

EPIDERMAL AND VENATION STUDIES IN APOCYNACEAE—VI

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ABSTRACT

The paper describes and evaluates the taxonomic value of the epidermal features and venation pattern of the leaves of 11 species of Apocynaceae viz., *Carissa carandas* Linn., *C. congesta* Wight, *C. hirsuta* Roth, *C. inermis* Vahl, *C. opaca* Stapf ex Parker, *C. paucinervia* A. DC., *C. spinarum* Linn., *C. suavissima* Bedd. ex Hook.f., *Trachelospermum lucidum* (D. Don) K. Schum., *Vinca major* Linn. and *Willoughbeia edulis* Roxb.

INTRODUCTION

The epidermal and venation studies carried out in 45 taxa of Apocynaceae yielded valuable data for use in taxonomy and pharmacognosy (Chandra *et al.*, 1969, 1972; Kapoor *et al.*, 1969; Sharma *et al.*, 1970; Mitra *et al.*, 1978). The present investigation involves 11 species of Apocynaceae, viz., *Carissa carandas* Linn., *C. congesta* Wight, *C. hirsuta* Roth, *C. inermis* Vahl, *C. opaca* Stapf ex Parker, *C. paucinervia* A. DC., *C. spinarum* Linn., *C. suavissima* Bedd. ex Hook. f., *Trachelospermum lucidum* (D. Don) K. Schum., *Vinca major* Linn. and *Willoughbeia edulis* Roxb. *Carissa carandas*, though already investigated on the basis of samples collected at Lucknow and reported upon in a previous communication (Kapoor *et al.*, 1969), has been included here again as some differences were observed in the material procured from Bombay. *Trachelospermum lucidum* has been studied on the basis of two specimens each obtained from distant localities falling in different phytogeographical zones and data have been separately recorded. *Carissa inermis* and *C. suavissima*, though regarded as conspecific, have, for the purpose of pre-

sent study, been treated as distinct for the reasons detailed under 'discussion'.

MATERIALS AND METHODS

Leaves were collected from vouchered herbarium specimens belonging to the following herbaria: Industrial Section (BSIS), Botanical Survey of India, Calcutta; Madras Herbarium (MH), Botanical Survey of India, Southern Circle, Coimbatore; Blatter Herbarium (BLAT), St. Xavier's College, Bombay and National Botanic Gardens, Lucknow (LWG). These were softened by soaking them in water for about 24 hours. The same method was then followed as described earlier (Chandra *et al.*, 1969). The voucher herbarium specimens used in the present study have been cited against each.

OBSERVATIONS

The important data with regard to the description and dimension of stomata and epidermal cells, stomatal index, average number of vein islets and vein endings per sq. mm and average palisade ratio are presented in the table. The details of the exomorphic and endomorphic features are described below.

Carissa carandas Linn. (*Irani 1984*; BLAT).

Exomorphic characters: Leaves 3.5-8.5 × 2.5-5.5 cm, opposite, simple, subsessile or shortly petiolate, broadly-elliptic to oblong-

elliptic, obtuse or retuse, shortly mucronate, base rounded or subcordate, entire, rather thinly coriaceous, dark green and shining on adaxial surface, lighter green on abaxial, glabrous on both the surfaces, mid-rib prominently raised on abaxial surface, impressed on adaxial, lateral veins 8-12 pairs, arched, looping and anastomosing near the margin, venation pattern distinct on both surfaces (Fig. 15), relatively more so on the adaxial. Petioles up to 0.2 cm long, glabrous.

Endomorphic characters: Epidermal cells on both surfaces pentagonal, straight-walled or walls slightly arched, abaxial (Fig. 1A) $10.0-20.0-30.0 \mu \times 10.0-11.5-15.0 \mu$, adaxial (Fig. 1B) $20.0-30.25-40.0 \mu \times 15.0-19.88-30.0 \mu$, irregular striations present, filled with granular substance, oil globules present, prismatic crystals of calcium oxalate present. Stomata confined to abaxial surface, $17.5-22.5-25.0 \mu \times 12.5-17.5-20.0 \mu$, mostly rubiaceous, occasionally cruciferous, occasionally superposedly contiguous, stomatal index 12.4-13.71-14.5. Trichomes absent. Vein islets 8-11-15 per sq. mm. Vein endings 2-3-4 per sq. mm. Palisade ratio 5-8-13.

C. congesta Wight (*P. Divakar 1710*, BLAT).

Exomorphic characters: Leaves 3.5-7.2 \times 2.0-3.5 cm, opposite, simple, ovate, somewhat elliptic-ovate, obovate, rhomboid or suborbicular, minutely apiculate, obtuse or subacute, base cuneate or subcuneate, entire, thinly coriaceous, glabrous on both the surfaces, pellucid dotted on abaxial, at times with minute hairs on margins near the base, midrib and laterals impressed on adaxial surface, slightly raised on abaxial, laterals about 5 pairs, slightly arched and looping, lower 2-3 pairs often arising quite close to each other, venation pattern almost indistinct (Fig. 16). Petioles 0.2-0.4 cm long, puberulus or glabrescent.

