

Faculty of Resource Science and Technology

Taxonomic Study of the Genus *Heptapleurum* Gaertn. (Araliaceae) in Sarawak

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Master of Science
2024

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A thesis submitted

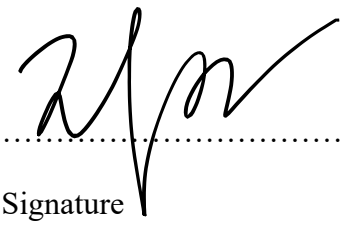
In fulfillment of the requirements for the degree of Master of Science

(Plant Systematics)

Faculty of Resource Science and Technology
UNIVERSITI MALAYSIA SARAWAK
2024

DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



……

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Date : 29 August 2024

ACKNOWLEDGEMENT

First of all, I would like to express my gratitude to my research supervisor, Dr Aida Shafreena binti Ahmad Puad for her guidance, motivation and patience throughout my Master study. It was such a privilege and honour for me to do my research under her supervision.

Next, I am deeply grateful to my co-supervisor, Professor Dr Tarmiji bin Masron for his guidance and advises in GIS and also allowing me to use the facilities in the CSIDH Lab at the Faculty of Social Sciences and Humanities (FSSH), UNIMAS for my map construction. Special thanks to Dr Norita Jubit and Mr Azizul for guiding me on how to use the software 'ArcMap 10.3'.

I would like to thank the staff of Sarawak Herbarium (SAR) at Forest Department Sarawak for giving me loan of all herbarium specimens of genus *Heptapleurum* from Sarawak Herbarium (SAR) for almost a year. Due to the global pandemic of Covid-19 that put restriction on inter-district travel in Sarawak, it was difficult for me to go to SAR to do my study.

My research could not be accomplished without the support of my family and friends. I am grateful to my family especially my parents, Ramnor bin Norshidi and Ramlah binti Mohidin for their prayers, love, support and encouragement throughout my study. Also to my awesome friends, Jyloerica Joling, Raihan Rashida binti Ruslan and Nursyahida binti

Abdullah for making my Master journey an enjoyable one. Last but not least, I would like to thank everyone who contributes either directly or indirectly during my study.

ABSTRACT

Heptapleurum Gaertn. is a genus that belongs to the Araliaceae family. Previously, all the species in this genus were placed under the Asian *Schefflera* J. R. Forst. & G. Forst.. After transferring all the species, the genus is now known as the largest genus in Araliaceae and can be found at tropical and subtropical of Asia and on several islands and archipelagos of the western Pacific. There are some studies of *Heptapleurum* that have been done in other regions. However, the information on the species in is still lacking and poorly understood in Sarawak. Therefore, the objectives of this study were to determine the number of *Heptapleurum* taxa in Sarawak, to construct a taxonomic key of *Heptapleurum* taxa in Sarawak, to describe all the *Heptapleurum* taxa in Sarawak based on the herbarium specimens and to make a distribution map of *Heptapleurum* taxa in Sarawak. The observation and measurements of both vegetative and reproductive parts were made from the herbarium specimens from Sarawak Herbarium (SAR) and Unimas. A distribution map was created by using ArcMap 10.3. Based on the observations of all 583 specimens, there are 73 *Heptapleurum* taxa in Sarawak. Out of 73 taxa, 25 taxa are published species, 27 taxa are unpublished and 21 are imperfectly known taxa. The distribution map, taxonomic key and description of all *Heptapleurum* taxa in Sarawak are presented here in this study. The genus can be found throughout Sarawak in various types of habitat with elevational ranges from near sea level up to the highest peak in Sarawak which is 2424 m on Mount Murud. From this study, it is concluded that there are still many undiscovered and unidentified taxa of *Heptapleurum* in Sarawak. Further study about this genus in Sarawak is much needed to improve the knowledge of this challenging genus.

Keywords: Description, distribution, elevation, herbarium specimens, Sarawak, taxonomy

Kajian Sistematik Heptapleurum Gaertn. di Sarawak Berdasarkan Spesimen Herbarium

ABSTRAK

Heptapleurum Gaertn. merupakan salah satu genus yang tergolong di dalam famili Araliaceae. Sebelum ini, kesemua spesies dalam genus ini terletak di bawah kumpulan Asian Schefflera. Setelah memindahkan kesemua spesies dari kumpulan tersebut, genus Heptapleurum kini dikenali sebagai genus yang terbesar dalam Araliaceae dan ianya boleh dijumpai di kawasan tropika and subtropika Asia dan juga di kepulauan Pasifik Barat. Terdapat beberapa kajian mengenai Heptapleurum telah dilakukan di beberapa tempat yang lain. Walau bagaimanapun, maklumat mengenai Heptapleurum di Sarawak masih kurang. Antara objektif kajian ini ialah untuk mengetahui bilangan spesies Heptapleurum di Sarawak, menghasilkan huraian kesemua spesies di Sarawak berdasarkan spesimen herbarium, membuat peta taburan Heptapleurum di Sarawak dan membina kunci taksonomi Heptapleurum di Sarawak. Kesemua pemerhatian dan ukuran terhadap bahagian vegetatif dan reproduktif dilakukan berdasarkan spesimen herbarium dari Herbarium Sarawak (SAR) dan Unimas. Peta taburan Heptapleurum dibuat menggunakan perisian 'ArcMap 10.3'. Setelah membuat pemerhatian daripada 583 spesimen kering, sejumlah 73 taksa Heptapleurum yang telah dikenalpasti di Sarawak. Daripada 73 taksa, 25 spesies sudah diterbit, 27 taksa belum diterbit dan 21 taksa yang tidak diketahui dengan sempurna. Sejumlah 30 spesimen adalah steril. Peta taburan, kunci taksonomi dan huraian kesemua spesies Heptapleurum di Sarawak telah dihasilkan. Genus ini boleh dijumpai di seluruh Sarawak di dalam pelbagai habitat dengan ketinggian dari berhampiran aras laut sehingga ke 2424 m iaitu di Gunung Murud. Daripada kajian ini, ia menunjukkan bahawa terdapat

banyak lagi spesies Heptapleurum yang masih belum ditemui dan tidak dikenali. Kajian lanjut mengenai genus ini di Sarawak amat diperlukan untuk meningkatkan pengetahuan secara lebih terperinci.

Kata kunci: *Huraian spesies, taburan, ketinggian, spesimen herbarium, Sarawak, taksonomi*

TABLE OF CONTENTS

		Page
DECLARATION		i
ACKNOWLEDGEMENT		ii
ABSTRACT		iv
ABSTRAK		vi
TABLE OF CONTENTS		viii
LIST OF TABLES		xiv
LIST OF FIGURES		xv
LIST OF ABBREVIATIONS		xxiii
CHAPTER 1:	**INTRODUCTION**	1
1.1	Study Background	1
1.2	Problem Statement and Objectives	3
CHAPTER 2:	**LITERATURE REVIEW**	5
2.1	Araliaceae	5
2.2	Genus *Heptapleurum* Gaertn.	7
2.2.1	General Characteristics of the Genus *Heptapleurum*	7
2.2.1.1	Stems	8
2.2.1.2	Leaves	8
2.2.1.3	Inflorescences	9
2.2.1.4	Flowers	10
2.2.1.5	Fruits	11
2.2.2	Distribution of *Heptapleurum*	12

2.2.3 Systematics of *Heptapleurum* 13

2.2.4 Uses and economic importance of *Heptapleurum* 14

2.2.5 The importance of herbarium specimens in scientific research 15

CHAPTER 3: MATERIALS AND METHODS 18

3.1 Herbarium Specimens 18

3.2 Species Identification 18

3.3 Morphological observation 19

3.4 Construction of Distribution Map of *Heptapleurum* species in Sarawak 20

3.5 IUCN Red List Assessment 21

CHAPTER 4: RESULTS 23

4.1 *Heptapleurum* taxa in Sarawak 23

4.2 Distribution of *Heptapleurum* taxa in Sarawak 29

4.3 Altitudinal Distribution of *Heptapleurum* taxa in Sarawak 32

4.4 Taxonomic Key of *Heptapleurum* taxa in Sarawak 35

4.5 Description of *Heptapleurum* taxa in Sarawak 41

4.5.1 *Heptapleurum abangmohtari* sp. nov. 41

4.5.2 *Heptapleurum acutissimum* (Miq.) Seem. 44

4.5.3 *Heptapleurum asahii* sp. nov. 47

4.5.4 *Heptapleurum avene* (Miq.) Seem. 50

4.5.5 *Heptapleurum barioense* sp. nov. 54

4.5.6 *Heptapleurum beccarianum* (Harms) Lowry & G. M. Plunkett 57

4.5.7 *Heptapleurum bernardleei* sp. nov. 61

4.5.8 *Heptapleurum bidenticarpum* sp. nov. 64

4.5.9 *Heptapleurum bipalmatifolium* (Merr.) Lowry & G. M. Plunkett 66

4.5.10 *Heptapleurum borneense* (Merr.) Lowry & G. M. Plunkett 69

4.5.11 *Heptapleurum bracteosum* sp. nov. 73

4.5.12 *Heptapleurum brookeanum* sp. nov. 76

4.5.13 *Heptapleurum burianum* sp. nov. 79

4.5.14 *Heptapleurum burkillii* (Merr.) Lowry & G. M. Plunkett 81

4.5.15 *Heptapleurum cephalotes* C. B. Clarke 84

4.5.16 *Heptapleurum conjunctum* sp. nov. 87

4.5.17 *Heptapleurum crenatum* (Puad & Frodin) Puad, T. J. Barkman, Lowry & G. M. Plunkett 90

4.5.18 *Heptapleurum ellipticum* (Blume) Seem. 93

4.5.19 *Heptapleurum ensiriengsense* sp. nov. 98

4.5.20 *Heptapleurum glaucophyllum* sp. nov. 100

4.5.21 *Heptapleurum havilandii* (Merr.) Lowry & G. M. Plunkett 104

4.5.22 *Heptapleurum kenayaense* sp. nov. 108

4.5.23 *Heptapleurum kuchingense* (Merr.) Lowry & G. M. Plunkett 110

4.5.24 *Heptapleurum lanatum* (Frodin, Puad & T. J. Barkman) Puad, T. J. Barkman, Lowry & G. M. Plunkett 113

4.5.25 *Heptapleurum lasiocalyx* (Ridl.) Lowry & G. M. Plunkett 116

4.5.26 *Heptapleurum laxiflorum* (Ridl.) Lowry & G. M. Plunkett 120

4.5.27 *Heptapleurum lesongense* sp. nov. 123

4.5.28 *Heptapleurum lineamentorum* (Frodin & Puad) Puad, T. J. Barkman, Lowry & G. M. Plunkett 125

4.5.29 *Heptapleurum littorale* (Miq.) Boerl. 128

4.5.30 *Heptapleurum lubangbayaense* sp. nov. 133

4.5.31 *Heptapleurum mamutiacum* (Puad, T. J. Barkman & Frodin) Puad, T. J. Barkman, G. M. Plunkett & Lowry 136

4.5.32 *Heptapleurum mangiferifolium* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry 139

4.5.33 *Heptapleurum mitragerum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry 143

4.5.34 *Heptapleurum mjoebergii* (Merr.) G. M. Plunkett & Lowry 147

4.5.35 *Heptapleurum multiarcuatum* sp. nov. 150

4.5.36 *Heptapleurum niahense* sp. nov. 155

4.5.37 *Heptapleurum obovatilimbum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry 157

4.5.38 *Heptapleurum paulchaii* sp. nov. 161

4.5.39 *Heptapleurum petiolosum* (Miq.) Seem. 164

4.5.40 *Heptapleurum primackii* sp. nov. 169

4.5.41 *Heptapleurum puehense* sp. nov. 171

4.5.42 *Heptapleurum rhodorifolium* sp. nov. 174

4.5.43 *Heptapleurum runiae* sp. nov. 176

4.5.44 *Heptapleurum sabahense* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry 179

4.5.45 *Heptapleurum semengohense* sp. nov. 182

4.5.46 *Heptapleurum subisense* sp. nov. 185

4.5.47 *Heptapleurum tetrandrum* (Merr.) G. M. Plunkett & Lowry 187

4.5.48 *Heptapleurum trineurum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry 192

4.5.49 *Heptapleurum truncatum* sp. nov. 196

4.5.50 *Heptapleurum verticillatum* sp. nov. 200

4.5.51 *Heptapleurum yahudwatii* sp. nov. 203

4.5.52 *Heptapleurum yiipuanchingae* sp. nov. 206

4.6 Imperfectly known taxa of *Heptapleurum* in Sarawak 208

4.6.1 *Heptapleurum* aff. *avene* 209

4.6.2 *Heptapleurum* aff. *beamanii* 210

4.6.3 *Heptapleurum* aff. *burkillii* 213

4.6.4 *Heptapleurum* aff. *cephalotes* 215

4.6.5 *Heptapleurum* aff. *crenatum* 217

4.6.6 *Heptapleurum* aff. *havilandii* 219

4.6.7 *Heptapleurum* aff. *lineamentorum* 221

4.6.8 *Heptapleurum* aff. *mamutiacum* 223

4.6.9 *Heptapleurum* aff. *mitragerum* 224

4.6.10 *Heptapleurum* aff. *sabahense* 226

4.6.11 *Heptapleurum* aff. *tetrandrum* 227

4.6.12 *Heptapleurum* aff. *winkleri* 230

4.6.13 *Heptapleurum* “anapense” 231

4.6.14 *Heptapleurum* “andersonii” 232

4.6.15 *Heptapleurum* “banyengii” 234

4.6.16 *Heptapleurum* “bidiense” 236

4.6.17 *Heptapleurum* “dinghoui” 237

4.6.18 *Heptapleurum* “lumutense” 239

4.6.19 *Heptapleurum* “murudense” 240

4.6.20 *Heptapleurum* “palutanense” 242

4.6.21 *Heptapleurum* “woenense” 243

CHAPTER 5: DISCUSSION 245

5.1 *Heptapleurum* taxa in Sarawak 245

5.2 Imperfectly known taxa of *Heptapleurum* in Sarawak 247

5.3 Distribution of *Heptapleurum* taxa in Sarawak 248

5.4 Elevational ranges and habitats of *Heptapleurum* taxa in Sarawak 253

5.5 Challenges of studying using herbarium specimens 255

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS 258

REFERENCES 260

LIST OF TABLES

		Page
Table 4.1	Published names of *Heptapleurum* species in Sarawak.	23
Table 4.2	Unpublished names of *Heptapleurum* taxa in Sarawak.	25
Table 4.3	Imperfectly known *Heptapleurum* taxa in Sarawak	26
Table 4.4	The *Heptapleurum* taxa with restricted distribution in Sarawak	31

LIST OF FIGURES

		Page
Figure 2.1	Limitation zone and branching zone of *Heptapleurum mangiferifolium.*	10
Figure 3.1	Map of Sarawak that is used to show *Heptapleurum* species distribution	21
Figure 4.1	The number of specimens of each *Heptapleurum* taxa in Sarawak	28
Figure 4.2	The distribution of *Heptapleurum* taxa in Sarawak	29
Figure 4.3	The altitudinal ranges of *Heptapleurum* taxa in Sarawak	33
Figure 4.4	*Heptapleurum abangmohtari* N. Ramnor & A. Puad, sp. nov. (S. 66165)	43
Figure 4.5	Distribution map of *H. abangmohtari* sp. nov. in Sarawak	43
Figure 4.6	*Heptapleurum acutissimum* (Miq.) Seem. (S. 52793)	46
Figure 4.7	Distribution map of *H. acutissimum* in Sarawak	47
Figure 4.8	*Heptapleurum asahii* N. Ramnor & A. Puad, sp. nov. (S. 54554)	49
Figure 4.9	Distribution map of *H. asahii* sp. nov. in Sarawak	49
Figure 4.10	*Heptapleurum avene* (Miq.) Seem. (S. 33239)	53
Figure 4.11	Distribution map of *H. avene* in Sarawak	54
Figure 4.12	*Heptapleurum barioense* N. Ramnor & A. Puad, sp. nov. (S. 50447)	56
Figure 4.13	Distribution map of *H. barioense* sp. nov. in Sarawak	57
Figure 4.14	*Heptapleurum beccarianum* (Harms) Lowry & G. M. Plunkett (S. 42903)	60
Figure 4.15	Distribution map of *H. beccarianum* in Sarawak	60

Figure 4.16	*Heptapleurum bernardleei* N. Ramnor & A. Puad, sp. nov. (S. 49412)	63
Figure 4.17	Distribution map of *H. bernardleei* sp. nov. in Sarawak	63
Figure 4.18	*Heptapleurum bidenticarpum* N. Ramnor & A. Puad, sp. nov. (S. 30073)	65
Figure 4.19	Distribution map of *H. bidenticarpum* sp. nov. in Sarawak	66
Figure 4.20	*Heptapleurum bipalmatifolium* (Merr.) Lowry & G. M. Plunkett (Nooteboom No. 2215)	68
Figure 4.21	Distribution map of *H. bipalmatifolium* in Sarawak	69
Figure 4.22	*Heptapleurum borneense* (Merr.) Lowry & G. M. Plunkett (S. 42146)	72
Figure 4.23	Distribution map of *H. borneense* in Sarawak	72
Figure 4.24	*Heptapleurum bracteosum* N. Ramnor & A. Puad, sp. nov. (S. 51115)	75
Figure 4.25	Distribution map of *H. bracteosum* sp. nov. in Sarawak	75
Figure 4.26	*Heptapleurum brookeanum* N. Ramnor & A. Puad, sp. nov. (S. 73239)	78
Figure 4.27	Distribution map of *H. brookeanum* sp. nov. in Sarawak	78
Figure 4.28	*Heptapleurum burianum* N. Ramnor & A. Puad, sp. nov. (S. 36743)	80
Figure 4.29	Distribution map of *H. burianum* sp. nov. in Sarawak	81
Figure 4.30	*Heptapleurum burkillii* (Merr.) Lowry & G. M. Plunkett (S. 37593)	83
Figure 4.31	Distribution map of *H. burkillii* in Sarawak	84
Figure 4.32	*Heptapleurum cephalotes* C. B. Clarke (S. 37920)	86
Figure 4.33	Distribution map of *H. cephalotes* in Sarawak	87

Figure 4.34	*Heptapleurum conjunctum* N. Ramnor & A. Puad, sp. nov. (S. 19518)	89
Figure 4.35	Distribution map of *H. conjunctum* sp. nov. in Sarawak	90
Figure 4.36	*Heptapleurum crenatum* (Puad & Frodin) Puad, T. J. Barkman, Lowry & G. M. Plunkett (S. 26432)	92
Figure 4.37	Distribution map of *H. crenatum* in Sarawak	93
Figure 4.38	*Heptapleurum ellipticum* (Blume) Seem. (S. 42024)	97
Figure 4.39	Distribution map of *H. ellipticum* in Sarawak	97
Figure 4.40	*Heptapleurum ensiriengense* N. Ramnor & A. Puad, sp. nov. (S. 78647)	99
Figure 4.41	Distribution map of *H. ensiriengense* sp. nov. in Sarawak	100
Figure 4.42	*Heptapleurum glaucophyllum* N. Ramnor & A. Puad, sp. nov. (S. 21278)	103
Figure 4.43	Distribution map of *H. glaucophyllum* sp. nov. in Sarawak	103
Figure 4.44	*Heptapleurum havilandii* (Merr.) Lowry & G. M. Plunkett (S. 42187)	107
Figure 4.45	Distribution map of *H. havilandii* in Sarawak	107
Figure 4.46	*Heptapleurum kenayaense* N. Ramnor & A. Puad, sp. nov. (S. 31524)	109
Figure 4.47	Distribution map of *H. kenayaense* in Sarawak	110
Figure 4.48	*Heptapleurum kuchingense* (Merr.) Lowry & G. M. Plunkett (S. 42716)	112
Figure 4.49	Distribution map of *H. kuchingense* in Sarawak	113

Figure 4.50	*Heptapleurum lanatum* (Frodin, Puad & T. J. Barkman) Puad, T. J. Barkman, Lowry & G. M. Plunkett (S. 33011)	115
Figure 4.51	Distribution map of *H. lanatum* in Sarawak	116
Figure 4.52	*Heptapleurum lasiocalyx* (Ridl.) Lowry & G. M. Plunkett (S. 46578)	119
Figure 4.53	Distribution map of *H. lasiocalyx* in Sarawak	119
Figure 4.54	*Heptapleurum laxiflorum* (Ridl.) Lowry & G. M. Plunkett (S. 50330).	122
Figure 4.55	Distribution map of *H. laxiflorum* in Sarawak.	122
Figure 4.56	*Heptapleurum lesongense* N. Ramnor & A. Puad, sp. nov. (S. 44298)	124
Figure 4.57	Distribution map of *H. lesongense* sp. nov. in Sarawak	125
Figure 4.58	*Heptapleurum lineamentorum* (Frodin & Puad) Puad, T. J. Barkman, Lowry & G. M. Plunkett (S. 26329)	127
Figure 4.59	Distribution map of *H. lineamentorum* in Sarawak	128
Figure 4.60	*Heptapleurum littorale* (Miq.) Boerl. (S. 17866)	132
Figure 4.61	Distribution map of *H. littorale* in Sarawak	132
Figure 4.62	*Heptapleurum lubangbayaense* N. Ramnor & A. Puad, sp. nov. (S. 84113)	135
Figure 4.63	Distribution map of *H. lubangbayaense* sp. nov. in Sarawak	135
Figure 4.64	*Heptapleurum mamutiacum* (Puad, T. J. Barkman & Frodin) Puad, T. J. Barkman, G. M. Plunkett & Lowry (S. 58233)	138
Figure 4.65	Distribution map of *H. mamutiacum* in Sarawak	138

Figure 4.66	*Heptapleurum mangiferifolium* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (S. 91443)	141
Figure 4.67	Distribution map of *H. mangiferifolium* in Sarawak	142
Figure 4.68	*Heptapleurum mitragerum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (S. 49791)	145
Figure 4.69	Distribution map of *H. mitragerum* in Sarawak	145
Figure 4.70	*Heptapleurum mjoebergii* (Merr.) G. M. Plunkett & Lowry (S. 80120)	148
Figure 4.71	Distribution map of *H. mjoebergii* in Sarawak	149
Figure 4.72	*Heptapleurum multiarcuatum* N. Ramnor & A. Puad, sp. nov. (S. 79219)	153
Figure 4.73	Distribution map of *H. multiarcuatum* sp. nov. in Sarawak	153
Figure 4.74	*Heptapleurum niahense* N. Ramnor & A. Puad, sp. nov. (S. 27296)	155
Figure 4.75	Distribution map of *H. niahense* sp. nov. in Sarawak	156
Figure 4.76	*Heptapleurum obovatilimbum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (S. 32387)	159
Figure 4.77	Distribution map of *H. obovatilimbum* in Sarawak	159
Figure 4.78	*Heptapleurum paulchaii* N. Ramnor & A. Puad, sp. nov. (S. 39612)	162
Figure 4.79	Distribution map of *H. paulchaii* sp. nov. in Sarawak	162
Figure 4.80	*Heptapleurum petiolosum* (Miq.) Seem. (S. 27442)	167
Figure 4.81	Distribution map of *H. petiolosum* in Sarawak	167
Figure 4.82	*Heptapleurum primackii* N. Ramnor & A. Puad, sp, nov. (S. 43348)	169
Figure 4.83	*Heptapleurum primackii* sp. nov. in Sarawak	170
Figure 4.84	*Heptapleurum puehense* N. Ramnor & A. Puad, sp. nov. (P. 4777)	172

Figure 4.85	Distribution map of *H.* of *H. puehense* in Sarawak	172
Figure 4.86	*Heptapleurum rhodorifolium* N. Ramnor & A. Puad, sp. nov. (S. 47804)	174
Figure 4.87	Distribution map of *H. rhodorifolium* sp. nov. in Sarawak	175
Figure 4.88	*Heptapleurum runiae* N. Ramnor & A. Puad, sp. nov. (S. 60085)	177
Figure 4.89	Distribution map of *H. runiae* sp. nov. in Sarawak	177
Figure 4.90	*Heptapleurum sabahense* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (S. 89467)	180
Figure 4.91	Distribution map of *H. sabahense* in Sarawak	181
Figure 4.92	*Heptapleurum semengohense* N. Ramnor & A. Puad, sp. nov. (S. 37628)	183
Figure 4.93	Distribution map of *H. semengohense* sp. nov. in Sarawak	183
Figure 4.94	*Heptapleurum subisense* N. Ramnor & A. Puad, sp. nov. (S. 89412)	185
Figure 4.95	Distribution map of *H. subisense* sp. nov. in Sarawak	186
Figure 4.96	*Heptapleurum tetrandrum* (Merr.) G. M. Plunkett & Lowry (S. 42578)	190
Figure 4.97	Distribution map of *H. tetrandrum* in Sarawak	191
Figure 4.98	*Heptapleurum trineurum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (S. 47740)	194
Figure 4.99	Distribution map of *H. trineurum* in Sarawak	195
Figure 4.100	*Heptapleurum truncatum* N. Ramnor & A. Puad, sp. nov. (S. 26749)	198
Figure 4.101	Distribution map of *H. truncatum* sp. nov. in Sarawak	198

Figure 4.102 *Heptapleurum verticillatum* N. Ramnor & A. Puad, sp. nov. (S. 28607) 201
Figure 4.103 Distribution map of *H. verticillatum* sp. nov. in Sarawak 202
Figure 4.104 *Heptapleurum yahudwatii* N. Ramnor & A. Puad, sp. nov. (S. 76345) 204
Figure 4.105 Distribution map of *H. yahudwatii* sp. nov. in Sarawak 204
Figure 4.106 *Heptapleurum yiipuanchingae* N. Ramnor & A. Puad, sp. nov. (S. 50387) 206
Figure 4.107 Distribution map of *H. yiipuanchingae* sp. nov. in Sarawak 207
Figure 4.108 *Heptapleurum* aff. avene (S. 65781) 209
Figure 4.109 *Heptapleurum* aff. *beamanii* (S. 35840) 212
Figure 4.110 *Heptapleurum* aff. *burkillii* (S. 19411) 214
Figure 4.111 *Heptapleurum* aff. *cephalotes* (S. 71978) 216
Figure 4.112 *Heptapleurum* aff. *crenatum* (S. 35961) 218
Figure 4.113 *Heptapleurum* aff. *havilandii* (S. 46812) 220
Figure 4.114 *Heptapleurum* aff. *lineamentorum* (S. 50433) 221
Figure 4.115 *Heptapleurum* aff. *mamutiacum* (S. 88377) 223
Figure 4.116 *Heptapleurum* aff. *mitragerum* (S. 78216). 225
Figure 4.117 *Heptapleurum* aff. *sabahense* (S. 39817). 226
Figure 4.118 *Heptapleurum* aff. *tetrandrum* (S. 96210). 228
Figure 4.119 *Heptapleurum* aff. *winkleri* (S. 48361) 230
Figure 4.120 *Heptapleurum* “anapense” 231
Figure 4.121 *Heptapleurum* “andersonii” 233
Figure 4.122 *Heptapleurum* “banyengii” 234

Figure 4.123 *Heptapleurum* “bidiense” 236

Figure 4.124 *Heptapleurum* “dinghoui” 237

Figure 4.125 *Heptapleurum* “lumutense” 239

Figure 4.126 *Heptapleurum* “murudense” 240

Figure 4.127 *Heptapleurum* “palutanense” 242

Figure 4.128 *Heptapleurum* “woenense” 243

LIST OF ABBREVIATIONS

A	Harvard University Herbaria
AAO	Area of occupancy
AAU	Aarhus University Herbarium
aff.	Species affinis
Bkt	Bukit
BO	Herbarium Bogoriense
c.	Circa
cm	Centimetre
CGE	Cambridge University Herbarium
diam.	Diameter
E	Royal Botanic Gardens Edinburgh Herbarium
IPNI	International Plant Names Index
IUCN	International Union for the Conservation of Nature
K	Royal Botanic Gardens Kew Herbarium
KEP	Forest Research Institute Malaysia (Kepong Herbarium)
Kpg.	Kampung
L	National Herbarium of the Netherlands, Leiden
m	Metre
mm	Millimetre
MO	Missouri Botanical Garden
Mt.	Mountain
NE	Northeast

Ng.	Nanga
NP	National Park
NW	Northwest
SAN	Sandakan Herbarium
SAR	Sarawak Herbarium
SBC	Sarawak Biodiversity Centre
SE	Southeast
Sg.	Sungai
SING	Singapore Botanic Gardens
sp. nov.	Species nova
SW	Southwest
Tg.	Tanjung
UKMB	Universiti Kebangsaan Malaysia Herbarium
Unimas	Universiti Malaysia Sarawak
US	United States National Herbarium

CHAPTER 1

INTRODUCTION

1.1 Study Background

Heptapleurum Gaertn. is a genus that belongs to the family Araliaceae and order Apiales. The genus was introduced in 1791 and its first species was from Sri Lanka (Gaertner, 1791). It is described as a small to medium-sized plant with many branches. Currently, there are 317 recognized species and 10 varieties in the newly reinstated genus, making *Heptapleurum* now the largest genus in Araliaceae. About 200 more species are yet to be published (Lowry & Plunkett, 2020). The genus is widely distributed in tropical and subtropical of Asia and several islands and archipelagos of western Pacific. The species can be found at various types of vegetation with altitude from 0 m up to 3600 m above sea level (Lowry & Plunkett, 2020).

Previously, all the *Heptapleurum* members were placed in the Asian clade of *Schefflera* J. R. Forst & G. Forst. Due to the polyphyly of *Schefflera,* the genus had to be restricted to its type (*S. digitata* J. F. Forst. & G. Forst.) and other seven members from the Pacific Islands. The resurrection of the genus *Heptapleurum* was done to place all the members of Asian clade of *Schefflera* (Lowry & Plunkett, 2020; Plunkett et al., 2020).

The Borneo island is the third largest island in the world and located at the southwestern part of the Pacific Ocean. There are three countries in Borneo which are Indonesia, Malaysia and Brunei. Kalimantan, Indonesia took the largest part of Borneo.

Sabah and Sarawak of Malaysia are situated at northwest and north tip of Borneo island respectively. They are also well known as East Malaysia. The smallest country in Borneo is Brunei, located between Sabah and Sarawak. Geographically, Borneo island is largely mountainous and some parts are lowlands especially in the central of Kalimantan and Sarawak. Mount Kinabalu is the highest peak in the island which is 4101 m above sea level. Some parts of Borneo are covered by navigable rivers which are very useful for human being in terms of transportation. The main river of East Malaysia is Rajang River, located in Sarawak. The climate in Borneo is hot and humid. It is wet monsoonal period between October till March and dry and calm of summer period for the rest of year. The average annual rainfall is 3800 mm. The wide variation of flora and fauna species in Borneo island is due to its dense rainforest (The Editors of Encyclopaedia Brittanica, 2019).

Sarawak, with a size of 12.4 million hectares has been highly acknowledged as a place with rich of biodiversity and high plant diversity. According to the Forest Department Sarawak (2022), as of February 2022, the land area of Sarawak consists of mixed dipterocarp (58.8%), peat swamp (2.6%), mangrove forest (0.6%) and others (38.5%). The others are including heath (kerangas), montane, beach or littoral, riverine or alluvial, limestone and secondary forest (Tawan et al., 2008). For the record, there are more than 8000 species of vascular plant species that found in Sarawak. Over 2000 tree species have been enumerated, more than 1000 orchids, 757 ferns and 260 palms are identified and there will be more new species that yet to be found and studied (Forest Department Sarawak, 2022).

The species of *Heptapleurum* are found in various habit such as trees, shrubs, woody epiphytes, hemiepiphytes and climbers. They can be easily recognized through their

distinctive palmate compound leaves arranged either alternately or spirally along their stems (Ahmad Puad et al., 2018). Several *Heptapleurum* species such as *H. actinophyllum* (Endl.) Lowry & G. M. Plunkett and *H. arboricola* Hayata are very popular as house plant. Some of the species have medicinal values. For example, *H. actinophyllum* is used in herbal medicine to promote blood circulation and reduce pain (Usvat, 2014).

At present, the number of *Heptapleurum* in Sarawak is still unknown. *Heptapleurum* species in Sarawak is still understudied and poorly understood. Therefore, a thorough study of this genus is much needed to figure out the number of *Heptapleurum* species occuring in Sarawak, its ecology and distribution to better understand this challenging genus.

1.2 Problem Statement and Objectives

The genus *Heptapleurum* especially on Borneo is still understudied until today. Although a study on *Heptapleurum* in Sabah, Malaysian Borneo has been carried out by Ahmad Puad et al. (2018), there are still much work that need to be done in Sabah as well as Sarawak specifically and Borneo generally. This is important in order to make progress and have a better understanding of this genus. There are many *Heptapleurum* species in Sarawak based on Sarawak Herbarium but the information on the species is still very limited. The distribution of *Heptapleurum* species in Sarawak for most species is remain uncertain until today. Therefore, more studies are needed to provide more understanding on *Heptapleurum* of Sarawak.

Prior to the relocation of all species in the Asian clade of *Schefflera* into *Heptapleurum* (Lowry & Plunkett, 2020), the information on the species in Sarawak are

scattered in several publications such as in Naturlichen Pflanzenfamilien (Harms, 1894), Repertorium Specierum Novarum Regni Vegetabilis (Harms, 1917), The Philippine Journal of Science (Merrill, 1918a), Journal of the Straits Branch of the Royal Asiatic Society (Merrill, 1918b) , Sarawak Museum Journal (Merrill, 1928), Kew Bulletin (Ridley, 1946), Webbia (Merrill, 1950), World Checklist & Bibliography Araliaceae (Frodin & Govaerts, 2003) and The Genus *Schefflera* in Sabah, Malaysian Borneo (Ahmad Puad et al., 2018).

Therefore, the objectives of this study were: 1) to revise the genus *Heptapleurum* in Sarawak including a taxonomic key to species in Sarawak and description of novel species; 2) to describe all of the *Heptapleurum* species in Sarawak and 3) to determine the distribution of *Heptapleurum* species in Sarawak .

CHAPTER 2

LITERATURE REVIEW

2.1 Araliaceae

Araliaceae or also known as the ginseng family of the flowering plants is classified under the order Apiales. According to APG IV (2016), the family comprise of 46 accepted genera. It is widely distributed with most species in the tropics and subtropics. The family can be found as herbs, shrubs, trees, or lianas with prickly or stellate hairs, sometimes palm-like, a few root-climbers. The major genera under Araliaceae are *Aralia* L. (67 species), *Dendropanax* Decne. & Planch. (92 species), *Eleutherococcus* Maxim. (38 species), *Hedera* L. (15 species), *Heptapleurum* Gaertn. (317 species), *Oreopanax* Decne. & Planch. (148 species), *Osmoxylon* Miq. (60 species), *Polyscias* J. R. Forst & G. Forst (116 species) and *Sciodaphyllum* P. Browne (131 species) (Frodin & Govaerts, 2003; Lowry et al., 2020; Lowry & Plunkett, 2020).

The noticeable features that can be seen in Araliaceae are the leaves often large, palmate, pinnate or simple, always spiral but rarely opposite or whorled and mostly with stipule (Simpson, 2010). There have been evolutionary development occurred in the inflorescence of Araliaceae. The inflorescences are either cymoid and racemoid with an advanced to cymoid, branches rearranged from paniculate to compound-umbellate, reduced to a single terminal umbellule, the development of inflorescence axis have been delayed resulting in pseudolateral position of inflorescence underneath the vegetative rosette, from numerous primary branches to fewer up to one, decreased in length of inflorescence axis including the compound umbellate inflorescence, sexual specialization within the

inflorescence and pachycaulous to leptocaulous inflorescence in which both can be observed in *Heptapleurum* (Frodin, 1982).

The flowers are small, actinomorphic, pentamerous and usually in umbels. Based on the study by Nuraliev et al. (2010), there are four groups of flowers that have been identified in the Araliaceae. The groups are namely Asian *Schefflera* clade (including *Tupidanthus*), *Plerandra, Tetraplasandra* and *Osmoxylon* group. From these groups, several trends in the structure of flowers have been observed such as the calyx reduction, increase in the number of stamen whorls and overall flower merism or only stamen, increase or decrease number of carpel, congenital fusion of petal with postgenital closure of corolla into a calyptra and appearance of either dissymmetrical or asymmetrical of flower throughout its development. It is suggested that the pentamerous tetracyclic polysymmetric flowers in Araliaceae is primitive. However, multiple losses were noticed during the construction of flowers possibly by evolution (Nuraliev et al., 2010). The ovary is inferior and each locule has single ovule. The fruit is a berry (Singh, 2010).

Araliaceae is pretty much known for its ornamental foliage plants such as *Heptapleurum, Fatsia japonica* (Thunb.) Decne. & Planch., *Eleutherococcus, Aralia* and *Hedera*. The cultivars of *Hedera helix* L. (Ivy) are usually used as houseplants. Some plants also being used medically such as roots of Ginseng plant (*Panax ginseng* C.A.Mey.) from China and Korea as stimulant and aphrodisiac (Singh, 2010). The barks, roots, stems and leaves of *Aralia* also being used as a traditional medicine for treating some sickness such as hepatitis, rheumatoid arthritis, bruises, lumps and carbuncles (Xu et al., 2022).

Previously, *Schefflera* J. R. Forst & G. Forst was known as the largest genus in Araliaceae with over 600 species. However, after several studies had shown that *Schefflera* is polyphyletic, most of the species had to be transferred out into the new genera which are *Astropanax* Seem. (33 species) (Lowry et al., 2017), *Cephalopanax* G. M. Plunkett, Lowry & D. A. Neill (2 species) (Plunkett et al., 2021), *Crepinella* Marchal. (32 species) (Lowry et al., 2019), *Didymopanax* Decne. & Planch. (37 species) (Fiaschi et al., 2020), *Frodinia* Lowry & G. M. Plunkett (2 species) (Plunkett et al., 2021), *Heptapleurum* Gaertn. (317 species) (Lowry & Plunkett, 2020), *Neocussonia* (Harms) Hutch, (16 species) (Lowry et al., 2017), *Plerandra* A. Gray (33 species) (Lowry et al., 2013) and *Sciodaphyllum* P. Browne (131 species) (Lowry et al., 2020). After moving all of the species to its respective genera, genus *Heptapleurum* is currently known as the largest genus in Araliaceae (Lowry & Plunkett, 2020).

2.2 Genus *Heptapleurum* Gaertn.

2.2.1 General Characteristics of the Genus *Heptapleurum*

The genus *Heptapleurum* can be found in various forms and has a woody habit such as trees, shrubs and woody epiphytes, hemiepiphytes or climbers. For example, *H. lanatum* may grow up to 20 m tall with trunk diameter of 20 cm. In contrast, the climber plant, *H. trineurum* grows only up to 2 or 3 m above ground with 1 cm of diameter of its stem (Ahmad Puad et al., 2018).

The species of genus *Heptapleurum* are palmately compound leaves, fused stipules extending into ligula appendage at the base of petiole, panicles that have inflorescence of umbels, capitula, racemules or spicules with the absence of articulation at the pedicel and no

prickles at the vegetative organs (Frodin, 1975). The number of leaflets ranging from one to as many as 18. Some of the species produced a single leaf with 10-cm long petiole while other species have leaves with petiole that can grow up to 100 cm in length (Ahmad Puad et al., 2018).

2.2.1.1 Stems

In *Heptapleurum,* the stem growth pattern is sympodial. Sympodial growth pattern is the growth of a shoot from the terminal meristem. When the terminal meristem forms an inflorescence, the shoot still can continue growing if only a lateral bud initiates a new meristem to produce a new shoot. This will produce a rhythmic series of successive shoots in a "zig-zag" manner, each with terminal inflorescence. In the beginning of the stem development, it is seen as rather pithy organ. The sapwood is formed as the shoot starts to mature and the larger "palmoid" species tend to have a bigger ratio of pith to sapwood. The ratio helps in giving the structural support for certain species to protect them from breakage owing to bad weather or fallen neighbouring trees. The species such as *H. lanatum* and *H. lineamentorum* have more sapwood in their stems for mechanical support. It is still unknown whether the environment plays a major role in the development of stem structures and compositions (Ahmad Puad et al., 2018).

2.2.1.2 Leaves

The leaves of *Heptapleurum* species are palmately compound and produced in alternate or spiral manner. The petiole is a more or less stem-sheathing base and well-developed basal stipular ligule. The sheath and ligule are less obvious when the stem starts to thicken in mature growth. The petioles may appear round (terete) in cross-section or

flattened on upper surface and they vary in length. The number of leaflets ranging from about five to 18 the most. Some species have their leaflets reduced to three (trifoliolate) and a few species are unifoliate such as *H. avene.* The leaflets of *H. bipalmatifolium* are twice compound with 30 or more leaflets (Ahmad Puad et al., 2018).

There are many different sizes, shapes, thickness, margins and venation shown on different leaf blades of *Heptapleurum* species. Most of the apex of leaves are rounded and some species are either acuminate, caudate or combination of both. The indumentum on upper surface of leaves are quite rare. Some species such as *H. lanatum* and *H. beamanii* (Puad, T. J. Barkman & Frodin) Puad, T. J. Barkman, Lowry & G. M. Plunkett shows hairy undersurface of the leaves. The venation of the leaves is described in terms of first-order, second-order and higher-order veins (Ahmad Puad et al., 2018).

2.2.1.3 Inflorescences

The inflorescences are compound and can also referred as being paniculate. There are three main section which are primary axis, secondary axis and tertiary axis. The primary axis consists of two parts which are Limitation zone and Branching zone. The Limitation zone is the final part of stem before transition, partly vegetative and partly reproductive. The length is measured from the last leaf to the first inflorescence branch. Figure 2.1 illustrates the limitation zone and branching zone of *H. mangiferifolium.*

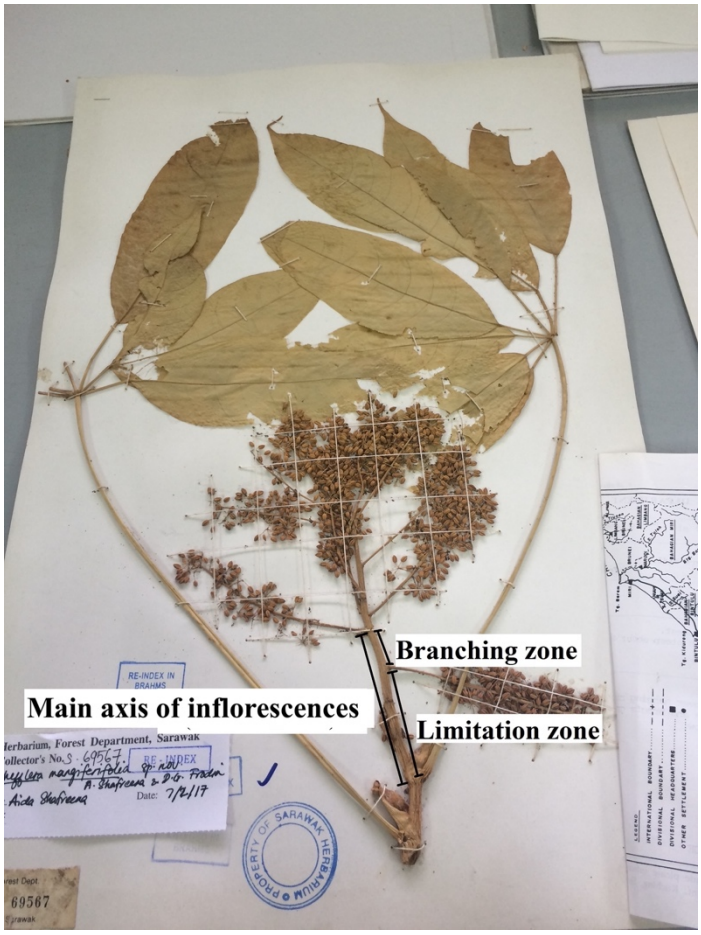


Figure 2.1: Limitation zone and branching zone of *Heptapleurum mangiferifolium.*

2.2.1.4 Flowers

The flowers of *Heptapleurum* species are small, radially symmetrical and less than 1 cm in diameter on average. The flowering and production of pollen period of *Heptapleurum* are very short as most of the petals are likely to fall off right after the buds open. Stamens play a major role in attracting the pollinators because it is longer than petals in length and it falls after the pollens are wholly shed. They are arranged alternately with the petals. They will elongate upwards and outwards once been released from bud (Ahmad Puad et al., 2018).

Calyx of the flowers are made up of entirely united sepals, more or less wholly fused with the ovary to form a cupule. It is hard to notice the cupule on the flowers. The calyx-rim

is an unfused portion of calyx, approximately 1 mm in height and may exist beyond the top of the cupule (Ahmad Puad et al., 2018).

There are two basic types of corolla that can be found in Bornean species. Some species shows the opening of petals from the bud apex. The petals are persistent and can be seen easily such as shown in *H. pachyphlebium* (Merr.) G. M. Plunkett & Lowry, *H. crenatum* and *H. matsallehii* (T. J. Barkman, Puad & Frodin) T. J. Barkman, Puad, G. M. Plunkett & Lowry. However, some of the other species have calyptrate corollas in which the fused petals separate from the base just above the calyx-rim and easily fall off from the flowers (Ahmad Puad et al., 2018).

The ovary of the flower is fused to the calyx and developed above it to form a disk or dome. The degree of superiority or inferiority of the ovary is usually known by observing the proportion of the ovary extended above the calyx. *Heptapleurum* is known to have inferior ovary in which the calyx covered more than half the ovary. The ovary is divided into three or more locules. The inner surface of locules will eventually turn into hard endocarp that will surround the seeds. The whole seed is known as pyrene (Ahmad Puad et al., 2018).

2.2.1.5 Fruits

The structure of the fruits in *Heptapleurum* are known as drupes. The seed coat is thin but the endocarp becomes lignified and mesocarp remains juicy until maturity. Exocarp will develop in the skin and it is highly responsible for the colour change when the fruits start to ripe. The maturity of fruits can be known through colours. Young fruits will show green colour and it will slowly turn into yellow, orange and red. When the fruits turn purple

or black, it indicates the end of maturity. The surface of fruits can be hairy when young and slowly it loses the indumentum as the fruits mature. When the fruits are ripening, the disk is more striking in colour, texture or both to attract dispersers (Ahmad Puad et al., 2018).

2.2.2 Distribution of *Heptapleurum*

Heptapleurum species can be found in most tropical and subtropical areas in Asia and also on the several islands and archipelagos of the western Pacific (Lowry & Plunkett, 2020). Some of the species are distributed widely and some are restricted. For example, *H. ellipticum* is one of the species that is widely distributed across Southeast Asia. *Heptapleurum tambuyukonense* (T. J. Barkman, Puad & Frodin) T. J. Barkman, Puad, G. M. Plunkett & Lowry on the other hand is found only limited to northwestern Sabah. Additionally, *H. filipes* (Merr.) Lowry & G. M. Plunkett only found at the south and southeast part of Sabah. In Sarawak, *H. mjoebergii* is endemic on Mount Murud. There are some *Heptapleurum* species that are endemic to Borneo such as *H. bipalmatifolium* and *H. kuchingense* (Ahmad Puad et al., 2018).

Based on Lowry and Plunkett (2020), the elevation of the *Heptapleurum* species is ranging from sea level up to 3600 m. Similar to the distribution, some species have wide ranges of elevation while some are restricted at certain elevation. For instance, the elevation ranges of *H. ellipticum, H. sabahense* and *H. avene* are wide which is from low up to over 1000 m. In contrast, *H. pachyphlebium* and *H. tambuyukonense* can only be found at elevation over 2000 m on Mount Kinabalu and Mount Tambuyukon in Sabah. As for *H. filipes, H. mangiferifolium*, *H. matsallehii* and *H. viridicephalum* (Puad & Frodin) Puad, T.

J. Barkman, G. M. Plunkett & Lowry, it can be found at elevation up to 500 m above sea level. (Ahmad Puad et al., 2018).

2.2.3 Systematics of *Heptapleurum*

Heptapleurum Gaertn. was firstly introduced in 1791. The first plant of the genus was found in Sri Lanka (Gaertner, 1791). Previously, *Heptapleurum* was subsumed under the genus *Schefflera* together with the other genera such as *Sciodaphyllum* P. Browne*, Paratropia* DC.*, Brassaia* Endl.*, Plerandra* A. Gray*, Tupidanthus* Hook.f. & Thomson*, Parapanax* Miq.*, Agalma* Miq.*, Didymopanax* Decne. & Planch. and *Astropanax* Seem. (Baillon, 1878; Harms, 1894-97).

Several phylogenetic analyses had shown that *Schefflera* is polyphyletic and none of the five clades under *Schefflera* are related (Fiaschi & Plunkett, 2011; Gostel et al., 2017; Li & Wen, 2014; Plunkett et al., 2005, 2020; Plunkett & Lowry, 2012). Due to that finding, *Schefflera* had to be restricted to its type which is *S. digitata* J. R. Forst & G. Forst with other seven Pacific Island species that belongs to the same clade. All the species that were belong in the African-Malagasy, Asian, Melanesian and Neotropical clades have to be transferred out of *Schefflera* into the new genera.

Plerandra A. Gray (Lowry et al., 2013) is expanded to accommodate the species in Melanesian clade based on the phylogenetic study by Plunkett and Lowry (2012). Based on the phylogenetic analyses done by Gostel et al. (2017), the members in African-Malagasy clade are now placed in newly resurrected genera which are *Astropanax* Seem. and *Neocussonia* (Harms) Hutch. (Lowry et al., 2017). The phylogeny of Neotropical *Schefflera*

had been studied by Fiaschi and Plunkett (2011) and Plunkett et al. (2020) and resulted that each subclade in Neotropical group has to be treated as separate groups (Lowry et al., 2020). Therefore, there are five genera, namely *Sciodaphyllum* P. Browne (Lowry et al., 2020), *Crepinella* Marchal (Lowry et al., 2019), *Didymopanax* Decne. & Planch. (Fiaschi et al., 2020), *Cephalopanax* and *Frodinia* (Plunkett et al., 2021).

Finally, the genus *Heptapleurum* was resurrected and all the members of Asian clades of *Schefflera* were transferred into *Heptapleurum.* After transferring all the species, it is reported that genus *Heptapleurum* is currently the largest genus in Araliaceae with 317 species and 10 varieties. It was estimated that there are about 200 new *Heptapleurum* species that have not been described yet (Lowry & Plunkett, 2020).

2.2.4 Uses and economic importance of *Heptapleurum*

The genus *Heptapleurum* is popularly cultivated as an ornamental plant owing to the leaves arranged in a ray-like formation, making the plant to look like an umbrella and low maintenance plant. Some of the famous *Heptapleurum* ornamental plants are *H. actinophyllum* (Endl.) Lowry & G. M. Plunkett and *H. arboricola* Hayata (DeFilipps, 1992). However, *H. arboricola* has been reported to be an invasive species in the Mediterranean area (Badalamenti, 2021).

Besides that, *Heptapleurum* also contains medicinal values that can help in treating some diseases. For example, *H. leucanthum* (R. Vig) Y. F. Deng has a high potential as an anti-cancer or as a source of antioxidants, anti-hyperpigmentation and antibiotics based on the extraction from the leaves (Potduang et al., 2007; Wang et al., 2021). Another

Heptapleurum species that contains a natural source of antioxidant is *H. stellatum* Gaertn. (Hebbar & Nalini, 2014; Ramakrishnan et al., 2022) that has strong cytotoxic activity against lung cancer line of A549 (Ramakrishnan et al., 2022). In Chinese medicine, the leaves, stem and roots of *H. actinophyllum* are used to prepare herbal medicine owing to the properties of bitter, sweet and warm that can be tasted from the medicine. The medicine is consumed to promote blood circulation and relieve pain. It is also can be used externally as it can be ground into a paste to treat injuries and stop the bleeding (Usvat, 2014).

2.2.5 The importance of herbarium specimens in scientific research

Herbarium specimens is a collection of dried plant materials at various location that have been preserved, flattened, dried and finally mounted on the herbarium sheet. For the reproductive parts of plants such as flowers and fruits, a paper pocket is used to store them. All the herbarium specimens are usually equipped with a label that contains information such as species name, date of collection, collector's name, locality, habitat and notes by the collectors (Frank, 2016).

The earliest time of making herbarium specimens was in the 16th century. An Italian physician and botanist, Luca Ghini (1490-1556) introduced the idea to his students while he was teaching in Bologna and Pisa, Italy (Stafleu & Cowan, 1976). During that time, the plant materials were bind using a book (Bridson & Forman, 1998). Later on in the 18th century, Carl Linnaeus collected numerous amounts of plant and found that Ghini's way was too challenging for him to store his massive plant collections. To solve the issue, he mounted each of his specimens on a paper sheet and stored them in cabinets. Up to today, Linnaeus' method is still working for storing the herbarium specimens (Müller-Wille, 2006).

Herbarium specimens can help researchers in various studies such as in taxonomy, morphology, systematics, anatomy, conservation, ecology, biodiversity, ethnobotany and paleobiology (Funk, 2003; Lavoie, 2013). There are numerous studies that have been done using the plant materials from the herbarium.

There are multiple studies of biodiversity that have been done using herbarium specimens. It is because the collections were made in different places and time (Le Bras et al., 2017). Magrini and Scoppola (2010) used herbarium specimens of three European *Ophioglossum* species (ferns) to get a better understanding of their taxonomic position using the method of geometric morphometrics. Some of the plants such as genus *Androsace* (rockjasmines) were poorly understood due to the plants growing in remote area such as at high elevation. The historical herbarium samples helped to acknowledge the taxonomy complex of the rockjasmines in temperate mountains of the Northern Hemisphere (Dentant et al., 2018). For the assessments of climate and environmental change, Hufft et al. (2018) and Meineke et al. (2018) stated that the used of specimens from herbarium were practical to provide the historical patterns for analyzing the global climate change and phenological drivers.

There are also few studies of chemical composition in plants using herbarium specimens. For example, to find out the air quality on selected location in Germany, Herpin et al. (1997) used moss specimens from herbarium collected between the year of 1845 and 1974 to analyze and compare the chemical composition of heavy metals with the moss specimens in 1991. Nielsen et al. (2017) and Shotbolt et al. (2007) also chose moss

herbarium samples to assess the chemical deposition over the time. In order to understand the functional trait diversity of alpine plants on the Swiss Alps, Körner et al. (2016) used the herbarium specimens for capturing the isotopes of carbon nitrogen. For study of the medicinal plant, Foutami et al. (2018) utilized the herbarium collections of a few *Salvia* species for the analysis of terpenoid.

With the advancement of technology nowadays, many herbaria have been digitizing the herbarium specimens. This action can help researchers to improve their study and observe more samples (Smith & Blagoderov, 2012). Before the study done by Cámara-Leret et al. in 2020, the information about the diversity of vascular plant of New Guinea was lacking despite the island is the largest tropical island in the world and known to have a high plant diversity. They mainly used the online taxonomic resources for this study (Cámara-Leret et al., 2020). Not only that, current modern technology also can perform the genomic sampling of herbarium specimens together with DNA sequencing and bioinformatics that can be used for the molecular work to do the phylogenetics analysis. This method helps to understand the evolutionary origins of plant species. For example, the phylogenetics analysis of genus *Themeda* was done using chloroplast genomes and nuclear ITS markers obtained from the herbarium samples (Dunning et al., 2017). The phylogenetics of the genus *Ambrosia* (Asteraceae) also have been done using herbarium collections (Martin et al., 2018). As for the study of the extinct genus, the herbarium specimens of *Hesperelaea* that were collected in 1875 for the first mitogenome reconstruction of Oleaceae (Van de Paer et al., 2016).

CHAPTER 3

MATERIALS AND METHODS

3.1 Herbarium specimens

This study was conducted by investigating on the herbarium specimens from Sarawak Herbarium (SAR) and Universiti Malaysia Sarawak (UNIMAS). A total of 583 herbarium specimens have been observed for this study that include 513 specimens from SAR and 70 from Unimas. The information such as species name, collection number, collectors' name, collection date, locality, habitat and notes were recorded in the Excel.

3.2 Species identification

The identification of the *Heptapleurum* species was done by referring to the latest annotation note on the herbarium specimens. The names were gathered to be checked on the website International Plant Names Index (IPNI) (https://www.ipni.org). If the name was available on IPNI search, the species had already been published. In contrast, if there was no result shown on IPNI, the species was identified as unpublished. Some specimens were identified as the *species affinis* of the published names so therefore, they were being placed under the imperfectly known taxa together with the specimens with incomplete herbarium specimens.

3.3 Morphological observation

All the vegetative and reproductive parts of *Heptapleurum* specimens were observed and recorded. The measurement was done according to description by Ahmad Puad et al. (2018). For the vegetative part, number of leaflets per palmate were noted. The petiole and petiolules' dimension and the length and width of blades were measured. The shape, apex, margin, base and surface features on the leaf blades were recorded. Stipular ligule was seen on its attachment, length and shape. The venation's characteristics and number of pairs were observed and recorded as well.

For the observation on the reproductive parts of *Heptapleurum*, the main axis of inflorescence (or infructescence) was measured. It is the length from the last leaf up to the main axis. The main axis consists of two parts which are limitation zone and branching or Branching zone. The length and surface of inflorescence branches were measured and recorded. The number and arrangement of umbels along the branches were also included. In each of the umbels along the branches, the details such as number of flowers or fruits per umbel, peduncles and pedicels' dimension and other distinct characteristics were taken. For flowers and fruits, the traits such as shape, dimension, cupule, calyx, petals, ovary, stamen, style and stigma were observed and recorded.

The measurement was done by using measuring tape and Vernier caliper. A stereo microscope, Olympus DP72 was used to aid in observing the small parts that was hardly observed by naked eyes. The description of species was made after the observation and measurement of all the available specimens. The distinct feature on every species were taken for the taxonomic key.

3.4 Construction of distribution map of *Heptapleurum* species in Sarawak

The distribution map of *Heptapleurum* species in Sarawak was created using a software 'ArcMap 10.3'. The spatial data were map of Sarawak, boundary of Sarawak, Malaysia, Brunei and Indonesia and South China Sea. The Digital Elevation Model (DEM) of East Malaysia was used for the projection of elevation on the map. The geodetic reference system that in the map is WGS 84. Figure 3.1 shows the Sarawak map that was used in the distribution of *Heptapleurum* taxa in Sarawak.

The attribute data for the map was the coordinates of all *Heptapleurum* specimens in SAR. The coordinates were expressed in both degrees, minutes, seconds and decimal degrees. Out of 583 total specimens, there were only 134 specimens with coordinates. The specimens without coordinates were being georeferenced by referring to the Sarawak Gazetteer (Mohizah et al., 2006), Google Map and Mapcarta based on their locality name on the herbarium label.

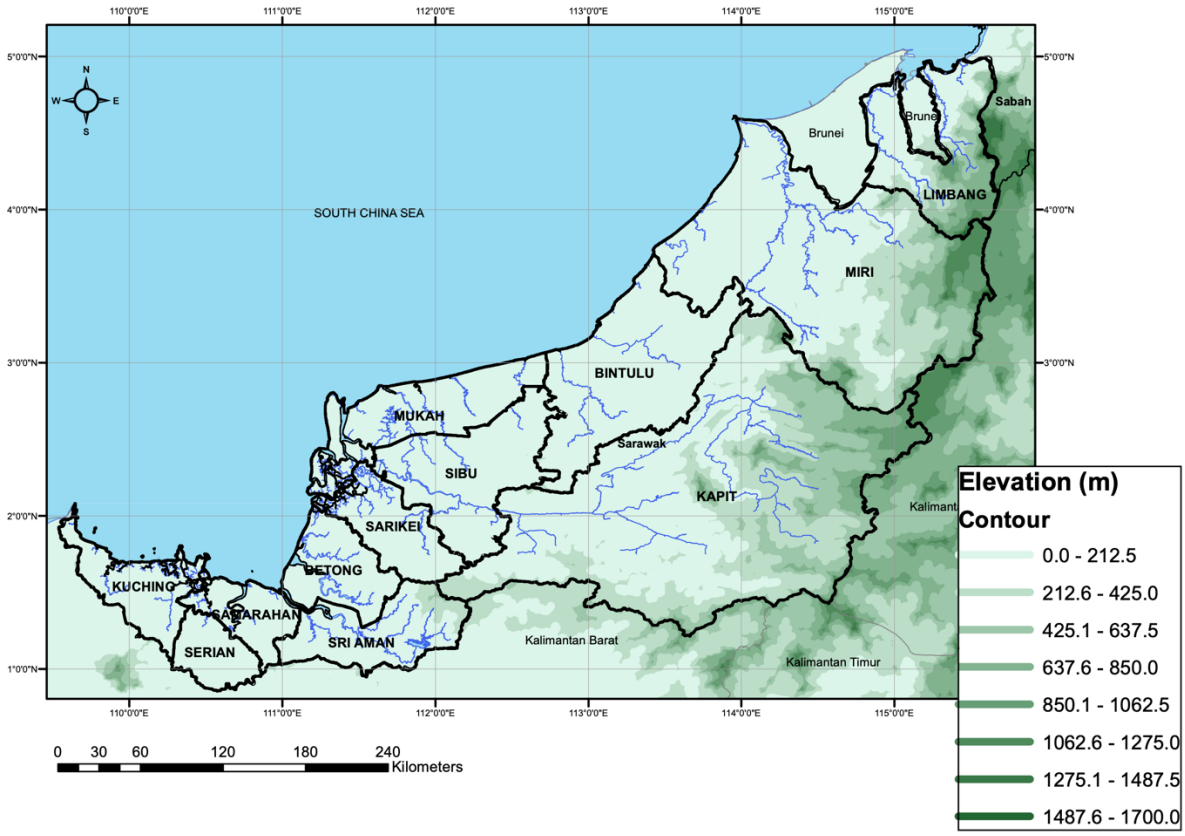


Figure 3.1: Map of Sarawak that is used to show *Heptapleurum* species distribution.

3.5 IUCN Red List Assessment

The assessment of IUCN Red List was done to provide the conservation status on the species (IUCN, 2022). The entire assessment was based on the georeferenced herbarium specimens following the IUCN Red List categories and criteria, version 3.1, second edition (IUCN, 2012). The extent of occurrence (EOO) and area of occupancy (AOO) were analysed using GeoCAT (https://geocat.kew.org/editor). According to Rivers et al. (2011), the number of herbarium specimens needed to obtain the consistent range estimates for conservation assessments is 15. Therefore, 11 *Heptapleurum* taxa were assessed in this study, namely *H. avene, H. elipticum, H. havilandii, H. littorale, H. mangiferifolium, H. multiarcuatum, H. petiolosum, H. tetrandrum, H. trineurum, H. truncatum* and *H.*

verticillatum. The rest of taxa were categorized as Data Deficient (DD). The imperfectly known taxa were not being assessed.

CHAPTER 4

RESULTS

4.1 *Heptapleurum* taxa in Sarawak

A total of 583 herbarium specimens were observed in this study. Currently, about 73 *Heptapleurum* taxa that have been identified with 25 of them are published names (Ahmad Puad et al., 2018; Frodin & Govaerts, 2003; Harms, 1894, 1917; Merrill, 1918a, 1918b, 1928, 1950; Ridley, 1946), 27 unpublished names and 21 imperfectly known taxa. Imperfectly known taxa were the *species affinis* of the published names and distinct species with incomplete specimens. A total of 30 specimens were not able to be identified owing to it being sterile. Therefore, they were placed under the unidentified *Heptapleurum.* All of the specimens were available in Sarawak Herbarium (SAR) and Universiti Malaysia Sarawak (Unimas). The list of published names is shown in Table 4.1 while the list of unpublished names is shown in Table 4.2. The taxon with the highest number of specimens in SAR is *H. petiolosum* with 49 specimens while about 22 taxa with only one specimen available in the herbarium. Figure 4.1 shows the number of specimens of *Heptapleurum* taxa in SAR and Unimas Herbarium.

Table 4.1: Published names of *Heptapleurum* species in Sarawak.

Published names of *Heptapleurum* species in Sarawak
1. *H. acutissimum* (Miq.) Seem.
2. *H. avene* (Miq.) Seem.
3. *H. beccarianum* (Harms) Lowry &. G. M. Plunkett

Table 4.1 continued

4. *H. bipalmatifolium* (Merr.) Lowry & G. M. Plunkett
5. *H. borneense* (Merr.) Lowry & G. M. Plunkett
6. *H. burkillii* (Merr.) Lowry & G. M. Plunkett
7. *H. cephalotes* C. B. Clarke
8. *H. crenatum* (Puad & Frodin) Puad, T. J. Barkman, Lowry & G. M. Plunkett
9. *H. ellipticum* (Blume) Seem.
10. *H. havilandii* (Merr.) Lowry & G. M. Plunkett
11. *H. kuchingense* (Merr.) Lowry & G. M. Plunkett
12. *H. lanatum* (Frodin, Puad & T. J. Barkman) Puad, T. J. Barkman, Lowry & G. M. Plunkett
13. *H. lasiocalyx* (Ridl.) Lowry & G. M. Plunkett
14. *H. laxiflorum* (Ridl.) Lowry & G. M. Plunkett
15. *H. lineamentorum* (Frodin & Puad) Puad, T. J. Barkman, Lowry & G. M. Plunkett
16. *H. littorale* (Miq.) Boerl.
17. *H. mamutiacum* (Puad, T. J. Barkman & Frodin) Puad, T. J. Barkman, G. M. Plunkett & Lowry
18. *H. mangiferifolium* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry
19. *H. mitragerum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry
20. *H. mjoebergii* (Merr.) G. M. Plunkett & Lowry
21. *H. obovatilimbum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry
22. *H. petiolosum* (Miq.) Seem.
23. *H. sabahense* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry
24. *H. tetrandrum* (Merr.) G. M. Plunkett & Lowry

Table 4.1 continued

25. *H. trineurum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry

Table 4.2: Unpublished names of *Heptapleurum* taxa in Sarawak.

Unpublished names of *Heptapleurum* taxa in Sarawak
1. *H. abangmohtari* sp. nov.
2. *H. asahii* sp. nov.
3. *H. barioense* sp. nov.
4. *H. bernardleei* sp. nov.
5. *H. bidenticarpum* sp. nov.
6. *H. bracteosum* sp. nov.
7. *H. brookeanum* sp. nov.
8. *H. burianum* sp. nov.
9. *H. conjunctum* sp. nov.
10. *H. ensiriengense* sp. nov.
11. *H. glaucophyllum* sp. nov.
12. *H. lesongense* sp. nov.
13. *H. lubangbayanense* sp. nov.
14. *H. multiarcuatum* sp. nov.
15. *H. niahense* sp. nov.
16. *H. palutanense* sp. nov.
17. *H. paulchaii* sp. nov.
18. *H. primackii* sp. nov.

