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A JOURNAL ON TAXONOMIC BOTANY, PLANT SOCIOLOGY AND ECOLOGY

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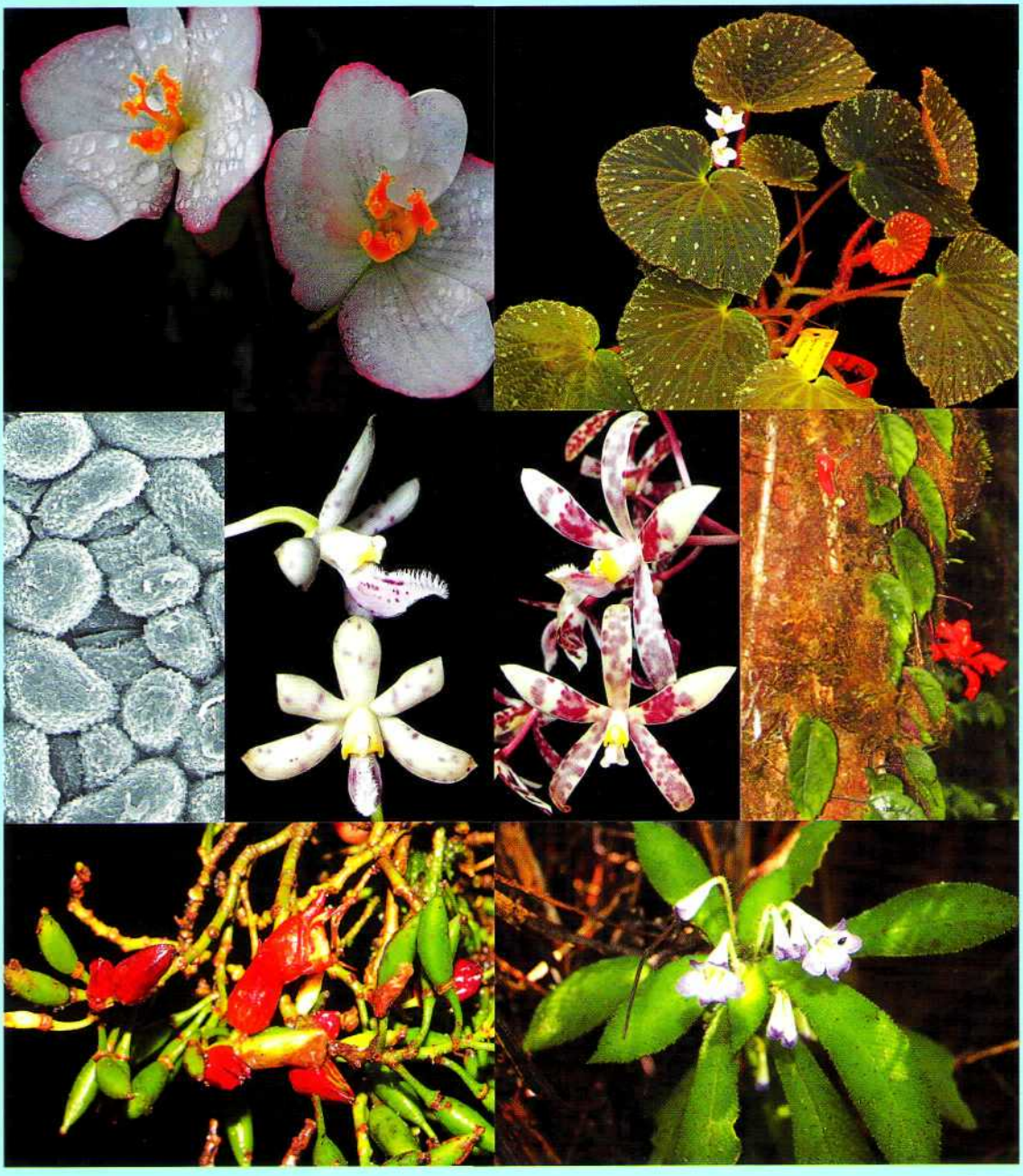

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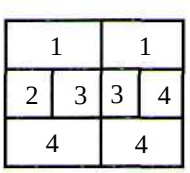
Correspondence on editorial matters and subscriptions for Reinwardtia should be addressed to:
HERBARIUM BOGORIENSE, BOTANY DIVISION,
RESEARCH CENTER FOR BIOLOGY- INDONESIAN INSTITUTE OF SCIENCES
CIBINONG SCIENCE CENTER, JLN. RAYA JAKARTA - BOGOR KM 46,
CIBINONG 16911, P.O. Box 25 Cibinong
INDONESIA
PHONE (+62) 21 8765066; Fax (+62) 21 8765062
E-MAIL: reinwardtia@mail.lipi.go.id



Cover images: 1. *Begonia holosericeoides* (female flower and habit) (Begoniaceae; Ardi *et al.); 2.* Abaxial cuticles of *Alseodaphne rhododendropsis* (Lauraceae; Nishida & van der Werff); *3. Dipodium puspitae, Dipodium purpureum* (Orchidaceae; O'Byrne); 4. *Agalmyla exannulata, Cyrtandra coccinea* var. *celebica, Codonoboea kjellbergii* (Gesneriaceae; Kartonegoro & Potter).

