Systematics, epidermal defense and bioprospecting of wild orchids

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References

References

Agrawal, A.A., Fishbein, M., Jetter, R., Salminen, J.P., Goldstein, J.B., Freitag, A.E., and Sparks, J.P. (2009). Phylogenetic ecology of leaf surface traits in the milkweeds (Asclepias spp.): chemistry, ecophysiology and insect behaviour. New Phytol. 183, 848-867.

Bakker, F. T., Lei, D. I., Yu, J., Mohammadin, S., Wei, Z., Van De Kerke, S., Gravendeel, B., Nieuwenhuis, M., Staats, M., Alquezar-planas, D. E. and Holmer, R. (2016). Herbarium genomics: plastome sequence assembly from a range of herbarium specimens using an Iterative Organelle Genome Assembly pipeline. Biol. J .Linn. Soc. 117, 33-43.

Banks, D. P. (2004) Handy Pocket Guide to Orchids of Indonesia. Periplus.

Barbehenn, R., and Constabel, C. P. (2011). Tannins in plant-herbivore interactions. Phytochem. 72, 1551-1565.

Barthlott, W., Mail, M., Bhushan, B. and Koch, K. (2017). Plant surfaces: Structures and functions for biomimetic innovations. Nano-Micro Lett. 9, 1–40.

Bates, D., Maechler, M., Bolker, B. and Walker, S. (2015). Fitting linear mixed-effects models using lme4. J. Stat. Softw. 67, 1-48.

Beena, C. (2011). Bioprospecting on the endangered medicinal plant Nervilia aragoana gaud. J. Progress. Agric. 2, 75–78.

Blattner, F. R. (1999). Direct amplification of the entire ITS region from poorly preserved plant material using recombinant PCR. Biotechniques 27, 1180–1186.

Bogarín, D., Pérez-Escobar, O. A., Groenenberg, D., Holland, S. D., Karremans, A. P., Lemmon, E. M., Lemmon, A.R., Pupulin, F., Smets, E., and Gravendeel, B. (2018). Anchored hybrid enrichment generated nuclear, plastid and mitochondrial markers resolve the Lepanthes horrida (Orchidaceae: Pleurothallidinae) species complex. Mol. Phylogenet. Evol. 129, 27–47.

Burd, M. (2007). Adaptive function of drip tips: A test of the epiphyll hypothesis in Psychotria marginata and Faramea occidentalis (Rubiaceae). J. Trop. Ecol. 23, 449–455.

Buyun, L., Tkachenko, H., Kovalska, L., and Osadowski, Z. (2016). Preliminary screening of Coelogyne ovalis Lindl. (Orchidaceae) for antimicrobial

activity against Staphylococcus aureus. in Dni laboratornoy meditsiny (Grodno: GrGMU), 10.

Cámara-Leret, R., Frodin, D. G., Adema, F., Anderson, C., Appelhans, M. S., Argent, G., et al. (2020). New Guinea has the world' s richest island. Nature 584, 1–5.

Cameron, K. M., Chase, M. W., Whitten, W. M., Kores, P. J., Jarrell, D. C., Albert, V. A., Yukawa, T., Hills, H.G., and Goldman, D.H. (1999). A phylogenetic analysis of the Orchidaceae: Evidence from rbcL nucleotide sequences. Am. J. Bot. 86, 208–224.

Caro, T. M., and O'Doherty, G. (1999). On the use of surrogate species in conservation biology. Conserv. Biol. 13, 805–814.

Carr, D. L. (2004). Proximate Population Factors and Deforestation in Tropical Agricultural Frontiers. Popul. Environ. 25, 585–612.

Chan, B., Balmforth, N. J. and Hosoi, A. E. (2005). Building a better snail: Lubrication and adhesive locomotion. Phys. Fluids 17, 1–10.

Chan, T. S. and Carlson, A. (2019). Physics of adhesive organs in animals. Eur. Phys. J. Spec. Top. 227, 2501–2512.

Cheng, T., Xu, C., Lei, L., Li, C., Zhang, Y., and Zhou, S. (2016). Barcoding the kingdom Plantae: New PCR primers for ITS regions of plants with improved universality and specificity. Mol. Ecol. Resour. 16, 138–149.

Clayton, D. (2002). The Genus Coelogyne: A Synopsis. Borneo: Natural History Publication.

Coley, P. (1980). Effects of leaf age and plant life history patterns on herbivory. Nature 284(5756), 545-546.

Contreras-Ortiz, N., Rodríguez-García, T., Quintanilla, S., Bernal-Villegas, J., Madriñán, S., and Gómez-Gutiérrez, A. (2019). The origin of Humboldt and Bonpland's holotype of Oncidium ornithorhynchum, clarified using +200-year-old DNA. Taxon 68, 471–480.

Cook, F. E. M. (1995). Economic Botany Data Collection Standard., eds. J. M. Lock and H. D. Prendergast Kew: the Royal Botanic Gardens.

Cragg, G. M., and Newman, D. J. (2013). Natural products: a continuing source of novel drug leads. Biochim. Biophys. Acta 1830, 3670–3695.

Crawford, N., Endlein, T., Pham, J. T., Riehle, M. and Barnes, W. J. P. (2016). When the going gets rough - studying the effect of surface roughness on

the adhesive abilities of tree frogs. Beilstein J. Nanotechnol. 7, 2116–2131.

Dangle, J. L., and Jones, J. D. G. (2001). Plant pathogens and integrated defence in plants. Nature 411, 826–833.

Darriba, D., Taboada, G. L., Doallo, R., and Posada, D. (2015). jModelTest 2: more models, new heuristics and high-performance computing Europe PMC Funders Group. Nat. Methods 9, 772.

Dashek, W. V (2000). Methods for the Cytochemical/ Histochemical Localization of Plant Cell/Tissue Chemicals. In Methods in Plant Electron Microscopy and Cytochemistry (ed. Dashek, W. V), pp. 27–35. New York, USA: Humana Press Inc.

De Candolle, A. P. (1813). Théorie élementaire de la Botanique. Paris: Deterville.

De Winter, A. J. and Gittenberger, E. (1998). The land-snail fauna of a square kilometre patch of rainforest in southwestern Cameroon: high species richness, low abundance and seasonal fluctuations. Malacologia 40, 231-250.

Denny, M. (1980). The role of gastropod pedal mucus in locomotion. Nature 285, 160–161.

Docters van Leeuwen, W. M. (1937). The Biology of epipogium roseum (D.Don) Lindl. Blumea 29 (6), 57–65.

Douwes, E., Crouch, N. R., Edwards, T. J., and Mulholland, D. A. (2008). Regression analyses of southern African ethnomedicinal plants: informing the targeted selection of bioprospecting and pharmacological screening subjects. J. Ethnopharmacol. 119, 356–364.