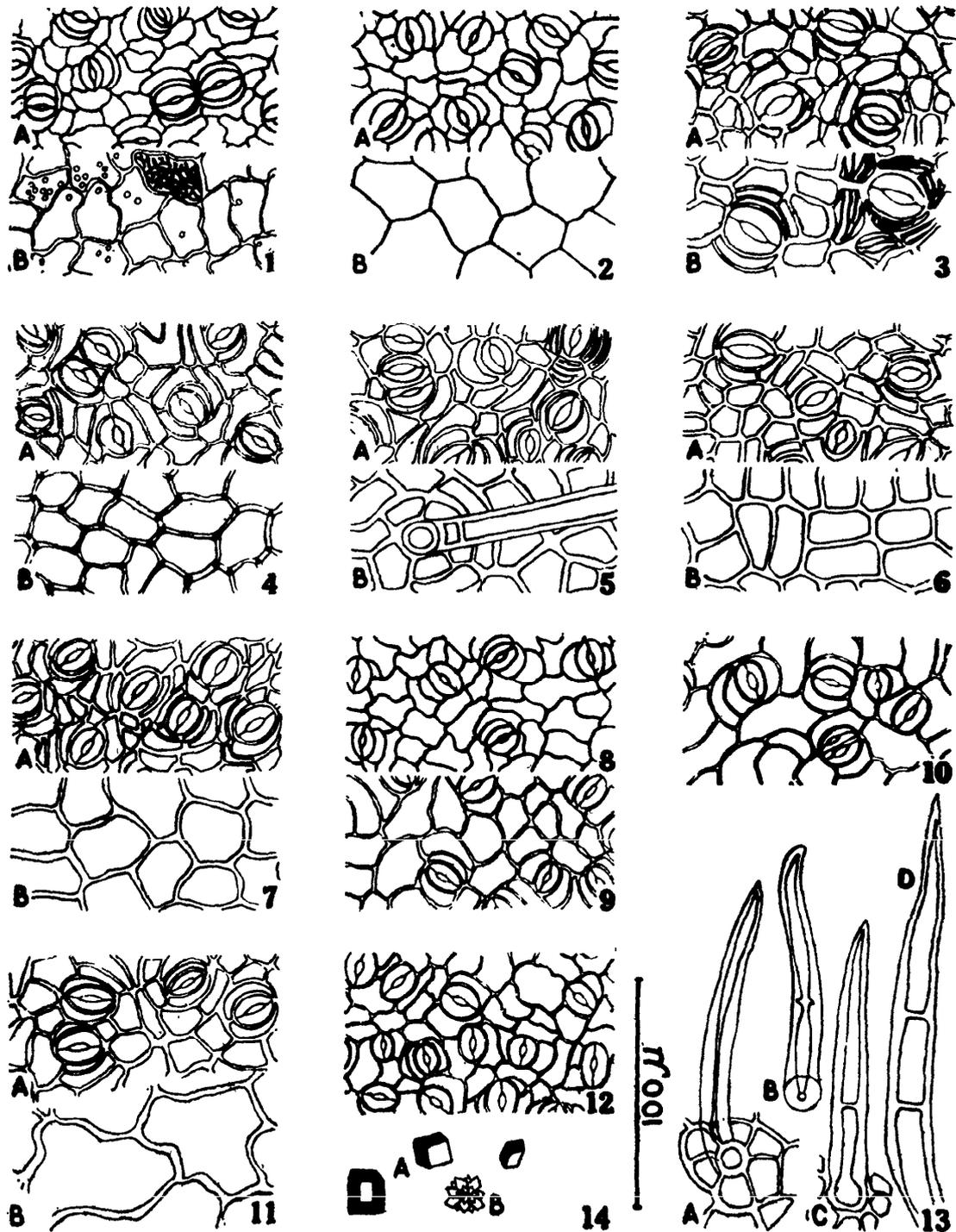
Endomorphic characters: Epidermal cells mostly straight-walled or walls slightly sinuous, straight-walled ones tetra-hexa-gonal,

walls slightly thick, abaxial (Fig. 2A) $15.0-20.5-30.0 \mu \times 7.5-11.0-15.0 \mu$, adaxial (Fig. 2B) $22.5-32.5-37.5 \mu \times 17.5-22.0-25.0 \mu$. Stomata confined to abaxial surface, $15.0-19.0-25.0 \mu \times 12.5-13.0-20.0 \mu$, rubiaceous, cyclocytic or ranunculaceous, occasionally juxtaposedly contiguous associated with each other in middle region only, stomatal index 19.87-20.00-20.44. Trichomes up to $375 \mu \times 10 \mu$, uniseriate, thick-walled. Vein islets 9-12-16 per sq. mm. Vein endings 2-3-5 per sq. mm. Palisade ratio 7.

C. hirsuta Roth (*G. V. Subbarao 40590*, MH; *Pallithanum 340*, BLAT).

Exomorphic characters: Leaves 3.5-8.5 \times 1.5-2.2 cm, opposite, simple, elliptic-oblong or elliptic-lanceolate, acute or acuminate, base cuneate or subcuneate, entire, coriaceous, softly hirsute on both surfaces, relatively more so on adaxial surface and on midrib abaxially, midrib impressed on adaxial surface, slightly raised on abaxial, lateral veins 8-12 pairs, lower ones arched to meet the rest, venation pattern more or less distinct (Fig. 17). Petioles 0.4-0.5 cm long, densely hairy.

Endomorphic characters: Epidermal cells tetra-hexa-gonal, straight-walled or walls slightly arched on both surfaces, abaxial (Fig. 3A) $15.0-21.0-32.5 \mu \times 10.0-13.0-22.5 \mu$, slightly thick-walled, adaxial (Fig. 3B) $17.5-28.25-37.5 \mu \times 10.0-17.0-25.0 \mu$, thick-walled, faint striations running parallel to stomata. Stomata present on both surfaces, abaxial $20.0-24.75-30.0 \mu \times 17.5-19.75-22.5 \mu$, adaxial $20.0-26.25-32.5 \mu \times 15.5-19.88-25.0 \mu$, rubiaceous, actinocytic or cyclocytic, elongated, occasionally juxtaposedly contiguous along the entire length or in the middle region only, stomatal index on abaxial surface 10.00-11.13-12.79, on adaxial surface 5.00-6.69-8.88. Trichomes (Fig. 13A) abundant, abaxial $100.0-175.0 \mu \times 10.0-17.5 \mu$, adaxial $87.5-300.0 \mu \times 10.0-15.0 \mu$, uniseriate, non-glandular, 1-5-celled, thick-walled, with pointed tapering ends. Vein islets 26-35-42



Figs. 1-12. **Foliar epidermis** (A-abaxial; B-adaxial): 1. *Carissa carandas* Linn. (striations shown only in a cell on adaxial surface). 2. *C. congesta* Wight. 3. *C. hirsuta* Roth (striations shown in a few cells only). 4. *C. inermis* Vahl (striations not shown). 5. *C. opaca* Stapf ex Parker (striations shown only in a few cells). 6. *C. paucineria* A. DC. 7. *C. spinarum* Linn. 8. *C. suavissima* Bedd. ex Hook. f. (abax.). 9. *Trachelospermum lucidum* (D. Don) K. Schum.—Assam specimen (abax.). 10. *T. lucidum* (D. Don) K. Schum.—Kumaon specimen (abax.). 11. *Vinca major* Linn. 12. *Willoughbeia edulis* Roxb. (abax.). Fig. 13. **Trichomes**: A. *Carissa hirsuta* Roth; B. *C. paucineria* A. DC.; C. & D. *Trachelospermum lucidum* (D. Don) K. Schum. (C-Assam specimen. D-Kumaon specimen). Fig. 14. **Crystals**: A. Prismatic B. Rosette.

per sq. mm. Vein endings 19-25-34 per sq. mm. Palisade ratio 4.

