THE GENUS *ATHYRIUM* ROTH IN MALESIA: A CHECKLIST WITH WORKING NAMES AND DISTRIBUTIONS

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ABSTRACT

Athyrium Roth is a terrestrial fern genus in Athyriaceae, mostly distributed in temperate and sub-tropical regions. In Malesia, this genus is confined to higher altitudes. We have scrutinised the names listed in the literature as well as those used from specimens housed in herbaria that are possibly true *Athyrium*. Of the 25 species names, 12 are attributed to the Philippines, eight are recognised from Java and seven from Borneo and Sumatra. Other parts of Malesia contribute fewer species. A list of names together with information on distribution and specimens examined is provided.

INTRODUCTION

Athyrium Roth is one of the largest genera in the family Athyriaceae, formerly included in Woodsiaceae. It is a terrestrial fern of medium size, mostly found in the temperate and sub-tropical regions of the northern hemisphere. In the tropics it is confined to higher altitudes (Kramer, 1990; Wang *et al.*, 2013). The genus is thought to be more closely related to *Cornopteris* Nakai and *Anisocampium* C.Presl than *Deparia* Hook. & Grev. or the second largest genus in the family, *Diplazium* Sw. (Liu *et al.*, 2008).

The current classification of Athyriaceae recognises five genera (Christenhusz *et al.*, 2011; Rothfels *et al.*, 2012): *Anisocampium* – four spp, only one in Malesia (Liu *et al.*, 2008); *Cornopteris* – nine spp, five in Malesia (Kato, 1979; 1986); *Athyrium* – ~220 spp, mostly northern hemisphere; in Malesia, at least ten species in the Philippines (Liu *et al.*, 2008) while the number in the rest of Malesia is unclear; *Diplazium* – 300–400 spp, including *Allantodia* Wall. and *Callipteris* Bory; in Malesia over 100 species (Wei *et al.*, 2015) of which 62 in western Malesia (Praptosuwiryo, 2008); and *Deparia* – ~70 spp, six in Malesia (Kato, 1984). This classification was constructed mainly from molecular phylogenetic studies.

A combination of character states distinguishes *Athyrium* from other related genera (Liu *et al.*, 2008; Rothfels *et al.*, 2012; Wang *et al.*, 2013). A confluent groove on the upper surface of the rachis, costae and costule distinguishes it from *Deparia* and the indusiate sori and absence of fleshy projection in grooves at the base of pinnae separate it from *Cornopteris*. The free veins, non-clathrate stipe scale with entire margin,

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inequilateral base of pinna and pinnule, swollen (persistent) stipe bases on ascending to erect rhizomes also separate it from *Anisocampium* and *Diplazium*. However, the relationship among species in this genus is complicated. Generic limits and species circumscription of *Athyrium* has, to some extent, been completed for China (Wang *et al.*, 2013), Japan (Adjie *et al.*, 2008) and most of Indochina (Lindsay & Middleton, 2012–). However, for Malesia, similar work remains to be initiated. This paper is a start and presents a survey into names used in Malesia and their distribution in the region.

NAMES IN THE LITERATURE AND SPECIMEN LABELS

The genus *Athyrium* was established in the early 18th century (Roth, 1799). The author believed that some species had a distinctive indusium that differentiated it from typical *Polypodium* L. or *Asplenium* L. where these species were usually placed. In the same account, he made seven new combinations and transferred five species of *Polypodium* into *Athyrium*. Some botanists, such as Presl (1836), Moore (1857) and Beddome (1873), recognised *Athyrium* as separate, while others, such as Willdenow (1810), Blume (1827) and Hooker & Baker (1868), had different views and treated *Athyrium* species in other genera. Below we present our survey of later literature that refers to Malesian taxa.

Christensen (1906) published a list of adopted valid fern species and synonyms in *Index Filicum*, followed by supplements in 1913, 1917 and 1934. Most of those species listed and considered to be valid appeared with information on their geographic occurrence. In these publications there are about 100 species names of *Diplazium* and *Athyrium* (including *Cystopteris* Bernh.).

Alderwerelt (1909) published a handbook of ferns in the Malesian region that contained 20 species names under *Athyrium* and indicated the relationships between names. Some names included in this publication are today considered species of *Deparia*, *Thelypteris* Schmidel and *Ctenitis* (C.Chr.) C.Chr. A supplement published almost ten years later (Alderwerelt, 1917) contained corrections and covered fern allies and additional fern species. In both books he recognised *Athyrium* and *Diplazium* under the tribe *Aspleniae*.