Doyle, J. J., and Doyle, J. L. (1987). A rapid DNA isolation procedure for small quantities of fresh leaf tissue. Phytochem. Bull. 19, 11–15.

Dressler, R. L. (1993). Phylogeny and classification of the orchid family. Portland: ORDioscorides Press.

Dressler, R. L. (1981). The orchids. Natural history and classification. Cambridge: Harvard University Press.

Dutta, D., and Wetterer, J. K. (2008). Ants in myrmecophytic orchids of Trinidad (Hymenoptera: Formicidae) Systematics and Evolution of the Tapinoma ants (Formicidae: Dolichoderinae) from the Neotropical region View project Ant stuff View project. Sociobiology 51, 249–254.

Eigenbrode, S. (2004). The effects of plant epicuticular waxy blooms on attachment and effectiveness of predatory insects. Arthropod. Struct. Dev. 33, 91-102.

Eloff, J. N. (1999). It is possible to use herbarium specimens to screen for antibacterial components in some plants. J. Ethnopharmacol 67, 355-360.

Ernst, M., Grace, O. M., Saslis-Lagoudakis, C. H., Nilsson, N., Simonsen, H. T., and Rønsted, N. (2015). Global medicinal uses of Euphorbia L. (Euphorbiaceae). J. Ethnopharmacol. 176, 90–101.

Ernst, M., Saslis-Lagoudakis, C.H., Grace, O. M., Nilsson, N., Simonsen, H. T., Horn, J. W., and Rønsted, N. (2016). Evolutionary prediction of medicinal properties in the genus Euphorbia L. Sci. Rep. 6, 30531.

FAO (2016). State of the World's Forests 2016 Forests and Agriculture: land-use challenges and opportunities. Rome.

Farr, D. F. (2006). On-line keys: more than just paper on the web. Taxon 55, 589–596.

Federle, W., Baumgartner, W. and Hölldobler, B. (2004). Biomechanics of ant adhesive pads: frictional forces are rate- and temperature-dependent. J. Exp. Biol. 207, 67–74.

Federle, W., Rohrseitz, K. and Hölldobler, B. (2000). Attachment forces of ants measured with a centrifuge: better "wax-runners" have a poorer attachment to a smooth surface. J. Exp. Biol. 203, 505–512.

Fiala, B., and Maschwittz, U. (1992). Food bodies and their significance for obligate ant-association in the tree genus Macaranga (Euphorbiaceae). Bot. J. Linn. Soc. 110(1), 61-75.

Finnigan, J. (2000). Turbulence in Plant Canopies. Annu. Rev. Fluid Mech. 32, 519–571.

Fischer, R., Richter, A., Wanek, W., and Mayer, V. (2002). Plant feed ants: food bodies of myrmecophytic Piper and their significance for the interaction with Pheidole bicornis ants. Oecologia 133, 186-192.

Fisher, B. L. (1992). Facultative ant association benefits a Neotropical orchid. J. Trop. Ecol. 8, 109–114.

Fitting, H. (1909a). Die Beeinflussung der Orchideenblüten durch die Bestäubung und durch andere Umstände. Zeitschrift für Bot. 1, 1–86.

Fitting, H. (1909b). Die Beeinflussung der Orchideenblüten durch die Bestäubung und durch andere Umstände. Bot. Jahrb. für Syst. 43, 24.

Fitting, H. (1910). Weitere entwicklungsphysiologische Untersuchungen an Orchideenblüten. Zeitschrift für Bot. 2, 225–267.

Fritz, S. A., and Purvis, A. (2010). Selectivity in mammalian extinction risk and threat types: A new measure of phylogenetic signal strength in binary traits. Conserv. Biol. 24, 1042–1051.

Gandrud, C. (2015). Reproducible Research with R and RStudio. 2nd ed. Boca Raton, Florida: CRC Press.

Gegenbauer, C., Mayer, V. E., Zotz, G., and Richter, A. (2012). Uptake of ant-derived nitrogen in the myrmecophytic orchid Caularthron bilamellatum. Annals of Botany 110(4), 757–766.

George, É., and George, J. C. (2011). Les Coelogynes. Paris: Belin.

Gong, B. and Zhang, G. (2014). Interactions between plants and herbivores: A review of plant defense. Act. Ecol. Sin. 34, 325-336.

Gorb, E and Gorb.S. (2002). Attachment ability of the beetle Chrysolina fastuosa on various plant surfaces. Entomol. Exp. Appl. 105, 13-28.

Govaerts, R., Bernet, P., Kratochvil, K., Gerlach, G., Carr, G., Alrich, P., et al. (2018). World Checklist of Orchidaceae. R. Bot. Gard. Kew.

Gravendeel, B., Chase, M. W., De Vogel, E. E., Roos, M. C., Mes, T. H. M., and Bachmann, K. (2001). Molecular phylogeny of Coelogyne (Epidendroideae; Orchidaceae) based on plastid RFLPS, matK, and nuclear ribosomal ITS sequences: Evidence for polyphyly. Am. J. Bot. 88, 1915–1927.

Gravendeel, B., de Vogel, E. F., and Schuiteman, A. (2005). "Coelogyninae," in Genera Orchidacearum Volume 4 Epidendroideae (Part One), eds. A. M. Pridgeon, P. J. Cribb, M. W. Chase, and F. N. Rasmussen (Oxford, UK: Oxford University Press (OUP)), 29–88.

Guisan, A., and Zimmermann, N. E. (2000). Predictive habitat distribution models in ecology. Ecol. Modell. 135, 147–186.

Gutiérrez, R. M. P. (2010). Orchids: A review of uses in traditional medicine, its phytochemistry and pharmacology. J. Med. Plants Res. 4, 592–638.

Haider, N., Nabulsi, I., and Kamary, Y. (2010). Identification of Orchidaceae Species of Northern West of Syria Based on Chloroplast DNA. Russ. J. Genet. 46, 948–959.

Hall, R. (2009). “Indonesia, Geology,” in Encylopedia of Islands, eds. R. Gillespie and D. Clague (Berkeley, California: University of California Press), 454–460.

Handini, E., Sukma, D., Sudarsono, S., and Roostika, I. (2018). Regenerasi Protokorm secara In Vitro dan Aklimatisasi Planlet Anggrek Cymbidium hartinahianum J.B. Comber & Nasution. J. AgroBiogen. 13, 91.

Handley, R., Ekbom, B., Ågren, J. (2005). Variation in trichome density and resistance against a specialist insect herbivore in natural populations of Arabidopsis thaliana. Ecol. Ent. 30(3), 284-292.

