JPPIPA 9(9) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Morphology Inflorescence and Anther Anatomy of *Musa campestris* var. *sarawakensis* from West Kalimantan, Indonesia

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Received: March 29, 2023
Revised: August 19, 2023
Accepted: September 25, 2023
Published: September 30, 2023

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DOI: 10.29303/jppipa.v9i9.3522

Abstract: *Musa campestris* is a unique banana, has erect inflorescence with beautiful bracts and mature fruit colors so that it can be used as an ornamental plant. this study's objective is to analyze the morphological inflorescences and anther anatomical characteristics of the *Musa campestris* var. *sarawakensis*. Plant materials were collected in Sanggau regency. Morphological characterizations were conducted using International Plant Genetic Resources Institute for *Musa* spp. Sampel of anther was prepared using paraffin method, stained with 2% safranin and 1% fast green. Main features observed for *Musa campestris* var. *sarawakensis* inflorescence has erect rachis position and color external bract are helpful to characterize the male bud. Additionally, the main characteristics of anther include the presence helical ribs in endothecium. As expected, tetrasporangiate anthers with single vascular bundle in male flowers was observed. The main morphology characteristics of inflorescence and anther anatomy of *Musa campestris* var. *sarawakensis* are highlighted in this study, contributing to provide more information about the characterization of this species in West Kalimantan.

Keywords: Anatomy; Anther; Inflorescence; *Musa campestris* var. *sarawakensis*

Introduction

Banana (Musaceae) is a fruit that is widely distributed in the world, popular and important, especially in rural communities (Hapsari et al., 2017). Indonesia is a center of origin (Simmonds, 1966) and a center of banana diversity (Daniells et al., 2001). It is estimated that more than 325 banana cultivars are found in Indonesia (Valmayor et al., 2002) and 12 wild banana species have been found (Nasution & Yamada, 2001). Indonesian wild banana species are found in Sumatra, Java, the Sunda Islands, Kalimantan, Sulawesi, Maluku and Papua (Sulistyaningsih et al., 2014).

Borneo Island, has 20 endemic wild banana species but only 15 species have been identified (Häkkinen, 2004) found in Sarawak, Malaysia. West Kalimantan as part of the island of Borneo, has wild banana species, namely: *M. campestris* Becc. var. *sarawakensis* is found in Singkawang (Sulistyaningsih & Irawanto, 2011), *M. balbisiana* in Batu Ampar District (Sunandar, 2017), *Musa borneensis* var. *sarawakensis* and *Musa campestris* var. *sarawakensis* are found in Bonti District, Sanggau Regency (Sunandar & Kurniawan, 2020).

Musa campestris is a unique banana, has erect inflorescence with beautiful bracts and mature fruit colors so that it can be used as an ornamental plant. *Musa campestris* has six varieties i.e var. *campestris*, var. *limbangensis*, var. *lawasensis*, var. *miriensis*, var. *sabahensis*, and var. *sarawakensis* (Häkkinen, 2004). Morphological characters are used to distinguish varieties of *Musa campestris*. Morphology is the most important basis for taxonomic description (Simpson, 2006). Morphology characters provide characteristics which can easily be used for identification or the phylogenic relationship. Morphological characters are easier to observe and more practical to use. Flower morphology is important marking characters in identification. Morphology is considered to be old fashioned but it is still the basis for the solution of taxonomical problems (Stuessy, 2009). The characters of

How to Cite:
Sunandar, A., Fajri, H., & Qurbaniah, M. (2023). Morphology Inflorescence and Anther Anatomy of Musa campestris var. sarawakensis from West Kalimantan, Indonesia. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 7154–7158. https://doi.org/10.29303/jppipa.v9i9.3522

plant inner structure have made significant contribution to plant systematics for more than 150 years (Judd, 2002). Anatomical characters and inner structure of plants have been used for identification and determination of phylogenic relationship. In many plant groups, notably monocotyledons, anatomical characteristics are significant taxonomic information (Zarrei et al., 2010). Though anatomy of Musaceae of vegetative parts such as leaves, rhizomes, petiol, and root have been generally studied (Madail et al., 2022; Sumardi & Wulandari, 2010; Sunandar & Kahar, 2017, 2018).

