AGRIKULTURA CRI Journal 2 (2) **ISSN: 2782-8816** **June 2022**

A JOURNEY IN SEARCH OF *Tetragonula biroi* (Friese 1898) PROPOLIS

Abu Hassan Jalil

Akadewmi Kelulut Malaysi,. 2625, Persiaran Rahmat
Teras Jernang, Bangi 43159, Selangor, Malaysia

**Corresponding author: abhuhsn@gmail.com*

Abstract — This paper looks into the mapping of *Tetragonula biroi* in the different islands of the Phlippines exploring into the propolis sources, the derivatives from different sources and exudates, harvesting and processing of propolis, and other research gaps involving the *T. biroi* species across regions. The dominant vegetation and host trees were scrutinized for the possible exudates utilized and processed by the bees. These are tabulated and charted with images from the Meliponaries, Bee Farms and Eco-Parks visited in many different islands of the Philippines regions. The resultant propolis and cerumen textures and consistency were compared for value-added product derivative considerations. The considerations include possibilities for use in aromatherapy, cosmeceuticals, nutraceuticals and pharmaceuticals. Some recommendations on the chemical processes and procedures for product derivatives are provided herein. Harvesting and post-harvest modus operandi are suggested with references from F.A.O. literature and past experiences.

Keywords **— Cerumen textures, host trees, meliponiculture, propolis, vegetation exudates**

INTRODUCTION

Biogeography Overview

Wallacea region (shown in black). Wallace's line (2) demarks the boundary of the Asian biogeographic realm to the west and the mixed fauna of the Wallacea region to the east, Huxley's line (1) shows Huxley's extension of the Wallace line to include the Philippines (Esselsty et al., 2010), Weber's line demarks the point of faunal balance between Australian and Asiatic influence on several taxa and Lydekker's line (4) demarks the western boundary of the Australian biogeographic region (Chandra n.d.). The map is redrawn from (O'Connell, 2013).

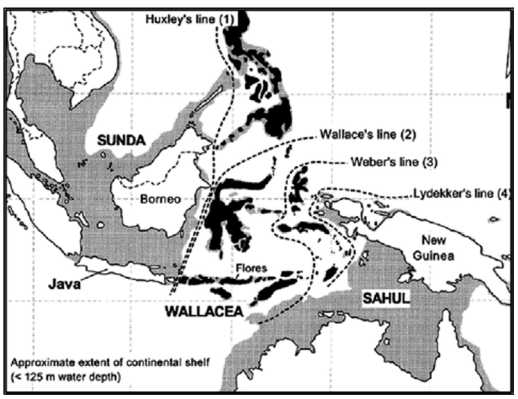


Fig. 1. Map of Wallacea Region (Shown in black).

Meliponiculture – Alternative Opportunities

Over the past decade, many losses in global apiculture call for alternatives and propolis plus pot-pollen products (Vit et al., 2018) and their derivatives. Do these questions arise; what is an alternative to Apiculture? What else besides honey? Are pollination and crop yields elements of agriculture worth considering? Are there other derivative products that can be developed? What about the Future of Agriculture incorporating Meliponiculture? What is the future of value-added beekeeping product innovation and demand? How does a farmer start or look for hives besides buying from hive hunters or ravaging nature? Hive hunters stock supply in unprepared transition areas. Termites' nests are the best bet to get from nature. The coexistence of stingless bee colonies in arboreal ants' and termites' nests in the Philippines is a phenomenon to be exploited (Jalil, 2019).

History of Agriculture Development and Migration

Delta valleys flourished with agriculture in the fertile lands. The rapid urban and industrial expansion has pushed the agriculture activities further upwards to higher ground. The overpopulation of the Urban delta regions (Personal Observations). This has led to overwhelming retardation of human amenities. Agriculture and food crop production are always necessary regardless of COVID-19 pandemic circumstances or otherwise. Highland agricultural stations with terraced plots and greenhouses for cultivation can be developed. It's a good thing that biological pollinating agents have not migrated much over the years (Eltz, 2003).

Inferences during Periodic Expeditions in Wallacea

Looking at the pollution and the mess that progress has possibly attributed to climate abnormalities, it is not surprising that the current COVID-19 pandemic hotspots are in highly urbanized populations.

Delta and valley living has been prone to floods in the past and more so in this age of climatic change. To achieve sustainable natural resources, one ultimately must migrate to highland suburbia. Cleaner remote areas in higher altitudes appear safer and more promising. Agriculture on higher ground is the way forward.