C. inermis Vahl (*B. D. Sharma* 40356, MH; *A. N. Henry* 1367, BLAT).

Exomorphic characters: Leaves, 5.0-10.0 × 2.5-5.0 cm, opposite, simple, elliptic or elliptic-lanceolate, acute or acuminate, base acute, entire, coriaceous, darker on adaxial surface, lighter on abaxial, glabrous on both surfaces, midrib and veins raised on abaxial surface, main lateral veins 6-8 pairs, slightly arched, turning upwards to join the next higher one, venation pattern more distinct on the abaxial surface (Fig. 18). Petioles 0.3-0.5 cm long, glabrous.

Endomorphic characters: Epidermal cells penta- or hexagonal, oil globules present abundantly, abaxial (Fig. 4A) 15.0-20.75-25.0 μ × 7.5-12.5-17.5 μ, slightly sinuous-walled, walls slightly thick, adaxial (Fig. 4B) 25.0-29.0-37.5 μ × 12.5-21.25-25.0 μ, straight-walled or walls slightly arched, walls thick, thickenings prominent at corner of each cells, striations present. Stomata restricted to abaxial surface, 12.5-18.0-25.0 μ × 12.5-14.0-20.0 μ rubiaceous, cyclocytic or cruciferous, occasionally juxtaposedly contiguous, stomatal index 12.05-14.05-14.94. Vein islets 13-15-16 per sq. mm. Vein endings 17-25-36 per sq. mm. Palisade ratio 3-4-5.

C. opaca Stapf ex Parker (*P. V. Bole* 45, BLAT).

Exomorphic characters: Leaves 1.5-5.0 × 0.5-2.0 cm (rarely 2.5 cm), opposite, simple, elliptic or broadly ovate-elliptic to elliptic-oblong, apiculate or abruptly acute, base rounded or slightly cuneate, entire, thinly coriaceous, bright green adaxially, paler abaxially, sparsely villo-pubescent on adaxial surface, villo-pubescent on abaxial, midrib slightly raised on abaxial surface, venation pattern inconspicuous (Fig. 19). Petioles up to 0.2 cm long, hairy.

Endomorphic characters: Epidermal cells mostly pentagonal, thick-walled, abaxial (Fig. 5A) 17.5-25.0-32.5 μ × 7.5-15.0-22.5 μ with straight or slightly arched walls, stria-

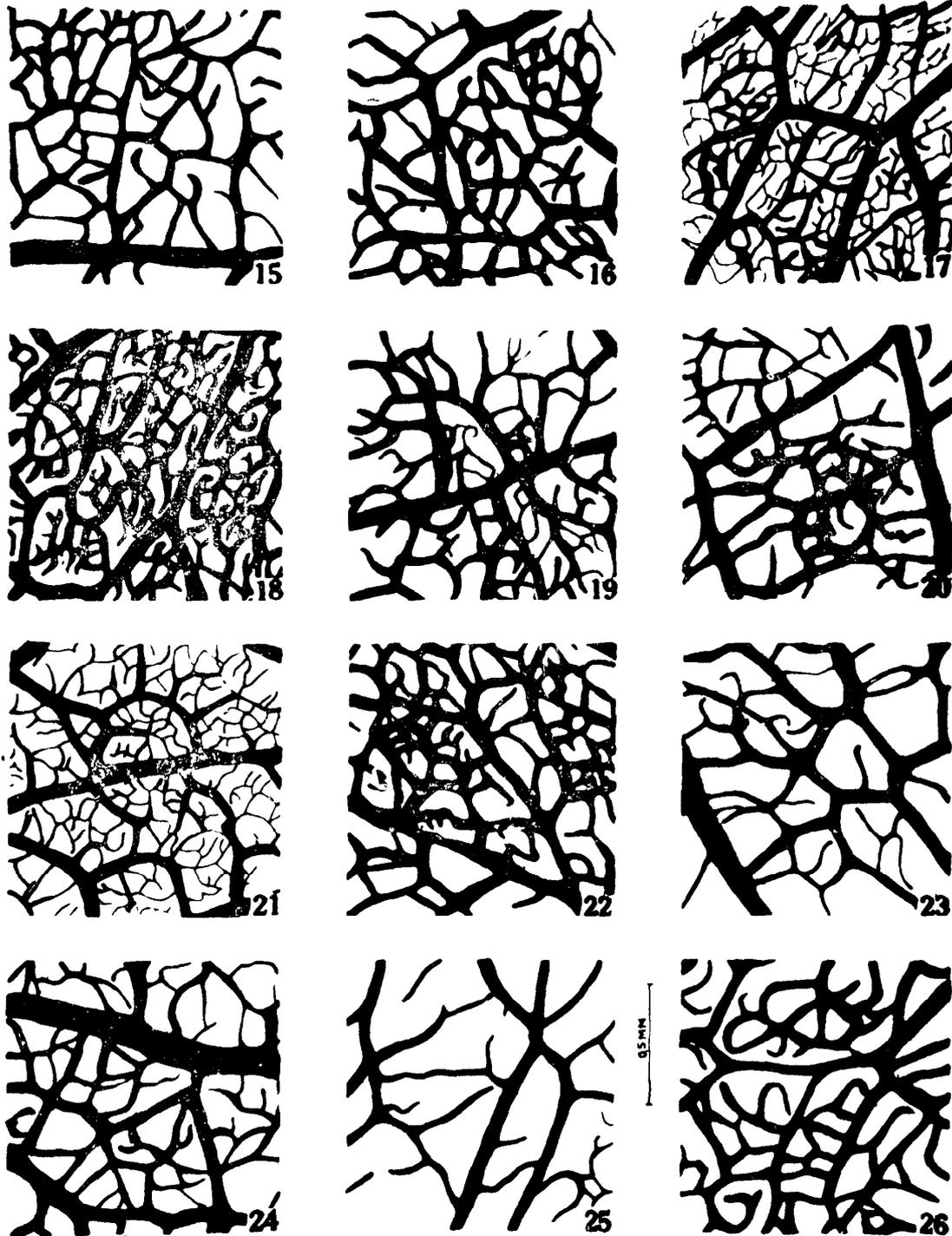
tions running parallel to stomata, adaxial (Fig. 5B) 20.0-29.5-37.5 μ × 12.5-19.0-25.0 μ, straight-walled, cells filled with dark reddish brown contents. Stomata confined to abaxial surface, 15.0-23.5-25.0 μ × 10.0-14.25-20.0 μ rubiaceous or cyclocytic, occasionally juxtaposedly contiguous along the entire length or only just touching, stomatal index 15.06-16.23-16.98. Trichomes present on both the surfaces, 137.5-350.0 μ × 7.5-20.0 μ, uniseriate, 4-5-celled, thick-walled and lignified, base rounded with tapering ends, surrounded by 6-8-celled hair bases. Vein islets 10-12-16 per sq. mm. Vein endings 2-4-6 per sq. mm. Palisade ratio 7-9-12.

