Medicinal plants of the Lesser Sunda Islands

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Abstract. The ethnobotanical studies of medicinal plants have been carried out including the main ethnic groups in the Lesser Sunda Islands. The recapitulation results from the six main ethnic groups of the Lesser Sunda Islands recorded 279 species of medicinal plants (consisting of 181 wild species and 98 domesticated plants) belonging to 225 genera and 83 families. Some species recorded belong to the threatened categories, such as Santalum album, Strychnos lucida, Alstonia scholaris, and Swietenia macrophylla. Compositae was the largest family comprising 19 species followed by Fabaceae with 18 species. Of the 95 sick complaints or disease types recorded, 17 of which used more than 10 species of medicinal plants. The most common disease to use medicinal plants was fever, which utilized 41 different species. There were many similarities in the uses of medicinal plants, the highest similarity was between Sumbawa and Timor with a similarity index of 0.40 and the lowest was between Sumba and Flores with a similarity index of 0.15. It is suspected that there are still many potential plants that have not been recorded and have not been utilized by the people of the Lesser Sunda Islands. Therefore, intensive data collections need to be continued in order to preserve local knowledge and conserve medicinal plant diversity.

1. Introduction
Occupying only 1.3% of the world’s land surface, Indonesia is one of the richest countries in terms of its biodiversity, including its plant diversity. However, currently not all the potential of the plant resources has been recorded and used. Only a small proportion of the plant species has been known about their benefits, especially those that have been used commercially. For instance, approximately 42% of the medicinal plants occur in lowland tropical rainforests, 18% in seasonal forests, 4% in coastal forests, and 3% in mangrove forests[18]. Yet not all the potential of these medicinal plants has been utilized optimally by the community, both for their own uses and for commercial purposes. According to Salim et al.[34] only 5% of the Indonesian medicinal plants have been used as phytopharmaca ingredients.

Lesser Sunda Islands is one of the Indonesia's bioregions that attracts attention and interest of many scientists in the world from time to time. However, the richness of the plant species in this region has not been explored and used for the benefit of the people. The geologists divided the Sunda Islands region into two groups, namely (1) the Greater Sunda to cover large islands such as Java, Sumatra, and
Kalimantan, and (2) the Smaller Sunda to include small islands such as Bali, Lombok, Sumbawa, Sumba, Flores, and Timor [50],[24],[22]. During the Dutch East Indies administration, this small island group was called as Lesser Sunda Islands, a translation of the Dutch words: "de Kleine Soenda-eilanden" (the Republic of Indonesia Law No. 8 of 1958) meaning that the Lesser Sunda Islands consist of Bali, Lombok, Sumbawa, Sumba, Flores, Solor, Alor, and other surrounding small islands, including the island of Timor[26], which is currently the territory of two countries, i.e. Indonesia and Timor Leste.

The Lesser Sunda Islands possesses a wealth of plant diversity of high economic values [38],[16] recorded number of flora from the Lesser Sunda Islands and even to date their writing is still considered as the main reference for flora from this region. Some of the famous plants are spice-producing plants and medicinal plants such as sandalwood, cinnamon, and sapan. On Sumbawa Island the commodity of sapan timber trade in 1831 was 2,187.5 piculs, in 1832 there were 3,172.5 piculs, and in 1882 there were 3,850 piculs. The Dagristel Batavia Castle in October 1664 noted the arrival of a sailboat from the "Mangary" (Manggarai) manned by eight people with a load of 50 piculs of jungle cinnamon [26].

Over time, the wealth of herbs and medicinal plants from the Lesser Sunda Islands naturally diminished. The ancestors' knowledge about the usage of natural medicines was eroded by the times. The loss of this traditional knowledge has slowly leaded local people to neglect medicinal plants that grow around them. Furthermore, they are increasingly unconcerned about how to manage forest resources sustainably [14].

This paper aims to recapitulate and assess medicinal plants used by the people of the Lesser Sunda Islands based on primary and secondary data. The recapitulation of these data is part of efforts to conserve useful medicinalflora, as well as the conservation of local knowledge about the Indonesian medicinal plants from the Bali-Nusa Tenggara bioregion (Lesser Sunda Islands).

