

## TAXONOMIC REVISION OF THE GENUS *PAVETTA* (RUBIACEAE) IN INDIAN SUB-CONTINENT

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### A B S T R A C T

Taxonomic revision of the genus *PAVETTA* (Rubiaceae) in Indian sub-continent results in recognition of 25 species and 8 extratypical varieties. 13 species and 6 varieties described earlier are reduced to synonyms, and 5 species reduced to varietal rank. Two new combinations (*P. indica* var. *glabrescens* (Kurz) Deb & Rout and *P. minor* (Hook.f.) Deb & Rout) have been published. Dichotomous keys have been prepared for identification of taxa of all levels. Critical notes on nomenclature, morphological characters etc. have been provided after description of species wherever necessary. Morphological characters have been studied thoroughly. Special attention has been given on characters like indumentum, colleters, domatia, bacterial leaf-galls, pollen, seed coat, corolla microcharacters etc. The anatomical characters (internode, node, petiole and leaf) of *P. indica* have been studied. Information available in literature on wood anatomy, chromosome numbers and pollen nuclear numbers have been incorporated.

Morphology of indumentum and bacterial leaf-galls have been studied in all taxa. Colleters have been studied in 28 taxa ; domatia found in 13 taxa. Microcharacters of outer surface of corolla tube (8 taxa) and inner surface of corolla lobes (19 taxa) have been studied under SEM in magnification up to 3200. Pollen morphology have been studied both in LM (27 taxa) and SEM (16 taxa). Seed coat morphology has been studied in cross section under compound microscope (13 taxa) and surface under SEM (10 taxa).

Of the species studied, 16 are distributed in India extending to adjoining region, 3 in Myanmar, Bhutan and Bangladesh and 9 species in Sri Lanka. *P. indica* is most widely distributed, almost throughout the country and extends to its adjoining region ; *P. birmahica* is endemic to Myanmar ; six species are endemic to Tamil Nadu (Nilgiri and Kuttalam hills), Kerala and Andhra Pradesh and one species is distributed in Andaman and Nicobar Islands.

## INTRODUCTION

The Rubiaceae is one of the largest families of flowering plants comprising about 659 genera and 10,700 species (Robbrecht 1988 ; Deb & Rout 1991). More than three fourth of its tribes are predominantly woody, distributed in tropical and subtropical regions ; only the Rubieae is concentrated in temperate regions. There are 108 genera and over 550 species in Indian Region.

PAVETTA L. is a large genus containing more than 400 species (Willis 1973) distributed in the tropical and subtropical regions of Africa, Asia and Australia. Bremekamp (1934) in his monographic study of the genus described 42 species from Indian subcontinent.(including Bangladesh, Bhutan, Myanmar, Nepal and Sri Lanka).He did not examine most of the specimens extant in Indian herbaria. Moreover, many specimens have since been collected from different parts of India, which deserved an indepth study. In view of these facts it was considered necessary to carry out a taxonomic revision of the genus.

## MATERIAL AND METHODS

The present taxonomic revision is based on herbarium specimens collected from India, Bangladesh, Bhutan, Myanmar, Nepal, Sri Lanka and Malaysia as extant in the herbaria viz. ASSAM, BM, BSD, BSI, BSIS, CAL, DD, E, K, L, LWG, MH and PBL and those

received on loan from K, BM, E, and L, supplemented by field study.

Flower buds, trichomes, colleter, pollen grains and fruits were collected either from herbarium specimens or from fresh collections, for morphological, palynological and seed coat studies.

The type specimens/isotypes of 39 taxa (as per Bremekamp 1934) have been studied on loan from BM, E, K, L and photographed and deposited at CAL. In 7 taxa, the types are present at K, but the photographs are extant at CAL, which were consulted. The microfiches of Wallichian herbarium at K (K-W) (IDC No. 638, 639) and de Candolle herbarium in G-DC (IDC No. 708) present at CAL were also consulted. Isotypes of 7 taxa present at CAL were discovered in course of the present investigation. Acronyms of the herbaria (as per Holmgren *et al.* 1981) consulted are used in citation of specimens.

Conventional herbarium methods currently in use for the taxonomic revisions have been followed. Protologues and original literature relating to the names, descriptions and typification of taxa have been consulted. Type specimens have been examined in most of the cases. In the event of non-availability of original type specimens, photographs and microfiches have been consulted. Morphological characters of every specimen have been critically examined and variation of every specimen has been checked and

unidentified specimens have been properly identified. Taxonomic ranks and nomenclature of taxa of all levels have been studied. Correct names and synonyms have been given as per International Code of Botanical Nomenclature (Greuter *et al.* 1988). For description of taxa, the terminologies were employed as per Lawrence (1951), Radford (1986) and Stearn (1973).

All available recent floras, journals and other related literature have been consulted. The treatment of taxa by different workers are cited chronologically just after the protologue reference. The types of correct names, synonyms or basionyms which were examined are cited.

Dichotomous keys have been prepared for identifications of taxa of all levels. Descriptions and identifications of taxa have been worked out after proper determination and examination of all the specimens of the taxa concerned and scrutiny of literature on them. The name of places of collection have been traced out as far as possible and plotted on maps and accordingly grouped in the list of herbarium specimens examined. An altitudinal distribution is also prepared. Metric system has been used in measurement and altitude. Data on colour of flowers and fruits, flowering and fruiting time, ecology, altitude, uses etc., of the specimens have been collected from the literature or collector's observation (field note). Notes regarding some points of taxonomic or other interest

have been given wherever necessary. The morphological characters of taxonomic importance of taxa have been illustrated.

*External morphology* : The specimens were examined with hand lens (10X) and Olympus binocular dissecting microscope under 10X and 20X. For microscopic observations, the flowers were transferred from herbarium specimens to water and allowed to soak for 4-5 hours or over night and then boiled in water and dissected. To study embryo and albumen, the seeds were kept in water for 24 hours and then boiled to make it soft. Then it was dissected and studied. During measurement, the length of leaves included the petiole length.

*Anatomy* : For anatomical studies of internodes, nodes, petiole and leaf, fresh material were used. The transverse sections were stained and mounted temporarily and observed under a compound microscope.

*Trichomes and colleters* : Trichomes of stem, leaf surfaces and parts of inflorescence were scrapped off by a blade on a slide, soaked in water and stained with safranin and temporarily mounted in glycerine. Those from inside of corolla tube were separated with the help of a needle from the dissected corolla and prepared in the same way. The trichomes present on the adaxial surface of stipules were observed with colleters.

Colleters were studied microscopically.

These were scarpped off the inside of stipules and calyx on a slide and mounted in the same procedure as for trichomes. Both colleters and trichomes were observed under a compound microscope equipped with an ocular micrometer and drawn using camera lucida.

*Domatia* : Domatia were observed in surface view under binocular Olympus dissecting microscope (20X), SEM and in cross section under low magnification using a compound microscope.

*Bacterial leaf-galls* : Bacterial leaf-galls were observed in surface view under binocular dissecting microscope (20X).

*Corolla* : The microcharacters on the outer surface of corolla tube and inner surface of corolla lobes were studied with the SEM under magnification up to 3200 from dried untreated herbarium material.

*Study of Pollen* : For light microscopic studies of pollen, the permanent slides were prepared by acetolysis method (Erdtman 1952). The mature flower buds were collected from herbarium specimens and kept in centrifuge tubes containing 60% alcohol and allowed to soak for 24 hours. Then the soaked material was gently crushed with a glass rod to release the pollen grains from the closed anthers. Then the crushed material was sieved through a brush wire mesh. The pollen containing alcohol was collected in centrifuge tube and centrifuged. Then the pollen

sediment was washed with glacial acetic acid and centrifuged. Then it was treated with freshly prepared acetolysis mixture (9 parts acetic anhydride and 1 part Conc. sulphuric acid). Then the tubes containing acetolysis mixture was heated on a water bath from 70°C to boiling point. The dispersion was then centrifuged and the sediment was first washed with glacial acetic acid and then with distilled water, each time followed by centrifugation. The tube containing the sediments were kept upside down on a filter paper to drain off excess water. A small pellet of solidified glycerine gelly was taken on the tip of a needle and brought in contact with pollen sediment. Then the gelly was transferred to a slide and warmed on a hot plate to melt, the pollen material in melted jelly was spread evenly with the help of needle, a cover slip placed on it and the space around the glycerine gelly was sealed by melted wax. The slides were prepared in duplicate, observed under compound microscope; for each taxon, at least 20 observations were taken for measurement of P, E, aperture, exine thickness etc. Then photographs were taken. After completion of study, the slides were deposited at CAL.

For SEM study, unacetolysed pollen materials were used. The pollen grains were mounted on the stubs with double adhesive tapes. The stubs were subjected to gold coating in a sputter coater and then used in Scanning Electron Microscope (P SEM 500).

**Seed Coat :** Mature fruits were kept in water for at least 24 hours to make it soft. Then seeds were removed and treated with 10%  $\text{HNO}_3$  for 24 hours to remove the outer walls. To determine the three dimensional structure of exotestal cells, both section and seed coat peels were examined light microscopically and correlated with SEM observations because "descriptions given in literature made from seed coat examined in surface view only (LM or SEM) are often inaccurate or misleading. SEM-graphs offer only additional information or sculpture patterns of thickening if the outer cell wall is withered or can be artificially removed" (Robbrecht & Puff 1986).

For LM studies, the sections and seed coat peels (unstained) were temporarily mounted in glycerine and observed with the help of compound microscope under magnification  $10 \times 10X$ . The drawings were made using camera lucida.

For SEM observations, the seed coats were dried in different grades of alcohol and then mounted on stubs using double adhesive tapes, gold coated, observed in SEM (P SEM 500) and then photographed.

#### POSITION AND CONSTITUTION OF THE TRIBE PAVETTEAE

B.C.J. Dumortier (1829) postulated the tribe *Pavetteae* (Type : *Pavetta* L.), basing on A. Richard's (1829) name *Pavetees* (as

"tribe"). A.P. de Candolle (1807) named the tribe *Coffeaceae* (*Coffeeae*) (Type : *Coffea* L.) and later on he (de Candolle 1830) subdivided the tribe into 2 subtribes namely *Coffeeae* and *Cephaelideae*, placing *Pavetta* in subtribe *Coffeeae*. This treatment was followed by A. Richard (1830), G. Don (1834), Wight & Arnott (1834), Lindley (1836) and Sonder (1894).

The name *Ixoreae* was postulated by Bentham (1849) as subtribe, which was followed by Grisebach (1861). A. Gray (1858) treated it as a tribe. J. D. Hooker (1873) divided de Candolle's *Coffeeae* into 3 tribes, *Ixoreae* being one of them. PAVETTA, IXORA, COFFEA and some other genera were included in tribe *Ixoreae*. This treatment was followed by Hiern (1877), K. Schumann (1891), Hutchinson & Dalziel (1931), Verdcourt (1958), Bremekamp (1966).

The correct name for the tribe *Ixoreae* (including *Coffea*) in the circumscriptions of J.D. Hooker (1873), K. Schumann (1891), Verdcourt (1958) and Bremekamp (1966) is *Coffeeae* s.l. Darwin (1976) rejected the name *Ixoreae* as a tribe as this name is invalid (as per International Code of Botanical Nomenclature) because it included PAVETTA and COFFEA which were published earlier as type genera of their own tribes. He did not mention any tribe name of IXORA but indicated the subfam. *Ixoroideae* Rafinsque (1820) as valid but mentioned tribe *Coffeeae* for *Coffea* and *Pavetteae* for *Pavetta*.

Robbrecht (1984) revived the name *Pavetteae* A. Rich. ex Dumortier (1829) and proposed to include in it, all the genera of old *Gardenieae-Coffeae* complex with terminal inflorescence [considered by Bremekamp (1834) as natural one] including *Leptactina* and *Dictiandra* (excluding *Coffea* which belong to *Coffeae* s.s.). Robbrecht & Bridson (1984) included another genus *Cladoceras* Bremek. (due to absence of ixoroid pollen mechanism, Bremekamp denied its position either in *Ixoreae* (*Coffeae* s.l.) or in *Gardenieae*) in *PAVETTA* near *TARENNA*, considering its monopodial architecture and terminal inflorescence, flower morphology, placentation, pollen, fruit and seed coat characters. Bridson & Robbrecht (1985) and Robbrecht & Puff (1986) discussed in detail about the delimitation of *Pavetteae* and included in it altogether 13 genera, distinguishing in two major groups : genera related to *IXORA* (*VERSTEEGIA*, *IXORA*, *CAPTAINCOOKIA*, *MYONIMA*, *DORICERA*, *RUTIDEA* and *NICHALLEA*) and genera related to *TARENNA* (*LEPTACTINA*, *DICTIANDRA*, *PAVETTA*, *TARENNA*, *TENNANTIA* and *CLADOCERAS*) which may deserve subtribal status.

Robbrecht (1988) added 4 more genera (*COLEACTINA*, *DUPERREA*, *HITOA* and *PACHYSTYLUS*) raising the total number of genera to 17 and tentatively included *Homollea*, *Homolliella*, *Paracephaelis* and *Schizenterospermum*. He characterized the tribe *Pavetteae* as "Shrubs, rarely climbing

or geofrutescent. Stipules interpetiolar, entire, (fimbriate in *Rutidea* ssp.). Raphides absent. Inflorescence mostly terminal, corolla lobes contorted to left. Ovary 2(-7)-locular, each axile placenta with 1-many ovules. Fruits fleshy. Seeds 1-numerous per locule, frequently with adaxial excavation. Exotestal cells sometimes parenchyma-like, mostly with thickenings along outer tangential walls. Embryo radicle inferior or latetral. Stylar pollen presentation present. Pollen grains 3- 4(-5)-colporate."

In India, the tribe *Pavetteae* is represented by three genera : *IXORA*, *PAVETTA* and *TARENNA*. These can be distinguished as per following key.

#### KEY TO THE GENERA

1. Flowers 5-(rarely 4) merous ;  
corolla tube stout, slightly shorter  
or longer than lobes (rarely much  
longer) ; ovules many (rarely 2 or  
1) in each locule ... *TARENNA*
- 1a. Flowers 4-merous ; corolla tube  
slender, two times or longer  
than lobes, ovules 1 in each  
locule ... 2
2. Bacterial leaf-galls common  
(rarely absent) ; bracts  
stipulary, membranous, sheath-  
ing at lower cyme branches ;  
style twice as long as the corolla  
tube ; stigma entire, rarely  
notched ... *PAVETTA*

- 2a. Bacterial leaf-galls absent ; bracts  
 foliar, coriaceous at lower cyme  
 branches ; style as long as or slightly  
 longer than corolla tube ; stigma  
 two lobed ... IXORA

## HISTORY OF THE GENERA

## PAVETTA L. AND IXORA L.

The genus PAVETTA L. was published for the first time by Rheede (1685) as "*Pavetta feu Malleamothe*". Burman (1737) described it as "*Sambucus humilis zeylanica Pawatha zeylanensibus*". Linnaeus (1747) published it as PAVETTA, and in 1753 (*Species Plantarum*) he described it unispecific (*P. indica*). The genus PAVETTA was also described in fifth edition of his *Genera Plantarum* (Linnaeus 1754).

IXORA L. was published for the first time by Rheede (1679) in *Hortus Indicus Malabaricus* as *Schetti* (2 : 17, t. 13) and *Bem Schetti* (2 : 19, t. 14). Plukenet (1696) named the plant as *Jasminum indicum*. Burman (1737) proposed the name *Jasminum flore tetrapetalo*. Rumphius (1743) named it as *Flamma sylvarum*. Linnaeus (1747) named it as IXORA. Then, in *Species Plantarum* (Linnaeus 1753) and *Genera Plantarum* ed. 5 (Linnaeus 1754), two species of the genus were described (*I. coccinea* and *I. alba*). He cited *Schetti* Rheede and the names proposed by Plukenet (*l.c.*) and Burman (*l.c.*) as synonyms under *I. coccinea* and *Bem Schetti* Rheede as synonym under *I. alba*. Adanson (1763) named the plant as *Schetti* following

Rheede (*l.c.*) citing his reference and also cited *Jasminum* of Plukenet (*l.c.*), Burman (*l.c.*) and *Ixora* L. as the synonyms.

Linnaeus (1753, 1754) did not indicate the distinguishing characteristics of calyx, corolla lobes and anthers in descriptions of PAVETTA and IXORA. However, the differences in the form of style was shown. In PAVETTA, the upper part of style is mentioned as "stigma crassiusculum" and that of IXORA as "stigma bifidum". This difference in the form of stigma is the principal diagnostic difference between the two allied genera. The description of fruits and seeds in *Genera Plantarum* (Linnaeus 1754) : "Bacca subrotunda unilocularis" in both the genera, "Sem. unicum, subrotundum, cartilagineum" in PAVETTA and "quattuor hinc convexa, inde angulata" in IXORA were wrong. In seventh edition of *Genera Plantarum* (Reichard 1778), a correct description of seed of PAVETTA is given : "Sem. bina, hinc convexa, cartilaginea". Gaertner (1788) described the fruits and seeds of both the genera correctly. Schreber (1789), Haenke (1791), Richard (1829), Sprengel (1830) and de Candolle (1830) followed these descriptions.

Jacquine (1763) established the genus SIDEROXYLOIDES as monotypic (*S. ferrum*). Schreber (1789) described the genus SIDERODENDRUM basing on SIDEROXYLOIDES Jacq. which was cited as synonym.

Houttuyn (1777) described CRINITA as a

monotypic genus (*C. capensis*) from south Africa, distinguishing it from PAVETTA in greater length of calyx lobes. Linneus f. (1781) treated this plant as *P. caffra* as the second species of PAVETTA. Bremekamp (1934) corrected the name of this species as *P. capensis* (Houtt.) Bremek.

Lamarck (1789) described 5 species of IXORA L. Jussieu (1791) in his *Genera Plantarum* included both PAVETTA and IXORA. Vahl (1794) described 4 species of PAVETTA (*P. glabra*, *P. alba*, *P. villosa* and *P. longiflora*). He described *I. parviflora* as a new species of IXORA from India. Swartz (1797) described *Pavetta pentandra*, which was later on found to be synonym of *Pelicouria domingensis* (Jacq.) DC. Willdenow (1798) treated *P. glabra* Vahl as a synonym of *P. indica* L. and included other four species.

Lamarck (1791) did not recognize PAVETTA as distinct genus and referred *P. indica* L. to IXORA. Poiret (1813) followed this view and transferred all known species of PAVETTA to IXORA and added a new species of his own. Roxburgh (1814, 1820, 1832), Bentham (1867) and Kurz (1877 a,b) followed Lamarck's view of treating PAVETTA as a synonym of IXORA. Baillon (1880), Kuntze (1891) and Castillo (1897) included other genera (including PAVETTA) with IXORA. Blume (1826), Richard (1829), Korthals (1851) and Miquel (1856, 1860) came to the same conclusion but in contradiction with

Lamarck, used the name PAVETTA for the combined genus.

Persoon (1805) included 6 species of PAVETTA : *P. amplexicaulis*, *P. indica* (*I. paniculata* Lam.), *P. villosa*, *P. longifloram*, *P. caffra* and *P. pentandra*. A.P. de Candole (1807) described the genus BACONIA as monotypic (*B. corymbosa*). Poiret (1808) called the same plant as *Verulamia*, the name was proposed by de Candolle who wished to dedicate it to the memory of Lord Bacone of Verulam and the name was apparently used while reading the paper in the institute. BACONIA differs from PAVETTA in bearded corolla throat and shortness of corolla tube and from IXORA in entire or shortly bilobate style.

Smith (1811) named *Flamma sylvarum* Rumph. (1743) as *Ixora longifolia* Smith, but it was later on identified as *Ixora fulgens* Roxb. (1820). Roxburgh (1814, 1820, 1832) treated 18 species of the genus IXORA. (including 2 species of PAVETTA : *P. indica* and *P. tomentosa* as *I. pavetta* and *I. tomentosa* respectively). He described 15 new species of IXORA. Roemer & Schultes (1818) included 5 species of PAVETTA. Jack (1820) described *Ixora pendula* as a new species. Roth (1821) treated 2 species of IXORA (*I. obovata* and *I. undulata*) and 4 species of PAVETTA. Moon (1821) reported *P. indica* from Sri Lanka. Blume (1826) published 3 new species under PAVETTA : *P. javanica* Bl. [*Ixora javanica* (Bl.) DC.],

*P. incarnata* and *P. salicifolia*.

Richard (1829) mentioned the terminal position of inflorescence and introduced for the first time, the aestivation of corolla which was accepted in the classification of the family Rubiaceae by J.D. Hooker (1873), Baillon (1880) and Schumann (1891). He described the flower as tetra- or pentamerous for which he included with PAVETTA, so many species belonging either to TARENNA, ENTEROSPERMUM, RUTIDEA or NEMATOSTYLIS.

Candolle (1830) treated PAVETTA and BACONIA as two distinct genera. He recognized the diagnostic value of the style and described it using correct terminology. He considered white colour of the flower as an important character which led him to include several white flowered species of IXORA, TARENNA, CANTHIUM, NEMATOSTYLIS, ENTEROSPERMUM in PAVETTA. He (*l.c.*) described the genus EUMACHIA as monotypic [*E. carnea* (Foster) DC.] basing on *Petesia carnea* Foster. He considered *Siderodendrum* Schr. as a distinct genus and included in it, 2 species : *S. triflorum* Vahl (*S. ferrum* Lam., *S. ferrum* Jacq.) and *S. multiflorum* A. Rich. He described 34 species of IXORA L.

G. Don (1834) described 32 species of PAVETTA including 6 species from India. Two new species *P. brunonis* and *P. naucleiflora* were described from India and Burma respectively. He described 43 species of IXORA including 12 new species. Wight &

Arnott (1834) described 6 species of PAVETTA from India including a new species *P. hispidula* Wt. & Arn. and 17 species of IXORA including 2 new species. Rafinesque (1838) established the genus BEMSETIA on the basis of *B. paniculata* which is a synonym of *Ixora barbata* Roxb.

Walpers (1843, 1848-9, 1851-2) treated 38 species of IXORA, 9 species of PAVETTA from India and some other species from Africa and Australia. He treated BACONIA DC., EUMACHIA DC., *Siderodendrum* Schreb. as distinct genera. He included 2 species under *Siderodendrum* : *S. macrophyllum* Benth. and *S. laxiflorum* Benth.

J.D. Hooker & G. Bentham (1849) gave an account of 5 species of PAVETTA from river Niger of West Tropical Africa. Dalzell (1850, 1851) described *P. siphonantha* and *I. pedunculata* as new species from India. Miquel (1856) described 45 species under PAVETTA including species of IXORA.

Montrozier (1860) described the genus PANCHEZIA as monotypic (*P. collina*). J. D. Hooker (1864) described *Baconia montana* as second species of the genus. Drury (1864) gave an account of 7 species of PAVETTA from India. Thwaites (1859) described 5 species of PAVETTA (including 2 new species : *P. angustifolia* and *P. involucrata*) and 5 species of IXORA (including 2 new species : *I. calycina* and *I. jucunda*) from Sri Lanka (Ceylon). Viellard (1865) established the

genus *Charpentiera* as monotypic (*C. bracteata*). Bremekamp (1934) identified it as *Ixora collina* (Montr.) Beauv.

S. Kurz (1872) described 7 species of IXORA from Burma and Andaman Islands. In 1875, he described *I. macrosiphon* from Andaman Islands. In 1877, he gave an account of 26 species of IXORA including 3 species of PAVETTA from Myanmar and Andaman Islands. He described 2 new varieties under *I. tomentosa* Roxb. (*P. indica* L. var. *tomentosa*): var. *roxburghii* Kurz and var. *glabrescens* Kurz.

J.D. Hooker (1873) treated SIDERODENDRUM Schreb., SIDEROXYLOIDES Jacq., PANCHEZIA Montr. and EUMACHIA DC. as synonyms under IXORA L. and BACONIA DC. as synonym under PAVETTA L. Hiern (1877) followed him and treated two species of BACONIA as *Pavetta baconia* Hiern (*B. corymbosa* DC.) and *P. hookeriana* Hiern (*B. montana* Hook.f.). He included 25 species of PAVETTA from Africa.

Brandis (1874) reported 4 species of PAVETTA and IXORA from North West and Central India. J. D. Hooker (1880) gave an account of 10 species of PAVETTA (including 4 new species) and 34 species of IXORA (including 3 new species) from Indian subcontinent. He reduced *P. siphonantha* Dalz. and *P. angustifolia* Thw. to varieties of *P. hispidula* Wt. & Arn. and *P. tomentosa* Roxb. ex Sm. to a variety of *P. indica* L.

Triman (1888, 1894) gave an account of 7 species of PAVETTA and 4 species of IXORA from Sri Lanka.

K. Schumann (1891) mentioned a new diagnostic character in PAVETTA that the bracts at the base of inflorescence are connate and stipular (placed at right angles with the branchlets), but in IXORA, it is free and foliar. He treated CRINITA Houtt., BACONIA DC., VARULAMIA DC. ex Poir. and CHARPENTIERA Viell. as synonymys of PAVETTA L. and SIDERODENDRUM Schreb., SIDEROXYLOIDES Jacq., EUMACHIA DC. and PANCHEZIA Montr. as synonyms of IXORA L. He treated 6 species of PAVETTA including 3 from Indian subcontinent. In 1899, he described a new genus : EXECHOSTYLUS as monotypic (*E. flaviflora*) for a West African plant. Hutch. & Dalz. (1931) reduced it to a species of PAVETTA : *P. flaviflorus* (K. Schum.) Hutch. & Dalz. Bremekamp (1934) treated it as a synonym of *Pavetta brachycalyx* Hiern (1877) and kept under subgenus BACONIA.

Talbot (1902) and Cooke (1904) reported on the occurrence of 2 species of PAVETTA from Bombay. Cooke (1904) described 7 species of IXORA from Maharashtra and Karnataka. Duthie (1903) gave an account of 2 species of PAVETTA from Upper Gangetic Plains. Prain (1903) reported 2 species of PAVETTA and 7 species of IXORA from Bangladesh, West Bangal and Bihar. King & Gamble (1905) gave an account of IXORA from Malay Peninsula, Myanmar and

Andaman Islands. Brandis (1906) included 7 species of PAVETTA and 30 species of IXORA from India and Myanmar. Strachey (1906) reported *P. indica* from Kumaon, Garhwal and Tibet. Bourdillon (1908), Rama Rao (1914) and Fyson (1932) reported on the occurrence of PAVETTA and IXORA from South India and Haines (1910, 1916, 1922) reported from Bihar, Orissa and Madhya Pradesh.

Craib (1914) described a new species and a new variety : *Ixora meeboldii* and var. *oblonga* from Myanmar. R.S. Hole (1919 a,b) described *Ixora butterwickii* from Burma as a new species. Gamble (1920) described 3 new species of IXORA : *I. lawsonii*, *I. monticola* and *I. saulieri* from South India. In 1921, he described 17 species of IXORA and 6 species of PAVETTA from South India. Parkinson (1923) gave an account of 4 species of IXORA from Andaman Islands. Ridley (1923) described 25 species of IXORA and 6 species of PAVETTA from Malay Peninsula, including some species from Indian subcontinent. Issac (1927) reported *P. indica* from Western India. Osmaston (1927) gave an account of 2 species of PAVETTA from Kumaon. Craib (1932) described *Ixora parkinsoniana* Craib as a new species from Burma.

Bremekamp (1929) gave an account of south African species of PAVETTA. In 1934 he treated 343 species of PAVETTA including 42 species from Indian subcontinent, out of which, 29 species were of his own. He treated

CRINITA Houtt., BACONIA DC., VERULAMIA DC. ex Poiret and EXECHOSTYLUS Schum. as synonyms of PAVETTA L. The name CRINITA was revived for one of the sections to which *P. capensis* (*Crinita capensis*) belongs and BACONIA for one of the two subgenera : BACONIA (DC.) Bremek. In subsequent publications (1936, 1937c, 1939a,b, 1948, 1953, 1956), he described some new species of PAVETTA from Africa (the total number of species increased to 406) and made some modifications to the infrageneric classifications of PAVETTA. In 1937c, he raised the section DIZYGOON to the rank of a subgenus. In 1937a, he gave an account of 165 species of IXORA from Malayasia. Then, he (Bremekamp 1937b) described 35 species of IXORA from Myanmar and Andaman Islands including 19 new species. In 1938, he added 7 new species from Myanmar and Assam. In 1959, he described 5 new species of IXORA from Indian subcontinent.

#### TAXONOMIC POSITION OF THE GENUS

##### PAVETTA L.

Linnaeus (1753, 1754, 1756, 1759, 1762, 1764a,b, 1767) placed the genus PAVETTA under class IV *Tetrandria Monogynia* Gleditsch (1764) placed it under class II *Petalostemones Tetranthereae*. Murray (1774, 1784, 1797), Gaertner (1788), Schreber (1789), Haenke (1791), Swartz (1797), Willdenow (1798), Turton (1820), Persoon (1805), Hedwig (1806), Jolyclerc (1810), Sprengel (1825, 1830), Roemer &

Schultes (1818, 1827) followed Linnaeus. Lamarck (1791) and Roxburg (1814, 1820, 1832) also followed Linnaeus but they did not recognize PAVETTA as a distinct genus and merged with IXORA.

A.L. de Jussieu (1791) named the family Rubiaceae and placed PAVETTA in group VI, characterized by "fructus monocarpus bilocularis dispermus, stamina quatuor, folia opposita, caulis plerumque frutescens". A.P. de Candolle (1830) placed it under tribe COFFEACEAE, subtribe COFFEEAE. A. Richard (1830), G. Don (1834), Wight & Arnott (1834), Lindley (1836, 1846), Sonder (1894) followed de Candolle. Endlicher (1838) placed it under tribe PSYCHOTRIAE, subtribe COFFEEAE. Lindley (1853) followed Endlicher, but without distinguishing any subtribe.

J.D. Hooker (1873) divided de Candolle's tribe COFFEEAE into three tribes IXOREAE, PSYCHOTRIAE and COUSSAREAE, placing PAVETTA in tribe *Ixoreae*. Hiern (1877), J.D. Hooker (1880), K. Schumann (1891), Hutchinson & Dalziel (1931), Verdcourt (1958), Hepper & Keay (1958), Bremekamp (1966) followed this.

Robbrecht (1984) changed the name of tribe as *Pavetteae* A. Rich. ex Dumortier (1829). Bridson & Robbrecht (1985), Robbrecht & Puff (1986) and Robbrecht (1988) placed the genus in this tribe.

In present investigation, the genus PAVETTA is placed in tribe *Pavetteae* A. Rich ex Dumortier.

#### TAXONOMIC SIGNIFICANCE OF MORPHOLOGICAL CHARACTERS

*Habit and habitat* : The habit is variable. It may be undershurb, shrub or small to large sized tree. Most of the species are shrubs of 2-3 m in height ; some species (*P. involucrata*, *P. naucleiflora*, *P. breviflora* var. *breviflora*, *P. subcapitata*, *P. travancorica*, *P. graciliflora* etc.) are shrubs or trees, few are undershurbs or shurbs (*P. minor*, *P. hispidula* var. *zeylanica*), but *P. birmahica*, *P. crassicaulis*, *P. indica* var. *tomentosa* etc. are variable in their habit from undershurbs to trees, reaching up to 10 m in height. *P. nemoralis* and *P. macraei* are undershurbs.

Normally, they grow in dense evergreen forests. *P. indica* and *P. graciliflora* grow plain areas to high altitude. *P. breviflora*, *P. hispidula* var. *zeylanica*, *P. wightii* etc. grow as under growth in evergreen forests.

*Stem* : Normally the main stem bears lateral branches. The stems are normally stout, but slender in *P. hohenackeri* and *P. thwaitesii* ; it is slender or stout in *P. gleniei*. The stems are terete in most of the species but subquadrangular in *P. involucrata*, *P. breviflora* var. *pubescens*, *P. brunonis*, *P. crassicaulis* etc.; terete or

subquadrangular in *P. macraei*, *P. birmachica* etc. ; terete or flattened in *P. hispidula* var. *angustifolia*, *P. naucleiflora* etc.

The stems are glabrous in *P. indica* var. *indica*, *P. blanda*, *P. involucrata*, *P. thwaitesii*, *P. oblanceolata*, *P. hohenackeri* etc., but pubescent in *P. indica* var. *tomentosa*, *P. macraei*, *P. birmachica* etc, glabrous or puberulous in *P. minor*, *P. hispidula* var. *zeylanica* etc. The stem of *P. madrassica*, *P. gleniei*, *P. praeterita*, *P. subcapitata* etc. are pubescent when young but glabrous in age. Young stems are green in colour, but become corky in age. The bark is yellow in *P. involucrata*, *P. breviflora* etc. or brown in *P. wightii*. The stem of *P. crassicaulis* is provided with short conical outgrowths. Internodes are normally long, but short in *P. nemoralis* and *P. praeterita*.

**Taxonomic significance :** Stem of *PAVETTA* have little taxonomic significance. Bremekamp (1934) considered corky nature of stem (vegetative and flowering) as a taxonomic character for distinguishing series under sect. *Pavettaster* of the subgenuss *PAVETTA* (*Eupavetta* Bremek.). It does not stand as a taxonomic character as the stems are green when young, but become corky in age. The green stems observed by Bremekamp are probably at an early stage of development. However, slender stems of *P. thwaitesii*, *P. hohenackeri* and short conical outgrowths on the stems of

*P. crassicaulis* are useful taxonomically.

**Leaves :** The leaves are petiolate, opposite, decussate. Ternate leaves occur only in *PAVETTA* sp. 1 (Roxburgh s.n. BM :). The leaves of a node are normally isophyllous (almost of same size), but anisophyllous leaves (of different sizes) have been observed below the cymes of *P. hispidula* var. *zeylanica*.

The size of leaves ranges from 2.5 to 20.5 cm in length and 0.5 to 12.0 cm in breadth. The shape of lamina is variable. It is elliptic (Fig.1 : f, k) in *P. gleniei*, *P. birmahica* etc.; obovate (Fig.-1 : d,h) in *P. involucrata*, *P. graciliflora*, *P. crassicaulis* etc. ; oblong (Fig.1: e,g) in *P. hispidula* var. *zeylanica*, *P. praeterita* etc. ; lanceolate (Fig. 1 : b,l) in *P. indica* var. *glabrescens*, *P. hispidula* var. *hispidula* etc., linear (Fig. 1 : j) in *P. hispidula* var. *angustifolia* ; linear-lanceolate (Fig. 1: j) in *P. thwaitesii* and oblanceolate (Fig. 1 : a,c) in *P. oblanceolata*, *P. blanda*, *P. praeterita* etc. *P. indica* is most variable in shape of leaves containing elliptic, obovate, oblanceolate or lanceolate leaves.

The apex may be rounded (*P. blanda*), obtuse (*P. involucrata*, *P. indica* var. *indica*), subacute (*P. graciliflora*), acute (*P. hispidula* var. *zeylanica*, *P. gleniei*, *P. praeterita* etc.), acuminate (*P. hispidula* var. *hispidula* & var. *angustifolia*, *P. indica* var. *glabrescens* etc.) or caudate (*P. oblanceolata*). The base may be acute (*P. gleniei*, *P. hispidula* var.

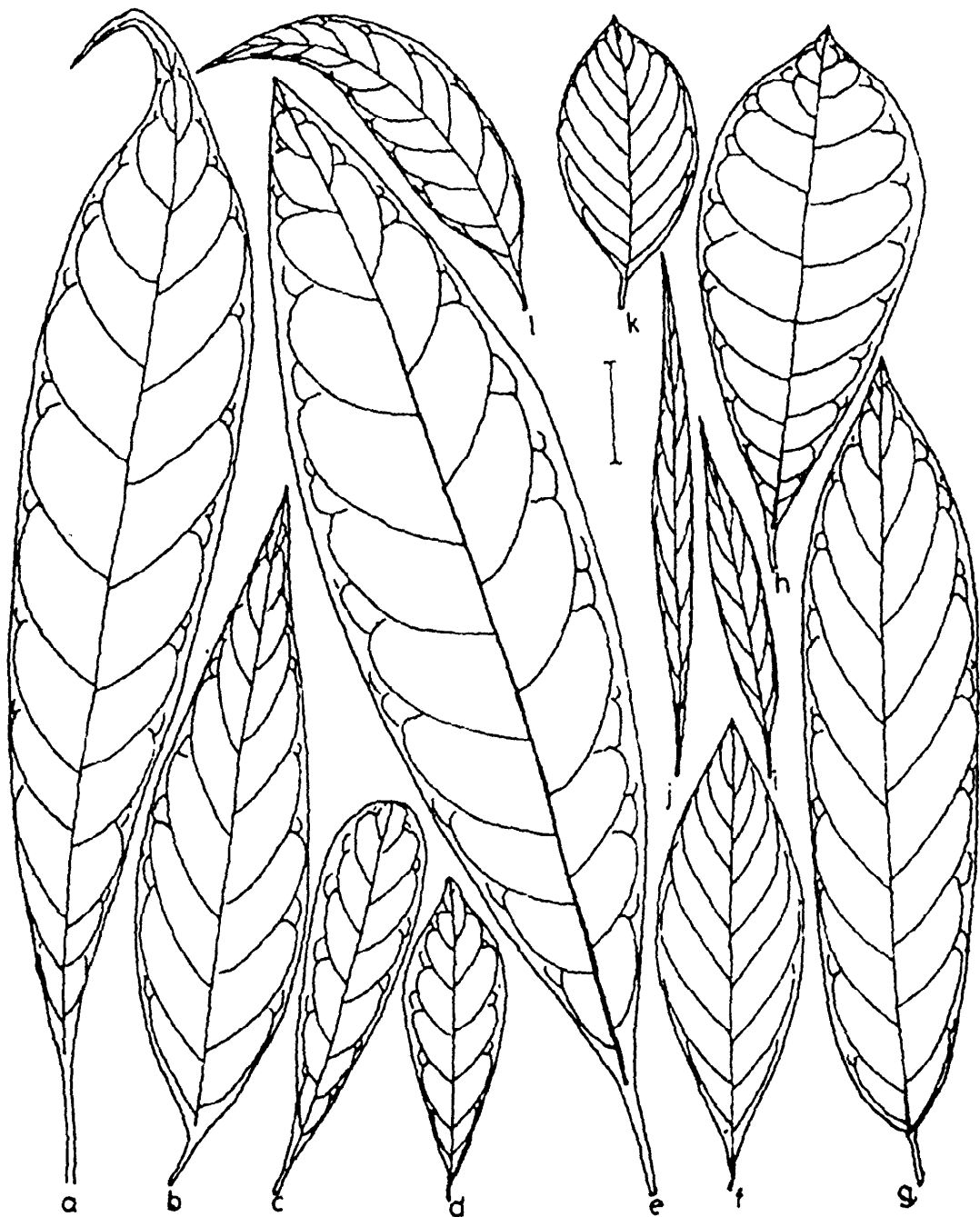


Fig. 1 : Leaves.

*angustifolia* etc.), cuneate (*P. hispidula* var. *zeylanica* & var. *hispidula* etc.), obtuse to rounded (*P. praeterita*) or attenuated (*P. oblanceolata*, *P. blanda*).

The leaf bases are normally equal, but unequal bases are also seen : frequently in *P. indica*, *P. subcapitata*, *P. naucleiflora*, *P. hispidula* etc., but rarely in *P. brunonis*, *P. graciliflora*, *P. birmahica* etc. or absent in *P. gleniei*, *P. crassicaulis* etc. The unequal bases are variable, even in the same specimen among different leaves. So it is having no taxonomic significance.

The margin of lamina is entire. In some herbarium specimens it may be sometimes revolute. Bremekamp (1929) considered the revolute margin to be a generic feature. This artificial characteristic is caused by the fact that the cellulose cell wall of collenchymatous cells in the leaf margin are saturated with water and when plant loses water during process of drying, the cell walls shrink and the leaf margin rolls adaxially to form a revolute margin (Herman *et al.* 1986 b).

The texture of the lamina may be membranous (*P. indica* var. *glabrescens*, *P. gleniei*, *P. hispidula* var. *siphonantha* etc.), subcoriaceous (*P. travancorica*, *P. madrassica*, *P. birmahica* etc.)

The surface of the leaf is glabrous in *P. indica* var. *indica*, *P. hispidula* var.

*angustifolia*, *P. blanda*, *P. thwaitesii* etc.; pubescent only on the nerves beneath in *P. indica* var. *glabrescens* ; ciliate on the nerves beneath in *P. breviflora* var. *ciliolata*; puberulous beneath in *P. wightii*, *P. madrassica* etc. ; tomentose beneath in *P. indica* var. *tomentosa* and hispid in *P. hispidula* var. *hispidula*.

The lamina contains bacterial leaf-galls (bacterial nodules, frequently in all species and domatia in some taxa are dealt separately.

Venation is unicostate reticulate. The midrib is canaliculate to subcanaliculate above and more prominent on the lower surface of lamina. The lateral nerves are alternate or subopposite, more prominent on lower surface of lamina, slender, frequently at 60° with the midrib but it is more spreading (at ca 90° with midrib) in *P. involucrata*.

Leaves of all species are petiolate. The size of petiole ranges from 0.2 to 0.5 cm in *P. nemoralis* ; 0.3 to 1.0 cm in *P. gleniei* or up to 4.2 cm in *P. indica* var. *glabrescens* & var. *tomentosa*, *P. hohenackeri* etc. Petioles may be slender, *P. subcapitata* etc. It may be glabrous in *P. thwaitesii*, *P. blanda* *P. hohenackeri* etc. ; puberulous in *P. madrassica*, *P. hispidula* var. *siphonantha* etc.; pubescent in *P. gleniei*, *P. subcapitata* etc.; hispid in *P. hispidula* var. *hispidula* or hirsute in *P. naucleiflora*.

Herman *et al.* (1986 a) observed fully

developed stomata in the adaxial protoderm of the leaf primordia of South African *Pavetta* spp. These early developing stomata, known as precocious stomata have also been reported from *Pavetta* spp. by Zimmermann (1902), Faber (1912) and Larsten & Horner (1976); for *Psychotria* spp. by Faber (1912), Lersten & Horner (1967), Horner & Lersten (1968), Whitmoyer & Horner (1970), Lersten (1974 a) and Lersten & Horner (1976) and for *Neurosea onodongensis* by Van Hove (19782). In *Psychotria* and *Neurosea* spp., however, these precocious stomata develop in the abaxial protoderm.

**Taxonomic significance :** The leaves are variable in shape in most of the species, but *P. hispidula* var. *angustifolia* and *P. thwaitesii* are distinguished from other varieties or species by linear or narrowly lanceolate leaves along with some other characters. Oblanceolate leaves, attenuated at base is the characteristic feature of *P. oblanceolata* (caudate-acuminate at apex) and *P. blanda* (rounded at apex).

**Domatia :** Domatia are dome-shaped cavities on the secondary nerve axils (also sometimes in tertiary nerve axils) of under surface of leaves. The mouth of domatia are fringed with hairs. These sometimes serve as shelter for small animals, e.g. acari; so they were called acaridomia (Bremekamp 1934; 14). Jacobs (1966) described a domatium as pit, a pocket, a hair tuft or variously combined. Schumann (1891) referred these structures as scrobiculae. "It is probable that more taxa are provided with domatia in the

Rubiaceae than in all other woody dictyledons" (Jacobs l.c.). De Wildman (1938) enumerated African plants possessing domatia. Out of 250 taxa, 165 are rubiaceous. Lersten & Horner (1976) observed that domatia are not common in *PAVETTA* occurring in a few sections only. Robbrecht & Puff (1986) reported "all existing type of domatia found in the family Rubiaceae are known to occur in the GARDENIEAE and related tribes" Robbrecht (1979 : 248 & 1987 ; 45) reported four types of domatia; only tuft domatia in *TRICALYSIA* subgenus *EMPOGONA* and all other types (pocket, pit and crypt) in *TRICALYSIA* subgenus *TRICALYSIA*. Herman *et al.* (1987 ; 54) reported domatia in 6 species of *PAVETTA* from South Africa.

In the present study, three types of domatia; tuft, pocket and pit (Robbrecht : 1987) have been observed in 13 species (Table -1). Tuft domatia are common, occurring in all 13 species; pocket domatia occur in two species (*P. graciliflora* and *P. indica* var. *tomentosa*) and pit domatia occur in one species (*P. graciliflora*) only.

**Taxonomic significance :** According to Jacobs (1966), domatia may be of limited taxonomic significance as a supporting character. Steenis (1968) stated "This should, however, not lead to the conclusion that the constant occurrences of domatia is to be regarded only as supporting character which means that it should have less value than other vegetative or generative character"

The domatia in *PAVETTA* spp. studied have limited taxonomic significance. Many

species (13 out of 25 : 52%) are characterized by absence of domatia. *P. graciliflora* contains all the three types of domatia (Fig. 2 : a-c). Seven species have domatia of frequent occurrence and one species (*P. minor*) has occasional occurrence (many

specimens do not contain domatia) and in five species (*P. birmahica*, *P. breviflora* var. *pubescens*, *P. crassicaulis*, *P. hispidula* var. *zeylanica* and *P. praeterita*), the domatia have been observed in one specimen each (Table -2).

Table -1

Occurrence of Domatia types in *PAVETTA* species.

| <u>Name of species</u>                                                                                             | <u>Domatia types</u> |               |            |
|--------------------------------------------------------------------------------------------------------------------|----------------------|---------------|------------|
|                                                                                                                    | <u>Tuft</u>          | <u>Pocket</u> | <u>Pit</u> |
| 1. <i>P. birmahica</i> Bremek.                                                                                     | +                    |               |            |
| 2. <i>P. breviflora</i> DC. var. <i>pubescens</i> Bremek.                                                          | +                    |               |            |
| 3. <i>P. crassicaulis</i> Bremek.                                                                                  | +                    |               |            |
| 4. <i>P. gardneri</i> Bremek.                                                                                      | +                    |               |            |
| 5. <i>P. graciliflora</i> Wall. ex Ridley                                                                          | +                    | +             | +          |
| 6. <i>P. hispidula</i> W. & A. var. <i>zeylanica</i> Hook.f.                                                       | +                    |               |            |
| 7. <i>P. indica</i> L. var. <i>glabrescens</i> (Kurz) Deb & Rout<br>var. <i>tomentosa</i> (Roxb. ex Smith) Hook.f. | +                    | +             |            |
| 8. <i>P. madrassica</i> Bremek.                                                                                    | +                    |               |            |
| 9. <i>P. minor</i> (Hook.f.) Deb & Rout                                                                            | +                    |               |            |
| 10. <i>P. naucleiflora</i> G. Don                                                                                  | +                    |               |            |
| 11. <i>P. praeterita</i> Bremek.                                                                                   | +                    |               |            |
| 12. <i>P. subcapitata</i> Hook.f.                                                                                  | +                    |               |            |
| 13. <i>P. wightii</i> Hook.f.                                                                                      | +                    |               |            |

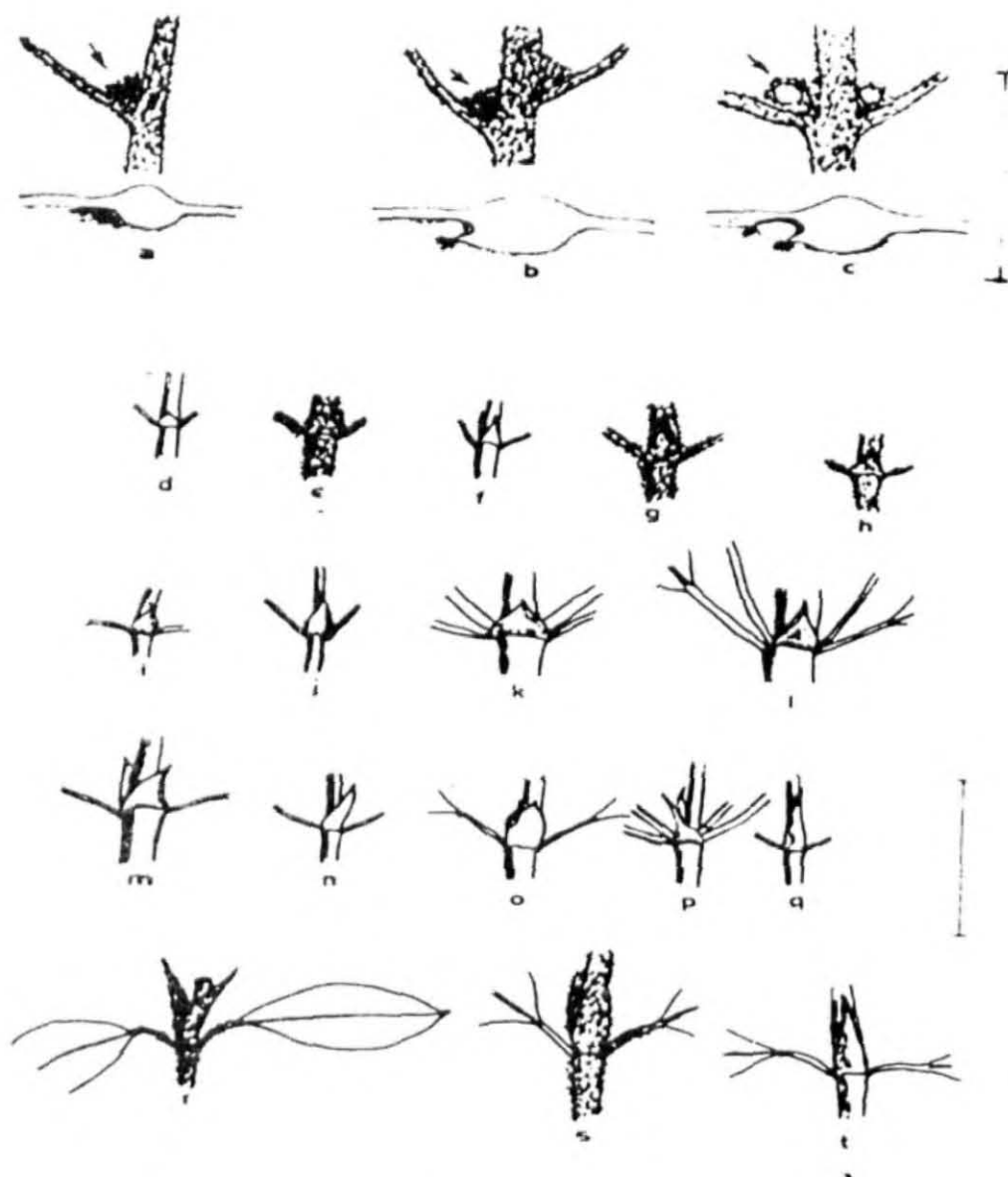
+ = Present

— = Absent

Table -2

Rare occurrence of tuft domatia in *PAVETTA* species.

| <u>Name of species</u>                                       | <u>Specimens bearing domatia</u>            |
|--------------------------------------------------------------|---------------------------------------------|
| 1. <i>P. birmahica</i> Bremek.                               | J.S. Gamble 115 K.                          |
| 2. <i>P. breviflora</i> DC. var. <i>pubescens</i> Bremek.    | Bourne 2046 K.                              |
| 3. <i>P. crassicaulis</i> Bremak.                            | Stocks s.n. K.                              |
| 4. <i>P. hispidula</i> W. & A. var. <i>zeylanica</i> Hook.f. | Thawaites C.P. 742 CAL.                     |
| 5. <i>P. praeterita</i> Bremek.                              | R. Wight s.n. (Kew<br>Distrib. No. 1478) K. |



**Fig. 2 :** a-c. Domatia occurring in *P. graciliflora*. (The domatia in secondary nerve axils and a cross-section in the direction indicated by the arrow) a. tuft-domatia (N.C. Nair 4531); b. pocket-domatia & c. pit-domatia (N.P. Balakrishnan 667). d - t, Stipules of *Pavetta* sp. d - *P. madrassica* (Wight 1481); e. *P. indica* var. *tomentosa* (M.A. Rau 10392); f. *P. graciliflora* (N.P. Balakrishnan 189); g. *P. naucleiflora* var. *naucleiflora* (Ba Pe 830); h. *P. subcapitata* (G.Mann s.n.); i. *P. naucleiflora* var. *glabrituba* (Griffith 2113); j. *P. thwaitesii* (R. Wight 1484); k. *P. hispidula* var. *zeylanica* (N. C. Nair 69737); l. *P. crassicaulis* (Stocks s.n.); m. *P. wightii* (R. Wight s.n.); n. *P. breviflora* var. *breviflora* (B.D.Sharma 39811); o. *P. indica* var. *glabrescens*, (King's collector 394); p. *P. oblanceolata* (Beddome 3920); q. *P. hohenackeri* (Hohenackeri 1379); r. *P. breviflora* var. *pubescens* (Sebastine 2699); s. *P. brunonis* (P. Bhargava 56907); t. *P. involucreta* (Thwaites C.P. 428).

Scale lines: for a - c equal 2 mm, for d - t equals 30 mm.

*Bacterial leaf-galls (Bacterial nodules):* Bacterial leaf-galls are swelling in the leaf blades containing symbiotic bacterial colonies in Rubiaceae (also known from Myrsinaceae and Dioscoriaceae). These have been variously termed by different authors, such as : "bacterial nodules" (Georgevitch 1916, Bremekamp 1933, 1934, Lersten & Horner 1976, Verdcourt 1976, Herman *et al.* 1986 b, 1987, Bridson & Verdcourt 1988), "galles bacteriennes" (Petit 1962) and "bacteriocidies" (N. Halle 1970). Robbrecht (1988 : 51) rejected the term "Bacterial nodules" for these structures, since it implies a more or less globose shape and accepted "galls" (Kuster 1911). In Rubiaceae, bacterial leaf-galls have been reported from more than 400 species belonging to three genera : *SERICANTHE*, *PAVETTA* AND *PSYCHOTRIA* (Robbrecht *l.c.*). Horner & Lersten (1972) defined bacterial nodules as internal cavities in the leaf lamina, open to the exterior by way of stomatal pores only in early stages of nodule development. In *PAVETTA*, nodule always opens to the adaxial leaf surface (Faber 1911, Van Hove 1972, Lersten & Horner 1976).

Hohnel (1881) discovered bacterial rods from leaf nodules of *Ardisia* (Myrsinaceae), but misinterpreted them as precipitated protein. Trimen (1894) described the bacterial nodules as "thickened worts" in the leaves of *Pavetta indica*, *P. angustifolia*, *P. involucrata* and *P. gleniei*. Zimmermann (1902) discovered the rods of bacteria in

leaves of three species of *PAVETTA* and thus discovered bacterial nodules. Von Faber (1912, 1914) observed in 4 species of *PAVETTA* and 1 species of *PSYCHOTRIA* that the bacteria of the nodules are capable of fixing free atmospheric nitrogen. Miehe (1911-1916) isolated bacteria from leaf nodules of *Ardisia* (Myrsinaceae). Boodle (1923), Humm (1944), Schwartz (1959), Yamada (1954, 1960), Schaede (1962), Lange (1966), Stewart (1966), Bond (1967), Scott (1969), Becking (1970), Horner (1972) and Lersten & Horner (1976) have reviewed bacterial leaf nodules.

The bacteria enter the leaf through stomata, usually described as "precocious stomata" (developing earlier than the normal stomata) (Zimmermann 1902, Von Faber 1912 ; Lersten & Horner 1967 ; Whitmoyer & Horner 1970 ; Van Hove 1972). Then the pore is sealed off by the cuticular growth. The nodule is completely surrounded (except at the stomatal pore) by one to three layers of close fitting parenchyma cells, which isolate it from the surrounding normal mesophyll cells with thick primary wall and containing chloroplast and starch (Zimmermann 1902). Faber (1912) called them as "bacterial tissues"; Lersten & Horner (1967) as "intrusive mesophyll". The inter cellular spaces of these tissue are filled with rod shaped bacteria. Zimmermann (1902) observed rod shaped bacteria in four species of *PAVETTA*. In *P. indica*, the rods were noticeably larger ; 3-4  $\mu\text{m}$  in length.

Whitmoyer & Horner (1970) examined the nodules of all ages from *Psychotria punctata*. They sampled leaves of increasing size and age and grouped them into five stages. On examination by light and electron microscope, they found that the bacteria grow up to stage II. In stage III both growing (dividing) and degenerating bacteria are seen. Then this degeneration continues and in stage V, no living bacteria are seen.

Lersten (1974 a,b) suggested that a change in colleter type from standard to dendroid may reflect a change in colleter secretion to a substance better suited for supporting the bacteria. Lersten's (1975) survey of collectors in 16 species of 111 genera from all tribes reveals that only standard collectors were found except 3 genera (PAVETTA, PSYCHOTRIA AND TRICALYSIA) with varying degree of dendroid collectors. Dendroid collectors are therefore exceedingly rare in the family except among nodulated taxa, where they are the rule rather than exception.

Histochemical staining of the colleter secretion in the section of *Psychotria bacteriophila* buds (Horner & Lersten 1968) indicates that carbohydrates and proteins are present.

Horner & Lersten (1972) reviewed the literature pertaining to the nomenclature of the bacteria. Five species of bacteria have been isolated from seven species of PAVETTA

(Faber 1912, Rao 1923, Ziegler 1958, Knosel 1962, Bettelheim *et al.* 1968 Yamada 1970, 1972). Faber (1912) and Rao (1923) reported *Mycobacterium rubeacearum* from *Pavetta indica* L.

In isolated bacteria, Faber (1912), Rao (1923), Gordon (1963), Silver *et al.* (1963), Centifanto (1964), Centifanto & Silver (1964), and Bettelheim *et al.* (1968) are of opinion that bacteria fixes nitrogen, but Yamada (1972) gave a negative view. In studying bacteria in leaves Grobbelaar *et al.* (1971) got a positive result (in support of N<sub>2</sub> fixation by bacteria) where as Bond (1959), Lohr (1968), Becking (1971), Silver & Astridge (1971) and Grobbelaar & Groenwald (1974) got negative result.

Rao (1923), Humm (1944) and Baldrati (1942) reported that the nodulated plants are used as manure, probably because of the notion that like legumes, they would provide the soil with increased N<sub>2</sub> due to the presence of bacteria. This assumption has not gained sufficient support in tropical areas and is not borne out by the nitrogen fixation studies.

Miehe (1913 b) believed that bacteria produce some kind of stimulating substance for normal growth of host plant. This view was later on supported by Nemec (1932), De Jongh (1938 b), Yamada (1960), Silver *et al.* (1963), Becking (1971), La Motte & Lersten (1972) and Rodrigues Pereira *et al.* (1972). De Jongh (1938 b) and all subsequent workers

present results that show either IAA or Cytokinin may be the growth substance which the bacteria supply the nodulated plants that have become totally dependent on them through the course of their evolution. Humm (1944), Edwards & La Motte (1975) strongly implicate Cytokinins as the primary growth substance supplied by the bacteria.

In the present study, bacterial leaf-galls have been studied in 25 species. These are circular in outline in all species, but rarely the shape may be elliptic or oblong. By union of two or more galls the shape may be curved, branched, dumbbell-shaped or stellate, as in *P. indica* var. *indica*. The size may be 0.3-1.5 mm across in circular, 0.5-2.0 × 0.3-1.5 mm in oblong galls. The galls are normally associated with secondary or tertiary nerves, or nerves of higher order, but in rare cases it may be associated with the midrib (*P. subcapitata*). The galls have also been observed rarely on the stems of *P. indica* var. *glabrescens* (G. Panigrahi 9540 CAL !) and embryo (both on cotyledons and radicle) of *P. graciliflora* (N. Bhargava 6595 CAL !) and *P. indica* var. *tomentosa* (R. S. Rao 73737 CAL !).

The galls are usually more prominent on lower surface of lamina but sometimes more prominent on upper surface in *P. birmahica*, *P. hohenackeri*, *P. hispidula* var. *hispidula*, *P. breviflora* var. *ciliolata*, *P. indica* var. *indica*. Larger number of galls have been observed in glabrous leaves and smaller

numbers in pubescent leaves. Sometimes these are absent and if present, it is very difficult to observe, perhaps due to hairiness. Sometimes in hairy leaves, more hairs are present on galls. In tomentose leaves (*P. subcapitata*, *P. indica* var. *tomentosa*), the nodules can be seen on keen observation. Lersten & Horner (1976) observed galls in very less numbers of collections of *P. tomentosa* (= *P. indica* var. *tomentosa*), but in present study, these have been observed in almost all specimens.

*Taxonomic significance* : The bacterial leaf-galls in Indian species of *PAVETTA* have no taxonomic value as various shapes of galls are present in a single species, even in the single leaf of a specimen. The number of galls also varies from species to species or even in the same specimen among different leaves. So the galls can not be used for delimitation of specific or infraspecific taxa.

Bacterial leaf-galls of *PAVETTA* have some taxonomic significance in the generic level. Bremekamp (1933 : 271 ; 1934 : 15) stated : "these nodules are useful in determining African and Asiatic bacteriophilous Rubiaceae of which no flowers or fruits are available : if the latter are Asiatic, they always belong to *PAVETTA* or *PSYCHOTRIA*, and then a look at the stipules is enough to decide the question ; if the latter is entire, the plant is *PAVETTA*, if they are bicuspidate or bicaudate, it belongs to *PSYCHOTRIA*" The presence of galls in *PAVETTA*

is also a point of difference from allied genus IXORA.

Lersten & Horner (1976) reported that out of 406 species of PAVETTA (Bremekamp 1934, 1936, 1937c, 1939a,b, 1948, 1953, 1956), 353 species (87%) have bacterial nodules. In subgenus BACONIA, 11 species of ser. *Enodulosae* and all 4 species of the subgenus DIZYGOON are nodule free. The ser. *Biseriales* of subgenus BACONIA contain 12 species with linear nodules along the midrib. Under subgenus PAVETTA (*Eupavetta* Bremek.) the sect. *Graptophyllum* includes 11 species with branched nodules along the midrib.

**Stipules :** The interpetiolar stipules of the Rubiaceae are considered to be the result of fusion of four independent stipules from the two opposite leaves (Sinnot & Bailey 1914 ; Bierhorst 1971 ; Neubauer 1981).

The stipules are interpetiolar, usually in a pair of 2, rarely 3 (in one species : PAVETTA sp. 1), free or connate at base or along the whole length, forming a tube around the stem. These are persistent, but the upper part becomes scarious and deciduous, the base only remaining persistent in *P. breviflora*, *P. hohenackeri* etc.

The stipules may be very small : 1.5  $\times$  2.0 mm (*P. thwaitesii*) or large : 10 - 20  $\times$  3-5 mm (*P. involucrata*). It is triangular or ovate (Fig. 2 : j,k) in *P. thwaitesii*,

*P. hispidula* var. *zeylanica* ; triangular (Fig. 2 : m) in *P. gleniei*, *P. macraei*, *P. wightii* etc. ; narrowly triangular (Fig. 2 : q,r,s) in *P. involucrata*, *P. breviflora*, *P. hohenackeri* etc. ; triangular at the base but subulate above (Fig. 2 : p) in *P. oblanceolata* ; oblong-triangular (Fig. 2 : s) in *P. brunonis* and aristate (Fig. 2 : g) in *P. naucleiflora*.

The apex is acute-acuminate in *P. involucrata*, *P. hohenackeri* etc. ; cuspidate in *P. indica* var. *indica* & var. *tomentosa*, *P. wightii* etc. The abaxial surface is glabrous in *P. indica* var. *indica*, *P. thwaitesii*, *P. blanda* etc., puberulous in *P. birmahica*, *P. madrassica* var. *hispidula*. The adaxial surface contains colleters in all species which are described separately.

**Taxonomic significance :** Bremekamp (1934) considered stipules as important character (along with other characters) for distinguishing series : Ser. *Angustistipulae* (with narrowly triangular stipules) ; Ser. *Glomeratae* (with triangular stipules) ; ser. *Scariostipulae* (narrowly triangular stipules with scarious margin) and ser. ; *Nilagiricae* (long-triangular stipules) under sect. *Pavettaster* of subgen. PAVETTA (*Eupavetta* Bremek.).

The present study shows that the stipules are useful for delimitation of species : *P. breviflora*, *P. involucrata*, *P. hohenackeri* etc. are distinguished by their narrowly

triangular stipules. Subulate and oblong-triangular stipules are the characteristic feature of *P. oblanceolata* and *P. brunonis* respectively.

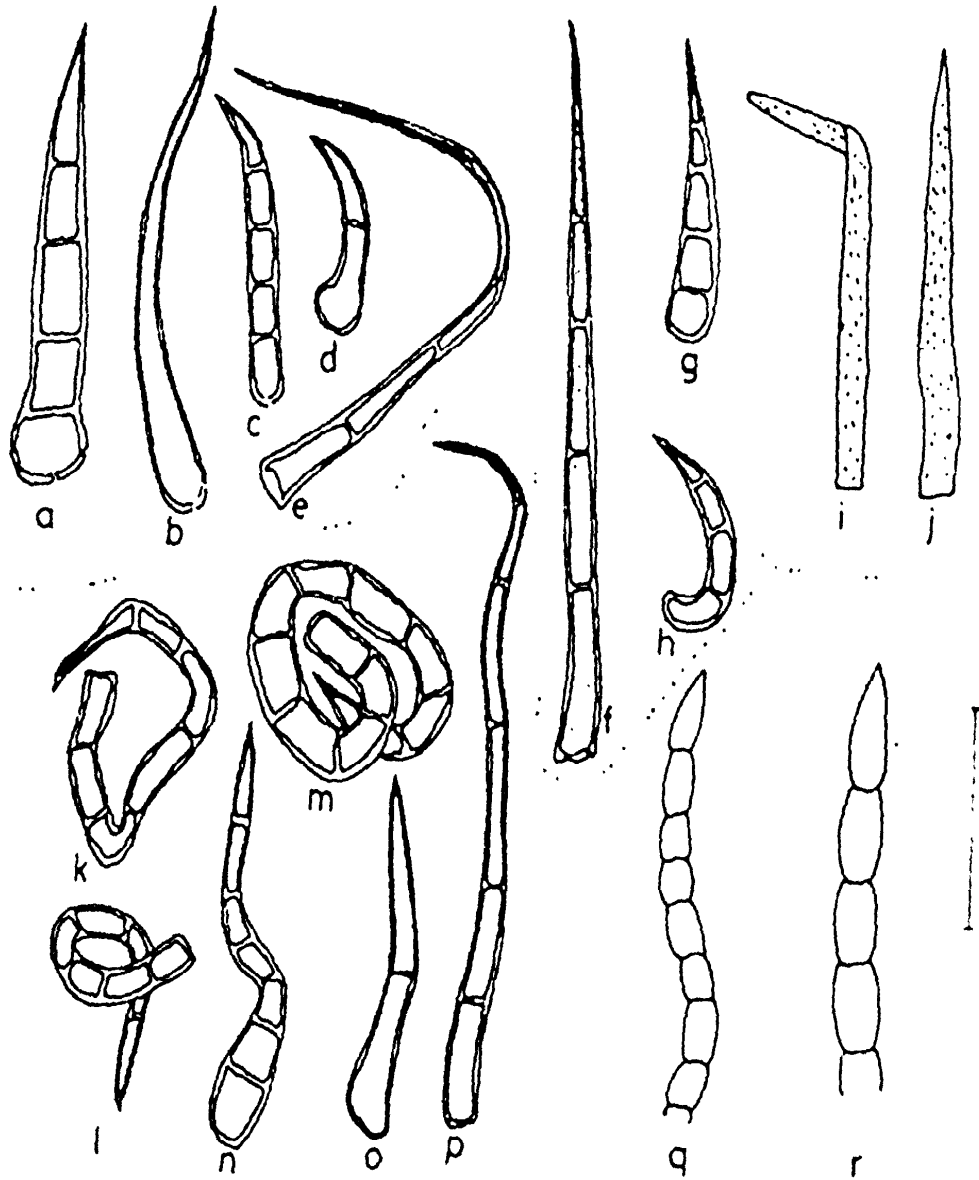
*Calcium-oxalate crystals* : *Ixoroideae* is characterized by absence of Calcium-oxalate crystals in the form of raphides with an exception to *Argocoffeopsis* of the tribe *Gardenieae* (Robbrecht 1988). However, raphides have not been observed in Indian species of *PAVETTA* during present investigation.

*Trichomes* : Rubiaceous trichomes are unbranched, unicellular or uniseriate. The only exceptions are T-shaped trichomes of *Coptosapelta* and multiseriate trichomes in inflorescence of *Octodon setosum* (Pares & Raut 1953). Glandular hairs are entirely lacking. Verdcourt (1958 : 222-224) distinguished two types of trichomes in Rubiaceae viz. internal indumentum (inside the corolla : on the tube inside, the stamens and the style) and external indumentum (on the all other plant organs). Robbrecht (1979: 254) recognized a third type of trichome inside the stipules (intermingled with collectors) in some *TRICALYSIA* species. These are pluricellular with thin walls and septa (where as the external indumentum in other organs are pluricellular, thick-walled and cylindrical). "The external indumentum of a particular rubiaceous taxon is always remarkably uniform ; all parts bear hairs of the same type, showing only minor diversity

e.g. in size. The hairs inside stipules, bracts and calyces are the only exceptions to this since they are frequently thinwalled, articulate when the rest of the indumentum is composed of thick-walled cylindrical hairs" (Robbrecht 1988 : 64). Lersten (1974 b : 133) observed in *PAVETTA* spp. that trichomes associated with collectors are two types viz. large thin walled septate and non septate. The latter type is the commonest one. Hermon *et al.* (1986 b) studied nonglandular hairs on both the adaxial and abaxial leaf surfaces of South African *PAVETTA* ssp. The indumentum consists of uni- and bicellular non glandular hairs ; the bicellular hairs consists of a cell and an acute terminal cell.

In the present study, trichomes have been studied in 28 taxa. These can be classified into three groups viz. internal indumentum, external indumentum and trichomes intermingled with collectors.

i) *Internal indumentum* : These may occur as pilose inside the corolla tube in most of the species (except *P. breviflora* in which the corolla is completely glabrous), forming a ring below the throat of corolla (*P. involucrata*), pubescent at the throat of corolla tube (*P. gleniei*, *P. macraei*, *P. thwaitesii* etc.) or pubescent on the corolla lobes inside (*P. blanda*, *P. thwaitesii*, *P. gleniei*, *P. naucleiflora* var. *naucleiflora* etc.). These are unicellular, flat ribbon-like with pitted surface; apex is acute (Fig. 3 : j) or subacute (Fig. 3 i.). All taxa contain



**Fig. 3 :** *Pavetta* trichomes. : a h. external indumentum : a. *P. hispidula* var. *angustifolia* (Bernardi 14128) ; b. *P. subcapitata* (G. Mann s.n.) ; c. *P. macraei* (J. Macrae 24) ; d. *P. indica* var. *glabrescens* (G. Watt 6802) ; e. *P. gleniei* (G. Davidse et al 9093) ; f. *P. naucleiflora* var. *glabrituba* (Griffith s.n.) ; g. *P. minor* (Hohenackeri 2426) ; h. *P. indica* var. *glabrescens* (G. Watt 11185). i & j. internal indumentum : i. *P. thwaitesii* (Thwaites C.P. 2611) ; j. *P. macraei* (J. Macrae 24). k - r. trichomes intermingled with collectors : k. l. p. *P. wightii* (C.E.C. Fischer 1560) ; m. *P. praeterita* (Subramanyam 3069) ; n. *P. indica* var. *tomentosa* (A. S. Rao 38739) ; o. *P. indica* var. *indica* (K. Ramamurthy 13018) ; q. *P. blanda* (Thwaites C.P. 2456) ; r. *P. breviflora* var. *breviflora* (Beddome 3912).

Scale line equals 300  $\mu$ m.

internal indumentum of same type, except variation in length : from 272  $\mu\text{m}$  (*P. indica* var. *indica*) to 1200  $\mu\text{m}$  (*P. macraei*).

ii) *External indumentum* : These may be present almost in all parts, restricted to some parts or absent. These are tomentose in *P. indica* var. *tomentosa*, *P. subcapitata*, *P. brunonis* etc. ; hispid in *P. hispidula* var. *hispidula*, *P. praeterita*, *P. macraei* etc. ; villous in *P. gleniei*, *P. crassicaulis* etc. ; puberulous in *P. wightii*, *P. minor*, *P. hispidula* var. *zeylanica* etc., pubescent in *P. indica* var. *glabrescens* etc. The taxa characterized by absence of external indumentum are *P. oblanceolata*, *P. indica* var. *indica*, *P. breviflora* var. *breviflora*, *P. involucrata*, *P. thwaitesii*, *P. hohenackeri* etc.

The size of hairs varies from 32  $\mu\text{m}$  to 912  $\mu\text{m}$ . Hairs of different plant parts are normally different in size. Hairs on the different plant parts are normally different in size. Hairs on the nerves of leaf are normally longer than those of the intercostal area. Smallest hair (32  $\mu\text{m}$ ) recorded in *P. wightii* and largest (912  $\mu\text{m}$ ) in *P. brunonis*. Number of cells varies from 1 to 15. Unicellular (along with pluricellular) hairs occur in *P. hispidula* var. *zeylanica* and *P. subcapitata* (Fig. 4 : b). In *P. brunonis*, the number of cells increases up to 15. The hairs are normally straight (*P. hispidula*) or curved (*P. indica* var. *glabrescens*). Apical cell is acute, straight (Fig. 3. a) in *P. hispidula* var. *angustifolia*, *P. minor* ; or curved (Fig. 3. c,d) in *P. macraei*,

*P. indica* var. *glabrescens* etc. The basal cells are broad, the upper cells with parallel cell walls (*P. hispidula* var. *angustifolia*, *P. macraei*, *P. indica* var. *glabrescens*) or abruptly taper with conical appearance (Fig. 3 : g) as in *P. minor*. In *P. gleniei*, the hair is whip like due to very long and curved apical cell (Fig. 3 : e). The outer wall is normally smooth, but pitted in *P. gleniei*, *P. naucleiflora* var. *glabrituba* and *P. birmahica* (Fig. 3 f.).

iii) *Trichomes intermingled with collectors* : The trichomes of this category are present inside stipules, bracts or calyces. These may be plenty in *P. macraei*, *P. hispidula* var. *angustifolia* etc., few in *P. gleniei*, *P. travancorica* etc. or absent in *P. oblanceolata*, *P. thwaitesii* etc. The colour of these hairs is normally silky white, but brown in some specimens of *P. indica* var. *glabrescens*.

These trichomes are of two types : pluricellular articulated and pluricellular cylindrical. The latter type may be straight or coiled. Pluricellular articulated type (Fig. 3 q,r) is found in only two species (*P. blanda*, *P. breviflora* var. *breviflora*). Pluricellular cylindrical straight type (Fig. 3 o,p) is the common one, found in all species except *P. wightii* and *P. praeterita* where some hairs are of coiled type (Fig. 3 k,l,m) along with normal straight ones. The number of cells vary from 2 (*P. indica* var. *indica*) to 17 (*P. minor*). The cell walls are normally

parallel and apical cell is acute or subacute, but in *P. indica* var. *tomentosa*, the basal cells are very broad and the upper ones are curved abruptly (Fig. 3 n). Longest hair (2080  $\mu$ m) in *P. gleniei* and shortest (64  $\mu$ m) in *P. naucleiflora* var. *glabrituba*.