Table 4.2 continued

19. *H. puehense* sp. nov.
20. *H. rhodorifolium* sp. nov.
21. *H. runiae* sp. nov.
22. *H. semengohense* sp. nov.
23. *H. subisense* sp. nov.
24. *H. truncatum* sp. nov.
25. *H. verticillatum* sp. nov.
26. *H. yahudwatii* sp. nov.
27. *H. yiipuanchingae* sp. nov.

Table 4.3: Imperfectly known *Heptapleurum* taxa in Sarawak

Imperfectly known *Heptapleurum* taxa in Sarawak
1. *Heptapleurum* aff. *avene*
2. *Heptapleurum* aff. *beamanii*
3. *Heptapleurum* aff. *burkillii*
4. *Heptapleurum* aff. *cephalotes*
5. *Heptapleurum* aff. *crenatum*
6. *Heptapleurum* aff. *havilandii*
7. *Heptapleurum* aff. *lineamentorum*
8. *Heptapleurum* aff. *mamutiacum*
9. *Heptapleurum* aff. *mitragerum*
10. *Heptapleurum* aff. *sabahense*
11. *Heptapleurum* aff. *tetrandrum*

Table 4.3 continued

12. *Heptapleurum* aff. *winkleri*
13. *Heptapleurum* “anapense”
14. *Heptapleurum* “andersonii”
15. *Heptapleurum* “banyengii”
16. *Heptapleurum* “bidiense”
17. *Heptapleurum* “dinghoui”
18. *Heptapleurum* “lumutense”
19. *Heptapleurum* “murudense”
20. *Heptapleurum* “palutanense”
21. *Heptapleurum* “woenense”

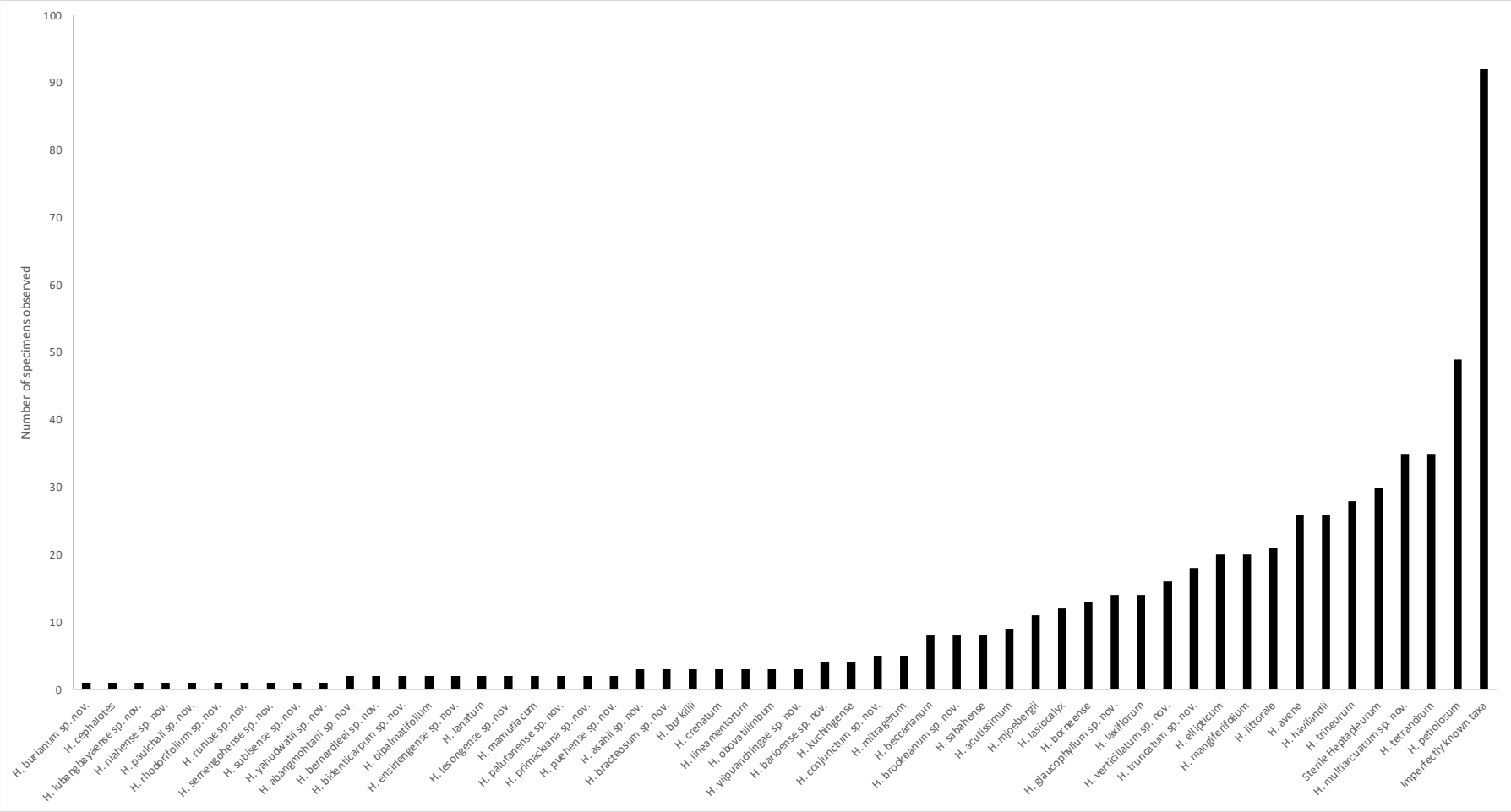


Figure 4.1: The number of specimens of each *Heptapleurum* taxa in Sarawak.

Heptapelurum petiolosum has the highest number of specimens available which is 49. There are 11 taxa with only one specimen, namely *H. burianum, H. cephalotes, H. lubangbayaense, H. lumutense, H. murudense, H. niahense, H. paulchaii, H. rhodorifolium, H. semengohense, H. subisense* and *H. yahudwatii.*

4.2 Distribution of *Heptapleurum* taxa in Sarawak

A total of 583 specimens were used to map out the distribution of all *Heptapleurum* taxa in Sarawak. The distribution of *Heptapleurum* taxa in Sarawak is shown in the Figure 4.2.

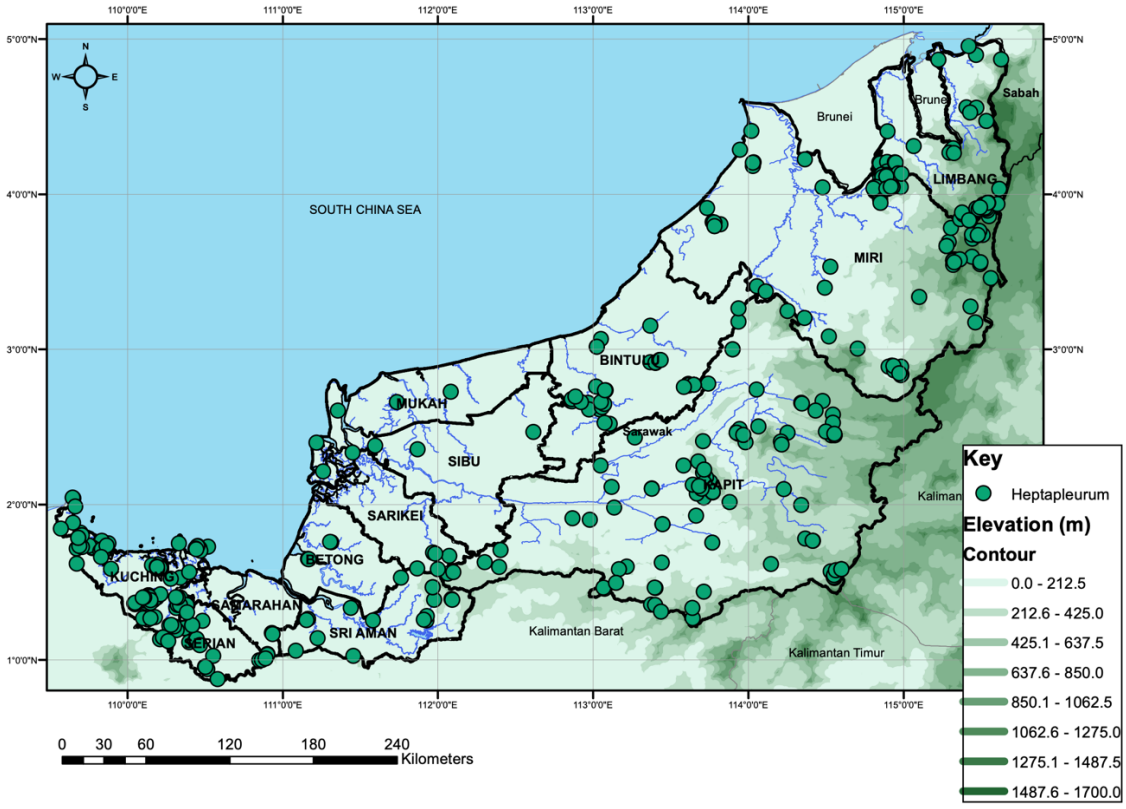


Figure 4.2: The distribution of *Heptapleurum* taxa in Sarawak.

Based on the Figure 4.2, *Heptapleurum* species can be found throughout Sarawak. The most *Heptapleurum* collections were from Kuching, Miri and Kapit. However, the bias in sampling can also be seen in most of the divisions especially in Miri. It is obvious that the collections were massively done in Kelabit Highlands area where Pulong Tau National Park is located at and Gunung Mulu National Park. In Bintulu, most of the *Heptapleurum* specimens were collected in Tatau area. There were 18 collections in Sri Aman and 17 specimens were found in Limbang. About 13 specimens were collected in Serian at limestone vegetation. For the rest of the Sarawak divisions which are Samarahan, Betong, Sarikei, Sibu and Mukah, less than 10 specimens were reported.

Some of the *Heptapleurum* taxa have restricted distribution in Sarawak in which they were recorded at certain part of Sarawak only while the others can be found throughout Sarawak. There are nine taxa distributed throughout Sarawak, namely *H. avene, H. beccarianum, H. ellipticum, H. glaucophyllum, H. littorale, H. mangiferifolium, H. multiarcuatum, H. truncatum* and *H. verticillatum.* Three taxa distributed from the Central Sarawak to the Northern region which are *H. lasiocalyx, H. mamutiacum* and *H. trineurum* while *H. tetrandrum* is the only species that distributed in Southern to Central Sarawak. The *Heptapleurum* taxa with restricted distribution in Sarawak are shown in Table 4.4 below.

Table 4.4: The *Heptapleurum* taxa with restricted distribution in Sarawak.

Southern Sarawak	Central Sarawak	Northern Sarawak
1. *H. andersonii**	1. *H. abangmohtari**	1. *H. barioense**
2. *H. borneense*	2. *H. acutissimum*	2. *H. bernardleii**
3. *H. brookeanum**	3. *H. asahii**	3. *H. bidenticarpum**
4. *H. burianum**	4. *H. conjunctum**	4. *H. bipalmatifolium*
5. *H. burkillii*	5. *H. ensiriengense**	5. *H. bracteosum**
6. *H. cephalotes*	6. *H. lumutense**	6. *H. crenatum*
7. *H. havilandii*	7. *H. runiae**	7. *H. lanatum*
8. *H. kuchingense*		8. *H. lineamentorum*
9. *H. laxiflorum*		9. *H. mitragerum*
10. *H. lesongense**		10. *H. mjoebergii*
11. *H. lubangbayaense**		11. *H. murudense**
12. *H. petiolosum*		12. *H. niahense**
13. *H. puehense**		13. *H. obovatilimbum*
14. *H. semengohense**		14. *H. paulchaii**
15. *H. yiipuanchingae**		15. *H. primackii**
		16. *H. rhodorifolium**
		17. *H. sabahense*
		18. *H. subisense**
		19. *H. yahudwati*i*

* Unpublished *Heptapleurum* taxa

4.3 Altitudinal Distribution of *Heptapleurum* taxa in Sarawak

The altitudinal distribution for specimen was obtained from their herbarium label. However, not all specimens have their elevation recorded by the collectors. For the specimens without information on elevation, an elevation range was estimated according to their locality and habitat. Figure 4.3 shows the elevational ranges of all 52 *Heptapleurum* taxa in Sarawak which were the published and unpublished taxa.

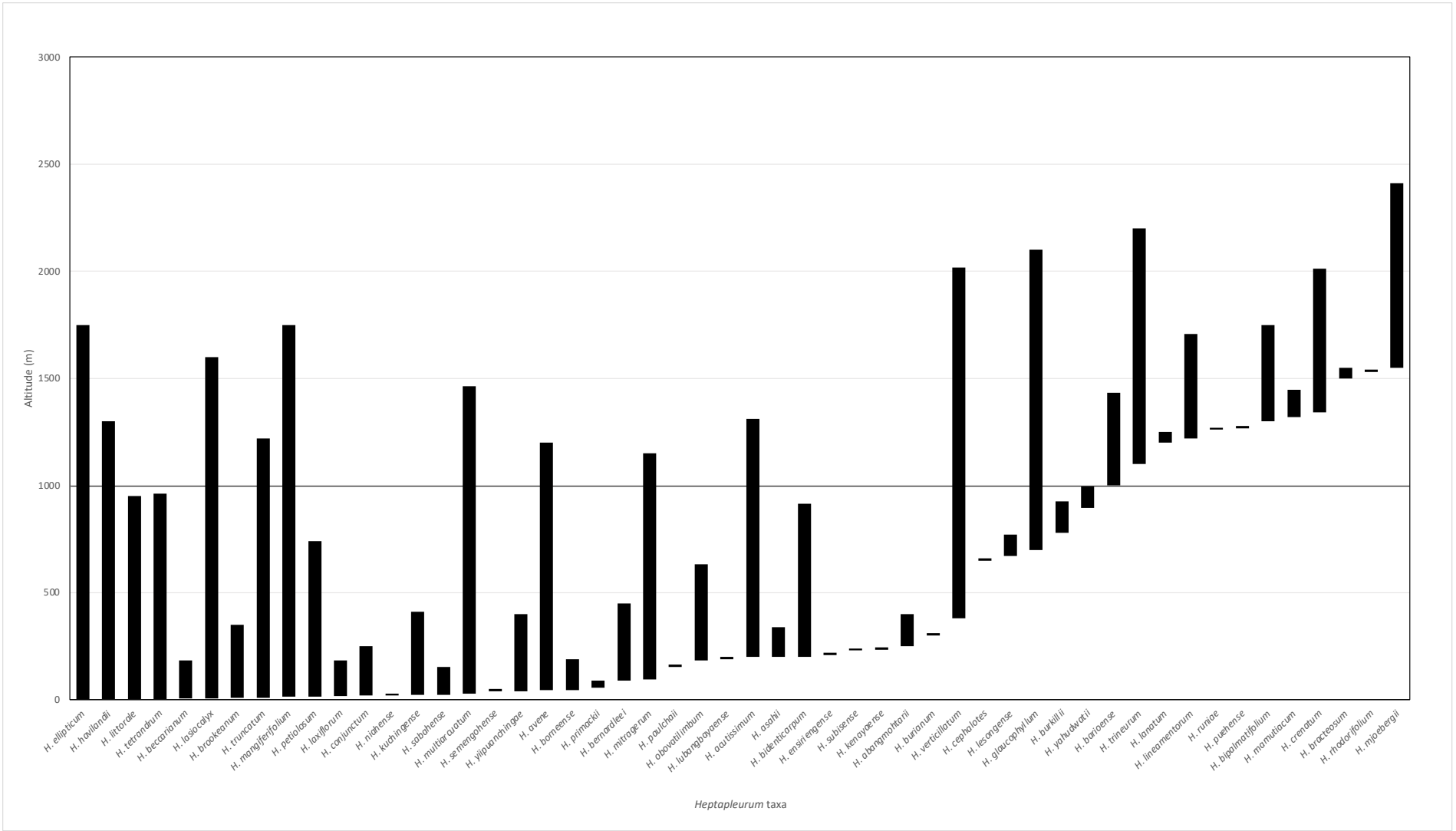


Figure 4.3: The altitudinal ranges of *Heptapleurum* taxa in Sarawak.

Based on Figure 4.3, the number *Heptapleurum* taxa recorded below 1000 m is more than the taxa recorded at above 1000 m. About 11 taxa can be found at elevational ranges both below and above 1000 m and they are *H. acutissimum, H. avene, H. ellipticum, H. glaucophyllum, H. havilandii, H. lasiocalyx, H. mangiferifolium, H. multiarcuatum, H. mitragerum, H. truncatum* and *H. verticillatum*.

There are 30 *Heptapleurum* taxa recorded at elevation below 1000 m. They were recorded at lowland vegetation and on hills. The taxa are *H. abangmohtari, H. asahii, H. beccarianum, H. bernardleei, H. bidenticarpum, H. borneense, H. brookeanum, H. burianum, H. burkillii, H. cephalotes, H. conjunctum, H. ensiriengense, H. kenayaense, H. kuchingense, H. laxiflorum, H. lesongense, H. littorale, H. lubangbayaense, H. mitragerum, H. niahense, H. obovatilimbum, H. paulchaii, H. petiolosum, H. primackii, H. sabahense, H. semengohense, H. subisense, H. tetrandrum, H. yahudwatii* and *H. yiipuanchingae.*

About 12 taxa are recorded over 1000 m in Sarawak, namely *H. barioense, H. bipalmatifolium, H. bracteosum, H. crenatum, H. lanatum, H. lineamentorum, H. mamutiacum, H. mjoebergii, H. puehense, H. rhodorifolium, H. runiae* and *H. trineurum.* These taxa are recorded mostly in montane vegetation from 1100-2433 m above sea level.

Some of the *Heptapleurum* taxa in Sarawak have broad elevational ranges in which they occurred at below and above 1000 m. The taxa are *H. acutissimum, H. avene, H. ellipticum, H. glaucophyllum, H. havilandii, H. lasiocalyx, H. mangiferifolium, H. multiarcuatum, H. truncatum* and *H. verticillatum.* There are only five taxa that recorded

over 2000 m in Sarawak. The taxa are *H. crenatum, H. glaucophyllum, H. mjoebergii, H. trineurum* and *H. verticillatum.*

4.4 Taxonomic Key of *Heptapleurum* taxa in Sarawak

A taxonomic key of 52 *Heptapleurum* taxa in Sarawak based on 25 published and 27 unpublished taxa is constructed.

1. Leaf twice palmately compound
   Leaflet blades thin, chartaceous, both surfaces dull, ovate to elliptic, apex caudate, base acute, margin entire or sometimes weakly toothed……***H. bipalmatifolium***
   Leaf once palmately compound……..…**2**

2. Unifoliolate leaf……..……**3**
   More than one leaflet……..……**6**

3. Leaf blade broadly cordate
   Leaflet blades 27.4-44.7 cm long × 23.3-34.8 cm wide……***H. asahii***
   Leaf blade not cordate……**4**

4. More than one inflorescence branches
   Stipular ligule persistent, leaf blades thickly coriaceous with glossy upper surface, broadly oval to ovate, both upper and lower surfaces covered with hairs.....***H. mjoebergii***
   Single and terminal inflorescence branch……..……..…**5**

5. Umbels up to 5 per branch
   Entirely glabrous, leaf blades elliptic, thickly coriaceous……..***H. abangmohtari***
   Umbels more than 5 per branch
   Leaflet blades thin, usually elliptic to lanceolate, sometimes ovate, glabrous, both surfaces dull…….....***H. acutissimum***

6. Inflorescence in heads……**7**
   Inflorescences not in heads…….……**9**

7. Inflorescence heads diameter more than 1 cm with > 100 flowers
   Entirely covered with brown woolly hairs, leaf blades thickly coriaceous and oblong…….……..***H. lanatum***
   Inflorescence heads diameter less than 1 cm with < 100 flowers……**8**

8. Flower heads 4-5 mm diam., about 20 flowers per head
   Leaflets narrowly elliptic to slightly oblanceolate……..……***H. burianum***
   Flower heads 5.8-6.6 mm diam., about 28 flowers per head

Leaflets thin, narrowly oblong, upper surface appears glossy while below dull and sparsely hairy……...……...…….***H. cephalotes***

9. Leaflets with midrib flanked by two arcuate nerves extending from base
   Leaf blades narrowly lanceolate to ovate to oval, length 2.5-9.6 cm, wide 0.7-2.5 cm, thick, coriaceous, both surfaces dull…….……..***H. trineurum***
   Leaflets with single midrib and absence of additional arcuate nerves from base……**10**

10. Leaves generally 2 or 3-foliolate……...…**11**
    Leaves more than 3-foliolate……**17**

11. Petiole length 0-5 cm long…….……...……..…**12**
    Petiole length 5.1 cm and longer……**14**

12. Petiolules up to 1 cm long
    Leaf blades lanceolate to elliptic, glabrous, upper surface glossy while below dull……...***H. mamutiacum***
    Petiolules length 1 cm and longer……**13**

13. Leaf blades coriaceous, mostly elliptic, ovate to lanceolate, 3.8-21.3 cm long × 1-7.8 (13.3) cm wide……***H. avene***
    Leaf blades dull on both surfaces, broadly ovate to oval, 23.1-29 cm long × 12.2-13.1 cm wide……..…***H. niahense***

14. Inflorescence branches length 20 cm and longer…...……**15**
    Inflorescence branches length less than 20 cm long……...…**16**

15. Peduncles length less than 7 cm long
    Peduncles length 0.7-0.9 cm long……...***H. kenayaense***
    Peduncles length more than 7 cm long
    Peduncles length 7.0-9.1 cm long…….***H. paulchaii***

16. Umbels more than 5 per branch
    Leaf blades ovate to elliptic to obovate, coriaceous with unequal side……..***H. lesongense***
    Umbels less than 5 per branch
    Leaf blades elliptic to ovate with unequal sides, thick and coriaceous……...***H. burkillii***

17. Leaf margin toothed…….…….**18**
    Leaf margin entire…….**25**

18. Leaf margin toothed along the margin…….…….**19**
    Leaf margin toothed at the upper half of the leaflets……**20**

19. Flowers ovary superior
    Leaf blades elliptic, oval to obovate, length 9.3-18.3 cm, wide 4.7-9 cm……***H. crenatum***
    Flowers ovary inferior
    Leaf blades oblong to lanceolate, thinly coriaceous, glossy upper surface……...***H. verticillatum***

20. The longest length of leaf blades not more than 11 cm long
    Blades ovate or oval, length 6.5-10.7 cm and wide 3.5-5.1 cm……...***H. puehense***
    Leaf blades less than 11 cm long…....…….**21**

21. Peduncles always shorter than pedicels
    Leaflets mostly elliptic, to ovate-elliptic, chartaceous……..***H. petiolosum***
    Peduncles mostly longer than pedicels.……..…**22**

22. Peduncles length 3.2 cm and longer
    Peduncles 3.2-4.6 cm long……..……***H. primackii***
    Peduncles length less than 3.2 cm…….**23**

23. Stigmata more than 10
    Flower buds obovoid with widest point above cupule, cupule campanulate, calyx-rim spreading, ovary half inferior, disk strongly convex……..***H. mitragerum***
    Stigmata less than 10…….**24**

24. Buds c. 8 per umbel, cupule obconic, petals 7 and acuminate…...…….***H. bernardleei***
    Buds c. 16 per umbel, cupule campanulate, petals 5-6 and lanceolate……..……..***H. sabahense***

25. Lateral inflorescence 1-5 times longer than wide……..**26**
    Lateral inflorescence more than 5 times longer than wide…….**36**

26. Lower surface of leaves covered with dense hairs
    Entirely covered with dense hairs, leaf blades thickly coriaceous, broadly elliptic to oblong-elliptic to oval……...…..……***H. bracteosum***
    Leaf surfaces glabrous……...**27**

27. Often asymmetrical leaf blades
    Leaflets broadly oval to ovate to elliptic, rarely oblong, 7.1-26.3 cm long × 4-11.5 cm wide, coriaceous…….***H. littorale***
    Symmetrical leaf blades……**28**

28. Leaf blades 4 times longer than wide
    Blades narrowly oblong to oblanceolate, length 8.6-16.3 cm and 1.8-3.4 cm wide, coriaceous, upper surface glossy……***H. rhodorifolium***
    Leaf blades 1-3 times longer than wide……..…**29**

29. The distance between each petiole along stem is less than 0.5 cm
    Petioles base swollen and lenticellate, 24.3 cm long × 0.3-0.4 cm diam., leaf blades narrowly oblong-elliptic, glabrous, both surfaces dull……***H. subisense***
    The distance between each petiole along stem is 0.5 cm and longer……..…**30**

30. The spacing between each second-order venation is more than 1 cm apart……**31**
    The spacing between each second-order venation is less than 1 cm apart……..**32**

31. Leaf blades broadly elliptic to ovate, 9.5-41 cm long and 6.1-14.5 cm wide, Second-order venation yellowish, 5-8 pairs and spacing between the veins 2.5-5 cm apart……***H. laxiflorum***
Leaf blades elliptic to oval, 7-17 cm long and 2.8-8.6 cm wide, Second-order venation weakly visible, 5-6 pairs and spacing between the veins 1.2-3.3 cm apart……..…***H. ellipticum***

32. Leaf apex caudate…….……**33**
Leaf apex not caudate……**34**

33. Inflorescence branches not more than 4 cm long
Inflorescence branches 1.5-3.8 cm long × 0.06-0.10 cm diam. ……...***H. ensiriengense***
Inflorescence branches more than 4 cm long
Inflorescence branches 4.4-13.3 cm × 0.06-0.17 cm diam……..…***H. mangiferifolium***

34. Stipular ligule persistent with length 1.5 cm and longer
Leaf blades obovate to narrowly oblong with mucronate to abruptly acuminate apex…….……***H. glaucophyllum***
Stipular ligule partially fused with length shorter than 1.5 cm…….**35**

35. Sparsely hairy on petiole, petiolules and midrib of leaves
Leaf blades thinly coriaceous, oval, ovate and elliptic, length 4.3-10.2 cm, width 1.8-4.2 cm……...***H. barioense***
Petiole, petiolules and any parts of leaves glabrous
Leaf base cuneate with elliptic to obovate blades and broadly caudate-acuminate apex……..…***H. yahudwatii***

36. Stigmata 4 and less……**37**
Stigmata more than 4…….**42**

37. Fruits entirely glabrous
Fruits narrowly ellipsoid to obovoid, length 2-5 mm × diam. 1.2-2 mm, ¾ to 4/5 inferior, disk slightly sloping and somehow glaucous, stylar column 0.5 mm with 3-4 green stigmata on top…….***H. tetrandrum***
Fruits entirely covered with sparse hairs……**39**

38. Cupule narrowly tubular with length 5 mm × diam. 1-2 mm
Fruits 5 mm long × 1-2 mm diam., deeply sulcate and sparsely hairy, ovary almost inferior, disk slightly glaucous, stigmata sessile on top of disk, mostly 3-4, sometimes 1-2…….***H. bidenticarpum***
Cupule obconic with length 4 mm × 1.5-2 mm
Fruits 4 mm long × 1.5-2 mm diam., deeply sulcate with somehow obconic cupule with length of 3 mm, ovary ¾ to almost inferior, disk slightly glaucous with 4 stigmata on top of united style with length 1 mm…….***H. lasiocalyx***

39. Stylar column 2 mm and longer…….**40**
Stylar column less than 2 mm long……**42**

40. Apex of fruit truncate

Fruits semi globose or ellipsoid, 4-10 mm long × 2.5-6.5 mm diam., stylar column 2-4 mm long topped by 7-8 stigmata……...***H. truncatum***
Apex of fruit slightly sloping……**41**

41. Second-order leaf venation brochidodromous with 12-23 pairs veins on each side
Leaf blades leathery, broadly and elongately elliptic or ovate to oblong-elliptic to oblong-ovate with length 19.5-45.2 cm long × 4.2-17.4 cm wide……***H. multiarcuatum***
Second-order leaf venation eucamptodromous with 5-7 pairs veins on each side
Leaf blades thickly coriaceous, narrowly obovate to elliptic, 13.5-23.2 cm long × 3.7-7 cm wide……..……...***H. yiipuanchingae***

42. Length of branching zone 10 cm and longer……..**43**
Length of branching zone less than 10 cm long ……**45**

43. Number of umbels per branch less than 20
Leaf blades broadly ovate, 28-34 cm long by 10-15 cm wide……***H. lubangbayaense***
Number of umbels per branch more than 20…….**44**

44. Leaves 6-7 foliolate, blades broadly oblong-elliptic to oblong ovate, 24-40.7 cm long × 9.6-12.3 cm wide, apex caudate-acuminate…….……..***H. conjunctum***
Leaves 7-14 foliolate, blades oblong to oblong-obovate, 14.8-23.6 cm long × 4.3-10.8 cm wide, apex acuminate……***H. kuchingense***

45. More than 10-foliolate
Leaf blades broadly elliptic to oblong-elliptic, 21.3-32 cm long × 7.8-16 cm wide, lower surface lightly covered with brown stellate hairs……***H. beccarianum***
Less than 10-foliolate……**46**

46. Leaf blades mainly oblong
Leaves 9-10 foliolate, blades 12.3-22.3 cm long × 3.4-5.4 cm wide, apex mostly mucronate to apiculate up to 1.2 cm long……..…***H. lineamentorum***
Leaf blades not oblong……..**47**

47. Reticulation of veins not visible
Leaf blades obovate to oblong-obovate, 5-18.1 cm long × 1.6-9 cm wide, apex mostly mucronate to acuminate……..***H. havilandii***
Reticulation of veins strongly visible and coarse……..**48**

48. Inflorescence branches length more than 90 cm
Inflorescence branches 93.0-97.5 cm long × 0.4-0.5 cm diam……...…...***H. runiae***
Inflorescence branches length less than 90 cm……..**49**

49. Longest peduncles length 1.5 cm and more
Leaves 5-foliolate, blades elliptic, 21.1-28.2 cm long by 5.8-9.2 cm wide, apex caudate up to 4.4 cm long……..……...……***H. semengohense***
Longest peduncles length not exceed 1.5 cm long…….**50**

50. Pedicels almost sessile to 2 mm long

Fruits glabrous, 6-12 per umbel, ovoid, 1.5-4 mm long × 0.8-2.6 mm diam., deeply sulcate……...***H. brookeanum***

Pedicels length longer than 2 mm……..**51**

51. Leaves foliolate 3-9, blades elliptic, ovate or oval with length 11.5-23.3 cm and width 4.1-12 cm…….***H. borneense***

    Leaves foliolate 6-10, blades obovate or elliptic with length 10.5-27.5 cm and width 4-8.6 cm……...***H. obovatilimbum***

4.5 Description of *Heptapleurum* taxa in Sarawak

There are about 73 *Heptapleurum* taxa that have been described in this study which include 25 published species, 27 newly described taxa and 21 imperfectly known taxa. The imperfectly known taxa were described in the sub-chapter 4.6.

4.5.1 *Heptapleurum abangmohtari* N. Ramnor & A. Puad, sp. nov. (Figure 4.4)

Type material: Bintulu: Lumut Range, 400 m, mixed dipterocarp forest, 29 Sep 1992, *Abg Mohtar & Yii Puan Ching, S. 66165* (holotype: SAR!; isotypes: KEP, K, CGE).

Epiphyte. ***Leaves*** unifoliolate and arranged alternately along stem, glabrous. Stipule very short, 0.2-0.3 cm, almost fused and truncate. Petiole 1.5-3.3 cm long × 0.19-0.24 cm diam. Blades thickly coriaceous with recurved and entire margin, 8-11.4 cm long × 3.1-4.3 cm wide, elliptic. Apex obtuse and base convex to cuneate. Second-order venation eucamptodromous, closely spaced and almost parallel, 11-21 pairs on each side, weakly visible on both surfaces. Reticulations not visible. ***Inflorescences*** terminal, main axis above last leaf 0.2 cm long. Bracts very short and not persistent. Terminal single-branched; 7 cm long × 0.16 cm diam. and entirely glabrous. Umbels 5 with 3 on terminal cluster and 2 on subsidiary cluster. Each cluster c. 1.5 cm apart. Peduncle angular, length 5-7 mm. Pedicels 0.5-1 mm long. Both peduncles and pedicels are greenish yellow. ***Flowers*** about 10 per umbel. Cupule obconic c. 2 mm long with narrow, slightly toothed calyx-rim. Petal oblong, thick, c. 2 mm long. Ovary inferior. Disk flat with slender stylar column at 2-2.5 mm high. Stigmata almost fused on top. ***Fruits*** not seen.

Distribution: Borneo (Central Sarawak) (Figure 4.5)

Conservation status: *Heptapleurum abangmohtarii* is assessed as Data Deficient (DD).

Habitat: Mixed dipterocarp and peat swamp forest up to 400 m above sea level.

Notes: The taxon differs from *H. avene,* found in Borneo, Lesser Sunda Island and Sumatera, by having ultimately one leaf and one inflorescence branch with lesser umbels.

Derivation of name: The taxa is named after Mr Abang Mohtar bin Abang Pawozan, a botanist and plant collectors at Forest Department Sarawak. He was a Senior Assistant Director of the Research, Development and Innovation Division, Forest Department Sarawak and has officially retired in May 2015 (Forest Department Sarawak, 2015).

Specimen listing: BINTULU. Lumut Range, 400 m, 29 Sep 1992, *Abg Mohtar & Yii Puan Ching, S. 66165* (SAR, KEP, K, CGE); Trail to Julan Loagan, 30 Sep 2006, *Julia S. et al., S. 97118* (SAR, KEP, SAN).



Figure 4.4: *Heptapleurum abangmohtari* N. Ramnor & A. Puad, sp. nov. (S. 66165).

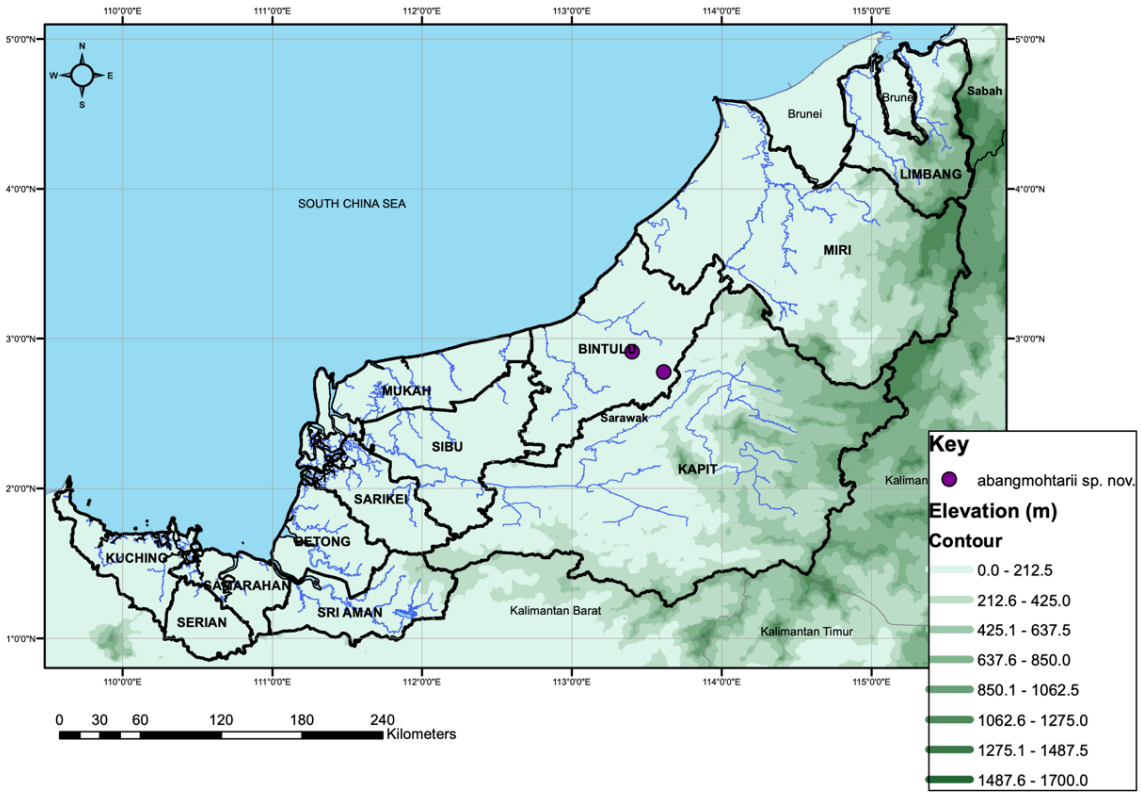


Figure 4.5: Distribution map of *H. abangmohtari* sp. nov. in Sarawak.

4.5.2 *Heptapleurum acutissimum* (Miq.) Seem. (Figure 4.6)

Journal of Botany, British and Foreign 3: 79 (Seemann, 1865).

Basionym: *Paratropia acutissima* Miq., *Annales Musei Botanici Lugduno-Batavi* 1: 20 (Miquel, 1863).

Synonym: *Schefflera acutissima* (Miq.) Harms, in H. G. A. Engler & K. A. E. Prantl, *Naturlichen Pflanzenfamilien* 3 (8): 37 (Harms, 1894).

Type material: "Borneo autralis" or Southern Borneo, *Korthals.*

Epiphyte or climbers. ***Leaves*** unifoliolate that arranged alternately along the stem. Stipule partially fused with rounded apex, about 0.8 cm long. Petiole 1-5 cm long × 0.9-2.2 mm diam. Petiolule 0.6-1.2 cm long × 1-2.5 mm diam. Blades thin, usually elliptic to lanceolate but sometimes can be found ovate, glabrous, 11.7-28 cm long × 4.0-10.5 cm wide. Adaxial and abaxial surfaces dull. Apex slender caudate extending from 1.0 to 2.7 cm long. Margin entire. Base acute to obtuse. Second-order venation from 7-14 pairs on each side, brochidodromous, spreading-ascending. Reticulations coarse. ***Inflorescences*** terminal. Limitation zone up to 4.5 cm long, marked by 0.9-1.2 cm long bracts. Single-branched, (5.3-) 10-20.5 cm long × 0.08-0.16 cm diam., slender, sparsely to moderately pubescent. Umbels 12-14, racemosely arranged along the branch. Peduncles 0.2-1.5 cm long upon maturity. Subtending bracts 2-6 mm long, not persistent. Pedicels 1-5 mm long. Both peduncles and pedicels green. ***Flowers*** about 12 per umbels, yellowish. Buds globose, dimension 1.5 mm long × 1.5 mm diam. Cupule funnel-shaped with length c. 0.5 mm long. Petal 2 mm long with prominent trinerved. Stamen 2 mm long. Stylar mound raised. ***Fruits*** when ripened

orange, narrow ellipsoid-obovoid, 3.5-4 × 1.4 mm, glabrous. Ovary ¾ to almost inferior. Disk convex with stigmata on top. Stigmata 4-5, separated in a ring.

Distribution: Borneo and Sumatera. In Sarawak, the plant is recorded in Bintulu and Kapit divisions. (Figure 4.7)

Conservation status: *Heptapleurum acutissimum* is assessed as Data Deficient (DD).

Habitat: Riverine, mixed dipterocarp, logged-over and on hill in mossy submontane forest with elevation ranges from 200-1310 m above sea level.

Notes: *Heptapleurum acutissimum* can be easily recognized by its unifoliolate and thin leaf with elliptic to lanceolate blades and long caudate apex. The single-branched inflorescence covered by racemosely arranged, 12 to 14 umbellules. Specimen S. 71857 has much broader leaflets and extremely short inflorescence branch compared to the other specimens. The peduncles of *H. acutissimum* are usually less than 1 cm long but in specimen S. 52793, the peduncles elongated up to 1.5 cm long.

Specimen listing: BINTULU. Sebauh. Bkt. Sekiwa, Tubau, 200 m, 26 Aug 1986, *Abg Mohtar et al., S. 52793* (K). **Tatau.** Sg. Mayong (Mayeng), 213 m, 2 Jun 1956, *J. W. Purseglove, P. 5314* (SAR). **KAPIT. Bukit Mabong.** SE Hose Mountain (above Ulu Melinau fall), 1219 m, 20 Aug 1967, *B. L. Burtt & A. M. Martin, B. 4998* (SAR); North Semperaja, Mujong, Baleh, 17 Apr 1964, *Othman Haron, S. 19875* (K, L, SING); Bkt. Salong, Ulu Sampurau, Melinau, 122 m, 20 Aug 1967, *Ilias Paie, S. 25879* (CGE); Path

from Ulu Sampurau to Ulu Melinau, Melinau, 1310 m, 15 Apr 1980, *Hj Othman et al., S. 40959* (CGE, L). **Belaga.** Batu Laga Plateau, 960 m, 23 Mar 1989, *Yii Puan Ching, S. 56956*; NE of Batu Laga Plateau, 820 m, 19 Jun 1995, *Runi et al., S. 71857* (K, L, KEP); Sg. Murun (Murum), 16 Aug 2000, *Yahud et al., S. 84882* (SAR, K, L).



Figure 4.6: *Heptapleurum acutissimum* (Miq.) Seem. (S. 52793).

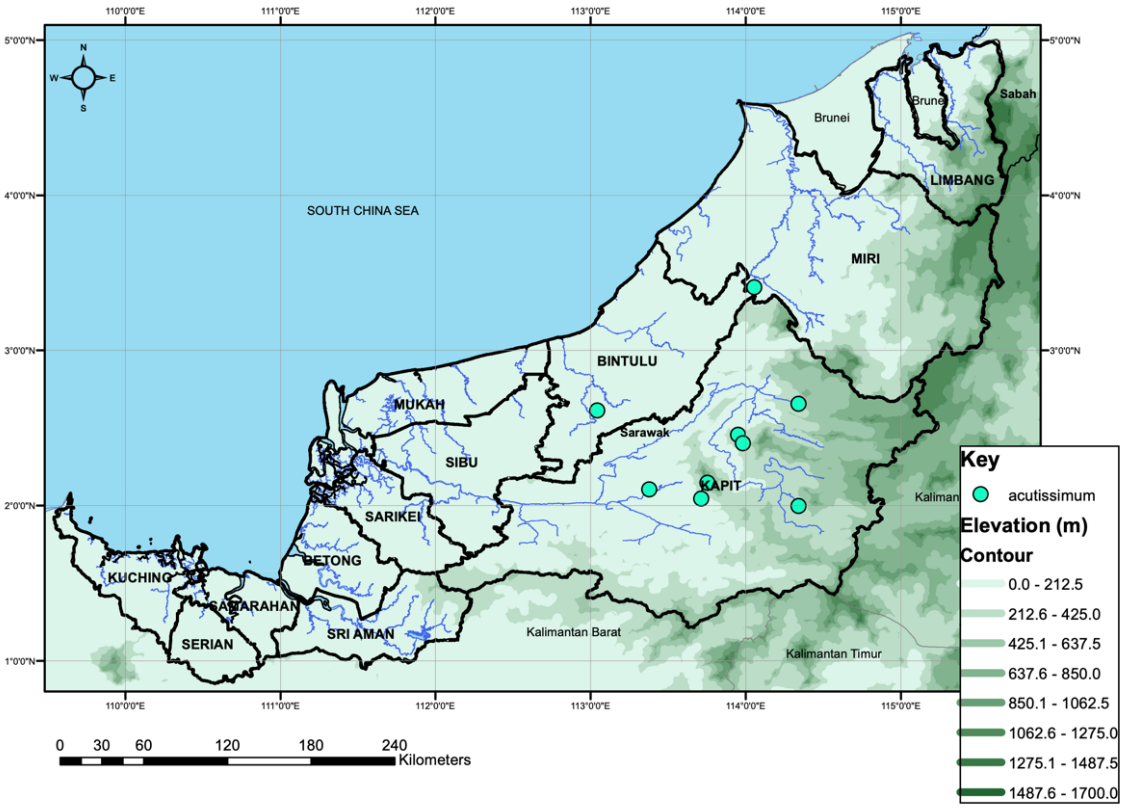


Figure 4.7: Distribution map of *H. acutissimum* in Sarawak.

4.5.3 *Heptapleurum asahii* N. Ramnor & A. Puad, sp. nov. (Figure 4.8)

Type material: Kapit: Sg. Entulu, 220 m, streambank, 15 Jul 1987, *Bernard Lee, S. 54554* (holotype: SAR!; isotypes: CGE, K).

Epiphyte. ***Leaves*** unifoliolate. Petiole lenticellate, sparsely hairy, 23-29 cm long × 0.35-0.5 cm diam. At the base, stipule persistent with length of 1.6-3 cm long. Blade broadly cordate, 27.4-44.7 cm long × 23.3-34.8 cm wide and glabrous. Petiolule 1.5-3 cm long. Apex obtuse and sometimes truncate, base cordate, margin minutely and sparsely toothed. Second-order venation about 8-16 pairs with basal veins 4-6, semicraspedodromous, widely spaced and spreading-ascending. ***Inflorescences*** terminal. Limitation zone 0.5-2 cm long and branching

zone obscure. Branches up to 4, 3-11.5 cm long × 2-3.5 mm diam., covered with brown stellate hairs. Umbellules 5-15 per branch, arranged in clusters. Peduncles almost sessile to 0.15 cm in length. Pedicels usually much longer than peduncles, 1.5-2 mm long. ***Flowers*** buds hairy, 2 mm long × 1 mm diam., ellipsoid to ovoid, numerous per umbellules, Cupule funnel or cup-shaped. Calyx-rim slightly spreading. Ovary entirely inferior. Disk flat with stylar column with length 1 mm long. Stigmata 5-7. ***Fruits*** not seen.

Distribution: Central Sarawak (Figure 4.9)

Conservation status: *Heptapleurum asahii* is assessed as Data Deficient (DD).

Habitat: Along streams with elevation around 220 m above sea level.

Notes: The taxon is easily distinguishable from the other *Heptapleurum* species by having broadly cordate leaf. The other *Heptapleurum* taxa with unifoliolate leaf and single-branched are *H. abangmohtari* and *H. acutissimum.*

Derivation of name: The taxa is named after Asah ak Unyong, a local plant collector in Sarawak.

Specimen listing: KAPIT. Sg. Entulu, 220 m, 15 Jul 1987, *Bernard Lee, S. 54554* (SAR, CGE, K); Ng. Sebaning, Nov 1988, *Othman et al., S. 56466* (SAR); Sg. Kui, 26 Apr 1991, *Runi et al., S. 63045* (KEP, CGE, K, L, SAN).



Figure 4.8: *Heptapleurum asahii* N. Ramnor & A. Puad, sp. nov. (S. 54554).

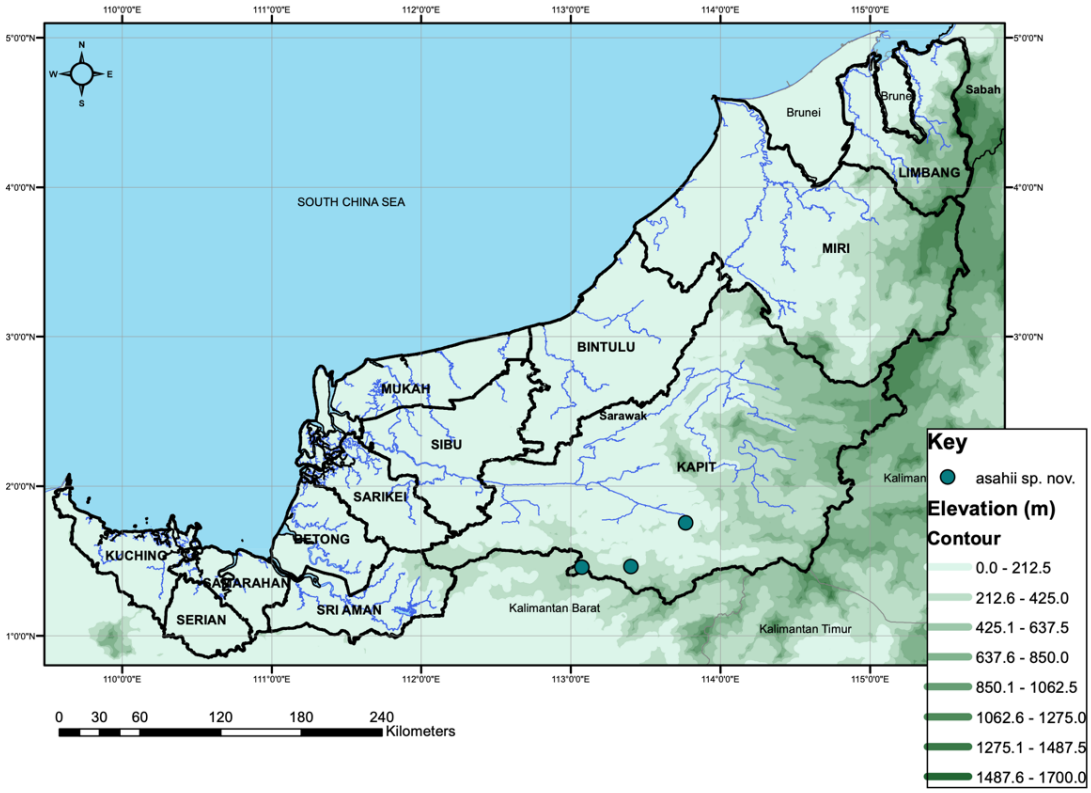


Figure 4.9: Distribution map of *H. asahii* sp. nov. in Sarawak.

4.5.4 *Heptapleurum avene* (Miq.) Seem. (Figure 4.10)

Journal of Botany, British and Foreign 3: 79 (Seemann, 1865)

Basionym: *Paratropia avenis* Miq., *Annales Musei Botanici Lugduno-Batavi* 1: 19 (Miquel, 1863).

Synonym: *Schefflera avenis* (Miq.) Harms in H. G. A. Engler & K. A. E. Prantl, *Naturlichen Pflanzenfamilien* 3 (8): 38 (Harms, 1894).

Type material: "Sumatra occidentalis", *Korthals s. n.* (lectotype: L; isolectotype: L).

Mostly epiphyte, sometimes climber, creeper on rock or slender terrestrial. ***Leaves*** usually bifoliolate or trifoliolate, rarely unifoliolate. Stipular ligule persistent and 1.2-2.9 cm long. Petioles 0.5-3.2 cm long × 0.2-0.4 cm diam. Petiolules 0.4-2 cm long × 0.15-0.30 cm diam. Blades mostly thick, coriaceous, elliptic, ovate or lanceolate, rarely obovate, both symmetrical or asymmetrical, 3.8-21.3 cm long × 1.0-7.8 (-13.3) cm wide. Apex mucronate to acute-acuminate to acuminate to caudate-acuminate with length 0.3-1.1 cm. Base convex and rounded. Margin entire. Second-order venation numerous, narrowly spaced, pinnate, almost parallel. Reticulations mostly not visible. ***Inflorescences*** terminal. Limitation zone 0.6-5.8 cm long. Branching zone 0-1.3 cm long. Branches reddish, 3-6, 7-22.5 cm long × 0.20-0.25 cm diam, slender, sparsely pubescent to glabrous. Umbellules 6-9 along half of the branch with terminal cluster of 2-4 umbels, followed by 1-3 subsidiary umbellules, each cluster quite distant from one another. Peduncles 0.2-1.4 cm long and red to reddish brown. Pedicels yellowish green about 1.5-5 mm long. ***Flowers*** 5-11. Bud ellipsoid, ovoid or globose, 3-5 mm long × diam. 2.5-4 mm. Widest point of buds usually above the cupule. Cupule obconic or campanulate. Calyx-rim slightly spreading, either entire or minutely

toothed. Corolla calyptrate. Stamen length 2-3.5 mm. Disk from slightly sloping to convex at maturity. Stylar mound slightly elevated from the disk. Ovary half inferior. ***Fruits*** ellipsoid to ovoid, glabrous, half inferior, 4-5 mm long × 4-5.5 mm diam. Stigmata 7-10, sessile.

Distribution: Borneo, Lesser Sunda Island and Sumatera. In Sarawak, the plant is recorded in Kuching, Serian, Sri Aman, Bintulu, Kapit and Miri divisions. (Figure 4.11)

Conservation status: This taxon is known from 24 specimens found in 23 locations (AOO = 96 km^2) from Kuching, Sri Aman, Bintulu, Kapit and Miri divisions. It is assessed as Endangered.

Habitat: The species can be found near riverbank, in dipterocarp forest, secondary forest, kerangas, on limestone and sandstone rocks, mossy and submontane vegetation. Altitudinal ranges from 100 m up to 1200 m above sea level.

Notes: *Heptapleurum avene* can be identified by its bi to trifoliolate leaves (rarely unifoliolate), persistent stipular ligule and numerous and somehow parallel Second-order venation. As for the inflorescence branches, they are slender with length much longer than the leaves overall and along them are 6-9 umbellules arranged in clusters along half of the branches. The flowers have calyptrate corolla and half inferior ovary. The maturing fruits are ellipsoid or ovoid with sessile, 7 to 10 stigmata on top. The leaf blades were much smaller in size in the specimens that were found in heath forest and locality over 1000 m above sea level. On the other hand, specimen S. 77757 has extremely broad oval and unifoliolate leaf

that is rarely observed in *H. avene.* Specimen S. 33239 was found overhanging on *Dipterocarpus oblongofolia* (*oblongofolius*) by the stream. The local Iban name of this species is Rukang.

Specimen listing: KUCHING. Matang, Jun 1890, *G. D. Haviland, Hav. 665/196*. **Bau.** Bkt Jambusan, 100 m, 13 Nov 1985, *Yii et al., S. 50331* (CGE, K, L, KEP, SAN). **SERIAN.** Sg. Semeran, 2 Dec 1985, *Abg Mohtar et al., S. 49267* (US, K, L, KEP, SAN). **SRI AMAN.** Mt. Lesong, Lingga, 620 m, 27 Nov 1981, *Bernard Lee, S. 44001* (CGE, K, L, SAN, MO). **BINTULU. Tatau.** Bkt. Kana, Ulu Sg. Sangan, 700 m, 10 Jul 1994, *Yii Puan Ching & Asah, S. 64955* (KEP, K, L, SAN); Bkt. Lumut, 800 m, 23 Sep 1992, *Abg Mohtar & Yii Puan Ching, S. 65892* (KEP, K, CGE); Ulu Sg. Anap, 290 m, 30 Oct 1996, *Rantai Jawa et al., S. 75195* (KEP, K, L, SAN, CGE). **KAPIT. Bukit Mabong.** N. Semperaja, Mujong, Baleh, 200 m, 14 Apr 1964*, Ilias Paie, S. 19863* (K, L, SING); Near Rumah Rapek, Btg. Rejang, 19 Sep 1973, *Paul Chai et al., S. 33239* (L, K, KEP, CGE, MO); Ulu Balleh, 600 m, 17 Nov 1979, *Othman et al., S. 42478* (CGE, L, K, KEP, SAN); Sg. Libau, Btg. Baleh, 20 Jul 1987, *Bernard Lee, S. 54697*; Nanga Sg. Mengiong, Baleh, 27 Sep 1989, *Hj. Othman et al., S. 57871* (CGE, K, L, KEP, SAN); Sg. Jitang, Btg. Balui, 300 m, 28 Feb 1992, *Runi et al., S. 62036* (KEP, CGE). **Belaga.** Bkt. Dema, 1200 m, 26 Aug 1978, *Bernard Lee, S. 39848* (CGE, L, K, E); Usun Apau Plateau, 685 m, 25 Oct 1994, *Lai, Rantai et al., S. 69467* (KEP, K, L, SAN). **Song.** Lanjak Entimau Wildlife Sanctuary (steep slope near riverbank), 320 m, 21 Mar 1998, Rantai, *Patsipun et al., S. 77757* (SAR). **MIRI. Bario.** Kelabit Highland, Baram, 1067 m, 6 Nov 1974, *Paul Chai, S. 35316* (L, K, CGE); Mt. Murud, 21 Aug 1991, *Rena, Rantai et al., S. 63336* (KEP, CGE); Pa Umor, Baram, 1000 m, 22 Sep 1996, *Yahud Hj. Wat et al., S. 71966* (KEP, K, L, SAN, CGE); Long Balih, Bario, 1050 m, 10 Nov 1996,

Julaihi et al., S. 75289 (KEP, K, L, CGE). **Subis.** Mt. Subis (summit), Niah National Park, 20 Aug 2002, *Kit Pearce et al., S. 89413* (SAR, K, L). **Marudi.** Sg Mentawai, Mulu National Park, 7 Oct 1977, *Paul Chai, S. 39753* (CGE, L, K, KEP, SAN, MO). **Telang Usan.** Sg. Palutan, Sg. Silat Basin, 550 m, 31 Mar 2003, *Lim, Basco, S. 90336* (SAR); Sg Palutan, 380 m, 3 Apr 2003, *Julia S. et al., S. 90974* (SAR).



Figure 4.10: *Heptapleurum avene* (Miq.) Seem. (S. 33239).

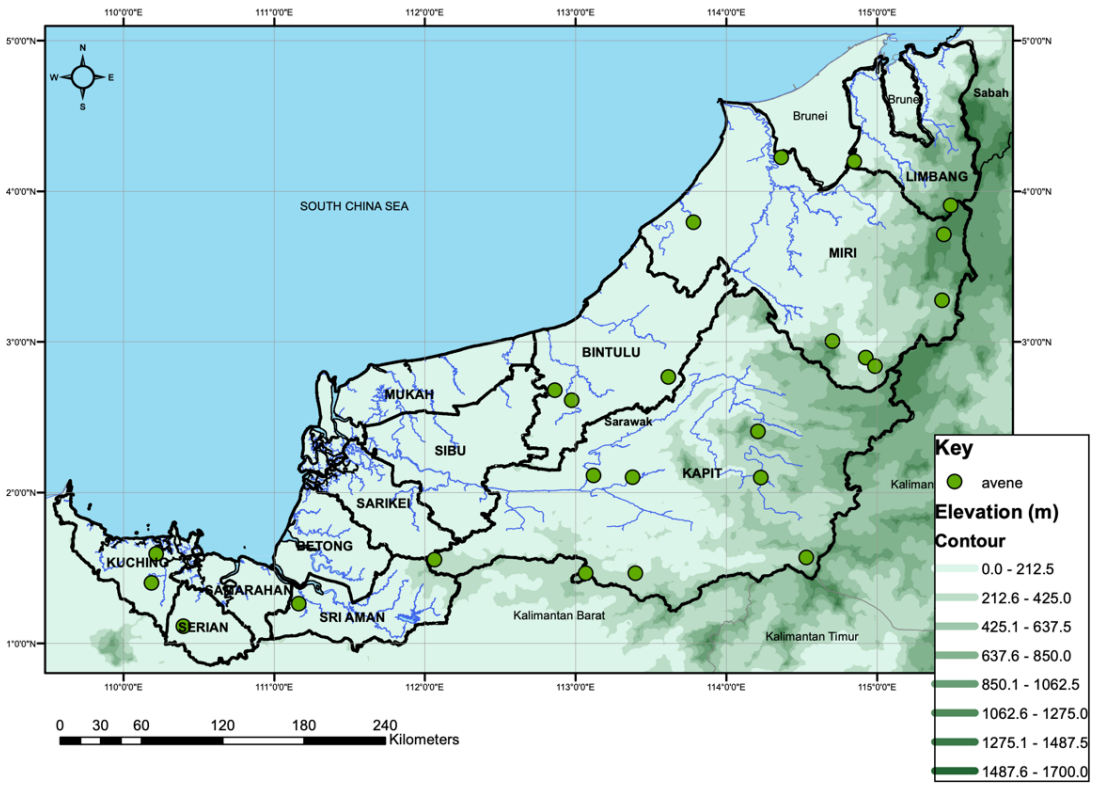


Figure 4.11: Distribution map of *H. avene* in Sarawak.

4.5.5 *Heptapleurum barioense* N. Ramnor & A. Puad, sp. nov. (Figure 4.12)

Type material: Miri: Pa Ukat, 1000 m, kerangas forest, 28 Jul 1985, *Dayang Awa et al., S. 50447* (holotype: SAR!).

Small tree c. 2 m tall, epiphyte or climber. ***Leaves*** 3-5 foliolate. Stipule partially fused, rounded with length 0.3-1.3 cm long. Sparsely hairy on petiole, petiolules and midrib of leaves. Petiole 5.3-6.6 cm long × 0.15-0.19 cm diam. Petiolules 0.8-2 cm long × 0.15 cm diam. Blade thinly coriaceous, oval, ovate and elliptic, 4.3-10.2 cm long × 1.8-4.2 cm wide. Apex mucronate to acuminate, 2-10 mm long. Margin recurved with a couple of minute tooth margin on upper half or entirely entire. Base obtuse. Second-order venation 9-12 pairs

on each side with narrow spacing and spreading-ascending towards margin. ***Inflorescences*** terminal, limitation zone c. 1 cm long and branching zone c. 2 cm long, marked by short, rounded bracts. Lateral branches, peduncles and pedicels covered in woolly dense hairs. Branches 4-8, very congested along the main axis with corymb-like arrangement, 3.5-15.1 cm long × 0.19-0.30 cm diam. Umbellules c. 12 per branch. Peduncles 0.15-1.8 cm long. Pedicels 1-4 mm long. Bracteoles mostly longer than buds. ***Flower*** buds about 20 per umbel, 0.2 mm long × 0.11 mm diam. Cupule hairy, conic or funnel-shaped with narrow and minutely toothed calyx-rim on top. Petals 5-6, length 3 mm long. Disk truncate with elevated stylar mound on top centre. ***Fruits*** not seen.

Distribution: Northern Sarawak (Figure 4.13)

Conservation status: *Heptapleurum barioense* is assessed as Data Deficient (DD).

Habitat: Kerangas and submontane forest on the ridge with altitudinal ranges from 1000-1433 m above sea level.

Notes: The taxon differs from *H. mjoebergii,* also found in Bario, Miri by having more than one leaf with thin blade. While most of the specimens have broadly oval leaflets, specimen S. 20175 has narrowly elliptic blades. The plant is called ‘War Tukang’ by the Kelabit people.

Derivation of name: The taxa is named after a place, Bario that is located at the Kelabit Highlands in Miri, Sarawak. All the specimens were collected from Bario.

Specimen listing: MIRI. Bario. Kubaan Pungor Pawan, 1433 m, 29 Jun 1964, *Anderson, S. 20175* (SAR); Pa Ukat, 1000 m, 28 Jul 1985, *Dayang Awa et al., S. 50447* (SAR); Kampung Bario, 1200 m, 15 May 1988, *Yii Puan Ching, S. 56245*; Pa Ukat, 16 Mar 1997*, Mohizah et al., S. 75021* (KEP, CGE).



Figure 4.12: *Heptapleurum barioense* N. Ramnor & A. Puad, sp. nov. (S. 50447).

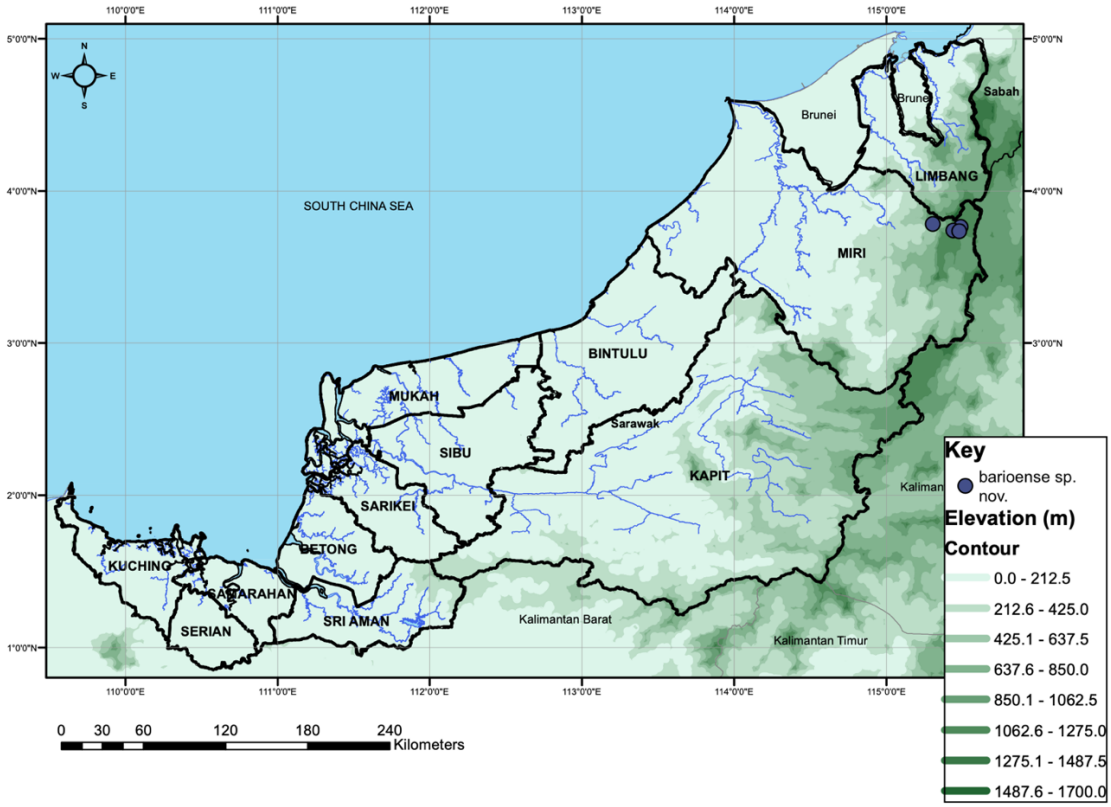


Figure 4.13: Distribution map of *H. barioense* sp. nov. in Sarawak.

4.5.6 *Heptapleurum beccarianum* (Harms) Lowry & G. M. Plunkett (Figure 4.14)

Novon 28 (3): 147 (Lowry & Plunkett, 2020).

Basionym: *Schefflera beccariana* Harms, *Repertorium Specierum Novarum Regni Vegetabilis. Centralblatt für Sammlung und Veroffentlichung von Einzeldiagnosen neuer Pflanzen* 15: 20 (Harms, 1917).

Type material: Borneo: Ohne Standortsangabe, *Beccari no. 888* (holotype: LE; isotype: M; lectotype: K).

Scandent shrub, epiphyte or tree about 12 m tall. ***Leaves*** 10-13 foliolate. Stipule acute, inrolled, up to 6 cm long, persistent. Petioles 78-81 cm long × 0.65-1.1 cm diam. Petiolules

5-11.2 cm long × 0.21-0.30 cm diam. Blades broadly elliptic to oblong-elliptic, 21.3-32 cm long × 7.8-16 cm wide. Under surface lightly covered with brown stellate hairs. Apex apiculate to caudate with length up to 2 cm long. Margin entire. Base obtuse to rounded. Second-order venation 8-11 pairs, arcuate, eucamptodromous and more prominent when dry. Reticulations weak. ***Inflorescences*** terminal with limitation zone c. 4.5 cm long and branching zone 6-8.5 cm long. Entirely covered in dense brown hairs. Lateral branches slender, numerous, 37-65.5 cm long × 0.3-0.5 cm diam. Umbellules up to 70 and racemosely arranged along ¾ of the branch. Peduncles 1.1-2.5 cm long × 0.05 cm diam., slender and purplish. Pedicels 6-8 mm long. ***Flowers*** yellowish green. Buds globose, 1.5-2 mm long × 1.3 mm diam. Cupule cup-shaped, covered in hairs. Petals 7, lanceolate, creamy, 1-1.5 mm long and lanceolate. Stamen light green with 2 mm long. Disk glaucous, slightly sloping. ***Fruits*** c. 14 per umbel, ellipsoid to globose-ellipsoid, 3-5 mm long × 2-3 mm diam. Stigmata 7-8 and sessile. Ovary ½ to 3/5 inferior. Immatured fruits green.

