

A CONTRIBUTION TO THE ECOLOGICAL ANATOMY OF MARITIME STRAND PLANTS OF INDIA

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ABSTRACT

The present paper deals with the ecological anatomy of seven representative species of strand/dune habitat. An attempt is made to give habitat descriptions of each plant supplemented with anatomical features of ecological significance.

INTRODUCTION

Available anatomical information relating to the coastal strand plants of India is scanty and inadequate. Except a few notings by Fyson and Balasubrahmanyam (1919) and Mullan (1933 a, b ; 1940) practically no attempt has been made for anatomical studies on pioneer strand/dune plants of Indian coast.

MATERIAL AND METHODS

The following materials *i.e.* *Asparagus dumosus* Baker, *Capparis cartilaginea* Decne, *Cyperus pedunculatus* (R. Br.) Kern., *Euphorbia rosea* Retz., *Fimbristylis junciformis* Vahl, *Hydrophylax maritima* L. f. and *Psilostachys sericea* Hook. f. were collected during the ecological survey of Indian coast in the years 1960 and 1968. The customary methods were employed in studying anatomical structures chiefly of root, stem and leaf. Only typical strand plants were chosen for anatomical study. For each plant three counts per square meter were made to find out its sociability.

Asparagus dumosus Baker (Liliaceae)

It is a perennial found scattered on the sandy shores at a few localities only of Dwarka, Beyt island and up to Porbunder in Saurashtra coast (Rao *et al.*, 1963). It has been reported in Jemadar Ka Landa near Karachi (Cooke, 1908) and Sindh (Pakistan) at Glorlam on limestone hills (Blatter *et al.*, 1929). Thus its spread appears to be apparently confined to a small area of this sub-continent. It is found on sandy mounds of the back shore in the form of a much branched undershrub. The branches are flexuous and ridged having deltoidly cuspidate leaves. The root stock is stout bearing numerous tubiform uniformly elongated fasciculated roots. In Saurashtra, this plant is found in pure stands or sometimes associated with *Cyperus conglomeratus* Rottb., *C. arenarius* Retz., *Sporobolus tremulus*

(Willd.) Kunth and *Melanocenchrus abyssenica* (R. Br.) Hochst. It is found growing on coastal sand having moderately alkaline calcareous soils of extremely poor organic matter. Counts per square meter show: *Asparagus* 10, *Cyperus* 3; *Asparagus* 12, *Sporobolus* 1, *Melanocenchrus* 2; *Asparagus* 4, *Cyperus* 5, *Sporobolus* 3.

Internal structure :

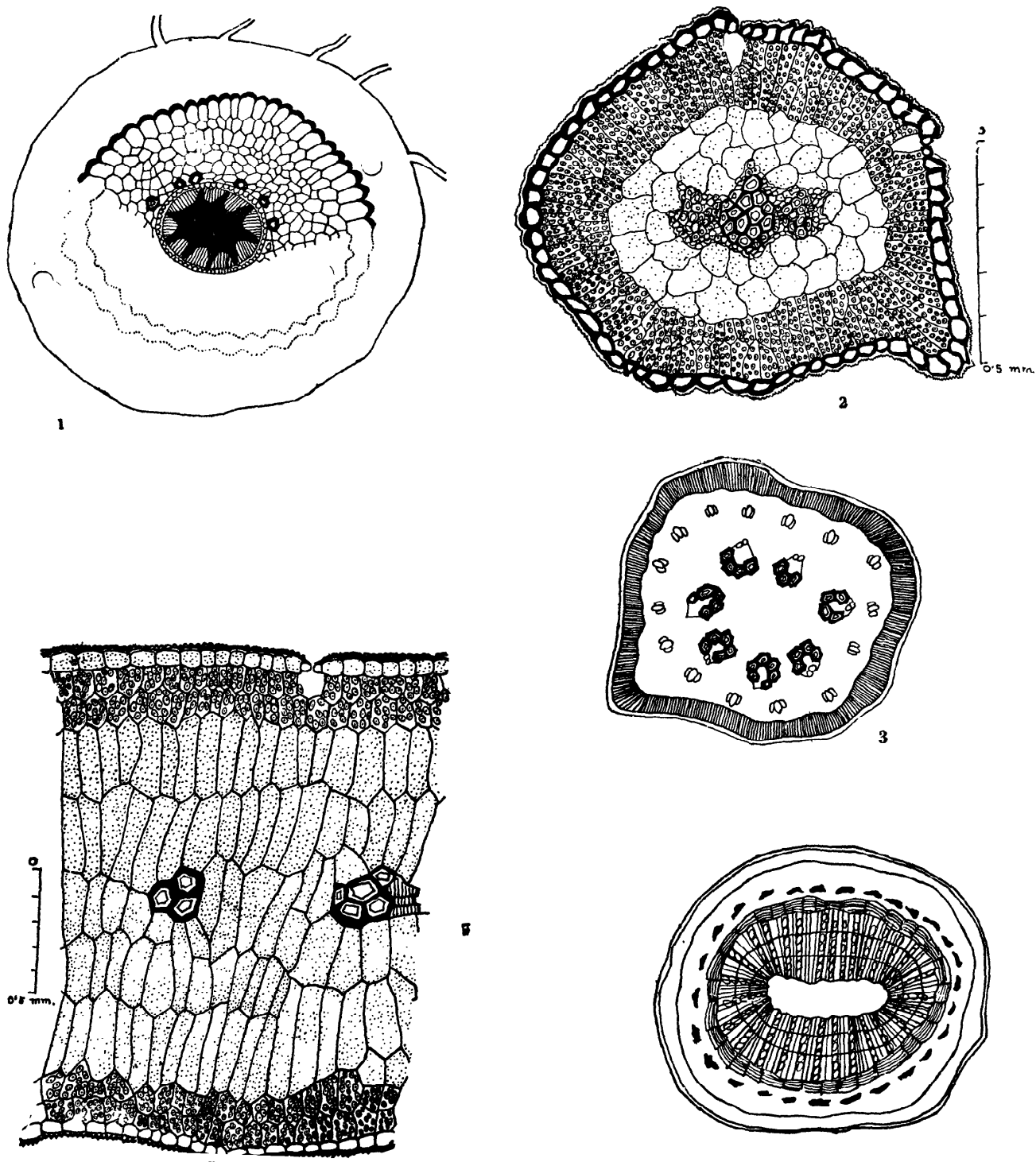
Root (Fig. 1): Stele small, vasculature polyarch with sclerosed pith; phloem group radially disposed in patches alternating with xylem group; endodermis present, passage cells clear. A few cells abutting endodermis, thick walled, forming a discontinuous ring. Cortex wide; divisible into outer and inner circles separated by well organised exodermis. Outer cortex, many layered, colourless; inner cortex, less wide, polygonal, walls thin and lacunate. Epiblema not regular, uniseriate, compact, thin walled and sinuous.