Lersten & Curtis (1977 : 130) observed spiral wall thickenings in trichomes in the shoot apices of *Pavetta lasiopepsis* and cleared leaves of several taxa of Rosaceae and Betulaceae. Herman *et al.* (1986b) observed the same type of wall thickenings in the trichomes of the adaxial leaf surface of *Pavetta capensis* subsp. *komghensis*. This type of wall thickenings were reported earlier in the trichomes of seeds (Uphof 1962, Kippist 1845 ; Schaffnit 1906 ; Ochon 1932; Bremekamp 1944). However, this type of wall thickenings have not been observed in the present study. SEM study of trichomes of under surface of leaf of *P. indica* var. *glabrescens* and *P. graciliflora* shows that the surface of trichomes is rough due to presence of some outgrowths.

**Taxonomic significance :** Internal indumentum and trichomes intermingled with colleters are taxonomically less significant, where as the external indumentum can be useful in delimiting certain infraspecific taxa. *P. naucleiflora* var. *glabrituba* and *P. breviflora* var. *ciliolata* & var. *pubescens* are distinguished from their typical varieties based on the trichome characters along with certain other characters.

**Colleters :** The colleters are non-trichomatic pluricellular mucilage secreting structures inside stipules, bracteoles and calyces in the Rubiaceae and other families of Asteridae (Loganiaceae, Apocynaceae etc.). These have been variously termed by different authors, such as : "Drusenzotten" (Solleder 1893), "Shaggy hairs" (Solleder 1908), "glandular shaggy hairs" (Metcalf & Chalk 1950), "harzdecernierende drusen" (Krause 1909), "Cerocystes" (F. Halle 1967), "squamelles" (Ramaya & Bahadur 1968) used the term "colleteren" (in english "colleters" and the secretion he terms "Blastocolla") is now generally used (Foster 1949 ; Uphof 1962 ; Esau 1965 ; Lersten 1974 a,b, 1975 ; Verdcourt 1976 ; Robbrecht 1978, 1979, 1988, Robbrecht & Puff 1986 ; Puff 1986 ; Rogers 1987 ; Herman *et al.* 1986a).

The presence of colleters on the stipules covering the apical meristem is considered to be a characteristic feature of the Rubiaceae by Schumann (1891), Solleder (1908), Humm (1944), Metcalf & Chalk (1950), Bremekamp (1957), Wunderlich (1971) and Van Hove & Kagoyre (1974). Lersten & Horner (1967), Horner & Lersten (1968) and Lersten (1974a) described the collectors of *Psychotria* spp. in detail. Krause (1909) and Van Hove (1972) described those of *Gardenia* and *Neurosea* respectively.

Lersten (1974a) examined collectors of about half the species of *PSYCHOTRIA* L. and found that most species lacking bacterial

nodules had standard collectors, where as most species with bacterial nodules had dendroid collectors. Other nodulated species had brush like collectors. He speculated that such conspicuous changes in collector structure should reflect some changes in secretory product, probably to a substance more capable of supporting nodule bacteria within the closed apical chamber above the shoot apex.

Von Faber studied the collector morphology of *PAVETTA* ssp. as early as 1912. Lersten (1974 b) studied collector morphology of 77 species of *PAVETTA* including 7 species from India and Sri Lanka. Herman *et al.* (1986a) observed the same in 16 species of *PAVETTA* from south Africa. Lersten (1974 a,b) observed that in *PSYCHOTRIA* and *PAVETTA*, dendroid or brushlike collectors occurs in species with bacterial leaf nodules. Lersten's (1975) survey of collector types in the Rubiaceae in vegetative buds of 116 species of 111 genera representing all tribes (as per Schumann 1891), correlated the association of dendroid or brush like collectors with nodulated species. Among the three genera with bacterial nodules and dendroid or brush like collectors (*PAVETTA*, *PSYCHOBRIA* and *TRICALYSIA*) the correlation is strongest. He regarded that the nodule symbiosis in *PAVETTA* is an early event. Van Hove & Kagoyre (1974) on a survey of collectors (stipular glands) in 20 species of *PSYCHOTRIA* and *TRICALYSIA* rejected the hypothesis that dendroid collectors are necessary to sustain

the symbiosis.

The rubiaceous collectors in most of the genera are cylindrical to some what conical, consisting of an axis of elongated cells covered by palisade like epidermis. Lersten (1974 a,b) called this as "standard". Apart from this he described four other types of modified collectors from *PAVETTA*, *PSYCHOTRIA* and *TRICALYSIA*, which are characterized by bacterial leaf galls. Robbrecht (1978, 1979, 1982, 1983, 1987., 1988) studies the collector morphology in many species of *TRICALYSIA* and *SERICANTHE* and could not agree with the typology of Lersten (*l.c.*), but distinguished between five different types of collectors *viz.* dendroid, brush-like, feathery, winged and filiform collectors.

Horner & Lersten (1968) and Fahn (1979) reported the absence of cuticle on the dendroid collectors, but Herman *et al.* (1986a) demonstrated a very distinct cuticle. This observation corresponds with that of Krause (1909), Von Faber (1912) and Uphof *et al.* (1962). The collectors in the shoot apices of plants are thought to secrete a mucilaginous substance (Lubbock 1890, 1895, Groom 1893; Solereder 1908 ; Von Faber 1912 ; Metcalfe & Chalk 1950 ; Esau 1960 ; Lersten 1974 a,b ; Fahn 1979). F. Halle (1967) gave a survey of the investigation carried out to determine the secretory mechanism and chemical nature of collector secretion in *Gardenia imperialis*. The secreted substances are of waxy nature (esters of higher fatty acids

and higher alcohols). The biological significance of colleter secretion is obviously enhancing the meristematic tissues' protection already offered by stipules or calyces. In *PAVETTA* and genera with bacterial leaf galls, the colleter secretion also plays an important role in the symbiotic cycle.

In the present study, colleter morphology has been studied in 28 taxa. The collectors are few in numbers in 9 taxa (*P. gleniei*, *P. hispidula* var. *hispidula* & var. *angustifolia*, *P. nemoralis*, *P. birmahica* etc.) occurring in single row at the base of the stipules or bracts inside ; or in large numbers in 17 taxa (*P. macraei*, *P. hispidula* var. *siphonantha*, *P. oblanceolata*, *P. involcrata* etc.) covering the entire inner (adaxial) surface of the stipules, but in *P. travancorica* and *P. hispidula* var. *zeylanica*, there may be few to many collectors. In *P. graciliflora*, the collectors are observed inside the calyx. These collectors are of same nature as found inside stipules, bracts, but smaller in size.

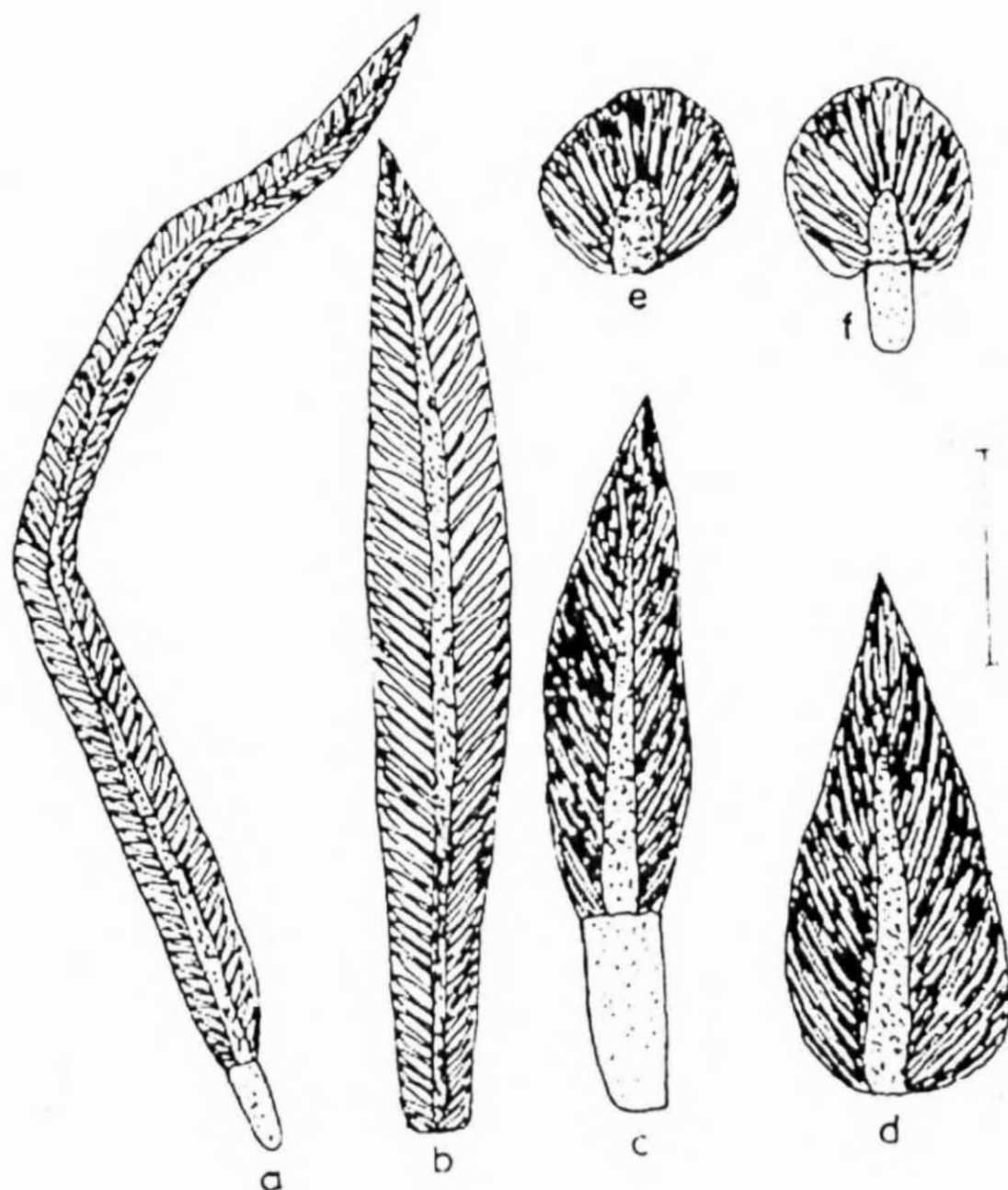
Size of collectors in the taxa studied varies as 176-1600 × 32-480 µm. The smallest collector (176 µm) is present in *P. indica* var. *indica* and largest (1600 µm) in *P. involcrata* and *P. travancorica*. The narrowest collector (32 µm) is observed in *P. indica* var. *glabrescens* and broadest (480 µm) in *P. oblanceolata*.

The collectors may be distinctly stalked or sessile. In some species, both types are

found. The length of stalk varies from 32 µm to 448 µm. The largest stalk is found in *P. graciliflora*.

Three types of collectors (as per Robbrecht 1988) are found viz. dendroid, feathery and brush-like. Standard collectors are entirely lacking. Dendroid collectors occur in 8 taxa and feathery in 15 taxa. Brush-like collectors mixed with feathery collectors occur in 3 taxa. In *P. hispidula* var. *hispidula*, both dendroid and feathery collectors are present and *P. travancorica*, all the three types of collectors are present.

Dendroid collectors with distinct stalk (Fig. 4 a) are present in 4 taxa (*P. breviflora* var. *breviflora*, *P. graciliflora*, *P. indica* var. *indica* & var. *tomentosa*) ; sessile dendroid collectors (Fig. 4 b) are present in 4 taxa (*P. gleniei*, *P. involcrata*, *P. wightii*, *P. naucleiflora* var. *glabrituba*) ; stalked feathery collectors (Fig. 4c) are present in 6 taxa (*P. hispidula* var. *siphonantha*, *P. thwaitesii*, *P. subcapitata*, *P. naucleiflora* var. *naucleiflora*, *P. brunonis*, *P. sp. 1.*) ; sessile feathery collectors (Fig. 5 d) are present in 8 taxa (*P. macraei*, *P. oblanceolata*, *P. praeteriata*, *P. hispidula* var. *angustifolia*, *P. nemoralis*, *P. hohenackeri*, *P. minor*) and both sessile and stalked feathery collectors in one taxon ; *P. hispidula* var. *zeylanica*. Brush-like collectors (mixed with feathery collectors) with stalk (Fig. 4 f) are found in *P. blanda* ; sessile in *P. birmahica* (Fig. 4e) and stalked or sessile in *P. crassicaulis*. In *P. hispidula*,



**Fig. 4 :** *Pavetta* - collectors. : a & b. dendroid collectors : a. stalked dendroid collectors of *P. graciliflora* (S. Kurz s.n. ) ; b. sessile dendroid collector of *P. involucrata* (Thwaites C.P. 428 ). c & d. feathery collectors : c. stalked feathery collector of *P. blanda* (Thwaites C.P. 2456) ; d. sessile feathery collector of *P. hispidula* var. *angustifolia* (Bernardi 14128). e & f. brushlike collectors : e. sessile brushlike collector of *P. birmahica* (Griffith 3010) ; f. stalked brushlike collector of *P. blanda* (Thwaites C.P. 2456 ).

Scale line equals 300  $\mu$ m.

the collectors (dendroid or feathery) are always stalked. In *P. travancorica*, the three types of collectors found are sessile or stalked. Lersten (1974 b) described the collectors of *P. thwaitesii* as dendroid, but in present study, it is found to be feathery.

The presence of a distinct cuticle on the collectors as demonstrated by Krause (1909), Von Faber (1912), Uphof *et al.* (1962) and Herman *et al* (1986 a) is confirmed in all the taxa studied.

**Taxonomic significance :** The occurrence of collectors is an important criterion to define the *Gentianales* (Wagenitz 1959) or to include *Theligonum* in the *Rubiaceae* (Wunderlich 1971). Petit (1954) redilimited *Pseudomussaenda* against *Mussaenda* on the basis of collector position on the calyx. Robbredth (1979, 1982, 1983, 1987) confirmed the subgenera and sections of *Tricalysia* on the basis of different collector types.

In the present study, different collectors distributed in various series of section *Pavettaster* under subg. PAVETTA (*Eupavetta* Bremek.) (as per Bremekamp 1934) are as follows :

Ser. *Angustisepalae*, *Glomeratae*, *Longisepalae* are characterised by dendroid collectors. In ser. *Carinatae*, 7 taxa are characterized by feathery collectors whereas *P. hispidula* var. *hispidula* contains both

feathery and dendroid collectors. In ser. *Angustistipulae*, three types of collectors are present. In ser. *Brevisepalae*, two species (*P. thwaitesii* and *P. nemoralis*) are characterized by feathery collectors whereas *P. blanda* contain both feathery and brush-like collectors. Ser. *Vestitae* and *Scariosistipulae* are characterized by both feathery and dendroid collectors. In ser. *Griseipedaee*, brush-like collectors are mixed with feathery collectors.

**Evolutionary trends :** "Large number of collectors, more or less covering the entire inside of the stipules (in many *Gardenieae*) is perhaps the primitive condition" (Robbrecht & Puff 1986). Lersten (1974 a) treated standard collectors as primitive, from which the other forms (dendroid, brush-like etc.) have been derived. So, dendroid collectors are treated here as primitive from which the other forms (dendroid, brush-like etc.) have been derived. Standard collectors are completely absent in the taxa studied. So, dendroid collectors are treated here as primitive collectors (*Angustisepalae*, *Glomeratae*, *Longisepale* and *Vagae*) are thus primitive. Those predominated by feathery collectors (*Carinate*, *Brevisepalae*, *Vestitae* and *Scariostipulae*) are advanced and the ser. *Griseipedaee*, with both brush-like and feathery collectors is intermediate.

**Inflorescence :** Inflorescence in PAVETTA ssp. is mostly terminal, trichotomously branched, loose, compact corymbose or

subcapitate cymes. Axillary inflorescence (Fig. 6 : 8,10) is present in 3 species (*P. gleniei*, *P. travancorica*, *P. sp. 1*). Only one specimen of *P. hispidula* var. *angustifolia* (Simpsons 9727 BM :) bears axillary inflorescence.

The peduncle varies from short to long or may be absent so that the inflorescence becomes sessile. Terminal loosely corymbose cymes with long peduncles up to 5.5 cm is found in *P. crassicaulis*, *P. brunonis*, *P. hohenackeri* etc., where as sessile or subsessile cyme is present in large number of taxa (*P. hispidula* var. *zeylanica*, *P. madrassica*, *P. thwaitesii* etc). The cyme may be coincompact corymbose (Fig. 5 : 5) in *P. breviflora*, *P. nemoralis* etc., subcapitate (Fig. 5 : 6,9) in *P. subcapitata*, *P. involucrata* and *P. glomerata*.

The number of flowers per inflorescence varies from 8 to 150 or more. Species with few flowerd cymes are *P. thwaitesii* (9-50 flowers), *P. madrassica* (9-20 flowers), *P. hispidula* var. *angustifolia* (8-22 flowers), *P. hohenackeri* (15-36 flowers). *P. oblanceolata* (30-40 flowers). Species with many flowered cymes are *P. indica*, *P. wightii*, *P. brunonis*, *P. breviflora* etc.

The inflorescence may be glabrous (*P. breviflora* var. *breviflora*, *P. thwaitesii*, *P. blanda*, *P. oblanceolata*, *P. graciliflora* etc.), puberulous (*P. minor*, *P. wightii* etc.) pubescent (*P. indica* var. *glabrescens*), hispid

(*P. hispidula* var. *hispidula*) or tomentose (*P. indica* var. *tomentosa*).

*Taxonomic significance* : Bremekamp (1934) considered axillary inflorescence as taxonomic character (along with other characters) is describing two series of section *Pavettaster* under subgenus *Pavetta* viz. ser. *Angustisepalae* and ser. *Angustistipulae*. He also described the inflorescence of *P. madrassica* as "aliquae axillares", but it is found to be terminal.

In the present study, the inflorescence is useful in delimitation of species. Axillary inflorescence is the characteristic feature of *P. gleniei*, *P. travancorica* and *P. sp. 1*., but terminal in other speciers. *P. breviflora* is characterized by compact corymbose cymes ; where as, *P. subcapitata*, *P. involucrata* and *P. glomerata* are characterized by subcapitate cymes.

*Bracts* : Bracts in *PAVETTA* are stipulary, membranous, connate, sheathing at lower cyme branches. Those on the upper cyme branches are free. The size ranges from ca 3 × 2 mm (*P. madrassica*) to 8-13 × 7-15 mm (*P. involucrata*). The shape is mostly triangular or ovate-triangular, but suborbicular in *P. involucrata*. The apex is cuspidate in all species. The abaxial surface is glabrous in *P. travancorica*, *P. oblanceolata*, *P. involucrata*, *P. thwaitesii* etc., puberulous in *P. madrassica*. *P. hispidula* var. *siphonantha* etc., pubescent



**Fig. 5 :** *Pavetta* Inflorescences. 1. *P. hispidula* var. *zeylanica* (Fischer 2800) ; 2. *P. graciliflora* (N.P. Balakrishnan 5161) ; 3. *P. birmahica* (A. Huk s.n.) ; 4. *P. thwaitesii* (Thwaites C.P. 2611) ; 5. *P. breviflora* var. *breviflora* (M.Gangopadhyay & D.C. Mondal 2470) ; 6. *P. involucrata* (Thwaites C.P. 428) ; 7. *P. gleniei* (Thwaites C.P. 2815) ; 8. *P. travancorica* (Bourne 530) ; 9. *P. subcapitata* (King's collector s.n.) 10. *P. hispidula* var. *angustifolia* (Simposon 9727).

Scale line equals 5 cm.

in *P. gardneri*, *P. macraei* etc. and hispid in *P. hispidula* var. *hispidula*, *P. gleniei* etc. The adaxial surface contains colleters and trichomes (intermingled with colleters) of the same nature as found in stipules.

**Taxonomic significance :** Bracts in *PAVETTA* are of less taxonomic significance in specific or infraspecific level. However, it is important in generic level. The nature of bract in *PAVETTA* is one of the distinctions from its most allied genus *IXORA* (In which the bracts are foliar, coriaceous and free at lower cyme branches). Among the Indian species, the bracts of *P. involucrata* are broader and suborbicular, which is one of the distinctions from its allied species.

**Flowered :** Flowers of *PAVETTA* are sessile or pedicellate, bracteolate or ebracteolata, bisexual, tetramerous, actinomorphic, with gamosepalous calyx, gamopetalous corolla, epipetalous stamens. bicarpellary inferior ovary, long style with slender undivided or notched (rarely two lobed) stigma and annual epigynous disk. Sessile or subsessile flowers are present in three species : *P. subcapitata*, *P. involucrata* and *P. glomerata* with subcapitate inflorescence. The other species have pedicellate flowers. The pedicels vary from 0.5 mm (*P. nemoralis*) to 20 mm (*P. hohenackeri*) in length. The pedicels are glabrous in *P. oblanceolata*, *P. hohenackeri*, *P. thwaitesii* etc., puberulous in *P. wightii*, *P. minor* etc. ; pubescent in *P. birmahica*,

*P. indica* var. *glabrescens* etc., tomentose in *P. indica* var. *tomentosa*, *P. brunonis* etc. and hispid in *P. hispidula* var. *hispidula*, *P. macraei* etc.

Bracteoles at the base of hypanthium are completely absent in *PAVETTA* which is one of the characters of distinction from its most allied genus *IXORA*. The flowers are tetramerous. Pentamerous species as mentioned in some old literature are now referred to *TARENNA*. Bremekamp (1934) observed some pentamerous flowers (mixed with normal tetramerous ones in the same inflorescence) in specimen : *Thwaites C.P.* 2815a (K !), of *Pavetta gleniei* is verified.

The radial symmetry (actinomorphy) of flower is constant throughout the genus.

**Hypanthium :** Hypanthium is almost completely fused with the ovary wall. It ranges from ca 0.8 × 0.7 mm (*P. birmahica*) to ca 2 × 2 mm (*P. involucrata*). The shape is obovoid in *P. gleniei*, *P. blanda*, *P. involucrata* etc. or subglobose in *P. gardneri*, *P. graciliflora* etc.

The hairiness of hypanthium varies considerably. It is glabrous in *P. indica* var. *indica*, *P. thwaitesii*, *P. blanda* etc., puberulous in *P. wightii*, *P. minor* etc., pubescent in *P. indica* var. *glabrescens* etc. ; tomentose in *P. indica* var. *tomentosa*, *P. birmahica*, *P. subcapitata* etc., hispid in *P. hispidula* var. *hispidula*, *P. praeterita*,

*P. macraei* etc. and villous in *P. naucleiflora* var. *naucleiflora* and var. *glabrituba*, *P. gleniei* etc.

**Calyx :** The term calyx is used here for the structure placed above the hypanthium. It consists of a distinct tube (called the calyx tube) and 4 distinct lobes. Small and reduced lobes interstitial between four normal lobes are seen only in *P. macraei* (Fig. 6 n.).

The calyx tube ranges from  $0.5 \times 0.7$  mm (*P. madrassica*) to  $2 \times 3$  mm (*P. macraei*, *P. gardneri*). It is broader above in *P. hohenackeri*, *P. naucleiflora*, *P. subcapitata* etc.; cupular in *P. indica* var. *indica*, *P. graciliflora* etc., campanulate in *P. gardneri*, *P. macraei*, *P. involucrata* etc. The outer surface of the limb tube is glabrous in *P. indica* var. *indica*, *P. thwaitesii*, *P. hohenackeri* etc.; puberulous in *P. wightii*, *P. hispidula* var. *zeylanica*, *P. minor* etc.; pubescent in *P. subcapitata*, *P. indica* var. *glabrescens* etc.; hispid in *P. hispidula* var. *hispidula*, *P. gardneri* etc. and hirsute in *P. naucleiflora*, *P. gleniei* etc. The inner surface is normally glabrous but pubescent in *P. graciliflora* and *P. praeterita*.

Calyx is deciduous in most of the species, but persistent in fruits of *P. gleniei*, *P. involucrata*, *P. madrassica*, *P. crassicaulis* etc.

Calyx lobes are variable in size, shape and hairiness. The size varies  $0.2 \times 0.2$  mm

(*P. graciliflora*) to  $2.5-5.0 \times 0.2-0.3$  mm (*P. gleniei*). The shape is dentate (Fig. 6 a,b) in *P. graciliflora*, *P. indica* var. *indica* etc.; triangular (Fig. 6 : f,g) in *P. indica* var. *glabrescens*, *P. hispidula* etc.; narrowly triangular (Fig. 6 : i) in *P. wightii*; ovate (Fig. 6 l,n) in *P. praeterita*, *P. macraei* etc.; subquadrate (Fig. 6 : m) in *P. gardneri* and subulate (Fig. 6 : o-q) in *P. gleniei*, *P. involucrata*, *P. sp. 1.* etc. The apex is acute in *P. hispidula*; acuminate in *P. indica* var. *glabrescens*, *P. wightii*, *P. macraei* etc.; mucronate in *P. gardneri* and rounded in *P. praeterita*. The outer and inner surface of lobes are glabrous in *P. indica* var. *indica*, *P. blanda*, *P. thwaitesii* etc.; puberulous in *P. wightii*, *P. minor* etc.; pubescent in *P. indica* var. *glabrescens*, *P. breviflora* var. *pubescens* etc.; tomentose in *P. indica* var. *tomentosa*; villous in *P. gleniei*, *P. naucleiflora*; hispid in *P. hispidula* var. *hispidula*, *P. macraei* and ciliate in *P. breviflora* var. *ciliolata*; but puberulous only on the margin in *P. hispidula* var. *angustifolia*; puberulous outside but glabrous within in *P. hispidula* var. *zeylanica*, *P. nemoralis*; pubescent outside but glabrous within in *P. brunonis* and glabrous outside but pubescent within and at margin in *P. involucrata*.

The calyx of PAVETTA is normally actinomorphic, but rarely becomes zygomorphic due to presence of small lobes interstitial between normal lobes in *P. macraei*.

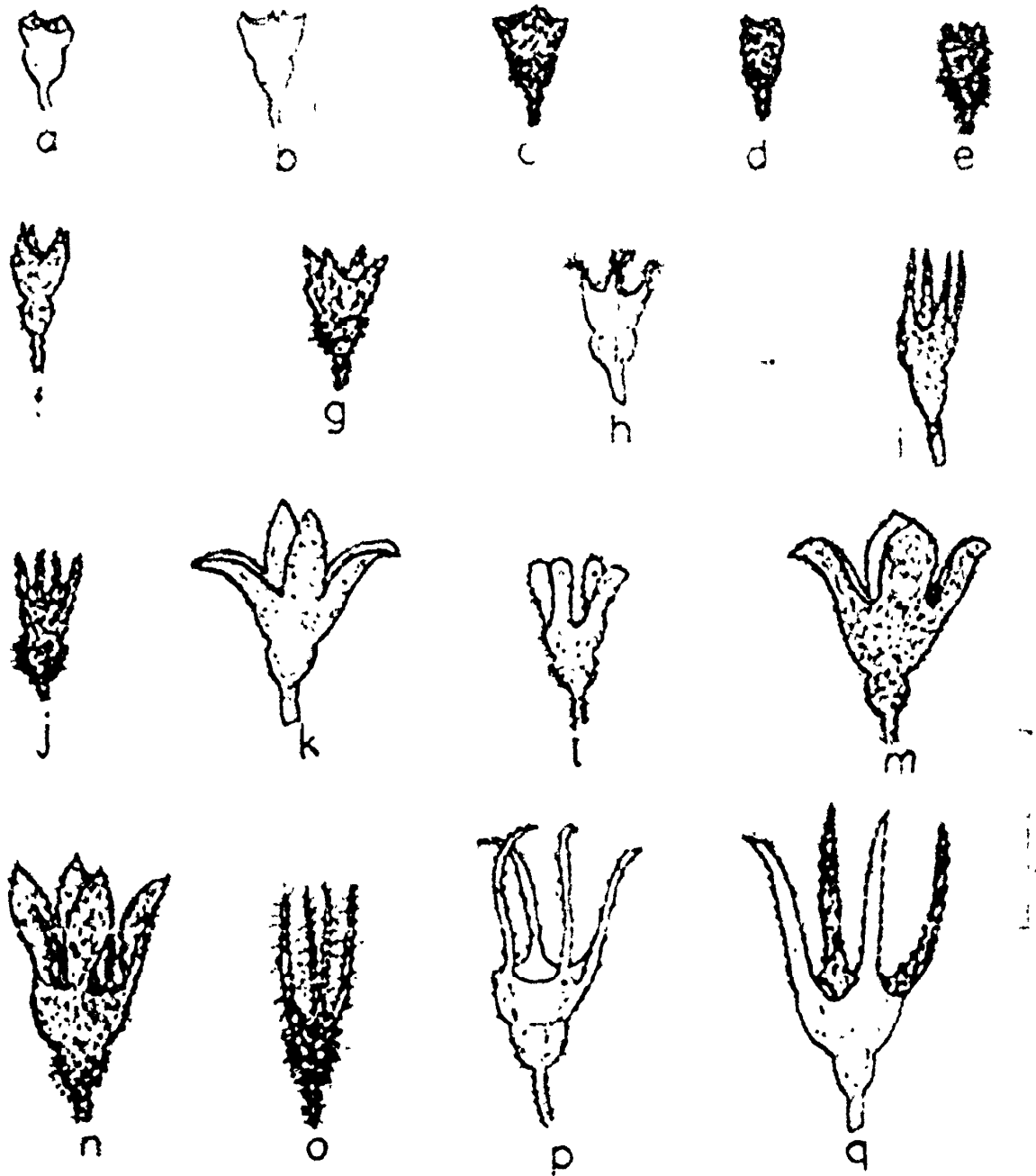


Fig. 6 : *Pavetta* - Calyces : a. *P. indica* var. *indeca* (Wight 254) ; b. *P. graciliflora* (N.P. Balakrishnan 189); c. *P. indica* var. *tomentosa* (M. A. Rau 10342); d. *P. subcapitata* (King's collector s.n.) ; e. *P. naucleiflora* var. *naucleiflora* (Ba Pe 830) ; f. *P. indica* var. *glabrescens* (Cox & Hutchinson 560) ; g. *P. hispidula* var. *hispidula* (Wight 1343) ; h. *P. breviflora* var. *ciliolata* (G.King s.n.) ; i. *P. wightii* (W. Koelz 11071) ; j. *P. brunonis* (P. Bhargava 56907); k. *P. hispidula* var. *zeylanica* (Walker 1164) ; l. *P. praeterita* (Wight. 1478) ; m. *P. gardneri* (Gardneri 52) ; n. *P. macraei* (J. Macraei 24) ; o. *P. gleniei* (Fosberg 53573) ; p. *P. sp.* 1. (Roxburgh s.n.) ; q. *P. involucrata* (Beddome 3931)

Scale line equals 5 mm.

**Taxonomic significance :** Calyx of PAVETTA is very much useful in delimitation of infrageneric taxa. Hook.f. (1980) arranged the species of PAVETTA into two groups, basing on the length of calyx teeth : one with calyx teeth much shorter than the ovary and other with calyx teeth elongate, equalling or longer than the ovary. Bremekamp (1934) considered calyx as the main character for classification of species into sections and series. In the present study, the calyx is considered as one of the important characters for distinguishing species. *P. gleniei*, *P. brunonis*, *P. involucrata* etc. are distinguished by subulate or narrowly triangular calyx.

**Corolla :** The corolla is gamopetalous with a long tube and four distinct lobes. It is generally white or creamy white, except *P. canescens* DC. (from Angola and Zaire) which is red in colour. However, it is white in all Indian species studied.

The corolla tube is cylindrical, slightly widened at the throat, generally two times or longer than the lobes except *P. breviflora* and *P. involucrata* where the tube and lobes are almost of equal length. The length of the tube varies from 5-6 mm (*P. birmahica*, *P. indica* var. *tomentosa*, *P. breviflora* etc.) to 34 mm (*P. hispidula* var. *zeylanica*) ; the breadth varies from 0.5 to 1.0 mm (*P. birmahica*, *P. graciliflora*, *P. thwaitesii*) to 3.0 mm (*P. involucrata*). It is normally glabrous outside but pilose in *P. naucleiflora* var

*naucleiflora* and one specimen (*Gamble* 15021 K !, MH !) of *P. indica* var. *tomentosa*. The inside of corolla tube is normally pubescent but glabrous in *P. breviflora*. The throat of corolla tube is glabrous in most of the species but pubescent in *P. macraei*, *P. thwaitesii*, *P. gleniei* and *P. indica* var. *glabrescens*. (some specimens).

Normally, there are 4 corolla lobes. Only in one specimen (*Thwaites* C.P. 2815 a K ! of *P. gleniei*), there are 5 lobes in few flowers (intermingled with the normal 4-lobed flowers in the same inflorescence). The length of lobes varies from 2.5 mm (*P. birmahica*) to 15 mm (*P. hispidula* var. *zeylanica*) ; the breadth varies from 1.8 mm (*P. birmahica*) to 6.0 mm (*P. hispidula* var. *zeylanica*). The lobes are oblong (Fig. 7 b) in *P. hispidula* var. *hispidula*, *P. oblanceolata* etc. ; obovate (Fig. 7 : a) in *P. subcapitata* ; elliptic-oblong (Fig. 7 : f) in *P. birmahica* ; lanceolata (Fig. 7 : m) in *P. thwaitesii* ; narrowly lanceolate (Fig. 7 : o,p) in *P. involucrata*, *P. sp.* 1. The apex is rounded in *P. subcapitata*; mucronulate in *P. hispidula* var. *zeylanica*, *P. oblanceolata* acuminate in *P. thwaitesii*, *P. involucrata* ; acute in *P. gleniei*. The lobes are glabrous in most of the species, but pubescent on both sides in *P. naucleiflora*, at the apex outside in *P. macraei*, at the base within in *P. thwaitesii*, *P. gleniei* and inside in *P. blanda*.

The corolla is strictly actinomorphic in all species studied. aestivation of corolla is

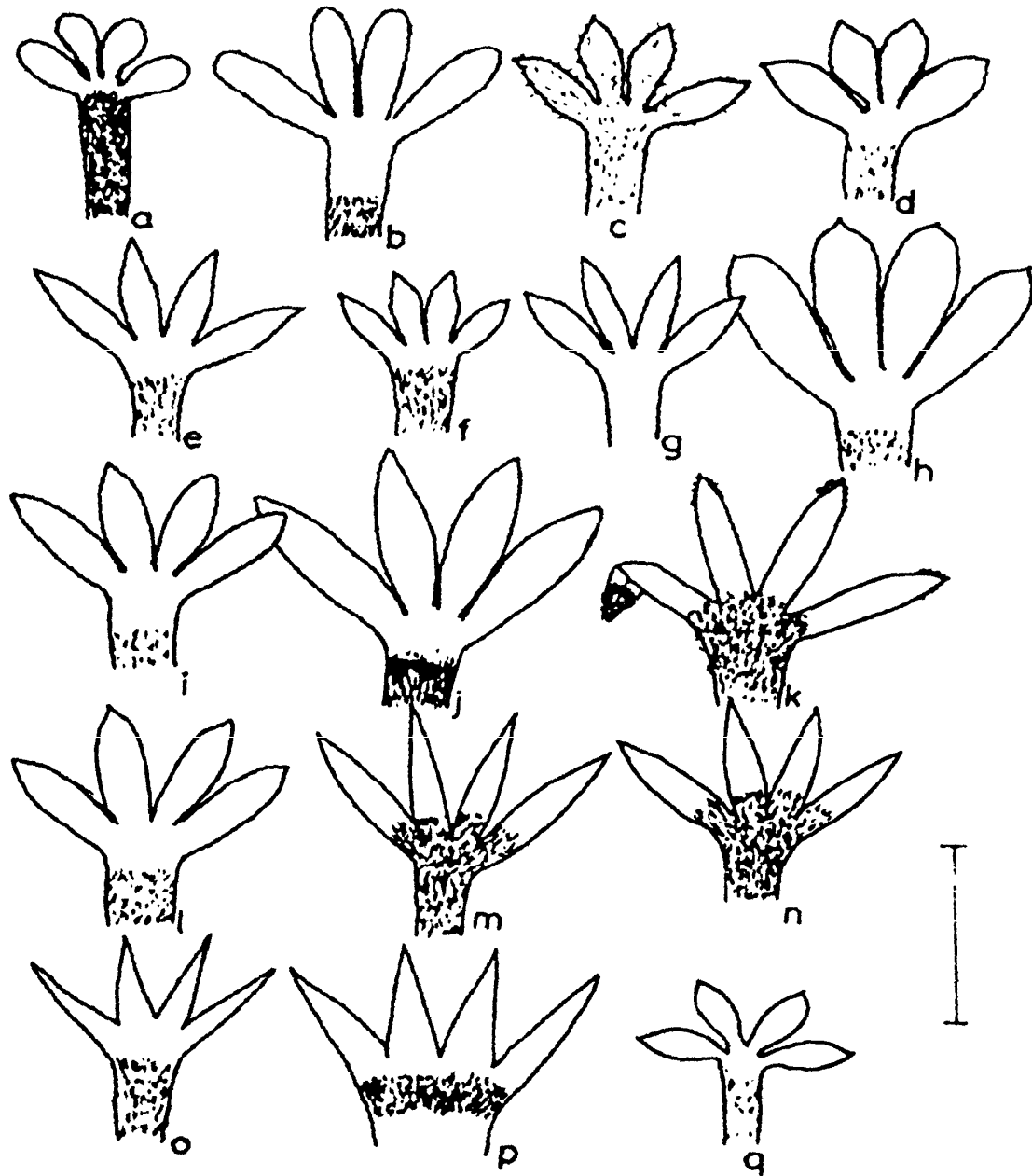


Fig. 7 : *Pavetta* - corollas. : a. *P. subcapitata* (King's collector s.n) ; b. *P. hispidula* var. *hispidula* (Henry & Chandrabose 19272) ; c. *P. naucleiflora* var. *naucleiflora* (Ba Pe 830) ; d. *P. brunonis* (P. Bhargava 56907) ; e. *P. wightii* (R. Wight s.n) ; f. *P. birmahica* (A. Huk s.n) ; g. *P. breviflora* var. *ciliolata* ( G. King s.n. ) ; h. *P. hispidula* var. *zeylanica* (Thwaites C.P. 742) ; i. *P. hispidula* var. *siphonantha* (B.V. Reddi 97842) ; j. *P. nemoralis* (Meebold 12228) ; k. *P. macraei* (J. macrae 24) ; l. *P. oblanceolata* (Beddome 3920) ; m. *P. thwaitesii* (Thwaites C.P. 2611) ; n. *P. gleniei* (Thwaites C.P. 2815) ; o. *P. sp. 1* (Roxburgh s.n) ; p. *P. involucrata* (Thwaites C.P. 428) q. *P. madrassica* (W. Elliot s.n.). Scale line equals 15 mm for a, b, h, i, k - m, o, q ; 10 mm for c - e, g, j, p ; 6 mm for f & n .

generally an important generic character ; sometimes also for delimitation of the tribe in the Rubiaceae. PAVETTA, as a member of the tribe Pavetteae is characterized by corolla lobes contorted to the left, as in other genera of the tribe.

*Taxonomic significance* : Corolla of PAVETTA is useful taxonomically in generic, subgeneric and specific level. Corolla tube is normally double the length of the lobes. Bremekamp (1934) distinguished between subgenus BACONIA (DC.) Bremek. and subgenus PAVETTA (*Eupavetta* Bremek.) in corolla bearded at throat (corolla throat glabrous or arachnoid, but never bearded in subgen. PAVETTA). The series *Carinatae* Bremekamp (1934) is characterized by longer and broader corolla tube and lobes are of equal length (an exception in this genus) is seen in *P. breviflora* and *P. involucrata*. Corolla tube and lobes are pilose in *P. naucleiflora* var. *naucleiflora*, in which respect it differs from var. *glabrituba*. Corolla lobes are lanceolate in *P. thwaitesii*, narrowly lanceolate in *P. involucrata* etc.

*Microcharacters of corolla* : The micromorphology of rubiaceous corolla was examined for the first time by Robbrecht (1987 : 51) in some *Tricalysia* species. Subsequently he (Robbrecht 1988) made a short series of SEM-observations of corolla throughout the family and concluded "seemingly the corolla-surface is of no

significant systematic importance in the Rubiaceae, except perhaps at lower ranks"

In the present study, corolla surface was examined under SEM in 8 taxa for outer surface of corolla tube and 19 taxa for inner surface of corolla lobes. The outer surface of corolla tube shows elongate epidermal cells with much finer longitudinal cuticular striations, which is uniform for all the species studied, thus having no taxonomic significance.

The linner surface of corolla lobes normally shows ridged or irregularly folded epidermal cells with rugose, striate or smooth cuticular surface, which is predominant and observed in 17 taxa. Building epidermal cells with rugose or rugulose cuticular surface and depressed epidermal cells with rugose or striate cuticular surface are of rare occurrence (in two taxa each). *P. indica* var. *glabrescens* shows both bulging and depressed epidermal cells. As the cuticular surface patterns of inner surface of corolla is predominated by one type and there is variation within one taxon even, it is also having no taxonomic significance.

*Androecium* : A single whorl of 4 epipetalous stamens is attached at the mouth of corolla tube, alternating with the lobes. The anthers are borne on distinct filaments, exerted and spirally twisted after dehiscence in open flowers. This torsion is due to loss of water and disappears when the flowers are boiled.

Filaments vary in length from 0.5 mm (*P. birmahica*) to 3.0 mm (*P. hispidula* var. *zeylanica*). These are normally glabrous but puberulous in *P. hispidula* var. *zeylanica*, *P. thwaitesii* and *P. hohenackeri*.

The anthers are dorsifixed above the base, more or less equalling the length of the corolla lobes, 2-lobed, acute at apex (due to presence of sterile appendages), sagittate at base and glabrous. These are proterandrous (dehisce in bud stage), the two theca dehisce by longitudinal splitting of septa. Robbrecht & Puff (1986 : 87) and Robbrecht (1988 : 87) reported the occurrence of multilocellate anthers (transverse septa divide the anthers locules into horizontal chambers) in some species of *PAVETTA*. However, this has not been observed in the present study. The length of anthers varies from 2.5 mm (*P. birmahica*) to 11.5 mm (*P. hispidula* var. *zeylanica*).

**Taxonomic significance :** The anthers have taxonomic significance in subgeneric level. Bremekamp (1939 a) distinguished subgenus *DIZYGOON* Bremekamp from other two subgenera of the genus : *PAVETTA* (*EUPAVETTA* Bremek. and *BACONIA* DC.) Bremek. mainly on the nature of anthers and style. In *DIZYGOON*, the anthers in open flowers are not spirally twisted, whereas it is spirally twisted in other two subgenera. This happens due to the shortness and great width of anthers in *DIZYGOON*.

**Gynoecium :** Gynoecium in *PAVETTA* is bicarpellary, consisting of ovary, disk and a long style provided with stigmatic surface at the tip. Ovary is obovoid, inferior and syncarpous. Its size ranges from  $0.6 \times 0.7$  mm (*P. birmahica*) to  $1.5 \times 1.8$  mm (*P. involucrata*). It is two loculed with 1 ovule in each loculus. Placentation is axile. The ovules are pendulous from upper part of the septum, unitegmic, anatropous and with superior micropyle. Septa are thin and complete. The ovary is crowned by a fleshy annular disk which surrounds the base of the style. Disks are glabrous in all the species studied.

The styles are long-exserted, almost double in length of the corolla tube, glabrous, sometimes the exserted portion partly or wholly becomes puberulous or pubescent as in *P. subcapitata*, *P. wightii*, *P. hispidula* var. *siphonantha*, *P. macraei* etc. The upper part of style acts as pollen receptacle (receptaculum pollinis), thickened, club-shaped, 8-ribbed, normally puberulous (*P. subcapitata*, *P. brunonis*, *P. wightii* etc.), but glabrous in *P. thwaitesii*, *P. crassicaulis* etc. The length of style varies from 10 to 17 mm (*P. breviflora*, *P. birmahica*) to 68-75 mm (*P. hispidula* var. *zeylanica*).

The stigmatic surface is confined to the extreme tip of the style. This may be very small, normally not visible (*P. naucleiflora*, *P. subcapitata*, *P. hispidula*, etc.) or it may consist of two clear minute lobes (0.1 to

0.2 mm) (*P. oblanceolata*, *P. thwaitesii*, *P. hohenackeri* etc.). In *P. gleniei* only, the stigma is clearly two lobed (lobes *ca* 1 mm).

**Taxonomic significance :** The nature of style and stigma have less taxonomic significance in specific or infraspecific level, but have more importance in generic and subgeneric level. The long exserted style almost double of the corolla tube and the undivided (rarely notched) stigma of PAVETTA is the main diagnostic feature from its most allied genus IXORA (in which the style is almost as long as the corolla tube or slightly longer than it and the stigma is always distinctly two lobed). Bremekamp (1939 a) distinguished subg. (DIZYGOON Bremek. from other two subgenera : PAVETTA (EUPAVETTA Bremek. and BACONIA DC.) Bremek. in nature of anther and the apical part of style (spathulate in DIZYGOON, but terete in other two subgenera).

**Fruits :** Fruits of PAVETTA are drupes, normally stalked, rarely sessile, spherical subglobose or 2-lobed, frequently black and shining, sometimes white or coloured in the subgenus BACONIA (Bremekamp 1934 ; 19), glabrous or pubescent, crowned with persistent calyx teeth or not, scarcely fleshy, containing 1 or 2 chartaceous pyrenes. Pyrenes are always one seeded. Spherical or subglobose fruits contain one pyrene, so one seeded whereas 2-lobed fruits contain 2 pyrenes, thus two seeded. Spherical fruits are common, whereas 2-lobed fruits are of rare

occurrence, mixed with spherical or subglobose fruits in the same infructescence. The pericarp consists of 3 distinct zones : outer epicarp containing 2-4 layers of parenchymatous cells ; middle mesocarp containing 8-12 layers of parenchymatous cells and inner endocarp containing 1 layer of stone cells (sclerenchymatous).

Stalked fruits are common, but in *P. subcapitata* and *P. involucrata*, the fruits are sessile or subsessile. The size of fruits ranges from 4-5 mm (*P. thwaitesii*) to 12 mm (*P. hispidula* var. *zeylanica*).

The fruits are glabrous in most of the species (*P. indica* var. *indica*, *P. graciliflora*, *P. travancorica* etc.) (Fig. 8 A,B), but puberulous (Fig. 8 : D, E) in *P. madrassica* ; pubescent (Fig. 9 : F, K) in *P. indica* var. *tomentosa*, *P. hispidula* var. *hispidula* etc., hirsute (Fig. 8 : Q, R) in *P. gleniei* and pilose (Fig. 8 : O) in *P. naucleiflora* var. *naucleiflora*.

Fruits in most of the species are without persistent calyx, but others possess it. The calyx may be very small in *P. madrassica* and very large in *P. gleniei* and *P. involucrata* (Fig. 8 : D,E,P, M).

**Taxonomic significance :** Fruits of PAVETTA have some taxonomic significance. Persistent calyx in fruits of *P. gleniei*, *P. involucrata*, *P. madrassica* etc., fruits puberulous in *P. madrassica* ; pilose in

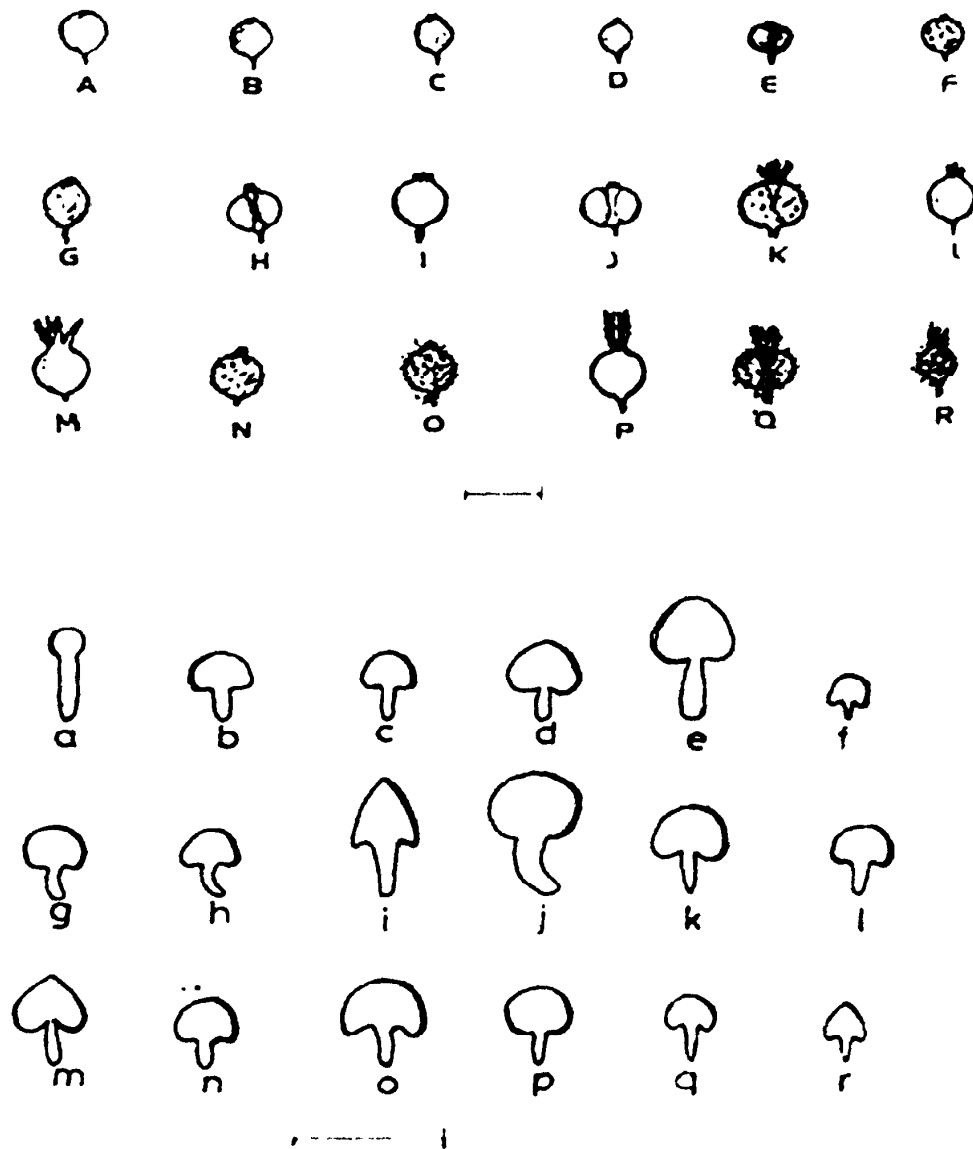


Fig. 8 : *Pavetta* - Fruits (A - R) and embryo types (a - r). A. *P. graciliflora* (N. P. Balakrishnan 667) ; B. *P. travancorica* (N. Venugopal 15990) ; C. , *P. birmahica* (S. Mokim 36) ; D & E. *P. madrassica* (Wight 1481) ; F. *P. indica* var. *tomentosa* (R. S. Rao 71737) ; G. *P. indica* var. *glabrescens* (R. N. Banerjee 18703) ; H. *P. hispidula* var. *siphonantha* (B. V. Reddi 101161) ; I. *P. hispidula* var. *zeylanica* (Gamble 15555) ; J. *P. hispidula* var. *angustifolia* (Thwaites C. P. 267) ; K. *P. hispidula* var. *hispidula* (A. N. Henry 48143) ; L. *P. breviflora* var. *ciliolata* (Wight 1479) ; M. *P. involucrata* (Tirvengadam et al. 594) ; N. *P. subcapitata* (Prazer s.n.) ; O. *P. naucleiflora* var. *naucleiflora* (Scortechini s.n.) ; P. R. *P. gleniei* (P. Thwaites C. P. 2815 a ; Q & R : Thwaites C. P. 2815 c.). Scale line for A-R equals 10 mm. a. *P. gleniei* (Thwaites C. P. 2815) ; b. *P. travancorica* (Bourne 530) ; c. *P. hispidula* var. *hispidula* (Henry & Chandrabose 19272) ; d. *P. hispidula* var. *siphonantha* (B. V. Reddi 97842) ; e. *P. hispidula* var. *zeylanica* (Thwaites C. P. 742) ; F. *P. involucrata* (Thwaites C. P. 428) ; g. *P. blanda* (Thwaites C. P. 2426) ; h. *P. subcapitata* (Prazer s. n.) ; I. *P. naucleiflora* var. *naucleiflora* (Scortechini s. n.) ; j. *P. breviflora* var. *ciliolata* (Wight 1479) ; k, l, n. *P. indica* var. *glabrescens* (k : G. King s. n. ; l : King's collector 513 ; n. R. N. Banerjee 18703) ; m. *P. graciliflora* (N. P. Balakrishnan 667) ; o. *P. crassicaulis* (S. D. Mahajan 6853) ; p. *P. birmahica* (S. Mokim 36) ; q. *P. indica* var. *indica* (R. C. Rout 3601) ; r. *P. indica* var. *tomentosa* (M. A. Rau 10392). Scale line equals 2 mm for a, b, g, i & j ; 4 mm for c - e, h, k, m - r ; 5 mm for f & l.

*P. naucleiflora* etc. are useful for identification of specific or infraspecific taxa.

**Seeds :** There are one (by abortion of one ovule) or two seeds, attached to the upper part of the septum. These are hemispherical with a wide circular or semicircular excavation in the ventral face filled with placental parenchyma. The size of seeds ranges from 3 mm (*P. blanda*) to 7 mm (*P. hispidula* var. *zeylanica* and var. *hispidula*, *P. crassicaulis*).

**Seed coat :** The seed coat probably in all Rubiaceae is exotestal (Corner 1976). The outer epidermis (exotesta) forms the mechanical layer where as the endotestal cells mostly become crushed during the development and enlargement of the endosperm. The exotesta of a whole seed is often not entirely uniform with respect to size and shape of the cells. Around the cavity of excavated seeds, the exotestal cells are much more elongated than elsewhere.

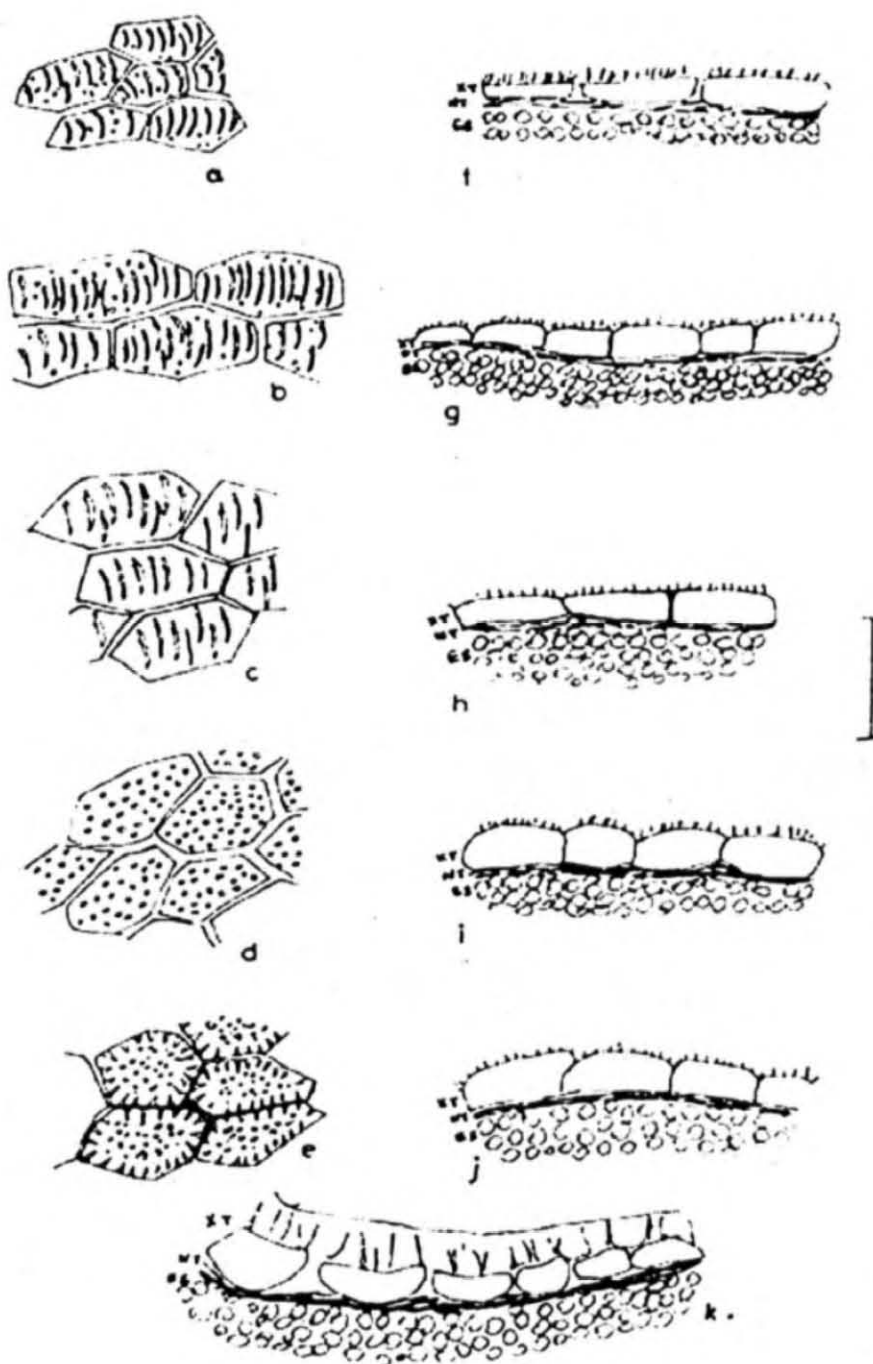
Seed coat has been examined in 13 taxa under LM (both seed coat peels and sections) and 10 taxa under the SEM. The seed coat is exotestal. It is thickened in all the taxa studied. The thickenings occur as continuous plates with intrusions from the lumen of exotestal cells (Fig. 9) which was also reported by Robbrecht & Puff (1986). The thickening is more at the margin of excavation.

The exotestal cells are normally

hexagonal, rarely pentaor tetragonal in outline (Fig. 9 : a-e), with straight walls. The exotestal cell ranges from 48  $\mu$ m to 240  $\mu$ m and thickness ranges from 16  $\mu$ m to 90  $\mu$ m.

LM study shows types of cuticular surfaces : striate (Fig. 9 :c), granulate (Fig. 9 : d) and striate-granulate (Fig. 9 : a,b,e). Striate surface has been observed in one taxon only: *P. indica* var. *indica* ; granulate surface in 3 taxa : *P. crassicaulis*, *P. hispidula* var. *siphonantha* and *P. graciliflora* and striate granulate surface in 9 taxa : *P. subcapitata*, *P. indica* var. *glabrescens* & var. *tomentosa*, *P. breviflora* var. *breviflora*, *P. hispidula* var. *hispidula* & var. *zeylanica*, *P. blanda*, *P. travancorica* and *P. minor*. SEM study shows 8 types of surfaces : colliculate in *P. indica* var. *indica*, *P. involucrata* ; colliculate-pusticulate in *P. hispidula* var. *angustifolia* ; colliculate-scribulate in *P. gleniei* ; striate-reticulate in *P. naucleiflora* var. *naucleiflora* reticulate-foveate in two taxa : *P. madrassica* and *P. brunonis* ; striate in *P. breviflora* var. *breviflora* ; rugose in *P. breviflora* var. *ciliolata* and pusticulate in *P. birmahica*. *P. indica* var. *indica* shows both striate and colliculate surface.

The seed coat is very distinct and useful for delimitation of species or infraspecific taxa. In generic level, seed coat of *PAVETTA* (exotestal) is also useful for distinction from its most allied genus *IXORA* in which the seed coat is parenchymatous.



**Fig. 9 :** *Pavetta* - seed coat (LM). a - e in surface view ; f - j in cross section with adjacent tissue (after removal of outer cell walls artificially) ; k, in cross-section with outer cell wall. a & f, *P. subcapitata* (Prain's collector 394) ; b & g. *P. breviflora* var. *breviflora* (M. Gangopadhyay & D.C. Mondal 2462) ; c, h & k. *P. indica* var. *glabrescens* (c & h. G. Panigrahi 4441 ; k. R.N.Banerjee 18703) ; d & i. *P. graciliflora* (King's collector s.n) ; e & j. *P. hispidula* var. *zeylanica* (Thwaites C.P. 742). XT = Exotesta ; NT = Endotesta & ES = Endosperm.

Scale line equals 200  $\mu$ m.

**Endosperm** : The endosperm is always entire and horny. It consists of moderately thickened cells, filled with brown or purplish contents, starch. Oily endosperms are entirely lacking.

**Embryo** : The embryo of *PAVETTA* consists of two foliaceous flat cotyledons with weak venation and a radicle with a conical or flat base, generally straight, rarely curved and inferior. Plumule is very minute and always enclosed within the cotyledons.

The embryo ranges 1.5 mm (*P. gleniei*) to 3 mm (*P. indica* var. *glabrescens*, *P. graciliflora*) ; radicle ranges from 0.6 mm (*P. involucrata*) to 1.4 mm (*P. graciliflora*) and cotyledon ranges from  $0.3 \times 0.3$  mm (*P. gleniei*) to  $1.8 \times 2.0$  mm (*P. indica* var. *glabrescens*).

The cotyledons and radicle are normally of equal length or cotyledons slightly longer than radicle, but in *P. gleniei* (Fig. 8 : a), the radicle is much longer (1.2 mm) than the cotyledons ( $0.3 \times 0.3$  mm) and in *P. involucrata* (Fig. 8 : f), the radicle is much shorter (0.6 mm) than the cotyledons ( $1.2 \times 1.8$  mm).

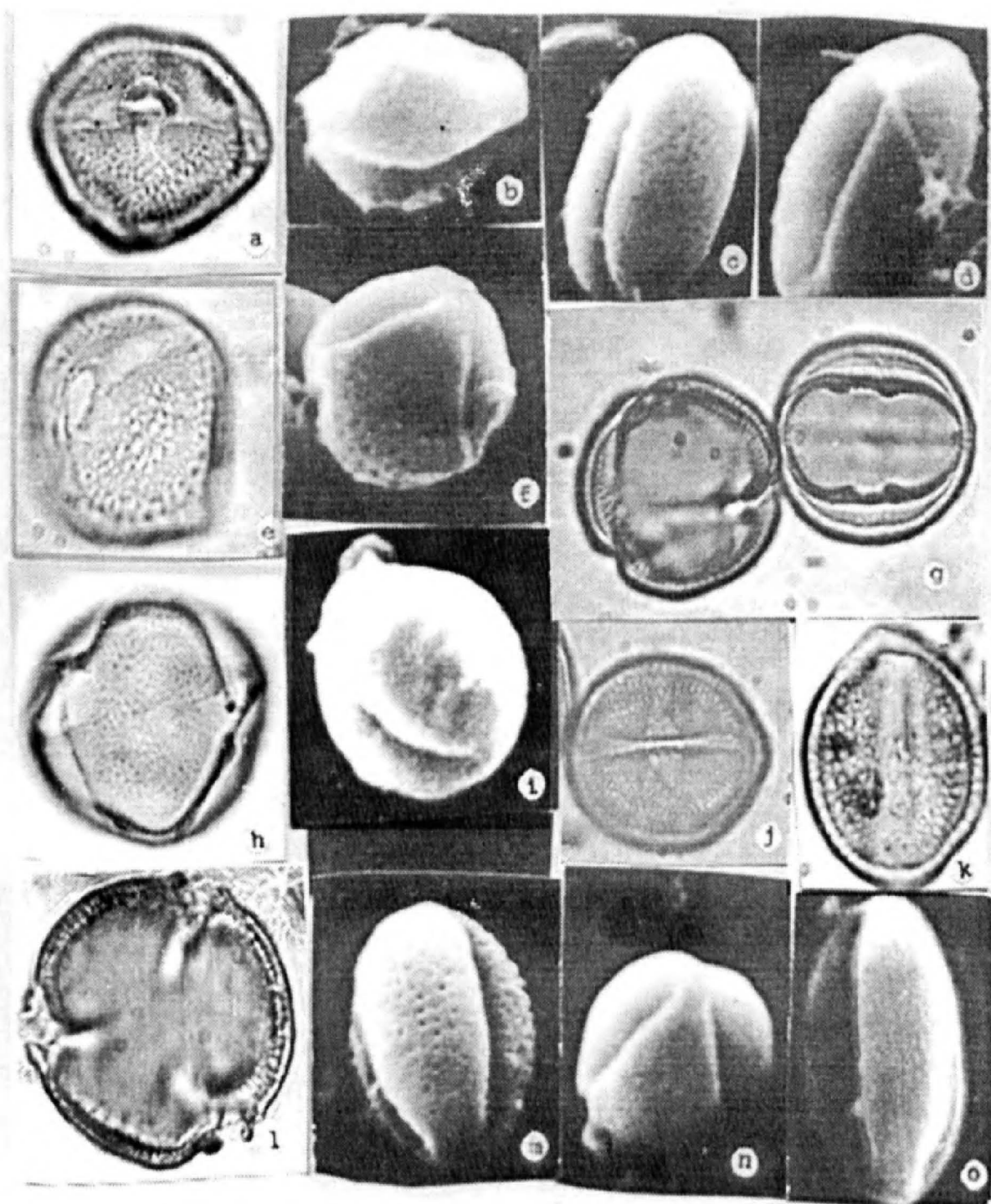
The radicle is normally straight in *P. gleniei*, *P. hispidula* var. *hispidula* etc., but curved (Fig. 8 : h) in *P. subcapitata*, *P. breviflora* var. *ciliolata*. The shape of cotyledons is ovate in *P. hispidula* var. *zeylanica*, *P. graciliflora* etc. orbicular in

*P. gleniei*, *P. breviflora* var. *ciliolata*, *P. birmahica* etc. ; reniform in *P. crassicaulis*, *P. indica* var. *glabrescens* etc. The apices of cotyledons are frequently rounded, but subacute in *P. naucleiflora* and obtuse in *P. graciliflora*; the base is generally cordate to subcordate, but rounded in *P. gleniei*, *P. birmahica* etc.

**Pollen morphology** : Pollen morphology of 27 taxa have been studied under light microscope and 16 taxa under the SEM. The pollen morphological features evidenced from such studies are tabulated under 7 main heads : pollen size, pollen shape, aperture number, ectocolpium, endocolpium, apocolpium and exine (Table-3).

The pollen grains are medium sized (as per Erdtman 1952) :  $25-44 \times 18-37 \mu\text{m}$  ; the smaller grains :  $25 \times 25 \mu\text{m}$  is found in *P. travancorica* and largest grain :  $44 \times 27 \mu\text{m}$  in *P. hispidula* var. *siphonantha*.

The pollen grains are prolate in 6 taxa : *P. hispidula* var. *siphonantha*, *P. thwaitesii* (Fig.-11 : o, p), *P. hohenackeri* (Fig. 10 : m), *P. graciliflora* (Fig. - 10 : a), *P. indica* var. *indica* and var. *tomentosa* ; subprolate in 9 taxa : *P. macraei*, *P. involucrata* (Fig. 11 : c), *P. wightii*, *P. subcapitata* (Fig.-12 : g,q), *P. breviflora* var. *pubescens*, *P. birmahica*, *P. crassicaulis*, *P. indica* var. *glabrescens* and *P. sp. 1* ; prolate-spheroidal in 9 taxa : *P. gleniei*, *P. oblanceolata* (Fig.-11 : l), *P. praeterita*, *P. hispidula* var.



**Fig. 10 :** Pollen grains (a, e, g, h, j, k & l. LM  $\times 1000$  ; b, c, d, f, i, m, n, o, SEM  $\times 3200$  ) a & b. *P. graciliflora* (S. Kurz s.n. ) ; e & f. *P. blanda* (Thwaites C.P. 2456) ; h. *P. wightii* (Wight s.n. ) ; i. *P. nemoralis* (A. Meebold 12228) ; l. *P. breviflora* var. *breviflora* (M. Gangopadhyay & D.C.Mondal 2470) ; m. *P. hohenackeri* (Hohenackeri 1379) ; c, g, j. *P. crassicaulis* (R. S. Raghavan 80939) ; d & k. *P. indica* var. *indica* (d, T. F. Bourdillon 263 ; k, Gamble 12396) ; o. *P. indica* var. *tomentosa* (Wall. Cat. 6183 a) ; n. *P. travancorica* (B. V. Shetty 10292).

