Species distribution of genus *Salacca*

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**Abstract.** Salak is native plant from tropics that is grouped in genus *Salacca*. Species number of this genus based on valid name is 23 species. The spread of salak species in the world has never been published full in one paper. Several publication often informed only one species of salak but the others informed more. Therefore this paper aims to present the distribution salak species in the world. All of specimen salak were observed from Herbarium Bogoriense, Bogor; Herbarium Leiden, Netherlands; Herbarium Kewense, England. The specimens observed amounted to 515 sheets. Result showed the distribution of salak species is concentrated in three regions namely Borneo, Malay Peninsular, and Sumatra. Borneo island is highest diversity of salak because there were found 11 salak species, that indicated as centre of salak diversity and centre of salak origin in the world. Most of the species from this genus are restricted to very small areas. The salak habitat varied with wide range of altitudes, from 5 m fsl to 1700 m fsl, but most of them are in the lowlands. The species with the widest range of altitudes are *S. dolicholepis* but *S. wallichiana* and *S. zalacca* were most found in several regions. There is relationship between salak species and distribution areas statistically.

1. Introduction

Salak is native plant from tropics that is grouped in genus *Salacca*, subfamily Calamoideae, family Arecaceae. *Salacca* was firstly described by [1], based on specimen collection *Salacca edulis* and then known as synonym as *Salacca zalacca*. In 1791, Gaertner described *Calamus zalacca* based on fruit collection from Thunberg that is *S. edulis* Reinw. The *Salacca* Reinw. name is valid publication for genus *Salacca* but in several publication others, this genus still often is written *Zalacca* [2].

The most number of species and morphological variation was found in Malay Peninsular and Borneo [3]. In book of Genera Palmarum: A Classification of Palms mention that *Salacca* was 15 species spread in the world [4]. More than two decades next, the number species of this genus increased but still noted that amount species was not described [3,5]. In fact based on specimen collection at Bogoriense Herbarium, much more collection were identified yet. The last new species, *Salacca acehensis*, is found in Sumatra, specially at Gunung Leuser National Park, in administrative including: Aceh Province, Southeast Aceh Regency, Kemiri Mount.; and North Sumatra Province, Langkat, Bukit Lawang Bahorok [6]. Until now the number of species from this genus is expected increasing because high probability to found new species.
Species number of genus *Salacca* in the world based on valid name is 23 species [6,7]. From amount authors as experts specialist in Arecaceae, Dr. JP Mogea is author who most contributed of his work to published the existence salak species.

The spread of salak in the world has never been published full in one paper. Several publication often informed only one species of salak but the others informed more. Therefore this paper aims to present the distribution salak species in the world.

2. Method

All of specimen salak were observed from Herbarium Bogoriense, Bogor; Herbarium Leiden, Netherlands; Herbarium Kewense, England. The specimens observed amounted to 515 sheets representing 20 species of salak as seen in Table 1. Three other species, namely *Salacca flabellata*, *S. sarawakensis* and *S. stolonifera* were based on the publication. Data analysis using Chi-squared test to check the relationship between the salak species and its area of distribution [8].

### Table 1. Location of salak specimen observed

| Species               | Location of Specimen                   | Herbarium                  |
|-----------------------|----------------------------------------|----------------------------|
| 1. *S. acehensis*     | Sumatra                                | Bogoriense, Kewense, Leiden |
| 2. *S. affinis*       | Sumatra, Malay Peninsular, Java, Borneo| Bogoriense                 |
| 3. *S. bakeriana*     | Borneo                                 | Kewense                    |
| 4. *S. clemensiana*   | Philippine                             | Kewense                    |
| 5. *S. dolicholepis*  | Borneo                                 | Bogoriense                 |
| 6. *S. dransfieldiana*| Borneo                                 | Bogoriense                 |
| 7. *S. glabrescens*   | Malay Peninsular                       | Bogoriense, Kewense        |
| 8. *S. graciliflora*  | Malay Peninsular                       | Bogoriense                 |
| 9. *S. griffithii*    | Thailand                               | Kewense                    |
| 10. *S. lophospatha*  | Borneo                                 | Kewense, Leiden            |
| 11. *S. magnifica*    | Borneo                                 | Bogoriense                 |
| 12. *S. minuta*       | Malay Peninsular                       | Kewense                    |
| 13. *S. multiflora*   | Malay Peninsular                       | Kewense                    |
| 14. *S. ramosiana*    | Borneo                                 | Bogoriense                 |
| 15. *S. rupicola*     | Borneo                                 | Kewense                    |
| 16. *S. secunda*      | India                                  | Kewense                    |
| 17. *S. sumatrana*    | Java, Sumatra                          | Bogoriense, Kewense, Leiden|
| 18. *S. vermicularis* | Borneo                                 | Bogoriense                 |
| 19. *S. zalacca*      | Thailand                               | Bogoriense                 |