Stem (Fig. 3): Angular or sub-cylindrical with projections. Pith broad, parenchymatous, cells spherical, large, compact and lacunate. Vascular bundles scattered, closed; sub-epidermal sterome, many layered; cortex, compact, sub-spherical or polygonal cells, thick walled and less lacunate, epidermis uniseriate, compact, big sized and papillate, intercepted by ridges and stomata; ridges multicellular and project outwards.

Leaf (Cladode—Fig. 2): More or less triangular. Centric vasculature, surrounded by 2-layered, polygonal colourless cells. Outer 2 layered palisade cells, epidermis uniseriate, compact, thick walled, cutinised, cuticle thick and hypostomatous.

Capparis cartilaginea Decne. (Capparaceae)

It is found growing on backshore habitats at Dwarka (Saurashtra coast). It is a woody, well grown evergreen shrub with innumerable radiating



Figs. 1-3 : *Asparagus dumosus* Baker. 1. T. S. of adult root (not to scale). 2. T. S. of leaf (Cladode). 3. T. S. of aerial branch (not to scale).
 Figs. 4-5 : *Capparis cartilaginea* Decne. 4. T. S. of an adult branch (not to scale). 5. T. S. of a thick brittle leaf.

branches holding thick brittle fleshy leaves with plenty of wax coating. This does not form a pure stand and infrequently associated with other plants. The plant acquires a shrubby form under protective shade conditions.

Its chief associates are the local plants represented by *Kickxia ramosissima* (Wall.) Janch., *Heliotropium bacciferum* Forsk., *Echinops echinatus* Roxb., *Limonium stocksii* (Boiss) O. Kuntze and *Sclerocarpus africanus* Jacq. Counts per square meter show: *Capparis* 1, *Fagonia* 2, *Indigofera* 3; *Capparis* 2, *Kickxia* 6, *Sericostoma* 2; *Capparis* 1, *Heliotropium* 3, *Pulicaria* 2. The shrubby plant grows in sandy soils of a loamy sand texture characterised by high percentage of calcium carbonate, moderate salinity and a very low percentage of total soluble salts and organic matter.

Internal structure :

Stem (Fig. 4): Sub-cylindrical. Pith broad, central big cells, parenchymatous, compact and peripheral small cells. Vascular tissue extensive, single ring development, conspicuous multiple collateral bundles separated by medullary rays, phloem in patches. Cortex small, divisible into inner and outer. Inner cortical cells big, compact and a few are sclerotic above the phloem patches, a few cells, broad, colourless, thin walled, may be for water storing. Outer cortical cells compact, collenchymatous, a few layered. Epidermis biseriate, uniform, thick, cutinised; cuticle thick and wavy. Lenticel present.

Leaf (Fig. 5): Isobilateral. Mesophyll differentiated: peripheral cells compact, chlorophyllous; aqueous tissue homogeneous, compact, colourless, parenchymatous with straight lateral walls. Vascular bundles many, centrally disposed, collateral. Epidermis uniseriate, cutinised, compact, colourless, cuticle thick, wavy and hypostomatous.