Distribution: Borneo. In Sarawak, the plant is recorded in Kuching, Miri and Limbang divisions. (Figure 4.15)

Conservation status: *Heptapleurum beccarianum* is assessed as Data Deficient (DD).

Habitat: In mixed dipterocarp forest on hill, riverine and secondary forest with altitude up to 183 m above sea level.

Notes: *Heptapleurum beccarianum* is generally a large plant. The species can be recognized by its broadly elliptic to oblong-elliptic blades with upper surfaces covered with sparse hairs.

At the petiole base, there is a persistent stipular ligule with the length of free portion can be up to 6 cm long. The entire inflorescence part is covered in dense hairs. The maturing fruits are ellipsoid to globose-ellipsoid with 7-8 sessile stigmata on top. More than half specimen collections of *H. beccarianum* were collected in early 1900s by Hewitt and the Clemens in Kuching and Matang. Then, in late 1970s, the species were recorded at Niah and Mulu in Miri and Medamit in Limbang. So far, there is no record *H. beccarianum* at the Central part of Sarawak. One of the *H. beccarianum* specimens collected in Miri was found on the crown of Myristicaceae tree with its main root reaching the ground.

Specimen listing: KUCHING. Matang, Jun 1906, *Hewitt, A.R.1.5* (SAR); Mt. Matang, 12 Apr 1905, *J & M. S. Clemens, No. 20993* (SAR); Matang, *Hullett, Hav. 818/832* (SAR, SING); Kuching, 13 Oct 1905, *Hewitt, Series 205* (SAR, SING); Kuching, 13 Oct 1905, *Hewitt, Series 206* (SAR, SING). **MIRI. Subis.** Ulu Sg. Sah, Niah, 183 m, 12 Jul 1977, *Ilias Paie, S. 39063* (CGE, SAR). **Mulu.** Ulu Sg. Berar, Gunung Mulu National Park, 30 Sep 1977, *Paul Chai, S. 39591* (CGE, L, K). **LIMBANG.** Ulu Sg. Ensungei, Medamit, 14 Sep 1980, *Rena et al., S. 42903* (CGE, L, K, KEP).



Figure 4.14: *Heptapleurum beccarianum* (Harms) Lowry & G. M. Plunkett (S. 42903).

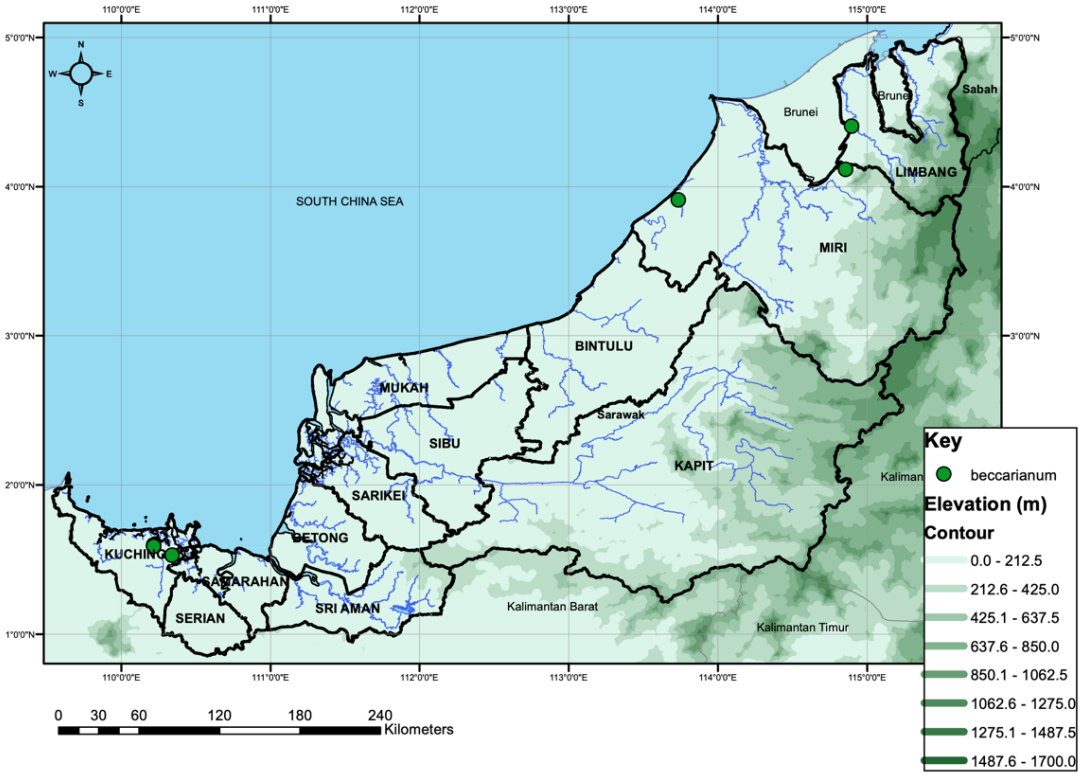


Figure 4.15: Distribution map of *H. beccarianum* in Sarawak.

4.5.7 *Heptapleurum bernardleei* N. Ramnor & A. Puad, sp. nov. (Figure 4.16)

Type material: Miri: Lubang Cina, Sg. Terikan, Gunung Mulu National Park, riverine forest, 25 Apr 1985, *Abg Mohtar & Othman Ismawi, S. 49412* (holotype: SAR!; isotypes: CGE, KEP).

Epiphyte. ***Leaves*** 5-6 foliolate. Stipule not seen. Petiole 28.3-61.5 cm long × 0.40-0.59 cm diam., sparsely hairy. Petiolules 2.5-7.5 cm long × 0.11-0.19 cm diam. Blades broadly or narrowly elliptic with length 13.5-30.2 cm and 7.9-11.4 cm wide, thin, dull surfaces. Apex caudate with length 1.6-3.1 cm. Margin upper half minutely and sparsely toothed. Base convex or slightly concave. Second-order venation eucamptodromous, 6-8 pairs, widely apart (2-3.5 cm), curving towards margin. ***Inflorescences*** terminal. Main axis above last leaf 2.5-4 cm with obscure branching zone. Terminal branches 3 or fewer, arranged in corymb-like, 16.7-21.5 cm long × 0.23-0.31 cm diam., covered with dense brown hairs. Peduncles 4-10 mm long and pedicels 1 mm long. Umbellules up to 20 per branch, racemose along most of the branch length. Bracteoles persist. ***Flower*** purplish green. Buds c. 16 per umbel, globose, dimension 2-3 mm long × 1.1-1.9 mm diam., entirely hairy. Cupule obconic with toothed calyx. Petals 7, acuminate, 2 mm long × 1.25 mm wide. Disk truncate. Stylar column about 1 mm long. ***Fruit*** not seen.

Distribution: Northern Sarawak (Figure 4.17)

Conservation status: *Heptapleurum bernardleii* is assessed as Data Deficient (DD).

Habitat: Along stream and in riverine forest at low elevation about 450 m above sea level.

Notes: The plant differs from *H. sabahense* in Borneo by having less number of umbels on the inflorescence branches. There are two specimens recorded for this taxon with slightly different leaves. Specimen S. 49412 has broadly elliptic with slightly concave base while the blades of S. 52367 are narrowly elliptic with convex base.

Derivation of name: The taxa is named after a plant collector, Bernard Lee Meng Hock. He worked as a Forest Officer in Forest Department Sarawak and has collected many plant specimens including *Calophyllum* (Guttiferae) with Dr John Burley, a Research Associate from Arnold Arboretum (Forest Department Sarawak, n.d.).

Specimen listing: MIRI. Mulu. Lubang Cina, Sg. Terikan, Gunung Mulu National Park, 25 Apr 1985, *Abg Mohtar & Othman Ismawi, S. 49412* (SAR, CGE, KEP). **LIMBANG. Lawas.** Sg. Lutok, Ulu Trusan, 450 m, 4 May 1986, *Bernard Lee, S. 52367* (CGE).



Figure 4.16: *Heptapleurum bernardleei* N. Ramnor & A. Puad, sp. nov. (S. 49412).

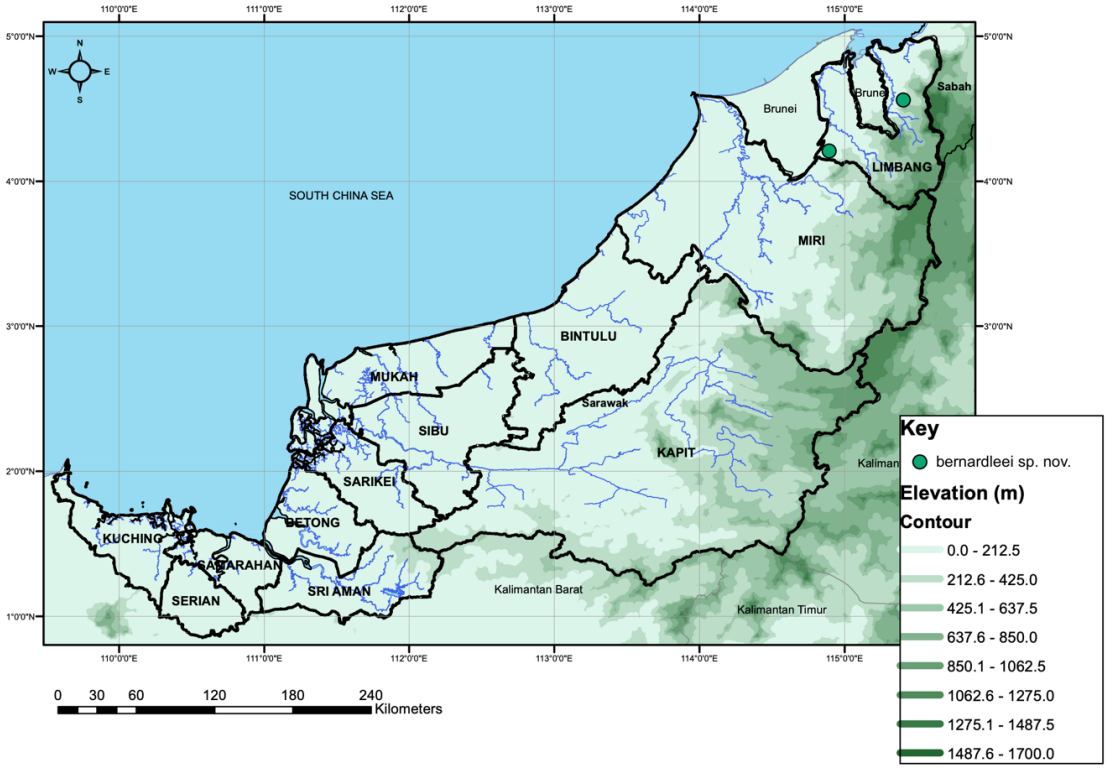


Figure 4.17: Distribution map of *H. bernardleei* sp. nov. in Sarawak.

4.5.8 *Heptapleurum bidenticarpum* N. Ramnor & A. Puad, sp. nov. (Figure 4.18)

Type material: Miri: Mt. Api, limestone slope, 914 m, 5 Sep 1970, *Paul Chai, S. 30073* (holotype: SAR!).

Climber or small tree about 3 m tall. ***Leaves*** up to 4-foliolate and entirely glabrous. Stipule 0.7 cm. Petiole 10-12.2 cm long × 0.25-0.26 cm diam. Petiolule 1.3-4.5 cm long × 0.15-0.20 cm diam. Blades slightly obovate to elliptic, sometimes with unequal sides, 9-21 cm long × 4.3-7.3 cm wide. Apex caudate-acuminate to caudate, extending up to 2 cm long. Margin entire. Base cuneate. Second-order venation weakly visible, pinnate-arcuate, 5-7 pairs on each side, camptodromous and ascending towards margin. ***Inflorescences*** terminal. Each branch bearing a short bract. Limitation zone 3-3.5 cm long and branching zone c. 0.5 cm long. Terminal branches about 4, slender, moderately hairy, 26.6-35 cm long × 0.24 cm diam. Umbellules racemosely and closely arranged along most of the branch length and numerous. Peduncles 2-5 mm long. Pedicels extremely short with length of 0.5 mm long. ***Flowers*** not seen. ***Fruits*** narrowly tubular, 5 mm long × 1-2 mm diam., deeply sulcate and sparsely hairy. Ovary almost inferior. Disk slightly glaucous. Stigmata sessile on top of disk, mostly 3-4, sometimes 1-2.

Distribution: Northern Sarawak (Figure 4.19)

Conservation status: *Heptapleurum bidenticarpum* is assessed as Data Deficient (DD).

Habitat: On the limestone slope and scree in open forest at altitudinal ranges of 200-914 m above sea level.

Notes: This taxon differs from *H. tetrandrum,* recorded in Borneo, by having long and narrow tubular fruits and short pedicels.

Derivation of name: The taxa is named based a combination of genus *Bidens,* herbaceous flowering plant in daisy family, Asteraceae and a Greek word, carp, meaning 'fruit'. It is referring to the elongated fruits that resembles the fruits of *Bidens* especially *B. pilosa* L.

Specimen listing: MIRI. Mulu. Mt. Api, 914 m, 5 Sep 1970, *Paul Chai, S. 30073* (SAR); NW of Sg. Lansat, 200 m, 15 Nov 1977, *G. Argent et al., No. 744* (SAR).



Figure 4.18: *Heptapleurum bidenticarpum* N. Ramnor & A. Puad, sp. nov. (S. 30073).

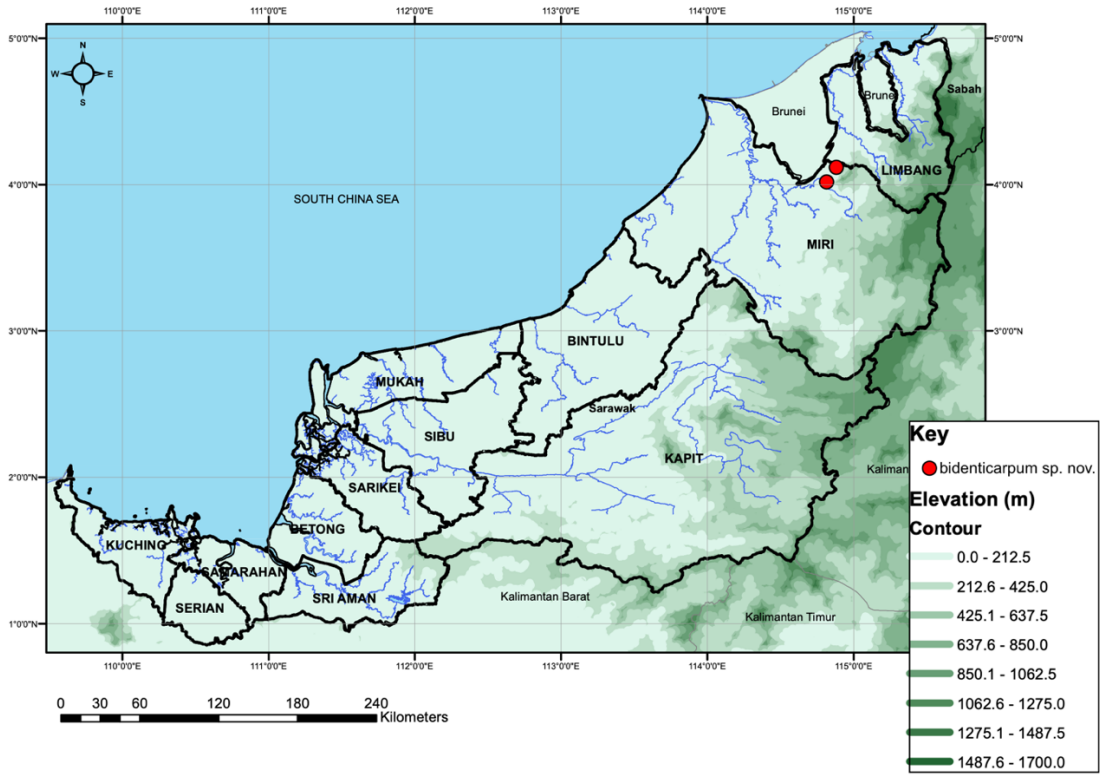


Figure 4.19: Distribution map of *H. bidenticarpum* sp. nov. in Sarawak.

4.5.9 *Heptapleurum bipalmatifolium* (Merr.) Lowry & G. M. Plunkett (Figure 4.20)

Novon 28 (3): 148 (Lowry & Plunkett, 2020)

Basionym: *Schefflera bipalmatifolium* Merr., *Philippine Journal of Science, Section C, Botany* 13: 99 (Merrill, 1918a).

Type material: Borneo (Sabah), Mt Kinabalu, Kiau, 6 November 1915, *M. S. Clemens 10072* (holotype: PNH; isotypes: A, UC).

Treelet with 2 m height or epiphyte 2 m tall. ***Leaves*** bipalmately compound on angular petioles, 26-49 cm long × 0.32-0.63 cm diam, 7-8 leaves produced at the first verticil with petiolules about 3.5-6.7 cm long × 0.08-0.11 cm diam., followed by 3-6 leaves. Stipular

ligule partially fused with free portion about 2.6 cm long. Blades thin, chartaceous, both surfaces dull, ovate to elliptic, 13.3-20 cm long × 4.5-8.5 cm wide. Apex caudate with length 2.0-2.5 cm long. Base acute. Margin either entire or toothed but not prominent. Second-order venation 7-9 pairs, eucamptodromous, pinnate-arcuate and conspicuous on both surfaces. ***Inflorescences*** terminal. Limitation zone 3 cm long followed by branching zone more or less 1 cm long. Branches 8, length 39.5-42 cm × 0.35 cm diam, angular as well. Umbellules numerous, heavily congested along the branch. Peduncles very short, length 1 mm at most. Pedicels 3-4 mm long. ***Flower*** buds obovoid with flattened apex. Cupule obconic with 2 mm apart. Ovary inferior. Disk flat. Stylar column 0.5-1 mm long, topped by 5 separated stigmata. ***Fruits*** not seen.

Distribution: Borneo. In Sarawak, the plant is recorded in Miri divisions. (Figure 4.21)

Conservation status: *Heptapleurum bipalmatifolium* is assessed as Data Deficient (DD).

Habitat: Hill dipterocarp forest near stream and primary forest with elevation of 1300-1750 m above sea level.

Notes: *Heptapleurum bipalmatifolium* is the only species with twice-palmately compound leaves with thin, elliptic to ovate blades and long caudate apex. There is no evidence of once-palmately leaves yet in Sarawak. The inflorescence branches were spike-like when found in habitat and the flowering period is non-seasonal (Ahmad Puad et al., 2018). The umbellules along each branch are many and congested. Flower buds obovoid with flattened disk, 1 mm high stylar column and 5 separated stigmata on top.

Specimen listing: MIRI. Bario. Batu Buli, Kelabit Highlands, 1750 m, 23 Apr 1970, *Nooteboom & Paul Chai, Nooteboom 2215* (SAR); Proposed Gunung Murud National Park, 1300 m, 15 Sep 1982, *Yii Puan Ching, S. 44672* (CGE).



Figure 4.20: *Heptapleurum bipalmatifolium* (Merr.) Lowry & G. M. Plunkett (Nooteboom No. 2215).

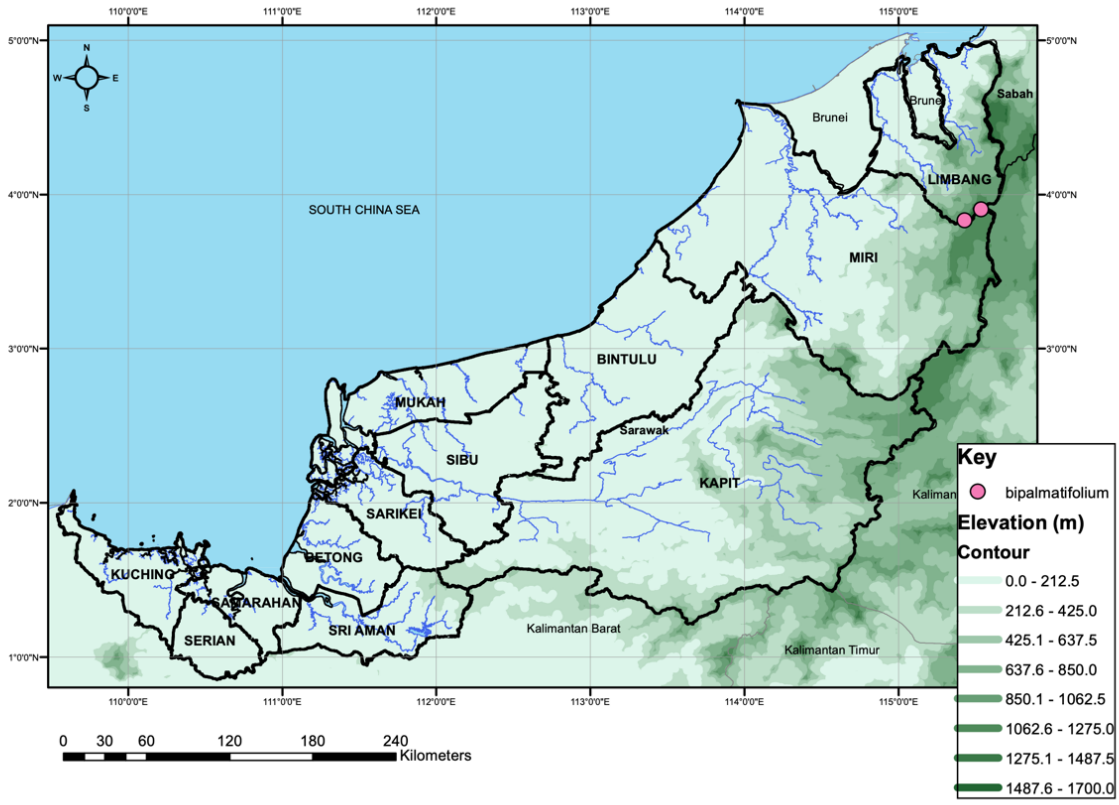


Figure 4.21: Distribution map of *H. bipalmatifolium* in Sarawak.

4.5.10 *Heptapleurum borneense* (Merr.) Lowry & G. M. Plunkett (Figure 4.22)

Novon 28 (3): 148 (Lowry & Plunkett, 2020).

Basionym: *Schefflera borneensis* Merr. *Philippine Journal of Science, Section C, Botany* 13: 100 (Merrill, 1918a).

Type material: Sarawak, vicinity of Kuching, July & August 1911, *Native Collector 798* (holotype: PNH).

Small tree, epiphyte or climber. ***Leaves*** 3-9 foliolate. Stipule partially fused, apex truncate, persistent, 0.7-1.2 cm long. Petioles slender, 18-22.5 cm long × 0.15-0.40 cm diam. Petiolules 2-8.5 cm long × 0.1-0.2 cm diam., vary in length. Blades elliptic, ovate to oval,

thin, length 11.5-23.3 cm long × 4.1-12 cm wide. Apex caudate-acuminate to caudate with length 0.9-3 cm. Margin entire. Base concave. Second-order venation 5-9 pairs, gradually curving towards margin, yellowish, eucamptodromous, widely spaced. Reticulations coarse. ***Inflorescences*** terminal, paniculate. Limitation zone about 2.5-7 cm long. Branching zone about 1.5-1.8 cm long. Bracts along the main axis 2-2.7 cm long, acute tipped. Lateral branches 7-16, congested along the axis, slender, (4-) 13-28 cm long × 0.10-0.15 cm diam., densely covered with hairs. Umbellules numerous, arrangement racemose along the branch length. Peduncle pubescent, 1-4 mm long, subtended by bracts but not persistent, 3-6 mm long. Pedicels 2-4 mm long, glabrous and purple coloured. ***Flowers*** 6-11 per umbel, bud whitish, 1-2 mm long × 1-1.5 mm diam., widest point above the cupule, globose. Cupule campanulate and creamy. Petals pale pink. Disk somehow flat, glaucous. Stamen 5, cream and length up to 3 mm long. Stigmata 5, fused and slightly elevated from the disk. ***Fruits*** not seen.

Distribution: Borneo. In Sarawak, the plant is recorded in Kuching, Sri Aman and Betong divisions. (Figure 4.23)

Conservation status: *Heptapleurum borneense* is assessed as Data Deficient (DD).

Habitat: Most of the specimens were collected at limestone area. Also recorded in ‘rubber garden’, riparian forest and lowland forest. Elevation ranges from 46 m to 152 m above sea level.

Notes: The notable features of this species including petiolules vary in length, blades usually broadly elliptic to ovate to oval with long caudate tip and concave base, arcuate lateral veins that are widely spaced and small inflorescences covered with densely fine hairs. The flowers have 5 petals and stamen. The earliest collection of this species was done by Garai, one of the Haviland collectors (van Steenis-Kruseman, 1950) at 'near Kuching' in January 1891. After that, more similar specimens were collected in Bau and Padawan, Kuching specifically in limestone vegetation. Outside of Kuching, each specimen was collected at Lundu, Lubok Antu and Saratok.

Specimen listing: KUCHING. Near Kuching, Dec 1891, *Garai, Hav. 1123/938* (SAR); Near Kuching, Jan 1892, *Garai, Hav. 1369/956* (SAR); Teng Bukap, Padawan, 12 Jan 1973, *James Mamit et al., S. 32618* (L, K, SING, SAN). **Bau.** Bkt. Kolong, Tai Ton, 46 m, 14 Dec 1965, *Paul Chai & L. H. Seng, S. 16172* (K, L, SING, SAN, A); Bkt. Jebong, 8 Jan 1972, *J. A. R Anderson & Paul Chai, S. 32153* (SAR); Bidi, Krokong road, 22 Oct 1979, *James Mamit, S. 42146* (CGE, L, K, KEP, SAN); Mt Maja, 21 Oct 1979, *B. & K. Bremer, No. 1702* (SAR); Bkt. Jambusan, 100 m, 13 Nov 1985, *Yii et al., S. 50337* (CGE, K, L, KEP, SAN); Jambusan road, 85 m, 13 Dec 1994, *Rantai Jawa et al., S. 70010* (KEP, CGE, K, L, SAN). **Lundu.** Mt. Gading, 152 m, 19 Sep 1955, *J. W. Purseglove & M. Shah, P. 4556* (SAR, SING). **SRI AMAN. Lubok Antu.** Sg Segera, 18 Nov 2001, *Endela T. et al., S. 83817* (SAR, K, L, KEP). **BETONG. Saratok.** Sg. Sebetan (rubber garden), 23 Jun 1987, *Hj Othman & Munting, S. 54386* (CGE, K).



Figure 4.22: *Heptapleurum borneense* (Merr.) Lowry & G. M. Plunkett (S. 42146).

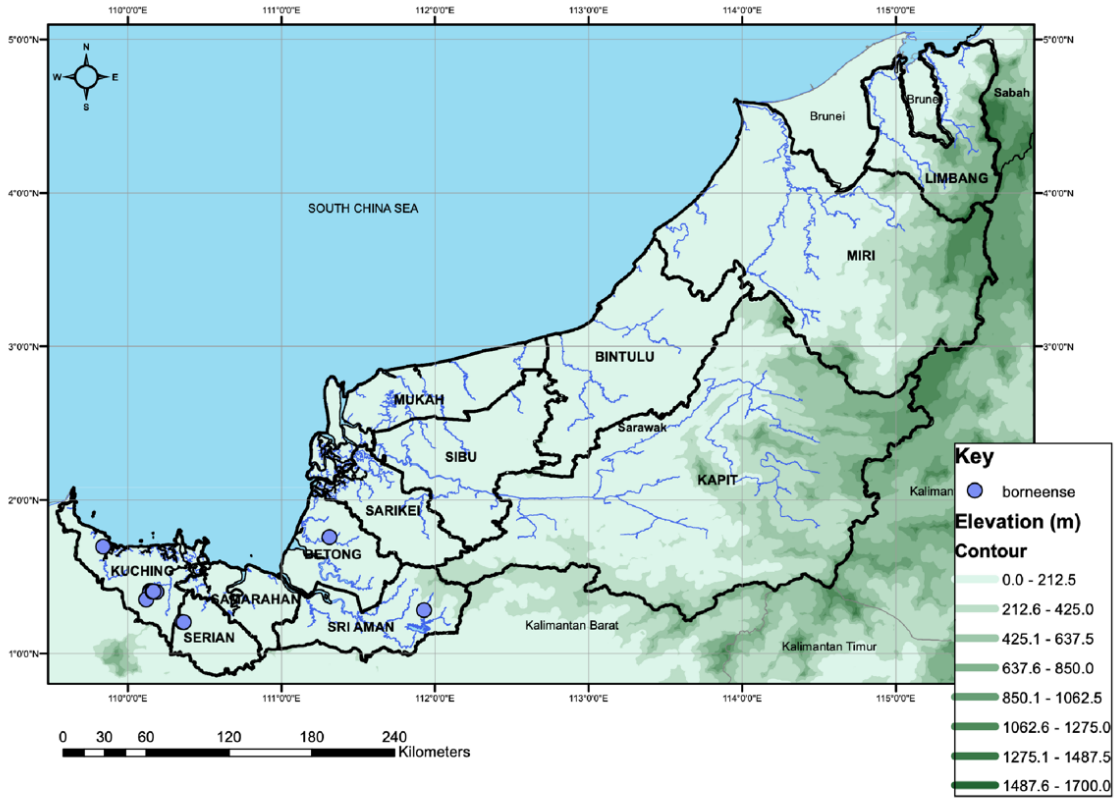


Figure 4.23: Distribution map of *H. borneense* in Sarawak.

4.5.11 *Heptapleurum bracteosum* N. Ramnor & A. Puad, sp. nov. (Figure 4.24)

Type material: Miri: Tama Abu Range, on a ridge, 1550 m, 6 Sep 1985, *Dayang Awa & Bernard Lee, S. 51115* (holotype: SAR!; isotypes: CGE, K, L).

Small tree about 2-5 m tall. ***Leaves*** 5-6 foliolate. Stipule about 3-3.8 cm long, not persistent. Petiole (16-) 38-52 cm long × 0.4-0.6 cm diam. Petiolules vary in length, 3.8-7.5 cm long × 0.2 cm diam. Both petiole and petiolules covered with densely brown stellate hairs. Blades thickly coriaceous, lower surface covered with hairs, broadly elliptic to oblong-elliptic to oval, (7.0-) 18.5-30 cm long × 6.1-9.8 cm wide. Apex caudate with length 1.7-2.5 cm long. Base obtuse. Margin entire. Second-order venation 9-12 on each side, prominent on lower surface, spreading-ascending, camptodromous. Reticulations very weak and some not visibly seen on leaves. ***Inflorescence*** terminal, entirely covered with brown hairs, limitation zone 5-8 cm long and branching zone 1.5-5.5 cm long. Every branch marked by long bracts with length 6.7-7 cm long. Branches 5, congested along the branching zone, 21.1-26.2 cm long × 0.2-0.4 cm diam. Umbellules 16-28 per branch and scattered along the branch. Peduncles 1.4-2.7 cm long, each subtended by bracts with length (0.8-) 1.5-2.5 cm long. Pedicels 4-5 mm long. ***Flowers*** greenish yellow, entirely covered with light brown hairs, cupule green and obconic to campanulate. Petals about 6 with length 1.5-2 mm long. Stamen 3 mm long. Disk flat with stylar column c. 1 mm long. Ovary inferior. ***Fruits*** about 45 per umbel, green to greenish yellow, glabrous with bracteole 2-3 mm long. Deeply sulcate due to drying. Globose with dimension 4-5 mm long × 1.5-3 mm diam. Almost inferior. Stylar column 1-1.5 mm long. Stigmata 6-7.

Distribution: Northern Sarawak (Figure 4.25)

Conservation status: *Heptapleurum bracteosum* is assessed as Data Deficient (DD).

Habitat: Ridge and near river at elevation 1500-1550 m above sea level.

Notes: The taxon differs from *H. beccarianum,* found in Borneo, by having persistent bracts at the base of peduncles, less and shorter inflorescence branches. The plant is almost entirely covered in dense brown hairs except on the upper surface of leaves.

Derivation of name: The specific epipthet is from the Latin word '*bractea*' referring to the persistent bract of the flowers.

Specimen listing: MIRI. Bario. Ulu Sg. Limbang to Batu Lawi, 1530 m, 12 Aug 1985, *Dayang Awa & Bernard Lee, S. 50784* (CGE, K, L); Tama Abu Range, 1550 m, 6 Sep 1985, *Dayang Awa & Bernard Lee, S. 51115* (SAR, CGE, K, L). **LIMBANG.** Mt. Pagon, 1500 m, 19 Aug 1984, *Dayang Awa & Bernard Lee, S. 47984* (KEP).



Figure 4.24: *Heptapleurum bracteosum* N. Ramnor & A. Puad, sp. nov. (S. 51115).

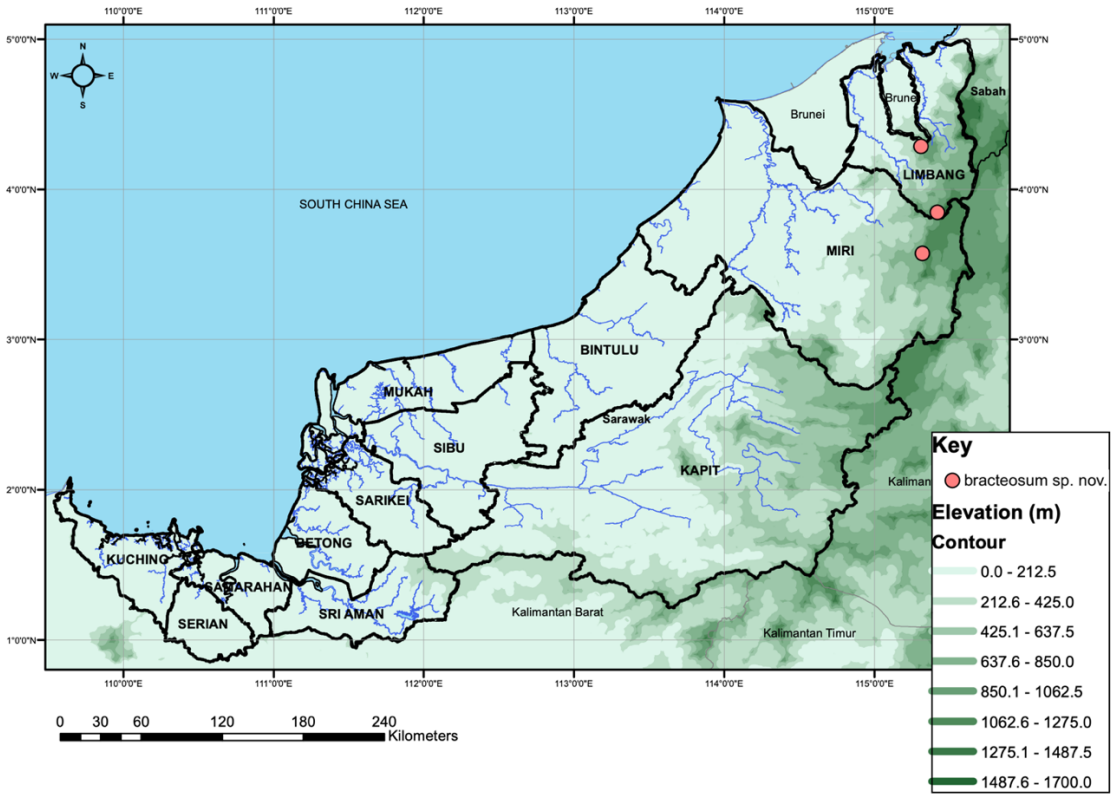


Figure 4.25: Distribution map of *H. bracteosum* sp. nov. in Sarawak.

4.5.12 *Heptapleurum brookeanum* N. Ramnor & A. Puad, sp. nov. (Figure 4.26)

Type material: Serian: Bkt Terebat, Mongkos, kerangas forest, 19 Jun 1996, *Jamree et al., S. 73239* (holotype: SAR!).

Epiphyte or small tree. ***Leaves*** 5-8 foliolate. Stipule acute, 1.4-4.5 cm long. Petiole 12.5-50.5 cm long × 0.20-0.54 cm diam. Petiolules vary in length, 1-10.5 cm long × 0.08-0.21 cm diam. Blades elliptic to oblong-elliptic, sometimes broadly ovate or oval, thin, dull surfaces, glabrous, 10.2-31.5 cm long × 3.3-12 cm wide. Margin entire. Base concave to slightly decurrent. Apex caudate lengthening up to 2.4 cm long. Second-order venation curved, eucamptodromous, sometimes appear yellowish, (4-) 7-11 pairs on each side, wide spacing between each vein (c. 1-2.5 cm apart) and coarse reticulations. ***Inflorescences*** terminal. Limitation zone 3-7.5 cm long and branching zone 1-2.5 cm long. Branches 10-16, arrangement corymb, congested along the axis, covered with brown stellate hairs, 14-24 cm long × 0.16-0.20 cm diam. Umbellules numerous on most of the branch length. Peduncles 0.1-1 cm long and pedicels almost sessile up to 0.2 cm long. Both of peduncles and pedicels purplish. ***Flowers*** not seen. ***Fruits*** glabrous, reddish yellow, 6-12 per umbel, ovoid, 1.5-4 mm long × 0.8-2.6 mm diam., deeply sulcate due to drying. Ovary almost inferior. Disk somehow glaucous. Stigmata sessile, separated on top, (4-) 5-6 (-7).

Distribution: Southern Sarawak (Figure 4.27)

Conservation status: *Heptapleurum brookeanum* is assessed as Data Deficient (DD).

Habitat: Mixed dipterocarp, heath, riverine and limestone rocks. Altitudinal ranges from 50 m up to 350 m above sea level.

Notes: The taxon differs from *H. gracile* Blume ex Seem. and *H. mangiferifolium*, also recorded in Borneo. Comparing to *H. gracile, H. brookeanum* has larger leaflets with numerous veins and more number of inflorescence branches with pedicellate flowers. As for *H. mangiferifolium,* they can be distinguished by the distant of inflorescence branches along the axis and the spacing length between secondary venation.

Derivation of name: The species is named after the Rajah of Sarawak, Sir James Brooke. During his rule in Sarawak, he encouraged the European scientists to come to Sarawak for studying its natural environment. The work was continued by his nephew, Charles in 1868 (Friends of Sarawak Museum, 2021).

Specimen listing: KUCHING. Arboretum Semengoh Forest Reserve, 20 Oct 1966, *Banyeng & Benang, S. 26216* (K, L, CGE); 31 Dec 1966, *J.A.R. Anderson, S. 27071* (SAR); 15 Aug 1991, *Frodin et al., No. 2107* (SAR); Bkt Woen, Padawan, 350 m, 2 Oct 1987, *Yii Puan Ching, S. 61451* (K, CGE); Bkt Bah, Padawan, 25 Nov 1992, *Lesmy & Jugah, S. 65166* (KEP); Ethnobotanical Garden, Semengoh Nature Study Centre, 50 m, 23 Nov 1994*, Yii Puan Ching et al., S. 64556* (KEP, K, SAN). **Lundu.** Sg Sebuluh, 24 Feb 1991, *Hj Othman et al., S. 61906.* **SERIAN.** Bkt Terebat, Mongkos, 19 Jun 1996, *Jamree et al., S. 73239.*



Figure 4.26: *Heptapleurum brookeanum* N. Ramnor & A. Puad, sp. nov. (S. 73239).

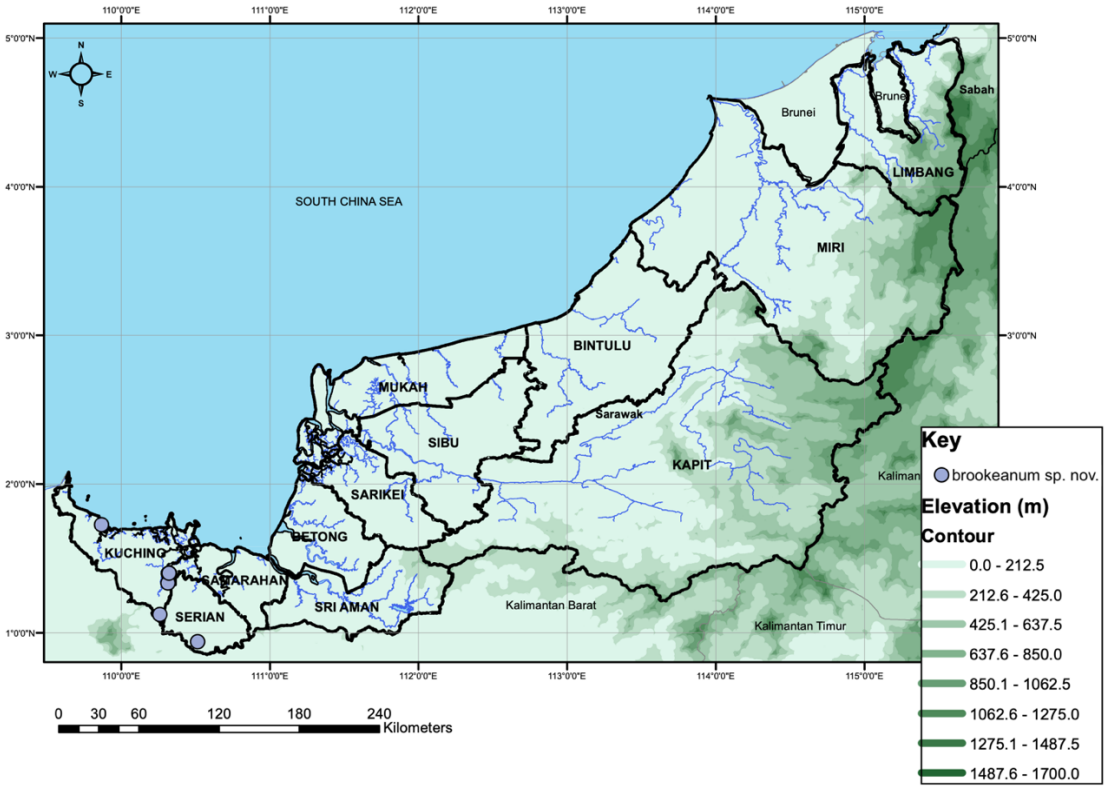


Figure 4.27: Distribution map of *H. brookeanum* sp. nov. in Sarawak.

4.5.13 *Heptapleurum burianum* N. Ramnor & A. Puad, sp. nov. (Figure 4.28)

Type material: Samarahan: Mt. Buri, disturbed primary mixed dipterocarp forest, 300 m, 14 Sep 1975, *Paul Chai, S. 36743* (holotype: SAR!; isotypes: CGE, L, K, KEP, MO).

A hemiepiphyte. ***Leaves*** 6-foliolate. Stipule partially fused, persistent, acute. Petioles swollen at the base, congested along the stem, slender, hairy, 19.5-30 cm long × 0.22-0.27 cm diam. Petiolules 2.9-4 cm long × 0.10-0.11 cm diam. Blades narrowly elliptic to slightly oblanceolate with length 6.5-15 cm × width 2.2-4.3 cm. Apex broadly caudate-acuminate with length 0.6-1.3 cm. Margin entire. Base obtuse. Second-order venation 7-9 pairs, pinnate and camptodromous. ***Inflorescences*** terminal. Limitation zone 1 cm and branching zone 19.5 cm long. Each branch marked by short, acuminate bracts. Branches 16, slender, covered with brown hairs and 35-39.5 cm long. Peduncles angular, brown, 4-7 mm long. Umbellules more or less 40 per branch, in heads, 4-5 mm diam. with sessile and separated c. 20 flowers per head. ***Flowers*** glabrous, whitish green, 1.5 mm long × 1.5 mm diam. Cupule cupuliform with calyx rim-like. Ovary inferior. Apex flat and glaucous. Stamen c. 2 mm long. Anther brown. Stigmata sessile and indistinct. ***Fruits*** not seen.

Distribution: Southern Sarawak (Figure 4.29)

Conservation status: *Heptapleurum burianumi* is assessed as Data Deficient (DD).

Habitat: Disturbed primary mixed dipterocarp forest around 300 m above sea level.

Notes: Notable characteristics of this species is inflorescences in heads with about 20 flowers per head. Other species with inflorescence in heads are *H. cephalotes* and *H. lanatum.* Compared to those two species, *H. burianum* has the smallest head and holds the fewest flowers per head. The ovary is inferior with truncate and glaucous disk. At this stage, the stigmata are indistinct. No fruits are available for observation.

Derivation of name: The taxa is named after Mount Buri in Simunjan where the specimen was collected.

Specimen listing: SAMARAHAN. Simunjan. Mt. Buri, 300 m, 14 Sep 1975, *Paul Chai, S. 36743* (SAR, CGE, L, K, KEP, MO).



Figure 4.28: *Heptapleurum burianum* N. Ramnor & A. Puad, sp. nov. (S. 36743).

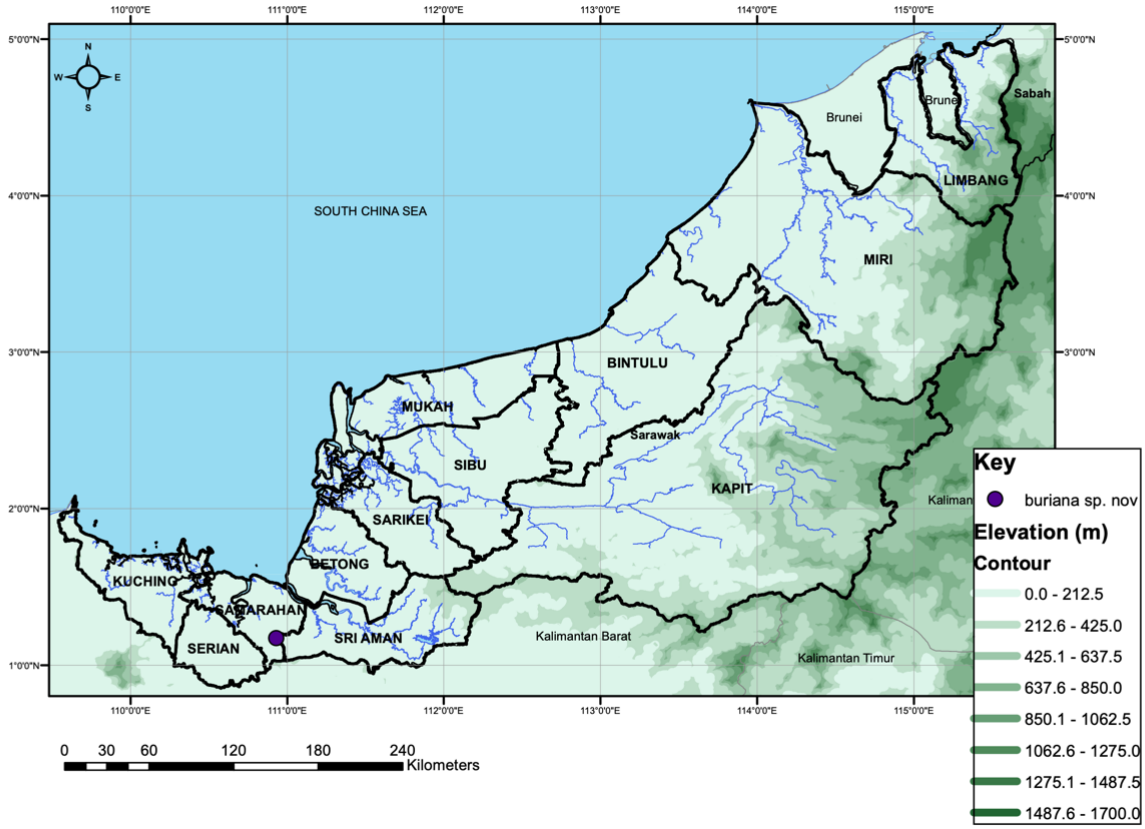


Figure 4.29: Distribution map of *H. burianum* sp. nov. in Sarawak.

4.5.14 *Heptapleurum burkillii* (Merr.) Lowry & G. M. Plunkett (Figure 4.30)

Novon 28 (3): 148 (Lowry & Plunkett, 2020).

Basionym: *Schefflera burkillii* Merr., *Journal of the Straits Branch of the Royal Asiatic Society* 79: 28 (Merrill, 1918b).

Type material: Sarawak, Matang road, 11 August 1911, *Native Collector 802* (holotype: A; lectotype, K).

A small tree or climber. ***Leaves*** bifoliolate to trifoliolate. Stipule rim-like and narrow at the petiole base. Petiole 3-6 cm long × 1-2 mm diam. Petiolules 0.3-1.3 cm long × 1.5-2 mm

diam. Blades elliptic to ovate with unequal sides, thick, coriaceous, 6.5-10.1 cm long × 2.2-4.5 cm wide. Apex acute to acute-acuminate, c. 1.3 cm long. Margin entire. Base obtuse to cuneate. Second-order venation somehow straight and anastomosing. ***Inflorescences*** terminal. Limitation zone 1.2-6.2 cm long. Branching zone about 1.4 cm long. Terminal branches about 2-3, corymb-like, length 2.0-7.5 cm long. Umbellules not more than 5 per branch, with 3 at terminal and 2 umbels on subsidiary cluster. Peduncles 0.8-2.0 cm long. Pedicels up to 3 mm long. ***Flowers*** in buds, 10-12 per umbel, 3 mm long × 2.5 mm diam., ellipsoid. Cupule c. 1 mm long, obconic. Petal 2 mm long. ***Fruits*** not seen.

Distribution: Borneo. In Sarawak, the plant is recorded in Kuching division. (Figure 4.31)

Conservation status: *Heptapleurum burkillii* is assessed as Data Deficient (DD).

Habitat: On ridgetop and summit vegetation with elevation from 780 m to 927 m above sea level.

Notes: *Heptapleurum burkillii* is a small plant and it can be identified by its bi or trifoliolate leaves that are thick and coriaceous, not more than 3 terminal branches with length slightly longer than petiole, umbels per branch from 5 and less and peduncles slender up to 2 cm long. On Bungoh Range, the plant was recorded as a small sapling whereas on Mount Santubong, the species was found climbing on a tree.

Specimen listing: KUCHING. Mt. Santubong, 780 m, 22 Aug 1976, *P. J. Martin, S. 37593* (CGE, L, K, KEP, MO). **Bau.** Bungoh (Bungo) Range, 1067 m, 9 Oct 1957, *E. F. Brunig, S. 7630* (SAR); Bungo Range, 1067 m, Oct 1957, *S. 9512* (SAR).

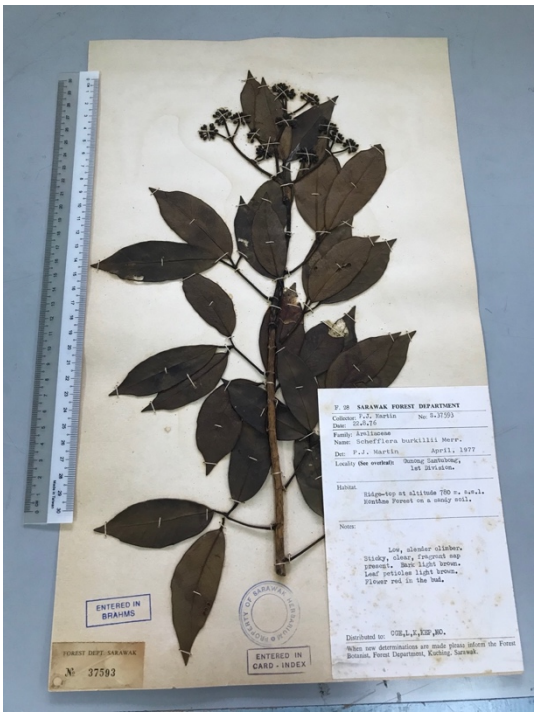


Figure 4.30: *Heptapleurum burkillii* (Merr.) Lowry & G. M. Plunkett (S. 37593).

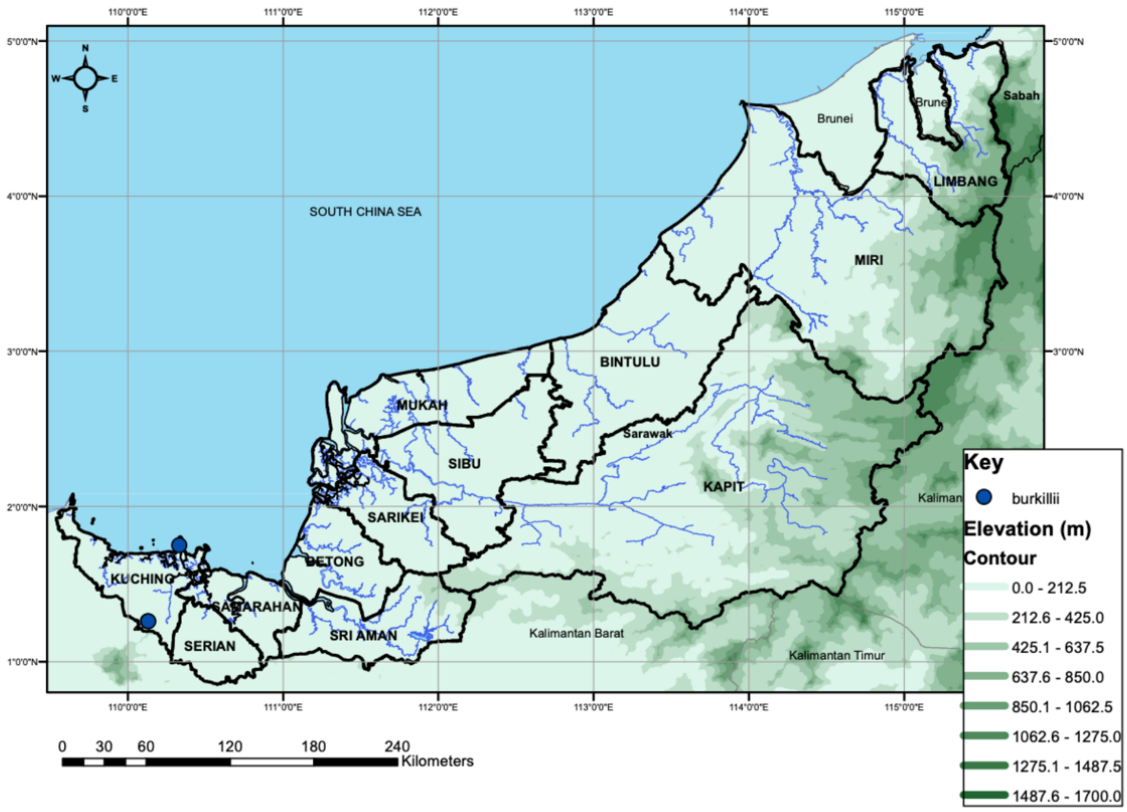


Figure 4.31: Distribution map of *H. burkillii* in Sarawak.

4.5.15 *Heptapleurum cephalotes* C. B. Clarke (Figure 4.32)

In J. D. Hooker, *Flora of British India* 2 (6): 731 (Clarke, 1879).

Synonyms: *Schefflera cephalotes* (C. B. Clarke) Harms, in H. G. A. Engler & K. A. E. Prantl, *Naturlichen Pflanzenfamilien* 3 (8): 36 (Harms, 1894). *Brassaia cephalotes* (C. B. Clarke) Hutch., *Genera of Flowering Plants* 2: 622 (Hutchinson, 1967).

Type material: Melacca, *W. Griffith, No. 2700* (holotype: K; isotype: BR).

Climber about 20 m long. ***Leaves*** 7-9 foliolate. Petiole covered with hairs, 15-23 cm long × 0.25-0.26 cm diam. Stipular ligule at the petiole base obtuse with free portion 0.5 cm long. Petiolules 1.7-3.1 cm long × 0.10-0.14 cm diam, somehow glabrescent. Blades thin,

narrowly oblong, 8.7-14 cm long × 2.8-3.4 cm wide with entire margin and convex base. Apex acuminate extending up to 0.8 cm long. Upper surface appears glossy while below dull and sparsely hairy. Petiole, petiolule and midrib on lower surface of leaves yellowish. Second-order venation about 18 pairs on each side, weakly raised, eucamptodromous and gradually curving. ***Inflorescences*** terminal. Limitation zone 1-1.5 cm long and marked by bract scars. Branching zone 1-2 cm long. Branches along the main axis closely spaced, spreading, 21-23 cm long × 0.22-0.24 cm diam., covered with hairs. Umbellule heads in globose racemosely arranged along half to ¾ of the branches, 5.8-6.6 mm diam. Peduncles up to 2 mm long. ***Flower buds*** sessile, 28 per heads, whitish, covered with brown hairs, obovoid with apex flattened, 3 mm long × 2 mm diam., cupule funnel-shaped topped by calyx rim-like. Filament and style green in colour. Anther purple. ***Fruit*** not seen.

Distribution: Borneo, Malaya, Sumatera, Thailand. In Sarawak, the plant is recorded in Kuching. (Figure 4.33)

Conservation status: *Heptapleurum cephalotes* is assessed as Data Deficient (DD).

Habitat: On ridge, transitioning forest of hill dipterocarp to submontane forest. Elevation 650 m above sea level.

Notes: The inflorescences of *H. cephalotes* are in heads that quite distinct compared to the other species of *Heptapleurum.* Another species with inflorescence in heads is *H. lanatum.* Compared to *H. lanatum*, the heads of *H. cephalotes* are much smaller in size and fewer number of flowers per head. Other features that help to distinguish *H. cephalotes* are having

narrowly, conspicuous oblong leaflets, glossy upper surfaces, dull and sparsely hairy lower surfaces. According to Lowry & Plunkett (2020), *H. cephalotes* is widely distributed in Peninsular Malaysia, Borneo, Sumatra and Peninsular Thailand. However, there is only one specimen for this species in the herbarium.

Specimen listing: KUCHING. Lundu. Mt. Gading, 650 m, 2 Dec 1976, *P. J. Martin, S. 37920* (L, K, KEP, CGE, SAN).

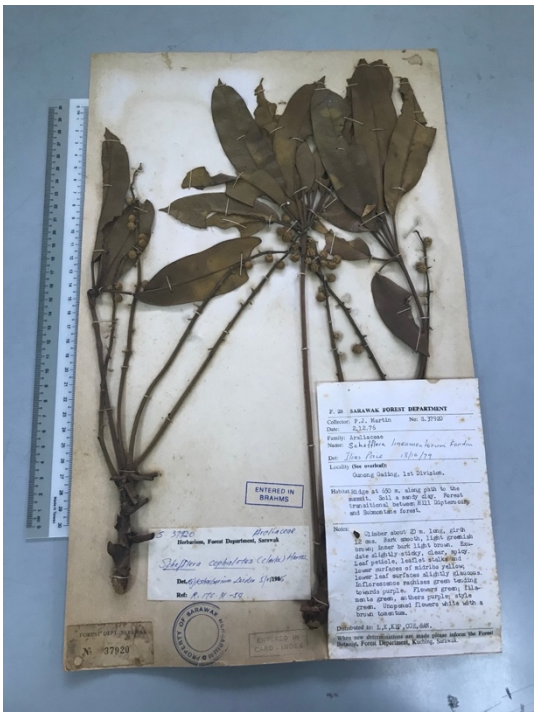


Figure 4.32: *Heptapleurum cephalotes* C. B. Clarke (S. 37920).

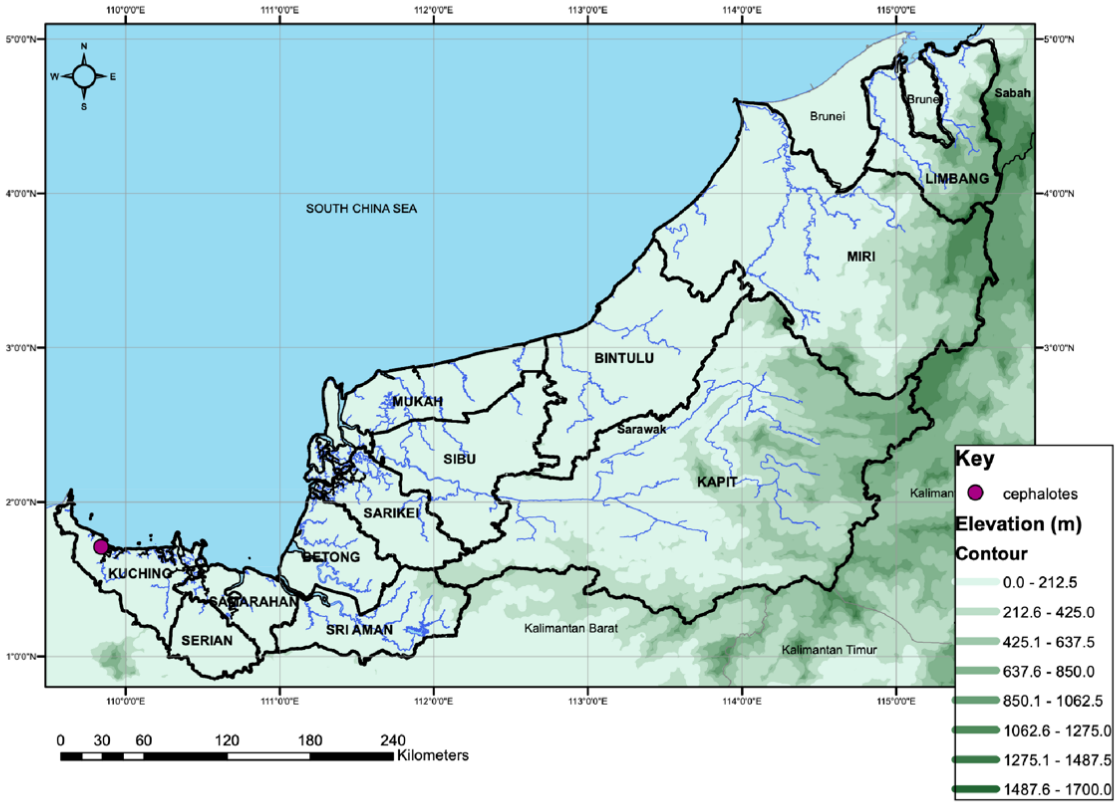


Figure 4.33: Distribution map of *H. cephalotes* in Sarawak.

4.5.16 *Heptapleurum conjunctum* N. Ramnor & A. Puad, sp. nov. (Figure 4.34)

Type material: Bintulu: Path to Bkt. Kamantan, Anap, secondary forest, 11 Oct 1963, *Ilias Paie, S. 19518* (holotype: SAR!; isotypes: K, L).

Climber or epiphyte. ***Leaves*** 6-7 foliolate. Stipular ligule partially fused with length 3.6-6 cm long. Petiole 34.8-50 cm long × 0.5-0.7 cm diam. Petiolules vary in length, 3-13.7 cm long × 0.2-0.3 cm diam. Blades broadly oblong-elliptic to oblong-ovate, 24-40.7 cm long × 9.6-12.3 cm wide, entirely glabrous. Apex caudate-acuminate with length 1.2-1.6 cm long. Margin entire. Base obtuse to concave. Second-order venation 11-15 pairs on each side,

yellowish, eucamptodromous, gradually spreading-ascending and terminated along the margin. ***Inflorescences*** terminal. Limitation zone 7.5-9.6 cm long, marked by broad, acute bracts. Branching zone 53.5-72 cm long. Lateral branches numerous, hairy, 14.2-50.2 cm long × 0.2-0.25 cm diam. Umbellules numerous along most of the branch. Peduncles 0.2-1.5 cm long; pedicels 1-7 mm long and both of them deep purple. ***Flower*** buds up to 10 per umbel, green to white. Ellipsoid to slightly obovoid, 1.5-2.5 mm long × 1.5-2 mm diam. Cupule campanulate. ***Fruit*** globose, 2/3 inferior, glabrous, sessile stigmata 5.

Distribution: Central Sarawak (Figure 4.35)

Conservation status: *Heptapleurum conjunctum* is assessed as Data Deficient (DD).

Habitat: A low elevation plant that can be found up to 250 m above sea level in low dipterocarp, riparian and secondary forest.

Notes: The plant differs from *H. eucaudatum* (Merr.) Lowry & G. M. Plunkett and *H. gracile* by having larger leaves and inflorescences. The inflorescences also very similar to *H. kuchingense* but the inflorescences axis is much more elongated which can be up to 72 cm long.

Derivation of name: The name is derived from the Latin adjective *conjuctus* referring to the continuously joined inflorescence branches along the elongated branching zone.

Specimen listing: BINTULU. Tatau. Ulu Mayeng, Kakus, 20 m, 7 Oct 1963, *P. S. Ashton, S. 19282* (K); Path to Bkt. Kamantan, Anap, 11 Oct 1963, *Ilias Paie, S. 19518* (SAR, K, L). **KAPIT. Belaga.** Sg. Semawat, 250 m, 21 Oct 1981, *Carlo Hansen, No. 752* (SAR); 15 Oct 1981, *Othman Ismawi et al., S. 43635* (CGE). **MIRI. Tinjar.** Ulu Sg. Sekiwa, 29 Aug 1974, *Sylvester Tong, S. 34945* (CGE, L, K, KEP, MO).

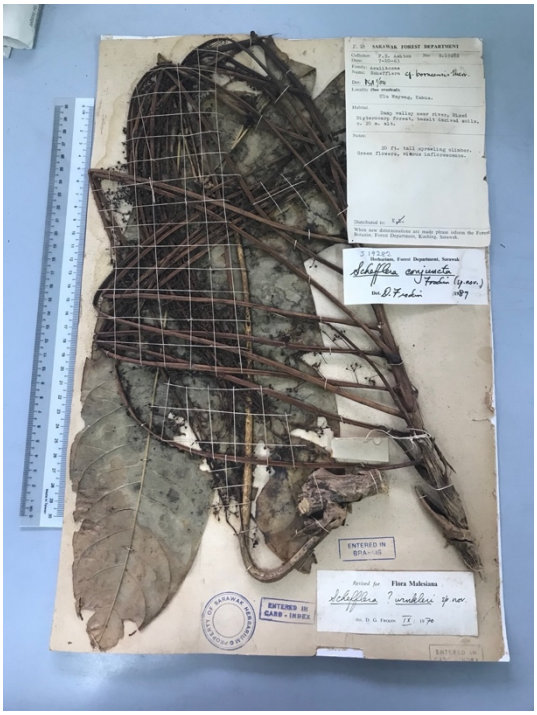


Figure 4.34: *Heptapleurum conjunctum* N. Ramnor & A. Puad, sp. nov. (S. 19518).

