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Fruit Epidermal Micromorphology in the Systematics of *Abrus* Adanson (Papilionaceae) in Parts of Tropical West Africa

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Abstract: Comparative epidermal studies using simple microscopy on herbarium and fresh fruit samples of three *Abrus* Adanson species (*A. canescens* Welw. ex Bak, *A. precatorius* L. and *A. pulchellus* Wall. ex Thw.) and a new collection of *Abrus* sp. occurring in parts of Tropical West Africa shows they are characterized by stomata, trichomes and other epidermal features. The epidermal cell shape in the species is irregular with straight anticlinal pattern in the new collection *Abrus* sp. but straight and arcuate in the other three. Observed differences in the dimensions of epidermal cell is such that a similarity of sort exists between *A. pulchellus* and the new collection *Abrus* sp. With ten stomata types observed in the species, stomata features are the most striking features. The restriction of sunken paracytic stomata in *A. precatorius,* brachy-para-hexacytic monopolar type in the new collection *Abrus* sp. and hexacytic and contiguous types in *A. canescens,* are reasonably diagnostic. Stomata in-groups of two occurring in clusters of between 10-13 were observed in *A. pulchellus* and *A. canescens.* Stomatal Index (SI) values are distinct for each species with values of 2.81 and 15.74 in *Abrus* sp. and *A. pulchellus*, respectively being the lowest and highest in the genus. The glandular multicellular and simple unbranched trichomes are present in all species as well as crystals encrusted in cells. The study aims at improving systematic information on the genus, which is hitherto scanty.

Key words: *Abrus,* crystals, epidermis, stomata, trichome

INTRODUCTION

Abrus Adanson is a small pantropic genus belonging to the family Papilionaceae[1]. Its members are lesser known and utilized among the legumes[2] although great potentials for exploitation abound for the plant. Some members have been employed in ethnomedical, ethnopharmacological and toxicological uses[3-9]. The leaves and leafy twigs of some are used in the preparation of liquorice[10,11].

The re-emergence of medicinal plants as healthcare alternatives[12] calls for greater interest into poorly utilized plant genetic resources as these. In the face of increasing threat to these resources, mounting bioprospecting for new drugs of plant origin and general complacency on conservation, any effort at better understanding and proper documentation of plant genetic resources is worthwhile. *Abrus* species are potential genetic resources open to bioprospecting. The species are climbing, twining or scrambling slender sub-woody liana with pinnate leaves, rachis ending in a bristle, stamens connate in a sheath with racemose flowers[1]. Brettler[13] recorded four species in the genus while Verdcourt[14,15] reported thirteen. Labat[16] reported a new species *A. longibracteatus* Labat from Laos and Vietnam, while Thulin[17] published *A. baladensis* Thulin and *A. gawwenensis* from Somalia as *species nova.* In tropical West Africa, three species of *Abrus*, *A. precatorius* L., *A. pulchellus* Wall. and *A. canescens* Welw. ex Bak, have been reported by Hutchinson and Dolgiel[1]. At present *A. canescens,* which used to occur in the northern savanna area of Nigeria is almost extinct as efforts made to make collections for this study failed. The variability of the vegetative features and the conflicting reports of the exact number of species in this genus somewhat poses a bit of controversy on the taxonomy of the genus.

Epidermal characters as taxonomic tools have been extensively used amongst the Papilionaceae[18-21]. These studies, which utilized information from the structure, development and types of stomata, trichome and trichome types and various other quantitative and qualitative epidermal characters for taxa elucidation dwelt only on the leaf surface. Studies on the epidermal features of the fruit surface per se are generally uncommon. However,

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Olowokudejo[22] demonstrated the importance of epidermal characteristics of the fruit surface in the genus *Biscutella* where he reported remarkable topographic diversity in trichome and stomata features useful in taxa elucidation. Despite the enormous uses of *Abrus* species in Tropical West Africa[9], information on the systematics of the genus is scanty. Thus, the search for characters of taxonomic value has been extended to the fruit surfaces of the species of this genus as part of a multidisciplinary approach[23] to the systematics of the genus. The detailed descriptive qualitative and quantitative epidermal data amassed herein provides additional information on the taxonomy of the genus. Also included are the fruit epidermal characteristics of a new collection simply referred to as *Abrus* sp. collected from the Niger Delta area of Nigeria[23] whose identity is undergoing confirmation. We hope that findings will be invaluable to conservation and biotechnological exploitation of this plant.