Hanley, M.E., Lamont, B.B., Fairbanks, M.M. and Rafferty, C.M. (2007). Plant structural traits and their role in anti-herbivore defence. Perspect. Plant Ecol. 8, 157-178.

Hanna, G. and Barnes, W. J. P. (1991). Adhesion and detachment of the toe pads of tree frogs. J. Exp. Biol. 155, 103-125.

Hart, M. L., Forrest, L. L., Nicholls, J. A., and Kidner, C. A. (2016). Retrieval of hundreds of nuclear loci from herbarium specimens. Taxon 65, 1081–1092.

He, J., Chen, F., Chen, S., Lv, G., Deng, Y., Fang, W., Liu, Z., Guan, Z. and He, C. (2011). Chrysanthemum leaf epidermal surface morphology and antioxidant and defense enzyme activity in response to aphid infestation. J. Plant Physiol. 168, 687-693.

Hebert, P. D. N., Cywinska, A., Ball, S. L., and DeWaard, J. R. (2003). Biological identifications through DNA barcodes. Proc. R. Soc. B Biol. Sci. 270, 313–321.

Heller, J. and Ittiel, H. (1990). Natural history and population dynamics of the land snail Helix texta in Israel (Pulmonata: Helicidae). J. Molluscan Stud. 56, 189–204.

Heywood, V. H. (2017). The future of plant conservation and the role of botanic gardens. Plant Divers. 39, 309–313.

Holttum, R. E. (1970). The Historical Significance of Botanic Gardens in S. E. Asia. Taxon 19, 707–714.

Hollingsworth, R.G., Follett, P., and Armstrong, J. (2003). Effects of irradiation on the reproductive ability of Zonotoides arboreus a snail pest of orchid roots. Ann. Appl. Biol. 143 (3), 395-399.

Hollingsworth, R.G., and Sewake K.T. (2002). The orchid snail as a pest of orchids in Hawaii. Manoa: University of Hawaii, 1-2.

Hsiao, Y. Y., Pan, Z. J., Hsu, C. C., Yang, Y. P., Hsu, Y. C., Chuang, Y. C., et al. (2011). Research on orchid biology and biotechnology. Plant Cell Physiol. 52, 1467–1486.

Huelsenbeck, J. P., Larget, B., and Alfaro, M. E. (2004). Bayesian phylogenetic model selection using reversible jump Markov chain Monte Carlo. Mol. Biol. Evol. 21, 1123–1133.

Isah, T. (2019). Stress and defense responses in plant secondary metabolites production. Biol. Res. 52, 39.

Jacquemart, A.-L., Lhoir, P., Binard, F., and Descamps, C. (2016). An Interactive Multimedia Dichotomous Key for Teaching Plant Identification. J. Biol. Educ. 50, 442–451.

Jeffree, C. (1986). The cuticle, epicuticular waxes and trichomes of plants, with reference to their structure, functions and evolutions. In B.E. Juniper and T.R.E. Southwood (eds.): Insects and the plant surface, London: Edward Arnold, 23-64.

Joshi, G. C., Tewari, L. M., Lohani, N., Upreti, K., Jalal, J. S., and Tewari, G. (2009). Diversity of Orchids in Uttarakhand and Their Conservation Strategy with Special Reference to Their Medicinal Importance. Rep. Opin. 1, 47–52.

Kati, V., Devillers, P., Dufrene, M., Legakis, A., Vokou, D., and Lebrun, P. (2004). Testing the Value of Six Taxonomic Groups as Biodiversity Indicators at a Local Scale. Conserv. Biol. 18, 667–675.

Katoh, K., and Standley, D. M. (2013). MAFFT multiple sequence alignment software version 7: improvements in performance and usability. Mol. Biol. Evol. 30, 772–780.

Kearse, M., Moir, R., Wilson, A., Stones-Havas, S., Cheung, M., Sturrock, S., et al. (2012). Geneious Basic: An integrated and extendable desktop software platform for the organization and analysis of sequence data. Bioinformatics 28, 1647–1649.

Kembel, S. W., Cowan, P. D., Helmus, M. R., Cornwell, W. K., Morlon, H., Ackerly, D. D., Blomberg, S.P. and Webb, C.O. (2010). Picante: R tools for integrating phylogenies and ecology. Bioinformatics 26, 1463–1464.

Kim, H. M., Oh, S. H., Bhandari, G. S., Kim, C. S., and Park, C. W. (2014). DNA barcoding of orchidaceae in Korea. Mol. Ecol. Resour. 14, 499–507.

Kim, J. Y., Park, S. C., Hwang, I., Cheong, H., Nah, J. W., Hahm, K. S. and Park, Y. (2009). Protease inhibitors from plants with antimicrobial activity. Int. J. Mol. Sci. 10, 2860–2872.

Konno, K., Inoue, T. A. and Nakamura, M. (2014). Synergistic defensive function of raphides and protease through the needle effect. PLoS One 9, 1–7.

Kores, P. J. (1989). A precursory study of Fijian orchids. Allertonia 5, 1–222.

Kosina, R., and Szkudlarek, M. (2015). Floral variability in selected species of the genus. Mod. Phytomorph. 8, 27–29.

Kovács, A., Vasas, A., and Hohmann, J. (2008). Natural phenanthrenes and their biological activity. Phytochemistry 69, 1084–1110.

Kress, W., Wurdack, K., and Zimmer, E. (2005). Use of DNA barcodes to identify flowering plants. Proc. Natl. Acad. Sci. 102, 8369–8374.

Krings, W., Faust, T., Kovalev, A., Neiber, M.T., Glaubrecht, M. and Gorb, S. (2019). In slow motion: radula motion pattern and forces exerted to the substrate in the land snail Cornu aspersum (Mollusca, Gastropoda) during feeding. R. Soc. Open Sci. 6, 190222.

Labonte, D., Clemente, C. J., Dittrich, A., Kuo, C.-Y., Crosby, A. J., Irschick, D. J. and Federle, W. (2016). Extreme positive allometry of animal adhesive pads and the size limits of adhesion-based climbing. Proc. Natl. Acad. Sci. 113, 1297–1302.

Lahaye, R., Van Der Bank, M., Bogarin, D., Warner, J., Pupulin, F., Gigot, G., et al. (2008). DNA barcoding the floras of biodiversity hotspots. Proc. Natl. Acad. Sci. U. S. A. 105, 2923–2928.

Lai, J.H., del Alamo, J.C., Rodríguez-Rodríguez, J. and Lasheras, J.C. (2010). The mechanics of the adhesive locomotion of terrestrial gastropods. J. Exp. Biol. 213, 3920-3933.

Lawler, L. J. (1984). "Ethnobotany of the Orchidaceae," in Orchid Biology: Reviews and Perspectives, vol III, ed. J. Arditti (New York: Cornell University Pressm), 27–149.