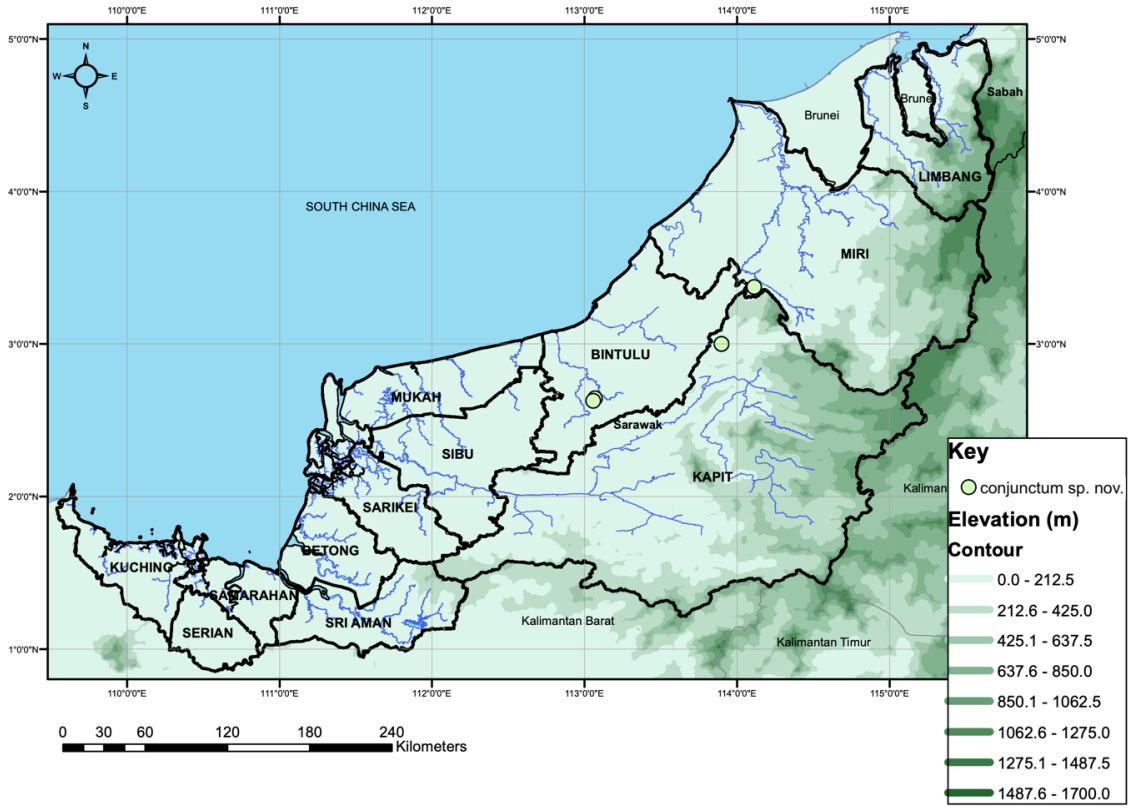


Figure 4.35: Distribution map of *H. conjunctum* sp. nov. in Sarawak.

4.5.17 *Heptapleurum crenatum* (Puad & Frodin) Puad, T. J. Barkman, Lowry & G. M. Plunkett (Figure 4.36)

Novon 28 (3): 151 (Lowry & Plunkett, 2020).

Basionym: *Schefflera crenata* Puad & Frodin, *The Genus Schefflera in Sabah, Malaysian Borneo* 96 (Ahmad Puad et al., 2018).

Type material: Bundu Tuhan, *Saihek Lantoh, SAN 74133* (holotype: SAN; isotypes: A, K, L, SAR, SING).

Epiphyte plant. ***Leaves*** 5-9 foliolate. Stipule persistent, acute, free portion 3-3.5 cm long. Petiole 14.2-20 cm long × 0.30-0.35 cm diam. Petiolule 3-6.5 cm long × 0.15-0.20 cm diam.

Blades elliptic, oval to obovate, 9.3-18.3 cm long × 4.7-9 cm wide. Apex broadly acuminate. Base rounded. Margin fully toothed. Second-order venation 8-13 pairs on each side, eucamptodromous, ascending gradually and terminating at the toothed margin. ***Inflorescences*** terminal, paniculate. Limitation zone 2.7-3 cm long and branching zone 1.5-3 cm long, marked by bract scars. Branches 4-8, 6.5-19.5 cm long × 0.20-0.35 cm diam. Umbellules 6-13 per branch and scattered along ¾ of the branch, widely apart. Terminal umbels 3-4. Peduncles 1.3-3.7 cm long × 0.10-0.15 cm diam, slender, slightly curved. Pedicels 3-8 mm long. ***Flower*** buds 6-11 per umbel, globose with flattened apex, pubescent. 3-5 mm long × 2.5-4 mm diam. Cupule 1-1.5 mm long × 2.5 mm wide, cupuliform. Suture 6-7. Ovary superior. ***Fruits*** ellipsoid, initially green turning yellow, 4-6 mm long × 4 mm diam. Ovary half inferior. Disk strongly convex topped by 6-7 sessile stigmata.

Distribution: Borneo. In Sarawak, the plant is recorded in Miri division. (Figure 4.37)

Conservation status: *Heptapleurum crenatum* is assessed as Data Deficient (DD).

Habitat: Submontane mossy forest and near riverbank at altitudinal ranges of 1341-2012 m above sea level.

Notes: One of the notable characteristics of *H. crenatum* is entirely toothed margin on leaf blades that are either elliptic, oval or obovate. The umbellules along the inflorescence branches are scattered and distant from each other. The flower buds are globose with flattened apex. As for the maturing fruits, they are ellipsoid with strongly convex disk topped

by 6-7 sessile stigmata. The ovary is initially superior during anthesis, turning to half inferior as the fruits are fully matured.

Specimen listing: MIRI. Bario. Ulu Sg. Belaban, Camp 4, Mt. Murut (Murud), 5 Oct 1967, *Ilias Paie, S. 26432* (K, L, CGE). Ulu Sg. Limbang, route to Batu Lawi, 1560 m, 14 Aug 1985, *Dayang Awa & Bernard Lee, S. 50803* (CGE, K, L, KEP); Mt. Murud, 2012 m, 8 Aug 2005, *Kit Pearce et al., S. 95354* (SAR, KEP, K).



Figure 4.36: *Heptapleurum crenatum* (Puad & Frodin) Puad, T. J. Barkman, Lowry & G. M. Plunkett (S. 26432).

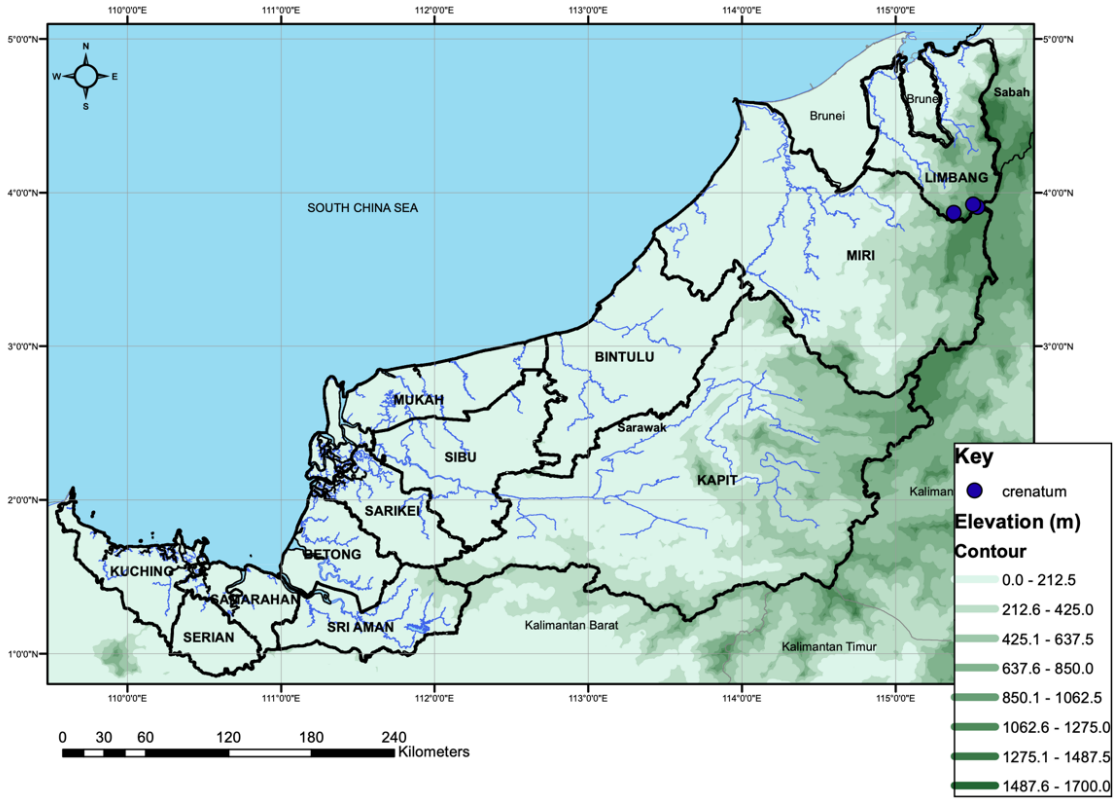


Figure 4.37: Distribution map of *H. crenatum* in Sarawak.

4.5.18 *Heptapleurum ellipticum* (Blume) Seem. (Figure 4.38)

Journal of Botany, British and Foreign 3: 78 (Seemann, 1865).

Basionym: *Sciodaphyllum ellipticum* Blume, *Bijdragen tot de Flora van Nederlandsch Indie* 15: 878 (Blume, 1826).

Synonyms: *Paratropia elliptica* (Blume) Miq., *Bonplandia* 4: 138 (Miquel, 1856). *Schefflera elliptica* (Blume) Harms, in H. G. A. Engler & K. A. E. Prantl, *Naturlichen Pflanzenfamilien* 3 (8): 39 (Harms, 1894).

Type material: Java, Indonesia.

Epiphyte or climber on tree such as *Eugenia* sp. and *Ficus* sp. Not many recorded as crawler or shrub. ***Leaves*** 5-foliolate, glabrous. Stipular ligule on the base unfused, obtuse, 4-6 mm long. Petioles slender 10-16 cm long × 0.16-0.30 cm diam. Petiolules 1.5-7.5 cm long × 0.10-0.15 cm diam. Blades elliptic to oval, rarely narrow elliptic to slightly obovate, 7-17 cm long × 2.8-8.6 cm wide. Apex 0.4-1.5 cm long, broadly to abruptly acuminate. Margin entire. Base rounded to convex. Second-order venation 5-6 pairs, unequal number on both sides, widely spaced about 1.2-3.3 cm apart, strongly ascending, not prominent, coarse. ***Inflorescences*** terminal. Limitation zone 1.4-3.5 cm long and branching zone 4.5-19.5 cm long and marked by bract scars. Lateral branches more or less 6, glabrous, 3-10 cm long × 0.18-0.42 cm diam. Umbellules (4-) 8-14 per umbel, scattered and widely spaced from one another. Peduncles up to 1.7 cm long × 0.05 cm diam. Pedicels 2-8 mm long. ***Flowers*** 6-7 per umbel, bud ellipsoid, 2-3 mm long. Cupule green, funnel-shaped, 1 mm long, with calyx rim-like. Petal 1 mm long, oblong and pale yellow. Disk glaucous. Stamen white. Anther yellow. Ovary pale green. ***Fruits*** more or less 6 per umbel, glabrous, globose-ellipsoid, 4/5 inferior ovary, length about 5 mm long. Stigmata 5-6, sessile on top. Disk slightly conic.

Distribution: Andaman Island, Assam, Bangladesh, Bismarck Archipelago, Borneo, Cambodia, Caroline Island, China South-Central, China Southeast, Christmas Island, East Himalaya, India, Jawa, Laos, Lesser Sunda Island, Malaya, Myanmar, Nepal, New Guinea, Nicobar Island, Philippines, Queensland, Sulawesi, Sumatera, Taiwan, Thailand, Vietnam and West Himalaya. The species was introduced in Mauritius, Réunion and Windward Island. In Sarawak, the plant is recorded in Kuching, Betong, Kapit, Miri and Limbang divisions. (Figure 4.39)

Conservation status: This taxon is known from 21 specimens found in 17 locations (AOO = 68 km^2) from Kuching, Betong, Kapit, Miri and Limbang divisions. It is assessed as Endangered.

Habitat: Mixed dipterocarp, riparian, peat swamp, near rivers, mangrove, beach forest, secondary forest, limestone, submontane and mossy forest. Altitudinal ranges from near sea level up to 1750 m above sea level.

Notes: *Heptapleurum ellipticum* is widely distributed in India, Taiwan, Vietnam, Cambodia, Laos, Myanmar, Thailand, Peninsular Malaysia, Sumatra, Java, Christmas Island, Borneo, Sulawesi, Lesser Sunda Islands, Timor, Moluccas, Philippines, New Guinea, Bismarck Archipelago, Australia and Caroline Islands (Ahmad Puad et al., 2018). This entirely glabrous plant can be recognized by the elliptic to ovate blades with entire margin. The branching zone can be up to 19 cm long. The umbellules are quite distant from each other along the branches. The fruits are globose-ellipsoid with 5-6 locules. The stigmata on top are sessile. Based on the collectors' note of specimen S. 76133, this species can be used to treat seizures (sawan) by burning the leaves, stems and roots to ashes and spread them on the whole body. The local name of this species is 'Akar Kuku Bajang' and 'Rukang Akar'.

Specimen listing: KUCHING. Sg. Maong, 28 Aug 1966, *J. A. R. Anderson, S. 25999* (K, L, CGE); Bintawak Industrial Area, 24 Jun 1976, *James Mamit, S. 37660* (L, K, MO, KEP, SAN); 12th Miles, Kuching-Serian Road, 2 Jan 1997, *Jegong et al., S. 76133* (KEP, K). **Bau.** Wind Cave trail, 10 Feb 1999, *Julaihi et al., S. 82226* (KEP, K, L). **LUNDU.** Mt. Gading, 91 m, 19 Sep 1955, *J. W. Purseglove, P. 4563* (CGE, SAR); Mt Gading, 579 m, 24 Sep 1974,

James Mamit, S. 35147 (L, K, MO, A, CGE); Sia (Siar) beach, 26 Mar 1980, *Yii Puan Ching, S. 42024.* **Sematan.** Tg. Satiman, Datu Protected Forest, 26 May 1980, *Bernard Lee, S. 41953* (CGE, K, L, KEP, SAN); Sg. Bandir, Mt. Pueh, Sematan, 200 m, 29 Aug 1996, *Rantai Jawa et al., S. 75120* (KEP, CGE, K, L, SAN); Tanjung Datu National Park, 8 Jul 1999, *Teo et al., S. 82635* (SAR, K, L, KEP, MO); Tg Serabang, 100 m, 10 Jul 1999, *Teo S. P. et al., S. 82649* (SAR, K, L, KEP, SAN). **BETONG. Pusa.** Saribas, Jul 1892, *Kalong, Hav. 2078/1592* (SAR); Sg. Saribas, 4 Jul 1964, *Bojeng b. Sitam, S. 19671* (K, L, A). **Saratok.** Tuai Rumah Sulau, Sg Anak, 5 Dec 1985, *Ilias Paie et al., S. 44217.* **KAPIT. Bukit Mabong.** Hose Mountains, 1270 m, 30 Nov 1991, *Lai et al., S. 63950* (KEP, CGE, K, L, SAN). **MIRI. Mulu.** Sg. Tapin, Gunung Mulu National Park, 90 m, 4 Feb 1978, *I. Nielsen, No. 223* (AAU, SAR). **Bario.** Lepo Bunga, Mt Murud, 1750 m, 26 Mar 1999, *Julaihi et al., S. 70882*; Pulong Tau NP, 1220 m, 5 Feb 2005, *Kit Pearce et al., S. 93468* (SAR). **Telang Usan.** Sg. Puah, Long Banga, 578 m, 25 Aug 2016, *Syahida Emiza et al., FRI 66984* (KEP, SAR). **LIMBANG. Lawas.** Btg Sundar, 12 Aug 1974, *James et al., S. 34229* (L, K, CGE, MO, A); Sg Mudak, Ba' Kelalan, 20 Aug 2002, *Runi et al., S. 86525*.



Figure 4.38: *Heptapleurum ellipticum* (Blume) Seem. (S. 42024).

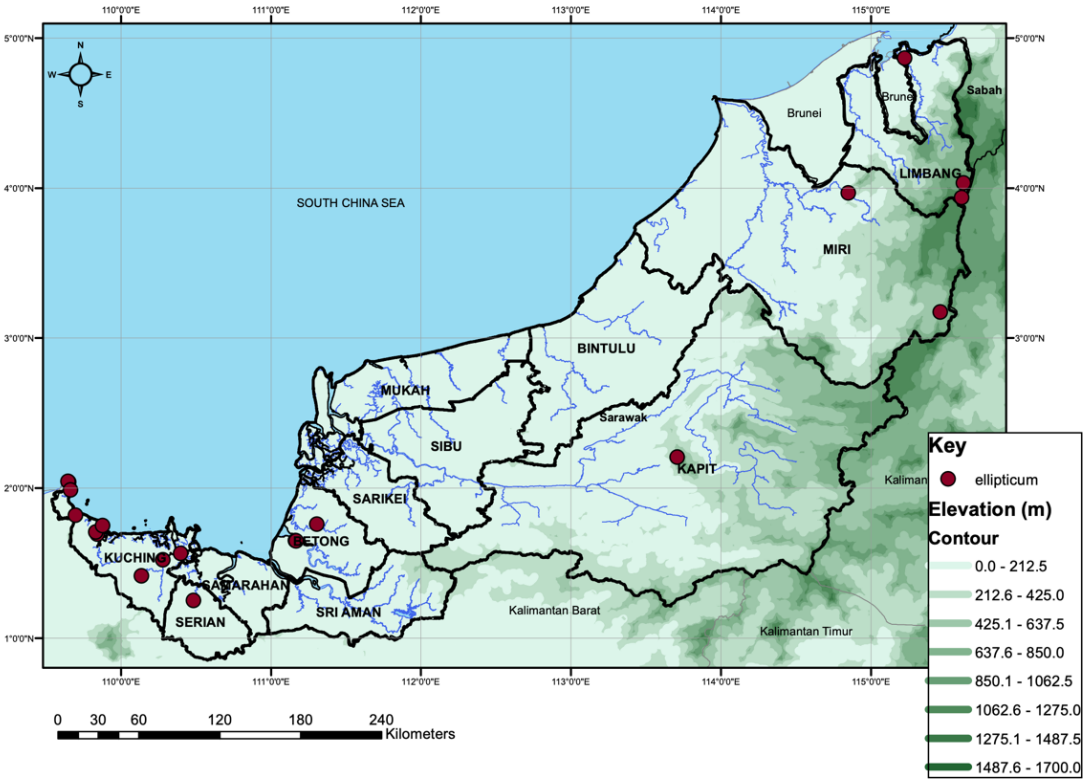


Figure 4.39: Distribution map of *H. ellipticum* in Sarawak.

4.5.19 *Heptapleurum ensiriengense* N. Ramnor & A. Puad, sp. nov. (Figure 4.40)

Type material: Sibu: Sg. Ensirieng, lowland dipterocarp forest, 210 m, 12 May 1998, *Jemree et al., S. 78647* (holotype: SAR!; isotypes: KEP, K).

Epiphyte on tree. ***Leaves*** 3-4 foliolate. Stipule obtuse, 0.3-0.5 cm in length. Petiole 7.7-11.5 cm long × 0.10-0.15 cm diam. Petiolules 1.2-3.7 cm long × 0.06-0.08 cm in diam. Blades elliptic, thin, 9-16.2 cm long × 2.8-4.6 cm wide. Margin entire. Apex caudate extending to 1.3-2.2 cm long. Base cuneate. Second-order venation 7-9 pairs, camptodromous, spreading-ascending and weakly visible on both surfaces. ***Inflorescences*** terminal with limitation zone 5 cm long and branching zone 5.5 cm long. Branches 5, with 2 at terminal and 3 at lateral, 1.5-3.8 cm long × 0.06-0.10 cm diam. Terminal branch has the shortest length. Each branch marked by a bract. Umbels 3-5 per branch, occurring at upper half of branch. Peduncles 0.3-0.7 cm long and pedicels 0.2-0.3 cm long respectively. ***Flowers*** not seen. ***Fruits*** c. 15 per umbel, 1-2 mm long × 0.7-1.3 mm diam. Cupule campanulate. Disk glaucous with separated, sessile stigmata on top, 5-6. Ovary almost inferior.

Distribution: Central Sarawak (Figure 4.41)

Conservation status: *Heptapleurum ensiriengense* is assessed as Data Deficient (DD).

Habitat: Lowland dipterocarp forest at elevation 210-220 m above sea level.

Notes: The leaves of this Ulu Ensirieng species are quite similar to *H. mangiferifolium.* However, their inflorescences can help to differentiate both of the species. *Heptapleurum mangiferifolium* has more branches and umbellules and also longer branches than *H. ensiriengense.* Iban people called this plant 'Raba Cit'.

Derivation of name: The taxa is named after the locality of the collected specimen, Ensirieng river in Kanowit, Sibu.

Specimen listing: SIBU. Kanowit. Sg. Ensirieng, 210 m, 12 May 1998, *Jemree et al., S. 78647* (SAR, KEP, K); Ulu Ensirieng, 220 m, 19 Feb 2003, *Rantai Jawa et al,* S. *88798* (SAR, K).

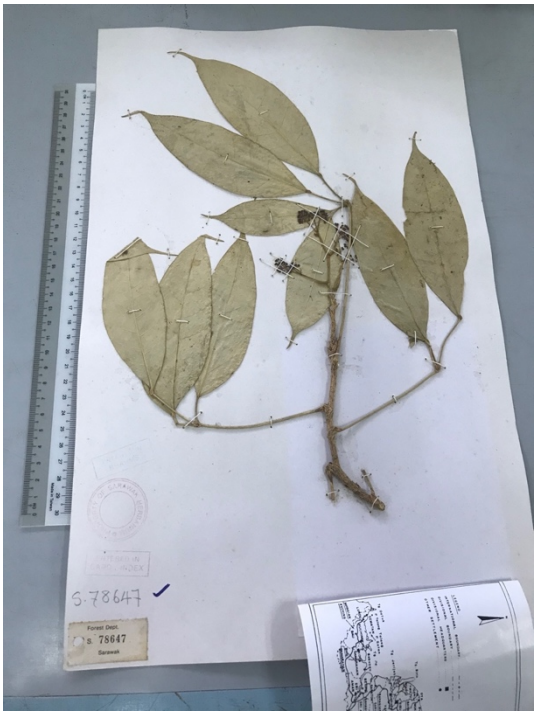


Figure 4.40: *Heptapleurum ensiriengense* N. Ramnor & A. Puad, sp. nov. (S. 78647).

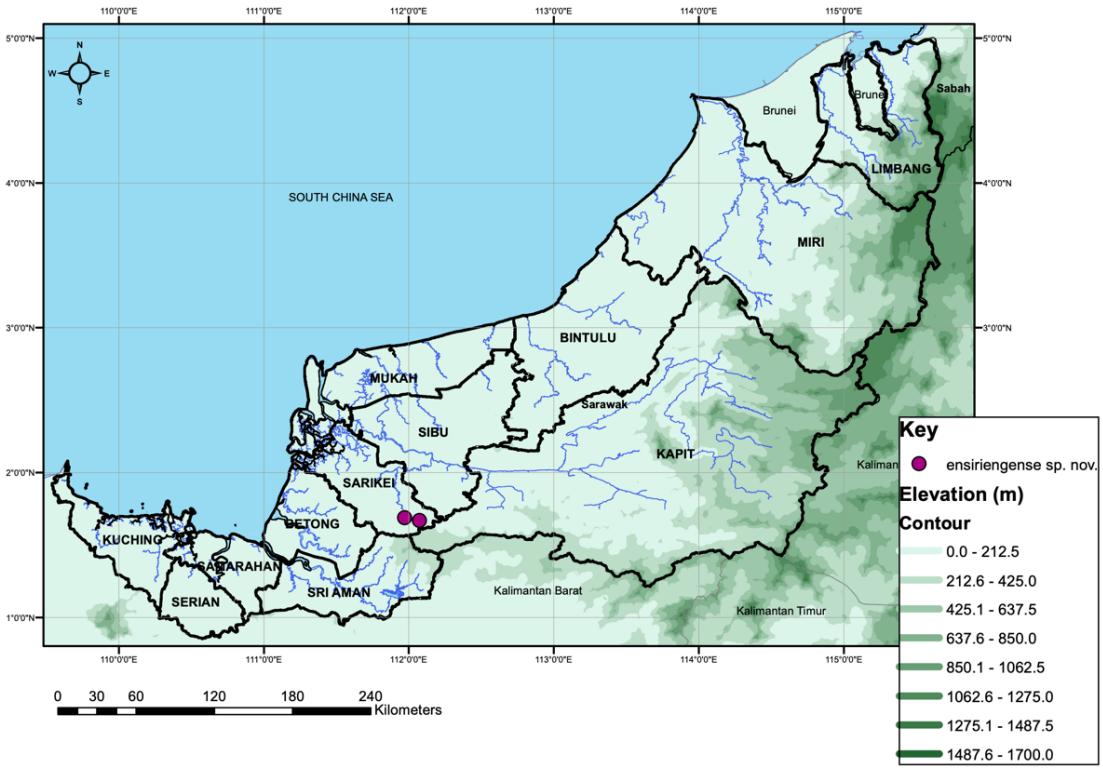


Figure 4.41: Distribution map of *H. ensiriengense* sp. nov. in Sarawak.

4.5.20 *Heptapleurum glaucophyllum* N. Ramnor & A. Puad, sp. nov. (Figure 4.42)

Type material: Kapit: Hose Mountains, mossy heath forest, edge of sandstone scarp, 900 m, 18 Apr 1964, *P.S. Ashton, S. 21278* (holotype: SAR!).

A slender tree about 2-3.6 m tall or epiphyte with lenticellate stem. ***Leaves*** 6-9 foliolate. Stipule free portion, acute to obtuse, persistent, 1.5-4.5 cm long. Petiole (6.5-) 11-20.5 cm long × 0.2-0.5 cm diam. Petiolules 1.7-4.7 cm long × 0.14-0.25 cm diam. Blades thickly coriaceous, adaxial surface glossy while abaxial surface somehow glaucous, glabrous, obovate to narrowly oblong, 8-18.7 cm long × 2.7-7.4 cm wide. Base acute to obtuse. Margin entire. Apex mucronate to abruptly acuminate, 0.4-1.3 cm long. Second-order venation

numerous, brochidodromous, closely spaced that the veins almost in parallel, spreading-ascending and weak reticulations. ***Inflorescences*** terminal. Main axis above last leaf marked by acute bracts. Limitation zone (0.5-) 2.0-5.5 cm long and branching zone 0-4 cm long. Branches sparsely hairy with bract scars at the base, Branches 6-12 with corymb-like arrangement, 6-20 cm long × 0.16-0.40 cm diam. Umbellule 7-17 per branch, terminal cluster 3-4 umbels, scattered along most of the branch length. Peduncles 0.6-2.0 cm long and pubescent. Pedicels 1-4 mm long and glabrous. ***Flower*** buds c. 9-16 per umbel, ovoid, 2-3 mm long × 1.5-2.2 mm diam. Widest point below cupule, calyx rim-like. Cupule funnel-shaped. Petal 5 with length c. 2.5 mm long. Disk truncate. Stylar column up to 0.5 mm long. Ovary inferior. ***Fruits*** ovoid, 5 mm long × 3 mm diam. Cupule campanulate. Ovary 4/5 inferior. Locule 5-6. Disk convex with sessile stigmata.

Distribution: Throughout Sarawak (Figure 4.43)

Conservation status: *Heptapleurum glaucophyllum* is assessed as Data Deficient (DD).

Habitat: On hill, ridge and mountain in heath, logged-over forest, mossy and montane forest with elevation ranging from 700 m to 2100 m above sea level.

Notes: The plant differs from *H. havilandii,* found in Borneo, by having larger stipule, numerous and closely arranged secondary venation, stout and shorter inflorescence branches and bigger fruits.

Derivation of name: The name is derived from the Ancient Greek words of *glaukos* meaning “gray” and *phyllon* meaning “leaf”. It is referring to the glaucous on the margin and abaxial surface of the leaves.

Specimen listing: BETONG. Bkt. Sadok, 14 Oct 1982, *Banyeng & Ilias Paie, S. 45040*. **BINTULU. Sebauh.** Bkt. Bandong, Merurong Plateau, 1204 m, 15 May 1960, *E.F. Brunig, S. 8778* (SAR); Bkt. Skelap, Merurong Plateau, 16 Oct 1984, *Othman et al., S. 48978* (KEP). **KAPIT. Bukit Mabong.** Hose Mountains, 900 m, 18 Apr 1964, *P.S. Ashton, S. 21278* (SAR); Bkt. Goram (summit), 880 m, 28 Feb 1975, *Paul Chai, S. 36107* (CGE, L, K, KEP). **Belaga.** Batu Laga, 700 m, 1 Sep 1984*, Abang Mohtar, S. 48099*; NE of Batu Laga Plateau, 820 m, 21 Jun 1995*, Runi et al., S. 71880* (K, KEP, CGE); Bkt. Robertson, 1200 m, 7 Aug 1999, *Julaihi et al., S. 80649* (KEP); Bkt. Robertson, 1900 m, 10 Aug 1999, *Julaihi Lai et al., S. 81072* (SAR); Singu Camp, Bkt. Matalun, 1200 m, 13 Aug 2001, *Yahud et al., S. 84478* (SAR, K). **MIRI. Bario.** Bkt. Lawi (second summit), 1840 m, 17 Aug 1984, *Dayang Awa & Bernard Lee, S. 50864*; Batu Lawi, 2100 m, 2 Oct 1996*, Julaihi et al., S. 73181* (KEP); SW of Pulong Tau NP, 1400 m, 13 May 2005, *Kit Pearce et al., S. 95240* (SAR). **LIMBANG.** Mt. Pagon, 1570 m, 16 Aug 1984, *Dayang Awa & Bernard Lee, S. 47915* (SAR).



Figure 4.42: *Heptapleurum glaucophyllum* N. Ramnor & A. Puad, sp. nov. (S. 21278).

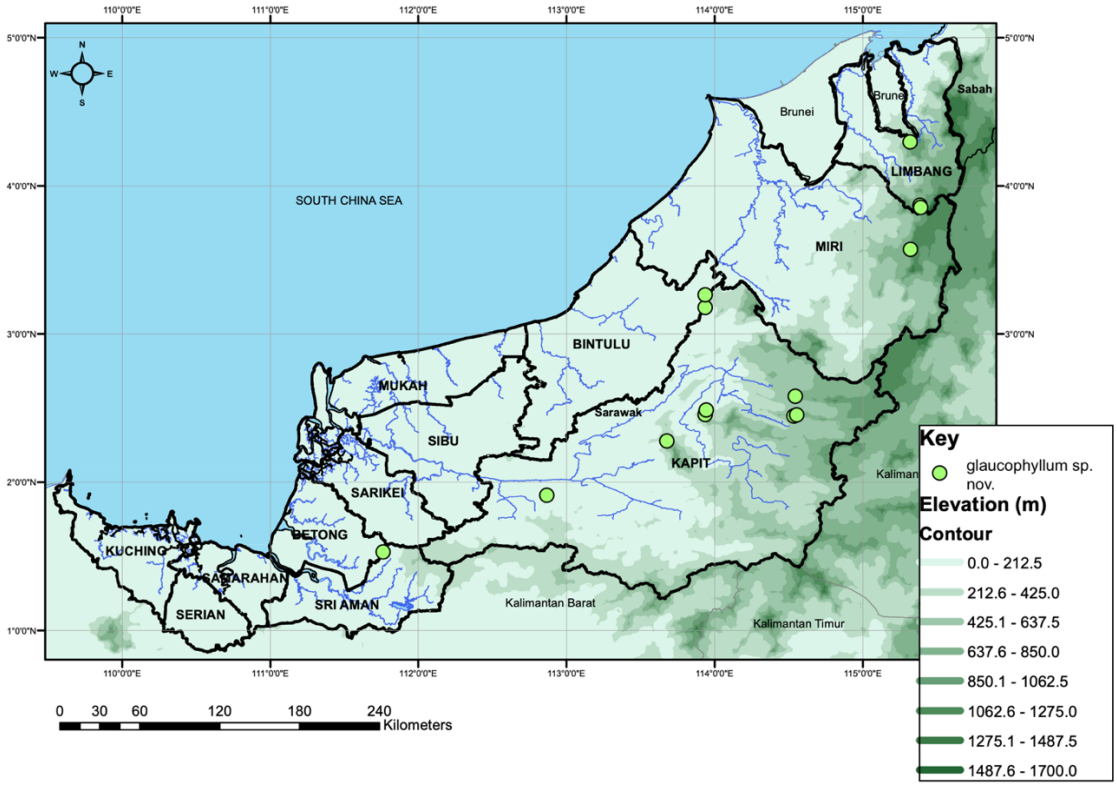


Figure 4.43: Distribution map of *H. glaucophyllum* sp. nov. in Sarawak.

4.5.21 *Heptapleurum havilandii* (Merr.) Lowry & G. M. Plunkett (Figure 4.44)

Novon 28 (3): 154 (Lowry & Plunkett, 2020).

Basionym: *Schefflera havilandii* Merr., *Journal of the Straits Branch of the Royal Asiatic Society* 79: 29 (Merrill, 1918b).

Type material: Sarawak, near Kuching, 23 November 1892, *G. D. Haviland 192* (holotype: K).

Epiphyte at height 2-10 m tall, small tree 1-3 m tall or climber on rocks. ***Leaves*** 5-9 foliolate. Entirely glabrous. Stipule partially fused, length of 0.6-1.7 cm long, tip obtuse. Petioles slender with 7-16 cm long × 0.20-0.35 cm diam. Petiolules slender, 1.5-6.2 cm long × 0.10-0.25 cm diam. Blades mostly obovate to oblong-obovate, thickly coriaceous, 5-18.1 cm long × 2.6-9 cm wide. Adaxial surface glossy, abaxial surface dull. Apex 0.2-1.5 cm long, mucronate to acuminate and rarely caudate-acuminate. Margin entire. Base convex to cuneate. Second-order venation eucamptodromous, strongly ascending, 5-9 pairs on each side. Reticulations weak or sometimes not visible. ***Inflorescences*** terminal. Limitation zone 2-3 cm long. Branching zone up to 6.7 cm long. Numerous branches, slender, 31-69.5 cm long × 0.2-0.3 cm diam, closely spaced along the main axis. Bracts tip acute, about 0.8-2 cm long at the base of each branches. Entire part covered in light brown pubescent, sometimes glabrescent. Umbellules numerous, arranged in racemose along ¾ of the branch length. Peduncles purple, covered with fine silvery hairs, 0.5-1.5 cm long × 0.05-0.10 cm diam. Pedicels 0.3-0.4 cm long and pale green. ***Flowers*** 7-15 per umbel. Buds slightly obovoid, green, glabrescent, 2-3 mm long × 1.5-2.5 mm diam. Cupule cupuliform, hairy, 2 mm long. Calyx-rim like. Petals 5-6, usually shorter than cupule, 1 mm long. Stamen 2 mm long.

Filaments white with dark purple anthers. Disk flat and glaucous. Stigmata sessile, white and not fully separated at this stage. Ovary inferior and green in colour. ***Fruits*** ellipsoid, 3 mm long × 2-2.5 mm diam., glabrous. Ovary ¾ inferior. Disk barely sloping and slightly glaucous. Stigmata 4-6, separated and slightly elevated on top.

Distribution: Borneo. In Sarawak, the plant is recorded in Kuching. (Figure 4.45)

Conservation status: This taxon is known from 23 specimens found in 9 locations (AOO = 48 km^2) from Kuching division. It is assessed as Endangered.

Habitat: The species is usually found growing on rocks at coastal area, heath and shallow peat swamp forest and rarely recorded in the submontane mossy forest. Most of the species recorded at low elevation except on the mountain at elevation 1300 m above sea level.

Notes: The species usually occurs at low elevation area at near sea level. However, specimen S. 45886 was recorded at 1300 m on Mount Kanyi, Lundu. The leaves there are much smaller with long caudate-acuminate apex compared to other specimens with broader blades and extremely short apex. *Heptapleurum havilandii* can be recognized by glabrous, thickly coriaceous obovate to oblong-obovate leaf blades, upper surface always glossy even in dried state and weakly visible arcuate venation on both surfaces. The fruits are ellipsoid with glaucous and barely elevated disk on top. The stigmata are 4 to 6 and separated.

Specimen listing: KUCHING. Near Kuching, *G. D. Haviland, Hav. 500/192* (SAR, CGE); Kuching, 25 May 1893, *Bartlett/Haviland, No. 1* (SAR); *No. 2* (SAR); Teluk Asam, Bako National Park, 21 May 1956*, J. W. Purseglove, P. 5060* (SAR, SING); 5 May 1967, *J. A. R. Anderson, S. 25572* (K, CGE); Tg. Pandan, Bako National Park, Mar 1957, *Abang Muaz, S. 7701* (SAR); Teluk Paku, Bako National Park, 22 Apr 1959, *J. Carrick & I. C. Enoch, JC 51* (K, L); 5 Apr 1976, *J. D. Mamit, S. 37489* (CGE, L); Bako National Park (exposed rocks on coast), 15 m, 7 Apr 1959, *Brunig S. 12070* (SAR); Telok Tajor, Bako National Park, 5 Jun 1963, *P. S. Ashton, S. 17931* (K, L, CGE, SAN); Bako National Park, 28 Aug 1977, *Benjamin C. Stone, No. 13442* (SAR); 19 Jun 1988, *Abang Mohtar, S. 53038* (KEP, CGE); Tg. Melano, Bako National Park, 46 m, 12 May 1980, *Yii Puan Ching, S. 42187* (CGE, L, K); Summit trail, Kubah NP, 521 m, 2 Mar 2015, *Aishah et al., KNPS* 14; 733 m, 2 Mar 2015, *Aishah et al., KNPS* 3; 690 m, 2 Mar 2015, *Aishah et al., KNPS 5*; 690 m, 2 Mar 2015, *Aishah et al., KNPS 7*; 645 m, 2 Mar 2015, *Aishah et al., KNPS 8*; 631 m, 2 Mar 2015, *Aishah et al., KNPS 9.* **Lundu.** Mt. Kanyi, 1300 m, 22 Apr 1984, *Dayang Awa & Ilias Paie, S. 45886* (K, CGE); Kpg. Perigi, 24 Sep 1991, *Hj. Othman et al., S. 63816* (KEP, K, L, SAN, MO); Biawak, 25 Oct 1991, *Hj Othman Ismawi et al., S. 58994*; Belungei-Lundu, 3 Dec 1991, *Hj. Othman et al., S. 63897* (KEP, K); Bedaun, Sematan, 4 Oct 1994, *Hj Othman et al., S. 65463* (KEP, K, L, SAN); Lundu-Pueh Road, 9 Feb 1996, *Stephen Teo & Awang Enjah, S. 68080* (KEP, K, L, SAN); Sematan, 23 Mar 2002, *Jong Lip Khiong, S. 81692* (SAR).



Figure 4.44: *Heptapleurum havilandii* (Merr.) Lowry & G. M. Plunkett (S. 42187).

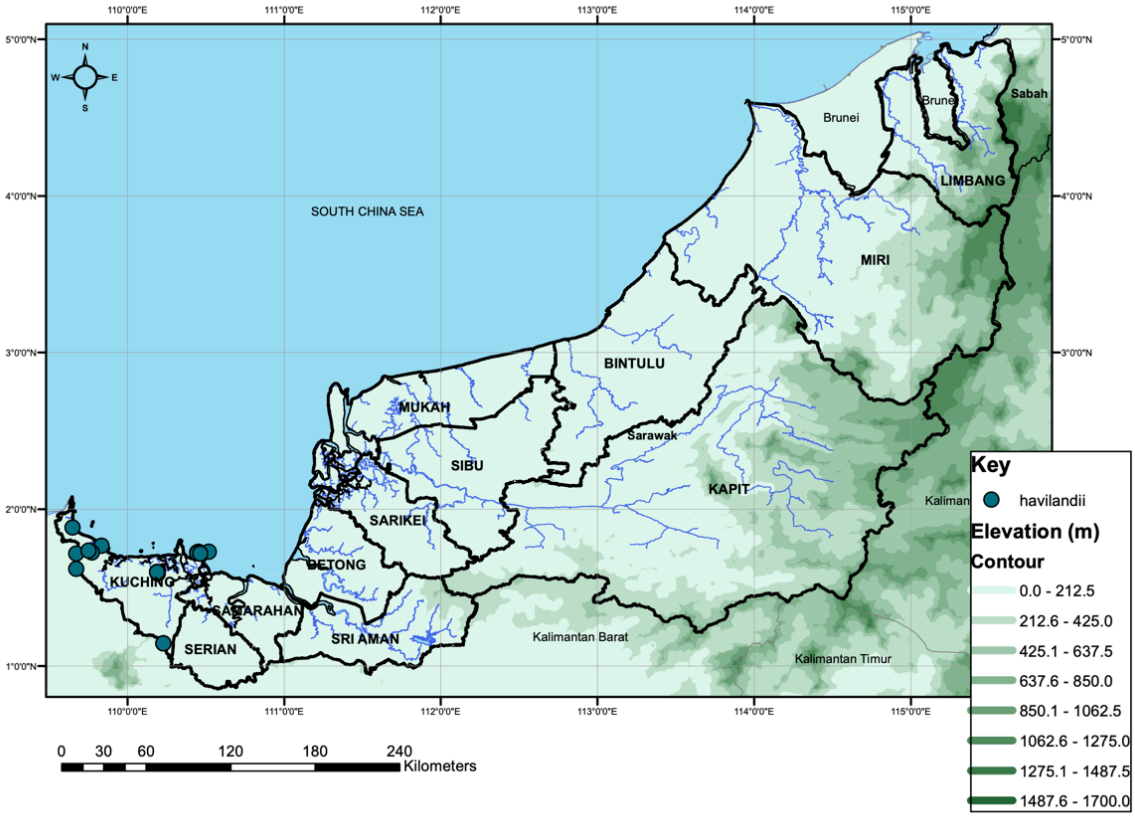


Figure 4.45: Distribution map of *H. havilandii* in Sarawak.

4.5.22 *Heptapleurum kenayaense* N. Ramnor & A. Puad, sp. nov. (Figure 4.46)

Type material: Limbang: Kenaya Forest Reserve, hillslope, 244 m, 27 Oct 1971, *Paul Chai & Ilias Paie, S. 31524* (holotype: SAR!; isotype: L).

Epiphyte. ***Leaves*** trifoliolate. Stipular ligule very short, about 2 mm long. Petiole 8.5-9.5 cm long × 0.25 cm diam. Petiolules 2.3-5.5 cm long × 0.15-0.17 cm diam. Blades entire, broadly ovate, 9.5-21 cm long × 5.5-10.6 cm wide. Apex caudate-acuminate up to 2.2 cm long. Base obtuse. Second-order venation ascending, 8-12 pairs, unequal spacing between each vein. Weak reticulations. ***Inflorescences*** terminal, limitation zone c. 6 cm long and branching zone unclear. Branches slender, sparsely hairy, 24-30 cm long × 0.3-0.35 cm diam. Umbellules scattered along the branches. Peduncles 7-9 mm long × 0.5 mm diam. Pedicels 3 mm long. ***Flowers*** not seen. ***Fruits*** initially greenish to whitish, about 8-9 per umbel, narrowly obovoid, 3-5 mm long × 1.5-2 mm diam. Ovary 3/5 inferior with sloping disk. Stylar almost fused at 1 mm high with 3-5 stigmata on top.

Distribution: Northern Sarawak (Figure 4.47)

Conservation status: *Heptapleurum kenayaense* is assessed as Data Deficient (DD).

Habitat: On the hillslope about 244 m elevation. The soil stated to be derived from the sandstone.

Notes: This taxon differs from *H. lasiocalyx,* also found in Borneo, by having longer limitation zone, sparser hairs on inflorescences, disk not glaucous and more stigmata.

Derivation of name: The plant is named after its first collection locality which was in Kenaya Forest Reserve in Lawas.

Specimen listing: LIMBANG. Lawas. Kenaya Forest Reserve, 244 m, 27 Oct 1971, *Paul Chai & Ilias Paie, S. 31524* (SAR, L).

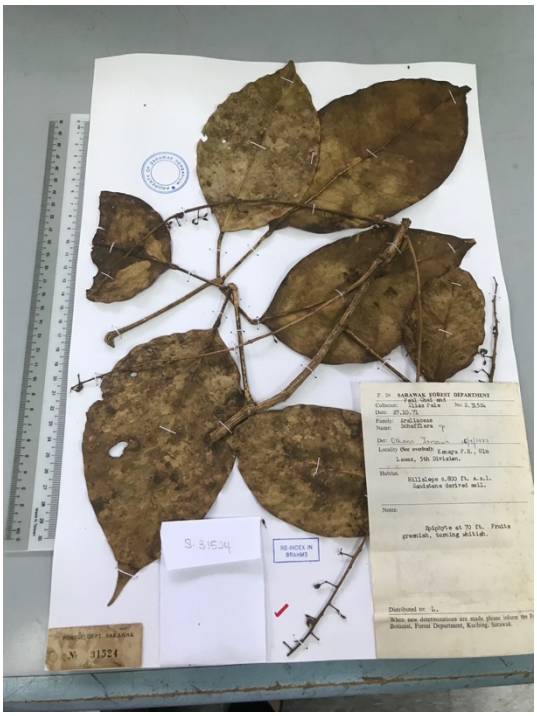


Figure 4.46: *Heptapleurum kenayaense* N. Ramnor & A. Puad, sp. nov. (S. 31524).

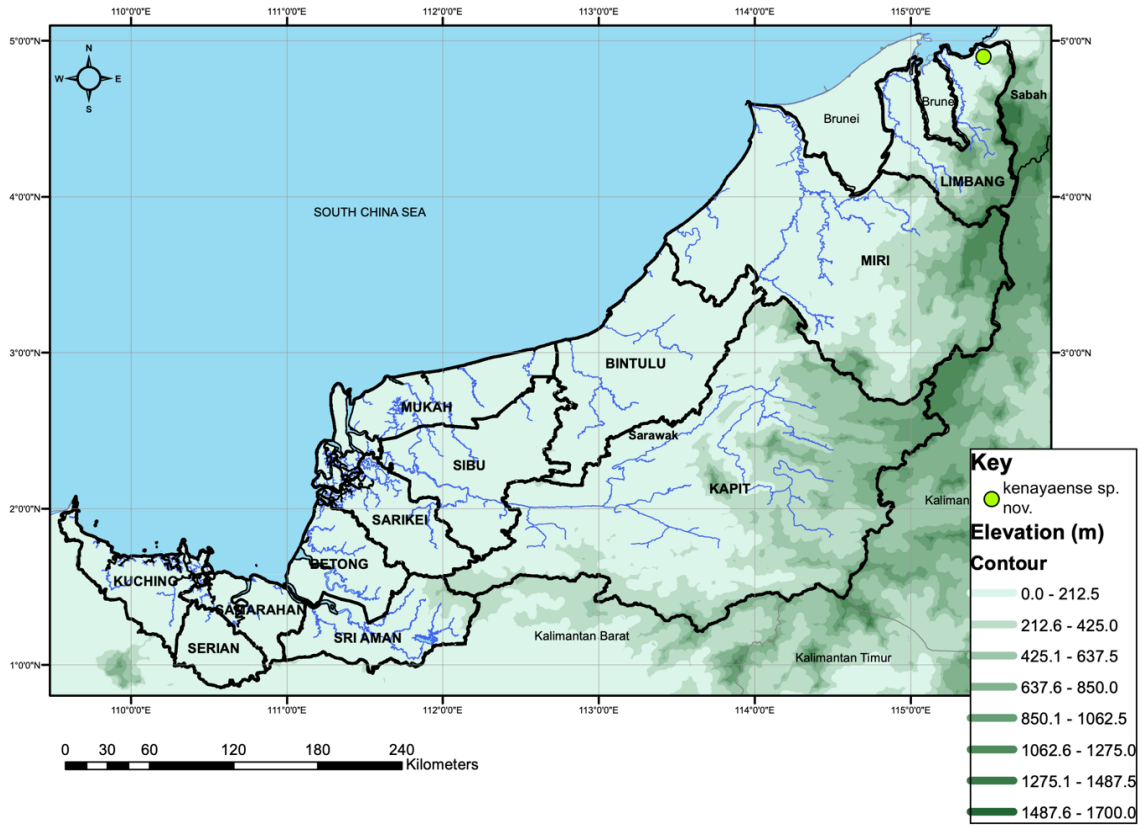


Figure 4.47: Distribution map of *H. kenayaense* in Sarawak.

4.5.23 *Heptapleurum kuchingense* (Merr.) Lowry & G. M. Plunkett (Figure 4.48)

Novon 28 (3): 156 (Lowry & Plunkett, 2020).

Basionym: *Schefflera kuchingensis* Merr., *Webbia* 7: 318 (Merrill, 1950).

Type material: Kuching, 25 January 1893, *G. D. Haviland, No. 2948* (holotype: K).

Epiphyte or climber with stem covered with lenticels. ***Leaves*** 7-14 foliolate, entirely glabrous. Stipular ligule 1.7-3.1 cm long, acute, persistent. Petiole slender, 41-72.5 cm long × 0.45-0.53 cm diam. Blades oblong to slightly oblong-obovate, 14.8-23.6 cm long × 4.3-10.8 cm wide. Apex 0.5-1.5 cm long and acuminate. Base cuneate to rounded. Margin entire.

Second-order venation up to 14 pairs on each side, camptodromous, almost parallel, not prominent, closely spaced. Reticulations distinct. ***Inflorescences*** terminal, paniculate and entirely covered with brown hairs. Limitation zone 4-4.5 cm long. Branching zone at most 13 cm long. Branches congested along the axis, slender, 39-56 cm long × 0.2-0.3 cm diam., each of them bearing a bract at the base. Umbellules numerous, congested and racemosely arranged along about half of the branches. Peduncles 1-3 cm long × 0.05 cm diam. Pedicels 3-6 mm long. ***Flowers*** c. 20 per umbel. Bud 1 mm long × 1 mm diam. Cupule funnel-shaped, 0.5 mm long or less. Calyx-rim toothed. Disk convex. Ovary half inferior. Stigmata sessile at the top. ***Fruits*** length 1 mm long × 1 mm diam. and almost globose.

Distribution: Borneo. In Sarawak, the plant is recorded in Kuching and Sri Aman divisions. (Figure 4.49)

Conservation status: *Heptapleurum kuchingense* is assessed as Data Deficient (DD).

Habitat: On hill in heath and mixed dipterocarp forest. Low elevation up to 410 m above sea level.

Notes: There are only three specimens recorded for this species. The notable features of *H. kuchingense* are having oblong to slightly oblong-obovate leaflets topped by acuminate apex. The second-order and intersecondary venation on the blade surface are almost indistinguishable. As for the inflorescences, the branches are slender, covered in densely brown hairs and closely spaced along the Branching zone with numerous umbellules along each branch. Both flowers and fruits of this species are very small. During the observation,

the fruits were not fully matured. According to the Iban people in Kampung Pungor Tapang in Sri Aman, the plant is called ‘Kayu Ala’.

Specimen listing: KUCHING. Semengoh Arboretum, 14 Sep 1976, *Bernard Lee, S. 37777* (L, K, CGE); Kubah NP, 140 m, 17 Feb 2015, *Aishah et al., KNPS 22.* **SRI AMAN.** Path to Kpg. Kara, Kpg. Pungur Tapang, 95th Miles, 5 Sep 1980, *Ilias Paie, S. 42716* (CGE, L, K, SAN); Sabal Sisi (logging road), 410 m, 22 Feb 1995, *Runi et al., S. 71243*.



Figure 4.48: *Heptapleurum kuchingense* (Merr.) Lowry & G. M. Plunkett (S. 42716).

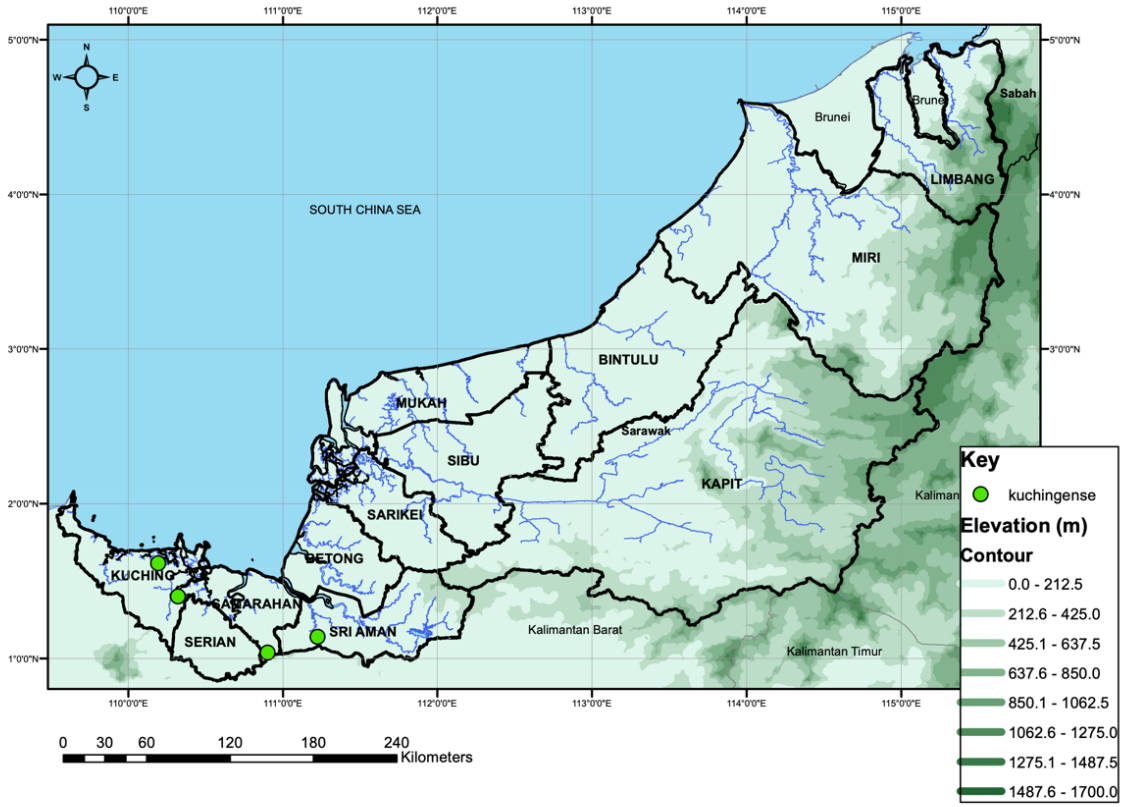


Figure 4.49: Distribution map of *H. kuchingense* in Sarawak.

4.5.24 *Heptapleurum lanatum* (Frodin, Puad & T. J. Barkman) Puad, T. J. Barkman, Lowry & G. M. Plunkett (Figure 4.50)

Novon 28 (3): 156 (Lowry & Plunkett, 2020).

Basionym: *Schefflera lanata* Puad & Frodin, *The Genus Schefflera in Sabah, Malaysian Borneo* 111 (Ahmad Puad et al., 2018).

Type material: Crocker Range Park, *Sugau et al., JBS 65* (holotype: SAN; isotypes: K, L, SING).

Epiphyte or climber. ***Leaves*** 9-13 foliolate. Petiole 42.5 cm × 0.73-0.90 cm diam. Petiolule 7.5-9.0 cm long × 0.25-0.30 cm diam. Both petiole and petiolules covered in brown stellate hairs. Blades thickly coriaceous, oblong, 33-35.2 cm long × 9.5-12.1 cm wide. Adaxial surface glabrous, abaxial surface covered with densely brown woolly hairs. Apex mucronate and 3-6 mm long. Margin entire. Base rounded. Second-order venation eucamptodromous, about 10-19 pairs on each side. Reticulations distinct. ***Inflorescences*** terminal. Lateral branches c. 67.7 cm long and moderately to heavily covered with brown stellate hairs. Umbellules in heads along ¾ of the branch length. Peduncles 3-8 mm long × 2.8-3.3 mm diam. Flowers in globose capitula, 1.16-1.65 cm diam. ***Flowers*** more or less 150 per head, very close together, sessile, about 3 mm long and covered with stellate hairs. ***Fruits*** not seen.

Distribution: Borneo. In Sarawak, the plant is recorded in Limbang division. (Figure 4.51)

Conservation status: *Heptapleurum lanatum* is assessed as Data Deficient (DD).

Habitat: On hillside in montane forest with altitude ranges of 1200-1250 m above sea level.

Notes: *Heptapleurum lanatum* is a large plant that can be easily recognized by its numerous, broadly oblong leaflets that densely covered in pubescent and strikingly red inflorescence in heads. There are about 150 flowers per head. This plant is strictly distributed on hill over 1000 m elevation at Lawas, near the border of Sabah. Another species with inflorescence in heads is *H. cephalotes.* However, the heads of *H. cephalotes* are smaller and they held less flowers than *H. lanatum.* The limitation zone and branching zone of the species is unknown

owing to poor way of collecting specimens in which the vegetative and reproductive parts were broken and separated.

Specimen listing: LIMBANG. Lawas. Bkt. Batanga, Maligan Range, 1250 m, 15 Mar 1973, *Ilias Paie, S. 33011* (CGE, L, K); Bkt. Binuda, 1200 m, 10 Mar 1991, *Rena et al., S. 60745* (KEP, CGE, K).



Figure 4.50: *Heptapleurum lanatum* (Frodin, Puad & T. J. Barkman) Puad, T. J. Barkman, Lowry & G. M. Plunkett (S. 33011).

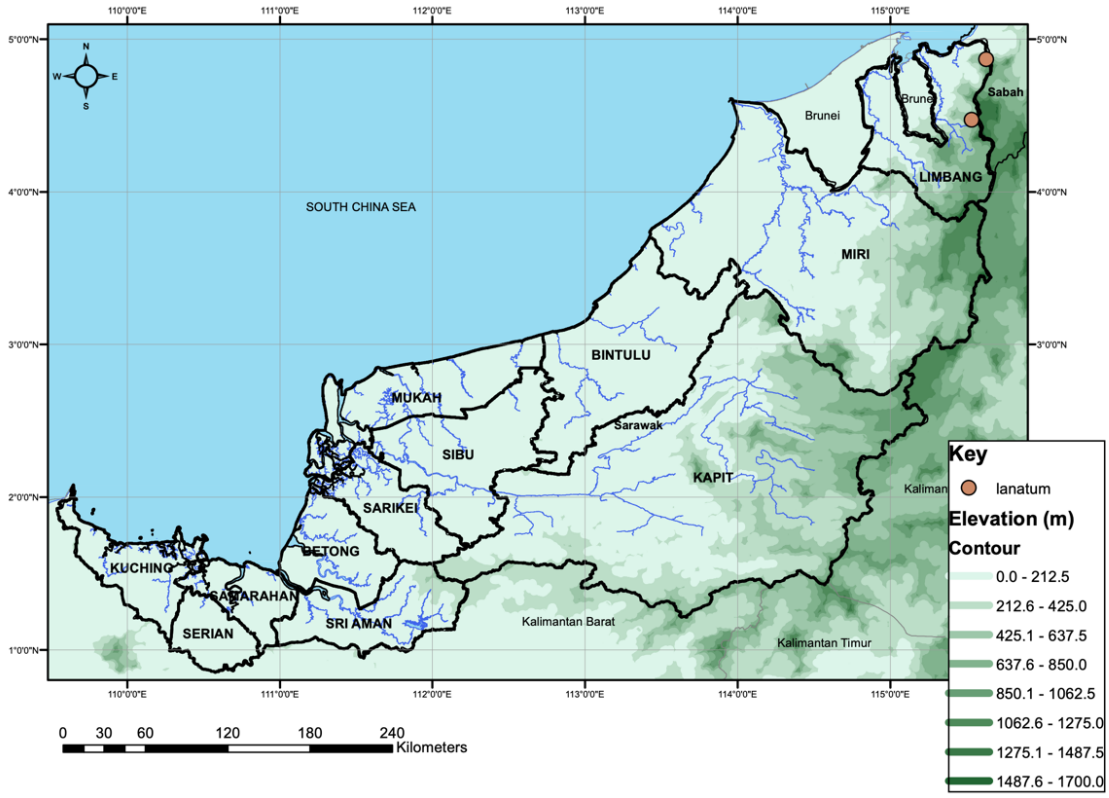


Figure 4.51: Distribution map of *H. lanatum* in Sarawak.

4.5.25 *Heptapleurum lasiocalyx* (Ridl.) Lowry & G. M. Plunkett (Figure 4.52)

Novon 28 (3): 156 (Lowry & Plunkett, 2020).

Basionym: *Schefflera lasiocalyx* Ridl., *Kew Bulletin* 1(1): 41 (Ridley, 1946).

Type material: Sarawak, near Kuching, *Haviland & Hose 3212* (holotype: K).

Epiphyte on trees about 7-25 m tall, creepers or rarely small tree. ***Leaves*** 3-5 foliolate. Stipule partially fused, obtuse, 0.2-1.3 cm long. Petiole 5.6-16 cm long × 0.10-0.35 cm diam. Petiolule (0.5) 3.0-6.5 cm long × 0.12-0.20 cm diam. Blades thin, elliptic to ovate to oval, 6.2-22 cm long × (1.8-) 5.0-8.2 cm wide. Apex caudate and 1.2-2.5 cm long. Margin entire. Base cuneate. Second-order venation weak, brochidodromous, 5-13 pairs on each side.

Inflorescences terminal. Limitation zone 2.0-2.8 cm long. Branching zone obscure up to 4 cm long. Entire part covered with light brown dense hairs. Branches up to 6, 15-55.3 cm long × 0.20-0.25 cm diam, slender. Umbellules numerous and arranged in racemose, head-like when young. Peduncles initially sessile and lengthening up to 8 mm long upon maturity. Pedicels almost sessile to 2 mm long. ***Flower*** buds up to 15 per umbel, slightly obovoid with flattened apex, 1.5-3.5 mm long × 1-2 mm diam. Petal calyptrate. Inferior ovary. ***Fruits*** initially green, turn yellow in maturity, 4 mm long × 1.5-2 mm diam., deeply sulcate with somehow obconic cupule with length of 3 mm. Ovary ¾ to almost inferior. Disk slightly glaucous with 4 stigmata on top of united style with length 1 mm long.

Distribution: Borneo. In Sarawak, the plant is recorded in Kapit and Miri divisions. (Figure 4.53)

Conservation status: *Heptapleurum lasiocalyx* is assessed as Data Deficient (DD).

Habitat: Commonly found near riverbank or riparian forest. Elsewhere, the plant also recorded in dipterocarp forest, heath forest and peat swamp from low up to 1600 m above sea level.

Notes: One of the epiphyte specimens was recorded on *Diospyros* sp. The species resembles *H. tetrandrum* especially the leaves. The inflorescence part is important in order to correctly identify both of the almost similar species. *Heptapleurum lasiocalyx* has much densely pubescent inflorescences with thinner fruits. The cupule on the fruits of *H. lasiocalyx* is obconic while *H. tetrandrum* has cupuliform and much wider in diameter. The distribution

of *H. lasiocalyx* is more on the Northern part of Sarawak and they probably didn't cross the Southern part of Sarawak where *H. tetrandrum* is widely spread. However, these two species were collected in Kapit which is located at the centre of Sarawak. More collection and fieldwork needed to be done in order to understand the distribution of *H. lasiocalyx* and *H. tetrandrum* in Borneo.

Specimen listing: KAPIT. Song. Sg. Joi, Ulu Katibas, 24 Jun 1993, *Yii Puan Ching, S. 64891* (KEP). **MIRI.** Bakam Road (6 ½ Miles), 61 m, 4 Dec 1966, *Sibat ak Luang, S. 25198*; Sg. Riam Libau, Lambir NP, 18 Sep 1978, *Rena George, S. 40287*; Lambir NP; 25 Sep 1978, *Rena George, S. 40424*; 3 Jul 1983, *Bernard Lee, S. 46578* (K, LEP, CGE); Sg Dalam, 18 Oct 1995, *Yii Puan Ching et al., S. 71477* (KEP, CGE, K, L, SAN, SAR). **Mulu.** Bukit Berar, Mulu NP, 29 Sep 1977, *Paul Chai, S. 39559*; Lubang Cina, Sg. Terikan, 29 Apr 1985, *Runi et al., S. 49482*; Camp 1, Mulu NP, 250 m, 20 Oct 1991, *Runi et al., S. 63559* (KEP). **Bario.** Batu Lawi, 1600 m, 19 Aug 1985, *Dayang Awa & Bernard Lee, S. 50929* (CGE, KEP).



Figure 4.52: *Heptapleurum lasiocalyx* (Ridl.) Lowry & G. M. Plunkett (S. 46578).

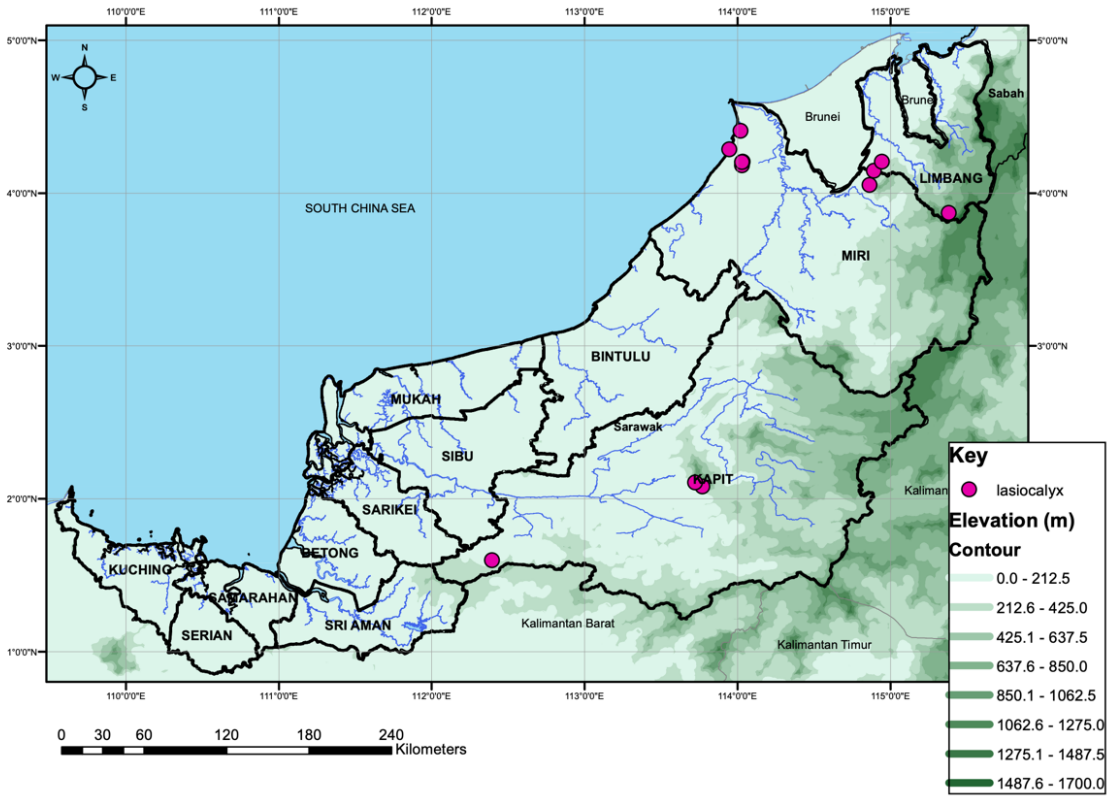


Figure 4.53: Distribution map of *H. lasiocalyx* in Sarawak.