C. paucinervia A. DC. (*Subbarao* 40205, MH).

Exomorphic characters: Leaves up to 4.0 × 1.3 cm, opposite, simple, elliptic-ovate to elliptic-lanceolate, acuminate, base acute, entire, thinly coriaceous, on adaxial surface puberulus only in the groove of midrib in lower half region, otherwise glabrous, glabrous on abaxial, midrib and laterals both more or less conspicuous in dried specimens on abaxial surface but not prominently raised, lateral veins 2-3 pairs, oblique, ascending acutely from near the base to run through a larger part of lamina, venation pattern indistinct (Fig. 20). Petioles, 0.2-0.4 cm long, glabrous.

Endomorphic characters: Epidermal cells on abaxial surface (Fig. 6A), tetra-hexagonal, 17.5-27.75-42.5 μ × 10.0-14.75-22.5 μ, straight-walled or walls slightly arched, walls thick. rosette crystals of calcium oxalate abundantly present (Fig. 14B), on adaxial surface (Fig. 6B) tetra-penta-gonal, 22.5-32.5-45.0 μ × 15.0-22.5-30.0 μ straight-walled or walls slightly arched. Stomata confined to abaxial surface, 22.5-26.0-30.0 μ × 15.0-17.5-22.5 μ, rubiaceous, cyclocytic or actinocytic, occasional giant stomata (35 μ × 23 μ) with wide aperture, stomatal index 17.30-19.00-19.13. Trichomes (Fig. 13B) 100-250 μ × 10-20 μ uniseriate, 2-3-celled, thick-walled, non glandular, base rounded, surrounded by

6-9 cells. Vein islets 22-23-24 per sq. mm. Vein endings 3-4-5 per sq. mm. Palisade ratio 6. **C. spinarum** Linn. (*M. Chandrabose* 45138, MH).
Exomorphic characters: Leaves 1.0-4.5 ×



Figs. 15-26. **Venation pattern**: 15. *Carissa carandas* Linn. 16. *C. congesta* Wight. 17. *C. hirsuta* Roth. 18. *C. inermis* Vahl. 19. *C. opaca* Stapf ex Parker. 20. *C. paucinervis* A. DC. 21. *C. spinarum* Linn. 22. *C. suavissima* Bedd. ex Hook. f. 23. *Trachelospermum lucidum* (D. Don) Schum.-Assam specimen. 24. *Trachelospermum lucidum* (D. Don) Schum.-Kumaon specimen. 25. *Vinca major* Linn. 26. *Willoughbeia edulis* Roxb.

1.0-2.5 cm, opposite, simple, broad-ovate, elliptic or suborbicular, apiculate, base slightly acute or rounded, entire, thinly coriaceous, glabrous on both surfaces, adaxial shining, abaxial pellucid-dotted, midrib raised abaxially, impressed adaxially, lateral veins 6-8 pairs, slightly looping near the margins, venation pattern prominent on both surfaces as veins and veinlets raised (Fig. 21). Petioles 0.4-0.6 cm long, glabrous or with few scattered minute hairs.

Endomorphic characters: Epidermal cells mostly tetra-hexa-gonal, straight-walled or walls slightly arched, thick-walled, abaxial (Fig. 7A) $17.5-25.5-37.5 \mu \times 10.0-15.0-20.0 \mu$ adaxial (Fig. 7B) $25.0-38.75-50.0 \mu \times 15.0-27.25-37.5 \mu$ prismatic crystals of calcium oxalate present. Stomata confined to abaxial surface, $15.0-20.25-25.0 \mu \times 10.0-16.25-20.0 \mu$, rubiaceous, cyclocytic or ranunculaceous, occasionally juxtaposedly contiguous, stomatal index 17.74-18.45-20.0. Vein islets 35-36-37 per sq. mm. Vein endings 17-18-19 per sq. mm. Palisade ratio 4-5-6.

C. suavissima Bedd. ex Hook. f. (*Almeida* 657, BLAT).

Exomorphic characters: Leaves 4.0-13.5 \times 3.5-5.0 cm, opposite, simple, broad-ovate to elliptic-ovate, acute or acuminate, base usually rounded, entire, coriaceous, darker on adaxial surface lighter on abaxial, glabrous on both surfaces, midrib and lateral veins raised on abaxial surface, impressed on adaxial, main lateral veins 6-8 pairs, ascending, venation pattern conspicuous on abaxial surface (Fig. 22). Petioles 0.3-0.5 cm long, glabrous.

Endomorphic characters: Epidermal cells penta- or hexa-gonal, oil globules present but sparsely, abaxial (Fig. 8) $10.0-18.25-30.0 \mu \times 5.0-11.75-15.0 \mu$, slightly sinuous-walled, slightly thick-walled, adaxial $10.0-23.25-37.5 \mu \times 7.5-16.75-25.0 \mu$, straight-walled or walls slightly arched, walls thick but no prominent thickenings at the corners. Stomata confined to abaxial surface, $15.0-18.0-22.5 \mu \times 10.0-13.0-17.5 \mu$, rubiaceous

mostly or cruciferous, occasionally juxtaposed but just only touching, stomatal index 16.22-16.67-17.28. Vein islets 11-14-18 per sq. mm. Vein endings 18-20-24 per sq. mm. Palisade ratio 6.