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LEAF ANATOMY OF PANDANUS SPP. (PANDANACEAE) FROM SEBANGAU AND BUKIT BAKA-BUKIT RAYA NATIONAL PARK, KALIMANTAN, INDONESIA

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EKA FATMAWATI TIHURUA
Herbarium Bogoriense, Botany Division, Research Center for Biology-LIPI, Cibinong Science Center, Jln. Raya Jakarta-Bogor Km. 46, Cibinong 16911, Bogor, Indonesia. E-mail: ekaf001@lipi.go.id

INA ERLINAWATI
Herbarium Bogoriense, Botany Division, Research Center for Biology-LIPI, Cibinong Science Center, Jln. Raya Jakarta-Bogor Km. 46, Cibinong 16911, Bogor, Indonesia. E-mail: inaerlinawati@gmail.com; ina_erlinawati@yahoo.com

ABSTRACT
TIHURUA, E. F. & ERLINAWATI, I. 2014. Leaf anatomy of *Pandanus* spp. (Pandanaceae) from Sebangau and Bukit Baka-Bukit Raya National Park, Kalimantan, Indonesia. *Reinwardtia* 14 (1): 223 – 231. ― Cross sections of leaves of *Pandanus* spp. showed that their leaf anatomy is similar, whilst paradermal sections indicated that crystal numbers differ. Variation was found in the anticlinal epidermal cell walls, stomata, hypodermis, sclerenchyma, mesophyll and crystals, as discussed in this paper.

Key words: Bukit Raya-Bukit Baka National Park, leaf anatomy, *Pandanus* spp., Sebangau.

ABSTRAK
TIHURUA, E. F. & ERLINAWATI, I. 2014. Anatomi daun Pandanus spp. (Pandanaceae) dari Sebangau dan Taman Nasional Bukit Baka-Bukit Raya, Kalimantan, Indonesia. *Reinwardtia* 14(1): 223 – 231. ― Irisan melintang daun *Pandanus* spp. menunjukkan bahwa anatomi daunnya sama, akan tetapi irisan paradermal mengindikasikan bahwa jumlah kristalnya berbeda. Variasi yang ditemukan di dinding sel epidermal antiklinal, stomata, hypodermis, sklerenkim, mesofil dan kristal dibahas dalam makalah ini.

Kata kunci: Taman Nasional Bukit Raya-Bukit Baka, anatomi daun, *Pandanus* spp., Sebangau.

INTRODUCTION

Pandanus is one of the member of Pandanaceae family which has the broadest geographical distribution, occurring throughout the Old World tropics, from East Africa westward to Polynesia, widely distributed to East Asia and Pacific (Stone, 1965) with tree and shrub habit (Nadaf & Zanan, 2012), contains more than 600 species (Kam, 1971). Pandan of Kalimantan is still little known. The exploration conducted in Sebangau National Park (Palangkaraya, Central Kalimantan) and Bukit Raya-Bukit Baka National Park (West Kalimantan) in 2006 found several *Pandanus* spp. including specimens belonging to the *Pandanus motleyanus* complex species, which species is synonymised with *P. yvanii* Solms according to Keim *et al.* (2011). Also four new species of *Pandanus* were collected. Recognizing and identifying species is difficult, therefore additional characters, *e.g.* leaf anatomy, are needed to support the morphological approach.

Little work has been done on the leaf anatomy of *Pandanaceae*. Kam (1971) has investigated the leaf anatomy of *Pandanus* species in Malaya, while Pasaribu (2010) conducted leaf anatomy of *Freycinetia* species from Sumatra, Rahayu *et al.* (2012) observed *Pandanus* species from Java and Nadaf & Zanan (2012) investigated leaf micromorphology of Indian Pandanaceae. The aim of this study is to get more information about the anatomical leaf structure (including leaf micromorphology and transversal section) of some *Pandanus*, which was collected from two locations in Kalimantan to support morphological data of *Pandanus* spp.

MATERIAL AND METHODS

We used 18 collections (Table 1) of *Pandanus* from Sebangau National Park, Palangkaraya, Central Kalimantan and Bukit Raya-Bukit Baka National Park, West Kalimantan. The paraffin method with modification (Sass, 1951) and para-

dermal cuttings (Cutler, 1978) were used for this study.

RESULTS AND DISCUSSION

Pandanus spp. have straight, wavy and curved anticlinal walls. The epidermis cells vary in shape between square, polygonal and sometimes irregular (Fig. 1). Anatomically there are two types of leaf known from the collections (Table 1). The anatomy of the first type shows a dorsiventral parenchyma with the mesophyll differentiated into palisade and sponge tissue. The second type shows a homogenous leaf anatomy, lacking a differentiation into palisade and sponge tissue. Dorsiventral leaves are the common type shown by all *Pandanus* species except the *P. johoriensis* complex and *P. yvanii*, which have both leaf types.

Adaxial epidermis anticlinal cell walls are straight in *P. helicopus, P. johoriensis* and *Pandanus* sp., while straight to wavy could be find in *P. aristatus, P. pachyphyllus, Pandanus cf ridley, P. vinaceus* and *P. yvanii*. Abaxial epidermis anticlinal cell walls of *P. aristatus, P. johoriensis, Pandanus* sp. are straight; straight to wavy of abaxial epidermis anticlinal cell walls in *Pandanus helicopus, P. cf ridley, P. vinaceus*, *P. yvanii* and slightly wavy in *P. pachyphyllus*.

Shape of epidermis cell in both surfaces are square to polygonal found in all examined *Pandanus* species, but straight to slightly irregular in adaxial epidermis of *P. yvanii* and abaxial epidermis cell of *P. helicopus* and *P. yvanii*.

Special focus on stomata

The stomata of Pandanaceae are tetracytic and found on the adaxial and abaxial surface, but less numerous adaxially. The stomata are level to the epidermal cells in the transverse section. The stomata may be accompanied by papillae. The papillae appear on the subsidiary or sometimes on

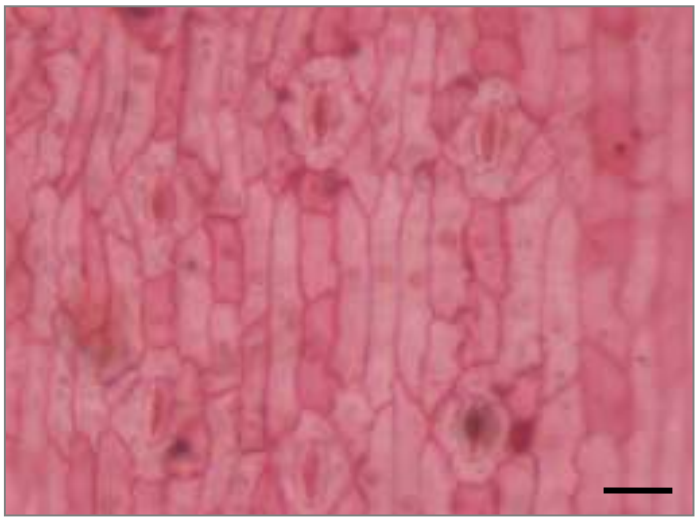

Fig. 1. Lower surface of *Pandanus* leaf. Scale bar 20 µm.