4.5.26 *Heptapleurum laxiflorum* (Ridl.) Lowry & G. M. Plunkett (Figure 4.54)

Novon 28 (3): 157 (Lowry & Plunkett, 2020).

Basionym: *Schefflera laxiflora* Ridl., *Kew Bulletin* 1(1): 42 (Ridley, 1946).

Type material: Sarawak, Bidi, limestone, *C. J. Brooks* (holotype: K).

Shrub or epiphyte. ***Leaves*** 3-5 foliolate. Stipular ligule at the base of petiole curved, margin curled, obtuse, free portion 0.5-2 cm long. Petioles slender, 14-32.3 cm long × 0.21-0.40 cm diam. Petiolules vary in length, 0.5-7.5 cm long × 0.12-0.23 cm diam. Blades broadly elliptic to ovate, 9.5-41 cm long × 6.1-14.5 cm wide. Apex acuminate to caudate-acuminate extending to caudate with 1.2-2.2 cm long. Margin entire. Base usually convex, concave to obtuse, rarely oblique. Second-order venation 5-8 pairs on each side, widely spaced about 2.5-5 cm apart, arcuate, prominent, yellowish, eucamptodromous. ***Inflorescences*** terminal, paniculate. Limitation zone 1.2-4.5 cm long with few bracts along the main axis, 1.8-2.5 cm long, curved and obtuse tip. Branching zone 0.3-3.7 cm long. Branches 9-18, entirely purplish, subtended by bracts at base, 4.5-11.5 cm long, covered with white stellate hairs. Umbellules numerous, closely arranged along the branches. Peduncles 0.3-1.4 cm long, pedicels 1-5 mm long and both of them covered with pubescent. ***Flowers*** petals white. Stamen 5-6, pale green. ***Fruits*** 6-7 per umbel, glossy, from green to yellow or pink, slightly obovoid, glabrescent, 4-5 mm long × 2.2-3 mm diam., almost inferior. Stigmata sessile, 5-6.

Distribution: Borneo. In Sarawak, the plant is recorded in Kuching. (Figure 4.55)

Conservation status: *Heptapleurum laxiflorum* is assessed as Data Deficient (DD).

Habitat: Frequently seen at the limestone area. A couple of specimens recorded at secondary vegetation at gold mine area and mixed dipterocarp forest near logging road. Elevation 40-180 m above sea level.

Notes: *Heptapleurum laxiflorum* has broadly elliptic to ovate leaflets that are longer than the inflorescence branches at terminal. The petiolules are vary in length and the second-order venation is strongly arcuate and widely spaced on leaf surface. The hairy branches are congested along the short branching zone. The maturing fruits are slightly obovoid, deeply sulcate, entirely inferior and 5-6 sessile stigmata.

Specimen listing: KUCHING. Kuching, 25 May 1893, *E. G. Bartlett & G. D. Haviland, Hav.May.25.1893* (SAR, SING). **Bau.** Bidi Cave, year 1929, *J. & M. S. Clemens, No. 20629* (SAR); Bau (limestone rocks), 61 m, 15 Sep 1955, *J. W. Purseglove, P. 4478* (SING); Seburan, 76 m, 29 May 1960, *J.A.R. Anderson, S. 12910* (SAR); Bkt Jambusan, 8 Oct 1977, *Bernard Lee, S. 38612* (CGE, L, K); Bidi, 22 Oct 1979, *James Mamit, S. 42138* (SAR); Bkt. Jambusan, 100 m, 13 Nov 1985, *Yii et al., S. 50330* (CGE, K, L); Bkt Bidi, 40 m, 15 Nov 1985, *Yii et al., S. 50392* (CGE); Bkt Batu, 4 Feb 1999, *Jamree et al., S. 82031* (KEP); Mt. Ropih, 18 Jan 2002, *Malcom D. et al., SBC 1530* (SBC); Mt. Batu, 180 m, 20 Feb 2002, *Meekiong K. et al., SBC 1934* (SBC); Bau (foothill), 180 m, 8 May 2002, *Meekiong K. et al., SBC 3138* (SBC); Mt Umbut, 180 m, 20 May 2002, *Julia S. et al., SBC 3400* (SBC). **Lundu.** Bkt. Putin, 15 Mar 1989, *Hj Othman Ismawi et al., S. 57146* (SAR).



Figure 4.54: *Heptapleurum laxiflorum* (Ridl.) Lowry & G. M. Plunkett (S. 50330).

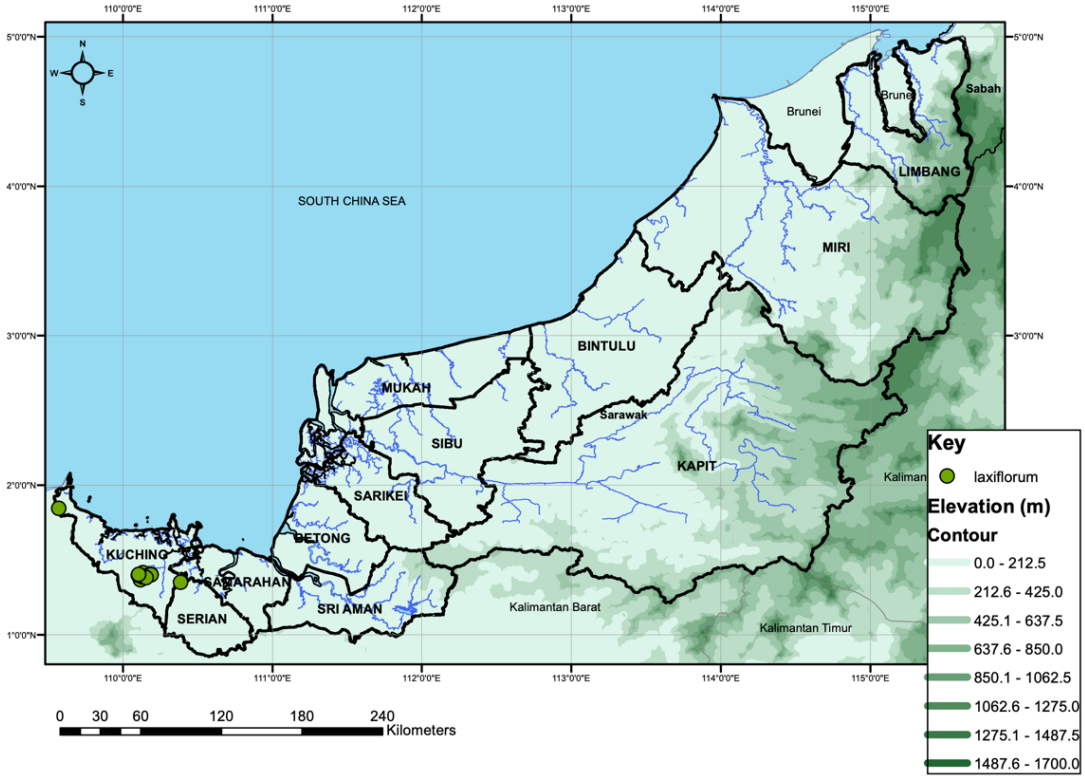


Figure 4.55: Distribution map of *H. laxiflorum* in Sarawak.

4.5.27 *Heptapleurum lesongense* N. Ramnor & A. Puad, sp. nov. (Figure 4.56)

Type material: Sri Aman: Mt. Lesong, on summit, mossy forest, 740 m, 4 Dec 1981, *Bernard Lee, S. 44296* (holotype: SAR!; isotypes: FHO, K, L, SAN, KEP).

Shrub up to 2 m high with lenticellate stem. ***Leaves*** trifoliolate. Stipular ligule 3-5 mm long and obtuse. Petiole 6-8.2 cm long × 0.15-0.25 cm diam. Petiolule 0.8-1.4 cm long × 0.15 mm. Blades ovate to elliptic to obovate, each side unequal, 7.3-13.5 cm long × 3.1-7.2 cm wide, coriaceous. Apex acuminate with length 0.8-1.5 cm long. Margin weakly and sparsely toothed along ¾ margin. Base oblique and rounded. Second-order venation 11-13 pairs, pinnate and eucamptodromous. ***Inflorescences*** terminal, limitation zone 1.5-2 cm long marked by some lenticels and branching zone obscure. Terminal branches 2-3 with bract scars at the base, 6.6-12.5 cm long × 0.2-0.25 cm diam., glabrous. Umbellules 6-7 per branch, scattered along the more than half of branch length, quite congested. Peduncles 1-2.7 cm long × 0.05-0.15 cm diam. Pedicels 3-7 mm long. ***Flowers*** not seen. ***Fruits*** 8-15 per umbel, globose or depressed-globose, glabrous, 4-5 mm long × 3-4 mm diam. Ovary ¾ inferior. Disk raised with stylar column of 0.5-1 mm long. Stigmata 6-9.

Distribution: Southern Sarawak (Figure 4.57)

Conservation status: *Heptapleurum lesongense* is assessed as Data Deficient (DD).

Habitat: Ridgetop and summit vegetation that covered with shrubberies about 6 m high and ground covered with mosses. Elevation of 670-740 m above sea level.

Notes: The plant differs from *H. burkillii* from Borneo by having larger leaflets and minutely toothed margin. There are only two specimens and both of them found at the same locality.

Derivation of name: The taxon is named after Mount Lesong in Sri Aman, Sarawak where the specimens were recorded.

Specimen listing: SRI AMAN. Lingga. Mt. Lesung (Lesong), 670 m, 1 Dec 1981, *Carlo Hansen, No. 1093* (SAR); Mt. Lesong, 740 m, 4 Dec 1981, *Bernard Lee, S. 44296* (SAR, FHO, K, L, SAN, KEP).



Figure 4.56: *Heptapleurum lesongense* N. Ramnor & A. Puad, sp. nov. (S. 44296).

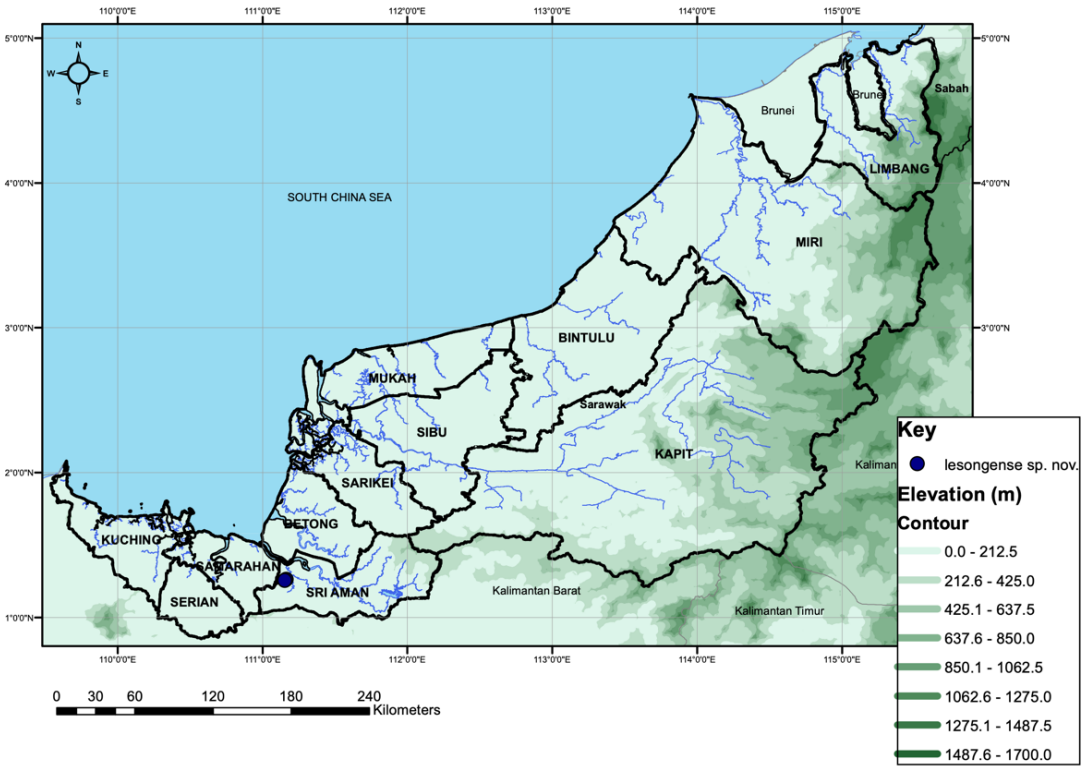


Figure 4.57: Distribution map of *H. lesongense* sp. nov. in Sarawak.

4.5.28 *Heptapleurum lineamentorum* (Frodin & Puad) Puad, T. J. Barkman, Lowry & G. M. Plunkett (Figure 4.58)

Novon 28 (3): 157 (Lowry & Plunkett, 2020).

Basionym: *Schefflera lineamentorum* Frodin & Puad, *The Genus Schefflera in Sabah, Malaysian Borneo* 118 (Ahmad Puad et al., 2018).

Type material: Kundasang, *Madu, SAN-A 1770* (holotype: SAN; isotypes: BO, K, KEP, L, PNH, SAR, SING).

A climber or epiphyte. ***Leaves*** 9-10 foliolate. Petiole slender, 29.5-51 cm long × 0.29-0.41 cm diam. Stipular ligule obtuse with length 1-1.2 cm long. Petiolule 3-6.7 cm long × 0.10-

0.14 cm diam. Blades narrowly oblong, glabrous, 12.3-22.3 cm long × 3.4-5.4 cm wide. Apex abruptly mucronate to apiculate, 0.2-1.3 cm long. Base cuneate to convex. Margin entire. Adaxial surface glossy. Second-order venation 9-11 pairs, eucamptodromous, strongly curved towards margin, yellowish on below surface. ***Inflorescences*** terminal, paniculate, sparsely pubescent. Limitation zone 4.5 cm long and branching zone 8.5 cm long. Bract scars marking the zone. Lateral branches up to 11, 27.5-43.5 cm long × 0.17-0.21 cm diam. Umbellules numerous along most of the branch length. Peduncles and pedicels length 3-5 mm long and 1-2 mm long respectively. ***Flower*** buds about 14 per umbel. Dimension 3 mm long × 1.8-2.2 mm diam., ellipsoid. Cupule cup-shaped, 1 mm long with calyx rim-like. Petal calyptrate and white. Inferior ovary. Apex truncate. Stamen purple. Stigmata indistinct. ***Fruits*** not seen.

Distribution: Borneo. In Sarawak, the plant is recorded in Miri division. (Figure 4.59)

Conservation status: *Heptapleurum lineamentorum* is assessed as Data Deficient (DD).

Habitat: On ridge and mountain in submontane and mossy forest at elevation of 1219-1707 m above sea level.

Notes: *Heptapleurum lineamentorum* is distinguishable by its narrowly oblong, 9-10 foliolate leaves and broadly mucronate to apiculate apex. The inflorescences are covered with sparse hairs with numerous and congested umbellules along slender branches.

Specimen listing: MIRI. Bario. Sg Belaban, Mt Murud, 1707 m, 29 Sep 1967, *Ilias Paie, S. 26329* (K, L, CGE). **Mulu.** Mt Mulu, 1300 m, 5 May 1977, *Bernard Lee, S. 38876* (CGE, L, K, SAN).



Figure 4.58: *Heptapleurum lineamentorum* (Frodin & Puad) Puad, T. J. Barkman, Lowry & G. M. Plunkett (S. 26329).

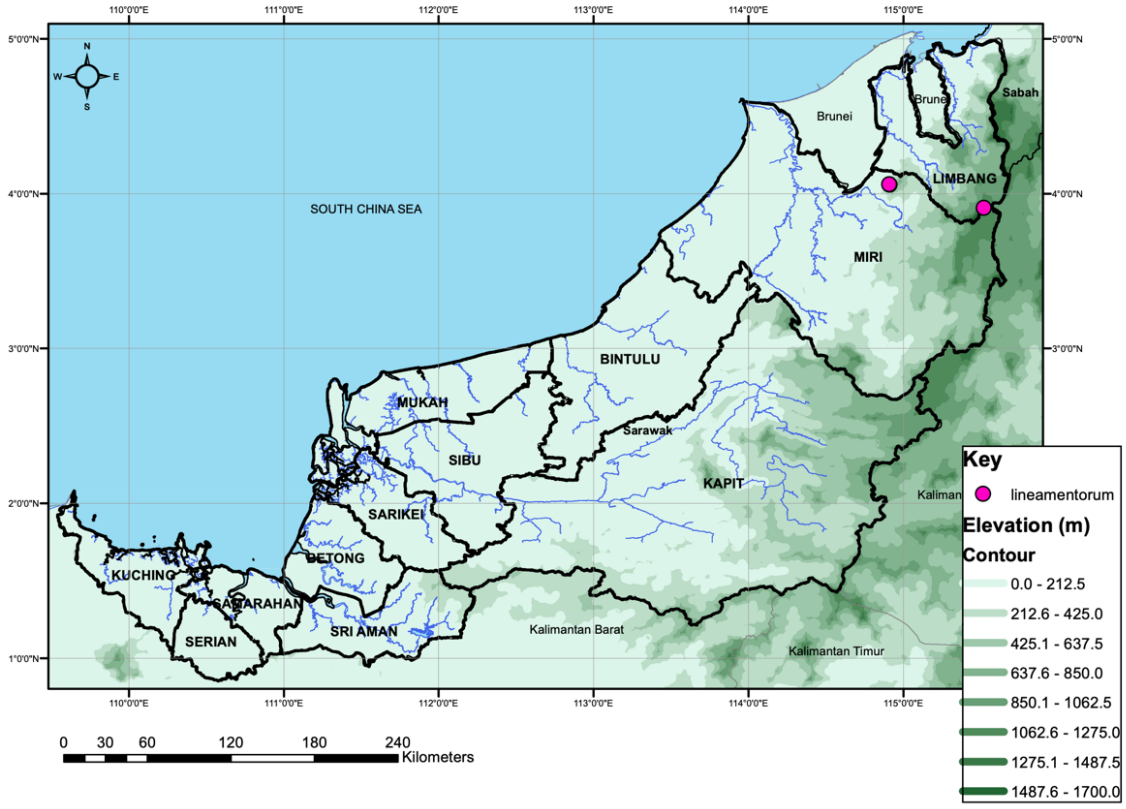


Figure 4.59: Distribution map of *H. lineamentorum* in Sarawak.

4.5.29 *Heptapleurum littorale* (Miq.) Boerl. (Figure 4.60)

Handleleiding tot de Kennis der Flora van Nederlandsch Indie 1 (2): 647 (Boerlage, 1890).

Basionym: *Parapanax littoralis* Miq., *Flora van Nederlandsch Indie, Eerste Bijvoegsel* 3: 339 (Miquel, 1861).

Synonyms: *Paratropia littoralis* (Miq.) Teijsm. & Binn. *Catalogus Plantarum in Horto Botanico Bogoriensi Cultarum Alter. Bataviae* 167 (Teijsmann & Binnendijk, 1866). *Schefflera littoralis* (Miq.) Harms, in H.G.A. Engler & K.A.E. Prantl, *Naturlichen Pflanzenfamilien* 3 (8): 38 (Harms, 1894).

Type material: Sumatra, [near Siboga], *Teysmann 1072.H.B.* (lectotype: L; isolectotypes: L, U).

Epiphyte, climber or shrub with lenticellate stem. ***Leaves*** 3-6-foliolate. Entirely glabrous. Stipular ligule persistent with free portion 2.2-3.5 cm long. Petiole 13-32.5 cm long × 0.2-0.6 cm diam, yellowish and slender. Petiolules 1-8.8 cm long × 0.1-0.3 cm diam. Blades broadly oval to ovate to elliptic, rarely oblong, 7.1-26.3 cm long × 4-11.5 cm wide, lateral leaflets often unequal, coriaceous. Base rounded and obtuse, sometimes oblique. Margin minutely toothed or sometimes undulate. Apex broadly acuminate or acute-acuminate, 0.4-1.5 cm long. Upper surface green while below yellow. Second-order venation 9-15 pairs on each side, almost parallel, camptodromous, not quite prominent. Reticulations weak and sometimes not visible. ***Inflorescences*** terminal and paniculate. Limitation zone 1-6.5 cm. Branching zone 0-5 cm, marked by bracts 1.3-2.6 cm long and not persistent. Branches 3-9, glabrous, 9-31 cm long × 0.2-0.35 cm diam. Umbellules per branch 7-16 (terminal 3-7, subsidiary always lesser than terminal cluster), wide spacing between each umbel or cluster. Peduncle stout, glabrous, 1-4.5 cm long × 0.05-0.15 cm diam. Pedicels 0.2-1 cm long. Both peduncles and pedicels yellowish green. ***Flowers*** buds up to 28 per umbel, dimension 3-5 mm long × 2-4 mm diam., globose or ovoid and glabrous. Cupule green, cup or funnel-shaped, 1-2 mm long × 2-3 mm wide. Calyx-rim minutely toothed, projecting. Petals 5-8, lanceolate, thick, 3-4 mm long. Stamen 4 mm long, alternating with each petal. Filament white and anther yellow. Disk white, truncate with stylar mound raised at the centre up to 1 mm. Stigmata green and indistinct at this stage. ***Fruits*** globose-ellipsoid, glabrescent to glabrous. Dimension 4-5 mm long × 3-4 mm diam. Ovary 2/3 to 3/5 inferior. Disk convex.

Stigmata sessile, 6-7 and prominent. Initially green, then turning yellow and red when ripened.

Distribution: Borneo and Sumatera. In Sarawak, the plant is recorded in Kuching, Samarahan, Mukah, Bintulu, Kapit, Miri and Limbang divisions. (Figure 4.61)

Conservation status: This taxon is known from 21 specimens found in 18 locations (AOO = 72 km^2) from Kuching, Samarahan, Mukah, Bintulu, Kapit and Miri divisions. It is assessed as Endangered.

Habitat: Dipterocarp forest, near riverbank, coastal vegetation, logged-over forest, peat swamp, on hill, primary and secondary forest. Elevation from 3 m up to 950 m above sea level.

Notes: The characteristics of *H. littorale* are having broadly oval to ovate to elliptic blades with almost parallel but not too prominent second-order venation. The stipular ligule at the petiole base persistent with free portion length up to 3.5 cm. The umbellules are arranged in clusters and the peduncles are stout with length of 4.5 cm. The matured fruits are globose-ellipsoid with sessile stigmata arranged in a ring on top. The vernacular name of this species is 'Kuku Menaung' (Iban). There are a few specimens recorded epiphytic on the trees, namely *Gonystylus bancanus* (Ramin) and *Xylocarpus granatum* (Nyireh Bunga). These trees are commonly growing in mixed swamp forest and mangrove swamp respectively. Based on the description of *H. littorale* in Sabah, the plant has 7-8 stigmata (Ahmad Puad et

al., 2018). However, the stigmata on the fruits of *H. littorale* in Sarawak is from 6 to 7 stigmata, lesser than in Sabah.

Specimen listing: KUCHING. Telok Asam, Bako NP, 21 May 1956, *J.W. Purseglove, P. 5061* (SING); 3 Jun 1963, *P.S. Ashton, S. 17866* (K, L, SING, SAN, A); Bako NP, 28 Aug 1977, *Bot. Hons. Students, No. 13* (SAR). Semengoh Arboretum, 61 m, *Rosli, S. 14764* (K, L, S). **Bau.** Stringos, 250 m, 4 Jul 1996, *Rantai Jawa & Lai S.T., S. 72986*; Bungo Range, 270 m, 10 Jul 1996, *Mohizah et al., S. 74476* (KEP, K, L, SAN). **SAMARAHAN. Simunjan.** Sabal-Balai Ringin FR, 430 m, *L.C.J. Julaihi et al., S. 83492* (KEP, K); 26 Jun 2000, *L.C.J. Julaihi et al., S. 83595* (KEP, K, L, SAN, MO). **MUKAH. Daro.** Pulau Bruit, 9 Sep 1957, *J.A.R. Anderson, S. 9046* (SAR). **Tanjung Manis.** Sg Padah, Paloh PF, 17 Jul 1971, *Paul Chai et al., S. 26747* (K, L, SING, SAN, A, BO, KEP). **BINTULU, Tatau.** Sg Kana, Anap, 19 Jun 1982, *Abg Mokhtar, S. 44856.* **Sebauh.** Pengkalan Resam, Sg Penyilam, 1 Oct 2006, *Julia S. et al., S. 97154* (SAR). **KAPIT. Bukit Mabong.** Bkt Salong, 950 m, 27 Apr 1976, *Paul Chai, S. 37293* (L, K, CGE); Sg Sebatu, Menyiong, 13 Nov 1979, *Othman et al., S. 41386* (CGE, L, K); Sg Entulu, Mengiong, 18 Jul 1987, *Bernard Lee, S. 54618*; Sg Entemu, Mengiong, 21 Oct 1988, *Hj Othman et al., S. 61719* (CGE, K, L, KEP, SAN); Ng Entemu, Mengiong, 22 Oct 1988, *Hj Othman et al., S. 61761*; Sg Serani, Balleh, 200 m, 5 May 1991, *Runi et al., S. 63192*. **MIRI. Bario.** Sg Seraan (west of Mt Murud), 660 m, 14 Mar 1997, *Lai S.T. et al., S. 75958* (KEP, CGE, K); **Mulu.** Camp 3, Gunung Mulu NP, 613 m, 12 May 2015, *Aishah et al., SNA 144*. **LIMBANG. Lawas.** Behind Kpg Kuala Lawas, 3 m, 10 Jul 1958, *J.A.R. Anderson, S. 9113* (SAR).



Figure 4.60: *Heptapleurum littorale* (Miq.) Boerl. (S. 17866).

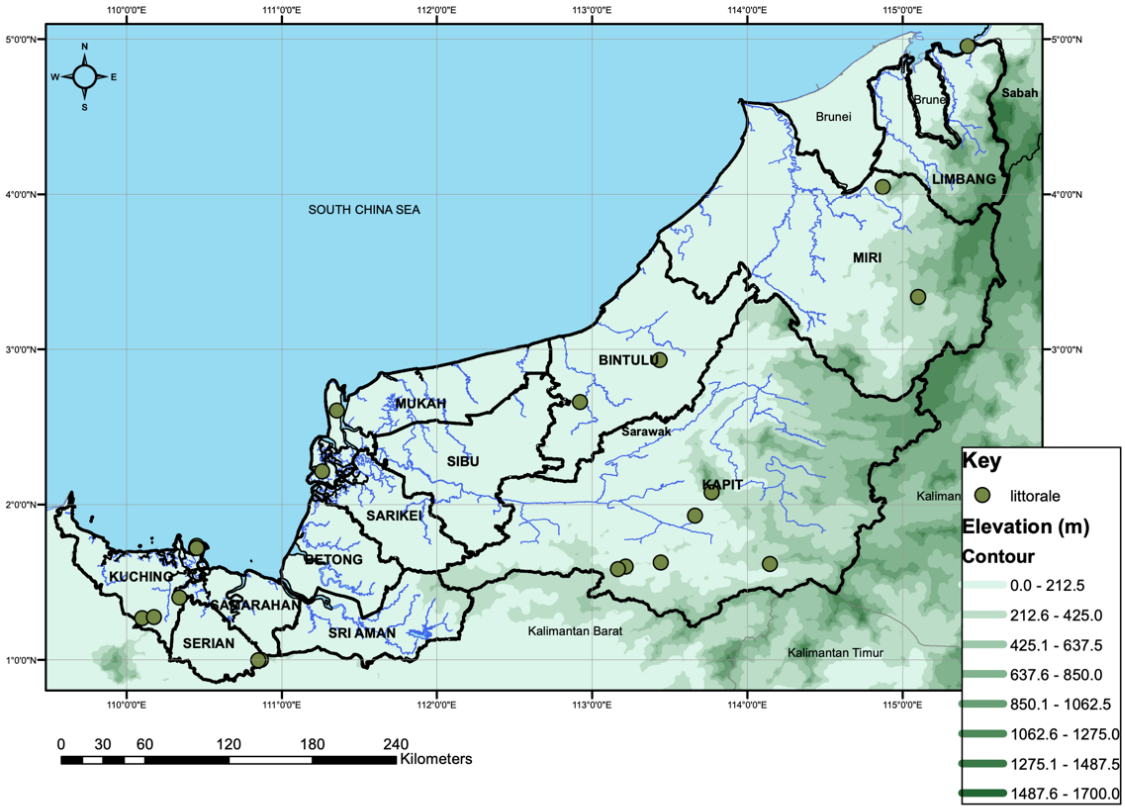


Figure 4.61: Distribution map of *H. littorale* in Sarawak.

4.5.30 *Heptapleurum lubangbayaense* N. Ramnor & A. Puad, sp. nov. (Figure 4.62)

Type material: Sri Aman: Tg. Asam, Sg. Lubang Baya (Batang Ai NP), along river, 190 m, 12 Mar 2000, *Rantai Jawa et al., S. 84113* (holotype: SAR!; isotypes: KEP, K).

A slanting tree c. 4 m tall. ***Leaves*** 5-foliolate. Stipular ligule 2 cm long and seems to be easily broken due its thinness. Blades broadly ovate, entire, apex broadly acute-acuminate with length about 2 cm and rounded base. Petiole longer than inflorescence branches with length 34 cm long × 0.4 cm diam. Petiolules vary in length from 2.5-10 cm long × 0.1-0.2 cm diam. Blades 28-34 cm long × 10-15 cm wide. Apex broadly acute-acuminate with length 2-3 cm long. Second-order venation 7-8 pairs on each side with wide spacing in between, eucamptodromous, arcuate, yellowish on abaxial surface but not quite visible on adaxial surface. ***Inflorescences*** terminal, paniculate. Limitation zone c. 4 cm long while the branching zone c. 18 cm long. Bracts closely spaced along the limitation zone with length of 1.7-2.5 cm long. Branches covered in light brown pubescent, about 15 with length 3.5-16.5 cm long × 0.05-0.1 cm diam. At the base of each branch marked by a bract about 0.5-1 cm long. Umbellules 8-18 per branch and quite widely spaced along the branch. Peduncles slender up to 1.5 cm long and pedicels length 4-7 mm long. ***Flower*** buds 7-10 per umbel, ellipsoid to slightly globose, 1 mm long × 0.5 mm diam. Cupule funnel-shaped and very short. Disk glaucous, convex with indistinct stigmata on top of short stylar mound. Petal 1 mm long with prominent midvein and thin. Filament 3-4 mm long and anther 0.5 mm long. Ovary superior. ***Fruits*** not seen.

Distribution: Southern Sarawak (Figure 4.63)

Conservation status: *Heptapleurum lubangbayaense* is assessed as Data Deficient (DD).

Habitat: Along river at altitude of 190 m above sea level.

Notes: This taxon differs from *H. ellipticum* by having larger leaflets and superior ovary. There is only one specimen collected for this taxon.

Derivation of name: The name is derived from a river in Lubok Antu, Sarawak, Lubang Baya river where this plant was discovered.

Specimen listing: SRI AMAN. Lubok Antu. Tg. Asam, Sg. Lubang Baya (Batang Ai NP), 190 m, 12 Mar 2000, *Rantai Jawa et al., S. 84113* (SAR, KEP, K).



Figure 4.62: *Heptapleurum lubangbayaense* N. Ramnor & A. Puad, sp. nov. (S. 84113).

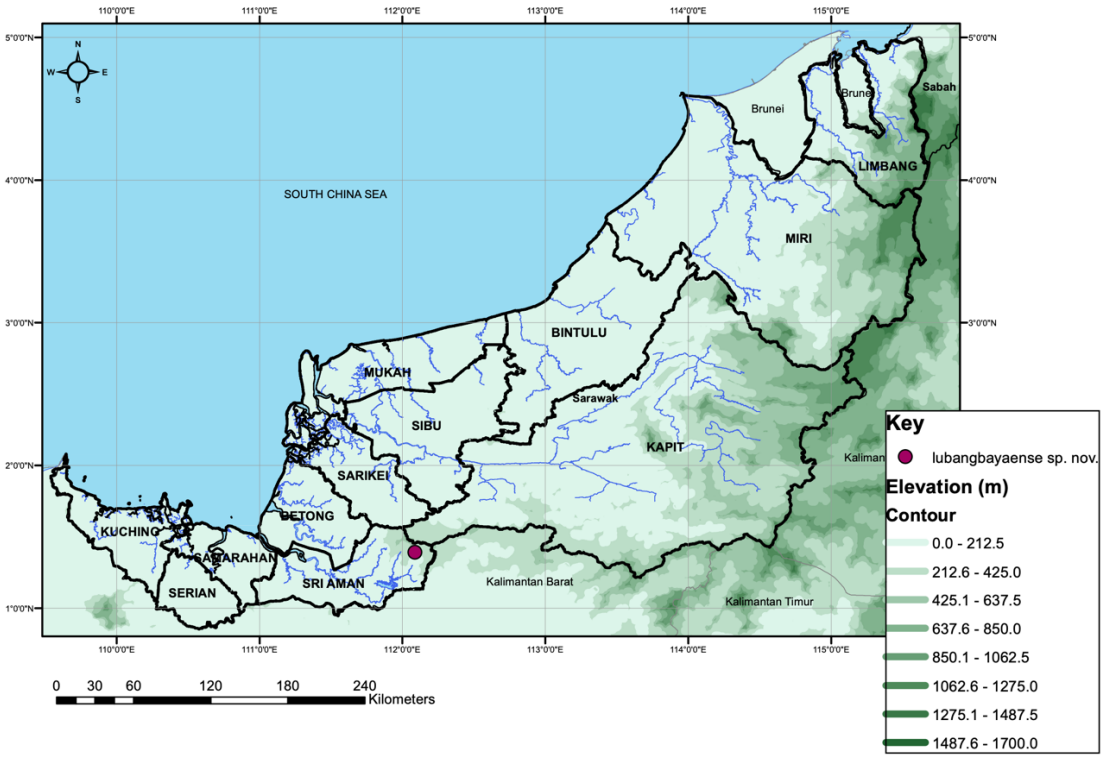


Figure 4.63: Distribution map of *H. lubangbayaense* sp. nov. in Sarawak.

4.5.31 *Heptapleurum mamutiacum* (Puad, T. J. Barkman & Frodin) Puad, T. J. Barkman, G. M. Plunkett & Lowry (Figure 4.64)

Novon 28 (3): 158 (Lowry & Plunkett, 2020).

Basionym: *Schefflera mamutiaca* Puad, T. J. Barkman & Frodin, *The Genus Schefflera in Sabah, Malaysian Borneo* 126 (Ahmad Puad et al., 2018)

Type material: Tenompok, [Camp], *Clemens & Clemens 30387* (holotype: K; isotypes: A, B, BO, G, HBG, L, NY, UC).

Common epiphyte or climber. ***Leaves*** 2-3 foliolate and entirely glabrous. Stipule dark, rounded apex, partially fused. Petiole 3.5-5 cm long × 0.1 cm diam. Petiolules 0.3-0.6 cm long × 0.06-0.07 cm diam. Blades lanceolate to elliptic with 5-7.8 cm long × 1.7-3.2 cm wide. Adaxial surface glossy while abaxial surface dull. Apex broadly acute-acuminate to acuminate. Margin minutely and sparsely toothed on upper half. Base rounded. Second-order venation 4-7 pairs on each side, brochidodromous, weak on surface. ***Inflorescences*** terminal. Limitation zone up to 4.5 cm long while branching zone 0-2.2 cm long. Branches c. 2, 7-13.5 cm long × 0.11-0.20 cm diam. Umbels 3-6 per branch, arranged in whorl and covering half of the branch. Peduncles 1.3-3.6 cm in length × 0.03-0.08 cm diam. Pedicels 7-9 mm long. Both peduncles and pedicels purple. ***Flowers*** 5-7 per umbel. Buds brown-yellow. Cupule obconic, length 1.5-2 mm. Petal 2-3 mm long and lanceolate. ***Fruit*** globose, green, 6 mm long × 4 mm diam., disk sloping with sessile stigmata 6 on top.

Distribution: Borneo. In Sarawak, the plant is recorded in Kapit and Miri divisions. (Figure 4.65)

Conservation status: *Heptapleurum mamutiacum* is assessed as Data Deficient (DD).

Habitat: On ridge and mountain at elevation of 1320-1448 m above sea level.

Notes: Generally, *H. mamutiacum* is a small plant, *H. mamutiacum* can be recognized by its 2-3 foliolate, lanceolate to elliptic blades topped by broadly acute-acuminate apex. The margin is toothed on the upper half of blades. The second-order venation is brochidodromous with 4 to 7 pairs of veins. As for inflorescence, the branches length exceeded the leaflets with umbellules covered half of the length. The peduncles are slender and maturing fruits are globose with 6 sessile stigmata on top. This species is recorded over 1000 m elevation on ridge and mountain.

Specimen listing: KAPIT. Bukit Mabong. Hose Mountains, 1448 m, 11 Apr 1980, *B. L. Burtt, B. 12860* (SAR). **MIRI. Mulu.** Camp 3, Mt Mulu, 1320 m, 8 Mar 1990, *Yii Puan Ching & Abu Talib, S. 58223* (KEP).



Figure 4.64: *Heptapleurum mamutiacum* (Puad, T. J. Barkman & Frodin) Puad, T. J. Barkman, G. M. Plunkett & Lowry (S. 58233).

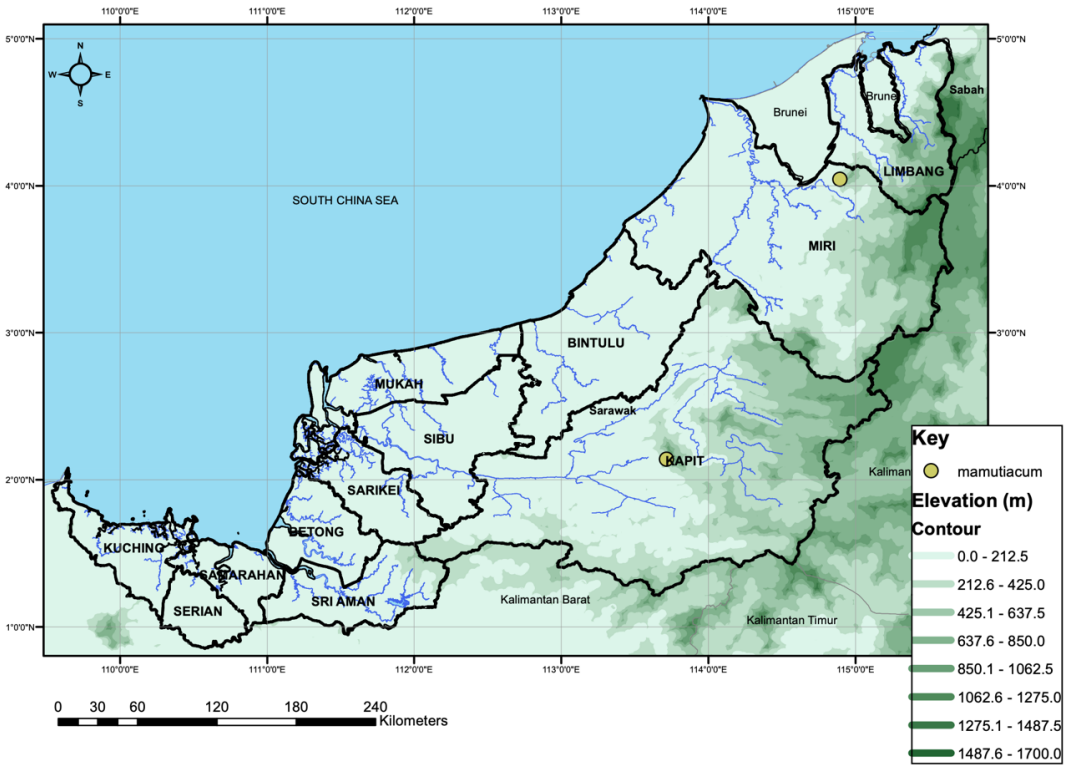


Figure 4.65: Distribution map of *H. mamutiacum* in Sarawak.

4.5.32 *Heptapleurum mangiferifolium* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (Figure 4.66)

Novon 28 (3): 158 (Lowry & Plunkett, 2020).

Basionym: *Schefflera mangiferifolia* Frodin & Puad, *The Genus Schefflera in Sabah, Malaysian Borneo* 130 (Ahmad Puad et al., 2018).

Type material: Tambulanan, Keningau, *Amin & Patrick, SAN 68999* (holotype: SAN; isotypes: E, K, KEP, L).

Epiphyte, small tree or climber. ***Leaves*** 6-9 foliolate, entirely glabrous. Stipular ligule persistent, 1-2.5 cm long, oblong with acute tip. Petiole slender with length 11-29 cm × 0.11-0.38 cm diam. Petiolules 0.8-10.5 cm long × 0.05-0.2 cm diam, usually vary in length. Blades thin, broad or narrow, elliptic to oblong-elliptic to elongate ovate, 9.3-29.5 cm long × 3.2-9.7 cm wide. Apex caudate-acuminate to caudate up to 1.2-3.5 cm long. Margin entire. Base cuneate to convex and rarely concave. Second-order venation numerous, appeared prominent on the surfaces when dry, spreading then ascending, eucamptodromous. Reticulations coarse. ***Inflorescences*** terminal, paniculate. Limitation zone 1.5-12 cm long, marked by acicular bracts. Branching zone 0.5-6.5 cm long. Branches c. 12, arranged in corymb-like, moderately pubescent, 4.4-13.3 cm long × 0.06-0.17 cm diam. Umbellules congested and racemosely arranged along half to ¾ of the branch length. Peduncles sparsely hairy, 0.3-1.5 cm long. Pedicels glabrescent with length 0.5-5 mm long. ***Flowers*** not seen. ***Fruits*** glabrous, 7-11 per umbel, ellipsoid or obovoid, 3-5 mm long × 1.7-2.8 mm diam. Ovary inferior. Disk glaucous. Stylar column elevated almost 1 mm long. Stigmata 5-9.

Distribution: Borneo. In Sarawak, the plant is recorded in Sri Aman, Bintulu, Kapit and Miri. (Figure 4.67)

Conservation status: This taxon is known from 19 specimens found in 10 locations (AOO = 72 km^2) from Sri Aman, Bintulu, Kapit and Miri divisions. It is assessed as Endangered.

Habitat: Frequently found near stream. Can also be found in mixed dipterocarp, primary forest, on hill, ridge and montane forest. Altitudinal ranges from 50 m up to 1750 m above sea level.

Notes: Based on the morphology, the species can be distinguished by its thin, elliptic to oblong-elliptic to elongately ovate, long caudate apex and corymb-like inflorescence branches with their length usually shorter than petiole. The fruits are inferior with stigmata 5 to 9 on a stylar column at length almost 1 mm tall. *Heptapleurum mangiferifolium* in Sabah mostly recorded below 500 m above sea level (Ahmad Puad et al., 2018). However, in Sarawak, three specimens are found over 1000 m with 1750 m being the highest. They are located on Mount Murud, Batu Buli Hill and Tama Abu Range. Elsewhere, the species is found at 950 m and lower.

Specimen listing: SRI AMAN. Lubok Antu. Mabau, Ulu Sg. Engkari, 500 m, 14 Dec 1994, *Yii Puan Ching et al., S. 69567* (KEP, SAN, CGE). **BINTULU. Tatau.** Sg Kakus, 12 Nov 1963, *Minoru Hirano & Mitsuru Hotta, No. 1111* (SAR). **KAPIT. Belaga.** R. Biak (R. Luar), 578 m, 30 Oct 1955, G. H. Pickles, S. 2967 (CGE); Wong Temaju, Sg Murum, 270 m, 15 May 1994, *Lai et al., S. 68590*. **Bukit Mabong.** Sg Entejum, Ulu Mengiong, 27 Oct

1988, *Hj Othman et al., S. 56082.* **MIRI. Bario.** Tama Abu Range, 1550 m, 6 Sep 1985, *Dayang Awa & Bernard Lee, S. 51120* (SAR); Mt. Murud, 1710 m, 7 Aug 1991, *Rena et al., S. 60338* (KEP); Mt Batu Buli, 1250 m, 26 Sep 1996, *Julaihi et al., S. 73136* (KEP); Lepo Bunga, Mt. Murud, 1750 m, 26 Mar 1999, *Julaihi et al., S. 70809* (KEP, K); Ulu Sg. Baong, near Camp A (Pulong Tau NP), 9 May 2007, *Bramley et al., S. 96522* (SAR, K), 12 May 2007, *Bramley et al., S. 96562* (SAR). **Tinjar.** Long Dapoi, Tinjar, 6 Apr 1965, *Sibat Ak Luang, S. 22974* (SAR). **Mulu.** Sg. Melinau Paku (Mt. Mulu), 50-100 m, 21 Mar 1964, *Mitsuru Hotta, No. 15226* (SAR); Mt. Mulu, 450 m, 5 Apr 1978, *I. Nielsen, No. 947* (AAU); Pantu ridge (Mt. Mulu), 14 May 1985, *Abg Mohtar & Othman Ismawi, S. 49787* (CGE); Bkt. Pantu, Mt Mulu, 120 m, 18 May 1996, *Julaihi et al., S. 74377* (KEP); Gunung Mulu NP, 28 m, 20 Jan 2015, *Aishah & Fatiha, SNA* 27. **Telang Usan.** Sg. Palutan, 27 Mar 2003, *Sugau, S. 91443* (SAR); 725 m, 29 Mar 2003, *R. Kiew & P. Leong, S. 91616* (SAR); Sg Silat Basin, 380 m, 3 Apr 2003, *Julia S. et al., S. 91862*.



Figure 4.66: *Heptapleurum mangiferifolium* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (S. 91443).

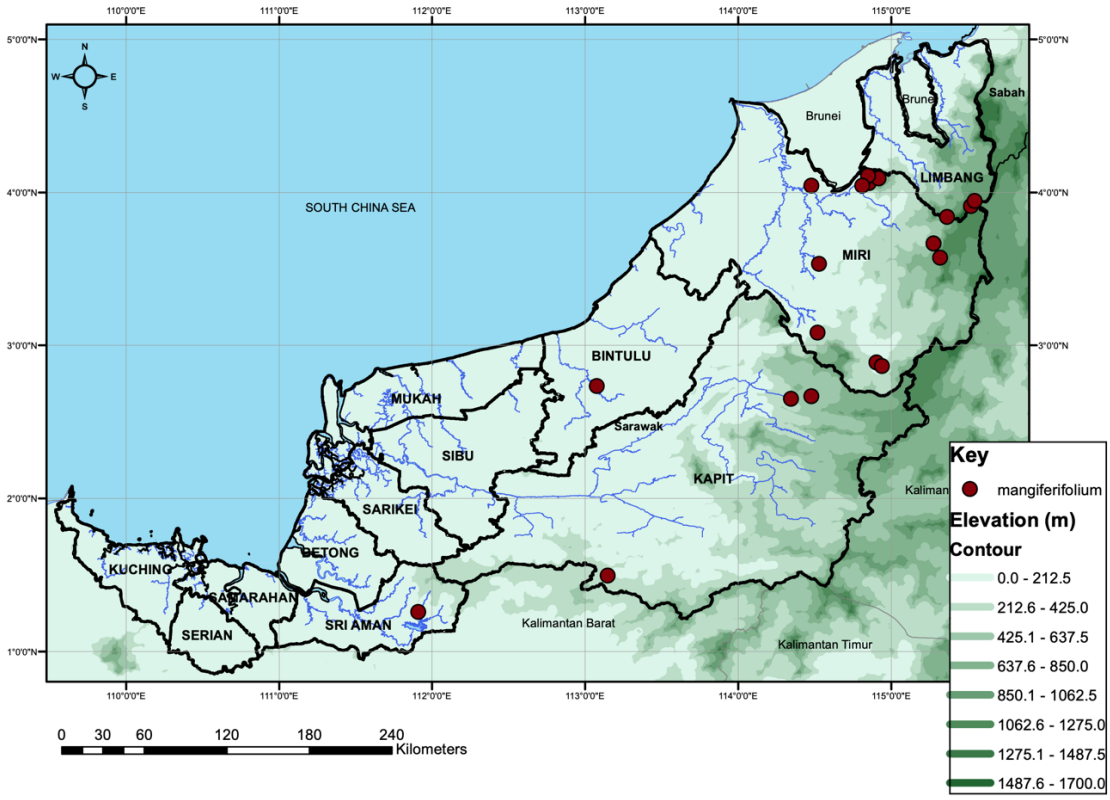


Figure 4.67: Distribution map of *H. mangiferifolium* in Sarawak.

4.5.33 *Heptapleurum mitragerum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (Figure 4.68)

Novon 28 (3): 159 (Lowry & Plunkett, 2020).

Basionym: *Schefflera mitragera* Frodin & Puad, *The Genus Schefflera in Sabah, Malaysian Borneo* 140 (Ahmad Puad et al., 2018).

Type material: Kota Belud, Minitinduk Gorge [below Tenompok], *Clemens & Clemens 27400* (holotype: BM, isotypes: A, B, BO, G, HBG, L, M, SING).

Epiphyte on tree at height about 9 m. ***Leaves*** 4-8 foliolate. Entirely glabrous. Stipule not seen. Petiole 42 cm long × 0.5 cm diam., slender. Petiolules 2.7-5.7 cm long × 0.25 cm diam.

Blades oblong-elliptic to elliptic to obovate, coriaceous, 20.5-29.5 cm long × 7.4-9.3 cm wide. Apex 1-1.5 cm long, acuminate passing to caudate-acuminate. Margin upper half toothed, below entire. Base cuneate or convex. Venation prominent on abaxial surface. Second-order venation c. 9 pairs, darken when dry, at first spreading then curving and terminating at margin. Reticulation weak. ***Inflorescences*** terminal. Limitation zone 2 cm long while branching zone 2 cm long. Branches 8, closely spaced, heavily pubescent, length 33-42.5 cm long × 0.4-0.5 cm diam. Umbellules about 17 per branch along most of the branch length, racemosely arranged. Each peduncle subtended by lanceolate bracts at length 0.4-0.8 cm long. Peduncle 1.5-2.5 cm long × 0.1-0.13 cm diam. Pedicels 0.7-1 cm long × 0.05-0.06 cm diam. Both peduncle and pedicel covered in hairs. ***Flowers*** 15-17 per umbel, buds obovoid, 5-6 mm long × 4 mm diam., widest point above cupule. Cupule campanulate, 1-3 mm long × 3 mm wide, hairy. Calyx-rim spreading. Ovary half inferior. Disk strongly convex above narrow calyx-rim. Stigmata 8 to 13 and sessile. ***Fruits*** not seen.

Distribution: Borneo. In Sarawak, the plant is recorded in Miri division. (Figure 4.69)

Conservation status: *Heptapleurum mitragerum* is assessed as Data Deficient (DD).

Habitat: Commonly found near the riverbank with elevation up to 1150 m above sea level.

Notes: The leaflets of *H. mitragerum* are quite similar to *H. sabahense* and *H. petiolosum.* However, they can be easily differentiated by their inflorescences. *Heptapleurum mitragerum* has longer branches than *H. sabahense.* As for *H. petiolosum,* the peduncles are usually shorter than pedicels, in contrast to *H. mitragerum* in which the peduncles are much

slender than pedicels. Besides that, *H. mitragerum* also has more stigmata than *H. petiolosum.* The stigmata can be up to 13 and arranged in sessile ring on top of apex. The species is collected at two places in Miri which is at Mulu and Bario. The toothed margin of the specimens in Mulu is round while the Bario specimens have much sharper toothed. In Sabah, this species is normally recorded at 800-1220 m (Ahmad Puad et al., 2018). Compared to in Sarawak, the elevation is as low as 100 m up to 990 m. There is no record yet over 1000 m above sea level.

Specimen listing: MIRI. Bario. Sg Lapon (behind airport), 990 m, 24 Sep 1996, *Yahud Hj Wat et al., S. 71999* (KEP, K, L, SAN, CGE); Sg Kelapang, Ramudu, 830 m, 23 Mar 1997, *Yahud Hj wat et al., S. 75078* (KEP, CGE). **Mulu.** Path from Melinau Gorge to Sg Bera (Mulu NP), 25 Jun 1975, *Ilias Paie, S. 36506*; Pantu ridge (Mulu NP), 14 May 1985, *Abg Mohtar & Othman Ismawi, S. 48791* (CGE, K, L, KEP); Camp 5, Gunung Mulu NP, 1150 m, 22 May 1996, *Julaihi Lai, S. 74672* (KEP); Bkt Pendeka, Gunung Mulu NP, 300 m, 16 May 1996, *Julaihi et al., S. 74677* (KEP, CGE).



Figure 4.68: *Heptapleurum mitragerum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (S. 49791).

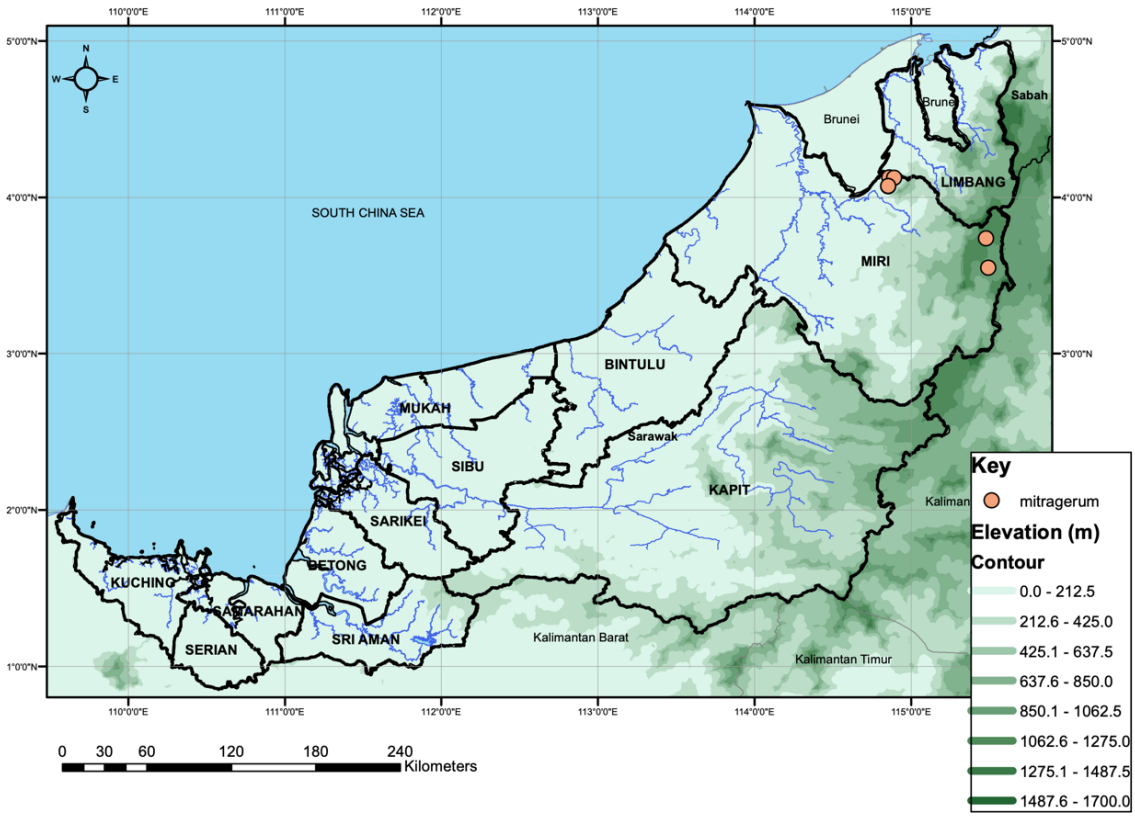


Figure 4.69: Distribution map of *H. mitragerum* in Sarawak.

4.5.34 *Heptapleurum mjoebergii* (Merr.) G. M. Plunkett & Lowry (Figure 4.70)

Novon 28 (3): 159 (Lowry & Plunkett, 2020).

Basionym: *Schefflera mjoebergii* Merr., *Sarawak Museum Journal iii.* 538 (Merrill, 1928).

Type material: Mount Murud, 1900 m, 1 October 1922, *E. Mjoberg, No. 117* (holotype: UC).

Mostly shrub, sometimes epiphyte or climber. ***Leaves*** unifoliolate. Stipular ligule persistent, acute to obtuse, 2.3-3.4 cm long. Petiole 2.6-6.6 cm long × 0.3-0.4 cm diam. Blades thickly coriaceous with glossy adaxial surface, broadly oval to ovate, 11.3-21.9 cm long × 6.3-14.4 cm wide, both surfaces hairy. Apex mucronate, about 0.3-0.5 cm long. Margin mostly entire or sometimes sparsely toothed. Base convex, rounded and sometime unequal. Second-order venation 7-13 pairs on each side, pinnate and raised on under surface but not contrast in colour. Reticulation weak and sometimes not visible. ***Inflorescences*** terminal, paniculate, entirely covered with dense woolly hairs and reduced upon maturity. Limitation zone 2-5.7 cm long while branching zone absent to 2 cm long. Bracts not persistent. Lateral branches 3-5, 9.6-13.4 cm long × 0.2-0.25 cm diam. Umbellules 6-10 per branch with terminal umbels about 3-5, quite distant from one another, peduncles 1.2-3.3 cm long × 0.1-0.15 cm diam., pedicels 0.2-0.6 cm long. ***Flower*** buds 11-12 per umbel, initially the buds appeared head-like with sessile buds and gradually both peduncles and pedicels lengthening, covered in dense hairs, ellipsoid, 4-5 mm long × 3 mm diam. Cupule cup-shaped with projecting calyx-rim above. Petal thick, lanceolate, 5-6 with length c. 3 mm long. Stamen 5-6, arranged alternately with petal. Disk flat with stylar column up to 1 mm high. ***Fruits*** depressed-

globose to globose, deeply sulcate, 6 mm long × 5-7 mm diam., 5-6 locular, ovary 2/3 inferior, disk slightly sloping, stylar column 2 mm high and stigmata indistinct.

Distribution: Borneo. In Sarawak, the plant is recorded in Miri division. (Figure 4.71)

Conservation status: *Heptapleurum mjoebergii* is assessed as Data Deficient (DD).

Habitat: Montane and mossy forest on the hill, ridge and sandstone summit with elevation about 1550-2410 m above sea level.

Notes: The main characteristics of *H. mjoebergii* are having a unifoliolate leaf that thick, broadly ovate to oval and both surfaces are covered in dense pubescent topped by short mucronate apex. The stipular ligule is long and persistent. The inflorescences also covered in hairs with umbellules covered about three-fifth of the branches. The fruits are mainly globose with stylar column up to 2 mm long. There are some specimens that have similar characteristics with *H. mjoebergii* and for now they are being placed under *H.* sp. aff. *beamanii* in 'Imperfectly known taxa'.

Specimen listing: MIRI. Bario. Mt. Murud, 2103 m, 9 Oct 1967, *Ilias Paie, S. 26467* (CGE); 2300 m, 10 Sep 1982, *Yii Puan Ching, S. 44487* (CGE, K); 2350 m, 27 Apr 2002, *Yahud et al., S. 88339* (KEP, MO); 2350 m, 27 Apr 2002, *Yahud et al., S. 88364*; 2400 m, 21 Mar 1999, *L. C. J. Julaihi, S. 80120* (KEP); 2400 m, 26 Mar 1999, *Julaihi et al., S. 70894* (KEP, K); 2433 m, 9 Aug, 2005, *Kit Pearce et al., S. 95366* (SAR); 2433 m, 9 Aug 2005, *Kit Pearce et al., S. 95375* (SAR, KEP, K, L); Tama Abu Range, 1550 m, 6 Sep 1985,

Dayang Awa & Bernard Lee, S. 51145 (CGE, K, L, KEP, SAN, MO, BRUN); Batu Lawi (second summit), 1840 m, 17 Aug 1985, *Dayang Awa & Bernard Lee, S. 50857* (CGE, K, L, KEP, SAN, MO); Batu Buli, 1900 m, 29 Sep 1996, *Julaihi et al., S. 73152* (KEP, CGE).



Figure 4.70: *Heptapleurum mjoebergii* (Merr.) G. M. Plunkett & Lowry (S. 80120).

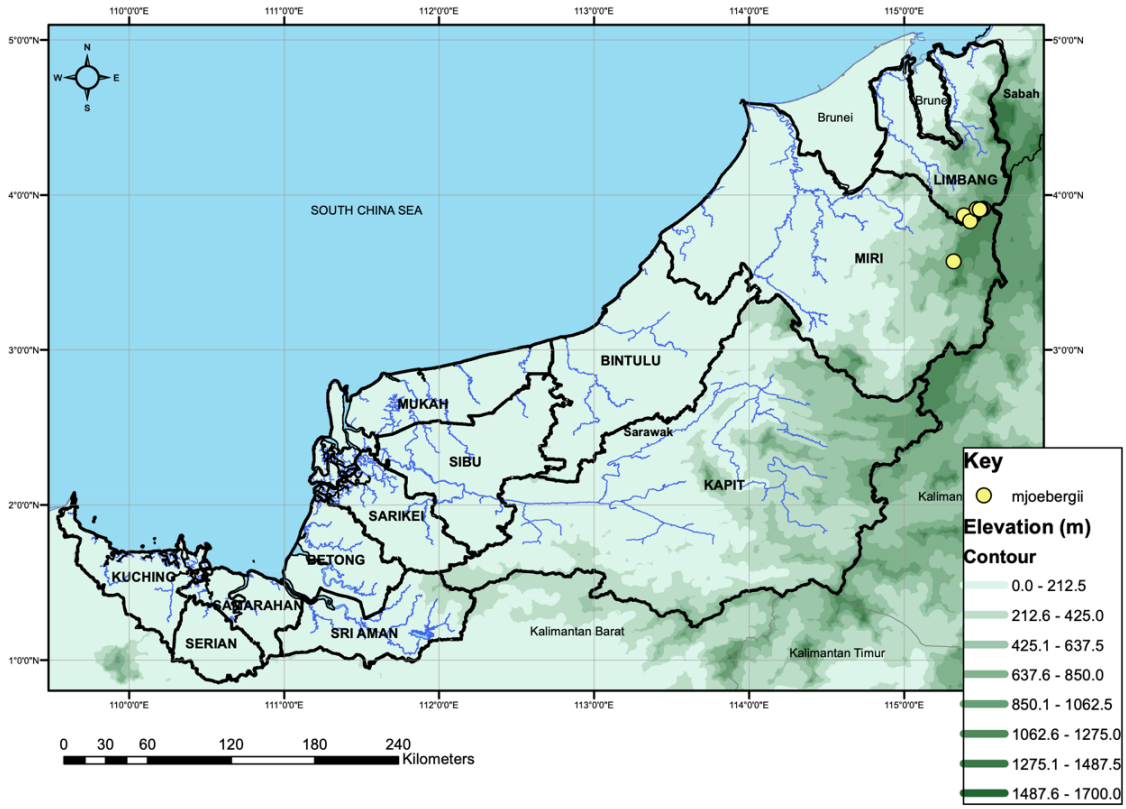


Figure 4.71: Distribution map of *H. mjoebergii* in Sarawak.

4.5.35 *Heptapleurum multiarcuatum* N. Ramnor & A. Puad, sp. nov. (Figure 4.72)

Type material: Sarikei: Sg Merinum (Lanjak Entimau Wildlife Sanctuary), lowland mixed dipterocarp forest, 11 Feb 1998, *Julaihi et al., S. 79219* (holotype: SAR!).

Mostly epiphyte and rarely a climber or small tree. ***Leaves*** (6-) 9-13 foliolate. Stipular ligule very thin, not persistent, free portion 2.5-4.5 cm long. Petiole base swollen, lenticellate, (39-) 61.5-153 cm long × 0.4-1.85 cm diam. Petiolules vary in length from 3.7- 20 cm long × 0.1-0.35 cm diam. Blades leathery, broadly and elongately elliptic or ovate to oblong-elliptic to oblong-ovate, 19.5-45.2 cm long × 4.2-17.4 cm wide. Apex slender caudate up to 4.5 cm

long. Margin entire. Base convex to rounded and sometimes oblique. Second-order venation mostly brochidodromous with the first two veins not joining the vein above, spreading-ascending about 12-23 pairs on each side. Reticulations coarse. ***Inflorescences*** terminal with limitation zone about 1-4 cm long, marked by numerous, congested, curled, caudate bracts with length 2.5-5 cm long. Branching zone extended up to 26 cm long. Lateral branches numerous and very closely spaced along the branching zone, 16-52.5 cm long × 0.1-0.5 cm diam., entire part covered with dense hairs. Umbellules numerous, very congested, racemosely arranged along the 4/5 of the branch length. Peduncle 1-3 (-6) mm long and greenish brown. Pedicels usually much longer than peduncles, up to 7 mm long and yellowish. ***Flowers*** buds 7-15 per umbel, ovoid, 1-3 mm long × 1-2 mm diam. Cupule campanulate with toothed calyx. Petals about 5-7. Stamen yellow. Disk somehow flat. ***Fruits*** ellipsoid, 3-6 mm long × 2-4 mm diam. Ovary half inferior. Disk initially flat to slightly sloping with stylar column 2 mm high. Stigmata almost fused, about 5-7.

Distribution: Central to Northern Sarawak (Figure 4.73)

Conservation status: This taxon is known from 35 specimens found in 29 locations (AOO = 104 km^2) from Sarikei, Sibu, Mukah, Bintulu, Kapit, Miri and Limbang divisions. It is assessed as Endangered.

Habitat: The species is commonly found near riverbank. Other than that, the plant can also be found in dipterocarp forest, primary and secondary forest and even in the limestone area. The lowest elevation recorded for the species is 30 m while the highest is 1100 m above sea level.

Notes: The plant differs from *H. longifolium* (Blume) Seem., found in Sumatera to Jawa by having mainly brochidodromous secondary venation, numerous and congested umbellules along the inflorescence branches and the length of pedicels are mostly longer than peduncles. Most of the specimens of *H. multiarcuatum* were found as epiphyte on the trees such as *Shorea* sp. and *Eugenia* sp. There is one specimen recorded climbing on the Meliaceae tree. As for the shrub, it can be found in the mixed dipterocarp forest with the height of 2 m tall while another shrub found on a rock in limestone forest. There are two specimens with extremely narrow blades which are S. 81001 and S. 91687. The plants that were collected on the limestone are mostly smaller compared to the other specimens.

