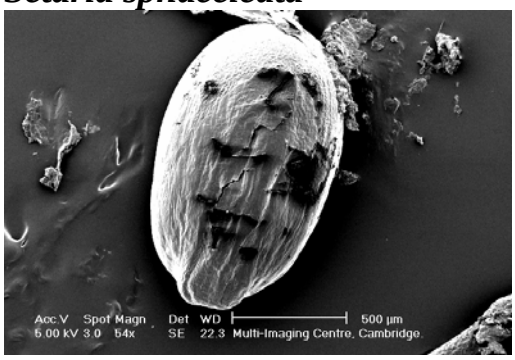
archaeobotanical, Southern Neolithic



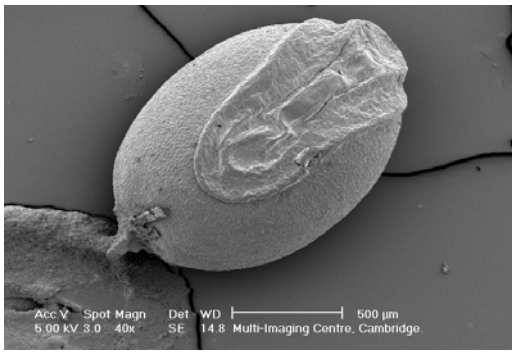


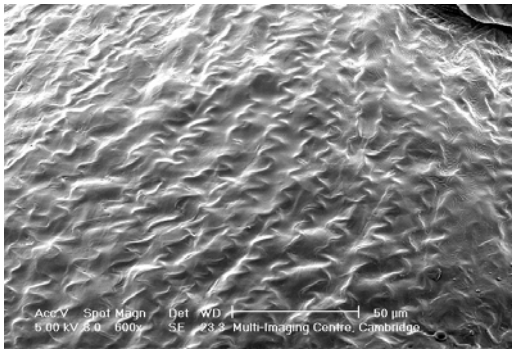


Setaria sphaceleata



Setaria palmifolia

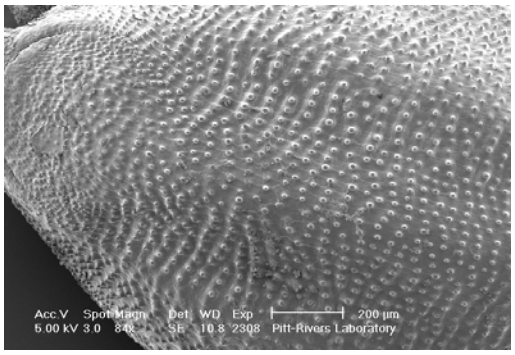




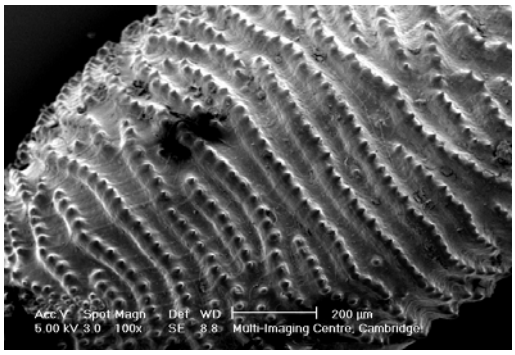
pericarop, dorsal surface

Setaria, Brachiaria, Urochloa (and a few obscure adjacent genera) have rugose/beaded ornamentation on their lemmas and paleas. Lemmas are generally mosr useful, while paleas are largely similarly beaded. Lemmas and paleas in other millet genera are essentially smooth and generally non-distinctive

