

Athyrium nakanoi Makino (Athyriaceae), a new record from the Philippines and an identification key to the Malesian *Athyrium* Sect. *Polystichoides*

Fulgent P. Coritico^{*1,2}, Victor B. Amoroso^{1,2} and Yea-Chen Liu³

Abstract

Athyrium nakanoi Makino is a new fern species record for the Philippines, discovered in Mt. Dulang-Dulang, Kitanglad Range, Mindanao, Philippines extending its original distribution from India, Nepal, Bhutan, China, Taiwan and Japan, Indonesia and Malaysia. Diagnostic description of the species is provided together with its distribution, conservation status and a dichotomous key to the Malesian *Athyrium* Sect. *Polystichoides*.

Keywords: Mindanao, Athyriaceae, ferns, pteridophytes

Introduction

The Philippines is home to 1,100 species of ferns and lycophytes (“pteridophytes”), belonging to 154 genera and 34 families (Amoroso *et al.* 2016). This number continues to increase with new species and new records that have been discovered recently in the country by conducting field work in the unexplored mountain ecosystems. The genus *Athyrium* is mainly distributed in the Asian temperate region, with ca. 220 species in the world (PPG1 2016, Wardani & Adjie 2018). *Athyrium* is represented in the Philippines by 12 species (Wardani & Adjie 2018). These species include *A. anisopterum* Christ., *A. aristulatum* Copel., *A. brevipinnulum* Copel., *A. drepanopteron* (Kunze) Milde, *A. erythropodium* Hayata, *A. fauriei* (Christ) Makino, *A. mearnsianum* (Copel.) Alderw., *A. minutum* Copel., *A. oreopteris* Copel., *A. philippinense* Christ, *A. puncticaule* (Blume) T. Moore and *A. sarasinorum* Christ. These species differ mainly in (1) the presence or absence of spines on the adaxial rachis, costa and costular surfaces of the fronds, (2) the rhizome, dimensions and directions of growth,

from short- to long-creeping, or suberect to erect, (3) divisions of fronds, from pinnate, bi-pinnate to tripinnate-pinnatifid, (4) shape of indusia, from round to reniform, J-shaped or oblong to short linear, (5) shape of sori highly variable from reniform to elongate (Liu *et al.* 2009).

Mt. Kitanglad Range Natural Park in northern Mindanao, Philippines, is a protected area and considered as one of the ASEAN Heritage Parks in northern Mindanao, the Philippines. Encompassing 37,236 ha over the North Central portion of Bukidnon and with the highest elevation of 2,938 m, the park is the headwaters of three major river systems and with frequent visitors (NORDECO & DENR 1998). The range is characterized by three vegetation types, namely, the agroecosystem, lower montane forest and mossy forest, with 661 species, 264 genera, and 106 families of vascular plants (Amoroso *et al.* 2011).

Material and Methods

In April 2012, a botanical exploration on ferns and lycophytes was conducted (FPC and VBA) by means of a transect walk from the foot of Mt. Dulang-Dulang, Kitanglad, Lantapan, Bukidnon up to the summit. Species along the trail were recorded and a complete set of herbarium voucher specimens was collected and deposited at Central Mindanao University (CMUH). All specimens were processed with the wet method (Hodge 1947). It was during that trip that *Athyrium nakanoi* Makino was collected, its identity was later confirmed by YCL. Here we present the diagnostic description based on the studied specimens, distribution notes and conservation status of this species and provided a dichotomous key to the Malesian species of *Athyrium* Sect. *Polystichoides*.

¹Department of Biology, College of Arts and Sciences, Central Mindanao University, Musuan, Bukidnon 8710, Philippines

²Center for Biodiversity Research and Extension in Mindanao (CEBREM), Central Mindanao University, Musuan, Bukidnon 8710, Philippines

³Department of Biological Resource, National Chiayi University, No. 300 University Road, Chiayi City 60004, Taiwan

*Corresponding email: cfulgent@gmail.com

Date Submitted: 06 April 2019

Date Accepted: 15 December 2019

Taxonomic Treatment

Athyrium nakanoi Makino, Bot. Mag. (Tokyo) 23: 247. 1909.
Asplenium macrocarpum var. *unipinnatum* C.B. Clarke, Trans. Linn. Soc. London, Bot. 1(7): 489. 1880.
Nephrolepis tenuissimum Hayata, Icon. Pl. Formosan. 4: 202–204, f. 137.1914.= *Athyrium tenuissimum* (Hayata) Merr. Philipp. J. Sci. 13(3): 126–127. 1918. Type: TAIWAN. Arisan. *U. Faurie* s.n. (BM001045350).
Athyrium obtusifolium Rosenst., Hedwigia 56: 335. 1915. Type: TAIWAN. Arisan. *U. Faurie*, 364 (MICH1191196, MICH1190130, BM001045349).

