

MORPHOLOGICAL STUDIES IN SOME SPECIES OF *PANICUM* L*

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ABSTRACT

Morphology of four species of *Panicum*, viz., *P. antidotale*, *P. cymbiforme*, *P. decompositum* and *P. repens*, is described. Some new morphological features of diagnostic value, which have not been reported earlier for these species, are described and illustrated. An assemblage of characters supposed to be primitive on the evolutionary scale are also described and their phylogenetic significance discussed.

The Family Gramineae, popularly known as the 'grass family', is, beyond doubt, one of great morphological complexity and is considered to be one of the most difficult for the taxonomist. The genus *Panicum*, containing over 500 species, is the largest in the tribe Paniceae as well as the entire Gramineae. A majority of the economically-important grasses in this genus are soft and palatable, having considerable potential for forage. In spite of the fact that the grasses comprising the genus *Panicum* play an important role in the agricultural economy of many countries, particularly the tropical ones like ours, comparatively very little attention has been paid to the study of the fundamental aspects and cytotaxonomic classification of this fascinating group of plants. Much work in morphology, cytology and taxonomy remains to be done before a full understanding of the evolution of this genus is achieved.

In view of the great importance of the genus and the comparatively little systematic work done on it in this country or abroad, the present investigations on the cytotaxonomy of the genus *Panicum* were started in the year 1959. Here in this paper details regarding morphology of four species of *Panicum* are given and some new diagnostic features which do not seem to have been reported earlier, are described.

MATERIAL

The material for the present investigation included the following species:

Panicum antidotale Retz.: Popularly known as blue panic grass, it is one of the valuable and nutritious grasses in India ideally suited for arid and semi-arid regions. This grass appears to be native of Northern India and is reported to grow luxuriantly in Punjab and Upper Gangetic plains and the Jammu Province (Chopra, Handa, Kapoor and Singh, 1956).

Panicum cymbiforme D. K. Hughes (EC 9719) : This Australian species behaves as an annual under Indian (Delhi) conditions. After seeding it dies out and comes up in the following year from the shattered seed of the previous year.

Panicum decompositum Br. (EC 14384): A native of Australia, is a very tender and succulent, perennial grass with a typical, highly branching and spreading type of inflorescence. Probably it owes its specific name to its decompound type of inflorescence whose branches spread on all sides. The grass, being quite leafy, appears to have high promise as feed for the live-stock. It remains almost green in winter also.

Panicum repens L.: Commonly known as Torpedo grass, it has a wide ecological range. This stoloniferous, perennial grass owes its specific epithet to its prostrate habit of growth. The grass seems to thrive well in moist conditions and can withstand flooding. Considerable possibilities therefore exist for its being used in permanent pastures in the more humid tropics and subtropics. On the other hand, it is drought-resistant also as its rhizomes remain alive during spells of long, dry period. The stoloniferous, prostrate growth habit of the grass makes it well suitable for soil conservation.

EXPERIMENTAL RESULTS AND DISCUSSION

A detailed description of the morphology (including floral morphology) of the four species has been given by Jauhar (1963, Ph. D. Thesis). In addition to the characters described for them in the literature, a number of new characters of diagnostic value were discovered and are described below for these four species:

Panicum antidotale Retz. (Plate I, figs. 1-11)

The morphological description based on the present observations tallies, to a large measure, with the one given by Blatter and McCann (1935)

* Part of the thesis submitted by the author in partial fulfilment of the requirements for the Ph. D. degree of the Post-graduate School, I.A.R.I., New Delhi, 1963.

who compiled their data from a number of authoritative sources, and also with that given by Bor (1960). However, some of the important characters, including those which seem to be of diagnostic value, have not been reported by the earlier taxonomists. Some of these characters are:

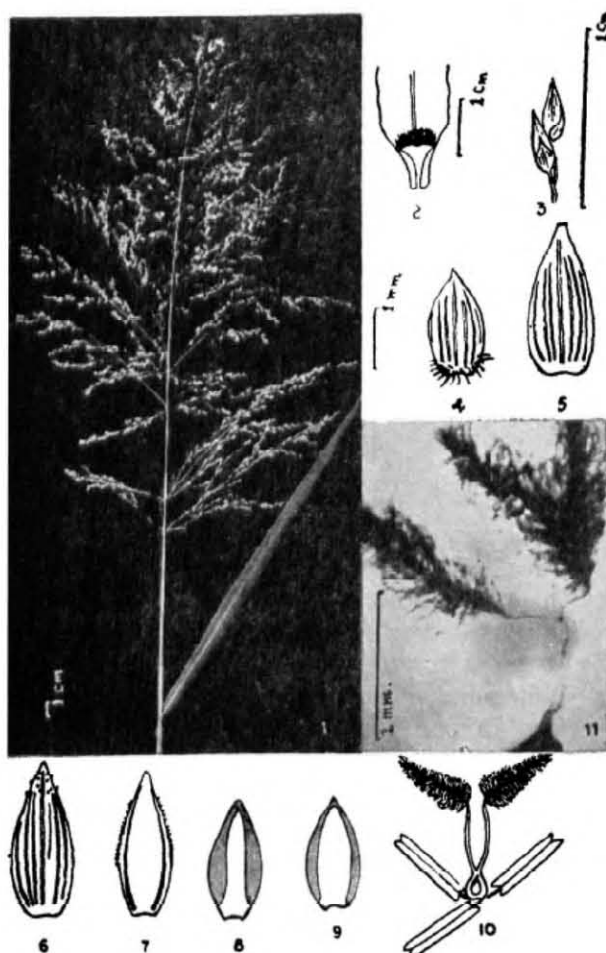


Plate I. *Panicum antidotale* Retz.

Figs. 1-11: 1. Panicle. 2. A portion of leaf showing ligule. 3. A pair of acuminate spikelets. 4. Lower glume showing 7 nerves and minute bristles at its base. 5. Upper glume showing 7 nerves and notched apex. 6. Lower lemma showing anastomosis. 7. Lower palea showing heavily serrated margins. 8. Upper lemma. 9. Upper palea. 10. Pistil and stamens. 11. Trifid stigma occurring occasionally in this grass.

Note the foliaceous, multi-nerved glumes. Figs. 4-10 are to the same scale. Stamens of the staminate floret have not been shown.

A procerus, hardy, densely tufted, perennial grass varying greatly in height. Culms 150.4-290.5 cm tall (upto 150 cm tall, Blatter and McCann, 1935 pp. 163-164), glabrous, woody, conspicuously 11-17 noded, highly branched above; nodes and internodes glabrous and free from pigmentation. Leaves glabrous, striated (Fig. 1) with scaberulous,

undulating margins and prominent mid-rib; leaf-sheaths scaberulous, a white patch present at the joint of the leaf blade and leaf-sheath. Second leaf 16.5-33.6 cm long and 0.8-1.5 cm broad. Ligule (Fig. 2) membranous, fimbriated, 1.8-2.1 mm long, no hairs behind the ligule. Panicle (Fig. 1) 23.4-44.7 cm long (15-23 cm long, Blatter and McCann, 1935), highly effuse and branched, 29-48 branches; branches almost filiform, lower ones fascicled, 9.8-22.2 cm long (7.5-10 cm, Blatter and McCann, 1935). Spikelets (Fig. 3) almost crowded and somewhat obliquely placed on the panicle branchlets; 3.2-3.4 mm long (upto 3 mm long, Blatter and McCann, 1935), almost acuminate; 2-flowered, the upper hermaphrodite and the lower male. The glumes and lower lemma almost foliaceous and strongly nerved. Lower glume (Fig. 4) 1.95-2.15 mm long, longer than 3/4 the upper glume, 5-7 nerved, acutely to acuminate-pointed. Blatter and McCann (1935) described it as half as long as the upper glume, 3-nerved, sub-obtuse. Bor (1960) classifies this species under the group of species having lower glume one-quarter to half or one-half to three quarters the length of the spikelet or more. Upper glume (Fig. 5) 2.45-2.60 mm long, 7-10 nerved, apex somewhat notched. Several unicellular bristles about 0.5 mm long arise from the base of the glumes (Fig. 4). Lower lemma (Fig. 6) slightly longer than the upper glume, and not equal to it as described by Blatter and McCann, 1935; paleate, 7-9, rarely 10-nerved. Nerves of glumes and lower lemma sometimes exhibiting anastomosis and small spine-like projections scattered on the surface of the glume and lower lemma. Lower palea (Fig. 7) 2.4-2.5 mm long, slightly shorter than the lower lemma (and not equal to it as described by Blatter and McCann, 1935), almost ovate-oblong, acutely pointed, with margins heavily serrulated (Fig. 7). Upper lemma (Fig. 8) 1.9-2.0 mm long, somewhat coriaceous, smooth, cream-white, inconspicuously nerved (visible under $\times 90$). Upper palea (Fig. 9) sub-coriaceous, acutely pointed. Anthers upto 1.5 mm long, whitish to cream-white with a violet tinge (and not yellow as in other species investigated here). Pistil mostly 2-fid; 3-fid stigmas (Fig. 11) were observed in about 8 per cent. of spikelets examined; stigma highly plumose (Figs. 10, 11), upto 1.4 mm long, chalky white (not pigmented as in all other species investigated here).