## Pollen morphological characters of PAVETTA spp.

Table - 3 :

| Sl. No. | Name of the taxa                                     | Material studied              | Pollen size ( $\mu\text{m}$ )            | Pollen shape      | Aperture number       |
|---------|------------------------------------------------------|-------------------------------|------------------------------------------|-------------------|-----------------------|
| 1.      | <i>P. gleniei</i> Hook.f.                            | <i>G. Davidse et al.</i> 9039 | 28 $\times$ 25<br>(25-31 $\times$ 21-27) | Prolatespheroidal | 3-zono<br>colpororate |
| 2.      | <i>P. sp.</i> 1                                      | <i>Roxburgh</i> s.n.          | 43 $\times$ 37<br>(37-46 $\times$ 33-42) | Subprolate        | "                     |
| 3.      | <i>P. travancorica</i> Bremek.                       | <i>B.V. Shetty</i> 10292      | 25 $\times$ 25<br>(22-30 $\times$ 22-26) | Spheroidal        | "                     |
| 4.      | <i>P. macraei</i> Bremek.                            | <i>J. Macrae</i> 24           | 35 $\times$ 30<br>(32-43 $\times$ 26-35) | Subprolate        | "                     |
| 5.      | <i>P. oblanceolata</i> Bremek.                       | <i>Beddome</i> 3920           | 30 $\times$ 28<br>(27-32 $\times$ 26-30) | Prolatespheroidal | "                     |
| 6.      | <i>P. praeterita</i> Bremek.                         | <i>R. Wight</i> 1478          | 35 $\times$ 32<br>(32-38 $\times$ 28-35) | "                 | "                     |
| 7.      | <i>P. hispidula</i> Wt. & Arn. var. <i>hispidula</i> | <i>B.V. Shetty</i> 27962      | 37 $\times$ 36<br>(32-40 $\times$ 25-40) | "                 | "                     |
| 8.      | —var. <i>siphonantha</i> (Dalz.) Hook.f.             | <i>B.V. Reddi</i> 97798       | 44 $\times$ 27<br>(39-46 $\times$ 25-33) | Prolate           | "                     |
| 9.      | —var. <i>zeylanica</i> Hook.f.                       | <i>Thwaites C.P.</i> 742      | 36 $\times$ 33<br>(30-40 $\times$ 29-37) | Spheroidal        | "                     |
| 10.     | —var. <i>angustifolia</i> (Thw.) Hook.f.             | <i>Thwaites C.P.</i> 267      | 36 $\times$ 33<br>(32-41 $\times$ 26-35) | Prolatespheroidal | "                     |
| 11.     | <i>P. involucrata</i> Thw.                           | <i>Thwaites C.P.</i> 428      | 33 $\times$ 28<br>(26-34 $\times$ 25-32) | Subprolate        | "                     |
| 12.     | <i>P. wightii</i> Hook.f.                            | <i>R. Wight</i> s.n.          | 35 $\times$ 28<br>(32-38 $\times$ 23-32) | "                 | 3-zono<br>colporate   |
| 13.     | <i>P. blanda</i> Bremek.                             | <i>Thwaites C.P.</i> 2456     | 30 $\times$ 30<br>(28-34 $\times$ 24-33) | Spheroidal        | "                     |
| 14.     | <i>P. nemoralis</i> Brenck.                          | <i>Meebold</i> 12228          | 33 $\times$ 30<br>(30-38 $\times$ 25-32) | Prolatespheroidal | "                     |
| 15.     | <i>P. thwaitesii</i> Bremek.                         | <i>Thwaites C.P.</i> 2611     | 32 $\times$ 24<br>(30-38 $\times$ 20-27) | Prolate           | 3-zono<br>colpororate |
| 16.     | <i>P. naucleiflora</i> var. <i>naucleiflora</i>      | <i>K. Biswas</i> 908          | 29 $\times$ 26<br>(24-32 $\times$ 24-28) | Prolatespheroidal | "                     |
| 17.     | <i>P. subcapitata</i> Hook.f.                        | <i>Prain's Collector</i> 990  | 30 $\times$ 26<br>(29-34 $\times$ 24-28) | Subprolate        | "                     |

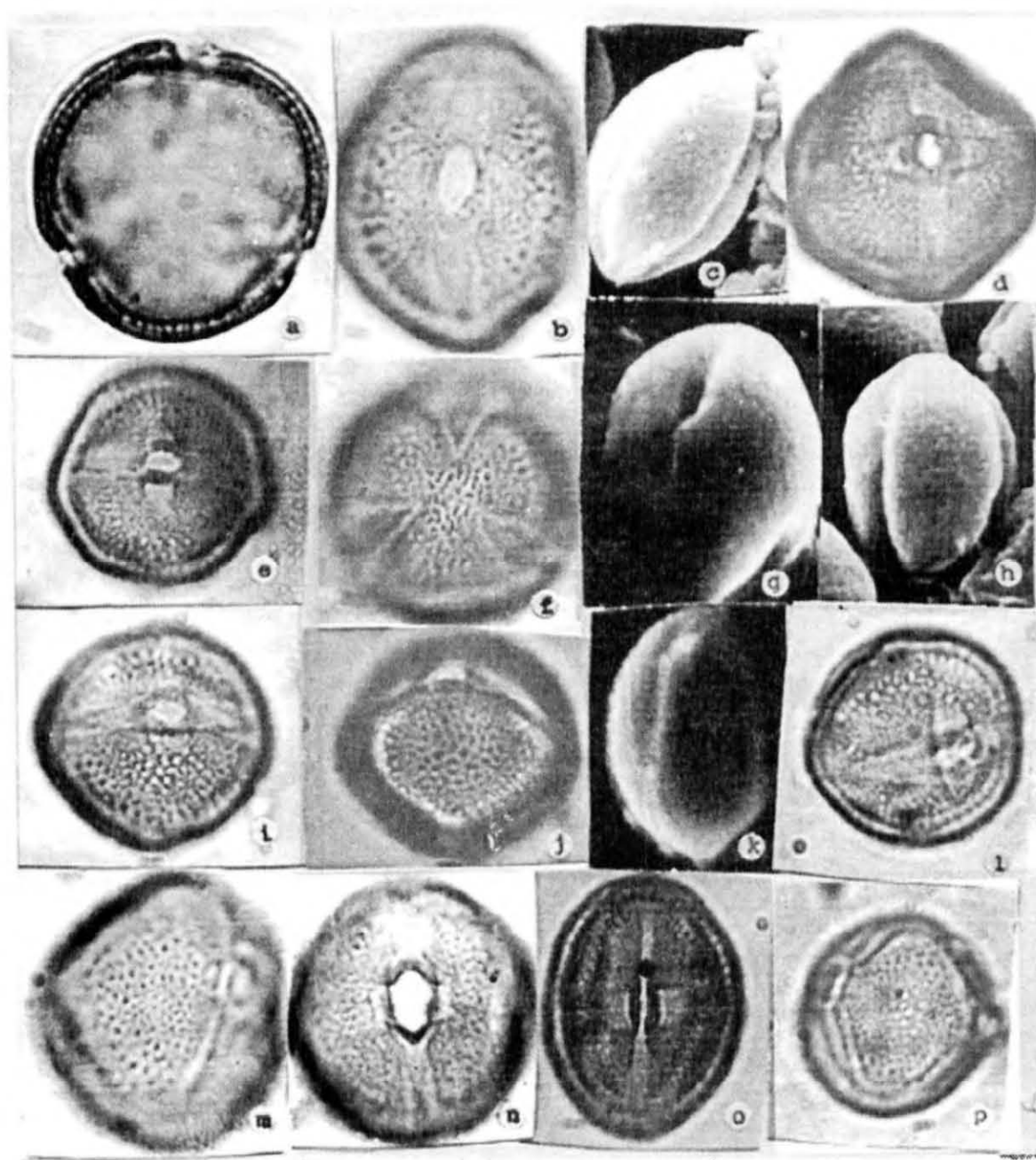
Pollen morphological characters of *PAVETTA* spp.

| Ectocolpium size ( $\mu\text{m}$ ) | Endocolpium                   |                          |                          | Apocolpium diameter ( $\mu\text{m}$ ) | Exine     |                             |
|------------------------------------|-------------------------------|--------------------------|--------------------------|---------------------------------------|-----------|-----------------------------|
|                                    | OS type                       | OS 'A' ( $\mu\text{m}$ ) | OS 'B' ( $\mu\text{m}$ ) |                                       | Thickness | Surface                     |
| 22 × 2<br>(20-22 × 2-3)            | A <sub>2</sub> B <sub>1</sub> | 5 × 13<br>(4-6 × 12-15)  | 4.5 × 3                  | 6 - 7                                 | 2         | Finely reticulate           |
| 34 × 4<br>(29-36 × 3-6)            | A <sub>3</sub> B <sub>1</sub> | 7 × 14<br>(4-11 × 12-15) | 6 × 4                    | 8 - 9                                 | 2         | Very finely reticulate      |
| 20 × 2<br>(15-24 × 1-3)            | A <sub>2</sub> B <sub>1</sub> | 4 × 11<br>(3-6 × 9-13)   | 5 × 2                    | 4 - 5                                 | 1.5       | Reticulate                  |
| 30 × 2<br>(23-36 × 2-4)            | A <sub>3</sub> B <sub>1</sub> | 6 × 12<br>(4-6 × 10-15)  | 6 × 2                    | 6                                     | 2         | "                           |
| 23 × 2<br>(20-26 × 2-3)            | "                             | 4 × 12<br>(4-6 × 10-15)  | 5 × 3                    | 5                                     | 2         | Finely reticulate           |
| 27 × 3<br>(25-32 × 2-4)            | "                             | 5 × 15<br>(4-6 × 12-20)  | 5 × 3                    | 7 - 8                                 | 2         | Reticulate                  |
| 27 × 4<br>(24-35 × 3-5)            | "                             | 5 × 12<br>(4-9 × 9-17)   | 5 × 2                    | 7                                     | 2         | "                           |
| 35 × 4<br>(30-39 × 4-6)            | "                             | 7 × 10<br>(4-10 × 7-16)  | 7 × 4                    | 8 - 9                                 | 1.5       | "                           |
| 26 × 4<br>(23-30 × 3-6)            | "                             | 6 × 12<br>(5-8 × 10-16)  | 5 × 2                    | 7                                     | 2         | "                           |
| 31 × 4<br>(24-32 × 2-5)            | "                             | 5 × 12<br>(4-7 × 8-15)   | 5 × 4                    | 6 - 7                                 | 2         | "                           |
| 25 × 3<br>(20-28 × 2-5)            | "                             | 5 × 12<br>(4-7 × 8-15)   | 6 × 4                    | 12                                    | 2         | "                           |
| 28 × 4<br>(26-31 × 2-5)            | A <sub>3</sub>                | 4 × 14<br>(4-7 × 10-16)  |                          | 7                                     | 1.5       | "                           |
| 22 × 3<br>(20-26 × 2-5)            | "                             | 5 × 10<br>(4-7 × 7-15)   |                          | 6                                     | 2         | Striate reticulate (medium) |
| 25 × 3<br>(23-29 × 2-4)            | "                             | 5 × 10<br>(4-7 × 7-13)   |                          | 6                                     | 1.5       | Fine reticulate             |
| 26 × 2<br>(23-32 × 2-3)            | A <sub>3</sub> B <sub>1</sub> | 5 × 8<br>(4-6 × 8-13)    | 5 × 2                    | 7                                     | 1.5       | Reticulate                  |
| 24 × 2<br>(19-26 × 2-4)            | "                             | 5 × 11<br>(4-6 × 10-17)  | 5 × 3                    | 5                                     | 2         | Reticulate (medium)         |
| 25 × 3<br>(23-28 × 2-4)            | "                             | 5 × 12<br>(3-6 × 10-14)  | 5 × 3                    | 5                                     | 2         | Reticulate                  |

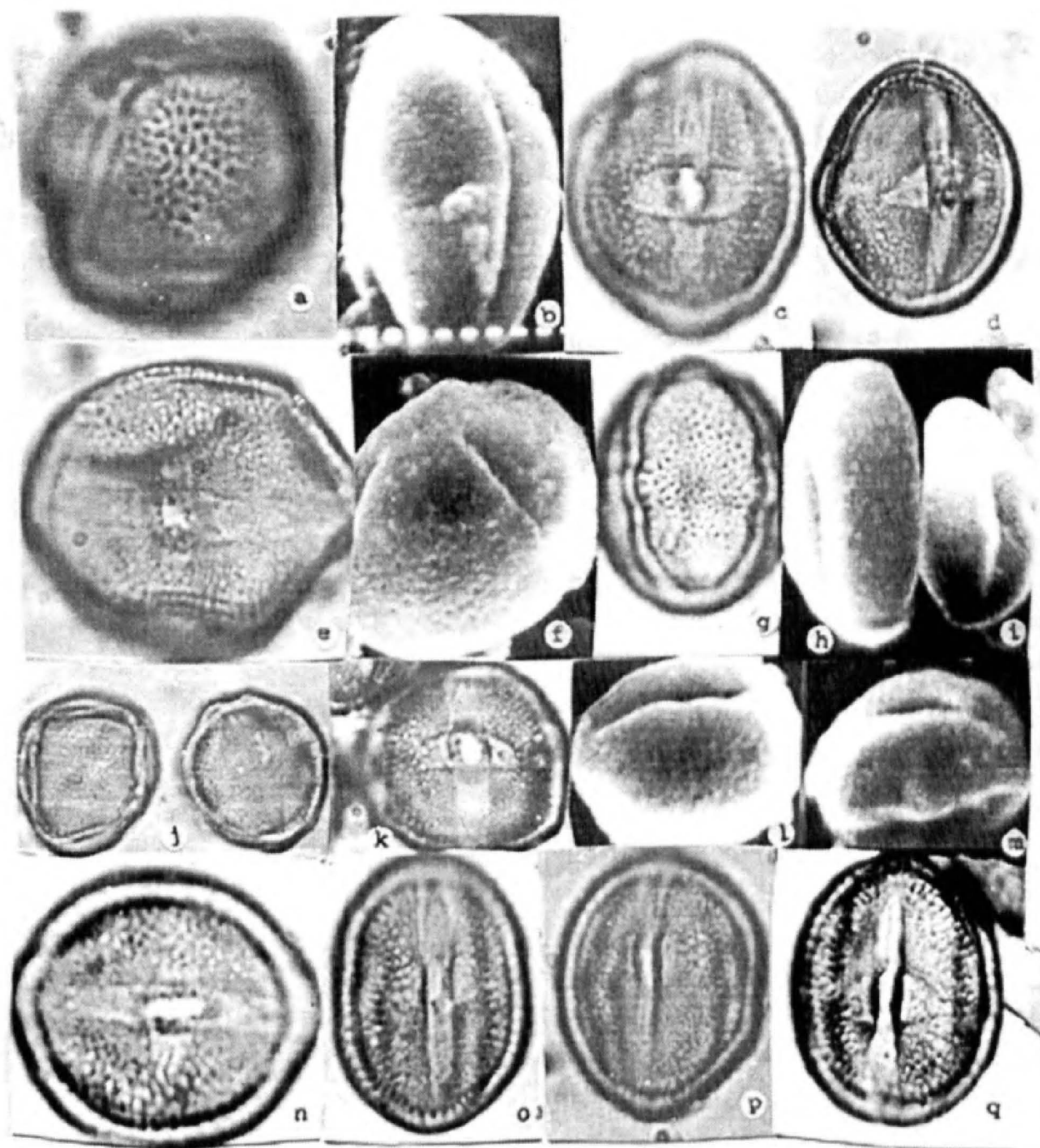
| Sl. No. | Name of the taxa                            | Material studied                | Pollen size ( $\mu\text{m}$ )            | Pollen shape      | Aperture number  |
|---------|---------------------------------------------|---------------------------------|------------------------------------------|-------------------|------------------|
| 18.     | <i>P. breviflora</i> var. <i>breviflora</i> | <i>Gangopadhyay et al.</i> 2470 | $33 \times 32$<br>(30-34 $\times$ 30-36) | Prolatespheroidal | 3-zono colporate |
| 19.     | —var. <i>pubescens</i> Bremek.              | <i>Sebastine</i> 2699           | $30 \times 26$<br>(25-34 $\times$ 25-29) | Subprolate        | „                |
| 20.     | <i>P. hohenackeri</i> Bremek.               | <i>Hohenacker</i> 1379          | $37 \times 27$<br>(32-38 $\times$ 23-29) | Prolate           | „                |
| 21.     | <i>P. graciliflora</i> Wall. ex Ridley      | <i>S. Kurz</i> s.n.             | $31 \times 23$<br>(26-36 $\times$ 21-28) | „                 | „                |
| 22.     | <i>P. brunonis</i> G. Don                   | <i>P. Bhargava</i> 56907        | $28 \times 25$<br>(25-30 $\times$ 24-28) | Prolatespheroidal | 3-zono colporate |
| 23.     | <i>P. birmahica</i> Bremek.                 | <i>A. Huk</i> 76                | $27 \times 22$<br>(23-30 $\times$ 19-23) | Subprolate        | „                |
| 24.     | <i>P. crassicaulis</i> Bremek.              | <i>R.S. Raghavan</i> 80939      | $32 \times 25$<br>(27-36 $\times$ 20-29) | „                 | 3-zono colporate |
| 25.     | <i>P. indica</i> L. var. <i>indica</i>      | <i>Gamble</i> 12396             | $32 \times 18$<br>(29-35 $\times$ 15-22) | Prolate           | „                |
| 26.     | —var. <i>glabrescens</i> (Kurz) Deb & Rout  | <i>R. S. Rao</i> 7126           | $29 \times 23$<br>(23-31 $\times$ 18-27) | Subprolate        | 3-zono colporate |
| 27.     | —var. <i>tomentosa</i> (Roxb. ex Sm.) Kurz  | <i>Wall. Cat.</i> 6173a         | $33 \times 23$<br>(26-37 $\times$ 19-25) | Prolate           | 3-zono colporate |

Pollen morphological characters of *PAVETTA* spp.

| Ectocolpium<br>size ( $\mu\text{m}$ ) | Endocolpium                   |                          |                          | Apocolpium<br>diameter ( $\mu\text{m}$ ) | Exine     |                              |
|---------------------------------------|-------------------------------|--------------------------|--------------------------|------------------------------------------|-----------|------------------------------|
|                                       | OS type                       | OS 'A' ( $\mu\text{m}$ ) | OS 'B' ( $\mu\text{m}$ ) |                                          | Thickness | Surface                      |
| 27 × 3<br>(24-28 × 1-3)               | A <sub>3</sub>                | 6 × 12<br>(5-8 × 11-15)  |                          | 3                                        | 2         | Finely reticulate            |
| 25 × 2<br>(20-27 × 1-3)               | "                             | 5 × 11<br>(4-6 × 10-15)  |                          | 5 - 6                                    | 2         | Reticulate                   |
| 30 × 3<br>(27-32 × 2-5)               | "                             | 5 × 10<br>(4-6 × 7-14)   |                          | 7                                        | 2         | Coarsely<br>reticulate       |
| 23 × 3<br>(19-27 × 2-4)               | A <sub>2</sub>                | 4 × 10<br>(3-5 × 7-12)   |                          | 6                                        | 1         | Reticulate                   |
| 22 × 2<br>(19-23 × 2-3)               | A <sub>2</sub> B <sub>1</sub> | 5 × 12<br>(4-5 × 10-15)  | 5 × 2.5                  | 5                                        | 2         | Reticulate<br>heterobrochate |
| 20 × 2<br>(17-23 × 1-2)               | A <sub>3</sub> B <sub>1</sub> | 4 × 7<br>(2-5 × 6-13)    | 4 × 2                    | 6                                        | 1.5       | Reticulate                   |
| 23 × 3<br>(20-32 × 2-6)               | A <sub>3</sub>                | 5 × 10<br>(4-7 × 7-12)   |                          | 6                                        | 1         | Reticulate                   |
| 24 × 4<br>(22-28 × 3-7)               | "                             | 5 × 8<br>(3-6 × 7-10)    |                          | 7                                        | 1         | Medium<br>reticulate         |
| 20 × 2<br>(18-24 × 2-3)               | A <sub>3</sub> B <sub>1</sub> | 5 × 11<br>(3-7 × 8-13)   | 5 × 2                    | 6                                        | 1         | Finely reticulate            |
| 25 × 2<br>(18-30 × 2-3)               | A <sub>3</sub>                | 5 × 12<br>(4-6 × 8-14)   |                          | 7                                        | 1.5       | Reticulate                   |



**Fig. 11 :** Pollen grains (a-f, i, j, l, n-p. LM  $\times 1000$ ; g, h, k, m. SEM  $\times 3200$ ) a. *P. gleniei* (G. Davidse et al. 9039); b, e & f. *P. travancorica* (b. Beddome 3913; e & f. B. V. Shetty 10292); c & d. *P. involucrata* (Thwaites C.P. 428); g. *P. hispidula* var. *hispidula* (B.V. Shetty 27962); h & i. *P. naucleiflora* var. *naucleiflora* (K. Biswas 908); j, k & m. *P. brunonis* (P. Bhargava 56907); l, o & p. *P. thwaitesii* (Thwaites C.P. 2611); n. *P. oblanceolata* (Beddome 3920).



**Fig. 12:** Pollen grains (a, c - e, g, k, n - q. LM  $\times 1000$ ; j. LM  $\times 400$ ; b, f, h, i, l, m. SEM  $\times 3200$ ) a, b & e. *P. hispidula* var. *angustifolia* (Thwaites C.P. 267); c, d, h, l, m, o & p. *P. indica* var. *glabrescens* (c & h. G. Panigrahi 9500; d & m. R. S. Rao 7126; o & l. King's collector 513; p. S. M. Toppin 3032); f, j & k. *P. hispidula* var. *zeylanica* (Thwaites C.P. 742); g & q. *P. subcapitata* (Prain's collector 990); i & n. *P. birmahica* (A. Huk 76).

*hispidula* & var. *angustifolia* (Fig. 12 : a), *P. nemoralis* (Fig.-10 : i), *P. naucleiflora* var. *naucleiflora*, *P. breviflora* var. *breviflora* and *P. brunonis* and spheroidal in 3 taxa : *P. travancorica* (Fig. - 11 : b), *P. hispidula* var. *zeylanica*, (Fig.-12 : f, j, k) and *P. blanda* (Fig. 10 : e, f).

Apocolpium diameter varies from 3  $\mu\text{m}$  (*P. breviflora* var. *breviflora*) to 12  $\mu\text{m}$  (*P. involucrata*). Thickness of exine varies from 1  $\mu\text{m}$  (*P. indica* var. *indica* & var. *glabrescens*, *P. crassicaulis* etc.) to 2  $\mu\text{m}$  (*P. gleniei*, *P. subcapitata*, *P. hispidula* var. *angustifolia* etc.). The exine surface is reticulate in all taxa except *P. blanda*, where it is striate-reticulate. The size of lumina varies from 1  $\mu\text{m}$  (*P. sp. 1*) to 2  $\mu\text{m}$  (*P. hohenackeri*).

The apertures of PAVETTA pollen are of three main types : Colpus (meridionally elongated narrow outer aperture) OSA (equatorially elongated inner aperture) and OSB (a pore encircled by a distinct costa). OSA is again of two types :  $A_2$  (when it ends some distance from the colpus in a diffuse indistinct manner, due to gradual thinning of nexine thickness) and  $A_3$  (when it has some definite limits, due to abrupt change in nexine thickness). In some species, the apertures are bipartite, containing colpus and OSA and the grain is called colporate ; in other species, the apertures are tripartite (or composite) containing colpus and compound OS (containing OSA and OSB) and the grain is

called colporate (Lewis 1965). The aperture complexity of PAVETTA species has the resemblance of pollen aperture of certain taxa of *Hedyotis* subgenus *EDRISIA* (Lewis l.c.). Vasanthi (1976, 1978) reported the presence of composite aperture in *Pavetta breviflora* var. *ciliolata* and *P. calophylla* (*P. hispidula* var. *zeylanica*).

In all the taxa studied, the pollen grains are with 3 outer apertures (ectocolpium) and 3 inner apertures (endocolpium). Bipartite apertures (colpus and OSA) are present in 10 taxa and tripartite apertures (colpus, OSA and OSB) are present in 17 taxa. Ectocolpium is narrow and elongated. In most of the species, the ectocolpium ends acute, but round in *P. brunonis*, *P. gleniei* and *P. sp. 1*. The colpus membrane is normally smooth but granulate in *P. macraei*, *P. hispidula* var. *angustifolia*, *P. involucrata*, *P. naucleiflora* var. *naucleiflora* etc. The ectocolpium varies in size from  $20 \times 2 \mu\text{m}$  in *P. travancorica*, *P. birmahica* to  $35 \times 4 \mu\text{m}$  in *P. hispidula* var. *siphonantha*. OSA varies in size from  $4 \times 7 \mu\text{m}$  in *P. birmahica* to  $7 \times 14 \mu\text{m}$  in *P. sp. 1*. and OSB varies in size from  $4 \times 2 \mu\text{m}$  in *P. birmahica* to  $7 \times 4 \mu\text{m}$  in *P. hispidula* var. *siphonantha*.

On the basis of aperture structures, 27 taxa of PAVETTA are distinguishable into 4 palynological groups : Group 1 and 2 are characterized by a simple OS circumscribed by varying nexinous thickenings ; group 3 and 4 by compound OS.

## KEY TO THE POLLEN TYPES

- |     |                                                          |     |           |
|-----|----------------------------------------------------------|-----|-----------|
| 1.  | Pollen grains colpororate<br>(Containing OSA only)       | ... | 2         |
| 1a. | Pollen grains colpororate<br>(Containing OSA & B)        | ... | 3         |
| 2.  | OSA ends diffuse, <i>i.e.</i><br>type $A_2$              | ... | Group - 1 |
| 2a. | OSA ends have definite limits,<br><i>i.e.</i> type $A_3$ | ... | Group - 2 |
| 3.  | OSA ends diffuse, <i>i.e.</i><br>type $A_2 B_1$          | ... | Group - 3 |
| 3a. | OSA ends have definite<br>limits, type $A_3 B_1$         | ... | Group - 4 |

Group-1 contains 1 taxon (*P. graciliflora*) ; group-2 contains 9 taxa (*P. wightii*, *P. blanda*, *P. nemoralis*, *P. breviflora* var. *breviflora* & var. *pubescens*, *P. hohenackeri*, *P. crassicaulis*, *P. indica* var. *indica* & var. *tomentosa*) ; group-3 contains 3 taxa (*P. gleniei*, *P. travancorica*, *P. brunonis*) and group-4 contains 14 taxa (*P. macraei*, *P. oblanceolata*, *P. praeterita*, *P. involucrata*, *P. thwaitesii*, *P. naucleiflora* var. *naucleiflora*, *P. subcapitata*, *P. birmahica*, *P. indica* var. *glabrescens*, *P. hispidula* var. *siphonantha*, var. *angustifolia*, var. *zeylanica* & var. *hispidula* and *P. sp.* 1.).

*Taxonomic significance* : The pollen

morphological characters studied have some taxonomic significance. The nature of OS is very significant and supports the following delimitation made during present investigation on the basis of other morphological characters.

i) *P. assamica* Bremek., *P. amabilis* Bremek., *P. bengalensis* Bremek., *P. griffithii* Bremek. and *P. neglecta* Bremek. have been reduced to synonyms under *P. indica* var. *glabrescens* (Kurz) Deb & Rout (*P. indica* L. var. *polyantha* Hook.f.) (All with  $A_3 B_1$  type of OS).

ii) *P. thomsonii* Bremek. var. *glaberrima* Bremek. (*thomsonii*) has been reduced to a synonym under *P. indica* L. var. *indica* (with  $A_3$  type of OS in both).

iii) *P. siphonantha* Dalz., *P. zeylanica* (Hook.f.) Gamble and *P. agrostiphylla* Bremek. have been reduced to varieties of *P. hispidula* Wt. & Arn. and *P. calophylla* Bremek. to a synonym of *P. hispidula* var. *zeylanica* Hook.f. (All with  $A_3 B_1$  type of OS).

*Evolutionary trends* : Among four OS types,  $A_2$  is treated as most primitive and  $A_3 B_1$  as most advanced (Lewis 1965). Hence, *P. graciliflora* (with  $A_2$  type of OS) belonging to ser. *Vagae*, subser. *Communes* is treated as most primitive and ser. *Carinatae*, *Glomeratae*, *Vestitae* under Sect. *Pavettaster* of subg. *PAVETTA* (*Eupavetta* Bremek. 1934), predominated by  $A_3 B_1$  type of OS are

considered as advanced. This also correlates with the colleter morphology. Ser. *Carinatae* and *Vagae* (predominated by deatherly colletes) are treated as advanced as Lersten (1974) treated feathery colletes as most advanced among other types of colletes.

**Pollen nuclear number :** The mature angiospermic pollen grains are either binucleate or trinucleate. Schurhoff (1924) recognized for the first time, the phylogenetic significance of pollen nuclear numbers in angiosperms and proposed that taxa with trinucleate pollen are phylogenetically advanced compared with taxa with binucleate grains. Brewbaker (1967) studied the pollen cytology of a large number of angiosperm families (including Rubiaceae, chiefly on temperate taxa) and confirmed the speculation made by Schurhoff and showed that angiosperm genera are in general monotypic with respect to pollen nuclear number, either binucleate or trinucleate. Mathew & Philip Omana (1986) investigated the distribution and systematic significance of pollen nuclear number in 103 species representing 32 genera under 15 tribes of Rubiaceae from South India. Out of 32 genera, 23 are binucleate, 8 trinucleate and one with both type of grains. They noted that there is some recognisable association between pollen nuclear number and pollen aperture number such that the binucleate species are 3-aperturate and trinucleate ones 6 or more aperturate. All 4 species of *PAVETTA* studied by them are binucleate and 3 aperturate.

Mathew & Philip Omana (*l.c.*) discussed the systematic significance of pollen nuclear number supplemented with evidences from chromosomal and palynological data. They showed, as regards the delimitation and systematic position of various tribes, Bremekamp's (1966) classification was shown to be very large in agreement with cytological and palynological data.

**Chromosomal data :** The subfamily *Ixoroideae* is characterized by  $x=11$  as the prevailing chromosome base number (Kiehn 1985). Both di and polyploidy ( $2x$ ,  $4x$ ,  $6x$ ) are recorded in *PAVETTA* (Kiehn 1985, Bridson & Robbrecht 1985, Robbrecht & Puff 1986). Among polyploid species, the chromosome number is reported to be  $6 \times (66)$  in *P. schumanniana* P. Hoffm. ex K. Schum. (Lewis 1966) and  $4 \times (44)$  in *P. gardeniifolia* Hochst. (Fagerlind 1937).

## ANATOMY

Anatomical studies have been done in one species (*P. indica* L.) only. The information on stem (internode and node) anatomy, wood anatomy, petiole anatomy and leaf anatomy as available in literature are incorporated.

**Internode anatomy :** The anatomy of internode of *P. indica* L. in transverse section shows that the cortex consists of circular parenchymatous cells. The stele is encircled by a well defined starch sheath. The

individual collateral vascular bundles are not distinguishable due to occurrence of secondary growth at an early stage. Two types of crystals are observed : 'rhomboidal crystals' in the crystal idioblasts or crystal sclerenchyma tissues of phloem (also reported by Solereder 1908 and Metcalfe & Chalk 1950) and 'crystal sand' in the thin walled tissues of the cortex and pith (also reported by Larsten 1974a). Herman *et al.* (1986 a) studied the anatomy of internode of 16 species from South Africa and observed these two types of crystals.

According to Franceschi & Horner (1980), the presence and shape of crystals can be of diagnostic value and the occurrence of two or more types of crystals in the taxa might be of particular importance for classification. They also reported the relationship between the presence of crystals and bacterial leaf-galls (nodules) and proposed that the bacteria utilize the crystals.

"As the anatomy of internode of different taxa does not differ significantly, it can not be used in the delimitation of taxa. However, presence of both rhomboidal crystals and crystal sand in different tissues may be taxonomically significant at genus, family and subfamily level" (Herman *et al. l.c.*).

**Nodal anatomy :** A 3:3 nodal pattern (3 gaps and 3 leaf trace per leaf) is presumably the basic type of nodal vascular pattern in the Rubiaceae (Naubauer 1981). According

to Sinnot (1914) and Sinnot & Bailey (1914), the unilacunar node of *PAVETTA* spp. and most other representatives of the family Rubiaceae is phylogenetically more advanced, which is considered to be a reduction of more primitive trilacunar node. The evolutionary sequence in the nodal pattern (as stated by Robbrecht & Puff 1986) is 3:3-1:3 1:1.

The anatomy of node of *P. indica* L. shows that it possesses unilacunar node with one trace (1 : 1 nodal pattern *i.e.* 1 gap and 1 leaf trace per leaf), which was also reported by Robbrecht & Puff (1986). Herman *et al.* (1986a) reported the same type of nodal pattern in 16 species of *PAVETTA* from South Africa and concluded that "although the nodal structure is the same for all the *PAVETTA* ssp. studied, it is therefore not important in delimitation of taxa, but important for intergeneric and interfamilial comparisons"

In generic level, a 1:1 nodal pattern in *PAVETTA* is one of the distinctions from its most allied genus *IXORA*, which possesses 3:3 nodal pattern.

Dahlgren (1975) showed a close relationship between the order *Oleales* (*Oleaceae*) and *Gentianales* (containing among others, the family *Rubiaceae*) under the super order *Gentiananae*, basing on anatomical and gross morphological characters.

**Wood anatomy :** Koek-Noorman (1972)

studied the wood anatomy of Gardenieae, Ixoreae and Mussaendeae. She observed that wood anatomy of PAVETTA is homogeneous with IXORA, RENNELIA and RUTIDEA. The vessels are solitary, small and numerous. The fibre tissue consists of fibre tracheids. The rays are exclusively uniseriate or uni- and multiseriate. The axial parenchyma is usually scanty and diffuse. Small rhombic crystals occur in the axial parenchyma or in the procumbent upright or ray cells. She found tyloides, scarcely occurring in the axial parenchyma cells of the samples of *Ixora grandifolia* and *I. macrophylla* which were reported by Janssonius (1926) for *Pavetta indica* var. *montana* (*P. blanda* Bremek.)

The observations of Koek-Noorman (*l.c.*) agree fully with that of Janssonius (*l.c.*) and Chang (1951).

Koek-Noorman (*l.c.*) pointed out that the wood anatomy of the *Gardenieae* and *Ixoreae* is very similar. This supports the classification of Verdcourt (1958) and Bremekamp (1953, 1966) in which *Gardenieae* and *Ixoreae* are placed in one subfamily *Ixoroideae*. The wood anatomy of *Mussaendeae* sensu Bremekamp deviates in some respects from that of the *Gardenieae* and *Ixoreae*.

**Petiole anatomy :** Petiole anatomy appears to be of more taxonomic importance than is generally accepted, provided it is used with direction (Hare 1942-3). Stebbins (1974)

proposed the hypothesis that the sessile leaves of the original Anthophyta had elliptic or obovate lamina which gradually formed an indistinct petiole. The leaves of early dicotyledonous plants develop quickly from this form into leaves with a distinct petiole and leaf blade.

Herman *et al.* (1986b) studied the petiole anatomy of 16 taxa of South African PAVETTA. They observed two types of main vascular bundles *i.e.* cylindrical (found in 9 taxa with petiolate leaves) and crescent shaped (in 2 taxa with subsessile leaves). In *P. indica* the main vascular bundle is crescent shaped, though the leaves are petiolate.

Applying Stebbins' (1974) hypothesis to the length of the petiole and shape of its main vascular bundle in PAVETTA spp., Herman *et al.* (*l.c.*) deduced that in Sect. *Aethiopinymphe*, *P. kotzei* (with long petiole and cylindrical main vascular bundle) is probably most advanced; *P. inandensis* (with its long petiole but crescent shaped main vascular bundle) represented a possible intermediate evolutionary form and *P. lanceolata* (with short petiole and crescent shaped main vascular bundle) would represent the most primitive form.

Kiew & Ibrahim (1982) studied the petiole anatomy of CHIONANTHUS and OLEA (Oleaceae). Mujica & Cutler (1974) studied petiole anatomy of *Olinia* ssp. (Oliniaceae). Dahlgren (1975) grouped the order *Oleales*

and *Gentianales* containing Rubiaceae in the super order Gentiananae, there by showing a close relationship between family Rubiaceae and Oleaceae. The relationship is supported by the similarities in petiole anatomy of *OLEA*, *CHIONANTHUS* (Oleaceae) and *OLINIA* (Oliniaceae) with *PAVETTA* (Herman *et al.* l.c.).

**Leaf anatomy :** The leaf anatomy of *P. indica* L. shows that it is dorsiventral, the mesophyll tissue is differentiated into palisade and spongy parenchyma. The palisade parenchyma is 1 or 2 layered. The leaves are hypostomatic. The stomata are typical rubiaceous type (paracytic). Herman *et al.* (1986b) observed that out of 16 taxa of *PAVETTA*, 2 are amphistomatic and others hypostomatic. In 2 species, there is no distinct zonation of the palisade and spongy parenchyma.

Robbrecht & Puff (1986) observed that in young leaves of *PAVETTA* cultivated in the green house, tannins were lacking, whereas they are present in leaves of plants of the same species fixed in the field.

## BIOLOGY

The biological significance of ants and mites as available in published literature for a number of genera of Rubiaceae (*MYRMECODIA*, *TRICALYSIA*, *NAUCLEA*, *CANTHIUM*, *GARDENIA* etc.) has not been observed in *PAVETTA*. Robbrecht (1988)

observed a few cases of occurrence of mites in domatia in herbarium material. Domatia have been reported in 13 Indian species of *PAVETTA*, but in no case the mites have been observed to be associated with these.

However, bacterial leaf-galls are common in *PAVETTA* and have biological significance. All Indian species studied contain bacterial leaf-galls. The bacteria have been reported to live in galls, blastocolla secreted by the colletes and surrounding the growth apex, from which they are able to infect the ovules and consequently seeds. Nitrogen fixing activities of bacteria inside the galls as suggested by earlier workers (Faber 1912 ; Rao 1923 ; Gordon 1963 ; Silver *et al.* 1963) has now been rejected (Lohr 1968 ; Becking 1971 ; Yamada 1972 etc.). According to recent studies (Becking 1971 ; La Motte & Lersten 1972 etc.), the galls produce growth regulating substances like IAA or Cytokinins.

Association of fungi with *PAVETTA* has not been observed during present investigation.

## FLORAL BIOLOGY

N. Halle (1966) distinguished two types of flowering rhythm of the Rubiaceae, viz. synchronous (all flowers of an inflorescence open at the same time) and asynchronous (consecutive anthesis within the inflorescence). In *PAVETTA* the former type

of flowering rhythm (synchronous) is present.

#### POLLINATION

PAVETTA among most rubiaceous genera is zoophilous. The flower contains a long narrow corolla tube. The nectariferous epigynous disk attracts the insects with long mouth parts which performs pollination.

*Stylar pollen presentation* : In PAVETTA the flowers are proterandrous. The anthers mature first and the pollens are shed in the bud stage on the outside of the stigmas and/or the upper part of the style, which serves as a 'receptaculum pollinis'. The more affinity in pollen deposition is ensured by increased surface area and irregularity of the pollen receptacle, caused by swelling, hairs, grooves or ridges. After the anthesis, the style grows up with deposited pollen grains on it. The pollen grains are then transported by the insects to the stigmatic surface of the flowers in receptive stage.

Bremekamp (1934, 1952, 1966) introduced the terminology "ixoroid pollen mechanism" and considered it to be of great taxonomic importance. He accepted it as the major criterion to define his subfamily Ixoroideae.

Verdcourt (1958) did not consider ixoroid pollen mechanism as a taxonomic character in distinguishing the Rubiaceae into 3 subfamilies : Cinchonoideae, Rubioideae

and Guettardoideae. He united all genera of the family with normally developed endosperm and without raphides in the subfamily Cinchonoideae (including subfam. Ixoroideae and Cinchonoideae of Bremekamp). He pointed out that Bremekamp over-estimated its importance. Robbrecht & Puff (1986) and Robbrecht (1988) accepted Bremekamp's view. Robbrecht (*l.c.*) considered ixoroid pollen mechanism as one of the important features to restrict subfamily Ixoroideae to 5 tribes : *Gardenieae*, *Pavetteae*, *Hypobathreae*, *Aulacocalyceae* and *Coffeae*.

#### DISTRIBUTION

PAVETTA L. occurs in Africa, Asia, Australia, Melanesia and most of the tropical Pacific region but absent from North and South America, Madagascar and New Zealand. The subgenus BACONIA (DC.) Bremek. occurs only in Tropical West Africa: the Congo Basin, Uganda, Kenya, Tanzania and Northern Borders of South Tropical Africa; the subgenus PAVETTA (EUPAVETTA Bremek.) is represented throughout Africa and the Old World Tropics and subgenus DIZYGOON Bremek. is restricted to the Zaire Basin and Angola.

Among the species of PAVETTA distributed in Indian subcontinent, *P. indica* is most widely distributed, almost throughout the country and extends to its adjoining region. *P. indica* var. *indica* occurs in Assam,

West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Goa, Lakshadweep and Sri Lanka ; var. *glabrescens* occurs in Arunachal Pradesh, Nagaland, Mizoram, Manipur, Tripura, Meghalaya, Assam, Sikkim, West Bengal, Orissa, Bhutan, Bangladesh, Nepal, and Burma ; var. *tomentosa* occurs throughout the country (except Gujarat and Rajasthan), Burma and Nepal. Among species restricted to eastern region are : *P. subcapitata* distributed in Arunachal Pradesh, Nagaland, Meghalaya, Assam and extends up to Garhwal region of Uttar Pradesh ; *P. naucleiflora* var. *naucleiflora* occurs in Bangladesh, Burma and also extends up to Malaysia and var. *glabrituba* occurs in Bhutan and Burma. *P. birmahica* is endemic to Burma only.

Among species restricted to southern part of India, 6 species are endemic to Tamil Nadu (Two species : *P. wightii* and *P. hohenackeri* in Nilgiri hills and one species: *P. praeterita* in Kuttalam hills), Kerala (*P. oblanceolata* and *P. nemoralis*) and Andhra Pradesh (*P. madrassica* in Simhachalam). Species distributed in Tamil Nadu, Kerala and Karnataka are *P. breviflora*, *P. brunonis*, *P. travancorica* and *P. hispidula* var. *zeylanica* (also occurs in Sri Lanka). *P. minor*, *P. hispidula* var. *hispidula* and var. *siphonantha* occur in these states and extend up to Maharashtra, *P. crassicaulis* occurs in Tamil Nadu, Kerala, Goa, Maharashtra and Gujarat. The distribution of

PAVETTA sp. 1 is not properly known (India Orientalis, as per Roxburgh's collection at BM).

*P. graciliflora*, the only species is distributed in Andaman and Nicobar Islands, which is also extended to Peninsular Malaysia and Thailand (Siam).

Eight species endemic to Sri Lanka are : *P. blanda* (also rarely occurs in Lakshadweep islands of India), *P. gardneri*, *P. gleniei*, *P. glomerata*, *P. hispidula* var. *angustifolia*, *P. involucrata*, *P. macraei* and *P. thwaitesii*.

The species of PAVETTA occurs both in plain areas and in high altitudes. *P. indica* var. *indica* grows both in plain areas (sea level) and up to an elevation of 1100 m. *P. graciliflora* normally grows in sea level, but rarely up to 400 m in altitude. *P. gleniei* grows in between 3-420 m in altitude. Highest altitude (up to 2640 m) is attained by *P. indica* var. *tomentosa*. The species distributed in Nilgiri hills of Tamil Nadu : *P. wightii*, *P. hohenackeri*, *P. breviflora* etc. grow in elevation from 1050 to 2300 m.

#### SYSTEMATIC TREATMENT OF THE GENUS PAVETTA L.

**Pavetta** L. Sp. Pl. 1:110. 1753 ; Gen. Pl. ed. 5, 49. 1754 ; Syst. Nat. 94. 1756 & ed. 10, 2 : 894. 1759 ; Sp. Pl. ed. 2, 1 : 160. 1762 & ed. 3, 160. 1764 ; Gen. Pl. ed. 6,

54. 1764 ; Syst. Nat. ed. 12, 2 : 120. 1767 ; Gleditsch, Syst. Pl. Stam. Sit. 166. 1764 ; Murray, Syst. Veg. ed. 13, 129. 1774 ; ed. 14, 153. 1784 & ed. 15, 153. 1797 ; Gaert. Fru. Sem. Pl. 1 : 166. t. 25, fig. I. 1788 ; Schreber, Gen. Pl. ed. 8, 1 : 71. 1789 ; Haenke, Gen. Pl. ed. 8, 1 : 111. 1791 ; Juss. Gen. Pl. 226. 1791 ; Vahl, Symb. 3 : 11. 1794 ; Willd. Sp. Pl. ed. 4, 1 (2) : 610-1798 ; Turton, Gen. Syst. Nat. 5 : 216. 1802 ; Pers. Syn. Pl. Emch. Bot. 1 : 131. 1805 ; Hedwig, Gen. Pl. 60. 1806 ; Jolycl. Syst. Sex. Veg. 1 : 123. 1810 ; Roem. & Schult. Syst. Veg. 3 : 173. 1818 & 3 : 109. 1827 ; Roth, Nov. Pl. 87. 1821 ; Sprengel, Syst. Veg. ed. 16. 407. 1825 & Gen. Pl. ed. 9, 90. 1830 ; DC. Prodr. 4 : 490. 1830 ; G. Don, Gen. Syst. Gard. Bot. 3 : 574. 1834 ; Wight & Arn. Prodr. Fl. Pen. Ind. Or. 1 : 430. 1834 ; Royle, Ill. Bot. 238. 1835 ; Lindl. Nat. Syst. Bot. 246. 1836 ; Walps. Rep. Bot. Syst. 2 : 480. 1843 ; Ann. Bot. Syst. 1 : 1848 & 2 : 753. 1851 ; Hook.f. & Benth. in Hook. Nig. Fl. 413. 1849 ; Miq. Fl. Ind. Bat. Suppl. 222. 1860 ; Dalz. & Gibs. Bomb. Fl. 112. 1861 ; Benth. Fl. Hongk. 157. 1861 ; Drury, Hand Book Ind. Pl. 1 : 571. 1864 ; Thw. Enum. Pl. Zeyl. 155. 1859 ; Hook.f. in Benth. & Hook.f. Gen. Pl. 3 : 114. 1873 ; Brand. For. Fl. 245. 1874 ; Bedd. in Ind. For. 3 : 203. 1877 ; Hiern in Oliv. Fl. Trop. Afr. 3 : 167. 1877 ; Hook.f. Fl. Brit. Ind. 3 : 149. 1880 ; Forbes & Hemsley,

Enum. Pl. 1 : 385. 1886 ; Bir wood in Journ. Bomb. Nat. Hist. Soc. 2 : 118. 1887 ; Trimen, Hort. Zeyl. 43. 1888 ; Schum. in Engl. & Prantl Nat. Pflanz. fam. IV. 105. 1891 ; Prain in Journ. Asiat. Soc. Beng. 60 (4) : 316. 1891 ; Kuntze, Rev. Gen. Pl. 1 : 286. 1891 ; Prain in Journ. Bomb. Nat. Hist. Soc. 7 : 475. 1893 ; Trimen, Fl. Ceyl. 2 : 394. 1894 ; Sonder in Harvey & Sonder, Fl. Cap. 3 : 19. 1894 ; Gammie in Rec. Bot. Surv. Ind. 1 (5) : 81. 1895 ; Gamble, Trees Shr. 49. 1869 ; Birdwood in Journ. Bomb. Nat. Hist. Soc. 10 : 411. 1896 ; Kanj. For Fl. 206. 1901 ; Gage in Rec. Bot. Surv. Ind. 1 : 347. 1901 ; Wood in Rec. Bot. Surv. Ind. 2 (1) : 110. 1902 ; Duthie, Fl. Upp. Gang. Pl. 1 : 390. 1903 ; Prain, Beng. Pl. 1 : 417. 1903 ; Gammie in Journ. Bomb. Nat. Hist. Soc. 15 : 287. 1903 ; Cooke, Fl. Pres. Bomb. 2 : 41. 1904 ; Fischer in Journ. Bomb. Nat. Hist. Soc. 15 : 574. 1904 ; Gage in Rec. Bot. Surv. Ind. 3 : 66. 1904 ; King & Gamble in Journ. Asiat. Soc. Beng. 73 (2) : 83. 1905 ; Prain in Rec. Bot. Surv. Ind. 3 (2) : 223. 1905 ; Brandis, Ind. Trees 387. 1906 ; Blatter in Journ. Bomb. Nat. Hist. Soc. 18 : 409. 1908 ; Bourdill. For. Trees Travanc. 225. 1908 ; Blatter in Journ. Bomb. Nat. Hist. Soc. 19 : 326. 1909 ; Haines, Fl. Chot. Nagp. 506. 1910 ; Craib in Kew Bull. 1911 (10) : 395. 1911 ; Merrill, Fl. Manila 452. 1912 ; Matsum. Ind. Fl. Jap. 2 : 594. 1912 ; Gibs. in Journ.

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Fl. Tam. Nad. 2 : 19. 1987 ; Nair, Fl. Court. 2 : 321. 1987 ; Bridson & Verdc. in Polhill, Fl. Trop. East Afr. Rubiac. (2) : 618. 1988; Singh, Fl. East Karn. 1 : 351. 1988 ; Panigr. & Murti, Fl. Bilaspur 1 : 289. 1989.

*Baconia* DC. in Ann. Muz. Natl. Hist. Nat. Paris 9 : 219. 1807 & Prodr. 4 : 485. 1830 [Type : *B. corymbosa* DC. = *P. corymbosa* (DC.) Williams].

*Crinita* Houttuyn, Nat. Hist. 2(7) : 361. t. 40, 1, 1777 [Type : *C. capensis* Houttuyn = *P. capensis* (Houtt.) Bremek.].

*Exechostylus* K. Schum. in Engl. Bot. Jahrb. 28 : 67. 1899 (Type : *E. flaviflora* K. Schum. = *P. brachycalyx* Hiern).

*Pavate* Adanson, Fam. 2 : 145. 1763.

*Verulamia* DC. ex Poiret in Lamk. Encycl. Meth. Bot. 8 : 543. 1808 [Type : *V. corymbosa* DC. ex Poiret = *P. corymbosa* (DC.) Williams].

Shrubs or small trees, rarely undershrubs or herbs. Leaves opposite, decussate (rarely ternate, only in one unnamed species), petiolate or sessile ; lamina usually provided with bacterial leafgalls (bacterial nodules) and rarely with domatia on the secondary (rarely tertiary) nerve axils on lower surface ; bacterial leaf-galls normally circular, rarely

elliptic, oblong, linear or branched ; domatia tuft, pocket or pit type ; external indumentum uni-or multicellular, straight or curved, with smooth (rarely pitted) outer walls ; stipules with a triangular to truncate limb, cannate at the base or up to the whole length, bearing a short or long arista, with colleters and hairs within ; colleters dendroid, feathery or brush-like ; trichomes intermingled with colleters, silvery white, rarely brown, pluricellular, articulated or cylindrical. Inflorescence terminal on main and lateral branches, rarely axillary, sessile to subsessile or peduncled trichotomously branched loose or compact corymbose, rarely subcapitate cymes ; bracts connate, stipule like, membranous ; bracteoles usually small, free, sometimes absent. Flowers few to many (rarely one), bisexual, pedicellate or subsessile to sessile, 4-merous. Hypanthium globose to subglobose or obovoid. Calyx tube cylindrical, broader above or campanulate, short or long, persistent or deciduous ; teeth short or long, dentate, triangular, ovate, obovate, subquadrate, lanceolate or subulate, rarely absent. Corolla white to creamy or greenish white, rarely red (in *P. canescens* DC. from Angola and Zaire) ; tube cylindrical, slightly widened at throat ; throat glabrous or pubescent, rarely bearded ; lobes elliptic, lanceolate, oblong, obovate or ovate, contorted to the left in bud ; internal indumentum unicellular, flat ribbon like with pitted surface. Microcharacters of outer surface of corolla tube : epidermal cells

elongate with much finer longitudinal cuticular striations ; inner surface of corolla lobes ; epidermal cells ridged or irregularly folded, with rugose, striate or smooth cuticular surface. Stamens attached at the mouth of the tube, exserted and spreading or reflexed in mature flowers; filaments short ; anthers dorsifixed above the base, linear, more or less equalling the corolla lobes in length, 2-lobed, acute at apex, sagittate at base, longitudinally dehiscent, twisted when dry (except subg. *DIZYGOON* Bremek.) ; pollen medium sized, prolate, subprolate, prolate-spheroidal or spheroidal, 3-zonocolporate or 3-zonocolpororate. Ovary 2-loculed ; placenta axile, fleshy, pendulous from the upper part of the septum ; ovules solitary (? rarely paired), immersed or partly immersed in the cup like placenta ; disc annular, fleshy ; style long-exserted,  $\pm$  two times longer than the corolla tube, slender, glabrous or subglabrous below, sometimes the exserted portion puberulous or pubescent, the upper part acts as pollen receptacle (receptaculum pollinis), thickened club shaped, 8 ribbed, puberulous ; stigmatic surface confined to the bidentate (rarely two distinct lobes) apex of the style. Fruit a drupe, black and shining, rarely white or coloured, spherical (globose) or subglobose to didymous (2-lobed), rarely fleshy ; containing 1(-2) chartaceous pyrenes ; seeds 2 or 1 (by abortion), attached to the upper part of the septum, hemispherical with a wide circular to semicircular excavation in the centre of the ventral face (flat side) ; seed

coat exotestal, cells hexagonal, rarely pentagonal or tetragonal, with straight walls ; cuticular surface striate, granulate, striate-granulate, colliculate, colliculate-pusticulate, colliculate-scrobiculate, striate-reticulate, reticulate-foveate or pusticulate ; endosperm entire and horny ; embryo small dorsal ; radicle straight or curved, inferior ; cotyledons 2,  $\pm$  equal ; plumule minute, enclosed within the cotyledons.

*Type* : *P. indica* L. [Sri Lanka (Ceylon), Herman 56 BM].

*Distrib.* : More than 400 (?) species (Bremekamp 1948, 1953, 1956) in the Old World tropics ; 42 species recognized by Bremekamp (1934) in Indian subcontinent are reduced in the present investigation to 25 species and 8 extratypical varieties (33 taxa).

#### INFRAGENERIC CLASSIFICATION

A.P. de Candolle (1830), G. Don (1934), Walpers (1834, 1848, 1851) arranged the species of *PAVETTA* L. in 3 or 4 groups, according to their geographical distribution, viz. Asiatic, African, Madagascan and Australian. They did not consider any taxonomic character for their grouping. Hooker f. (1880) classified the species into two groups, according to the length of the calyx teeth : \* Calyx teeth much shorter than the ovary and \*\* Calyx teeth elongate, equalling or longer than the ovary.

Bremekamp (1934, 1937) treated the genus under 3 subgenera namely subg. EUPAVETTA Bremek. (=PAVETTA), BACONIA (DC.) Bremek. and DIZYGOON as shown in the key below.

Key to the subgenera of PAVETTA L.  
(Bremekamp 1939a)

1. Anthers in the open flowers  
not spirally twisted ; apical  
part of the style spatulate ... Subg. DIZYGOON
- 1a. Anthers in the open flowers  
spirally twisted ; apical part  
of the style terete. ... 2
2. Corolla throat bearded ... Subg. BACONIA
- 2a. Corolla throat glabrous or  
arachnoid, but never bearded Subg. PAVETTA  
(=EUPAVETTA)

Of these three subgenera, only one, namely subg. PAVETTA is represented in Indian sub-continent.

The subgenus PAVETTA was divided into 18 sections of which only the section

*Pavettaster* comprising 12 of 19 series are included in this study. The series were distinguished on the basis of shape, length and nature of calyx teeth and stipules, nature of flowering shoot, position of inflorescence etc.

Bremekamp (1934, 1939a,b) distinguished species sometimes on the basis of one or two quantitative characters. Very often slight difference in length of the calyx teeth or hairiness of the leaf or corolla tube were sufficient for him to distinguish species. On the other hand, he did not hesitate to postulate species on the basis of very incomplete or insufficient material bearing no flowers or fruits. Due to unsatisfactory delimitation of taxa, Bridson (1978) and Kok & Grobbelaar (1984) reduced a number of species to synonymy.

Ser. *Angustisepalae*, comprising 2 species, namely *P. gleniei* and *P. malacophylla* represent one species only. Ser. *Angustistipulae*, comprising 3 species namely *P. travancorica*, *P. concanica* and *P. laeta* represent one species also.

In view of these facts it is not considered worth while to recognize series and subseries under the section, for which a general key to all the available species is given below :

# KEY TO THE SPECIES OF *PAVETTA* L.

|     |                                                                                                                                                              |     |                            |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|----------------------------|
| 1.  | Inflorescence axillary                                                                                                                                       | ... | 2                          |
| 1a. | Inflorescence terminal                                                                                                                                       | ... | 4                          |
| 2.  | Stipules broadly triangular, coriaceous, calyx teeth subulate, longer than 2.5 mm                                                                            | ... | 3                          |
| 2a. | Stipules narrowly triangular, scarious, calyx teeth dentate or triangular, up to 0.5 mm                                                                      | ... | 22. <i>P. travancorica</i> |
| 3.  | Leaves opposite, cymes loosely corymbose, corolla tube 7 - 15 mm long, <i>ca</i> 1 mm across, pubescent at throat, corolla lobes oblong or oblong-lanceolate | ... | 7. <i>P. glenie</i>        |
| 3a. | Leaves ternate, cymes compact corymbose, corolla tube 20 - 24 mm long, <i>ca</i> 2 mm across, glabrous at throat ; corolla lobes narrowly triangular         | ... | 7a. <i>P. sp.</i> 1        |
| 4.  | Cymes corymbose                                                                                                                                              | ... | 5                          |
| 4a. | Cymes capitate or subcapitate                                                                                                                                | ... | 11                         |
| 5.  | Corolla tube 20-34 mm long                                                                                                                                   | ... | 6                          |
| 5a. | Corolla tube 5 - 15 mm (rerely 18 mm) long                                                                                                                   | ... | 13                         |
| 6.  | Stipules subulate                                                                                                                                            | ... | 19. <i>P. oblanceolata</i> |
| 6a. | Stipules triangular or ovate                                                                                                                                 | ... | 7                          |
| 7.  | Stipules never scarious calyx teeth traingular                                                                                                               | ... | 8                          |

- |      |                                                                                                                                                                         |     |                           |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|---------------------------|
| 7a.  | Stipules scarious at margin ; calyx teeth subquadrate, elliptic, obovate or elliptic-obovate                                                                            | ... | 9                         |
| 8.   | Corolla lobes 9 - 15 × 2.5 - 6.0 mm, style stout, thickened at the middle, fruits pubescent or glabrous                                                                 | ... | 10. <i>P. hispidula</i>   |
| 8a.  | Corolla lobes 5 - 6 × 2 mm, style slender, fruits puberulous                                                                                                            | ... | 15. <i>P. madrassica</i>  |
| 9.   | Calyx teeth subquadrate, mucronate at apex, plant body puberulous                                                                                                       | ... | 6. <i>P. gardneri</i>     |
| 9a.  | Calyx teeth elliptic, obovate or elliptic-obovate, acute, obtuse or rounded at apex, plant body pubescent or hispid                                                     | ... | 10                        |
| 10.  | Calyx teeth acute at apex, corolla tube pubescent at throat, apex of corolla lobes acuminate, pubescent outside                                                         | ... | 14. <i>P. macraei</i>     |
| 10a. | Calyx teeth obtuse or rounded at apex, corolla tube glabrous at throat, apex of corolla lobes rounded, glabrous                                                         | ... | 20. <i>P. praeterita</i>  |
| 11.  | Calyx teeth up to 0.3 mm long, broadly triangular, corolla tube 16 - 22 mm long, double or more longer than lobes, lobes rounded or mucronulate at apex                 | ... | 21. <i>P. subcapitata</i> |
| 11a. | Calyx teeth 0.8 - 4.5 mm long, narrowly triangular or lanceolate, corolla tube up to 8 mm long, almost equal in length with the lobes, lobes acute or acuminate at apex | ... | 12                        |
| 12.  | Bracts 8 - 13 × 7 - 15 mm ; calyx teeth 2.0 - 4.5 mm, linear-lanceolate, pubescent within ; corolla lobes narrowly lanceolate                                           | ... | 13. <i>P. involucrata</i> |
| 12a. | Bracts 3.0 - 4.5 × 3.5 - 4.5 mm ; calyx teeth <i>ca</i> 0.8 mm, narrowly triangular, glabrous ; corolla lobes oblong                                                    | ... | 8. <i>P. glomerata</i>    |
| 13.  | Cymes compact corymbose ; corolla tube slightly longer than the lobes, fully glabrous                                                                                   | ... | 3. <i>P. breviflora</i>   |

|       |                                                                                                                                                                |                                |    |
|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|----|
| 1999] | ROUT AND DEB : TAXONOMIC REVISION OF THE GENUS <i>PAVETTA</i> (RUBIACEAE)                                                                                      |                                | 67 |
| 13a.  | Cymes loosely corymbose ; corolla tube double or more longer than the lobes, atleast pubescent within                                                          | ...                            | 14 |
| 14.   | Calyx teeth narrowly triangular or subulate                                                                                                                    | ...                            | 15 |
| 14a.  | Calyx teeth triangular, dentate or truncate                                                                                                                    | ...                            | 16 |
| 15.   | Leaves densely pubescent beneath, stipules 12 - 17 × 5 - 7 mm, oblong-triangular, subcoriaceous, cymes pubescent, calyx teeth subulate, pubescent.             | ... 4. <i>P. brunonis</i>      |    |
| 15a.  | Leaves puberulous beneath ; stipules 6 - 8 × 5 - 6 mm, broadly triangular, scarious at margin ; cymes puberulous ; calyx teeth narrowly lanceolate, puberulous | ... 24. <i>P. wightii</i>      |    |
| 16.   | Stipules narrowly triangular, peduncles 4.5 - 6.0 cm, slender                                                                                                  | ... 11. <i>P. hohenackeri</i>  |    |
| 16a.  | Stipules broadly to ovate-triangular or aristate, peduncles 0 - 1.6 cm stout                                                                                   | ... 17                         |    |
| 17.   | Stipules aristate, inflorescence and pedicels hispid with white spreading hairs, fruit hispid                                                                  | ... 17. <i>P. naucleiflora</i> |    |
| 17a.  | Stipules broadly or ovate-triangular, inflorescence and pedicels glabrous, puberulous, pubescent, tomentose or hirsute ; fruits never hispid                   | ... 18                         |    |
| 18.   | Calyx teeth broadly triangular                                                                                                                                 | ... 19                         |    |
| 18a.  | Calyx teeth narrowly triangular, truncate or dentate                                                                                                           | ... 7a                         |    |
| 19    | Stem thick, with short conical outgrowths, leaves broadly obovate, cymes hirsute                                                                               | ... 5. <i>P. crassicaulis</i>  |    |

- |      |                                                                                                                                                                        |     |                           |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|---------------------------|
| 19a. | Stems slender, without conical outgrowths, leaves narrowly obovate or oblanceolate, cymes glabrous or puberulous                                                       | ... | 20                        |
| 20.  | Internodes short, leaves acuminate at apex, cymes and pedicels puberulous, corolla tube glabrous at throat, lobes <i>ca</i> 9.5 × 3.0 mm, glabrous                     | ... | 18. <i>P. nemoralis</i>   |
| 20a. | Internodes long, leaves rounded at apex, cymes and pedicels glabrous or sparsely pubescent, corolla tube pubescent at throat, lobes 5.5 - 6.0 × 2 mm, pubescent within | ... | 2. <i>P. blanda</i>       |
| 21.  | Leaves narrowly lanceolate, pedicels 10 - 15 mm, slender, corolla lobes lanceolate                                                                                     | ... | 23. <i>P. thwaitesii</i>  |
| 21a. | Leaves elliptic, obovate, oblanceolate or oblong, pedicels up to 7 mm, stout, corolla lobes oblong or elliptic                                                         | ... | 21                        |
| 22.  | Stipules scarious at margin, leaves densely puberulous beneath, inflorescence and calyx puberulous                                                                     | ... | 16. <i>P. minor</i>       |
| 22a. | Stipules coriaceous, never scarious at margin, leaves glabrous, pubescent or tomentose beneath ; inflorescence and calyx glabrous, pubescent or tomentose              | ... | 22                        |
| 23.  | Lateral nerves closely arranged, corolla tube 5 - 6 mm, slender, lobes <i>ca</i> 2.5 mm long                                                                           | ... | 1. <i>P. birmahica</i>    |
| 23a. | Lateral nerves distantly arranged, corolla tube 8 - 18 mm long, lobes 4 - 8 mm long                                                                                    | ... | 23                        |
| 24.  | Cyme branches slender, limb-tube cupular, with colleters within, calyx deciduous in fruits                                                                             | ... | 9. <i>P. graciliflora</i> |
| 24a. | Cyme branches stout, limb-tube broader above, without colleters, calyx persistent in fruits                                                                            | ... | 12. <i>P. indica</i>      |

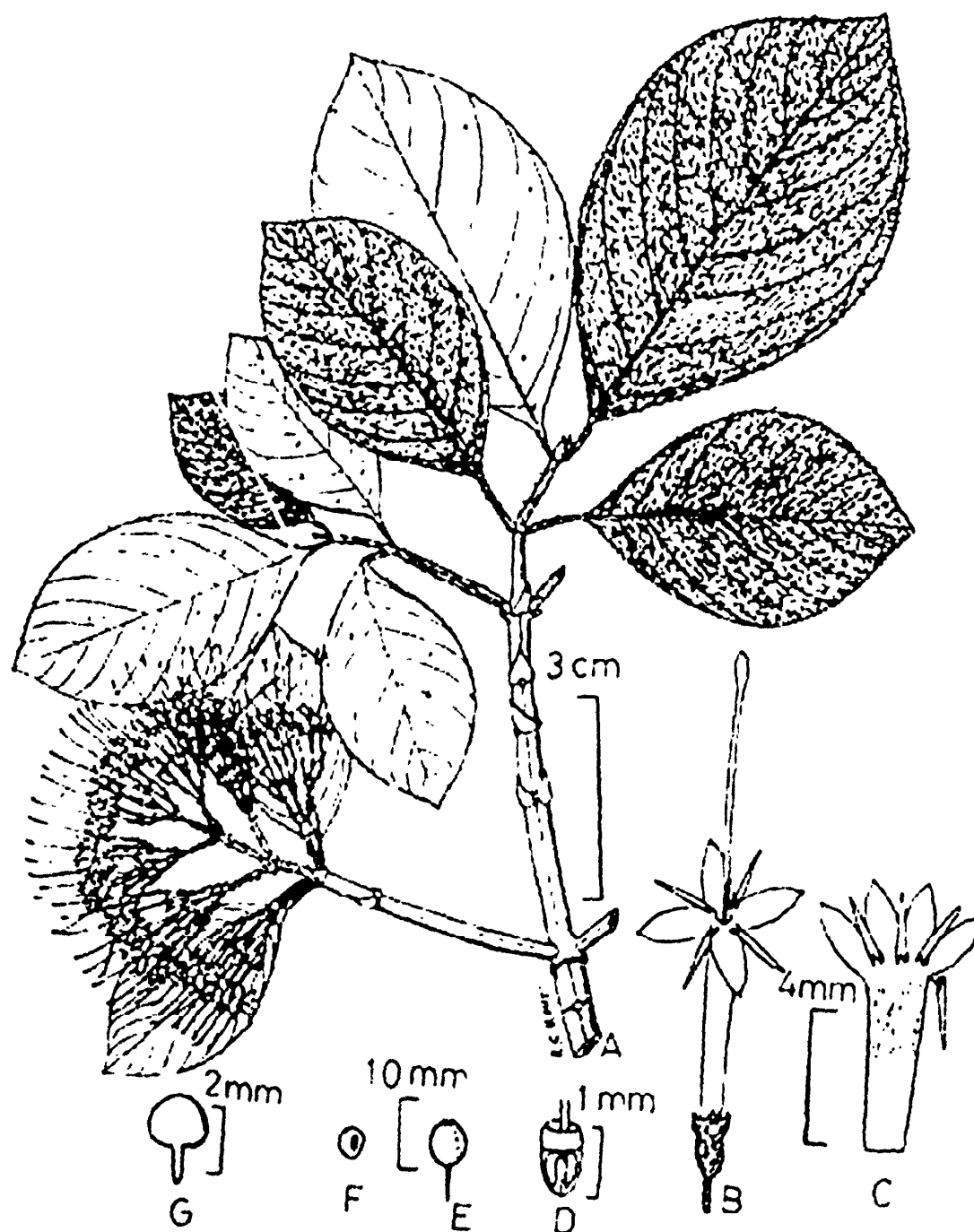
1. ***Pavetta birmahica* Bremek.** in Fedde Repert. 37 : 115. 1934 (Type : Burma : Thayetungo dist., Minhea, 17. 12. 1904, *J. H. Lace* 2698 holo. K !, iso. CAL !); Deb and Rout in Journ. Bomb. Nat. Hist. Soc. 89 (3) : 349. 1992.

*P. birmahica* Bremek. var. *glabrescens* Bremek. (= *birmahica*, l.c. 116 & var. *tomentosa* Bremek. l.c. 116 (Type : Burma, Griffith s.n. ex Herb. E.I.C. No. 3010 holo. K !, iso. CAL !).

*P. gamblei* Bremek. in Fedde Repert. 37: 114. 1934 (Type : Burma : Irawaddi, Mejanoung, 4. 5. 1872, *J. S. Gamble* 115 holo. K !, photo CAL !). (Fig-13)

Shrubs or small trees, 1.2–4.5 m high, erect, branched; stem stout, terete, sometimes 4-angled, puberulous or pubescent when young, glabrous and corky in age. Leaves 2.5–10.2 × 1.6–6.2 cm, elliptic, rarely elliptic-lanceolate, shortly acuminate or rounded at apex, cuneate or acute at base, subcoriaceous or coriaceous, glabrate or sparsely pubescent above, tomentose beneath, rarely glabrous; bacterial leaf-galls rarely present on secondary or tertiary nerves, circular, 0.3–1.0 mm, prominent on upper surface invisible on lower surface; domatia normally absent, rarely present, tuft type (only seen in Gamble 115 K !) on secondary nerve axils; lateral nerves 8–13 pair, alternate, slender; petioles 0.3–1.5 cm, stout, pubescent; stipules persistent, interpetiolar, 5–7 × 3–6 mm,

broadly triangular, acute at apex, coriaceous, puberulous outside, with colleters and trichomes inside; colleters few on adaxial surface of stipules, 256–880 µm long, 96–240 µm broad, sessile, feathery or brushlike; trichomes intermingled with colleters few, silvery white, 592–1440 µm long, 16–32 µm across, pluricellular, cylindrical, 4–9 celled, apical cell acute, outer wall smooth. Inflorescence terminal, sessile or subsessile, trichotomously branched, corymbose cymes on spreading branches, 4.5–10.0 cm across, pubescent; peduncles up to 0.2 cm, pubescent; bracts 5–6 × 4–6 mm, cuspidate, membranous, puberulous. Flowers 100–250; pedicels 2.5–4.0 mm, pubescent. Hypanthium ca 0.8 × 0.8 mm, obovoid, pubescent; calyx tube ca 0.5 × 1.0 mm, broader above, pubescent; teeth ca 0.2 × 0.1 mm, dentate, pubescent. Corolla tube 5–6 mm long (rarely 8 mm), 0.5–1.0 mm across, cylindrical, glabrous outside, pubescent within; lobes ca 2.5 × 1.0 mm, elliptic-oblong, acute at apex, glabrous. Microcharacters of outer surface of corolla tube: epidermal cells elongate, surface with fine longitudinal cuticular striations; inner surface of corolla lobes: epidermal cells ridged, surface smooth or striate. Filaments ca 0.5 mm, slender, glabrous; anthers ca 2.5 mm; pollen 27 × 22 (23–30 × 19–23) µm, subprolate; 3-zonocolporate, ectocolpium 20 × 2 (17–23 × 1–2) µm, colpus membrane smooth, ends acute; ora compound, combining types A<sub>3</sub> and B<sub>1</sub>; type A<sub>3</sub> lalongate, 4 × 7 (2.5 × 6–13) µm; type B<sub>1</sub> lolongate, 4 × 2 µm, thickened, apocolpium



**Fig. 13 :** *P. birmahica* Bremek. : A. habit ; B. flower ; C. corolla split open ; D. placentation ; E. fruit ; F. seed ; G. embryo. A - C. from A. Huk s.n.; E - G. from S. Mokim 36.

diameter 6  $\mu$ m ; exine 1.5  $\mu$ m, reticulate, columellate. Ovary *ca* 0.7  $\times$  0.6 mm, disc *ca* 0.4  $\times$  0.6 mm ; style 10-13 mm long, rarely 18-22 mm, stout, glabrous or puberulous below stigma ; stigma *ca* 0.5 mm, glabrous or puberulous. Drupes 6-7 mm across, globose, subglobose or didymous, 1 or 2 seeded, glabrous ; seeds *ca* 4 mm ; exotestal surface pusticulate ; embryo *ca* 2.5 mm ; radicle *ca* 1.0 mm, stout ; cotyledons 2, equal, *ca* 1.5  $\times$  1.5 mm, reniform, obtuse at apex, subcordate at base ; plumule minute, enclosed within cotyledons.

*External indumentum* 112-608  $\mu$ m long, 8-24  $\mu$ m across, pluricellular, cylindrical, 3-5 celled, curved or straight, apical cell acute, outer wall pitted.

*Fl.* : May-December, *Fr.* : July- January.

*Distrib.* : MYANMAR:Thayetungo, Mergui:

*Specimens examined* : MYANMAR : Merigui, Griffith s.n. ex Herb. E.I.C. No. 3005 (CAL); Upper Burma, 13. 7. 1890, Abdul Huk s.n. (CAL) ; September 1890, Abdul Huk s.n. (CAL, MH) ; Sheyebo, June 1891, Abdul Huk 64 (CAL) ; Tabodowa, July 1891, Abdul Huk s.n. (CAL) ; Kyaukunyaung, July 1891, Abdul Huk s.n. (CAL) ; Shan Hills, 1892, Abdul Huk 76 (CAL) ; Minbu, Sept. 1902, S. Mokim 36 (CAL, MH) & 169 (CAL) ; Prome, 19. 12. 1903, Coll. ? 20806 (BSIS) ;

Meiktila, 17.6.1911, Coll. ? 3288 (DD).

**2. *Pavetta blanda* Bremek.** in Fedde Repert. 37: 94 : 1934 pp. (excl. synonyms and Indian specimens) (*Type* : Sri Lanka : 900-1200 mm., 1854, Thwaites C.P. 2456 K !, iso. BM !, CAL!) ; Deb & Rout in Journ. Bombay Nat. Hist. Soc. 89 (3) : 351. 1992.

*P. indica* L. var. *montana* Hook.f. Fl. Brit. Ind. 3 : 150. 1880.

*P. indica* Thw. Enum. Pl. Zeyl. 155. 1859 (excl. var. r & s) ; Trimen, Fl. Ceyl. 2 : 349. 1894. (Fig. 14)

Shrubs, 2.0-2.5 m high, erect, branched; stem stout, terete, glabrous, sparsely pubescent when young, grey barked. Leaves 4-12  $\times$  1.2-3.8 cm, narrowly obovate or oblanceolate, rounded at apex, acute or attenuated at base, subcoriaceous, glabrous, shining above ; bacterial leaf-galls few to many on mature leaves, absent in some young ones, on the secondary or tertiary nerves, circular (0.5-1.5 mm), rarely elliptic (1.5  $\times$  2.0 mm) or oblong (*ca* 2  $\times$  1 mm), more prominent on lower surface ; domatia absent midrib subcanaliculate above ; lateral nerves 6-8 pair, alternate or subopposite, more prominent beneath ; petioles 0.5-1.4 cm, glabrous ; stipules persistent, interpetiolar, 1.5-3.0  $\times$  3.0-5.0 mm, broadly triangular, shortly cuspidate, coriaceous, glabrous outside, with colleters and trichomes inside ;

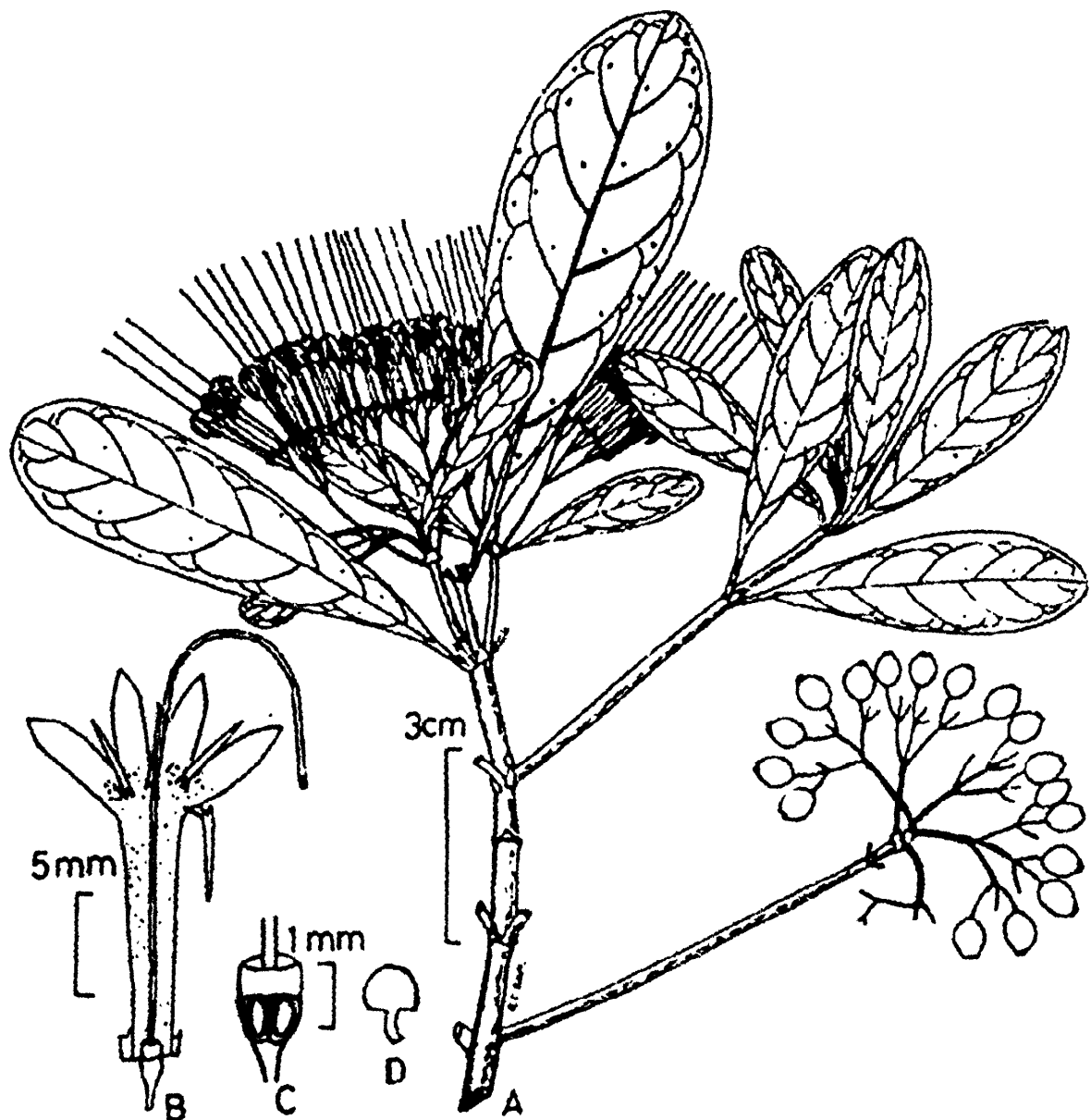


Fig. 14 : *P. blanda* Bremek. : A. habit ; B. flower split open showing floral parts ; C. placentation ; D. embryo.  
All from Thwaites C.P. 2456.

colleters plenty on the adaxial surface of stipules and bracts, 320-720  $\mu\text{m}$  long, 160-240  $\mu\text{m}$  broad, stalked feathery or brush-like; stalk 64-240  $\mu\text{m}$  long; trichomes intermingled with colleters, few, 320-368  $\mu\text{m}$  long, 16-24  $\mu\text{m}$  across, pluricellular, articulated, 6-9 celled, apical cell acute, outer wall smooth. Inflorescence terminal, sessile or subsessile trichotomously branched, loosely corymbose cymes, 5-6 cm across, glabrous or sparsely pubescent; peduncles up to 0.3 cm, glabrous; bracts 3-4  $\times$  3-5 mm, cuspidate, membranous, glabrate outside, with colleters within. Flowers 25-100; pedicels 3-5 mm, glabrous. Hypanthium *ca* 1.0  $\times$  1.2 mm, obovoid, glabrous; calyx tube *ca* 1.0  $\times$  1.5 mm, broader above, glabrous; teeth 0.6-0.8  $\times$  0.8-1.0 mm, broadly triangular, acute at apex, glabrous; Corolla tube 10-13 mm long, 1.0-1.2 mm across, cylindrical, glabrous outside, sparsely pubescent within, pubescent at throat; lobes 5.5-6.0  $\times$  2.0 mm, oblong, acute at apex, glabrous outside, pubescent within; internal indumentum 448-960  $\mu\text{m}$  long, 19-28  $\mu\text{m}$  broad, unicellular, ribbon-like, acute at apex, outer wall pitted. Microcharacters of inner surface of corolla long, epidermal cells ridged, surface rugose. Filaments 1-1.2 mm long, glabrous; anthers *ca* 4.5 mm; pollen 30  $\times$  30 (28-34  $\times$  24-33)  $\mu\text{m}$ , spheroidal; 3-zonocolporate; ectocolpium 22  $\times$  3 (20-26  $\times$  2-5)  $\mu\text{m}$ , colpus membrane smooth, ora simple, type A<sub>3</sub>, lalongate, 5  $\times$  10 (4-7  $\times$  7-15)  $\mu\text{m}$ , not thickened, tenuimarginate; apocolpium diameter 6  $\mu\text{m}$ ; exine 2  $\mu\text{m}$ ,

striate-reticulate, columellate. Ovary *ca* 0.8  $\times$  1.0 mm; disc *ca* 0.5  $\times$  1.0 mm; style 30-32 mm, slender, glabrous; stigma *ca* 0.5 mm, notched, glabrous. Drupes 4-8  $\times$  4-11 mm across, subglobose or didymous, glabrous, black when dry, shining, with persistent calyx, 1 or 2 seeded; seeds 3-5 mm; exotestal cells 80-128  $\mu\text{m}$  long, 16-24  $\mu\text{m}$  thick, hexagonal, with striate walls, surface striate-granulate; embryo 2.0-2.5 mm; radicle *ca* 1.0 mm, stout, curved; cotyledons 2, equal, *ca* 1.5  $\times$  1.8 mm, reniform, rounded at apex, subcordate at base; plumule minute, enclosed within cotyledons.