Cyperus pedunculatus (R. Br.) Kern. (Cyperaceae)

The plant was treated as a separate monotypic genus *Remirea maritima* Aubl. However, recently Kern (1958) has treated this plant under *Cyperus* sub gen. *Mariscus* in view of its resemblance in the shape of spikelet, nut, glume and involucre to the above section. Now the plant is under a new combination as above.

It is a good sand binder and sometimes it is found in association with *Ipomoea pes-caprae* (L.) R. Br. It spreads widely and rarely forms a mat. Its presence along with *Spinifex littoreus* (Burm. f.) Merr. and *Scaevola taccada* (Gaertn.) Roxb. is not un-

common. Counts per square metre are: *Cyperus pedunculatus* 6 (aerial branches), *Spinifex littoreus* 2, *Oldenlandia herbacea* 3; *Cyperus pedunculatus* 4, *Launaea sarmentosa* 6; *Cyperus pedunculatus* 7, *Ipomoea pes-caprae* 2, *Scaevola taccada* 1.

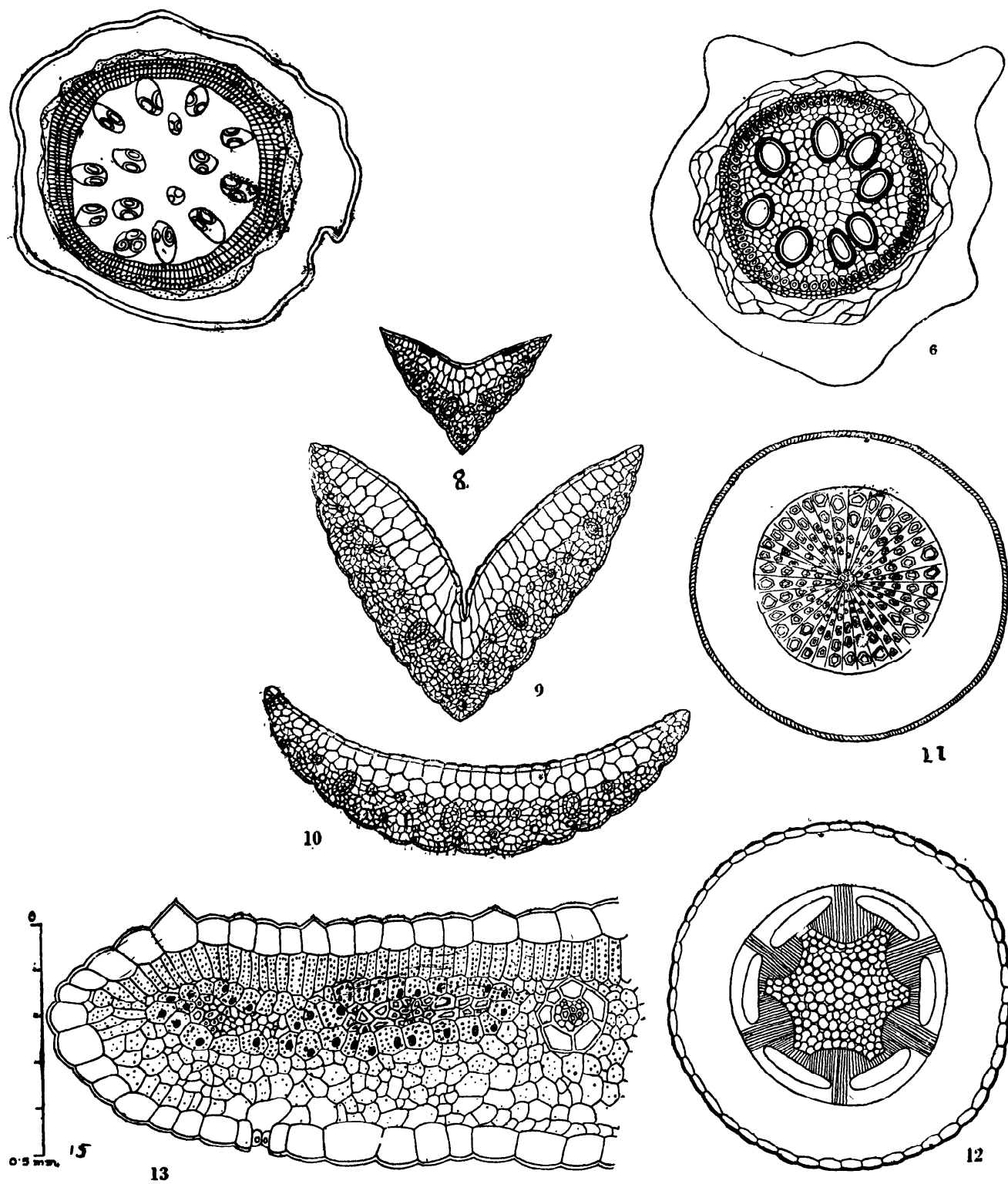
It is a sea shore perennial sedge showing complete fidelity to the beach especially along the back shore habitats of both the coasts of India. Its occurrence along the West Coast beyond the coastal areas of Mysore has not been recorded. However, its reported occurrence (Shah 1963, 1964) in the inland paddy fields in Gujarat is a case of mistaken identity. It has a long rhizome up to 15 ft. bearing tufted stems, and rooting at nodes. The stems are leafy above bearing spikelets. It is found colonising non-saline, coarse sand, mildly calcareous and moderately alkaline habitats of poor organic matter.