Leonti, M., Cabras, S., Eugenia Castellanos, M., Challenger, A., Gertsch, J., and Casu, L. (2013). Bioprospecting: Evolutionary implications from a post-olmec pharmacopoeia and the relevance of widespread taxa. J.

Ethnopharmacol. 147, 92–107.

Levin, D. (1973). The role trichomes in plant defense. Q. Rev. Biol. 48(1), 3-15.

Lev-Yadun, S., and Ne'eman, G. (2012). Does bee or wasp mimicry by orchid flowers also deter herbivores? Arthropod. Plant. Interact. 6, 327–332.

Li, T. S. C., Mazza, G., Cottrell, A. C., and Gao, L. (1996). Ginsenosides in Roots and Leaves of American Ginseng. J. Agric. Food Chem. 44, 717–720.

Light, M. H. S., and Macconaill, M. (2014). In Plain Sight Discovering Insect Herbivores of Orchids. The Native Orchid Conference Journal 11, 13–19.

Lin, Y.-L., Chen, W.-P., and Macabalang, A. D. (2005). Dihydrophenanthrenes from Bletilla formosana. Chem. Pharm. Bull. (Tokyo). 53, 1111–1113.

Lindenmayer, D. B., Margules, C. R., and Botkin, D. B. (2000). Indicators of biodiversity for ecologically sustainable forest management. Conserv. Biol. 14, 941–950.

Lindsay, S., and Middleton, D. (2009). Development of a multi-access key to the ferns of Thailand. Thai For. Bull. (Bot). Special issue: papers from the 14th Flora of Thailand meeting, 134-137

Lopez, R. G., and Runkle, E. S. (2004). The effect of temperature on leaf and flower development and flower longevity of Zygopetalum Redvale "Fire Kiss" orchid. HortScience 39, 1630–1634.

Lopez, R. G., and Runkle, E. S. (2005). Environmental physiology of growth and flowering of orchids. HortScience 40, 1969–1973.

Lucas-Barbosa, D. (2016). Integrating studies on plant-pollinator and plant-herbivore interactions. Trends Plant Sci. 21(2), 125-133.

Luchtel, D. L. and Deyrup-Olsen, I. (2001). The biology of terrestrial molluscs. In Body wall: form and function (ed. Barker, G. M.), pp. 147–178. Wallingford (U.K.): CAB International.

Majumder, P. L., Sen, S., and Majumder, S. (2001). Phenanthrene derivatives from the orchid Coelogyne cristata. Phytochemistry 58, 581–586.

Mangold, J., and Parkinson, H. (2013). Plant Identification Basics. Mont. State Univ. Ext. Mt. Guid. 9, 1–8.

Marasini, R., and Joshi, S. (2013). Antibacterial and Antifungal Activity of Medicinal Orchids Growing in Nepal. J. Nepal Chem. Soc. 29, 104–109.

Marshall, S. A. (2018). Field Photography and the Democratization of Arthropod Taxonomy. Am. Entomol. 54(4), 207–210.

Martellos, S. (2010). Multi-authored interactive identification keys: The FRIDA (FRiendly IDentificAtion) package. Taxon 59, 922–929.

Maryanto, I., and Higashi, S. (2011). Comparison of zoogeography among rats, fruit bats and insectivorous bats on Indonesian islands. Treubia 38, 33–52.

Mckee, A., Voltzow, J., and Pernet B. (2013). Substrate attributes determine gait in a terrestrial gastropods. Biol. Bull. 224(1), 53-61.

Meer Mohr, J. C. van der (1931). Ueber Ameisen als Schneckenfeinde. Misc. Zool. Sumatrana 52, 1–3.

Miller, M. A., Wayne, P., and Schwartz, T. (2010). Creating the CIPRES Science Gateway for Inference of Large Phylogenetic Trees. in 2010 Gateway Computing Environments Workshop (GCE) (New Orleans, LA), 1–8.

Ministry of Environment and Forestry of Indonesia. (2015) The Fifth National Report to the Convention on Biological Diversity. Jakarta.

Moerman, D. E. (1991). The medicinal flora of native North America: an analysis. J. Ethnopharmacol. 31, 1–42.

Moin, S., Sahaya, S. B., Servin Wesley, P., and Chitra Devi, B. (2012). Bioactive potential of Coelogyne stricta (D. Don) Schltr: An ornamental and medicinally important orchid. Journal of Pharmacy Research 5, 2191–2196.

Moreno-Rueda, G. (2006). Habitat use by the arid-dwelling land snail Iberus g. gualtieranus. J. Arid Environ. 67, 336–342.

Mursidawati, S., Ngatari, N., Irawati, I., Cardinal, S., and Wati, R. K. (2015). Ex situ conservation of Rafflesia patma Blume (Rafflesiaceae)- an endangered emblematic parasitic species from Indonesia. Sibbaldia 13, 99–109.

Mutsaers, J. A. E. M., Doornbos, L., and Knecht, N. M. (2001). Bacteriologie voor laboratorium en kliniek 2. 4th ed. Utrecht: Syntax Media.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., and Kent, J. (2000). Biodiversity hotspots for conservation priorities. Nature 403, 853–858.

Newman, B. J., Ladd, P., Batty, A., and Dixon, K. (2007). Ecology of orchids in urban bushland reserves - can orchids be used as indicators of vegetation condition? Lankesteriana 7, 313–315.

Newman, D. J., Cragg, G. M., and Snader, K. M. (2000). The influence of natural products upon drug discovery (Antiquity to late 1999). Nat. Prod. Rep. 17, 215–234.

Nixon, K.C. (1999). The parsimony ratchet, a new method for rapid parsimony analysis. Cladistics 1, 407-414.

O'Byrne, P. (1994) Lowland Orchids of Papua New Guinea. Edited by S. B. G. National parks Board. SNP Publishers.

Olson, D. M., Dinerstein, E., Wikramanayake, E. D., Burgess, N. D., Powell, G. V. N., Underwood, E. C., et al. (2001). Terrestrial Ecoregions of the World: A New Map of Life on Earth. Bioscience 51, 933.

Orme, D., Freckleton, R., Thomas, G., Thomas, P., Fritz, S., Isaac, N. and Pearse, W. (2013). CAPER: Comparative Analyses of Phylogenetics and Evolution in R. Methods Ecol. Evol. 3, 145–151.

Pant, B. (2014). Medicinal orchids and their uses: Tissue culture a potential alternative for conservation. African J. Plant Sci. 7, 448–467.

Pant, B. and Raskoti, B. B. (2013) Medicinal Orchid of Nepal. Kathmandu: Himalayan Map House Pvt. Ltd.