Table 1. Specimens examined of *Pandanus.*

No	Species	Collection numbers	Herbarium
1	*P. aristatus* Martelli	*Ary P. Keim* 778	BO
2	*P. helicopus* Kurz. ex Miq.	*Ina Erlinawati* 140; *Ina Erlinawati* 157	BO
3	*P. johoriensis* Martelli	*Elizabeth A. Widjaja* 8051; *Elizabeth A. Widjaja* 8054 A; *Elizabeth A. Wijaya* 8054 C	BO
4	*P. pachyphyllus* Merr.	*Ary P. Keim* 767	BO
5	*Pandanus cf ridley* Martelli	*Wita Wardani* 431	BO
6	*Pandanus* sp.	*Muhammad Amir* 359	BO
7	*P. vinaceus* B.C.Stone	*Muhammad Amir* 313	BO
8	*P. yvanii* Solms	*Ina Erlinawati* 58; *Ina Erlinawati* 102; *Ina Erlinawati* 136; *Darnsfield* 4311; *Kostermans* 12823; *Wita Wardani* 439	BO

the adjacent epidermal cells. The papillae on the terminal subsidiary cells are simple, forked or sometimes dendritic. Whereas papillae on the lateral subsidiary cells are globose in 3-7 alignments. (Fig. 2B & 2C). Based on the presence of papillae four classes of stomatal types (Tomlinson, 1965) can be discerned. The first type consists of unspecialized stomata lacking papillae (Fig. 2A). The second type shows stomata with papillae on the terminal and lateral of subsidiary cells as shown by *P. aristatus*, *P. vinaceus* and *P. yvanii* (Fig. 2B). The third type has papillae on the subsidiary cells of the stomata and on the neighboring epidermal cells (Fig. 2C); they are found in *P. helicopus*, *P. johoriensis, Pandanus cf. ridley* and *P. yvanii*. The fourth type is defined by dendritic papillae present on the whole surface of the leaf. This type is found in *P. pachypilus* (Fig. 2D). Tomlinson (1965) mentioned that there are five types of stomata followed by Rahayu *et al.* (2012) in their study about *Pandanus* in Java. In this study, we could not find the type of stomata which papillose are arranged in the lateral subsidiary cells.

Hypodermis

All examined *Pandanus* species has hypodermis tissue in the adaxial and abaxial side (Fig. 3), except for *P. aristatus* that has this tissue only on adaxial part. The hypodermis tissue occur in 2 rows sometimes more.

Mesophyll

The palisade also occur in the adaxial and abaxial part (Fig. 3) but not in *P. pachyphyllus* and *Pandanus cf ridley* that only occur in adaxial part. Cuboid (Fig. 3) and raphide crystal (Fig. 4) are distributed in the mesophyll of all *Pandanus* species leaf.

Specific Descriptions of *Pandanus* species in Kalimantan

***P. aristatus* Martelli**

Leaf dorsiventral. Adaxial and abaxial epidermis anticlinal cell walls straight and curved, sometimes wavy in the adaxial surface. Epidermis cell shape square, polygonal (Fig. 5A). Stomata in both surface with papillae on subsidiary cell at the abaxial side (Fig. 7A). Two layers hypodermis in the adaxial part of leaf. Mesophyll differentiated into 2-3 palisade layers in the adaxial and 1 layer in the abaxial part of leaf. *Pseudolacuna* between two vascular bundles (Fig. 10A).