*Fls.* : March-May ; *Frts.* : August-November.

*Ecology* : Evergreen forests, at 900 1700 m in altitude.

*Distrib.* : INDIA : Lakshadweep Islands ; Sri Lanka : Central Province, Uva Province, Western Province.

*Specimens examined* : INDIA. LAKSHADWEEP ISLANDS : Cardamum, 15. 11. 1891, *H. M. I. M. Investigator* s.n. (CAL).

SRI LANKA : Western Province, August 1836, *Thwaites C.P.* 37 & s.n. (CAL) ; *Thwaites C.P.* 2512 (CAL, K) ; 900 m, *Thwaites C.P.* 1663 (CAL) ; Adam's Peak, 1. 3. 1883, *Coll.* ? s.n. (MH) ; Central Province, Jhella Saungar, 22. 11. 1919, *D. O. Witt* 109 (DD) ; Thisaya, *J. Donald*

2164 (DD) ; Sita Ratmalie estate, Haputale, ca 1700 m, 8. 5. 1969, *Kostermans* 23939 (K.); Uva Province, Badulla dist., Ohiya-Welimada Road, 1625 m, 23. 9. 1974, *D. D. Tirvengadam & Shelton Wass* 572 (K).

Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 19. 1987.

*Ixora candolleana* Kuntze, Rev. Gen. Pl. 1 : 286. 1981.

**3. Pavetta breviflora** DC. Prodr. 4 : 491. 1830 (*Type* : India : Tamil Nadu, Nilgiri hills, *Leschenault* 35 G, microfische CAL !); G. Don, Gen. Syst. Gard. Bot. 3 : 574. 1834 ; Wight, Ic. Pl. Ind. Or. t. 1035, 1844 ; Walps. Ann. Bot. Syst. 1 : 373. 1848 ; Drury, Hand Book Ind. Fl. 1 : 573. 1864 ; Beddome, Fl. Sylv. For. Man. 134/7. 1874 ; Hook.f. Fl. Brit. Ind. 3 : 151. 1880 ; Brandis, Ind. Trees 387. 1906 ; Rama Rao, Fl. Pl. Trav. 214. 1914 ; Ramasw. in Rec. Bot. Surv. Ind. 6 : 135. 1914 ; Fyson, Fl. Nilgiri & Puln. Hill Tops 1 : 195. 1915 ; Gamble, Fl. Pres. Madras 633. 1921 ; Fyson, Fl. South Ind. Hill St. 1 : 285. 1932 ; Bremek. in Fedde Repert. 37 : 98. 1934 ; Rangan. in Ind. For 64 : 529. 1938 ; Kapoor in Journ. Bomb. Nat. Hist. Soc. 61 : 363. 1964 ; Meher-Homji in Bull. Torrey Bot. Club 94 : 235. 1967 ; Ramasw. & Razi in Bull. Bot. Soc. Bengal 21 : 97. 1967 & Fl. Bangalore dist. 585. 1973 ; Sharma *et al.* in Bull. Bot. Surv. Ind. 15 : 59. 1973 ; Sharma *et al.* in Biol. Mem. 2 : 72. 1977 ; Rao & Razi, Syn. Fl. Mysore 573. 1981 ; Saxena & Brahmam in Jain & Rao, Ass. Thr. Pl. Ind. 85. 1988 ; Sharma *et al.* Fl. Karnataka 130. 1984 ; Ahmed. & Nayar, End. Pl. Ind. Reg. 1 : 162. 1987 ;

Shrubs or small trees, erect, branched ; stem stout, terete, quadrangular or subquadrangular, glabrous or pubescent when young, glabrous and corky in age ; bark yellow. Leaves petiolate, elliptic or elliptic-obovate, rarely oblanceolate, acute or acuminate at apex, acute at base, subcoriaceous or membranous, glabrous or glabrescent above, glabrous, densely pubescent or ciliate on the nerves beneath ; bacterial leaf-galls few to many, present on the secondary or tertiary nerves, circular or elliptic, more prominent on either surface ; domatia rarely present, tuft type on secondary nerve axils ; midrib subcanaliculate above ; lateral nerves 7-13 pair, alternate or subopposite, more prominent beneath ; petioles 0.3-1.6 cm, stout, glabrous above, glabrous or pubescent beneath ; stipules persistent, interpetiolar, 7-15 × 2.5-6.0 mm, narrowly triangular, coriaceous or subcoriaceous, scarious at margin, glabrous, sparsely ciliate or pubescent outside, with colleters and trichomes inside ; colleters stalked, dendroid ; trichomes intermingled with colleters pluricellular, articulated type, apical cell acute, outer wall smooth. Inflorescence terminal, subsessile or sessile, trichotomously branched, compact corymbose cymes, glabrous or pubescent ;

bracts broadly triangular, membranous, pubescent. Flowers pedicellate ; pedicels stout, glabrous or pubescent. Hypanthium obovoid, glabrous or sparsely pubescent ; calyx tube glabrous, ciliate or pubescent outside, glabrous within ; teeth 4, dentate, narrowly triangular or subulate, glabrous, ciliate or pubescent outside, glabrous within. Corolla tube 4-8 mm long, 0.5-1.5 mm across, cylindrical, glabrous ; lobes oblong, rarely lanceolate, acute, acuminate or mucronulate at apex, glabrous. Stamens : filaments up to 1 mm, glabrous ; anthers 2.2-5.0 mm, dorsifixed above the base, 2-lobed, acute at apex, sagittate at base, dehiscing longitudinally ; pollen subprolate or prolate-spheroidal, 3-zonocolporate, ora simple, type A<sub>3</sub>, lalongate ; exine reticulate, columellate. Ovary 2-loculed with 1 pendulous ovule in each loculus ; disc annular ; style slender or stout, glabrous, rarely puberulous above ; stigma simple, fusiform, glabrous or puberulous. Drupes globose or subglobose, glabrous with persistent calyx teeth ; seeds hemispherical, excavated.

#### KEY TO THE VARIETIES

1. Stipules and bracts pubescent outside ; cymes pubescent ; calyx teeth subulate, pubescent ... (c) var. *pubescens*
- 1a. Stipules and bracts glabrous outside ; cymes glabrous ; calyx teeth triangular or dentate, glabrous or ciliate ... 2

2. Leaves ciliate on the nerves beneath ; calyx teeth broadly triangular, ciliate ... (b) var. *ciliolata*

- 2a. Leaves glabrous ; calyx teeth narrowly triangular or dentate, glabrous ... (a) var. *breviflora*

#### (a) var. *breviflora*

Sharma *et al.* Fl. Karnataka 130. 1984 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2: 19. 1987.

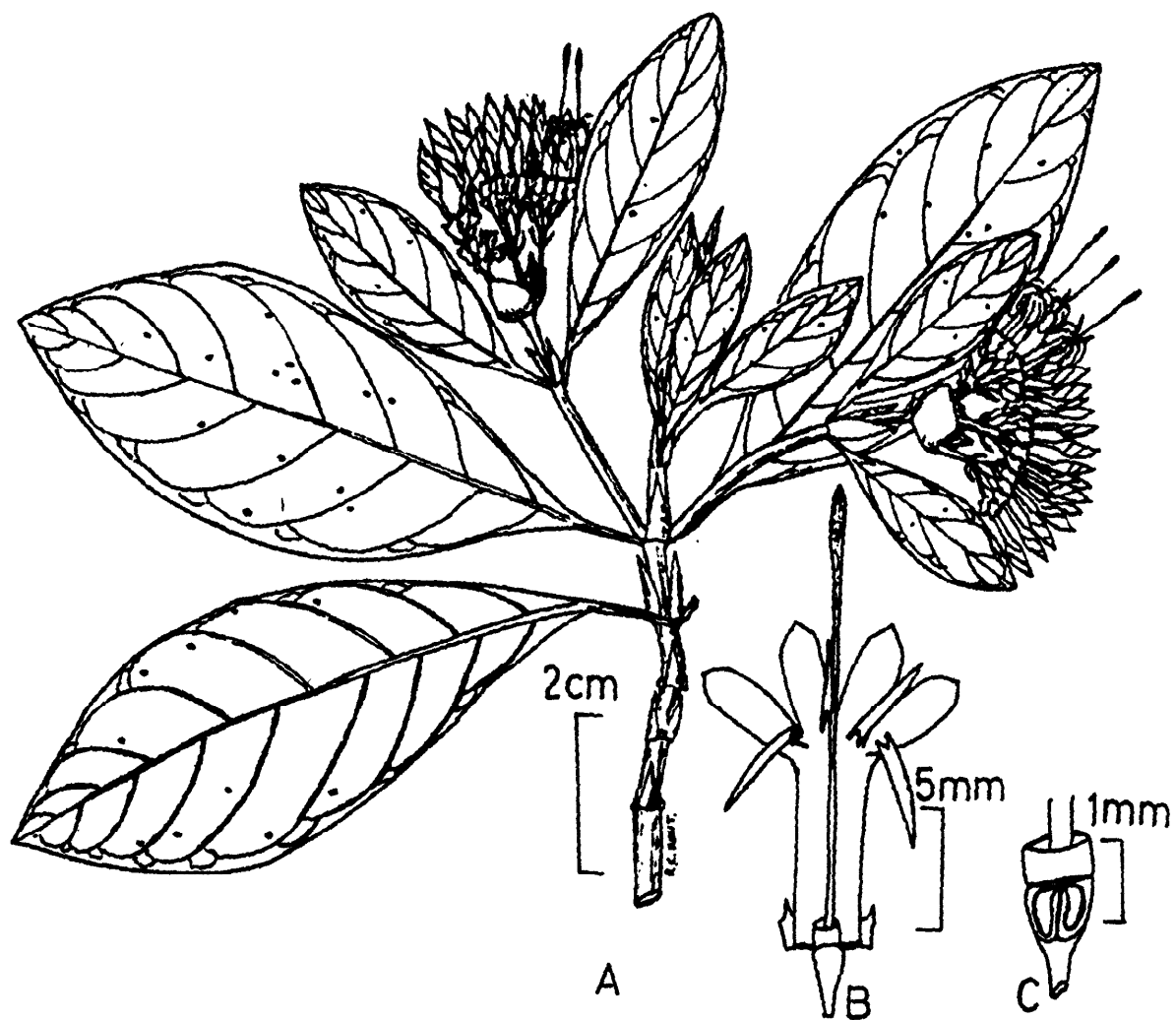
*P. breviflora* DC. var. *glaberrima* Bremek. in Fedde Repert. 37 : 98. 1934 ; Barnes in Journ. Bomb. Nat. Hist. Soc. 44 : 443. 1944 ; Kammathy *et al.* in Bull. Bot. Surv. Ind. 9 : 219. 1967 ; Sharma *et al.* in Biol. Mem. 2 : 72. 1977 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 20. 1987.

*P. breviflora* DC. var. *subcoriacea* Gamble, Fl. Pres. Madras 633. 1921 (Type : Karnataka : Bababoodan hills, 1800 m, Oct. 1908, A. Meebold 10734, Lecto. CAL ! ) ; Sebast. & Vivekan. in Bull. Bot. Surv. Ind. 9 : 174. 1967 ; Sharma *et al.* Fl. Karn. 131. 1984 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 20. 1987.

*P. blanda* Bremek. in Fedde Repert. 37 : 94. 1934, pp. (Indian specimens only : the Srilankan specimens belong to *P. blanda*).

(Fig. 15)

Shrubs or small trees up to 6 m high, erect, branched ; stem stout, subquadrangular, glabrous ; bark yellowish. Leaves 5.5-13.0 ×



**Fig. 15 :** *P. breviflora* DC. var. *breviflora* : A. habit ; B. flower split open showing floral parts; C. placentation. All from Gangopadhyay & Mondal 2470.

1.6-5.5 cm, elliptic or elliptic-obovate, acute at apex and base, subcoriaceous, glabrous ; bacterial leaf-galls few to many on secondary or tertiary nerves, circular (*ca* 1 mm) or elliptic ( $1.1.5 \times 0.5$  mm), more prominent on lower surface ; domatia absent ; midrib subcanaliculate above ; lateral nerves 9-12 pairs, alternate or subopposite, more prominent beneath ; petioles 0.5-1.5 cm, stout, glabrous ; stipules interpetiolar, 7-10  $\times$  3-4 mm, narrowly triangular, subcoriaceous, scarious at margin, base persistent, glabrous outside, with colleters and trichomes inside ; colleters few on the base of stipules within, 560-960  $\mu$ m long, 128-240  $\mu$ m broad, stalked, dendroid ; stalk 64-96  $\mu$ m long, trichomes intermingled with colleters, few, 304-352  $\mu$ m long, 16-24  $\mu$ m across, pluricellular, articulated, 6-8 celled, apical cell acute, outer wall smooth. Inflorescence terminal, peduncled, trichotomously branched, corymbose cymes, 4 - 6 cm across, glabrous ; bracts 8  $\times$  11  $\times$  5  $\times$  6 mm, broadly triangular, membranous, glabrous. Flowers 40  $\times$  50 ; pedicels 1.5  $\times$  3.0 mm, glabrous. Hypanthium *ca* 1  $\times$  1 mm, obovoid, glabrous ; Calyx tube *ca* 1.0  $\times$  1.8 mm, broader above, glabrous ; teeth 0.4 - 0.5  $\times$  0.2 mm, narrowly triangular or dentate, glabrous ; Corolla tube *ca* 8 mm long, *ca* 1.5 mm across, cylindrical, glabrous ; lobes *ca* 5.0  $\times$  2.5 mm, oblong, mucronulate at apex, glabrous. Microcharacters of inner surface of corolla lobes : epidermal cells ridged with smooth cuticular surface. Filaments *ca* 0.8 mm,

glabrous ; anthers 4.5 - 5.0 mm, glabrous ; pollen 33  $\times$  32  $\mu$ m (30 - 34  $\times$  30  $\times$  36)  $\mu$ m, prolate-spheroidal ; 3-zonocolporate ; ectocolpium 27  $\times$  3 (24-28  $\times$  1-3)  $\mu$ m, colpus membrane smooth ; ora simple, type  $A_3$ , lalongate, 6  $\times$  12 (5-8  $\times$  11-15)  $\mu$ m, faint ; apocolpium diameter 3  $\mu$ m, circular ; exine 2  $\mu$ m, finely reticulate, columellate, ovary *ca* 0.8  $\times$  1.0 mm ; disc *ca* 0.5  $\times$  1.0 mm ; style *ca* 14 mm long, stout, glabrous ; stigma *ca* 3 mm, fusiform, glabrous. Drupes 6-7 mm across, globose or subglobose, glabrous, 1 seeded ; seeds *ca* 4 mm ; exotestal cells 96-220  $\mu$ m long, 30-50  $\mu$ m thick, hexagonal, with straight walls, surface striate-granulate.

*Fl.* : March-May ; *Fr.* : June-December.

*Ecology* : As undergrowth in evergreen forests at 1700-2250 m in altitude.

*Distrib.* : INDIA : Karnataka, Kerala, Tamil Nadu.

*Specimens examined* : INDIA. KERALA : Travancore, Mukara, 5.9, 1913, *M. Rama Rao* 1660 (CAL).

TAMIL NADU : Nilgiri dist. Ootakamund, 10. 8. 1978, *G. King* s.n. (CAL) ; 14. 8. 1878, *G. King* s.n. (CAL) ; Kandalmand shola, 2250m, June 1883, *J. S. Gamble* 12034 (DD) ; Ketu, 2100 m, June 1885, *J. S. Gamble* 16198 (DD) ; 24.5.1961, *P. Guniet* 606 (CAL) ; Coonoor, Lambis rock, 1800 m, May

1883, *J. S. Gamble* 11593 (CAL, K); 1800m, 2. 12. 1971, *N.C. Rathakrishnan* 39106 (MH); T. R. Bazar, 1950 m, 22.2.1972, *B. D. Sharma* 39881 (MH); Kunna Kombai shola, 1750 m, 18.2.1973, *E. Vajravelu* 43640 (MH); Bengal Mattam, 2000 m, 22.5.1957, *K. M. Sebastine* 3319 (CAL, MH); Avalauche, 1925 m, 28.12.1970, *B. V. Shetty* 37624 (MH); Pulney hills, 1885, *R.H. Beddome* 3912 (BM); June 1897, *A.G. Bourne* 530 (CAL); Kodaikanal Bombay shola, L. T. I. Plot 1/66, 23.9.1967, *K.N. Subramanian* 2656 (DD); Konakarai R. F., 1700 m, 19.11.1970, *E. Vajravelu* 37024 (MH); Pillar rock, 2000 m, 17.3.1982 *M. Gangopadhyay & D.C. Mondal* 2470 (CAL). Chimunjee, 1200 m, *T.F. Bourdillon* 561 (CAL); Tirunelveli dist., Kanni Katti, 31.5.1901, *C. A. Barber* 3010 (CAL); Agastirmalai, 22.5.1901, *C. A. Barber* 2937 (CAL).

*Note* : Bremekamp (1934) treated *P. breviflora* var. *subcoriacea* Gamble (1921) as a synonym under *P. blanda* Bremek., which was based on *P. indica* L. var. *montana* Hook.f. (1880) and limited to Srilanka only. The Indian specimens cited by Bremekamp (l.c.) fully agree with *P. breviflora* var. *breviflora*. So, *P. breviflora* DC. var. *subcoriacea* Gamble is treated here as a synonym under *P. breviflora* DC. var. *breviflora*.

(b) var. ***ciliolata*** Gamble ex Bremek. in Fedde Repert. 37 : 98. 1934 (*Type* :

Madras, *Gamble* 14276 holo. K : photo CAL :) ; Blasco in Journ. Bomb. Nat. Hist. Soc. 67 : 524. 1970 ; Shetty & Vivekan. in Bull. Bot. Surv. Ind. 13 : 33. 1971 ; Sharma *et al.* in Biol. Mem. 2 : 72. 1977; Abraham & Mehrotra in Journ. Econ. Tax. Bot. 3 : 866. 1982 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 20. 1987. (Fig. 16)

Shrubs erect, branched ; stem stout, quadrangular, glabrous ; bark yellowish. Leaves 4.5 - 14.0 × 1.0 - 4.5 cm, elliptic or elliptic-obovate, acute or acuminate at apex, acute at base, subcoriaceous, glabrous above, ciliate on the nerves beneath ; bacterial leaf-galls many on secondary or tertiary nerves, circular (0.5 - 1.2 mm) or elliptic (1.0 - 1.5 × 0.5 - 0.7 mm), more prominent on upper surface ; domatia absent ; midrib subcanaliculate above ; lateral nerves 10 - 12 pair, alternate or subopposite, more prominent beneath ; petioles 0.4 - 1.6 cm, stout, glabrous ; stipules interpetiolar, 10 - 15 × 3-5 mm, narrowly triangular, coriaceous, scarious at margin, persistent at base, glabrous outside, with colleters and trichomes inside. Inflorescence terminal, sessile or subsessile, trichotomously branched, corymbose cymes, 2.5 - 4.5 cm across, glabrous ; bracts 4 - 7 × 4 - 6 mm, broadly triangular, cuspidate, membranous, glabrous. Flowers 40 - 80 ; pedicels, 2 - 4 mm, glabrous. Hypanthium 0.5 - 1.0 × 0.8 - 1.2 mm, obovoid, glabrous ; calyx tube 1.0 × 1.0 - 1.8 mm, broader above or cylindrical, ciliate

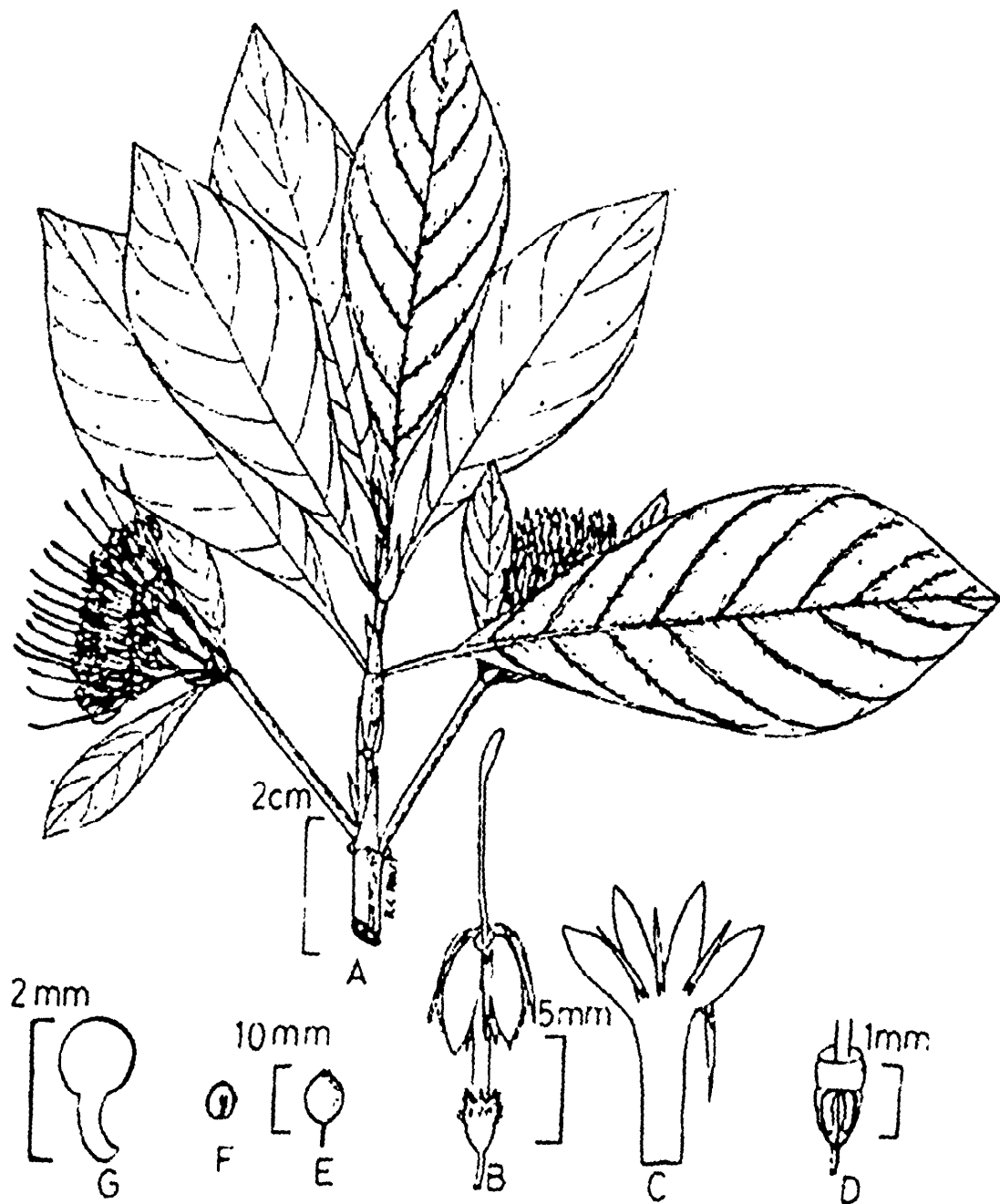


Fig. 16 : *P. breviflora* DC var. *ciliolata* Gamble ex Bremek. : A. habit ; B. flower ; C. corolla split open ; D. placentation ; E. fruit ; F. seed ; G. embryo. All from G. King s.n. .

outside, glabrous within ; teeth  $0.4 - 0.8 \times 0.2 - 0.6$  mm, broadly triangular, ciliate. Corolla tube  $4 - 8$  mm long,  $0.5 - 1.2$  mm across, cylindrical, glabrous ; lobes  $3.5 - 5.0 \times 1.0 - 2.0$  mm, oblong, rarely lanceolate, mucronulate or acuminate at apex, glabrous. Filaments *ca*  $0.5$  mm, glabrous ; anthers  $2.2 - 5.0$  mm. Ovary  $0.8 \times 0.7 - 1.0$  mm ; disc  $0.5 \times 0.7 - 1.0$  mm ; style  $12 - 17$  mm (rarely  $6$  mm) long, slender, glabrous below, puberulous above ; stigma  $1 - 3$  mm, clavate, puberulous. Drupes  $5.5 - 6.0$  mm across, globose or subglobose, glabrous, shining, 1-seeded ; seeds *ca*  $4.5$  mm ; exotestal surface rugose ; embryo *ca*  $2$  mm ; radicle *ca*  $1$  mm, stout, curved ; cotyledons  $2$ , *ca*  $1 \times 1$  mm, equal, suborbicular ; plumule minute, enclosed within cotyledons.

*Fl.* : April-May ; *Fr.* : May-August.

*Ecology* : As undergrowth in evergreen forests, at  $300 - 2300$  m in altitude.

*Distrib.* : INDIA : Tamil Nadu.

*Specimens examined* : INDIA. TAMIL NADU : Nilgiri dist., Ootakamund, 6.8. 1878, *G. King* s.n. (CAL) ; Arambu shola, 2220 m, 17.4.1961, *C.E.C. Fischer* 3952 (CAL) ; Cooner, May 1883, *M. A. Lawson* s.n. (MH) ; June 1883, *M.A. Lawson* s.n. (MH) ; 1770 m. 27.5.1917, *C.E.C. Fischer* 4085 (CAL) ; 5.1.1958, *S.P. Sethi & Nagi* 26158 (DD) ; Lovedala, 2100 m, May 1885, *J.S. Gamble* 16154 (DD) ; Meliar, 1500 m, May

1886, *J. S. Gamble* 17243 (MH) ; Bikkatti, 1500 m, May 1889, *J. S. Gamble* 20564 (DD) ; Dodaikombai, 1800 m, 20.6.1970, *B.V. Shetty* 34340 (MH) ; Najanad, 2125 m, 8.7.1970, *J. L. Ellis* 34524 (MH) ; Long wood, Kotagiri, 2200 m, 31.7.1970, *E. Vajravelu* 35185 (MH) ; 2025 m, 2.7.1973, *E. Vajravelu* 44322 (MH) ; *Coll.* ? s.n. (E) ; Snowdown R. F., 2300 m, 2.9.1970, *B. D. Sharma* 36004 (MH) ; Shola east of Bikkapattimund, 1900 m, 24.3.1972, *G. V. Subbarao* 40460 (MH) ; Kateri falls, 1825 m, 3.12.1972, *E. Vajravelu* 39194 (MH) ; Kodaikanal, 300 m, May, 1913, *Coll.* ? 633 (CAL) ; Iyerpadi, Anamalai hills, 1290 m, 28.5.1914, *C. E. C. Fischer* 3743 (CAL). Peninsula India Or., 1866 - 7, *R. Wight* s.n. (*Kew Distribution No.* 1479 K).

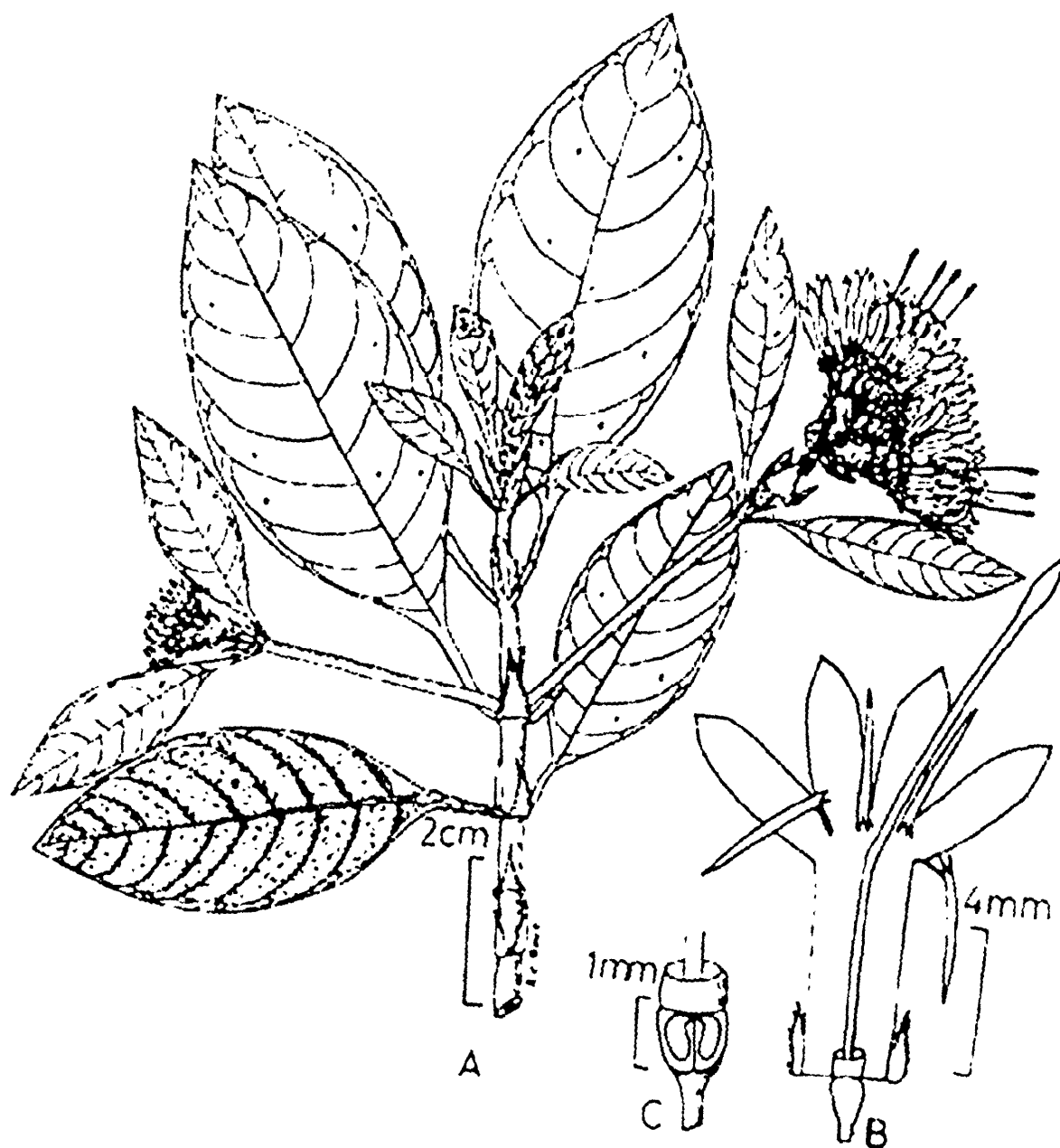
*Notes* : i) The habit of this plant in written field note (*S. P. Sethi & Nagi* 26158 DD) as woody climber is probably erroneous.

ii) The specimen *King* s.n. (CAL) differs from other specimens in small flowers ( $4$  mm), lanceolate corolla lobes, short style ( $6$  mm).

(c) var. **pubescens** Bremek. in Fedde Repert. 37 : 98. 1934 (*Type* : Tamil Nadu, Pulneys, Shenthadi Kanal, *Bourne* 2046 K !, photo CAL !) ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 20. 1987.

(Fig. 17)

Shrubs erect, branched ; stem stout, 4-angled, corky in age, glabrous, pubescent



**Fig. 17 :** *P. breviflora* DC. var. *pubescens* Bremek. A. habit ; B. flower split open showing floral parts ; C. placentation. All from *Sebastine 2699*.

when young. Leaves 4.7–16.9 × 6.0 cm, elliptic or elliptic-ovate, rarely oblanceolate, acuminate at apex, acute at base, membranous, glabrous or glabrate above, densely pubescent beneath; bacterial leaf-galls few to many on secondary or tertiary nerves, circular (0.5–1.0 mm), more prominent on lower surface; domatia tuft type, rarely present on secondary nerve axils (in type specimen only); lateral nerves 7-13 pair, alternate or subopposite, more prominent beneath; petioles 0.3-1.5 cm, glabrous above, pubescent beneath; stipules persistent, interpetiolar, 8-12 × 2.5-6.0 mm, narrowly triangular, scarious at margin, pubescent outside, with colleters and trichomes within; colleters many on the adaxial surface of stipules; trichomes intermingled with colleters plenty. Inflorescence terminal, shortly peduncled, trichotomously branched, corymbose cymes, 4.0-5.0 cm across, densely pubescent; bracts *ca* 6 × 6 mm, broadly triangular, membranous, pubescent. Flowers 80-100; pedicels up to 2 mm, pubescent. Hypanthium *ca* 1.5 × 1.5 mm, obovoid, glabrous or sparsely pubescent; calyx tube *ca* 0.5 × 1.5 mm, broader above, pubescent outside, glabrous within; teeth 0.8-1.0 × 0.3 mm, subulate, pubescent outside, glabrous within. Corolla tube *ca* 6 mm long, 1.5 mm across, cylindrical, glabrous; lobes *ca* 5.0 × 1.5 mm, oblong, acute at apex, glabrous. Filaments *ca* 1 mm long, glabrous; anthers *ca* 4 mm; pollen 30 × 26 (25-34 × 25-29)  $\mu$ m,

subprolate, 3-zonocolporate; ectocolpium 25 × 2 (20-27 × 1-3)  $\mu$ m, colpus membrane smooth; ora simple, type A<sub>3</sub>. lalongate, 5 × 11 (4-6 × 10-15)  $\mu$ m; apocolpium diameter 5-6  $\mu$ m; exine 2  $\mu$ m, reticulate, columellate, lumina *ca* 1  $\mu$ m. Ovary *ca* 0.8 × 0.8 mm; disc *ca* 0.5 × 0.8 mm; style *ca* 13 mm, stout, glabrous; stigma *ca* 2 mm, fusiform, glabrous. Drupes 6-7 mm across, black, shining, sparsely pubescent, with persistent calyx teeth, 1 seeded; seeds *ca* 4 mm.

*Fl.* : March-April; *Fr.* : December - ?

*Ecology* : Evergreen forests, at 1667-1800 m in altitude.

*Distrib.* : INDIA : Kerala, Tamil Nadu.

*Specimens examined* : KERALA : Travancore, Devicolum, 1800 m, Dec. 1990, A. Meebold 13433 (CAL); Kottayam dist., 1700 m, 26.4.1966, B.V. Shetty 27390 (CAL, MH).

TAMIL NADU : Nilgiri dist., Kateri Road to Kurdha, 1967 m, 27.3.1957, K. M. Sebastine 2699 (CAL, MH).

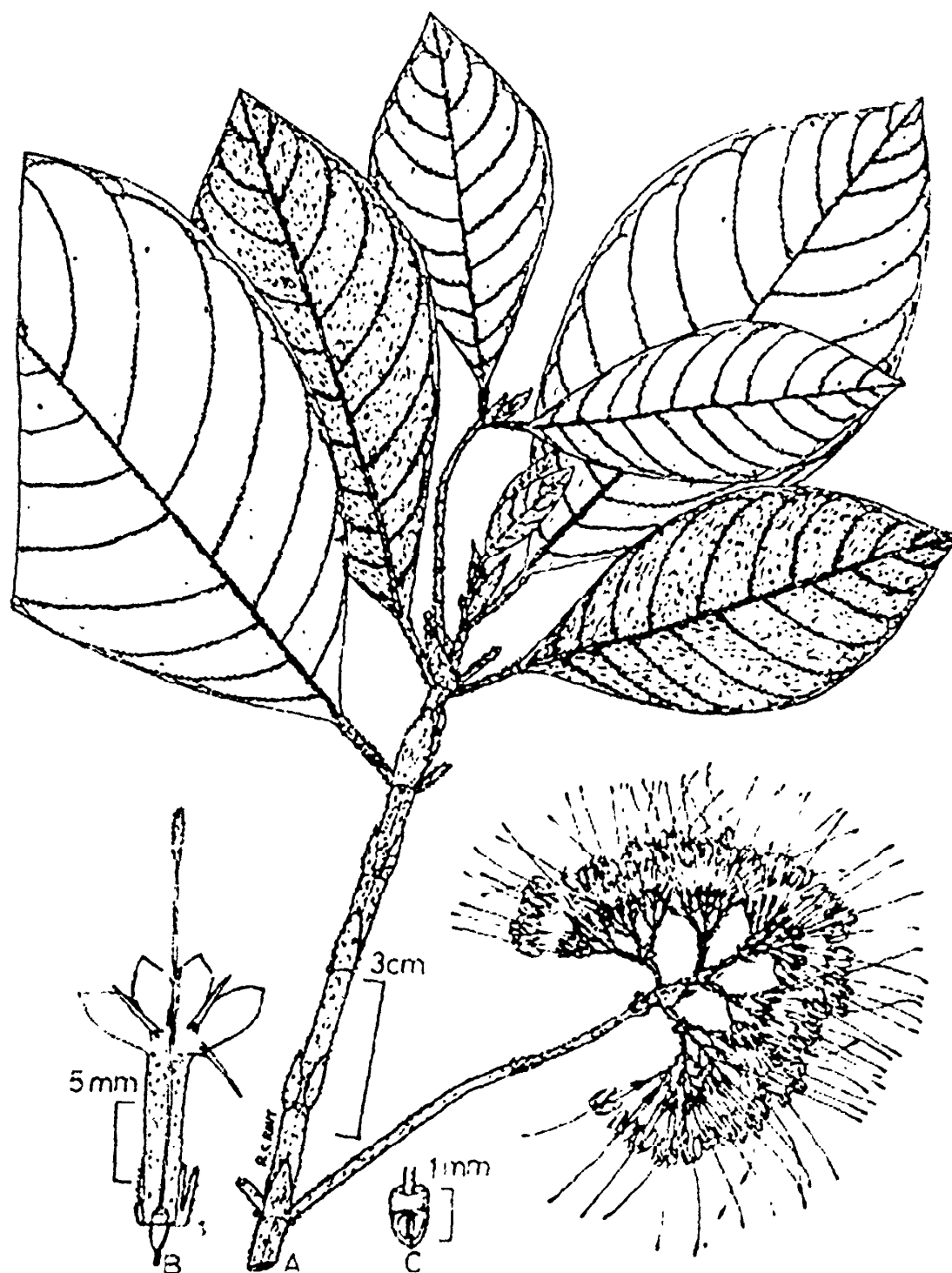
4. **Pavetta brunonis** G. Don, Gen. Syst. Gard. Bot. 3 : 575. 1834 (*Type* : Tamil Nadu, Nilgiri hills, Wall. Cat. 6172 lecto. K-W, microfische CAL !); Walpers. Rep. Bot. Syst. 2 : 480. 1843 & Ann. Bot. Syst. 1 : 373. 1848; Dalz. & Gibs. Bomb.

Fl. 112. 1861 ; Drury, Hand Book Ind.  
Fl. 1 : 572. 1864 ; Hook.f. Fl. Brit. Ind.  
3 : 152. 1880 ; Brandis, Ind. Trees 387.  
1906 ; Rama Rao, Fl. Pl. Travanc. 214.  
1914 ; Gamble, Fl. Pres. Madras 634.  
1921 ; Bremek. in Feede Repert. 37 : 112.  
1934 ; Sharma *et al.* in Biol. Mem. 2 :  
72. 1977 ; Ahmed & Nayar, End. Pl. Ind.  
Reg. 1 : 162. 1987 ; Swaminath. in Henry  
*et al.* Fl. Tam. Nad. 2 : 20. 1987.

*Ixora nilagirica* Kuntze, Rev. Gen. Pl.  
1: 286. 1891. (Fig. 18)

Shrubs, 2-3 m high, erect, branched ;  
stem stout, 4-angled, glabrous and corky in  
age, pubescent when young. Leaves 5.5 - 17.0  
 $\times$  2.5 - 7.5 cm, elliptic-obovate, acute or  
acuminate at apex, cuneate, acute or  
attenuated at base, membranous, glabrescent  
or sparsely pubescent above, densely  
pubescent beneath ; bacterial leaf-galls few  
to many on secondary or tertiary nerves,  
circular, *ca* 1 mm, more prominent on upper  
surface ; domatia absent ; midrib canaliculate  
and pubescent above, tomentose beneath ;  
lateral nerves 10 - 12 pair, pubescent ; stipules  
persistent, interpetiolar, 12 - 17  $\times$  5 - 7 mm,  
oblong-triangular, acute at apex,  
subcoriaceous, pubescent outside, with  
colleters and trichomes within ; colleters  
many, 256 - 1152  $\mu$ m long, 50 - 256  $\mu$ m  
broad, stalked, feathery ; stalk 32 - 96  $\mu$ m  
long ; trichomes intermingled with colleters,  
plenty, silvery white, 80-1760  $\mu$ m long, 24 -

32  $\mu$ m across, pluricellular, cylindrical, 5  
13 celled, apical cell acute, straight, outer wall  
smooth. Inflorescence terminal, sessile or  
peduncled, trichotomously branched,  
corymbose cymes, 7 - 8 cm across, pubescent ;  
peduncles up to 1 cm long, pubescent ; bracts  
6 - 7  $\times$  5 mm, cuspidate, membranous,  
pubescent outside, glabrous within. Flowers  
*ca* 100 ; pedicels 2 - 4 mm, pubescent.  
Hypanthium *ca* 1  $\times$  1 mm, obovoid,  
pubescent. Calyx tube *ca* 0.5  $\times$  1.0 mm,  
broader above, pubescent outside, glabrous  
within ; teeth 1.5 - 2.0  $\times$  0.3 mm, subulate,  
acute at apex pubescent outside, glabrous  
within. Corolla tube 9 - 12 mm long, *ca*  
1 mm across, cylindrical, glabrous outside,  
pilose within ; lobes 4.5 - 5.0  $\times$  2.5 mm,  
oblong, mucronulate at apex, glabrous ;  
internal indumentum 480 - 640  $\mu$ m long, 16-  
24  $\mu$ m broad, unicellular, ribbon-like, acute  
at apex, surface pitted. Microcharacters of  
inner surface of corolla lobes : epidermal cells  
ridged, surface rugose. Filaments 0.2  
0.5 mm, slender, glabrous ; anthers 3.5 - 4.5  
mm ; pollen 28  $\times$  25 (25 - 30  $\times$  24-28)  $\mu$ m,  
prolate-spheroidal ; 3-zonocolporate ;  
ectocolpium 22  $\times$  2 (19 - 23  $\times$  2-3)  $\mu$ m, colpus  
membrane smooth, ends round ; ora  
compound, combining types  $A_2$  and  $B_1$  ; type  
 $A_2$  lalongate, 5  $\times$  12 (4-5  $\times$  10-15)  $\mu$ m, type  
 $B_1$  lolongate, 5  $\times$  2.5  $\mu$ m, thickened ;  
apocolpium diameter 5  $\mu$ m ; exine 2  $\mu$ m,  
medium reticulate, heterobrochate. Ovary *ca*  
0.8  $\times$  0.8 mm ; disc *ca* 0.5  $\times$  0.8 mm ; style 20  
- 25 mm long, slender, glabrous, puberulous



**Fig. 18 :** *P. brunonis* G. Don : A. habit ; B. flower split open showing floral parts ; C. placentation. All from Bhargava 56907.

below stigma ; stigma *ca* 2 mm, simple, fusiform, puberulous. Drupes 7-10 × 7-11 mm, subglobose or didymous, sparsely pubescent, with persistent calyx teeth 1 or 2 seeded ; seeds *ca* 4 mm ; exotestal surface reticulate-foveate ; embryo *ca* 2.2 mm ; radicle *ca* 1 mm, stout ; cotyledons 2, equal, foliaceous, *ca* 1.2 × 1.2 mm, reniform, rounded at apex, cordate at base ; plumule minute, enclosed within cotyledons.

*External indumentum* 96-912 µm long, 12-48 µm across, pluricellular, cylindrical, 3-15 celled, apical cell acute, straight, outer wall smooth.

*Fl.* : April - May ; *Fr.* : May - June.

*Ecology* : In evergreen forests, at 100-1500 m in altitude.

*Distrib.* : INDIA : Karnataka, Kerala, Tamil Nadu.

*Specimens examined* : KARNATAKA : Mysore, *G. Thomson* s.n. (CAL) ; Chikmagalur dist., Honnamadevi falls, shola forest, 3.5.1978, *M. Ahmed et al.* 906 (CAL).

KERALA : Malabar, Concan & C., *Stocks*. *Law & C.* s.n. (L.) ; Cannanore dist., Chandanathode, 1000 m, 17.4.1966, *J. L. Ellis* 27093 (MH) ; Palghat dist., Varadimalai, 1150 m, 19.4.1978, *P. Bhargava* 56907 (CAL, MH) ; Poochipana shola, *ca* 1000 m, 1.5.1980, *V. J. Nair* 67422 (MH) ; *ca* 1100 m, 1.5.1980, *V. J. Nair* 67431

(CAL, MH).

TAMIL NADU : Nilgiri dist., Nilgiri hills, April 1847, *R. Wight* s.n. (CAL, DD) ; Northern slopes, 1500 m, *R. H. Beddome* s.n. (MH) ; Ootterlony valley, May 1889, 1500m, *J. S. Gamble* 20527 (CAL, DD) ; Western slopes, Develayam, May 1900, *C. A. Barber* 2027 (MH) ; *C. A. Barber* s.n. (MH) ; Coimbatore dist., Anamalai, Udumanparai, 15.5.1903, *C. A. Barber* 5890 (MH) ; 1873, *R. H. Beddome* s.n. (MH).

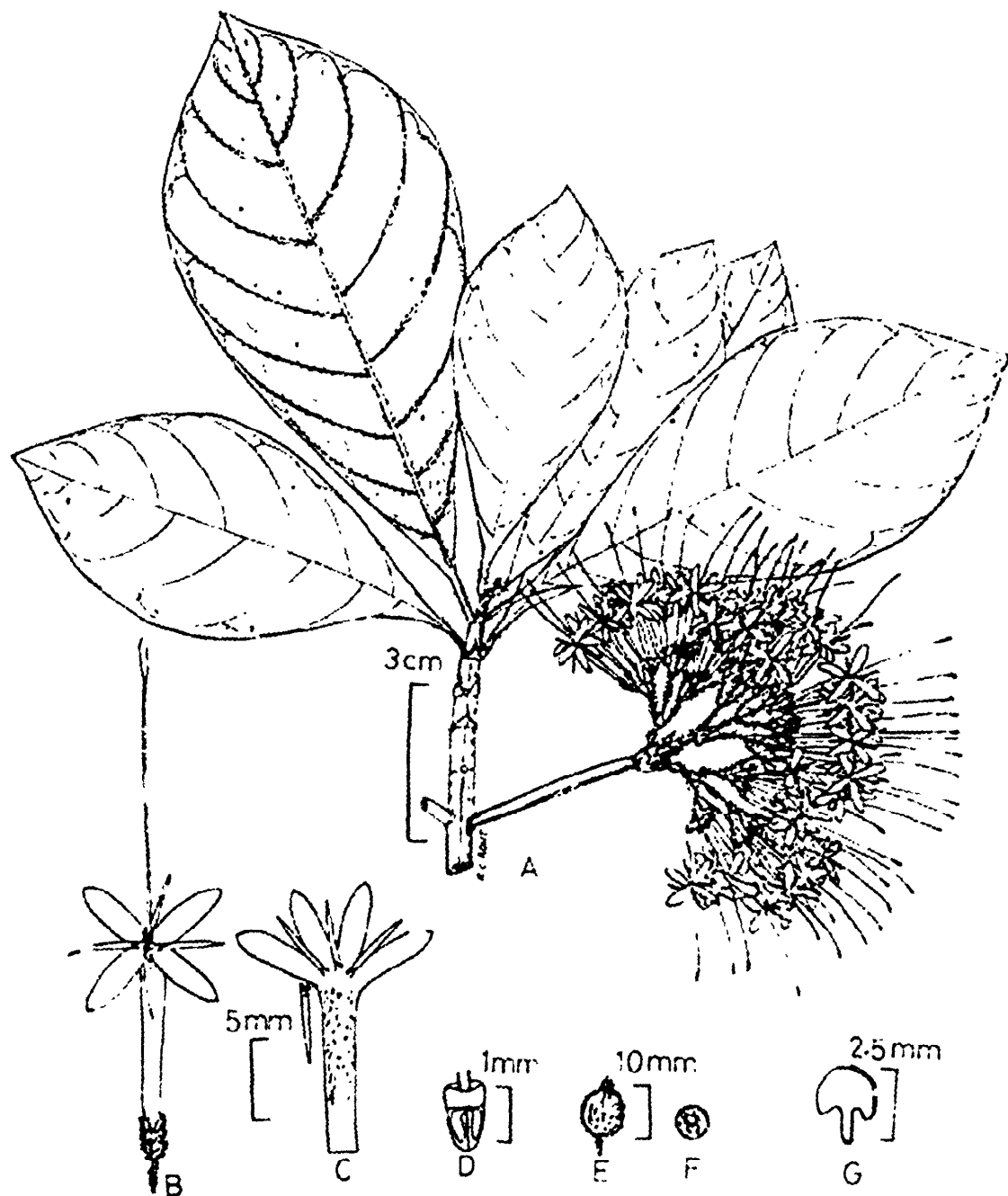
5. *Pavetta crassicaulis* Bremek. in Fedde Rept. 37 : 112. 1934 (*Type* : Maharashtra : Konkan, *Stocks* s.n. holo. K ! photo CAL !) & Fedde Rept. 47 : 25. 1939 ; Sant. & Merch. in Bull. Bot. Surv. Ind. 3 : 109. 1961 ; Sebast. in Bull. Bot. Surv. Ind. 4 : 224. 1962 ; Panigr. in Bull. Bot. Surv. Ind. 8 : 8. 1966 ; Kammathy *et al.* in Bull. Bot. Surv. Ind. 9 : 219. 1967 ; Sant. in Rec. Bot. Surv. Ind. 16 : 119. 1967 ; Vajrav & Rathak. in Bull. Bot. Surv. Ind. 9 : 39. 1967 ; Vajrav. *et al.* in Bull. Bot. Surv. Ind. 10 : 74. 1968 ; Chrian & Pataskar in Bull. Bot. Surv. Ind. 11 : 389. 1969 ; Shah & Suryan. in Bull. Bot. Surv. Ind. 11 : 294. 1969 ; Reddi in Bull. Bot. Surv. Ind. 11 : 250. 1969 ; Singh & Singh in Journ. Bomb. Nat. Hist. Soc. 68 : 787. 1971 ; Mitra in Journ. Bomb. Nat. Hist. Soc. 69 : 22. 1972 ; Sanyal in Ind. For. 99 : 156. 1973 ; Brahmam & Saxena in Journ. Econ. Tax. Bot. 1 : 122. 1980 ; Saxena

*et al.* in Ind. Journ. For. 3 : 88. 1980 ; Biswas & Maheswari in Journ. Bomb. Nat. Hist. Soc. 77 : 224. 1980 ; Karthikeyan *et al.* in Rec. Bot. Surv. Ind. 21. 168. 1981 ; Raghavan *et al.* in Rec. Bot. Surv. Ind. 21 : 42. 1981 ; Bole & Almedia in Journ. Bomb. Nat. Hist. Soc. 79 : 321. 1982 ; Shah in Jain & Rao, Ass. Thr. Pl. Ind. 53. 1983 ; Sharma *et al.* Fl. Karnataka 131. 1984 ; Rao, Fl. Goa 2 : 215. 1986 ; Sharma & Laxmi. in Journ. Econ. Tax. Bot. 8 : 442. 1986 ; Nair in Ind. Journ. For. 9 : 213. 1986 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 20. 1987 ; Singh, Fl. East. Karnatak 1: 352. 1988 ; Sadhale *et al.* in Journ. Econ. Tax. Bot. 15(1) : 170. 1991 ; Deb & Rout in Journ. Bomb. Nat. Hist. Soc. 89 (3) : 349. 1992.

*Pavetta stocksii* Bremek. in Fedde Repert. 37: 113. 1934 (*Type* : Loc. ? *Stocks* s.n. holo. 'K' photo CAL !); Sant. & Merch. in Bull. Bot. Surv. Ind. 3 : 110. 1961 ; Karthikeyan *et al.* in Rec. Bot. Surv. Ind. 21: 168. 1981. (Fig. 19)

Undershrubs, shrubs or small trees, 1.5-3.5 m high, erect, branched ; stem stout, quadrangular, thick, with short internodes, glabrous, provided with short conical outgrowths, corky in age. Leaves 5-15 × 2.1-6.0 cm, broadly obovate, acute or shortly acuminate at apex, acute at base, subcoriaceous or coriaceous, glabrous or

glabrescent above, sparsely or densely pubescent beneath, sometimes only on nerves, densely pubescent when young ; bacterial leaf-galls plenty, rarely few, on tertiary or quarternary nerves, rarely on secondary nerves, circular (0.3-1.0 mm), rarely elliptic (*ca* 1.0 × 0.5 mm), more prominent on lower surface ; domatia normally absent, rarely present, tuft type, on secondary nerve axils (in *Stocks* s.n. K !); midrib subcanaliculate or canaliculate above ; lateral nerves 8 -10 pair, densely pubescent beneath, alternate ; petioles 0.4-1.5 cm, sparsely pubescent ; stipules persistent, interpetiolar, 5-9 × 4-9 mm, broadly triangular, cuspidate, coriaceous, glabrous outside, with colleters and trichomes within ; colleters few on the adaxial surface of stipules, 320-640 µm long, 112-240 µm broad, sessile or stalked, brushlike or feathery ; stalk up to 48 µm long ; trichomes intermingled with colleters, plenty, silvery white, 320-1760 µm long, 24-32 µm across, pluricellular, cylindrical, 5-8 celled, apical cell acute, narrow, basal cell broader, outer wall smooth. Inflorescence terminal on axillary branches, sessile or subsessile, trichotomously branched, corymbose cymes, 7.5-8.5 cm across, hirsute ; bracts 8 × 6-7 mm, cuspidate, membranous, puberulose above, glabrous beneath. Flowers 30-100 ; pedicels 1-3 mm, hirsute. Hypanthium *ca* 1 × 1 mm, obovoid, hispid ; Calyx tube *ca* 0.5 × 1.5 mm, broader above, hirsute outside, glabrous within ; teeth *ca* 1.0 × 0.8 mm,



**Fig. 19 :** *P. crassicaulis* Bremek. : A. habit ; B. flower ; C. corolla split open ; D. placentation ; E. fruit ; F. seed ; G. embryo. A - D. from R. S. Raghavan 80623 ; E - G. from S. D. Mahajan 6853.

broadly triangular, acute at apex, hispid. Corolla tube *ca* 11 mm long, 1 mm across, cylindrical, glabrous outside, pilose within ; lobes *ca*  $5.0 \times 1.5$  mm, oblong, subacute at apex, glabrous. Microcharacters of outer surface of corolla tube : epidermal cells elongated, surface with longitudinal cuticular striations; inner surface of corolla lobes ; epidermal cells ridged, surface rugose. Filaments *ca* 0.6 mm long, slender, glabrous; anthers *ca* 5 cm ; pollen  $31 \times 25$  ( $27 - 36 \times 20 - 29$ )  $\mu\text{m}$ , subprolate, 3-zonocolporate, ectocolpium  $23 \times 3$  ( $20 - 32 \times 2 - 6$ )  $\mu\text{m}$  ; ora simple, type  $A_3$ , lalongate,  $5 \times 10$  ( $4 - 7 \times 7 - 12$ )  $\mu\text{m}$  ; apocolpium diameter 6  $\mu\text{m}$  ; exine 1  $\mu\text{m}$ , reticulate. Ovary *ca*  $0.7 \times 0.6$  mm ; disc *ca*  $0.5 \times 0.6$  mm ; style *ca* 28 mm long, slender, glabrous below, puberulous above ; stigma *ca* 0.5 mm, glabrous or puberulous. Drupes 7 - 8 mm across, globose or subglobose, pubescent, with persistent calyx teeth, 1 seeded ; seeds *ca* 5 mm ; exotestal cells 64 - 96  $\mu\text{m}$  long, 16 - 24  $\mu\text{m}$  thick, hexa- or pentagonal, with straight walls, surface granulate ; embryo *ca* 2.5 mm ; radicle *ca* 1 mm, stout ; cotyledons 2, equal, *ca*  $1.5 \times 2.0$  mm, radicle *ca* 1 mm, stout ; cotyledons 2, equal, *ca*  $1.5 \times 2.0$  mm, reniform, rounded at apex, cordate at base ; plumule minute, enclosed within cotyledons.

*External indumentum* 160-880  $\mu\text{m}$  long, 16-40  $\mu\text{m}$  across, pluricellular, cylindrical, 3 - 9 celled, straight or curved, apical cell acute, outer wall smooth.

*Fl.* : March-May ; *Fr.* : June-December.

*Ecology* : Evergreen forests, at 750 1350 m, in altitude.

*Distrib.* : INDIA : Goa, Gujarat, Karnataka, Maharashtra, Tamil Nadu.

*Specimens examined* : GOA : Volpui, 12.6.1976, S. R. Paul & S. J. Husain 107453 (LWG) ; Maloli forest, 19.11.1980, P. S. H. Khan *et al.* 12381 (LWG).

KARNATAKA : Kundadaguda, Agumbe, 15.5.1962, R. S. Raghavan 80623 (CAL) ; Shimoga dist., Kavaledurga, 24.5.1962, R.S. Raghavan 80939 (CAL).

MAHARASHTRA : Bombay, Dalzell s.n. (CAL, DD) ; Dec. 1889, V. M. Tilak 88 (E) ; Andhri, 25.12.1953, Kaul *et al.* 5954 (LWG); Pune dist., 29.9.1906, G. M. Ryan (BM) ; Sakar Pathar, Ambaune, 750 m, 8.3.1962, R.S. Rao 69791 (BSI, CAL) ; 1.2.1963, B.V.Reddi 68339 (BSI, CAL) ; Nandagaon forest, 21.12.1963, B. V. Reddi 93262 (CAL); Tiskari forest, 5.2.1964, B. V. Reddi 96111 (CAL) ; 21. 4.1964, Arora & Kalni 91716 (LWG). 20.4.1942, H. Santapau 15456 (DD); 5.6.1959, G. Saran & U. Shankar 61608 (LWG) ; St. Xavier's villa, 18.11.1961, M. Y. Ansari 32839 (BSI, CAL) ; Meroli, 15.6.1956 S. K. Jain 2289 (CAL) ; Dharwar, Ansighat, 1.5.1950, A.R. Bragenza 17 (DD). Mahabaleshwar, 28.4.1952, M. K. Patel s.n. (DD) ; 1350 m,

3.1.1957, *S. D. Mahajan* 13025 (BSI, CAL); 10.9.1957, *S. D. Mahajan* 6853 (BSI, CAL); Ghodnadi, 14.8.1956, *B.S. Rajgurav* 7755 (CAL); Lingmale road, 2.6.1960, *K.C. Kanodia* 62335 (E). Siroda, 23.6.1957, *S. K. Jain* 18804 (CAL); Gureghar forest, 20.6.1968, *R. S. Rao* 105075 (CAL); Lonavala, 5.9.1956, *S. K. Jain* 5967 (CAL); 11.9.1956, *B. S. Rajgaurav* 7755 (CAL); Lingmale road, 2.6.1960, *K. C. Kanodia* 62335 (E). Siroda, 23.6.1957, *S.K. Jain* 18804 (CAL); Gureghar forest, 20.6.1968, *R. S. Rao* 105075 (CAL); Lonavala, 5.9.1956, *S. K. Jain* 5967 (CAL); 11.9.1956, *S.D. Mahajan* 6889 (BSI, CAL); Bhimshankar, 30.3.1957, *G. S. Puri* 12585, 12622 & 12623 (CAL). Kolaba dist., Bhisra, Dongarwadi, 26.5.1958, *S. K. Jain* 34184 (CAL). Purandhar, 29.10.1961, *M.Y. Ansari* 32635 (CAL); Malavali, Ravivasma press, 6.3.1962, *R. S. Rao* 33084 (CAL). Western Ghats, *T. Cooke* 153 (CAL).

**6. *Pavetta gardneri* Bremek.** in Fedde Repert. 37 : 89. 1934 (Type : Sri Lanka, *Gardner* 52 holo. K ! photo CAL !).

Shrubs erect, branched ; stem stout, puberulous when young, glabrescent in age. Leaves petiolate, 6 - 15 × 1 - 4 cm, narrowly obovate or oblanceolate, rarely lanceolate, acuminate at apex, acute or attenuated at base, coriaceous, black when dry, glabrescent above, puberulous beneath ; bacterial leaf-galls few on tertiary nerves, circular, 0.5 - 1.0 mm, more prominent on lower surface ;

domatia tuft type, present on secondary nerve axils ; midrib subcanaliculate, puberulous above ; lateral nerves 7 - 12 pair, slender, alternate or subopposite, more prominent beneath ; petioles 0.4 - 1.6 cm, puberulous ; stipules persistent, interpetiolar, 5 - 8 × 3 - 5 mm, triangular, cuspidate, coriaceous, scarious at margin, puberulous outside, with colleters and trichomes inside ; colleters many 400 - 800 µm long, 96-218 µm broad, stalked, dendroid ; trichomes intermingled with colleters many, silvery white, 800 - 1200 µm long, 16 - 24 µm across, pluricellular, cylindrical, 6 - 9 celled, apical cell acute, outer wall smooth. Inflorescence terminal, sessile or subsessile, trichotomously branched corymbose cymes with 1-2 pairs of reduced leaves at the base, 10 - 11 cm across, puberulous ; 0 - 0.2 cm, stout, puberulous ; bracts 3 - 4 × 3 - 4 mm, triangular, cuspidate, scarious, puberulous. Flowers 20 - 37 ; pedicels 2 - 6 mm, stout, puberulous. Hypanthium *ca* 1.2 × 1.2 mm, obovoid, puberulous. Calyx tube *ca* 2 × 3 mm, campanulate, puberulous ; teeth 1.5 - 2.0 × 1.0 - 1.2 mm, subquadrangular, micronulate at apex, puberulous. Corolla tube 22 - 25 mm long, 2.0 - 2.5 mm across, cylindrical, glabrous outside, pilose within, glabrous at throat ; lobes 9 - 10 × 3.5 - 4.5 mm, oblong, mucronulate at apex, glabrous. Stamens : filaments 0.5 - 1.0 mm, stout, glabrous ; anthers 5 - 6 mm. Ovary *ca* 1 × 1 mm ; disc *ca* 0.5 × 1.0 mm ; style 68 - 73 mm long, stout below, puberulous above ; stigma *ca* 1 mm, simple, puberulous. Fruits not seen.

*Fl. : & Fr. ? :*

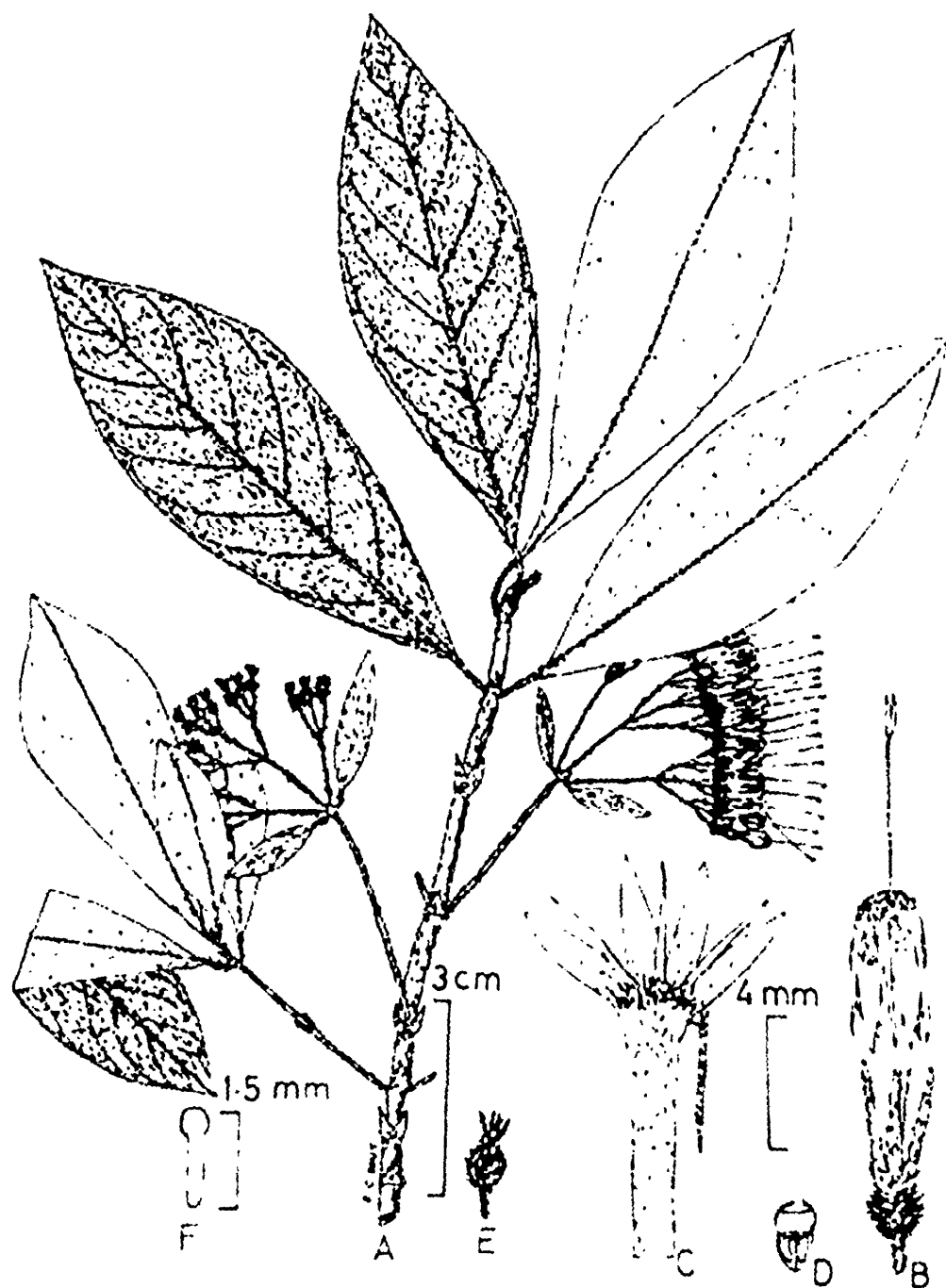
*Distrib. : SRI LANKA.* endemic.

*Note :* This species is represented by type collection only.

- 7. *Pavetta gleniei* Hook.f.** *Fl. Brit. Ind.* 3 : 152. 1880 (*Type : Sri Lanka, Batticaloa dist., Thwaites C.P.* 2815 K ! iso. CAL ! BM !), Trimen, *Hort. Zeyl.* 43. 1888 & *Fl. Ceyl.* 2 : 350. 1894 ; Bremek. in *Fedde Repert.* 37 : 80. 1934 ; Deb & Rout in *Journ. Bomb. Nat. Hist. Soc.* 89(3) : 348. 1992. *P. gleniei* Hook.f. var. *glabrescens* Bremek. (=var. *gleniei*) in *Fedde Repert.* 37 : 81. 1934 (*Type : Thwaites C.P.* 2815a, holo. K ! photo CAL !), *nom. superfl.* *P. gleniei* Hook.f. var. *pubescens* Bremek. *l.c.* 81 (*Type : Thwaites C.P.* 2815 b, holo. K ! photo. CAL ! ). *P. malacophylla* Bremek. *l.c.* 81 (*Type : Thwaites C.P.* 2815c, holo. 'K ! photo CAL ! ). *P. tomentosa* Thw. *Enum. Pl. Zey.* 156, 1859, non Roxb. ex Sm., 1819. *Ixora gleniei* (Hook.f.) Kuntze, *Rev. Gen. PL.* 1 : 286. 1891. (Fig. 20)

Shrubs *ca* 2 m high, erect, branched ; stem stout or slender, terete or subquadrangular, pubescent when young, glabrous and corky in age. Leaves petiolate, 3 16 × 0.7 - 5.3 cm, elliptic, elliptic-oblong or lanceolate, rarely elliptic-obovate or oblanceolate, acute or subacute, rarely obtuse or rounded at apex, cuneate, acute or obtuse

at base, coriaceous, rarely membranous, green, rarely black above (when dry), sparsely or densely pubescent above, tomentose (rarely sparsely or densely pubescent) beneath ; bacterial leaf-galls many or few on secondary or more finer nerves, circular (0.3-1.0 mm), rarely elliptic (*ca* 1.0 × 0.5 mm), more prominent on lower surface ; domatia absent ; midrib canaliculate above ; lateral nerves 6-13 pair, alternate or subopposite, more prominent beneath ; petioles 0.3 1.5 cm, pubescent ; stipules persistent, interpetiolar, forming intrapetiolar sheath, 4-7 × 3-6 mm, broadly triangular, shortly cuspidate, with cusps 1.5-3.0 mm, subcoriaceous, pubescent outside, with colleters and trichomes inside ; colleters few at the base of stipules inside, 880-1520 µm long, 112 - 240 µm broad, sessile, dendroid ; trichomes intermingled with colleters few, silvery white, 960 2080 µm long, 16 32 µm broad, pluricellular, cylindrical, 6 8 celled, apical cell acute, straight, outer wall smooth. Inflorescence axillary peduncled trichotomously branched loosely corymbose cymes with a pair of small reduced elliptic lanceolate leaves at the base or not, 3 - 7 cm across, hispid (with long white spreading hairs) ; peduncles 3.5 - 9.0 cm long, slender, hispid ; bracts 3 5 × 2 4 mm, triangular, cuspidate, membranous, hispid. Flowers 12-38 ; pedicels 2 6 mm, slender, hispid. Hypanthium *ca* 1.0 × 1.2 mm, obovoid ; calyx tube *ca* 1.0 × 1.8 mm, broader above, hispid ; teeth 2.5 - 5.0 × 0.2 - 0.3 mm, enlarged in fruits



**Fig. 20 :** *P. gleniei* Hook. f. A. habit ; B. flower ; C. corolla split open ; D. placentation ; E. fruits ; F. embryo. All from *Thwaites C.P.* 2815.

(up to 8 mm), subulate, hispid. Corolla tube 7 - 15 mm long, *ca* 1 mm across, cylindrical, glabrous outside, pilose within, pubescent at throat ; lobes  $4-6.5 \times 1.2-2.5$  mm, oblong or oblong-lanceolate, acute at apex, glabrous (rarely pubescent in Walker 14 pp.) outside, pubescent within below. Microcharacters of outer surface of corolla tube : epidermal cells elongated, surface with fine longitudinal cuticular striations ; inner surface of corolla lobes : epidermal cells ridged, surface smooth or striate. Filaments *ca* 1 mm, slender, glabrous ; anthers *ca* 4.5 mm, sparsely pubescent ; pollen  $28 \times 25$  ( $25 - 31 \times 21 - 27$ )  $\mu\text{m}$ , prolate-spheroidal, 3-zonocolporate ; ectocolpium  $22 \times 2$  ( $20 - 22 \times 2 - 3$ )  $\mu\text{m}$ , colpus membrane smooth, ends round ; ora compound, combining types  $A_2$  and  $B_1$  ; type  $A_2$  lalongate,  $5 \times 13$  ( $4-6 \times 12-15$ )  $\mu\text{m}$  ; type  $B_1$   $4.5 \times 3$   $\mu\text{m}$ , lalongate, apocolpium diameter 6-7  $\mu\text{m}$ , exine 2  $\mu\text{m}$ , finely reticulate, lumina circular. Ovary *ca*  $1 \times 1$  mm ; disc *ca*  $1 \times 1$  mm, annular ; style 14 - 30 mm, slender, glabrous below, sparsely puberulous above ; stigma simple, clavate or 2-lobed, lobes *ca* 1 mm, lanceolate, acute at apex, glabrous or puberulous. Drupes 6 - 7  $\times$  6 - 8 mm, globose or didymous, hirsute, with persistent calyx ; seeds 1 or 2, *ca*  $4 \times 3.5$  mm, excavated ; seed coat colliculate-scrobiculate ; embryo *ca* 1.5 mm, radicle *ca* 1.2 mm, stout ; cotyledons 2, *ca*  $0.3 \times 0.3$  mm, equal, orbicular ; plumule minute, enclosed within cotyledons.

*External indumentum* 352-800  $\mu\text{m}$  long,

16-32  $\mu\text{m}$  across, pluricellular, cylindrical ; 3-8 celled, apical cell acute, curved on leaf beneath, pedicels and hypanthium ; straight on other parts, outer wall pitted.

*Fl.* : December ; *Fr.* : January.

*Ecology* : In plain areas, road side thicket or slopes, up to 420 m in altitude.