Some important aspects of anatomical characters which have taxonomical values are flower anatomy and its development, anther development and pollen structure. Morphoanatomical studies have also contributed to the characterization of *Musa* spp. as in *Musa acuminata* (Fingolo et al., 2012) and *Musa x paradisiaca* (Vilhena et al., 2019). There are no reports to date describing morpho-anatomical features for *Musa campestris* var. *sarawakensis* inflorescences in West Kalimantan**.** Thus, this study's objective is to analyze the morphological inflorescences and anther anatomical characteristics of the *Musa campestris* var. *sarawakensis* that could contribute to the characterization of *Musa campestris* var. *sarawakensis* from West Kalimantan**.**

Method

Musa campestris var. *sarawakensis* were collected at Gunam Village, Parindu District, Sanggau Regency. Morphological descriptors for inflorescences were used to characterize the plant material, including some descriptors from International Plant Genetic Resources Institute for *Musa* spp. (International Plant Genetic Resources Institute, 1996).

In order to analyze of vegetative structures (root, leaf blade, and petiole) and generative structure (bract, male flower, and anther) were prepared using paraffin method (Sass, 1951). *Paraffin method procedure*. Material was fixed in FAA solution; (ii) the materials were washed repeatedly in 50% ethanol and dehydrated with tert-butanol series (1-VI); (iii) infiltration step: the mixture of tert-butanol was replace with liquid paraffin for 24 hours; (iv) Steps involved in the embedding process include: immersing the material in pure liquid paraffin for an hour before utilizing that paraffin to create the embedding; (v) using a rotary microtome to slice the embedded sample into thin sections for a slide. The material was cut into thin slices and stained with 2% safranin and 1% fast-green; (vi) the stained slides were examined using an Olympus microscope, and an optic lab camera was used to capture pictures. Data analysis was done descriptively based on anatomical character record used light microscope.

Result and Discussion

Morphology Inflorescence of Musa campestris var. *sarawakensis*

The rachis position of *Musa campestris* var. *sarawakensis* is erect, male bud normal, male bud shape ovoid, slightly pointed apex, pink-purple color of external bract, pink-purple color of internal bract, not revolute bract behaviour, lifting one at a time. Male flower 5 per bract, the compound tepal 3 cm long, orange in the upper part and cream at the base, ribbed at the dorsal angles, with 5-toothead, the free tepal rectangular, 2.8 cm long, translucent white colour, thread-like apex shape. The stamen 2.4 cm long, 5 stamen, white colour filament, inserted, cream colour anther, cream pollen sac colour. White style basic colour, without pigmentation, same level, straight, bright yellow stigma colour. Straight ovary shape, white ovary basic colour (Figure 1).

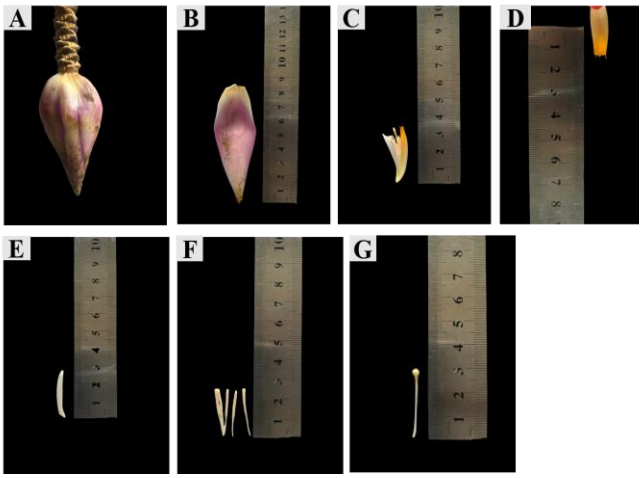

Figure 1. Morphology characteristics inflorescence of *Musa campestris* var. *sarawakensis*; (A) Male Bud (B) Bract (C) Male Flower (D) Compound Tepal (E) Free Tepal (F) Stamen (D) Style.

Variation in inflorescence morphology were found between *Musa campestris* var. *sarawakensis* in this study with *Musa camprestris* var. *sarawakensis* at another location. (Häkkinen, 2004) reported *Musa camprestris* var. *sarawakensis* in Sarawak has purple color of external bract, compound tepal orange in the upper part and watery green at the base. (Sulistyaningsih & Irawanto, 2011) reported *Musa camprestris* var. *sarawakensis* in Singkawang, West Kalimantan has rounded shape of male bud, bright purple colour of external bract, compound tepal orange in the upper part and green at the base. (Sunandar & Kurniawan, 2020) reported *Musa camprestris* var. *sarawakensis* in Bonti District, Sanggau Regency, West Kalimantan has yellow color in the upper part of compound tepal.