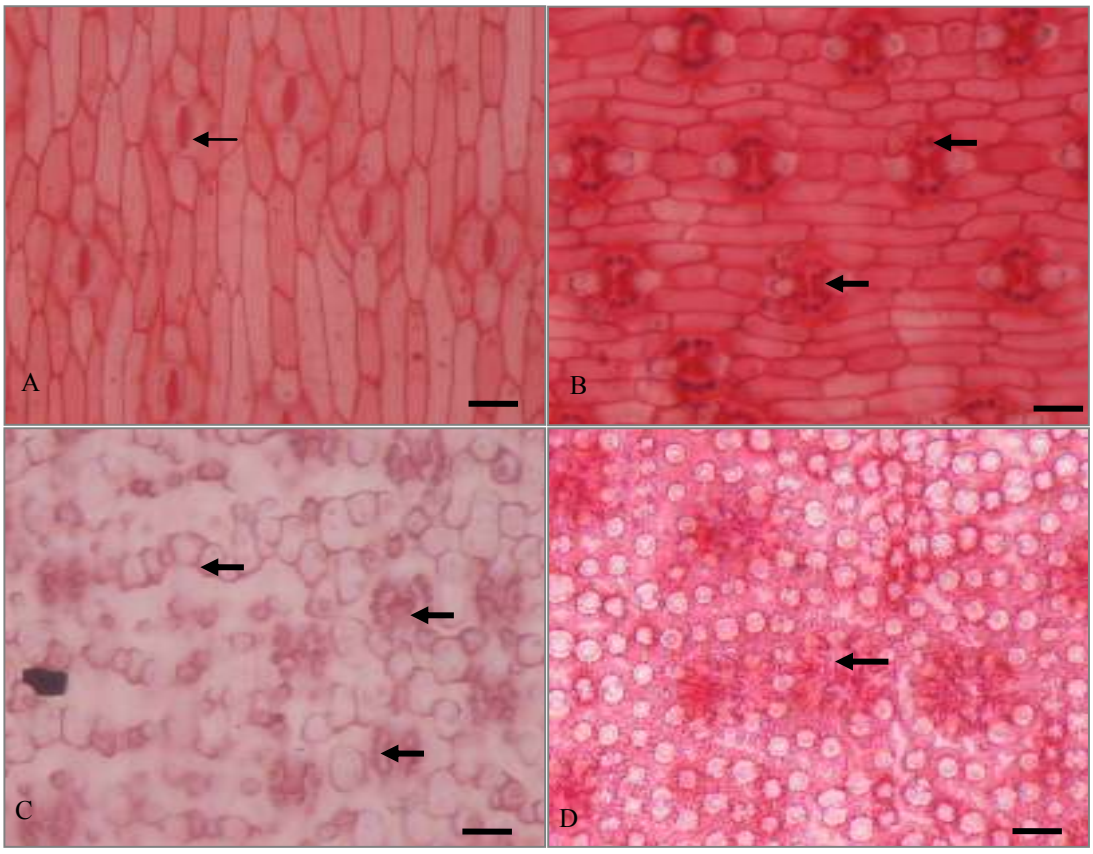

Fig. 2. Variation of stoma in *Pandanus spp*. There are 1st type unspecified stomata (A), 2nd type (B), 3rd type (C) and 4th type of stomata (D). Stomata (thin arrow), papillae (thick arrow). Scale bar 20 µm.

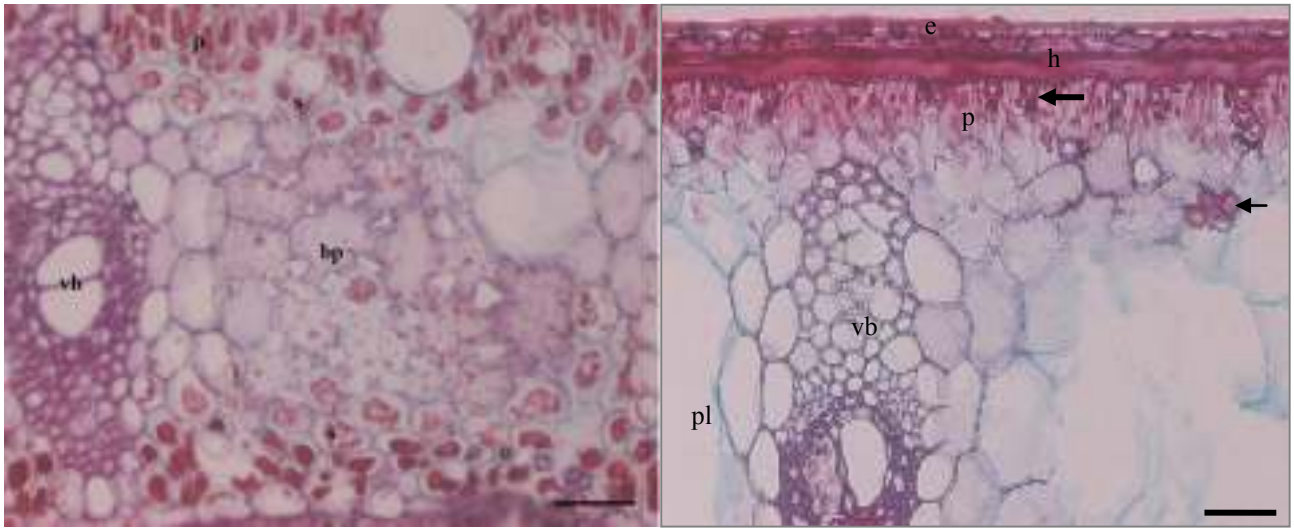

Fig. 3. Cross section of *Pandanus* leaf. Leaf with branched parenchyma (*stellate*) exist between 2 vascular bundles (above), when get mature leaf, it will form *pseudolacuna* (below). bp: branched parenchyma; e: epidermis; h: hypodermis layer; p: palisade tissue; pl: pseudolacuna; s: sponge tissue; vb: vascular bundle; crystal in mesophyll (thin arrow); schlerenchyma (thick arrow). Scale bar 50 µm.

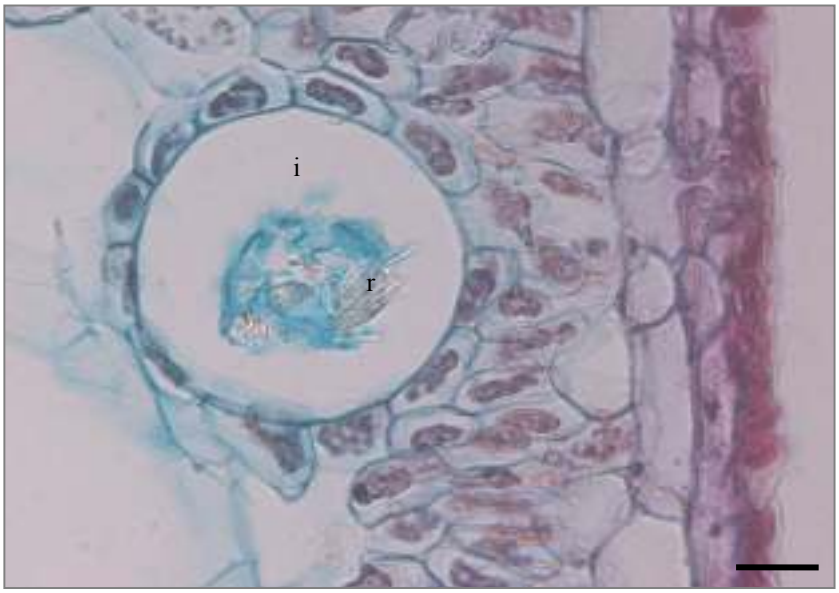

Fig. 4. Cross section of *Pandanus* leaf. Idioblast cell (i) with raphides (r) present in the mesophyll. Scale bar 20 µm.