MATERIALS AND METHODS

Fresh and herbarium specimens were used in this study (Table 1). Herbarium specimens were obtained from Forestry Herbarium Ibadan (FHI) and University of Ibadan Herbarium (UIH). Voucher specimens of all the living materials studied are deposited in the University of Port Harcourt Herbarium (UPH).

The fruit epidermis of *Abrus* species occurring in tropical West Africa were studied from fresh and herbarium samples (*A. precatorius, A. pulchellus* and the new collection *Abrus* sp.) fixed directly into the fixative formal acetic alcohol i.e. FAA (1 part formaldehyde, 1 part glacial acetic acid, 18 parts 70% ethanol v/v) and from herbarium materials only (*A. canescens*) (Table 1). Initial soaking in water for between 8-12 h revived the herbarium samples. The fresh samples were washed under tap water and together with the herbarium samples of *A. canescens* transferred into dishes containing 5% sodium hypochlorite (domestic bleach) for 12 to 24 h. Within this period, the sodium hypochlorite achieves the gradual digestion and disintegration of the hypodermal tissues of the fruit surfaces leaving a thin epidermal layer, which simply floats in the bleach solution or is carefully removed using a camel hair brush. The clear epidermal layers obtained were subsequently washed in several changes of distilled water, stained in 1% safranin for 1 min and temporarily mounted in glycerin. The preparations were observed and studied with a LEITZ microscope at objective lens 10 and 40 microscope magnification. Twenty microscope field views chosen at random from 5 fruit samples for each species were used to enumerate and study the number and types of stomata, trichomes and other epidermal cells. In each case, the median section of the fruit surface was used for the studies. Stomatal indices were computed according to Stace[24], stomatal type according to Dilcher[25], Metcalfe and Chalk[26], Stace[27], trichome morphology according to Metcalfe and Chalk[26], Sasikala and Narayanan[28], trichome density and distribution according to Olowokudejo[29]. The microscopic observations on these species were supplemented by ocular measurements of the length and width of epidermal cell, stomata and trichome at objective lens 40 on a LEITZ microscope. Standard deviation of the means in each case was computed as a means of comparison.

Photomicrographs were taken with a LEITZ DIAPLAN (Photomicroscope) fitted with LEICA WILD MPS 52 camera at objective lens 10 and 40 as indicated on the plates.

RESULTS

Cell shape: The epidermis of the fruits of the species show one type of cell shape, i.e. irregular (Fig. 1-4 and Table 2).

Anticlinal cell wall patterns: The anticlinal wall pattern in the species is straight to arcuate with only *Abrus* sp. possessing straight wall pattern (Table 2 and Fig. 1-4).

Cell size: This varied from 27.27±9.64x13.77±2.97 μm in *A. precatorius* to 61.40±43.92x13.77±5.61 μm in *Abrus* sp. (Table 2). A wide range of variation occurred in the epidermal cell length but epidermal cell width of the species were observed to exist within a somewhat close range of 10.80 – 29.70 μm.

Cell wall thickness: The cell wall thickness ranged generally from 1.35 to 8.10 μm. *A. precatorius, A. pulchellus* and *A. canescens* have closely related cell wall thickness. Mean epidermal cell wall thickness of 4.05±1.85 μm in *Abrus* sp. which is distant from the other species, was the highest.

Costal cells: The costal cells are parallel in arrangement, elongated, rectangular shaped, with long arms straight, arcuate or wavy and having straight to oblique end walls.