Paradis, E., Claude, J., and Strimmer, K. (2004). APE: Analyses of phylogenetics and evolution in R language. Bioinformatics 20, 289–290.

Pawlicki, J. M. (2004). The effect of molluscan glue proteins on gel mechanics. J. Exp. Biol. 207, 1127–1135.

Pedersen, H., Petersen, G., Gravendeel, B., Barkman, T. J., de Boer, H., Sulistyo, B. P. and Seberg, O. (2019). Phylogenetics of Dendrochilum (Orchidaceae): Evidence of pronounced morphological homoplasy and predominantly centric endemism. Taxon 68, 1173–1188.

Peleg, A. Y., and Hooper, D. C. (2010). Hospital-Acquired Infections Due to Gram-Negative Bacteria. N. Engl. J. Med. 362, 1804–1813.

Peltola, H., Aho, J., Hassinen, A., Kellomäki, S. and Lemettinen, M. (1993). Swaying of trees as caused by wind: analysis of field measurements. Silva Fenn. 27, 113–126.

Pfeifer, M., Heinrich, W., and Jetschke, G. (2006). Climate, size and flowering history determine flowering pattern of an orchid. Bot. J. Linn. Soc. 151, 511–526.

Plett, J. M., Wilkins, O., Campbell, M. M., Ralph, S. G. and Regan, S. (2010). Endogenous overexpression of Populus MYB186 increases trichome density, improves insect pest resistance, and impacts plant growth. Plant J. 64, 419–432.

Podroužková, S., Janovský, Z., Horáčková, J. and Juřičková, L. (2015). Do snails eat exotic plant species invading river flood plains?. J. Moll. Stud. 81, 139-146.

Pramanik, D., Dorst, N., Meesters, N., Spaans, M., Smets, E., Welten, M. and Gravendeel, B. (2020). Evolution and development of three highly specialized floral structures of bee - pollinated Phalaenopsis species. Evodevo 11, 1–20.

Price, Z., Mayes, S., Billotte, N., Hafeez, F., Dumortier, F., and MacDonald, D. (2007). "Oil Palm," in Technical Crops, ed. C. Kole (Berlin, Heidelberg: Springer Science+Business Media), 93–107.

Pridgeon, A. M., Cribb, P. J., Chase, M. W., and Rasmussen, F. N. (2005). Genera Orchidacearum vol.4 Epidendroideae (Part 1). Oxford, USA: Oxford University Press.

Prior, D. J. (1985). Water-regulatory behaviour in terrestrial gastropods. Biol. Rev. 60, 403–424.

Priya, K., and Krishnaveni, C. (2005). Antibacterial effect of bulbophyllum neilgherrense wt. (Orchidaceae). An in vitro study. Anc. Sci. Life 25, 50–502.

Prüm, B., Seidel, R., Bohn, H.F., and Speck, T. (2012). Plant surfaces with cuticular folds are slippery for beetles. J. R. Soc. Interface 9, 127-135.

Purkayastha, J. (2016). Bioprospecting of Indigenous Bioresources of North-East India. Singapore: Springer Singapore.

Purnomo, D. W., Magandhi, M., Kuswantoro, F., Risna, R. A. and Witono, J. R. (2015). Pengembangan Koleksi Tumbuhan Kebun Raya Daerah Dalam Kerangka Strategi Konservasi Tumbuhan Di Indonesia. Bul. Kebun Raya 18, 111–124.

Qian, C. D., Jiang, F. S., Yu, H. S., Shen, Y., Fu, Y. H., Cheng, D. Q., Gan, L.S. and Ding, Z.S. (2015). Antibacterial biphenanthrenes from the fibrous roots of Bletilla striata. J. Nat. Prod. 78, 939–943.

R Core Team. (2018). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.

Ramakrishna, A., and Ravishankar, G. A. (2011). Influence of abiotic stress signals on secondary metabolites in plants. Plant Signal. Behav. 6, 1720–1731.

Ramalho, A. J., Zappi, D. C., Nunes, G. L., Watanabe, M. T. C., Vasconcelos, S., Dias, M. C., et al. (2018). Blind testing: Dna barcoding sheds light upon the identity of plant fragments as a subsidy for cave conservation. Front. Plant Sci. 9, 1–10.

Rani, P., and Jyothsna, Y. (2010). Biochemical and enzymatic changes in rice plants as mechanism of defense. Acta Physiol. Plant 32, 695-701.

Reinwardt, C. G. C. (1823). Redevoering van C.G.C. Reinwardt over hetgeen het onderzoek van Indië tot uitbreiding der natuurlijke historie heeft toegebracht. Amsterdam.

Robinson, M. M., and Zhang, X. (2011). Traditional medicines: Global situation, issues and Challenges. Switzerland.

Rosinski, M. (1992). Anatomie, Untersuchungen zur funktionellen Anatomie, der Laubblattstrukturen epiphytischer Coelogyninae und Eriinae (Orchidaceae). PhD thesis, Saarland University, Germany.

Ruinen, J. (1953). Epiphytosis.A second view on epiphytism. Ann. Bogor. 1, 101–158.

Ruzin, S. E. (1999). Plant Microtechnique and Microscopy. New York: Oxford University Press.

Särkinen, T., Staats, M., Richardson, J. E., Cowan, R. S., and Bakker, F. T. (2012). How to Open the Treasure Chest? Optimising DNA Extraction from Herbarium Specimens. PLoS One 7, 1–9.

Sasidharan, R. and Venkatesan, R. (2019). Seed elaiosome mediates dispersal by ants and impacts germination in Ricinus communis. Front. Ecol. Evol. 7, 1–8.

Saslis-Lagoudakis, C. H., Klitgaard, B. B., Forest, F., Francis, L., Savolainen, V., Williamson, E. M., et al. (2011). The use of phylogeny to interpret cross-cultural patterns in plant use and guide medicinal plant discovery: An example from pterocarpus (leguminosae). PLoS One 6, e22275.

Saslis-Lagoudakis, C. H., Savolainen, V., Williamson, E. M., Forest, F., Wagstaff, S. J., Baral, S. R., Watson, M.F., Pendry, C.A. and Hawkins, J.A. (2012). Phylogenies reveal predictive power of traditional medicine in bioprospecting. Proc. Natl. Acad. Sci. 109, 15835–15840.

Savoia, D. (2012). Plant-derived antimicrobial compounds: Alternatives to antibiotics. Future Microbiol. 7, 979–990.

Schneider, C. A., Rasband, W. S. and Eliceiri, K. W. (2012). NIH Image to ImageJ:25 years of image analysis. Nat. Methods 9, 671–675.