Advantages to Highland Crops

Better air quality and lower concentration of human population, hence doing away with environmental pollution. There is no soil nutrient exhaustion and less water pollution from lowland industrialization. Abundant natural pollinating agents for better crop yields.

Considering all these factors allows one to harvest quality products from Meliponiculture in agriculture settings. In Meliponiculture, the harvestable products are honey, propolis and pot-pollen.

Meliponiculture in a Nutshell - Propolis Products

In the Philippines, the most prolific species for obtaining Meliponiculture products is *Tetragonula biroi* (Ciar et al. (n.d.)). This data we gather from reports in the Handbook of Meliponiculture Vol 1 2016 (Mostoles, 2017).

Following were the objectives:

1. To observe different textures and consistency of *T. biroi* propolis across regions.
2. To ascertain the derivative products of propolis from different vegetative exudates.
3. To scrutinize the different *T.* nr. *biroi* types.
4. To infer the operating procedures in meliponiculture in the Philippines.

METHODOLOGY

Over five years of periodic expedition in the Philippines to conduct mapping of Meliponiculture activities among stingless beekeepers and their product development efforts. Information on the vegetation was provided by the beekeepers and methods of harvesting bee products were observed and recorded. The vegetation and host trees were examined for possible exudates utilized and processed by the stingless bees. ere scrutinized for the possible exudates utilized and processed by the bees. These were tabulated and charted with images from the meliponaries and Eco-Parks visited. The resultant propolis and cerumen textures and consistency were compared for value-added product derivative for possible use in aromatherapy, cosmeceuticals, nutraceuticals and pharmaceuticals.

DISCUSSION

Several varying stingless bee species exist throughout Wallacea and S.E.A., with diverse propolis and pot-pollen (Vit et al. 2018) characteristics and properties (Vit et al., 2013). The stingless bee's array has a wide selection of vegetative sources in Wallacea (Raes et al., 2014) and can adapt to varying sources in the many habitable conditons (Roubik, 2006). There is a need to arrange group discussions to exchange and share regional findings inter islands and higher altitudes.

There is a need to consolidate research on stingless bee propolis & pot-pollen across regions. Compare results of derivative products of propolis from different vegetative exudates. Organize clinical trials of the various products with relevant authorities. Need for D.N.A. sequencing and analysis of the different stingless bee types. Set standard operating procedures (S.O.P.) in meliponiculture and propolis & pot-pollen harvesting.

Propolis Textures and Consistency

The chart below shows the vegetative exudates that may influence different textures and consistency of cerumen and propolis produced in a stingless beehive.

Different bee species have varied preferences in foraging exudates for different uses in nest building material and defence and hive protective purposes (Michener 1961 & 2007). In the Sunda regions, bee species are often categorized by their dependence on specific exudates (Sakagami; 1978 & 1989; Schwarz 1937 &

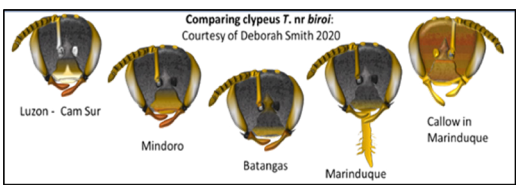
Table 1. Propolis Texture and Consistency from Phloem and Sap of Different Vegetative Sources.

Exudate	Texture Range	Consistency	Vegetative Source
Phloem	Fluff & Soft (for involucrum sheath)	gluey and gummy	Leaf shoots Flower buds
Sap	Soft & Pliable (for pots & entrance)	Sticky to tacky	Saplings Leaf petiole Sepal
Latex Milk Gum	Limber to semi-hard (at times for pillars)	moderately hard, can be cut with little effort.	Trunk branches Fruit Rind Stem Pedicel
Resin	Semi-hard to brittle (usually batumen)	Semi-dry to rough and flaky	Dipterocarps, Evergreen Resinous trees (Appannah 1998)

1939) e.g., some are dependent on resin while some are only on latex, milky sap or gum (Leonhardt, 2010 & Leonhardt et al., 2010). However, it appears that *Tetragonula biroi* can utilize a wide variety of exudates (Starr & Sakagamim, 1987).

T. nr. *biroi* variety (Smith in AAA Conf. 2020)

There are several varying near biroi specimens throughout Wallacea (Mostoles & Baja, 2017); one is the true *biroi* that Friese described from PNG (Sahul) in 1898 (Freise, H. 1898). The *T. nr. biroi* array (Baltazar, 1966; Rasmussen, 2008)) has a wide selection of vegetative sources in Wallacea and can adapt to varying sources in Sunda and Sahul (Welzen & Alahuhta, 2005).



