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RESISTANCE OF SOME NEW CLONES OF EUCALYPTUS TO INSECTS CAUSING GALL IN MOUNT MUTIS, EAST NUSA TENGGARA

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ABSTRACT

Resistance of some new clones of eucalyptus to insects causing gall in Mount Mutis, East Nusa Tenggara. Eucalyptus (*Eucalyptus* spp.) is a fast-growing tree native in Australia, Papua, and Eastern part of Indonesia. It is valued for its timber, oil, gum, and resin, and as an ornamental tree. Many eucalyptus clones have been developed and planted for timber production in Sumatera. Several galls caused by insects are known as serious pests of eucalyptus and can reduce the quality and quantity of the timber production. This study was aimed to identify the gall inducers and describe the galls that formed on the eucalyptus clones which planted in Mt. Mutis, East Nusa Tenggara Province. The research was conducted from October 2017 to July 2018. A total of 855 seedlings consisting of 57 clones and 15 plants for each clone were planted in Mt. Mutis. Observations of the gall symptoms were done biweekly on each plant. Gall symptoms were directly observed and identified, included the form, size, location, color, and insect that caused the gall. There were four types of gall forms were recorded. One type of gall caused by *Ophelimus* sp. (Hymenoptera: Eulophidae) which similar to the gall recorded in Sumatera and Java. The other three gall forms had never been reported in Indonesia. The insects that associated with galls were Hymenoptera and Diptera orders. The type of gall that was mostly found in the eucalyptus clones was the big clustered leaf gall caused by *Fergusonina* sp. (Diptera: Fergusoninidae). There were only two clones which were included as susceptible clones based on the type of gall formed, C35 and C53. There were 27 eucalyptus clones with no gall infestations which were considered as the good candidate of resistance eucalyptus clones that can develop to control gall inducers on eucalyptus.

Key words: Eulophidae, gall, resistance

INTRODUCTION

Eucalyptus (*Eucalyptus* spp.) is an Australian endemic plant that can grow in tropical and subtropical climates. In Australia, there are more than 600 species of eucalyptus growing naturally. This plant is a plant that is always green throughout the year because it can occupy several ecological niches (Nair, 2007). In addition to Australia, eucalyptus can be found growing naturally in eastern Indonesia, including Papua, Timor and Sulawesi. However, in the last few decades, eucalyptus has also been found on the islands of Sumatra and Kalimantan as industrial plants (CABI, 2005). This is because eucalyptus has many benefits, as raw material for paper, wood, essential oils, and home ornaments.

The area of eucalyptus plantations in Indonesia is 300,000 ha which is the second largest area after Thailand (Nambiar & Harwood, 2004). Eucalyptus production in Indonesia as an industrial plant in the form of logs or processed wood still fluctuates every year. In the 2015 BPS production data, eucalyptus wood production amounted to 2.11 million m^3 (4.81%) which occupies the fifth position for wood production in Indonesia (BPS, 2015). But in 2016, eucalyptus wood production in Indonesia decreased by 1.81 million m^3 (4.29%) (BPS, 2016) and increased again in 2017 to 3.81 million m^3 (7.75%) which occupied the fourth position for wood production in Indonesia (BPS, 2017). Fluctuations in the value of eucalyptus production in Indonesia are due to interference from plant pests, especially insect pests. Some important insect pests on eucalyptus plants that have been reported in Indonesia include: *Helopeltis* spp. (Hemiptera: Miridae), shoot borer *Alcides* sp. (Coleoptera: Curculionidae), several species of termites (Isoptera: Termittidae), stem borer *Zeuzera coffeae* (Lepidoptera: Cossidae), and *Agrilus* sp. (Coleoptera: Brupestidae) (Nair, 2000). In addition to some of these pests, there are also insects causing gall on the eucalyptus.

Gall is one of the symptoms that appear on the plant. Gall occurs due to abnormal growth of plant tissue. The abnormal growth of plant tissue can be caused by mechanical injury, mites, phytophagous insects, and plant pathogens. Gall is one of the adverse symptoms of eucalyptus plants because it can reduce the quality and quantity of wood and oil produced. Gall can occur in the leaves, fruit, flowers, stems, and branches that can inhibit the rate of photosynthesis of plants so that plants become stunted or dead (Berry & Withers, 2002). The formation of gall caused by phytophagic insects is by means of adult female insects which cause the gall to thrust its ovipositor into plant tissue to lay eggs and develop which then forms a hollow.

Gall formed on plant parts are caused by different insects and have different characteristics. Eucalyptus plant gall is caused by insects from the Hymenoptera Order, Diptera Order and Hemiptera Order. Insects that cause gall on eucalyptus are *Eucalyptodiplosis germinis*, *E. mcintyrei*, *Epichrysocharis burwelli* Schauff, *Fergusonina* sp., *Glycaspis* sp., *Leptocybe invasa* Fisher & La Salle, *Ophelimus eucalypti*, *Ophelimus maskelii*, and *Quadrastichodella* sp. (Boucek, 1977; Franco *et al*., 2016; Kolesik *et al*., 2002; Lawson *et al*., 2012; Mendel *et al.,* 2004; Sharma *et al*., 2015; Schauff & Garrison, 2000; Taylor & Davies, 2010).