***Pandanus helicopus* Kurz. ex Miq.**

Leaf dorsiventral. Adaxial epidermis cell with straight and slightly curved wall; while abaxial epidermis cell wall straight, slightly wavy and curved. Adaxial and abaxial epidermis cell shape square, polygonal, with elongated cells in the adaxial and slightly irregular in the abaxial (Fig. 5B). Stomata in the adaxial epidermis sometimes present with papillae in the polar subsidiary cell, while papillae of abaxial epidermis cell occur at the subsidiary and/or epidermal cells (Fig. 7B). Hypodermis two layers in the adaxial and abaxial part of the leaf; long and thin, square. Palisade 1-3 layers in the adaxial and a layer in the abaxial part of the leaf (Fig. 9A). Stellate parenchyma laid between 2 vascular bundles.

***Pandanus johorensis* Martelli complex**

Leaf homogen or dorsiventral. Adaxial and abaxial epidermis cell has straight wall, slightly curved in the abaxial side (Fig. 5C). Adaxial and abaxial epidermis cell shape are square and polygonal shape. Adaxial epidermis is showed short and long cell conspicuously. Stomata in the both leaf surface with papillae in the epidermal and subsidiary cells of abaxial surface (Fig. 7C). Hypodermis two layers in the adaxial and abaxial part, sometimes up to 3 layers in adaxial. Dorsiventral leaf has 2-5 layers adaxial palisade and 1-3 layers abaxial palisade. Stellate parenchyma occurs in the middle of the leaf of this species.

***Pandanus pachyphyllus* Merr.**

Leaf dorsiventral. Adaxial epidermal cell wall straight, curved and slightly wavy. Abaxial epidermal cell slightly wavy wall. Dendritic papillae covered epidermis cells and stomata (Fig. 7D, see appendix). 2-3 layers hypodermis presents in the adaxial and abaxial part of leaf. Mesophyll was differentiated into 2 layers of palisade in the adaxial part of leaf and sponge below. Pseudolacuna presents between 2 vascular bundles.

***Pandanus* cf. *ridley* Martelli**

Leaf dorsiventral. Adaxial and abaxial epidermis cell wall is straight and slightly wavy, also wavy anticlinal cell wall in the abaxial surface. Epidermis cell shape is square, polygonal in the the both surface. There are short and long cells in the adaxial surface (Fig. 6A). Stomata in the both surface and papillae present in epidermal and subsidiary cells of abaxial surface (Fig. 8A). Hypodermis 2-3 layers in the adaxial and 2 layers in the abaxial part of leaf (Fig. 9B). Mesophyll is arranged by palisade tissue adaxial part of the leaf 1-3 layers and sponge below with branched parenchyma.

***Pandanus* sp.**

Leaf dorsiventral. Adaxial and abaxial epidermis with straight anticlinal cell wall and square shape. Unspecialized stomata in both leaf surface (Fig. 6B & 8B). Hypodermis two layers on both part of leaf. 1-2 layers of palisade took place in adaxial and a layer in the abaxial leaf part, sponge exist between both parts. Branched sponge between 2 vascular bundles (Fig. 9).

***Pandanus vinaceus* B. C. Stone**

Leaf dorsiventral. Adaxial and abaxial epidermis has straight, slightly curved, slightly wavy wall; square and curved polygonal in shape or sometimes slightly wavy in the abaxial epidermis. Stomata spread in both surface, but papillae occur only at subsidiary cells of the abaxial surface (Fig. 8C). Two layers of hypodermis in both part of leaf. Palisade tissue 1-2 layers in the adaxial part (Fig. 10C) and single layer in the abaxial part with sponge took place between them.

***Pandanus yvanii* Solms**

Leaf homogen or dorsiventral. Anticlinal cell wall of adaxial and abaxial epidermis is straight, very slightly wavy-wavy, slightly curved. Epidermis cell shape in the both surfaces is square, polygonal, curved or slightly irregular; sometimes short and long cells present obviously in the adaxial surface. Stomata distributed in both leaf surfaces, but papillae only present in the subsidiary and epidermis cell of abaxial epidermis (Fig. 8D). Hypodermis 2-3 layers in both part of leaf; flat shape. Palisade 1-4 layers in the adaxial and 1-2 layers in the abaxial part. Branched sponge (*stellate*) laid in the middle part of leaf between vascular bundles.

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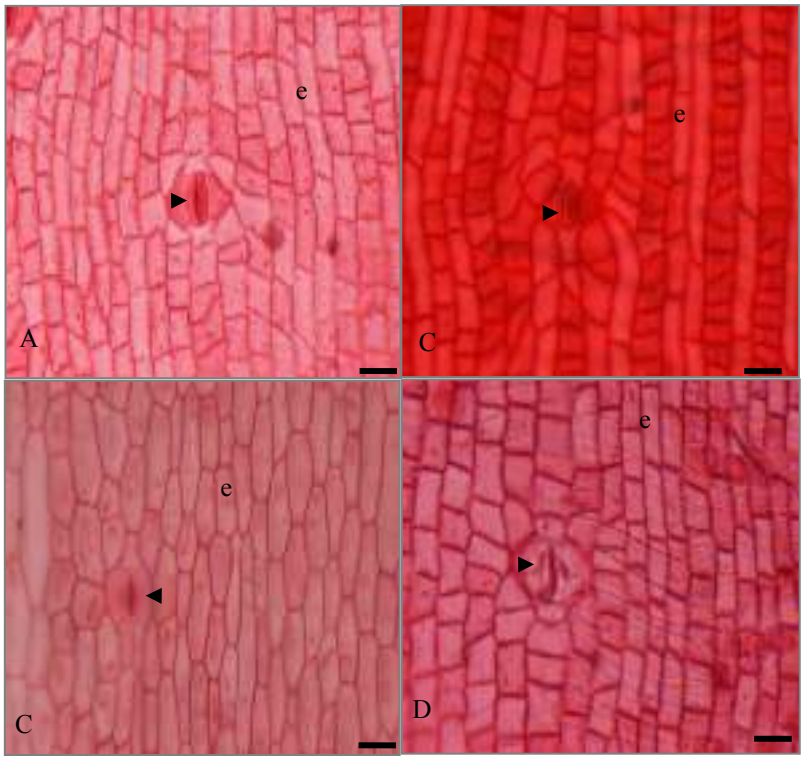

Fig. 5. Adaxial surface of *P. aristatus* Martelli (A), *P. helicopus* Kurz. ex Miq. (B), *Pandanus johoriensis* Martelli (C), *P. pachyphyllus* (D). e: epidermal cell, stomata (arrow head) present in both surface of leaf and *papillae* (arrow) seen only in abaxial surface. Scale bar 20 µm.