Internal structure :

Root (Fig. 6): Sub-quadrangular or sub-spherical. Stele wide: vascular polyarch, ground tissue sclerosed, endodermis and a few layers of inner cortex sclerenchymatous and conspicuous. Cortex differentiated; inner cortex: polygonal cells, lacunar, lacunae caused by disintegration of radial or tangential cells, many cells with tannin or phlobaphene; outer cortex: cells clear and compact, less lacunar. Epiblema uniseriate, small, polygonal; outgrowths many.

Stem (Fig. 7—Aerial shoot): Sub-cylindrical, wavy outline. Stele wide, thin-walled polygonal cells compact, less lacunar, colourless or a few with tannin. Vascular bundles scattered/more or less in two series, vary in size, collateral closed bundles encircled by small sized, colourless, thick-walled cells; endodermis distinct. Cortex not wide, two series of cells; outer compact, polygonal cells, 2 layered, colourless, thick walled; inner spherical cells, many layered compact but less lacunar, intercepted by cortical centric vascular bundles. Epidermis uniseriate; small sized, not cutinised.

Rhizome: Sub-spherical, wavy outline. Stele wide; vascular bundles in two series, scattered, peripheral bundles small; collateral, sheathed by one layered sclerenchyma. Pith cells polygonal, less lacunar intercepted by tannin bearing scattered cells; peripheral cells with starch grains. Endodermis distinct. Sclerenchymatous ring beneath 4 to 5 layered, small lumen. Cortex not wide, spherical, cells abutting the endodermis rich in tannin. Epidermis uniseriate, small, thick walled and cutinised; sub-epidermal collenchyma two or three layered.



Figs. 6-10 : *Cyperus pedunculatus* (R. Br.) Kern. 6. T. S. of root (not to scale). 7. T. S. of stem (not to scale). 8, 9 & 10. T. S. of leaf at various levels (not to scale).
 Figs. 11-13 : *Euphorbia rosea* Retz. 11. T. S. of root (not to scale). 12. T. S. of stem (not to scale). 13. A portion of leaf—T. S.

Leaf (Figs. 8-10): It is not fully formed but consists of a basal sheath followed by well developed midrib region with reduction of lamina and almost tapering tip. Thus the structure of the leaf varies from the base to the tip. Basal portion: lamina of uniform width angular at the margins. Epidermis uniseriate, surface slightly undulating, cutinised, stomata present on abaxial side. Sub-epidermal sclerenchymatous strands at lower and upper epidermis; more at lower epidermis and at regular intervals. Mesophyll differentiated into two parts: root stock; and stem branches are flexuous, elongate upper large hyaline cells of 2 layers, and lower region of small cells enclosing vascular bundles in rows at regular intervals. Vascular bundles collateral, different sizes, in rows of 2 or 3, each bundle with a ring of thickened cells surrounding funnel-shaped cells with chloroplast.

Middle portion: Leaf folded and V-shaped; correspondingly the large colourless cells of the mesophyll are compact, broad and bigger at the midrib. Vascular bundles of uniform size.

Tip portion: More or less triangular with slight depression at the adaxial side. Sub-epidermal sclerotic strands are present, more and closely set at lower epidermis. Colourless hyaline cells compact and not wide. Vascular bundles of varied sizes present; collateral and of cyperaceous type.

Euphorbia rosea Retz. (Euphorbiaceae)

It is found in scattered patches along the marine strand ecosystems of Karnataka, Kerala, Tamil Nadu and Orissa States. A small herb with woody perennial root stock; and stem branches are flexuous, elongated and bear small fleshy leaves. The beauty of this little plant is its rosy cymes all along the sandy backdrop during the rainy season. It is found in association with *Geniosporum tenuiflorum* (L.) Merr., *Phyllanthus rotundifolius* Klein, *Cyperus arenarius* Retz., *Oldenlandia umbellata* L. and *Launaea sarmentosa* (Willd.) Alston. Counts per square metre show: *Euphorbia rosea* 3, *Phyllanthus rotundifolius* 2, *Cyperus arenarius* 1, *Euphorbia rosea* 7, *Phyllanthus rotundifolius* 2, *Oldenlandia umbellata* 1, *Euphorbia rosea* 4, *Cyperus arenarius* 2, *Geniosporum tenuiflorum* 1. It grows on sandy, neutral soil free from salts and of poor organic matter.