Trachelospermum lucidum (D. Don) K. Schum. Syn. *T. fragrans* Hook. f. (*Prairie* 1886, BSIS; S. L. Kapoor SLK 70138, LWG).

Exomorphic characters: Leaves 5.0-14.0 \times 1.3-4.5 cm, opposite, simple, elliptic, elliptic-oblong or elliptic-lanceolate, more or less caudate with acute or obtuse apex, base acute, margin entire, thickened, at times revolute. glabrous and shining on adaxial surface, pale and nearly glabrous on abaxial except with scattered hairs on veins and margins, veins raised on abaxial surface (Fig. 23), lateral veins 10-15 pairs, nearly straight or slightly arched, somewhat looping near the margin. Petioles 0.4-1.3 cm long, puberulus.

Endomorphic characters: (Assam, *Prairie* 1886, BSIS): Epidermal cells tetra-pentagonal, straight-walled, or walls slightly arched (Fig. 9) $15.0-21.25-30.0 \mu \times 10.0-13.75-22.5 \mu$, cell walls relatively more thickened, adaxial $15.0-18.25-25.0 \mu \times 7.5-13.75-20.0 \mu$, prismatic crystals not observed. Stomata restricted to abaxial surface, $12.5-18.25-25.0 \mu \times 7.5-10.0-15.0 \mu$ rubiaceous, stomatal index 18.75-19.75-20.87. Trichomes (Fig. 13C) $137.5-225.0 \mu \times 12.5-20.0 \mu$, uniseriate, non-glandular, usually 2-3-celled, thick-walled. Vein islets 8-10-14 per sq. mm. Vein endings 3-5-8 per sq. mm. Palisade ratio 3-4-6.

Endomorphic characters: (Kumaon, Kapoor SLK 70138, LWG): Epidermal cells on abaxial surface (Fig. 10) $20.0-34.0-50.0 \mu \times 10.0-17.25-30.0 \mu$, walls arched or slightly sinuous, adaxial mostly pentagonal, $20.0-27.0-37.5 \mu \times 12.5-19.25-30.0 \mu$, straight-walled or walls slightly arched, thick-walled, oil globules present rarely, prismatic crystals present (Fig. 14A). Stomata confined to abaxial surface, $15.0-20.0-25.0 \mu \times 7.5-11.5-17.5 \mu$, rubiaceous, occasionally juxtaposedly contiguous

throughout the length, stomatal index 24.72-25.00-26.65. Trichomes (Fig. 13D) $200-250 \mu \times 17.5-20.0 \mu$ uniseriate, non-glandular, usually 2-3-celled, thick-walled, pitted, with pointed tapering ends. Vein islets 12-15-17 per sq. mm (Fig. 24). Vein endings 7-10-11 per sq. mm. Palisade ratio 5-6-8.

Vinca major Linn. (*D. B. Deb* 31022, MH; *S. L. Kapoor* SLK 70195, LWG).

Exomorphic characters: Leaves 2.5-6.5 \times 2.0-4.5 cm, opposite, simple, broad-ovate or elongate-ovate, acute or blunt, base subcordate or subacute, margin entire, hairy, thinly coriaceous, hairy on adaxial surface on midrib and occasionally with few scattered hairs on some of the laterals, otherwise glabrous, completely glabrous on abaxial surface, midrib conspicuously raised on both surfaces except towards the apex, lateral veins 5-6 pairs, faintly raised on adaxial surface, almost inconspicuous on abaxial, straight or slightly arched, venation pattern inconspicuous (Fig. 25). Petioles 0.6-1.0 cm long, glabrous, channelled.

Endomorphic characters: Epidermal cells filled with oil globules, abaxial (Fig. 11A) $25.0-50.25-87.5 \mu \times 15.0-23.25-37.5 \mu$, straight-walled or walls slightly arched, adaxial (Fig. 11B) $37.5-63.75-87.5 \mu \times 25.0-42.25-62.5 \mu$, sinuous-walled. Stomata confined to abaxial surface, $17.5-30.0-37.5 \mu \times 15.0-19.5-25.0 \mu$ rubiaceous, mostly elongated with wide aperture. stomatal index 16.66-18.58-20.83. Vein islets 2-4-6 per sq. mm. Vein endings 1-3-4 per sq. mm. Palisade ratio 4-5-6.

Willoughbeia edulis Roxb. (*G. Watt* 1895, BSIS).

Exomorphic characters: Leaves 7.5-15.5 \times 3.5-9.0 cm, simple, oblong, ovate-oblong or obovate-oblong, abruptly shortly caudate or obtusely acuminate, base cuneate or rounded, margin thickened, entire, slightly undulate, coriaceous or thinly so, dark on adaxial surface, reddish brown on abaxial, glabrous on both surfaces, midrib stout, raised on abaxial surface, deeply channelled on adaxial, lateral veins about 10-12 pairs,

nearly straight, arching near the margin, prominent with many intermediate ones, venation pattern conspicuous (Fig. 26). Petioles 0.5-1.5 cm long, glabrous.

Endomorphic characters: Epidermal cells on both surfaces sinuous-walled or slightly so, abaxial (Fig. 12) $12.5-18.5-25.0 \mu \times 5.0-9.5-12.5 \mu$ adaxial $25.0-31.5-37.5 \mu \times 12.5-20.25-25.0 \mu$ Stomata restricted to abaxial surface, $15.0-19.0-25.0 \mu \times 10.0-13.0-17.5 \mu$, mostly rubiaceous or cyclocytic, occasionally juxtaposedly contiguous in the middle region only, stomatal index 18.45-20.0-20.83. Vein islets 11-15-21 per sq. mm. Vein endings 8-11-12 per sq. mm. Palisade ratio 3-4-5.

