PROS SEM NAS MASY BIODIV INDON
Volume 1, Nomor 6, September 2015 ISSN: 2407-8050
Halaman: 1318-1323 DOI: 10.13057/psnmbi/m010610

Diversity of *Selaginella* in the karstic region of Sewu Mountains, Southern Java

Keanekaragaman *Selaginella* di kawasan karst Pegunungan Sewu, Jawa bagian selatan

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Manuscript received: 27 March 2014. Revision accepted: 7 July 2015.

Abstract. *Setyawan AD, Sugiyarto, Susilowati A, Widodo. 2015. Keanekaragaman* Selaginella *di kawasan karst Pegunungan Sewu, Jawa bagian selatan. Pros Sem Nas Masy Biodiv Indon 1: 1318-1323*. Pegunungan Sewu merupakan rangkaian pegunungan menengah (400-500 m. dpl), terletak di bagian selatan Pulau Jawa, merupakan salah satu kawasan karst paling lengkap di Indonesia baik secara geologi, ekologi, ekonomi dan budaya. Kawasan karst dicirikan oleh batuan yang terangkat dari dasar laut dan mudah larut oleh air hujan, sehingga membentuk kubah-kubah bukit, lembah-lembah, dan gua-gua di bawah tanah. Kawasan ini mudah mengalami kekeringan karena tidak mampu menahan air. Sementara itu, *Selaginella* merupakan tumbuhan herba yang membutuhkan air sebagai media untuk fertilisasi. Penelitian ini bertujuan untuk mengetahui jenis-jenis *Selaginella* yang mampu bertahan hidup pada habitat karst Pegunungan Sewu. Penelitian lapangan dilakukan beberapa kali pada Agustus 2007, November 2011 dan Agustus 2013. Dilakukan pula pengamatan lembar herbarium *Selaginella* koleksi Herbarium Bogoriense (BO), Pusat Penelitian Biologi, LIPI, Cibinong, Bogor, namun dari 600 lembar herbarium *Selaginella* dari Jawa tidak ada yang berasal dari Pegunungan Sewu. Dalam penelitian ini ditemukan empat jenis *Selaginella,* yaitu: *S. ciliaris, S. involvens, S. plana,* dan *S. repanda. S. ciliaris* merupakan jenis yang memiliki keragaman morfologi sangat tinggi sehingga mampu tumbuh pada berbagai habitat. Keberadaan *S. involvens* cukup menarik karena jenis ini biasanya tumbuh di dataran tinggi. *S. plana* merupakan jenis dataran rendah, sehingga dapat ditemukan di tempat-tempat lembab dan teduh. *S. repanda* merupakan jenis yang beradaptasi dengan kawasan kering, sehingga sangat mudah dijumpai di kawasan Pegunungan Sewu.

Kata kunci: Jawa selatan, karst, kering, Pegunungan Sewu, *Selaginella*

Abstract. *Setyawan AD, Sugiyarto, Susilowati A, Widodo. 2015. Diversity of* Selaginella *in the karstic region of Sewu Mountains, Southern Java. Pros Sem Nas Masy Biodiv Indon 1: 1318-1323.* Sewu mountains are a series of medium-sized mountains (400-500 m asl.), located in the southern part of Java Island, are one of the most complete karst areas in Indonesia, both in geology, ecology, economy and culture. Karst region is characterized by a rock lifted from the seabed and easily dissolved by rainwater, thus forming the domes of hills, valleys, and underground caves. This area is prone to drought because it is not able to hold water. Meanwhile, *Selaginella* is a herbaceous plant that requires water as a media to fertilization. This study aims to determine wether the species of *Selaginella* are able to survive in karst habitats of Mts. Sewu or not. Fieldwork was conducted several times in August 2007, November 2011 and August 2013. These should include observation on herbarium sheets of *Selaginella* collection from Herbarium Bogoriense (BO), the Research Center for Biology, IIS (LIPI), Cibinong, Bogor, but of 600 herbarium sheets of *Selaginella* of Java, no specimen comes from Mts. Sewu. In this study, it was found four species of *Selaginella*, namely: *S. ciliaris, S. involvens, S. plana,* and *S. repanda. S. ciliaris* is a species that has a very high morphological diversity so that they can grow in a variety of habitats. The existence of *S. involvens* is quite interesting because this species usually grows in highlands. *S. plana* is a lowland species, so it can be found in moist places and shady. *S. repanda* is a species adapted to dry areas, making it very easy to be found in the Mts. Sewu region.

Keywords: Southern Java, karst, dry, Sewu Mountains, *Selaginella*

INTRODUCTION

Karst regions cover an area of 15.4 million hectares in Indonesia. These regions are formed between 700,000 and 470 million years ago, through the uplifting of the sea floor, followed by drying and hardening. These areas are evenly distributed throughout Indonesia, indicating that many islands are actually from the sea floor. Karst rocks are relatively susceptible to dissolution by water, thus that the karst regions are characterized by a lot of hills (dome, cone-shaped or tower hills), closed basin (valleys and lakes), underground rivers and caves (Van Bemmelen 1949; Gillison 1996; MoE 2004). Some geologically, ecologically, economically and social culturally important karst areas in Indonesia are Sewu Mountains of southern Java, Maros Mountains of South Sulawesi and Lorentz

Mountains of Papua. These three ecosystems have been proposed to UNESCO to become a World Heritage Sites.

