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Comparative epidermal morphology of West African species of *Jatropha* L. (Euphorbiaceae)

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OLOWOKUDEJO, J. D., 1993. **Comparative epidermal morphology of West African species of *Jatropha* L. (Euphorbiaceae).** Leaf epidermal morphology of the eight species of *Jatropha* found in West Africa has been studied by both light and scanning electron microscopy. The cells of adaxial and abaxial epidermises are usually polygonal with either straight or curved anticlinal walls. Wax occurs in some species in the form of either flakes, particles or plugs, while in others prominent cuticular striations are found which may be parallel or random. Paracytic and brachyparacytic stomata which may be superficial, or sunken with either narrow or wide cuticular rim occur on both surfaces of the abaxial surface only. Stomatal size varies both within and between taxa. Pubescent and glabrous species occur within the genus. Trichomes are either unicellular or uniseriate. The presence of stalked glands on leaf margins is unique to *J. gossypiifolia*. Evidence is presented to show the close relationship between *J. neriifolia* and *J. atacorensis*. Other variable micromorphological characters of the epidermis include cell size, periclinal walls, distribution and density of trichomes. The taxonomic significance of these features in identification and elucidation of species affinity is discussed.

ADDITIONAL KEY WORDS: Epidermal features – taxonomy – West Africa.

CONTENTS

INTRODUCTION

The genus *Jatropha* L. (Euphorbiaceae) comprises *c.* 175 herbaceous and woody species of shrubby habit native in both old and new world tropics. The major economic importance of *Jatropha* is its medicinal and ornamental uses in various countries. Many of the species are easily propagated by seed or cuttings, thus enhancing their utility in horticulture both as ornamental shrubs in tropical gardens and as live hedges for protection against bush fire in most African villages. *Jatropha gossypiifolia* L., for example, is planted as an ornamental for its

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shining, purple tinged foliage and deep-red flowers. *Jatropha multifidia* L. is also outstanding in the garden for its huge deeply cut leaves and small coral red clusters of flowers while *J. podagrica* Hook., which grows rapidly from seed (Rowley, 1978), is a garden curiosity with its short swollen stem, large fan-like lobed leaves and flat head of showy red flowers borne most of the year round.

The various medicinal applications of some *Jatropha* species in West Africa have been enumerated by Dalziel (1937), Oliver (1960), Ayensu (1978) and Irvine (1961), among others. For example, the seeds of *J. curcas* contain a purgative oil used in traditional medicine as a remedy for dropsy, sciatica, paralysis, worms and skin diseases. Moreover, the leaf decoction is used as a mouthwash, lactogogue and rubifacient. The crushed leaves are made into lotions for the treatment of guinea-worm sore, sluggish ulcers, cuts and wounds while a cold or hot infusion of the leaves, with lime juice added, is a common remedy for fevers and a diuretic for rheumatism. The leaf juice of *J. gossypiifolia* is used for curing sores on the tongues of babies while the leaf decoction serves as a vermifuge, purgative and a cure for fever. The seed oil of *J. multifida* has curative properties similar to those of *J. curcas*.

The foregoing wide spectrum of folkloric uses of these species may be due to the presence of many groups of chemical substances, such as flavonoids, lignans, alkaloids, cyanogenic glucosides and glucosinolates, which have been reported by Rizk & El-Missiry (1986) and Rizk (1987), among others.

Earlier taxonomic accounts of the genus have been evaluated and revised by Dehgan & Webster (1979), who recognized two subgenera, ten sections and ten subsections to accommodate the 165–175 known species. Furthermore, Dehgan (1980) showed that epidermal features provided information consistent with an earlier revision of the genus and could be used as distinguishing characters, usually significant at the species level.

Eight species of *Jatropha* are found in West Africa, but there has been little or no detailed taxonomic work done on the genus except for the floristic account of Hutchinson & Dalziel (1954). Although Dehgan (1980) examined the leaf epidermis of 37 species by SEM, only four of these are found in West Africa and the specimens studied were few and unrepresentative geographically. In this study the lead epidermises of representative specimens of all eight species have been examined by both light and scanning electron microscopy in order to obtain a more complete picture of the epidermis. The nomenclature of Hutchinson & Dalziel (1954) is adopted, while the classification scheme is that given in Dehgan & Webster (1979), where there was some doubt about the affinity of *J. atacorensis* A. Chev, one of the species being studied and tentatively placed in section *Tuberosae* Pax subsection *Tuberosae* Dehgan & Webster. The aim of this investigation is to determine the patterns of variation in epidermal characteristics and assess their value in species identification and classification. It is also hoped that the results may be of assistance in elucidating the taxonomic relationships of the various taxa, especially *J. atacorensis* A. Chev. and *J. neriifolia* Müll. Arg.

MATERIAL AND METHODS

West African specimens of *Jatropha* were examined in FHI, K and LUH. Additional specimens were collected in the wild and voucher specimens

deposited in LUH. Herbarium abbreviations follow Holmgren *et al.* (1981). Two to five specimens of each species were examined by SEM and light microscopy.

Small pieces of each leaf sample (*c.* 6 mm square) taken from a standard central position were fixed to labelled stubs with double-sided adhesive tape. Each sample was coated with gold in Polaron E-5000 sputter coater and scanned in a JEOL JSM-T20 scanning electron microscope operated at an accelerating voltage of 12.5 keV at the Electron Microscopy Unit, School of Plant Sciences, University of Reading.

Epidermal preparations for light microscopy were obtained using the techniques of Olowokudejo & Nyananyo (1990) with slight modifications. An area *c.* 5–8 mm square was taken from identical regions of each leaf, usually midway between the base and apex of the lamina. Leaves from herbarium specimens were revived by boiling in water for 5–10 min. Each sample was macerated in concentrated nitric acid for *c.* 2–24 hours, depending on the nature of the leaf. Abaxial and adaxial epidermises were then separated using fine forceps and a dissecting needle. The cleaned epidermises were stained in safranin and mounted in glycerine.

Drawings were made using a Wild M12 microscope with camera lucida attachment. Fifty cells and stomata were selected randomly from all specimens of each species and measured. Descriptive statistics of means, standard deviations and standard errors were calculated for all quantitative characters.

RESULTS

The data presented in Table 1 are a summary of the range of variation in epidermal characteristics as seen by light microscopy. Scanning electron microscopic features of both abaxial and adaxial leaf surfaces are illustrated in Figs 1–26. The listing of species follows the revised infrageneric arrangements of Dehgan & Webster (1979) and Dehgan (1980).

SEM of abaxial and adaxial surfaces

The surface features of the leaves are described separately below for each species. Three to four representative micrographs of each taxon are shown to depict the general appearance, the nature of the stomatal complex, type of cuticular ornamentation or epicuticular secretions such as waxes. The micromorphological characters are reasonably constant for each species but the ornamentations of the abaxial surface are usually more numerous and diverse than those of the adaxial.