Most of the above characters do not seem to have been taken note of by the earlier taxonomists. These characters being almost constant for the species should be of great help in its diagnosis.

***Panicum cymbiforme* D. K. Hughes (Plate II, figs. 1-10).**

Morphologically, the present material resembles largely with the one described by Hughes (1923). The present author has, however, noticed a few characters which do not seem to have been reported upon by Hughes. Some of the characters indicated below appear to be of diagnostic value for this species:

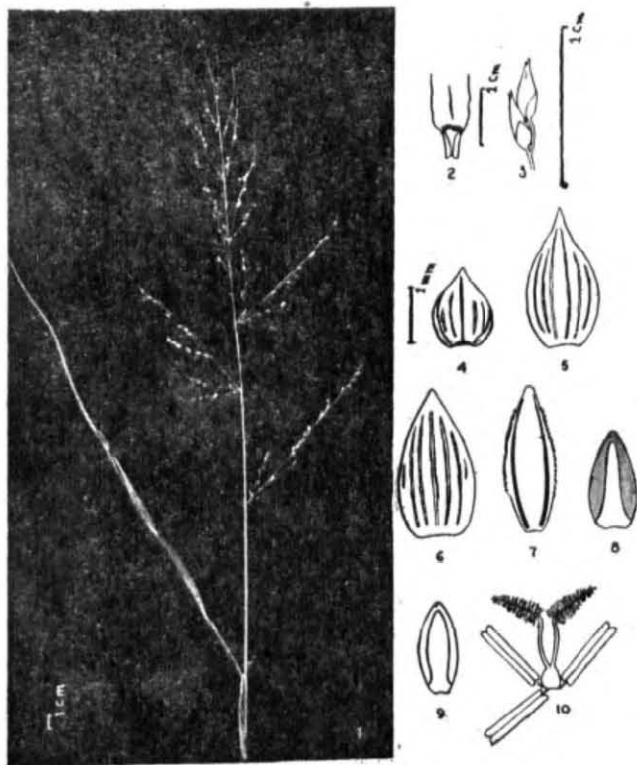


Plate II. *Panicum cymbiforme* Hughes

Figs. 1-10: 1. Panicle. 2. A portion of leaf showing ligule. 3. A pair of acuminately-pointed spikelets. 4. Lower glume with 5 nerves. 5. Upper glume with 7 nerves. 6. Lower lemma. 7. Lower palea showing heavily serrated margins. 8. Upper lemma. 9. Upper palea. 10. Pistil and stamens.

Note the foliaceous nature of the glumes. Figs. 4-10 are to the same scale. Stamens of the staminate floret have not been shown.