Anther Anatomy of Musa campestris var. sarawakensis

The anthers are tetrasporangiate (Figure 2A) and the locules are separated by the septum (Figure 2B). The tetrasporangiate of anther also found in *Musa* x *paradisiaca* (Vilhena et al., 2019). Mature anther wall consists of one layer of endothecium with thickening, helical ribs type (Figure 2B). One layer of thin-walled swelling epidermal cells and one layer of thin-walled endothecium with annular or helical thickening that shrink comprise the mature anther wall in *Ensete glaucum* and *Ensete superbum* (Inta et al., 2015). Xue et al., (2005) discovered that the *Musella* anther wall is composed of epidermis with annular and helical thickening and a decreased endothecium. However, Endothecial cells show no fibrous thickening in *Helianthus annuus* (Çetïnbaş & Ünal, 2015). Four main types of endothecium thickening have been observed, and these tend to occur in a species-specific manner: (i) annular rib types, which are single radial rings which are un-connected and run in parallel to each other; (ii) helical rib types, which form as a helix along the periclinal cell axis, which is also described as a U-shaped thickening; (iii) reticulate ribs, where irregular thickening forms on every face with multiple sites of branching and anastomising sites to form a network; and (iv) palmate ribs, where ribs and a solid plate form in the inner periclinal wall of every cell (Wilson et al., 2011).

The connective tissue is composed of epidermis with thin-walled cell, parenchyma cells, and single collateral vascular bundle which locate in the center. Spherical grains of pollen were occasionally visible in the locules (Figure 2B). in *Ensete glaucum* and *Ensete superbum,* The connective tissue consists of of parenchyma cells, amphicribal bundles in the center, and a connective tissue cavity formed on both sides of the bundles (Inta et al., 2015).

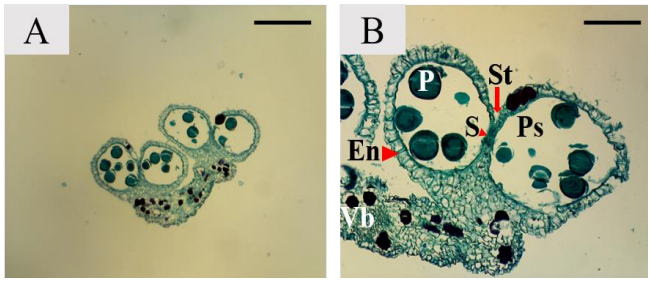

Figure 2. Anther anatomy of *Musa campestris* var. *sarawakensis*; (A) Anther (B) Mature Pollen Stage. En=endothecium thickening (head arrow), P=pollen, Ps=pollen sac, S=septum (head arrow), St=stomium (arrow), Vs=vascular bundle. Bar = 100 µm.

The epidermis, endothecium, middle layer, and tapetum are the four layers that make up the anther wall. Different anther wall layers serve different purposes for pollen production. The Anther development is protected by the layers of the epidermis. The tapetum provides materials for pollen wall formation and nutrients for microspore development. The formation of endothecium wall thickenings, which consist of cellulose and lignin, occurs subsequent to the differentiation phase of anther cell layers. This process is highly reliant on the presence of auxins and jasmonic acid (Cecchetti et al., 2013). The regulation of auxin function is governed by the transcription factor MYB26, which is encoded by a gene in the lignin biosynthesis pathway. The process of lignification in endothecium walls is accompanied by the removal of the intermediate layer and tapetum cells. Additionally, distinctive thickenings are formed and there is an observed activity of phosphotransfer proteins (Yang et al., 2007, 2017). The endothecium is responsible for anther dehiscence to disperse pollen when they are mature (van der Linde & Walbot, 2019).

The position of the anther opening is determined by the location of the stomium, which is created by the differentiation of epidermal cells within the anther to form a single cell region (Figure 2B). The two lobes of the anther (septum), which separate to form a single locule, and the stomium, which is made of modified epidermal cells and splits to facilitate anther opening, are two types of specialized cells involved in anther opening (Wilson et al., 2011).