Karst region has a specific hydrological and landform conditions; derived from soluble rocks (limestone, marble, gypsum, halite) and has many fissures (Ford and Williams 2007). There are 17 major karst area in Indonesia, of which two are the best karst and regarded as the prototype of a tropical karst area, namely Maros (Sulawesi) and Gunung Sewu (Java) (Balazs 1968). Gunung Sewu is a type of extensive karst area with thousands of conical and dome hills, and there are valleys between hills with terrarosa soil that can hold water and be used for farmland. The rivers flow into the subsurface through caves and sinkholes, and form the underground river system. This type is found along the southern mountains of East Java to Yogyakarta (Lehman 1936).

Mts. Sewu (Gunung Sewu) (0-512 m asl.) is the karst mountain range stretched along the southern coast of Java, in the districts of Gunungkidul (Yogyakarta), Wonogiri (Central Java), and Pacitan (East Java). The western part of the region is bordered by the Opak River, the eastern part is bordered by Gulf of Pacitan, and the southern part is bordered by the Indian Ocean, whereas the northern part's borders are more complex, such as Baturagung Mountains, Panggung Basin, and Baturetno Basin (Van Bemmelen 1949; Bronto and Hartono 2001) (Figure 1).

Mts. Sewu consists of thousands of conical karst hills (about 40,000 hills) (Balazs 1968), therefore it is called thousand mountains (Gunung Sewu). There are also karst valleys, karst lake (443 pounds), karst caves (119 caves) with stalactites and stalagmites and underground rivers. The longest cave is Luweng Jaran in Pacitan (25 km), while the deepest cave is Luweng Ngepoh (200 m) (Mac Donald and Partners 1984). The area of limestone sediment reaches 1300 km^2. Karst length from west to east is 85 km, while the width from north to south about 10-15 km. At the Wonosari basin, karst thickness is more than 200 m, while in the mountainous southern part is about 650 m (Flathe and Pfeiffer 1965; Haryono and Day 2005; Haryono et al. 2009).

Karst vegetation is highly dependent on local environmental condition in which a stand grows. At Mts. Sewu, there are at least 65 families of plants (253 species). Native plant of Mts. Sewu karst areas include banyan trees, such as: *Ficus benjamina, F. glomerata, F. callosa, F. consociata, F. ribes, F. drupacea* and *F. annulata*; there are also *Feroniella lucida* and *Tetrameles nudiflora*. Another native plant is only found in a small relics and not abundant (Hadisusanto 2011). *Selaginella* is a herbaceous plant that requires a lot of water to grow and carry out reproduction. This plant is relatively abundant in the humid highlands and the area with high rainfall, but there is also species that adapt in relatively dry areas, such as karst and deserts.

This study is to determine the species diversity of *Selaginella* in Mts. Sewu, southern Java, Indonesia. It is an extension study of Setyawan et al. (2015), which only discusses the diversity of *Selaginella* in Mts. Sewu located at Yogyakarta province, while the remaining areas in the provinces of Central Java and East Java are not covered, therefore there is no complete overview of the diversity of *Selaginella* in Mts. Sewu.

MATERIALS AND METHODS

Study areas

This research is primarily conducted in the karst area of Mts. Sewu, but also along its border area, in the southern part of Java that is administratively includes the districts of Gunungkidul (Yogyakarta), Wonogiri (Central Java) and Pacitan (East Java), Indonesia (Figure 1). Several surveys of *Selaginella* had been carried out, with altitude between 0 and 500s m asl. Geographically, the study area is located between -7.8388° and -8.2548° (S) and between 110.3148° and 111.0799° (E), the total area of karst more than 1300 km^2. The altitude varies from 0 m in the southern coastal area to 512 m asl. in the north; the temperature is ranging between 24-32^{o}C, the relative humidity is 80-85%, the average rainfall is 1500-2986 mm (Haryono and Day 2005; BPS Gunungkidul 2014, BPS Wonogiri 2014). More than half of the region's land is used for dryland farming; the remainder is agroforestry (community forests), state forest, home garden, rivers, lakes, developing areas (settlements, roads), etc. Healthy forest is only found in a limited size such as Wanagama forest.

Procedures

The field work was conducted several times in August 2007, November 2011 and August 2013. All *Selaginella* species were recorded and collected as herbarium specimens and living collection for the experimental garden in Kejiwan, Wonosobo, Central Java (768 m asl.). Both living plants and herbarium specimens were observed. Specimens of field collection were deposited at Herbarium Soloense (SO), Sebelas Maret University, Surakarta, Indonesia and some selected specimens will be sent to Herbarium Bogoriense (BO), Research Center for Biology, IIS (LIPI), Cibinong, Bogor, Indonesia. It was also conducted examination of the herbarium sheet of Selaginella from Herbarium Bogoriense (BO), but of 600s herbarium sheets of Java Selaginella only one collected from Sewu Mountains, i.e. CA Backer 2750 (*S. plana*). A total of 19 herbarium specimens of *Selaginella* have been collected from 13 locations of the study area during field observations and one specimen from BO. Each herbarium specimen was unique, distinguished by location and time of collection. Data passport collected along with the specimens were used as standard for herbarium specimens.