Backer and Posthumus published their work on the ferns of Java in 1939 (Backer & Posthumus, 1939). In this book, *Athyrium* comprises eight species and includes species of *Anisocampium*. In the same year, Posthumus published a list of fern species for the Lesser Sunda Islands with three species of *Athyrium* that also included *Anisocampium* species (Posthumus, 1939). This treatment placed *Athyrium* and *Diplazium* next to *Lindsaea* Dryand. ex Sm., *Diplaziopsis* and *Asplenium* in the family Polypodiaceae.

The treatment of Philippine ferns by Copeland (1960) contains 62 species of *Athyrium*. Here he reduced all *Diplazium* into *Athyrium* but recognised *Calipteris* and *Anisocampium* as separate. Together with another 32 genera, he placed them in the family Aspidiaceae. Price (1972) suggested that Copeland had failed to understand the *Athyrium* group and misplaced species in the treatment. He listed 11 species under *Athyrium* and placed some of Copeland's *Athyrium* into *Athyriopsis*, *Cornopteris* and *Diplazium*.

Holttum's *Ferns of Malaya* (1954) reduced all related genera into *Athyrium* and placed it within *Cystopteris* under the sub-family Athyrioideae of the family Dennstaedtiaceae. In the next edition (1966), he recognised *Diplazium* as separate from *Athyrium*.

Copeland (1949) published an article on Aspidiaceae of New Guinea in which he listed 40 species under *Athyrium*, including some *Diplazium* species, in addition to a new *Athyrium* species. Parris *et al.* (1992) published a book on the fern flora of Mt Kinabalu and listed five species of *Athyrium* with one endemic species unidentified.

Names extracted from the literature were scrutinised against current available revisions to separate the 'true' *Athyrium* species from those considered synonyms or that might now belong to other genera. The literature referred to includes Liu *et al.* (2008) for *Anisocampium*, Kato (1979; 1986) for *Cornopteris*, Kato (1984) for *Deparia* and Wang *et al.* (2013) for flora of China. Some names were excluded from our list based on their implicit description, which indicated they belong to other genera. Names and notes were also recorded from herbaria of Bogor (BO), Leiden (L, through its e-portal http://bioportal.naturalis.nl), Kew (K), the Natural History Museum of London (BM) and Edinburgh (E). Some type specimens were accessed through JSTOR Global Plants (https://plants.jstor.org/), in particular from Missouri Botanical Garden (MO), University of Michigan (MICH), University of California (UC) and Gray Herbarium (GH). A list of specimens examined is given with an indication of whether they were accessed only from online images.

LIST OF SPECIES

1. ***Athyrium amoenum*** **C. Chr.**, Gardens' Bulletin Singapore 7:267, pl.56 (1934) – Type: Holttum SFN 25530 (BO, K)

Distribution: Borneo

Specimens examined: Sinclair 9170 (K), Parris & Croxall 304 (K), P.J. Edwards s.n. (K), M. Kato *et al.* 1462 (K), Parris 111570 (K), W. Meijer SAN 22066 (K), J & M.S. Clemens 50907 (BM, K), 29045 (BO, BM, K)

Note: Wang (2013) includes this name under *A. rhachidisorum* (Hand.-Mazz.) Ching but omits Borneo from its distribution. There are specimens housed in BM under this name but labelled *A. rhachidisorum* by "Zhongren Wang" in 1999 (J & M.S. Clemens 29967, 29045). This requires further investigation.

2. ***Athyrium anisopterum*** **Christ**, Bull. Boiss. 6:962 (1898) – Type: A. Henry 10109 (isotype MO)

Distribution: Borneo, Sulawesi, Java, Peninsular Malaysia, Philippines

Specimens examined: M.R. Hendersen SFN 23462 (K), E.A. Turnan 844 (K), R. Molesworth-Allen 5021 (K), R.E. Holttum SFN 31324 (K), A.G. Piggot 3098 (K), Bunnemeijer 12167 (BO), W. Meijer 2752 (BO), 2757 (BO), C.G.G.J. van Steenis 7129 (BO), Docters van Leeuwen-Reijnvaan 12323 (BO), C.A. Backer & O.

Posthumus 338 (BO), (photos) Kato *et al.* 1440 (L), 1476 (L), G. Roedl Linder 114 (L)

Note: This species is probably part of a species complex.