Internal structure:

Root (Fig. 11): Stele is wide, vasculature tetrarch, secondary growth common interspersed with xylem parenchyma. Pith absent. Endodermis absent. Phloem in a ring. Cortex less wide, many layered,

compact, parenchymatous, thick walled cells with starch grains. In frequently, a few cells with tannin.

Epiblema one layered. Sub-epiblema cells small sized, compact, free from starch grains but charged with tannin or phlobaphene.

Stem (Fig. 12): Cylindrical. Pith small, cells uniform in size without contents. Vasculature endarch. Collateral bundles in a ring separated by medullary rays, phloem in patches. Cortex small, many layered, in frequently interspersed by tannin bearing cells. Epidermis, uniseriate, compact, homogeneous, intercepted by depressed stomata. Outer epidermal wall cutinised; cuticle thick and uniform.

Leaf (Fig. 13): Hypostomatous, mesophyll differentiated. Palisade one layered, compact vertically disposed, abutting on a sheath of large parenchymatous cells charged with chloroplast and enlarged nucleus encircling the vascular bundles. Spongy cells many layered, lacunar, less chlorophyllous, traversed by elongated tubular laticifers. Epidermis distinct. Uniseriate with depressed stomata, more in lower epidermal layer. Upper epidermis thick walled, cuticularised, cuticle thick and uniform. Outer wall in a few cells conical; lower epidermis uniseriate, spherical or subspherical cells compact intercepted by stomata; cutinised and cuticle uniform.

Fimbristylis junciformis Vahl (Cyperaceae)

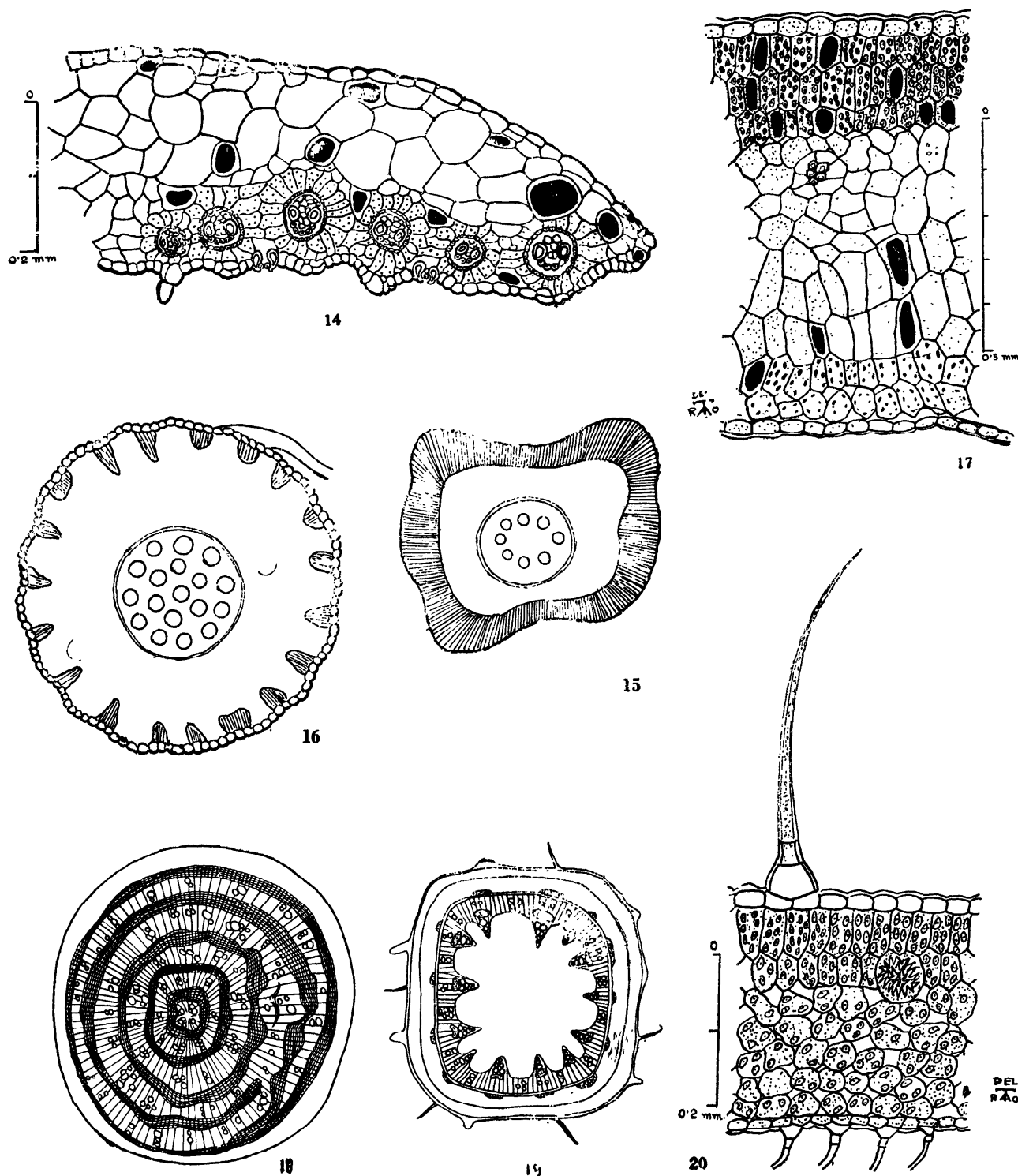
An interesting sedge on the sandy humps along, the Konark/Puri coastal bulge. It is found growing in abundance under maritime influence and has an inward extension up to the altitude of 1000 m.