Terrestrial, evergreen. Rhizome stout, horizontal, ascending at the apex. Stipes 5 to 12 cm long, tufted at the apex of rhizome, purple, base swollen to round, pubescent. Scales on stipe base lanceolate, russet to pale brown, becoming smaller, narrow lanceolate and scattered towards the upper part of stipe. Laminae mostly lanceolate to ovate, 10–30 cm by 4–5 cm, rather thin to papery, pinnate; pinnae lanceolate to deltoid, middle ones with 1.5–2.8 cm in length, 0.6–1 cm wide, acroscopic side elongated becoming auriculate, pinna-petiole 1–2 mm long; rachis and costae pubescent, on both surface without spines. Sori large, reniform with prominent indusia, median and crossing the veinlet; indusia translucent brown, margin serrate or ciliate. Spores brown, rugate type, granulate on surface.

Distribution: North India, Nepal, Bhutan, China (Yunnan,

Tibet), Taiwan, Japan, Indonesia (Sumatra), Malaysia (Pahang, Sabah) and the Philippines (Mindanao).

Philippines: It grows in upper montane forest near water sources on cliffs at an elevation of 2,000–2,200 m. The associated vegetation consisted primarily of large trees, 25–40 m tall, including *Lithocarpus* spp. (Fagaceae), *Dacrydium elatum* (Roxb.) Wall. ex Hook., *Phyllocladus hypophyllum* Hook.f., *Podocarpus* sp. (Podocarpaceae) and *Ficus* spp. (Moraceae). The shrub layer consisted of *Lasianthus* spp. (Rubiaceae), *Melastoma malabathricum* L., *Medinilla* spp. (Melastomataceae), as well as tree ferns, *Alsophila fuliginosa* Christ and *Sphaeropteris elmeri* R.M.Tryon (Cyatheaceae). The ground cover was dominated by more fern species including *Plagiogyria pycnophylla* (Kunze) Mett. (Plagiogyriaceae), *Cranfillia vulcanica* (Blume) Gasper & V.A.O.Dittrich (Blechnaceae), *Ptisana sylvatica* (Blume) Murdock (Marattiaceae), *Asplenium* spp. (Aspleniaceae), and some species of mosses and liverworts.

Specimen examined: PHILIPPINES. Mindanao, Mt. Dulang-Dulang, Kitanglad Range Natural Park, Bukidnon, N 08° 15.301'; E 125° 09.321'; 1,634 masl. January 20, 2014, Coritico, *F.P. 044* (CMUH00008408).

Additional specimens examined: INDONESIA. Sumatra. *Iwatsuki, K.* et al. 1158 (BO1500101); *van Steenis, C.G.G.J.* 8524 (BO1488342, BO1488341). MALAYSIA. Borneo, Sabah, *Holtum, R.E.* 25526 (BO1488244); Malay Peninsula, Pahang,

Table 1. Comparison of the Philippine specimens and specimens deposited in different herbaria

Character	Philippine Specimen	Specimens deposited in the herbaria (BO, KYO, PE, PNH, PYU, SING, TAI, TAIF)
Stipe scale color	pale brown	pale brown
Pinnule apex	rounded	rounded
Pinnule margin	crenate	crenate
Pinna –petiole	1-2 mm	3-5 mm
Lamina length	10-30 cm	5-25 cm
Lamina width	4-5 cm	3-7 cm
Pinnule length	1.5-2.8 cm	1.5-3 cm
Pinnule width	0.6-1 cm	0.5-1 cm
Stipe length	5-12 cm long	1-10 cm long



Plate 1. *Athyrium nakanoi*, a. habit, b. lamina outline, c. pinnules showing the auricle, d. costa pubescent and e. stipe base scale (F.P. Coritico 044) – Photos by F.P. Coritico

Holtum, R.E. 31324 (BO1488252), TAIWAN. Arisan. *Faurie, U.J. 364* (BM001045350); Pingtung Co., Chingshuiyin, *Wang, B.J. 17417* (TAIF163608); Taoyuan Co., North Cross Highway, *Lu, P.F. 6005* (TAIF); *Lu, P.F. 10139* (TAIF 163608); Chiayi Co., Alishan, *Tzeng, Y.Z. 795* (TAIF201683); Hualien Co., Kuanfu logging trail, *Lu, P.F. 7560* (TAIF202684); Tomeili to Paoyai, *Lee, P.H. 3487* (TAIF249127); Ilan Co., Cueifeng Lake, *Lu, P.F. 7612* (TAIF202730); *Lu, P.F. 8760* (TAIF220779); Yuanianghu, *Lu, P.F. 8800* (TAIF220577); *Lu, S.Y. 21926* (TAIF229375); *Lu, S.Y. 21193* (TAIF271254).