3. Results and Discussion

Salak distributed from Myanmar, Thailand, Malay Peninsular, Singapore, Sumatra, Java, Bali, Borneo, Celebes, Ambon, to Philippine (Table 2). Borneo island is highest diversity of salak because there were found 11 salak species. Accordingly Boerneo island could mentioned as centre of salak diversity in the world. The second level for salak diversity was found in the Malay Peninsular, there is seven salak species. Four salak species found in Peninsular Malaya are very important to be conserved for the sustainability of germplasm because there were spread over limited areas, namely *S. flabellata*, *S. minuta*, *S. multiflora*, and *S. graciliflora*. Indeed according to Dransfield most of the species from this genus are restricted to very small areas [5]. Even the last new species, *S. acehensis*, it may be vulnerable or even endangered species based on its conservation status according to the IUCN criteria [6]. Although still need sufficient data to perform a proper evaluation from this species. The high rates of deforestation outside protected area in Mount. Leuser National Park and the apparently small total extent of the species range could given strong reason to conserve it.
Table 2. Spread of Salacca in the world

| Species                  | Myanmar | Thailand | India | Malay Peninsular | Sumatra | Java & Bali | Borneo | Celebes | Ambon | Singapore | Philippine |
|--------------------------|---------|----------|-------|-----------------|---------|-------------|--------|---------|-------|-----------|------------|
| S. acehensis             | +       |          |       |                 |         |             |        |         |       |           |            |
| S. affinis               | +       | +        |       |                 |         |             |        |         |       |           |            |
| S. bakeriana             | +       | +        |       |                 |         |             |        |         |       |           |            |
| S. clemensiana           | +       |          |       |                 |         |             |        |         |       |           |            |
| S. dolicholepis          | +       |          |       |                 |         |             |        |         |       |           |            |
| S. dransfieldiana        |         |          |       |                 |         |             |        |         |       |           |            |
| S. flabellata            |         |          |       |                 | +       |             |        |         |       |           |            |
| S. glabrescens           | +       |          |       |                 |         |             |        |         |       |           |            |
| S. graciliflora          |         |          |       |                 |         |             |        |         |       |           |            |
| S. griffithii            | +       | +        |       |                 |         |             |        |         |       |           |            |
| S. lophospatha           |         |          |       |                 |         |             |        |         |       |           |            |
| S. magnifica             |         |          |       |                 |         |             |        |         |       |           |            |
| S. minuta                |         |          |       |                 |         |             |        |         |       |           |            |
| S. multiflora            |         |          |       |                 |         |             |        |         |       |           |            |
| S. ramosiana             |         |          |       |                 | +       |             |        |         |       |           |            |
| S. rupicola              |         |          |       |                 |         |             |        |         |       |           |            |
| S. sarawakensis          |         |          |       |                 |         |             |        |         |       |           |            |
| S. secunda               | +       |          |       |                 |         |             |        |         |       |           |            |
| S. stolonifera           | +       |          |       |                 |         |             |        |         |       |           |            |
| S. sumatrana             |         |          |       |                 |         |             |        |         |       |           |            |
| S. vermicularis          |         |          |       |                 |         |             |        |         |       |           |            |
| S. wallichiana           | +       | +        |       |                 | +       |             |        |         |       |           |            |
| S. zalacca               | +       | +        |       |                 | +       |             |        |         |       |           |            |

The distribution of salak species is concentrated in three regions. That based on distribution and probability in statistically for Borneo Island consists of 11 salak species so that has a probability of 0.3, Malay Peninsular consists of seven salak species so it has a probability of 0.2, and Sumatra consists of five salak species so that has a probability of 0.1 (Figure 1). While in some areas there are 3, 2, and 1 of salak species with each probability 0.08, 0.05, and 0.02 respectively. The highest level of probability in Borneo indicates that the island is not only a center of salak diversity but it can also be considered as a center of salak origin.