It has tufted stems of 2 to 15 cm, closely adpressed to the substratum, often clothed by shining rusty scales. The stems are leafy at the terminus and bear umbellate spikelets. Its ecological niche is noteworthy. Its close prostrate branching stems on sandy mounds protect the underlying loose sand from wind erosion. It is found in association with *Euphorbia rosea*, *Drosera indica*, *Launaea sarmentosa* and *Cyperus arenarius*. Counts per square metre show: *Fimbristylis junciformis* 5, *Euphorbia rosea* 3, *Phyllanthus rotundifolius* 1, *Fimbristylis junciformis* 7, *Drosera burmani* 14, *Launaea sarmentosa* 2.

The niche structure of this plant consists of sandy soil, neutral pH value, free from excess of soluble salts and organic matter.

Internal structure:

Root (Fig. 15): Sub-quadrangular or sub-spherical. Stele is small. Vasculature polyarch, ground



Figs. 14-16 : *Fimbristylis junciformis* Vahl 14. T. S. of portion of leaf. 15. T. S. of adult aerial branch (semi diagrammatic). 16. T. S. of root (semi diagrammatic).

Figs. 17 : *Hydrophyllax maritima* L. f. 17. T. S. of a portion of leaf.

Figs. 18-20. : *Psilostachys sericea* Hook. f. 18. T. S. of root (semi diagrammatic). 19. T. S. of stem (aerial—not to scale). 20. A portion of leaf—T. S.

tissue of uniform cells, small and compact. Endodermis distinct and conspicuous. Cortex differentiated ; inner cortex ; small sized cells, thick walled and compact. Outer cortex : cells sub-spherical compact, cells with phlobaphaene. Epiblema uniseriate, big sized cells more or less conical without outgrowths.

Stem (Rhizome—Fig. 16): Cylindrical or sub-cylindrical, wavy in outline. Stele : wide, vascular bundles innumerable, scattered and compact, amphivasal bundles separated from each other by one or two layered cells. Cells clear, infrequently charged with tannin/phlobaphaene.

Endodermis distinct. Cortex : wide, compact, polygonal cells with plenty of tannin/phlobaphaene idioblastic cells, scattered, sometimes in groups. Epidermis uniseriate. Sub-epidermal region with sclerotic plates/patches distributed along the periphery.

Leaf (Fig. 14): Epidermis uniseriate ; upper layer big, cutinised, slightly protruding here and there ; lower layer small, slightly cutinised, surface undulating unicellular hairs on raised knobs consisting of big sized epidermal cells. Hypostomatous, sub-epidermal stands beneath the knobs. Mesophyll differentiated. Upper hypodermal layer 3-5 layered of unequal sized cells, compact, clear or tannin charged ; beneath photosynthetic cover layer.

Hydrophyllax maritima L. f. (Rubiaceae)

It is found on sandy sea beaches, growing on the varied strand/dune habitats. It occurs in isolated patches and usually not associated with other plants on physiographically active beaches. Infrequently this may be found along with *Ipomoea pes-caprae* (L.) R. Br. Its fidelity is recorded on both the coasts of India except coastal West Bengal. This plant is a strand pioneer and forms a good plant cover on dune sand soil because the branches extend in all directions from a centre and are thickly set to form a mat. The stem is crooked, curiously bent, rooting at nodes with erect branches bearing succulent opposite leaves, lilac flowers and corky fruits.

It is found on loamy sand with moderate alkalinity and a stratum extremely high in calcium carbonate percentage. Organic matter is, however, extremely low and soils are free of soluble salts.

Infrequently, it is found in association with other strand plants. Sample counts per square meter from the sandy strand of Saurashtra are: *Hydrophyllax* (aerial branches) 9, *Launaea sarmentosa* 3 ; *Hydrophyllax* 5, *Ipomoea* 2 ; *Hydrophyllax* 3, *Oldenlandia*

2, *Cyperus niveus* 5.

Internal structure :

Root : Exarch. Vascular tissue well developed, interspersed with xylem parenchyma. Pith absent. Endodermis absent. Phloem in a ring. Cortex less wide ; parenchymatous cells, less lacunar, infrequently interspersed with crystalliferous idioblasts. Epiblema uniseriate, compact, cell wall thick. Secondary growth, common. Sub-epiblema cells suberised and thick.