Epidermal cell number: The average epidermal cell number per field view varied from 175 in *A. pulchellus* to 304 in *Abrus* sp. It is 293 in *A. canescens* and 300 in *A. precatorius*.

Stomatal complex: Ten types of stomata were observed to adorn the fruit epidermis of the *Abrus* species. These are

Table 1: Sources of plant materials examined

Taxa	Serial No. of species studied	Collector and accession/ herbarium number	Collection date	Locality	Remarks
Abrus precatorius	001	Agbagwa 001 UPH*	17/5/98	Emeabiam, Owerri West, L. G. A., Imo State	
	002	Agbagwa 002 UPH*	15/8/98	Orazi road, Port Harcourt. Climbing on a barbed fence	
	003	Agbagwa 010 UPH*	2/8/99	Forestry Research Institute of Nigeria (FRIN), Ibadan	
	004	Agbagwa 005 UPH*	16/1/99	69 Independence Layout,Enugu	In private compound
	005	Agbagwa 011 UPH*	12/12/99	Ibiono Ibom, Akwa Ibom State	
	006	Bernays, E. UIH 16216	8/4/75	Iwo Road, Ibadan (½ mile from New Ife road)	
	007	Williamson, R. UIH 15402	14/12/73	Kaiama, Kolokuma Area Yenegoa Division	
	008	Vermeer, D. UIH 16712	1975	W. of J. W. Donga, Benue Province, 7o15'N 9o40'E	
	09	Olorunfemi FHI 57085	26/9/66	Kabama forest reserve, Zaria	
	010	Magaji FHI 17962	15/9/67	Seven Miles on 6/7 range Runka Forest Reserve, Katsina. On savanna woodland	
	011	Onochie, C. FHI 7194	22/4/44	Umuikem, Onitsha	
	012	FHI 98709	17/9/77	Northern Province, Karonga District, Mali Vinthukhutu 2 miles North of Chilumba 1800ft	Republic of Mali
	013	Adam FHI 84029	21/1/48	M'Bao, Rufisque District, Senegal. Rep	Republic of Senegal
	014	Daramola FHI 78539	20/9/75	Creek edge near New Prisons Calabar, S.E.	
Abrus pulchellus	015	Agbagwa 003 UPH*	21/12/98	Emeabiam, Owerri-West L. G. A., Imo State	
	016	Agbagwa 004 UPH*	6/01/99	Behind Chemical Engineering Dept. Choba, Uniport	
	017	Agbagwa 006 UPH*	12/2/99	After the Mosque, University of Ibadan Nigeria	
	018	Agbagwa 007 UPH*	1/3/99	Botanical Garden University of Calabar, Nigeria	
	019	Agbagwa 009 UPH*	3/5/99	KM 4, along Kolo-Creek/Rumuekpe Pipeline, Imiringi, Bayelsa State	
	020	Agbagwa 012 UPH*	29/11/2000	High Secondary forest, opposite IITA office, Onne Station	
	021	Latilo FHI. Bret 1961	1/3/61	Acharane F. R., Idah District, Kabba	
	022	Ujor E. FHI 29395	22/11/51	Gambari South F.R. Ibadan	
	023	Gbile, Olorunfemi, Binuyo FHI 20588	7/2/69	Ogbesse River Bank Ogbesse-Owo Rd; Owo Ondo. Det. As A.*ulchellus* *p*Wall 6/3/69, *A.fruticulosus* Wall. Ex.W. and A. 1/11/61; A. pulchellusThro. Sp. 1/4/71	Det. As *fruiticulosus* and*A. pulchellus* wall. Ex wight et Am. wall respectively at Kew
	024	Onochie PSP 132 FHI 43187	16/11/58	Akpaka, F. R. Onitsha Det. As *A. fruticulosus* Wall. Ex wight et Arn. and *A. palichellus* Wall, Respectively at Kew	
	025	Jones FHI 6359	11/10/43	Oyo	Seen for revised Edn. of F. W. T.A
	026	Emwiogbon FHI 43539	14/11/61	Shasha F.R, Oyo, Ife District	
Abrus canesceus	027	Meikle UIH 2098	21/1/50	Kontagora Division by roadside, about 4k from Kontagora	
	028	Olorunfemi Binuyo, 96811 Babagbemi FHI	23/11/81	Iyere-Ogura Road, Owo District, Ondo State	Cited specimen F. W. T. A. Edn. 2, 1958
	029	Latilo FHI 62268	14/11/68	Egbe, Yagba District of Kabba, Kwara State.	
	030	Latilo FHI 64726	3/12/71	North East, Bauchi about 10 miles east of Aliya village in Ngeji village	
	031	Eimnnjeze and Ognntayo FHI 71358	8/10/74	Savanna – woodland, beside a stream, Omu-Aran, Kwara State	
	032			Omu-Aran, Kwara State	
	033	Ohaeri (1037) FHI 78891	20/10/75	Shika farm, Zaria	
	034	Daramola and Adebisiyi FHI 38433	14/10/58	On the line 15, Savanna woodland area, Bunu District, Kabba	