The specimens were identified by using several early literatures on *Selaginella* in Malay Archipelago, i.e. Alston (1934a, 1935a,b, 1937, 1940); and also by using several latest references from Malay Archipelago and adjacent area such as Wong (1982, 2010), Tsai and Shieh (1994), Li and Tan (2005), Chang et al. (2012), and Setyawan et al. (2012, 2013), Zhang et al. (2013). In addition to direct observations, the literatures were used to guide the preparation of description. Meanwhile, the global distribution was mainly according to Hassler and Swale (2002) and Chang et al. (2012). Locality is according to the administrative division of sub-district level. Data were also subjected to analysis of distribution using DIVA-GIS program.

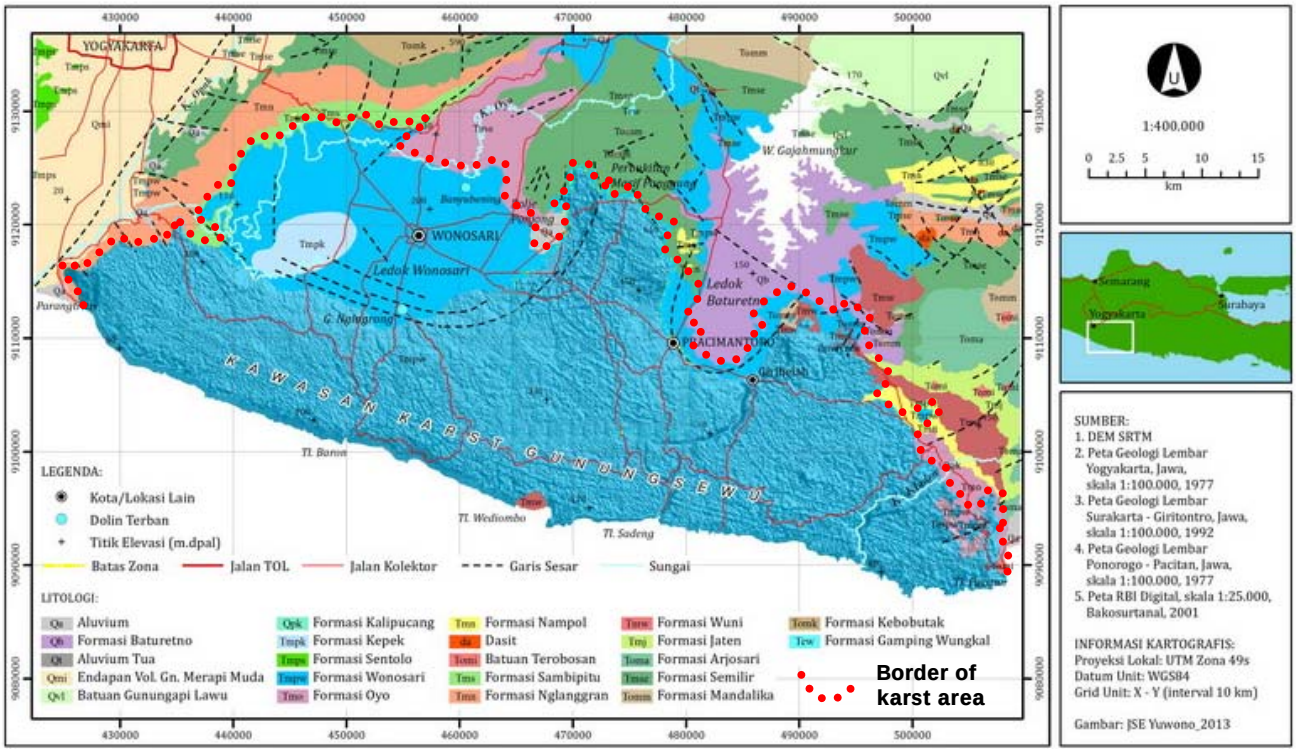


Figure 1. Mts. Sewu karst area and the surrounding areas (Yuwono 2013)

RESULTS AND DISCUSSION

In this study, four species of *Selaginella* are found, namely: *S. ciliaris, S. involvens, S. plana,* and *S. repanda. S. ciliaris* has a very high morphological diversity and is also suspected to have a high genetic diversity, and therefore able to grow on a variety of different habitats. In this study, *S. ciliaris* is only found in 4 of the 13 locations, since the research conducted in the transition season, the turning over of the dry season to rainy season. *S. ciliaris* is known to rapidly grow and develop in the rainy season, where water resources are abundant and die in the dry season, except in small amounts in humid places. This is known as r strategy, where the population is capable for rapidly growing in large quantities at certain times, when environmental conditions favor (MacArthur and Wilson 2001). Meanwhile, other *Selaginella* has K strategy, which is a strategy to only grown in unlimited quantities, and survives throughout the year. However, as the herbaceous plants, abundance is lower in the dry season than in the rainy season.