DISCUSSION

In the taxa studied here (Table 1) the walls of adaxial epidermal cells are straight or slightly arched in *Carissa carandas*, *C. hirsuta*, *C. inermis*, *C. paucinervia*, *C. spinarum*, *C. suavissima* and *Trachelospermum lucidum*; straight or slightly sinuous in *Carissa congesta*; just straight in *C. opaca*; and sinuous in *Vinca major* and *Willoughbeia edulis* (in latter at times slightly sinuous). The adaxial epidermal cells are noticeably large ($63.75 \mu \times 42.25 \mu$) in *Vinca major* and noticeably small ($18.25 \mu \times 13.75 \mu$) in *Trachelospermum lucidum* (Assam specimen). Among the *Carissa* spp. adaxial epidermal cells are largest in *C. spinarum* ($38.75 \mu \times 27.25 \mu$) and smallest in *C. suavissima* ($23.25 \mu \times 16.75 \mu$); in other species of *Carissa* the average varies from $28.25-32.50 \mu \times 17.0-22.5 \mu$). The abaxial epidermal cells are straight-walled or with walls slightly arched in *Carissa carandas*, *C. hirsuta*, *C. opaca*, *C. paucinervia*, *C. spinarum*, *Trachelospermum lucidum* (Assam specimen) and *Vinca major*. They are straight- or slightly sinuous-walled in *Carissa congesta*; slightly sinuous-walled in *C. inermis*, *C. suavissima* and *Trachelospermum lucidum* (Kumaon specimen), in latter

arched also. In *Willoughbeia edulis* the walls are sinuous or slightly so. The abaxial epidermal cells are largest in *Vinca major* ($50.25 \mu \times 23.25 \mu$) and smallest in *Willoughbeia edulis* ($18.5 \mu \times 9.5 \mu$). Among *Carissa* spp., the largest (in area) are in *C. paucinervia* ($27.75 \mu \times 14.75 \mu$), closely followed by *C. spinarum* ($25.5 \mu \times 15.0 \mu$) and *C. opaca* ($25.0 \mu \times 15.0 \mu$); in rest of the *Carissa* spp., the size varies from $18.25-21.0 \mu \times 11.0-13.0 \mu$. In general, in a particular species, adaxial epidermal cells are larger than the abaxial ones but in *Trachelospermum lucidum* it is *vice versa*.

Stomata as a rule are present only on the abaxial surface and are of rubiaceous type, though other type of stomata may also be seen interspersed with the rubiaceous ones. *Carissa hirsuta* possesses stomata on the adaxial surface also, though they are relatively sparse with stomatal index 5.00-6.69-8.88 in comparison to 10.33-11.13-12.79 of the abaxial surface. Occasionally cruciferous stomata may be seen in *Carissa carandas*, *C. inermis* and *C. suavissima*; cyclocytic in *C. congesta*, *C. hirsuta*, *C. inermis*, *C. opaca*, *C. paucinervia*, *C. spinarum* and *Willoughbeia edulis*; ranunculaceous in *Carissa congesta* and *C. spinarum* and actinocytic in *C. hirsuta* and *C. paucinervia*. The stomata are longest in *Vinca major* (30μ). Among the *Carissa* spp., they are longest in *C. paucinervia* (26.0μ), followed by *C. hirsuta* (24.75μ), *C. opaca* (23.5μ), *C. carandas* (22.5μ), *C. spinarum* (20.25μ) and *C. congesta* (19.0μ); they are of equal length in *C. inermis* and *C. suavissima* (18μ). The widest stomata are observed in *C. hirsuta* (19.75μ) and *Vinca major* (19.5μ), followed by *Carissa carandas* and *C. paucinervia* (both 17.5μ), *C. spinarum* (16.25μ); the narrowest are observed in *Trachelospermum lucidum* (Assam specimen 10.0μ ; Kumaon specimen 11.5μ). In *Carissa hirsuta* the stomata of the adaxial surface are slightly larger ($26.25 \mu \times 19.88 \mu$) than of the abaxial surface ($24.75 \mu \times$

19.75μ). The stomatal index is of the highest order in *Trachelospermum lucidum* (Kumaon specimen) and distinctly lowest in *Carissa hirsuta*. Among the *Carissa* spp. the stomatal index is of the highest order in *C. congesta* (19.87-20.00-20.44), closely followed by *C. paucinervia* and *C. spinarum* and then *C. suavissima* and *C. opaca*.

The venation patterns of the different species, as illustrated in figures from 15 to 26, give an idea of the general pattern and relative thickness of veins and veinlets. The number of vein islets per sq. mm is highest in *Carissa spinarum* (36) and *C. hirsuta* (35), and lowest in *Vinca major* (4); in other *Carissa* spp. the average figure is quite high in *C. paucinervia* (23), followed by *C. inermis* and *C. suavissima* (15 and 14 respectively). The number of vein endings per sq. mm are of a very high order in *Carissa hirsuta* and *C. inermis* (in both 25) and of a very low order in *Trachelospermum lucidum*—Assam specimen (5), *Carissa opaca*, *C. paucinervia*, (in both 4), *C. carandas*, *C. congesta* and *Vinca major* (in all 3); *Carissa suavissima* (20) and *C. spinarum* (18) are towards the high side whereas *Trachelospermum lucidum* (Kumaon specimen) and *Willoughbeia edulis* with average figures of 10 and 11 respectively form the middle order.

The average palisade ratio is exactly same in several species. In *Carissa hirsuta*, *C. inermis*, *Trachelospermum lucidum* (Assam specimen) and *Willoughbeia edulis* it is 4; in *Carissa spinarum* and *Vinca major* it is 5; in *C. paucinervia*, *C. suavissima* and *Trachelospermum lucidum* (Kumaon specimen) it is 6. In *Carissa congesta*, it is 7, *C. carandas* 8 and the highest figure of 9 is recorded in *C. opaca*.

Trichomes, wherever present, have been found to vary in dimension but they are always uniseriate, non-glandular, thick-walled and 1- to several-celled.