There has been no revision of the Philippine *Athyrium* after the work of Copeland (1958). However, comprehensive revision of the family Athyriaceae in Taiwan has been published by Liu *et al.* (2009) and the taxonomic revision of *Athyrium* for Flora Malesiana is ongoing by the present authors. The specimens of *A. nakanoi* varies among themselves mainly in the size of the lamina ranging from 5.0–30.0 by 3.0–7.0 cm, pinnae (1.5–3.0 by 0.5–1.0 cm), stipes (1.0–12.0 cm) and pinnae-petiole (1.0–5.0 mm). Specimen in the Philippines still falls within the morphological range displayed by *A. nakanoi*.

Several infrageneric classifications of *Athyrium* have been proposed primarily based on gross morphology and phylogenetic studies (Liu *et al.* 2011, Rothfels *et al.* 2012, PPG1 2016, Wardani & Adjie 2018, Wei *et al.* 2018).

Athyrium nakanoi belongs to the section *Polystichoides* Ching & Y.T. Hsieh (Wei *et al.*, 2018), which is regarded as a natural group under the genus *Athyrium* including *A. anisopterum* Christ, *A. drepanopterum* (Kunze) Milde and *A. puncticaule* (Blume) T. Moore for the Malesian species. The group has notable morphological characters different from other species of *Athyrium* such as enlarged acroscopic pinnule in the basal pinnae, setae or spines absent on the adaxial surface of costae and costules, curved sori and perisporiate spores (Liu & Fraser-Jenkins 2006, Liu *et al.* 2007).

Key to the species of *Athyrium* Sect. *Polystichoides* for Malesian region including the Philippines

1. Rachis pubescent on both surface.....2
1. Adaxial surface of rachis glabrous.....3
2. Frond bipinatifid, pinna-margin serrate —
India, Sri Lanka, Thailand, Vietnam, China, Peninsular Malaysia, Sumatra, Java,
Borneo, Taiwan and Philippines.....*A. puncticaule*
2. Fronds pinnate, pinna-margin crenate —
India, Nepal, Bhutan, China, Taiwan, Japan and
Philippines.....*A. nakanoi*

3. Pinnate or only with free pinnulae at the base of pinnae —
India, Sri Lanka, Thailand, Vietnam, China, Taiwan, Peninsular Malaysia, Borneo, Sulawesi, Java and Philippines.....*A. anisopterum*

3. Pinnate tripinnatifid to tripinnate —
Bhutan, India, Myanmar, Nepal, China, Vietnam and
Philippines.....*A. drepanopterum*

Notes on Distribution

The new record of *Athyrium nakanoi* is yet another new fern record for the Philippines, like the discoveries of *Athyrium erythropodum* Hayata (Liu *et al.* 2008), *Phanerosorus major* Diels (Barcelona & Pelsner 2014), and *Stenolepia tristis* (Blume) Alderw (Chang *et al.* 2013), *Alsophila commutata* Mett. (Coritico *et al.* 2017). With increased sampling efforts, the ranges of taxa and regional species numbers will likely increase since many areas in the Malesian region, particularly remote mountain ecosystems, are still unexplored and insufficiently sampled.

Conservation Status

Ebihara *et al.* (2012) reported 835 species of pteridophytes as rare and threatened in Asia by consolidating data from published local red lists and knowledge from the pteridologists in different regions. This assessment did not include *A. nakanoi*. In the Philippines, *A. nakanoi* is known from one location and probably restricted to higher elevations, thus further limiting the potential area of occupancy on neighbouring islands of Mindanao. Despite being widely distributed in East Asia, we recommend listing the species as Endangered (EN) for the Philippines at national level.

Acknowledgements

We would like to thank the Biodiversity Management Bureau (BMB) of the Department of Environment and Natural Resources (DENR) Region 10 for the gratuitous permit. Center for Biodiversity Research and Extension in Mindanao (CEBREM) and Central Mindanao University (CMU) for the logistic support and to the local people in the area for the helped during the conduct of the fieldwork. The funding support from the Commission on Higher Education (CHED) and Department of Science and Technology - Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (DOST-PCAARRD) is also acknowledged. We thank the anonymous reviewers whose comments have greatly improved this manuscript.