Stem : Sub-cylindrical with smooth surface. Pith cells broad, large, clear, thin walled, parenchymatous, polygonal, becoming smaller at the periphery and often interspersed with tanniniferous idioblasts. Vascular tissues well developed in concentric rings. Well developed secondary wood, phloem in ring, parenchyma wall sinuous and compact ; companion cells present ; infrequently intercepted by tanniniferous idioblasts. Endodermis present. Pericycle present. Cortex wide, parenchymatous, thin walled and divisible into 2 portions. Sub-epidermal outer cortical cells 2 to 3 layered, compact, chlorophyllous, more or less rounded. The inner cortex many layered, polygonal, big sized cells with air space, thick walled and free from contents, intercepted by innumerable tanniniferous idioblasts. Epidermal cells small, compact, outer wall papillose, cutinised, thin, intercepted by stomata.

Leaf (Fig. 17): Hypostomatous. Mesophyll differentiated: Palisade in row, 3 layered, compact, chlorophyllous intercepted by tanniniferous idioblasts. Spongy cells slightly tubular of polygonal, less chlorophyllous, lacunar, intercepted by a few tanniniferous idioblasts. Veins a few ; each is a collateral vascular bundle with border parenchymatous cell. Marginal tips with hydathodes. Epidermis uniseriate, compact, cutinised and intercepted by stomata.

Psilostachys sericea (Koen. ex Roxb.) Hook. f. (Amaranthaceae)

Its occurrence is recorded on the sandy banks and islands of the Saurashtra coast situated along the gulf of Cambay. The increasing frequency of its collection would seem to indicate that this species is now well established in at least in the Saurashtra coast and recently it has been recorded as far south as Juhu (Bombay) (Shah 1964). Along the eastern coast it is reported only at Nellore, Krishnapatnam and Corangi on sea shore sand (Gamble 1957).

It is a slender semi erect or decumbent branching villous herb with thick root stock. It is a pioneer

on sandy mounds often found in association with *Borreria articularis* (L. F.) F. N. Will., *Ipomoea pes-caprae* (L.) R. Br., *Launaea sarmentosa* (Willd.) Alston and *Cyperus arenarius* Retz. Sample counts per square metre are: *Psilostachys* 9, *Borreria* 3; *Psilostachys* 6, *Launaea* 3; *Psilostachys* 7, *Cyperus* 3. The breadth of its niche consists of sandy relief which is highly calcareous, free from salts and organic matter.

Internal structure :

Root (Fig. 18): Primary stage: Diarch with alternate phloem, pericycle present. Cortex parenchymatous; endodermis not distinct. Secondary stage: Secondary growth in continuous concentric woody zones separated by parenchymatous cells, sometimes anastomoses. Each ring is composed of collateral bundles joined together by fibrous conjunctive tissue. Size of vascular zone and the distance between the adjacent zones decreases centrifugally. Epiblema cells tubular, compact, thin walled. Cortical cells compact, tubular, large, thin walled, but lateral walls, sinuous.

Stem (Fig. 19): Quadrangular, stele wide. Pith: Central, wide, compact and clear cells; peripheral cells close to the bundles, small, compact and clear. Vascular tissue, ring of equal size, collateral bundles, joined by conductive tissue, phloem in patches. Secondary wood conspicuous. Endodermis present. Cortex: small, parenchymatous, polygonal, thick walled, compact, less lacunar and cells above secondary wood sclerotic.

Epidermis uniseriate, cells compact, big, interspersed by stomata, cutinised, thick cuticle. Sub-epidermal cells 4 to 5 layered, polygonal, chlorophyllous, crystalliferous idioblasts present. Epidermal outgrowths in the form of simple hairs, or multiple cells to form a base for the hair.

Leaf (Fig. 20): Mesophyll differentiated: palisade and spongy. Palisade in row, 2 layered, compact, chlorophyllous; spongy cells, polygonal, less chlorophyllous, lacunar intercepted by crystalliferous idioblasts at irregular intervals and more in midrib and veins region. Vascular bundles collateral with border parenchyma. Epidermis uniseriate, compact, not homogeneous; epidermal outgrowths of unequal length and size; lower epidermis, small, compact cells; hairs of unequal length and size and plenty.

CONCLUSIONS

In the present study of a few plants showing complete fidelity to the strand/dune areas of the Indian coast there is a clear evidence that these

plants exhibit the following anatomical features of ecological interest: Of the root, sclerotic pith (*Asparagus dumosus*), inner cortex sclerenchymatous, cortical lacunae, cells with tannin or phlobaphene (*Cyperus pedunculatus*), crystalliferous idioblasts, sub-epiblema cells suberised and thick (*Hydrophylax maritima*), secondary growth in concentric woody zones, epiblema cells conical without outgrowth and big-sized (*Psilostachys sericea*), cortical parenchymatous cells with starch grains (*Euphorbia rosea*), uniseriate epiblema with conical cells (*Fimbristylis junciformis*); of the stem, angular or sub-cylindrical with projections, many sub-epidermal sterome (*Asparagus dumosus*), sub-cylindrical, colourless water storing cells in the inner cortex, a few layered collenchyma, epidermis biseriate, thick wavy cuticle (*Capparis cartilaginea*).