2. Methods

Ethnobotanical studies specifically related to medicinal plants have been carried out in several areas of the Lesser Sunda Islands which include the six main islands, namely Bali, Lombok, Sumbawa, Sumba, Flores, and Timor. The results of a number of surveys from six sampled ethnic groups were considered to represent the indigenous people of each island. For the island of Bali, Bali Aga is considered a native of Bali who inhabits the mountainous region. The Bima tribe that inhabits a large part of Sumbawa Island is considered to represent the island of Sumbawa. Sasak is the main indigenous tribe who inhabits the island of Lombok and uses the Sasak language. On Sumba Island there are indigenous people who speak Kambera. The Wolomeze are taken as representatives of indigenous tribes on Flores, while on Timor Island there are tribes of Dawan. Data from four ethnic groups (i.e. Bali, Lombok, Sumba, and Flores) are the primary data collected from the survey team's own data, while data from the other two ethnic groups (Sumbawa and Timor) are those from the other people's research (i.e [53],[6]) which has been completed by the authors with some information from other sources (references).

These medicinal plant species from six sampled ethnics are included in a table using the Microsoft Office Excel Worksheet program. After all data is entered, then scientific names validation is carried out referring to various literature (i.e [47],[9],[20]) and digital information sources such as www.theplantlist.org. All scientific names that are synonyms are replaced, made into one name using the accepted name based on theplantlist.org, so there is no duplication in calculating the total number of species. Furthermore, data groupings are made based on the category of medicinal plants, ethnic users of medicinal plants and categories of sick complaints/diseases cured or treated by medicinal plants. Based on these data, the similarity of the medicinal plant species used by (between) ethnicities is calculated with a similarity index,

\[ IS = \frac{2W}{a + b} \]

\( W \) = the same number of medicinal plant species, expressed by ethnic A and B

\( a \) = number of species of medicinal plants utilized by ethnic A
b = number of species of medicinal plants utilized by ethnic B

3. Results and Discussion

3.1. Diversity of medicinal plants

Medicinal plants are a commodity group that is widely used by the people of the Lesser Sunda Islands. The results of Iswandono et al. [14] in the Ruteng Forest area, Manggarai, shows that the use group which has the highest number of plant species is medicinal plants consisting of 73 species (28.57%) and food plants comprising 40 species (15.87%). This result is also in line with the results of the research conducted by Hidayat [10] in the Ngada area and Metananda [21] in Lombok. Meanwhile, the results of medicinal plants and herbal medicine research (Ristoja) conducted by the Ministry of Health in East Nusa Tenggara [7] identified 330 species of plants used in traditional medicinal herbs, in West Nusa Tenggara Wibowo and [51] recorded 155 species, while in Bali [27] have identified 85 species of medicinal plants used by the people of Bali Aga.

Communities in the Lesser Sunda Islands use many local names to refer medicinal plant species, consequently many plants named with different dialects or local languages refer to the same plant species or synonym [48]. Therefore, in the data processing of this paper there are also many similarities (synonyms) of the medicinal plant species recorded from several ethnic areas in this bioregion.

After the process of recapitulation and checking the names of species synonyms from the six main ethnic groups in the Lesser Sunda Island, 279 species of medicinal plants have been recorded belonging to 225 genera and 83 families. These medicinal plants consist of 181 (65%) wild species and 98 (35%) domesticated or cultivated species, as shown in figure 1. These wild species are generally collected directly from forest areas or shrubs. This data is slightly different from the data released by the DPP GP Jamu in 2016 [34], in which the medicinal plants come from cultivation are 22% and from direct harvest is 78%. Some medicinal plant species are included in the category of threatened or rare plants, such as Santalum album, Strychnos lucida, Alstonia scholaris, Swietenia macrophylla, and some other medicinal plant species. East Nusa Tenggara is known as the largest Santalum album or sandalwood producing area in Indonesia. Sandalwood is one of the high value forest commodities. This wood can be used as a perfume maker. Traditional residents also use it to make various art craft items. In terms of sick treatments, the people of Sumba use this species to treat painful menstruation and dysentery. Based on the IUCN redlist (2019), Santalum album together with Alstonia scholaris, Geniostoma rupestre, and Swietenia macrophylla are included in the Vulnerable category. Meanwhile Corypha utan, Boesenbergia rotunda, Azadirachta indica, Ziziphus jujuba, Foeniculum vulgare, Oenanthe javanica, Tamarindus indica, Hibiscus elatus, Hibiscus tiliaceus, Fraxinus griffithii, and Strychnos lucida are included in the Least Concern category. Strychnos lucida or sea bidara is one of the rare plants that is widely used by the people of Bali and West Nusa Tenggara as a mixture of traditional medicines. This species has long been used for various treatments such as malaria, stomach ache, toothache, high blood pressure, and fever [35].