Geographically, the locations of three areas (Borneo, Malay Peninsular, and Sumatra) or mention as the triangle region are contiguous. This indicates that these three areas have a high probability to finding new species or levels of salak diversity were higher if was compared to other regions. Based on the proximity of the island, Borneo closer to the Malay Peninsular than Sumatra, it also affects the variation of salak morphology that is found on both. Borneo as the center of salak diversity has a habit from the dwarf to large, with variations of leaves, inflorescences, and fruits. Likewise Malay Peninsular has the same variation as borneo but less number of species. While Sumatra only has variations on habit and fruit of salak.

Morphological variations of habit, leaves, inflorescences, and fruit are as germplasm sources that is very important for genetic engineering for superior salak. The three regions are suspected very highly successful for developing Indonesian cultivated salak in the future. Although the production center of Indonesian salak cultivation currently is in Java [9].
Figure 1. The number of salak species in regions

Data from all of salak specimen collection examined, it was found that the salak habitat varied (Table 3). Salak is found on ridges, hillsides or valleys of lowland dipterocarps, limestone hills, as well as swamps, wellspring, and streams of the river. According to Beccari salak habitat is also in the lake area [10]. Salak species is discovered in open areas of secondary forest or disturbed forests to primary forests, from limestone areas, alluvial soil, to fertile topsoil. In the forest, the young leaves of the salak as the food that is targeted by the elephant.

| Species         | Habitat                                                                 |
|-----------------|-------------------------------------------------------------------------|
| S. acehensis    | Sumatra: Province Aceh, Aceh Tenggara Regency, Kemiri Mount., near     |
|                 |  dipterocarp hill and lowland forest, near river, 1200 m fsl; Province  |
|                 |  North Sumatra, Langkat, Bahorok, Lawang Hill, near dipterocarp hill,  |
|                 |  200 m fsl.                                                              |
| S. affinis      | Java: Bogor: Bogor Botanical Garden; Borneo, East Kalimantan: West     |
|                 |  Kutai; Camp Tikah ACTR Longbagun, 100 m fsl.; Tabang, Tapele, in       |
|                 |  Batukenye Mount. along Belayan River, 120 m fsl.; Sakatak, West       |
|                 |  Tarakan; Bali Papan, LPH Wanariset, 150 m fsl.; Ma Analong, Ma Lun,   |
|                 |  Kelinjau River, 150 m fsl.; Pujungan Regency, Cagar Alam Kayan Mentarang,   |
|                 |  Gong River, 424-450 m fsl.; South Kalimantan: Kiu, Meratus Mount.,     |
|                 |  Besar Barabai Mount., 200 m fsl.; Sumatra, South Sumatra: Palembang,  |
|                 |  Koeboertreken, 10 m fsl.; Batu Seburong, Negeri Batin, Muara dua, 350 |
|                 |  m fsl.; West Sumatra: Padang, Hutan Lindung Panti, 50 m fsl.; Jambi:    |
|                 |  Kerinci Regency, Penetai Mount., along Penuh River, 300-500 m fsl.;   |
|                 |  Malay Peninsular, East Malaysia: Kedah, Labong River.                   |
| S. bakeriana    | Borneo, Sarawak: Kuching Division.                                       |
| S. clemensiana  | Philippine, Mindanao: Lanao Lake, Camp Keithley.                         |
| S. dolicholepis | Borneo, Kinabalu: Tenompok, 500 feet; Sabah, Kinabalu, Ranau, Liwagu,   |
|                 |  1700 m fsl.                                                             |
| S. dransfieldiana| Borneo, Kalimantan East: Ma Analong, Ma Lun, Kelinjau River; 150 m fsl.; |
|                 |  South Kalimantan: Barabai, Datar Alai, Batang Alai, 350 m fsl.; Besar   |
|                 |  Mount., Ratan Aral, 500 m fsl.                                           |
| S. flabellata   | Malay Peninsular, Kemaman, Nipah River.                                   |
S. glabrescens  Malay Peninsular, Pahang: Senyum Mount.; Singapore, Lawn; Padang Chong, Kroh F.R.; Perak, Kroh; Kedah, Weng.
S. graciliflora  Malay Peninsular, Johor: Ulu Endau, Janing Mount.
S. griffithii  Thailand, Mae Hong Son: Mae Hong Son, 500 m fsl.
S. lophopspatha  Borneo, Sabah.
S. magnifica  Borneo, East Kalimantan: Tarakan, Sekatak,  
S. minuta  Malay Peninsular, Johor: Labis F.R., Ulu Endau, Janing Mount., 200 m fsl.
S. multiflora  Malay Peninsular, Selangor: Besut, Ulu Setiu FR Lawit Mount., 50 m fsl.
S. ramosiana  Borneo, Sandakan: Sepilok Sea, Philippine.
S. rupicola  Borneo, Sarawak; planted in Arboretum Semengoh,  
S. sarawakensis  Borneo, Sarawak.
S. secunda  India, Upper Assam: Mishmee Mount.
S. stolonifera  South Peninsular of Thailand.
S. sumatrana  Sumatra, West Sumatra: Muara Kualampi, 300 m fsl.; North Sumatra: Sibolangit, 250-600 m fsl.; around 15 km from North Prapat, 800 m fsl.; Padang Sidempuan, Kampung Hutakodje, 280 m fsl.; Sibolangit, 700 m fsl.; Aceh: Southeast Aceh, Kutacane, Kubur Panjang, 400 m fsl.
S. vermicularis  Borneo, South Kalimantan: 100-200 m fsl.; Barabai, 350 m fsl.; East Kalimantan: Tarakan, Nunukan.
S. wallichiana  Thailand, Rayong: Baneselui, West Daya Bangkok, Malay Peninsular, Sumatra, Singapore.
S. zalacca  Java, Jakarta: Batavia; West Jawa: 250 m fsl.; Tasikmalaya, Cisalanak, Cibatu, 5 m fsl.; Tukung Gede Mount., 300 m fsl.