Table 1: Continue

Taxa	Serial No. of species studied	Collector and accession/ herbarium number	Collection date	Locality	Remarks
	035	Opayemi FHI 68859	18/11/72	5 miles after Oyo on Iseyin Road., savanna near a stream	
	036	FHI 77678 Photo No. 1723	1855	Angola No. 2249	Typespecimen: type of british museum herbarium
	037	Olurunfemi Oguntayo, Ihe FHI 88335	20/9/78	Savanna: Ogamnana-Lokoja Road, Okene, Kwara State	as *A. frutensis*
	038	Latilo FHI 73554	10/11/75	Baissa-Mararraba Road, North Eastern State	Savanna area
	039	Mullenders FHI 42593	1/4/47	Kaniama-Haut Lomani (Congo Belge)	Specimen from Ex Herbario Horti Botanici Yangambiensis. (Congo Belge)
	040	Amshoff FHI 31707	1972	Near Sindou, 5 11Wo, 10 49No, Upper Volta	Presently Burkina Faso Specimen from Plantae Upper Volta. exsiccatae Herbarium vadense
	041	Rwaburindore FHI 104671	20/1/83	Kanyanya Valley, W. Mengo District Kyadondo District of Uganda. Lat Oo23N long. 32o 36'E. Altitude 1200 M	Uganda Flora of Uganda
	042	Adams and Akpabla FHI 53186	18/12/50	Climbing on shrubs near swamps: from Ghana Herbarium	Cited F. W. T.A. Edn. 2, 1.574
	043	Morton FHI 14626	14/11/65	Kameron to Kuruboula, about 2 miles from Kameron	In damp savanna in Kameron
Abrus sp.	044	Agbagwa 013 UPH*	1/12/2000	Taylor Greek area, Biseni, Bayelsa State	High tropical rainforest area

UPH*: Fresh specimens deposited at the University of Port Harcourt Herbarium

Table 2: Qualitative and quantitative epidermal cell characteristics of fruits of *Abrns* species studied

Taxa	Epidermal cell Shape	Anticlinal cell wall pattern	Epidermal cell length range(µm)	Epidermal cell length (µm)	Epidermal cell width range (µm)	Epidermal cell width (µm)	Number of epidermal cells per view	Epidermal cell wall thickness range (µm)	Epidermal cell wall thickness (µm)
A. precatorins	Irregular	Straight, Arcuate	16.20-48.60	27.27±9.64	10.80-16.20	13.77±2.97	300	1.35-2.70	2.30±0.65
A. pulchellus	Irregular	Straight, Arcuate	19.00-81.00	47.30±21.47	8.10-18.90	14.83±3.66	175	1.35-2.70	2.03±0.71
A. canesceus	Irregular	Straight, Arcuate	16.00-57.00	36.20±14.59	8.19-29.70	18.90±6.85	293	1.35-2.70	1.49±0.49
Abrus sp.	Irregular	Straight, Arcuate	14.00-138.00	61.40±43.92	8.10-18.90	13.77±5.61	304	2.70-8.10	4.05±1.85