3. ***Athyrium appendiculiferum*** **Alderw.**, Bull. Jard. Bot. Buitenzorg ser. 2, 16: 3 (1914) – Type: C.G. Matthew 676 (BO, K)

Distribution: Peninsular Malaysia, Sumatra

Specimens examined: Cheang Kon Chez s.n. (K), E.A. Turnan 340 (K), H. Surback 79 (BO)

4. ***Athyrium aristulatum*** **Copel.**, Philipp. J. Sci. 1 (Suppl. 4): 253. (1906) – Type: Copeland 1880 (holotype MICH)

Distribution: Sulawesi, Philippines, Sumatra

Specimens examined: M. Ramos & G. Edano 40236 (BO), E.D. Merril 6963 (BO), (photo) E. Hennipman 5443 (L), M. Jacobs 7291 (L), E.D. Merril 1141 (L), 967 (L), J. v. Borssum Waalkes 2213 (L)

5. ***Athyrium brevipinnulum*** **Copel.**, Philipp. J. Sci., C 3: 291. (1908) – Type: Copeland 1939 (holotype MICH)

Distribution: Philippines

Specimens examined: (photo) Copeland 1939 (MICH)

6. ***Athyrium clemensiae*** **Copel.**, Philipp. J. Sci., C 12: 58. (1917) – Type: M.S. Clemens 10621 (isotype MICH)

Distribution: Borneo

Specimens examined: M. Kato *et al.* 1497 (K), Parris & Croxall 8739 (K), 8779 (K), R.E. Holttum SFN 25486 (K), Parris 11593 (K), B.E.G. Molesworth-Allen 3269 (K), J. & M.S. Clemens 27049 (BO)

7. ***Athyrium drepanopteron*** **(Kunze) Milde**, Fil. Eur. 49 (1867) – *Polypodium drepanopteron* Kunze, Linnaea 23:318 (1850) – Type: not known

Distribution: Peninsular Malaysia, Philippines, Sumatra

Specimens examined: Penang (?) 389 (E), Elmer 22347 (BO), K. Iwatsuki *et al.* 1448 (BO)

8. ***Athyrium erythropodum*** **Hayata**, Icon. Pl. Formosan. 4: 233–234, f. 163 (1914) – *Athyrium sungkangense* C.M. Kuo (1997) 155, nom. nud. – Type: Hayata & Sasaki s.n. (?)

Distribution: Java, Lesser Sunda Islands (Flores), Philippines

Specimens examined: Sapiin 2768 (BO), 2749 (BO), Posthumus 3968 (BO), 3364 (BO), 3611 (BO), T. Nakai s.n. (BO), Ramos & Edano 40181 (BO)

Note: The first record of this species in the Malesian region was reported by Liu *et al.* (2008) from the Philippines. The occurrence in Java and Flores is reported here.

Liu also examined specimens in BO in 2014 and relabelled some specimens of *A. nitidulum* (Sapiin 2768, 2749) or *A. nigripes* (Posthumus 3968, 3611, 3364) as *A. erythropodum*. This species is probably part of a species complex.

9. ***Athyrium fauriei* (Christ) Makino**, Bot. Mag. (Tokyo) 17: 160 (1903) – *Nephrodium fauriei* Christ, Bull. Boiss. 4:671 (1896); *Aspidium fauriei* (Christ) Christ, Bull. Boiss. 6:193 (1898) – Type: U.B. Faurie 10980, 13751 (syntype MO)

Distribution: Philippines

Specimens examined: not seen

Note: Wang (2013) included the Philippines in the distribution of this species.

10. ***Athyrium gedeanum* (Rac.) Christ**, J. Bot. (Morot) 19:68 (1905) – *Asplenium gedeanum* Rac., Pterid. Buitenz. 223. (1898) – Type: Raciborski s.n. (BO, K)

Distribution: Java, Sumatra

Specimens examined: Lorzing 532 (BO), H. Surbeck 90 (BO), Osawa *et al.* A-615 (BO), K. Iwatsuki *et al.* 982 (BO), C.G. Matthew 506 (BO)

11. ***Athyrium kutaiense* C. Chr.**, Dansk Bot. Ark. 9(3): 55. (1937) – Type: Endert 3779 (holotype BO)

Distribution: Borneo

Specimens examined: Endert 3779 (BO)

12. ***Athyrium mearnsianum* (Copel.) Alderw.**, Mal. Ferns Suppl. 279 (1917) – *Athyrium nigripes* var. *mearnsianum* Copel., Phil. Journ. Sci. 3C 291 (1908) – Type: Elmer 6543 (?)

Distribution: Sulawesi, Java, Philippines

Specimens examined: O. Posthumus 3498 (BO), 2968 (BO), 3965, C.A. Backer 21884 (BO), A.H.G. Alston 12847 (BO)

Note: Specimens from Java and Sulawesi in BO were identified by Yeachen Liu in 2014. We have not seen specimens from the Philippines. This species is probably part of a species complex.