Schönherr, J. (1982). Resistance of Plant Surfaces to Water Loss: Transport Properties of Cutin, Suberin and Associated Lipids. In Physiological Plant Ecology II. Encyclopedia of Plant Physiology (New Series), vol 12 (ed. Lange O.L., Nobel P.S., Osmond C.B., Z. H.), pp. 153–179. Berlin, Heidelberg: B. Springer.

Schönherr, J. (1976). Water permeability of isolated cuticular membranes: the effect of cuticular waxes on diffusion of water. Planta 131, 159-164.

Servigne, P. and Detrain, C. (2008). Ant-seed interactions: Combined effects of ant and plant species on seed removal patterns. Insectes Soc. 55, 220–230.

Sharma, H., Sujana G., and Manohar Rao, D. (2009). Morphological and chemical components of resistance to pod borer, Helicoverpa armigera in wild relatives of pigeon pea. Arthropod Plant Interact. 3, 151-161.

Shaw, J. M. H. (2016). Registrar's notes on names in the register. Orchid Rev. Suppl. 124, 36.

Sheehan, D. and Hrapchak, B. (1980). Theory and Practice of Histotechnology. 2nd ed. Ohil: Battelle Press.

Shibu, S., Devi, B. C., Moin, B. S., and Wesley, S. (2013). Medicinal orchid of western ghats, India. Asia J. Pharm. Clin. Res. 6, 114–118.

Shirtcliffe, N. J. and Newton, M. I. (2012). Wet Adhesion and Adhesive Locomotion of Snails on Anti-Adhesive Non-Wetting Surfaces. PLoS ONE 7, 5–9.

Sikes, D.S., Lewis, P.O.(2001). Beta software, version 1.PAUPRat:PAUP* implementation of the parsimony ratchet.

Singh, A., and Duggal, S. (2009). Medicinal Orchids: An Overview. Ethnobot. Leafl. 13, 351–363.

Singh, S., and Singh, A. K. (2012). Medicinal properties and uses of orchids: a concise review. Elixir Appl. Bot. 52, 11627–11634.

Siqueira, C. F. D. Q., Cabral, D. L. V., Peixoto Sobrinho, T. J. D. S., De Amorim, E. L. C., De Melo, J. G., Araújo, T. A. D. S., et al. (2012). Levels of tannins and flavonoids in medicinal plants: Evaluating bioprospecting strategies. Evidence-based Complement. Altern. Med. 2012, 1–7.

Smith, W. L., and Wheeler, W. C. (2006). Venom evolution widespread in fishes: A phylogenetic road map for the bioprospecting of piscine venoms. J. Hered.

97, 206–217.

Soberón, J., Rodríguez, P., and Vázquez-Domínguez, E. (2000). Implications of the Hierarchical Structure of Biodiversity for the Development of Ecological Indicators of Sustainable Use. AMBIO A J. Hum. Environ. 29, 136–142.

Sodhi, N. S., and Brook, B. W. (2006). Southeast Asia biodiversity in crisis. Cambridge: Cambridge University Press.

Sodhi, N. S., Posa, M. R. C., Lee, T. M., Bickford, D., Koh, L. P., and Brook, B. W. (2010). The state and conservation of Southeast Asian biodiversity. Biodivers. Conserv. 19, 317–328.

Spatz, H. C. and Bruechert, F. (2000). Basic biomechanics of self-supporting plants: Wind loads and gravitational loads on a Norway spruce tree. For. Ecol. Manage. 135, 33–44.

Spehn, E., Rudmann-Maurer, K., Körner, C., and Maselli, D. (2010). Mountain Biodiversity and Global Change. Swiss Agency for Development and Cooperation SDC.

Staats, M., Cuenca, A., Richardson, J. E., Ginkel, R. V. van, Petersen, G., Seberg, O. and Bakker, F.T. (2011). DNA damage in plant herbarium tissue. PLoS One 6: e28448.

Stamakis, A., Hoover, P., Rougemontm J. (2008). A rapid bootstrap algorithm for the RAxML web servers. Syst. Biol. 57, 758-771.

Steinberger, Y., Grossman, S., Dubinsky, Z. and Shachak, M. (1983). Stone microhabitats and the movement and activity of desert snails, Sphincterochila prophetarum. Malacol. Rev. 16, 63–70.

Stern, W. (2014). Anatomy of the Monocotyledons Volume X: Orchidaceae. Oxford, USA: Oxford University Press.

Strutzenberger, P., Brehm, G., and Fiedler, K. (2012). DNA Barcode Sequencing from Old Type Specimens as a Tool in Taxonomy: A Case Study in the Diverse Genus Eois (Lepidoptera: Geometridae). PLoS One 7, 1–7.

Subedi, A., Chaudhary, R. P., van Achterberg, C., Heijerman, T., Lens, F., van Dooren, T. J. M. and Gravendeel, B. (2011). Pollination and protection against herbivory of Nepalese Coelogyninae (Orchidaceae)1. Am. J. Bot. 98, 1095–1103.

Subedi, A., Kunwar, B., Choi, Y., Dai, Y., van Andel, T., Chaudhary, R. P., de Boer, H.J. and Gravendeel, B. (2013). Collection and trade of wild-harvested

orchids in Nepal. J. Ethnobiol. Ethnomed. 9, 1–10.

Sudarmono, Latifah, D., Hartini, S. and Wawangningrum, H. (2016). Hand-pollination of the giant corpse flower in the Bogor Botanic Gardens. Int. J. Conserv. Sci. 7(4), 1153-1160.

Sukarya, D. G. and Witono, J. R. (2017) Kebun Raya Bogor. Two Centuries of Sowing the Earth's Plant Diversity in Indonesia. Jakarta: Sukarya & Sukarya Pandetama.

Sulistyo, B. P., Boos, R., Cootes, J. E., and Gravendeel, B. (2015). Dendrochilum hampelii (Coelogyninae, Epidendroideae, Orchidaceae) traded as 'Big Pink' is a new species, not a hybrid: evidence from nrITS, matK and ycf1 sequence data. PhytoKeys 56, 83–97.

Suprayitno, N., Narakusumo, R. P., von Rintelen, T., Hendrich, L., and Balke, M. (2017). Taxonomy and Biogeography without frontiers – WhatsApp, Facebook and smartphone digital photography let citizen scientists in more remote localities step out of the dark. Biodivers. Data J. 5, e19938.

Swofford, D.L. (2002). PAUP. Phylogenetic Analysis Using Parsimony (and Other Methods), Version 4.0 Beta 10. Sinauer Associates, Sunderland.

Teijsmann, J. E. (1861) Bijdrage tot de geschiedenis der kina-kultuur op Java. Buitenzorg.

Teoh, E. S. (2016) Medicinal orchids of Asia, Medicinal Orchids of Asia. Switzerland: Springer International Publishing.