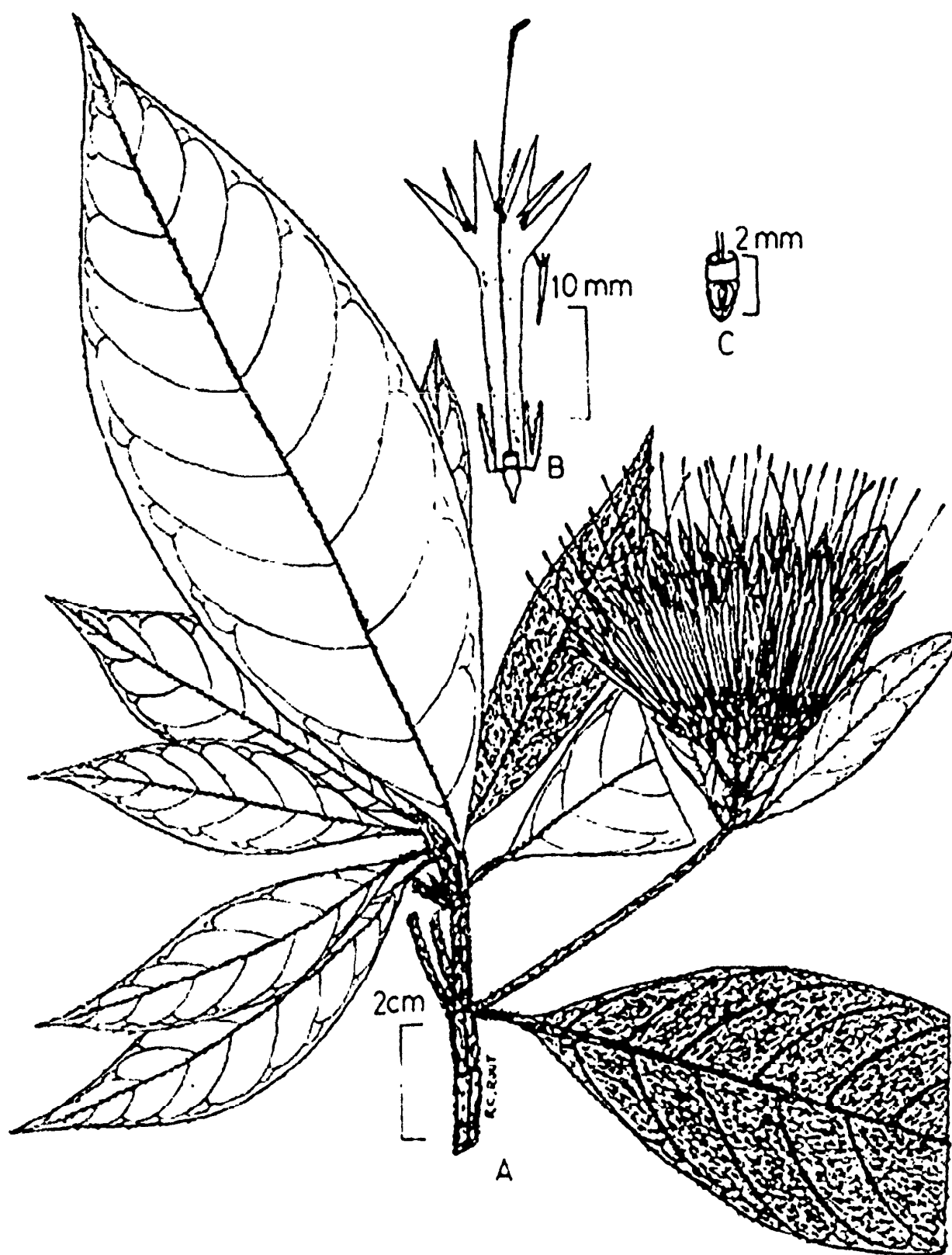
*Distrib.* : SRI LANKA : Batticaloa dist., Jaffna dist., Anuradhapuram dist.

*Specimens examined* : SRI LANKA (Ceylon): Walker 14 (E) ; Jaffna dist., North of Paranthan, 10.12.1970, F. R. Rosberg 53573 (E.L) : Anuradhapuram dist., Ritigala strict Natural Reserve, Ascent along eastern slope of Wannatikande, 420 m, 20.1.1973, A.H.M. Jayasuriya 1032 (L) : Valachchenai, 3 m, 4.12.1974, G. Davidse & D. B. Sumithraarachchi 9093 (CAL).

*Note* : *P. glenie* Hook.f. is distinguishable by its axillary long peduncled inflorescence, subulate calyx teeth persistent in fruits, corolla tube pubescent at the throat; corolla lobes oblong or oblong-lanceolate.

**7a. Pavetta sp. 1.** *Type* : India Orientalis, Roxburg s.n. (holo. BM !, photo CAL !).  
(Fig. 21)

Shrubs ; stem stout, angled, pubescent. Leaves petiolate, ternate (in threes),  $8 - 16 \times 2.3 - 5.6$  cm, elliptic-oblong or elliptic-obovate, acute at apex, acute or cuneate at base, subcoriaceous, glabrous or pubescent above, tomentose beneath ; bacterial leaf-



**Fig. 21 :** *P. sp. 1* : A. habit ; B. flower split open showing floral parts ; C. placentation. All from *Roxburgh* s.n.

galls rarely present on secondary or more finer nerves, circular, *ca* 0.5 mm, more prominent on upper surface, domatia absent; lateral nerves 8 - 14 pair, alternate or subopposite, more prominent beneath; petioles 0.8 - 1.2 cm, pubescent; stipules deciduous interpetiolar, 3.5 - 8.0 × 3 - 5 mm, broadly triangular, cuspidate, subcoriaceous, pubescent outside, with colleters and hairs within; colleters many on the adaxial surface of stipules, 448 - 672  $\mu$ m long, 96 - 128  $\mu$ m broad, stalked, feathery; stalk 80 - 160  $\mu$ m long; trichomes intermingled with colleters, many, 288 - 1280  $\mu$ m long, 16 - 24  $\mu$ m across, pluricellular, cylindrical, 5 - 12 celled, apical cell acute, outer wall smooth. Inflorescence axillary peduncled trichotomously branched compact corymbose cyme, 6 - 7.5 cm across, pubescent, with a pair of reduced narrowly elliptic-oblong leaves at the base; peduncle 4 - 6 cm, pubescent; bracts 5 - 6 × 4 - 5 mm, cuspidate, membranous, pubescent. Flowers 50 - 60; pedicels 4 - 6 mm, stout, sparsely pubescent. Hypanthium *ca* 1.0 × 1.5 mm, obovoid, glabrous or sparsely pubescent; calyx tube *ca* 1.5 × 2.5 mm, campanulate, glabrous or sparsely pubescent; teeth 4, 4.0 - 4.5 × 0.3 - 0.5 mm, subulate, sparsely pubescent. Corolla tube 20 - 24 mm long, *ca* 2 mm across, cylindrical, glabrous outside, pubescent within, glabrous at throat; lobes 8 - 9 × 2 mm, narrowly triangular, acuminate at apex, glabrous; internal indumentum 320 - 656  $\mu$ m long, 24 - 32  $\mu$ m broad, unicellular, ribbon like, acute or subacute at apex, surface pitted.

Filaments 1.0 - 1.5 mm, slender, glabrous; anthers 6.5 - 7.0 mm; pollen 43 × 37 (37 - 46 × 33 - 42)  $\mu$ m, subprolate; 3-zonocolporate; ectocolpium 34 × 4 (29 - 36 × 3 - 6)  $\mu$ m, colpus membrane smooth, ends round; ora compound; combining types A<sub>3</sub> and B<sub>1</sub>; type A<sub>3</sub> lalongate, 7 × 14 (4 - 11 × 12 - 15)  $\mu$ m, type B<sub>1</sub> lalongate, 6 × 4  $\mu$ m, thickened; apocolpium diameter 8 - 9  $\mu$ m; exine 2  $\mu$ m, very finely reticulate, lumina 1  $\mu$ m, circular. Ovary *ca* 1.2 × 1.2 mm, disc *ca* 1.0 × 1.2 mm, annular; style 36 - 40 mm long, stout, glabrous below, puberulous above; stigma 1.5 - 2.0 mm, simple, entire, clavate, puberulous. Fruits not seen.

*External indumentum* 240 - 752  $\mu$ m long, 13 - 24  $\mu$ m across, pluricellular, cylindrical, 2 - 5 celled; apical cell long, narrow, acute at apex, outer wall smooth.

*Fl. & Fr.:* ?

*Distrib.:* INDIA.

*Note:* This species is based on a single collection: *Roxburgh* s.n.. This specimen was determined by Bremekamp as *Pavetta gleniei* Hook. f. On critical examination, it was found to be totally different from that species. The differences are: leaves in threes; cymes compact; pedicels stout; hypanthium and pedicels sparsely pubescent; corolla tube longer and broader, glabrous at throat; corolla lobes narrowly triangular, acuminate at apex, glabrous within.

8. ***Pavetta glomerata*** Bremek. in Fedde Repert. 37 : 93. 1934 (Type : Sri Lanka, Central Province, May 1866, *Thwaites* C. P. 3924 holo. K ! photo CAL !).

Shrubs erect, branched ; stem stout, terete, glabrous. Leaves petiolate, 7.5-14.7 × 1.9-4.0 cm, obovate or oblanceolate, rarely elliptic, acute at apex, acute or attenuated at base, coriaceous, glabrous : bacterial leaf-galls many, present on secondary or tertiary nerves, circular (0.5-1.0 mm) or elliptic (*ca* 2 × 1 mm), rarely oblong (*ca* 5 × 1 mm), more prominent on lower surface ; domatia absent ; lateral nerves 7-10 pair, alternate or subopposite, more prominent beneath ; petioles 0.5-1.2 cm, stout, glabrous ; stipules persistent, interpetiolar, 6-9 × 3-4 mm, narrowly triangular, acuminate at apex, scarious at margin, glabrous outside, with few colleters and trichomes within ; colleters 480-1200 µm long, 48-240 µm broad, sessile, dendroid ; trichomes intermingled with colleters few, silvery white, 320-800 µm, long, 16-24 µm across, unicellular, cylindrical, outer wall smooth. Inflorescence terminal on short axillary branches, sessile, subcapitate cymes, with a pair of leaves at the base, 3.0-3.6 cm across ; bracts 3.0-4.5 × 3.5-4.5 mm, suborbicular, cuspidate, glabrous. Flowers 20-25, subsessile ; pedicels up to 1.5 mm, stout, glabrous. Hypanthium *ca* 1.5 × 1.5 mm, obovoid, glabrous ; calyx tube *ca* 0.5 × 1.5 mm, broader above, glabrous ; teeth *ca* 0.8 × 0.3 mm, narrowly triangular, acute at apex, glabrous. Corolla

tube *ca* 6 mm long, *ca* 2 mm across, cylindrical, glabrous outside, pilose within ; lobes *ca* 6 × 2 mm, oblong, acute at apex, glabrous. Filaments *ca* 0.5 mm, slender, glabrous ; anthers *ca* 4.5 mm. Ovary *ca* 1 × 1 mm ; disc *ca* 0.5 × 0.8 mm ; style 12-13 mm, slender, glabrous ; stigma *ca* 1.2 mm, simple, clavate, puberulous.

*Fl.* : May ; *Fr.* : ?

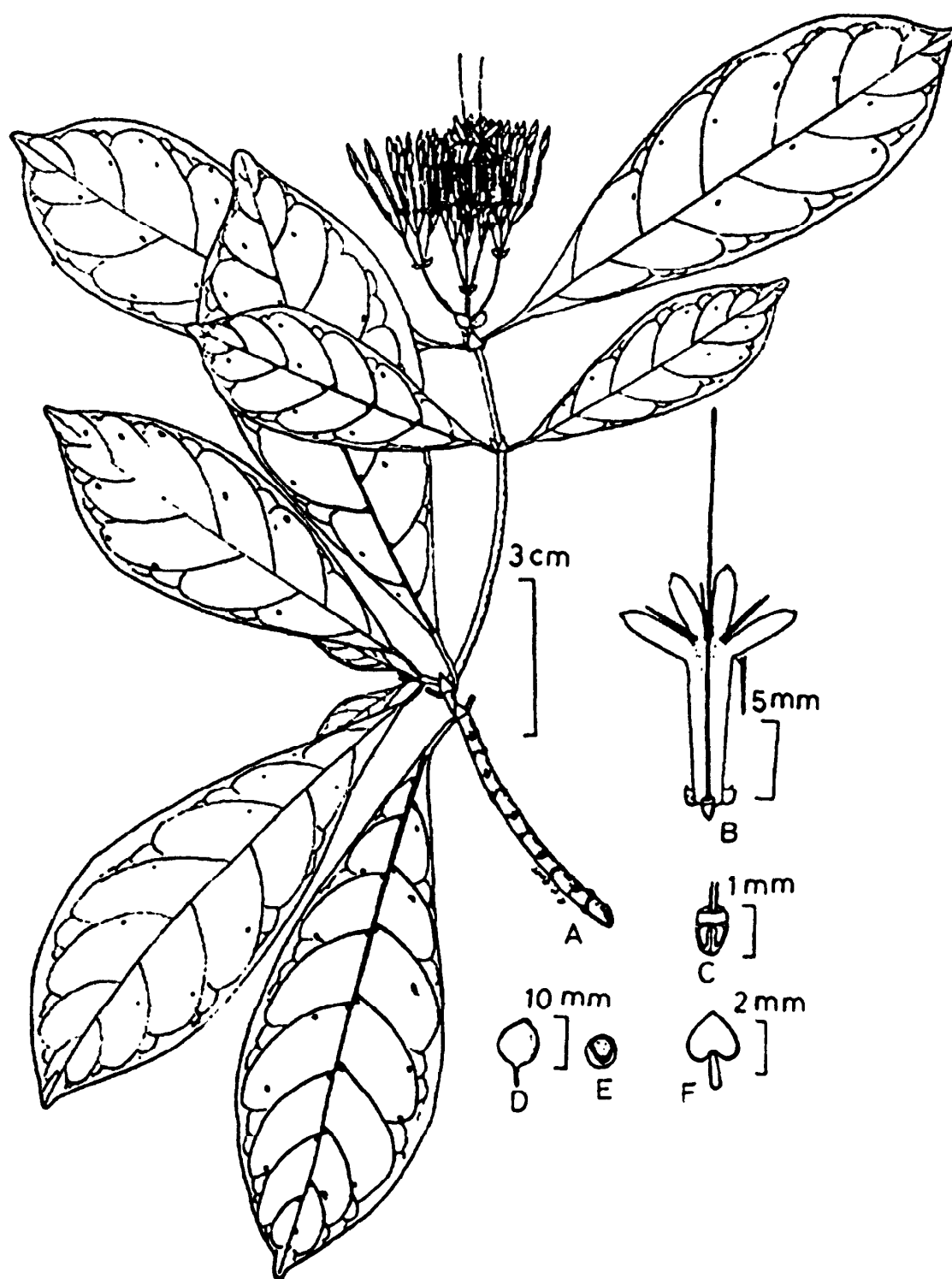
*Distrib.* : SRI LANKA : Central Province.

*Notes* : 1) This species is represented by type collection only. The type of this species has been cited in protologue (*Bremekamp l.c.*) as *Thwaites* C.P. 3934 K, but it has been verified that the type specimen at K (annotated by the author) bears the number 3924. So, it has been probably printed erroneously in protologue as *Thwaites* C.P. 3934 in place of *Thwaites* C.P. 3924.

2) *P. glomerata* is closely allied to *P. involucrata* from which it differs in smaller and narrower calyx tube, smaller calyx teeth, smaller bracts at the base of cyme.

9. ***Pavetta graciliflora*** Wall. ex Ridley in Journ. Str. Br. Roy. Asiat. Soc. 86 : 296. 1922 & Fl. Mal. Pen. 2 : 100. 1923 (Type : Siam, *Finlayson* s.n. ex Wall. Cat. 6178 holo. K ! microfiche CAL !) ; Bremek. in Fedde Repert. 37 : 102. 1934 ; Craib, Fl. Siam. 2 (2) : 167. 1934 pp. (Fig. 22)

*P. indica* auct. non. L., Prain in Journ. Asiat. Soc. Bengal 60 (2) : 361. 1891.



**Fig. 22 :** *P. graciliflora* Wall ex Ridley : A. habit ; B. flower split open showing floral parts ; C. placentation ; D. fruit ; E. seed ; F. embryo. A - C from N. P. Balakrishnan 5161 ; D - F. from N. G. Nair 4531.

Shrubs or small trees, 2–10 m high. erect, branched; stem stout, terete, glabrous. Leaves  $4.5–23.0 \times 1.0–1.8$  mm, narrowly obovate, elliptic-lanceolate or lanceolate, rarely broadly elliptic, subacute to obtuse at apex, attenuated or acute at base, membranous, shining above, glabrous on both sides, rarely pubescent on nerves beneath; bacterial leaf-galls few to many on secondary or tertiary nerves, circular (0.5–2.0 mm) or elliptic ( $ca\ 1 \times 0.5$  mm), more prominent on lower surface; domatia frequently present on secondary nerve axils, tuft, pocket or pit type; lateral nerves 6–11 pair, alternate, slender, more prominent beneath; petioles 0.3–2.5 cm, glabrous; stipules persistent, interpetiolar,  $2–6 \times 2.5–6.0$  mm, ovate-triangular, cuspidate, subcoriaceous, glabrous outside, with colleters and trichomes within; colleters few on the adaxial surface of stipules,  $316–1280\ \mu\text{m}$  long,  $56–112\ \mu\text{m}$  broad, stalked, dendroid; stalk  $112–448\ \mu\text{m}$  long; trichomes intermingled with colleters, plenty, silvery white,  $640–1840\ \mu\text{m}$  long,  $16–24\ \mu\text{m}$  across, pluricellular, cylindrical, 6–13 celled, apical cell acute, outer wall smooth. Inflorescence terminal, subsessile or shortly peduncled trichotomously branched, loosely corymbose cymes, 4–15 cm across, glabrous; peduncles up to 1.6 cm, glabrous; bracts  $5–8 \times 5–9$  mm, triangular, cuspidate, membranous, glabrous; Flowers 40–200; pedicels 4–6 mm, glabrous. Hypanthium  $ca\ 0.8 \times 0.8$  mm, subglobose, glabrous; calyx tube  $1.0–1.2 \times 1.5–2.0$  mm, cupular, glabrous

outside, with colleters within; teeth  $ca\ 0.2 \times 0.2$  mm, dentate, glabrous. Corolla tube 8–12 mm long, 1.0–1.5 mm across, cylindrical, glabrous outside, sparsely pubescent within; lobes  $4–5 \times 1–2$  mm, oblong, acute at apex, glabrous; internal indumentum  $512–912\ \mu\text{m}$  long,  $32–48\ \mu\text{m}$  broad, unicellular, ribbon-like, acute at apex, surface pitted. Filaments  $ca\ 0.5$  mm, slender, glabrous, anthers 3–4 mm; pollen  $31 \times 23$  ( $26–36 \times 21–28$ )  $\mu\text{m}$ , prolate; 3-zonocolporate, ectocolpium  $23 \times 3$  ( $19–27 \times 2–4$ )  $\mu\text{m}$ , colpus membrane smooth, ends acute; ora simple, type  $A_2$ , lalongate,  $4 \times 10$  ( $3–5 \times 7–12$ )  $\mu\text{m}$ ; apocolpium diameter  $6\ \mu\text{m}$ ; exine  $1\ \mu\text{m}$ , reticulate, columellate, thick at poles. Ovary  $ca\ 0.6 \times 0.6$  mm; disc  $ca\ 0.3 \times 0.6$  mm; style 18–30 mm long, slender, glabrous; stigma  $ca\ 1$  mm, simple, clavate, glabrous. Drupes 5–8 mm across, subglobose or didymous, glabrous, 1–2 seeded; seeds  $ca\ 4$  mm; exotestal cells  $80–210\ \mu\text{m}$  long,  $30–80\ \mu\text{m}$  thick, hexagonal, with straight walls, surface granulate; embryo  $ca\ 3$  mm; radicle  $ca\ 1.4$  mm, stout; cotyledons 2,  $ca\ 1.6 \times 1.8$  mm, reniform, obtuse at apex, cordate at base; plumule minute, enclosed within cotyledons.

*Fl.*: March–June; *Fr.*: July–December.

*Ecology*: Inland forest, at 0–400 m in altitude.

*Distrib.*: INDIA: Andaman & Nicobar Islands; MYANMAR; MALAYSIA; THAILAND (Saim).

*Specimens examined*: INDIA : ANDAMAN ISLANDS : North Andamans, Saddle beak, *ca* 400 m, 27.3.1977, *N. P. Balakrishnan* 5161 (CAL). Middle Andamans, Bakultala, 6.11.1977, *N. Bhargava* 6407 (CAL, PBL). South Andamans : Mt. Harriet, 16.8.1884, *King's collector* 111 & 262 (CAL) ; Rungachang, *D. Prain* s.n. (CAL) ; 7.10.1895, *King's collector* s.n. (CAL) ; Aug. 1896, *R. L. Heinig* 36 (CAL) ; Port Blair, May 1890, *G. King* s.n. (CAL) ; Pyth ghat, Pal mount, 12.7.1890, *King's collector* s.n. (CAL) ; Hobdaypur hill jungle, 6.6.1891, *G. King* s.n. (CAL) ; Manpur hill jungle, 46. 1892, *King's collector* s.n. (CAL) ; Dhanikhari hill jungle, 2.7.1892, *King's collector* s.n. (CAL) ; 7.9.1977, *N. Bhargava* & *N. G. Nair* 6238 (CAL) ; Balughat hill jungle, 1.10.1892, *King's collector* s.n. (CAL) ; Goplakabang hill jungle, 27.5.1893, *King's collector* s.n. (CAL) ; 16.9.1895, *King's collector* s.n. (CAL) ; Bumlitani hill jungle, 21.10.1891, *King's collector* s.n. (CAL) ; Mangunj hill jungle, 6.1.1894, *King's collector* s.n. (CAL) ; Port mount jungle hill, 28.7.1894, *King's collector* s.n. (CAL) ; Jarwa creek hill jungle, 8.12.1894, *King's collector* s.n. (CAL) ; Jarwa creek village, 22.4.1961, *G. Saran & Party* 79427 (LWG) ; Bajajag valley, January 1897, *R. L. Heinig* s.n. (CAL) ; Nov. 1900, *D. Prain's collectors* 256 (CAL) ; 15.11.1901, *R. L. Heinig* 83 & 475 (CAL) ; 12.12.1910, *R. L. Heinig* 263 (CAL) ; 1918, *Convict* s.n. (CAL) ; Naya sahar inland forest. *ca* 150 m, 29.5.1973, *N. P. Balakrishnan* 343 (MH) ; *ca* 30 m, 25.11.1978, *P. Basu* 7062

(CAL) ; Guptapara island forest, *ca* 10 m, 23.11.1973, *N. P. Balakrishnan* 626 (MH) ; 5.11.1977, *P. Basu* 6609 (CAL) ; Tusnabad inland forest, *ca* 150 m, 14.12.1973, *N. P. Balakrishnan* 667 (CAL) ; Chiriatapu inland forest, 29.5.1974, *K. Thothathri* & *N. G. Nair* 1068 (CAL) ; Jirkatang, *ca* 50 m, 17.6.1978, *N. P. Balakrishnan* & *N. G. Nair* 6968 (CAL). Little Andamans, Hat bay, 17.8.1976, *N. Bhargava* 4163 (CAL) ; Dugong creek, 1.9.1976, *N. Bhargava* 4330 (CAL, PBL) ; 29.11.1977, *N. Bhargava* 6596 (CAL). Nicobar islands, Mangrove bay, *S. Kurz* s.n. (CAL) ; Watering core, *S. Kurz* s.n. (CAL) ; Katchall, February 1875, *S. Kurz* s.n. (CAL) ; 3.3.1875, *S. Kurz* s.n. (CAL) ; Camorta, 6.2.1893, *King's collectors* s.n. (CAL) ; East bay, 15.11.1976, *P. Chakraborty* 4676 (CAL) ; North Nicobars, Car Nicobar, 11.8.1902, *C.G. Rogers* s.n. & 27 (CAL) ; Tree top, sea level, 3.6.1975, *N. G. Nair* 2662 (CAL, PBL) ; Kakana, sea level, 14.6.1975, *N. G. Nair* 2725 (CAL) ; Arong, 29.9.1976, *N. G. Nair* 4531 (CAL).

MYANMAR : Great Cocos islands, 7.12.1889, *D. Prain* s.n. (CAL) ; 1890, *D. Prain* s.n. (CAL).

10. *Pavetta hispidula* Wt. & Arn. Prodr. 431. 1834 (*Type* : Western Ghats, *R. Wight* 1343 holo. K ! photo CAL ! ) ; Walps. Rep. Bot. Syst. 2 : 480. 1843 ; Drury, Hand Book Ind. Fl. 1 : 572. 1864 ; Hook.f. Fl. Brit. Ind. 3 : 151. 1880 ; Talbot, Syst. list 111. 1894 pp. (excl.

syn.) : Birdwood in Journ. Bomb. Nat. Hist. Soc. 10 (3) : 411. 1896 ; Brandis, Ind. Trees 387. 1906 pp. ; Talbot, For. Fl. Bomb. Sind 2 : 119. 1911 ; Rama Rao, Fl. Pl. Trav. 213. 1914 ; Fischer in Rec. Bot. Surv. Ind. 9 (1) : 95. 1921 ; Gamble, Fl. Pres. Madras 633. 1921 ; Bremek. in Fedde Repert. 37 : 91. 1934 ; Subram. in Bull. Bot. Surv. Ind. 1 (1) : 131. 1959 ; Arora in Journ. Ind. Bot. Soc. 45 : 311. 1966 ; Sharma *et al.* in Bull. Bot. Surv. Ind. 15 : 59. 1973 ; Sant. & Henry Dict. Fl. Pl. Ind. 126. 1976 ; Sharma *et al.* in Biol. Mem. 2 : 72. 1977 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 20. 1987 ; Vajrav. in Journ. Econ. Tax. Bot. 11. 226. 1987.

Shrubs or small trees erect, branched ; stem stout or slender, terete or flattened, hispid, corky in age. Leaves petiolate, 4.5 25.2 × 0.5 7.8 cm, oblong-lanceolate, lanceolate, obovate, oblong, elliptic, elliptic-oblong, oblanceolate or linear-lanceolate, acute, acuminate or caudate at apex, acute, cuneate or attenuated at base, coriaceous, subcoriaceous or membranous, black or brownish pale when dry, glabrous or scabraous above, densely pubescent or glabrous beneath, nerves densely hispid, pubescent or glabrous beneath ; bacterial leaf-galls few to many on secondary or more finer nerves; circular, elliptic or oblong ; domatia rarely present ; lateral nerves 7 11 pair ; petioles 0.4 3.2 cm, hispid,

puberulous or glabrous ; stipules deciduous or persistent, interpetiolar or intrapetiolar, ovate or triangular, cuspidate, hispid, pubescent or glabrous outside, with colleters and trichomes within ; colleters few to many on the adaxial surface of stipules, stalked or sessile, dendroid or feathery ; trichomes intermingled with colleters few to many, pluricellular, cylindrical, straight or curved, apical cell acute, outer wall smooth. Inflorescence terminal, rarely axillary, sessile or subsessile, trichotomously branched corymbose cymes, hispid, pubescent, puberulous or glabrous ; bracts triangular, cuspidate, membranous, pubescent, puberulous or glabrous. Flowers pedicellate; pedicels stout, hispid, pubescent, puberulous or glabrous. Hypanthium subglobose or obovoid, hispid, puberulous or glabrous ; calyx tube obovoid, hispid, puberulous or glabrous outside, glabrous or pubescent within ; teeth narrowly or broadly triangular, rarely oblong, acute at apex, hispid or puberulous. Corolla tube cylindrical, glabrous outside, pilose within ; lobes oblong, acute, acuminate or mucronulate at apex, glabrous. Filaments slender or stout, glabrous or puberulous ; anthers dorsifixed above the base, 2-lobed, acute at apex, sagittate at base, dehiscing longitudinally ; pollen prolate-spheroidal, prolate or spheroidal, 3-zonocolporate, ora compound, combining types A<sub>3</sub> and B<sub>1</sub> ; type A<sub>3</sub> lalongate, type B<sub>1</sub> lolongate, exine reticulate, columellate. Ovary 2-loculed with 1 pendulous ovule in

each locus ; disc annular ; style stout, thickened at the middle, glabrous below, thin and puberulous above ; stigma simple, clavate or notched, glabrous or sparsely pubescent. Drupes subglobose or didymous,

green, black when dry, glabrous or sparsely pubescent, with persistent calyx ; seeds 1 or 2 ; exotestal cells hexagonal, with straight walls, surface granulate, striate granulate, colliculate or pusticulate.

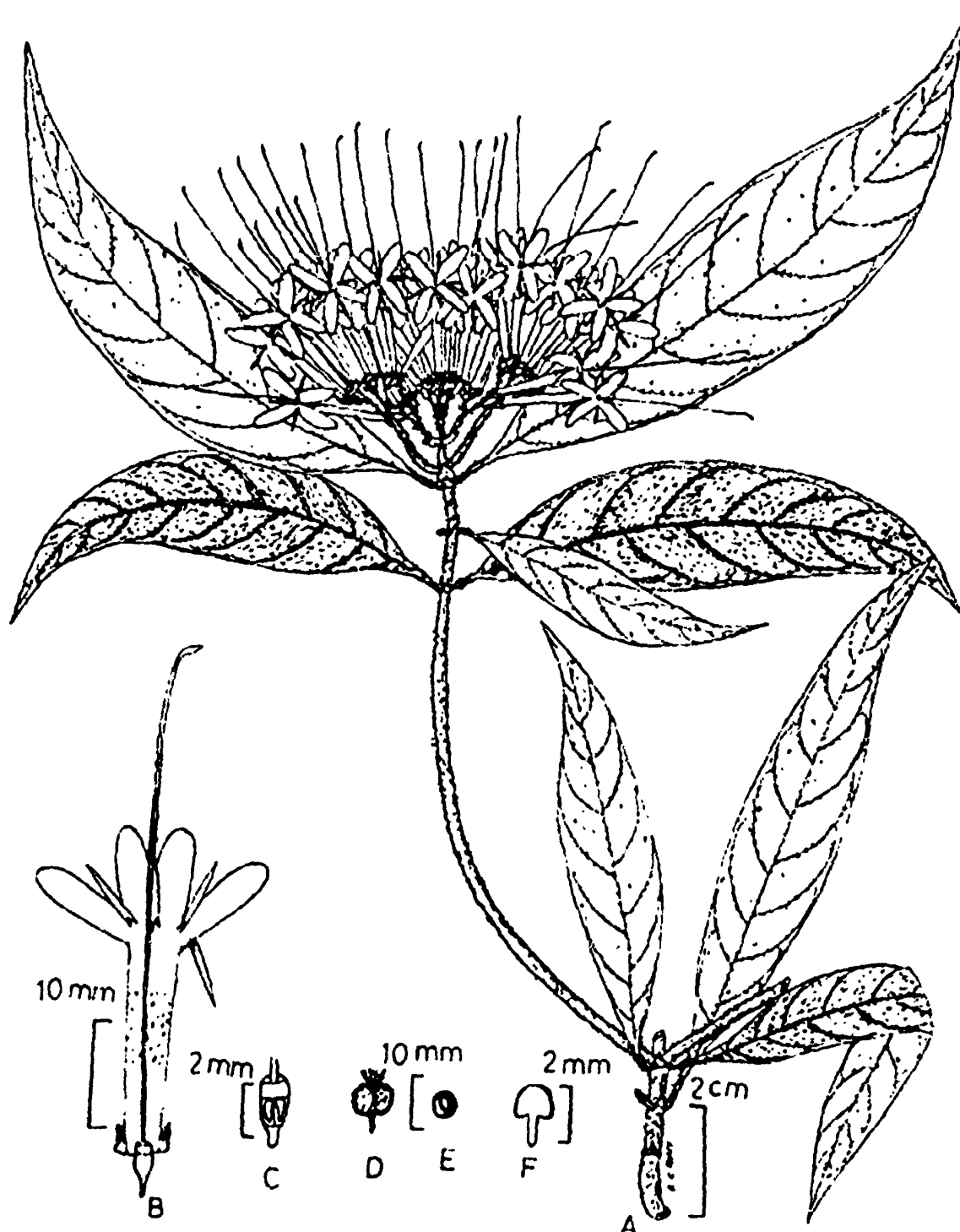
#### KEY TO THE VARIETIES

- |                                                                                                                                           |     |                              |
|-------------------------------------------------------------------------------------------------------------------------------------------|-----|------------------------------|
| 1. Leaves black when dry, cyme branches less robust ; hypanthium and calyx glabrous, pubescent or hispid                                  | ... | 2                            |
| 1a. Leaves brownish pale when dry, cyme branches more robust ; hypanthium and calyx puberulous                                            | ... | (c) var. <i>zeylanica</i>    |
| 2. Leaves linear-lanceolate, glabrous, cymes glabrous                                                                                     | ... | (d) var. <i>angustifolia</i> |
| 2a. Leaves lanceolate, oblanceolate, elliptic-lanceolate or obovate, pubescent at least on the nerves beneath ; cymes pubescent or hispid | ... | 3                            |
| 3. Leaves lanceolate or oblanceolate, coriaceous, scabrous above, densely puberulous or pubescent beneath, cymes hispid                   | ... | (a) var. <i>hispidula</i>    |
| 3a. Leaves obovate or elliptic-lanceolate, membranous, glabrous above, pubescent on the nerves beneath ; cymes pubescent                  | ... | (b) var. <i>siphonantha</i>  |

(a) var. **hispidula** Hook.f. Fl. Brit. Ind. 3 : 151. 1980 (var. 1). (Fig. 23)

Undershurbs, shrubs or small trees, 1-4 m high, erect, branched ; stem stout, terete, densely hispid when young, sparsely pubescent and corky in age. Leaves petiolate, 5.7-15.0 × 1.3-3.2 cm, oblong-lanceolate or lanceolate, rarely elliptic, acuminate at apex, cuneate or acute at base, coriaceous or subcoriaceous, black when dry, scabrous

above, densely puberulous or pubescent beneath, nerves densely hispiduloua beneath ; bacterial leaf-galls few, rarely many, on secondary or more finer nerves, circular (*ca* 1 mm) or elliptic (0.7-1.0 × 0.3-0.5 mm), more prominent on upper surface ; domatia absent ; lateral nerves 9-10 pair, alternate or subopposite, more prominent beneath ; petioles 0.6 -1.5 cm, stout, pubescent ; stipules persistent, interpetiolar, *ca* 3 × 2 mm, triangular, cuspidate,



**Fig. 23 :** *P. hispidula* Wt. & Arn. var. *hispidula* : A. habit ; B. flower split open showing floral parts ; C. Placentation ; D. fruits ; E. seed ; F. embryo. A- C. from Henry & Chandrabose 19272 ; D F. from A. N. Henry 48143.

subcoriaceous, hispid outside, with colleters and trichomes within ; colleters few on adaxial surface of stipules, 400 - 1120  $\mu\text{m}$  long, 112 - 208  $\mu\text{m}$  broad, stalked, feathery or dendroid ; stalk 64 - 80  $\mu\text{m}$  long ; trichomes intermingled with colleters few, 352 - 1136  $\mu\text{m}$  long, *ca* 32  $\mu\text{m}$  across, pluricellular, cylindrical, 6 - 14 celled, apical cell acute, outer wall smooth. Inflorescence terminal, subsessile, trichotomously branched corymbose cymes, 6 - 6.5 cm, across, densely hispid ; penduncles 0.2 - 0.3 cm, long, hispid ; bracts *ca* 5  $\times$  5 mm, broadly triangular, membranous, pubescent. Flowers *ca* 30 ; pedicels 3.0 - 3.5 mm, hispid. Hypanthium *ca* 1.2  $\times$  1.2 mm, subglobose, hispid ; calyx tube *ca* 1.0  $\times$  1.0 mm, broader above, hispid outside, glabrescent within ; teeth *ca* 0.5  $\times$  0.5 mm, narrowly triangular, acute at apex, hispid outside, pubescent within. Corolla tube 20 - 22 mm, long, *ca* 2 mm across, cylindrical, glabrous outside, pilose within ; lobes *ca* 10  $\times$  3 mm, oblong, mucronulate at apex, glabrous. Microcharacters of inner surface of corolla lobes ; epidermal cells ridged with smooth cuticular surface. Filaments *ca* 1.5 mm, slender, glabrous ; anthers *ca* 7 mm ; pollen 37  $\times$  36 (32 - 40  $\times$  25-40)  $\mu\text{m}$ , prolate-spheroidal, 3-zonocolporate ; ectocolpium 27  $\times$  4 (24 - 35  $\times$  3-5)  $\mu\text{m}$ , colpus membrane granulate ; ora compound, combining types  $A_3$  and  $B_1$  ; type  $A_3$  lalongate, 5  $\times$  12 (4 - 9  $\times$  9 - 17)  $\mu\text{m}$  ; type  $B_1$  lolongate, 5  $\times$  2  $\mu\text{m}$ , thickened ; apocolpium diameter 7  $\mu\text{m}$  ; exine 2  $\mu\text{m}$ , reticulate. Ovary *ca* 1  $\times$  1 mm, disc *ca*

0.5  $\times$  1.0 mm ; style 43 - 48 mm, thickened at middle, glabrous below, puberulous above ; stigma *ca* 2 mm, clavate, glabrous. Drupes 5-6  $\times$  6-10 mm across, subglobose or didymous, green, black when dry, sparsely pubescent, with persistent calyx, 1 or 2 seeded ; seeds *ca* 4  $\times$  3.5 mm ; exotestal cells 64 - 96  $\mu\text{m}$  long, 32 - 40  $\mu\text{m}$  thick, hexagonal, with straight walls, surface striate granulate ; embryo *ca* 2.2 mm, radicle *ca* 1.0 mm, stout ; cotyledons 2, equal, *ca* 1.2  $\times$  1.2 mm, reniform rounded at apex, cordate at base ; plumule minute, enclosed within cotyledons.

*External indumentum* 160-400  $\mu\text{m}$  long, 16-48  $\mu\text{m}$  across, pluricellular, cylindrical, 2-7 celled, apical cell acute, straight or curved, outer wall smooth.

*Fl.* : March - July ; *Fr.* : August-December.

*Ecology* : Evergreen forest at 400-1200m in altitude.

*Distrib.* : INDIA : Kerala, Maharashtra, Tamil Nadu.

*Specimens examined* : INDIA. KERALA : Travancore, Shencollate, Aug.-Sept. 1913, C. C. Calder & M. S. Ramaswami 759 (CAL) ; Anankairi-Tummalai, 22.3.1915, C. C. Calder 1460 (CAL) ; Palghat dist., Silent valley, 950 m, 11.10.1965, E. Vajravelu 26132 (CAL, MH) ; 950 m, 28.5.1966, E. Vajravelu 27704 (CAL) ; Evergreen forest,

27.6.1976, *C. E. Ridsdale* 301 (L) ; Quilon dist., Allapad, 400 m, 23.5.1979, *C. N. Mohanan* 63035 (MH) ; Thathenglan, 850m, 8.12.1980, *N.C. Nair* 69166 (CAL, MH).

TAMILNADU : Coimbatore dist., Tamgadrami temple, 1290m, 24.1.1931, *S. R. Raju & Naganathan* 4934 (MH) ; Tirunelveli dist., bank of river Inchi Kwithi, 725 m, 5.7.1964, *A. N. Henry & M. Chandrabose* 19272 (CAL, MH) ; Ayilandan pillai estate, 580 m, 24.7.1966, *B. V. Shetty* 27962 (CAL, MH) ; Kanyakumari dist., beyond Sengumal estate, Panagudi, 775 m, 9.2.1972, *B. D. Sharma* 40066 (MH) ; Kalikesham river side, ca 700 m, 30.8.1976, *A. N. Henry* 48143 (CAL, MH).

PENINSULAR INDIA, 1866-8, *R. Wight* s.n. (*Kew Distrib. No.* 1478 pp.) (CAL, L).

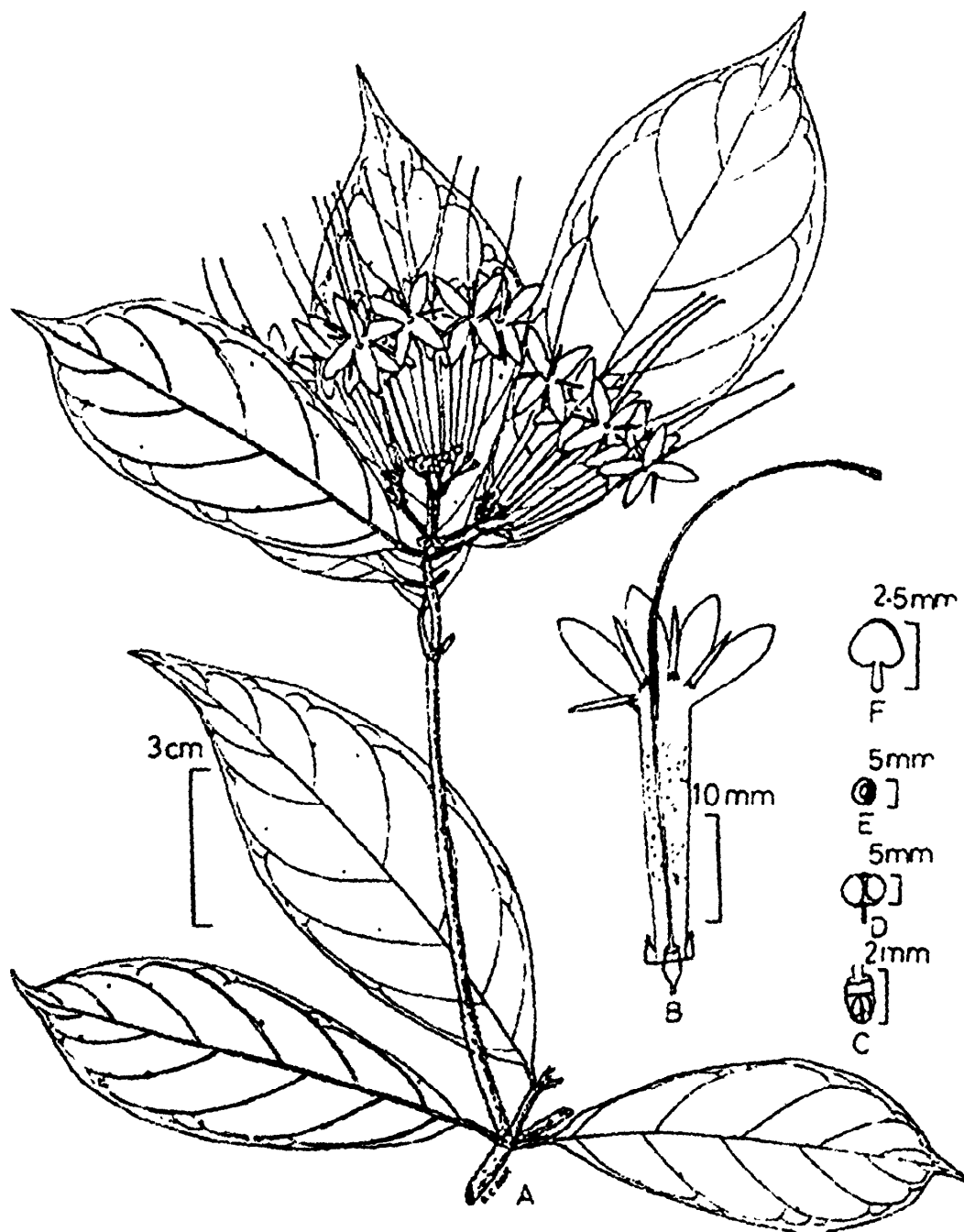
(b) var. *siphonantha* (Dalz.) Hook.f. *Fl. Brit. Ind.* 3 : 151. 1880 ; Birdwood in *Journ. Bomb. Nat. Hist. Soc.* 2 : 118. 1887 ; Cooke, *Fl. Pres. Bomb.* 2 : 41. 1904 ; Blatter in *Journ. Bomb. Nat. Hist. Soc.* 36 : 792. 1933.

*Pavetta siphonantha* Dalz. in Hook. *Journ. Bot.* 2 : 133. 1850 (*Type* : Maharashtra, Bombay, Konkan, *Dalzell* s.n. K : photo CAL ! ) ; Walps. *Ann. Bot. Syst.* 2 : 753. 1851 ; Dalz. & Gibs. *Bomb. Fl.* 112. 1861 ; Drury, *Hand book Ind. Fl.* 1 : 572. 1864 ; Bedd. in *Trans. Linn. Soc.* 25(2) : 219. 1866 & *Fl. Sylv. For. Man.* 134/8. 1874 ; Bremek.

in Fedde *Rept.* 37 : 90. 1934 ; Sant. in *Rec. Bot. Surv. Ind.* 16 (1) : 137. 1953 ; ed. 2, 107. 1960 S ed. 3, 120. 1967 ; Reddi in *Bull. Bot. Surv. Bot. Surv. Ind.* 11 : 250. 1969 ; Sharma *et al.* *Fl. Karnataka* 131. 1984 ; Ahmed. & Nayar, *End. Pl. Ind. Reg.* 1 : 162. 1987.

*P. hispidula* Wt. & Arn., Talbot, *Syst. List.* 111. 1894 pp.; Brandis, *Ind. Trees* 387. 1906, pp. ( Fig. 24)

Shrubs or small trees, 3.0-4.5 m high, erect, branched ; stem stout, terete, glabrous or glabrescent, corky in age. Leaves petiolate, 5.7 - 20.0 × 2.5-6.5 cm, obovate, rarely elliptic, oblong or lanceolate, acuminate or caudate at apex, cuneate or attenuated at base, membranous, black when dry, glabrous above, nerves pubescent beneath ; bacterial leaf-galls few on secondary or more finer nerves, circular (0.5-1.0 mm), more prominent on lower surface ; domatia absent; lateral nerves 7-8 pair, alternate, rarely subopposite, more prominent beneath ; petioles 0.5-2.5 cm, stout, puberulous ; stipules persistent, interpetiolar, ca 2 × 1.5cm, broadly triangular, cuspidate, coriaceous, glabrous outside, with colleters and trichomes inside ; colleters many on adaxial surface of stipules, 560-912 µm long, 112-224 µm broad, stalked, feathery ; stalk 80-122 µm long, trichomes intermingled with colleters, few, 400-1200 µm long, 24 - 32 µm across, pluricellular, cylindrical, 4 - 11 celled, apical cell acute, outer wall smooth. Inflorescence



**Fig. 24 :** *P. hispidula* Wt. & Arn. var. *siphonantha* (Dalz.) Hook. f. A. habit ; B. flower split open showing floral parts ; C. placentation ; D. fruit ; E. seed ; F. embryo. A-C. from B. V. Reddi 97842 ; D - F. from B. V. Reddi 101161.

terminal, subsessile, trichotomously branched corymbose cymes, 7-7.5 cm across, pubescent; peduncles up to 0.5 cm long, pubescent; bracts *ca* 4 × 3 mm, triangular, cuspidate, membranous, puberulous. Flowers 20-40; pedicels 2-10 mm, stout, pubescent. Hypanthium *ca* 1 × 1.2 mm, obovoid, pubescent; calyx tube *ca* 1.2 × 1.5 mm, broader above, sparsely pubescent; teeth 0.8-1.0 × 0.8-1.0 mm, triangular, acute at apex, sparsely pubescent. Corolla tube 26-27 mm long, *ca* 2 mm across, cylindrical, glabrous outside, pilose within; lobes *ca* 9 × 2.8 mm, oblong, mucronulate at apex, glabrous. Microcharacters of inner surface of corolla lobes; epidermal cells ridged with rugose cuticular surface. Filaments *ca* 1.5 mm, slender, glabrous; anthers *ca* 7 mm; pollen 44 × 27 (39-46 × 25-33)  $\mu$ m, prolate, 3-zonocolporate; ectocolpium 35 × 4 (30-39 × 4-6)  $\mu$ m, ora compound, combining types  $A_3$  and  $B_1$ ; type  $A_3$  lalongate, 7 × 10 (4-10 × 7-16)  $\mu$ m; type  $B_1$  lolongate, 7 × 4  $\mu$ m, thickened; apocolpium diameter 8-9  $\mu$ m; exine 1.5  $\mu$ m, medium reticulate, columellate, lumina 1.0-1.5  $\mu$ m. Ovary *ca* 1 × 1 mm; disc *ca* 0.8 × 1.0 mm; style 40-55 mm long, thick and glabrous below, thin and puberulous above; stigma *ca* 1.8 mm, subclavate, scabrous. Drupes 5-6 × 7-8 mm across, didymous or subglobose, glabrous; seeds 1 or 2, *ca* 4 mm; exotestal cells 96-128  $\mu$ m long, 24-48  $\mu$ m thick, hexagonal, with straight walls, surface granulate; embryo *ca* 2.5 mm; radical *ca* 1 mm, stout; cotyledons 2, equal, *ca* 1.5 × 2.0 mm, reniform, rounded

at apex, subcordate at base; plumule minute, enclosed within cotyledons.

*External indumentum* 48-288  $\mu$ m long, 16-24  $\mu$ m across, pluricellular, cylindrical, 2-5 celled, apical cell acute, curved, outer wall smooth.

*Fl.* : March-June; *Fr.* : January.

*Ecology* : Dense evergreen forests at 550 m altitude.

*Distrib.* : INDIA : Karnataka, Kerala, Maharashtra.

*Specimens examined* : INDIA. KARNATAKA : Dakshin Kanada, Mangalore, 1849, *R. F. Hohenacker* 423 (BM, L); Coll.? 2386 (L); Uttar Kanadam 9.5. 1888, *W. A. Talbot* 1651 (CAL); Karwar, June 1918, *T. R. Bell* 4055 (K); Mysore, Saklasapur, 28.4.1905, *C. A. Barber* 7058 (CAL, MH); Agumbe, Belehalli forest, 18.5.1952, *K. S. Srinivasan* s.n. (BSIS); Kundadaguda, 15.5.1960, *R. S. Raghavan* 80640 (BSI, CAL); Nalur, 15.5.1960, *R. S. Raghavan* 62472 (BSI, CAL); Balehalli, 15.5.1960, *R. S. Raghavan* 62696 (BSI, CAL); Ghatibagh, 13.5.1962, *R. S. Raghavan* 80519 (BSI, CAL).

KERALA : Malabar, *Stocks et al* s.n. (CAL, L); Law s.n. pp. (K.); *Stocks* s.n. (CAL); Cannanore dist., Pannoth, *ca* 550 m, 24.3.1980, *V. S. Ramachandran* 66880

(CAL) ; Wynaad dist., Lakkidi, 20.3.1984, *R. T. Balakrishnan* 40003 (CAL).

MAHARASHTRA : *Dalzell* s.n. (DD) ; Western Ghats, 1884, *T. Cooke* 146 (CAL) ; Jog falls, 28.4.1939, *N. L. Bor* 11351 (DD) ; Pune dist., Sakar Pathar hill slopes, 26.4.1964, *B. V. Reddi* 97783 (BSI, CAL) ; Lonaula, 27.4.1964, *B. V. Reddi* 97798 (BSI, CAL) ; 24.11.1964, *B. V. Reddi* 101161 (BSI, CAL) ; Katepani forest, Ambanne-Lonaula, 27.5.1964, *B. V. Reddi* 97842 (BSI, CAL).

(c) var. *zeylanica* Hook.f. Fl. Brit. Ind. 3 : 151. 1880 (*Type* : Sri Lanka. Hantane, April 1846, *Thwaites* C. P. 742 holo. K ! iso. BM ! CAL ! MH !) ; Alston in Suppl. to Trimen, Fl. Ceyl. 152. 1931.

*Pavetta zeylanica* (Hook.f.) Gamble, Fl. Pres. Madras 633. 1921 ; Bremek. in Fedde Repert. 37 : 90. 1934 ; Rothe in Journ. Econ. Tax. Bot. 7 : 249. 1985 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 21. 1987.

*P. zeylanica* (Hook.f.) Gamble var. *puberula* Bremek. in Fedde Repert. 37 : 90. 1934 (= var. *zeylanica*) ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 21. 1987, *nom. superfl.*

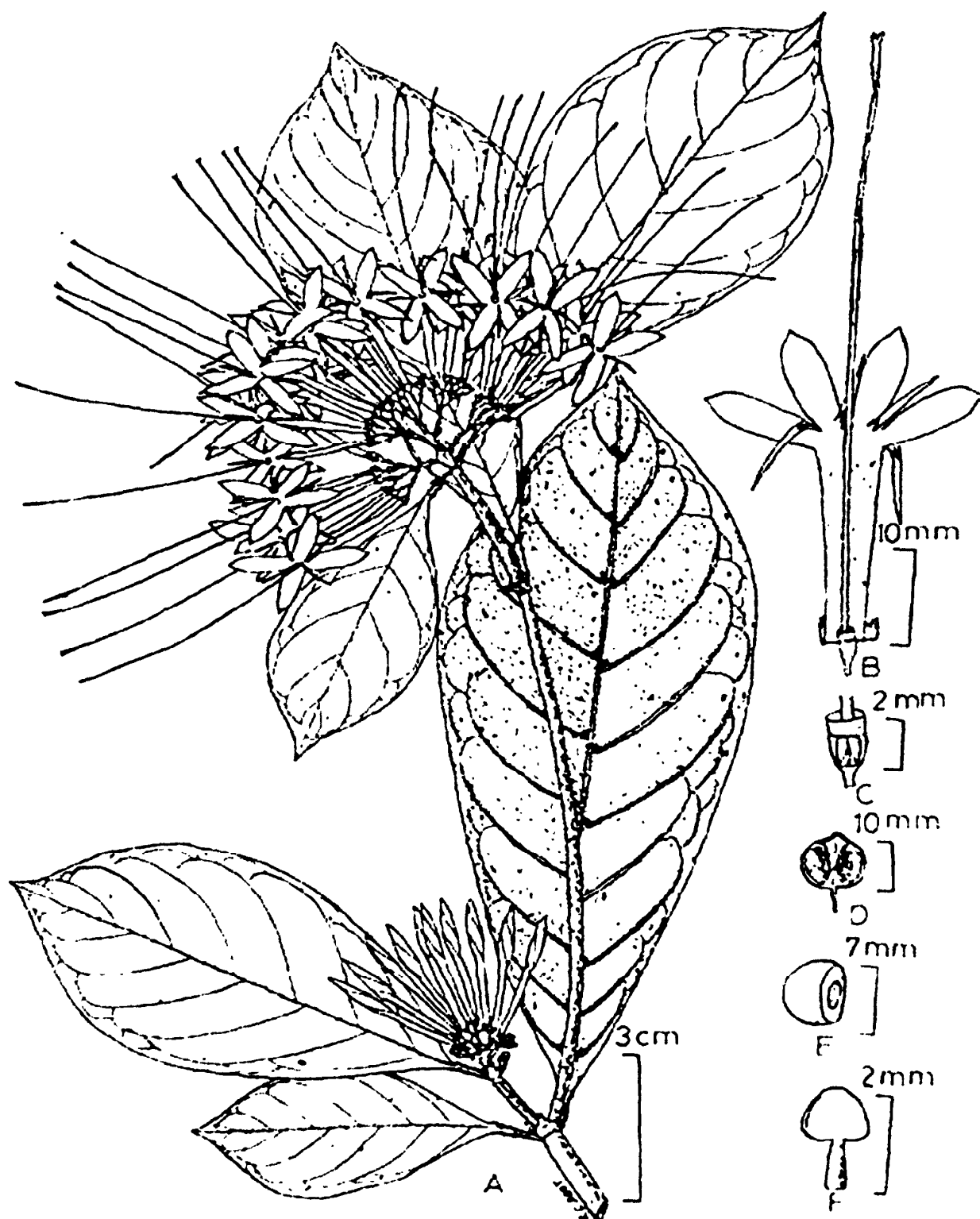
*P. zeylanica* (Hook.f.) Gamble var. *glabra* Bremek l.c. (*Type* : Sri Lanka, Coll. ? 123 holo K ! photo CAL !) *syn. nov.*

*P. calophylla* Bremek. in Fedde Repert. 37 : 90. 1934 (*Type* : Tamil Nadu, Nilgiri,

Devala, 900 m, Nov. 1884, *J. S. Gamble* 15555 holo. K ! photo CAL !) ; Sharma *et al.* in Biol. Mem. 2 : 72. 1977 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 20. 1987 ; Nair in Journ. Econ. Tax. Bot. 16 (3) : 643. 1992, *syn. nov.*

*P. hispidula* Thw. Enum. Pl. Zeyl. 156. 1859, *non* Wt. & Arn. 1834. (Fig. 25)

Shrubs, 1-2 m high, erect, branched ; stem stout, terete, glabrous or puberulous. Leaves petiolate, 5.5 – 25.2 × 2.7-7.8 cm, elliptic, elliptic-oblong, obovate or oblanceolate, acute, acuminate or caudate at apex, acute or cuneate at base, coriaceous or subcoriaceous, brownish pale when dry, glabrous above, glabrous, glabrescent or puberulous beneath; bacterial leaf-galls few to many on secondary or more finer nerves, circular (0.3-1.0 mm), elliptic (*ca* 1 × 0.5 mm) or oblong (*ca* 1.5 × 0.5 mm), more prominent on lower surface ; domatia rarely present (tuft type) on secondary nerve axils (*Thwaites* C. P. 742 CAL :) ; midrib subcanaliculate above ; lateral nerves 6-11 pair, alternate or subopposite, more prominent beneath ; petioles 0.5-3.2 cm stout, glabrous or puberulous ; stipules deciduous or persistent, interpetiolar, 3 – 15 × 2.4 - 6.0 mm, ovate or triangular, cuspidate, coriaceous or subcoriaceous, puberulous or glabrous outside, with colleters and trichomes inside ; colleters few to many, 432 – 1280 µm long, 128 – 256 µm broad, sessile or stalked feathery ; stalk 32 - 96 µm long, trichomes



**Fig. 25 :** *P. hispidula* Wt. & Arn. var. *zeylanica* Hook. f. A. habit ; B. flower split open showing floral parts ; C. placentation ; D. fruit ; E. seed ; F. embryo. All from *Thwaites C.P.* 742.

intermingled with colleter, few, silvery white, 464 - 1008  $\mu\text{m}$  long, 16 - 32  $\mu\text{m}$  across, pluricellular, cylindrical, 5 - 12 celled, straight or curved, outer wall smooth. Inflorescence terminal, sessile or subsessile trichotomously branched, corymbose cymes or terminating long (rarely short) axillary branches, with 1-2 pairs of anisophyllous (rarely isophyllous) leaves at the base, 5.5 - 11.0 cm across, puberulous or glabrous, cyme branches robust; peduncles upto 0.3 cm long, puberulous or glabrous; bracts 3.0 - 5.5  $\times$  4 - 6 mm, broadly triangular, membranous, glabrous or puberulous outside, puberulous beneath. Flowers 26 - 54; pedicels 2 - 11 mm long, stout, puberulous. Hypanthium 1.0 - 1.8  $\times$  1.0 - 1.6 mm, obovoid, puberulous; calyx tube 1 - 2  $\times$  2 - 2.5 mm, campanulate, puberulous outside, glabrous within; teeth 0.8 - 2.0  $\times$  0.4 - 1.2 mm, broadly triangular, acute at apex, puberulous. Corolla tube 22 - 34 mm long, 2.0 - 2.5 mm across, cylindrical, glabrous outside, pubescent within; lobes 10 - 15  $\times$  3.5 - 6.0 mm, oblong, acute or acuminate at apex, glabrous; internal indumentum 480 - 672  $\mu\text{m}$  long, ca 32  $\mu\text{m}$  broad, unicellular, flat, ribbon-like, surface pitted. Microcharacters: Inner surface of corolla lobes: epidermal cells bulging or ridged with striate, rugose or smooth cuticular surface. Filaments 1.5 - 3.0 mm, slender, glabrous; anthers 7 - 12 mm long; pollen 36  $\times$  35 (30 - 40  $\times$  29 - 37)  $\mu\text{m}$ , spheroidal, 3-zonocolporate; ecotocolpium 26  $\times$  4 (23 - 30  $\times$  3 - 6)  $\mu\text{m}$ , colpus membrane

smooth, ends acute; ora compound, combining types  $A_3$  and  $B_1$ ; type  $A_3$  lalongate, 6  $\times$  12 (5 - 8  $\times$  10-16)  $\mu\text{m}$ ; type  $B_1$  lalongate, 5  $\times$  2  $\mu\text{m}$ , thickened; apocolpium diameter 7  $\mu\text{m}$ ; exine 2  $\mu\text{m}$ , medium reticulate, columellate, lumina small near poles, amb circular. Ovary ca 1.2  $\times$  1.0 mm, disc ca 0.8  $\times$  1.0 mm; style 64-75 mm long, stout, glabrous below, puberulous above; stigma 0.5-1.0 mm, simple or notched, puberulous. Drupes 6 - 12 mm across, subglobose or didymous, glabrous, 1 or 2 seeded; seeds 5-7 mm, exotestal cells 64-160  $\mu\text{m}$  long, 50-80  $\mu\text{m}$  thick, hexagonal, with straight walls, surface striate-granulate; embryo ca 2 mm; radicle ca 1 mm, stout; cotyledons 2, equal, ca 1  $\times$  1 mm, foliaceous, ovate, rounded at apex, plumule minute, enclosed within cotyledons.

*External indumentum* 64-128  $\mu\text{m}$  long, 16-32  $\mu\text{m}$  across, 1-4 celled, apical cell acute, straight or curved, outer wall smooth.

*Fl.* : December-August; *Fr.* : January-September.

*Ecology* : In evergreen forests as undergrowth, at 500-1500 m altitude.

*Distrib.* : INDIA : Karnataka, Kerala, Tamil Nadu; SRI LANKA.

*Specimens examined* : INDIA. KARNATAKA : Hassan dist., Devarunde, 15. 4.

1971, *T. P. Ramamoorthy* 1602 (E) ; Bisleghat, 4. 5. 1971, *C. J. Saldanha & T. P. Ramamoorthy* 1657 (E).

KERALA : Wynaad dist., 1884, *M. A. Lawson* s.n. (DD, K) ; Travencore, Cardamom hills, 1050 m, 30.1.1895, *T. F. Bourdillon* 521 (MH) ; Malabor, South Atapadi hills, 840 m, 23.5.1911, *C.E.C. Fischer* 2800 (CAL) ; Idikki dist., 1000 m, 17.12.1974, *K. Vivekananthan* 45323 (MH); Forest down to Kundipujha dam, 1000 m, 10.3.1975, *E. Vajravelu* 46269 (MH) ; Palghat dist., Silent valley, 24.6.1976, *C. E. Ridsdale* 245 (L) ; eastern slope, 950 m, 17.1.1980, *P. Bhargava* 65527 (CAL) (MH); Kanapara estate, hospital area, 1100 m, 22.12.1980, *N. C. Nair* 69737 (CAL, MH) ; bank of Kamathanthode, 850 m, 17. 3. 1984, *N. C. Nair* 81267 (MH) ; Siruvani, ca 1500 m, 2.4.1990, *R.C. Rout* 3623 (CAL) ; Pathenthode, 750 m, 7.4.1978, *N. C. Nair* 56643 (CAL, MH) ; Kurisumalai, 750 m, 73.1979, *M. Mohanan* 59470 (MH) ; Trivandrum dist., Boneccord, 1300 m, 8.3.1979, *M. Mohanan* 61729 (MH); Adirumalai, 850 m, 3.3.1980, *M. Mohanan* 66009 (CAL, MH).

TAMIL NADU : Anamalai hills, 1200 m, *R. H. Beddome* 34 (CAL) ; Iyerpadi, 1200 m, 6.4.1914, *C. E. C. Fischer* 3719 (CAL) ; Kutallum hills, 1885, *R. H. Beddome* 3924 (BM) ; Udambansholay, 1500 m, Dec. 1909, *A. Meebold* 874 (CAL) ; Tirunelveli dist., Kuthiraivetti, 1050 m, 31.8.1963, *A. N.*

*Henry* 17391 (CAL, MH) ; Ramanathpuram dist., Sarthakoil, 1050 m, 13.6.1979, *S. R. Srinivasan* 63584 (MH) ; Sethur hills, 850 m, 15. 3. 1980, *S. R. Srinivasan* 65967 (CAL, MH) ; Naduthotham, 1300 m, 9. 3. 1981, *S. R. Srinivasan* 68035 (CAL, MH) ; Sengallteri, 1000 m, 29.6.1983, *N. Parthasarathy* 551 (MH) ; Coimbatore dist., Kodamparai, 1125 m, 20.2.1980, *M. Chandrabose* 65867 (CAL, MH) ; Siruvani hills, ca 500 m, 2.4.1990, *R. C. Rout* 3620 (CAL).

SRI LANKA : ?, 1821, *Moon* s.n. (L) ; *Walker* 1164 (E) ; Colombo, 1878, *M. N. Beckett* 239 (CAL) ; Gammaduma, jungle, 6.6.1927, *A. H. G. Alston* 660 (MH).

*Note* : *P. hispidula* var. *zeylanica* Hook.f. (1880) was raised to a specific status by Gamble (1921). Bremekamp (1934) distinguished 2 varieties under it : var. *puberula* Bremek. (var. *zeylanica*) and var. *glabra* Bremek., on the basis of hairiness of shoots, petioles and leaves ; shoots and petioles pubescent, leaves scabrous above and puberulous beneath, stipules pubescent and inflorescence puberulous in former and plant body entirely glabrous (except ovary and calyx) in latter variety. He (l.c.) further postulated *P. calophylla* as a new species, distinguishing it from *P. zeylanica* in leaves with 9-10 pair of nerves, oblong or narrowly obovate (leaves obovate with 6-8 pair of nerves in *P. zeylanica*). Study of protologues

and types along with other recent collections reveal that this species is variable in shape and hairiness of leaves. The leaves of *Thwaites C. P.* 742 (isotype of *P. zeylanica* at CAL ! BM !) are oblong or narrowly obovate. The lateral nerves are 6-11 pair. So, the new varieties and species described by Bremekamp (*l.c.*) do not stand. Moreover, *P. zeylanica* differs from *P. hispidula* in leaves brownish pale when dry, cyme branches more robust, hypanthium and calyx puberulous. These differences are not sufficient to treat it as a species. Hence, Hooker f. 's (*l.c.*) view is accepted here in treating it as a variety ; the new species and varieties of Bremekamp (*l.c.*) are treated here as synonyms under it.

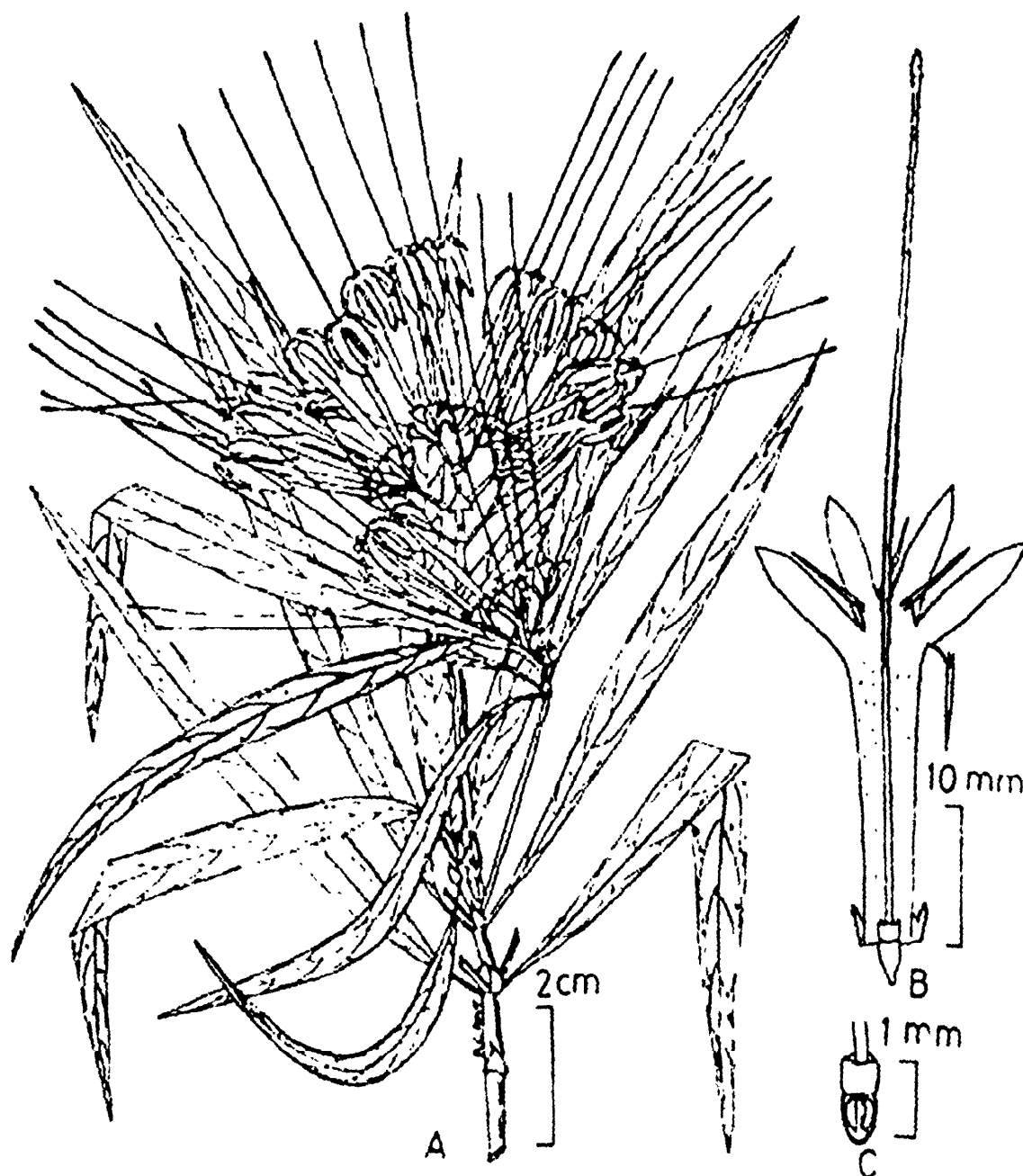
(d) var. **angustifolia** (Thw.) Hook.f. Fl. Brit. Ind. 3 : 151. 1880 (*Type* : Sri Lanka, Adam's Peak, 1854, *Thwaites C. P.* 267 K ! photo CAL ! , iso. BM ! CAL !).

*Pavetta angustifolia* Thw. Enum. Pl. Zeyl. 156. 1859 ; Beddome, Ic. Pl. Ind. Or. t. 99. 1874 & Fl. Sylv. For. Man. 134/8. 1874 ; Trimen, Hort. Zeyl. 43. 1888 & Fl. Ceyl. 2 : 350. 1894 ; non. *Pavetta angustifolia* (Lam.) Roxb. et Smith in Syst. 3 : 174. 1818.

*Pavetta agrostiphylla* Bremek. in Fedde Repert. 37 : 89. 1934 ; Backer & Bakh. Fl. Java 2 : 234. 1965, *Syn. nov.* (Fig. - 26).

Shrubs erect, branched ; stem slender, terete or flattened, glabrous. Leaves petiolate,

4.5 -20.0 × 0.5-3.0 cm, linear or linear lanceolate, acuminate at apex, attenuated at base, coriaceous, black when dry, glabrous on both surfaces ; bacterial leaf-galls few on secondary or more finer nerves, circular (0.5-1.0 mm), more prominent on lower surface ; domatia absent ; midrib subcanaliculate above ; lateral nerves 7 - 11 pair, alternate or subopposite, slender, more prominent beneath ; petioles 0.4 - 2.0 cm, glabrous ; stipules persistent, intra-or interpetiolar, 4 - 6 × 4 - 5 mm, triangular, cuspidate, subcoriaceous, scarious, sparsely pubescent outside, with colleters and trichomes inside ; colleters few on adaxial surface of stipules 400 - 512 µm long, 160-240 µm broad, sessile, feathery ; trichomes intermingled with colleters, many, 960 - 1520 µm long, 28-32 µm across, pluricellular, cylindrical, 5 - 8 celled, apical cell acute, straight, outer wall smooth. Inflorescence terminal, rarely axillary, sessile or peduncled trichotomously branched corymbose cymes, 4-8 cm across, glabrous or pubescent ; peduncles up to 3 cm, glabrous ; bracts 3-4 × 3-4 mm, triangular, cuspidate, membranous, sparsely pubescent outside, glabrous within. Flowers 8-22 ; pedicels 3-7 mm, stout, glabrous. Hypanthium *ca* 1.2 × 1.8 mm, obovoid, glabrous ; calyx tube *ca* 1.2 × 2.0 mm, broader above, glabrous ; teeth 1-1.2 × 0.6-0.8 mm, oblong or triangular, acute at apex, sparsely pubescent on the margin. Corolla tube 20 - 22 mm long, 1.5 - 3.0 mm across, cylindrical, glabrous outside, sparsely pubescent within ; lobes 10-12 × 2.5-3.0 mm, oblong, acute at



**Fig. 26 :** *P. hispidula* Wt. & Arn. var. *angustifolia* (Thw.) Hook. f. A. habit ; B. flower split open showing floral parts ; C. placentation ; All from *Thwaites C.P.* 267.

apex, glabrous. Microcharacters of outer surface of corolla tube : epidermal cells elongated, surface with fine longitudinal cuticular striations ; inner surface of corolla lobes epidermal cells ridged with striate or rugose cuticular surface. Filaments *ca* 2 mm, stout, puberulous; anthers 7-8 mm ; pollen  $36 \times 33$  ( $32 - 41 \times 25-35$ )  $\mu\text{m}$ , prolate-spheroidal, 3-zonocolporate, ectocolpium  $31 \times 4$  ( $24 - 32 \times 2 - 5$ )  $\mu\text{m}$ , colpus membrane granulate, ora compound, combining types  $A_3$  and  $B_1$  ; type  $A_3$  lalongate,  $5 \times 12$  ( $4-7 \times 8-15$ )  $\mu\text{m}$  ; type  $B_1$  lalongate,  $5 \times 4$   $\mu\text{m}$ , elliptic, thickened, apocolpium diameter 6  $\mu\text{m}$ , exine 2  $\mu\text{m}$ , medium reticulate, columellate. Ovary *ca*  $1 \times 1$  mm, disc *ca*  $1 \times 1$  mm ; style 48-65 mm, stout, glabrous below, puberulous above ; stigma *ca* 2 mm, simple, clavate, puberulous. Drupes 5-6  $\times$  5-8 mm across, subglobose or didymous, glabrous ; seeds 1 or 2, *ca* 4 mm ; exotestal surface colliculate or pusticulate ; embryo *ca* 2 mm; radicle *ca* 1 mm, stout ; cotyledons 2, equal, foliaceous, *ca*  $1 \times 1$  mm, reniform, rounded at apex, cordate at base ; plumule minute, enclosed within cotyledons.