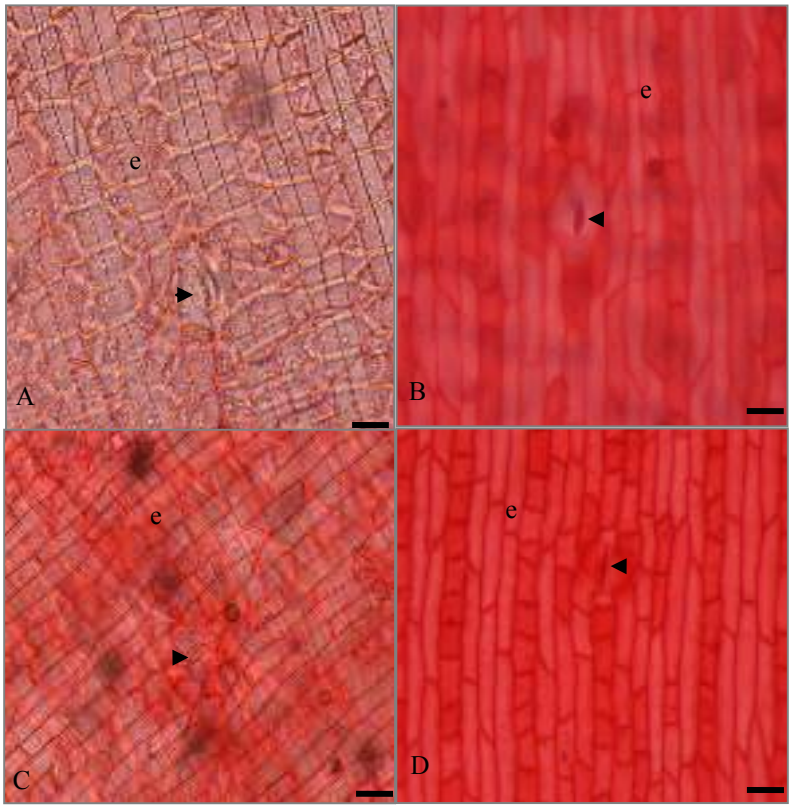

Fig. 6. Adaxial surface of *Pandanus cf riedly* (A), *Pandanus sp* (B), *P. vinaceus* B.C. Stone (C), *P. yvanii* Solms. (D) leaves. e: epidermal cell, stomata (arrow head) present in both surface of leaf and *papillae* (arrow) seen only in abaxial surface. Scale bar 20 µm.

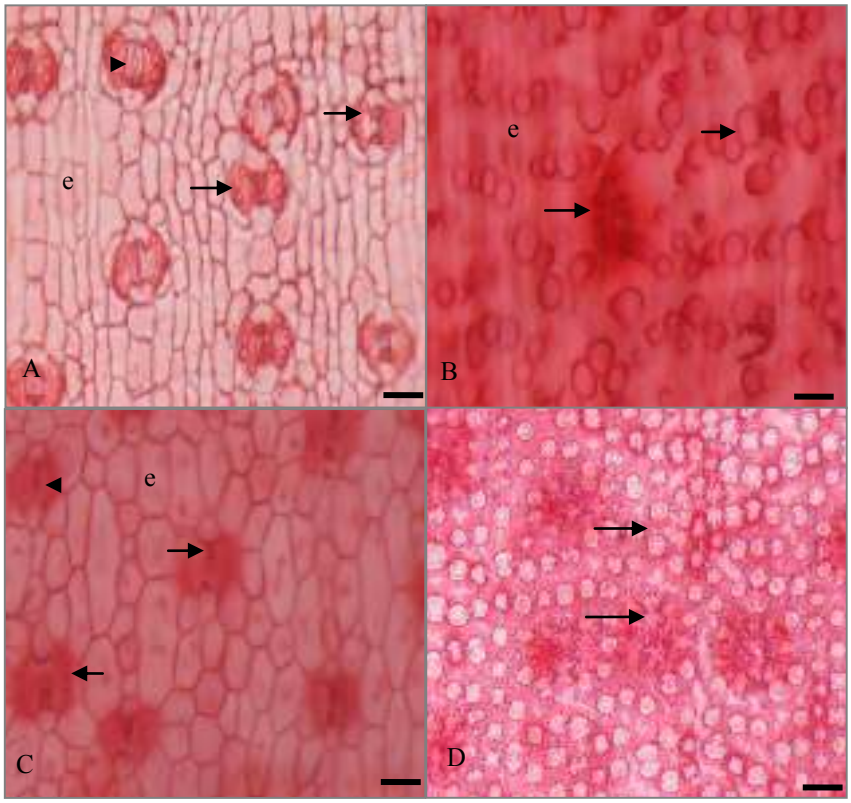

Fig. 7. Abaxial surface of *P. aristatus* Martelli (A), *P. helicopus* Kurz. ex Miq. (B), *P. johoriensis* Martelli (C), *P. pachyphyllus* (D) leaves. e: epidermal cell, stomata (arrow head) present in both surface of leaf and *papillae* (arrow) in simple, forked or dendritic type seen only in abaxial surface. Scale bar 20 µm.