Derivation of name: The taxa name is derived from the combination words of Latin in which the word *multus* meaning "many" and *arcuatus* meaning "bow-like" or "arched". The name is referring to the many second-order venation of the plant that arching towards the leaf margin.

Specimen listing: SARIKEI. Pakan. Sg Merinum (Lanjak Entimau Wildlife Sanctuary), 11 Feb 1998, *Julaihi et al., S. 79219* (SAR). **SIBU. Kanowit.** Ulu Sg Sapali, Ngemah, 10 Oct 1996, *Stephen Teo et al., S. 75575*. **MUKAH.** Mukah Hills, 18 Jul 1997, *Stephen et al., S. 77386.* **BINTULU. Tatau.** Sg Mayeng, 183 cm, 4 Jun 1956, *J.W. Purseglove, P. 5360* (SING); Simpang Tiga, Ulu Mayeng, 130 m, 4 Oct 1963, *Paul Chai, S. 19234* (K, L, SING); 30 m, 7 Oct 1963, *P.S. Ashton, S. 19302* (K); Sg Kakus, 11 Nov 1963, *Minoru Hirano & Mitsuru Hotta, No. 971* (SAR); Bkt Kana, 50-150 m, 22 Nov 1963, *Mitsuru Hotta, No. 15543* (SAR); Bkt Sarang, 7 Oct 2004, *Julia et al., S. 94778* (SAR, SING); Gua Aki Bukok, 7 Oct 2005, Malcom et al., S. 95601; S. 95609; S. 95618; Gua Naga, 7 Nov 2005, Julia et al., S.

95706. **Sebauh.** Bkt Sekiwa, 200 m, 25 Aug 1986*, Abg Mohtar et al., S. 52752*. **KAPIT.** (Ng) Gat, Upper Rejang River, 1929, *J. & M.S. Clemens, No. 21868* (SAR); *No. 21869* (SAR). **Bukit Mabong.** Bkt Mabong (SE end of Hose Mountains), 5 Aug 1967, *Burtt & Martin, B. 4800* (SAR); Bkt Salong, 975 m, 19 Aug 1967, *Ilias Paie, S. 25857* (CGE); Bkt Tibang, 1067 m, 8 Jul 1969, *Anderson & Ilias Paie, S. 28511* (CGE, K); 884 m, 14 Jul 1969, *Ilias Paie, S. 28753* (SAR); Ulu Sg Apah, 280 m, 8 Mar 1975, *Ilias Paie, S. 36300* (L); Ulu Sg Melinau, 150 m, 4 May 1976, *Paul Chai et al., S. 37350* (K, L, KEP); Bkt Pantu, Sg Tasu, 600 m, 17 Mar 1987, *Yii Puan Ching, S. 53568* (US, K); Sg Nasang, Baleh, 21 Sep 1989, *Hj Othman et al., S. 57780* (CGE, K, L); Sg Entemu, Baleh, 21 Oct 1988, *Hj Othman et al., S. 61724* (CGE, K). **Belaga.** Ulu Longunan, 10 Apr 1963, *P.S. Ashton, S. 17723* (K, L); Sg Iban, 11 Nov 1982, *Bernard Lee, S. 45498* (K, L, KEP, SAN, CGE); Sg Danum, 490 m, 5 May 1994, *Lai et al., S. 67770*; Batu Laga Plateau, 1100 m, 16 Jun 1995, *Yii Puan Ching et al., S. 71775*; Bkt Robertson, 840 m, 8 Aug 1999, *Julaihi Lai et al., S. 81001*. **Song.** Sg Joh, Ulu Katibas, 100 m, 27 Jun 1993, *Abg Mohtar et al., S. 65005* (KEP); 150 m, 15 Nov 1997, *K.G. Pearce et al., ITTO/BB 0424* (SAR); Lanjak Entimau Wildlife Sanctuary, 380 m, *Patsipun et al., S. 78098* (SAR); Sg Biladayat, Mujok, 198 m, 3 Feb 2003, *Rantai et al., S. 90772*. **MIRI. Tinjar.** Dulit Range, Ulu Tinjar, 366 m, 11 Aug 1974, *Paul Chai, S. 34759* (CGE). **Telang Usan.** Sg Palutan, 470 m, 29 Mar 2003, *Awang Enjah et al., S. 91687* (SAR).



Figure 4.72: *Heptapleurum multiarcuatum* N. Ramnor & A. Puad, sp. nov. (S. 79219).

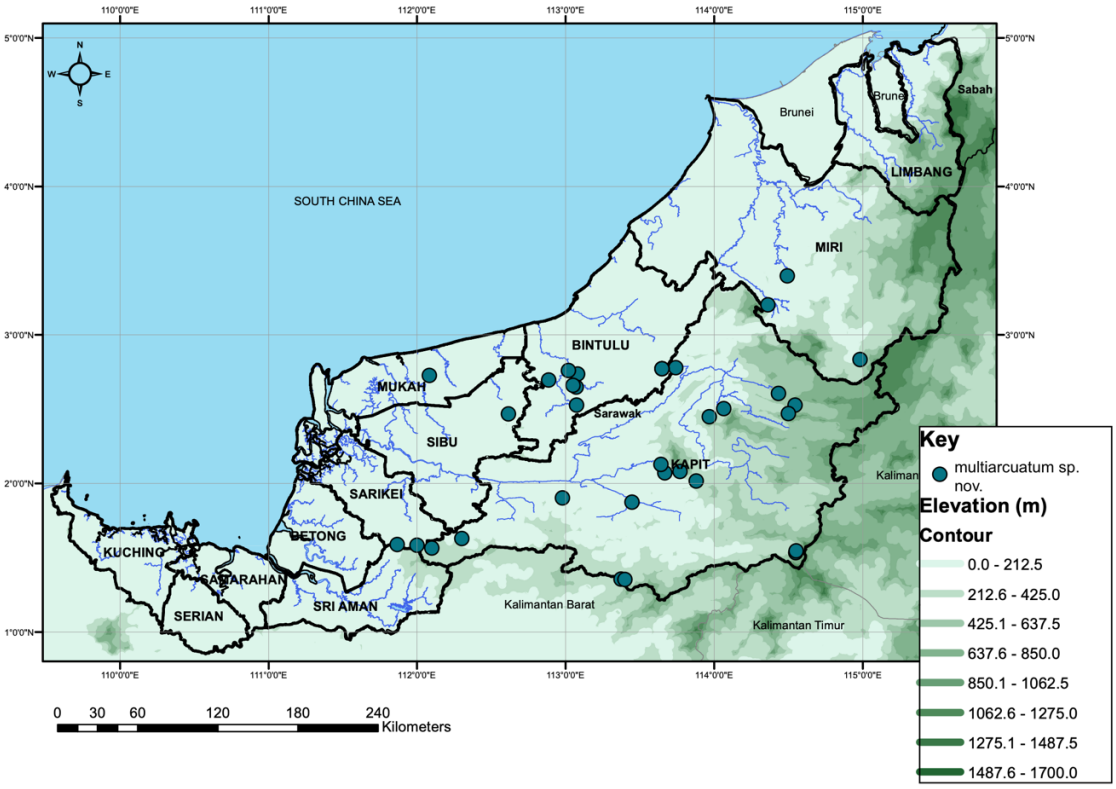


Figure 4.73: Distribution map of *H. multiarcuatum* sp. nov. in Sarawak.

4.5.36 *Heptapleurum niahense* N. Ramnor & A. Puad, sp. nov. (Figure 4.74)

Type material: Miri: Ulu Sg. Sekaloh, on mudstone outcropping from riverbank, 1 Dec 1966, *J. A. R. Anderson, S. 27296* (holotype: SAR!; isotypes: K, CGE).

Epiphyte. ***Leaves*** trifoliolate. Stipule prominent, truncate with free portion length at 1.8 cm long. Petiole 3.7 cm long × 0.36 cm diam. Petiolules 1.4-3.3 cm long, lateral ones are much shorter compared to centre petiolule. Blades broadly ovate or oval, 23.1-29 cm long × 12.2-13.1 cm wide, dull surfaces on both adaxial and abaxial surfaces. Apex acuminate, more or less 1 cm long. Margin inrolled and entire. Base rounded. Second-order venation weakly visible, camptodromous 11-14 pairs. ***Inflorescences*** terminal. Limitation zone 21.7 cm long with branching zone obscure, marked by few, acute and closely spaced bracts at the base. The branches slender, sparsely hairy, 67.3-77.3 cm long × 0.4-0.5 cm diam., much longer than blades. Umbellules numerous and racemosely arranged along the branch. Peduncles hairy and 2-4 mm long while pedicels 2-3 mm long. ***Flowers*** not seen. ***Fruits*** ellipsoid with campanulate cupule. Entirely glabrous. Dimension 3-5 mm long × 1.9-2.4 mm diam. Disk slightly sloping. Style united at 1 mm long, topped by 4-5 stigmata. Ovary 2/3 inferior.

Distribution: Northern Sarawak (Figure 4.75)

Conservation status: *Heptapleurum niahense* is assessed as Data Deficient (DD).

Habitat: On the mudstone outcropping from riverbank.

Notes: The plant differs from *H. avene,* found in Borneo, Lesser Sunda Island and Sumatera by having bigger leaves, longer and slender inflorescence branches. smaller fruits and less stigmata. Only one specimen recorded for this taxon.

Derivation of name: The taxa is named after the place of collection which is in Niah, Miri.

Specimen listing: MIRI. Niah. Ulu Sg. Sekaloh, 1 Dec 1966, *J. A. R. Anderson, S. 27296* (SAR, K, CGE).



Figure 4.74: *Heptapleurum niahense* N. Ramnor & A. Puad, sp. nov. (S. 27296).

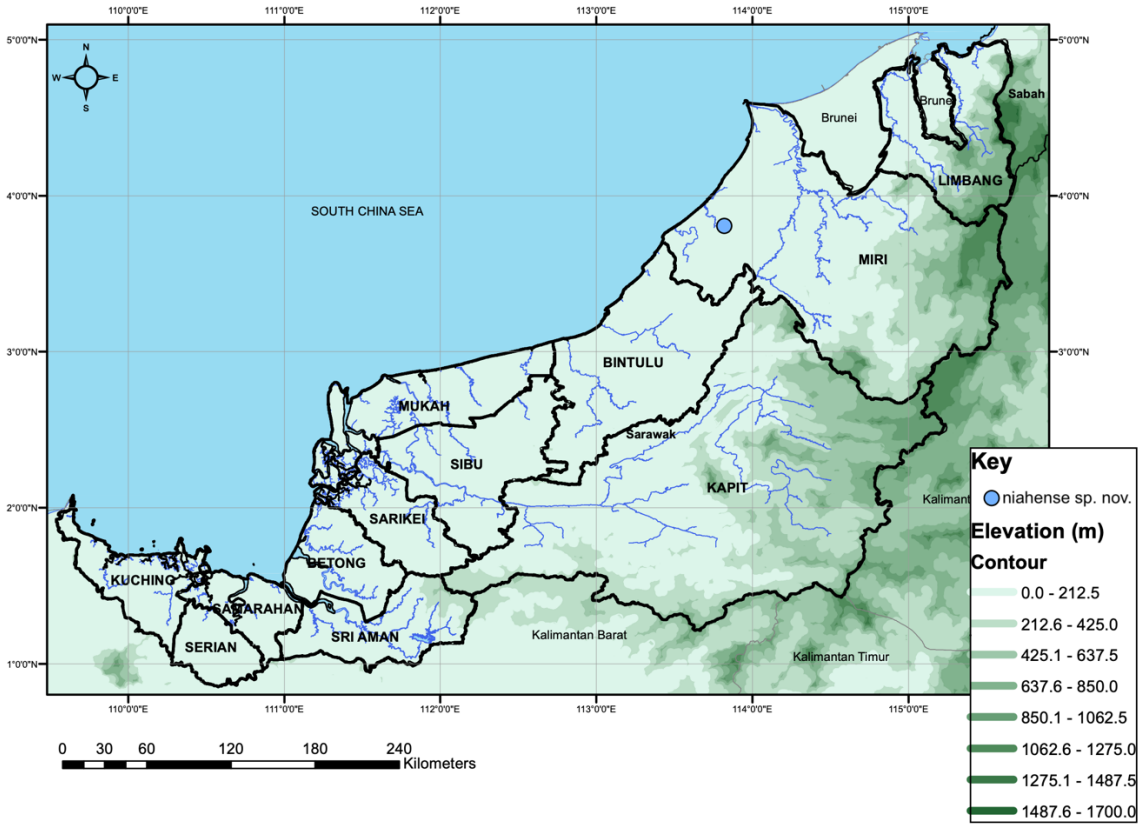


Figure 4.75: Distribution map of *H. niahense* sp. nov. in Sarawak.

4.5.37 *Heptapleurum obovatilimbum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (Figure 4.76)

Novon 28 (3): 161 (Lowry & Plunkett, 2020).

Basionym: *Schefflera obovatilimba* Frodin & Puad, *The Genus Schefflera in Sabah, Malaysian Borneo* 149 (Ahmad Puad et al., 2018).

Type material: Ulu Menanam, Tongod, *Dewol & Kodoh, SAN 88740* (holotype: SAN; isotypes: A, K, L).

Epiphyte plant on a tree of 2-15 m high. ***Leaves*** 6-10 foliolate. Entirely glabrous. Stipule persistent with length 1.6-3 cm long. Petiole slender, 14.5-25.5 cm long × 0.27-0.35 cm diam. Petiolules vary in length from 1.8-12 cm long × 0.01-0.15 cm diam. and slender. Blades narrowly obovate to elliptic, 10.5-27.5 cm long × 4-8.6 cm wide. Apex abruptly to broadly caudate-acuminate, 0.8-1.6 cm long. Margin entire. Base cuneate. Second-order venation 4-10 pairs, eucamptodromous, strongly curving towards margin, the spacing between each vein 1.5-3.2 cm wide, raised under surface of leaves, reticulations distinct. ***Inflorescences*** terminal with limitation zone 3-14 cm and branching zone 0.5-4 cm. Branches 6-13 slender, covered in moderate pubescent, 17.3-35.5 cm long × 0.15-0.25 cm diam. Umbellules numerous, congested along the branches, racemosely arranged. Peduncles 0.2-1 cm long and hairy. Pedicels 2.5-5 mm long, green, initially hairy and glabrescent when matured. ***Flowers*** bud ovoid to slightly ellipsoid, 2 mm long × 1 mm diam. Bracts subtended from the base of pedicels hairy and 0.15-0.2 cm long. Calyx pale green. Stamen yellow. Petals lanceolate, 1.5-2 mm long × 1 mm wide, very small. Disk convex and glaucous. Ovary half inferior. ***Fruits*** glabrous, yellow to orange, obovoid to globose, 4 mm long × 2-3 mm diam. Ovary 4/5 inferior. Disk convex. Stigmata 5, prominent, sessile, closely arranged next to one another forming a small circle.

Distribution: Borneo. In Sarawak, the plant is recorded in Miri and Limbang divisions. (Figure 4.77)

Conservation status: *Heptapleurum obovatilimbum* is assessed as Data Deficient (DD).

Habitat: Along streambank, on slope of limestone and ridge with elevation ranging from 183-632 m above sea level.

Notes: The species can be identified by its narrow obovate to elliptic blades, caudate-acuminate apex, second-order venation curving towards margin, the main axis above last leaf can be up to 17 cm long with moderately pubescent branches and congested umbellules along them. The maturing fruits are either globose or ellipsoid and on top of it is sloping disk with sessile stigmata of 5. The leaves of *H. obovatilimbum* and *H. multispicatum,* a species in Sabah, are almost similar. The inflorescences part of *H. obovatilimbum* such as pedunculate umbellules, closely spaced lateral branches and larger fruits can help to differentiate those two species (Ahmad Puad et al., 2018).

Specimen listing: MIRI. Mulu. Mt. Buda, Mulu National Park, 16 Oct 1977, *Paul Chai, S. 39867* (L, K, KEP). **LIMBANG.** Ulu Medamit (on slope), 183 m, 15 Oct 1972, *Erwin Wright & Othman Ismawi, S. 32387* (L, K). **Lawas.** Sg. Lutok, Bkt. Tebunan, Ulu Trusan, 450 m, 4 May 1986, *Bernard Lee, S. 52373* (CGE).



Figure 4.76: *Heptapleurum obovatilimbum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (S. 32387).

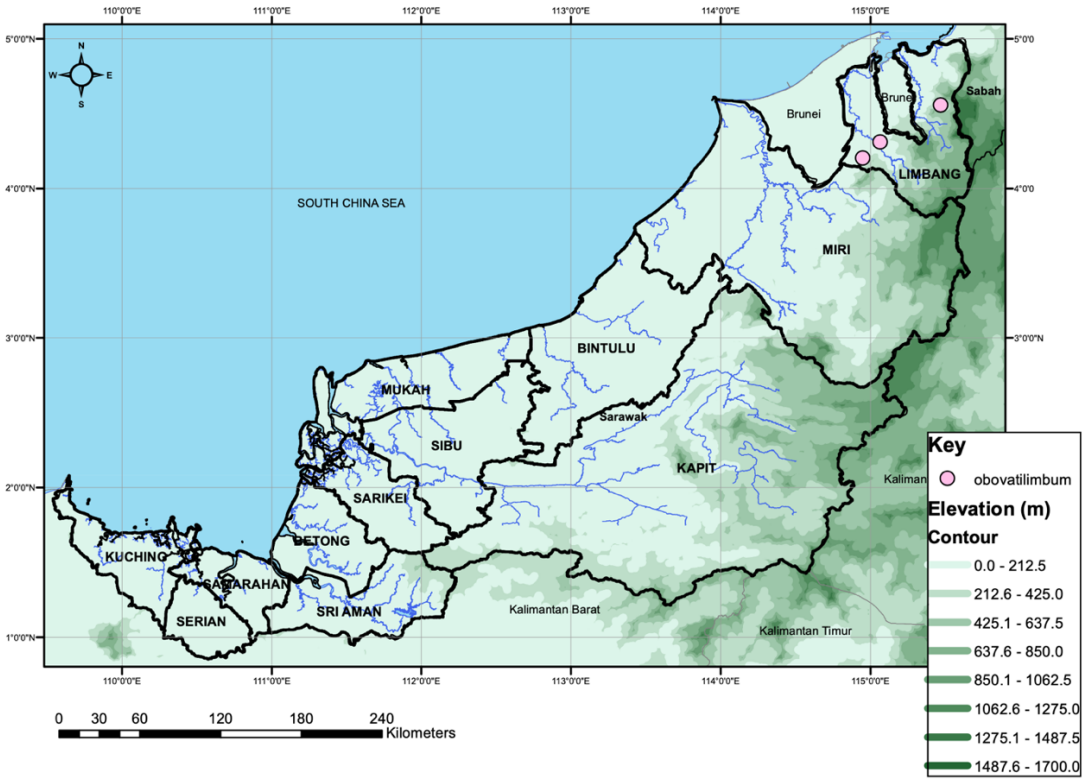


Figure 4.77: Distribution map of *H. obovatilimbum* in Sarawak.

4.5.38 *Heptapleurum paulchaii* N. Ramnor & A. Puad, sp. nov. (Figure 4.78)

Type material: Miri: Ulu Sg. Berar, on ridge top in mixed dipterocarp forest, 152 m, 2 Oct 1977, *Paul Chai, S. 39612* (holotype: SAR!; isotypes: CGE, L, K, KEP, SAN, MO).

Epiphyte. ***Leaves*** 2-3 foliolate. Stipular ligule truncate, almost fused, length 2 mm. Petiole 8.6-11.3 cm long × 0.18-0.19 cm diam. Petiolules 0.7-2.1 cm long × 0.11-0.14 cm diam. Both petiole and petiolules glabrescent. Blades oval, slightly unequal, thick, dull surfaces, 7.2-9.7 cm long × 3-4.6 cm wide. Apex acuminate passing to caudate-acuminate with length 1-1.9 cm long, rarely retuse. Base concave or cuneate. Margin entire. Second-order venation c. 7 pairs, weakly visible on below surface while not visible on upper surface, closely spaced, camptodromous. ***Inflorescences*** terminal, limitation zone 2.5 cm and branching zone 2.5 cm long. Branches 5 and more, sparsely pubescent, very slender, 24-29.5 cm long × 0.08-0.09 cm diam. Terminal umbel 2, sometimes with one umbel below. Peduncle 7-9.1 cm long × 0.04-0.05 cm diam. Pedicels 1.5-1.8 cm long. ***Flowers*** 7-9 per umbel, glabrous, initially green to yellow. Cupule funnel-shaped with calyx rim-like. Petal triangular, 2 mm long × 2 mm wide, c. 6 per flower. Ovary half inferior. Disk sloping with stylar column 0.5 mm long. ***Fruits*** not seen.

Distribution: Northern Sarawak (Figure 4.79)

Conservation status: *Heptapleurum paulchaii* is assessed as Data Deficient (DD).

Habitat: Ridgetop in mixed dipterocarp forest at elevation of 152 m above sea level.

Notes: The taxon is morphologically similar to *H. simplifolium* (Merr.) G. M. Plunkett & Lowry and *H. subdivaricatum* (Merr. ex Frodin) G. M. Plunkett & Lowry in the Philippines and *H. leiophyllum* (Harms) Lowry & G. M. Plunkett in West New Guinea through inflorescences. However, *H. simplifolium* has unifoliolate leaf while the leaflets are narrower in *H. subdivaricatum* comparing to *H. paulchaii. Heptapleurum leiophyllum* has more umbels per branch than *H. paulchaii.*

Derivation of name: The taxa is named to honour a forest botanist and plant collector, Dr Paul Chai Piang Kiang. He has been working for Forest Department Sarawak since January 1970 and actively collecting plants since then (van Steenis-Kruseman, 1974). He is now a consultant at Sarawak Forestry Corporation (SFC) (Sarawak Forestry Corporation, 2020).

Specimen listing: MIRI. Mulu. Ulu Sg. Berar, 152 m, 2 Oct 1977, *Paul Chai, S. 39612* (SAR, CGE, L, K, KEP, SAN, MO).



Figure 4.78: *Heptapleurum paulchaii* N. Ramnor & A. Puad, sp. nov. (S. 39612).

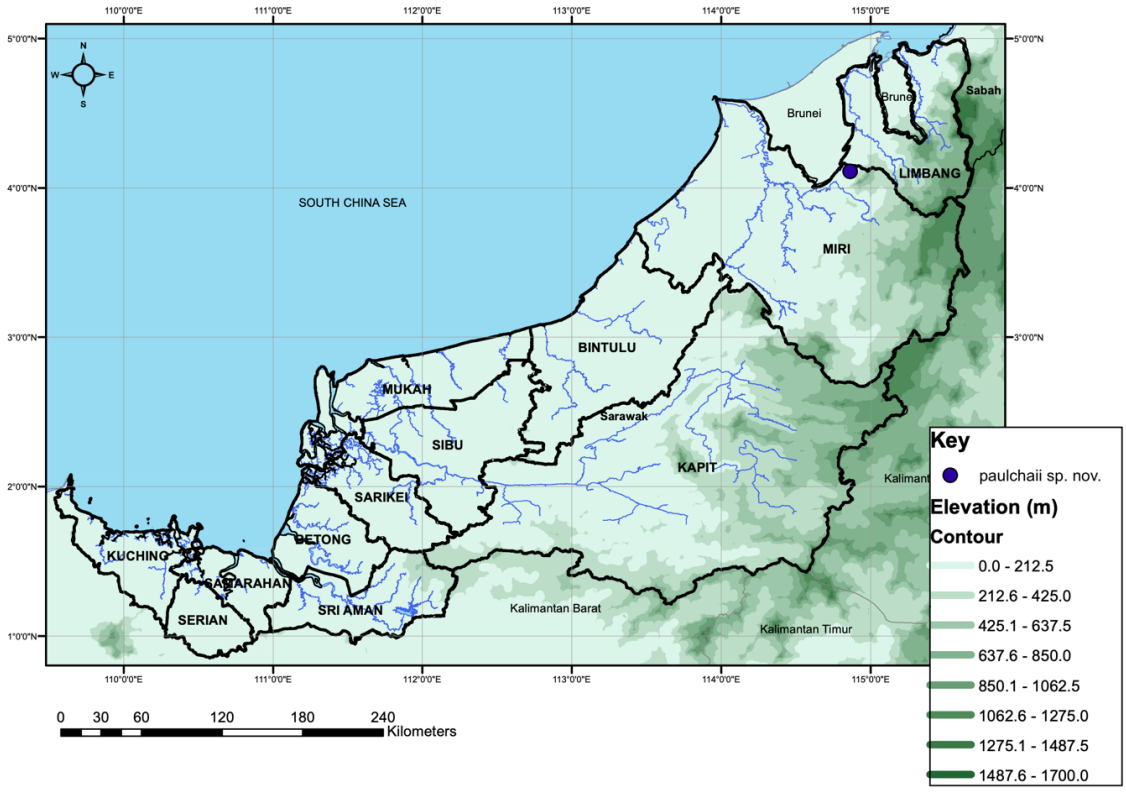


Figure 4.79: Distribution map of *H. paulchaii* sp. nov. in Sarawak.

4.5.39 *Heptapleurum petiolosum* (Miq.) Seem. (Figure 4.80)

Journal of Botany, British and Foreign 3: 78 (Seemann, 1865).

Basionym: *Paratropia petiolosa* Miq., *Annales Musei Botanici Lugduno-Batavi* 1: 24 (Miquel, 1863).

Synonym: *Schefflera petiolosa* (Miq.) Harms, in H.G.A. Engler & K.A.E. Prantl, *Naturlichen Pflanzenfamilien* 3 (8): 39 (Harms, 1894).

Type material: Southern Borneo, *Korthals s. n.* (holotype: K).

Straggling shrub, epiphyte or climber. ***Leaves*** 4-7 foliolate and entirely glabrous. Petiole 18-51.5 cm long × 2.5-5.5 mm diam. Petiolules varies in length, from 1-9 cm long × 0.07-0.35 cm diam., slender. Blades mostly elliptic, to ovate-elliptic, chartaceous, 9.2-35.1 cm long × (2.7-) 5.1-12.7 cm wide. Apex caudate, up to 2.6 cm long. Margins from weakly rounded to prominent serrate teeth. Base cuneate to rounded. Second-order venation 4-7 (-9) pairs on each side, strongly curving, wide spacing between each vein, reticulation coarse. ***Inflorescences*** terminal. Limitation zone 0.5-2 cm long and branching zone from 0-1 cm long. Branches 5-10, 12.5-41.3 cm long × 0.12-0.4 cm diam., covered in brown stellate hairs. Umbellules numerous, closely spaced and racemosely arranged along half to ¾ the branch. Peduncles almost sessile to 1 mm long, usually shorter than pedicels and covered with hairs. Subtended bracts at the base of peduncles 4-7 mm long, not persistent. Pedicels glabrous, up to 5 mm long. ***Flowers*** buds 6-10 per umbel, obovoid, 3-5 mm long × 2.5-5 mm diam., covered in pubescent. Cupule campanulate with spreading calyx-rim c. 0.5 mm long. Ovary half inferior. Corolla cream, oblong, length 3 mm and immediately falling off at anthesis. Disk green and sloping with cream stylar column raised up to 1 mm high. Stamen c. 2 mm

long with cream filaments and yellow anthers. Stigmata not fully separated. ***Fruits*** entirely glabrous, initially green to yellow and orange when riped. Dimension 5-5.5 mm long × 1.8-4.1 mm diam., globose, ovoid-globose to obovoid, 3/5 inferior. Cupule hairy or globose topped by extremely short calyx-rim. Disk convex. Stylar column 0.5-1 mm long. Stigmata distinct, (5-) 7-9, formed in a ring.

Distribution: Borneo. In Sarawak, the plant is recorded in Kuching and Serian divisions. (Figure 4.81)

Conservation status: This taxon is known from 49 specimens found in 34 locations (AOO = 108 km^2) from Kuching and Serian divisions. It is assessed as Endangered.

Habitat: Frequently recorded at limestone vegetation. Other vegetation such as near riverbank, mixed dipterocarp, secondary and submontane mossy. Elevation 25-750 m above sea level.

Notes: *Heptapleurum petiolosum* is easily recognized by its chartaceous leaflets, toothed margin on elliptic to ovate-elliptic blades, long caudate apex, slender inflorescence branches, peduncles length at most 1 mm long and pedicels can reach up to 5 mm long. Being the most collected species of *Heptapleurum* in Sarawak with 49 specimens, the variation of leaf blades is much more evident in term of length, width and margin. This species is known to have toothed margin on upper half of blades and most of the specimens has shown minute and widely spaced teeth. In some specimens such as S. 46300, S. 73588 and S. 82015, the teeth of their margin are much more prominent and closely spaced. Without the reproductive

part, the plant can be mistaken for *H. mitragerum* and *H. sabahense*. One of the specimens recorded were found climbing on *Saraca* tree near a stream. This species has the highest number of specimens in SAR. Most of the collections found at the limestone area of Bau, Padawan and Serian. In Lundu, the plant was collected near riverbank and on hill or mountain. The vernacular name of this species is 'Kuku Bajang'.

Specimen listing: KUCHING. Mt. Braang, Oct 1889, *G. D. Haviland, Hav. 277/193* (SAR); Mt. Bar, Mambong, Penrissen, 19 Feb 1993, *Lai Shak Teck & Rantai, S. 66001* (KEP, K, L, SAN); Kpg. Tiang Bekap, Kpg. Gayu, Padawan, 500 m, 1 Dec 1996, *Mohizah, Jegong et al., S. 66836*; Kpg. Bugut, Padawan, 17 Jan 1996, *Mohizah, Jegong et al., S. 66878* (KEP); Mt. Sebekab, Bengoh, Padawan, 100 m, 14 Jan 1997, *Jamree, Awang Enjah et al., S. 75812* (KEP, K, L, SAN); Mt. Braang, 8 Dec 2000, *Jemree, S. 84017* (SAR); Kuching and vicinity, year 1929, *J. & M. S. Clemens, No. 20511* (SAR); Bukit Pait, 152 m, 2 Mar 1969, *Erwin & Paul, S. 27442* (SAR); Mt. Braang (foothill), 360 m, 6 May 1975, *Paul Chai, S. 37353* (CGE, L, K, MO, SAN); Bkt. Manok (Mile 38, Padawan road), 2 Sep 1979, *James Mamit, S. 41097* (CGE, L); Mt. Bramlin (Braang), *Garai, Hav. 2020* (SAR, SING); Bkt. Bah, Kpg. Punau, 27 Nov 1992, *Lesmy & Jugah, S. 65179* (KEP, CGE). **Bau.** Bkt. Kapor, 9 Jul 1996, *Mohizah, Yahud et al., S. 74452* (KEP, K, L, SAN, MO); Mt. Juita, 4 Feb 1999, *Jamree et al., S. 82015* (KEP); Bkt. Batu, Jambusan, 2 Apr 1999, *Jamree et al., S. 82053* (SAR); Bkt. Gajah, 9 Feb 1999, *Jamree et al., S. 82079* (KEP); Mt. Aup, 9 Oct 2001, *Julia S. et al., SBC 577* (SBC); Mt. Aup, 35 m, 10 Oct 2001, *Kalu M. et al., SBC 669* (SBC); Mt. Podam, 30 m, 17 Oct 2001, *Kalu M. et al., SBC 798* (SBC); Mt. Apin, 150 m, 7 Nov 2001, *Donny JG et al., SBC 1368* (SBC); Mt. Ropih, 12 Dec 2001, *Donny JG et al., SBC 2011* (SBC); Mt. Doya, 180 m, 27 Feb 2002, *Julia S. et al., SBC 2045* (SBC); Mt. Aup, 14 May

2002, *Malcom D. et al., SBC 3306* (SBC); Seburan (limestone hill), 4 Sep 1970, *J. A. R. Anderson, S. 29381* (SAR); Bau (limestone rocks), 61 m, 15 Sep 1955, *J. W. Purseglove, P. 4471* (SAR, SING); Seburan (limestone boulder), 20 Mar 1966, *J. A. R. Anderson, S. 19143* (SAR); Lobang Angin, 91 m, 5 Sep 1980, *Yii Puan Ching, S. 41999* (CGE, L, K); Seburan (base of limestone hill), 8 Jun 1966, *J. A. R. Anderson, S. 25528* (K); Bt. Krasin, 50 m, 5 Sep 1964, *Anderson et al., S. 20278* (K); Bidi Cave, year 1929, *J. & M. S. Clemens, No. 20682* (SAR); Bau (foothill of limestone), 18 May 1986, *Abang Mohtar et al., S. 52907* (CGE); Tai Ton (limestone foothill), 18 May 1986, *Abang Mohtar et al., S. 52901* (CGE, K); Mt. Kawa, 10 Aug 1978, *Rena George, S. 38269* (CGE, L); Bidi (limestone), 20 May 1986, *Abang Mohtar et al., S. 52940* (CGE, K). **Lundu.** Mt. Berumput, 740 m, 13 Mar 1996, *Julaihi Lai, Jegong & Johnny, S. 73588* (KEP, SAR); Hydro Dam, Sg. Sebako, Sematan, 170 m, 11 Mar 1996, *Runi et al., S. 73321* (KEP, K, L); Pueh, Sg. Sebat, Sematan, 147 m, 24 Feb 2014, *Nur Safinas et al., S. 103827* (SAR); Mt. Gading, 579 m, 24 Sep 1974, *James Mamit, S. 35148* (L, K, MO, CGE); Sg. Sebumban (Gunung Gading National Park), 25 m, 21 Jul 1963*, Paul Chai, S. 18506* (K, L, SING, SAN, A, BO, KEP). **SERIAN.** Ulu Sg. Majat, Mt. Niyat, 27 Feb 2002, *S. Jemree & A. Enjah, S. 85588* (SAR, K); Bkt. Selabor (Silabur), 305 m, 30 Sep 1968, *Ilias Paie, S. 28110* (CGE, K); Mt. Selebur (Silabur), 20 Apr 1999, *Jamree, Patsipun et al., S. 82243* (KEP). **Tebedu.** 15th Mile [on cliff wall], 8 Feb 1985, *Abg Mohtar et al., S. 49236* (CGE, K); Bkt. Payang, KM 20, Serian-Tebedu road, 110 m, 19 Mar 1999, *Rantai Jawa et al., S. 78883* (SAR); Mt. Payang, 20 Apr 1999, *Jamree, Patsipun et al., S. 82264* (KEP, K); Bkt. Payang, 21 Jun 1996, *Jamree et al., S. 73262* (KEP, K); Mt. Beloban, 120 m, 28 Jun 1983, *Yii & Othman, S. 46300* (SAR); Tebakang-Tebedu road, 20 Jan 1989, *Abang Mohtar et al., S. 56171* (KEP, CGE).



Figure 4.80: *Heptapleurum petiolosum* (Miq.) Seem. (S. 27442).

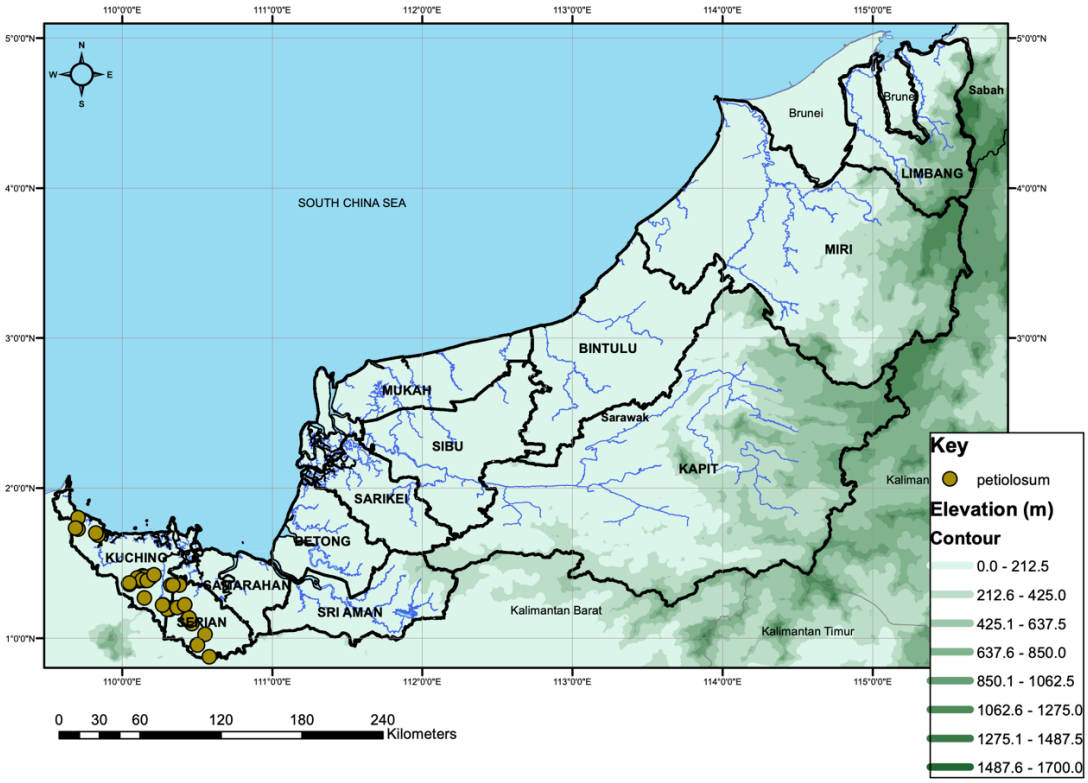


Figure 4.81: Distribution map of *H. petiolosum* in Sarawak.

4.5.40 *Heptapleurum primackii* N. Ramnor & A. Puad, sp. nov. (Figure 4.82)

Type material: Miri: Deer Cave, in rocky crevice at the base of a cliff, Gunung Mulu NP, 7 Mar 1981, *R. B. Primack, S. 43348* (holotype: SAR!; isotypes: CGE, L).

A huge plant found sprawling on forest floor and rock crevices at c. 1.3 m tall. ***Leaves*** 4-foliolate. Stipule not seen. Petiole 58.7 cm long × 0.64-0.74 cm diam. Petiolules 8.5-13.7 cm long × 0.27-0.32 cm diam. Both sparsely hairy. Blades glabrous, thick, broadly elliptic with 34.7-36 cm long × 14-14.8 cm wide, margin partially serrate. Apex caudate-acuminate and 2.3-3 cm long. Base obtuse. Second-order venation eucamptodromous, spacing between each vein 3.5-5.5 cm wide, arcuate. Reticulations weak. ***Inflorescences*** terminal, limitation zone 2 cm and branching zone more than 3 cm long. Lateral branches 5 and more, hairy, closely spaced to one another, 41.2 cm long × 0.32 cm diam. Umbellules c. 20 per branch, arranged in racemose. Peduncles slender with length of 3.2-4.6 cm long. Pedicels 5-7 mm long. ***Flowers*** pale green, about 35 per umbel. Bud ellipsoid with dimension 5 mm long × 2.6 mm diam. Cupule cup-shaped, 3-4 mm long. Apex somehow flat. Stylar column at the centre 1 mm long. Ovary inferior. Petal 5, thick and triangular. Stigmata 5. ***Fruit*** not seen.

Distribution: Northern Sarawak (Figure 4.83)

Conservation status: *Heptapleurum primackii* is assessed as Data Deficient (DD).

Habitat: Rocky crevices at the base of the cliff and in lowland mixed dipterocarp forest.

Notes: The taxon differs from *H. mitragerum* by having thicker leaves, longer peduncles, shorter pedicels, numerous flowers per umbel and less stigmata. There are only two specimens found for this taxon.

Derivation of name: The taxa is named after first collector of this plant, Richard Primack. He is a Professor of Biology in Boston University and expertise in conservation biology, plant ecology and climate change biology. He has done an extensive amount of fieldwork in Malaysia, New Zealand, Japan, Central America and many more (Pardee School of Global Studies, n.d.).

Specimen listing: MIRI. Mulu. Deer Cave, Gunung Mulu NP, 7 Mar 1981, *R. B. Primack, S. 43348* (SAR, CGE, L); Entrance of Deer Cave, 56 m, 3 Sep 2015, *Aishah et al., SNA 13.*



Figure 4.82: *Heptapleurum primackii* N. Ramnor & A. Puad, sp, nov. (S. 43348).

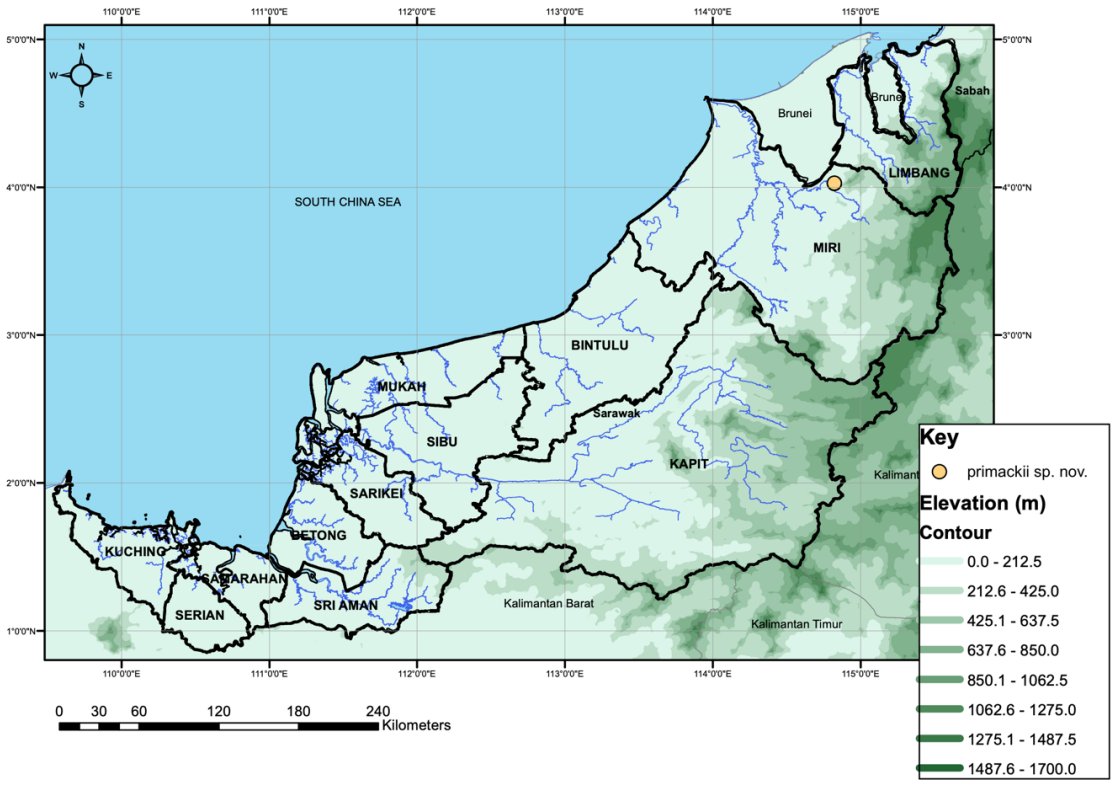


Figure 4.83: Distribution map of *H. primackii* sp. nov. in Sarawak.

4.5.41 *Heptapleurum puehense* N. Ramnor & A. Puad, sp. nov. (Figure 4.84)

Type material: Kuching: Mt. Pueh, rocky summit, 1267 m, 24 Sep 1955, *J. W. Purseglove, P. 4777* (holotype: SAR!; isotype: SING).

An epiphyte or scandent plant with lenticellate stem. ***Leaves*** 5-6 foliolate, entirely glabrous. Stipule free portion, truncate, up to 2.7 cm long. Petiole 10-19.4 cm long × 0.24 cm diam. Petiolules 2.2-7 cm long × 0.10-0.12 cm diam. Blades ovate or oval, 6.5-10.7 cm long × 3.5-5.1 cm wide. Apex acuminate, length up to 1.6 cm long. Margin partially sinuous. Base rounded. Second-order venation 10-15 pairs, weakly visible on surface, closely spaced, gradually ascending. ***Inflorescences*** terminal. Limitation zone 2.8 cm long. Branching zone

none. Terminal branches 4, 8.5-17.3 cm long × 0.35-0.4 cm diam. Umbellules 8-12 per branch along ¾ of the branch length. Peduncles curved, slender, extending up to 3 cm long. Pedicels 3-5 mm long. ***Flower buds*** up to 22 per umbel, glabrous, globose to ovoid. Dimension 3-4 mm long × 1.7-1.8 mm diam. Petal 6 with length 2 mm long. Cupule 1-2 mm long. Ovary inferior with stylar mound on top. ***Fruits*** not seen.

Distribution: Southern Sarawak (Figure 4.85)

Conservation status: *Heptapleurum puehense* is assessed as Data Deficient (DD).

Habitat: Rocky summit area of the mountain at elevation around 1267 m above sea level.

Notes: The plant has similar morphology with *H. burkillii* from Borneo and *H. affine* King from Southern Thailand to Peninsular Malaysia. Comparing to *H. puehense, H. burkillii* has shorter length of petiole and inflorescence branch while the leaves of *H. affine* are ovate-lanceolate to elliptic.

Derivation of name: The plant is named after its locality, Mount Pueh.

Specimen listing: KUCHING. Lundu. Mt. Poi (Pueh)**,** Sep 1929, *J. & M. S. Clemens, No. 20024* (SAR); Mt. Pueh, 1267 m, 24 Sep 1955, *J. W. Purseglove, P. 4777* (SAR, SING).



Figure 4.84: *Heptapleurum puehense* N. Ramnor & A. Puad, sp. nov. (P. 4777).

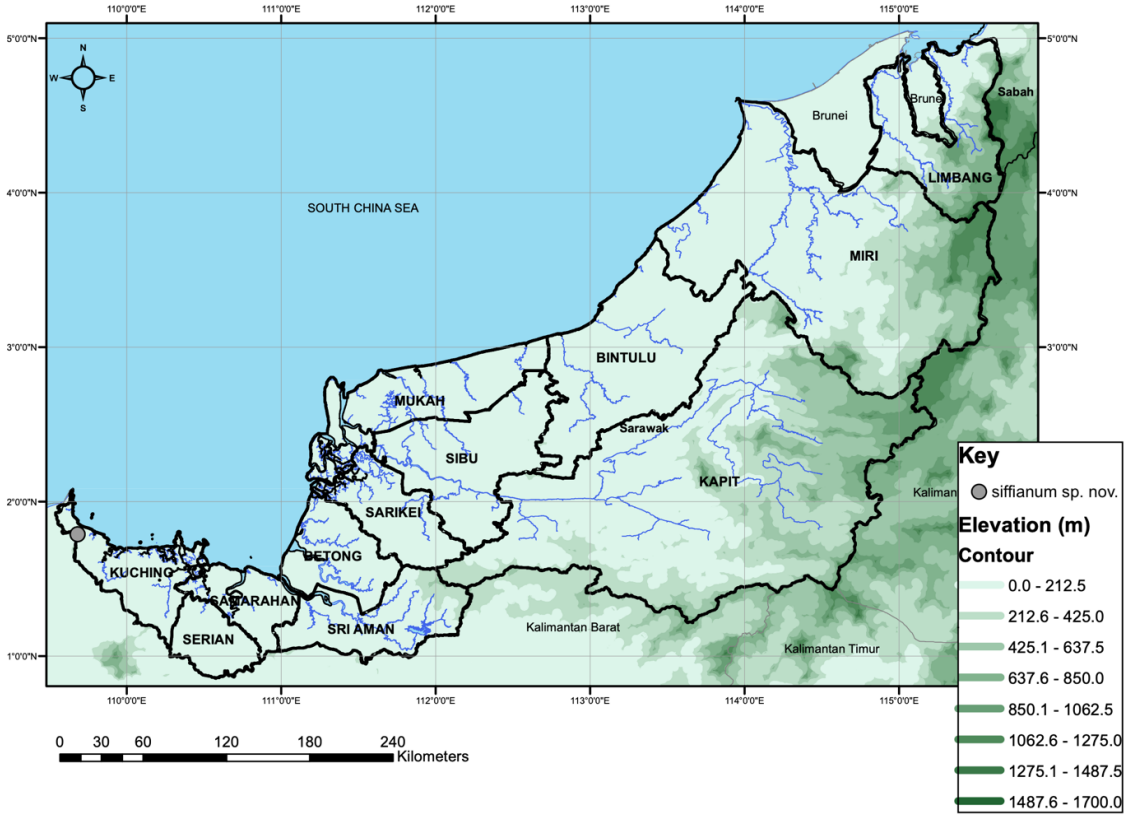


Figure 4.85: Distribution map of *H. puehense* sp. nov. in Sarawak.

4.5.42 *Heptapleurum rhodorifolium* N. Ramnor & A. Puad, sp. nov. (Figure 4.86)

Type material: Limbang: Mt. Pagon Priuk, submontane mossy forest, 1530 m, 11 Aug 1984, *Dayang Awa & Bernard Lee, S. 47804* (holotype: SAR!; isotype: KEP).

Epiphyte. ***Leaves*** 6-7 foliolate, entirely glabrous. Stipular ligule 1.3-2.5 cm long, acute, stiff and persistent. Petiole 17.3-19.3 cm long × 0.18-0.21 cm diam. Petiolules 1.4-3.5 cm long × 0.08-0.13 cm diam. Blades narrowly oblong to oblanceolate, 8.6-16.3 cm long × 1.8-3.4 cm wide. Apex broadly acute-acuminate with length 1.1-1.9 cm long. Base convex. Margin entire. Second-order venation pinnate, numerous and very closely spaced. ***Inflorescences*** terminal. Limitation zone 5.5 cm while branching zone c. 1 cm long. Branches 3, hairy up to peduncles, 8.2-10.5 cm long × 0.17-0.20 cm diam. Umbellules 6-8 per branch, distant from one another, scattered along most of the branch length. Peduncles 1.2-1.5 cm long. Pedicels 2-3 mm long and glabrous. ***Flowers*** 15 per umbel, buds ovoid, 3-4 mm long × 1.7-2 mm diam. Cupule funnel-shaped. Petal 5 with length 3 mm. ***Fruits*** not seen.

Distribution: Northern Sarawak (Figure 4.87)

Conservation status: *Heptapleurum rhodorifolium* is assessed as Data Deficient (DD).

Habitat: On the summit in submontane mossy forest at altitude of 1530 m.

Notes: The taxon differs from *H. rhododendrifolium* (Griff.) G. M. Plunkett & Lowry found in Himalaya, SE Tibet and North Myanmar, by having shorter length of branching zone and

numerous and closely spaced secondary venations. There is only one specimen for this taxon.

Derivation of name: The name is derived based on the genus *Rhododendron,* a woody plant of Ericaceae and *folius,* meaning "leaf". The leaflets strong recall the evergreen *Rhododendrom* species.

Specimen listing: LIMBANG. Mt. Pagon Priuk, 1530 m, 11 Aug 1984, *Dayang Awa & Bernard Lee, S. 47804* (SAR, KEP).

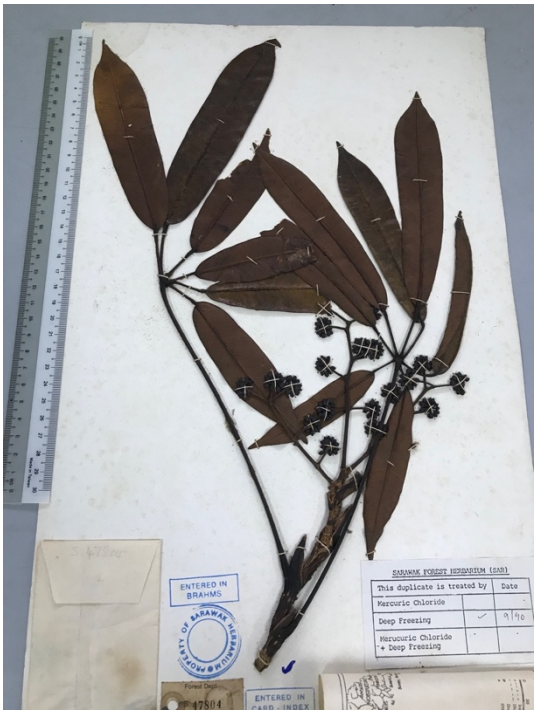


Figure 4.86: *Heptapleurum rhodorifolium* N. Ramnor & A. Puad, sp. nov. (S. 47804).

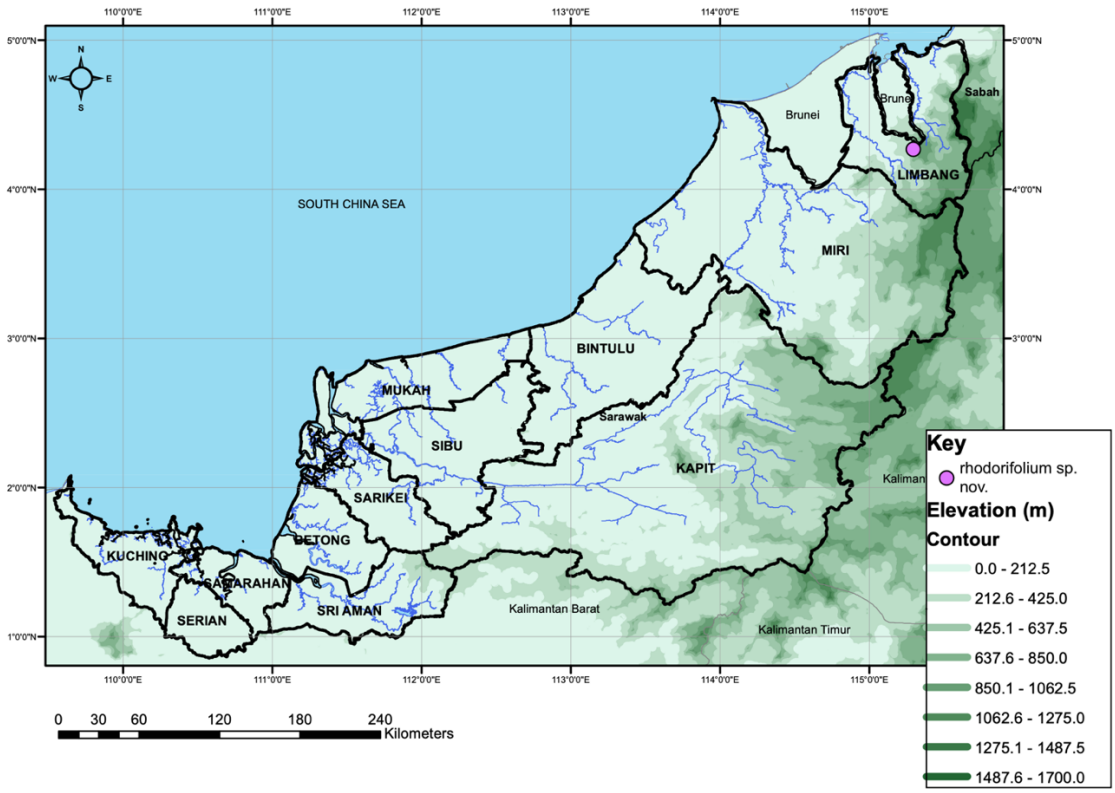


Figure 4.87: Distribution map of *H. rhodorifolium* sp. nov. in Sarawak.

4.5.43 *Heptapleurum runiae* N. Ramnor & A. Puad, sp. nov. (Figure 4.88)

Type material: Kapit: Bkt. Kumbong, submontane forest, 1260 m, 26 Feb 1992, *Runi et al., S. 60085* (holotype: SAR!).

An epiphyte at 10 m height. ***Leaves*** about 5-foliolate. Stipule partially fused, obtuse, 1 cm long. Petiole 38 cm long × 0.45 cm diam, glabrous. Petiolules 2.1-4.8 cm long × 0.1-0.2 cm diam. Blades narrowly elliptic, coriaceous, 14.3-20 cm long × 3.5-5.4 cm wide, both adaxial and abaxial surfaces dull. Apex acute-acuminate, margin entire and base convex. Second-order venation c. 24 pairs, gradually ascending, parallel, distinct reticulations. ***Inflorescences*** terminal. Limitation zone 2 cm long and branching zone 3.2 cm. Branches

16, closely spaced to one another, probably radiating based on the arrangement of branches along the main axis, 93-97.5 cm long × 0.4-0.5 cm diam., almost glabrous. Umbellules numerous, racemosely arranged along ¾ of the branch length. Peduncles dark green, glabrescent, 0.6-1.1 cm long × 0.1 cm diam. Pedicels 3-5 mm long and green. ***Flowers*** not seen. ***Fruits*** 12-13 per umbel, globose, 2-3 mm long × 2-3 mm diam., green, ovary 2/3 to almost inferior, glabrous. Stigmata sessile, 8-10, prominent.

Distribution: Central Sarawak (Figure 4.89)

Conservation status: *Heptapleurum runiae* is assessed as Data Deficient (DD).

Habitat: On hill in submontane forest at elevation of 1260 m above sea level.

Notes: The plant differs from *H. kuchingense* by having congested branches along the branching zone with larger branches. Only one specimen found for this taxon.

Derivation of name: The taxa is named after the main collector of the plant, Mdm. Runi Sylvester Pungga. She is also working at Forest Department Sarawak as a Senior Assistant Director. She is an expertise in botany, ethnobotany, ecology and biodiversity conservation (Forest Department Sarawak, 2023).

Specimen listing: KAPIT. Bkt. Kumbong, 1260 m, 26 Feb 1992, *Runi et al., S. 60085* (SAR).



Figure 4.88: *Heptapleurum runiae* N. Ramnor & A. Puad, sp. nov. (S. 60085).

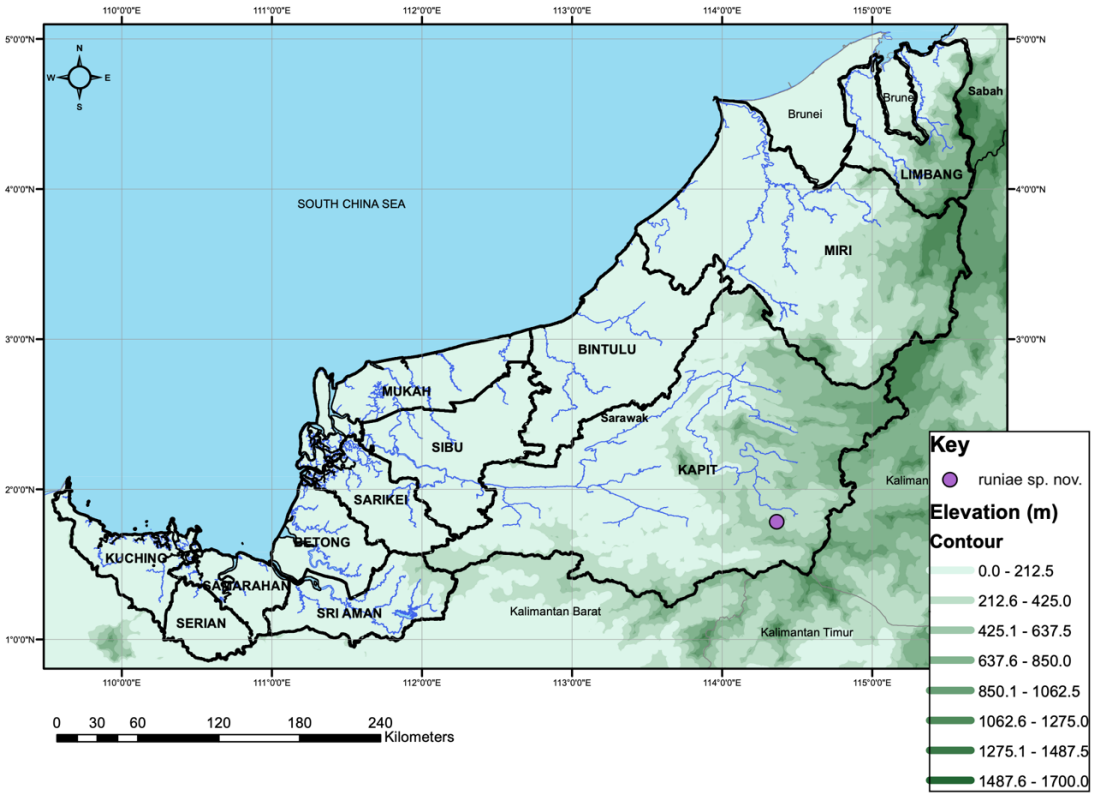


Figure 4.89: Distribution map of *H. runiae* sp. nov. in Sarawak.

4.5.44 *Heptapleurum sabahense* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (Figure 4.90)

Novon 28 (3): 165 (Lowry & Plunkett, 2020).

Basionym: *Schefflera sabahensis* Frodin & Puad, *The Genus Schefflera in Sabah, Malaysian Borneo* 168 (Ahmad Puad et al., 2018).

Type material: Mt Kinabalu, Eastern Shoulder [western of Poring], 4000 ft. (c. 1200 m), *Chew, Corner & Stainton, RSNB 1534* (holotype: SAN; isotypes: A, B, BO, CANB, K, L, LE).

A small tree at 1.5-5 m tall, epiphyte or climber plant. ***Leaves*** 4-6 foliolate. Leaflets entirely glabrous. Petioles slender with 32-52 cm long × 0.3-0.45 cm diam. Petiolules vary in length, 2-9.5 cm long × 0.1-0.2 cm diam and quite slender. Blades widely elliptic, length 16.3-26.5 cm long × 6-12 cm wide. Adaxial surface dark green, in contrast with abaxial surface in which the colour is much lighter. Apex broadly caudate-acuminate with its length extending to 2 cm long. Margin minutely toothed from middle to the apex. Base obtuse and convex. Second order venation 4-5 pairs, dark in colour, spacing between each vein 3-6.5 cm wide, strongly ascending towards the margin and ended at the toothed margin. Reticulations weak. ***Inflorescences*** terminal with limitation zone about 3-4 cm long while branching zone up to 8.5 cm long. Limitation zone marked by closely spaced, persistent bracts that circling around the axis, length about 1.2 cm. Branches 7 or more, 11.5-17 cm long × 2-3 mm diam., upright, erecto-patent and densely pubescent. Umbellules numerous, congested and racemosely arranged along most of the branch length. Peduncle 0.5 cm long × 0.05 cm diam, subtended by bracts about 0.5-0.6 cm long with caudate apex. Pedicels 0.6 cm long at most. Both

peduncles and pedicels densely hairy. ***Flowers*** 6-8 per umbel. Buds 2-4 mm long × 1.5-2.5 mm diam. Cupule campanulate and glabrescent. The widest point above the cupule. Calyx-rim prominent, minutely toothed and projecting. Petals 5-6, length 3 mm long, lanceolate. Stamen 5.5-6 mm long. Anther yellowish. Ovary ¾ inferior. Disk barely sloping with slightly raised stylar column at the centre. Stigmata somehow indistinct. ***Fruits*** not seen.

Distribution: Borneo. In Sarawak, the plant is recorded in Miri division. (Figure 4.91)

Conservation status: *Heptapleurum sabahense* is assessed as Data Deficient (DD).

Habitat: On rocks in swamp forest, by the stream and mixed dipterocarp forest with elevation from 27-152 m above sea level.

Notes: Until now, *H. sabahense* in Sarawak is recorded at Niah National Park and Gunung Mulu National Park in Miri. More fieldwork needed to be done in future to see whether there is more *H. sabahense* around Sarawak. In Sabah, this plant is common and it is also the most collected species there (Ahmad Puad et al., 2018). The leaves are similar to *H. mitragerum* and *H. petiolosum* but they can be easily differentiated by their inflorescence part. The inflorescence of *H. sabahense* is covered in dense brown hairs with congested umbellules along the branches. The length of peduncles and pedicels are almost the same.

Specimen listing: MIRI. Subis. Niah caves, 152 m, 4 Jun 1962, *Chew Wee-Lek, CWL. 302* (SAR, CGE); Niah National Park, 17 Aug 2002, *Kit Pearce et al., S. 89290* (SAR, K); Great Caves, Niah National Park, 22 Aug 2002, *Kit Pearce et al., S. 89467* (SAR). **Mulu.** Paku

Loop, Gunung Mulu NP, 49 m, 20 Jan 2015, *Aishah et al., SNA 3*; Sg Melinau, 31 m, 26 Aug 2015, *Aishah et al., SNA 5*; Kenyalang Loop, Mulu NP, 49 m, 3 Sep 2015, *Aishah et al., SNA 12*; Park Headquarters, Gunung Mulu NP, 36 m, 4 Sep 2015, *Aishah & Fatiha, SNA 14*; In front of security office, Gunung Mulu NP, 27 m, 20 Jan 2015, *Aishah & Fatiha, SNA 28*.



Figure 4.90: *Heptapleurum sabahense* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (S. 89467).

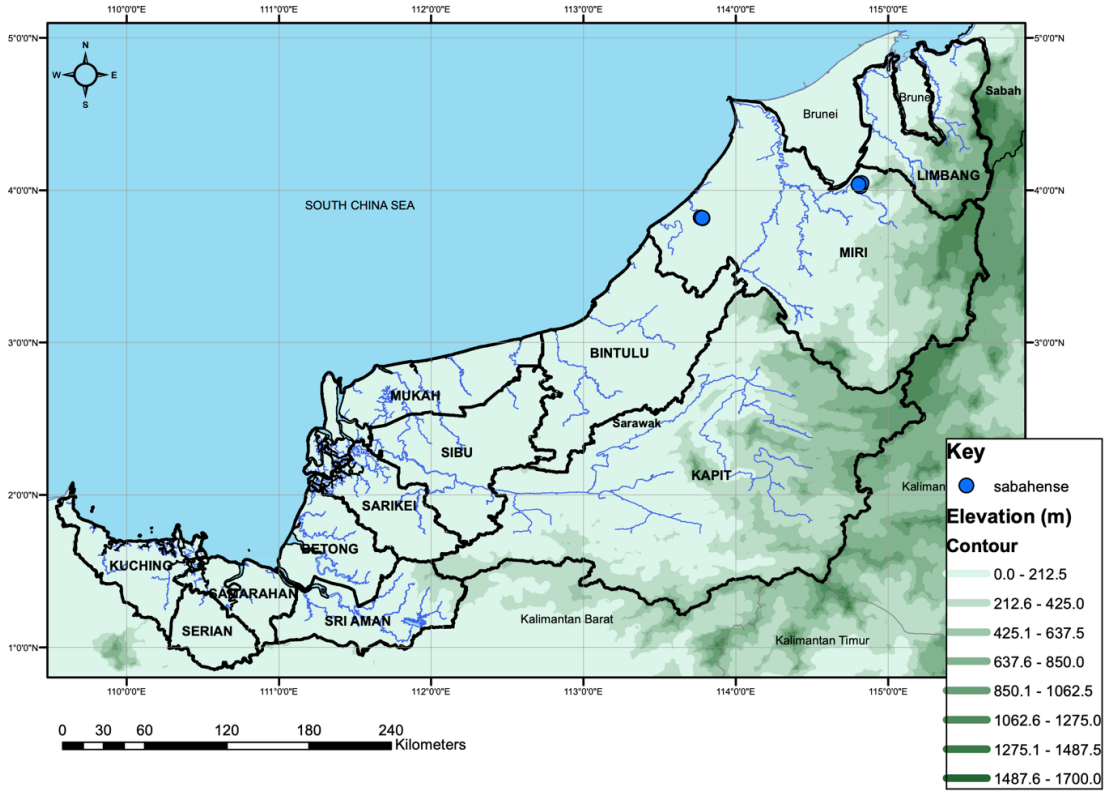


Figure 4.91: Distribution map of *H. sabahense* in Sarawak.