Selaginella involvens is only found in one of the 13 places, namely in Nglanggeran (502 m asl) which borders the karst area, part of the Baturagung mountains. This discovery is exciting because it usually grows in the highlands (> 1000 m asl.), such as the Dieng Plateau (Setyawan et al. 2015), Mts.Sindoro-Sumbing (Setyawan 2012), Mt. Merapi (Setyawan et al. 2012) and Mt. Lawu (Setyawan et al. 2013). *S. involvens* is a terrestrial plant, grows on the cliffs, but can also be xerophytic in the rocks crevices or epiphytes on trees (but very rarely). Setyawan et al. (2012) reported *S. involvens* attached to *Pinus merkusii*. In Nglanggeran, this species grows in moist places, on the sidelines of rocks, slightly open, and shaded. This place is also a favorable growing sites of *S. repanda*.

Selaginella plana is a typical lowland species and evenly grows in Java from the sea shore to the mountains with an altitude of about 1000 m asl. (Setiawan et al. 2012; Setyawan et al. 2013). In this study, this species can be found at an altitude of about 100 m asl. and is only about 20 m from sea shore in the Gulf of Pacitan (specimen of ADS 1006). This species is found both inside and outside of the karst region. *S. plana* can be found on neglected humid place, near the watering place, shaded from the sun, but rather open.

Selaginella repanda is an adapted species to dry areas, making it very easy to find in Mts. Sewu and the surrounding regions. It attaches to the rocks and uses leaf litter as source of nutrients, and mainly grows in a slightly shaded, humid and wet place. The leaves tend to be strong, pointed or tapered, as a form of adaptation to the dry areas. In this study, *S. repanda* has the highest frequency of appearance, which is found in 11 of the 13 sampling sites (85%).

Selaginella ciliaris (Retz.) Spring, Bull. Acad. Brux. 10: 23 (1843) (Figure 3A).

This plant is an annual herb, small, creeping, ascending or prostrate, stramineous, 3-11.5 cm long, glabrous, angular or sulcate, rooting at intervals but mostly near the base, in a clump or individually, green to yellowish green. *Stems* are decumbent, branched, without a significant main stem, 4-5

mm wide (incl. leaves). *Rhizophores* present at intervals especially near the base, originated from the ventral side in axils of branches, ca. 0.2.5 mm in diam. *Leaves* are dimorphic, arranged in 4 lanes (2 lateral, 2 median), single vein; *lateral leaves* are ovate to lanceolate, more or less symmetrical, 1.5-2 mm long, 0.6-1 mm wide, acuminate or acute apex, subcordate or rounded base, ciliate or serrulate margin, single vein, keeled, pointing outwards; *median leaves* are ovate to falcate, contiguous, nearly asymmetrical, 2-2.5 mm long, 0.6-1.5 mm wide, acute apex, cuspidate or aristate, subcordate or rounded base, serrulate margin but laciniate at basal, pointing upwards, minutely toothed, ciliate, slightly carinate, midrib prominent, single vein; *axillary leaves* are lanceolate to ovate, equally sided or slightly asymmetrical, 1.6-2.5 mm long, 1-1.5 mm wide, single vein, acute apex, subcordate or rounded base, exauriculate, ciliate, ciliate margin or laciniate at basal part, apically serrulate or finely toothed. *Strobili* are solitary, terminal, compact, flattened dorsiventrally or complanate, up to ca. 0.6-2 cm long; sporophylls are strongly dimorphic, spore greenish-yellowish orange.

Habitat and ecology: It is strongly influenced by season. Since it has small size and short roots, the plants die during the dry season and sprout new plantlets at the beginning of the rainy season (r-selection). Its habitat is the rock cliffs inside and the edges of forests, rock cliffs and rock walls at the edge of road, around ponds, springs and ditches, in the shade of many trees, e.g. bayan and coconut, the hills above the Bay of Pacitan. It is found at altitudes of 45-466 m asl.

Locality: Wonogiri (Nguntoronadi), Pacitan (Donorojo, Pacitan-city).

Distribution: N-Australia, S-China, India, Indonesia, Marianas, Micronesia, Myanmar, New Guinea, Palau Isl., Philippines, Sri Lanka, Solomons Isl., Taiwan, Thailand, Vietnam. In Indonesia: Java, Sulawesi, Maluku (Ternate).

Specimen observed: ADS 997, ADS 999, ADS 1001, ADS 50.