Table 3: Qualitative and quantitative stomatal and trichome features of fmits of *Abrus* species

		Stomatal siae						Trichome size			
Taxa	Stomata type (s)	Length (µm)	Width (µm)	Stomata length/ stomata width ratio	Stomata index (S I)	Trichome type	No of trichome foot cells	Trichome length (µm)	Trichome width (µm)	Trichome thickness (µm)	Trichome index (T I)
A. percatorius	Sunken paracytic type	28 08±3 64	24 57±4 11	1 10	12 17	Simple unbranched	6-8	186 83±51 84	17 55±3 02	4 32±1 06	4 49
						Glandular, multicellular	4-5	54 54±7 4	17 55±6 89		
A. pulchellus	Anisocytic, amphianisocytic staurocytic, actinocytic,	22 14±3 98	18 09± 16	1 20	15 74	Simple, unbranched	4-9	176 90±107 09	18 90±5 55	4 32±1 94	2 33
						Glandular, multicellular	4-7	48 30±5 76	20 40±3 60		
A. canescens	Amphianisocytic, anisocytic,	22 14±3 16	14 58±2 61	1 50	6 76	Simple, unbranched	9-16	393 50±147 67	24 57±3 48	4 99±0 91	11 55
	Staurocytic, hexacytic					Glandular multicellular	5-7	62 60±10 21	17 98±1 58		
	Actinocytic, cyclocytic, amphicyclocytic, contiguous										
Abrus sp	Cyclocytic, Amphicyclocytic,	31 05±6 52	21 87±5 16	1 40	2 81	Simple unbranched	11-15	397 20±237 28	20 10±2 33	4 73±1 59	5 61
	Brachy-para-hexacytic monopolar					Glandular multicellular	6-8	55,70±23 47	17 55±3 87		

paracytic, anisocytic, staurocytic, actinocytic, cyclocytic, para-hexacytic and brachy-parahexacytic–monopolar, anıphicyclocytic, anıphianisocytic (helicocytic) (Fig. 1-4). Also stomata in groups of two to thirteen occur in *A. pulchellus* and *A. canescens*. Contiguous stomata occur in *A. pulchellus* and *Abrus* sp. Sunken paracytic

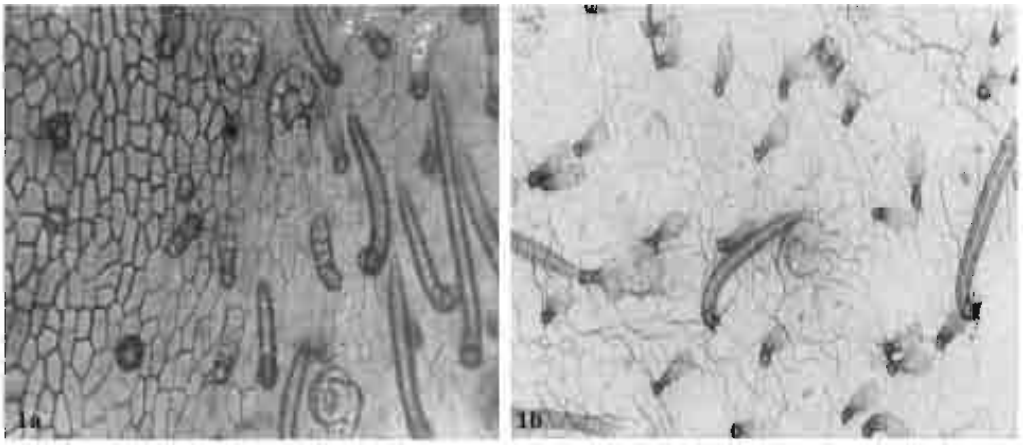

Fig 1: a: (x 560) showing fruit epidermises in *A. precatorius*. b: (x 560) notice the almost sunken stomata and the characteristic 2-3 glandular trichomes originating from one cell stalk