Literature Cited

- Amoroso, V.B., F.P. Coritico & P.W. Fritsch, 2016. Species Richness and Conservation Status of Ferns and Lycophytes in Mt. Hamiguitan Range Wildlife Sanctuary, Davao Oriental, Philippines. *Philippine Journal of Science*, 145: 127–137.
- Amoroso, V.B., S.H. Laraga & B.V. Calzada, 2011. Diversity and assessments of plants in Mt. Kitanglad Range Natural Park, Bukidnon, Southern Philippines. *Garden's Bulletin Singapore*, 63: 219–236.
- Barcelona J.F. & P.B. Pelsner, 2014. *Phanerosorus* (Matoniaceae), a new fern genus record for the Philippines. *Phytotaxa*, 170: 133–135.
- Chang, Y-H, L.Y. Kuo, W.L. Chiou, C.W. Chen, H.M. Chang & V.B. Amoroso, 2013. *Stenolepia* Alderw. (Dryopteridaceae), a fern genus new to the Philippines. *Philippine Journal of Science*, 142: 83–88.
- Copeland, E.B, 1958. Fern flora of the Philippines. Vol. 1–3. Manila Bureau of Printing, 555 pp.
- Coritico, F.P., V.B. Amoroso & M. Lehnert, 2017. New records, names and combinations of scaly tree ferns (Cyatheaceae) in eastern Malesia. *Blumea*, 62: 92–96.
- Ebihara, A., C.R.F. Jenkins, B.S. Paris, X.C. Zhang, Y.H. Yang, W.L. Chiou, H. M. Chang, S. Lindsay, D. Middleton, M. Kato, T.N. Praptosuwiryo, V.B. Amoroso, J.F. Barcelona, R.H.G. Ranil, C.H. Park, N. Murakami & A. Hoya, 2012. Rare and threatened pteridophytes of Asia. An enumeration of narrowly distributed taxa. *Bulletin of the National Museum of Nature and Science, Series B (Botany)*, 38: 93–119.
- Hodge, W.H, 1947. The use of alcohol in plant collecting. *Rhodora*, 49: 207–210.
- Liu, Y. C. & C.R. Fraser-Jenkins, 2006. *Athyrium puncticaule* (Blume) T. Moore (Woodsiaceae), new to Taiwan. *Taiwania*, 51: 293–297.
- Liu, Y.C., Z.R. Wang & H.Y. Liu, 2007. Confirmation of Two Endemic *Athyrium* Species (Woodsiaceae) in Taiwan. *American Fern Journal*, 97: 166–173.
- Liu, Y.C., C.R. Fraser-Jenkins, V.B. Amoroso & W.L. Chiou, 2008. *Athyrium erythropodum* (Woodsiaceae, Pteridophyta), a new Philippine record. *Blumea*, 53: 447–451.
- Liu, Y.C., W.L. Chiou & H.Y. Liu, 2009. Fern Flora of Taiwan: *Athyrium*. Taiwan Forestry Research Institute (TFRI Extension Series No. 198). Taipei, Taiwan, 111 pp.
- Liu, Y.C., W.L. Chiou, & M. Kato, 2011. Molecular phylogeny and taxonomy of the fern genus *Anisocampium* (Athyriaceae). *Taxon*, 60: 824–830.
- NORDECO & DENR, 1998. Integrating Conservation and Development in Protected Area Management in Mt. Kitanglad Range Natural Park, the Philippines. DENR, Manila, and NORDECO, Copenhagen. 138 pp.
- Pteridophyte Phylogeny Group (PPG1), 2016. A community-derived classification for extant lycophytes and ferns. *Journal of Systematics and Evolution*, 54: 563–603.
- Rothfels, C.J., M.A. Sundue, L.Y. Kuo, A. Larsson, M. Kato, E. Schuettpehl & K.M. Pryer, 2012. A revised family-level classification for eupolypod II ferns (Polypodiidae: Polypodiales). *Taxon*, 61: 515–533.
- Wardani, W. & B. Adjie. 2018. The genus *Athyrium* Roth in Malesia: a checklist with working names and distributions. *Sibbaldia*, 16: 39–48.
- Wei, R., A. Ebihara, Y.M. Zhu, C.F. Zhao, S. Hennequin & X.C. Zhang, 2018. A total-evidence phylogeny of the lady fern genus *Athyrium* Roth (Athyriaceae) with a new infrageneric classification. *Molecular Phylogenetics and Evolution*, 119: 25–36.