4.5.45 *Heptapleurum semengohense* N. Ramnor & A. Puad, sp. nov. (Figure 4.92)

Type material: Kuching: Engkabang Plantation, Semengoh, 24 Jun 1976, *Banyeng ak Ludong, S. 37628* (holotype: SAR!; isotypes: L, K).

Epiphyte on the tree trunk. ***Leaves*** 5-foliolate. Entirely glabrous. Stipule 3.2 cm long. Petiole 16-31 cm long × 0.34-0.46 cm in diam, angular. Petiolules length vary 2.6-6 cm long × 0.12-0.18 cm diam. Blade thin, entire, elliptic, 21.1-28.2 cm long × 5.8-9.2 cm wide. Apex broadly acuminate passing to slender caudate, 3.5-4.4 cm long. Base concave. Second-order venation 8-12 pairs, eucamptodromous, yellowish on under surface, spreading then ascending toward margin. ***Inflorescences*** terminal. Limitation zone 5.2 cm long and

branching zone 4 cm long, marked by few lanceolate bracts at the base of lateral branches with 2-2.8 cm long. Branches about 5, moderately hairy, 25.5 cm long × 0.10 cm diam. Umbellules c. 25 per branch and racemosely arranged along most of the branch length. Peduncles 0.5-1.5 cm long and pedicels 1-2 mm long. ***Flower*** very small with buds 1 mm long × 0.6 mm diam. Whitish when flowering. Cupule below the middle of buds. Ovary half inferior. Petal oblong, thin. Stamen 5, length 3-4 mm long. Disk glaucous, convex with stigmata on top. ***Fruits*** not seen.

Distribution: Southern Sarawak (Figure 4.93)

Conservation status: *Heptapleurum semengohense* is assessed as Data Deficient (DD).

Habitat: In the plantation area of Engkabang (*Shorea macrophylla*).

Notes: The plant differs from *H. mangiferifolium* by having longer leaf apex and longer inflorescence branches. For now, there is only one specimen recorded for this taxon.

Derivation of name: The taxa is named after the locality of the specimen, Semengoh Forest Reserve.

Specimen listing: KUCHING. Engkabang Plantation, Semengoh, 24 Jun 1976, *Banyeng ak Ludong, S. 37628* (SAR, L, K).



Figure 4.92: *Heptapleurum semengohense* N. Ramnor & A. Puad, sp. nov. (S. 37628).

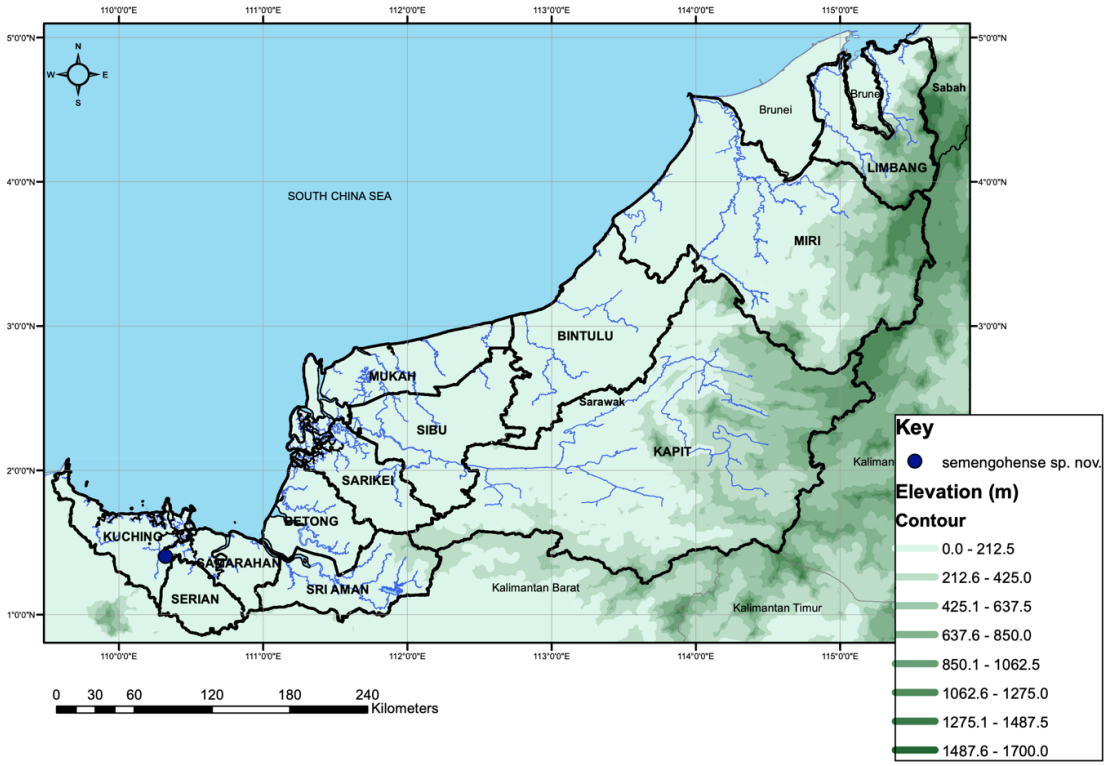


Figure 4.93: Distribution map of *H. semengohense* sp. nov. in Sarawak.

4.5.46 *Heptapleurum subisense* N. Ramnor & A. Puad, sp. nov. (Figure 4.94)

Type material: Miri: Mt. Subis, exposed limestone rocks, 20 Aug 2002, *Kit Pearce et al., S. 89412* (holotype: SAR!).

A climber. ***Leaves*** 7-foliolate. Petioles slender, glabrous, 24.3 cm long × 0.3-0.4 cm diam. Petiolules 1.2-3 cm long × 0.15 cm diam. Blades narrowly oblong-elliptic, glabrous, 19 cm or more long × 3.3-5.3 cm wide, both adaxial and abaxial surfaces dull. Adaxial surface dark green, abaxial light green. Apex broadly acute-acuminate, margin entire and base convex. Second-order venation 11 pairs on each side, curving, prominent and distantly spaced. Reticulations distinct. ***Inflorescences*** terminal, paniculate. Limitation zone 3 cm long and branching zone 8 cm long. Each branch marked by caudate bracts. Lateral branches 11, slender, congested along branching zone, 27.3 cm long × 0.25-0.30 cm diam. Umbellules c. 11 per branch and scattered along half of the branch, distant between each umbel getting closer towards apex. Peduncle bracts persistent, up to 0.4 cm long. Peduncles 3.1-4.1 cm long × 0.10 cm diam. Pedicels 5-7 mm long. ***Flower*** buds 8-11 per umbel, slightly obovoid, 5 mm long × 2 mm diam., glabrous. Cupule campanulate with length more than half of buds with calyx rim-like on top. Petals 4-5, almost 2 mm long. Stamen 4-5. Disk flat with stylar column 0.5-2 mm long. ***Fruits*** not seen.

Distribution: Northern Sarawak (Figure 4.95)

Conservation status: *Heptapleurum subisense* is assessed as Data Deficient (DD).

Habitat: Open summit of the limestone.

Notes: The taxon differs from *H. filipes* (Merr.) Lowry & G. M. Plunkett, also found in Borneo, by having less prominent venation and branches closely arranged along the branching zone. There is only one specimen recorded for this taxon.

Derivation of name: The taxa is named after the place of collection, Mount Subis at Niah National Park, Miri.

Specimen listing: MIRI. Subis. Mt. Subis, 20 Aug 2002, *Kit Pearce et al., S. 89412* (SAR).



Figure 4.94: *Heptapleurum subisense* N. Ramnor & A. Puad, sp. nov. (S. 89412).

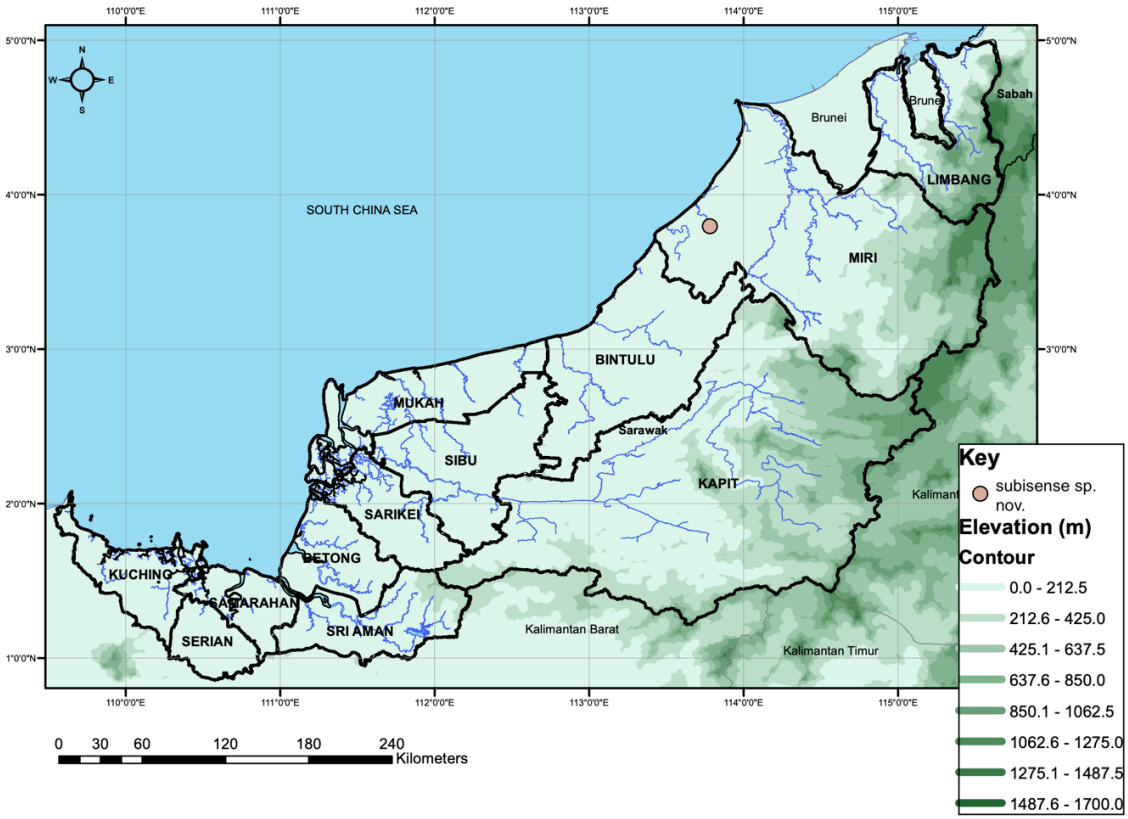


Figure 4.95: Distribution map of *H. subisense* sp. nov. in Sarawak.

4.5.47 *Heptapleurum tetrandrum* (Merr.) G. M. Plunkett & Lowry (Figure 4.96)

Novon 28 (3): 167 (Lowry & Plunkett, 2020).

Basionym: *Schefflera tetrandra* Merr. *Philippine Journal of Science, Section C, Botany* 13: 102 (Merrill, 1918a).

Type material: Sarawak, near Sandakan, *Native Collector 183, 184, 185, 426, 799, 801, 505, 1763, 2707* (holotype: PNH).

Commonly seen as epiphyte, sometimes scandent, climber or small tree. ***Leaves*** 3-8 foliolate. Stipule 3-7 mm long. Petioles slender, 4.5-15.7 cm long × 0.10-0.18 cm diam.

Petiolules 0.7-3.3 cm long × 0.08-0.13 cm diam. Blades glabrous, narrowly oblanceolate to elliptic to slightly obovate, 5.6-17.7 cm long × 1.9-5.1 cm wide. Apex caudate extending from 0.4-2.9 cm long. Base cuneate. Margin entire. Second-order venation 6-15 pairs on each side of midrib, either first or second vein from base extending all the way towards apex while the rest of the veins ascending towards margin, brochidodromous, weakly visible. ***Inflorescences*** terminal, limitation zone c. 1-2 cm long, marked by few, congested bracts, broadly lanceolate, acute, incurved and about 0.8-2 cm long. Branching zone 0-0.5 cm long. Branches 3-7(-10), very slender, covered with hairs, 9-55 cm long × 0.14-0.2 cm diam. Umbellules numerous and racemosely arranged along the branches. Peduncles sparsely pubescent, up to 1.2 cm long, subtended by inconstant acute, hairy, oblong to lanceolate, 0.5-3 mm long bracts. Pedicels hairy, 0.5-3 mm long. Peduncles and pedicels purplish. ***Flowers*** 6-11 per umbel. Bud ovoid to globose, 2 mm long × 1 mm diam. Cupule funnel-shaped, green, about 1 mm long or less, usually below the middle of the buds. Calyx-rim slight spreading and minutely toothed. Corolla connate and at first pale green to purplish green. Stamen 1 mm long and yellow. Disk flat and glaucous. Stylar column at the centre raised. ***Fruits*** glabrescent to glabrous, narrowly ellipsoid to obovoid, 2-5 mm long × 1.2-2 mm diam. Cupule cupuliform, Ovary ¾ to 4/5 inferior. Disk slightly sloping, somehow glaucous. Stylar column 0.5 mm long with 3-4 stigmata on top.

Distribution: Borneo. In Sarawak, the plant is recorded in Kuching, Samarahan, Serian, Sri Aman, Sarikei, Sibu and Kapit. (Figure 4.97)

Conservation status: This taxon is known from 33 specimens found in 20 locations (AOO = 92 km^2) from Kuching, Samarahan, Serian, Sri Aman, Betong, Sarikei, Mukah and Kapit divisions. It is assessed as Endangered.

Habitat: The species is recorded at various habitat such as in lowland dipterocarp forest, peat swamp, sandstone by sea, heath forest, on limestone, hill, ridge and submontane vegetation. Altitudinal ranges near sea level up to 961 m above sea level.

Notes: *Heptapleurum tetrandrum* shares most of the characteristics with *H. lasiocalyx.* However, there are some characters that differentiate these two species. For example, *H. tetrandrum* has smaller leaves. The flower buds of *H. tetrandrum* are glabresent to glabrous in which totally different to the buds of *H. lasiocalyx* that are covered in dense brown hairs. For the locality, most of the collection was done at Southern part of Sarawak. Only one specimen, S. 28625 was collected on Bukit Tibang in Kapit. The hill is located quite far from the Southern area in which it almost overlapped with the locality of *H. lasiocalyx* that commonly distributed on the Northern side of Sarawak.

Specimen listing: KUCHING. Kuching, 6 May 1893, *Haviland, Hav. 2454/1960* (SAR, SING); Kuching, Dec 1906, *Hewitt, Series 589* (SAR); Mt Matang, 762 m, *J. & M. S. Clemens, No. 20990* (SAR); Mt Matang, 610 m, *J. & M. S. Clemens, No. 22327* (SAR); Bako National Park (rocky coast), 30 Jan 1959, *Corner-Brunig, S. 10473* (K); Semengoh Forest Reserve, 91 m, 4 May 1961, *Ghazalli, S. 13682* (K); Telok Asam, Bako National Park, 3 Jun 1963, *P. S. Ashton, S. 17861* (K, L); Mt Matang, 800 m, 31 Jul 1963, *Paul Chai, S. 18533* (K, L, SING, SAN, A, BO); Bako National Park (beach forest), 18 Jul 1966, *Ding*

Hou, No. 553; Mt Matang, 701 m, 8 Jul 1976, *Sil. Laijanai, S. 37028* (USA, L, K); Lintang road (trail), Bako National Park, 14 Jul 1978, *Rena George, S. 38974* (CGE, L, K); Trail to Sg. Senduk, Matang Wildlife Centre, 80 m, 21 Jun 2003, *Yahud et al., S. 92665* (KEP); Ulu Serait, Bako National Park, 169 m, 26 Jul 2011, *Yahud, Shirley et al., S. 102321* (SAR, KEP, SAN); Summit Trail, Kubah NP, 477 m, 2 Mar 2015, *Aishah et al., KNPS 16*; 601 m, 2 Mar 2015, *Aishah et al., KNPS 12*; 628 m, 2 Mar 2015, *Aishah et al., KNPS 10*; 702 m, 2 Mar 2015, *Aishah et al., KNPS 4*; 783 m, 2 Mar 2015, *Aishah et al., KNPS 2*. **Bau.** Mt. Lanyang, 11 Apr 2002, *Connie G. et al., SBC 2850* (SBC). **Lundu.** Sg. Snibong, 16 Aug 1958, *J. A. R. Anderson, S. 9144* (L, K); Mt. Gading, 853 m, 5 Aug 1962, *B. L. Burtt & P. J. B. Woods, B. 2680*; Sg Sebuloh, 1 Oct 1985, *Hj. Othman Ismawi et al., S. 49905* (KEP); Lundu-Sematan road (near junction), 60 m, 22 Mar 2002*, Jong L.K., S. 85921* (SAR). **SAMARAHAN. Simunjan.** Bkt. Gaharu, 610 m, 2 Aug 1962, *B. L. Burtt, B. 2664*; Mt. Buri (ridge above third camp to Mt. Apong), 620 m, 22 Sep 1975, *P. J. Martin & O. Ismawi, S. 36936* (CGE, L, K, KEP, MO); Sabal Forest Reserve (Mile 78, Kuching-Sri Aman Road), 180 m, 16 Sep 1994, *Yii Puan Ching et al., S. 64535* (KEP, K, L); Summit of Klinkang (Kelinkang) Range, 730 m, 28 Jun 2000, *L. C. J. Julaihi et al., S. 83416*; Klinkang (Kelinkang) Range, 500 m, 22 Jun 2000, *L. C. J. Julaihi et al., S. 83519* (SAR, KEP, SAN). **SERIAN.** Bkt. Rawan, Tebakang, 730 m, 5 Apr 1983, *Dayang Awa & Ilias Paie, S. 45560* (K, L). **SRI AMAN.** Sg. Tissak (Tisak), Triso, 22 Nov 1955, *J. A. R. Anderson, S. 3187* (SAR); Path to Mt. Silantek, Ulu Sg. Silantek Kiri, 300 m, 26 Aug 1980, *Ilias Paie, S. 42578* (CGE, L, K, SAN). **SARIKEI.** Surong Irit, Binatang (Bintangor), 30 Apr 1958, *Sanusi bin Tahir, J. A. R. Anderson, S. 5211* (L, K, S, B). **SIBU. Kanowit.** Sg. Ensirieng (behind camp, trail from Sg. Jepiu to Bkt. Entimau, Ulu Mujok, Lanjak Entimau Wildlife Sanctuary, 260 m, 10 May 1998, *Kit Pearce & Julaihi, S. 78162* (KEP, K). **KAPIT. Song.** Munggu Gerugang, Ulu

Engkari, Lanjak Entimau Wildlife Sanctuary, Enjah & Patsipun, S. 77984 (SAR). **Bukit Mabong.** Bkt. Tibang (extreme headwaters of Balleh river), 3500 ft., 11 Jul 1969, *J. A. R. Anderson & Ilias bin Paie, S. 28625* (CGE).



Figure 4.96: *Heptapleurum tetrandrum* (Merr.) G. M. Plunkett & Lowry (S. 42578).

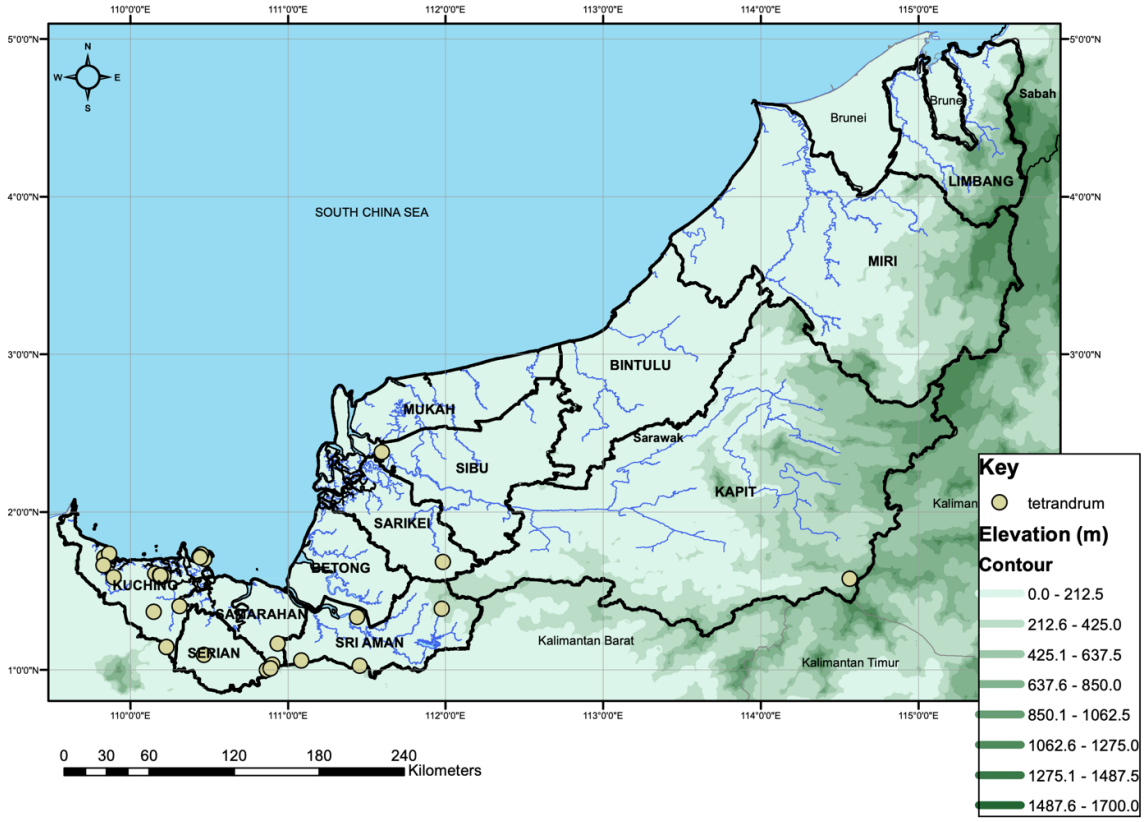


Figure 4.97: Distribution map of *H. tetrandrum* in Sarawak.

4.5.48 *Heptapleurum trineurum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (Figure 4.98)

Novon 28 (3): 167 (Lowry & Plunkett, 2020).

Basionym: *Schefflera trineura* Frodin & Puad, *The Genus Schefflera in Sabah, Malaysian Borneo* 195 (Ahmad Puad et al., 2018).

Type material: Mt Trus Madi, SE of Kaingaran, 4200 ft. [1252 m], *Wood & Wyatt-Smith, SAN-A 4372* (holotype: SING; isotypes: A, BRI, L).

Epiphyte, climber, straggling shrub or creepers on sandstone. ***Leaves*** 6-foliolate or less. Entirely glabrous. Stipule 0.2-0.6 cm long, obtuse to truncate, partially fused. Petioles 0.8-5.1 cm long × 0.5-1.5 mm diam., stout. Petiolules 0.1-1.4 cm long × 0.03-0.10 cm diam. Blades narrowly lanceolate to ovate to oval, 2.5-9.6 cm long × 0.7-2.5 cm wide, thick, coriaceous, both adaxial and abaxial surfaces dull. Apex broadly caudate-acuminate with length 0.8-2.3 cm long. Margin mostly entire or sometimes with a pair of teeth close to apex. Base acute to convex. Second-order venation c. 5 pairs, mostly not visible except the prominent trinerved veins at the base. Reticulations not visible. ***Inflorescences*** terminal. Limitation zone 0.5-13 cm long and marked by bract scars. Branching zone obscure. Branches 2-3, very slender, entirely glabrous, 6-9.5 cm long × 0.5-1.5 mm diam. Terminal umbels 3-5. Peduncles 1.7-4.2 cm long, slender. Pedicels 0.5-2.2 cm long, slender. Peduncles and pedicels green. ***Flowers*** 2-5 per umbel. Buds globose, glabrous, green, dimension 1-2.5 mm long × 0.8-1.8 mm diam. Cupule 0.5-1.5 mm long, funnel-shaped. Calyx-rim 5-toothed, projecting. Petals 5, yellowish, acuminate, 1-1.2 mm long. Stamen yellow. Disk initially flat, later sloping, resulting in decreasing length of stylar column. ***Fruits*** initially green turning yellow, angular, glabrous, dimension 2-5 mm long × 1.3-4.2 mm diam. Ovary ½ to 4/5 inferior. Disk convex with 5 sessile free stigmata.

Distribution: Borneo. In Sarawak, the plant is recorded in Kapit, Miri and Limbang divisions. (Figure 4.99)

Conservation status: This taxon is known from 27 specimens found in 8 locations (AOO = 80 km^2) from Kapit, Miri and Limbang divisions. It is assessed as Endangered.

Habitat: On hillside, ridgetop, submontane mossy forest up to open summit area with elevation ranges of 1100-2200 m above sea level.

Notes: This plant is generally small that can be easily identified by its trinerved venation at the base of leaf that extending up to the apex and narrowly lanceolate, ovate and oval leaflets. Both inflorescence branches and peduncles are very slender with length up to 9.5 cm and 2.2 cm respectively. The plant can only be found on hill or mountain with elevation over 1000 m above sea level. There are three different local names. In Iban, the species is called 'Kuku Bajang' while Kelabit people called it 'Takang/Tekang Payah'. For Penan people, it is known as 'Lakar'.

Specimen listing: KAPIT. Belaga. Bkt. Dema, 1320 m, 28 Aug 1978, *Bernard Lee, S. 39307* (CGE, L, K, KEP); Hill next to Bkt. Robertson (ridge top), 1200 m, 7 Aug 1999, *Julaihi et al., S. 80652* (KEP, K, L, SAN, MO); Bkt. Robertson (summit), 1900 m, 10 Aug 1999, *Julaihi Lai et al., S. 81076* (KEP, K, L, SAN, MO). **Bukit Mabong.** South-East end Hose Mountains (hill west of Ulu Melinau falls), 19 Aug 1967, *B. L. Burtt & A. M. Martin, B. 4970* (E); Bkt. Sampandai (Sanpandai), 1600 m, 11 Apr 1980, *Ilias Paie, S. 40898* (CGE, L, K, SAN, KEP, MEL). **MIRI. Bario.** Path from Long Rebala to Ba' Kelalan, Mt. Murud, 1676 m, 16 Oct 1965, *Ilias Paie, S. 26557* (K, L, CGE); Mt. Murud (east), 1800 m, 5 Apr 1970, *H. P. Nooteboom & Paul Chai, Nooteboom 1958* (SAR); Apo Dari (summit), Kelabit Highland, 1550 m, 17 Nov 1974, *Paul Chai, S. 35935* (L, K, MO, A, CGE); Proposed Gunung Murud National Park (between first and second summit), 2200 m, 13 Sep 1982, *Yii Puan Ching, S. 44619* (CGE, L, K); Batu Lawi (top of ridge), 1540 m, 6 Aug 1985, *Dayang Awa & Bernard Lee, S. 50666* (CGE, K, L, KEP); Pa Litan, Apad Runan, Kelabit Highland,

1580 m, 6 May 1988, *Yii Puan Ching, S. 55985* (CGE, K, L, KEP, SAN); Batu Buli, 1900 m, 29 Sep 1996, *Julaihi, Yahud, et al., S. 73151* (K, KEP, CGE); Pa Menalio (on ridge north), 1190 m, 3 May 2005, *Kit Pearce et al., S. 93493* (SAR, KEP, K, L); Tama Abu Range, 1800 m, 6 May 2005, *Kit Pearce et al., S. 94912* (SAR, KEP). **Mulu.** Camp 4, Mt Mulu, 1800 m, 27 Jan 1978, I. Nielsen, 442 (AAU); Mt Mulu, 1600 m, 8 May 1978, *G. Argent & B. Coppins, No. 1199* (SAR); Bkt Pelamau, 1100 m, 16 Apr 1997, *Haegens et al., 393* (L, SAR); Camp 4, Mt Mulu, 10 May 2015, 1710 m, *Aishah & Fatiha, SNA 126*; 1719 m, 10 May 2015, *Aishah & Fatiha, SNA 128*; 1772 m, 10 May 2015, *Aishah & Fatiha, SNA 104*; 1792 m, 10 May 2015, *Aishah & Fatiha, SNA 113*; 1807 m, 8 May 2015, *Aishah et al., SNA 83*; 1813 m, 10 May 2015, *Aishah et al., SNA 86*; 1821 m, 8 May 2015, *Aishah et al., SNA 77*; 1827 m, 8 May 2015, *Aishah et al., SNA 76*. **LIMBANG. Lawas.** Bkt. Pagon Kecil (summit), 1330 m, 9 Aug 1984, *Dayang Awa & Bernard Lee, S. 47740* (K, L, CGE); Bkt Tebunan, Ulu Trusan, 1450 m, 9 May 1986, *Bernard Lee, S. 52492* (CGE, K, L).



Figure 4.98: *Heptapleurum trineurum* (Frodin & Puad) Puad, T. J. Barkman, G. M. Plunkett & Lowry (S. 47740).

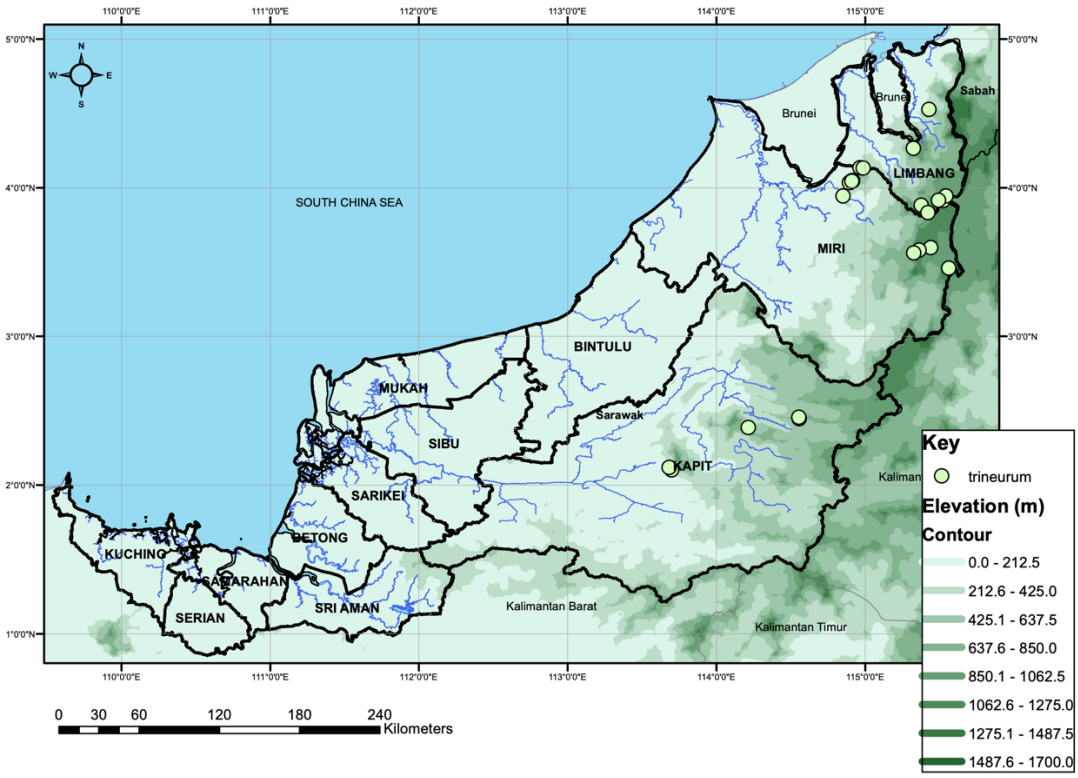


Figure 4.99: Distribution map of *H. trineurum* in Sarawak.

4.5.49 *Heptapleurum truncatum* N. Ramnor & A. Puad, sp. nov. (Figure 4.110)

Type material: Sibu: Paloh Protected Forest, source of the river, 17 Jul 1971, *Paul Chai et al., S. 26749* (holotype: SAR!; isotypes: K, L, SING, SAN, A).

Epiphyte or treelet. ***Leaves*** 4-6 foliolate. Stipular ligule persistent with free portion length 2.2-4.5 cm long. Petiole 10.5-29.8 cm long × 0.32-0.4 cm diam. Petiolules vary in length, 0.6-6.7 cm long × 0.2-0.25 cm diam. Blades broad, elliptic, obovate, oval or ovate, mostly blades have unequal sides, thick or thinly coriaceous, 9-23.5 cm long × 3.2-12.8 (-17.8) cm wide. Apex acute-acuminate to acuminate, 0.5-1.8 cm long. Base obtuse. Margin entire. Second-order venation numerous, almost parallel and closely spaced. ***Inflorescences***

terminal. Limitation zone 1.5-3.5 cm long and branching zone 0.5-5.5 cm long. Bracts at the branch base 1-3.2 cm long. Branches 2-4, 3.5-22.5 cm long × 3-9 mm diam. Umbellules c. 4-9 per branch, arranged in clusters. Each cluster is widely spaced. Terminal cluster usually has more umbels than subsidiary cluster. Peduncle 1-4.7 cm long × 0.15-0.3 cm diam., hairy, each subtended by 0.7-1.5 cm long bracts. Pedicels 2-5 mm long. ***Flower*** buds c. 35 per umbel, ellipsoid to globose-ellipsoid, 3-5 mm long × 2.5-4 mm. Cupule obconic with length 1-3 mm long, covered with hairs. Petals 6-9 with length 3-4 mm long. ***Fruits*** semi globose to ellipsoid with length of 4-10 mm long × 2.5-6.5 mm diam., glabrous and entirely inferior. Apex truncate with stylar column extended up to 2-4 mm long. Stigmata 7-8.

Distribution: Throughout Sarawak (Figure 4.101)

Conservation status: This taxon is known from 18 specimens found in 16 locations (AOO = 68 km^2) from Kuching, Sri Aman, Mukah, Kapit and Miri divisions. It is assessed as Endangered.

Habitat: Limestone, near riverbank, remnant forest, on hill and peat swamp forest at elevation from 10 m up to 1219 m above sea level.

Notes: The taxon differs from *H. politum* (Miq.) Seem., also found in Borneo by having more number of stigmata, more prominent stylar column and fruit remaining entirely inferior. The local Iban name for this species is ‘Kayu Ala’ while Bidayuh local called it ‘Gemerap’.

Derivation of name: The name is derived from a Latin word *truncatus* meaning "to shorten" or "to cut off". The name is referring to the truncate apex of fruits.

Specimen listing: KUCHING. Bkt Pait, Padawan, 152 m, 2 Mar 1969, *Erwin & Paul, S. 27431* (CGE, L, K). **Bau.** Bau (rocky limestone), 30 m, 15 Sep 1995, J. *W. Purseglove, P. 4438* (SAR, CGE); Seburan (Siburan), 4 Sep 1960, *J. A. R. Anderson, S. 29380* (SAR); Mt Payung, 23 Oct 2001*, Malcom et al., SBC 853* (SBC). **SRI AMAN.** Sg Tabut to Mujan, 10 Mar 1986, *Ilias Paie et al., S. 51987* (SAR). **Lubok Antu.** Sg Talangon, Ulu Sg Lubang Baya, Batang Ai NP, 200 m, 16 Mar, 2000, *Rantai Jawa et al., S. 84180* (KEP). **SIBU.** Sg Matalau, Lassa, 28 Jan 1967, *J. A. R. Anderson, S. 25552* (K, L). **TANJUNG MANIS.** Paloh Protected Forest, 17 Jul 1971, *Paul Chai et al., S. 26749* (SAR, K, L, SING, SAN, A). **KAPIT.** Gat, Upper Rejang river, 1929, *J. & M. S. Clemens, 21867* (SAR); Sg Bah (near Punan Bah), 21 Sep 1973, *S. Tong & Jugah, S. 33263* (CGE, L, K, MO); Sg Bena, Sut, 26 Apr 1980, *Ilias Paie, S. 41712* (CGE, L, K). **MIRI. Mulu.** Mt Api, 1219 m, 12 Jul 1961, *J. A. R. Anderson, S. 4730* (SAR); Mt Api, Pinnacles Camp, Mulu NP, 1200 m, 17 Apr 1978, *G. Argent & C. Jermy, Argent 1049* (SAR). **Bario.** Kuala Sg Buong, Pulong Tau NP (West), 14 May 2007, *Julia et al., S. 98294* (SAR).



Figure 4.100: *Heptapleurum truncatum* N. Ramnor & A. Puad, sp. nov. (S. 26749).

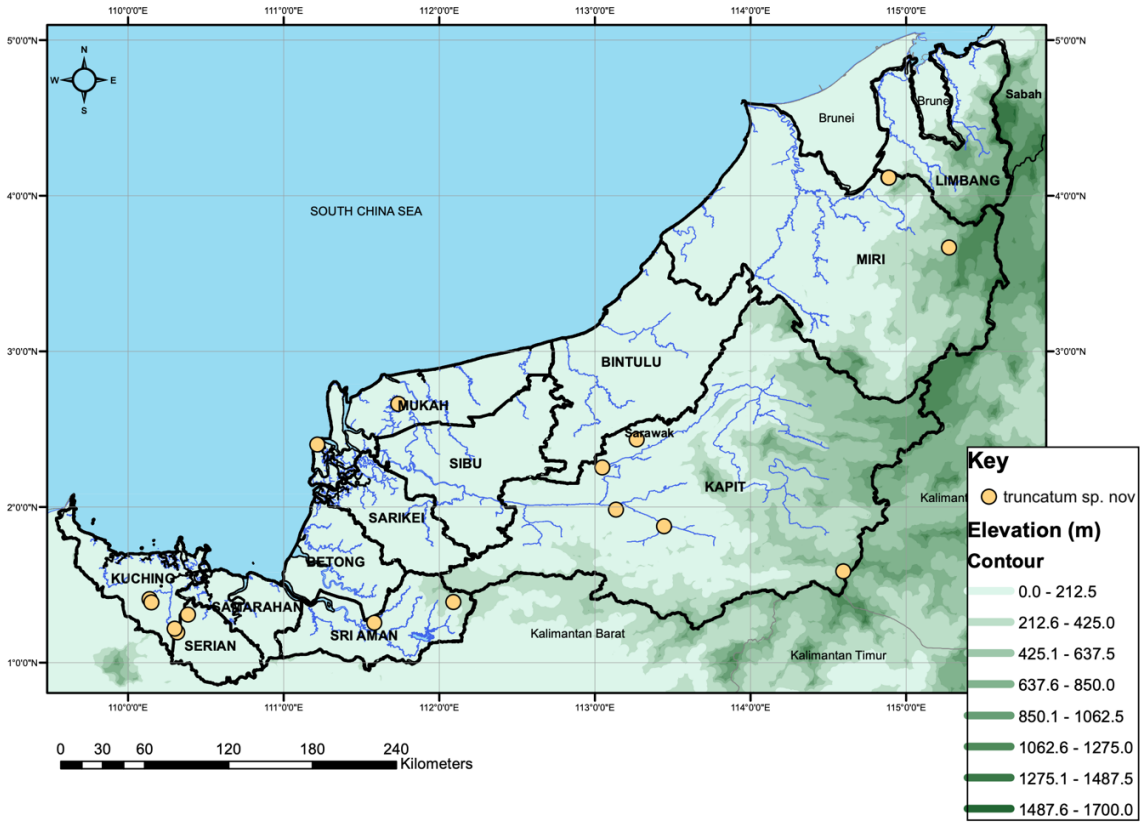


Figure 4.101: Distribution map of *H. truncatum* sp. nov. in Sarawak.

4.5.50 *Heptapleurum verticillatum* N. Ramnor & A. Puad, sp. nov. (Figure 4.102)

Type material: Kapit: Bkt Tibang, primary forest on ridge, 1068 m, 9 Jul 1969, *J. A. R. Anderson & Ilias Bin Paie, S. 28607* (holotype: SAR!; isotype: CGE).

Epiphyte or treelet up to 1.8 m tall. ***Leaves*** 6-9 foliolate. Stipule persistent, acute to obtuse, length 1.5-2.5 (-5.2) cm long. Petiole 13-18 (-27) cm long × 0.20-0.48 cm diam. Petiolules 2.5-4.2 (-7.5) cm long × 0.09-0.20 cm diam. Blades long or short oblong to lanceolate, thinly coriaceous, glossy upper surface, 6.3-25 cm long × 3-10.5 cm wide. Apex abruptly acuminate with length of 0.6-1.8 cm long. Margin weakly toothed or rarely entire. Base rounded. Second-order venation 13-22 pairs on each side, weakly visible on blade surfaces, camptodromous, gradually curving towards margin. Reticulations weak. ***Inflorescences*** terminal. Limitation zone 1.5-8 cm long. Branching zone 3.2-8.5 cm long. Branches 5-13, slender, glabrescent, 10.5-25.5 cm long × 0.15-0.28 cm diam. Umbellules 12-18 per branch, arranged either in pairs or whorl, along ¾ of branch, not congested along the branches. Peduncles 1-2.5 cm long × 0.05-0.15 cm diam. Pedicels 2-6 mm long × 0.5 mm diam. ***Flower*** buds 12-15 per umbel, ovoid, 2-4 mm long × 1-2.5 mm diam, glabrous. Ovary inferior. Cupule funnelform with calyx rim-like on top. Petals c. 5, thick, 2 mm long. Disk flat. ***Fruits*** glabrous, globose mostly, sometimes ellipsoid, 4-5 mm long × 3.2-3.7 mm diam., deeply sulcate. Ovary 3/5 inferior. Stigmata sessile on stylar mound, 7-8, arranged in a ring.

Distribution: Southern to Central Sarawak (Figure 4.103)

Conservation status: This taxon is known from 16 specimens found in nine locations (AOO = 52 km^2) from Sri Aman, Kapit and Miri divisions. It is assessed as Endangered.

Habitat: The species can be found in mixed dipterocarp, hill dipterocarp, on ridges, in submontane and up to the mountain or hill summit. Altitudinal ranges recorded from 380 m up to 1600 m above sea level.

Notes: The plant differs from *H. littorale,* recorded in Borneo and Sumatera by having lesser leaflets, oblong to lanceolate blades, lesser flowers per umbel and smaller flowers. One of the plants reported growing epiphytic on the *Calophyllum* tree.

Derivation of name: The name is originated from a Latin word *verticillus,* meaning "whorl". The name is referring to the circular or whorl arrangement of umbellules along the inflorescence branches.

Specimen listing: SRI AMAN. Lubok Antu. Bkt Lanjak, 1350 m, 6 Mar 1994, *Yii Puan Ching et al., S. 67520* (KEP, K) 1260 m, 2 Sep 1998, *Julaihi et al., S. 77546* (KEP). **KAPIT. Belaga.** Sg Berangan off Sg Balui, 510 m, 17 Aug 1995, *A. Zainudin, No. 5603* (UKMB). **Bukit Mabong.** Base of Bkt Kajang, Hose Mountains, 1300 m, 24 Mar 1964, *Banying ak Nyudong, S. 17213* (K, L); Bkt Tibang, 1068 m, 9 Jul 1969, *J. A. R. Anderson & Ilias Bin Paie, S. 28607* (SAR, CGE); Bkt Pendam, Menyiong, 1300 m, 22 Nov 1979, *Othman Ismawi, S. 41548* (CGE, L, K, KEP); Ulu Sg Buong, 740 m, 6 Mar 1992, *Runi et al., S. 63644* (KEP, CGE, K, L); Hose Mountains, 1600 m, 1 Dec 1991, *Lai et al., S. 63966* (KEP). **MIRI. Telang Usan.** Sg Palutan, 380 m, 3 Apr 2003, *Julia Sang et al., S. 90973* (SAR).

Mulu. Camp 4, Gunung Mulu NP, 1528 m, 10 May 2015, *Aishah & Fatiha, SNA 137*; 1719 m, 10 May 2015, *Aishah & Fatiha, SNA 123*; 1726 m, 10 May 2015, *Aishah & Fatiha, SNA 115*; 1726 m, 8 May 2015, *Aishah & Fatiha, SNA 66*; 1929 m, 8 May 2015, *Aishah & Fatiha, SNA 61*.



Figure 4.102: *Heptapleurum verticillatum* N. Ramnor & A. Puad, sp. nov. (S. 28607).

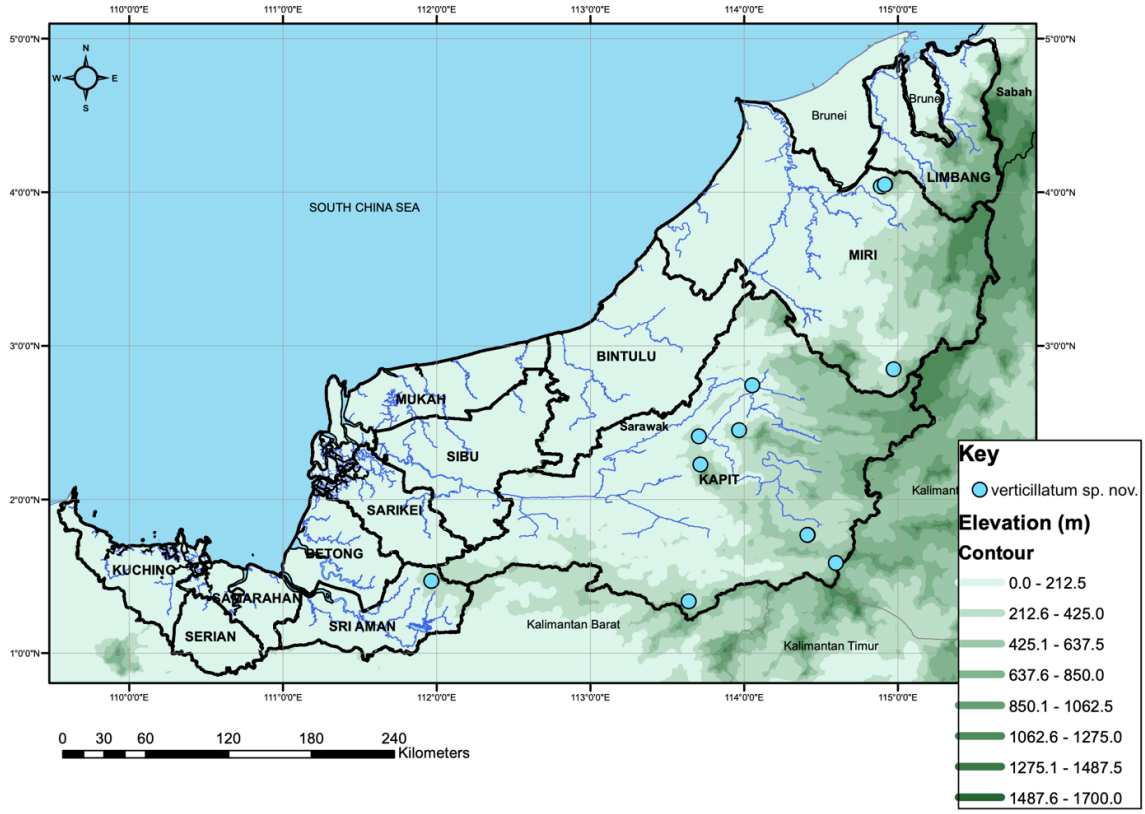


Figure 4.103: Distribution map of *H. verticillatum* sp. nov. in Sarawak.

4.5.51 *Heptapleurum yahudwatii* N. Ramnor & A. Puad, sp. nov. (Figure 4.104)

Type material: Miri: Sg. Kelapang, Ramudu, riverine forest, 895 m, 25 Mar 1991, *Yahud Hj. Wat et al., S. 76345* (holotype: SAR!; isotypes: KEP, CGE, K, L, SAN).

Epiphyte. ***Leaves*** 5-6 foliolate. Stipule 3 mm long, obtuse, partially fused. Petiole 14.3-17.4 cm long × 0.12-0.19 cm diam. Petiolules 3.4-5.6 cm long × 0.05 cm diam. Both petiole and petiolules slender. Blades narrowly elliptic to obovate, thin, dull on both surfaces, 10.8-12.4 cm long × 2.9-3.6 cm wide. Apex 0.9-1.0 cm long and broadly caudate-acuminate. Base cuneate. Margin entire. Second-order venation 6-7 pairs, camptodromous, visible on both

surfaces, spreading at first then strongly curved, terminating along the margin. Reticulation distinct. ***Inflorescences*** terminal. Limitation zone 0.2 cm long and branching zone 6.2 cm long. Branches widely scattered along the main axis, 8, 13.2-15.7 cm long × 0.08-0.10 cm diam. Umbellules 9-12 per branch, racemosely arranged, quite distant from one another. Peduncles 1-1.3 cm long. Pedicels 0.3-0.5 cm long. ***Flowers*** not seen. ***Fruits*** c. 8 per umbel. Thinly ellipsoid, glabrescent, 2-3.5 mm long × 1.3-1.6 mm diam. Cupule obconic. Ovary ½ inferior. Convex disk with separated 5 sessile stigmata arranged in a ring on top.

Distribution: Northern Sarawak (Figure 4.105)

Conservation status: *Heptapleurum yahudwatii* is assessed as Data Deficient (DD).

Habitat: Riverine situation at elevation of 835 m above sea level.

Notes: The taxon differs from *H. havilandii* by having longer and broader leaf apex and longer peduncles. There is only one specimen collected in Sarawak.

Derivation of name: The taxa is named after the main collector of the specimen, Mr. Yahud bin Haji Wat. He previously worked as a forest ranger in Forest Department Sarawak and contributed in fieldwork and plant identification. He has officially retired in 2019 (Forest Department Sarawak, 2019).

Specimen listing: MIRI. Bario. Sg. Kelapang, Ramudu, 895 m, 25 Mar 1991, *Yahud Hj. Wat et al., S. 76345* (SAR, KEP, CGE, K, L, SAN).

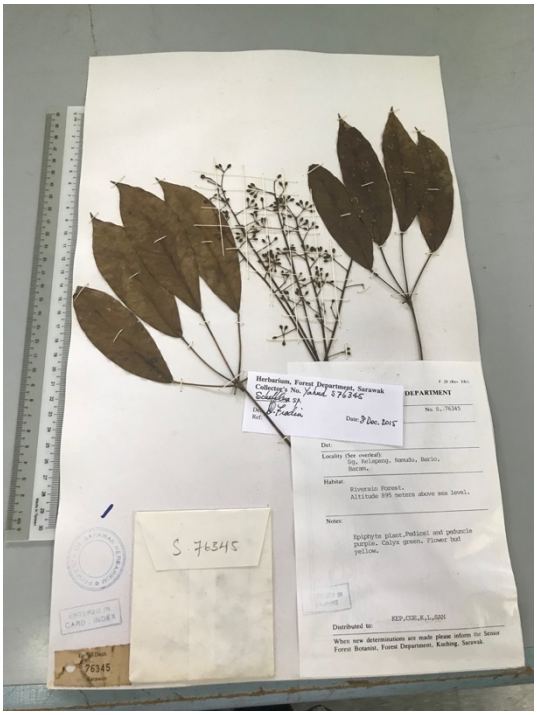


Figure 4.104: *Heptapleurum yahudwatii* N. Ramnor & A. Puad, sp. nov. (S. 76345).

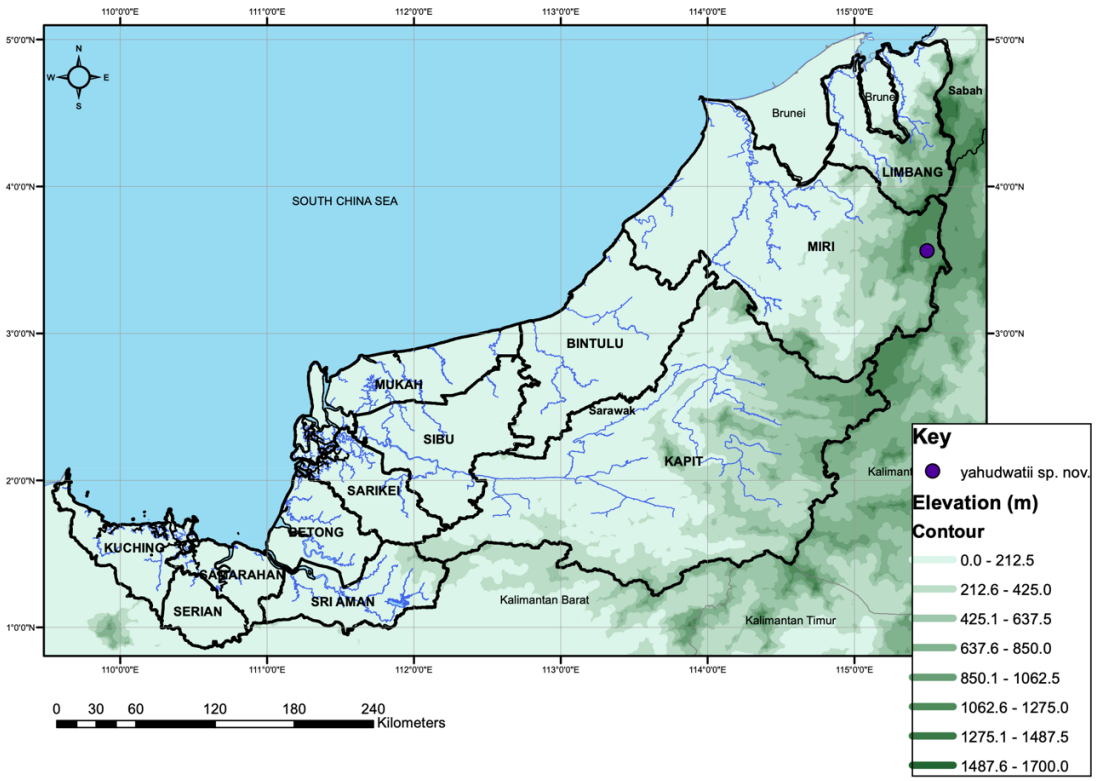


Figure 4.105: Distribution map of *H. yahudwatii* sp. nov. in Sarawak.

4.5.52 *Heptapleurum yiipuanchingae* N. Ramnor & A. Puad, sp. nov. (Figure 4.106)

Type material: Kuching: Bkt. Bidi, limestone hill, 40 m, 15 Nov 1985, *Yii et al., S. 50387* (holotype: SAR!; isotype: CGE).

Epiphyte at 2-3 m tall or small tree at 2.4 m tall. ***Leaves*** 5-9 foliolate. Petiole length 35.5-35.7 cm long × 0.35-0.58 cm diam., covered with lenticels. Petiolules 1.5-5.4 cm long × 0.14-0.22 cm diam. Blades thickly coriaceous, narrowly obovate to elliptic, 13.5-23.2 cm long × 3.7-7 cm wide. Apex abruptly caudate-acuminate with length 1-1.9 cm long. Base cuneate to convex. Margin entire. Second-order venation 5-7 pairs on each side, weakly visible on both surfaces, eucamptodromous, arcuate, widely spaced (2-4 cm), ascending. ***Inflorescences*** terminal with limitation zone c. 1 cm long and branching zone c. 1.5 cm long. Branches c. 6, 22-27.5 cm long × 0.20-0.26 cm diam. Umbellules numerous and scattered along branches. Peduncles 1-2 cm long × 0.08-0.10 cm diam. Pedicels 2-5 mm long. ***Flower*** buds c. 20 per umbel, slightly obovoid, 3 mm by 2 mm, hairy. Cupule campanulate with toothed calyx. ***Fruits*** globose, dimension 6-7 mm long × 4.2-4.6 mm diam., deeply sulcate due to drying. Almost inferior. Stylar column up to 2 mm long with separated stigmata 5-6 on top.

Distribution: Southern Sarawak (Figure 4.107)

Conservation status: *Heptapleurum yiipuanchingae* is assessed as Data Deficient (DD).

Habitat: Limestone hill at elevation from 40 m to 400 m above sea level.

Notes: The plant differs from *H. petiolosum,* also recorded in Borneo, by having entire margin, long and slender peduncles and less congested umbels along the inflorescence branch.

Derivation of name: The plant is named after one of the collectors, Yii Puan Ching. She is an active plant collectors for Forest Department Sarawak and has involved in the fieldwork of several studies (Chai, 1997; Ewel et al., 1983).

Specimen listing: KUCHING. Bkt. Braang, 400 m, 7 May 1975, *Paul et al., S. 37381* (CGE, L, K, MO, SAN). **Bau.** Bkt. Bidi, 40 m, 15 Nov 1985, *Yii et al., S. 50387* (SAR, CGE); S. 50389 (CGE).



Figure 4.106: *Heptapleurum yiipuanchingae* N. Ramnor & A. Puad, sp. nov. (S. 50387).

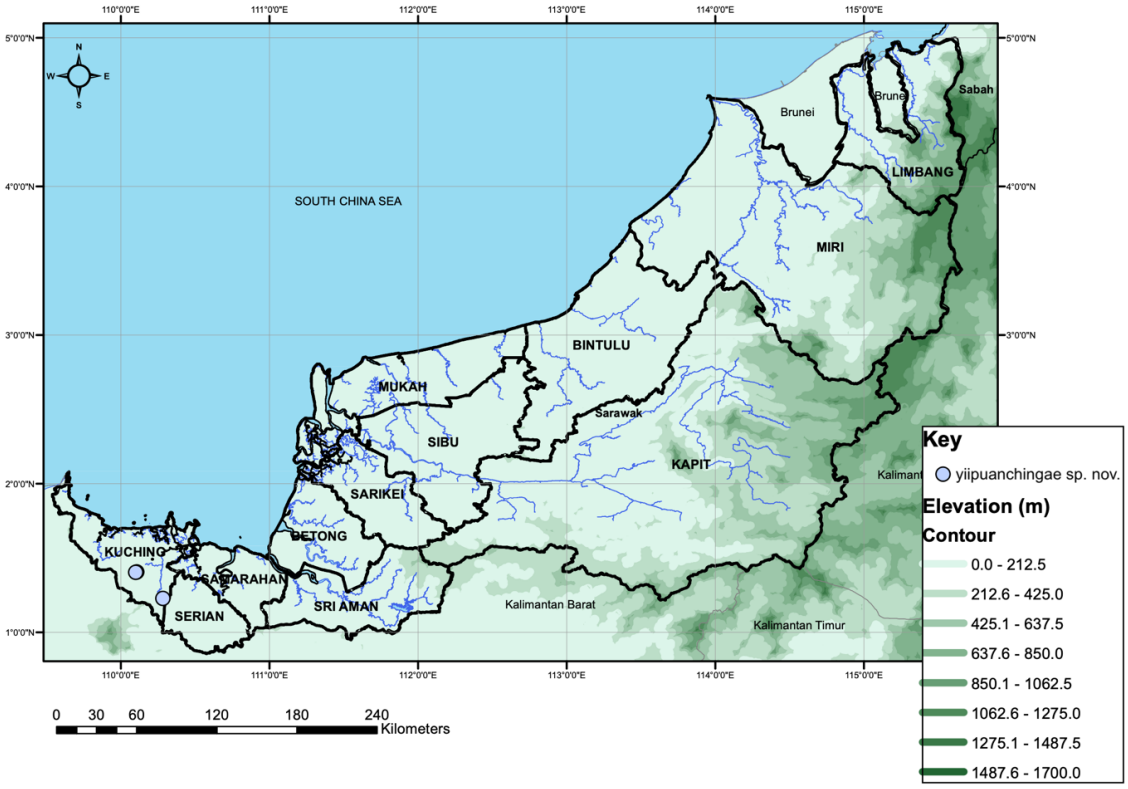


Figure 4.107: Distribution map of *H. yiipuanchingae* sp. nov. in Sarawak.

4.6 Imperfectly known taxa of *Heptapleurum* in Sarawak

Currently, there are 21 imperfectly known *Heptapleurum* taxa in Sarawak. About 12 of them are the *species affinis* of the existing species that possibly may be a new species but required more study and molecular work to solve the confusion of the specimens. The other nine taxa were lacking of important information on their specimens especially on the inflorescence part that is vital for the species identification and taxonomic key.

4.6.1 *Heptapleurum* aff. *avene* (Figure 4.108)

Epiphyte or climber. ***Leaves*** unifoliolate. Free portion of stipular ligule 1.3-3.3 cm long. Petiole 3-3.7 cm long × 0.15-0.16 cm diam. Petiolule 1-1.3 cm long × 0.16-0.2 cm diam. Blades thin, dull surfaces, broadly elliptic to ovate, 16.5-23.3 cm long × 5.1-9.8 cm wide. apex acuminate, 0.8-1.2 cm long. Margin partially entire. Base cuneate. Second-order venation eucamptodromous, 11-17 pairs, gradually ascending. Reticulations distinct, weakly visible. ***Inflorescences*** terminal. Limitation zone 1.2-1.5 cm long, marked with bracts 1.5-1.7 cm long. Branches 1-2, (1.5-) 2.7-6.5 cm long × 0.1-0.24 cm diam., glabrous. Umbellules 2-4 on each branch, arranged in pairs. Peduncles 0.5-2 cm long × 0.05-0.1 cm diam. Pedicels 1.5 mm long × 0.5 mm diam. Both peduncles and pedicels green. ***Flower*** buds 10-15 per umbel, green, globose to ovoid, 2-3 mm long × 1.5-2 mm diam., glabrous. Cupule funnel-shaped. Calyx-rim minutely many toothed and spreading. Petals 4-5, 1.5 mm long, lanceolate. ***Fruits*** ellipsoid with truncate disk. Stigmata 7 and sessile on top. Dimension 6 mm by 4 mm. Entirely inferior.

Notes: The specimens were recorded in mixed dipterocarp forest and near riverbank at elevation 210-250 m above sea level. In Iban, the local people called this ‘Kaba Putang’. This taxon might be related to *H. avene* as they share most of the morphological characteristics. However, this taxon is mainly unifoliolate while *H. avene* has 2-3 foliolate and rarely with unifoliolate leaf. Other than that, *H.* aff. *avene* has slightly toothed leaf margin, short and stout branches and less number of umbellules compared to *H. avene.* Molecular work is recommended to confirm these taxa.

Specimen listing: SIBU. Kanowit. East Base Camp, Ulu Sg. Ensirieng, 210 m, 12 May 1998, *Mohizah et al., S. 77526* (SAR). **BINTULU.** Lumut Range, 250 m, 19 Sep 1992, *Abg Mohtar & Yii Puan Ching, S. 65781* (KEP, K, CGE). **KAPIT.** Sg. Entemu, 21 Oct 1988, *Hj. Othman et al., S. 61716* (K, L, KEP).



Figure 4.108: *Heptapleurum* aff. avene (S. 65781).

4.6.2 *Heptapleurum* aff. *beamanii* (Figure 4.109)

A small shrub, epiphyte or climber. ***Leaves*** (1-) 3-5 (-6) foliolate. Stipule persistent, acute to obtuse with length (0.7-) 1.5-4.5 cm long. Petiole 3.2-11 cm long × 0.18-0.50 cm diam. Petiolules 0.5-3.5 cm long × 0.16-0.25 cm diam. Blades 6.3-18.5 cm long × 4-11.2 cm wide, oval to obovate, coriaceous, mostly thick, base obtuse to oblique. Adaxial surface glossy. Abaxial surface covered in pubescent. Apex mostly mucronate, sometimes obtuse and rarely acuminate to caudate-acuminate with length 1-3 (-10) mm long. Margin almost entire with

a pair of minute tooth close to apex. Base obtuse. Second-order venation camptodromous, ascending, 9-15 pairs on each side. ***Inflorescences*** terminal. Limitation zone 1-4.2 cm long and branching zone from none up to 2.5 cm long. Branches 3-6, arranged in corymb-like, stout, 7-17.5 cm long × 0.20-0.37 cm diam. Total umbels per branch 4-12 with terminal umbels 3-5, along more than half of branch length. Peduncles (0.8-) 1.2-3.3 cm long × 0.08-0.16 cm diam. Pedicels 2-7 mm long. ***Flowers*** up to 22 per umbel. Buds 4 mm long × 2.6 mm diam., ellipsoid to obovoid, cupule campanulate to obconic. Disk truncate. Petal 6, thick, about 3 mm long. ***Fruits*** depressed-globose, hairy to glabrous, 4-7 mm long × 3-5.6 mm diam., locules 5-6, disk slightly sloping with stylar column 1 mm long. Ovary half to 3/5 inferior.

Notes: In general, the plant has resemblance of *H. beamanii* (Puad, T. J. Barkman & Frodin) Puad, T. J. Barkman, Lowry & G. M. Plunkett in Sabah. *Heptapleurum beamanii* is endemic locally in Sabah, specifically around the Mount Kinabalu on ultramafic soil at elevation 1300-1450 m above sea level. Morphologically, the species can be identified by its coriaceous, rugose, elliptic or orbicular leaflets that heavily covered with rusty brown stellate hairs on both surfaces (Ahmad Puad et al., 2018). In Sarawak, there are about 16 *H.* aff. *beamanii* collected specimens at elevation ranges of 1550 m to 2434 m above sea level on Mount Murud, Tama Abu Range, Mount Mulu and Bario in Miri and Mount Pagon in Limbang. The specimens found on Mount Murud might be related to *H. mjoebergii* due to their broadly oval leaves except that they have more than one leaf. On the other hand, the plant on Mount Mulu has small oval blades. On Mount Pagon and Tama Abu Range, the leaves are much narrower with elliptic or slightly obovate blades. The other details on the specimens in Sarawak that differs from *H. beamanii* are having longer stipule, leaves with

oval or obovate blades, mucronate to obtuse apex, almost entire margin, more second-order lateral veins, lesser number of inflorescence branches, fewer umbels and longer style on maturing fruits. A molecular analysis is much needed to get a better understanding for this species.