(Illustration referenced to the AAA 2020 report on varieties of *T.* nr. *biroi* by Prof Deborah Smith). This diversity may account for the affinity and adaptability to foraging different vegetation types around the islands of the Philippines.

Observations of Dominant Vegetation in the Philippine Islands

During expeditions to different Islands in The Philippines, the dominant vegetation was recorded. In some instances, the host trees were examined for peculiar characteristics. There were cases where stingless bees occupied termite-infested trees (Jalil, 2019), and in certain regions, they were found to fall after a typhoon. Dipterocarps were observed in some regions like Mataas Na Kahoy in Batangas, Luzon and the Gawahon Eco-Park in Negros Occ. while Eucalyptus was favoured for their gum in some simulacra of some parks like Ilog Maria farm in Cavite and the Gawahon Eco-Park in Negros Occ. It was observed in mango plantations in Calatagan, Luzon and in Leyte, jackfruit plantations in Leyte and coconut plantations in Quezon and Sorsogon, Bicol Region. This is not highlighting monoculture crop settings, but these plantations have other forage sources for the bees. The issue is more on the dominant vegetation (Welzen & Alahuhta, 2005).

Below are some observations of vegetation provided or naturally available for stingless bees' concentration and Meliponaries for forage. Selection of unique dominant vegetation and possible high-grade derivative products from propolis were done.

UPLB Laguna	Campus	Raintree

Fig. 2. Host tree: Raintree (*Samanea saman*). Varying shapes and ornamentation but textures and consistency similar throughout.

CvSU Campus	Meliponary	Dragon Fruit

Fig. 3. CvSU, Cavite Dragon Fruit Farm -Sticky and a lot of muck left on the box surfaces.

Cavite	Indang	Los Pepes Bee Farm	Pomegranate

Fig. 4. Dominant vegetation: Pomegranate (*Pumica granatum*).

Silang	Ilog Maria	Bucari pine & Gum Tree

Fig. 5. Bucari pine & Gum tree - Resinous texture and gummy appearance.

Laguna	Alaminos	Anciado	Rambutan

Fig. 6. Dominant vegetation: Rambutan (Boonthai & Sawatthum, 2014). -Impending threats can cause Spikes.

Negros Occ	Gawahon Eco Park	Ricky Sobesta	Eucalyptus

Fig. 7. Gawahon Eco Park - Dominant vegetation - Eucalyptus Dried gummy slob.

Malitbog, Bongabong	HN Organic	Organic crops (Cinammon)

Fig 8. Organic crops (Cinammon) pulpy and pliable.

Mataas Na Kahoy	Cudia Farm	Dipterocarps *Shorea* sp.

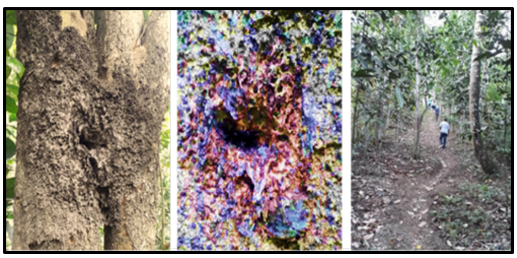


Fig. 9. *Dipterocarps Shorea sp.* Resinous texture.

Negros Occ	Gawahon Eco Park	Freddie Lozada	Lowland Dipterocarp

Fig. 10. Gawahon Eco Park - Dominant vegetation - Lowland Dipterocarp – Resinous.

Mindoro Occ	Sta Cruz	OMBKA	Cashew nut

Fig. 11. Cashew nut semi-hard and labyrinth -like.

Sorsogon	Bulusan	Balai Buhay Sa Uma	Avocado & Pili

Fig. 12. Sorsogon Avocado & Pili – Avocado sap & Pili resin “Elimi’.

East Samar	Maypangdan, Borongan City	Ruel B. Delantar	Cyathea Sp.

Figure 13. Host Tree: *Cyathea sp*. Dark and mucky cerumen.