Selaginella involvens (Sw.) Spring, Bull. Acad. Brux. 10: 136, no. 6 (1843) (Figure 3B)

This plant is a perennial herb, robust, ascending or erect, without branches on the lower half, with a creeping subterranean rhizome, fan-shaped frond, terrestrial, epiphythic or xerophytic, green to yellowish green, rolling up when dry, up to ca. 50 cm tall, 3-4 cm wide (incl. leaves). *Stems* are hard, but easily broken, main stems pinnately branched from half upward, dendritic, fan-shaped, stramineous, unbranched main stem 20-50 cm long, 1-1.4 mm in diam. with several leaves and dormant buds. *Rhizophores* present at intervals, only at creeping rhizomes. *Leaves* are on the rhizome scale-like, monomorphic, ovate, ciliate, sessile, acute apex, recurved or appressed, colorless to pale yellow or brown, about 1 mm long, 0.4-1 mm wide; Leaves of the main stem are monomorphic, ovate, sessil, nearly asymmetrical, well-spaced, appressed, 1-2 mm long, 1-1.7 mm wide, acute to attenuate apex, truncate base, auriculate or not, serrate to serrulate margin, lacerate at the auricule, long ciliate towards apex. Leaves of the branches are dimorphic, arranged in 4 lanes (2 lateral, 2 median), single vein, reaching the apex; *lateral leaves* are lanceolate to ovate, contiguous or overlapping, slightly ascending, asymmetrical, 1-2.5 mm long, 0.2-1.5 mm wide, slightly carinate, ciliate near the base, attenuate or acuminate apex, cuneate base or oblique with auriculate, vein curved and pointing to abaxial side, with 2 grooves beside the vein, adaxial blade forming two main-vein, margin denticulate or laciniate, spinose at the auricule; *median leaves* are ovate on the main stem but elliptical or laceolate to ovate on the top branch, asymmetrical, 1.5-2,8 mm long, 1-2.5 mm wide, acute apex, rounded to subcordate base, twisting to form miniature auricle at the base, single vein, obscure, having 1-2 groove(s) at the adaxial side and 2-3 grooves at the abaxial side on the top branch, inside the midrib, entire to serrate margin, laciniate at most basal part of margin, concentrated spinose at the auricle base, minutely ciliate, pointing upwards; *axillary leaves* are ovate to cordate or lanceolate to ovate, nearly symmetrical, 1-2.5 mm long, 0.5-1.5 mm wide, acute or attenuate apex, subcordate or cordate base, exauriculate, serrate margin but laciniate at basal, minutely ciliate or denticulate. *Strobili* are solitary, terminal, tetragonal, compact, up to 2 cm long; sporophylls are monomorphic.

Habitat and ecology: It is found on the crevices between the rocks of an ancient volcano Nglanggeran; at altitude of 502 m asl.

Locality: Gunungkidul (Patuk)

Distribution: Bhutan, Cambodia, China, India, Indonesia, Japan, Korea, Laos, Myanmar, Nepal, Palau Isl., Sri Lanka, Philippines, Taiwan, Thailand, Vietnam. In Indonesia: Java, Lesser Sunda Isl. (Flores), Kalimantan, Sulawesi.

Specimen observed: ADS 488.

Selaginella plana (Desv. ex Poir.) Hieron., Nat. Pflanzenfam. 1 (4): 703 (1901) (Figure 3C)

This plant is a perennial herb, stout, suberect to ascending with shallowly subterranean rhizome, without branches on the lower part, glabrous, fan-shaped, green, yellowish-green or brownish-green. *Stems* are suberect to ascending, branches on the upper half, up to 80 cm long, 4-10 cm wide (incl. leaves); rhizome shallowly creeping. *Rhizophores* rarely present, originated from the dorsal side of stem at the branch site, ca. 1-1.5 mm in diam. *Leaves* of the lower part and main stem are monomorphic, well-spaced, appressed, 1.5-3 mm long, 1-2 mm wide, upper part slightly spreading, ovate, asymmetrical, acute or acuminate apex, but rounded tip, translucent, entire margin. Leaves on the branches are dimorphic, arranged in 4 lanes (2 dorsal, 2 ventral), well-spaced at lower stem, but closely arranged at branches; *lateral leaves* are oblong to ovate, asymmetrical, 2.5-4 mm long, 2-3 mm wide, acute-acuminate to rounded apex, but rounded tip, sessile, single vein, obscure, not reaching the apex, rounded and truncate base, upper base with a spur-like lobe which overlaps the stem, transparent, entire margin; *median leaves* are ovate to oblong, asymmetrical, 1.5-2.8 mm long, 1-2 mm wide, acuminate-acute to obtuse-rounded apex, but rounded tip, sessile, single vein, obscure not reaching the apex, truncate or rounded base, transparent, entire margin;