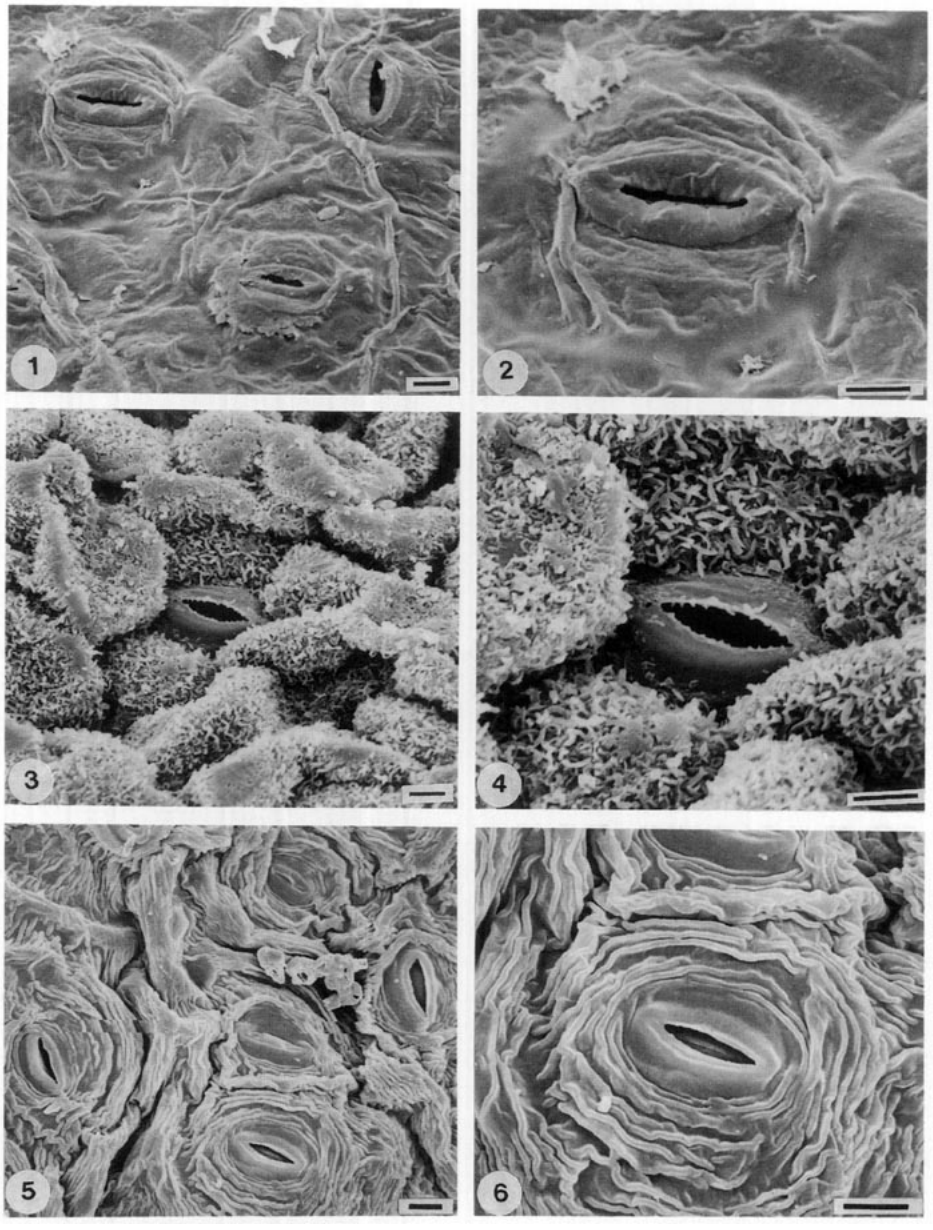
Subgenus *Jatropha* L.
Section *Jatropha*

Subsection *Adenophorae* Pax ex Dehgan & Webster.

Jatropha gossypiifolia L. is the only West African species represented. Anticlinal walls of abaxial epidermal cells marked by shallow depressions. Outer periclinal walls slightly convex with irregular cuticular folds and bands which traverse

TABLE 1. Epidermal characters of *Jatropha* species (adax. = adaxial surface; abax. = abaxial surface; mean ± standard error for quantitative characters)

Taxa		Anticlinal wall pattern	Max. cell width	Stomatal type	Stomatal length (μm)	Stomatal width (μm)	Trichomes
Subgenus *Jatropha*							
Section *Jatropha*							
Subsection *Adenophorae*							
J. gossypiifolia	adax.	Curved/straight	38.34 ± 1.47	Paracytic/brachyparacytic	28.01 + 0.23	8.62 ± 0.18	Uniseriate
	abax.	Curved/straight	36.21 ± 1.01	Paracytic/brachyparacytic	29.42 ± 0.54	8.94 ± 0.24	Glandular
Subsection *Pubescentes*							
J. chevalieri	adax.	Straight	38.92 ± 0.84	Paracytic/brachyparacytic	24.19 ± 0.20	7.44 ± 0.11	Absent
	abax.	Straight	37.82 ± 0.62	Paracytic/brachyparacytic	26.48 ± 0.38	7.62 ± 0.36	Absent
J. kamerunica	adax.	Straight	41.12 ± 1.28	Paracytic/brachyparacytic	20.86 ± 0.45	5.66 ± 0.18	Uniseriate
	abax.	Straight	28.64 ± 0.38	Paracytic/brachyparacytic	23.04 ± 0.76	6.18 ± 0.27	Uniseriate
Section *Peltatae*							
J. podagrica	abax.	Curved/straight	37.38.0.08	Absent			Absent
	abax.	Curved/straight	34.76 ± 0.57	Brachyparacytic	24.38 ± 0.34	8.22 ± 0.54	Absent
J. multifida	adax.	Curved/straight	40.24 ± 1.26	Absent			Absent
	abax.	Curved/straight	33.48 ± 0.62	Brachyparacytic	26.34 ± 0.51	8.31 ± 0.56	Absent
Section *Tuberosae*							
J. neriifolia	adax.	Curved/straight	33.81 ± 1.16	Paracytic	18.04 ± 0.09	6.02 ± 0.18	Unicellular
	abax.	Curved	28.92 ± 0.82	Paracytic	20.18 ± 0.26	6.02 ± 0.44	Unicellular
J. atacorensis	adax.	Curved/straight	32.24 ± 0.76	Paracytic	12/34 ± 0.14	4.12 ± 0.12	Unicellular
	abax.	Curved	22.78 ± 0.56	Paracytic	14.02 ± 0.42	4.18 ± 0.26	Absent
Subgenus *Curcas*							
Section Curcas							
J. curcas	adax.	Straight	37.84 ± 1.02	Paracytic	24.07 ± 0.11	8.09 ± 0.24	Absent
	abax.	Straight/curved	31.69 ± 1.08	Paracytic	25.68 ± 0.37	8.24 ± 0.31	Absent



