Philippine Journal of Science
142: 211-213, Special Issue
ISSN 0031 - 7683

The Selaginella Flora, A Good Indicator of the Philippine Pleistocene Island Groups[(1)]

Benito C. Tan

Department of Biological Sciences, National University of Singapore and
The Jepson and University Herbaria, University of California at Berkeley,
Berkeley, CA, USA

The present day distribution patterns of some species of Philippine *Selaginella* were observed to coincide with the alleged large island groups formed in the Philippines during the Pleistocene Ice age period. The dioecious reproductive biology of the plant group which produces large sized megaspore to house the female plant and separate small sized microspore to house the male plant has probably restricted the plant species from attaining long distance dispersal, and hence, resulted in having the locally generated species to spread slowly via only adjacent land connection over the geologic time period.

Key Words: *Selaginella*, Philippine Pleistocene Island Groups, Pleistocene Ice Age, megaspore, microspore, gametophyte, dioecy

INTRODUCTION

The taxonomy of the Philippine *Selaginella* has been studied by Alston (1935) and Tan and Jermy (1981). It consists today of a total of 50 species, which includes 46 indigenous and 26 or 56% are local endemics) and four introduced species (see Table 1). The high endemism of the genus is brought partly by its unique reproductive biology of having dioecious gametophytes and partly by the isolation of the population resulting from the geographical formation of the island groups in the Philippines in historical past.

Selaginella is an ancient group of vascular plants with a long lineage of more than 400 million years of evolution (Banks 2009, Korall & Kendrick 2002, Taylor et al. 2009). All modern species of *Selaginella* can reproduce asexually and expand their populations by means of stolon and rhizophoral growths (Swingle 1940, Bierhost 1971). At the gametophyte stage, however, *Selaginella* plants are dioecious, with the male gametophyte formed inside the microspore and the female gametophyte in the megaspore (Kramer and Green 1990). Even though in many species the microsporangia are formed together with the megasporangia in the same strobilus, the opportunity of a microspore with the male gametophyte to fall onto the close vicinity of the megaspore with the mature female gametophyte inside the megasporal wall to effect a successful fertilization is low. In all possibility, the formation of patches of populations of a species seen in the wild is clonal due mainly to the prevalent asexual multiplication of individual plants (Swingle 1940, Banks 2009). And if, however, there is a successful fertilization of the egg cell of the female gametophyte by the sperm cell released from a male gametophyte and has generated a new set of morphological and physiological characters expressed in individual plants worthy of a separate species recognition, the new species most likely will soon form a clonal population.

The megaspores of different *Selaginella* species which carry the new plant embryo after a successful fertilization, measure from 0.12 to 1.3 mm in diameter (Tryon 1949,

Corresponding Author: btakakia@yahoo.com

[1]This is a modified paper that was presented at the symposium of Biogeography of SE Asia held on May 30, 2000, at Leiden, The Netherlands

Table 1. List of Philippine species of Selaginella and their local and worldwide distributions.