A profusely flowering, annual grass, highly variable in height. Culms 90-122 cm tall, 7-10 noded; nodes with poorly pronounced nodal fuzziness (densely pubescent, according to Hughes, 1923), pigmented with Rood's Violet (Ridgway, 1912); internodes glabrous, Cosse green (upper ones) to Rood's violet or maroon (lower ones). Leaves almost glabrescent with apices and margins generally pigmented with maroon colour. Second leaf 16.8-37.2 cm long and 0.6-1.4 cm broad (30 cm long and 0.6 cm broad, Hughes, 1923). Leaf-sheaths glabrous, Bordeaux in colour. Ligule (Fig. 2) short, about 1 mm long, membranous, ciliate, small hairs and a

Tyrian pink pigment present behind it. Panicle (Fig. 1) 20-52.5 cm long (upto 40 cm long, Hughes, 1923), 9.8-16.4 cm broad, sparsely and laxly branched, branches being slender. Spikelets (Fig. 3) closely spaced and obliquely placed on the panicle branchlets; 3.32-3.45 mm long, acuminately pointed, Peacock green, when young, becoming pigmented with maroon at maturity. Lower glume (Fig. 4) 1.35-1.5 mm long (1 mm according to Hughes, 1923), more than $\frac{3}{4}$ the length of the upper glume, foliaceous, 3-5 nerved, sometimes 1-2 additional, inconspicuous nerves also present; acuminately pointed. Upper glume (Fig. 5), as the lower glume, somewhat boat-shaped (or Cymbiform, Hughes, 1923); 7-9 nerved (7 nerved, Hughes, 1923). Lower lemma (Fig. 6) 2.7-2.8 mm long, 5-9 nerved (5-7 nerved, Hughes, 1923). Lower palea (Fig. 7) almost equal in length to the upper lemma, almost oblong, tapering towards the apex which is obtuse and slightly cupular; margins heavily serrated. Upper lemma (Fig. 8) 1.8 mm long, laevigate, sub-coriaceous to coriaceous. Anthers almost deep orange in colour becoming somewhat blackish purple at the time of maturity.

***Panicum decompositum* Br. (Plate III, figs. 1-10)**

The present material of *Panicum decompositum* bears some resemblance with the specimens described by earlier taxonomists. Hughes (1923) has described four different varieties, viz., *tenuis*, *typicum*, *acuminatissimum* and *scaberrimum*, of *P. decompositum*, but the collection under the present study differs from all these four varieties described by him. The following are some of the additional distinguishing characters of the present collection of *P. decompositum*:

A dwarf, glabrous, tender, leafy, moderately tillering and densely tufted, perennial grass exhibiting erect-open type of growth habit. Culms 64-90 cm long, terete, unbranched, 6-8 noded; nodes and internodes smooth and almost laevigate. Leaves long, succulent, with inconspicuous mid-rib; second leaf 19.5-31.4 cm long and 0.5-0.7 cm broad. Ligule (Fig. 2) 1.3-1.4 mm long, fimbriate, having no hairs behind it. Inflorescence (Fig. 1) a large, highly spreading, thyrsoid panicle, about one-third the height of the plant, 20-32 cm long and 16-23 cm broad with 18-30 branches which spread on all sides giving the panicle a decompound appearance. At one point on the slender peduncle 1-6 secondaries arise which diverge to different directions giving birth to tertiary branchlets which bear the spikelets either singly or in pairs; quite often even secondaries may directly bear the spikelets which, in

that case, have very long, slender rachillae. *Spikelets* (Fig. 3) 2.6-2.7 mm long, acute, almost