Mindanao	Davao Oriental	Oriental Bee Farm	*Artocarpus gomezianus*

Figure 14. https://en.wikipedia.org/wiki/*Artocarpus_gomezianus.*

Care of Propolis and Post-Harvest Storage

1. Make sure boxes are completely dry - avoid damp lumber.
2. Smear internal surface with cerumen & wax, then flame to eradicate fungus spores and borer eggs.
3. Avoid Honey spills – they attract ants and cockroaches.
4. Eradicate cockroaches – they contaminate the propolis.
5. Full protective attire during harvesting – avoid Human contamination.
6. Keep harvested propolis cool and in a sealed container – avoid dissipation of aromatics

Aromatics are a major asset to cerumen produced from exudates of Resinous trees and Gum trees like Eucalyptus. One can only presume that these aromatics are the attractant for the bees in the first place. As propolis and cerumen are maintained, these aromatics makes it valuable for Aromatherapy. It is therefore imperative to keep products away from pests and contaminating vermin and bugs.

Contaminating Pests

Wax moths and cockroaches are among the common pests that may not destroy the colony but are detrimental to the quality of products obtained. Below are some cockroaches recorded in the hives during the travels.

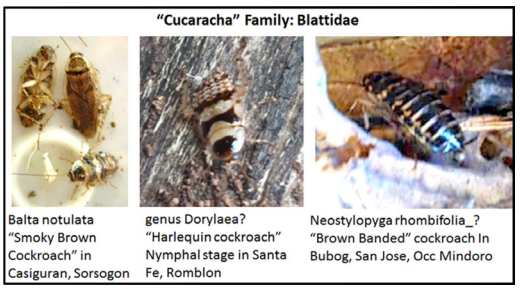


Fig. 15. Cockroaches recorded in the hives (Jalil 2018).

Types of Propolis

There are five types of propolis

1. Batumen is the hard cavity wall linings or the shell of a stingless bee nest. This part keeps intruders out.
2. Involucrum is a cerumen sheath enveloping the brood and may consist of many layers to regulate and stabilize the brood temperature and humidity.
3. Cerumen of the nest entrance tube or funnel, with resinous 'ornamental' spikes or flanges.
4. Storage pots. Also built with cerumen, they hold honey, pollen, rarely wax or resin.
5. Pillars hold all components in place and support the components as struts (Michener 1961; Roubik 1996; Jalil 2014; Jalil 2019).

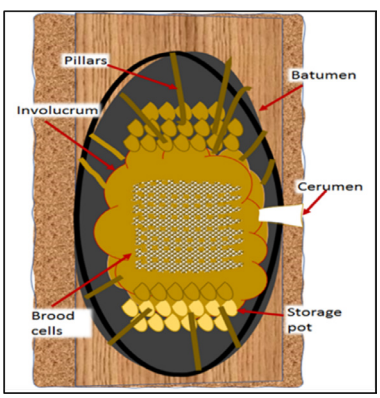


Fig. 16. Types of propolis.

CONCLUSIONS

- There is a need to consolidate research on *T. biroi* propolis across regions.
- Compare results of derivative products of propolis from different vegetative exudates.
- Organize clinical trials of the various products with relevant authorities.
- Need for D.N.A. sequencing and analysis of the different *T.* nr. *biroi* types
- Develop S.O.P. in meliponiculture of stingless bees (Cortopassi-Laurino et al, 2006) and the propolis harvesting (Krell, 1996).

REFERENCES

Appanah, S., & Turnbull, J.W (eds) 1998. A Review of Dipterocarps: Taxonomy, Ecology and Silviculture. Publisher: Center for International Forestry Research, Indonesia. Retrieved from: https://doi.org/10.17528/cifor/000463.

Baltazar, C. R. 1966. A Catalogue of Philippine Hymenoptera (with a bibliography, 1758-1963). Pacific Insects Monograph 8: 1- 488. Retrieved from: http://scinet.science.ph/union/Downloads/Baltazar,%20Clare%20R.%201966%20Pacific%20Insects%20Monograph%208(library)_14.pdf.

Boonthai, S. and Sawatthum, A., 2014, Efficacy of stingless bee as Insect pollinator of rambutan var. Sri Tong, pp. 214-215, In The 5th Phetchaburi Rajabhat University Research for Sustainable Thailand National Conference, Phetchaburi. Chandra, G. (n.d.). Wallace's Line, Weber's Line and Wallacea. Retrieved from IASZoology.com. http://www.iaszoology.com/wallacea/.

Ciar, R. R., Bonto, L.S., Bayer, Mc H.P., Rabajante, J.F., Lubag, S.P., Fajardo, A.C., Cervancia, C.R. (n.d). Foraging Behavior of Stingless Bees (*Tetragonula biroi* Friese): Distance, Direction and Height of Preferred Food Source. Retrieved from: https://arxiv.org/ftp/arxiv/papers/1310/1310.3919.pdf.