Thiers, B. M. (2019). The World's Herbaria 2018: A Summary Report Based on Data from Index Herbariorum. Available at: http://sweetgum.nybg.org/science/ih/.

Tóth, B., Hohmann, J., and Vasas, A. (2018). Phenanthrenes: A Promising Group of Plant Secondary Metabolites. J. Nat. Prod. 81, 661–678.

Treub, M. (1890). Études sur les Lycopodiacées VI. L'embryon et la plantule du Lycopodium cernuum L. Ann. du Jard. Bot. Buitenzorg 8, 1–37.

Treub, M. (1879). Notes sur l'embryogénie de quelques orchidées. Amsterdam, Chez Johannes Műller.

Trimanto, T., and Rahadiantoro, A. (2017). Acclimatization of Plant Collection from Moyo Island Forest, West Nusa Tenggara at Purwodadi Botanic Garden. Trop. Drylands 1, 43–49.

Vaidya, B., Shrestha, M., and Joshee, N. (2000). Report on Nepalese Orchid Species with Medicinal Properties. in Proceeding of Nepal-Japan Joint Symposium-2000, eds. T. Watanabe, A. Tokano, M. Bista, and H. Saiju (Japan Society for Conservation and Development of Himalaya Medicinal Resources), 146–152.

Vandenborre, G., Smagghe, G. and Van Damme, E. (2011). Plant lectins as defense proteins against phytophagus insects. Phytochem. 72, 1538-1550.

van der Pijl, L., and Dodson, C. H. (1966). Orchid flowers: their pollination and evolution. Miami, USA: University of Miami Press.

van Leeuwen, W. M. (1929). Mierenepiphyten II. Trop. Nat. 18, 131–139.

van Royen, P. (1979). The Alpine flora of New Guinea Vol.2. Vaduz: Cramer Verlag.

Vander Wall, S. B., Kuhn, K. M. and Beck, M. J. (2005). Seed Removal, Seed Predation, and Secondary Dispersal. Ecology 86, 801–806.

Vaz, A. P. A., Figueiredo-Ribeiro, R. D. C. L., and Kerbauy, G. B. (2004). Photoperiod and temperature effects on in vitro growth and flowering of P. pusilla, an epiphytic orchid. Plant Physiol. Biochem. 42, 411–415.

Verpoorte, R. (1998). Exploration of nature's chemodiversity: the role of secondary metabolites as leads in drug development. Drug Discov. Today 3, 232–238.

Vogel, S. (2013). Comparative biomechanics: life's physical world 2nd ed. Arizona, USA: Princeton University Press.

Voigt, D., Gorb, E. and Gorb, S. (2007). Plant surface-bug interactions: Dicyphus errans stalking along trichomes. Arthropod Plant Interact. 1, 221-243.

Wagner, G. J., Wang, E. and Shepherd, R. W. (2004). New approaches for studying and exploiting an old protuberance, the plant trichome. Ann. Bot. 93, 3–11.

Wang, J., Matsuzaki, K., and Kitanaka, S. (2006). Stilbene Derivatives from Pholidota chinensis and Their Anti-inflammatory Activity. Chem. Pharm. Bull. (Tokyo). 54, 1216–1218.

Wang, M., Wu, H., Xu, J., Li, C., Wang, Y. and Wang, Z. (2017). Five fatty acyl-coenzyme a reductases are involved in the biosynthesis of primary alcohols in Aegilops tauschii leaves. Front. Plant Sci. 8, 1–14.

Wang, Y. (2000). Medium, Nutrition, and Flower inducrion in potted blooming orchids. Hortechnology 10, 433–434.

Washington, J. A. (1996). Principles of Diagnosis, ed. S. Baron Galveston, Texas: University of Texas Medical Branch.

Wati, R. K., and Mursidawati, S. (2015). Orchidaceae catalogue of Bogor Botanic Gardens. LIPI Press.

Wati, R. K., van Vugt, R. R., and Gravendeel, B. (2018). A Linnaeus NG interactive key to the species of Glomera (Orchidaceae, Coelogyninae) from Southeast Asia. PhytoKeys 110, 9–22.

Watson, J. (2002). Orchid Pests and Diseases. Florida, USA: American Orchid Society.

Webb, C. O., Ackerly, D. D., and Kembel, S. W. (2008). Phylocom: Software for the analysis of phylogenetic community structure and trait evolution. Bioinformatics 24, 2098–2100.

Weber, A. (2014). Bitter fruits of accumulation: The case of Caspar Georg Carl reinwardt (1773-1854). Hist. Sci. 52, 297–318.

Went, F. W. (1926). On growth accelerating substances in the coleoptile of Avena sativa. Proc. Koenigliche Akad. der Wet. 30, 10–19.

Whitney, H. M. and Federle, W. (2013). Biomechanics of plant-insect interactions. Curr. Opin. Plant Biol. 16, 105–111.

Wickham, H. (2011). The Split-Apply-Combine Strategy for Data Analysis. J. Stat. Softw. 40, 1–29.

Widjaja, E. A., Rahayuningsih, Y., Rahajoe, J. S., Ubaidillah, R., Maryanto, I., Walujo, E. and Semiadi, G. (2014). Kekinian Keanekaragaman Hayati Indonesia 2014. Jakarta: LIPI Press.

Williams-Linera, G., and Baltazar, A. (2001). Herbivory on young and mature leaves of one temperate deciduous and two tropical evergreen trees in the understory and canopy of a Mexican cloud forest. Selbyana 22(2), 213-218.

Winkler, M., Hülber, K., Mehltreter, K., Franco, J.G., and Hietz, P. (2005). Herbivory in epiphytic bromeliads, orchids and ferns in a Mexican montane forest. J. Trop. Ecol. 21(2), 147-154.

Xu, C., Dong, W., Shi, S., Cheng, T., Li, C., Liu, Y., Wu, P., Wu, H., Gao, P. and Zhou, S. (2015). Accelerating plant DNA barcode reference library construction using herbarium specimens: Improved experimental techniques. Mol. Ecol. Resour. 15, 1366–1374.

Yam, T. W., and Arditti, J. (2009). History of orchid propagation: A mirror of the history of biotechnology. Plant Biotechnol. Rep. 3, 1–56.

Yang, X., Tang, C., Zhao, P., Shu, G., and Mei, Z. (2012). Antimicrobial constituents from the tubers of bletilla ochracea. Planta Med. 78, 606–610.

Yonzone, R., Lama, D., Bhujel, R. B., and Rai, S. (2013). Present availability status, diversity resources and distribution of medicinal orchid species in Darjeeling Himalaya of West Bengal, India. Int. J. Pharm. Pharm. Sci. 1, 14–35.