Rhizome: Sub-spherical, pith intercepted by tannin-bearing scattered cells, peripheral cells with starch grains, epidermis thick walled and cutinised, sub-epidermal collenchyma (*Cyperus pedunculatus*), sub-cylindrical, pith with tanniniferous idioblasts, vascular ring intercepted by tanniniferous idioblasts, sub-epidermal chlorophyllous cells; inner cortex with numerous tanniniferous idioblasts; epidermal cells with papillose outer wall, cutinised (*Hydrophylax maritima*), quadrangular, sub-epidermal cells chlorophyllous intercepted by crystalliferous idioblasts (*Hydrophylax maritima*). Simple hairs on a single base cell or elongated hairs on a multiple base cells (*Psilostachys sericea*). Sub-cylindrical rhizome plenty of tannin bearing cells sometime clustered, sub-epidermal sclerotic plates, conspicuous (*Fimbristylis junciformis*), cortex with tannin-bearing cells, cutinised epidermal cells intercepted by depressed stomata (*Euphorbia rosea*). Of the leaf (cladode), more or less triangular, centric leaf, 2 layered, polygonal colourless cells abutting 2 layered palisade cells, heavily chlorophyllous, epidermis cutinised, cuticle thick and hypostomatous (*Asparagus dumosus*), isobilateral, peripheral chlorophyllous cells, aqueous tissue compact, epidermis cutinised and stomata hypostomatous (*Capparis cartilaginea*), leaf folded and V-shaped and structure varies from base to tip, uniseriate epidermis upper bigger than lower, cutinised. Sub-epidermal sclerotic strands, mesophyll differentiated, funnel shaped chlorophyllous cells surrounding the collateral vascular bundles (*Cyperus pedunculatus*), multiple palisade, intercepted by tanniniferous idioblasts, marginal tips with Hydathodes, epidermis

cutinised and hypostomatous (*Hydrophylax maritima*), mesophyll differentiated intercepted by crystalliferous idioblasts, epidermal outgrowths of unequal length and size, lower epidermis with plenty of hairs of unequal length (*Psilostachys sericea*), epidermis cutinised, a few cells protruding, lower epidermis with raised knobs consisting of big sized epidermal cells, sub-epidermal stands beneath the knobs (*Fimbristylis junciformis*), mesophyll differentiated, vascular bundles ensheathed by one layered parenchymatous cells charged with chloroplast, laticifers in the spongy areas, epidermis thick-walled and cutinised, hypostomatous (*Euphorbia rosea*).

It is evident from these anatomical features that the investigated plant parts have a normal anatomical structure combined with a few structural features common to plants growing under dry conditions. Of course there is no experimental proof to say that they are caused as a result of the environment, but in all probability they are structural adaptations for their survival and propagation. Thus they constitute an adapted flora in view of the rigorous strand environment. Further the available edaphic evidence shows clearly that the plant growing in the strand zone has to overcome the ecological effects by suitable features of adaptive value.

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REFERENCES

- BLATTER, E., C. McCANN AND T. S. SABNIS. *The flora of the Indian Delta*, Madras. 1929.
- COOKE, T. *The flora of the Presidency of Bombay*. 1958.
- FYSON, P. F. AND M. BALASUBRAHMANYAM. Note on the Oecology of *Spinifex squarrosus* L. *J. Indian bot. Soc.* 1 : 19-24. 1919.
- GAMBLE, J. S. *Flora of the Presidency of Madras*. 1957.
- KERN, J. H. Flora malesianae precursores XXI. Notes on Malaysian and some S. E. Asian Cyperaceae VII. *Acta Botanica* 7 : 786-820. 1958.
- MULLAN, D. P. The Anatomy of the *Spinifex squarrosus* L. with special reference to the Morphology of the leaf blade. *J. Indian bot. Soc.* 18(4-6) : 241-246. 1940.
- Observations on the biology and physiological anatomy of some Indian halophytes. *Ibid.* 12 : 165-182. 1933a and 12 : 235-253. 1933b.
- RAO, T. A. AND K. R. AGGARWAL. Ecological studies on Saurashtra coast and neighbouring islands. III. *Arid Zone Symposium*. Jodhpur, 31-42. 1964 (1971).
- SHAH, C. K. The sedges of Sabarmati, *Vidya. J. Gujarat Univ.* 6 : 179-186. 1963.
- The flora of Taranga hills. *J. Oriental Institute* 1 : 458-474. 1964.
- SHAH, G. L. A note on some rare plants of Bombay. *J. Soc. Indian For.* 4 : 78-80. 1964.