13. ***Athyrium minutum* Copel.**, Univ. Calif. Publ. Bot. 18: 221. (1942) – Type: L.J. Brass & E. Myer-Drees 10107 (holotype MICH)

Distribution: Sulawesi, New Guinea, Philippines

Specimens examined: P.J. Eyma 899 (K), A.H. Everett s.n. (K), Brass 4481 (BM), J.R. Croft & M.J. Sands LAE 68471 (BM); photos: L.J. Brass & E. Meijer Drees 10107 (MICH), J.R. Croft 1409 (L), J.F. Veldkamp 6500 (L), M.M. J.v Balgooy 943 (L), Mangen J.-M. 1220 (L), M 610 (L), G. Hope ANU 16026 (L), C. Kalkman 5076 (L), R. Schodde 1952 (L)

14. ***Athyrium morobense* Copel.**, Phil. J. Sci. 78: 464. (1949) – Type: M.S. Clemens 41537 (holotype MICH)

Distribution: New Guinea

Specimens examined: (photo) M.S. Clemens 41537 (MICH), L.J. Brass 22348 (BM), 22350 (BM)

15. ***Athyrium myer-dreesii*** **Copel.,** Univ. Calif. Publ. Bot. 18: 222. (1942) – Type: L.J. Brass & E. Meijer Drees 9851 (GH)

Distribution: New Guinea

Specimens examined: (photo) L.J. Brass & E. Meijer Drees 9851 (GH)

16. ***Athyrium nigripes*** **(Blume) T. Moore**, Index. Fil. (T.Moore) XLIX Chr 224 Npfl. 224 (1857) – *Aspidium nigripes* Blume, Enum. Pl. Javae 2:162 (1828) – Type: Anon. s.n. (L, K), *Asplenium tenuifrons* Wall., Numer. List [Wallich] n. 206. (1829)

Distribution: Sulawesi, Java, Lesser Sunda Islands, Moluccas, New Guinea, Sumatra

Specimens examined: C.A. Backer 3326 (BO), 13602 (BO), 12654 (BO), 5131 (BO), Raciborski s.n. (BO), Mousset 1152 (BO), Docters van Leeuwen-Reijnvaan 12345 (BO), 12379 (BO), Lorzing 531 (BO), A. Schwartz 2009 (BO), Posthumus 3991 (BO), 176 (BO), A.G.H. Adelbert 165 (BO), 215 (BO), M.A. Donk P345 (BO), P704 (BO), P735 (BO), P699 (BO), C.G.G.H. van Steenis 4307 (BO), W. Meijer 1518 (BO). D.F. van Slooten 193 (BO), J. Jeswit 102 (BO), 107 (BO), S.M. Popta 201 (BO), Sapiin 2772 (BO), de Voogt 2345 (BO)

Note: This species is probably part of a species complex.

17. ***Athyrium nitidulum*** **(Kunze) Milde**, Bot. Zeitung (Berlin) 28: 370 (1870) – *Allantodia nitidula* Kunze, Bot. Zeitung (Berlin) 6: 191. (1848) – Type: not known

Distribution: Java, Sumatra

Specimens examined: (photos) leg ign 3710 (L), O. Bryant 944 (L)

Note: This species is probably part of a species complex.

18. ***Athyrium oreopteris*** **Copel.**, Philipp. J. Sci. 40:302, t.5. (1929) – Type: E.B. Copeland 2305 (Holotype MICH; Isotype UC)

Distribution: Philippines

Specimens examined: not seen

Note: Wang (2013) included this species under *A. oppositipennum* but omitted the Philippines from its distribution. As this name was established by a species collected from the Philippines further investigation is required regarding the use of these names.

19. ***Athyrium philippinense*** **Christ**, Philipp. J. Sci. 1 (Suppl. 4): 254. 1906 – *A. sarasinorum var. philippinense* Christ, Bull. Boiss. 6. 154. 1898. – Type: not known

Distribution: Philippines

Specimens examined: not seen

Note: This species was described from a plant collected in the Philippines by M.A. Loher (Christ, 1898) but no particular specimen was cited.

20. ***Athyrium pulcherrimum*** **Copel.**, Philipp. J. Sci. 8C: 141, pl. 3 (1913) – Type: not known

Distribution: Borneo

Specimens examined: J. & M.S. Clemens 30446 (K), 30519 (BO), M.A. Donk P209 (BO), A.C. Jermy & J.M. Rankin 315098 (BM), 315119 (BM), 315130 (BM), 315136 (BM), 315169 (BM), Holttum SFN 25507 (K), Parris 11608 (K).