The largest family contributing to medicinal plant species is Compositae with 19 species, followed by Fabaceae with 18 species. These two families are also often referred to as the largest family in terms of the number of medicinal plants [1],[44] Compositae or Asteraceae is the largest family of flowering plant groups in the number of species [25],[31],[3], [45]. Compositae is a taxa that can be found in various habitats and is often used as an alternative treatment material in various villages.
Most members of this family are wild plants, and even some of them are endemic species of the Lesser Sunda Islands, such as Vernonia coerulea. In contrast to Compositae, most plants from the family Fabaceae are domesticated or cultivated plants. Aside from being a medicinal plant, the family Fabaceae is often grown as a source of vegetables and spice foods, such as tamarind (Tamarindus indica), turi (Sesbania grandiflora), peanuts (Arachis hypogaea), and long beans (Psophocarpus tetragonolobus), and some are used as fence plants in the garden (i.e. Abrus precatorius, Gliricidia maculata, and Leucaena leucocephala). Most family members, also known as legumes, play an important role in plantation areas as soil fertilizers due to their ability to fixate nitrogen [36], [5]. Meanwhile in the Ngada area, Fabaceae is also the largest family group used in traditional ceremonies [33]. Overall there are 15 families, each of which contributes more than 5 species of medicinal plants that are used by the people of the Lesser Sunda Islands, as shown in Figure 2.

The most common genus belongs to Piper which contributes six species, two of which include popular plants and they begin to face threatening process, namely Piper cubeba and Piper retrofractum. Piper is the most common genus of medicinal plants because generally Piper spp. contain essential volatile oils which are typical for sick treatment or therapy such as eugeniol which acts as an antibacterial compound [23] and phenol which acts as an antifungal substance [17]. The second position is occupied by the genus Ficus which is represented by five species and all its members are wild plants which are generally obtained from the forests. Ficus or banyan is the largest genus, its members are found almost on all islands, especially in Nusa Tenggara, however, in this case only five species are indicated as sources of traditional medicines. Furthermore Syzygium is the genus that occupies the third position with four species, two of which are plants that are already known in Indonesia as herbs and spices, namely salam (Syzygium polyanthum) and cloves (Syzygium aromaticum). The next position is occupied by Citrus, Jatropha, Polyscias, and Zingiber where from each is contributing three species of medicinal uses. Polyscias, an excluding genus from the 15 largest families (Figure 2), however, is very popular in Indonesia. The Polyscias genus is usually known as mangkokan, belonging to the family Araliaceae. Besides being used as a medicinal plant, Polyscias members are also commonly used as vegetables by several ethnic groups in Indonesia.

3.2. Ethnic users

Based on the recorded data, no species of medicinal plants was utilized by all ethnicities sampled. However, there were nine species used by five different ethnicities namely Alstonia scholaris, Annona squamosa, Ceiba pentandra, Curcuma longa, Jatropha curcas, Moringa oleifera, Piper betle, Fsidium guajava, and Zingiber officinal. Meanwhile 10 other species were used by four different ethnicities, namely Ageratum conyzoides, Allium cepa, Allium sativum, Areca catechu, Imperata cylindrica,
Momordica charantia, Phyllanthus niruri, Physalis minima, Schleichera oleosa, and Tamarindus indica. The other medicinal plant species are mostly only used by three or less than three ethnic groups.

Most medicinal plants are those that have been cultivated or domesticated. Aside from being a medicinal plant, these domesticated medicinal plants are also used as food ingredients. For example, Moringa oleifera or kelor is also known as a vegetable in several areas of Bali and Nusa Tenggara. Riastiwi et al. [32] states that M. oleifera is spreading in the southern part of Bali, Lombok, Sumbawa, Kupang, Flores, Sumba, and Alor.

Although [27] only identified 85 species of medicinal plants from the island of Bali, the ethnic Balinese actually use the most medicinal plants because their customs and culture are very strongly tied to nature. Some of the Sasak people of Lombok Island are of Balinese ethnic origin, so it is not surprising that there are 33 similar plant species used as medicinal ingredients. This is because the two islands are geographically close together so they have similarities in customs, culture and art [29],[40]. Nevertheless, Lombok has the largest wealth of plant species compared to the other islands in Lesser Sunda, and this is due to the occurrence of diverse plants around the area of Mount Rinjani [49]. In fact, many Sasak ethnics in Lombok live around the foot of Mount Rinjani, where they use 147 species of medicinal plants. Thus the Sasak ethnic is the main ethnic group utilizing medicinal plants compared to the other ethnic groups in the Lesser Sunda Islands.