The presence of prismatic crystals of calcium oxalate distinguishes *Carissa carandas*,

Table 1: Epidermal features, venation pattern and palisade ratio

NAME OF SPECIES		STOMATA					EPIDERMAL CELL				VENATION		PALI- SADE RATIO (average)
		Type*	Size in μ (average)		Stomatal Index		Cell Wall		Cell size in μ (average)		Vein islets per sq. mm (average)	Vein endings per sq. mm (average)	
			Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1. <i>Carissa carandas</i> Linn.	Ru Cr	22.5 × 17.5	Absent	12.40- 13.71- 14.50	Absent	Straight or Slightly arched	Straight or Slightly arched	20.0 × 11.5	30.25 × 19.88	11	3	8	
2. <i>Carissa congesta</i> Wight	Ru Cy Ra	19.0 × 13.0	Absent	19.87- 20.00- 20.44	Absent	Straight or Slightly sinuous	Straight or Slightly sinuous	20.50 × 11.00	32.50 × 22.00	12	3	7	
3. <i>Carissa hirsuta</i> Roth	Ru Cy Ac	24.75 × 19.75	26.25 × 19.88	10.33- 11.13- 12.79	5.00- 6.69- 8.88	Straight or Slightly arched	Straight or Slightly arched	21.00 × 13.00	28.25 × 17.00	35	25	4	
4. <i>Carissa inermis</i> Vahl	Ru Cy Cr	18.0 × 14.00	Absent	12.05- 14.05- 14.94	Absent	Slightly sinuous	Straight or Slightly arched	20.75 × 12.50	29.0 × 21.25	15	25	4	
5. <i>Carissa opaca</i> Stapf ex Parker	Ru Cy	23.5 × 14.25	Absent	15.06- 16.23- 16.98	Absent	Straight or Slightly arched	Straight	25.00 × 15.00	29.5 × 19.0	12	4	9	
6. <i>Carissa paucinervis</i> A. DC.	Ru Cy Ac	26.0 × 17.5	Absent	17.30- 19.00- 19.13	Absent	Straight or Slightly arched	Straight or Slightly arched	27.75 × 14.75	32.5 × 22.5	23	4	6	

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
7. <i>Carissa spinarum</i> Linn.	Ru Cy Ra	20.25 × 16.25	Absent	17.74– 18.45– 20.00	Absent	Straight or Slightly arched	Straight or Slightly arched	25.50 × 15.00	38.75 × 27.25	36	18	5	
8. <i>Carissa suavissima</i> Bedd. ex Hook. f.	Ru Cr	18.0 × 13.0	Absent	16.22– 16.67– 17.28	Absent	Slightly sinuous	Straight or Slightly arched	18.25 × 11.75	23.25 × 16.75	14	20	6	
9. <i>Trachelospermum lucidum</i> (D. Don) Schum. (Assam)	Ru	18.25 × 10.0	Absent	18.75– 19.75– 20.87	Absent	Straight or Slightly arched	Straight or Slightly arched	21.25 × 13.75	18.25 × 13.75	10	5	4	
10. <i>Trachelospermum lucidum</i> (D. Don) Schum. (Kumaon)	Ru	20.0 × 11.5	Absent	24.72– 25.00– 26.65	Absent	Arched or Slightly sinuous	Straight or Slightly arched	34.0 × 17.25	27.0 × 19.25	15	10	6	
11. <i>Vinca major</i> Linn.	Ru	30.0 × 19.5	Absent	16.66– 18.58– 20.83	Absent	Straight or Slightly arched	Sinuuous	50.25 × 23.25	63.75 × 42.25	4	3	5	
12. <i>Willoughbeia edulis</i> Roxb.	Ru Cy	19.0 × 13.0	Absent	18.45– 20.00– 20.83	Absent	Sinuuous or Slightly sinuous	Sinuuous or Slightly sinuous	18.5 × 9.5	31.5 × 20.25	15	11	4	

*Ru, Rubiaceous ; Ra, Ranunculaceae ; Cr, Cruciferous ; Ac, Actinocytic ; Cy, Cyclocytic.

C. spinarum and *Trachelospermum lucidum* (Kumaon specimen) from the rest; rosette crystals of calcium oxalate are found in *Carissa paucinervia*.

As already stated the present study includes *Trachelospermum lucidum* obtained from two different localities, viz., Assam and Kumaon. Although both the specimens have some points in common, yet they differ in several features. While both have nearly similar type of epidermal cells, same type and nearly same size of stomata, the Kumaon specimen shows higher stomatal index, larger epidermal cells, higher number of vein islets and vein endings per unit area and higher palisade ratio. Prismatic crystals of calcium oxalate are present in Kumaon specimen but absent in Assam one. Oil globules are rarely present in Kumaon specimen whereas abundantly present in Assam one. This suggests a more detailed study of the two for the possible recognition and subsequent categorisation of one as distinct infraspecific taxon.

The other species of *Trachelospermum*, viz., *T. jasminoides* Lem., as reported by Chandra *et al.* (1972) differs from the present specimens of *T. lucidum* in lower stomatal index (14-16.6-17.5), much higher number of vein islets per same unit area (25) and much lower number of vein endings per same unit area (2). *T. jasminoides* showed ranunculaceous type of stomata in addition to the rubiaceous ones.

The genera *Vinca* and *Catharanthus*, at one time regarded as congeneric, have been distinguished on the basis of the latter being characterized by sessile, clustered flowers, salverform corolla with a cylindrical tube and sessile stamens with short filaments and ex-appendiculate anthers. The two species of *Catharanthus* as previously studied by us [*C. roseus* (Linn.) Don by Sharma *et al.*, 1970 and *C. pusillus* (Murr.) Don by Chandra *et al.*, 1972] show characteristic venation pattern, quite distinct from that of *Vinca major*, as investigated in the present

study. The importance of that feature as a generic character could, however, be claimed with certainty when more representatives of these two genera are studied.

The taxonomy of the Indian *Carissa* has been understood and interpreted differently by various workers from time to time.

De Candolle (1844) enumerated 8 Indian species of *Carissa*, viz., *C. carandas* Linn., *C. salicina* Lam., *C. diffusa* Roxb., *C. macrophylla* Wall., *C. spinarum* Linn., *C. paucinervia* A. DC., *C. hirsuta* Roth (*C. villosa* Roxb.) and *C. inermis* Vahl; one more was added later as the 9th one by Beddome. Hooker (1882) recognised only 5 species, viz., *C. carandas* Linn., *C. spinarum* A. DC., *C. paucinervia* A. DC., *C. macrophylla* Wall. and *C. suavissima* Bedd. ex Hook. f. He reduced *C. congesta* Wight as a variety of *C. carandas* and *C. hirsuta* Roth (*C. villosa* Roxb.) as a variety of *C. spinarum*. He considered *C. diffusa* Roxb. as conspecific with *C. spinarum* A. DC., and *C. inermis* Vahl and *C. dalzellii* Bedd. with *C. macrophylla* Wall. In addition, he remarked, "The Indian species of this genus are very difficult of definition and are probably reducible to one or two very variable forms ..."