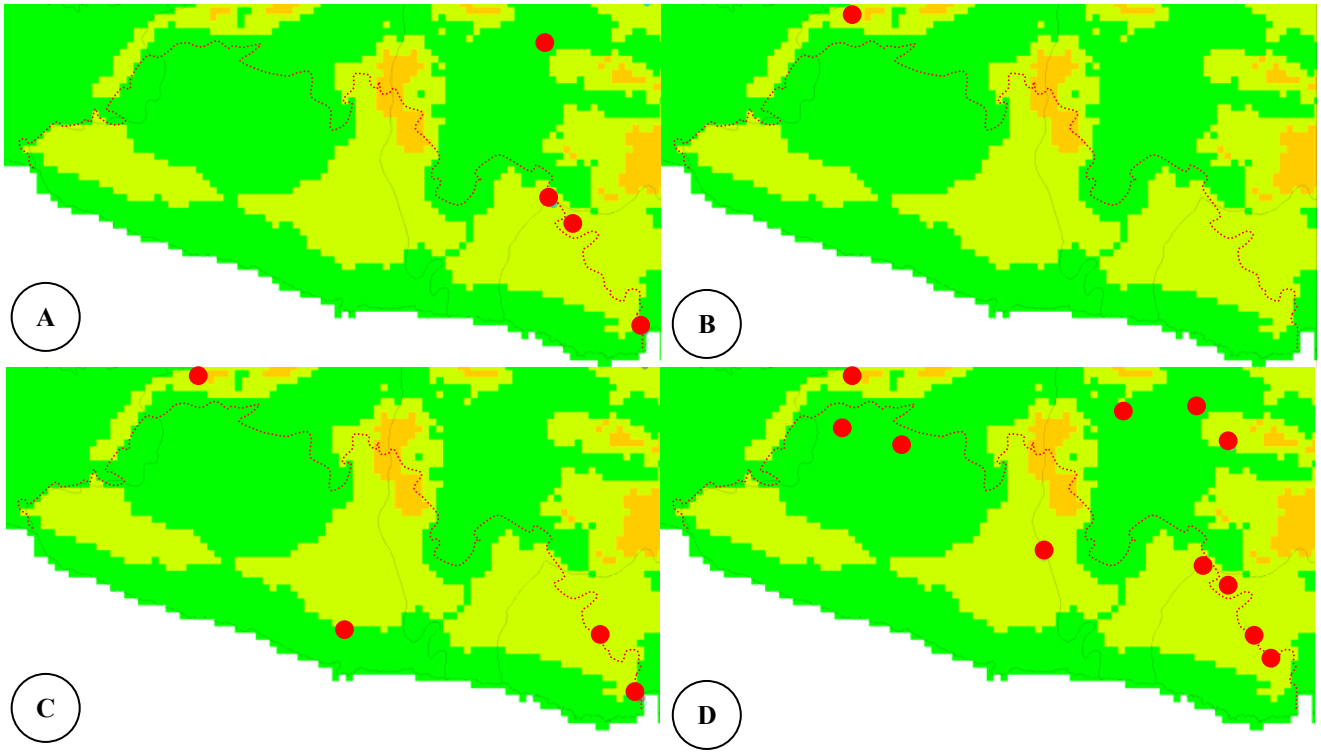
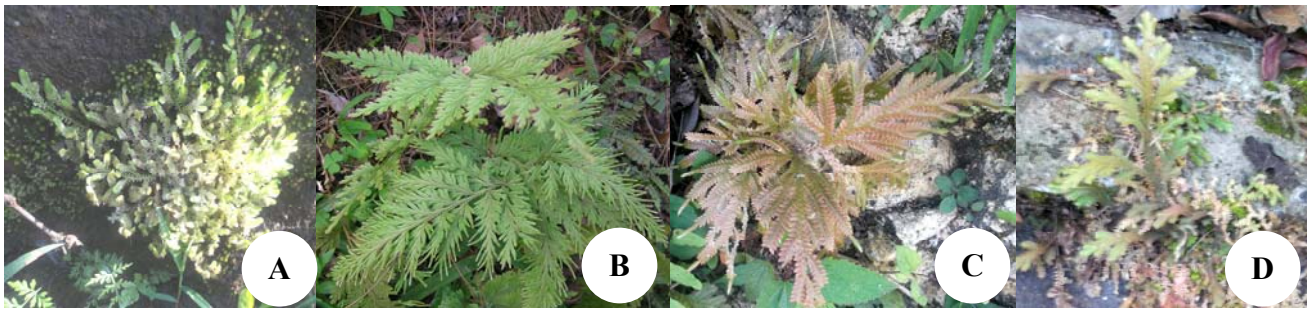


Figure 2. Selaginellas distribution in karst region of Mts. Sewu and the surrounding areas. A. *S. ciliaris,*B. *S. involvens,* C. *S. plana,* D. *S. remotifolia*. Note: ..... = Karst border area of Mts. Sewu, ● = *Selaginella* site collection.



Gambar 3. Selaginellas diversity of Mts. Sewu and the surrounding areas. A. *S. ciliaris,*B. *S. involvens,* C. *S. plana,* D. *S. remotifolia*.

axillary leaves are ovate or obovate-oblong, asymmetrical, 2.5-3.5 mm long, 1.5-2.5 mm wide, acute to slightly acuminate apex, minutely ciliate, rounded base, entire margin. *Strobili* are solitary, terminal, tetragonal, up to more than 3 cm long; sporophylls are monomorphic.

Locality: Gunungkidul (Patuk), Pacitan (Punung, Pacitan-city)

Habitat and ecology: It is found around the crevices between the rocks of an ancient volcano Nglanggeran, sheer cliffs cut for roads, springs at the foot of steep cliffs; at altitudes of 102-502 m asl.