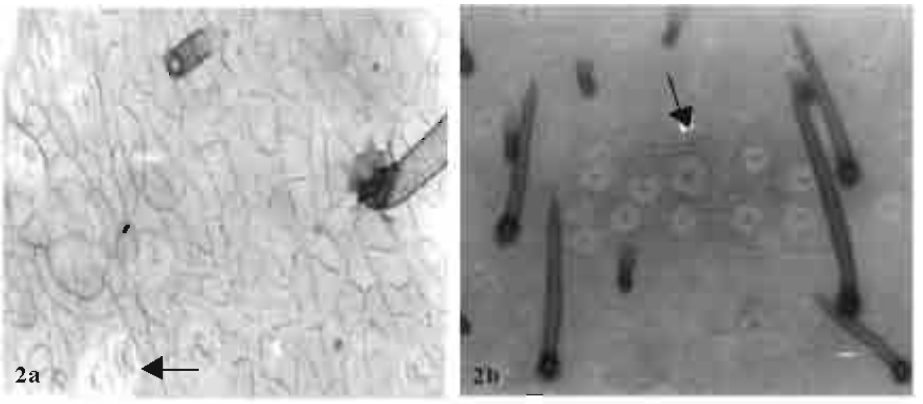

Fig 2: Showing fruit epidermises in *A. pulchellus*. a: (x 875) Notice one glandular and one simple trichome. Arrow points to contiguous stomata. b: (x 560) arrow shows a parahexacytic stomata with a cluster of 12 other stomata. Notice the characteristic guarding of the stomata by several trichomes

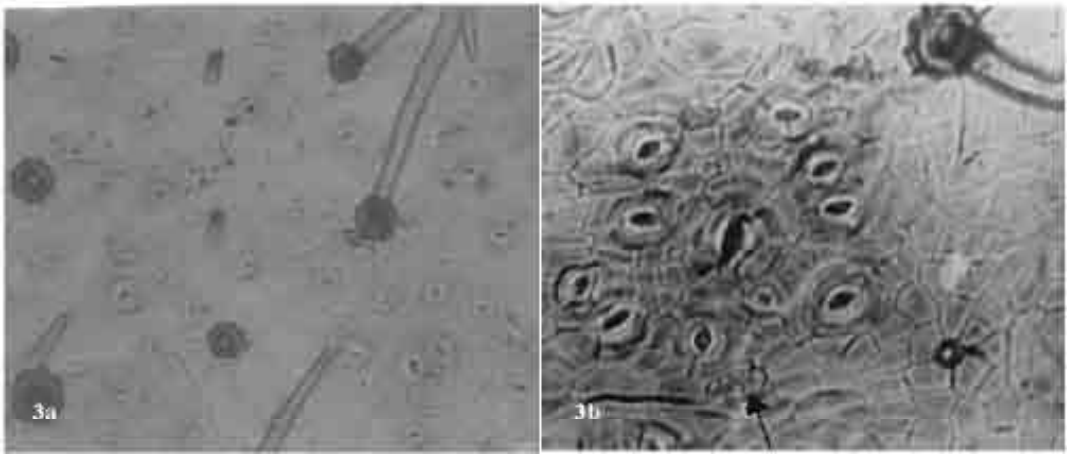

Fig 3: Showing fruit epidermises of *A. canescens*. a: (x 560) several cyclocytic stomata, glandular multicellular and simple unbranched trichome. b: (x 875) a large amphicyclocytic stomata surrounded by a cluster of 10 other cyclocytic types. Arrow shows 4 crystals encrusted into the cell