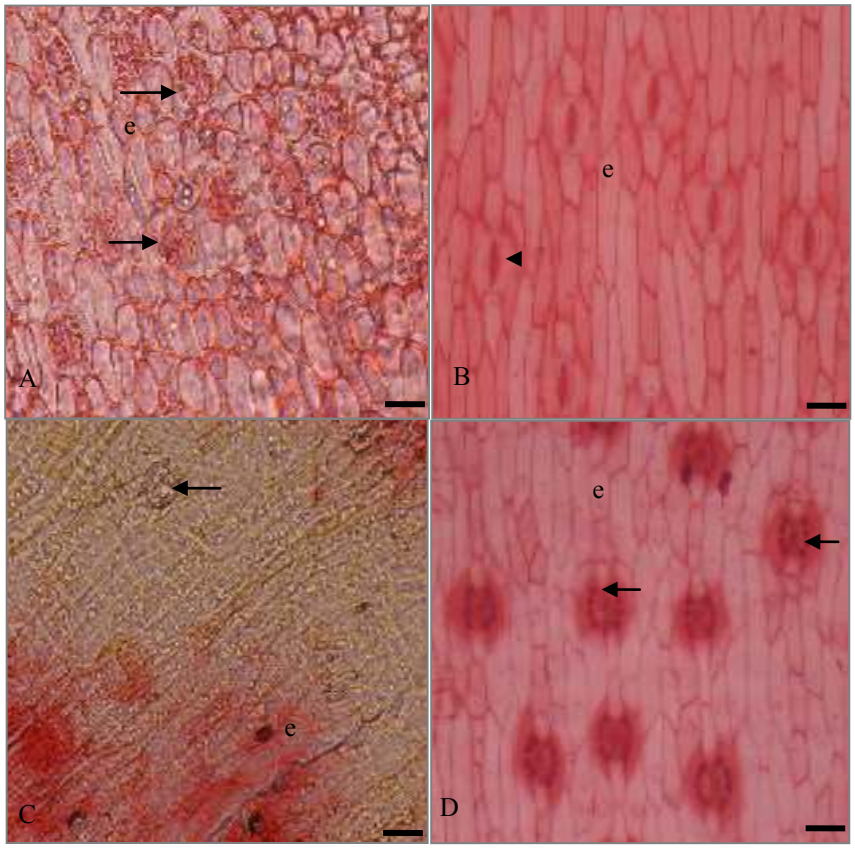

Fig. 8. Abaxial surface of *Pandanus* cf *ridley* Merr. (A) *Pandanus* sp. (B), *P. vinaceus* B. C. Stone (C), *P. yvanii* Solms. (D) leaves. e: epidermal cell, stomata (arrow head) present in both surface of leaf and *papillae* (arrow) seen only in abaxial surface. Scale bar 20 µm.