[* endemic species; ? doubtfully distinct species; + introduced species].
?* *Selaginella agusanensis* Hieron. – Philippines (Mindanao, Palawan).
S. alligans Hieron. – Philippines (Luzon and Mindanao); Indonesia (Sulawesi).
? **S. aenea* Warb. – Philippines (N & C Luzon, Mindanao).
S. apoensis Hieron. – Philippines (Mindanao, Mindoro); Indonesia (Seram, Sulawesi).
S. aristata Spring – Philippines (all islands); Indonesia (Buru, Java, Halmahera, Seram, Sulawesi)
**S. atimonanensis* B.C.Tan & Jermy – Philippines (Quezon Province).
**S. auriculata* Spring – Philippines (N & C Luzon).
S. biformis A. Br. – Philippines (all islands); India Myanmar, Thailand, China, Indonesia New Guinea.
S. boninensis Bak. – Philippines (N & C Luzon); Japan, China, Taiwan.
S. ciliaris (Retz.) Spring – Philippines (all islands); widespread in E & S Asia and N. Australia.
**S. copelandii* Hieron. – Philippines (Mindanao).
**S. cumingiana* Spring – Philippines (all islands).
S. cupressina (Willd.) Spring – Philippines (all islands); Indonesia (Ambon, Kalimantan, Halmahera, Java, Seram, Sulawesi); Malaysia (N Borneo).
S. delicatula (Desv.) Alston – Philippines (all islands); India, China, Taiwan, Thailand, Vietnam, Malaysia, Indonesia (Kalimantan, Halmahera, Sulawesi).
**S. elmeri* Hieron. – Philippines (S Luzon, Catanduanes, Leyte, Samar, E Mindanao).
S. engleri Hieron. (syn. *S. usterii* Hieron.) – Philippines (all islands); Borneo.
+*S. erythropus* (Mart.) Spring – Philippines (introduced as ornamental species).
**S. eschscholzii* Hieron. – Philippines (N Luzon).
**S. fenixii* Hieron. – Philippines (Luzon, Polillo, Negros, Bohol, Leyte).
**S. gastrophylla* Warb. – Philippines (Mindanao); Malaysia (N Borneo).
* *S. halconensis* Hieron. – Philippines (C Luzon, Mindoro, Palawan).
S. heterostachys Bak. – Philippines (N & C Luzon); Japan, China, Taiwan, Vietnam.
S. intermedia (Bl.) Spring (syn. *S. atroviridens* Spring, *S. ascendens* Alderw.) – Philippines Palawan, Mindanao, Jolo); India, Myanmar, Thailand, Malaysia, Indonesia, Singapoer.
**S. intertexta* Spring – Philippines (N & C Luzon).
S. involvens (Sw.) Spring (syn. *S. polyura* Warb., *S. peltata* Presl.). – Philippines (all islands); widespread in Asia.
* *S. jagorii* Warb. – Philippines (C & S Luzon, Mindoro, Sibuyan).
**S. lacerata* Warb. – Philippines (Negros, Panay).
**S. latifrons* Warb. – Philippines (S Luzon, Catanduanes, Leyte).
S. llanosii Hieron. – Philippines (all islands); Indonesia (Kalimantan, Halmahera); Malaysia (N Borneo).
S. longiaristata Hieron. (syn. *S. springiana* Alderw.) – Philippines (Palawan, Mindanao (Zamboanga)); Malaysia, Indonesia.
**S. luzonensis* Hieron. – Philippines (S Luzon, Catanduanes).
**S. magnifica* Warb. – Philippines (Mindanao).
S. moellendorfii Hieron. – Philippines (N Luzon); China, Taiwan, Indochina.
**S. myosuroides* (Kaulf.) Spring – Philippines (N & C Luzon).
?**S. neei* Hieron. – Philippines (N Luzon).
S. negrosensis Hieron. – Philippines (C & S Luzon, Negros, Panay, Samar, Mindanao (Mt. Apo).
S. nummularia Warb. – Philippines (all islands); Indonesia (Ambon, Halmahera, Sulawesi); Malaysia (N Borneo).
S. opaca Warb. – Philippines (all islands); Indonesia (widespread), New Guinea.
S. ornata (Hook. & Grev.) Spring – Philippines (N & C Luzon, Mindoro); Indochina, Malaysia and Indonesia.
**S. philippina* Spring – Philippines (all islands).
+*S. plana* (Desv.) Hieron. – Philippines (introduced as ornamental species).
?**S. presliana* Spring – Philippines (N & C Luzon).
**S. pricei* B.C. Tan & Jermy – Philippines (Leyte, Samar).
**S. procera* Alston – Philippines (S. Luzon, Catanduanes).
**S. ramosii* Hieron. – Philippines (N & C Luzon).
S. remotifolia Spring – Philippines (N & C Luzon, Negros); Japan, China, Taiwan, Indonesia (Java, Papua, Sumatra).
S. repanda (Desv.) Spring – Philippines (N & C Luzon, Panay); India, Indochina, Japan, China, Taiwan, Malaysia.
S. tamariscina (Beuav.) Spring – Philippines (N & C Luzon); widespread in E Asia, southward reaching Malaysian Borneo (Sabah).
+*S. uncinata* (Desv.) Spring – Philippines (introduced as ornamental species).
+*S. willdenowii* (Desv.) Bak. – Philippines (introduced as ornamental species).

Bierhost 1971, Valdespino 1993, Saxena 2009). The relatively large size and heavy weight of the megaspore very likely will prevent it from participating in long distance dispersal. The preference for closed forest habitat by the majority of species of *Selaginella* further limits the range of each species. It is therefore not surprising to see this plant group generates a high number of locally endemic species on islands and across continent.

The migration of species of *Selaginella* brought by the climate changes during the Pleistocene ice age in North America had been studied and analyzed by Tryon (1971). In this study, the combined impacts of the unique reproductive biology and the changing environmental conditions are pointed out as the two important factors resulting in evolutionary changes of the species formation. This proposed explanation seems to find support in the current distribution of some endemic species of Philippine *Selaginella* when viewed against the reported existence of large island groups of the archipelago during the Pleistocene ice age when the sea level was about 100 to 120 meters lower than present.