Zhang, Z., Wang, W. and Li, W. (2013). Genetic Interactions Underlying the Biosynthesis and Inhibition of β-Diketones in Wheat and Their Impact on Glaucousness and Cuticle Permeability. PLoS One 8, e54129.

Zhu, F., Qin, C., Tao, L., Liu, X., Shi, Z., Ma, X., et al. (2011). Clustered patterns of species origins of nature-derived drugs and clues for future bioprospecting. Proc. Natl. Acad. Sci. 108, 12943–12948.

Zvereva, E.L., and Kozlov, M.V. (2014). Effects of herbivory on leaf life span in woody plants: a meta-analysis J. Ecol. 102, 873-881.

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Curriculum Vitae

Richa Kusuma Wati was born on August 17th, 1984, in Malang, Indonesia, and grew up in East Java Province. Her passion for chemistry in high school led her to study Food Technology at Brawijaya University, Indonesia, where she obtained her bachelor's degree in 2006. Just before graduation, she was granted a double-degree scholarship from KEMDIKBUD. She completed her M.Sc in 2009 from Brawijaya University, Indonesia, and Mae Fah Luang University, Thailand, with publishing three papers about the purification of trypsin inhibitor from legumes to preserve fish products. After her graduation, she was accepted in Bogor Botanic Gardens-LIPI as a researcher. For her first task she was involved with orchid collections in the gardens. She met her mentor, Sofi Mursidawati, and worked together to manage the orchid collections. In 2015, they published an orchid catalog of the garden, fifteen years after the publication of the first catalog. During this time, she became interested in orchids and this led her to study orchids for her PhD project. Since November 2015, after receiving a scholarship from LPDP, she started her PhD research at Naturalis Biodiversity Center and Leiden University under the supervision of Prof. Barbara Gravendeel and Prof. Erik Smets. She will continue to work as an orchid researcher in Bogor Botanic Gardens. Her main future research projects will be focused on orchid ex-situ conservation, saving the endangered orchid species of Indonesia by applying genomics, taxonomy, systematics, and bio-prospecting. Richa is also interested in understanding orchid-pollinator-herbivore interactions.

List of Publications

Wati, R.K., de Graaf, E., Bogarin, D., Heijungs, R., van Vugt, R.R., Smets, E.F. & B.Gravendeel. 2021.Antimicrobial activity of necklace orchids is phylogenetically clustered and can be predicted with a biological response method. Frontiers in Pharmacology, section Ethnopharmacology (in press).

Wati, R.K., van Vugt, R.R. & B. Gravendeel. 2018. A Linnaeus NG interactive key to the species of Glomera (Orchidaceae, Coelogyninae) from Southeast Asia. Phytokeys 110:9

Gravendeel, B., Bogarin, D., Dirks-Mulder, A., **Wati, R.K**., & D. Pramanik. 2018. The orchid genomic toolkit. In: Proceedings of the 18th EOCCE-What future for orchids, pp.72-76. Cahiers De La Société Française D'orchidophilie 9:73-77.

Irawati, I., Witjaksono, W., Nugraheni, K.U., Isnaini, Y., Mursidawati, S., Handini, E., Garvita, R.V., Leksonowati, A., Rahayu, E.M.D., & **R.K Wati**. 2017. In vitro culture of Amorphophallus titanium (Becc.) Becc. Ex Archang at Bogor Botanic Gardens. Buletin Kebun Raya 20 (1):33-42.

Wati, R.K., & S. Mursidawati. 2015. Orchidaceae catalogue of Bogor Botanic Gardens. LIPI Press.

Mursidawati, S., Ngatari, N., Irawati, I, Cardinal, S., & **R.K. Wati**. 2015. Ex situ conservation of Rafflesia patma Blume (Rafflesiaceae) – An endangered emblematic parasitic species from Indonesia. Sibbaldia 13:99-110.

Wati, R.K., Theppakorn, T., Benjakul, S., & S. Rawdkuen.2010. Trypsin inhibitor from 3 legume seeds: fractionation and proteolytic inhibition study. Journal of Food Science 75(3): C223-C228.

Wati, R. K., Theppakorn, R., Benjakul, S., & S. Rawdkuen. 2009. Three-phase partitioning of trypsin inhibitor from legume seeds. Process Biochemistry 44(12):1307-1314.

Wati, R.K., Theppakorn, R. & S. Rawdkuen. 2009. Extraction of trypsin inhibitor from three legume seeds of the Royal Project Foundation. Asian Journal of Food and Agro-industry 2(3):245-254.

PE&RC Training and Education Statement

With the training and education activities listed below the PhD candidate has complied with the requirements set by the C.T. de Wit Graduate School for Production Ecology and Resource Conservation (PE&RC) which comprises of a minimum total of 32 ECTS (= 22 weeks of activities)

Review of literature (4.5 ECTS)

- Phylogenetic prospecting of Indonesian Coelogyninae (Orchidaceae) used as traditional antimicrobials

Post-graduate courses (7.8 ECTS)

- Metabolomics; IBL (2016)
- Phylogenetics; Wageningen University (2018)
- Introduction to ArcGIS; Leiden University & Naturalis (2018)

Laboratory training and working visits (0.3 ECTS)

- GGO Training for ML2 lab; Leiden University (2016)

Competence strengthening / skills courses (1.5 ECTS)

- Time management, self- management; Leiden University (2017)
- Effective communication; Leiden University (2017)
- Communication in science; Leiden University (2017)

Scientific integrity / ethics in science activity (0.3 ECTS)

- On being a scientist; Leiden University (2016)

Discussion groups / local seminars / other scientific meetings (6.6 ECTS)

- Learning from nature, learning from our ancestors, from tradition to evidence-based medicines (2016)
- Endless forms (2016-2019)

International symposia, workshops and conferences (5.1 ECTS)

- 18th European orchid council conference and exhibition; Paris (2018)
- 2nd Conference of the Netherlands Society for Evolutionary Biology (NLSEB); Wageningen (2019)
- 7th International orchid conservation congress; Royal Botanic Garden Kew (2019)

Societally relevant exposure (1 ECTS)

- Presentation; WEO (Werkgroep Europese Orchideeën), Maarn (2019)

Lecturing / supervision of practicals / tutorials (0.6 ECTS)

-Biology of Orchids

BSc thesis supervision (12 ECTS)

- Medicinal properties of Indonesian Coelogyne
- Antimicrobial properties of Indonesian Coelogyninae on antibiotic-resistant bacteria
- Bioprospection of Indonesian medicinal orchids (Coelogyninae) seems promising for finding potential new species for alternative drug discovery
- The epicuticular properties of orchids and their effect for snail herbivory activity