21. ***Athyrium puncticaule*** **T. Moore**, Index Fil. (T.Moore) 186 (1860) – Type: not known

Distribution: Borneo, Sulawesi, Java, Moluccas, Philippines, Sumatra

Specimens examined: Sapiin 2888 (BO), 2890 (BO), Lorzing 2425 (BO), 2549 (BO), A.G.L. Adelbert 144 (BO), 192 (BO), Raciborski s.n. (Kandang Badak), s.n. (Salak-Tjiapus) (BO), Holttum s.n. (Tandjakan Pantjawtulul) (BO), Bakhuizen v.d. Brink 4130 (BO), J.G. Hallier 494 (BO), A.H.G. Alston 12853 (BO), C.G. Matthew 519 (BO), 585 (BO), J. & M.S. Clemens 29033 (BO), 31745 (BO), 31798 (BO), 31959 (BM), 32518 (BO), 32816 (BM), 33226 (BM), de Voogt 2641 (BO), Kato *et al.* C-1567 (BO), C-12148 (BO), C-3300 (BO), Holttum SFN 25526 (BM), H. Winkler 1903, Parris 11451 (K), S.H. Collenette 21524 (K)

Note: There is a specimen in BO under this name identified as *A. nakanoi* by Yeachen Liu in 2014. However, this name has not been published and nor is it in Wang (2013). Parris *et al.* (1992) did not include this species in her checklist. This species is probably part of a species complex.

22. ***Athyrium sarasinorum*** **Christ**, Verh. Nat. Ges. Basel 11. 434. (1896); Ann. Jard. Bot. Buitenzorg. 15: 123, t. 15, f. 16 (1898) – Type: not known

Distribution: Sulawesi, Philippines

Specimens examined: (Photo) A.C. Jermy 7436 (L), 7434 (L)

23. ***Athyrium setiferum*** **C. Chr.**, Index Filic. 146 (1905) – Type: Hope s.n. (BM)

Distribution: New Guinea

Specimens examined: leg. ign. s.n. (no locality, BO-1488296) (BO), (photo) L.J. Brass & E. Meijer Drees 9857 (L), J.F.Veldkamp & J. Wiakabu 7738 (L)

Note: Wang (2013) included this name under *A. strigillosum* but omitted New Guinea from its distribution. This needs further investigation.

24. ***Athyrium triangulare*** **Alderw.**, Bull. Jard. Bot. Buitenzorg ser. 2, 20: 8 (1915) – Type: not known

Distribution: Java

Specimens examined: not seen

25. ***Athyrium sp. 1***, Pl. Kinabalu I. Fern & Allies. 129 (1992)

Distribution: Endemic to Mt Kinabalu (Borneo)

Specimens cited: Parris & Croxall 8861 (K), Parris 11451 (K)

The names presented are an initial working list of accepted species names in the genus *Athyrium* for the Malesian region. Some names are used for specimens with similar morphological appearance, such as *A. anisopterum*, *A. erythropodum*, *A. mearnsianum*, *A. nitidulum*, *A. nigripes* and *A. puncticaule*, and these have been marked in the notes as probably forming part of species complexes. Other names are only known from the protologue or from very few herbarium specimens, for example *A. kutaiense*, *A. philippense*, *A. triangulare*, or are as yet unidentified, such as *Athyrium sp.* 1, from Mt Kinabalu. Further work is needed to address these data deficiencies and to clarify species complex relationships.

REGIONAL DISTRIBUTION

This study found that the Philippines has 12 accepted species names, Java has eight, Borneo and Sumatra have seven. Other areas in Malesia have fewer. It appears that the taxa from both the Philippines and Java have been studied to a greater extent than those of other parts of the region. Considering that Sumatra, Sulawesi and New Guinea have a comparable range of high mountains, we might expect these large islands to have a similar number of *Athyrium* species to the Philippines. However, deeper taxonomic investigation is needed especially for the Philippine and Javanese species.

Some names recorded are from only one part of Malesia and are potentially endemic, such as *A. kutaiense* of Borneo, *A. myer-dreesii* of New Guinea and *A. triangulare* of Java. However, this is subject to taxonomic clarification of their status. *Athyrium setiferum* and *A. oreopteris* are both well represented by specimens from Malesia but are recorded in the *Flora of China* as synonyms of *A. oppositipenum* and *A. strigillosum* respectively. This requires further taxonomic investigation.

CONCLUSION

This preliminary survey has resulted in an initial list of 25 species names with information on their distribution. Brief specimen examination has suggested that several names are potential synonyms while some names are only known from the literature with no specimens linked to them. Both of these need further investigation. Scant *Athyrium* material from areas with high mountains such as Sumatra, New Guinea and Sulawesi suggest that botanical exploration should be directed to these islands.

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