*External indumentum* 400 - 560  $\mu\text{m}$  long, 48 - 80  $\mu\text{m}$  across, pluricellular, cylindrical, 3-5 celled, apical cell acute, straight, outer wall smooth.

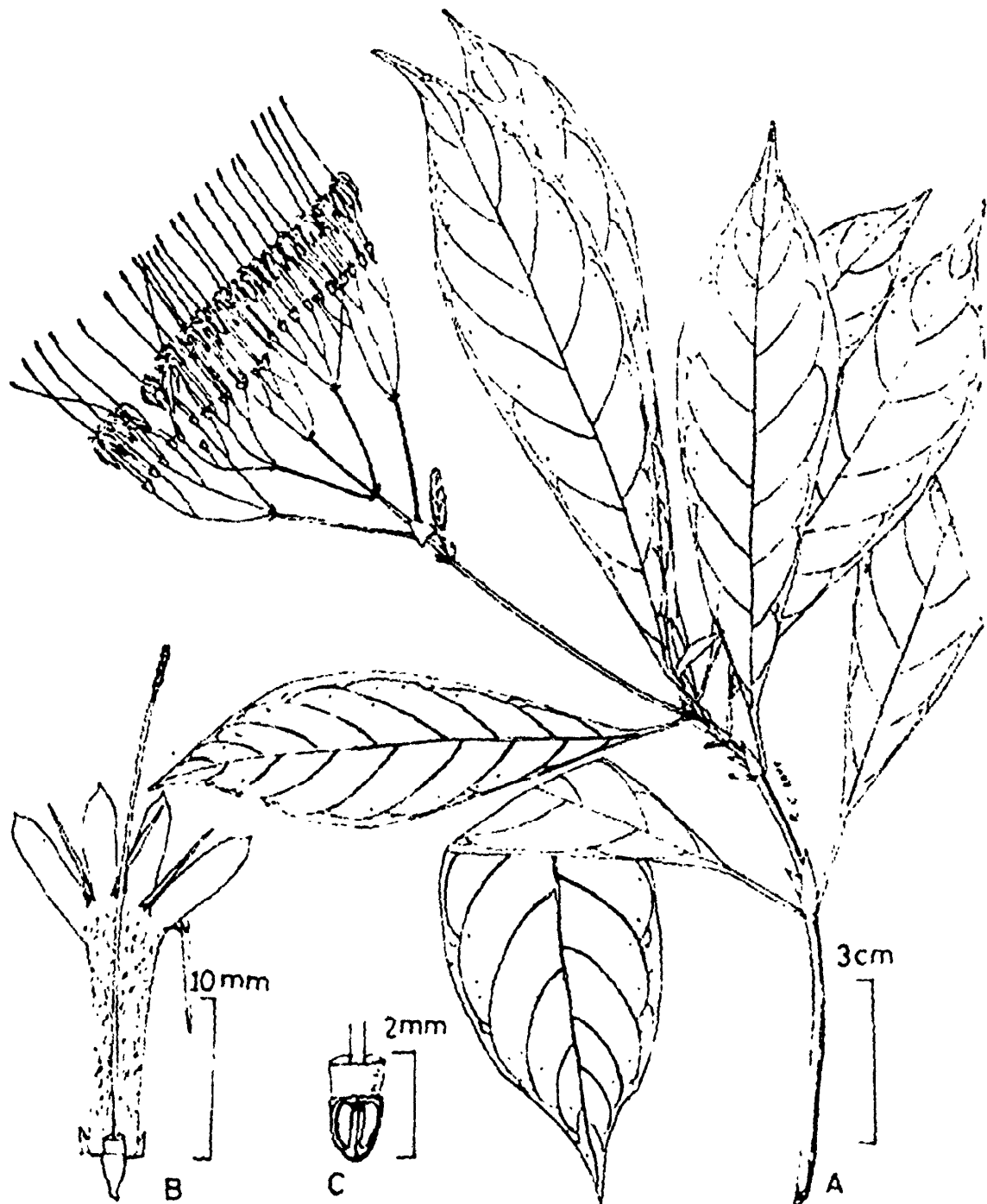
*Fl.* : March - August ; *Fr.* : ?

*Distrib.* : SRI LANKA (Ceylon) : Adam's Peak at 350 - 400 m altitude.

*Specimens examined* : SRI LANKA : Watsan, Aug. 1836, *Coll.* ?, s.n. (CAL) ; Haragama river bank, 29.5.1932, *N. D. Simpsons* 9727 (BM) ; Adam's Peak, Ratnapura, 350-400 m, 7.3.1973, *Bernardi* 14128 (BM) ; *Coll.* ?, s.n. (MH).

- 11. Pavetta hohenackeri** Bremek. in Fedde Repert. 37 : 98. 1934 (*Type* : Tamil Nadu, Nilgiri hills, Sispara, February, *Hohenacker* 1379 holo. K ! , photo CAL: iso. BM !, L !) Blasco in Journ. Bomb. Nat. Hist. Soc. 67 : 524. 1970 ; Sharma *et al.* in Biol. Mem. 2 : 72. 1977; Abraham & Mehrotra in Journ. Econ. Tax. Bot. 3 : 864. 1982 ; Ahmed. & Nayar, End. Pl. Ind. Reg. 1 : 162. 1987 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 20. 1987 ; Deb & Rout in Nayar & Sastry (ed.), Red Data Book 3 : 225 226 t. 1990. (Fig. 27)

Shrubs erect, branched ; stem slender, corky, terete, glabrous. Leaves 7.0-16.2  $\times$  1.8-4.1 cm, narrowly obovate or oblanceolate, acuminate at apex, cuneate or attenuated at base, membranous, glabrous ; bacterial leaf-galls few to many on secondary or more finer nerves, circular, 0.5-1.0 mm, more prominent on upper surface ; domatia absent ; lateral nerves 7-9 pair, slender, alternate, more prominent beneath ; petioles 0.8-2.0 cm, slender, glabrous ; stipules persistent, interpetiolar, 8-12  $\times$  3-4 mm, narrowly triangular, acute at apex, subcoriaceous,



**Fig. 27 :** *P. hohenackeri* Bremek. A. habit ; B. flower split open showing floral parts ; C. placentation. All from R. F. Hohenacker 1379.

scarios, glabrous, with colleters within ; colleters many, 640 - 1168  $\mu\text{m}$  long, 288 - 336  $\mu\text{m}$  broad, sessile, feathery ; trichomes absent. Inflorescence terminal, peduncled, trichotomously branched, loosely corymbose cymes, 5-7 cm across, glabrous ; peduncles 4.5-6.0 cm, slender, glabrous ; bracts 5-7  $\times$  3-4 mm, membranous, glabrous. Flowers 15-36 ; pedicels 5 - 20 mm long, slender, glabrous. Hypanthium *ca* 1  $\times$  1 mm, obovoid, glabrous ; calyx tube 0.7 - 0.8  $\times$  1.5 mm, broader above, glabrous ; teeth 0.4 - 0.5  $\times$  0.2 - 0.3 mm, narrowly triangular, acute at apex, glabrous. Corolla tube 14 - 18 mm long, 1.2 - 1.5 mm across, cylindrical, glabrous outside, pubescent within ; internal indumentum 320 - 640  $\mu\text{m}$  long, 16 - 32  $\mu\text{m}$  broad, unicellular, ribbon like, outer wall pitted ; lobes 7.0-7.5  $\times$  2.5 mm, oblong, mucronulate at apex, glabrous. Microcharacters of inner surface of corolla lobes : epidermal cells ridged with rugose cuticular surface. Filaments 1.0-1.5 mm, puberulous ; anthers *ca* 7 mm ; pollen 37  $\times$  27 (32-38  $\times$  23-29)  $\mu\text{m}$ , prolate, 3-zonocolporate ; ectocolpium 30  $\times$  3 (27-32  $\times$  2-5)  $\mu\text{m}$ , colpus membrane smooth ; ora simple, type A<sub>3</sub>, lalongate, 5  $\times$  10 (4 - 6  $\times$  7-14)  $\mu\text{m}$  ; apocolpium diameter 7  $\mu\text{m}$  ; exine 2  $\mu\text{m}$ , coarsely reticulate, columellate. Ovary *ca* 0.8  $\times$  0.8 mm ; disc *ca* 0.6  $\times$  0.8 mm ; style 28 - 31 mm long, slender, glabrous below, puberulous above ; stigma 1-2 mm, simple or slightly notched, puberulous. Fruits not seen.

*Fl.*: February ; *Fr.* : March - April.

*Ecology* : In the evergreen forests at 2200 m in altitude.

*Distrib.* : INDIA. Tamil Nadu : Nilgiri hills, Sispara ; Tiruchirapalli.

*Note* : This species is represented by type collection only. It is endemic to Sispara and Tiruchirapalli (Tamil Nadu). As it has not been collected after the original gathering, though the locality has been explored intensively in recent years by the Botanical Survey of India, it is apparently extinct.

**12. Pavetta indica** L. Sp. Pl. 1 : 110. 1753 ; Syst. Nat. ed. 10, 2 : 894. 1759 ; Sp. Pl. ed. 2, 1 : 160. 1762 & ed. 3, 1 : 160. 1764 ; Syst. Nat. ed. 12, 2 : 120. 1767 [*Type* : Sri Lanka (Ceylon), *Herman* 56 BM] ; Murray, Syst. Veg. ed. 13, 129. 1774 & ed. 14, 153. 1784 & ed. 15, 153. 1797 ; Gaert. Sem. Pl. 1 : 116. 1788 ; Willd. Sp. Pl. ed. 4, 1 (2) : 610. 1798 ; Turton, Gen. Syst. Nat. 5 : 216. 1802 ; Pers. Syn. Pl. 1 : 131. 1805 ; Roem. & Schult. Syst. Veg. 3 : 173. 1818 & 3 : 109. 1827 ; Moon, Cat. Pl. Ind. Ceyl. 10. 1821 ; Roth, Nov. Pl. 87. 1821 ; Sprengel, Syst. Veg. ed. 16, 407. 1825 ; DC. Prodr. 4 : 491. 1830 ; G. Don, Gen. Syst. Gard. Bot. 3 : 574. 1834 ; Wt. & Arn. Prodr. 1:431. 1834 ; Graham, Cat. Pl. Bomb. 92. 1839 ; Wt. Ic. Pl. 1 : t. 148. 1840 ;

Walpers, Rep. Bot. Syst. 2 : 480. 1843; Voight, Hort. Sub. Calc. 391. 1845; Miq. Fl. Ind. Bat. Suppl. 222. 1860; Dalz. & Gibs. Bomb. Fl. 112. 1861; Benth. Fl. Hongkong. 157. 1861; Drury, Hand Book Ind. Fl. 1 : 571. 1864; Anders. Cat. Pl. 27. 1865; Thw. Enum. Pl. Zeyl. 155. 1859; Brandis, For. Fl. 275. 1874; Bedd. in Ind. For. 3 : 203. 1877; Hook.f. Fl. Brit. Ind. 3 : 150. 1880; Forb. & Hems. Enum. Pl. 1 : 386. 1886; Birdwood in Journ. Bomb. Nat. Hist. Soc. 2 : 118. 1887; Trimen, Hort. Zeyl. 43. 1888; Schum. in Engl. & Prantl. Nat. Pflz. Fam. 4 : 107. 1891; Prain in Journ. Bomb. Nat. Hist. Soc. 7 : 475. 1893; Talbot, Syst. List. 111. 1894; Trimen, Fl. Ceyl. 2 : 349. 1894; Gammie in Rec. Bot. Surv. Ind. 1 (5) : 81. 1895; Gamble, List Trees Shrubs 49. 1896; Birdwood in Journ. Bomb. Nat. Hist. Soc. 10 : 411. 1896; Kanj. For. Fl. 206. 1901; Gage in Rec. Bot. Surv. Ind. 1 : 347. 1901; Duthie, Fl. Upp. Gang. Pl. 1 : 390. 1903; Prain, Beng. Pl. 1 : 417. 1903; Gammie in Journ. Bomb. Nat. Hist. Soc. 15 : 287. 1903; Cooke, Fl. Pres. Bomb. 2 : 41. 1904; Fischer in Journ. Bomb. Nat. Hist. Soc. 15 : 547. 1904; King & Gamble in Journ. Asiat. Soc. Bengal 73 (2) : 83. 1905; Prain in Rec. Bot. Surv. Ind. 3 (2) : 223. 1905; Brainds, Ind. Trees 387. 1906; Blatter in Journ. Bomb. Nat. Hist. Soc. 18 : 409. 1908; Bourd. For. Trees Travanc 225. 1908; Blatter in Journ. Bomb. Nat. Hist. Soc. 19 : 326. 1909;

Haines, For. Fl. Chot. 506. 1910; Craib in Kew Bull. 1911 : 395. 1911; Talbot, For. Fl. Bomb. Sind 2 : 117. 1911; Merrill, Fl. Manila 452. 1912; Matsum. Ind. Pl. Jap. 2 : 594. 1912; Gibs in Journ. Linn. Soc. (Bot.) 42 : 94. 1914; Rama Rao, Fl. Pl. Travanc. 213. 1914; Ramasw. in Rec. Bot. Surv. Ind. 6 (5) : 135. 1914; Haines, Descr. List 306. 1916; Fischer in Rec. Bot. Surv. Ind. 9 : 95. 1921; Gamble, Fl. Pres. Madras 633. 1921; Haines, Bot. Bih. Or. 2 : 456. 1922; Ridl. Fl. Mal. Pen. 2 : 100. 1923; Issac, Comm. Fl. Pl. West. Ind. 160. 1927; Mayuran. in Bull. Madras Govt. Mus. (N.S.) 2 : 147. 1929; Blatter in Journ. Bomb. Nat. Hist. Soc. 36 : 792. 1933; Kanj. For. Fl. Pilibhit 210. 1933 & For. Fl. Pl. U.P. 3 : 385. 1966; Bremek. in Fedde Repert. 37 : 118. 1934; Craib, Fl. Siam. Enum. 2 (2) : 168. 1934; Sayeed. in Journ. Asiat. Soc. Bengal (Sci.) 1 : 54. 1935; Alston, Kendy Fl. 49. 1938; Fischer in Rec. Bot. Surv. Ind. 12 (2) : 102. 1938; Kanj. *et al.* Fl. Assam 3 : 72. 1939; Biswas in Ind. For. Rec. 3 : (1) : 27. 1940; Mooney in Ind. For. Rec. 3 (2) : 115. 1914; Sayeed. in Journ. Bomb. Nat. Hist. Soc. 42 : 913. 1941; Sabins in Journ. Bomb. Nat. Hist. Soc. 42 : 369. 1941; Bal in Rec. Bot. Surv. Ind. 6 (10) : 74. 1942; Jain & Bharadw. in Ind. For. 75 : 311. 1949; Bond, Wild Fls. Ceylon 86. 1953; Sant. in Rec. Bot. Surv. Ind. 16 : 136. 1953; Mudaliar. & Kamath in

Journ. Bomb. Nat. Hist. Soc. 52 : 77. 1954 ; Kitamura in Kihara, Fauna Fl. Nep. Him. 1 : 231. 1955 ; Sant. & Rand. in Journ. Bomb. Nat. Hist. Soc. 53 : 194. 1955 ; Srivast. in Journ. Ind. Bot. Soc. 34 : 203. 1955 & 35 : 320. 1956 ; Sant. Fl. Purandh. 62. 1957 ; Balapure in Ind. For. 85 : 344. 1959 ; Raizada in Ind. For. 85 : 678. 1959 ; Subram. in Bull. Bot. Surv. Ind. 1 : 131. 1959 ; Puri & Mahajan in Bull. Bot. Surv. Ind. 2 : 124. 1960 ; Rao in Bull. Bot. Surv. Ind. 2 : 77. 1960 ; Sant. in Rec. Bot. Surv. Ind. 16 : 107. 1960 ; Deb in Bull. Bot. Surv. Ind. 3 : 312. 1961 ; Sriniv. & Subba Rao in Journ. Bomb. Nat. Hist. Soc. 58 : 170. 1961 ; Arora in Journ. Ind. Bot. Soc. 63 : 78. 1964 ; Ramasw. in Bull. Bot. Surv. Ind. 6 : 18. 1964 ; Banerjee in Rec. Bot. Surv. Ind. 19 : 52. 1965 ; Biswas, Pl. Darj. Sikkim Him. 427 : 1966 ; Jain & De in Bull. Bot. Surv. Ind. 8 : 52. 1966 ; Malick in Bull. Bot. Surv. Ind. 8 : 224. 1966 ; Matthew in Bull. Bot. Surv. Ind. 8 : 162. 1966 ; Rao in Bull. Bot. Surv. Ind. 8 : 300. 1966 ; Ellis *et al.* in Bull. Bot. Surv. Ind. 9 : 9. 1967 ; Sebast. & Ellis in Bull. Bot. Surv. Ind. 9 : 195. 1967 ; Subba Rao & Kumari in Bull. Bot. Surv. Ind. 9 : 104. 1967 ; Naidu & Rao in Ind. For. 93 : 123. 1967 ; Ellis in Bull. Bot. Surv. Ind. 10 : 155. 1968 ; Petal, For. Fl. Melghat 188. 1968 ; Rao & Verma in Bull. Bot. Surv. Ind. 11 : 408. 1969 ; Matthew in Bull. Bot. Surv. Ind. 12 : 85. 1970 ; Malhotra & Moorthy in

Bull. Bot. Surv. Ind. 13 : 304. 1971 ; Sastry & Rao in Bull. Bot. Surv. Ind. 15 : 99. 1973 ; Sant. & Henry, Dict. Fl. Pl. Ind. 126. 1976 ; Sald & Nicol. Fl. Hassan 587. 1976 ; Kulkarni & Thite in Journ. Bomb. Nat. Hist. Soc. 74 : 598. 1977 ; Sharma *et al.* in Biol. Mem. 2 : 72. 1977 & in Journ. Bomb. Nat. Hist. Soc. 75 : 27. 1978 ; Suri in Ind. For. 104 : 195. 1978 ; Bennet, Fl. Howrah 356. 1979 ; Hara & Gould in Hara & William, En. Fl. Pl. Nep. 2 : 206. 1979 ; Subr. & Kaly. in Ind. Journ. For. 3 : 441. 1980 ; Matthew, Mat. Fl. Tam. Nad. Carn. 1 : 235. 1981 ; Paul in Journ. Bomb. Nat. Hist. Soc. 78 : 26. 1981 ; Rao & Razi, Syn. Fl. Mysore 538. 1981 ; Deb in Ind. For. 107 : 579. 1981 ; Chaudh. & Pattn. in Journ. Econ. Tax. Bot. 3 : 806. 1982 ; Manil. & Shivr. Fl. Calic. 146. 1982 ; Nair in Ind. Journ. For. 5 : 207. 1982 ; Deb, Fl. Trip. State 2 : 77. 1983 ; Matthew, Fl. Tam. Nad. Carn. 3 (1) : 732. 1983 ; Biswas in Journ. Bomb. Nat. Hist. Soc. 81 : 222. 1984 ; Chaudh & Wadh. Fl. Him. Pr. 2 : 348. 1984 ; Guhabakshi, Fl. Murshid. 158. 1984 ; Naith. Fl. Cham 1 : 290. 1984 ; Polumin & Stainton, Fl. Himal. 174. 1984 ; Safui & Bhattach. in Journ. Econ. Tax. Bot. 5 : 803. 1984 ; Sharma *et al.* Fl. Karn. 131. 1984 ; Ellis, Fl. Nallam. 1 : 213. 1987 ; Nair in Journ. Econ. Tax. Bot. 11 : 380. 1987 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 20. 1987 ; Nair & Nair, Fl. Court. 2 : 321. 1987 ; Rao & Yogan. in Journ. Econ.

Tax. Bot. 9 : 199. 1987 ; Rastogi *et al.* in Journ. Econ. Tax. Bot. 9 : 423. 1987 ; Vajrav. *et al.* in Journ. Econ. Tax. Bot. 10 : 276. 1987 ; Vajrav. in Journ. Econ. Tax. Bot. 11 : 266. 1987 ; Singh, Fl. East. Karn. 1 : 352. 1988 ; Bhirav. & Mohan in Journ. Econ. Tax. Bot. 15 : 55. 1991 ; Deb & Rout in Journ. Bomb. Nat. Hist. Soc. 89 (3) : 351. 1992.

*Ixora indica* (L.) Kuntze, Rev. Gen. Pl. 1 : 286. 1891.

*I. paniculata* Lam. Encycl. 3 : 344. 1789.

*I. pavetta* Roxb. Hort. Beng. 11. 1814, *nom. nud.* & Fl. Ind. 1 : 396. 1820.

*Pavetta alba* Vahl, Sumbl. Bot. 3 : 11. 1794.

*P. obtusa* Pers. Syn. 1 : 131. 1805.

*P. crassicaulis* auct. non Bremek., Kar. & Panigrahi in Bull. Bot. Surv. Ind. 5 : 234. 1963 ; Panigr. *et al.* in Bull. Bot. Surv. Ind. 6 : 250. 1964 ; Ghosh *et al.* in Ind. For. 104 : 113. 1978 ; Bennet, Name Ch. Fl. Pl. 415. 1987.

*P. thomsonii* Bremek. in Fedde Repert. 37 : 99. 1934 ; Sald. & Nicol. Fl. Hassan 588. 1976.

Shrubs or small trees, 1-9 m high, erect, branched ; stem stout, terete or quadrangular,

glabrous or pubescent, corky in age. Leaves 3.0 - 26.5 × 1.0 - 12.0 cm, elliptic, elliptic-oblong, elliptic-obovate, elliptic-lanceolate, obovate, oblanceolate or ovate, obtuse, subacute or acuminate at apex, cuneate, acute or attenuated at base, membranous, subcoriaceous or coriaceous, glabrous, glabrescent, sparsely pubescent or scabrous above, glabrescent, pubescent or tomentose beneath, sometimes only on nerves beneath ; bacterial leaf-galls present ; domatia present or absent ; midrib canaliculate or subcanaliculate above, glabrous or pubescent ; lateral nerves 5 - 17 pair, alternate or subopposite, slender or stout, glabrous or pubescent, more prominent beneath ; petioles 0.4 - 4.2 cm, slender or stout, glabrous or pubescent ; stipules persistent, interpetiolar, 2-10 × 2 - 12 mm, broadly or narrowly triangular, cuspidate (cusps short or long), coriaceous or subcoriaceous, glabrous or pubescent outside, with colleters and trichomes within ; colleters few many on the adaxial surface of stipules, stalked, dendroid or sessile feathery, trichomes intermingled with colleters few to many, silvery white, multicellular, cylindrical. Inflorescence terminal on main shoot (rarely on axillary branches), sessile, subsessile or peduncled, trichotomously branched, corymbose cymes, glabrous, pubescent or tomentose ; peduncles up to 1 cm, glabrous or pubescent ; bracts 4-10 × 4 - 11 mm, broadly triangular, cuspidate, membranous, glabrous or pubescent. Flowers 40 - 250 ; pedicels 2 - 7 mm, glabrous, glabrescent or pubescent. Hypanthium 0.5-

1.2 × 0.5 - 1.2 mm, obovoid, or subglobose, glabrous, pubescent or tomentose ; calyx tube 0.5 - 1.0 × 1.0-1.5 mm, broader above, glabrous or pubescent ; teeth 0.2 - 0.8 × 0.1-0.6 mm, dentate or narrowly triangular, acute at apex, glabrous or pubescent. Corolla tube 8-18 mm long, 0.5-1.5 mm across, cylindrical, glabrous outside, pubescent within, glabrous at throat ; lobes 4-8 × 1.5-2.5 mm, elliptic, elliptic-oblong or oblong, acute, subacute, obtuse or mucronulate at apex, glabrous ; internal indumentum unicellular, ribbon-like. Microcharacters of outer surface of corolla tube : epidermal cells elongated with fine longitudinal cuticular striations ; inner surface of corolla lobes : epidermal cells ridged, bulging or depressed with rugose, striate or smooth cuticular surface. Filaments 0.5 - 1.5 mm, slender, glabrous ; anthers 3 - 6 mm ; pollen prolate or subprolate, 3-zonocolporate or 3-zonocolpororate. Ovary 0.7 - 0.8 × 0.6 - 0.8 mm ; disk 0.3 - 0.8 × 0.6 - 0.8 mm ; style 17 - 43 mm long, glabrous or puberulous below, puberulous above : stigma 0.5 - 3.0 mm, simple, clavate or slightly notched, puberulous or glabrous. Drupes 4 - 12 mm across, globose, subglobose or didymous, shining, glabrous or pubescent, with or without persistent calyx, 1 - 2 seeded ; seeds 3 - 5 mm ; exotestal cells hexa-or pentagonal, with straight walls, surface striate, granulate, striate-granulate or colliculate ; embryo 2 - 3 mm ; radicle 1 - 1.6 mm, stout ; cotyledons 2, equal, foliaceous, 1.0 - 1.8 × 1.0 - 2.0 mm, reniform, obtuse or rounded at apex, cordate

or subcordate at base ; plumule minute, enclosed within cotyledons.

#### KEY TO THE VARIETIES

1. Leaves glabrous beneath or nearly so, cymes glabrous or glabrescent ... (a) var. *indica*
- 1a. Leaves pubescent or tomentosa beneath or only on nerves ; cymes pubescent or tomentose ... 2
2. Leaves pubescent beneath or only on nerves ; cymes pubescent ; cymes branches not spreading ... (b) var. *glabrescens*
- 2a. Leaves tomentose beneath ; cymes tomentose ; cyme branches spreading ... (c) var. *tomentosa*

(a) var. *indica* ; Deb & Rout in Journ. Bomb. Nat. Hist. Soc. 89 (3) : 351. 1992.

*P. indica* L. var. *glabra* Blatter & Hallberg in Journ. Bomb. Nat. Hist. Soc. 36: 792. 1933.

*P. indica* L. var. *glabra* Bremek. in Fedde Repert. 37 : 119. 1934.

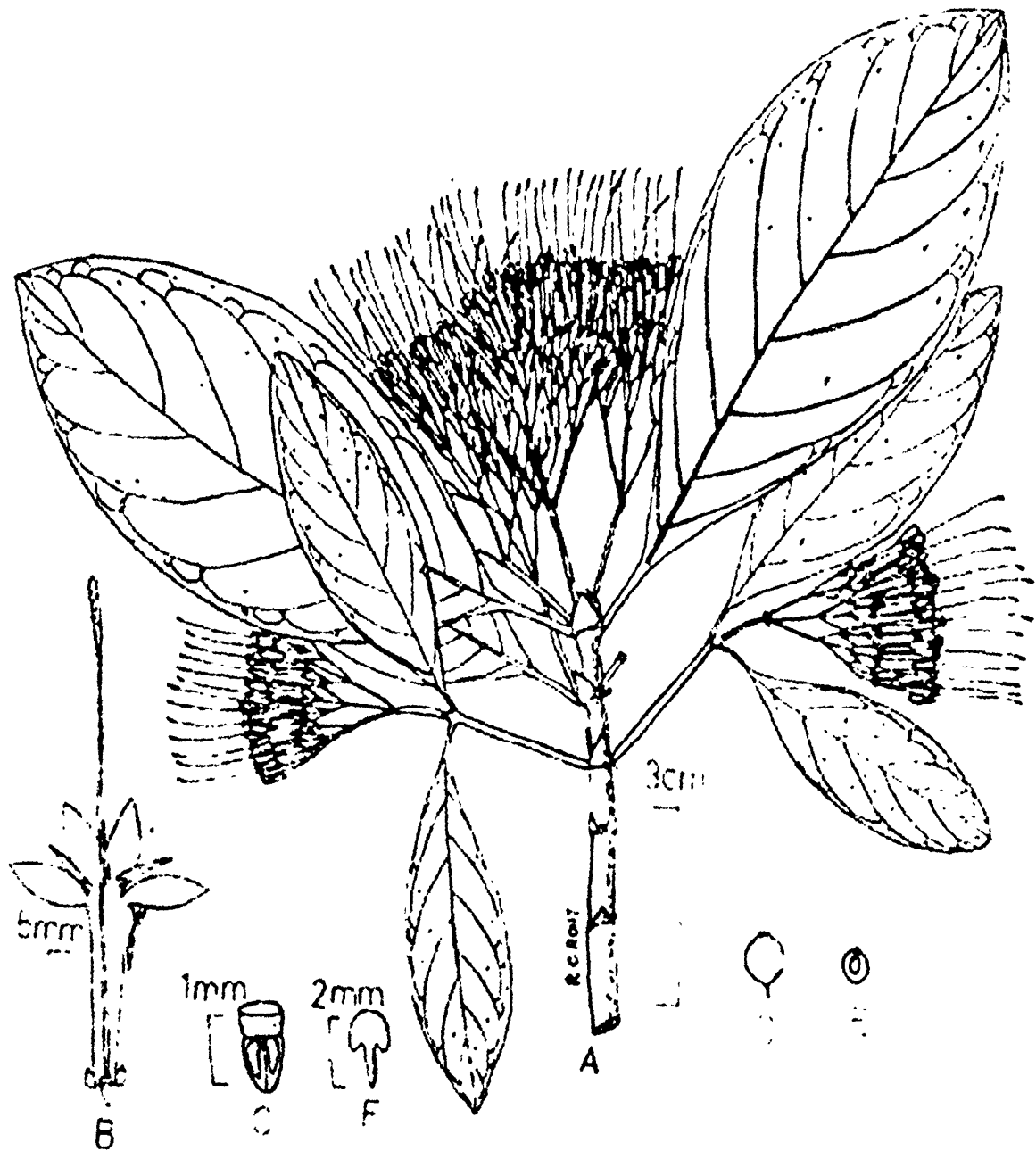
*P. thomsonii* Bremek. var. *glaberrima* Bremek. in Fedde Repert. 37 : 99. 1934 (Type: Mysore, *Thomson s.n.* holo. K ! photo CAL ! ) ; B. D. Sharma *et al.* Fl. Karnataka 131. 1984 ; Vajrav. in Journ. Econ. Tax. Bot. 12 : 62. 1988.

*P. thomsonii* Bremek. var. *thomsonii*, B. D. Sharma *et al.* Fl. Karnata Ka 131. 1984 ; Swaminath. in Henry *et al.* Tam. Nad. 2 : 21. 1987.

*P. Blanda* Bremek. in Fedde Repert. 37 : 94. 1934, pp. (Fig. 28)

Shrubs or small trees 3 - 4 m high, erect, branched ; stem stout, terete or 4-angled, glabrous, corky in age. Leaves 7.0 - 15.0 × 2.2 - 7.0 cm, elliptic or elliptic-oblong, rarely elliptic-lanceolate, obtuse or subacute at apex, cuneate or acute at base membranous, glabrous above, glabrous or glabrescent beneath ; bacterial leaf-galls many on secondary or tertiary nerves, elliptic (*ca* 1 × 0.5 mm) or circular (*ca* 0.5 mm), rarely curved, branched or dum-bell shaped (by union of 2 or more galls), more prominent on upper surface ; domatia absent ; midrib subcanaliculate above, glabrous ; lateral nerves 9 - 11 pair, alternate or subopposite, more prominent beneath ; petioles 0.4 - 2.0 cm, stout, glabrous ; stipules persistent, interpetiolar, 6 - 7 × 5 - 6 mm, broadly triangular, cuspidate, subcoriaceous, glabrous outside, with colleters and trichomes inside ; colleters few on adaxial surface of stipules, 176 - 880 µm long, 240 - 320 µm broad, stalked, dendroid ; stalk 80 - 96 µm ; trichomes intermingled with colleters few, 320 - 1328 µm long, 24 - 32 µm across, pluricellular, cylindrical, 2 - 14 celled, apical cell acute, outer wall smooth. Inflorescence terminal, shortly peduncled, trichotomously

branched, loosely corymbose cymes, 7 - 9 cm across, glabrous or glabrescent ; peduncles 0.3 - 0.8 cm long, glabrous ; bracts *ca* 5 × 5 mm, broadly triangular, cuspidate, membranous, glabrous. Flowers 100 - 250 ; pedicels 2.5 - 4.0 mm, glabrous, rarely glabrescent. Hypanthium *ca* 0.5 × 0.8 mm, obovoid, glabrous, rarely sparsely pubescent ; calyx tube *ca* 1 × 1 mm, broader above, glabrous, truncate or dentate ; teeth *ca* 0.2 × 0.1 mm, glabrous. Corolla tube 8 - 14 mm long, 0.5 - 1.0 mm, across, cylindrical, glabrous outside, sparsely pubescent within ; lobes 5.0 - 5.5 × 2.0 mm, elliptic-oblong, acute at apex, glabrous ; internal indumentum 272 - 256 µm long, 16 - 24 µm broad, unicellular, ribbon like, acute at apex, surface pitted. Microcharcters of outer surface of corolla tube : epidermal cells elongated, surface with fine longitudinal cuticular striations ; inner surface of corolla lobes : epidermal cells ridged with rugose cuticular surface. Filaments *ca* 0.5 mm, glabrous ; anthers *ca* 4 mm ; pollen 32 × 18 (29 - 35 × 15 - 22) µm, prolate ; 3-zonocolporate, ectocolpium 24 × 4 (22 - 28 × 3 - 7) µm, colpus membrane smooth, ends acute ; ora simple, type A<sub>3</sub>, lalongate, 5 × 8 (3 - 6 × 7 - 10) µm ; apocolpium diameter 7 µm ; exine 1 µm, medium reticulate, columellate, lumina *ca* 1 µm, circular. Ovary *ca* 0.8 × 0.7 mm ; disc *ca* 0.5 × 0.7 mm ; style 23 - 25 mm long, glabrous ; stigma *ca* 3 mm, *ca* simple, fusiform, puberulous. Drupes 5 - 6 mm across, globose, subglobose or didymous, glabrous, 1 or 2 seeded ; seeds 3 - 4 mm ;



**Fig. 28 :** *P. indica* L. var. *indica* : A. habit ; B. flower split open showing floral parts ; C. placentation ; D. fruit ; E. seed ; F. embryo. A - C. from *R. C. Rout* 3601 ; D - F, from *R. C. Rout* 3606.

exotestal cells 80 - 128  $\mu\text{m}$  long, 24 - 32  $\mu\text{m}$  thick, hexagonal, rarely pentagonal, with straight walls, surface granulates or colliculate ; embryo *ca* 2.5 mm ; radicle *ca* 1.5 mm, curved ; cotyledons 2, equal, *ca* 1.0  $\times$  1.2 mm, reniform, foliaceous, rounded at apex, cordate at base ; plumule minute, enclosed within cotyledons.

*Fl.* : April-August ; *Fr.* : May-November.

*Ecology* : Evergreen forests, at 0-1100 m in altitude.

*Distrib.* : INDIA : Andhra Pradesh, Assam, Goa, Karnataka, Kerala, Lakshadweep, Orissa, Tamil Nadu, West Bengal ; SRI LANKA.

*Note* : As a very large number of collections are cited under this species, the specimens are cited district wise without mentioning localities and dates of collection.

*Specimens examined* : INDIA. ANDHRA PRADESH : Nellore dist., Sriharikota, *J. S. Gamble* 12396 (CAL), *M. S. Ramaswami* 1117 & 1239 (CAL) ; Vizagapatnam dist., *C. A. Barber* 1683 (MH) ; Godavari dist., *Bourne* 3313 (CAL) ; *M. S. Ramaswami* 624 & 1497 (CAL) ; *V. Narayanaswami* 3 (CAL), *C. A. Barber* s.n. & 17023 (MH), *D. C. S. Raju* 373 (CAL), *G. V. Subbarao* 24456 (MH), *J. L. Ellis* 25514 (CAL, MH) ; Kurnool dist., *J. L. Ellis* 16729 (MH) & 22043 (CAL, MH) ; Karimnagar dist., *G. V. Subbarao* 20122 (MH) & 27230 (CAL, MH), *J. L. Ellis*

32403 (CAL, MH), *G. V. Subbarao* 42550 (MH) ; Chittor dist., *M. Chandrabose* 45089 (MH).

ASSAM : Goalpara, *Buchanan Hamilton* 388 (E).

GOA : Agnidev, *J. Cherian* 106674 (BSIS, CAL).

KARNATAKA : Mysore & Carnatic, *G. Thomson* s.n. (CAL, MH) ; Ramanhalli, *C. A. Barber* 6975 (MH), *R. K. Arora* 35273 (CAL) ; South Kanar, Haleagadi, *C. J. Saldanha et al.* 8869 (CAL) ; Shimoga dist., 1859, *Coll.* ? 102 (CAL).

KERALA : Quilon, *T. F. Bourdillon* 263 (CAL, MH) ; Kozbencherry, *C. N. Mohanan* 63709 (CAL, MH) ; Palghat dist., *R. Wight* s.n. *ex Kew Distrib. No.* 1480 (CAL), *E. Vajravelu* 19070 (CAL, MH) & 45734 (MH) ; Trivandrum dist., *M. Mohanan* 61807 (CAL, MH) ; Kasaragod dist., *V. J. Nair* 73931 (MH).

LAKSHADWEEP : Kavarathi, *K. S. Srinivasan* 1792 (CAL).

ORISSA : Angul, *H. H. Haines* 4843 (K) ; Ganjam dist., *V. Narayanaswami* 5554 (MH) ; Cuttack dist., *H. F. Mooney* 3341 (DD), *G. Panigrahi* 8302 & 23445 (CAL) ; Jatadhar, *G. Panigrahi* 23883 (CAL), *V. Abraham* 35 (CAL) ; Puri dist., *C. P. Sreemadhavan* 1234 (CAL) ; Balasore dist., *A. K. Mukherjee* 6019

(CAL) ; Basta, *R. C. Rout* 3601, 3602 & 3603 (CAL) ; Baliapal, *R. C. Rout* 3605 & 3606 (CAL).

TAMIL NADU : Palni mountains, *R. Wight* s.n. ex *Kew Distrib. No.* 1480 pp. (K) & 1481 pp. (CAL), *Bourne* 1450 (CAL) ; Adyar, *G. Bidee* s.n. (MH) ; *J. S. Gamble* 17527 & 20708 (MH) ; North Arcot Dist., *J. S. Gamble* 15103 (CAL) ; Tippukaddu *R. F., K. Ramamurthy*, 16612 (CAL, MH) ; Madras, *M. Daruajulu* s.n. (BSIS) & *X. V. Miss* 53519 (LWG) ; S. Arcot dist., *Shamikutam, C. A. Barber* 790 (MH), Gingu, *K. Ramamurthy* 13018 (CAL, MH) ; Kallakurchi, *N. Venugopal & C. Manoharan* 17809 (CAL) ; Chidambaram, *P. Perumal* 17956 (CAL) ; N. Venugopal & *T. S. Jayasilan* 21150 (CAL) ; Madurai dist., *Kodaikanal, C. A. Barber* 7498 (MH) ; Pitchavaram, *S. R. Raju* 17837 (MH) ; Nagamari, *V. Narayanaswami* 19089 (MH) ; Karandamalai, *M. Chandrabose* 51714 (CAL) ; Thalaiyar, *K. Ramamurthy* 51591 (MH) ; Coimbatore dist., *Anamalais, V. Narayanaswami* 5394 (MH) ; Rajapalyam, *J. Saktharam Rao* 22212 (MH) ; Perur, *K. Subramanyam* 46 (CAL, MH) ; Tanjore dist., *K. M. Sebastine* 10624 (CAL, MH) ; *V. J. Nair* 57169 (CAL, MH) ; Mayavaram, *S. Ragupathy* 401 (CAL) ; Tirunelveli dist., *Sivanparai, J. Joseph* 15118 (CAL, MH) ; Salem dist., *E. Vajravelu* 20621 (CAL, MH) ; *N. Venugopal* 14544 (CAL) ; *S. R. Srinivasan* 79741 (MH) ; Ramnad dist., *K. Ramamurthy* 20948 (CAL, MH) ; *E. Vajravelu* 24705 (CAL, MH) & 24826 (CAL) ; *M.*

*Chandrabose* 29905 (MH) ; *E. Vajravelu* 33693 (CAL, MH) & 38620 (MH) ; Tiruchirapalli dist., *K. Ramamurthy* 24904 (CAL, MH) ; Thuraiyur dist., *N. Venugopal* 15783 (CAL) ; *K. M. Mathew & P. Perumal* 19224 (CAL) & *Periayayagam et al.* 23776 (CAL) ; Dharampuri dist., *K. M. Mathew & N. Venugopal* 20519 (CAL) ; Ramanathpuram dist., *N. C. Nair* 60870 (CAL, MH) ; Pudikkottai dist., *C. Arulappan* 95 (MH) ; Sirumalai hills, *K. Ramamurthy* 83825 (MH) ; Anna dist., *K. Ramamurthy* 85903 (MH).

WEST BENGAL : *S. Kurz* s.n. (CAL) ; Tista, *G. H. Cave* s.n. (CAL) ; Kurseong, *E. A. C. Modder* 67 (CAL) ; Darjeeling dist., *Sukna, K. Biswas* 73, 88 & 9806 (CAL) ; *S. K. Mukherjee* 4489 (CAL) ; Jalpaiguri dist., *C. R. Das* 26 (CAL) ; Hooghly, *Tantishal, P. Hajra* 25 (CAL) ; Bandipur, *P. Hajra* 216 (CAL) ; Bankura, *Sonamukhi, M. N. Sanyal* 738 (CAL).

SRI LANKA : Hambantota dist., *S. H. Somer et al.* 8855 (BM).

(b) var. *glabrescens* (Kurz) Deb & Rout in Journ. Bomb. Nat. Hist. Soc. 89 (3) : 351. 1992. *Ixora tomentosa* Roxb. var. *glabrescens* Kurz, For. Fl. Brit. Burma 2 : 19. 1877 (Type: Burma, Pegu, 23. 1. 1871, *S. Kurz* 3057 CAL, right hand specimen is selected as the lectotype, the other sheet of the same number is isolectotype).

*Pavetta amabilis* Bremek. in Fedde Repert. 37 : 100. 1934 (*Type* : Upper Burma, 1911-12, S. M. Toppin 3032 holo. "E !, iso. CAL !).

*P. assamica* Bremek. in Fedde Repert. 37 : 119. 1934 (*Type* : Assam, Gauhati, Simons 16 holo. K ! photo CAL !).

*P. bengalensis* Bremek. in Fedde Repert. 37 : 99. 1934 (*Type* : Bengal, Nov. 1850, Hooker & Thomson s.n. holo. K !, photo CAL !); Karthikeyan *et al.* in Rec. Bot. Surv. Ind. 21 (2) : 168. 1981; Sharma *et al.* Fl. Karnataka 131. 1984.

*P. griffithii* Bremek. in Fedde Repert. 37 : 99. 1934 & Fedde Repert. 47 : 22. 1939 (*Type* : Bhutan, Griffith 2114, holo. K !, photo CAL !).

*P. indica* L. var. *polyantha* Hook.f. Fl. Brit. Ind. 3 : 150. 1880 [*Type* : India, Meghalaya, Silhet Mt. (Jowai), F. De Silva & W. Gomez s.n. ex Wall. Cat. 6176 holo. K ! photo CAL !, Microfische CAL !]; King & Gamble in Journ. Asiat. Soc. Bengal 73 (2) : 83. 1905; Kar & Panigrahi in Bull. Bot. Surv. Ind. 5 : 234. 1963.

*P. neglecta* Bremek. in Fedde Repert. 37 : 92. 1934 [*Type* : Mizoram (Assam), S. Lushai hill, Thady forest, 1050 m, Aug., 1928, Wenger 214 holo. K !, photo CAL !]; Fischer in Rec. Bot. Surv. Ind. 12 (2) : 102. 1938.

*P. polyantha* Wall. Cat. 6176, *nom. nud.*

*P. polyantha* (Hook.f.) Bremek. in Fedde Repert. 37 : 103. 1934 & Fedde Repert 47 : 22. 1939.

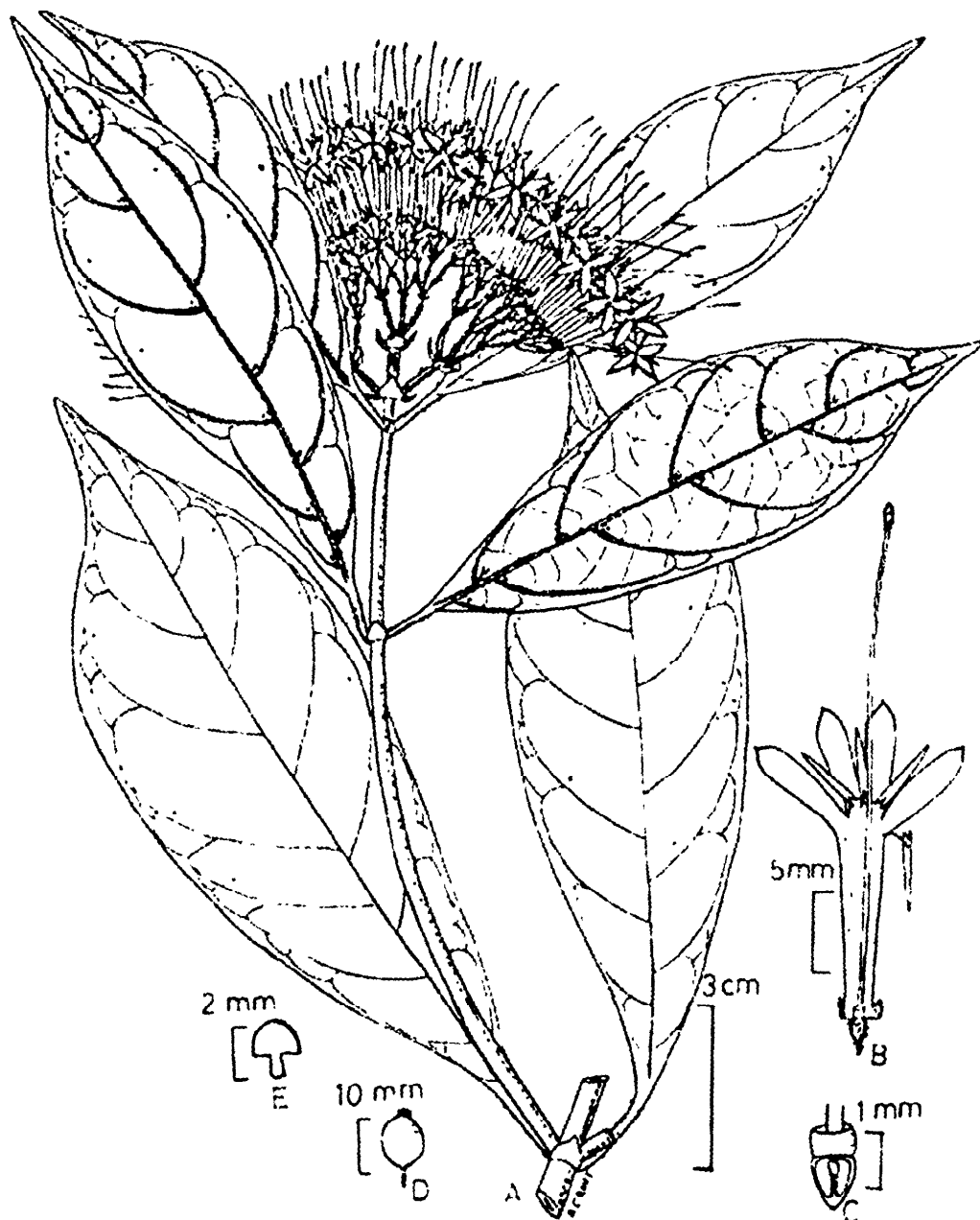
*P. polyneura* Bremek. in Fedde Repert. 37 : 120. 1934 (*Type* : Burma, South Tenasserim, Kyein Chaum. 12. 2. 1926, Maung Law Tek 1379 holo. K ! photo CAL !).

*P. rothiana* DC. Prodr. 4 : 491. 1830; Wt. & Arn. Prodr. 431. 1834.

*P. tomentosa* Roxb. ex Smith var. *glabrescens* (Kurz) Bremek. in Fedde Repert. 37 : 114. 1934.

*P. villosa* Heyne in Roth, Nov. Sp. 89. 1821, non Vahl. (Fig. 29).

Shrubs or small trees, 3 - 9 m high, erect, branched; stem stout, terete or 4-angled, puberulous or pubescent when young, glabrous and corky in age; bark grey or yellowish. Leaves 4.0 - 23.0 × 1.2 - 10.0 cm, elliptic, narrowly or broadly obovate, oblanceolate, elliptic-lanceolate, linear-lanceolate or lanceolate, acute, caudate-acuminate or obtuse at apex, cuneate, acute or attenuated at base, membranous, subcoriaceous or coriaceous, glabrous and shining above, puberulous or glabrous (rarely pubescent) beneath, sometimes pubescent only on nerves beneath; bacterial leaf-galls



**Fig. 29 :** *P. indica* L. var. *glabrescens* (Kurz) Deb & Rout. A. habit ; B. flower split open showing floral parts ; C. placentation ; D. fruit ; E. embryo. A -C. from *G. Watt* 6802 ; D & E. from *G. Panigrahi* 22534.

few to many on secondary or more finer nerves, circular (0.3 - 1.0 mm) or elliptic (*ca* 1.0 × 0.5 mm), prominent on either surface ; domatia tuft type, present on secondary nerve axils ; midrib subcanaliculate or canaliculate above ; lateral nerves 5 - 17 pair, alternate or subopposite, sometimes densely arranged, more prominent beneath ; petioles 0.5 - 4.0 cm, stout, puberulous or pubescent ; stipules persistent or deciduous above, persisting by base only, interpetiolar, 2 - 10 × 2 - 10 mm, broadly or narrowly triangular, rarely subquadrate, cuspidate, coriaceous or subcoriaceous, glabrous or pubescent outside, with colleters and trichomes inside ; colleters many on the adaxial surface of stipules, 400 - 960 µm long, 128 - 208 µm broad, sessile, feathery ; trichomes intermingled with colleters plenty, silvery white, 640 - 1440 µm long, 16 - 24 µm across, pluricellular, cylindrical, 6 - 14 celled, apical cell acute, outer wall smooth. Inflorescence terminal, sessile or shortly peduncled, trichotomously branched compact (rarely loose) corymbose denseflowered cymes, supported by some axillary branches at the base or not, sometimes provided with a pair of small reduced leaves at the base, 4.6 - 15.0 cm across, pubescent, rarely puberulous or glabrescent ; peduncles up to 1 cm, stout, pubescent or puberulous ; bracts 4 - 10 × 4 - 11 mm, broadly triangular, cuspidate, membranous ; pubescent or puberulous. Flowers 40 - 200 ; pedicels 2 - 6 mm stout, pubescent. Hypanthium 0.8 - 1.2 × 0.8 - 1.2 mm, obovoid, densely pubescent ; calyx

tube 0.5 - 1.0 × 1.0 - 1.5 mm, broader above, sparsely or densely pubescent ; teeth 0.3 - 0.8 × 0.2 - 0.6 mm, narrowly triangular or dentate, acute at apex, pubescent. Corolla tube 10 - 18 mm, long, 1.0 - 1.5 mm across, cylindrical, glabrous outside, pilose within ; lobes 4 - 8 × 1.2 - 2.5 mm, oblong, subacute or mucronulate at apex, glabrous, rarely puberulous within or at margin ; internal indumentum 320 - 640 µm long, 16 - 32 µm broad, unicellular, ribbon like, acute at apex, surface pitted. Microcharacters of outer surface of corolla tube : epidermal cells elongated, surface with fine longitudinal cuticular striations ; inner surface of corolla lobes : epidermal cells ridged, surface rugulose, striate or smooth. Filaments 0.5 - 1.5 mm, slender, glabrous ; anthers 4 - 6 mm ; pollen 29 × 23 (23 - 31 × 18 - 27) µm, subprolate, 3-zonocolporate, ectocolpium 20 × 2 (18 - 24 × 2 - 3) µm, colpus membrane smooth, ends acute ; ora compound, combining types  $A_3$  and  $B_1$  ; type  $A_3$  lalongate, 5 × 11 (3 - 7 × 8 - 13) µm ; type  $B_1$  lalongate, 5 × 2 µm, not thickened ; apocolpium diameter 6 µm ; exine 1 µm, finely reticulate, lumina 1 µm ; Ovary 0.7 - 0.8 × 0.6 - 0.8 mm ; disc 0.3 - 0.8 × 0.6 - 0.8 mm ; style 20 - 43 mm long, slender, glabrous below, puberulous above ; stigma 0.5 - 2.0 mm, simple, clavate or slightly notched, puberulous above. Drupes 5 - 12 mm across, subglobose or didymous, shining, glabrous, rarely sparsely pubescent, with persistent calyx teeth, 1 - 2 seeded ; seeds 4 - 5 mm ; exotestal cells 60 - 240 µm long, 30 - 90 µm

thick, hexagonal, with straight walls, surface striate or striate-granulate ; embryo 2.3 mm ; radicle 1.0 - 1.6 mm, stout ; cotyledons 2, equal, 1.2 - 1.8 × 1.8 - 2.0 mm, reniform, obtuse or rounded at apex, cordate or subcordate at base ; plumule minute, enclosed within cotyledons.

*External indumentum* 77 - 528 µm long, 14 - 32 µm across, pluricellular, cylindrical, 2 - 6 celled, apical cell acute or subacute, curved, outer wall smooth.

*Fl.* : May - November; *Fr.* : June - December.

*Ecology* : Evergreen or semievergreen forests, at 50 - 1500 m in altitude.

*Distrib.* : INDIA : Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Sikkim, Tripura, West Bengal ; BANGLADESH ; BHUTAN ; MYANMAR : Upper Burma, Tenasserim ; NEPAL.

*Specimens examined* : INDIA. ARUNACHAL PRADESH : Duphla hills, *J. L. Lister* s.n. (CAL); Dismar, *U. N. Kanjilal* 3248 (DD) ; Pasighat, *G. K. Deka* 16969 (ASSAM) ; Amartala to Baha, *G. Panigrahi* 15172 (CAL) ; Kalaktang North, *G. Panigrahi* 15437 (CAL) ; Subansiri, *G. V. Subbarao* 24652 (CAL) ; Lohit dist., Dalai bank, Haynliang, *A. S. Rao* 48070 (CAL).

ASSAM : *Perry* 3 (CAL) ; *C. Jenkins* s.n.

pp. (L.) ; Gwahatti 1831, *Coll.* ? s.n. (CAL) ; May 1847, *Coll.* ? s.n. (CAL) ; *Coll.* ? s.n. (CAL) ; 1882, *Master* s.n. (DD) ; *Masters* s.n. (L.) ; Cachar, *J. C. Prazer* 35 (CAL) ; Sadiya, *G. A. Gammie* 250 (CAL) ; Rajahbarrio, *G. Watt* 11259 (BSIS, CAL) ; Nakachari, *G. Watt* 11153 (BSIS, CAL) ; Kamrup dist., *U. N. Kanjilal* 5451 (DD) C. F. C. Beeson ; 2, 3 (DD) ; Goalpara dist., Haltugaon, *R. S. Rao* 7126 (CAL) ; Jara reserve, *G. Panigrahi* 9500 (CAL) ; Kulsi reserve forest, *G. Panigrahi* 9540 (CAL) ; A. S. Rao 38955 (CAL) ; Ranga R. F., *G. Panigrahi* 11453 (CAL) ; Anari Bazar, *G. Panigrahi* 27401 (CAL) ; Kuziranga forest, *J. G. Srivastava* 79991 (LWG) ; Sattargaon, A. S. Rao 38829 (CAL) ; Mauman forest, Bako, A. S. Rao 39084 (CAL).

MANIPUR : Keithemabi, *G. Watt* 6802 (CAL) ; W. Manipur, *A. Meebold* 9194 (CAL) ; Ching Mairog, *D. B. Deb* 877 (CAL).

MEGHALAYA : Khasi & Jaintia hills, *S. Kurz* 323 & s.n. (CAL) ; *Coll.* ? s.n. (L.) ; Oldham s.n. (CAL) ; *G. King* s.n. (DD) ; Cherrapunji, *G. Gallatly* 209 (CAL) ; Cox & Hutchinson 560 (E) ; Nong Hulem, *U. N. Kanjilal* 7270 (ASSAM) ; Shollong, *C. B. Clarke* 44212 (CAL) ; *G. Panigrahi* 4441 (CAL) ; Umling, *U. N. Kanjilal* 4023 (CAL) ; *Coll.* ? 6 (CAL) ; Nongpoh, *J. Joseph* 42349 (ASSAM) ; Tharia, *U. N. Kanjilal* 4613 (CAL, DD) ; Garo hills, Tura forest, *R. N. De* 20573 (ASSAM), *B. K. Nayar et al.* 50835 & 50160 (LWG) ; Burnihat, *W. N. Koelz*

22707 (L) ; *W. N. Koelz* 25130 (L) ;  
*Baghmera, G. Panigrahi* 225434 (CAL).

MIZORAM : *Hungnuam, B. Godfrey* 457 (CAL) ; *Sairang B. Godfrey* 426 (CAL) ;  
*Lushai hills, A. T. Gage* 82 (CAL, MH) ;  
*Sangao, T. R. Chand* 7028 (CAL) ; *Lungleh, A. T. Gage* 176 (CAL) ;  
*Hmuntha, W. N. Koelz* 27427 (L).

NAGALAND : *Naga hills, Koio, G. Watt* 11778 (CAL) ;  
*Bakajam, N. L. Bor* 18465 (DD, L) ; *Dimapur W. N. Koelz* 25172 (L).

ORISSA : *Dandakaranya, Bandamamidi, R. S. Rao* 18554 (CAL) ;  
*Bagjhol forest, G. V. Subbarao* 30033 (CAL) ;  
*Cuttack dist., Jambu island, M. K. Ghosh* 307 (CAL).

SIKKIM : *Ryang, G. King* 520, 1017, 2107 (CAL) ;  
*C. B. Clarke* 37927 (CAL, K.) ; *Tista, G. H. Cave* s.n. (CAL, E) ;  
*Maka, J. C. Dawa* 38 (CAL) ; *Dikchu, K. Biswas* 6723 (CAL) ;  
*Kumani forest, K. Biswas* 9865 (CAL) ;  
*Sikkim, Mrs. Tounoud* 631 (CAL) ; *B. D. Sharma* 147 (CAL) ;  
*N. C. Mazumdar & R. M. Dutta* 211 (CAL).

TRIPURA : *Hmumpui, K. Biswas* 4993 (CAL) ;  
*Kumarghat, D. B. Deb* 857 (CAL) ;  
*Kailashahar, D. B. Deb* 2656 (CAL).

WEST BENGAL : *Calcutta, J. W. Helfer* 91 (CAL) ;  
*Bengal, J. D. Hooker & Thomson* s.n. (K) ;  
*Siliguri, C. B. Clarke* 11653 C, D (CAL) ;  
*S. Kurz* s.n. (CAL) ; *Chandannagar,*

*A. Hussain* s.n. (CAL) ; *Kurseong, A. Saban* 269 K (DD) ;  
*Jalpaiguri dist., Rajabhatkhawa, K. Biswas* 1551 (CAL) ;  
*J. K. Sikdar* 4266 (CAL) ; *V. Narayanaswami et al.* 2343, 2371 (CAL) ;  
*Poro forest, B. Krishna* 457 (BSIS) ; *Buxa, V. Narayanaswami et al.* 2878 (CAL) ;  
*Howrah, Baksara, D. C. Bhowmik* 14 (CAL) ;  
*Hooghly, Bandipur, P. Hazra* 216 (CAL) ;  
*Debanandapur, S. Sen* 592 (CAL) ;  
*Chengail, B. V. Shetty* 2 (CAL) ; *Darjeeling, D. Das* 58 (CAL) ;  
*Birbhum, R. K. Basak* 737 (CAL) ; *Jalpaiguri, U. T. Range, R. C. Bhattacharyya* s.n. (DD) ;  
*Midnapur, S. Maji* 1607 (CAL) ; *West Dinajpur, R. N. Banerjee et al.* 18703 (CAL) ;  
*Bengal and borders, K. Biswas* 5765 (CAL).

BANGLADESH : *Sylhet, May 1829, Wallich* s.n. (BM) ;  
*Dacca, C. B. Clarke* 6777 (CAL) ; *Chittagong hill tracts, C. B. Clarke* 19599 (CAL) ;  
*J. L. Lister* s.n. (CAL) ; *Sitapahar range, R. Ellis* 27 (CAL) ;  
*Badal Khan* 87 (CAL) ; *J. M. Cowan* 1929 & s.n. (E) ;  
*Kodala hill, Badal Khan* 394 & 513 (CAL) ; *Kaliabar hills, Abbu Hussain* 41 (CAL).

BHUTAN : *Pahnab, Dangba forest, G. King* s.n. (CAL) ;  
*Bhummelu valley, G. L. Searight* 200 (CAL) ;  
*Buxa, R. E. Cooper* 1036 (BM) ; *Sarbhag division, Gaylegphyg, G. Sengupta* 1354 (CAL).

MYANMAR : *Pegu, Attran river, Wall. Cat.* 26175 (CAL) ;  
*S. Kurz* s.n. & 1442 (CAL) ; *Bhamo, T. Anderson* s.n. (CAL) ;  
*Yomah, S. Kurz* 1440 (CAL) ; *Martaban, S. Kurz* 1441

(CAL) ; Moulmein, *R. Scott* 60 (CAL) ; *King's collector* 436 (CAL) ; *J. C. Prazer* 34 & s.n. (CAL) ; Tavoy, *S. Mokim* 653 (CAL) ; Sedi Chaung, *P. T. Russell* 1835 (CAL) ; Katha, *A. Rodger* 70 (CAL) ; Upper Chindwin, Kindet, *J. C. Prazer* 277 (CAL) ; *J. M. D. Mackenzie* 111 (CAL) ; *C. G. Rogers* 1050 (CAL, DD, E) ; Mergui, *C. C. Calder* s.n. (CAL) ; Tena dist., *K. Biswas* 447 (CAL) ; Thaengyin dist., Yetagun Chaung, *M. Ba Pe* 12805 (DD) ; Tenasserim, *A. F. G. Kerr* 21652 (DD, K) ; Rangoon, *C. E. Parkinson* 14940 (DD) ; Gayson, *C. E. Parkinson* 15188 (DD).

NEPAL : *V. Puri* 400, 490, 491 & 549 (DD) (CAL, DD) ; Rupakot Tal, *Stainton, Sykes & Williams* 5232 (E) ; Ghabung Khola (Pokhra), *Stainton, Sykes & Williams* 547 (E).

(c) var. **tomentosa** (Roxb. ex Sm.) Hook.f. Fl. Brit. Ind. 3 : 150. 1880 ; Kanjilal, For. Fl. Sch. Circ. 206. 1901 ; Wood in Rec. Bot. Surv. Ind. 2 : 110. 1902 ; Duthie, Fl. Upp. Gang. Pl. 1 : 390. 1903 ; Prain, Beng. Pl. 1 : 417. 1903 ; Cooke, Fl. Pres. Bomb. 2 : 41. 1904 ; Gage in Rec. Bot. Surv. Ind. 3 : 66. 1904 ; Prain in Rec. Bot. Surv. Ind. 3 : 223. 1905 ; Strachey, Cat. Pl. 82. 1906 ; Brandis, Ind. Trees 387. 1906 ; Blatter in Journ. Bomb. Nat. Hist. Soc. 18 : 409. 1908 ; Craib in Kew Bull. 1911 : 395. 1911 ; Talbot, For. Fl. Bomb. Sind. 2 : 119. 1911 ; Parker, For. Fl. Punjab 281. 1918 ; Fischer in Rec.

Bot. Ind. 9 : 95. 1921 ; Gamble, Fl. Pres. Madras 633. 1921 ; Haines, Bot. Bih. Or. 456. 1922 ; Blatter in Journ. Bomb. Nat. Hist. Soc. 36 : 792. 1933 ; Kanjilal, For. Fl. Pilibhit 210. 1933 ; Sant. Fl. Purandhar 62. 1957 ; Deb in Bull. Bot. Surv. Ind. 3 : 312. 1961 ; Kar & Panigr. in Bull. Bot. Surv. Ind. 5 : 234. 1963 ; Rao in Journ. Bomb. Nat. Hist. Soc. 61 : 313. 1964 ; Rao in Bull. Bot. Surv. 8 : 300. 1966 ; Ellis *et al.* in Bull. Bot. Surv. Ind. 9 : 9. 1967 ; Arora in Bull. Bot. Surv. Ind. 10 : 63. 1968 ; Ellis in Bull. Bot. Surv. Ind. 10 : 155. 1968 ; Vajravelly *et al.* in Bull. Bot. Surv. Ind. 10 : 74. 1968 ; Matthew in Journ. Bomb. Nat. Hist. Soc. 72 : 340. 1975 ; Matthew, Mat. Fl. Tam. Nad. Carn. 1 : 235. 1981 ; Rao & Razi, Syn. Fl. Mysore 538. 1981 ; Tribedi *et al.* in Bull. Bot. Surv. Ind. 24 : 119. 1982 ; Ellis, Fl. Nallam. 1 : 214. 1987 ; Deb & Rout in Journ. Bomb. Nat. Hist. Soc. 89 (3) : 351. 1992.

*Ixora roxburghii* Kuntze, Rev. Gen. Pl. 1 : 296. 1891.

*I. tomentosa* Roxb. Hort. Beng. 11. 1814, *nom. nud.* & Fl. Ind. 1 : 396. 1820.

*I. tomentosa* Roxb. var. *roxburghii* Kurz. For. Fl. Brit. Burm. 2 : 19. 1877 (Type : Burma, Paris 12 K).

*Pavetta indica* L. ssp. *tomentosa* (Roxb. ex Sm.) Bennet, Fl. Howrah dist., 356. 1979

& Name Changes Fl. Pl. 415. 1987.

*P. indica* L. var. *mollis* Bremek. in Fedde Repert. 37 : 119. 1934 (Type : Andhra Pradesh, Cuddaph dist., Guvalacharam ghat, 300 m, July 1884, *J. S. Gamble* 15021 holo. K !, photo CAL ! iso. CAL ! & MH !).

*P. praecox* Bremek. in Fedde Repert. 37 : 114. 1934 (Type : Karnataka, Belgum, April, *Ritchie* 352 holo. K :, photo CAL :). Sebast. in Bull. Bot. Surv. Ind. 4 : 224. 1962 ; Sharma *et al.* Fl. Karnataka 131. 1984 ; Ahmed. & Nayar, End. Pl. Ind. Reg. 1 : 162. 1987 ; Nair in Ind. Journ. For. 9 : 213. 1986 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 21. 1987.

*P. tomentosa* Roxb. ex Sm. in Rees Cycl. 26, n. 2 : 1819 (Type : *Roxb. ill.* No. 169, CAL : as in Wight, Icon. t. 186. 1840) ; Roth, Nov. Pl. 89. 1821 ; DC. Prodr. 4 : 490. 1830 ; Wight & Arn. Prodr. 1 : 431. 1834 ; G. Don, Gen. Syst. 3 : 574. 1834 ; Royle, ill. 1 : 238. 1835 ; Walps. Rep. Bot. Syst. 2 : 480. 1843 ; Voight, Hort. Sub. Calc. 391. 1845 ; Drury, Hand Book Ind. Fl. 1 : 572. 1864 ; Brandis, For. Fl. 275. 1874 ; Bedd. in Ind. For. 3 : 203. 1877 ; Schum. in Engl. & Prantl, Nat. Pflanz. Fam. 4 : 107. 1891 ; Fischer in Journ. Bomb. Nat. Hist. Soc. 15 : 547. 1904 ; Ridley, Fl. Mal. Pen. 2 : 100. 1923 ; Bremek. in Fedde Repert. 37 : 113. 1934 ; Craib, Fl. Sim. Enum. 2 (2) : 170. 1934 pp. ; Barnes in Journ. Bomb. Nat. Hist. Soc. 44 : 443. 1944 ; Rau in Bull. Bot. Surv. Ind.

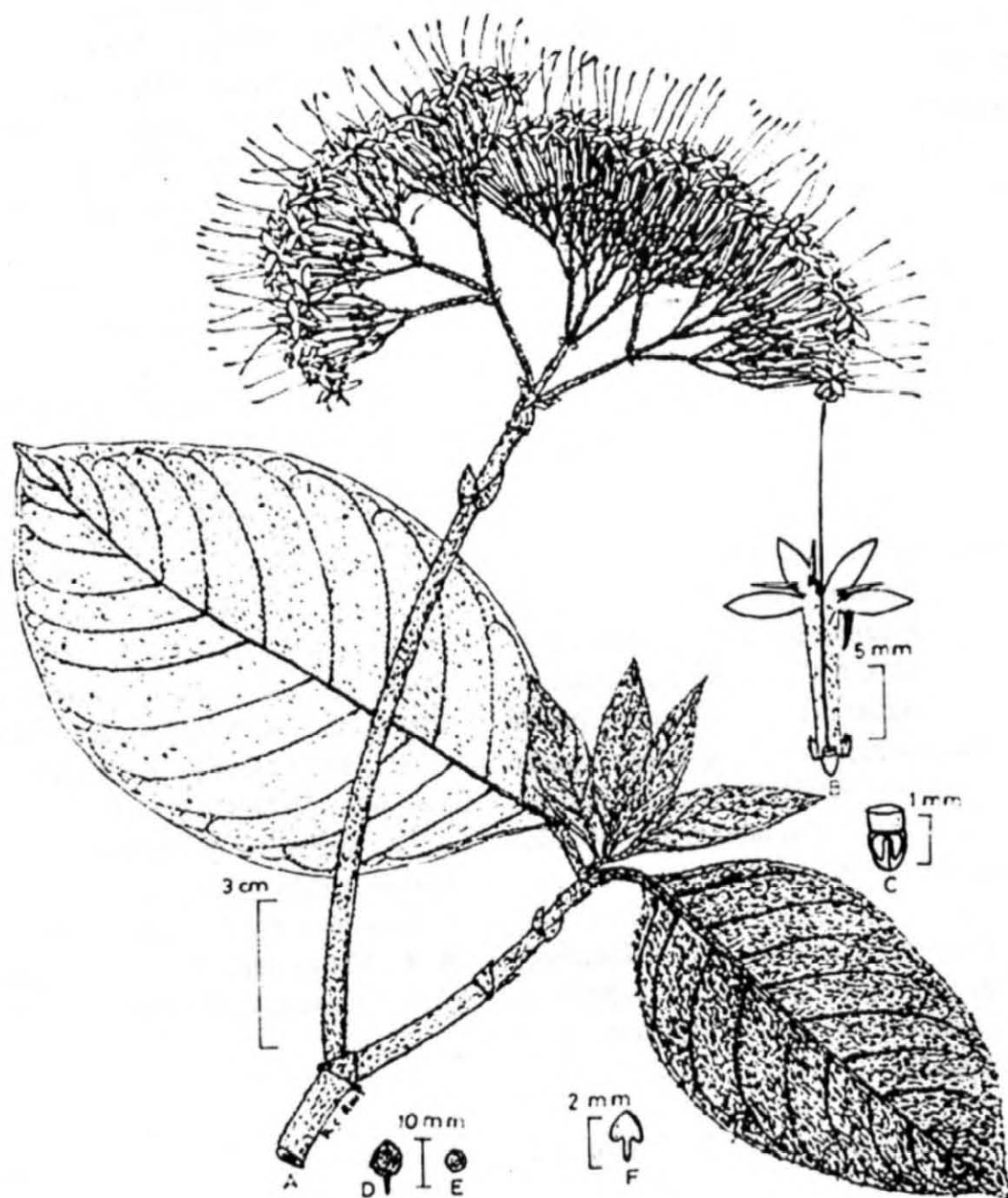
3 : 230. 1961 ; Raizada *et al.* in Ind. For. 88 : 504. 1962 ; Panigrahi *et al.* in Bull. Bot. Surv. Ind. 6 : 250. 1964 ; Sen & Naskar in Bull. Bot. Surv. Ind. 7 : 53. 1965 ; Kammathy *et al.* in Bull. Bot. Surv. Ind. 9 : 219. 1967 ; Sant. in Rec. Bot. Surv. Ind. 16 : 120. 1967 ; V. Naidu & P. Rao in Ind. For. 93 : 123. 1967 ; Dey *et al.* in Journ. Bomb. Nat. Hist. Soc. 65 : 395. 1968 ; Gupta, Fl. Nainital 163. 1968 ; Dakshini in Journ. Bomb. Nat. Hist. Soc. 67 : 183. 1970 ; Malhotra & Moorthy in Bull. Bot. Surv. Ind. 13 : 304. 1971 ; Malla, Fl. Langtang 124. 1976 ; Pant in Journ. Bomb. Nat. Hist. Soc. 73 : 293. 1976 ; Sant. & Henry, Dict. Fl. Pl. Ind. 126. 1976 ; Sald. & Nicol. Fl. Hassan 587. 1976 ; Sharma *et al.* in Boil. Mem. 2 : 72. 1977 ; Brahmam & Saxena in Bull. Bot. Surv. Ind. 20 : 78. 1978 ; Raizada, Fl. Mussorie 1 : 301. 1978 ; Sharma *et al.* in Journ. Bomb. Nat. Hist. Soc. 75 : 27. 1978 ; Raizada *et al.* in Ind. Journ. For. 2 : 343. 1979 ; Hara & Gould in Hara & Williams, Enum. Fl. Pl. Nepal 2 : 206. 1979 ; Paul in Journ. Bomb. Nat. Hist. Soc. 78 : 26. 1981 ; Bole & Almedia in Journ. Bomb. Nat. Hist. Soc. 79 : 322. 1982 ; Manilal & Shivr. Fl. Calicut 146. 1982 ; Matthew, Ill. Fl. Tam. Nad. Carn. 2 : 343. t. 343, 1982 & Fl. Tam. Nad. Carn. 3 (1) : 733. 1983 ; Rao & Reddy in Jain & Rao, Ass. Thr. Pl. Ind. 168. 1983 ; Chaudh. & Wadh. Fl. Himachal Pr. 2 : 349. 1984 ; Naith. Fl. Chamoli 1 : 290. 1984 ; Sharma *et al.* Fl. Karnataka 131. 1984 ; Sikdar in Journ. Econ. Tax. Bot. 5 : 519. 1984 ; Malhotra & Aswal in Journ. Econ. Taxon. Bot. 6 : 601. 1985 ; Verma *et al.* Fl. Raipur, Durg 178. 1985 ;

Rao, Fl. Goa 215. 1986 ; Deb & Dutta in Journ. Econ. Tax. Bot. 10 : 40. 1987 ; Koshy & Shah in Journ. Econ. Tax. Bot. 10 : 101. 1987 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 21. 1987 ; Vajravelu in Journ. Econ. Tax. Bot. 11 : 266. 1987 ; Sharma *et al.* in Ind. Journ. For. 10 : 292. 1987 ; Singh, Fl. East. Karnataka 1 : 352. 1988 ; Panigrahi & Murti, Fl. Bilaspur 1 : 289. 1989 ; K. Murthy in Journ. Econ. Tax. Bot. 14 : 321. 1990 ; Bhirav. & Mohan in Journ. Econ. Tax. Bot. 15 : 55. 1991.