During the geological Pleistocene Period, there were at least four large island groups formed in the Philippines, namely the Greater Luzon, Greater Panay-Negros-Cebu, Greater Mindanao (including Leyte and Samar), and Greater Palawan (see Heaney and Regalado 1998). Mindoro was alleged to form a much larger island that can serve effectively as a stepping stone for an exchange of migration of plant species from Palawan to Mindoro and southern Luzon, and vice versa. At other time during the Pleistocene ice age, Zambales and Southern Luzon (Bicol Region) had been hypothesized to form a separate island group.

Table 1 shows that there are eight distinct species endemic to northern and southern Luzon today. These are *S. atimonanensis* B.C. Tan & Jermy, *S. auriculata* Spring, *S. eschscholzii* Hieron., *S. intertexta* Spring, *S. myusuroides* (Kaulf.) Spring, *S. ramosii* Hieron., *S. luzonensis* Hieron., and *S. procera* Alston. The first six are endemic to northern and central Luzon, with *S. eschscholzii* restricted in occurrence to the highlands of Central Cordillera. The last two mentioned species, *S. luzonensis* and *S. procera*, are endemic to the Bicol Region of southern Luzon. While the other Philippine endemic, *S. jagorii* Warb., has a broad distribution covering Mindoro, Sibuyan Island, central and southern Luzon. The two locally endemic species, namely *S. luzonensis* and *S. procera*, seems to support a period of isolation of southern part from the central and northern parts of Luzon in geological past.

More interestingly, the present day distribution of *S. lacerata* Warb. coincides with the proposed Greater Panay-Negros Island Group in Pleistocene past. Similarly, the distribution of *S. elmeri* supports the proposal for a past land connection between the region of western Visayas (Leyte and Samar islands) and the Mindanao island proper. Finally, the geological connection between the islands of Leyte and Samar has the support from the present distribution of *S. pricei* (see Table 1).

The poor capability of *Selaginella* species in achieving long distance dispersal is also shown by the limited range of present day distribution of species found between the Philippine archipelago and the surrounding countries and their major island groups. Seen in this light, it is probably not an artifact of under-collecting effort shown by the distribution range of *S. apoensis* Hieron., ranging from Sulawesi and Seram of Indonesia to Mindanao Island of the Philippines (Alston 1940). The distributions of *S. boninensis* Bak., *S. heterostachys* Bak. and *S. moellendorfii* Hieron. from Japan, China, Taiwan to northern Luzon of the Philippines (Alston 1935, Tan & Jermy 1981) are additional examples of species range of *Selaginella* that reflect more of an existence of a closer land proximity in the past than the outcome of a historical chanced dispersal.

REFERENCES

ALSTON AHG. 1935. The Philippine species of *Selaginella*. Philippine Journal of Science 58: 359-383.

ALSTON AHG. 1940. The *Selaginellae* of the Malay Islands. III. Celebes and the Moluccas. Bulletin Jard. Botany Buitenzorg III, 16: 343-350.

BANKS JA. 2009. *Selaginella* and 400 Million Years of Separation. Annual Review of Plant Biology 60: 223-238.

BIERHOST DW. 1971. Morphology of Vascular Plants. New York: MacMillan.

HEANEY LR, REGALADO JC. 1998. Vanishing Treasures of the Philippine Rainforests. Chicago: The Field Museum of Natural History.

KORALL P, KENRICK P. 2002, Phylogenetic relationships in Selaginellaceae based on *rbcL* sequences. American Journal of Botany 89: 506–517.

KRAMER KU, GREEN PS. 1990. Pteridophytes and Gymnosperms. In: K. Kubitzki (ed.), Genera of Vascular Plants. Berlin: Springer-Verlag.

SAXENA NP. 2009. Objective Botany. New Delhi: Krishna Prakashan Media (P) Ltd.

SWINGLE CF. 1940. Regeneration and vegetative propagation. Botanical Review 6: 301-355.

TAN BC, JERMY AC. 1981. Two new species of *Selaginella* from the *Philippines*. Fern Gazette 12: 169-173.

TAYLOR TN, TAYLOR EL, KRINGS M. 2009. Paleobotany, the Biology and Evolution of Fossil Plants. Second edition. New York: Elsevier.

TRYON A. 1949. Spores of the genus *Selaginella* in North America north of Mexico. Annals of the Missouri Botanical Garden 36: 413-431.

TRYON R. 1971. The process of evolutionary migration in species of *Selaginella*. Brittonia 23: 89-100.

VALDESPINO IA. 1993. Selaginellaceae. In: N.R. Morin (ed.), Flora of North America 2: Pteridophytes and Gymnosperms. New York: Oxford University Press.