Distribution: Indonesia, Malaysia (Peninsular). In Indonesia: Java, Lesser Sunda Isl. (Bali, Flores, Sumbawa, Solor, Timor), Sulawesi, Sumatra, Maluku (Ambon, Banda, Buru, Ceram, Kei Isl., Ternate). Introduced to Asia: India, Philippines, Taiwan. Introduced to America: Barbados, Brazil, British Guyana, Colombia, Costa Rica, Dominica, Ecuador, Honduras, Jamaica, Martinique, Panama, Puerto Rico, USA (Florida), St. Kitts, St. Thomas, Trinidad. Introduced to Africa: Tanzania.

Specimen observed: ADS 489, ADS 1003, ADS 1006 and CA Backer 2750 (BO!).

Selaginella repanda (Desv. ex Poir.) Spring, Gaud. Voy. Bonite Bot. 1: 329 (1846) (Figure 3D)

This plant is a perennial (or sometimes annual) herb, terrestrial or epiphytic, ascending from decumbent base, ciliate, brownish or reddish green, scabrous; multiple branched at creeping stem, forming ascending dendritic, fan-shaped generative stem. *Stems* are oval or terete, stramineous, 2-forked, consists of two stem types, i.e. creeping on the ground (vegetative), multiple branched, forming diffuse mats, up to ca. 40 cm long, 3-4 mm wide (incl. leaves); or decumbent to ascending (generative), dendritic, fan-shaped, especially at the mature ones, ca. 10-

25 cm long, 4-5 mm wide (incl. leaves). *Rhizophores* present at creeping stem, and sometimes also on base of ascending ones, originated from ventral side in axils of branching stem, ca. 1 mm in diam. *Leaves* are dimorphic, those on main stem larger than those on branches, arranged in 4 lanes (2 lateral, 2 median), sparsely arranged at main stem but overlapping at the branches, single vein; *lateral leaves* are oblong-falcate, asymmetrical, approximate, spreading, 2-2.5 mm long, 1-1.5 mm wide, acute apex, rounded base, ciliolate margin, minutely denticulate to apex, single vein; *median leaves* are smaller than the lateral ones, asymmetrical, approximate, obliquely ovate at branches, 1-2 mm long, 0.5-1 mm wide, slightly carinate or not, long acuminate to shortly aristate apex, obliquely subcordate base, not peltate, long ciliate margin (denticulate to apex), reflexed, parallel to axis; *axillary leaves* are ovate or ovate-lanceolate, less or more symmetrical 2-3 mm long, 1-1.5 mm wide, acute or acuminate apex, rounded-obtuse base, exauriculate, ciliolate margin, single vein. *Strobili* are solitary, terminal, compact, subtetragonal or subcomplanate, 2-6 mm long; sporophylls are submonomorphic or sometimes dorsal sporophylls longer, spores orange-brown to bright yellow.

Locality: Gunungkidul (Patuk, Playen, Rongkop), Wonogiri (Nguntoronadi, Wuryantoro), Pacitan (Donorojo, Pringkuku, Punung).

Habitat and ecology: It is commonly found around small streams in secondary forests and karst hills, around ponds, springs, production forest of Banaran, riverside of Wuryantoro being dried up, on the banks of river dried up under the bridge, in a pool and leafy trees, around the spring water and ditches, shaded by trees, e.g. bayan and coconut, in the crevices between the rocks of Nglanggeran ancient volcano, karst cliffs, steep rock cliffs inside and the edges of forests, steep rock cliffs and the rock wall at the edge of road, steep cliffs that cut for the road; at altitudes of 129-466 m asl.

Distribution: Bhutan, Cambodia, China (common), India (from Sikkim to Tamil Nadu), Indonesia, Laos, Malaysia (Perlis), Myanmar, Nepal, Philippines, Taiwan, Thailand, Vietnam. In Indonesia: Java, Lesser Sunda Isl. (Sumbawa, Timor), Sumatra.

Specimen observed: ADS 48, ADS 49, ADS 134, ADS 485, ADS 486, ADS 487, ADS 998, ADS 1000, ADS 1002, ADS 1004 and ADS 1005.

ACKNOWLEDGEMENTS

The authors thank the Herbarium Bogoriense (BO), RCB-IIS (LIPI), Cibinong-Bogor, Indonesia for facilitating the herbarium materials.

REFERENCES

Alston AHG. 1935a. The *Selaginella* of the Malay Islands: I. Java and the Lesser Sunda Islands. Bull Jard Bot Buitenzorg 3 (13): 432-442.

Alston AHG. 1935b. The Philippines species of *Selaginella*. Philippines J Sci 58: 359-383.

Alston AHG. 1937. The *Selaginella* of the Malay Islands: II. Sumatra. Bull Jard Bot Buitenzorg 3 (14): 175-186.

Alston AHG. 1940. The *Selaginella* of the Malay Islands: III. Celebes and the Maluku. Bull Jard Bot Buitenzorg 3 (16): 343-350.

Alston, AHG. 1934. The genus *Selaginella* in the Malay Peninsula. Gard Bull Strait Settl 8: 41-62.

Balazs D. 1968. Karst Regions in Indonesia. Karszt-Es Barlangkutatas 5: 3-61.