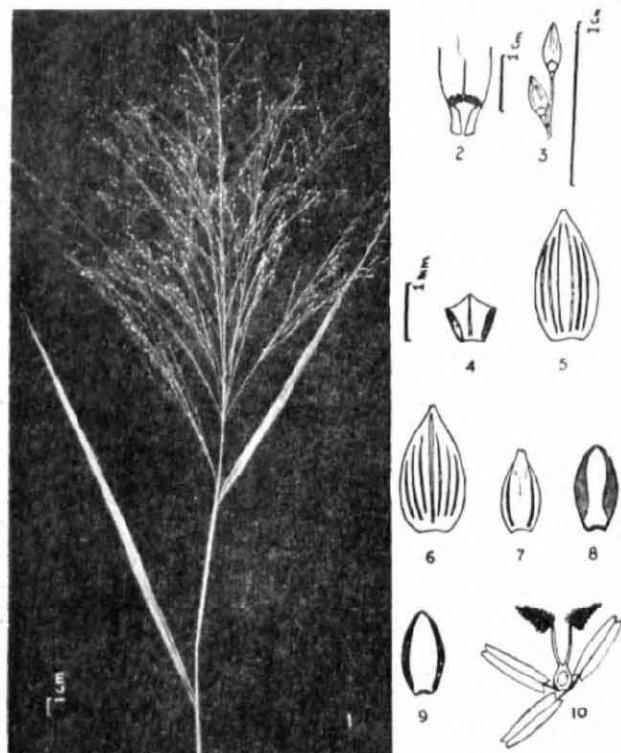


Plate III. *Panicum decompositum* Br.

Figs. 1-10: 1. A highly branched, spread, thyrseoid panicle. 2. A portion of leaf showing ligule. 3. A pair of spikelets with long rachillae. 4. Lower glume. 5. Upper glume. 6. Lower lemma with a notched apex. 7. Lower palea with a cupular apex. 8. Upper lemma. 9. Upper palea. 10. Pistil and stamens.

Note: figs. 4-10 are to the same scale. Stamens of the staminate floret have not been shown.

ovate, light parrot green, suffused with purple pigment at maturity. *Lower glume* (Fig. 4) 0.8-0.9 mm long and 0.85-1.0 mm broad, about one-third the length of the spikelet; faintly 1 nerved, semi-hyaline, apex abruptly pointed. *Upper glume* (Fig. 5) 2.3-2.4 mm long, 5-8, generally 6-7 nerved (6 nerved, Willis, 1963). *Lower lemma* (Fig. 6) almost similar to the upper glume. *Lower palea* (Fig. 7) 1.4-1.5 mm long (i.e. much shorter than the upper lemma), almost oblong, tapering towards the apex which is somewhat cupular, thin, hyaline, snowy-white in colour, with smooth margins. *Upper lemma* (Fig. 8) obtuse, with an inconspicuous central nerve, smooth and glossy. *Upper palea* (Fig. 9) obtuse. *Stigmas* (Fig. 10) short, feebly plumose, spinel-red in colour.

Most of these characters which typify this species have not been described by earlier taxonomists (Hughes, 1923; Willis, 1963).

Panicum repens L. (Plate IV, figs. 1-10)

The culture of *P. repens* under the present study is similar, to a large extent, with the one described in the literature. Some of the following important characters, however, do not seem to have been reported earlier. These characters appear to be of diagnostic value:

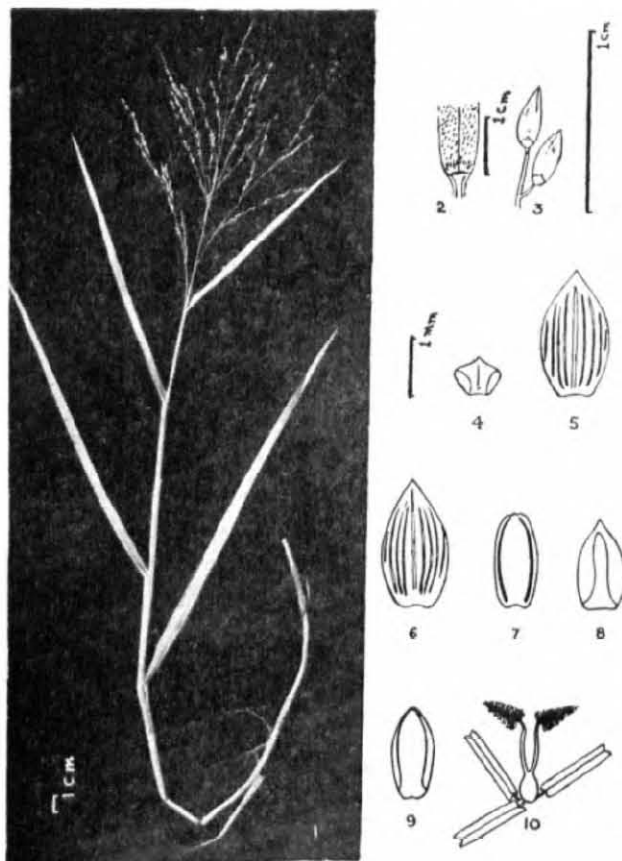


Plate IV. *Panicum repens* L.