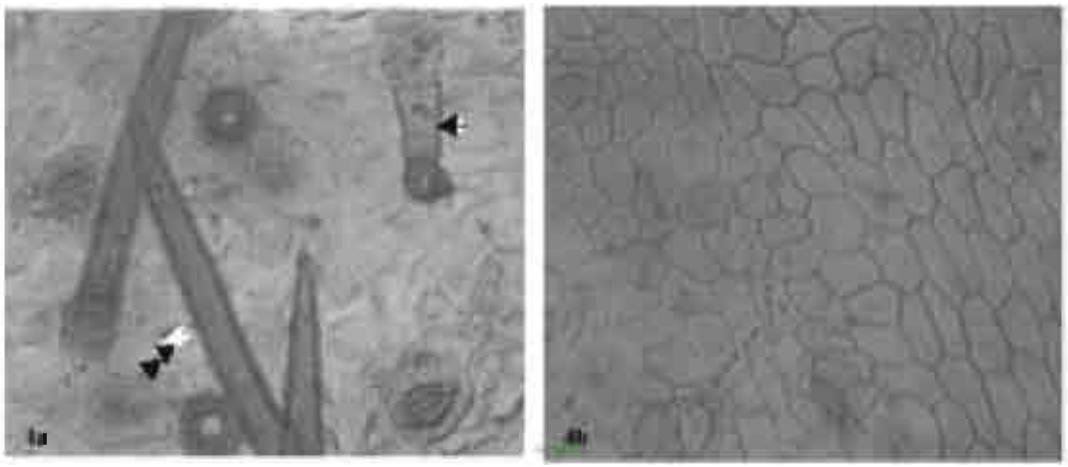

Fig. 4: Showing fruit epidermises in Abrus sp. a: (x 875) arrow point to multicellular glandular trichome. Double arrow indicates simple unbranched trichome. b: (x 560) notice the thick epidermises wall

stomata were observed in *A. precatorius,* amphianisocytic and para-hexacytic types in *A. pulchellus* and *Abrus* sp. *Abrus pulchellus* had the highest stomatal index of (15.74). The stomatal sizes of the species ranged from 22.14±3.16x14.58±2.61 μm in *A. canescens* to 31.05±6.52x21.87±5.16 μm in *Abrus* sp. (Table 3).

Cell inclusion: Crystal sand and prismatic crystals are of common occurrence in the fruit surfaces of the species of *Abrus.* In *Abrus* sp., they occur ranging from cluster of four to several chains linked together (Fig. 4), but are few in the cells of the other species.

Trichomes: Two types of trichomes, glandular multicellular and simple unbranched, were observed on the fruit surfaces of all the species. In *A. precatorius*, 2-5 glandular multicellular trichomes often originate from the same cell stock. The highest trichome index of 11.55 for simple, unbranched trichomes in the species was recorded in *A. canescens* while *A. pulchellus* had the least trichome index value of 2.33 (Table 3).

DISCUSSION

Epidermal cell shape in the species is generally irregular with straight or arcuate anticlinal wall pattern (Table 2). In the new collection *Abrus* sp. a strict adherence to straight anticlinal pattern, which contrasts with the other three species where straight and arcuate types occur was observed. The quantitative results of the epidermal cell wall thickness follow the anticlinal wall pattern with affinity between *A. precatorius, A. pulchellus* and *A. canescens,* but distant values of 4.05±1.85 for *Abrus* sp. (Table 2). Ogundipe and Akinrinlade[21] reported high variability in the dimensions of epidermal cells of another leguminous genera *Albizia* and concluded that it was difficult to make clear distinction between the species using such character. However, we note that such a character can be made useful by amassing much quantitative data and making systematic comparison based on it, as was the case in this study. For instance, the seemingly high average mean values of 47.30±21.47x14.83±3.66 μm and 61.40±43.92x13.77±5.61 μm for the fruit surfaces of *A. pulchellus* and *Abrus* sp., respectively distinguishes them from the other two species (Table 2).