Conclusion

This study highlights the primary inflorescence morphology and anther anatomy of *Musa campestris* var. *sarawakensis*. Features as erect rachis position and color external bract are helpful to characterize the male bud. Additionally, the main characteristics of anther include the presence helical ribs in endothecium. As expected, tetrasporangiate anthers with single vascular bundle in male flowers was observed. As a result, the morphology inflorescence and anther anatomy characteristics described in this study help to characterize this species as it is grown in West Kalimantan.

Acknowledgments
The authors would like to appreciate the Universitas Muhammadiyah Pontianak for funding this study.

Authors Contribution
Authors listed in this article contributed to the research and development of the article. The authors have read and agreed to the published version of the manuscript.

Funding
This paper funded by Lembaga Penelitian dan Pengabdian, Universitas Muhammadiyah Pontianak.

Conflicts of Interest
The authors declare no conflict of interest.

References

Cecchetti, V., Altamura, M. M., Brunetti, P., Petrocelli, V., Falasca, G., Ljung, K., Costantino, P., & Cardarelli, M. (2013). Auxin controls Arabidopsis anther dehiscence by regulating endothecium lignification and jasmonic acid biosynthesis. *The Plant Journal: For Cell and Molecular Biology*, *74*(3), 411–422. https://doi.org/10.1111/tpj.12130

Çetïnbaş, A., & Ünal, M. (2015). Anther Ontogeny and Microsporogenesis in *Helianthus annuus* L. (Compositae). *Notulae Scientia Biologicae*, *7*(1), 52-56. https://doi.org/10.15835/nsb719474

Daniells, J. W., Arnaud, E., & Sharrock, S. L. (2001). *Musalogue, a catalogue of Musa germplasm: Diversity in the genus Musa* (2nd ed). INIBAP.

Fingolo, C. E., Braga, J. M. A., Vieira, A. C. M., Moura, M. R. L., & Kaplan, M. A. C. (2012). The natural impact of banana inflorescences (*Musa acuminata*) on human nutrition. *Anais Da Academia Brasileira de Ciências*, *84*(4), 891–898. https://doi.org/10.1590/S0001-37652012005000067

Häkkinen, M. (2004). *Musa campestris* Becc. *(Musaceae)* varieties in northern Borneo. *Folia Malaysiana*, *5*(2), 81–100.

Hapsari, L., Kennedy, J., Lestari, D. A., Masrum, A., & Lestarini, W. (2017). Ethnobotanical survey of bananas (*Musaceae*) in six districts of East Java, Indonesia. *Biodiversitas Journal of Biological Diversity*, *18*(1), 160–174. https://doi.org/10.13057/biodiv/d180122

Inta, W., Traiperm, P., & Swangpol, S. C. (2015). Floral Micromorphology of the Genus " *Ensete* " Bruce ex Horan. (*Musaceae*) in Thailand. *Taiwania*, *60*(3), 99–106. https://doi.org/10.6165/tai.2015.60.99

International Plant Genetic Resources Institute. (1996). *Descriptors for banana (Musa spp.)*. International Plant Genetic Resources Institute. https://www.bioversityinternational.org/e-library/publications/detail/descriptors-for-banana-musa-spp/

Judd. (2002). Taxonomic Evidence: Structure and Biochemical Character. In *Plant Systematic: A Phylogenetic Approach*. Sinaeur Ass. Inc.

Madail, R. H., Pio, L. A. S., Rezende, R. A. L. S., Pasqual, M., & Silva, S. de O. e. (2022). Banana leaf anatomy characteristics related to ploidy levels. *Acta Scientiarum. Agronomy*, *44*, e55709. https://doi.org/10.4025/actasciagron.v44i1.55709

Nasution, R., & Yamada, I. (2001). *Pisang-pisang liar di Indonesia* (Cet. 1.). Puslitbang Biologi-LIPI.

Sass, J. (1951). *Botanical Microtehnique*. Iowa State Coll Pr.

Simmonds, N. (1966). *Bananas* (2nd ed). Longmans.

Simpson, M. G. (2006). *Plant Systematics*. Elsevier Academic Press.

Stuessy, T. F. (2009). Plant Taxonomy. In *The Systematic Evaluation of Comparative Data*. Columbia University Press.

Sulistyaningsih, L. D., & Irawanto, R. (2011). Penyebaran *Musa campestris* Becc. Var. Sarawakensis Häkkinen. *Berk. Penel. Hayati Edisi Khusus*, *5A*, 121–124.