*P. tomentosa* Roxb. ex Sm. var. *roxburghii* (Kurz) Bremek. in Fedde Repert. 37 : 114. 1934. (Fig. 30)

Undershurbs, shrubs or small trees, 1-7 m high, erect, branched ; stem stout, terete or 4-angled, pubescent, corky in age. Leaves 3.0-26.5 × 1.0-12.0 cm, elliptic, elliptic-obovate, ovate or lanceolate, acute, acuminate, subacute, obtuse or rounded at apex, acute, cuneate or obtuse at base, coriaceous, sparsely to densely pubescent or scabrous (rarely glabrous, shining) above, tomentose beneath ; bacterial leaf-galls rarely present on secondary or tertiary nerves, circular (0.5-1.0 mm) or elliptic (*ca* 1.0 × 0.5 mm), rarely elongated or branched ; more prominent on adaxial surface, invisible on lower surface (due to hairiness) ; domatia present, pocket type on secondary nerve axils ; midrib subcanaliculate above ; lateral nerves 8-17 pair, alternate or subopposite, more prominent beneath ; petioles 0.7-4.2 cm,

stout, rarely slender, pubescent ; stipules persistent, interpetiolar, 2.5-10.0 × 3 - 12 mm, broadly (rarely narrowly) triangular, cuspidate (cusps 2 - 7 mm), sheath connate at base or on whole length leaving only cusps free, coriaceous, pubescent or puberulous outside, with colleters and trichomes inside ; colleters many on the adaxial surface of stipules, 640 - 1120 µm long, 128 - 272 µm broad, stalked, dendroid ; stalk 80 - 128 µm long ; trichomes intermingled with colleters plenty, silvery white, 512 - 1760 µm long, 16 - 24 µm across, pluricellular, cylindrical, 5 - 14 celled, apical cell acute, outer wall smooth. Inflorescence terminal on main shoot (rarely on short axillary branches), sessile or subsessile trichotomously branched, loosely corymbose cymes, with much spreading branches ; 5 - 24 cm across, tomentose, rarely pubescent ; peduncles up to 0.8 cm, pubescent ; bracts 4 - 9 × 7 - 11 mm, cuspidate, membranous, pubescent or puberulous. Flowers 60 - 250 ; pedicels 3 - 7 mm, pubescent. Hypanthium *ca* 1 × 1 mm, subglobose, pubescent or tomentose ; calyx tube *ca* 0.5 × 1.2 mm, campanulate or broader above, pubescent ; teeth 0.5 - 0.8 × 0.3 - 0.5 mm, narrowly triangular, acute at apex, pubescent. Corolla tube 8 - 15 mm long, 0.5 - 1.2 mm across cylindrical, glabrous (rarely pubescent) outside, pilose within ; lobes 4 - 6 × 1.8 - 2.5 mm, elliptic or oblong acute or subacute, rarely rounded at apex, glabrous, rarely pubescent inside ; internal indumentum 592 - 768 µm long, *ca* 24 µm broad, unicellular, ribbon-like, acute at apex, surface



**Fig. 30 :** *P. indica* L. var. *tomentosa* (Roxb. ex Sm.) Hook. f. : A. habit ; B. flower split open showing floral parts ; C. placentation ; D. fruit ; E. seed ; F. embryo. A - C. from M. A. Rau 10392 ; D - F. from G. King 2150.

pitted. Filaments 0.5 - 1.0 mm, slender, glabrous; anthers 3.0 - 4.5 mm; pollen  $33 \times 23$  ( $26 - 37 \times 19 - 25$ )  $\mu\text{m}$ , prolate, 3-zonocolporate; ectocolpium  $25 \times 2$  ( $18 - 30 \times 2 - 3$ )  $\mu\text{m}$ , colpus membrane smooth, ends acute; ora simple, type  $A_3$ , lalongate,  $5 \times 12$  ( $4 - 6 \times 8 - 11$ )  $\mu\text{m}$ , apocolpium diameter 7  $\mu\text{m}$ ; exine 1.5  $\mu\text{m}$ , reticulate, columellate. Ovary *ca*  $0.7 \times 0.7$  mm; disc *ca*  $0.4 \times 0.7$  mm; style 17 - 35 mm long, glabrous below, puberulous above; stigma *ca* 1 mm, simple, clavate, puberulous. Drupes 4 - 7 mm across when subglobose,  $5 - 7 \times 7 - 9$  mm across when didymous, black or brown when dry, shining, pubescent, with persistent calyx teeth, 1 - 2 seeded; seeds 3 - 4 mm; exotestal cells 48 - 96  $\mu\text{m}$  long, *ca* 30  $\mu\text{m}$  thick, hexa- or pentagonal, with straight walls, surface striate-granulate; embryo *ca* 2 mm; radicle *ca* 1 mm, stout, inferior; cotyledons 2, equal, *ca*  $1 \times 1$  mm, reniform subacute at apex, cordate at base; plumule minute, enclosed within cotyledons.

*External indumentum* 160 - 752  $\mu\text{m}$  long, 16 - 32  $\mu\text{m}$  across, pluricellular, cylindrical, 4 - 7 celled, curved, apical cell acute, outer wall smooth.

*Fl.* : April - November; *Fr.* : Throughout the year.

*Ecology* : Evergreen forests, at 30 - 2640 m, in altitude.

*Distrib.* : INDIA : Andhra Pradesh, Assam,

Bihar, Goa, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Punjab, Sikkim, Tamil Nadu, Uttar Pradesh, West Bengal, BURMA, NEPAL, MALAYSIA, THAILAND (SIAM).

*Specimens examined* : INDIA. ANDHRA PRADESH : Visakhapatnam dist., C.A. Barbar 1600 (MH); Anantagiri, N.P. Balakrishnan 810 (CAL); G. V. Subbarao 19547 (MH) & 21740 (CAL, MH); Guntur dist., C. A. Barbar 4664 (MH); Godavari dist. C. A. Barbar 5169 (MH); Rampa hills, M. S. Ramaswami 1557 (CAL); Mardumalai, V. Narayanaswami 332 (CAL); Dummalonda R. F., G. V. Subbarao 68625 (CAL, MH); Nellore dist., M.S. Ramaswami 1369 (CAL); Karnool dist., J. L. Ellis 22157 (CAL, MH); Madgola, Paderu, G. V. Subbarao 28074 (CAL, MH); Chittore dist., G. V. Subbarao 31948 (CAL, MH); Prakasham dist., J. L. Ellis 42258 (MH); Nallamalais, R. K. Mohan 0385 (CAL); R. K. Mohan 0577 (CAL); Tanjavaram, G. V. Subbarao 42629 (MH).

ASSAM : S. N. Bal 406 (CAL).

BIHAR : Parasnath, T. Anderson s.n. (CAL); S. Kurz s.n. (CAL) D. Prain s.n. (CAL), V. Chandra 34283 (LWG), S. Kurz 65 (CAL); Rajmahal hill, S. Kurz s.n. (CAL); Singhbhum dist., Chotanagpur, J. J. Wood s.n. (CAL); Noada, J. S. Gamble 9051 (DD); Salwoh, Palamen, J. S. Gamble 8799 (CAL);

Kolhoa, *J. S. Gamble* 9140 (DD) ; *H. H. Haines* 313 (CAL) ; Kobbira, *K. Prasad* 34378 (BSIS) ; Patung Gara, *G. V. Subbarao* 22944 (CAL) ; Bichaborn, *J. K. Maheshwari* 77018 (LWG) ; Gurupur, *C. B. Clarke* 21425 (CAL) ; Ranchi dist., *C. B. Clarke* 20932 (CAL), *K. C. Kanodia* 1271 (CAL) ; *S. K. Mondal* 4440 (BSIS) ; *S. K. Mondal* 4547 (BSIS) ; Patna dist., Bankipur, *D. Hoppers* s.n. (BSIS) ; Netarhat, *S. R. Paul* 88814, 80599, 95405 95440 (LWG) ; Rajgir hills, *J. G. Srivastava* 20640 (LWG) ; *G. Saran* 25886 (LWG) ; *J. G. Srivastava* 46553 (LWG) ; Hazaribagh, *V. Chandra* 28131 & 28202 (LWG) ; Koderma reserve forest, *V. Chandra* 28356 (LWG) ; Ghagra falls, *V. Chandra* 36507 (LWG) ; *V. Chandra* 36890 (LWG) ; *F. H. W. Kerr* 2216 A (BM) ; Dharampur, *G. Panigrahi* 11730 (CAL) ; Pakhar hills, *K. C. Kanodia* 1375 (CAL).

GOA : Colomba, *J. Cherian* 106283 (BSIS, CAL).

HARYANA : Hissar, Jwalamukhi, *S. K. Malhotra* 29141 (BSD, CAL).

HIMACHAL PRADESH : Simla, *I. H. Burkill* 27078 (CAL) ; Kangra dist., Palampur, *R. N. Parker* s.n. (CAL) ; Mandi, *J. G. Srivastava* 58455 (LWG).

KARNATAKA : Teritaere, *A. Meebold* 9716 (CAL) ; Uttar Kanada, *G. S. Puri* 1202 (CAL) ; Mudigaere, *G. S. Puri*, 19750 (CAL) ; Mysore dist., Tirthaballi, *R. S. Raghavan*

74259 (CAL) ; Dodasarihalli, *R. S. Rao* 73737 (CAL) ; Chathurakallu betta, *A. S. Rao* 80057 (CAL) ; Arsanahalli, *A. S. Rao* 79882 (CAL) ; Yemmegadehalli, *A. S. Rao* 80274 (CAL) ; Agumbe, *R. S. Raghavan* 80623 (CAL) ; Bellary dist., *S. B. Manohar*, 9039 (CAL).

KERALA : Malbar, *Stocks et al.* s.n. (CAL) ; Pathanamthitta hills, *C. N. Mohanan* 61227 (CAL, MH) ; Achencoil, *C. N. Mohanan* 61268 (CAL) ; Palghat dist., *R. Wight* s.n. (*Kew Distrib. No.* 1492) (CAL) ; *J. Joseph* 17060 (MH) & 17146 (CAL, MH) ; *C. P. Sreemadhavan* 1018 (MH), *E. Vajravelu* 32204 (CAL, MH) ; Travancore, Colaturpolong, *T. F. Bourdillon* 818 (CAL) ; *C. A. Barber* 7350 (MH) ; Koni, *C. C. Calder & M. S. Ramaswami* 25 (CAL) ; Thorai, *C. C. Calder* 1599 (CAL) ; Cochin, *A. Meebold* 1012404 (CAL) ; Kottayam, *K. Vivekananthan* 21364 (MH) ; *K. Vivekananthan* 24355 (CAL, MH), *B. D. Naithani* 24183 (CAL, MH), *J. L. Ellis* 25747 (CAL, MH), *V. T. Antony* 432 (MH) ; Trichur dist., *K. M. Sebastine* 27200 (CAL, MH) ; Idikki dist., Okkarai, *B. D. Sharma* 42100 (MH) ; Trivandrum dist., *J. Joseph* 41989 (MH), *M. Mohanan* 63299 (CAL, MH), *M. Mohanan* 69251 (CAL, MH), Cannanore dist., *V. S. Ramachandra* 52332 & 62764 (CAL, MH).

MADHYA PRADESH : Bilaspur, *J. K. Maheshwari*, 4075 & 4196 (CAL) ; Borders of Bihar, *S. K. Murti* 19010 (CAL) ;

Kapildhara, Bailadila, *G. Panigrahi* 1011 (CAL) ; Joshpur division, *C. M. Arora* 3828 (CAL) ; Sidhi, *G. Sengupta* 14427 (CAL).

MAHARASHTRA : Bombay, *N. Dalzell* s.n. (CAL) ; Dompā forest, *J. Fernandes* 2427 (CAL) ; Kulkarni evergreen forest, *G. S. Puri* 2016 (CAL) ; Mudigere, Kudrogundi, *S. D. Mahajan* 34648 (BSI, CAL).

MANIPUR : Kalanaga hills, *G. Watt* 6793 (BSIS, CAL) ; Imphal, *D. B. Deb* 4 (CAL) & *J. G. Srivastava* 88994 (LWG) ; Shugnu, *D. B. Deb* 1197 (CAL) ; *D. B. Deb* 2620 (CAL) ; Longal hill, *D. B. Deb* s.n. (CAL).

MEGHALAYA : Khasi & Jaintia hills, Umling, *U. N. Kanjilal* 4026 (ASSAM) ; Umsaw, *R. N. De* 18846 (ASSAM) & *A. S. Rao* 38739 (ASSAM, CAL).

MIZORAM : Lushai hills, Ramphai to Burma boarder, *D. B. Deb* 31016 (ASSAM).

NAGALAND : Naga hills, Kohima, *D. Prain* s.n. (CAL). Piphima, *A. Meebold* 9195 (CAL).

ORISSA : Angul dist., *J. H. Lace* 2606 (DD) ; Ganjam dist., *I. H. Burkill* 20443 (BSIS) ; *V. Narayanaswami* 5984 & 5799 (MH) ; Mayurabhanj dist., *D. Hopper* 38823 (BSIS, CAL). *H. F. Mooney* 3907 (DD) ; Keonjhar dist., *G. Panigrahi* 8436 & 8582 (CAL) ; Koraput dist., *R. S. Rao* 18420, 18425 (CAL) & *G. Panigrahi* 20936 & 23407

(CAL) ; *G. V. Subarao* 30005 (CAL) ; Kondamalai parbat, *G. V. Subbarao* 30157 (ASSAM, CAL) ; Debata parbat, *G. V. Subbarao* 30301 (CAL) ; Rayagada, *S. L. Kapoor* 66957 (LWG).

PUNJAB : Baijnath, *M. A. Rau* 12637 (BSD) ; Hoshiarpur, *O. P. Mishra* 41751 & 44536 (BSD, CAL).

SIKKIM : *S. Kurz* s.n. (CAL) ; Betro, Pankabaree, *S. Kurz* s.n. (CAL) ; *J. D. Hooker* s.n. (CAL) ; *T. Anderson* 167 (CAL) ; Banjeet, *T. Anderson* 321 & s.n. (CAL) ; *G. King* 224 & 2150 (CAL) ; *J. L. Lister* s.n. (CAL) ; Mearspo, *G. A. Gammie* s.n. (DD) ; Chooyong, *Kari* s.n. (CAL) ; Rieng, *Rhomod* 303 (CAL) ; *N. C. Mazumdar & R. M. Dutta* 457 (CAL).

TAMIL NADU : Coimbatore, *C.E.C. Fischer* 1086 & 1930 (CAL), *Munch* 108 (CAL) ; Nilambur division, *S. N. Chatterjee* 7 (DD) ; Baliyoddu, *V. Narayanaswami* 18945 (MH) ; Talakarai, *V. Narayanaswami* 18975 (MH) ; Arepalayam, *V. Narayanaswami* 3414 (MH) ; Siruvani, *K. Subramanyam* 3048 (CAL, MH) ; Konamalai, *C. P. Sreemadhavan* 565 (MH) ; Ezhuvari, *C. P. Sreemadhavan* 655 & 825 (MH) ; Annamalai, *R. H. Beddome* s.n. (MH) ; Nilgiri dist., *M. A. Lawson* s.n. (MH) ; *J. S. Gamble* 15445 (MH) ; Sylviculturalist, 451/1 (DD) ; *B. D. Sharma* 35543 (MH) ; Salem dist., *Perrotter* 308 (CAL) ; *A. V. N. Rao* 26787 (MH) ; *A. Mohan* 12995 & 13603 (CAL) ;

*N. Venugopal* & *T. S. Jayasilan* 18791 (CAL); *R. C. Rout* 3626 (CAL) ; Attur, *K. Murugesan* 14926 (CAL) ; Rasipuram, *N. Venugopal* 16003 (CAL) ; Madurai dist., *Bourne* 718 (MH), *M. Ramavelu* 131 (MH), *B. V. Shetty* 10272 (CAL, MH), *J. Joseph* 12763 & 14136 (MH) ; Ramnad dist., *E. Vajravelu* 39742 & 41732 (MH) ; Kanniyakumari dist., *A. N. Henry* 48228 (CAL, MH) ; *M. Chandrabose* 54282 (MH); *N. Venugopal* 14512 (CAL) ; S. Arcot dist., *K. M. Matthew* & *N. Venugopal* 13859 (CAL); *K. Ramamurthy* 83864 (MH) ; Tiruchi dist., *N. Venugopal* 15740 (CAL) ; Dharampuri dist., *K. M. matthew* 16524 (CAL), *K. M. Matthew* & *N. Venugopal* 23215 (CAL).

UTTAR PRADESH : *Royle* 97/22 (DD) ; Dehradun, *Jameson* 316 (DD), *G. King* 12 (CAL), *J. F. Duthie* 2592 (DD) ; Lachimala, *C. A. Webb* 92 & 93 (BSIS), *P. W. Mackinnon* s.n. (CAL) ; Rargarh, *U. N. Kanjilal* s.n. (DD), *A. Meebold* 2321 (CAL), *H. O. Saxena* 1904 (DD) ; New forest, *M. B. Raizada* s.n. (DD) ; Tourns valley, *D. Mani* s.n. (MH), *G.S. Srivastava* 6862 (LWG) ; Kaulagarh, *K. M. Balapure* s.n. (DD) ; Asarari, *J. G. Srivastava* 6946 (LWG), *B. S. Aswal* 40173 (BSD) ; Rajaji sanctuary, *T. A. Rao* 3243 (BSD, CAL); Tapakeswar, *T. A. Rao* 3048 (BSD) ; Mothrowala, *K.M.M. Dakshini* 5488 (BSD, CAL) ; Sahasradhara, *S. K. Malhotra* 28231 (BSD) ; *P. Pradhan* 217 (CAL) ; Sahasahi, *A. S. Rao* 53730 (BSD) ; Mussorie, *G. King* s.n. (CAL) ; Nainital, *T. Anderson* s.n. (CAL),

*T. Anderson* s.n. (CAL); Kumaon, *Thomson* s.n. (CAL) ; Kaladoonju, *C. Davidson* s.n. (DD); Nalapani, *J. F. Duthie* 1686 (DD) ; Bagettar, *C. H. Collet* 103 (CAL) ; Sarju valley, *J. F. Duthie* 5640 (DD) ; Narain, *N. Gill* 87 (CAL, LWG) ; Jeolikote, *N. Gill* 535 (CAL, LWG) ; Saria Tab, *N. Gill* 692 (CAL, LWG); S. Mandla, *D. O. Witt* 13 (DD) ; Chapta, *C. M. Arora* 49991 (BSD, CAL) ; Murthinwala swamp, *U. N. Kanjilal* s.n. (DD), *P. W. Mackinnon* s.n. (CAL) ; Oli village, *Srikishan* s.n. (DD) ; Almora, *Inayat* 24491 (DD) ; Lahaichoae, *Inayat* 26069 (DD) ; Kolucham, *R. S. Hole* s.n. (DD) ; Kalshi, *R. S. Hole* s.n. (DD), *J. H. Lyall* 6029 (DD) ; *B. Dutt* 19 (DD) ; Bageswar, *D. D. Awasthi* 660 (LWG) ; *D.D. Awasthi* 982 (LWG) ; Chifluwa, *D. D. Awasthi* 1570 (LWG) ; Dharwi, Chalthi, *D. D. Awasthi* 2016 (LWG) ; Kangra dist., *Baijnath, R. N. Parker* s.n. (DD) ; Lachiwala, *J. H. Lace* 3064 (DD) ; Kuluwala, *R. S. Hole* s.n. (DD) ; Nayar valley, *A. E. Osmaston* 91 (DD) ; Ramnagar, *H. Singh* 102 (DD) ; Dasagadam, *G. H. Cave* s.n. (CAL) ; Mungpoo, *C. W. Cousins* 35 (CAL) ; Mothronwala, *B. L. Gupta* s.n. (DD) ; Kulu valley, *S. K. Jain* & *R. C. Bharadwaja* s.n. (DD) ; Garhwal, *Kapoor & Jhamman* 27177 (LWG) ; Botwalchari, *M. A. Rau* 6439 (BSD); Nand Pryag, *M. A. Rau* 10392 (BSD, CAL), *H. O. Saxena* 1929 (DD) ; Mohand, *S. K. Malhotra* 15948 (BSD, CAL), *H. O. Saxena* 2121 (DD) ; Rober's cave, *C. R. Babu* 32255 (BSD, CAL) ; Golatappar, *C. M. Arora* 38878 (BSD, CAL) ; Corbet National Park, *P. C. Pant*

40150 (BSD, CAL) ; Kanda, *P. C. Pant* 43787 (CAL) ; Gorakhocot, *K. P. Janardhanan* 51203 (BSD, CAL) ; Dumunda, *K. P. Janardhanan* 51436 (BSD, CAL) ; Putanikhal, *K. P. Janardhanan* 51454 (BSD, CAL) ; Tehri dist., Ghansali, *A. K. Goel* 65926 (BSD) ; Pithoragarh dist., *C. M. Arora* 66156 (BSD), *C. L. Malhotra* 51572 (BSD).

WEST BENGAL : Siliguri, *C. B. Clarke* 11653 & 26511 (CAL), Darjeeling, *C. B. Clarke* 13479 & 26296, 35468 (CAL) ; Pashak, *I. H. Burkill* 32292 (BSIS) ; Kurseong, *Coll. ?* 185 D (DD) ; Bengal and borders, *K. Biswas* s.n. (CAL) ; Kalimpong, *K. Biswas* 8438 (CAL) ; Jalpaiguri, *S. K. Malhotra* 925 (DD), *J. K. Sikdar* 290 & 500 (CAL) ; Bankura, *S. K. Mukherjee* 5459 (CAL) ; Purulia dist. *U. Chatterjee* 105 & 298 (CAL) ; Matha, *K. C. Malick* 85 (CAL) ; *S. V. Pradeep & T. Mathew* 13124 (CAL) ; Midnapur dist., *G. Sengupta* 566 (CAL), *S. Maji* 1518 (CAL) ; Howrah dist., *S. S. R. Bennet* 255, 588 (CAL) ; Murshidabad dist., *D. N. Guhabakshi* 18, 108 & 200 (CAL) ; Malda, *R. M. Dutta* 428 (CAL).

MYANMAR : Irawaddi, *Wall. Cat.* 6173 H (CAL) ; Moulmein, *Coll. ?* 60 (CAL) ; Tagoung, *T. Anderson* s.n. (CAL) ; Martaban, *Brandis* 1272 (CAL) ; Attran, *Brandis* s.n. (DD) ; Maymyo hill, *Badal Khan* 44 (CAL) ; *J. H. Lace* 3212 (CAL, DD) ; Paradaung, *A. Rodgar* 107 (CAL), *M. Ba Pe* 13164 (CAL) ; Pwedaung, *Po Khant* 2087 (DD) ;

Upper Burma, *A. Huk* 46 (CAL) ; *J. C. Prazer* s.n. (CAL) ; Southern Shan State, *A. Khalil* s.n. (CAL) ; Taungui, *A. Khalil* s.n. (CAL) ; Fortstedman, *A. Khalil* s.n. (CAL) ; *S. S. S. Sai Kaw*, *A. Khalil* s.n. (CAL) ; *S. S. S. Keng Taung*, *A. Khalil* s.n. (CAL) ; Tamu, *A. Meebold* 7540 (CAL) ; Khata dist., *J. H. Lace* 4428 (DD) ; *A. Rodger* 70 (CAL), *Ba Pe* 984 (DD), *C. E. Parkinson* 14607 (DD) ; Tagoon, *C. E. Parkinson* 14630 (DD) ; Yetagone, *F. G. Dickason* 7805 (CAL) ; Iwwk Sawk, *F. G. Dickason* 8761 (L) ; Insein, *Po Khant* 345 (DD) ; Aka dist., *Po Khant* 3195 (DD) ; Kampetlet, *M. Gale* 5469 (DD).

NEPAL : *Wall. Cat.* 6173 a (CAL) ; Segani, *Wall. Cat.* 6173 (CAL) ; Wapsakhani, *M. L. Banerjee* 403 (CAL) ; Dhabung Khola, *V. Puri* 549 (CAL).

*Uses* : The leaves of *P. indica* contain high percentage of nitrogenous substances due to presence of bacterial leaf-galls (bacterial nodules) and are used by the cultivators as green manure (Faber 1912 ; Boodle 1923 ; Humm 1944 ; Corner 1952 ; Deb 1981). The roots are bitter, possessing apertient qualities and are prescribed in visceral obstructions ; these are pulverised and mixed with ginger and rice water and given in dripsy ; the leaves are boiled in water and a fomentation is made which is used in haemorrhoidal pains (Watt 1892 ; Chopra *et al.* 1956). The root bark contains D-Mannitol and some alkaloids (Banerjee & Ghosh 1956 ; Gibs 1974).

**13) *Pavetta involucrata*** Thw. Enum. Pl. Zeyl. 156. (*Type* : Sri Lanka, *Thwaites C.P.* 428 K !, iso. CAL ! BM !) ; Beddome, Ic. Fl. Ind. Or. tab. 100. 1874 & Fl. Sylv. For. Man. 134/8, 1874 ; Anal. tab. 29. fig. 6, 1874 ; Hook.f. Fl. Brit. Ind. 3 : 152. 1880 ; Schum. in Engl. & Prantl, nat. Pflz. fam. 4 : 107. 1891 ; Trimen, Fl. Ceyl. 2 : 350. 1894 ; Bremek. in Fedde Repert. 37 : 92. 1934.

*Ixora involucrata* (Thw.) Kuntze, Rev. Gen. Pl. 1 : 287. 1891. (Fig. 31)

Large shrubs or small trees, 2.5 - 7 m tall, erect, branched ; stem stout, 4-angled, glabrous, rarely sparsely pubescent, bark yellow. leaves petiolate, 3.3 - 14.2 × 1.4 - 4.7 cm, ovate or oblanceolate, rarely elliptic, acute or subacute at apex, attenuated or rounded at base, coriaceous or subcoriaceous, glabrous; bacterial leaf-galls few to many, scattered on secondary or tertiary nerves, circular (1.0 - 1.5 mm) or elliptic (*ca* 2 × 1 mm), more prominent on lower surface ; domatia absent ; midrib subcanaliculate above ; lateral nerves 10 - 12 pair, alternate or subopposite, more prominent beneath ; petioles 0.3 - 1.2 cm, stout, glabrous ; stipules deciduous, interpetiolar, 10 - 20 × 3 - 5 mm, narrowly triangular, acute at apex, sometimes bifid, coriaceous, scarious at margin, glabrous (rarely pubescent) outside, with colleters and trichomes inside ; colleters many on adaxial surface of stipules and bracts, 560-1600 µm long, 64-320 µm broad, sessile, dendroid ;

trichomes intermingled with colleters few, silvery white, 400 - 1600 µm long, 16 - 24 µm across, unicellular, cylindrical, outer wall smooth. Inflorescence terminal on short axillary branches with one internode, sessile, subcapitate cymes, with a pair of reduced lanceolate leaves at base, 2.5 - 3.0 cm across ; bracts 8 - 13 × 7 - 15 mm, suborbicular, cuspidate, membranous, glabrous. Flowers 20 - 30, sessile or subsessile ; pedicels up to 2 mm, stout, glabrous. Hypanthium *ca* 2 × 2 mm, obovoid, glabrous ; Calyx tube 1.5 - 2.0 × 2.5 - 3.0 mm, campanulate, glabrous outside, pubescent within ; teeth 2.0 - 4.5 × 0.4 - 0.6 mm, linear-lanceolate, acuminate at apex, glabrous outside, sparsely to densely pubescent within and at margin. Corolla tube 7 - 8 mm long, 2.5 - 3.0 mm across, cylindrical, widened above, glabrous outside, pilose within below the throat ; internal indumentum 480-800 µm long, 16 - 24 µm broad, unicellular, flat, ribbon-like, acute at apex, surface smooth ; corolla lobes 7 - 8 × 3 mm, narrowly lanceolate, acuminate at apex, glabrous. Filaments *ca* 0.5 mm, slender, glabrous ; anthers 5.5 - 6.0 mm ; pollen 33 × 28 (26 - 34 × 25 - 33) µm, subprolate, 3-zonocolporate ; ectocolpium 25 × 3 (20-28 × 2 - 5) µm, colpus membrane granulate ; ora compound, combining types A<sub>3</sub> and B<sub>1</sub> ; type A<sub>3</sub> lalongate, 5 × 12 (4 - 7 × 8 - 15) µm ; type B<sub>1</sub> lolongate, 6 × 4 µm, thickened ; apocolpium diameter 12 µm, amb circular ; exine 2 µm, reticulate, lumina 1 - 2 µm, tectate, columellate. Ovary *ca* 1.5 × 1.8 mm,

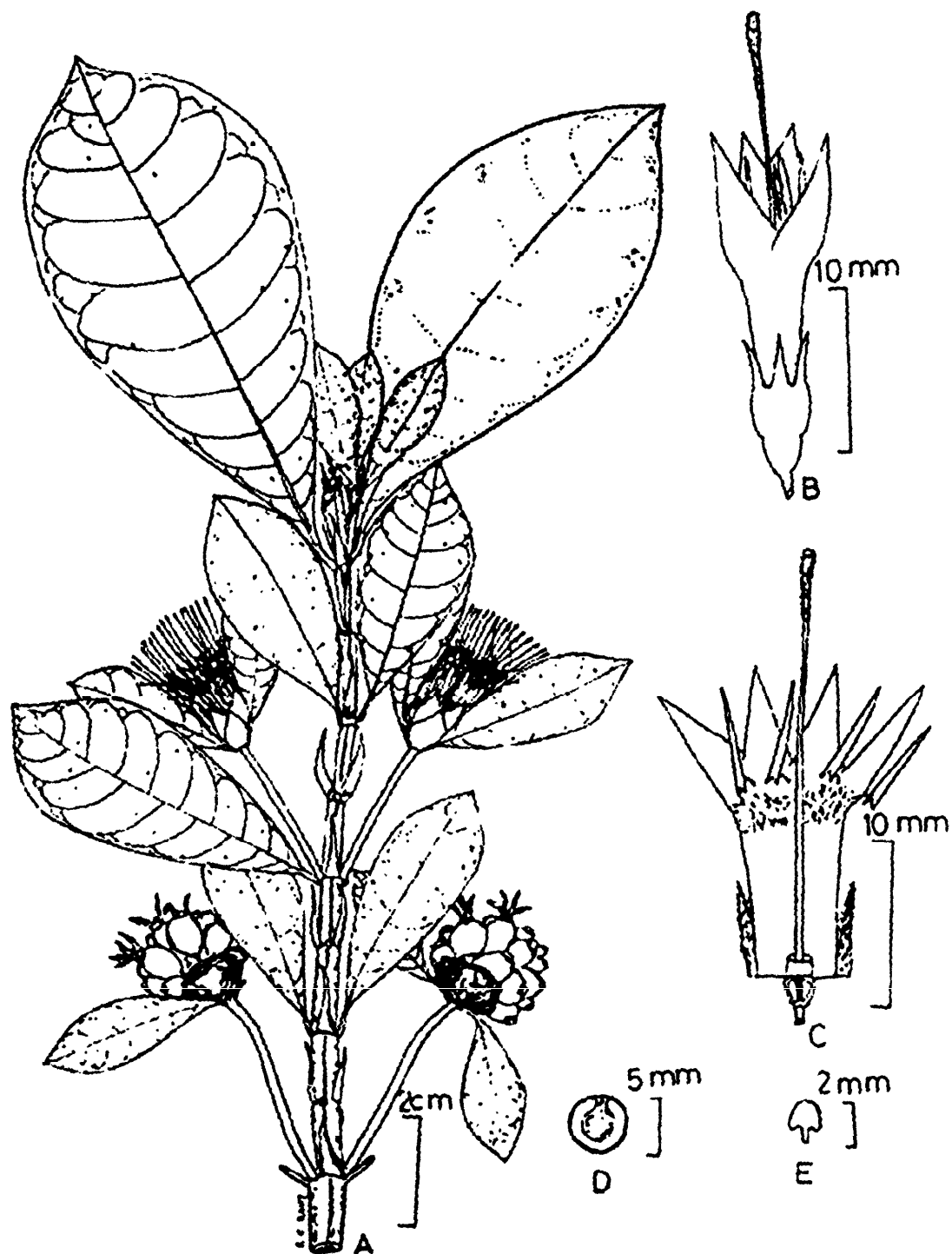


Fig. 31 : *P. involucrata* Thw. A. habit ; B. flower split open showing floral parts ; C. placentation ; D. seed ; E. embryo. All from Thwaites C.P. 428.

2 loculed with 1 pendulous ovule in each locules ; disc *ca* 1.2 × 1.8 mm ; style 20-21 mm long, stout, glabrous below, puberulous above ; stigma *ca* 2.5 mm, clavate, simple or notched, pubescent. Drupes sessile or subsessile, 6-10 mm, globose or subglobose, glabrous with persistent calyx teeth ; seeds 5.0 - 5.5 mm ; exotestal surface colliculate ; embryo *ca* 1.8 mm ; radicle *ca* 0.6 mm, stout ; cotyledons 2, 1.2 × 1.5 mm, reniform, rounded at apex, cordate at base ; plumule minute, enclosed within cotyledons.

*Fl.* : March - September ; *Fr.* : April - October.

*Ecology* : In dense evergreen forest or secondary montane forests at 1500 - 2100 m in altitude.

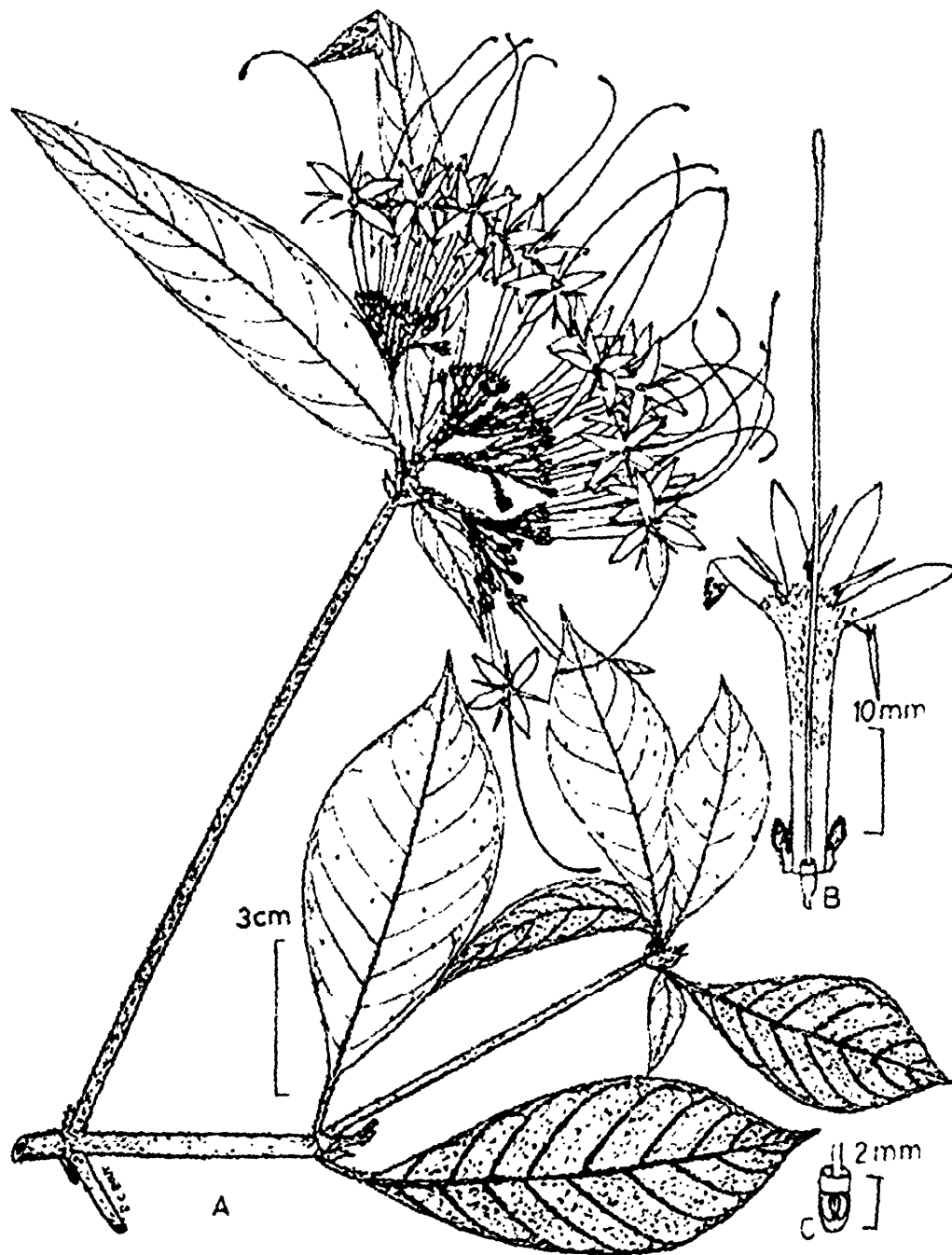
*Distrib.* : SRI LANKA : Central Province : Nuwara Eliya dist., Uva Province : Badulla dist.

*Specimens examined* : SRI LANKA : Central Province, Walker 84 (E) ; Black pool, 15.4.1859, *Thwaites* s.n. (CAL) ; 1885, 1500-2100 m, *R. H. Beddome* 3931 (BM) ; Nuwara Eliya dist., Horton plains, 2100 m, 28.3.1968, *F. R. Rosberg & D. M. Dombois* 49996 (E) ; Pidurutalagala, mount Padro, 2000 m, 22.9.1974, *D. D. Tirvengadam & Waass* 545 (E) ; Uva province, Badulla dist., Namunukula, 2100 m, 24.9.1974, *D. D. Tirvengadam et al.* 594 (E).

*Note* : The type of this species was cited by Bremekamp (1934) as *Thwaites* C.P. 438 (K), but in the protologue, Thwaites (1859) cited the specimens : *Thwaites* C.P. 428, 458 & 1717 only. So, *Thwaites* C. P. 438 can not be the type. As *Thwaites* C. P. 428 (K.) agrees fully with the protologue, it is selected as the lectotype ; the duplicates (isolecto.) are at BM and CAL.

**14. *Pavetta macraei* Bremek.** in Fedde Repert. 37 : 89. 1934 [*Type* : Sri Lanka (Ceylon), J. Macrae 24 holo. BM :]. (Fig. 32)

Undershurbs, *ca* 1.5 m high, erect, branched ; stem stout, terete or subquadrangular, pubescent. Leaves petiolate, 4.5-15.0 × 1.2-5.0 cm, obovate or lanceolate, acute or acuminate at apex, cuneate or acute at base, subcoriaceous, scabrous above, pubescent and strigose on the nerves beneath ; bacterial leaf-galls few to many on secondary or tertiary nerves, circular, 0.5-1.0 mm, more prominent on upper surface ; domatia absent ; midrib subcanaliculate and pubescent above ; lateral nerves 8-11 pair, alternate or subopposite, stout, more prominent on lower surface ; petioles 0.5-1.5 cm, pubescent ; stipules persistent, interpetiolar, 5-7 × 3.5-6.0 mm, triangular-ovate, cuspidate (cusps 3-4 mm), scarious at margin, pubescent outside, with colleters and trichomes within ; colleters many on adaxial surface of stipules, 512



**Fig. 32 :** *P. macraei* Bremek. : A. habit ; B. flower split open showing floral parts ; C. placentation. All from *J. Macrae* 24.

976  $\mu\text{m}$  long, 128-320  $\mu\text{m}$  broad, feathery ; trichomes intermingled with colleters, many, silvery white, 800 - 1136  $\mu\text{m}$  long, *ca* 32  $\mu\text{m}$  across, pluricellular, 6 - 9 celled, cylindrical, apical cell acute, outer wall smooth. Inflorescence terminal sessile or subsessile trichotomously branched corymbose cymes, 10-11 cm across, hispid ; peduncles 0 - 0.4 cm long, pubescent ; bracts 4 - 5  $\times$  3 - 4 mm, membranous, pubescent outside, glabrous within. Flowers *ca* 50, white ; pedicels 4 - 7 mm, stout, hispid. Hypanthium *ca* 1.5  $\times$  1.5 mm, obovoid, hispid ; Calyx tube *ca* 2  $\times$  3 mm, campanulate, hispid outside, glabrous within ; teeth 4 - 6, 4 longer with 1 or 2 smaller sometimes, 3 - 4  $\times$  1 - 1.5 mm, elliptic or elliptic or elliptic-obovate, acute at apex, pubescent. Corolla tube 20 - 28 mm long, 1.5-2.5 mm across, tubular, glabrous outside, pubescent within and at throat ; lobes 12 - 14  $\times$  3 - 4 mm, oblong or oblong lanceolate acuminate at apex, pubescent outside at apex ; internal indumentum 304 - 1200  $\mu\text{m}$  long, 16 - 32  $\mu\text{m}$  broad, unicellular, flat, ribbon like, acute at apex, outer wall pitted. Filaments 1.2 - 2.0 mm, slender, glabrous ; anthers 7 - 8 mm, pollen 35  $\times$  30 (32 - 43  $\times$  26 - 35)  $\mu\text{m}$ , subprolate ; 3-zonocolporate ; ectocolpium 30  $\times$  2 (23 - 36  $\times$  2 - 4)  $\mu\text{m}$ , colpus membrane granulate ; ora compound, combining types  $A_3$  and  $B_1$  ; type  $A_3$  lalongate, 6  $\times$  12 (4 - 6  $\times$  10 - 15)  $\mu\text{m}$ , Type  $B_1$  lalongate, 6  $\times$  2  $\mu\text{m}$ , thickened ; apocolpium diameter 6  $\mu\text{m}$  ; exine 2  $\mu\text{m}$ , medium reticulate. Ovary *ca* 1.5  $\times$  1.2 mm, disk *ca* 0.8  $\times$  1.0 mm, style 60 - 75 mm, stout,

glabrous below, puberulous above ; stigma 2 - 3 mm, clavate, puberulous. Fruits not seen.

*External indumentum* 160 - 544  $\mu\text{m}$  long, 24 - 33  $\mu\text{m}$  across, pluricellular, cylindrical, 5 - 8 celled, apical cell acute, straight or curved, outer wall not pitted.

*Fl.* : April ; *Fr.* : ?

*Ecology* : Evergreen forests at 1000 m in altitude.

*Distrib.* : SRI LANKA. Endemic.

*Specimens examined* : SRI LANKA : Rassegalle above Balngoda, 1000 m, 28.4.1973, *Kostermans* 24650 (L).

*Note* : *P. macraei* Bremek. differs from its allied species. *P. hispidula* and *P. praeterita* in elliptic or elliptic obovate larger calyx teeth ; corolla tube pubescent at throat ; corolla lobes acuminate at apex and pubescent at apex outside ; 1 or 2 small interstitial lobes of calyx among 4 normal lobes.

**15. *Pavetta madrassica* Bremek.** in Fedde Repert. 37 : 91. 1934 (*Type* : Andhra Pradesh, Simhachalam, 1852, *W. Elliot* s.n. holo. E :). (Fig. 33)

Shrubs erect, branched ; stem stout, terete, puberulous when young, glabrous and corky in age. Leaves petioles, 3-11.5  $\times$  1.2 - 4.5 cm, elliptic or elliptic-oblong, acute or subacute at apex, acute at base, coriaceous,

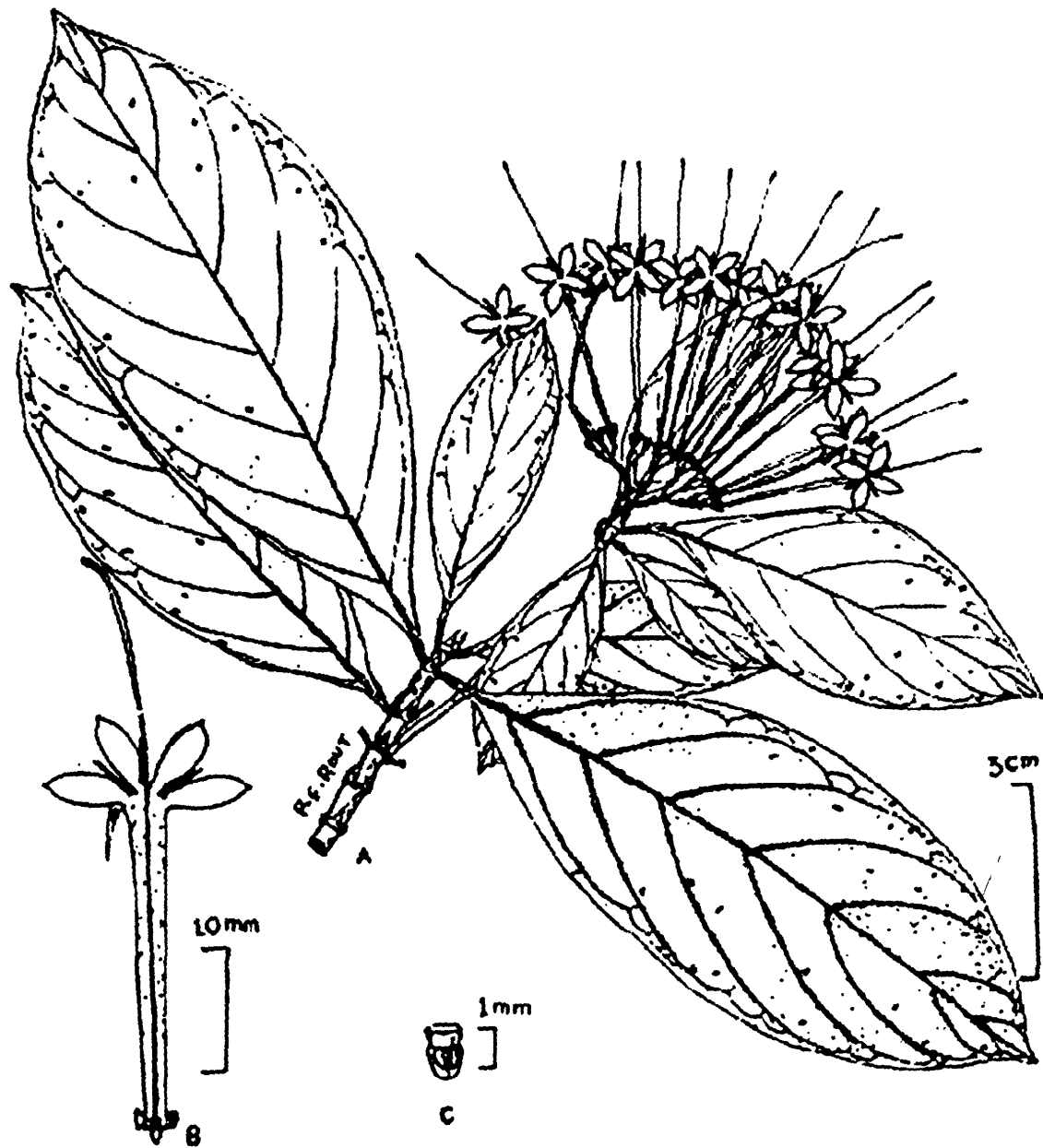


Fig. 33 : *P. madrassica* Bremek. : A. habit ; B. flower split open showing floral parts ; C. placentation ; All from W. Elliot s.n.

glabrous or glabrescent above, densely puberulous beneath ; bacterial leaf-galls plenty in some leaves, few in other, rarely absent, distributed on tertiary or quaternary nerves, rarely on secondary nerves, circular (*ca* 1 mm), rarely elliptic (*ca* 1 × 0.5 mm), depressed from adaxial surface, more prominent on lower surface ; domatia tuft type, present on secondary nerve axils ; midrib subcanaliculate and puberulous above, densely puberulous beneath ; lateral nerves 5 - 11 pair, alternate, more prominent beneath ; petioles 0.5 - 1.4 cm, flattened and canaliculate above, puberulous ; stipules persistent, interpetiolar, 3 - 4 × 2 - 5 mm, broadly triangular, cuspidate, coriaceous, puberulous outside, with colleters inside ; colleters few on the adaxial surface of stipules, 500 - 800 µm long, 112 - 192 µm broad, sessile, dendroid ; trichomes absent. Inflorescence terminal on short axillary branches, sessile or subsessile, trichotomously branched corymbose cymes, 4.5- 7.0 cm across, puberulous ; peduncles up to 0.2 cm, puberulous ; bracts *ca* 3 × 2 mm, ovate-triangular, cuspidate, membranous, puberulous. Flowers 9 - 20 ; pedicels 2 - 3 mm, puberulous. Hypanthium *ca* 1 × 1 mm, subglobose, puberulous ; calyx tube *ca* 0.5 × 1.2 mm, broader above, puberulous outside, glabrous within ; teeth 0.4 - 1.0 × 0.3 - 0.6 mm, triangular, acute at apex, puberulous outside, glabrous within. Corolla tube *ca* 28 mm long, *ca* 1 mm across, cylindrical, glabrous outside, pubescent

within ; lobes 5 - 6 × 2 mm, oblong or oblong-obovate, mucronulate at apex, glabrous. Microcharacters of inner surface of corolla lobes : epidermal cells ridged with smooth or striate cuticular surface. Filaments *ca* 1 mm, slender, glabrous ; anthers 5 - 6 mm. Ovary *ca* 0.8 × 0.8 mm ; disc *ca* 0.5 × 0.8 mm ; style 45 - 47 mm long, slender, glabrous ; stigma *ca* 1 mm, fusiform, glabrous. Drupes 4 - 5 × 4 - 7 mm, subglobose or didymous ; black when dry, with persistent calyx, puberulous ; seeds 1 or 2, 2.5 - 3.0 mm ; exotestal surface reticulate-foveate ; embryo *ca* 1.5 mm ; radicle *ca* 0.7 mm ; cotyledons 2, *ca* 0.8 × 0.5 mm, reniform, rounded at apex, cordate at base ; plumule minute, enclosed within cotyledons.

*Fl. & Fr.* : ?

*Ecology* : Hill forest.

*Distrib.* : INDIA. Andhra Pradesh : Simhachalam.

*Specimens examined* : INDIA : Peninsular Indiae Orientalis, 1866 - 7, *R. Wight* s.n. (*Kew Distrib. No.* 1481) (K, CAL, pp.).

*Notes* : 1) This species is represented by types specimens collected by *W. Elliot* in 1852 and *R. Wight* in 1866. It has not been collected since then.

2) Bremekamp (1934) cited *R. Wight* 1481 (K), a fruiting specimen as a paratype

of this species. The duplicate of this collection at CAL contains two different specimens : the upper one belongs to this species and the lower one is *P. indica* L. var. *indica*.

- 16. Pavetta minor** (Hook.f.) Deb & Rout in Journ. Bombay Nat. Hist. Soc. 89 (3) : 352 : 1992. *Pavetta indica* L. var. *minor* Hook.f. Fl. Brit. Ind. 3 : 150. 1880 (Type: Tamil Nadu, Shevaghiry hills, R. Wight s.n. (Kew Distrib. No. 1483) holo. K ! photo CAL !); Gamble, Fl. Pres. Madras 633. 1921 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 20. 1987. *P. blanda* Bremek. in Fedde Repert. 37 : 94. 1934 pp. (excl. type from Sri Lanka). *P. thomsonii* Bremek. var. *puberula* Bremek. in Fedde Repert. 37 : 99. 1934 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 21. 1987 ; Ramachandra Swamy *et al.* in Journ. Econ. Tax. Bot. 16 (3) : 688. 1992. (Fig. 34)

Shurbs, 1.5 - 3.0 m high, erect, branched; stem stout, terete, glabrous or puberulous. Leaves 3 - 18 × 1.1 - 6.0 cm, elliptic, elliptic-obovate or oblanceolate, acute or acuminate, rarely subacute at apex, cuneate, acute or attenuated at base, membranous or subcoriaceous, glabrous or sparsely puberulous above, densely puberulous beneath ; bacterial leaf-galls few, on secondary or tertiary nerves, circular, 0.5 - 1.0 mm, more prominent on upper surface ; domatia present, tuft type, on secondary nerve

axils, sometimes absent ; lateral nerves 5 - 10 pair, alternate or subopposite, slender, more prominent beneath ; petioles 0.3 - 1.5 cm, slender, glabrous or puberulous ; stipules persistent, interpetiolar, 3 - 6 × 3 - 6 mm, broadly ovate, cuspidate, coriaceous, scarious at margin, glabrous or puberulous outside, with colleters and trichomes within; colleters many on adaxial surface of stipules, 320 - 960 µm long, 128 - 192 µm broad, sessile or stalked, feathery ; stalk up to 64 µm long ; trichomes intermingled with colleters many, 640- 1600 µm long, ca 32 µm across, pluricellular, cylindrical, 10- 17 celled, apical cell acute, outer wall smooth. Inflorescence terminal, trichotomously branched, loosely corymbose cymes, supported by some axillary branches, 6.5 - 14.9 cm across, puberulous ; peduncles up to 0.5 cm, puberulous ; bracts 3-5 × 3.5-5.0 mm, cuspidate, membranous, puberulous. Flower bracts 3 - 5 × 3.5 - 5.0 mm, puberulous. Hypanthium ca 0.8 × 0.7 mm, obovoid, puberulous ; calyx tube ca 0.8 × 1.0 mm, broader above, puberulous; calyx teeth ca 1.0 × 0.3 mm, narrowly triangular, acute at apex, puberulous. Corolla tube 10 - 13 mm long, 0.8 - 1.0 mm across, cylindrical, glabrous (rarely puberulous) outside, sparsely pubescent within ; lobes 4 - 5 × 1.5 - 2.0 mm, oblong, subacute or rounded at apex, glabrous ; internal indumentum 480 - 800 µm long, 16 - 32 µm broad, unicellular, ribbon-like, acute at apex, surface pitted. Filaments ca 1 mm, slender, glabrous ; anthers 4.0

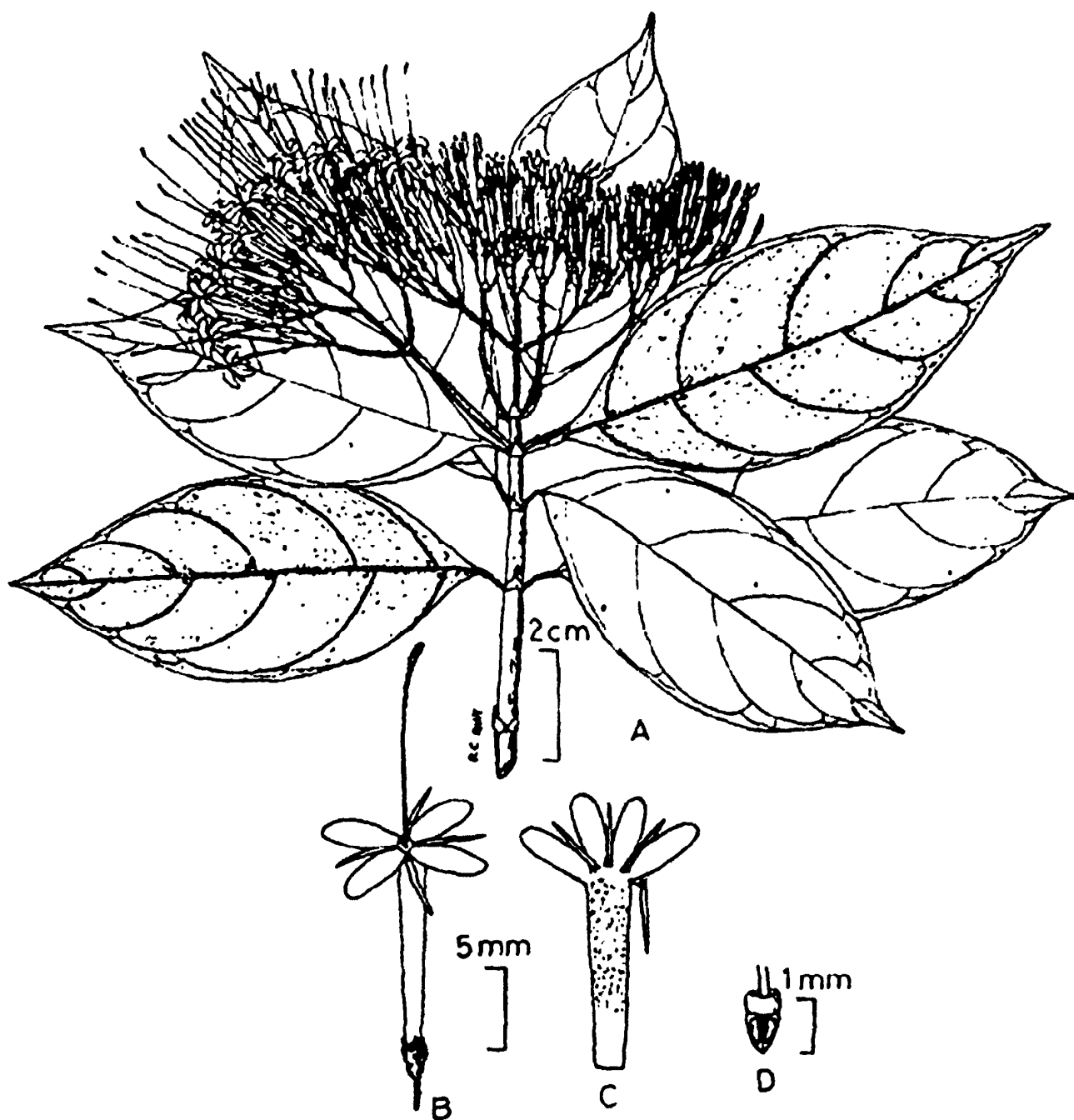


Fig. 34 : *P. minor* (Hook.f.) Deb & Rout. A. habit ; B. flowers ; C. corolla split open ; D. placentation. All from Hohenacker 2426.

4.4 mm ; pollen  $32 \times 24$  ( $27 - 38 \times 18 - 28$ )  $\mu\text{m}$ , prolate, 3-zonocolporate ; ectocolpium  $26 \times 3$  ( $22 - 34 \times 2 - 3$ )  $\mu\text{m}$ , colpus membrane smooth, ends round ; ora simple, type  $A_3$ , lalongate,  $5 \times 10$  ( $3 - 6 \times 8 - 12$ )  $\mu\text{m}$  ; apocolpium diameter 6  $\mu\text{m}$  ; exine 1  $\mu\text{m}$ , finely reticulate, columellate. Ovary  $ca 0.7 \times 0.7$  mm.; disc  $ca 0.4 \times 0.6$  mm ; style 23 - 32 mm, slender, glabrous below, puberulous above ; stigma 1.5 - 2.0 mm, simple, entire or slightly notched. Drupes  $ca 5$  mm across, globose, glabrous, shining, 1 seeded ; seeds  $ca 3.5$  mm ; exotestal cells 64-80  $\mu\text{m}$  long, 16 - 24  $\mu\text{m}$  thick, hexagonal, with straight walls ; surface striate-granulate ; embryo  $ca 1.8$  mm, radicle  $ca 0.8$  mm ; cotyledons 2, equal foliaceous,  $ca 1.0 \times 1.0$  mm, reniform, rounded at apex, subcordate at base ; plumule minute, enclosed within cotyledons.

*External indumentum* 80 - 336  $\mu\text{m}$  long, 16 - 48  $\mu\text{m}$  across, pluricellular, cylindrical, 3 - 6 celled, apical cell acute, curved, rarely straight, outer wall smooth.

*Fl.* : February - June ; *Fr.* : August November.

*Ecology* : Evergreen forests at 125 - 800 m in altitude.

*Distrib.* : INDIA. Karnataka, Kerala, Maharashtra, Tamil Nadu.

*Specimens examined* : KARNATAKA : North Kanara, evergreen forest, 10.04.1883,

W. A. Talbot 337 (K.) ; Mysore, Sagar, Satalalu forest, 30.5.1952, K. Srinivasan s.n. (BSIS).

KERALA : Cottayam, *Hohenacker* 2426 (BM) ; Travancore, Aug. - Sept. 1913, C. C. Calder & M. S. Ramaswami 306 (CAL) ; Mundagamunzhi, 27. 8. 1913, M. Rama Rao 1484 (CAL) ; Kollar, 150 m, 2.4.1915, C. C. Calder 1627 (CAL) ; 9. 4. 1915, C. C. Calder & M. S. Ramaswami 1629 (CAL) ; V. Narayanaswami 528, 1528 (CAL) ; Ernakulum dist., Bhagavathikutam, Kaleyattor, 125 m, 11. 12. 1970, B. V. Shetty 33470 (CAL) ; Cannanore dist., Kannothe,  $ca 175$  m, 4. 11. 1978, V. S. Ramachandran 58225 (CAL, MH) ; Ambayathode,  $ca 550$  m, 20. 2. 1979, V. S. Ramachandran 60055 (CAL, MH) ;  $ca 140$  m, 25. 2. 1979, V. S. Ramachandran 61903 (CAL) ; 26. 4. 1979, V. S. Ramachandran 61605 (CAL, MH) ; 28. 4. 1979, V. S. Ramachandran 61629 (CAL, MH) ; 18. 6. 1979, V. S. Ramachandran 62658 (CAL) ; Panoth Reria,  $ca 500$  m, 2 - 5. 1979, V. S. Ramachandran 61697 (CAL, MH) ; Quilon dist., Allapad, 400 m, 23. 5. 1979, C. N. Mohanan 63035 (CAL) ; Nedumpoyil,  $ca 550$  m, 14. 8. 1979, V. S. Ramachandran 63954 (CAL, MH).

MAHARASHTRA : Kunta, 28. 4. 1939, N. L. Bor 11382 (DD).

TAMIL NADU : Anamalai, 1885, R. H. Beddome 3914 (BM) ; Nilgiri hills,

Ooracamund, 25.9.1934, *Sylviculturist* 451/2 (DD) ; Nadugani, 575 m, 24. 5. 1971, *J. L. Ellis* 38504 (MH) ; Kutallum, 800 m, 5. 6. 1976, *C. E. Ridsdale* 27 (K). India Or., *Roxburgh* s.n. (BM).

UTTAR PRADESH : Western Himalaya, Garhwal, 30.5.1902. *Inayat* 26095 (CAL, DD).

BANGLADESH : Chittagong hill tracts, Kaptai, 4.4.1876, *J. L. Lister* s.n. (CAL).

**17. *Pavetta naucleiflora*** G. Don, Gen. Syst. Gard. Bot. 3 : 575. 1834 (*Type* : Panang, 1822, *Wall. Cat.* 6171 K :), *Microfische* & iso. (CAL !); *Walps. Rep. Bot. Syst.* 2 : 480. 1843 ; *Hook. f. Fl. Brit. Ind.* 3 : 152. 1880 ; *King & Gamble in Journ. As. Soc. Beng.* 73 (2) : 85. 1905 ; *Brandis, Ind. Trees* 387. 1906 ; *Ridley, Fl. Mal. Pen.* 2 : 100. 1923 ; *Craib, Fl. Siam. Enum.* 2 (2) : 168. 1934 ; *Bremek. in Fedde Repert.* 37 : 95. 1934, *Blumea suppl.* 1 : 112. 1937 & *Fedde Repert* 47 : 21. 1939 ; *Kanjilal et al. Fl. Assam* 3 : 72. 1939.

*Ixora naucleiflora* (G. Don) Kurz, For. Fl. Brit. Burma 2 : 19. 1877 & *Journ. As. Soc. Bengal* 46 (2) : 147. 1877.

*Rutidea ? mollis* Bl. ex DC. *Prodr.* 4 : 495. 1830 ; *Miq. Fl. Ned. Ind.* 2 : 300. 1857 & in *Ann. Mus. Bot. Lugd. Bat.* 4 : 256. 1869 ; *Boerl. Handl. Fl. Ned. Ind.* 2 (1) : 107 & 142.

1891. *Saprosma ? mollis* (Bl. ex DC.) Boerl. *Handl. Fl. Ned. Ind.* 2 (1) : 142. 1891.

Shrubs or small trees, erect, branched ; stem stout, terete, or flattened, hirsute. Leaves elliptic-oblong, elliptic or lanceolate, acuminate or caudate at apex, acute or cuneate at base, membranous or subcoriaceous, scabrous or sparsely pubescent above, sparsely or densely tomentose beneath ; bacterial leaf-galls few to many on secondary or tertiary nerves, circular or elliptic, more prominent on lower surface ; domatia tuft type, present on secondary nerve axils ; midrib canaliculate or subcanaliculate above, hirsute ; lateral nerves 9 - 11 pair ; petioles 0.8 - 3.4 cm, stout, hirsute ; stipules persistent, interpetiolar, aristate, coriaceous, with colleters and trichomes within ; colleters stalked, feathery or sessile dendroid ; trichomes intermingled with colleters pluricellular, cylindrical, apical cell acute. Inflorescence terminal, subsessile, trichotomously branched loosely corymbose cymes with 1 - 2 pairs of small leaves at the base, hispid ; peduncles 0.5 - 1.0 cm, hispid ; bracts cuspidate, membranous, pubescent outside, glabrous within. Flowers 28 - 70 ; pedicels 3 - 8 mm, hispid. Hypanthium obovoid, hispid ; Calyx tube broader above, hispid. outside, glabrous within ; teeth triangular, acute at apex, hispid. Corolla tube 10 - 15 mm long, ca 1 mm across, cylindrical ; lobes oblong, mucronulate at apex. Microcharacters of inner surface of corolla lobes : epidermal cells bulging with rugose

cuticular surface. Filaments 1-1.5 mm, glabrous ; anthers 3 - 5 mm ; pollen subprolate, 3-zonocolporate ; ora compound, combining types  $A_3$  and  $B_1$  : exine reticulate, columellate. Ovary  $0.6 \times 0.8$  mm ; disc  $0.4 - 0.5 \times 0.8$  mm ; style 20 - 35 mm, slender, glabrous below : puberulous above ; stigma simple or minutely 2 lobed, glabrous or puberulous. Drupes 5 - 7 mm across, spherical or subglobose, pilose, black when dry, with persistent calyx teeth, 1 seeded ; seeds *ca* 5 mm ; embryo *ca* 2 mm ; radicle *ca* 1 mm, stout, inferior ; cotyledons 2, *ca*  $1.0 \times 0.8$  mm, reniform, subacute at apex, subcordate at base ; plumule minute, enclosed within cotyledons.

*External indumentum* 112 - 800  $\mu$ m long, 16 - 32  $\mu$ m across, pluricellular, cylindrical, 5 - 8 celled, apical cell acute, straight, or curved, outer wall smooth or pitted.

#### KEY TO THE VARIETIES

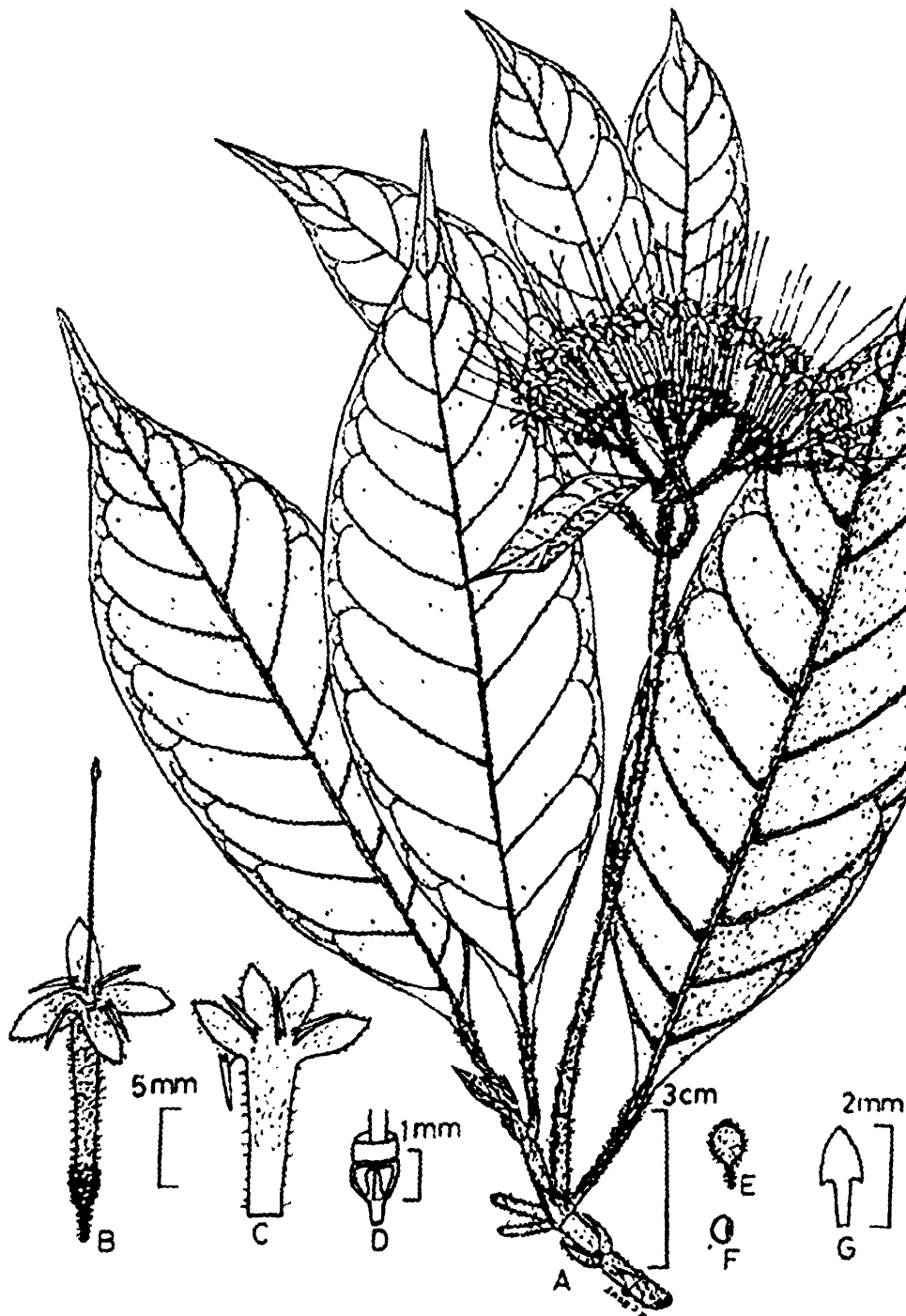
Leaves elliptic-oblong ; colleters stalked, feathery ; corolla tube and lobes pilose outside, lobes pubescent within ; stigma slightly notched (a) var. *naucleiflora*

Leaves broadly elliptic or lanceolate ; colleters sessile dendroid ; corolla tube outside and lobes glabrous ; stigma simple (b) var. *glabrituba*

(a) var. *naucleiflora*

*P. naucleiflora* G. Don var. *pilosituba* Bremek. in Fedde Repert. 37 : 95. 1934.  
(Fig. 35)

Shrubs or small trees erect, branched ; stem stout, terete, or flattened, hirsute when young, corky in age. Leaves 6.0 - 22.5  $\times$  22.2 - 7.5 cm, elliptic-oblong, acuminate or caudate at apex, acute or cuneate at base, membranous, scabrous above, sparsely or densely tomentose beneath ; bacterial leaf-galls few to many on secondary or tertiary nerves, usually circular (0.3 - 0.5 mm), rarely elliptic (*ca*  $1.0 \times 0.6$  mm), more prominent on lower surface ; domatia tuft type, present on secondary nerve axils, midrib subcanaliculate above, hirsute on both sides ; lateral nerves 10 - 11 pair, puberulous above, pubescent beneath ; petioles 1.0 - 3.4 cm, hirsute ; stipules persistent, interpetiolar, 5 - 7  $\times$  5 - 6 mm, aristate coriaceous, hispid above, with colleters and trichomes within ; colleters many on the adaxial surface of stipules, 496-992  $\mu$ m long, 96 - 144  $\mu$ m broad, stalked, feathery ; stalk 48 - 64  $\mu$ m long, trichomes intermingled with colleters, few, 160 - 336  $\mu$ m across, pluricellular, cylindrical, 3 - 5 celled, apical cell acute. Inflorescence terminal, subsessile, trichotomously branched, loosely corymbose cymes with 1 or 2 pairs of small lanceolate leaves at the base, 6.0 - 8.5 cm across, hispid, branches covered with white spreading hairs ; peduncles 0.5 - 1.0 cm, hispid ; bracts 4 - 5  $\times$  4 - 5 mm, cuspidate, membranous, pubescent



**Fig. 35 :** *P. naucleiflora* G. Don var. *naucleiflora* A. habit ; B. flower ; C. corolla split open ; D. placentation ; E. fruit ; F. seed ; G. embryo. A - D. from *Ba Pe* 830 ; E - G. from *Scrotechini* s.n.

above, glabrous beneath. Flowers 40 - 70 ; pedicels 3 - 8 mm, rarely 1 mm, hispid. Hypanthium *ca* 1 × 1 mm, obovoid, hispid ; Calyx tube 1.0 × 1.0 - 1.3 mm, broader above, hirsute outside, glabrous within ; teeth 0.4 × 0.7 × 0.3 mm, narrowly triangular, acute at apex, hirsute on both sides. Corolla tube 11 - 14 mm long, *ca* 1 mm, across, cylindrical, pilose outside, sparsely pubescent within ; lobes 4.5 - 6.0 × 2.0 - 2.5 mm, oblong, mucronulate at apex, pilose outside, sparsely pilose within. Microcharacters of inner surface of corolla lobes ; epidermal cells bulging with rugose cuticular surface. Filaments *ca* 1.5 mm, glabrous ; anthers 3 - 5 mm, pollen 31 × 24 (27 - 34 × 21 - 25)  $\mu$ m, subprolate ; 3-zonocolporate ; ectocolpium 24 × 3 (20 - 26 × 2 - 4)  $\mu$ m ; ora compound, combining types  $A_3$  and  $B_1$  ; type  $A_3$  lalongate, 5 × 12 (4 - 8 × 9 - 14)  $\mu$ m ; type  $B_1$  lolongate, 5 × 3  $\mu$ m, thickened ; apocolpium diameter 6  $\mu$ m ; exine 1  $\mu$ m, reticulate, columellate, lumina 1  $\mu$ m. Ovary *ca* 0.6 × 0.8 mm ; disc *ca* 0.4 × 0.8 mm ; style 22 - 35 mm, glabrous below, puberulous above ; stigma slightly two lobed, lobes *ca* 0.3 mm, glabrous or puberulous. Drupes 5 - 7 mm across, globose or subglobose, pilose, black when dry, with persistent calyx teeth, 1 seeded ; seeds *ca* 5 mm ; exotestal surface striate-reticulate ; embryo *ca* 2 mm ; radicle *ca* 1 mm, stout ; cotyledons 2, *ca* 1.0 × 0.8 mm, reniform, subacute at apex, subcordate at base ; plumule minute, enclosed within cotyledons.