Figures 1–6. SEM of leaf abaxial surfaces in Section *Jatropha*. Figs 1, 2. *J. gossypiifolia* (Nigeria; *Latilo 24434*, FHI). Fig. 1. Slightly convex outer periclinal walls with irregular folds of cuticle, wax plugs and flakes. Fig. 2. Stomata, sunken with thick cuticular rims. Figs 3, 4. *J. chevalieri* (Senegal; *Kesby 16*, K). Fig. 3. Convex outer periclinal walls with dense wax flakes. Fig. 4. Stomata, deeply sunken with wide cuticular rims. Figs 5, 6. *J. kamerunica* (Senegal; *Nongonierma 568*, K). Fig. 5. Striated outer periclinal wall. Fig. 6. Stomata with concentric rings of striae. All scale bars = 5 μm.

several cells and may coalesce into micropapillae in places (Fig. 1). Stomata slightly sunken with thick and prominent cuticular rims (Fig. 2). Wax plugs and flakes present.

Adaxial surface similar to abaxial surface. Anticlinal walls indistinct, being

obscured by irregular folds of cuticle. Stomata sunken with thick cuticular rim. Wax plugs present (Fig. 19).

Subsection *Pubescentes* Pax.

The two species, *J. chevalieri* Beille and *J. kamerunica* Pax & K. Hoffm., occurring in West Africa were examined.

Jatropha chevalieri: boundaries of abaxial epidermal cells clearly indicated by grooves of varying width and depth (Fig. 3). Outer periclinal walls convex. Stomata deeply sunken with wide cuticular rim (Fig. 4). Whole surface covered by dense wax flakes and particles which completely obscure epidermal patterns.

Anticlinal walls of adaxial epidermal cells marked by raised ridges (Fig. 20). Outer periclinal walls flat or slightly convex. Stomata sunken with wide cuticular rim. Wax covering in form of fine flakes and small particles; particularly dense over periclinal walls.

Jatropha kamerunica: abaxial anticlinal cell walls marked by furrows. Outer periclinal walls flat or slightly convex with numerous randomly orientated striae (Fig. 5). Stomata slightly sunken with wide cuticular rim and concentric rings of striae (Fig. 6). Simple uniseriate trichomes with swollen basal cells present (Fig. 7). Wax absent.

Anticlinal walls of adaxial epidermal cells also marked by furrows (Fig. 21). Outer periclinal walls flat or slightly convex and completely covered with both parallel and randomly orientated striae. Stomata superficial with prominent cuticular rim. No wax.

Section *Peltatae* (Pax) Dehgan & Webster

Jatropha podagrica Hook. and *J. multifida* L. are the only species of this section found in West Africa.

Jatropha podagrica: outline of abaxial epidermal cells partially defined by raised ridges of unequal thickness and varying height (Fig. 8). Outer periclinal walls flat. Stomata superficial with narrow cuticular rim (Fig. 9). Wax deposits consisting of dense flakes on the entire surface.

Adaxial cell boundaries marked by ridges. Periclinal walls convex with depressions around each cell. Micropapillae found on both anticlinal and periclinal walls (Fig. 22). Stomata absent. Wax present in form of few fine flakes.

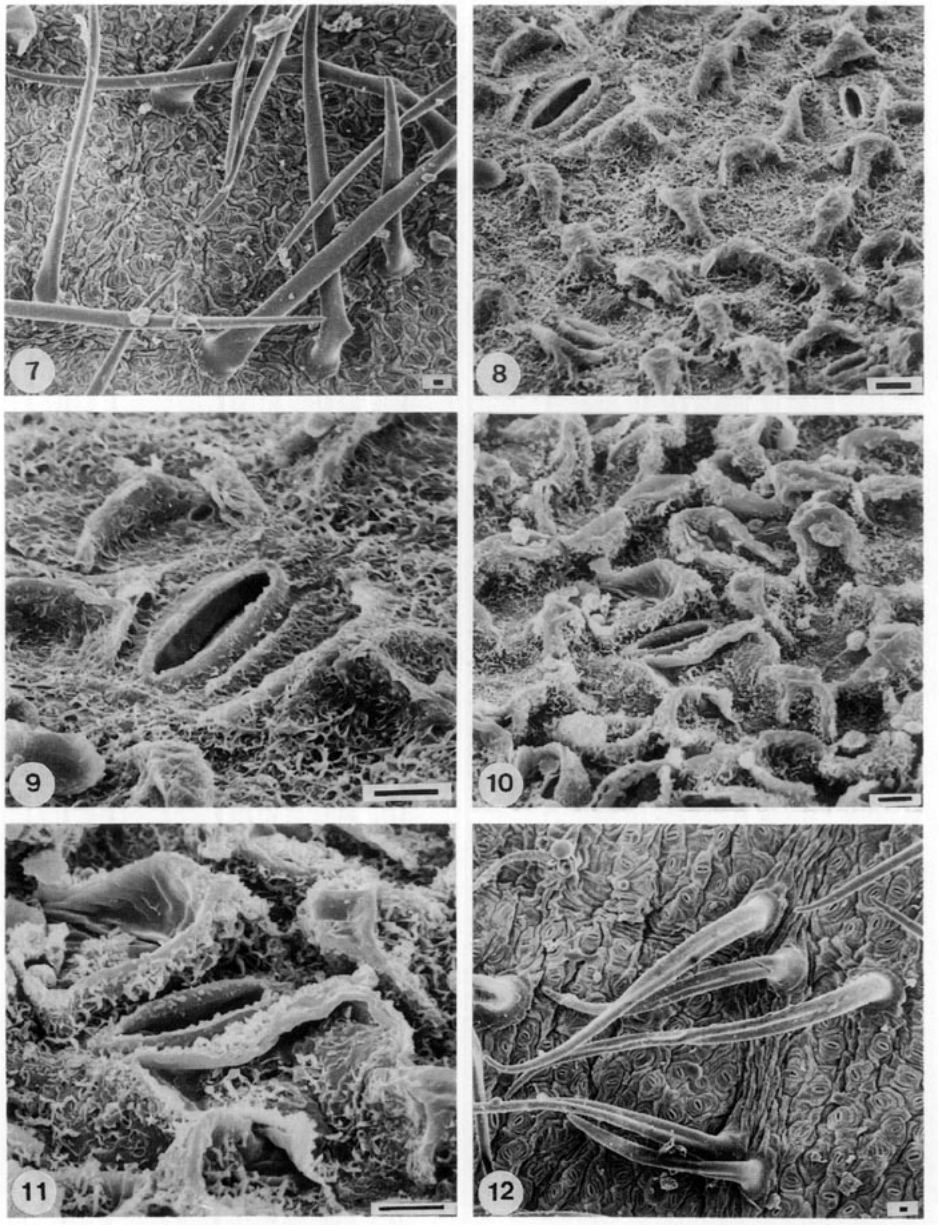
Jatropha multifida: abaxial anticlinal cell walls marked by prominent ridges of varying height and thickness. Outer periclinal walls of epidermal cells flat or slightly convex (Fig. 10). Stomata slightly sunken with narrow cuticular rim (Fig. 11). Wax covering dense, consisting of fine flakes and occasionally large particles.