Figs. 1-10: 1. A distichously-leaved culm with effuse panicle. 2. A portion of the pubescent leaf showing ligule. (Note small hairs behind the ligule). 3. A pair of spikelets. 4. A rudimentary lower glume. 5. Upper glume, 9 nerved. 6. Lower lemma, 9 nerved. 7. Lower palea showing flat apex with a small protuberance. 8. Upper lemma. 9. Upper palea. 10. Pistil and stamens.

Note: figs. 4-10 are to the same scale. Stamens of the staminate floret have not been shown.

A tough, decumbent, semi-aquatic, ruderal, perennial grass with rhizomes long and creeping; multi-noded and distichously-leaved, growing upto 127 cm tall. *Leaves* coriaceous, with involute margins, tending to become rolled, finely pubescent on the upper surface. *Ligule* (Fig. 2), a small, membranous, ciliated rim about 1 mm long. *Panicle* (Fig. 1) 13.5-21.0 cm long, 10-16 cm broad. *Spikelets* (Fig. 3) about 3 mm long sub-sessile, ovate-oblong, acute to acuminate, glabrous, sea-green. *Lower glume* (Fig. 4), a small, almost rudimentary, orbicular structure, inconspicuously 1 nerved; about

one-fifth the length of the spikelet. *Upper glume* (Fig. 5) 2-2.1 mm long, 8-10 nerved (7-9 nerved, Meredith, 1955), sometimes 1-2 additional, faint nerves also present. *Lower palea* (Fig. 7) oblong, exceedingly thin, hyaline, with apex flat and slightly sunken; a small protuberance is present in the sunken portion of the apex; 2 nerved. *Upper lemma* (Fig. 8) acutely pointed, semi-coriaceous, 3 nerved, the nerves being faint and inconspicuous, feebly rugulose. *Stigmas* (Fig. 10) finely plumose, pink.

MODE OF REPRODUCTION

The seed progenies of *P. antidotale* exhibited a tremendous range of variation from plant to plant with regard to several characters, for example, height of culm (varying from 150.4-290.5 cm), number of internodes (11-17), length (9.2-16.4 cm) and thickness (2.4-3.8 mm) of second internode; length (16.5-33.6 cm) and breadth (0.8-1.5 cm) of second leaf, length of panicle (23.4-44.7 cm) and length of longest secondary (9.8-22.2 cm). This large variation in the seed progeny indicates the predominantly sexual mode of reproduction facilitating natural gene-flow in this species. Narayan (1960) also observed predominantly sexual mode of reproduction in this species.

The seed progenies of *P. cymbiforme* also presented a wide range of variation from plant to plant in respect of several characters, including culm height (90-122 cm) and thickness (2.5-3.2 mm), length and breadth of leaf (16.8-37.2 by 0.6-1.4 cm), length, width and branching of panicle (19.8-52.5 cm, 9.8-16.4 cm and 11-29 branches). A slight variation in hairiness of leaf and nodes was also observed. This variation in all these characters from plant to plant strongly suggests the presence of predominantly sexual mode of reproduction in this species.

