1. INTRODUCTION

1.1. Background and scientific problems

1.1.1. Variability of *Eusideroxylon zwageri*

Bulian/ulin/belian/borneo ironwood (ironwood) (*Eusideroxylon zwageri* Teijsm. & Binn.), synonymous with *Bihania borneensis* Meissner and *Eusideroxylon lauriflora* Auct., belongs to the family of Lauraceae, tribus of Cryptocaryeae and subtribus of Eusideroxylineae (Kostermans, 1957). Symington (1940) cit. in De Wit (1949) described a new species in this genus, *Eusideroxylon melagangai* Sym., but Kostermans (1979) moved it into the new genus Potoxylon (*Potoxylon melagangai*).

The variability of *E. zwageri* has been reported by many scientists since the middle of 19th century (see Van Lijnden & Groll, 1851; Teijsmann, 1858; Teijsmann & Binnendijk, 1863; Heyne, 1927; Koopman & Verhoef, 1938; De Wit, 1949; Kostermans, *et al.,* 1994). However, they did not give further explanation about this variability. Most of them only reported the variability, which was recognized by local people based on certain morphological structures such as fruit form or bark and wood structures.

Van Lijnden and Groll (1851) reported that local people in Kalimantan recognized three types of *E. zwageri*. Teijsmann (1858) and Teijsmann and Binnendijk (1863) reported some variability of *E. zwageri*'s fruits and used the term "variety" to explain their variability. One of the types that was mentioned is *bulian telor* (local name, telor = egg), which is found in Banka island and has a rounded fruit shape.

Heyne (1927) reported that there are four types of *E. zwageri* in West Kalimantan. The first is *belian tando*, which is reddish brown. The second is *belian lilin,* which is very suitable for foundations and floors. The third is *belian tembaga,* which is yellow and is utilized for foundations and floors. The fourth is *belian kapur,* which is brown and is the only type which is easy to split; therefore, it is suitable for shingles.

Furthermore, Koopman and Verhoef (1938) reported that the native people distinguished several types of *E. zwageri* based on fruit form and wood characteristics. In Palembang, Sumatra, the first type of *E. zwageri* is *onglen regis*, with long cylindrical, and clearly pointed fruit. The second is *onglen arang*, with large, thick and more oval fruit. The third type is *onglen*

Koenjit, which has wood that is yellow in color and easy to split. The fourth is *onglen arang* with dark-colored wood that is not easy to split, and the last is *onglen regis* with wood characteristics that are in-between. There is no further explanation about these types of *E. zwageri*. In Jambi, Sumatra, one distinguishes *boelian arang* and *boelian kapur;* the last has white lines or hyphens in the cortex. These characteristics of the cortex would go together with a thick cross-section of leaves.

De Wit (1949) reported that in Jambi, *E. zwageri* is known as *bulian gundjing* or *bulian regis*, *bulian rambai*, *bulian ketimun* (with large fruit) and *bulian terkujung.* Additionally, several varieties can possibly be distinguished within *E. zwageri* based on the form and size of the fruits. In practice, `*bulian sirap,*` having wood suitable for the manufacture of shingles, is sometimes distinguished from `*bulian tanduk*` or `*bulian daging,*` which are suitable for the production of timber (Kostermans, *et al.,* 1994).

Local people recognized four types of *E. zwageri* which grow in the Senami forest in Jambi, Indonesia - namely *daging, kapur, sirap,* and *tanduk*. The meaning of those vernacular names is directly related to the wood or bark structure of each type. *Daging* means “meat”, and this describes an *E. zwageri* type whose wood is not easy to split; it is also watery and relatively heavier than other types. *Kapur* means “chalk” and this name is used to describe the *E. zwageri* type which has smooth bark and a whitish color. The word *sirap* means “shingle” and is used to describe the *E. zwageri* type whose wood is easy to split, making it very suitable for shingle production. *Tanduk* means “horn”. It is used to describe the type of *E. zwageri* that has waved and bruised bark like a horn structure, especially in the base of the trunk.

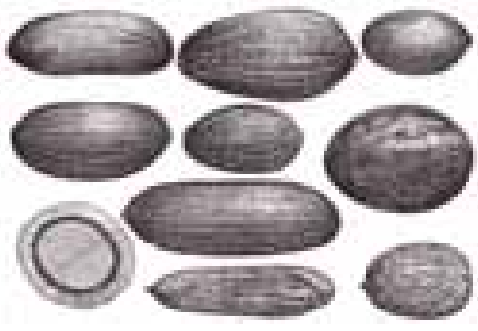

Figure 1. Variation of fruits in *E. zwageri.* Tranverse section through fruit showing sarcocarpuim, putamen and cotyledons (De Wit, 1949)

The timber of *E. zwageri* is known to vary; however, it has never been determined that there is a correlation between wood quality and other botanical characteristics (Koopman and Verhoef, 1938). Additionally, the fruits of *E. zwageri* differ widely in size and shape. It is generally considered that this variable shape of no specific importance, and this view has been shared by systematists (De Wit, 1949).