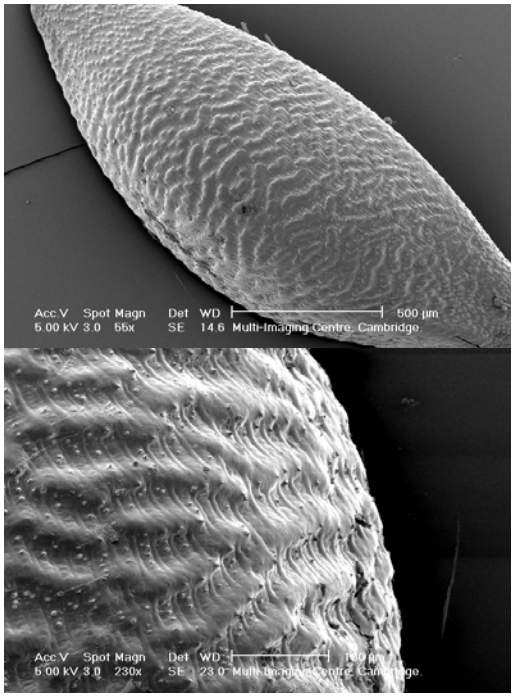
Lemma sculpturing	Palea sculpturing	Taxa	Figures
I. coarsely rugose to sulcate			
coarse linear rugae/ sulcae, with prominent teeth		***Setaria pumila***	6.20a,c
coarse linear rugae, smooth and untoothed	longitudinal ribs w/ regularly spaced pusticulae that often join into porminent transverse rows (rugae)	*Setaria sphaceleata*	6.20e
II. medium to fine rugose			
fine to medium rugae, , undulate and discontinuous, occasional granulations but without teeth	middle portion rugose like lemma; base and apex longitudinally ribbed w/ sparse pusticulae	*Brachiaria ramosa*	6.21a, c
fine to medium rugae, forming fairly continuous and straight lines, with minute teeth	pusticulae arranged in longitudinal rows, occasionally forming transverse rugae	*Setaria verticillata*	6.21b, d
III. minimally rugose or favulariate			
finely rugose, rugae beaded (composed of fairly distinct pusticulae)	pusticulae arranged in longitudinal rows, occasionally forming transverse rugae	*Setaria italica* (including ssp. *viridis*)	6.20f
Favulariate (short, discnontinuous and irregular bumps and ridges)	pusticulae arranged in longitudinal rows, occasionally forming transverse rugae	***Setaria palmifolia***	6.20b, d