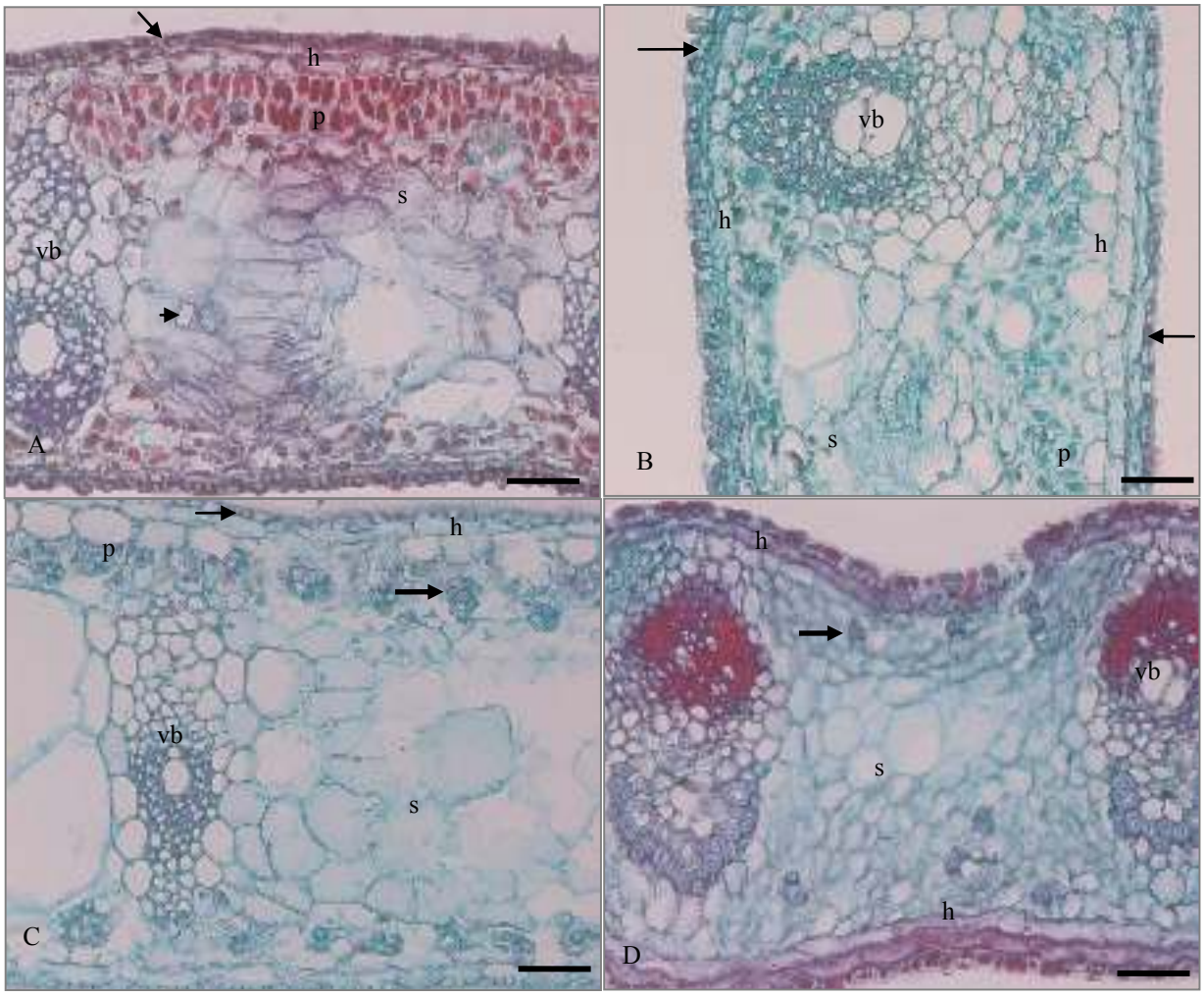

Fig. 9. Cross section of *P. helicopus* Kurz. ex Miq. (A), *Pandanus* cf *ridley* Martelli (B), *Pandanus* sp. (C), *P. johoriensis* Martelli (D) leaves. A single layer of epidermis in the adaxial and abaxial surface (thin arrow); h: hypodermis in the adaxial and abaxial part; p: palisade; pl: pseudolacuna; s: isodiametric or stellate sponge underneath the palisade lay between 2 vascular bundles; vb: vascular bundle, cuboid crystal is showed by arrow head and sclerenchyma (thick arrow). Scale bar 50 µm.

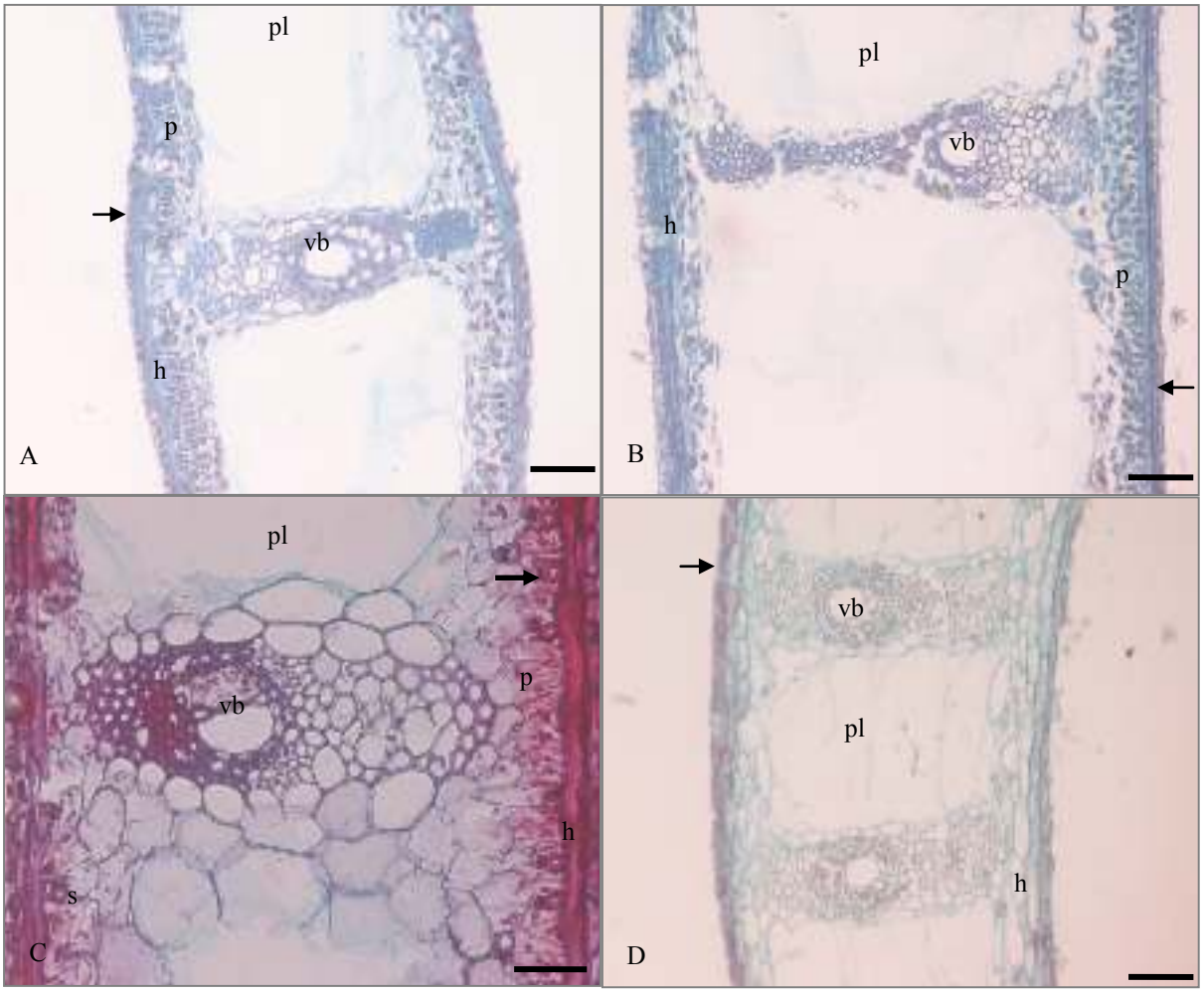

Fig. 10. Cross section of *P. aristatus* Martelli (A), *P. pachyphylus* Merr. (B), *P. vinaceus* B.C. Stone (C), *P. yvanii* Solms. (D) leaves. Adaxial and abaxial epidermis showed by arrow; h: hypodermis; p: palisade; pl: pseudolacuna in the mature leaf; vb: vascular bundle. Scale bar 100 µm except *P. vinaceus* B. C. Stone 50 µm.

INSTRUCTION TO AUTHORS

Scope. *Reinwardtia* is a scientific irregular journal on plant taxonomy, plant ecology and ethnobotany published in December. Manuscript intended for a publication should be written in English.

Titles. Titles should be brief, informative and followed by author's name and mailing address in one-paragraphed.

Abstract. English abstract followed by Indonesian abstract of not more than 250 words. Keywords should be given below each abstract.

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Jln. Raya Jakarta - Bogor, Km 46
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