Outer walls of adaxial epidermal cells prominently convex or domed, with a low relief pattern of small micropapillae. Anticlinal walls indicated by shallow and deep grooves of more or less uniform width. Stomata absent. Wax present as dense particles on the surface (Fig. 23).

Section *Tuberosae* Pax

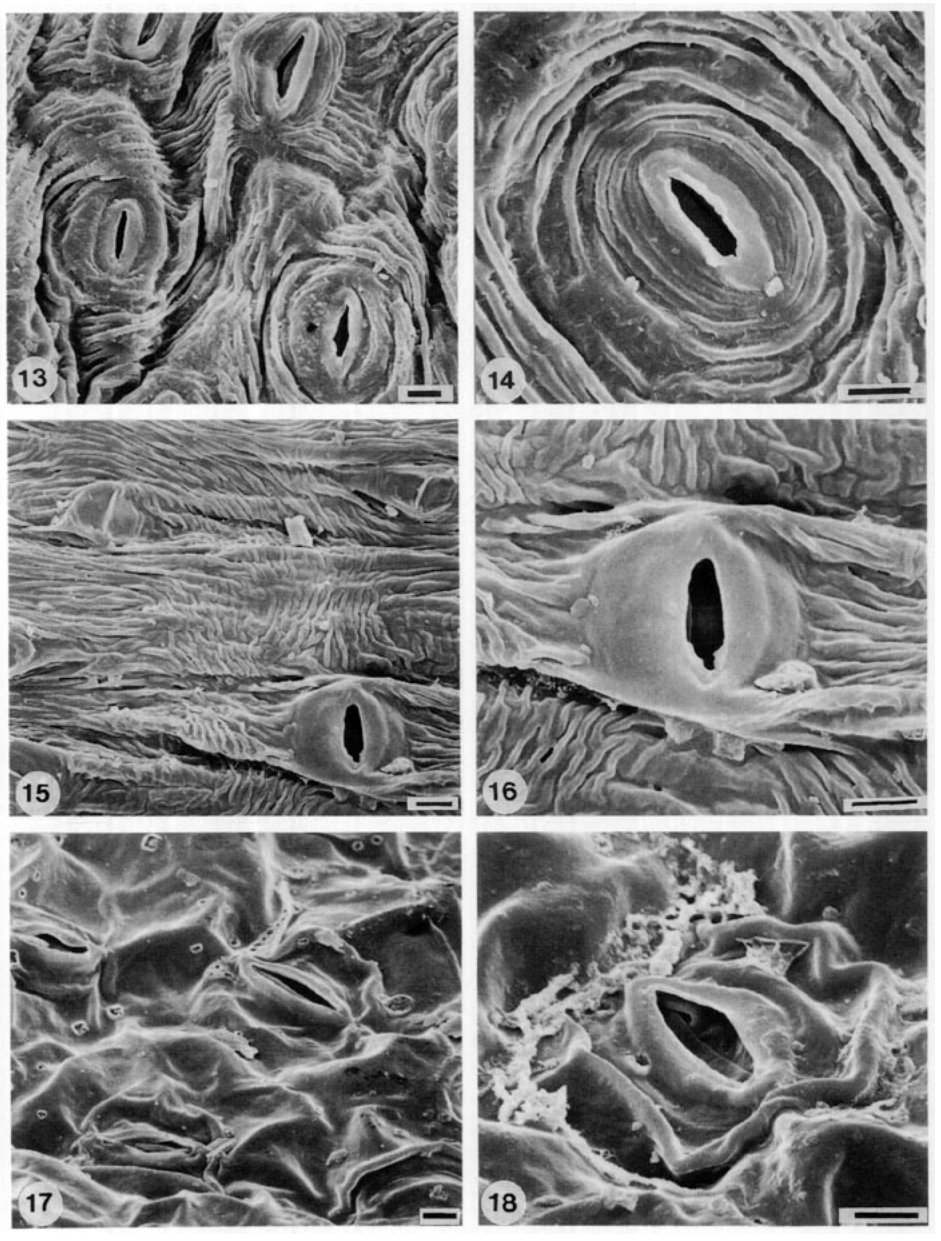
Subsection *Tuberosae* Dehgan & Webster

Two West African species are represented in this group, viz: *J. neriifolia* Müll. Arg. and *J. atacorensis* A. Chev. The taxonomic affinity of the latter is uncertain (Dehgan & Webster, 1979).



Figures 7–12. SEM of leaf abaxial surfaces in Sections *Jatropha, Peltatae* and *Tuberosae*. Fig. 7. *J. kamerunica* (Senegal; *Nongonierma 568* K), simple uniseriate hairs with swollen basal cells. Figs 8, 9. *J. podagrica* (Nigeria; *Olowokudejo 51*, LUH). Fig. 8. Anticlinal walls, indicated partially by ridges and dense wax flakes on periclinal walls. Fig. 9. Superficial stoma wth narrow cuticular rim. Figs 10, 11. *J. multifida* (Sierra Leone; *Deighton 1987*, K). Fig. 10. Prominent ridges indicating anticlinal cell walls and dense wax flakes on outer periclinal walls. Fig. 11. Slightly sunken stoma with narrow cuticular rim. Fig. 12. *J. neriifolia* (Nigeria; *Gbile & Daramola 60526*, FHI), simple unicellular trichomes. All scale bars = 5 μm.