The islands of Sumba and Timor can be interpreted as a side part of the continent of Australia [4]. However, there is only few information on medicinal plants from the island of Timor, where Solikin [37] only found 8 species of plants that were used as medicine by the residents around the Mount Mutis Nature Reserve. In Timor there are Dawan ethnics, where usually they build settlements on hills and mountains near the forest. Since a long time ago they have used forest plants as traditional medicines [28]. From the island of Sumba, there have not been found many results of the inventory of medicinal plants. In this paper, the two islands have almost the same number of medicinal plants, but only 11 plants have the same species names. The medicinal plant species from Timor have more resemblance to other islands, compared to the island of Sumba. In fact, based on similarity index calculations (Table 3) Timor Island had the highest similarity index with Sumbawa compared to the other islands (0.40). In this paper, Yuliati [53] research results obtained 71 species of medicinal plants from Sumbawa Island, and this figure was higher than the research results conducted by Jannah and Safnowandi [15] in Sumbawa Besar, where only 40 species were found. On the other hand the smallest similarity index was between Sumba and Flores islands, valuing 0.15 or only 8 species of the same medicinal plants. Some other research results from the island of Flores related to the usage of medicinal plants came from Ruteng where 73 species were found [14] and from Sikka 13 species [19]. However some species of them were the same plants. In detail, the similarity index of plant species used as medicine by ethnic groups in the Lesser Sunda Islands is as shown in Table 1 below:

|       | Bali   | Lombok | Sumbawa | Sumba | Flores | Timor   |
|-------|--------|--------|---------|-------|--------|---------|
| Bali  | 33 sp  | 19 sp  | 16 sp   | 19 sp | 20 sp  | 19 sp   |
| Lombok| 35 sp  | 16 sp  | 20 sp   | 15 sp | 24 sp  | 11 sp   |
| Sumbawa| 11 sp  | 8 sp   | 8 sp    | 11 sp | 12 sp  |         |
| Flores|       |        |         |       |        |         |
| Timor |       |        |         |       |        |         |

3.3. Types of diseases

The recapitulation results of diseases suffered by the people of the Lesser Sunda Islands were obtained from 18 major groups of sick complaints/diseases which were related to internal organs, including head; eye; ear-nose-throat; teeth and mouth; cough and flu; digestive system; respiratory system;
womanhood; wound and bitten by animals; skin disease; fever; joints, muscles and bones; cancer; body odor (sweat); aphrodisiac and sex; swollen and paralyzed; and complaints related to beverages. Each of these groups is described further into a more specific complaint so that 95 types of sick complaints/diseases are obtained.

Of the 95 types of sick complaints/diseases recorded, there are 17 types of complaints/diseases that utilize more than 10 species of medicinal plants. Fever is a group of diseases or complaints that use the most diverse medicinal plant species, comprising 39 recorded species. Fever is also the most popular sick complaint in the Lesser Sunda Islands. Bali uses 6 species, Lombok 4 species, Sumbawa 22 species, Sumba 4 species, Flores 3 species, and Timor 4 species. However, the plants used by the six ethnic groups for curing fever generally differ in species, except Hibiscus elatus, Imperata cylindrica, Momordica charantia, and Paederia foetida, each of which is used by two different ethnicities. The fever in this study was categorized into 2 groups: common cold due to flu (39 species used) and fever leading to malaria disease (22 species). Malaria is a disease that has contracted a lot in the East Nusa Tenggara region [8]. Of the 50 medicinal plant species found in Timor Island, 17 of which are used for malaria treatment. Taek et al. [42] recorded 96 plant species used by the ethnic Tetun (Timor Leste) in various recipes for malaria treatment, while 44 species were used in Malaka, West Timor [41]. There are still many medicinal plants, especially for malaria drugs, which have not been recorded. In general, people believe that plants with a bitter taste usually function as malaria drugs, such as Carica papaya, Momordica charantia, Melia azedarah, Alstonia scholaris, Alstonia spectabilis, and Strychnos ligustrina. In detail, 17 sick complaints/diseases that utilize more than 10 species of medicinal plants are shown in Table 2.