Specimen listing: MIRI. Mulu. Mt Mulu, 2240 m, 16 Oct 1991, *Runi et al., S. 63456* (KEP, K, L, CGE); 2320 m, 14 Mar 1990, *Yii Puan Ching & Abu Talib, S. 58562*; 2374 m, 16 Jun 1975, *Paul Chai, S. 35840* (L, K); Camp 4, Mt Mulu, 2370 m, 20 Mar 1978, *Carlo Hansen, No. 527* (SAR); Camp 4, Gunung Mulu NP, 1736 m, 10 May 2015, *Aishah & Fatiha, SNA 129*; 1784 m, 10 May 2015, *Aishah & Fatiha, SNA 106*; 1799 m, 10 May 2015, *Aishah & Fatiha, SNA* 94; 1826 m, 10 May 2015, *Aishah et al., SNA 87*; Summit Trail, Gunung Mulu NP, 1810 m, 10 May 2015, *Aishah et al., SNA 85*; 2080 m, 8 May 2015, *Aishah et al., SNA 56*; 2104 m, 8 May 2015, *Aishah et al., SNA 54*; 2140 m, 10 May 2015, *Aishah et al., SNA 49*; 2192 m, 11 May 2015, *Aishah et al., SNA 46*; 2218 m, 8 May 2015, *Aishah et al., SNA 43*; 2278 m, 8 May 2015, *Aishah et al., SNA 36*; 2287 m, 8 May 2015, *Aishah et al., SNA 33.* **MIRI. Bario.** Mt Murud (second summit), 2042 m, 2 Oct 1967*, Ilias Paie, S. 26386* (K, CGE); Mt Murud (east), 1800 m, 5 Apr 1970, *H. P. Nooteboom & P. Chai, Nooteboom 1961* (SAR); Mt Murud (lower summit), 2250 m, 19 Aug 1991. *Rena et al., S. 63320* (KEP, CGE, K); Tama Abu Range, 1750 m, 8 Sep 1985, *Dayang Awa & Bernard Lee, S. 51148* (CGE); 1800 m, 6 May 2005, *Kit Pearce et al., S. 94905* (SAR); Mt Murud (new trail), 2058 m, 8 Aug 2005, *Kit Pearce et al., S. 95312* (SAR); Church Camp, Mt Murud, 2248 m, 10 Aug 2005, *Kit Pearce et al., S. 95446* (SAR, KEP, K); Mount Murud, 2079 m, 18 Sep 2006, *Jacqualine & Shalih, S. 96916* (SAR); Lepo Bunga, 1820 m, 6 Aug 2009, *Aurelia et al., S. 105281* (SAR); *S. 105298* (SAR); Mt Murud (summit), 2343 m, 7 Aug 2009, *Rantai Jawa*

et al., S. 104667 (SAR). **LIMBANG.** Bkt Pagon, 1770 m, 17 Aug 1984, *Dayang Awa & Bernard Lee, S. 47942* (KEP).



Figure 4.109: *Heptapleurum* aff. *beamanii* (S. 35840).

4.6.3 *Heptapleurum* aff. *burkillii* (Figure 4.110)

Epiphyte. ***Leaves*** 3-6 foliolate. Petiole 7-9 cm long × 2-3 mm diam. Petiolules 1.1-3 cm long × 1-3 mm diam. The blades elliptic, oval to ovate, 6-17 cm long × 2.7-5 cm wide. Base obtuse to rounded, margin entire and apex from acuminate to caudate-acuminate with length from 1 cm-2.5 cm long. Second-order venation about 7-9 pairs, more visible on lower surface of leaves, and camptodromous. ***Inflorescences*** terminal, limitation zone 2.5-4 cm long. Branching zone obscure. Terminal branches from 2 to 4, covered in brown hairs. Umbellules 5-10 per branch. Terminal cluster always has more umbels than subsidiary cluster. Peduncles

from 0.4-1.5 cm long × 0.5-2 mm diam. Pedicels 5 mm long. ***Flower buds*** unopened and semi globose with flattened summit. Dimension 2 mm long × 1 mm diam. Cupule obconic with 1 mm long. Calyx spreading with its length almost 0.5 mm long. ***Fruits*** not seen.

Notes: These two specimens are classified under *H.* aff. *burkillii* as most of the parts are identical to the species. However, there are some features are different from *H. burkillii*. Specimen S. 19411 has more than 3-foliolate leaves, longer petiole, more than 2 branches and umbellules more than 5 on each branch compared to *H. burkillii.* In contrast, specimen S. 29291 shares most of the characteristics with *H. burkillii* except the stipule. The stipule is not seen on specimen S. 29291. Molecular analysis is recommended to determine if it discriminates among taxa studied.

Specimen listing: BINTULU. Tatau. Bukit Naoung (Kana), 1100 m, 11 Oct 1963, *Banying ak Nyudong, S. 19411* 9K, L, SING). **KAPIT. Bukit Mabong.** Bukit Salong, 1312 m, 22 Aug 1967, *Ilias Paie, S. 29291* (K, CGE).



Figure 4.110: *Heptapleurum* aff. *burkillii* (S. 19411).

4.6.4 *Heptapleurum* aff. *cephalotes* (Figure 4.111)

Epiphyte or climber. ***Leaves*** 6-9 foliolate. Stipular ligule persistent, obtuse with length 5-7 mm. Petiole and petiolule covered with hairs. Petiole length 18-38 cm × diam. 3-3.5 mm and petiolules 4.2-5.7 cm by 1.5 mm. Leaf blades narrowly oblong to oblong-elliptic, 11.6-20 cm long × 4.2-5.8 cm wide. The lower surface of blades is covered with brown hairs. Apex acute-acuminate to acuminate extending at 7-8 mm long. Base acute. Margin entire. Second-order venation 17-18 pairs on each side, eucamptodromous and weakly visible on both surfaces. Reticulations distinct. ***Inflorescences*** terminal with the limitation zone 1.3-2.7 cm long and branching zone 3.5-9.5 cm long. Bracts at the base of each branch 1.2-1.5 cm long. Entire part densely pubescent. Branches 9-13, 11.8-19.3 cm long × 1.5-2 mm diam. Umbellules in heads and racemosely arranged along ¾ of the branch. Peduncles initially

sessile to 3 mm long when matured. The inflorescence heads c. 7 mm diam. and each head hold up to 40 buds. ***Individual buds*** obovoid, small with dimension of 2 mm long × 1.5 mm diam., densely hairy and apex flattened. ***Fruits*** not seen.

Notes: All three specimens for this species were collected in Bario, Miri at elevation from 1000-1340 m. Most of the parts are identical to *H. cephalotes* except this has slightly bigger leaflets and inflorescence heads, holding more individual flowers per head and the buds are smaller compared to *H. cephalotes.* To confirm either these specimens are related to *H. cephalotes* or not, molecular work is needed to be done.

Specimen listing: MIRI. Bario. Kelabit Highland, 1000 m, 21 Sep 1996, *Yahud Hj Wat et al., S. 71957* (KEP, K, L, SAN, CGE); Pa Umor, 1000 m, 22 Sep 1996, *Yahud Hj Wat et al., S. 71978* (KEP, K, L, SAN, CGE); Long Rapung, 1340 m, 18 Aug 2005, *Kit Pearce et al., S. 96003* (SAR).



Figure 4.111: *Heptapleurum* aff. *cephalotes* (S. 71978).

4.6.5 *Heptapleurum* aff. *crenatum* (Figure 4.112)

Epiphyte. ***Leaves*** 4-5 foliolate. Stipule broad, acute to obtuse, free portion 1.0-2.5 cm long. Petiole length 10-25.3 cm long × 0.20-0.30 cm diam. Petiolules 2.6-6.5 cm long × 0.13-0.20 cm diam. Blades oval to broadly ovate, coriaceous, 8.7-14.8 cm long × 4.6-8 cm wide. Apex apiculate, 0.6-1.0 cm long. Base obtuse. Margin almost widely crenate. Second-order venation 6-12 pairs on each side, spreading-ascending, camptodromous. Reticulation distinct. ***Inflorescences*** terminal, paniculate. Limitation zone 3-6.5 cm long marked by bracts. Branching zone 1.3-3.0 cm long. Branches congested, 3-9, densely hairy, 6.8-15 cm long × 0.20 cm diam. Umbellules c. 11 per branch along most of the branch length, distantly spaced from one another. Peduncles 0.4-2.0 cm long, pedicels 1-4 mm long and both of them pubescent and purple-coloured. ***Flower*** bud ovoid, green to brownish, about 10 per umbel,

dimension 2-3.5 mm long × 1.5-2.5 mm diam. Cupule hairy with minutely toothed calyx-rim. Flowers petal 5 with length 2.5 mm long, acute. Stamen between petals, 4-5 mm. Disk flat. Stylar 0.5 mm long. Stigmata indistinct. ***Fruit*** not seen.

Notes: At a glance, this species has a resemblance of *H. crenatum.* However, there are a few details that differentiate these taxa. this taxon has shorter stipule free portion, lesser number of leaves, blades oval to ovate, more and congested lateral branches, umbellules with longer peduncles and shorter pedicels and smaller flower buds. This taxon is recorded at elevation ranging between 884-1780 m on Hose Mountains and Batu Laga Plateau in Kapit, Bukit Mersing in Bintulu and Mount Mulu in Miri.

Specimen listing: BINTULU. Tatau. Bukit Mersing Park Reserve, 958 m, 14 Nov 1974, *S. Laijanai, S. 35961.* **KAPIT. Belaga.** Batu Laga Plateau, 885 m, 12 Sep 1984, *Abang Mohtar, S. 48251* (SAR). **Bukit Mabong.** Hose Mountains, 1600 m, 1 Dec 1991, *Lai et al., S. 63976* (KEP). **MIRI. Mulu.** Camp 4, Gunung Mulu NP, 1780 m, 12 Mar 1990, *Yii Puan Ching & Abu Talib, S. 58468.*



Figure 4.112: *Heptapleurum* aff. *crenatum* (S. 35961).

4.6.6 *Heptapleurum* aff. *havilandii* (Figure 4.113)

Epiphyte or small tree c. 4 m tall. ***Leaves*** 5-9 foliolate and entirely glabrous. Stipular ligule at the base of petiole persistent, acute and up to 1.6 cm long. Petiole 10.6-35 cm long × 1.5-4 mm diam. Petiolules 1.7-5 cm long × 0.6-2 mm diam. The leaf blades mostly obovate, sometimes elliptic and oblanceolate, 6.6-15.5 cm long × 3-7.5 cm wide. Adaxial surface glossy. Apex length 1-4 (-6) mm long and mostly mucronate, some leaves with acute-acuminate to caudate apex and rarely retuse. Base convex to cuneate and rarely rounded. Margin entire. Second-order venation 5-10 pairs on each side, eucamptodromous, ascending towards margin with weak reticulations. ***Inflorescences*** terminal, limitation zone from 3.5-5 cm long, marked by bracts up to 2 cm long. Branching zone up to 10 cm long. The branches 7-12, slightly pubescent, slender at length 11-53.2 cm long × 1-2.7 mm diam. Bract at the

base of branch 0.6-1 cm long. Umbellules numerous and racemosely arranged along the branches. Peduncles 0.2-1.4 cm long while pedicels at 1-6 mm long. The bracteoles are about 1 mm long. ***Flowers*** 8-11 per umbel, 1.5-2 mm diam. and entirely glabrous. Cupule campanulate with length 1.5-2 mm long. Petals 5-6. Stamen 3 mm long. Disk truncate. Ovary inferior. ***Fruits*** globose, glabrous, deeply sulcate due to drying, 2.5-3 mm long × 1.1-2.5 mm diam. Ovary from 2/3 to almost inferior. Stigmata 5-6 on top of sloping disk.

Notes: The specimens were recorded near rivers, heath and mixed dipterocarp forest at elevation ranging from 10-900 m above sea level. These specimens are almost identical to *H. havilandii* except each of them has slight differences that placed them under the species affinis. Specimen S. 78358 has narrowly oblanceolate leaflets while S. 56021 has dull and thin leaves. Most of the specimens have mucronate to caudate apex but for specimen S. 46812, the apex is retuse. Finally, specimen S. 39721 and Hotta 15775 have short inflorescence branches in which *H. havilandii* has long slender branches. In one of the herbarium notes, the Iban local called this species 'Kayu Ala'. More specimens are needed to evaluate the range of characteristics to confirm this species. Based on the distribution of *H. havilandii* in figure 4.44, the species is restricted in Kuching. However, most of the specimens in this taxon were recorded outside of Southern Sarawak and therefore, in order to confirm the occurrence of species in areas outside Kuching, more specimens are needed.

Specimen listing: KUCHING. Lundu. Serayan road to Sematan, 10 m, 22 Sep 1998, *Patsipun et al., S. 78358.* **SIBU.** Sg Trusan Rantau Panjang, 22 Feb 1999, *Tahud Hj Wat et al., S. 82525.* **BINTULU. Tatau.** Minah Camp at Sg Kakus, 30-80 m, 26 Feb 1964, *Mitsuru Hotta, No. 15775* (SAR). **MIRI. Mulu.** Sg Mentawai, 6 Oct 1977, *Paul Chai, S. 38721* (L,

K, KEP, SAN, MO, A). **KAPIT. Belaga.** Dulit Range, 900 m, 17 Oct 1983, *Dayang Awa & Yii Puan Ching, S. 46812* (K, L, KEP). **Bukit Mabong.** Ng Entajum, 24 Oct 1988, *Hj Othman et al., S. 56021* (CGE, K, L, KEP, SAN).



Figure 4.113: *Heptapleurum* aff. *havilandii* (S. 46812).

4.6.7 *Heptapleurum* aff. *lineamentorum* (Figure 4.114)

Tree about 10 m tall. ***Leaves*** 5-7 foliolate, narrowly oblanceolate blades, coriaceous, 7.8-9.3 cm long × 2.9-3.7 cm. Petiole 15.5-22.5 cm long × 2.3-3 mm diam. Petiolules 2.5-4 cm long × 1-1.4 mm diam. Apex 3-4 mm long and abruptly acuminate on top of the blades. Base cuneate. Margin entire. Second-order venation about 7 pairs on each side, pinnate and eucamptodromous. ***Inflorescences*** terminal, limitation zone of 2.3 cm long and branching zone 11.5 cm long. Bracts somehow not persistent. Branches 9, slender and somehow distant

from one another, 26.5-41.5 cm long × 3-4 mm diam. Umbellules more or less 30 per branch and racemosely arranged on the branches. ***Flowers*** not seen. ***Fruits*** 7 to 11 per umbel. Peduncles deep purple with length of 1.2-1.7 cm long while pedicels 3-6 mm long. Cupule campanulate with slightly sloping and glaucous disk on top. Stigmata sessile. Ovary ¾ inferior.

Notes: For most parts, the specimen resembles *H. lineamentorum.* However, this plant has a smaller number of leaflets, shorter petiole and petiolules and smaller leaflets compared to *H. lineamentorum.* More specimens are needed to confirm this taxon.

Specimen listing: MIRI. Bario. Pa' Ukat, 1000 m, 27 Jul 1985, *Dayang Awa et al., S. 50433* (CGE, K, L, KEP, SAN).

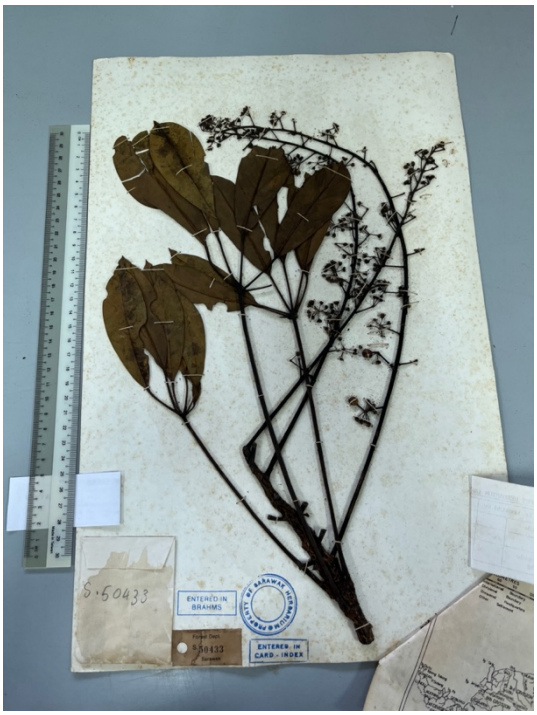


Figure 4.114: *Heptapleurum* aff. *lineamentorum* (S. 50433).

4.6.8 *Heptapleurum* aff. *mamutiacum* (Figure 4.115)

Shrub, epiphyte or climber. ***Leaves*** 3-4 foliolate. Stipule persistent, free portion 0.7-1.2 cm long. Petioles 2.7-5.8 cm long × 0.11-0.16 cm diam. Petiolules 0.4-1.5 cm long × 0.08-0.15 cm diam. Blades elliptic to ovate with unequal sides, 4.2-9 cm long × 1.6-4.2 cm wide. Apex broadly acuminate, 0.5-1.3 cm long. Base rounded. Margin minutely toothed. Second-order venation 4-12 pairs on each side. ***Inflorescences*** terminal. Main axis above last leaf 1.5-3.5 cm long. Terminal branches 2-3, glabrous, 1.1-4.7 cm long × 0.10-0.25 cm diam. Terminal umbels 4-5. Peduncles 0.6-2.0 cm long × 0.05-0.12 cm diam. Pedicels 2-5 mm long. ***Flowers*** up to 15 per umbel. Buds semi globose, dimension 3 mm long × 1.9-2 mm diam. Cupule cup-shaped. Petals 5-6, 1.5-2 mm long × 1.5 mm wide. Ovary inferior. Disk truncate with stylar column 1 mm long above. ***Fruits*** depressed-globose, glabrous, 4-6 mm long × 2.7-4.5 mm diam. Disk flat. Stylar column 0.5-0.8 mm long. Stigmata 5-6. Ovary almost inferior.

Notes: The specimens were recorded in montane forest and on summit of Mount Murud and Tama Abu Range with the altitudinal ranging from 1260-2350 m above sea level. The plant resembles *H. mamutiacum.* However, there are slight differences on inflorescence part between these two taxa. *Heptapleurum mamutiacum* has longer branches, umbels arranged in whorl, less number of flowers per umbel and sessile stigmata compared to *H.* aff. *mamutiacum.* Molecular work is needed to be done to confirm whether these taxa are related or not.

Specimen listing: MIRI. Bario. Mt Murud, 2200 m, 8 Apr 1970, *H. P. Nooteboom & P. Chai, Nooteboom 2052* (SAR); Helipad near church, Mt Murud, 2100 m, 22 Mar 1999,

Julaihi et al., S. 80080 (KEP, K, L, SAN, MO); Mt Murud, 2350 m, *Yahud, Mahmud et al., S. 88303* (KEP); Mt Murud, 2100 m, 28 Apr 2002, *Yahud, Mahmud et al., S. 88377* (KEP, CGE); Tama Abu Range (summit), 1800 m, 6 May 2005, *Kit Pearce et al., S. 94915* (SAR, KEP, K, L); Church Camp, Pulong Tau NP, 2248 m, 10 Aug 2005, *Kit Pearce et al., S. 95444* (SAR, KEP); Long Belaban, 1260 m, 12 Aug 2005, *Kit Pearce et al., S. 95479* (SAR); Lepo Bunga to Mt Murud, 1820 m, 6 Aug 2009, *Aurelia D. C. et al., S. 105284* (SAR).



Figure 4.115: *Heptapleurum* aff. *mamutiacum* (S. 88377).

4.6.9 *Heptapleurum* aff. *mitragerum* (Figure 4.116)

Epiphyte. ***Leaves*** 5-6 foliolate. Stipule not seen. Petiole 16-22 cm long × 2.4-3.2 mm diam. Petiolules vary in length. from 0.9-3.5 cm long × 1-2 mm diam. Leaf blades elliptic to ovate, 8.9-23.3 cm long × 3.6-8.8 cm wide. Apex long caudate with length 0.9-1.8 cm. Base acute

to concave. Margin from half to ¾ toothed. Second-order venation 5-7 pairs, eucamptodromous, arcuate, prominent on abaxial surface and broadly spaced from one another. ***Inflorescences*** terminal. Limitation zone c. 2 cm long and branching zone 2.8 cm long. Branches c. 5, slender, covered with dense pubescent, 24-40.5 cm long × 1.5-3.6 mm diam. Umbellules 18-28 per branch, sparsely and racemosely arranged along most of the branch. Peduncles 3-6 mm long × 0.3-1.1 mm diam. ***Flowers*** c. 12 per umbel. Pedicels 3-4 mm long. Buds thinly ellipsoid, 6-7 mm long × 2.8-3.2 mm diam. and the widest point always above the cupule. Cupule campanulate and 2-2.5 mm long. Petal 8-9-sutured. Entire bud covered with sparse hairs. ***Fruits*** not seen.

Notes: The specimen was recorded along the river in Lubok Antu, Sri Aman which is located in the Southern Sarawak. Based on the distribution map of *H. mitragerum* in figure 4.69, the species is mainly occurred in the Northern part. More samples should be collected between Northern Sarawak and Sri Aman to confirm the range of distribution.

Specimen listing: SRI AMAN. Lubok Antu. Ulu Sg Engkari, 4 Apr 1998, *Rantai et al., S. 78216* (KEP).



Figure 4.116: *Heptapleurum* aff. *mitragerum* (S. 78216).

4.6.10 *Heptapleurum* aff. *sabahense* (Figure 4.117)

A scrambler. ***Leaves*** 5-foliolate. Petiole 51.3 cm long × 4.2 cm diam. Petiolules slender and vary in length, from 3.8-9 cm long × 1.3-1.7 mm diam. Broadly elliptic and thin blades, 18-23.4 cm long × 7.3-11.5 cm wide. Apex acuminate up to 8 mm long. Base convex. Margin prominently toothed on upper half of leaves. Second-order venation eucamptodromous, arcuate, about 7 pairs on each side and broadly spaced in between of them. Both leaf surfaces have similar colouration and dull. Stipular ligule seems not persistent.

Notes: Only one sterile specimen collected. Although vegetatively it looks similar to *H. sabahense,* it could not be confirmed. More specimens are needed to confirm this species.

Specimen listing: KAPIT. Belaga. Bkt Lobang, 25 Aug 1978, *Bernard Lee, S. 39817* (CGE, L, K, KEP, E).



Figure 4.117: *Heptapleurum* aff. *sabahense* (S. 39817).

4.6.11 *Heptapleurum* aff. *tetrandrum* (Figure 4.118)

Epiphyte, climber or slender tree about 1.83-2 m tall. ***Leaves*** 3-5 foliolate. Petiole 5.8-15 cm long × 1.5-2.2 mm diam. while petiolules length 1.5-6.1 cm long × 0.8-1.5 mm diam. Leaflet blades largely elliptic, also obovate, ovate, oval to lanceolate, 8.5-19.6 cm long × 3.6-8 cm wide. Apex acute-acuminate to caudate extending up to 2.8 cm long. Base convex to cuneate. Margin entire. Second-order venation 5-8 pairs, brochidodromous and weakly visible on both surfaces. ***Inflorescences*** terminal with limitation zone 1.5-5.5 cm long and branching zone 0-0.5 cm long. The zones marked by closely spaced and acute bracts. Branches up to

13, 11.8-37.5 cm long × 0.9-2 mm diam. Umbellules along the branches are numerous and racemose. Peduncles 0-4 mm long with a bract at the base with length 1-2 mm long. Pedicels 0-2 mm long. ***Flowers*** 5-12 per umbel. Buds globose-obovoid, 1.5-3 mm long × 0.6-1.5 mm diam. Cupule 1 mm long funnel-shaped. Stamen 2-2.5 mm long. Disk glaucous and convex. Stylar column raised to 0.5 mm long with indistinct stigmata on top. ***Fruits*** entirely glabrous, obovoid to ellipsoid with dimension of 3-5 mm long × 1-1.6 mm diam. Disk remains glaucous. Ovary ¾ to 4/5 inferior. Stylar column at 0.5 mm high with stigmata 3-5.

Notes: There are 18 specimens annotated under this collection. Most of them were collected at the central part of Sarawak which is in Bintulu and Kapit. One of specimen, S. 86150, was found at Kuching in which most *H. tetrandrum* species was found. However, due to the almost sessile umbels and sessile fruits found on its inflorescence, it should not be in *H. tetrandrum* for now. There are also specimens with sessile umbels such as S. 64958, S. 65871 and S. 80893. In contrast, specimens S. 48095, S. 65750 and S. 97855 are pedunculate but their buds and fruits are sessile. The rest are both pedunculate and pedicellate.

Specimen listing: KUCHING. Borneo Highland Resort, 920 m, 26 May 2001, *Julaihi Lai & Jemree, S. 86150* (SAR). **SIBU.** Sg Trusan, Rantau Panjang, 25 Feb 1999, *Yahud Hj Wat et al., S. 82597* (KEP). **BINTULU. Sebauh.** Sg Kemena, 2 Apr 1963, *P.S. Ashton, S. 18359* (K, L); Ulu Segan, 23 Aug 1968, *Erwin Wright, S. 27155* (CGE, K); Wong Pasang, Sg Segan, 14 Sep 1972, *Paul Chai, S. 31987* (L, K, SING, SAN); Lumut Range, 400 m, 18 Sep 1992, *Abang Mohtar & Yii Puan Ching, S. 65750* (SAR); Lumut Range, 750 m, 22 Sep 1992, *Abang Mohtar & Yii Puan Ching, S. 65871* (SAR); Bkt Lumut, 780 m, 17 May 1999, *Julaihi et al., S. 80893* (KEP); Conservation area of Sg Penyilam, 6 Oct 2005, *Rantai Jawa et al.,*

S. 96210 (SAR, KEP); Sg Menaung, Penyilam, 9 Oct 2005, *Rantai Jawa et al., S. 96287* (SAR, KEP); Pengkalan Resam, Sg Penyilam, 1 Oct 2006, *Julia Sang et al., S. 97134* (SAR). **Tatau.** Sg Kakus, 30-80 m, 11 Nov 1963, *Minoru Hrano & Mitsuru Hotta, No. 1025* (SAR); Bkt Kana, 700 m, 7 Oct 1994, *Yii Puan Ching & Alex, S. 64958.* (K, L). **KAPIT. Song.** Sg Kerimau Besai, Ulu Katibas, 140 m, 17 Sep 1997, *P.P.K. Chai et al., ITTO/BC 0129* (BO). **Belaga.** Batu Laga, 700 m, 1 Sep 1984, *Abang Mohtar, S. 48095* (SAR). **Bukit Mabong.** Bkt Tibang, 1067 m, 8 Jul 1969, *J.A.R. Anderson, S. 28515* (CGE); Bkt Batu Tiban, 1000 m, 19 Apr 1986, *Yii et al., S. 52130* (CGE, K). **MIRI. Bario.** Long Lobang river, 15 May 2007, *R. De Kok et al., S. 97855* (SAR, K, KEP).

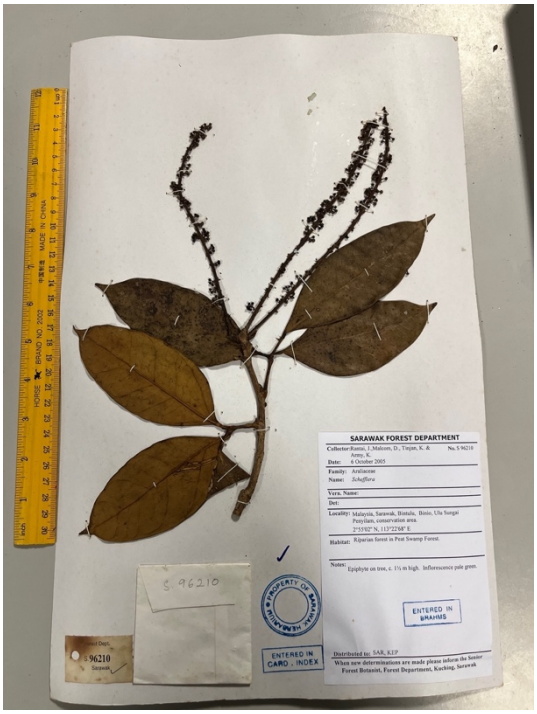


Figure 4.118: *Heptapleurum* aff. *tetrandrum* (S. 96210).

4.6.12 *Heptapleurum* aff. *winkleri* (Figure 4.119)

Epiphyte at 2 m tall. ***Leaves*** 7-foliolate. Stipule persistent, broad, acute, 3.5 cm in length. Petiole slender, 23 cm long × 0.37 cm diam. Petiolules 4-5 cm long × 0.17 cm diam. Blades slightly lanceolate, narrow, 20-26.3 cm long × 4.8-6.5 cm wide. Apex acuminate. Base convex. Margin entire. Second-order venation spreading then strongly ascending, eucamptodromous. ***Inflorescences*** terminal. Limitation zone 9.5 cm long. Branching zone 36 cm long. Lateral branches c. 30, covered in pubescent, 19.5-31 cm long × 0.35 cm diam., slender, distant along main axis. Umbellules numerous, racemosely arranged along the branch. Peduncles 5-8 mm long. Pedicels 2-3 mm long. ***Flowers*** not seen. ***Fruits*** globose, 4 mm long × 2.3 mm diam., 5-loculed, glabrous and deeply sulcate due to drying. Ovary ¾ inferior. Stigmata 5 and sessile on top.

Notes: The collectors annotated specimen *Yii Puan Ching S. 48361* as *H. winkleri* (Harms) G. M. Plunkett & Lowry. The plant was collected in riparian vegetation near Melatai River in Kapit at elevation of 210 m above sea level. After comparing the specimen with the description by Harms in 1917, most of the parts are similar except that this specimen has shorter petiole, narrow lanceolate blades, fewer and shorter inflorescence branches and shorter peduncles and pedicels. As for the inflorescence, the protologue described the species has small and numerous flowers along the many slender branches. The description of fruits is unavailable. The type specimen was described as a small tree with height around 5 m tall and collected in heath forest at Southeast Borneo which is in Kalimantan, Indonesia (Harms, 1917). However, there is only one specimen collected for this species in Sarawak. More specimens are needed to confirm this species.



Figure 4.119: *Heptapleurum* aff. *winkleri* (S. 48361)

4.6.13 *Heptapleurum* "anapense" (Figure 4.120)

Epiphyte. ***Leaves*** 7-foliolate, thin, narrowly oblong with glossy under surface. Blades 32-37 cm long × 8-8.8 cm wide with convex base and entire margin. Petiole 45 cm long × 0.50 cm diam. Petiolules slender, 7.5-11.5 cm long. Apex caudate and 1.5-2 cm long. Second-order venation 16-19 pairs, eucamptodromous, appear yellowish especially on the under surface and widely spaced. ***Inflorescences*** terminal with branches 10 or more with length up to 50 cm long. Umbellules numerous along ¾ of the branch length, arranged racemosely. Peduncles 0.7-1.1 cm long. Pedicels 3-5 mm long. ***Flowers*** not seen. ***Fruits*** pale green, ellipsoid with dimension of 4 mm long × 2.7-2.9 mm diam. Ovary ¾ to entirely inferior. Stigmata 5 and sessile.

Notes: The specimen was recorded along Anap River in Bintulu at 290 m above sea level. The taxon is very notable with narrowly oblong leaf blades with its length is four times longer than width. However, due to lack number of specimen and unclear length of the main axis above the last leaf, this plant is placed under imperfectly known taxa. More fieldwork should be done to collect more of this species.

Specimen listing: BINTULU. Tatau. Sg. Anap, 290 m, 30 Oct 1996, *Rantai Jawa et al., S. 75196* (KEP, CGE).



Figure 4.120: *Heptapleurum anapense* sp. nov. (S. 75196).

4.6.14 *Heptapleurum* "andersonii" (Figure 4.121)

Climber on rock at c. 21 m high. ***Leaves*** 4-5 foliolate. Stipule free portion, acute with length 2.4-3.5 cm, curved upwards. Petiole 3-3.3 cm long × 0.2-0.3 cm diam. Petiolules 1.2-2.5 cm long × 0.12-0.19 cm diam. Blades narrowly elliptic or lanceolate, thin, glossy upper surface,

8.6-14 cm long × 2.4-4.5 cm wide. Apex from acute-acuminate to acuminate and 0.4-1 cm long. Margin entire with acute to obtuse base. Second-order venation eucamptodromous, parallel, spreading-ascending, 8-12 pairs. Reticulations not visible. ***Inflorescences*** terminal. Limitation zone 1-4.5 cm and branching zone up to 1 cm. Branches 3-6, 7-8.8 cm long × 0.11-0.15 cm diam, covered with white pubescent. Bracts at the branch base 0.9-2.5 cm long. Umbellules 8-9 per branch along half of the branch length. Peduncles hairy, 1-4 mm long. Pedicels glabrous, 0.5-1 mm long. ***Flower*** buds about 8 per umbel, glabrous, 1-4 mm long × 0.8-2 mm diam., somehow ellipsoid. Cupule funnel-shaped with calyx rim-like.

Notes: There are two specimens recorded for this taxon from the limestone at Teng Bukap, Kuching and Mount Silabur, Serian at elevation c. 274 m above sea level. The inflorescence on both specimens were too young to be fully described. More collection on this plant should be done at different developmental stages of inflorescences.

Specimen listing: KUCHING. Teng Bukap, Padawan, 13 Jan 1973, *James Mamit, S. 32670* (L, K). **SERIAN.** Mt. Silabur, 274 m, 30 Sep 1964, *J. A. R. Anderson, S. 20914* (SAR).



Figure 4.121: *Heptapleurum andersonii* sp. nov. (S. 32670).

4.6.15 *Heptapleurum* "banyengii" (Figure 4.122)

A 2.4 m tall treelet. ***Leaves*** trifoliolate with short stipular ligule that partially fused at the base of petiole with length of 3 mm. Petiole 5.4-5.8 cm long × 0.15-0.2 cm diam. Petiolules 1-2 cm long × 0.15-0.2 cm diam. Blades undulate, thick, coriaceous, oval or ovate, glabrous, 10.3-14.7 cm long × 4.5-6.6 cm wide. Adaxial surface glossy. Apex acute-acuminate with length 0.7-1.1 cm long and base rounded. Second-order venation camptodromous, 10-12 pairs, closely spaced but spreading-ascending towards margin. ***Inflorescences*** terminal. Branching zone 1 cm. Branches 4, glabrescent, 4-6 cm long × 0.15-0.2 cm diam. Umbellules 6-8 per branch along upper half to ¾ of branch length. Peduncles 0.8-1.3 cm long × 0.1 cm diam. Pedicels 1-2 mm long × 1.5-2 mm diam. Both peduncles and pedicels glabrous.

Flower buds per umbel 8-9, semi globose, 3 mm long × 2.5 mm diam. Cupule campanulate and below the middle of bud. Calyx-rim slightly spreading. ***Fruits*** not seen.

Notes: The plant was recorded on the summit of Hose Mountain at elevation 1350 m above sea level. There is only one specimen recorded for this taxon and it needs more specimens to have a complete species description.

Specimen listing: KAPIT. Bukit Mabong. Hose Mountain, 1350 m, 22 Mar 1964, *Banyeng ak Ludong, S. 17646* (K, L, SING, SAN, A, BO).



Figure 4.122: *Heptapleurum banyengii* sp. nov. (S. 17646).

4.6.16 *Heptapleurum* "bidiense" (Figure 4.123)

Epiphyte. ***Leaves*** 7-8 foliolate. Stipule not persistent. Petiole 51.7-56 cm long × 0.45-0.52 cm diam., entirely covered with lenticels, slender. Petiolules vary in length, 2.2-9.7 cm. Blades broadly obovate or elliptic, 15.7-20.5 cm long × 4.7-8.6 cm wide, margin entire, base cuneate. Apex caudate-acuminate extending to caudate with length 0.5-2.2 cm long. Second-order venation 6-8 pairs, eucamptodromous, spacing between each vein c. 1-2.5 cm wide, ascending and conspicuous on both surfaces. ***Inflorescences*** terminal, not fully developed in this specimen. Branches about 5, length 4.6-7.6 cm × diam. 0.16-0.20 cm, covered in dense woolly hairs. Umbellules around 15 per branch. Peduncles 1-3 mm long and pedicels 0.5 mm long. ***Flower*** buds c. 30 per umbel, 1 mm long × 0.6 mm diam., densely hairy, globose. Cupule funnel-shaped. ***Fruits*** not seen.

Notes: The plant was recorded in limestone forest of Mount Bidi, Kuching at elevation 250 m above sea level. The inflorescences were too young to be observed and described which is why this taxon is placed under imperfectly known taxa for now.

Specimen listing: KUCHING. Bau. Mt. Bidi, 250 m, 7 Jul 1996, *Mohizah et al., S. 74414* (KEP).



Figure 4.123: *Heptapleurum bidiense* sp. nov. (S. 74414).

4.6.17 *Heptapleurum* "dinghoui" (Figure 4.124)

A climbing plant. ***Leaves*** 8-foliolate. Stipule 2 mm long and truncate. Petiole 51.5 cm long × 0.41 cm diam. Petiolules vary in length, 2.8-10.5 cm long × 0.18 cm diam. Both petiole and petiolules sparsely hairy. Blades thinly coriaceous, leathery surfaces, glabrous, oblong to slightly oblong-obovate, 14.5-19 cm long × 5.8-7.2 cm wide. Apex abruptly acuminate to 9 mm long. Margin entire. Base obtuse. Second-order venation eucamptodromous, 9-11 pairs, conspicuous on both surfaces, spreading then ascending with weak reticulations. ***Inflorescences*** branches slender and covered with pubescent, 39.5 cm long × 2 mm diam. Umbellules c. 15 per branch, racemosely arranged but a bit distant between one another. Peduncles 0.7-1 cm long and pedicels 2-6 mm long. ***Flowers*** not seen. ***Fruits*** sparsely hairy.

Bracteoles persistent. Narrowly ellipsoid, 5 mm long × 2 mm diam. Apex truncate. Ovary inferior. Stylar column slender, 3 mm long with 6, not fully separated stigmata on top.

Notes: There is only one specimen identified for this taxon. It was recorded near river at Segan Forest Reserve, Bintulu. It is known as 'Akar Kunya' by the Iban people. There is only one inflorescence branch on this specimen. The other important information such as the length of limitation and branching zone and number of branches were unknown. More specimens are needed to obtain more information especially on the inflorescence part.

Specimen listing: BINTULU. Segan Forest Reserve, 4 Jul 1966, *Ding Hou, No. 456* (SAR).

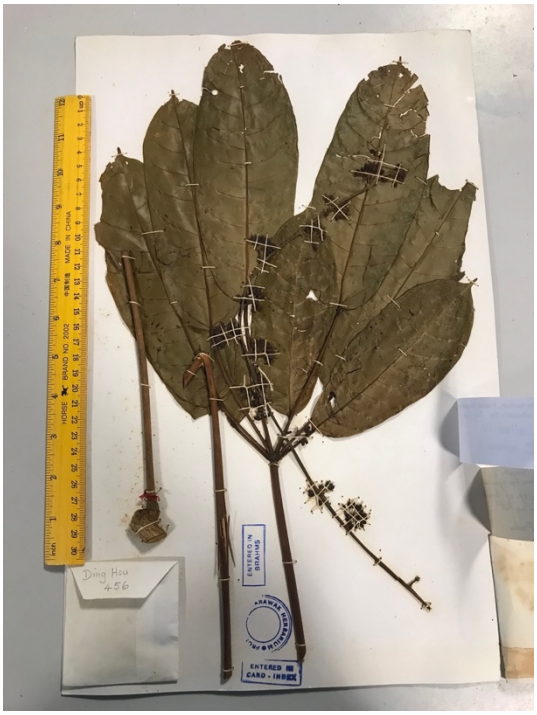


Figure 4.124: *Heptapleurum dinghoui* sp. nov. (Ding Hou No. 456).

4.6.18 *Heptapleurum* "lumutense" (Figure 4.125)

A creeper on rock. ***Leaves*** 4-7 foliolate. Stipule persistent with free portion 1.5 cm long. Petiole 8-15 cm long × 0.3-0.4 cm diam. Petiolules length 2.2-4 cm × 0.2-0.25 cm diam. Blades narrowly oblong-elliptic or ovate with sometimes unequal sides, length 10.7-13.4 cm long × 4.3-5.5 cm wide. Apex broadly acuminate about 1-2 cm long. Margin almost entire with a pair of teeth nearing apex. Base convex. Second-order venation weakly visible on surfaces, eucamptodromous, closely spaced with about 7-10 pairs, gradually ascending and closely spaced between each vein. ***Inflorescences*** terminal. Limitation zone c. 2.5 cm and branching zone obscure. At the base marked by bract scars. Branches 5, arranged corymb-like, covered with pubescence, 8.5-11.5 cm long × 2-3 mm diam. Umbellules less than 10 per branch and scattered along most of the branch length. Peduncles 3.5-9.5 mm long while pedicels 1-1.5 mm long. Both peduncles and pedicels are green. ***Flowers*** buds about 10 per umbel, yellowish green, 2 mm long × 1.5 mm diam., globose. Cupule funnel-shaped with prominent calyx-rim like on top. ***Fruits*** not seen.

Notes: The plant was recorded on the Lumut Range at 750 m above sea level. There is only one specimen available for this taxon and the inflorescences were too young to be described. In future, more samples of this plant should be collected at different inflorescence stages.

Specimen listing: BINTULU. Lumut Range, 750 m, 22 Sep 1992, *Abg Mohtar & Yii Puan Ching, S. 65839* (KEP, K, CGE).



Figure 4.125: *Heptapleurum lumutense* sp. nov. (S. 65839).

4.6.19 *Heptapleurum* "murudense" (Figure 4.126)

A treelet about 2 m tall. ***Leaves*** 7-9 foliolate, entirely glabrous. Stipular ligule truncate with length 4-8 mm. Petiole 11.7-15.7 cm long × 0.3-0.35 cm diam. Petiolule 2.4-4 cm long × 0.1-0.15 cm diam. Blades elliptic, 7.6-10.7 cm long × 3.5-4.3 cm wide, coriaceous. Apex broadly acute-acuminate, 0.6-0.8 cm long. Margin entire. Base obtuse. Second-order venation 9-13 pairs, brochidodromous. Not much distinct between secondary and intersecondary venation. Reticulation distinct. ***Inflorescences*** terminal, branches shorter than petiole. Limitation zone 1.5 cm long and branching zone 2.5 cm long. Entirely glabrous. Lateral branches 6, 6.8-8 cm long × 0.15-0.2 cm diam. Bracts reduced. Umbellules along 3/5 of the branch length, 7-9 umbels per branch. Peduncles 1-2 cm long × 0.1 cm diam. with subtending bracts not persistent. Pedicels 0.3-0.4 cm long. ***Flower buds*** 12-14 per umbel,

green, somehow globose, 2-2.5 mm long × 1.5-2 mm diam. Cupule funnel-shaped with spreading and narrow calyx-rim. Suture c. 5. ***Fruits*** not seen.

Notes: The specimen was recorded on Mount Murud at 2100 m above sea level. There is only one specimen and the inflorescence was still young to be described. More collection on this plant should be done especially during its fruiting stage.

Specimen listing: MIRI. Bario. Mt Murud, 2100 m, 28 Apr 2002, *Yahud et al., S. 88201* (KEP, CBG).



Figure 4.126: *Heptapleurum murudense* sp. nov. (S. 88201).

4.6.20 *Heptapleurum* "palutanense" (Figure 4.127)

An epiphyte or climber plant. ***Leaves*** 11-13 foliolate with petiole 46-78 cm long × 0.85-0.9 cm diam. Petiolules slender, 5.7-14.5 cm long × 0.2-0.3 cm diam., lightly pubescent. Blades broadly oval to elliptic, 19-25.2 cm long × 8-11.6 cm wide with aristate apex 1-2.3 cm long. Margin upper half serrate. Base concave and rounded. Below surface light green while upper surface dark green. Second-order venation spreading-ascending to strongly ascending. ***Inflorescences*** terminal. Limitation zone c. 2.5 cm long and branching zone c. 8.3 cm long. Lateral branches c. 10, very closely spaced, spirally arranged along axis, slender, 60 cm long × 0.4 cm diam. and sparsely hairy. Umbellules arranged in racemose, numerous, appear head-like. Peduncles 2.2-3.1 cm long × 1-3 mm diam., green with brown base. Pedicels green and 6-6.5 mm long. ***Flower*** buds at most 40 per umbel, pale yellow, obovoid, 3 mm long × 2 mm diam. Cupule campanulate or obconic at length 1.5 mm long with calyx rim-like on top. Petal in white and triangular. Apex truncate with stylar column c. 0.5 mm long. Stamen 5 and white. Ovary inferior. ***Fruits*** not seen.

Notes: This large plant was recorded on Palutan Hill, Miri in dipterocarp forest at elevation ranging from 790-800 m above sea level. The information especially on the inflorescence part is still lacking as the inflorescence is still young. Therefore, this taxon is placed under incompletely known taxa. To improve the description on this plant, more collection should be made.

Specimen listing: MIRI. Telang Usan. Bkt. Palutan, 800 m, 28 Mar 2003, *Yahud Wat et al., S. 91123*; Sg. Palutan, 790 m, 28 Mar 2003, *Kiew et al., S. 91284* (SAR, KEP).



Figure 4.127: *Heptapleurum palutanense* sp. nov. (S. 91123).

4.6.21 *Heptapleurum* "woenense" (Figure 4.128)

Epiphyte. ***Leaves*** 7-9 foliolate. Stipular ligule incurved with its free portion 2.4 cm long. Petiole 18-20.5 cm long × 0.25 cm diam. Petiolule 2-4.6 cm × 0.1-0.15 cm diam. Blades narrowly elliptic to ovate, 11.5-19 cm long × 4.1-6.9 cm wide. Apex slender caudate with length 1.5-2.4 cm long. Margin entire. Base obtuse. Second-order venation c. 9 pairs, eucamptodromous, gradually ascending towards margin. Reticulations coarse. ***Inflorescences*** terminal with unclear limitation zone and branching zone c. 1.9 cm long. Branches very close to one another, c. 7, slender, covered with brown stellate hairs, 20-28 cm long × 0.15 cm diam. Umbellules numerous, scattered and racemosely arranged along most of the branch length. Peduncles slender, up to 1.8 cm long. Pedicels 4-5 mm long.

Flowers 10-11 per umbel. Cupule conic. Disk glaucous, sloping with stylar mound. Stamen 5 with 3 mm long. ***Fruits*** not seen.

Notes: There is only one specimen recorded from Woen Hill, Kuching in disturbed mixed dipterocarp forest at 350 m above sea level. The inflorescence part is detached from the main axis resulting in the unknown length of limitation zone. Because of that, more collection should be done on this plant to get a better understanding especially on its main axis.

Specimen listing: KUCHING. Bkt. Woen, 350 m, 10 Feb 1987, *Yii Puan Ching, S. 61449.*



Figure 4.128: *Heptapleurum woenense* sp. nov. (S. 61449).

CHAPTER 5

DISCUSSION

5.1 *Heptapleurum* taxa in Sarawak.

A systematic and thorough study of *Heptapleurum* in Borneo in general began a few years ago with the publication of *Heptapleurum* species in Sabah, Malaysia Borneo (Ahmad Puad et al., 2018). This study is the first attempt to thoroughly observe all specimens collected and recorded in SAR and Unimas in order to determine the number of species or taxa in Sarawak. Unpublished work by Mohd Noor (2013) and Ramnor (2019) reported 47 *Heptapleurum* taxa in Sarawak. In this study, more taxa have been recorded with 73 taxa based on the observation of 583 herbarium specimens.

The recent study of *Heptapleurum* taxa in Sabah reported 33 taxa with 29 distinct species and four varieties of species (Ahmad Puad et al., 2018). Out of 29 species, 14 of them are also recorded in Sarawak, namely *H. avene, H. bipalmatifolium, H. crenatum, H. ellipticum, H. lanatum, H. lasiocalyx, H. lineamentorum, H. littorale, H. mamutiacum, H. mangiferifolium, H. mitragerum, H. obovatilimbum, H. sabahense* and *H. trineurum.* The number of *Heptapleurum* in Sarawak is much higher than in Sabah with 61 taxa recorded for Sarawak. However, only 25 of the taxa were published and in scattered publications (Ahmad Puad et al., 2018; Clarke, 1879; Harms, 1894, 1917; Lowry & Plunkett, 2020; Merrill, 1918a, 1918b, 1928, 1950; Ridley, 1946). There are still many taxa that are yet to be discovered and studied in Sarawak.

Based on the distribution map of *Heptapleurum* in Sarawak in Figure 4.2, *Heptapleurum* species can be found all over the Sarawak divisions. The specimens were frequently collected in Kuching, Kapit and Miri. Less than 10 specimens were recorded in Samarahan, Betong, Sarikei, Sibu and Mukah divisions. There are still many parts in Sarawak with no collection of *Heptapleurum.* Collection bias should be addressed when working with herbarium specimens (Daru et al., 2018). In Sarawak, most of the specimens were collected in lowland vegetation and protected areas such as national parks and nature reserves. Collection bias also occured in Sabah as well with majority of specimens were collected at Mount Kinabalu and there is no collection in most of part in North and East (Ahmad Puad et al., 2018).

The most frequently collected taxa in Sarawak are *H. petiolosum, H. tetrandrum* and *H. multiarcuatum.* These specimens were mostly found at accessible location and at low elevation of 1000 m and lower. Similarly in Sabah, *H. ellipticum* and *H. sabahense* were frequently collected due to the same reasons as well (Ahmad Puad et al., 2018). These species were well-described owing to having many specimens as their differences being shown in the morphology such as the leaf shape and numbers as well as the length of the inflorescence branches (Ahmad Puad et al., 2018). In contrast, about 60 *Heptapleurum* taxa in Sarawak have less than 15 specimens collected per taxon at SAR. This includes 17 of the published species which are *H. acutissimum, H. beccarianum, H. burkillii, H. bipalmatifolium, H. borneense, H. cephalotes, H. crenatum, H. kuchingense, H. lanatum, H. lasiocalyx, H. laxiflorum, H. lineamentorum, H. mamutiacum, H. mitragerum, H. mjoebergii, H. obovatilimbum* and *H. sabahense.* About 22 taxa with only one herbarium specimen. Although the lack of collection on the unpublished taxa, they can be recognized

as a newly found taxon because of the distinctiveness in morphology compared to the other known and published species.

Based on a study to determine the conservation status of a species, each species should have at least 15 herbarium specimens to obtain the consistent range estimate for assessments of conservation status (Rivers et al., 2011). In this study, there were 11 taxa with more than 15 collections and all of them were assessed as Endangered.

It was also apparent that *Heptapleurum* in Sarawak exhibited both phenomena of "Linnaean" and Wallacean shortfalls (Hortal et al., 2015). Linnaean shortfall is the inconsistency between the number of described species and the number species that actually exist while the Wallacean shortfall is the lack of information about the geographical distribution of the species (Lomolino, 2004). Both of these phenomena also occurred in Sabah as well (Ahmad Puad et al., 2018).

There are 27 unpublished *Heptapleurum* species in Sarawak. To published all of these new plants, further study is needed such as collecting more specimens from the field and observing more specimens from other herbaria.

5.2 Imperfectly known taxa of *Heptapleurum* in Sarawak

There are currently 21 imperfectly known taxa in Sarawak, with 12 of them identified as *species affinis* of the published species and the other nine taxa might be a distinct species but required more specimen and study to confirm it.

In this study, the specimens were identified as the *species affinis* mostly because of the morphological characteristics that almost similar to the type specimen of the published species. However, a slight difference found in the vegetative or reproductive parts put the

doubt on the specimen to be identified as the existing species. The *species affinis* may possibly belong to a new species if the distinctions implied a possible new identity (Bengtson, 1988; Lucas, 1986). However, some taxonomists suggested the species to be synonymous (Zidek, 1987). It is impossible to solve the complexity of the species without further action by doing more fieldwork and molecular testing on the specimens to obtain more data and knowledge on the complicated species (Váňa, 2002).

The other six taxa were imperfectly known mainly due to only having one specimen for each taxon and inflorescences were too young to be described. Not only that, the condition of the specimen was poor to be described in complete. Most of the specimens have their inflorescence branches separated from the main axis of the plant. The measurement of the limitation and branching zone is one of the main characteristics of *Heptapleurum* species (Ahmad Puad et al., 2018). Then, it is also very important to collect the plant with matured inflorescences in order to be fully described. In some species such as *H. lasiocalyx* and *H. mat-sallehii,* their flowers were initially sessile. Their peduncles and pedicels started to elongate in maturity (Ahmad Puad et al., 2018). Lastly, knowing the proper way to mount the specimen on to the herbarium sheet is very essential. One of the leaves of *H. banyengii* covered and sewed exactly on the main axis of the inflorescences in which it is important part to observe for the *Heptapleurum* identification. To avoid this careless mistake, make sure all the main parts of the plants are clear to observe before drying them.

5.3 Distribution of *Heptapleurum* taxa in Sarawak

The highest collection of *Heptapleurum* specimens in Sarawak is in Miri division. Miri also has the highest diversity with 27 taxa recorded. However, high level of collection

bias can be observed there as well with most of the collections were made in Bario and Pulong Tau forests and Mount Mulu forests. There are 17 taxa recorded in Bario and Pulong Tau forests with *H. barioense, H. bipalmatifolium, H. crenatum, H. mitragerum, H. mjoebergii, H. murud* and *H. yahudwatii* restricted there. These taxa seemed to prefer cooler climate as the average temperature recorded at 22°C and the temperature drops to 14°C at night (Kueh, 2007). Located at elevation ranging from 500 m to 2424 m above sea level, the mean relative humidity is 84%, lower than at lowland which is 95%. The richness of botanical plants in Bario and Pulong Tau forests can be explained as there are seven distinct forests which are lowland rainforest, lowland montane forest, upper montane forest, kerangas, alluvial, riparian and disturbed forest (Lim, 2006). Some of the high elevation species in Pulong Tau forests were strictly endemic (Tay, 2007) including *H. mjoebergii.* The high diversity of plant species in general including *Heptapleurum* taxa in Bario and Pulong Tau forests is because of the various type of forests with wide range of altitude, soils and topography such as exposed peaks and ridges, gentle and steep slopes, levees and floodplains (Pearce, 2006).

Another place in Miri with high number of *Heptapleurum* specimens is in Mount Mulu forests. There are 18 taxa recorded there with *H. bidenticarpum, H. paulchaii* and *H. primackii* restricted at Gunung Mulu National Park. Similar to Bario and Pulong Tau forests, there is also various type of forests in Mulu such as riparian, heath, peat swamp, lower montane forest, lowland mixed dipterocarp, upper montane limestone, lower montane limestone forest, lowland limestone forest and mossy forest (Hazebroek & Morshidi, 2001). The variety of geological type, wide range of elevation (50-2376 m above sea level) and multiple forests type contributed the species richness in Mount Mulu forests. Apart from

Bario and Pulong Tau forests and Mount Mulu forests, there are also some taxa that recorded only in certain places in Miri. *Heptapleurum niahense* and *H. subisense* were found only at Niah National Park while *H. palutanense* collected at Bukit Palutan or Sungai Palutan only. Despite many taxa in Miri, the high level of collection bias also obvious here. There are still many places especially at the central of Miri with no record of *Heptapleurum.*

The second highest collection of *Heptapleurum* is recorded in Kuching division. There are 17 *Heptapleurum* taxa recorded there with some restricted distribution such as *H. H. burkillii, H. cephalotes, H. havilandii, H. laxiflorum, H. puehense H. semengohense* and *H. yiipuanchingae*. There are three patterns that can be observed in Kuching. First, a massive collection of *Heptapleurum* specimens was made in limestone vegetation at Bau and Padawan with altitudinal range of 15-500 m above sea level. The collection at limestone was made continuously to Serian division. Taxa such as *H. borneense, H. laxiflorum* and *H. yiipuanchingae* were mostly collected in limestone forests. Second, the collections were made in the central of Kuching. The collections were recorded in Kubah National Park, Mount Matang, Bako National Park and Semengoh Arboretum in lowland dipterocarp forest, secondary forest, coastal and kerangas at elevation usually not over 1000 m above sea level. Historical collections by Haviland in 1890s also focused in central Kuching (van Steenis-Kruseman, 1950). Lastly, the collection in Kuching division is in the Southernmost Kuching which is at Lundu and Sematan forests. The collections were mostly recorded in Gunung Gading National Park, Mount Pueh forest and Tanjung Datu National Park in lowland dipterocarp forest, beach forest, riparian and montane forest. The only specimens of Kuching division over 1000 m were found here as well which is on Mount Kanyi and Mount Pueh. *Heptapleurum puehense* is probably endemic on the summit of Mount Pueh. The collection

bias in Kuching division is lower than in Miri although there is a small area of Kuching with no collection recorded such as shown in Figure 4.2. This could probably due to the rapid development in that area.

The third Sarawak division with high number of *Heptapleurum* collections is in Kapit division with 16 *Heptapleurum* taxa recorded here. The pattern of collection there seemed to be more scattered and widespread and therefore it is less bias although high concentration of taxa can be seen around Hose Mountains forest. About 17 taxa recorded in Kapit division at elevation from 40 m up to 1900 m above sea level. Most of the specimens were collected along the rivers, lowland dipterocarp, secondary forest, on ridges, hills and montane forest. There are three localized taxa that strictly found here, namely *H. asahii, H. banyengii* and *H. runiae.* No collection has been recorded in Northeast of Kapit division.

The *Heptapleurum* specimens in other divisions such as in Serian, Samarahan, Sri Aman, Betong, Sarikei, Sibu, Mukah, Bintulu and Limbang were under collected with less than 20 specimens recorded. The collections in these places were probably randomly done by the collectors. An extensive fieldwork should be focused especially in these divisions to confirm either the *Heptapleurum* specimens are totally absent or yet to be discovered.

Some of the *Heptapleurum* taxa in Sarawak are widely distributed across Sarawak such as *H. avene, H. ellipticum, H. glaucophyllum, H. lasiocalyx, H. littorale, H. mangiferifolium, H. truncatum* and *H. verticillatum.* All of them were found in more than one type of vegetation. The distribution of *H. ellipticum, H. lasiocalyx, H. littorale* and *H. mangiferifolium* also known to be widespread across Sabah as well. In contrast to *H. avene*,

it was highly concentrated at the west of Sabah (Ahmad Puad et al., 2018). In the Philippines, *H. ellipticum* was recorded at various places in primary and secondary forests (Pelser, 2022). The widespread distribution of *H. ellipticum* extended across tropical and subtropical Asia and northern Queensland, Australia (Frodin & Govaerts, 2003). The other widespread species such as *H. avene* and *H. littorale* are also native in Sumatera and Borneo (Frodin & Govaerts, 2003).

There are many *Heptapleurum* taxa in Sarawak with narrow distribution. Based on Table 4.3, about 15 taxa were restricted in Southern area, 19 taxa in Northern and 7 taxa Central of Sarawak. Some of them can only be found at specific type of vegetation such as *H. lanatum, H. lineamentorum, H. mamutiacum, H. mitragerum* and *H. trineurum.* Except for *H. mitragerum,* the others can be found only in montane forest over 1000 m above sea level. The specimens of *H. mitragerum* were collected only along rivers. All of these species are also recorded in Sabah with similar habitat (Ahmad Puad et al., 2018). On the other hand, there are some taxa that can be seen only at a specific locality such as *H. crenatum, H. bipalmatifolium* and *H. mjoebergii.* These specimens were recorded only at Pulong Tau in Miri. Contrary to the Sabah, *H. bipalmatifolium* there can be found around Mount Kinabalu and Mount Alab while *H. crenatum* was distributed from the Crocker Range Park to Kinabalu Park (Ahmad Puad et al., 2018). The distribution of *H. bipalmatifolium* and *H. crenatum* in Sabah is more widespread probably due to more specimens collected compared to Sarawak in which less than three specimens were reported for these two species. The lack of collections on most of the taxa in Sarawak should be acknowledged. About 18 *Heptapleurum* taxa in Sarawak has only one collection and therefore, the information on the plant distribution is not enough to be understood. Based on this study, the well-collected

taxa provided more information on the distribution compared to the poorly collected taxa in Sarawak.

5.4 Elevational ranges and habitat of *Heptapleurum* taxa in Sarawak

The study shows that *Heptapleurum* taxa in Sarawak can be found from near sea level up to 2410 m at various habitat. Most of the *Heptapleurum* taxa in Sarawak recorded with more than one growth form, depending on their locality and vegetation type. The highest number of *Heptapleurum* taxa recorded at the altitudinal range of 0-500 m in which it is the lowest range (Figure 4.3). These taxa were collected in lowland dipterocarp, riparian, peat swamp, heath, mangrove, coastal, limestone and secondary forest. The average temperature in this range is from 23°C up to 32°C (The Official Portal of Sarawak Government, n.d.). As suggested by Ahmad Puad et al. (2018), the environmental factors such as moisture, nutrient availability and suitable climate encourage the growth and diversification of *Heptapleurum* taxa.

In this study, the number of *Heptapleurum* taxa decreases as the elevation increases. It is contrast from Sabah as the number of *Heptapleurum* species found above and below 1000 m is nearly equal with elevation between 1250-1500 m recorded the highest number of taxa (Ahmad Puad et al., 2018). The lower montane zone of Sarawak is from about 700 m. Most of the taxa here were located at the Northern and Central part of the state such as in Pulong Tau National Park, Gunung Mulu National Park, Hose Mountains and many more. At high elevation, these plants were able to survive in slightly colder temperature. For example, during the day in Bario that located at elevation over 1000 m, the average temperature is 16°C-25°C. At night, it can drop to 11°C (The Official Portal of Sarawak

Government, n.d.). One way of *Heptapleurum* species to adapt on the high elevation is by having an extreme sclerophyllous leaf to avoid the loss of moisture (Ahmad Puad et al., 2018).

The least number of taxa in Sarawak were recorded from the elevation above 2000 m. There are five taxa, namely *H. crenatum, H. glaucophyllum, H. mjoebergii, H. trineurum* and *H. verticillatum* recorded. These specimens were found on Mount Murud, Mount Mulu and Batu Lawi Hill. In comparison to Sabah, there are only four species recorded at over 2000 m which are *H. bipalmatifolium, H. kinabaluense* (Puad, T. J. Barkman & Frodin) Puad, T. J. Barkman, Lowry & G. M. Plunkett, *H. pachyphlebium* and *H. tambuyukonense* (Ahmad Puad et al., 2018).

There are some species with extremely wide range of elevation which is from near sea level to 1750 m such as *H. avene, H. ellipticum, H. lasiocalyx, H. mangiferifolium* and *H. multiarcuatum.* These taxa in Sarawak were well-collected and can also be found in more than one type of vegetation. *Heptapleurum ellipticum* is known to be widespread across South East Asia (Frodin & Govaerts, 2003), the species is also known to have wide elevational ranges in Sabah (from near sea level to 1300 m) and the Philippines (from sea level to medium elevation) (Ahmad Puad et al., 2018; Pelser, 2022). There are also some *Heptapleurum* species outside of Sarawak and Borneo with elevational ranges more than 1000 m such as *H. oblongifolium* and *H. ovoideum* in the Philippines (Pelser, 2022) and *H. delavayi, H. hetaphyllum* and *H. pauciflorum* in China (Xiang & Lowry, 2007).

Some morphological differences can be observed at specimens of the same species that were collected at different elevation and vegetation. For example, the leaves of *H. avene* are much smaller in heath forest and locality over 1000 m compared to the specimens found in nutrient-rich habitat and lowland. Heath vegetation is known for having acidic soils and low amount of nutrients (Katagiri et al., 1991; Tsai, 2006). Similar observation has been made on the leaves of *H. lasiocalyx* on Batu Lawi at 1600 m. They are smaller compared to those at lower elevation. As for the species at low elevation but in different habitat, *H. multiarcuatum* on the limestone is much smaller compared to those in other lowland forests.

One species with completely different altitudinal ranges and habitat in Sabah and Sarawak which is *H. mangiferifolium.* According to Ahmad Puad et al. (2018), the plant in Sabah is frequently found along the rivers with elevation at most 500 m. However, there are records of *H. mangiferifolium* in Sarawak over 1000 m with the highest point is at 1750 m. They were collected in the montane forest on Batu Buli Hill, Tama Abu Range and Mount Murud at Pulong Tau National Park, Miri.

5.5 Challenges of studying using herbarium specimens

There are some challenges encountered while observing using the herbarium specimens. While collecting the information of the specimens from the herbarium label, some of important information were absent such as the detail of location of collection, coordinates, elevation and growth form of the plant. This problem occurred frequently on old specimens especially coordinates. The coordinates of these specimens must be searched manually through Sarawak Gazetteer (Mohizah et al., 2006) or Google Map for distribution map in Sarawak. For certain specimens, some collector stated the wrong elevation. For

example, specimen S. 105298 was collected at 5970 m on Mount Murud. The information was incorrect as the highest peak of Mount Murud is at 2424 m. All the locality must be checked before proceeding to the distribution mapping.

Another challenge during the study is that the specimens were lacking or having incomplete parts of inflorescences. It is very important for the species description and to observe the differences from the other species. A total of 30 specimens were sterile in which it was hard to make species identification just based on the leaves only. Although the inflorescences were available, some of them have either unopened flower, flowers with petals all gone and immatured fruits. The boiling of the dried flowers and fruits was not allowed by the SAR.

The way of storing and mounting for the big and bulky specimens such as *H. lanatum* and *H. multiarcuatum* was somehow improperly done. The plants have a very long parts such as petiole, petiolules, leaflets and branches and it was impossible to fit everything on a 42 × 29 cm herbarium sheet. Some collectors just broke some important parts to make it fit. Another problem that can be seen on most of the specimens was unclear length of the limitation zone. The vegetative and reproductive parts were always separated by using two herbarium sheets and therefore, the limitation zone remained unclear.

Lastly, there are some specimens believed to be misplaced in SAR. On the past studies by Mohd Noor (2013) and Ramnor (2019), the specimen of *H. remotiserratum* was available in SAR. However, it was not given during this study. The herbarium underwent renovation during this study and the herbarium specimens were being moved around. It is

believed that the specimen of *H. remotiserratum* was mixed with other specimens. Due to that, there is no *H. remotiserratum* observed in this study.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

From this study, there are a total of 73 *Heptapleurum* taxa in Sarawak. Out of 73 taxa, 25 of them have been published, 27 taxa are unpublished and 21 taxa are imperfectly known. There are still many *Heptapleurum* species in Sarawak that yet to be discovered and studied. About 44 taxa with less than five individuals recorded that resulting in incomplete description and poorly understood distribution. More fieldwork and molecular work on this genus should be done to get a complete species description and also to solve the complexity of the species that occurred in imperfectly known taxa.

After georeferencing all the specimens, it has shown that most of the specimens were recorded in Kuching, Miri and Kapit Divisions while less than 20 specimens recorded in Serian, Samarahan, Sri Aman, Betong, Sarikei, Sibu, Mukah and Limbang. The strong geographical bias can be observed especially in Miri Division. An extensive fieldwork should be carried out especially at poorly collected locality. Wider sampling distribution should be done instead of just heavily concentrated at one place only.

Although there are limitations using just herbarium specimens in this study, there are so many potentials of studying using the herbarium specimens. Until now, there are still many undiscovered plant species and herbarium specimen can help to provide data and references on the possibly new species or genus. Apart from plant taxonomy, the specimens from herbarium can also be used in the study of biodiversity, conservation, molecular

phylogenetics, evolution, medicine and many more. It is very important to collect and store all the specimens properly in the herbaria for future studies.

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