Cortopassi-Laurino, M., Imperatriz-Fonseca, V.L., Roubik, D.W., Dollin, A., Heard, T., Aguilr, I., Venturier, G. C., Eardley, C., & Nogueira-Neto, P. 2006. Global meliponiculture: challenges and opportunities. Apidologie 37, 275–292. Retrieved from: https://www.apidologie.org/articles/apido/pdf/2006/02/m6035sp.pdf.

Eltz, T., Bruhl, C.A., Imiyabir, Z., & Linsenmair, K.E. 2003. Nesting and nest trees of stingless bees (Apidae; Meliponini) in the lowland dipterocarp forest in Sabah, Malaysia, with implications for forest management. Forest Ecology and Management 172, 301-313. Retrieved from: https://homepage.rub.de/thomas.eltz/bilderE/pdfE/nester.pdf.

Esselstyn, J. A., Oliveros, C.H., Moyle, R. G., Peterson, A.T., McGuire, J.A. & Brown, R.M. 2010. Integrating phylogenetic and taxonomic evidence illuminates complex biogeographic patterns along with Huxley's modification of Wallace's Line. Journal of Biogeography 37 (11), 2054-2066. Retrieved from: https://doi.org/10.1111/j.1365-2699.2010.02378.x.

Freise, H. 1898. Die Trigona-arten Australiens. Termeszetrajzi Fuzetek 21: 427-431.

Jalil, A. H. 2014. Beescape for Meliponines: Conservation of Indo-Malayan Stingless Bees. Partridge Publishing Singapore. (ISBN: 9781482823622).

Jalil, A. H. 2018. Southern Luzon Meliponiculture Tour. Luzon, The Philippines: Akademu Kelulut Malaysia Sdn Bhd.. (ISBN: 978-967-2290-14-8).

Jalil, A. H. 2019. Cohabitation of Meliponines in Ants' or Termites' Arvoreal nests. Alademi Kelulut Malaysia Sdn Bhd. (ISBN: 978-967-2290-15-5).

Jalil, A. H. 2019. Visayas Meliponiculture Tour. Cebu, The Philippines: Akademi Kelulut Malaysia Sdn Bhd. (ISBN: 978-967-2290-16-2).

Jalil, A. H., & Roubik (ed), D. W. 2019. Filipino Meliponiculture and Beyond inc. MIMAROPA Tours. Mindoro, The Philippines: Akademu Kelulut Malaysia Sdn Bhd. (978-967-2290-19-3).

Jalil, A., & Roubik(ed), D. 2016. Handbook of Meliponiculture. Akademi Kelulut Malaysia Sdn Bhd. (ISBN: 978-967-14783-0-1).

Jalil, A., & Roubik(ed), D. 2018. Handbook of Meliponiculture Vol 2. Akademi Kelulut Malaysia Sdn Bhd. (ISBN: 978-967-2290-11-7).

Krell, R. 1996. Value-Added Products from Beekeeping. FAO Agricultural Services Bulletin, 124, Food and Agriculture Organization of the United Nations, Rome, Italy. (ISBN 92-5-103819-8). Retrieved from: https://www.apiservices.biz/documents/articles-en/value_added_products_from_beekeeping.pdf.

Leonhardt, S. D., Zeilhofer, S. Blüthgen , N. and Schmitt, T. 2010. Stingless Bees Use Terpenes as Olfactory Cues to Find Resin Sources, Chemical Senses, 35 (7) : 603–611. Retrieved from: https://doi.org/10.1093/chemse/bjq058.

Leonhardt, S.D., Jung, L.M., Schmitt, T. and S. Blüthgen, S. 2010.. Terpenoids tame aggressors: role of chemicals in stingless bee communal nesting. Behavioral Ecolology and Sociobioiology. 64: 1415–1423. Retrieved from: https://doi.org/10.1007/s00265-010-0956-6.

Michener, C. D. 1961. Observations on the Nests and Behavior of Trigona in Australia and New Guinea (Hymenoptera, Apidae). American Museum Novitates, No. 2026, 46pp. Retrieved from: http://hdl.handle.net/2246/3473.

Michener, C. D. 2007. The Bees of the World 2nd ed. John Hopkins University Press, Baltimore, 953pp. Retrieved from: https://static1.squarespace.com/static/5a849d4c8dd041c9c07a8e4c/t/5ad3bc968a922d44a4728936/1523825933048/Michener+2007+The+Bees+of+the+World.pdf.