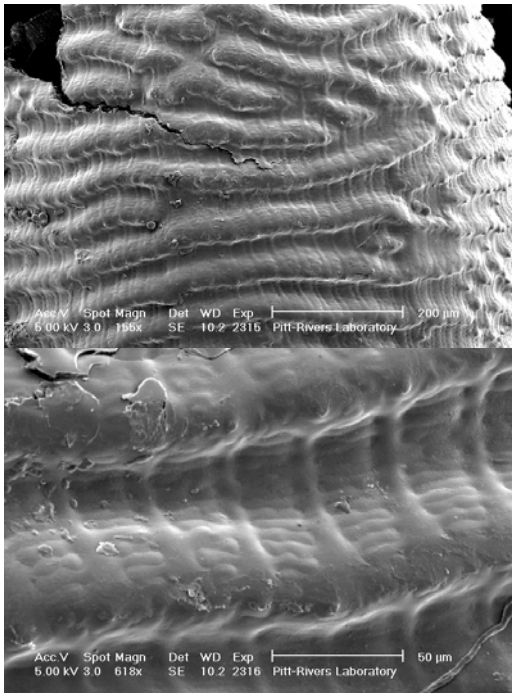
Setaria italica



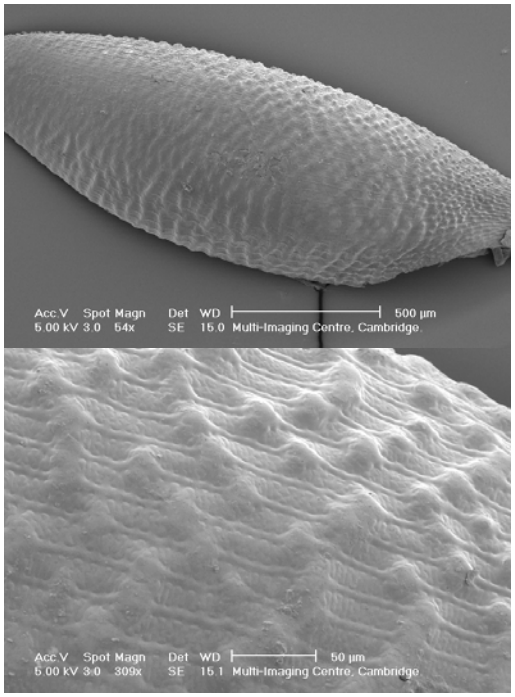
Setaria pumila



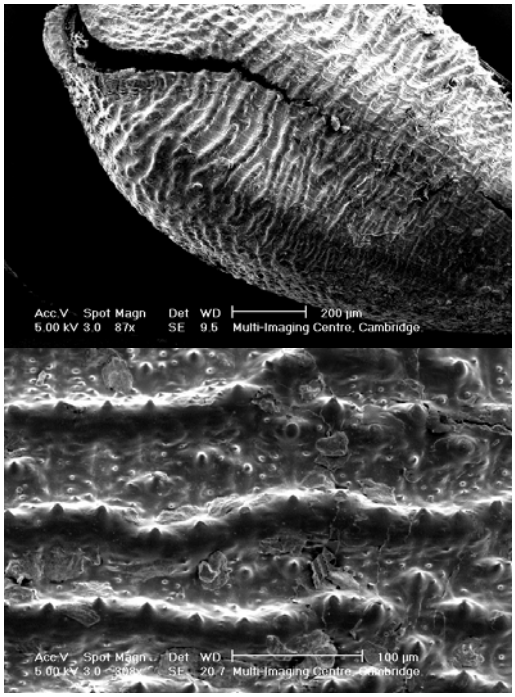
Brachiaria ramosa



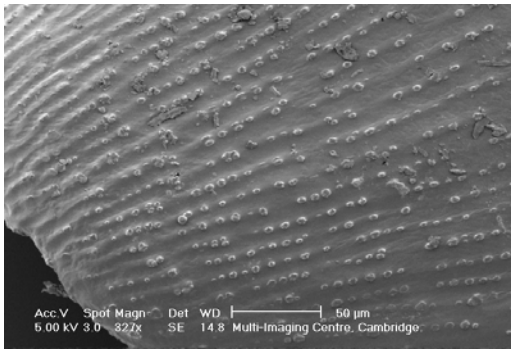
Setaria sphaceleata



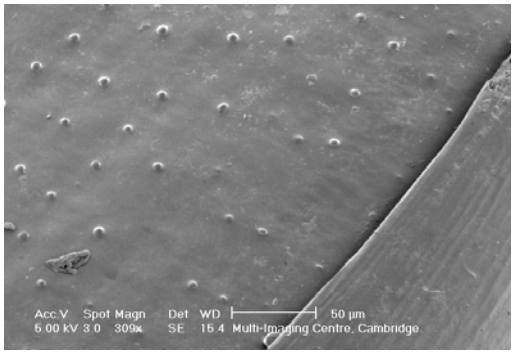
Setaria palmifolia



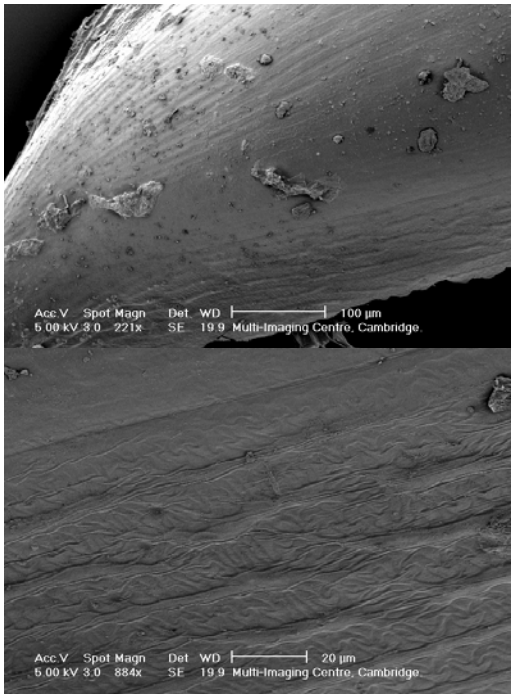
Setaria verticillata



Lemma surface: *Panicum sumatrense*



Echinochloa colona: palea surface



Echinochloa colonia lemma surface near fold