De Wit (1949) suggested that an investigation is necessary to find the actual relationship between fruit characteristics and other characteristics (flowers, leaves, timber) of *E. zwageri*. The opinion of earlier observers was confirmed and, as no detailed investigation had been carried out until now, received a firmer basis. He found that in a single tree the shape of the fruit is constant. The size may vary somewhat (see Fig.1), but one individual tree produces one single kind of fruit. Since in nature several kinds of fruit are found in one locality this points to the possible occurrence of *varieties* or *taxa* of lower rank. When a genetic analysis has been conducted and its results are combined with wood and other botanical properties, some units of varieties or taxa may become acceptable.

No type of *E. zwageri* has yet been thoroughly investigated. So far only local people, using knowledge of wood and other morphological structures, have been able to recognize the different characteristics among them. Therefore, it is important to conduct comprehensive research on morphological structures, genetic variation, seedling performance, wood properties, and growth performance of the types of *E. zwageri*. The main objective of this study is to prove whether types which are recognized by local people have genetic basis or not and to find the variability pattern of *E. zwageri*.

Sindhuveerendra, *et al.*, (1999) claimed that knowledge of the genetic variability of the species is a pre-requisite before initiating an efficient tree-breeding program, because it affects variation at the population level along with evolutionary potentials of the group concerned. Spread of genetic variability in the population is reflected to some extent in the morphology of the population, so the study of morphological characteristics of natural populations is often a useful stage in the study of genetic variability.

Variety is the appropriate term to use in this study. Darwin (1859) mentioned that varieties cannot be distinguished from species except, first, by the discovery of intermediate linking forms and, secondly, by a certain indefinite amount of difference between them. Additionally, Hardin, *et al*., (2001) argued that some patterns of within-species variation are

appropriately recognized by the categories of subspecies, varietas (variety), and forma (form), in descending order. The classical category below species was variety, and it is still commonly used.

1.1.2. Habitat and natural distribution of *E. zwageri*

The habitat of *E. zwageri* is lowland forests (500 meters and rarely reaching 625 meters above sea level). *E. zwageri* grows in Kalimantan, South and Southeast Sumatra (Jambi, Palembang, Bengkulu, Siak and Indragiri), Lampung, the southern part of West Sumatra, West Coast residency (Sijunjung) and the Philippines (Sulu archipelago - Tawi-Tawi) (see Fig 2.). It is a scattered component of the Dipterocarp forests. In some localities it forms a single dominant variant, in flat or sloping terrain, and also occurs in old secondary forests (Merril, 1923; De Boer, 1939; De Wit, 1949; Beekman, 1949; Suselo, 1987; MacKinnon, *et al.*, 1997). The natural distribution of *E. zwageri* is mainly in the regions of Sumatra and Borneo. Whitmore (1984) reported that these regions lie on the Sunda shelf at the heart of the western rain-forest block, and have close floristic similarity.

Figure 2. Map of *E. zwageri* distribution (indicated by dot line). (The original map is courtesy of www.countrywatch.com)

E. zwageri grows well in humid climates and it also could grow in places with short dry seasons (Koopman and Verhoef, 1938). Soedibja (1952) stated that *E. zwageri* is a shade-bearer species when immature. It is especially found in sandy soil and requires a fairly drained soil with a wet climate. In addition, Soerianegera (1974) reported that *E. zwageri* could be found in areas

with dry sub-humid climates and humid climates with precipitation of 2,000 to 6,000 mm per year.

Tuyt (1938) reported that *E. zwageri* is principally a shade-bearing tree and grows well in a damp soil. These two factors must be taken into consideration during the laying out of a plantation. The best results have been obtained by planting out the trees in shaded rows under old belukar or high virgin forest. In general, more shade-tolerant species exhibit a greater survivorship than less shade-tolerant species in light-limiting environments (Oliver and Larson, 1990; Kobe and Coates, 1997).

Soedibja (1952) reported that gradual exposure to sunlight as the *E. zwageri* seedlings increase in size does no harm, but too much light--and especially exposure immediately to full sunlight--check growth and the seedlings may die. After twelve years the *E. zwageri* must be cleaned from blukarweeds (secondary forest). Height increases with the depth of the clay/iron pan, the slope of the ground also affects height growth.

Gresser (1919) reported that most *E. zwageri* forests occur on level areas along rivers and adjacent hills. The vicinity of a river is not necessary, however, where the soil consists of loamy sand; the forests are found along rivers as well as on pure sand. In addition, Tuyt (1938) stated that *E. zwageri* grow well in the damp soil. De Wit (1949) reported that soils which are temporarily inundated, marshy or water-logged spots are always avoided by *E. zwageri*. Primary forests often contain larger or smaller groups of *E. zwageri* but they do not belong to giant forest trees.

1.1.3. The importance and current conditions of *E. zwageri*

E. zwageri is one of the most important construction woods in Indonesia. The wood is used for making furniture, window and door frames, harbors, heavy construction, roofs, bridges, railway sleepers, marine pilling, boat construction, fence posts, heavy duty industrial flooring, shingles and vehicle body work. Traditionally, the seed also can be used as a skin medicine.

The most valuable characteristic of *E. zwageri* is that it is not vulnerable to termites and other ubiquitous tropical wood-eating insects and fungi. For this reason, the wood is in great demand for construction throughout Indonesia (Peluso, 1992). Martawijaya, *et al.* (1989) explained that the physical characteristics of *E. zwageri* are excellent. Class of strength is one, durability class is one, and it is very hard, with a specific gravity of 0.88 – 1.19. Additionally,