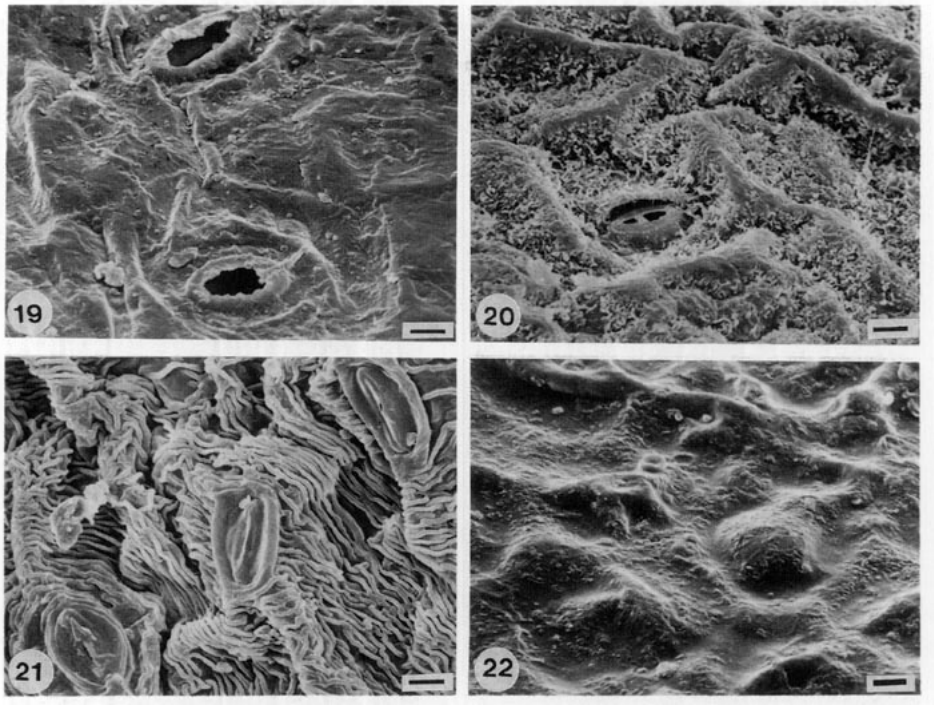
Jatropha neriifolia: abaxial anticlinal cell walls marked by either deep or shallow furrows of varying width. Outer wall of epidermal cells flat or slightly convex and ornamented with both parallel and randomly orientated striae



Figures 13–18. SEM of leaf abaxial surfaces in sections *Tuberosae* and *Curcas*. Figs 13, 14. *J. neriifolia* (Nigeria; *Gbile & Daramola 60526*, FHI). Fig. 13. Outer wall of epidermal cell showing parallel and randomly orientated striae. Fig. 14. Deeply sunken stoma with wide cuticular rim and concentric rings of striae. Figs 15, 16. *J. atacorensis* (Ivory Coast; *Geerling & Bokdam 2223*, K). Fig. 15. Numerous long parallel striae and cuticular folds. Fig. 16. Sunken stoma with overarching cuticular rim and wings of striae. Figs 17, 18. *J. curcas* (Cameroun; *Ogu 315*, FHI). Fig. 17. Irregular folds of cuticle. Fig. 18. Stomata and wax particles. All scale bars = 5 μm.

(Fig. 13). Stomata deeply sunken with wide cuticular rim and concentric rings of striae (Fig. 14). Trichomes of varying size with swollen basal cells tapering gradually to an acute apex (Fig. 12). Wax absent.

Adaxial surface similar to abaxial. Numerous parallel and randomly



Figures 19–22. SEM of leaf adaxial surfaces in Sections *Jatropha* and *Peltatae*. Fig. 19. *J. gossypiifolia* (Nigeria; *Latilo 24434*, FHI), sunken stomata with thick cuticular rims. Fig. 20. *J. chevalieri* (Senegal; *Kesby 16*, K), sunken stoma and fine flakes of wax. Fig. 21. *J. kamerunica* (Senegal; *Nongonierma 568*, K), numerous parallel and randomly orientated striae, and stomata. Fig. 22. *J. podagrica* (Nigeria; *Olowokudejo 51*, LUH), micropapillae and flakes of wax. All scale bars = 5 μm.

orientated striae present on the outer periclinal walls. Stomata sunken with concentric rings of striae. Trichomes present. No wax (Fig. 24).

Jatropha atacorensis: abaxial outer periclinal walls slightly convex with numerous long parallel striae and cuticular folds (Fig. 15). Anticlinal walls obscured by striae. Stomata slightly sunken with wide overarching cuticular rim and wings of striae (Fig. 16). Wax absent.

Adaxial surface with numerous parallel and randomly oriented striae and folds of cuticle continuous over several cells. Stomata superficial with wide cuticular rim. Wax absent (Fig. 25).

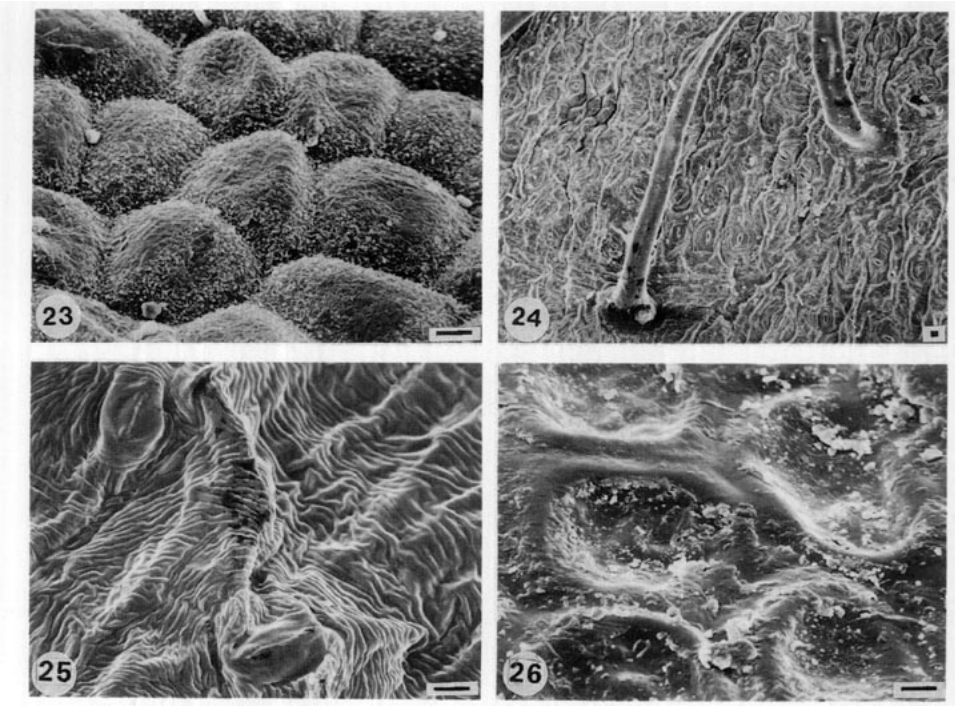
Subgenus *Curcas* (Adans.) Pax

Section *Curcas* (Adans.) Griseb.

Jatropha curcas L. is the only species of this subgenus found in West Africa.

Jatropha curcas: abaxial anticlinal walls obscured by irregular folds of cuticle. Outer periclinal walls flat or convex (Fig. 17). Stomata superficial with either narrow or wide cuticular rim and surrounded by curved striae of more or less uniform thickness (Fig. 18). Wax found as particles.

Adaxial cell boundaries indicated by shallow grooves of varying width. Outer periclinal walls slightly concave with raised edges and numerous micropapillae. Wax present as flakes and particles (Fig. 26).