ADDITIONAL DIAGNOSTIC CHARACTERS

Morphology, in the conventional sense, is concerned with the external organography of the plant and includes those characters which usually are visible to the naked eye or an eye aided by a hand lens. In the present investigation the minute floral characters were, however, examined under the low power of the Bausch and Lomb microscope ($\times 90$ magnification). This helped in bringing to light a number of new diagnostic characters of the glumes, lemmas and paleas, described above. Most of these, such as the variation in the number of nerves on the apices of floral parts and some others, do not seem to have been reported for these species

before. Some other characters were such as are not considered to be characteristic of either the particular species or even of the genus *Panicum*; such instances include the presence of bristles at the base of the glumes in *P. antidotale* (Pl. I, fig. 4). This character has not been noticed by earlier taxonomists and is not typical of the genus *Panicum*, but happens to be quite characteristic of the material (*P. antidotale*) studied by the present author. *Primitive characters and their phylogenetic significance:*

Within the grass family, specialisation has advanced along many lines. The Bambuseae are considered to be the most primitive of all living grasses (Bews, 1929; Lawrence, 1951; Harlan, 1956). The Panicoideae are relatively more advanced and specialised. Bews (1929), Hubbard (1948), Hutchinson (1948) and Harlan (1956) considered that the following characters represent primitive conditions within the family:

Woody or ligneous stems; highly branched and spreading panicle; spikelets many-flowered, flowers all fertile; glumes and lemmas foliaceous and many-nerved, the nerves being conspicuous; lower glume well developed (reduced or rudimentary condition representing advanced condition); stigma 3-fid.

The 'blue panic' grass (*P. antidotale*), supposedly indigenous to this country where it is known as *desi bansi* in the local dialect, bears considerable resemblance to the bamboos (locally known as 'bans') in as much as it possesses most of the primitive characters typical to the bamboos. Some of the important characters are:

Woody and highly branched culms, highly effuse and branched panicles, bearing branches in fascicles; spikelets borne in bunches; empty glumes and lower lemma foliaceous, with highly conspicuous, many nerves; lower glume well developed and with upto 8 nerves; upper glume and lower lemma with upto 10 nerves; rare occurrence of tri-carpellary ovary and highly plumose, tri-fid stigmas (Pl. I, fig. 11).

The above characters, which are common in the bamboos and are also present in *P. antidotale*, suggest the existence of some morphological affinity between the two. Harlan (1956) surmised that: "Rather directly derived from the bamboos and their allies is the Panicoideae, a sub-family recognised as early as 1810 by John Brown". The present study tends to support Harlan's views.

The 3-fid stigma condition is a highly primitive condition which appears to have some phyletic significance. The carpel number in the pistils of the

grass family has been a point of controversy among different workers. Haeckel (1887), Bews (1929), Rendle (1930) and others considered the pistil to consist of a single carpel terminated by 2-1 branched stigma, whereas Weatherwax (1929), Arber (1934), Randolph (1936) and others held the view that the gynoecium was fundamentally a tricarpellate organ with 3 carpels joined edge to edge. This view was supported by the detailed floral anatomy studies of Belk (1939). The present studies lend some support to the view expressed by Lawrence (1951) that the present day grass flower ovary has evolved from ancestral 3-carpelled stocks. This 3-fid stigma character seems to have been retained in *P. antidotale* through countless generations during which great divergence and evolution has occurred in other species of the genus *Panicum*. This feature is probably on its way to disappearance during the course of evolution of this genus. This possibility is indicated by the presence of a small, additional branch of stigma and also by the rare occurrence of this character.

The other species of *Panicum* studied here also possess an assemblage of primitive characters. The diploid taxon, *P. cymbiforme*, like the diploid primitive *P. antidotale*, has large, effuse panicles with branches more or less in whorls and spikelets almost crowded on the branches. Further, its lower glume is well developed and both the glumes and lower lemma are foliaceous and many-nerved. The Australian tetraploid species, *P. decompositum* has a semi-aquatic habitat similar to that of the tetraploid *P. repens*, which is considered to be primitive. Further, *P. decompositum* has a highly spread-thyrsoid panicle having long branches on all the sides, and bearing spikelets with very long, filiform rachillae. *P. repens* has the many-nerved condition of the upper glume and lower lemma.

Thus, the presence in different *Panicum* species, of a combination of primitive characters typical to bamboos, would support Harlan's view regarding the derivation of the Panicoideae from the bamboos and allied genera.

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