*External indumentum* 256 - 800  $\mu$ m long, 16 - 48  $\mu$ m across, pluricellular, cylindrical, 5 - 7 celled, apical cell acute, straight or curved, base broad, outer wall smooth.

*Fl.* : November-February ; *Fr.* : May - ?

*Ecology* : Evergreen forests, at 60 m - 510 m in altitude.

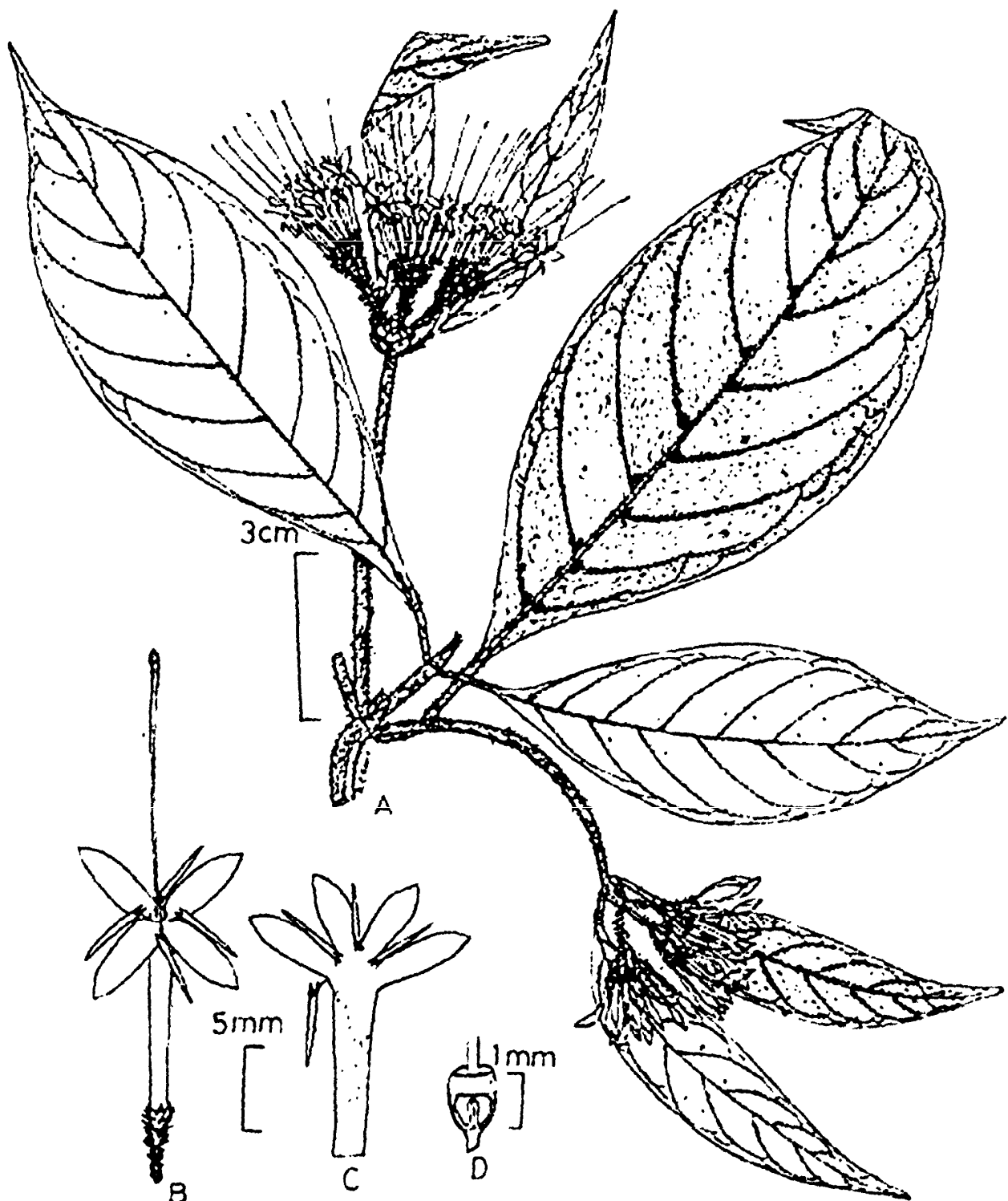
*Distrib.* : BANGLADESH ; MYANMAR, MALAYSIA.

*Specimens examined* : MYANMAR : TAVOY dist., Heinze, 510 m, 9.4.1921, *P. T. Russell* 1958 (CAL) ; Kaleinaung, 300 m, 28.1.1925, *Ba Pe* 830 (CAL, DD) ; Mergui dist., Leik Pok Chaung, 120 m, 1925 - 26, *Braybon's collector* 134 (DD) ; Miachung, 60 m, 13.2.1931, *K. Biswas* 908 (CAL).

MALAYASIA : Penang, Water fall, Feb. 1890, *C. Curtis* 2217 (CAL) ; Water fall above gardens, 10.11.1950, *J. Sinclair* 39032 (L.). Upper Perak, 90 m, May 1884, *L. Wray Jr.* 3619 (CAL) ; Sira Riman, *R. H. Yapp* 584 (CAL) ; *Scortechini* s.n. (CAL) ; Johore, Gunong Pulaii, Shaded evergreen forests, 200 m, 18.1.1981, *J. F. Maxwell* 81 - 17 (L.).

(b) var. **glabrituba** Bremek. in Fedde Repert. 37 : 96. 1934 (*Type* : Bhutan, 1850, *Griffith* s.n. ex *Kew Distrib. No.* 2113 K ! photo CAL !). (Fig. 36)

Large shrubs, erect, branched ; stem stout, tetrate or flattened, hirsute when young, corky in age. Leaves 10 - 19 × 2.5 - 7.0 cm,



**Fig. 36 :** *P. naucleiflora* G. Don var *glabrituba* Bremek. : A. habit ; B. flower ; C. corolla split open ; D. placentation. All from A . T. Gage 95.

elliptic or lanceolate, acuminate or caudate at apex, acute or cuneate at base, subcoriaceous, sparsely pubescent above, tomentose beneath ; bacterial leaf-galls few on secondary or tertiary nerves, circular, 0.5

1.0 mm, more prominent on lower surface ; domatia tuft type, present on secondary nerve axils ; midrib canaliculate or subcanaliculate above, hirsute ; lateral nerves 9 - 10 pair, alternate or subopposite, more prominent beneath, pubescent ; petioles 0.8 - 2.8 cm long, stout, hirsute ; stipules persistent, interpetiolar, 4 - 6 × 3.5 - 5.5 mm, aristate, coriaceous, hirsute outside, with colleters and trichomes within ; colleters few on the base of the stipules inside, 544 - 720 µm long, 192 - 208 µm broad, sessile, dendroid trichomes intermingled with colleters few, 64

480 µm long, 24 - 40 µm across, pluricellular, cylindrical, 4 - 6 celled, apical cell acute, outer wall smooth. Inflorescence terminal, sessile or subsessile, trichotomously branched, loosely corymbose cymes, with 1 or 2 pairs of small leaves at the base, 5 - 7.5 cm across, hispid, branches covered with white spreading hairs ; peduncles up to 1.0 cm long, hispid ; bracts 4.5 - 5.2 × 4.0 - 5.0 mm, cuspidate, membranous, pubescent outside, glabrous within. Flowers 28 - 52 ; pedicels 4 - 7 mm, hispid. Hypanthium *ca* 1 × 1 mm, obovoid, hispid ; calyx tube 0.3 - 0.6 × 0.4 mm, narrowly triangular, acute at apex, 35 mm, glabrous below, puberulous above ; stigma slightly two lobed, lobes *ca* 0.3 mm, glabrous or puberulous. Drupes 5

7 mm, across, globose or subglobose, pilose, black when dry, with persistent calyx teeth, 1 hirsute. Corolla tube 10 - 15 mm long, *ca* 1 mm across, cylindrical, broader above, glabrous outside, sparsely pubescent within ; lobes *ca* 5 × 2 mm, oblong, mucronulate at apex, glabrous. Filaments *ca* 1 mm, glabrous ; anthers 4.0 - 4.5 mm. Ovary *ca* 0.8 × 0.8 mm ; disc *ca* 0.5 × 0.8 mm ; style 20 - 32 mm, slender, glabrous below, puberulous above ; stigma *ca* 0.5 mm, simple, cavate, puberulous. Fruits not seen.

*External indumentum* 112 - 800 µm long, 16 - 32 µm across, pluricellular, cylindrical, 5 - 8 celled, apical cell acute, straight, or curved, outer wall pitted.

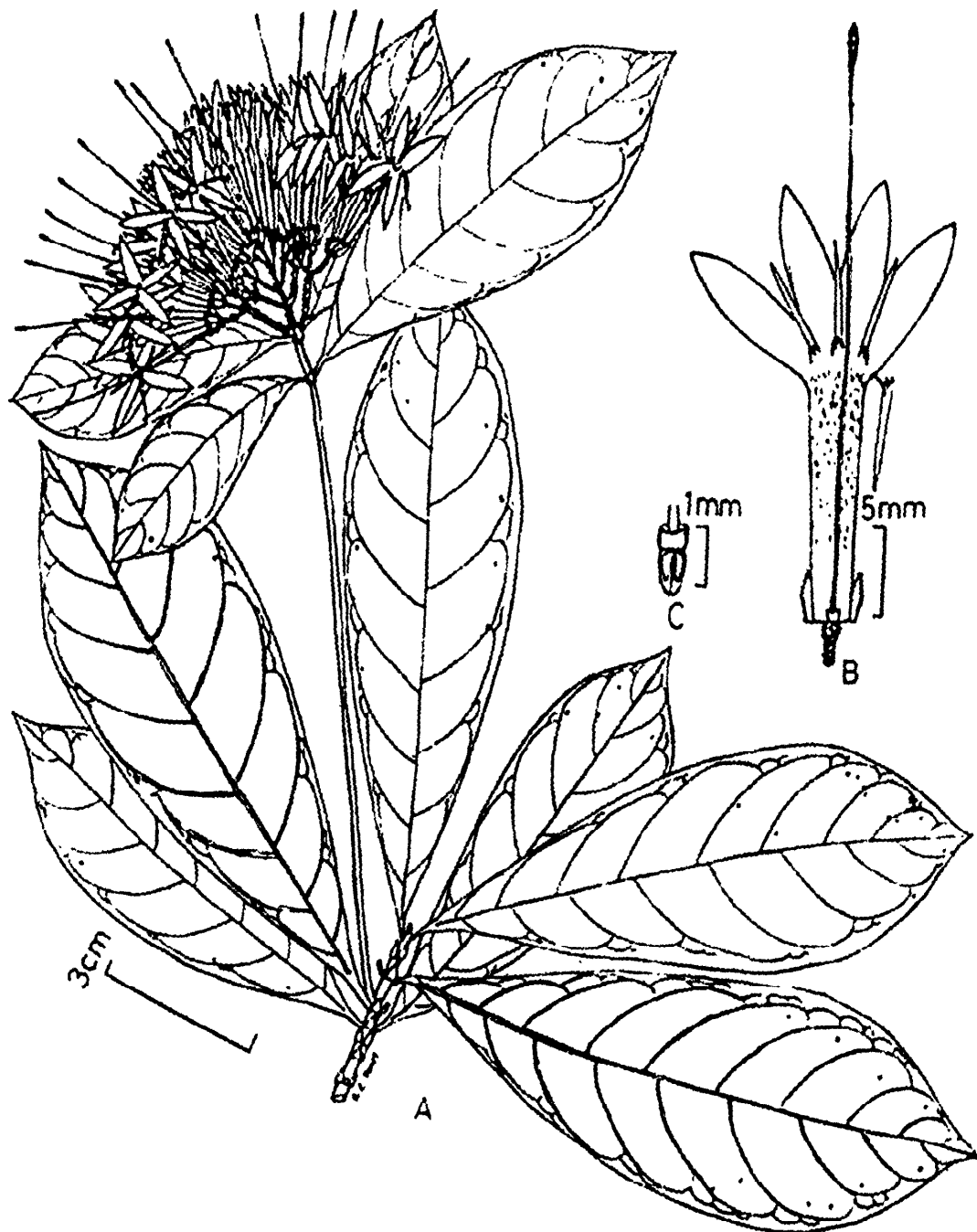
*Fl.* : February - ? ; *Fr.* : ?

*Distrib.* : BHUTAN ; MYANMAR. At 360 m in altitude.

*Specimens examined* : BHUTAN : East Himalaya, Bank of Kokery, 750 m, 1861 62, *Griffith* 3006 (CAL, K) and s.n. (CAL).

MYANMAR : Tavoy. Heinze Chaung, 360 m, 10.2. 1919, *P.T. Russel* 95 (CAL) ; *A.T. Gage* 95 (CAL).

**18. *Pavetta nemoralis* Bremek.** in Fedde Repert. 37 : 94. 1934 (*Type* : India : Kerala, Kavalay, 900 m, November 1910, *A. Meebold* 12228 holo. B. iso. CAL ! ) ; Ahmed. & Nayar, End. Pl. ! Ind. Reg. 1 : 162. 1987. (Fig. 37)



**Fig. 37 :** *P. nemoralis* Bremek. : A. habit ; B. flower split open showing floral parts ; C. placentation.  
All from A. Meebold 12228.

Undershrubs *ca* 0.6 m high, erect, branched ; stem stout, terete, glabrous, internodes very short. Leaves petiolate or subsessile, congested on stem, 4.5 - 16.0  $\times$  1.6 - 6.5 cm, narrowly obovate, acuminate at apex, acute at base, coriaceous, glabrous ; bacterial leaf-galls few on secondary or tertiary nerves, circular, 0.3 - 0.5 mm across, more prominent on lower surface ; domatia absent ; lateral nerves 7 - 9 pair, alternate or subopposite, more prominent beneath ; petioles 0.2 - 0.5 cm, glabrous ; stipules persistent, interpetiolar, *ca* 3  $\times$  3 mm, triangular, shortly cuspidate, coriaceous, glabrous outside, with colleters inside ; colleters few at the base of stipules inside, 352 - 704  $\mu$ m long, 128 - 240  $\mu$ m broad, sessile, feathery ; trichomes absent. Inflorescence terminal, sessile, trichotomously branched, compact corymbose cymes on slender axillary branches *ca* 6 cm across, puberulous ; bracts *ca* 3  $\times$  4 mm, cuspidate, membranous, glabrous. Flowers 90 - 100 ; pedicels 0.5 - 2.0 mm, stout, puberulous. Hypanthium *ca* 1.0  $\times$  0.6 mm, obovoid, puberulous ; calyx tube *ca* 1.0  $\times$  1.5 mm, broader above, puberulous outside, glabrous within ; teeth 1.0 - 1.2  $\times$  1.0 - 1.2 mm, broadly triangular, acute at apex, puberulous outside, glabrous within. Corolla tube *ca* 15 mm long, 1.0 - 1.5 mm across, cylindrical, glabrous outside, pubescent within ; lobes *ca* 9.5  $\times$  3.0 mm, oblong at apex, glabrous. Filaments *ca* 1 mm, slender, glabrous ; anthers *ca* 6 mm, pollen

33  $\times$  30 (30 - 38  $\times$  25 - 32)  $\mu$ m, prolate-spheroidal, 3-zonocolporate ; ectocolpium 25  $\times$  3 (23 - 29  $\times$  2 - 4)  $\mu$ m, colpus membrane smooth ; ora simple, type A<sub>3</sub>, lalongate, 5  $\times$  10 (4 - 7  $\times$  7 - 13)  $\mu$ m ; apocolpium diameter 6  $\mu$ m ; exine 1.5  $\mu$ m, finely reticulate. Ovary *ca* 0.7  $\times$  0.5 mm ; disc *ca* 0.5  $\times$  0.5 mm ; style *ca* 30 mm, slender, glabrous ; stigma *ca* 1.5 mm, simple, clavate, puberulous. Fruits not seen.

*Fl.* : November - ? ; *Fr.* : ?

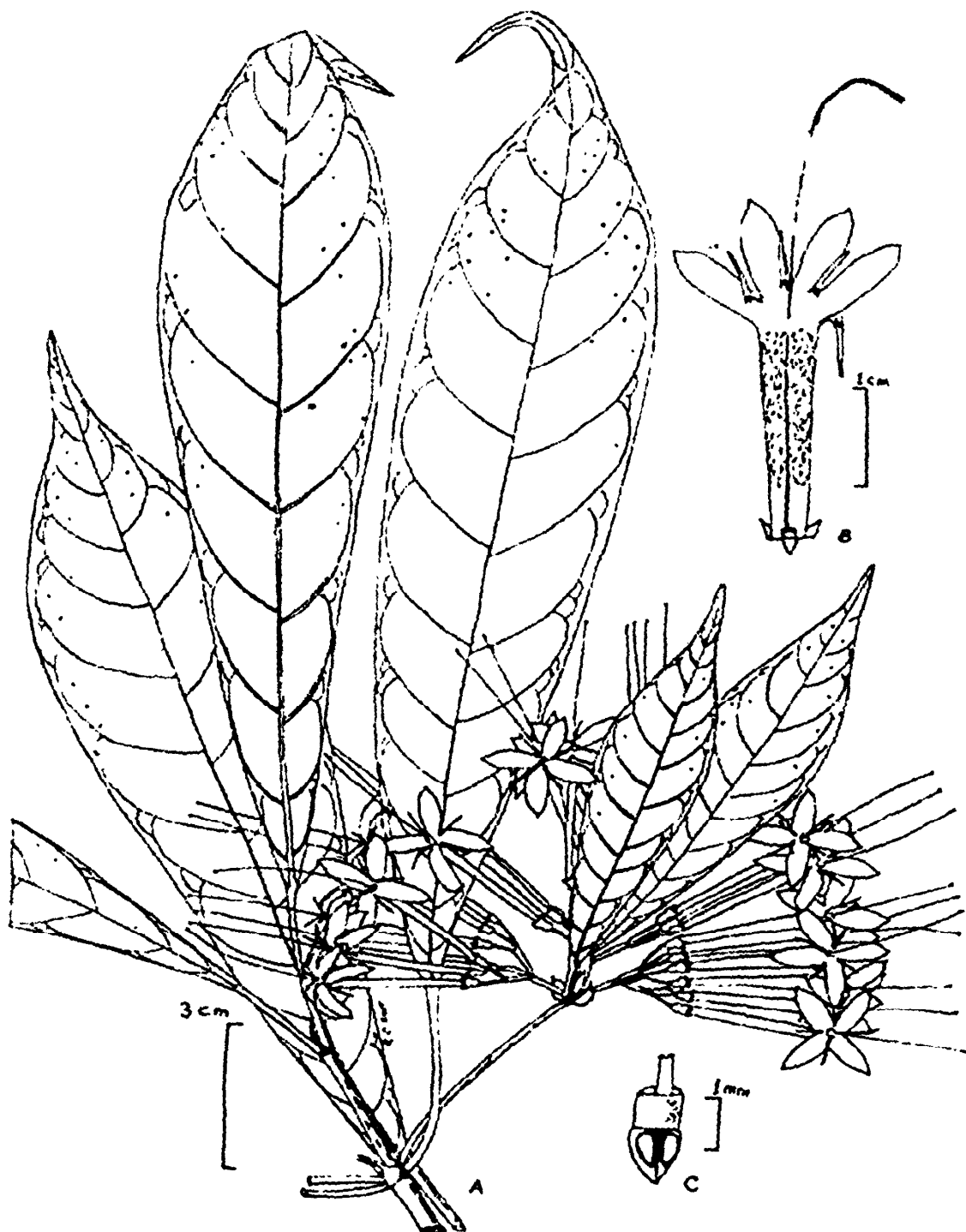
*Distrib.* : INDIA. Kerala : Cochin, in dense evergreen forest at 900 m in altitude.

Notes : i) This species is represented by type collection only. After the original gathering by A. Meebold in 1910, the plant has not yet been recollected.

ii) The stem of this species was described in protologue (Bremekamp 1934) as unbranched, but it is branched in the isotype at CAL.

**19. *Pavetta oblanceolata* Bremek.** in Fedde Repert. 37 : 91. 1934 (*Type* : Kerala, Attraymallay, 1847, *R. H. Beddome* 3920 holo. BM !, photo CAL !) ; Ahmed. & Nayar, End. Pl. Ind. Reg. 1 : 164. 1987 ; Deb & Rout in Nayar & Sastry (ed.) Red Data Book 3 : 227 - 228 t. 1990. (Fig. 38)

Shrubs erect, branched ; stem stout, 4-angled, glabrous. Leaves petiolate, 11-



**Fig. 38 :** *P. oblanceolata* Bremek. : A. habit ; B. flower split open showing floral parts ; C. placentation ; All from Beddome 3920.

25.5 × 25.5 × 1.8 - 4.5 cm, oblanceolate, acuminate or caudate at apex, attenuated at base, membranous, glabrous; bacterial leaf-galls few to many on secondary or more finer nerves, circular, 0.5 - 1.0 mm; domatia absent; midrib subcanaliculate above; lateral nerves 9 - 14 pair, alternate or subopposite, slender, more prominent beneath; petioles 1 - 4 cm long, slender, glabrous; stipules persistent, interpetiolar, 6 - 7 × 3 - 5 mm, triangular at base subulate above, subcoriaceous, glabrous outside, with colleters inside; colleters many on the adaxial surface of stipules, 528 - 1280 µm long, 192 - 480 µm broad, sessile, feathery; trichomes absent. Inflorescence terminal, sessile, trichomously branched corymbose cymes on slender axillary branches, 10 - 12 cm, across, glabrous; bracts 5 - 6 × 4 - 5 mm, triangular, cuspidate, membranous, glabrous. Flowers 30 - 40; pedicles 3 - 8 mm, glabrous. Hypanthium *ca* 1.2 × 1.2 mm, obovoid, glabrous; calyx tube *ca* 1.2 × 1.7 mm, broader above, glabrous; teeth 1.0 - 1.1 × 0.4 - 0.6 mm, narrowly triangular, acute at apex, glabrous. Corolla tube 23 - 25 mm long, 1.2 - 2.0 mm across, cylindrical, glabrous outside, pubescent within; lobes 8 - 9 × 3 mm, oblong, mucronulate at apex, glabrous; internal indumentum 320 - 480 µm long, 28.8 - 32.0 µm broad, unicellular, flat, ribbon-like, subacute at apex, outer wall pitted. Filaments *ca* 1.5 mm, slender, glabrous; anthers 6 - 7 mm; pollen 30 × 28 (27 - 32 × 26 - 30) µm, prolate-spheroidal; 3-zonocolporate, ectocolpium 23 × 2 (20 - 26 × 2 - 3) µm; ora

compound, combining types A<sub>3</sub> and B<sub>1</sub>; type A<sub>3</sub> lanlongate, 4 × 12 (4 - 6 × 10 - 15) µm; type B<sub>1</sub> lolongate, 5 × 3 µm, thickened; apocolpium diameter 5 µm; exine 2 µm, finely reticulate. Ovary *ca* 1 × 1 mm; disc *ca* 0.8 × 0.8 mm; style *ca* 55 mm long, stout, puberulous above, glabrous below; stigma slightly two lobed, lobes 0.2 - 0.3 mm, puberulose. Fruits not seen.

*Fl. & Fr.* : Winter.

*Distrib.* : INDIA. Kerala : Trivandrum dist., Adimalai, Agasthyamalai slopes; Palghat hills, Endemic.

*Note* : This species is known only from the type specimen collected by R. H. Beddome in 1847.

**20. Pavetta praeterita** Bremek. in Fedde Repert. 37 : 92. 1934 (*Type* : Tamil Nadu: Kuttalam hills, March 1835, R. Wight s.n. (*Kew Distrib. No.* 1478) holo. K !, photo CAL !, L : pp.) ; Ahmed. & Nayar, End. Pl. Ind. Reg. 1 : 162. 1987 ; Swaminath. in Henry *et al.* Fl. Tam. 2 : 21. 1987.

(Fig. 39)

Shrubs erect, branched; stem stout, terete, pubescent when young, glabrous and corky in age; internodes short. Leaves petiolate, 4.5 - 16.5 × 1.2 - 3.7 cm, elliptic, oblong or oblong-obovate, rarely narrowly obovate when young, acute or acuminate at apex, cuneate or acute at base, membranous,

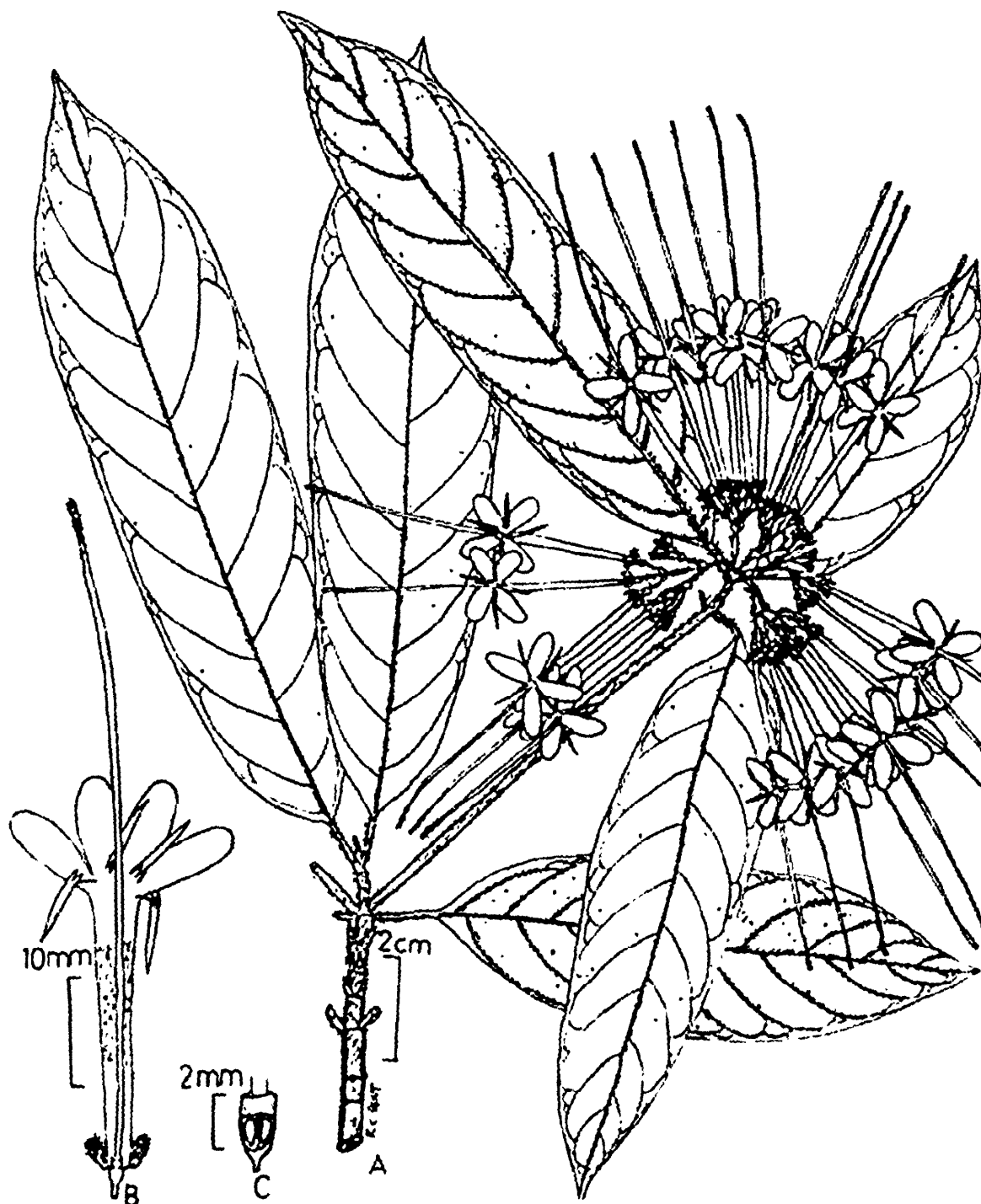


Fig. 39 : *P. praeterita* Bremek. : A. habit ; B. flower split open showing floral parts ; C. placentation ; All from Subramanyam 3069.

scabrous above, puberulous beneath with strigose nerves ; midrib subcanaliculate above, pubescent ; lateral nerves 8 - 11 pair, alternate or subopposite, slender, more prominent beneath ; bacterial leaf-galls few on secondary or tertiary nerves, circular, 0.5 - 0.7 mm, more prominent on lower surface ; domatia tuft type, rarely present (in *R. Wight* s.n. K !) on secondary nerve axils ; petioles 0.5 - 2.5 cm, pubescent ; stipules persistent, interpetiolar, 3 - 4 × 4 - 6 mm, triangular-ovate, cuspidate, subcoriaceous, scarious at margin, pubescent outside, with colleters and trichomes inside ; colleters many on the adaxial surface of stipules, 560 - 1280 µm long, 112 - 240 µm broad, sessile, feathery ; trichomes intermingled with colleters few, silvery white, 480 - 640 µm long, 32 - 56 µm across, pluricellular, cylindrical, 5 - 12 celled, straight or coiled, apical cell acute, outer wall smooth. Inflorescence terminal, sessile, trichotomously branched, corymbose cymes, 7 - 10 cm across, hispid ; bracts *ca* 3 × 4 mm, broadly triangular, membranous, pubescent outside, glabrous within. Flowers 20 - 40 ; pedicels 1 - 5 mm, hispid. Hypanthium *ca* 1.2 × 1.2 mm, obovoid, hispid ; calyx tube *ca* 1.5 × 2.0 mm, broader above, pubescent ; teeth 2.0 - 2.3 × 1.0 mm, obovate, obtuse at apex, pubescent. Corolla tube 20 - 30 mm long, 1 - 2 mm across, cylindrical, glabrous outside, pilose within, glabrous at throat ; lobes 8 - 9 × 2.0 - 3.5 mm, oblong, rounded at apex, glabrous. Filaments *ca* 2.0 mm, glabrous ; anthers *ca* 7 mm ; pollen 35 × 32 (32 - 38 × 28 - 35) µm,

prolate-spheroidal ; 3-zonocolporate ; ectocolpium 27 × 3 (25 - 31 × 2 - 4) µm ; ora compound, combining types A<sub>3</sub> and B<sub>1</sub> ; type A<sub>3</sub> lalongate, 5 × 15 (4 - 6 × 12 - 20) µm, type B<sub>1</sub> lolongate, 5 × 3 µm, thickened ; apocolpium diameter 7 - 8 µm, exine 2 µm, reticulate. Ovary *ca* 1 × 1 mm ; disc *ca* 0.8 × 1.0 mm ; style 42 - 74 mm, stout, glabrous below, slender and puberulous above ; stigma *ca* 0.5 mm, simple or slightly notched, puberulous. Fruits not seen.

*Fl.* : March - May ; *Fr.* : ?

*Distrib.* : INDIA. Tamil Nadu : Kuttalam hills ; Coimbatore dist., Siruvani, in evergreen forests at about 1000 m in altitude.

*Specimens examined* : INDIA : TAMIL NADU : Coimbatore dist., Shiruvani Adivaram, 1000 m, 30.5.1957, K. Subhramanyam 3069 (CAL, MH).

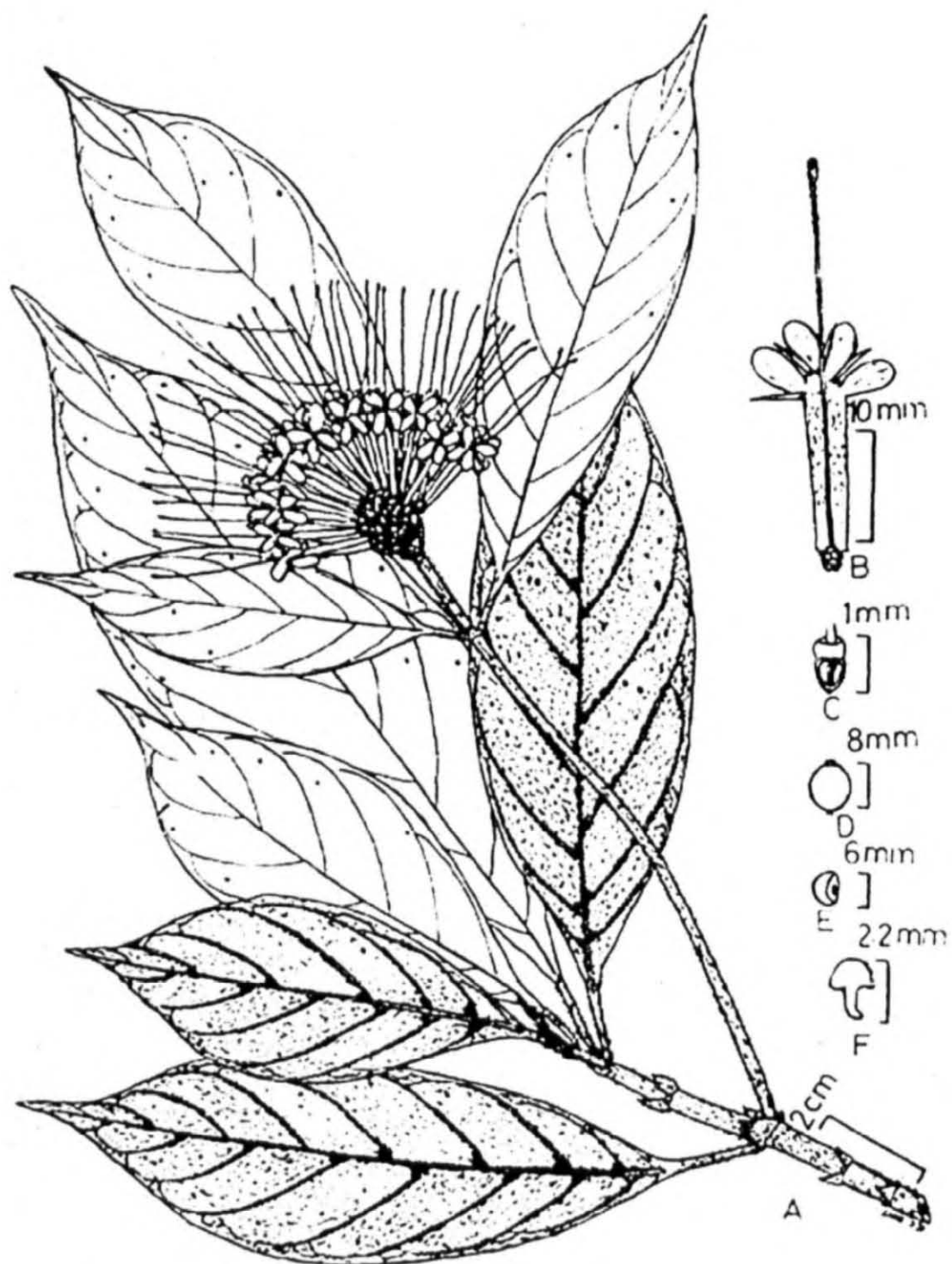
**21. Pavetta subcapitata** Hook.f. Fl. Brit. Ind. 3 : 150. 1880 (*Type* : India : Meghalaya, Jaintia hills, Silhet Mt., Gomez s.n. ex Wall. Cat. 6160 K ! microfische & iso. CAL !); Brandis, Ind. Trees 387. 1906 ; Osmaston, For. Fl. Kumaon 295. 1927 ; Bremek. in Fedde Repert. 37 : 95. 1934 ; Kanjilal *et al.* Fl. Assam 3 : 73. 1939 ; Biswas in Ind. For. Rec. 3 : 27. 1940 ; Sinclair in Bull. Bot. Soc. Bengal 9 : 97. 1955 ; Deb in Bull. Bot. Surv. Ind. 3 : 312. 1961 ; S. Rao in Bull. Bot. Surv. Ind. 8 : 300. 1996 ; Deb & Dutta in Journ. Bomb. Nat.

Hist. Soc. 70 : 79. 1973, & Journ. Econ. Bot. 10 : 40. 1987.

*Ixora subcapitata* Wall. Cat. 6160, *nom. nud.* (Fig. 40)

Shurbs or small trees 2.0 - 4.5 m high, erect, branched ; stem stout, terete, glabrous, pubescent when young ; bark brown. Leaves petiolate, 6.3 - 28.5 × 1.5 - 7.5 cm, elliptic, elliptic-oblong, lanceolate, obovate or oblanceolate, acuminate or caudate at apex, acute at base, membranous, glabrous or glabrescent and shining above, pubescent or puberulous beneath, rarely on nerves ; bacterial leaf-galls many on secondary or tertiary nerves, rarely on midrib, usually circular (0.5 - 1.0 mm), rarely elliptic (1.0 - 1.5 × 0.4 - 0.5 mm) or oblong (1.5 - 3.0 × 0.5 - 0.8 mm), more prominent on lower surface ; domatia tuft type, present on secondary nerve axils ; midrib canaliculate above ; lateral nerves 7 - 12 pair, alternate or subopposite, slender ; petioles 0.5 - 2.8 cm, puberulous or pubescent ; stipules persistent, interpetiolar, 4-6 × 3-5 mm, broadly triangular, cuspidate, coriaceous, pubescent outside, with colleters and trichomes inside, colleters many, 352 - 1216 µm long, 128 - 208 µm broad, stalked, feathery ; stalk 48 - 96 µm long ; trichomes intermingled with colleters, few, 386 - 1088 µm long, 26 - 32 µm across, pluricellular, cylindrical, 8 - 16 celled, apical cell acute, outer wall smooth. Inflorescence terminal, sessile or subsessile, subcapitate cymes, 5-6 cm across, pubescent ;

peduncles up to 0.4 cm, pubescent ; bracts 3 - 5 × 1-3 mm, broadly triangular, membranous, pubescent outside, glabrous within. Flowers 20 - 62, sessile or subsessile ; pedicels upto 1.5 mm, enlarged in fruits or not, stout, pubescent. Hypanthium *ca* 1 × 1 mm, obovoid, pubescent ; calyx tube *ca* 1.0 × 1.5 mm, broader above, pubescent outside, glabrous within ; teeth *ca* 0.3 × 0.2 mm, triangular, subacute at apex, pubescent outside, glabrous within. Corolla tube 16 - 22 mm long, *ca* 1 mm across, cylindrical, glabrous outside, pilose within ; lobes 5.0 × 6.5 × 2.0 - 3.0 mm, oblong or obovate, obtuse, rounded or mucronulate at apex, glabrous ; internal indumentum 448 - 656 µm long, 16 - 24 µm broad, unicellular, ribbon-like, subacute at apex, surface pitted. Microcharacters of inner surface of corolla lobes ; epidermal cells ridged with smooth or striate cuticular surface. Filaments *ca* 0.5 mm, glabrous ; anthers *ca* 5 mm ; pollen 30 × 26 (29 - 34 × 24 - 28) µm, subprolate, 3-zonocolporate, ectocolpium 25 × 3 (23 - 28 × 2 - 4) µm, colpus membrane smooth ; ora compound, combining types A<sub>3</sub> and B<sub>1</sub> ; type A<sub>3</sub> lalongate, 5 × 12 (3-6 × 10-14) µm ; type B<sub>1</sub> lalongate, 5 × 3 µm, thickened ; apocolpium diameter 5 µm ; exine 2 µm, reticulate. Ovary *ca* 0.8 × 0.8 mm ; disc *ca* 0.4 × 0.8 mm ; style 35 - 40 mm, slender, glabrous below, puberulous above ; stigma *ca* 3 mm, fusiform, pubescent. Drupes 7 - 8 mm across, subglobose, rarely didymous, pubescent, 1 (rarely 2) seeded ; seeds *ca* 6 mm, exotestal cells 64 - 184 µm long, 20 -



**Fig. 40 :** *P. subcapitata* Hook. f. : A. habit ; B. flower split open showing floral parts ; C. placentation ; D. fruit ; E. seed ; F, embryo. A-C. from King's collector s.n. ; D-F. from Prazer s.n.

50  $\mu\text{m}$  thick, hexagonal or pentagonal with straight walls, surface striate granulate ; embryo *ca* 2.2 mm ; radicle *ca* 1 mm, stout, curved ; cotyledons 2, *ca* 1.2  $\times$  1.2 mm, equal, reniform, rounded at apex, cordate at base ; plumule minute, enclosed within cotyledons.

*External indumentum* 240 - 640  $\mu\text{m}$  long, 16 - 56  $\mu\text{m}$  across, uni or pluricellular, cylindrical, 1 - 6 celled, apical cell acute, curved, basal cell broad, surface smooth.

*Fl.*: April-September ; *Fr.*: June November.

*Ecology* : Evergreen forests, at 60 - 1500 m, in altitude.

*Distrib.* : INDIA. Arunachal Pradesh, Assam. Meghalaya, Nagaland, Uttar Pradesh ; BANGLADESH.

*Specimens examined* : INDIA. ARUNACHAL PRADESH : Banfera, 13. 7. 1961, *D. B. Deb* 26700 (CAL).

ASSAM : *King's collector* s.n. (BSIS) ; Gwahati, September 1850, *Coll.* ? s.n. (CAL) ; *C. Jenkins* s.n. (DD) ; Debudanghebe, 60 m, April, *G. Mann* s.n. (CAL) ; Cachar, 1889, *J. C. Prazer* s.n. (CAL) ; 1891, *King's collector* s.n. (CAL) ; Darrang dist., Behali Res., 75 m, 7. 4. 1914, *U. N. Kanjilal* 3756 (CAL) ; Hojai, 102 m, 18. 4. 1914. *U. N. Kanjilal* 3834 (CAL) ; Mikir hills dist., Tamullaei forest, 24. 6. 1963, *D. B. Deb* 35313 (ASSAM) ; Kamrup dist., Chauduldei

lake, 17. 6. 1964, *A. S. Rao* 38901 (CAL).

MEGHALAYA : Khasi & Jaintia hills, 1500 m, 1878, *G. Gallatly* 102 (CAL) ; Jaintia hills, 1200 - 1500 m, May 1878, *Coll.* ? 752 (CAL) ; Khasi hills, 1880, *Fischer* s.n. (CAL) ; Khasi hills and Brahmaputra plains, *Kurz* s.n. (CAL) ; 900 - 1200 m, *Kurz* 286 (CAL) ; *G. Mann* s.n. (CAL) ; Shillong, May 1893, *King's collectors* s.n. (BSIS, CAL) ; Garo hills, *T. D. Srinivasan* 1692 (CAL).

NAGALAND : Naga hills, Baligao, November 1898, *Prain's collector* 394 (CAL) ; Tingale Bum, April 1899, *Prain's collector* 927 (DD, MH) ; May 1899, *Prain's collector* 990 (CAL) ; Ghaspani, 450 m, 24. 4. 1945, *N. L. Bor* 18466 (DD).

UTTAR PRADESH : Western Himalaya, Garhwal, 30. 5. 1902, *Inayat* 26095 (CAL, DD).

BANGLADESH : Chittagoan hill tracts, Kaptai, 4. 4. 1876, *J. L. Listèr* s.n. (CAL).

**22. *Pavetta travancorica* Bremek.** in Fedde Repert. 37 : 81. 1934 (*Type* : Travancore, June 1835, *R. Wight* s.n. (*Kew Distrib. No.* 1485) holo. K !, photo CAL !) ; Ahmed. & Nayar, End. Pl. Ind. Reg. 1 : 162. 1987 ; Deb & Rout in Journ. Bomb. Nat. Hist. Soc. 89 (3) : 349. 1992.

*P. bourdillonii* Silvadasan & Mohanan in Bot. Bull. Acad. Sin 40 : 61. 1999 (*Type* : Kerala, Agasthyimalai Hills, Althayar, June

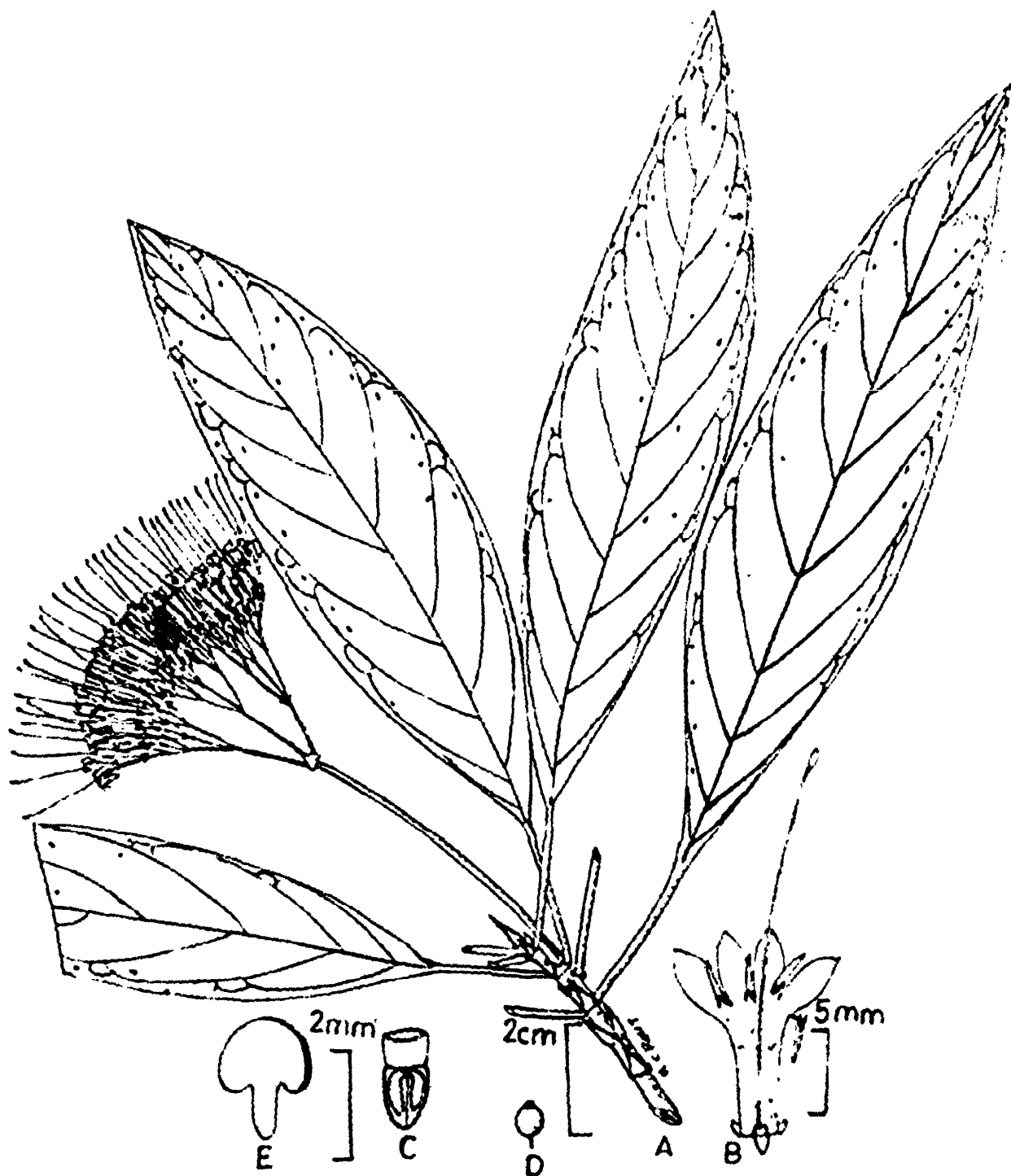
1994, Mohanan TBG & RI 12442 (holo. k : ISO. CAL !) *Syn. nov.*].

*P. concanica* Bremek. in Fedde Repert. 37 : 81. 1934 (Type : Konkan, Law s.n. holo. K !, photo CAL !) ; Sant. & Merch. in Bull. Bot. Surv. Ind. 3 : 109. 1961 ; Sant. in Rec. Bot. Surv. Ind. 16 : 119. 1967 ; Billore & Hemadri in Bull. Bot. Surv. Ind. 11 : 340. 1969 ; Karthikeyan *et al.* in Rec. Bot. Surv. Ind. 21 : 168. 1981.

*P. laeta* Bremek. in Fedde Repert. 37 : 82. 1934 (Type : Tamil Nadu, Pulney hill, 1914, R. A. Sauliere 673 holo. K !, photo CAL !) ; Sharma *et al.* in Biol. Mem. 2 : 72. 1977 ; Ahmed. & Nayar, End. Pl. Ind. Reg. 1 : 162. 1987 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 21. 1987. (Fig. 41)

Shrubs or small trees erect, branched ; stem stout, terete or subquadrangular, glabrous, rarely pubescent when young, corky in age. Leaves petiolate, 4.0 - 20.2 × 0.7 - 5.5 cm, elliptic, elliptic-lanceolate, subacute, acute or acuminate at apex, acute or attenuated at base, membranous or subcoriaceous, glabrous above, glabrous or pubescent beneath ; bacterial leaf-galls many in some leaves, few or absent in others, present on secondary or more finer nerves, circular (0.3 - 0.5 mm) or elliptic (*ca* 0.5 × 0.3 mm), more prominent on lower surface ; domatia absent ; midrib canaliculate above ; lateral nerves 5 - 14 pair, alternate or subopposite, more prominent beneath, slender ; petioles 0.8 - 3.5 cm, glabrous, rarely

pubescent ; stipules deciduous above, persistent below at base, interpetiolar, 5-9 × 4-5 mm, narrowly triangular, acute at apex, membranous, scarious, glabrous or rarely pubescent outside, with colleters and trichomes inside ; colleters few to many on adaxial surface of stipules, 352 - 1600 µm long, 112 - 320 µm broad, stalked or sessile, dendroid, feathery or brush-like ; stalk 64 - 160 µm long ; trichomes intermingled with colleters, few to many silvery white, 160 - 736 µm long, *ca* 24 µm across, pluricellular, cylindrical, 5 - 10 celled, apical cell acute, straight, outer wall smooth. Inflorescence axillary, peduncled, trichotomously branched, compact or loosely corymbose cymes, rarely with a pair of reduced lanceolate leaves at base, 3 - 8 cm across, glabrous, rarely pubescent ; peduncles 1.5 - 6.0 cm long, slender, glabrous or pubescent ; bracts 3 - 4 × 4 - 5 mm, cuspidate, membranous, glabrous or rarely pubescent. Flowers 30 - 90 ; pedicels 3 - 8 mm, glabrous or pubescent. Hypanthium 0.8 - 1.0 × 0.5 - 1.0 mm, obovoid or subglobose, glabrous or pubescent ; calyx tube 0.5-0.8 × 1.2 - 1.3 mm, broader above, glabrous, rarely pubescent outside ; teeth 0.2 - 0.5 × 0.3 - 0.4 mm, dentate or triangular, acute at apex, glabrous, rarely pubescent outside. Corolla tube 6.5 - 12 mm long, 1.0 - 1.2 mm across, cylindrical, glabrous outside, pubescent within ; lobes 4 - 6 × 1.5 - 3.0 mm, oblong, obtuse or acute at apex, glabrous ; internal indumentum 288 - 672 µm long, *ca* 24 µm broad, unicellular, flat, ribbon-like, acute or



**Fig. 41 :** *P. travancorica* Bremek. : A. habit ; B. flower split open showing floral parts ; C. placentation ; D, fruits ; E, embryo. A - C, from B.V. Shetty 10292; D & E, from N. Venugopal 15909.

subacute at apex, surface pitted. Microcharacters of outer surface of corolla tube : epidermal cells elongated, surface with fine longitudinal cuticular striations ; inner surface of corolla lobes : epidermal cells depressed, suborbicular, surface rugose. Filaments 0.8 - 1.5 mm, slender, glabrous ; anthers 4 - 5 mm, pollen  $25 \times 25$  ( $22 - 30 \times 22 - 26$ )  $\mu\text{m}$ , spheroidal, 3-zonocolporate ; ectocolpium  $20 \times 2$  ( $15 - 24 \times 1 - 3$ )  $\mu\text{m}$ , ora compound, combining types  $A_2$  and  $B_1$  ; type  $A_2$  lalongate,  $4 \times 11$  ( $3 - 6 \times 9 - 13$ )  $\mu\text{m}$  ; type  $B_1$  lolongate,  $5 \times 2$   $\mu\text{m}$ , thickened ; apocolpium diameter 4 - 5  $\mu\text{m}$  ; exine 1.5  $\mu\text{m}$ , reticulate, lumina 1  $\mu\text{m}$ . Ovary *ca*  $1.0 \times 0.7 - 0.8$  mm, disc  $0.6 - 0.8 \times 0.7 - 0.8$  mm ; style 18 - 26 mm long, slender, glabrous or sparsely puberulous above, glabrous below ; stigmatic lobes 2, minute, puberulous. Drupes 5 - 7 mm across, subglobose or slightly 2-lobed, black when dry, shining, glabrous or sparsely pubescent, with persistent calyx ; seeds 1 or 2, 3.5 - 4.0 mm ; exotestal cells 112 - 160  $\mu\text{m}$  long, 16 - 24  $\mu\text{m}$  thick, hexagonal, with straight walls, surface striate-granulate ; endosperm entire, horny ; embryo *ca* 2.2 mm ; radicle *ca* 1.0 mm, stout ; cotyledons 2, *ca*  $1.2 \times 1.5$  mm, reniform, obtuse at apex, cordate at base ; plumule minute, enclosed within cotyledons.

*External indumentum* 64 - 208  $\mu\text{m}$  long, 11 - 16  $\mu\text{m}$  across, pluricellular, cylindrical, 2 - 5 celled, apical cell acute, straight or curved, outer wall smooth.

*Fl.* : February - June ; *Fr.* : March - November.

*Ecology* : Evergreen or semievergreen forests, alt. 400 - 1365 m.

*Distrib.* : INDIA. Karnataka, Kerala, Tamil Nadu.

*Specimens examined* : KARNATAKA : near Dedguli estate, 1200 m, 11.7.1930, V. Narayanaswami 3880 (MH) ; Agumbe, Barakhana falls, 19.5.1960, R. S. Raghavan 62717 (CAL, E) ; Vangur, 10.3.1971, T. P. Ramamoorthy 1445 (K) ; Hassan dist., Neradi, 900 m, 17.2.1972, T. P. Ramamoorthy & K. N. Gandhi 2660 (E) ; Kodagu dist., Kutta, 9.11.1979, K. P. Sreenath & B.G. Singh 10320 (CAL) ; Chikmagalur dist., Jayapura, 650 m, 5.2.1980, M. Kameswara Rao 125 (CAL).

KERALA : Travancore, June 1835, R. Wight s.n. (*Kew Distrib. No.* 1486 pp.) (K! photo CAL !) ; Makara, 5.9.1913, M. Rama Rao 1663 (CAL) ; Kottayam dist., Maniyur, 1000 m, 19.4.1964, K. M. Sebastine 18316 (CAL).

TAMIL NADU : Kuttalam, April 1835, R. Wight 359 (E) ; August 1835, R. Wight 393 (E) ; Anamallays, 1885, R. H. Beddome 3913 (BM) ; Pulneys, Kodaikanal ghat, 15.5.1898, A. G. Bourne 530 (CAL) ; Coimbatore dist., Goddesal, 1200 m, 9.5.1906, C. E. C. Fischer 1086 (CAL) ;

Perumal slopes, above Mangaiai, 960 m, 12.5.1910, *C. E. C. Fischer* 1895 (CAL) ; *Sauliere* 446 (CAL) ; Perumalmudi, 965 m, 21.4.1970, *M. V. Viswanathan* 539 A (MH) ; Nilgiri hills, *Perrottet* 502 pp. (BM) ; Bakkapuram, 925 m, 17.4.1971, *N. C. Rathakrishnan* 37926 (MH) ; Malattaaru, Vasudevanallur, 400 m, *E. Vajravelu* 33927 (MH) ; Tinnevely dist., Therkumalai, 800 m, 24.4.1957, *K. Subramanyam* 2901 (MH) ; Madurai dist., Sirumalai, 900 m, 25.4.1958, *K. Subramanyam* 5767 (CAL, MH) ; Suruli falls, 475 m, 24.4.1960, *B. V. Shetty* 10292 (CAL, MH) ; 1075 m, 25.2.1978, *M. Chandrabose* 54282, 54283 (CAL) ; Salem dist., Yercaud, 1365 m, 30.6.1965, *A. V. N. Rao* 26903 (CAL) ; Namakkal, Kolli hills, Semmedu, Nachiarkoil shola, 1150 m, 17.4.1978, *A. Mohan* 12971 (CAL) ; Rasipuram, Mettukadu, 1050 m, 31.7.1978, *N. Venugopal* 15909 (CAL) ; Periakombai, *N. Venugopal* 15917 (CAL) ; Attur, Kumbakkal, 900 m, 21.9.1978, *N. Venugopal & C. Manoharan* 17566 (CAL) ; Ramnad dist., Kandiparai slopes, Ayyanarkoil, 910 m, 23.9.1971, *E. Vajravelu* 38713 (MH).

**23. *Pavetta thwaitesii* Bremek.** in Fedde Repert. 37 : 94. 1934 (Type : Sri Lanka, March 1836, *R. Wight* 1484 holo. K !, photo CAL !).

*Pavetta indica* auct. non L., Thwaites Enum. Pl. Zeyl. 156. 1869 (var. B) ; Hook.f.

Fl. Brit. Ind. 3 : 150. 1880 (var. 1) pp. (Fig. 42)

Shrubs erect, branched ; branches slender, terete below, flattend above, glabrous. Leaves petiolate, 4.5 - 12.5 × 0.6 - 2.6 cm, linear-lanceolate or elliptic-lanceolate, acuminate at apex, acute at base, subcoriaceous, glabrous ; bacterial leaf-galls many on secondary or more finer nerves, rarely absent in some leaves, circular (0.3 - 1.0 mm) or elliptic (1.0 - 1.5 × 0.5 - 1.0 mm), more prominent on lower surface ; domatia absent ; lateral nerves 4 - 9 pair, alternate, rarely subopposite, slender ; petioles 0.4 - 1.5 cm, slender, glabrous ; stipules persistent, interpetiolar, 1.5 - 2.0 × 1.0 - 1.5 mm, triangular, acute at apex, subcoriaceous, glabrous outside, with colleters inside ; colleters many, 352 - 748 µm long, 96 - 160 µm broad, stalked, feathery ; stalk 80 - 96 µm long ; trichomes absent with colleters. Inflorescence terminal subsessile trichotomously branched, loosely corymbose cymes with slender branches, 5.5 - 7.0 cm across, glabrous ; peduncles 0.2 - 0.8 cm, slender ; bracts 2 - 3 × 3 - 4 mm, cuspidate, membranous, glabrous. Flowers 9 - 50 ; pedicels 10 - 15 mm long, slender, glabrous. Hypanthium *ca* 1 × 1 mm, obovoid, glabrous ; calyx tube *ca* 1.0 × 1.2 mm, broader above, glabrous ; teeth *ca* 0.4 - 0.2 mm, narrowly triangular, acuminate at apex, glabrous. Corolla tube 10 - 15 mm long, 0.7 - 1.0 mm

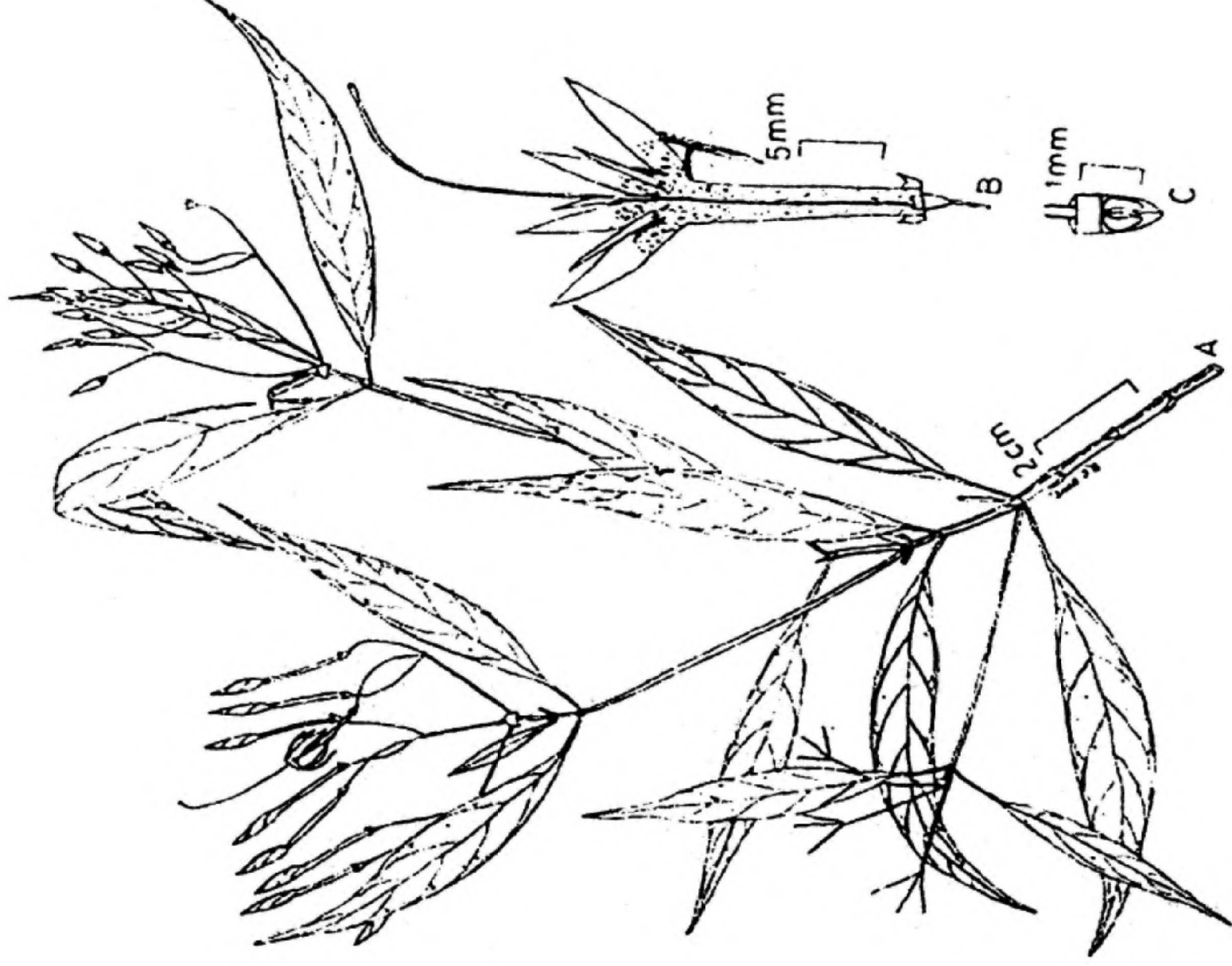


Fig. 42 : *P. thwaitesii* Bremk. A. habit ; B. flower split open showing floral parts ; C. placentation .  
All from *Thwaites* C.P. 2611.

across, cylindrical, glabrous outside, pubescent within and at throat ; lobes  $8 \times 10 \times 2$  mm, oblong-lanceolate, acuminate at apex, glabrous outside, pubescent within below ; internal indumentum  $400 - 512 \mu\text{m}$  long,  $24 - 32 \mu\text{m}$  broad, unicellular, ribbon like, acute or subacute at apex, outer wall pitted. Microcharacters of inner surface of corolla lobes : epidermal cells ridged, surface smooth or striate. Filaments *ca* 1.5 mm, flattened, puberulous ; anthers  $5 - 7$  mm ; pollen  $32 \times 24$  ( $30 - 38 \times 20 - 27$ )  $\mu\text{m}$ , prolate, 3-zonocolporate ; ectocolpium  $26 \times 2$  ( $23 - 32 \times 2 - 3$ )  $\mu\text{m}$ , ora compound, combining types  $A_3$  and  $B_1$  ; type  $A_3$  lalongate,  $5 \times 8$  ( $4 - 6 \times 8 - 13$ )  $\mu\text{m}$  ; type  $B_1$  lolongate,  $5 \times 2 \mu\text{m}$ , thickened ; apocolpium diameter  $7 \mu\text{m}$  ; exine  $1.5 \mu\text{m}$ , reticulate, lumina *ca*  $1 \mu\text{m}$ , columellate. Ovary *ca*  $1.0 \times 0.8$  mm ; style  $25 - 35$  mm, disc *ca*  $0.5 \times 0.8$  mm ; slender, glabrous ; stigma  $0.2$  mm, slightly notched, glabrous. Drupes  $4-5$  mm across, subglobose, glabrous.

*Fl.* : March ; *Fr.* : October.

*Ecology* : Evergreen forests, at 600 - 900 m altitude.

*Distrib.* SRI LANKA : Paradeniya, Amugamawa dist.

**24. *Pavetta wightii*** Hook.f. Fl. Brit. Ind. 3 : 152. 1880 (*Type* : Tamil Nadu : Nilgiri hills, January 1848, *R. Wight* 1480 pp.

lecto. K !, photo CAL ! ) ; Brandis, Ind. Trees 387. 1906 ; Gamble, Fl. Pres. Madras 643. 1921 ; Bremek. in Fedde Repert. 37 : 93. 1934 ; Sharma *et al.* in Biol. Mem. 2 : 72. 1977 ; Ahmed. & Nayar, End. Pl. Ind. Reg. 1 : 162. 1987 ; Swaminath. in Henry *et al.* Fl. Tam. Nad. 2 : 21. 1987 ; Deb & Rout in Nayar & Sastry, Red Data Book 3 : 229 - 330 t. 1990.

*Ixora wightii* (Hook.f.) Kuntze, Rev. Gen. Pl. 1 : 287. 1891. (Fig. 43)

Shrubs *ca* 3 m tall, erect, branched ; stem stout, terete, glabrous ; bark brown. Leaves petiolate,  $8 - 16 \times 1.8 - 5.5$  cm, elliptic-lanceolate or elliptic-oblong, acute at both ends, coriaceous, glabrous above, puberulous beneath with pubescent nerves ; bacterial leaf-galls many on tertiary or more finer nerves, rarely on midrib or secondary nerves ; normally circular ( $0.5 - 1.0$  mm), rarely elliptic (*ca*  $1.5 \times 1.0$  mm), oblong (*ca*  $2 \times 1$  mm), linear (*ca*  $3 \times 0.5$  mm), dumbbell-shaped or stellate, more prominent on lower surface ; domatia tuft type, present on secondary nerve axils ; midrib canaliculate above ; lateral nerves 11 - 13 pair, alternate or subopposite, more prominent beneath ; petioles  $0.7 - 2.0$  cm, stout, glabrous ; stipules persistent, interpetiolar,  $6-8 \times 5-6$  mm, broadly triangular, cuspidate, coriaceous, scarious at margin, glabrous outside, with colleters and trichomes within ; colleters many on adaxial surface of stipules,  $544 - 1520 \mu\text{m}$  long,  $144 - 240 \mu\text{m}$  broad, sessile or stalked,

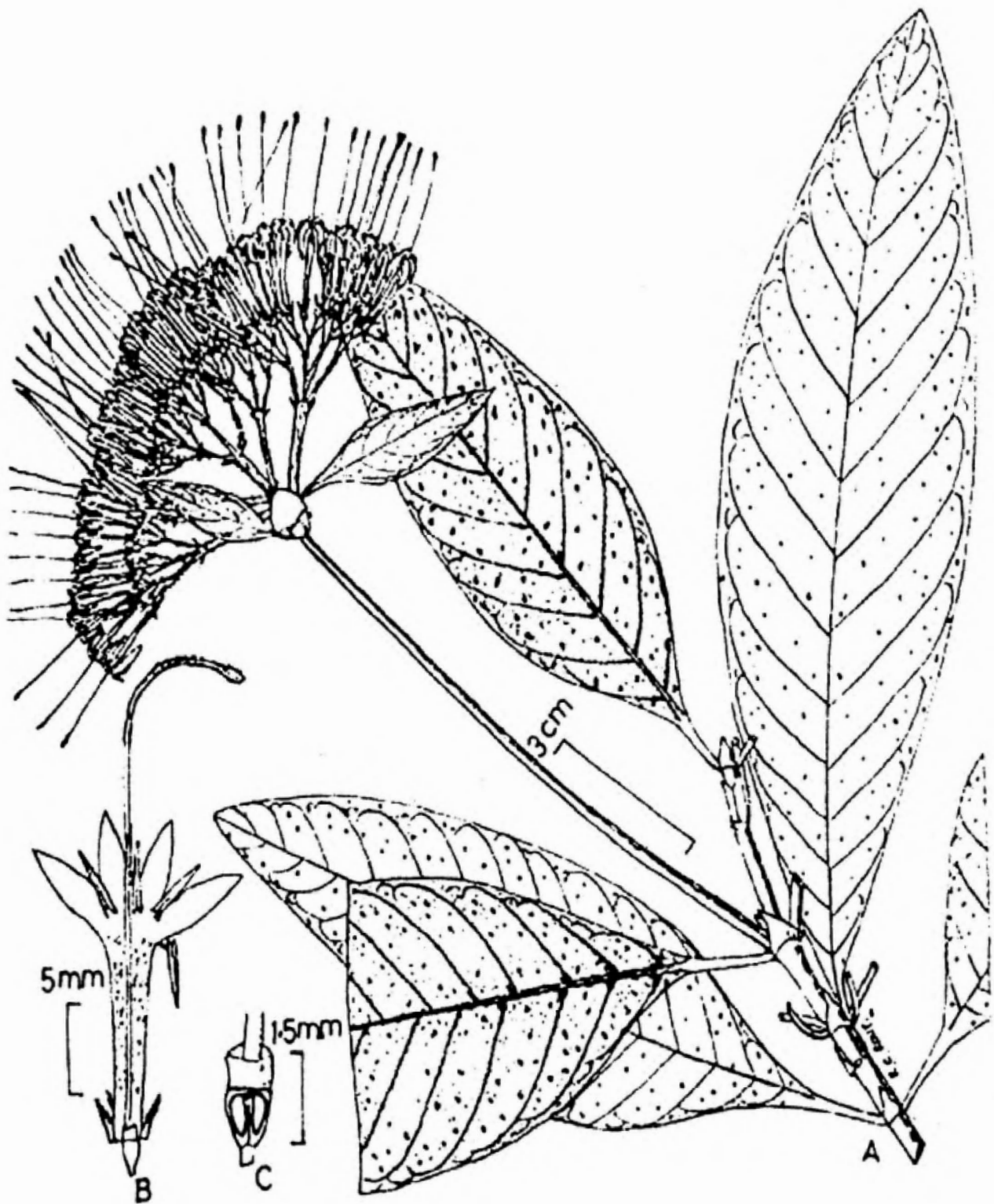


Fig. 43 : *P. wightii* Hook. f. : A. habit ; B. flower split open showing floral parts ; C. placentation. All from Wight s.n..

dendroid ; stalk up to 64  $\mu\text{m}$  long ; trichomes intermingled with colleters few, silvery white, 320 - 672  $\mu\text{m}$  long, 16 - 24  $\mu\text{m}$  across, pluricellular, cylindrical, straight or curved, rarely coiled, apical cell acute, outer wall smooth. Inflorescence terminal, subsessile, trichotomously branched corymbose cymes, 7 - 10 cm across, puberulous ; peduncles 0.2 - 0.3 cm, puberulous ; bracts *ca* 5  $\times$  7 mm, broadly triangular, membranous, glabrous. Flowers 50 - 80 ; pedicels 2 - 6 mm, puberulous. Hypanthium *ca* 1.0  $\times$  1.2 mm, obovoid, puberulous ; calyx tube *ca* 1.0  $\times$  1.5 mm, broader above, puberulous outside, glabrous within ; teeth 1.5 - 1.8  $\times$  0.7 mm, narrowly lanceolate, acute at apex, puberulous. Corolla tube 10 - 13 mm long, 0.8 - 1.0 mm, across, cylindrical, glabrous outside, pubescent within ; lobes 6.0 - 6.5  $\times$  1.8 mm, oblong, acute at apex, glabrous. Microcharacters of outer surface of corolla tube : epidermal cells elongated, surface with fine longitudinal cuticular striations ; inner surface of corolla lobes : epidermal cells ridged, surface rugose. Filaments *ca* 0.8 mm, slender, glabrous ; anthers 4.5 - 5.5 mm ; pollen 35  $\times$  28 (32 - 38  $\times$  23 - 32)  $\mu\text{m}$ , subprolate, 3-zonocolporate; ectocolpium 28  $\times$  4 (26 - 31  $\times$  2 - 5)  $\mu\text{m}$  ; ora simple, type  $A_3$ , lalongate, 4  $\times$  14 (4 - 7  $\times$  10 - 16)  $\mu\text{m}$ , thickened with equatorial bridge, tenuimarginate ; apocolpium diameter 7  $\mu\text{m}$  ; exine 1.5  $\mu\text{m}$ , reticulate, columellate, lumina 1 - 15  $\mu\text{m}$ . Ovary *ca* 1  $\times$  1 mm, disc *ca* 0.5  $\times$  1.0 mm ; style 25 - 31 mm, slender, glabrous below,

puberulous above ; stigma *ca* 1.5 mm, clavate, puberulose.

*External indumentum* 32 - 160  $\mu\text{m}$  long, 13 - 16  $\mu\text{m}$  across, pluricellular, cylindrical, 2 - 3 celled, apical cell narrow, acute, basal cell broad, outer wall smooth.

*Fl.* : January - March ; *Fr.* : January - April.

*Ecology* : In the sholas of the rain forest about 1050 - 1300 m in altitude.

*Distrib.* : INDIA. Tamil Nadu : Nilgiri hills, Coonoor valley, Kunjapani.

*Specimens examined* : INDIA. TAMIL NADU : Nilgiri hills, January 1848, *R. Wight* s.n. (CAL) ; Deva shola, Feb. 1886, *M. A. Lawson* s.n. (MH) ; Ramamyde estate, Coonoor valley, 1200 m, 9.1.1910, *C. E. C. Fischer* 1560 (CAL) ; Kunjapani, 1050 m, 19.2.1937, *W. Koelz* 11071 (E) ; Coonoor-Marappalam, 1300 m, 1.3.1972, *B. D. Sharma* 40360 (MH).

*Notes* : i) This species is endemic to Nilgiri hills (Coonoor valley, Kunjapani) of Tamil Nadu.

ii) The type of this species has been cited in protologue (Hook.f. 1880) as *Wight's* collection from Nilgiri hills. The lectotype was selected by Bremekamp (1934) as Nilgiri hills, *Wight* 1480 K. There are three specimens at CAL : Palghat, January 1850, *R. Wight* 1480, which differ from this species and belongs to *P. indica* var. *indica*.

iii) *P. wightii* Hook.f. differs from other species of the genus in leaves puberulous beneath, calyx teeth longer, lanceolate ; inflorescence, hypanthium and calyx puberulous.

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