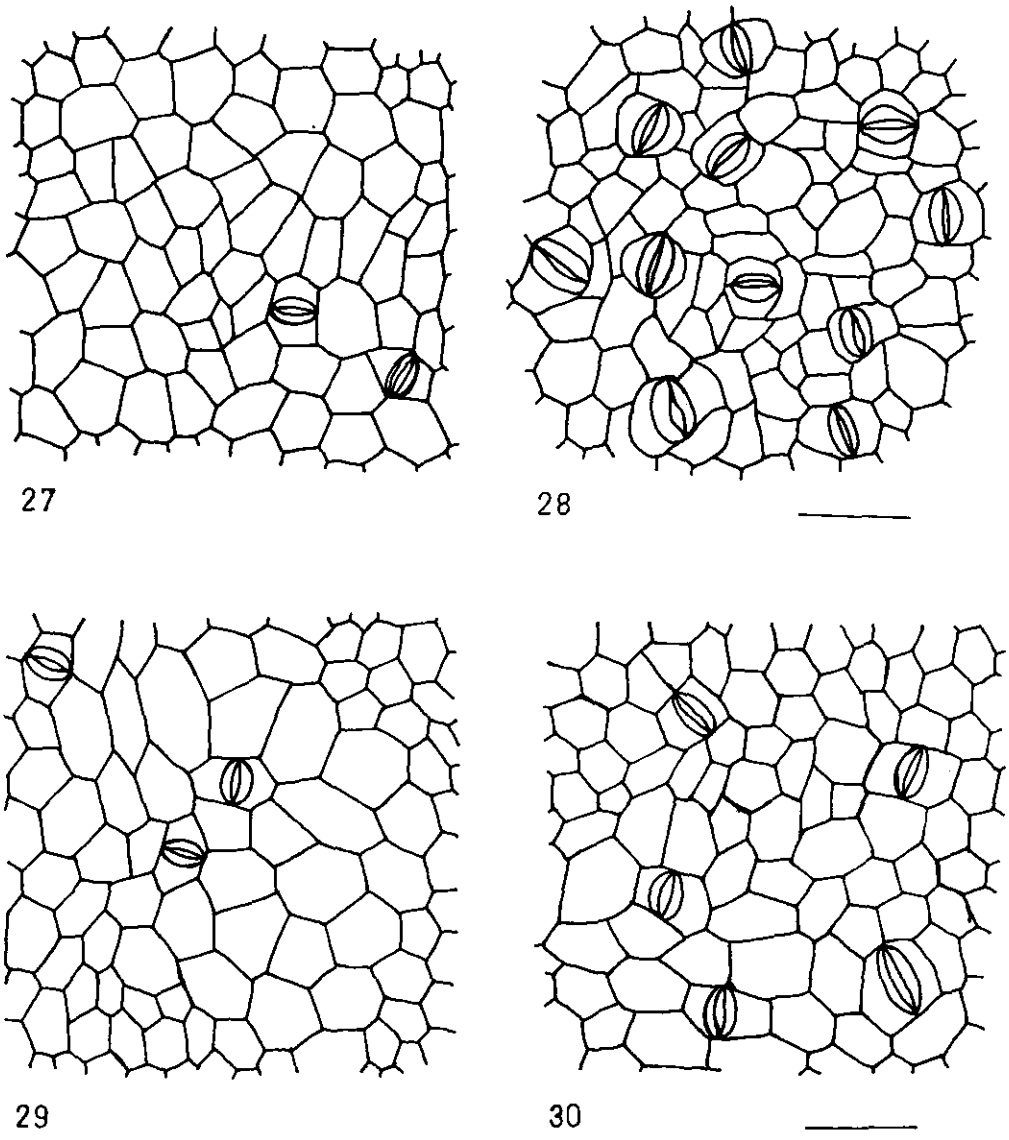


Figures 23–26. SEM of leaf adaxial surfaces in Sections *Peltatae*, *Tuberosae* and *Curcas*. Fig. 23. *J. multifida* (Sierra Leone; *Deighton 1987*, K), convex outer periclinal walls bearing micropapillae and wax particles. Fig. 24. *J. neriifolia* (Nigeria; *Gbile & Daramola 60526*, FHI), unicellular trichomes. Fig. 25. *J. atacorensis* (Ivory Coast; *Geerling & Bokdam 2223*, K), striae, cuticular folds and stomata with wide cuticular rims. Fig. 26. *J. curcas* (Cameroun; *Ogu 315*, FHI), concave outer periclinal walls, micropapillae and wax flakes. All scale bars = 5 μm.

Light microscopic features of epidermal surfaces

Abaxial and adaxial epidermal cells are usually polygonal with either straight or curved anticlinal walls (Figs 27–36). The cells vary in size both within and between the species, adaxial cells being generally bigger than those on the abaxial surface (Table 1). *Jatropha kamerunica* has the biggest cells while the smallest are found in *J. atacorensis* (Fig. 34), with mean measurements of 41.12 μm and 22.78 μm respectively. Epicuticular secretions which vary in form and distribution occur in some taxa. Wax in form of dense granules are noticeable on both surfaces of *J. multifida* while fine patterns of striae occur in *J. neriifolia* and *J. kamerunica*.