Mostoles, MDJ and S.M. Baja. 2017. Colony Characterization and Amplicon Sequencing of Stingless Bees (*Tetragonula biroi*). Proceedings of the Conference, Malaysia. p. 27. Retrieved from: https://cbsua.edu.ph/wp-content/uploads/2021/09/STINGLESS-BEES-HYMENOPTERA-APIDAE-MELIPONINI-UNDER-GENUS-Tetragonula-IN-THE-PHILIPPINES.pdf.

Mostoles, M. D. 2017. Meliponiculture in Philippines – (Meliponiculture Initiatives in Bicol Region). In: A. H. Jalil, Handbook of Meliponiculture. Akademi Kelulut Malaysia Sdn Bhd. (ISBN:978-967-14783-0-1). Retrieved from: https://www.academia.edu/35615675/Meliponiculture_in_Philippines.

Moure, J. S. 1961. A preliminary supra-specific classification of the Old World meliponine bees (Hym., Apoidea). Studia Entomologica, 4: 181-.242.

Nogueira-Neto P. 1997. Vida e criaçao de abelhas indigenas sem ferrao, Editora Nogueirapis, Sao Paulo.

O'Connell, D. 2013. An investigation into the cryptic diversity of sunbird species (Nectariniidae) across south-east Sulawesi (Sulawesi Tenggara). B.Sc.(Hons) Zoology, University College Dublin, 80 pp. DOI: 10.13140/2.1.1867.5523.

Poinar, G. O. 1992. Fossil Evidence of Resin Utilization by Insects. Biotropica, 24 (3): 466–468. Retrieved from: https://doi.org/10.2307/2388620.

Raes, N., Cannon, C.H., Hijmans, R.J., Piessens, T., Saw L.G., van Welzen, P.C. Ferry Slik, J.W.. 2014. Historical distribution of Sunda land's Dipterocarp rainforests at Quaternary glacial maxima. Proceedings of the National Academy of Sciences, 111 (47): 167 90-16795. Retrieved from: https://doi.org/10.1073/pnas.1403053111.

Rasmussen. 2008. Catalogue of the Indo -Malayan/Australasian stingless bees (Hymenoptera: Apidae: Meliponini). Zootaxa. 1935 (1):80pp. ISBN 978-1-86977-295-6 (paper back). DOI: https://doi.org/10.11646/zootaxa.1935.1.1.

Roubik, D. 2006. Stingless bee nesting biology. Apidologie 37 (2): 124-143. DOI: 10.1051/apido:2006026.

Sakagami, S. F. 1978. Tetragonula Stingless Bees of the Continental Asia and Sri Lanka (Hymenoptera, Apidae). Journal Faculty Science Hokkaido Univ. Ser. VI, Zool. 21 (2): 165-247. Retrieved from: http://hdl.handle.net/2115/27635.

Sakagami, S. F., Inoue, T., Yamane, S., & salmah, S. 1989. Nests of the Myrmecophilous Stingless Bee, Trigona moorei: How do Bees Initiate Their Nest Within an Arboreal Ant Nest? Biotropica, 21 (3): 265-274.

Schwarz, H. F. 1937. Results of the Oxford University Sarawak (Borneo) expedition: Bornean stingless bees of the genus Trigona. Bulletin American Museum of Natural History. 73: 281-328. Retrived from: http://hdl.handle.net/2246/870.

Schwarz, H. F. 1939. The Indo-Malayan Species of Trigona. Bulletin American Museum of Natural History. 76: 83-141. Retrieved from: http://hdl.handle.net/2246/867.

Starr, C. K.and Sakagami, S. F. 1987. An Extraordinary Concentration of Stingless Bee in the Philippines, with Notes on Nest Architecture (Hymenoptera: Apidae: Trigona spp). Insectes Sociaux. 34 (2): 96-107. Retrieved from: https://link.springer.com/content/pdf/10.1007/BF02223828.pdf.

Van Welzen, P.C., Parnell, J.A.N. and Ferry Slik, J.W.. 2011. Wallace's Line and plant distributions: Two or three phytogeographical areas and where to group Java? Biological Journal of the Linnean Society 103 (3): 531-545. https://doi.org/10.1111/j.1095-8312.2011.01647.

Vit, P., Pedro, S., & Roubik, D. 2018. Pot -Pollen in Stingless Bee Melittology. Springer International Publishing AG. DOI: 10.1007/978-3-319-61839-5.

Vit, P., Roubik, D. W., & Pedro, S. M. 2013. Pot Honey - A Legacy of Stingless Bees. Springer, DOI - 10.1007/978-1-4614-4960-7.