Salak habitat have a wide range of altitudes, from 5 m fsl to 1700 m fsl, but most of them are in the lowlands. Salacca affinis is found at the lowest altitude while S. dolicholepis is found at the highest altitude from sea level. The species with the widest range of altitudes are S. dolicholepis at an altitude of 200-1700 m fsl, but it does not have widest spread in the world. Even though S. acehensis is categorized as a vulnerable or even endangered species [6]. Analysis data in histogram showed that S. wallichiana is most found in several regions that mention as modus (Figure 2). Both of species were very reasonable because they are cultivated species. Salacca wallichiana is cultivated salak most popular in Thailand. While S. zalacca is cultivated species most popular in Indonesia specially in Java. It is unknown to its origin region but grows wild in West Java and South Sumatra. This species is also cultivated in Thailand, Malaysia, and has been introduced to New Guinea, Philippines, Queensland (Australia), Poniap Island (Caroline Islands), and Fiji Island [11]. This species has the most extensive cultivation area [12]. It has more than 20 cultivars in West, East, and Central of Java [13].

As well as for S. affinis and S. griffithii were also cultivated species. Since long time ago, S. affinis known as “linsum” (local name) in Sumatra and Malay Peninsular. Beside that S. wallichiana known as “salak kumbar” (local name) in Melayu was found in Myanmar, Thailand until South Sumatra and Malay Peninsular [12, 14, 15, 16]

Beside salak species and its distribution can be explained in probability, it can also to assess both relationships based on modus (data is most of appear in frequently) as seen in Figure 2. The modus of relationships between salak species and its distribution are S. wallichiana and S. zalacca. Furthermore, the hypothesis test pointed that based on Chi-squared test X² is 171.75. Then it was compared with p-value < 0.001=α indicated that there is relationship between salak species and distribution areas statistically [8].
4. Conclusion

The distribution of salak species is concentrated in three regions namely Borneo, Malay Peninsular, and Sumatra. Borneo islands is highest diversity of salak because there were found 11 salak species, that indicated as centre of salak diversity and centre of salak origin in the world. Most of the species from this genus are restricted to very small areas. The salak habitat varied with wide range of altitudes, from 5 m fsl to 1700 m fsl, but most of them are in the lowlands. The species with the widest range of altitudes is *S. dolicholepis* but *S. wallichiana* and *S. zalacca* were most found in several regions. It shows that there is relationship between salak species and distribution areas statistically.

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