Cooke (1904) considered *C. inermis* Vahl and *C. suavissima* Bedd. ex Hook. f., as distinct species, which, as will be seen later, have been regarded as conspecific. His *C. inermis* included *C. macrophylla* Wall., *C. lanceolata* Dalz. and *C. dalzellii* Bedd., all the three without being assigned any separate infraspecific status. His *C. spinarum* included *C. diffusa* Roxb., *C. hirsuta* Roth and *C. villosa* Roxb., all the three, again, without being assigned any independent infraspecific status. He recorded *C. arduina* Lam. as a species sometimes grown in gardens. This was later corrected to be *C. grandiflora* A. DC. by Parker (1924).

Haines (1919) observed that the different species of Indian *Carissa* are much confused in Herbaria and also in Hooker's Flora

(1882). After a critical study, Haines recognised: 1. *C. inermis* Vahl, with two varieties, var. *macrophylla* and var. *suavissima* (latter with a ? mark)—*C. dalzellii* Bedd. and *C. lanceolata* Dal. being reduced to synonymy; 2. *C. carandas* Linn. with its variety *talbotiana* (latter again with a ? mark); 3. *C. congesta* Wight; 4. *C. diffusa* Roxb., with its variety *scandens*—*C. villosa* reduced to synonymy and 5. *C. spinarum* Linn. with varieties *paucinervia* and *hirsuta*—*C. salicina* Lam. cited as a synonym of var. *paucinervia* but with a ? mark.

Haines (1921) while engaged on *Carissa* for his proposed Flora of Bihar and Orissa, published another note after examining type specimens in the herbarium of Linnaean Society. He observed that a North Indian element that occurred in his area and referred to *C. spinarum* did not exist in Linnaean Herbarium and was quite distinct from the true *C. spinarum* Linn. He discovered that Stapf named (in manuscript only*) this North Indian element in Kew Herbarium as *C. opaca* because of the indistinctness of the nervation. Further, Haines thought that De Candolle's *C. paucinervia* included, in part, *C. opaca* as well, as both seemed to him closely related. Depending upon whether one regarded *C. opaca* as a distinct species or a variety of *C. paucinervia*, Haines tabulated the nomenclature as follows: *Carissa paucinervia* A. DC. var. *opaca*=*C. opaca* Stapf mss=*C. spinarum* Lam. and most of other authors except Linn.

Haines (1922) further revised his opinion. In his final analysis, *C. spinarum* Linn. included *C. diffusa* Roxb. as its variety besides variety *scandens*. *C. inermis* Vahl included var. *inermis*, var. *macrophylla* (*C. macrophylla* Wall.) and var. *dalzellii* (*C. dalzellii* Bedd.). *C. suavissima* Bedd. ex Hook. f. was considered conspecific with *C. inermis* but suffixed with a sign of ?. *C. opaca* Stapf, *C.*

gangetica Stapf (both mss names) and *C. spinarum* of Fl. Brit. India and of most other authors, in whole or in part, were cited under *C. paucinervia* A. DC. He, however, qualified his treatment with the following remark: "Since writing the above I have learnt from Mr. Gamble, who knows the typical *C. paucinervia* that species is quite distinct and that the plants so named from Monghyr and other plains localities in Herbaria are errors of identification. If it be conceded our plant should be called *C. opaca* Stapf Mr. Gamble also keeps variety *gangetica* distinct"

Gamble (1923) placed *C. macrophylla* Wall. and *C. suavissima* Bedd. under *C. inermis* Vahl with definiteness; regarded *C. diffusa* Roxb. as conspecific with *C. spinarum* Linn., describing a new variety under the latter as var. *microphylla*; reinstated *Carissa hirsuta* Roth with which he considered *C. villosa* Roxb. to be conspecific; upheld *C. paucinervia* A. DC. and *C. salicina* Lam. as distinct species; and recorded *Carissa gangetica* Stapf ex Gamble as a new species.

The foregoing account clearly demonstrates the amount of confusion that exists in the literature and consequently in the herbaria due to repeated merging, splitting and re-alignment of the various taxa.

The data of the species of *Carissa* as presented here together with that of *C. grandiflora* A. DC. as reported earlier (Chandra *et al.*, 1972) may facilitate a better comprehension of this genus. It will be endeavoured to procure material of the remaining relevant taxa for a complete comparative account.

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*Parker (1924) validly published the manuscript name *C. opaca* of Stapf.

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REFERENCES

- CHANDRA, V., R. MITRA, S. L. KAPOOR AND L. D. KAPOOR. Epidermal and venation studies in Apocynaceae —IV. *Bull. bot. Surv. India* 14 : 76-82. 1972.
- , S. L. KAPOOR, P. C. SHARMA AND L. D. KAPOOR. Epidermal and venation studies in Apocynaceae-I. *Ibid.* 11 : 286-289. 1969.
- COOKE, T. The Flora of the Presidency of Bombay. 2, part I : 124-126. 1904.
- DE CANDOLLE, A. *Prodromus Systematis Naturalis Regni Vegetabilis*. Part 8 : 331-336. 1844.
- GAMBLE, J. S. Flora of the Presidency of Madras. Part V : 803-806. 1923.
- HAINES, H. H. Indian species of *Carissa*. *Indian Forester*. 45 (7) : 375-388. 1919.
- Indian species of *Carissa*-II. *Ibid.* 47 (9) : 377-379. 1921.
- The Botany of Bihar and Orissa. Part IV. 532-535. 1922.
- HOOKE, J. D. The Flora of British India. 3 : 630-632. 1882.
- KAPOOR, S. L., P. C. SHARMA, V. CHANDRA AND L. D. KAPOOR. Epidermal and venation studies in Apocynaceae-II. *Bull. bot. Surv. India* 11 : 372-376. 1969.
- MITRA, R., S. L. KAPOOR AND L. D. KAPOOR. Epidermal and venation studies in Apocynaceae-V. *Ibid.* 20 : 20-30. 1978.
- PARKER, R. N. A Forest Flora for the Punjab with Hazara and Delhi. Second Edition : 330-331. 1924.
- SHARMA, P. C., V. CHANDRA, S. L. KAPOOR AND L. D. KAPOOR. Epidermal and venation studies in Apocynaceae-III. *Bull. bot. Surv. India* 12 : 92-96. 1970.