Sulistyaningsih, L. D., Megia, R., & Widjaja, E. A. (2014). Two New Records of Wild Bananas (*Musa balbisiana* and *Musa itinerans*) from Sulawesi. *Makara Journal of Science*, *18*(1), 1–6. https://doi.org/10.7454/mss.v18i1.3043

Sumardi, I., & Wulandari, M. (2010). Anatomy and morphology character of five Indonesian banana cultivars (*Musa* spp.) of different ploidy level. *Biodiversitas Journal of Biological Diversity*, *11*(4), 167-175. https://doi.org/10.13057/biodiv/d110401

Sunandar, A. (2017). Short Communication: New record of wild banana (*Musa balbisiana* Colla) in West Kalimantan, Indonesia. *Biodiversitas Journal of Biological Diversity*, *18*(4), 1324–1330. https://doi.org/10.13057/biodiv/d180406

Sunandar, A., & Kahar, A. P. (2017). Morphology and Anatomy Characteristic of Pisang Awak (*Musa paradisiaca* cv. Awak) in West Kalimantan. *Biosaintifika: Journal of Biology & Biology Education*, *9*(3), 579-584. https://doi.org/10.15294/biosaintifika.v9i3.11258

Sunandar, A., & Kahar, A. P. (2018). Karakter Morfologi Dan Anatomi Pisang Diploid Dan Triploid. *Scripta Biologica*, *5*(1), 31-36. https://doi.org/10.20884/1.sb.2018.5.1.718

Sunandar, A., & Kurniawan, A. D. (2020). Distribution record of *Musa borneensis* var. *sarawakensis* Becc. And *Musa campestris* var. *sarawakensis* Becc. In West Kalimantan, Indonesia. *Journal of Tropical Biodiversity and Biotechnology*, *5*(3), 172–177. https://doi.org/10.22146/jtbb.57681

Valmayor, R. V., Jamaluddin, S., Silayoi, B., Kusumo, S., Danh, L., Pascua, O., & Espino, R. (2002). *Banana cultivar names and synonyms in Southeast Asia*. IPGRI.

van der Linde, K., & Walbot, V. (2019). Chapter Ten — Pre-meiotic anther development. In U. Grossniklaus (Ed.), *Current Topics in Developmental Biology* (Vol. 131, pp. 239–256). Academic Press. https://doi.org/10.1016/bs.ctdb.2018.11.001

Vilhena, R. de O., Marson, B. M., Budel, J. M., Amano, E., Messias-Reason, I. J. de T., & Pontarolo, R. (2019). Morpho-anatomy of the inflorescence of *Musa×paradisiaca*. *Revista Brasileira de Farmacognosia*, *29*(2), 147–151. https://doi.org/10.1016/j.bjp.2019.01.003

Wilson, Z. A., Song, J., Taylor, B., & Yang, C. (2011). The final split: The regulation of anther dehiscence.

Journal of Experimental Botany, *62*(5), 1633–1649. https://doi.org/10.1093/jxb/err014

Xue, C.-Y., Wang, H., & Li, D.-Z. (2005). Microsporogenesis and male gametogenesis in *Musella* (*Musaceae)*, a monotypic genus from Yunnan, China. *Annales Botanici Fennici*, *42*(6), 461–467.

Yang, C., Song, J., Ferguson, A. C., Klisch, D., Simpson, K., Mo, R., Taylor, B., Mitsuda, N., & Wilson, Z. A. (2017). Transcription Factor MYB26 Is Key to Spatial Specificity in Anther Secondary Thickening Formation. *Plant Physiology*, *175*(1), 333–350. https://doi.org/10.1104/pp.17.00719

Yang, C., Xu, Z., Song, J., Conner, K., Vizcay Barrena, G., & Wilson, Z. A. (2007). Arabidopsis MYB26/MALE STERILE35 Regulates Secondary Thickening in the Endothecium and Is Essential for Anther Dehiscence. *The Plant Cell*, *19*(2), 534–548. https://doi.org/10.1105/tpc.106.046391

Zarrei, M., Wilkin, P., Ingrouille, M. J., Zarre, S., & Chase, M. W. (2010). The systematic importance of anatomical data in Gagea (Liliaceae) from the Flora Iranica area. *Botanical Journal of the Linnean Society*, *164*(2), 155–177. https://doi.org/10.1111/j.1095-8339.2010.01081.x