### Table 2. Complaints/diseases that utilize medicinal plants of more than 10 species

| No. | Complaints/ disease groups | Specific complaints | Number of species | Threatened, endemic, or protected species |
|-----|----------------------------|---------------------|-------------------|-----------------------------------------|
| 1.  | Fever                      | Common cold         | 41                | Alstonia scholaris, Anaphalis longifolia, Swietenia macrophylla, Ziziphus jujuba, Foeniculum vulgare, Hibiscus elatus |
| 2.  | Teeth and mouth            | Sprue               | 34                | Alstonia scholaris, Uncaria gambir, Vernonia coerulea, Foeniculum vulgare |
| 3.  | Wounds                     | Cut, hurt           | 31                | Anaphalis longifolia, Z. jujuba |
| 4.  | Cough and flu              | Cough               | 28                | Alstonia spectabilis, Ziziphus jujuba, Amorphophallus variabilis |
| 5.  | Skin disease               | Ulcer               | 26                | Arcangelisia aflava, Melia azedarah, Melaleuca leucadendra, Piper retrofractum |
| 6.  | Skin disease               | Itchy               | 25                | Foeniculum vulgare, Melaleuca leucadendra |
| 7.  | Digestive system           | Diarrhea            | 25                | Foeniculum vulgare, Melaleuca leucadendra |
| 8.  | Fever                      | Malaria             | 22                | Alstonia scholaris, Azadirachta indica, Strychnos lucida |
| 9.  | Digestive system           | Colic               | 22                | Boesenbergia rotunda, Melaleuca leucadendra, Hibiscus tiliaeaeurs |
| 10. | Related to food / drinks   | Appetite            | 20                | Alstonia scholaris, Strychnos lucida, Swietenia macrophylla |
| 11. | Teeth and mouth            | Cavity              | 20                | Alstonia spectabilis |
| 12. | Joints, muscles and bones  | Rheumatism          | 19                | Arcangelisia flava, Melaleuca leucadendra, Piper cubeba |
| 13. | Swollen and                | Swollen             | 13                | Foeniculum vulgare, Piper cubeba |
Based on the IUCN red list 2019, several species shown on Table 2 are facing threatening processes. *Alstonia scholaris* is a species of medicinal plant that is most widely used by the people of Bali-Nusa Tenggara. This species is in fact not only used in the Lesser Sunda Islands but also in other bioregions, such as Papua and Sumatra. In general, *A. scholaris* is widely known as a malaria medicine, i.e. four of the six ethnicities in this study use it as a malaria medicine. Malaria is a serious type of disease, which affects many people in Indonesia [39], so that a considerable number of plant species are used to treat malaria. Based on the ethnobotany study in West Nusa Tenggara [12] the families of plants that are widely used as malaria drugs are Apocynaceae, Meliaceae, Compositae, and Lamiaceae.

In addition to the IUCN red list 2019, some other important species related to the 17 sick complaints above are also thought to face serious threats in nature. Based on the IUCN redlist 2008 [43], *Anaphalis* spp. or Edelweis members were included in the threatened category or plants in the condition of being threatened. In this study, *Anaphalis longifolia* was used by communities of around Mount Rinjani to treat fever and flu. While the other species are included in the Indonesian Biodiversity Strategy and Action Plan (IBSAP) document 2003-2020 and also plant species listed as the commodities of non-timber forest products (the Ministry of Forestry) attached to the Forestry Minister's Regulation number: P.35/Menhut-II/200 such as *Arcangelisia flava*, *Azadirachta indica*, *Melia azederach*, *Piper cubeba*, *Piper retrofractum*, and *Pterospermum javanicum*.

### 4. Conclusion

The Lesser Sunda Islands possess high biodiversity including medicinal plants. Each ethnic group in the Islands has different local knowledge in the use of medicinal plants. Based on the research conducted within several ethnicities, a considerable number of medicinal plant have been recorded with various uses. However, after careful recapitulation from six ethnic groups sampled representing the main islands of the Lesser Sunda Islands, only 279 plant species were used as medicines. Most of the plants used for treatment are wild plants. It is suspected that there are still many potential plants that have not been recorded and have not been utilized by the people of the Lesser Sunda Islands. Thus more intense data collections and conservation efforts are required to preserve and use sustainably the medicinal plants of the Lesser Sunda Islands region.

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