The ten types of stomata observed on the fruit surfaces of the species (Fig 1-4 and Table 3) in one way or the other could be harnessed for taxonomic purposes. Sunken paracytic stomata, the only type observed in *A. precatorius* does not occur in any other species. Similarly, the brachy-para-hexacytic monopolar type occurs only in *Abrus* sp. while the hexacytic and contiguous types, which occur only in *A. canescens*, differentiates it from the others. Strikingly, all stomatal types in *A. pulchellus* and two out of the three in *Abrus* sp. were observed in *A. canescens*., however, *A. pulchellus* and *Abrus* sp. do not have any stomata in common (Table 3). In this study stomata types specific to species delimit those species while the common ones were indications of generic affinity. Since most stomata in the genus are represented in *A. canescens,* it is possible that in stomatal ontogeny of the genus the stomata of *A. canescens* are of earlier origin. Strong taxonomic relationship exists in stomatal types between these *Abrus* species and other members of the Leguminosae, where

Table 4: Morphology and density distribution of trichomes in *Abrus* species

Taxa	Type of trichome	Density in (%)	Description
A. precatorius	Glandular multicellular and simple unicellular	11-29	Sparingly pubescent
A. pulchellus	Glandular multicellular and simple unicellular	1-10	Glabrescent
A. canesceus	Glandular multicellular and simple unicellular	30-49	Densely hairy
Abrus sp.	Glandular multicellular and simple unicellular	11-29	Sparingly pubescent

similar characters have been previously used in taxa elucidation. For instance, anomocytic, anisocytic, paracytic and cyclocytic stomata types, which occur in this genus, have been reported in other leguminous genera[18-21,26,30-32]. In these other genera, stomata types and in some cases their developmental patterns were variously utilized for taxa elucidation. Stomata in-groups of two occurring in clusters of between 10 and 13 as observed in *A. pulchellus* and *A. canescens* is a useful generic diagnostic character in some families, which in the Papilionaceae has only been reported in *Euchestra*[26]. This feature suggests taxonomic or evolutionary relatedness of *Abrus* to *Euchestra,* though the later does not occur in tropical West Africa. It also delimits these two species of *Abrus* from the others. Olowokudejo[22] successfully revealed remarkable topographic diversity in the genus *Biscutella* L. using fruit epidermal characters (stomata and trichome). Further applied these epidermal characters including anisocytic stomatal type (the only type in the genus) to achieve systematic classification of members of the genus[22]. In the present study, apart from achieving systematic elucidation of the genus, several of the stomatal features have been previously reported in other genera of Leguminosae, which implies taxonomic and evolutionary relationship to these genera.

Taxonomic variation on stomatal size and index useful in distinguishing species were observed on the fruit surfaces (Table 3). While *Abrus* sp. has an S.I of 2.81, in *A.* pulchellus it is 15.74. Edeoga and Osawe[19] and Ogundipe and Akinrinlade[21] reported the diagnostic significance of these characters in *Senna* and *Albizia* respectively. Carlquist[33] emphasized the contributions of the variation in stomatal size and index in delimiting species within a genus. High stomata index has been reported for the Leguminosae[19,32]. However, our observation in *Abrus* (Table 3) does not agree with these earlier reports. We expect this situation for a family as large as the Leguminosae with cosmopolitan distribution of species. For instance the reduced stomatal index and dimensions observed in *A. canescens* could be more of an adaptation to function. From distributional studies[23] *A. canescens* exists in the xerophytic savanna region of Nigeria. The glandular multicellular and simple unbranched trichomes were present on fruit surfaces of the four species, which depicts taxonomic and evolutionary relationship (Table 4). However, the ontogeny of the glandular multicellular heads differs in *A. precatorius* where 2-5 glandular heads originate anticlinally from one cell stock. In the other three species, each glandular head originates from one cell. Abubakar and Yunusa[20] recently demonstrated the importance of stomatal ontogeny in the taxonomic delimitation of species of *Acacia,* a leguminous genus. *A. canescens* was observed to have the highest values for simple unbranched trichome length (393.50±47.67 μm), glandular multicellular trichome length (62.60±10.21 μm), as well as trichome index (11.55), which according to Agbagwa[23] is related to the xerophytic habit of this species and the need to guide against water loss. Observations on trichomes in this study are similar to those of earlier authors on the Leguminosae that vividly applied and emphasized the taxonomic importance of these features in making reliable taxonomic conclusions[19-21,26].

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