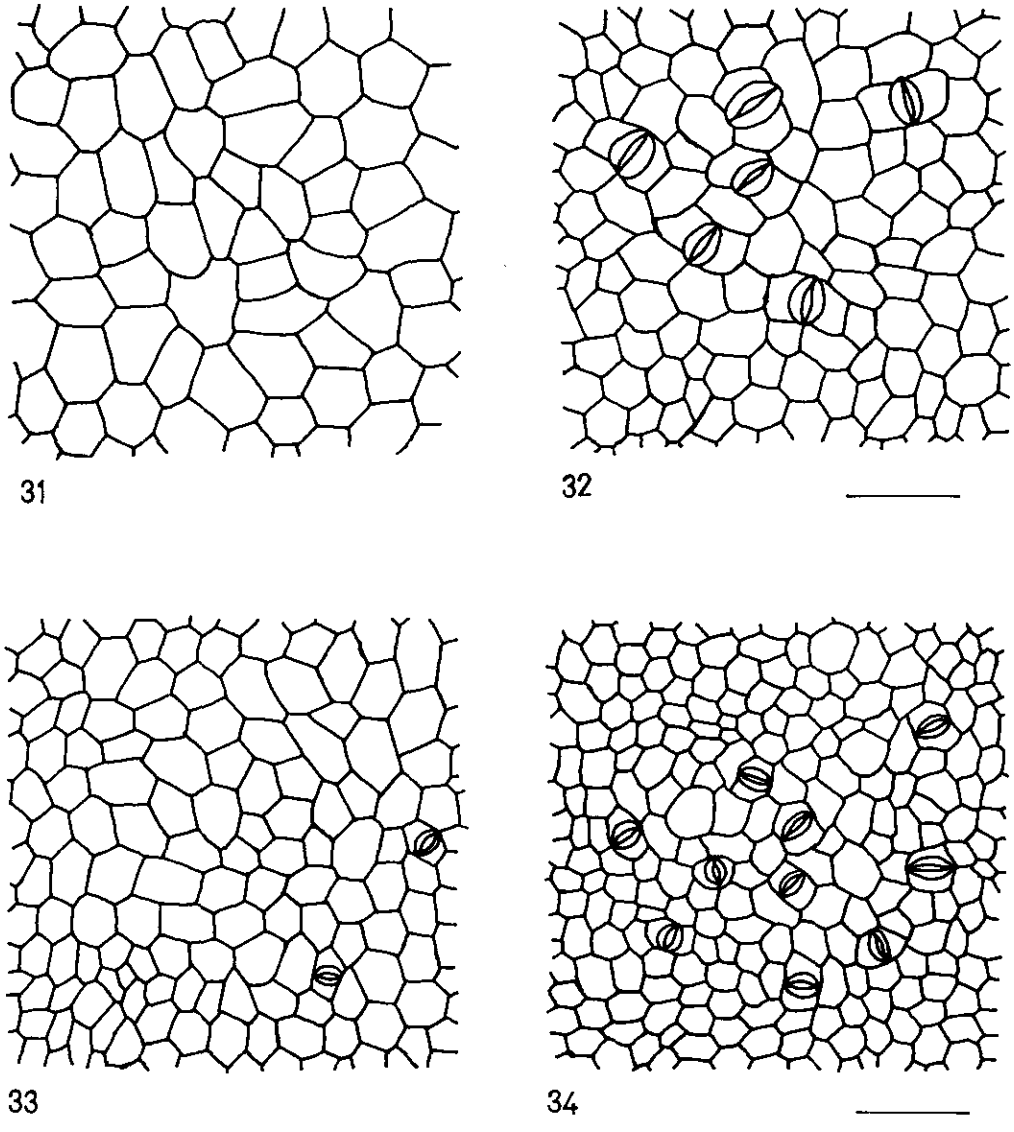
Stomata occur on both surfaces of *Jatropha* species except in *J. podagrica* and *J. multifida* (Fig. 31) where they are confined to the abaxial surface. Paracytic stomata are found in *J. neriifolia*, *J. atacorensis* (Figs 33, 34) and *J. curcas* (Figs 35, 36), while they are brachyparacytic in *J. podagrica* and *J. multifida* (Fig. 32). A mixture of both paracytic and brachyparacytic types characterizes the epidermal surfaces of *J. gossypiifolia* (Figs 27, 28), *J. chevalieri* (Fig. 30) and *J. kamerunica* (Table 1). Distinction between the two stomatal types is sometimes difficult to recognize because of the nature of the walls of the subsidiary and guard cells. There is considerable intra- and inter-specific variation in stomatal size within the genus. The stomata of *J. atacorensis* (Figs 33, 34) are generally the



Figures 27–30. Drawings of leaf epidermises of *Jatropha* species. Figs 27, 28. *J. gossypiifolia*. Fig. 27. Adaxial surface, showing stomata and anticlinal walls. Fig. 28. Abaxial surface, curved and straight anticlinal walls. Figs 29, 30. *J. chevalieri*. Fig. 29. Adaxial surface with stomata. Fig. 30. Abaxial surface showing straight anticlinal walls. Scale bars = 50 μm.

smallest, with mean values of 12.34 × 4.12 μm and 14.02 × 4.18 μm on the adaxial and abaxial surfaces respectively. *Jatropha gossypiifolia* (Figs 27, 28) has the largest stomata which measure 29.42 × 8.94 μm on the abaxial surface and 28.01 × 8.62 μm on the adaxial surface (Table 1).

Trichomes are found in four species where they vary in form, size, distribution and abundance. Dense unicellular hairs which range from 300 to 500 μm in length are found on both surfaces of the epidermis of *J. neriifolia* but in *J. atacorensis* they are confined to the major veins, only on the adaxial side, where they are sparsely distributed. In *J. kamerunica* a mixture of both long and short



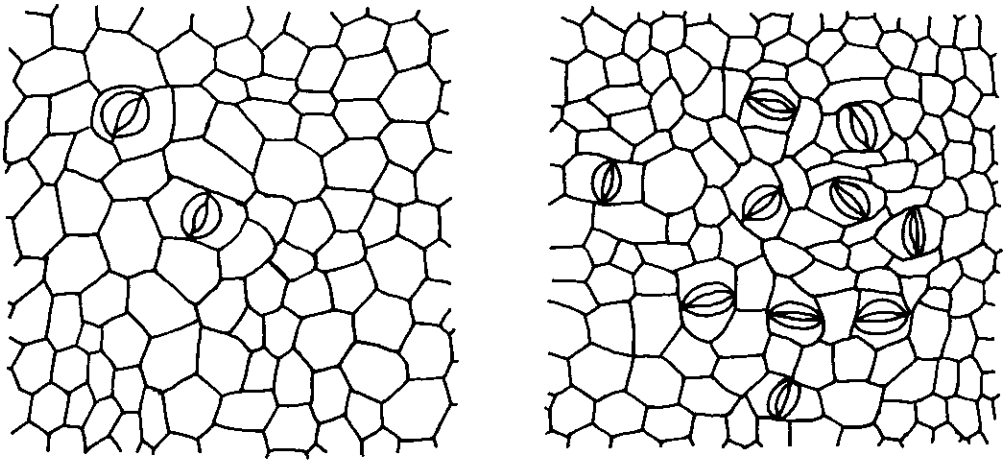
Figures 31–34. Drawings of leaf epidermises of *Jatropha* species. Figs 31, 32. *J. multifida.* Fig. 31. Adaxial surface. Fig. 32. Abaxial surface showing stomata. Figs 33, 34. *J. atacorensis.* Fig. 33. Adaxial surface with stomata. Fig. 34. Abaxial surface. Scale bars = 50 μm.

uniseriate trichomes, which are about 900 μm and 400 μm respectively, occurs chiefly on the veins on both sides. Stipitate glands and short uniseriate trichomes are found in abundance on the leaf margins of *J. gossypiifolia.*

DISCUSSION

The two complementary methods of observation employed in this study have revealed that micromorphological characters of the epidermis are of considerable taxonomic significance within the genus *Jatropha.*

Jatropha gossypiifolia is unique among the eight species investigated by the



Figures 35, 36. Drawings of leaf epidermises of *Jatropha curcas*. Fig. 35. Adaxial surface. Fig. 36. Abaxial surface. Scale bar = 50 μm.

possession of stalked glands and short uniseriate trichomes which are restricted to the margins of the leaf. Dehgan (1980) reported these hairs on both surfaces of the leaf while Castells *et al.* (1984) observed both simple and branched glandular hairs on the leaf margins only. Inamdar & Gangadhara (1977), however, did not observe any glandular trichomes, but instead recorded both unicellular and multicellular hairs on the leaves. The widest stomata recorded within the genus are also found on the abaxial and adaxial epidermises of this species. This observation is similar to those of Karatela & Gill (1984), but contrary to the findings of Raju & Rao (1977) who reported larger stomata in *J. curcas* than in *J. gossypiifolia*. There is considerable intraspecific variation and interspecific overlap in stomatal size within the genus, thereby limiting the diagnostic value of this character. The unusually small stomata of *J. neriifolia* and *J. atacorensis* are, however, useful for taxonomic discrimination.