BPS Gunungkidul. 2014. Gunung Kidul in Figures 2013. BPS Gunungkidul, Wonosari

BPS Wonogiri 2014. Wonogiri in Figures 2013. BPS Wonogiri, Wonogiri

Bronto, S. dan Hartono HG. 2001. Panduan Ekskursi Geologi Kuliah Lapangan. STTNAS, Yogyakarta. [Indonesian]

Chang HM, Chiou WL, Wang JC. 2012. Flora of Taiwan, Selaginellaceae. Endemic Species Research Institute, Nantou, Taiwan.

Flathe H, Pfeiffer D. 1965. Grundzuge der morphologie, Geology und Hydrogeologie im Karstgebiet Gunung Sewu (Java, Indonesien). Geologisches Jahrbuch 83: 533-562.

Ford DC, Williams PW. 2007. Karst Hydrology and Geomorphology. 2nd ed. Wiley, London.

Gillison D. 1996. Caves: Process, Development and Management. Blackwell, Oxford.

Hadisusanto S. 2011. Workshop Berbagai Informasi Untuk Meningkatkan Upaya Konservasi Kawasan Kawasan Karst Gunung Sewu dan Menoreh. Balai Konservasi Sumber Daya Alam Yogyakarta, 18 - 19 Oktober 2011. [Indonesian]

Haryono E, Day M. 2004. Landform Differentiation within The Gunung Kidul Kegelkarst, Java-Indonesia. J Cave Karst Stud 66 (2): 62-68.

Haryono E, Adji TA, Widyastuti M. 2009. Environmental problems of Telaga (Doline Pond) in Gununsewu Karst, Java Indonesia. In: White WB. Proceeding 15th International Congress of Speleology, Volume II, UIS, Texas, USA.

Hassler M, Swale B. 2002. Checklist of world ferns. http://homepages.caverock.net.nz;

Lehmann H. 1936. Morphologische Studien auf Java. Geographische Abhandlungen 3 (9): 1-114

Li ZJ, Tan BC. 2005. A review of the species diversity of *Selaginella* in Fujian Province of China. Acta Phytotaxonomica Sinica 43 (1): 50-59

MacArthur R, Wilson EO. 2001. The Theory of Island Biogeography (reprint ed.). Princeton University Press, New Jersey.

MacDonald and Partners. 1984. Greater Yogyakarta Groundwater Resources Study. Volume 3: Groundwater. Directorate General of Water Resources Development Project (P2AT), Ministry of Public Works, Government of The Republic of Indonesia, Jakarta.

MoE. 2004. State of Environmental Report of Indonesia. Ministri of Environment GoI, Jakarta.

Setyawan AD, Sugiyarto, Widiastuti A. 2012. Species diversity of Selaginella in Mount Merapi National Park, the central part of Java. Proc Soc Indon Biodiv Intl Conf 1: 102-106.

Setyawan AD, Sugiyarto, Widiastuti A. 2015. Species diversity of Selaginella in the Dieng Plateau, Central Java. Pros Sem Nas Masy Biodiv Indon 1: 980-985.

Setyawan AD, Sugiyarto, Susilowati A, Widodo. 2015. Diversity and distribution of *Selaginella* in the Provinve of Yogyakarta Special Region. Pros Sem Nas Masy Biodiv Indon 1: 986-991.

Setyawan AD, Sutarno, Sugiyarto. 2013. Species diversity of *Selaginella* in Mount Lawu, Java, Indonesia. Biodiversitas 14: 1-9

Setyawan AD. 2012. Altitudinal distribution of *Selaginella* in the southern part of Central Java, Indonesia. Proc Soc Indon Biodiv Intl Conf 1: 153-157.

Tsai JL, Shieh WC. 1994. Selaginellaceae. In: Huang TC (ed) Flora of Taiwan. Vol. 1. 2nd ed. Department of Botany, National Taiwan University, Taipei

van Bemmelen RW. 1949. The Geology of Indonesia, Martinus Nyhoff, The Haque, Nederland.

Wong KM. 1982. Critical observations on Peninsular Malaysian *Selaginella*. Gard Bull Sing 35 (2): 107-135

Wong KM. 2010. Selaginellaceae. In Parris BS, Kiew R, Chung RKC, Saw LG, Soepadmo E (eds) Flora of Peninsular 4 Malaysia Series 1. Ferns and Lycophytes. Malayan Forest Records No. 48. FRIM Kepong, Selangor.

Yuwono JSE. 2013. Karakter Geoarkeologis dan Proses Budaya Prasejarah Zona Poros Ponjong - Rongkop di Blok Tengah Gunungsewu. [Tesis]. Program Studi Geografi, Fakultas Geografi, Universitas Gadjah Mada, Yogyakarta. [Indonesian]

Zhang XC, Nooteboom HP, Kato M. 2013. Selaginellaceae. In: Wu ZY, Raven PH, Hong DY (eds.). Flora of China, Vol. 2-3 (Pteridophytes). Science Press, Beijing & Missouri Botanical Garden Press, St. Louis.