The prominently striated cuticle of *J. kamerunica, J. neriifolia* and *J. atacorensis* separates these taxa from others. Striation patterns have been found to be taxonomically significant in some other species of the genus, such as *J. integerrima* Jacq. and *J. panduraefolia* Andr. (Chaturvedi & Jehan, 1982). Stace (1965) and Wilkinson (1979), among others, have drawn attention to the systematic importance of cuticular striations which may characterize some species but may be quite variable in others. The unicellular trichomes, which were observed only in all specimens of *J. neriifolia* and *J. atacorensis*, constitute an important distinguishing feature. Moreover, the presence of comparatively small stomata on both abaxial and adaxial surfaces of these two taxa provides valuable additional characters in the assessment of taxonomic affinity among these species. This evidence suggests that *J. atacorensis* and *J. neriifolia* are more closely related to each other than to any other species of the genus in West Africa. The inclusion of the former with the latter in section *Tuberosae*, as suggested by Dehgan & Webster (1979), is therefore supported by the results of the present investigation.

Jatropha podagrica and *J. multifida* are the only two hypostomatic species within

the genus, contrary to the observations of Inamdar & Gangadhara (1978) who recorded stomata on both surfaces of the leaves of *J. podagrica*. These taxa also possess brachyparacytic stomata with a narrow cuticular rim. These features indicate taxonomic affinity between the two species which, expectedly, are grouped in the same section, *Peltatae*, on the basis of macromorphological characters. Each species can be separated from the other by the characteristic nature of the anticlinal and periclinal walls of the adaxial epidermis.

Epicuticular wax occurs on the leaf surfaces of five species in the form of either flakes, particles or plugs. The morphological patterns are, however, not sufficiently distinct to aid the recognition of individual taxa and are not correlated with any other micromorphological feature or the established infrageneric groupings. Wax morphology is particularly useful as an additional diagnostic character (Wilkinson, 1979) but its importance in species identification and classification varies from one group of plants to another (Hallam & Chambers, 1970; Hallam & Juniper, 1971; Martin & Juniper, 1970). Ecologically, Barthlott & Wollenweber (1981) and Barthlott (1990) have suggested an anti-contamination effect as probably the most important aspect of the widespread epicuticular wax crystalloids found in plants.

In agreement with the paracytic and brachyparacytic stomatal types reported here, Dehgan (1980) also found brachyparacytic stomata in all five species of section *Peltatae* which includes *J. podagrica* (from India) and *J. multifida* (from New Guinea), but the water stomata which Dehgan (1980) reported as frequent were not observed in my material. Moreover, this investigation has revealed that *J. gossypiifolia* and *J. curcas* are amphistomatic while Dehgan (1980) reported the presence of stomata on the abaxial surface only despite the fact that the specimens examined in this case were of West African origin, viz. *J. gossypiifolia* from Ghana and *J. curcas* from Senegal. Furthermore, the paracytic stomatal type is not restricted to subsgenus *Curcas* as indicated by Dehgan (1980), but is more widespread in subgenus *Jatropha* with the intraspecific occurrence of both paracytic and brachyparacytic types in subsections *Adenophorae* and *Pubescentes*. Karatela & Gill (1984) have also recorded the occurrence of paracytic stomata in *J. gossypiifolia*.

Previous studies of Raju & Rao (1977) indicated the presence of other stomatal types, apart from the paracytic and brachyparacytic, in *J. curcas* and *J. gossypiifolia*, but only at a very low frequency (1.2–3.0% for anisocytic and 0.2–1.2% for anomocytic). Somewhat higher frequencies (10% and 15% respectively) of anomocytic stomata were recorded for these two species by Karatela & Gill (1984), while Gupta (1985) reported both paracytic and anisocytic stomata in small leaf fragments of *J. curcas*. Anomocytic stomata have also been observed in specimens of *J. multifida* and *J. podagrica* by Inamdar & Gangadhara (1978). There is no simple explanation for these discrepancies which, in part, may be due to natural variation, which is expected in these geographically widespread species that usually grow in a wide variety of habitats, or may also be attributed to differences in the portions of the leaf chosen for study, for example, an area about 5–8 mm^2 taken from the centre of each leaf was investigated in the present study while Dehgan (1980) examined 2–3 mm^2 pieces and Raju & Rao (1977) examined whole mounts of the leaves. Another possible source of error is the different interpretation of stomatal types by different workers. These observations probably underscore the need to

standardize methods of investigation and definition of stomatal types in studies of this nature. It is also important that representative samples from all the geographic ranges of each species are examined before the results can be regarded as conclusive. However, the most prevalent type of stomata in *Jatropha* is, undoubtedly, the paracytic type which Raju & Rao (1977) regarded as the basic type for the family Euphorbiaceae.

Although the diverse micromorphological epidermal and cuticular characters alone are not sufficient for the delimitation of the various infrageneric groups, it is apparent from this study that these features are useful for the identification of the taxa and confirmation of species relationships. Mueller (1966), Cutler (1972) and Cutler & Brandham (1977) have shown that many leaf surface patterns are under strong genetic control and therefore little affected by the environment. However, like all other taxonomic evidence, epidermal characters must be interpreted with great circumspection.

The key presented below allows separation of all species studied:

KEY TO EIGHT WEST AFRICAN SPECIES OF *JATROPHA*

1 Wax present on abaxial and adaxial surfaces, no striae 2
- 2 Stomata on abaxial and abaxial epidermis, paracytic or brachyparacytic or both, stomata with wide cuticular rim 3
  - 3 Epidermis with uniseriate trichome and stipitate glands *J. gossypiifolia*
  - 3 Epidermis totally glabrous 4
    - 4 Stomata deeply sunken, striae absent *J. chevalieri*
    - 4 Stomata superficial with a ring of striae around the pore J. curcas
- 2 Stomata on abaxial epidermis only, brachyparacytic, with narrow cuticular rim 5
  - 5 Periclinal wall of adaxial epidermis prominently domed; anticlinal wall indicated by furrows *J. multifida*
  - 5 Periclinal wall of adaxial epidermis slightly convex; anticlinal wall indicated by ridges *J. podagrica*

1 Wax totally absent, abaxial and adaxial surfaces striate 6
- 6 Trichomes uniseriate *J. kamerunica*
- 6 Trichomes unicellular 7
  - 7 Anticlinal walls on both surfaces indicated by furrows; stomata deeply sunken *J. neriifolia*
  - 7 Anticlinal walls on both surfaces obscured by stria; stomata slightly sunken *J. atacorensis*

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