Environmentally friendly control of Eucalyptus gall can use natural enemies in the form of predators, parasitoids, and entomopathogens as well as the development of resistant plants. Utilization of resistant plants can be in the form of using resistant varieties or resistant clones. Resistant varieties and clones are plants that have the ability to tolerate the infestation of pests or pathogens at the same level (Mawardi & Suhendi, 2004). The use of resistant clones in eucalyptus plants has been widely carried out and reported in several countries, including in South Africa. Dittrich-Schroder (2012) reported that in South Africa, clones with resistant properties originate from a cross between *Eucalyptus nitens* and *E. grandis*, while susceptible plant species are from several other countries, including *E. camaludensis*, *E. botryoides*, *E. grandis*, *E. gunii*, and *E. robusta* (Goud *et al*., 2010 & Thu *et al*., 2009).

The effectiveness of clone use is difficult to compare between one region and another because there are several factors, one of which is the environmental factor. A clone plant from two species can grow well and avoid plant-disturbing organisms in South Africa. It does not mean that the clone will also be resistant if planted in Indonesia. Information on the types of eucalyptus clones that are resistant to attack by insects causing gall is still limited in Indonesia, so it is necessary to test new types of clones for insects causing gall. The purpose of clone endurance testing is to find out which type of clone has the highest level of endurance. The new clones of the test results can be used as an effort to control insects causing gall on eucalyptus so that the production value of eucalyptus in Indonesia can increase.

MATERIALS AND METHODS

Research Site. The study was conducted in October 2017 to July 2018. It was done in Gunung Mutis, Timor Tengah Selatan Regency, Nusa Tenggara Timur Province and the Insect Biosystematics Laboratory, Department of Plant Protection, IPB.

Sampling. Clone preparation and planting. Observations were made on 57 hybridized seedling clones coded C1 - C57 with a total of 855 plant seedlings. The seedlings were from the Province of Riau and North Sumatra transported into Mt. Mutis in July 2017 which have passed the checking and licensing stages of Plant Quarantine. The seedlings brought were those in 3 months old after crossing.

The seedlings were left for three months for the acclimation process. After passing the acclimatization stage, the seedlings were ready to be planted on 31 October 2017 in three different plots. The seeds were planted in 3 different plots with 57 clones, each consisting of 5 plants. The planting process followed the contour of the place with a spacing of 2 x 3 m and was planted randomly.

Observation of Gala Symptoms. Observations began at two weeks after transplanting at intervals of two weeks. Observations were made by observing the symptoms of the gall and the intensity of infestation of the insects causing gall. Symptomatic plant parts were directly observed including the color, position of the gall formation (twigs, leaf bones, leaf edges and leaf center), forms of gall (round, oval, open and closed), number of nodules formed in each plant part, and the number of leaves per plant formed by gall. At the last observation, all symptomatic portions were taken and stored in plastic containers until insects contained in the gall came out.

Gall Infestation Rate in Plants. Observation of the gall infestation rate was not done by looking at how the insects causing gall cause symptoms to form but was by counting the number of nodules formed on each leaf and the number of plants infested by insects causing

gall. Calculation of the percentage of plants infested by insects causing gall uses the following formula:

$$\% \text{ Infested Plants} = \frac{\text{Number of Plant infested by type of goal}}{\text{Number of plants planted}} \times 100\%$$

After knowing the type of gall formed, the level of endurance of eucalyptus plant clones can be divided into four types based on the type of gall formed in the clone. The division of clone resistance level is as follows:

resistant = no gall formed
moderately resistant = 1 type of gall formed
medium = 2 types of gall formed
vulnerable = >2 types of gall formed

While the level of clone resistance, based on the number of plants infested by gall, it is divided into three types, as follows:

low = 0 plan infected by gall
moderate = 1-7 plants infected by gall
high = >7 plants infected by gall

Data Analysis. Data tabulation and graphic creation used Microsoft Excel 2016 and Minitab 17 Statistical Software programs.

RESULTS AND DISCUSSION

Clones are individuals resulting from crossing of two species vegetatively. The use of cloned plants has been done to improve the quality of offspring of a plant. Plants widely propagated by cloning include gum, rubber, cocoa and eucalyptus. The use of clones in eucalyptus plants is mostly done in South Africa (Dittrich-Schroder, 2012). Propagation of eucalyptus plants can be done vegetatively to increase the production value, especially in Indonesia. The cause of the unstable value of eucalyptus production is the presence of phytophagous insects, especially insects causing gall. Insects causing gall on eucalyptus plants damage plants by forming nodules on the parts of eucalyptus plant. Gall is one of the adverse symptoms of eucalyptus plants because it can reduce the quality and quantity of wood and oil produced.

The results of observations of 57 eucalyptus clones obtained 4 types of gall formed in two parts of the plant, such as the leaves and twigs. The four types of gall were the small nodule leaf gall, large nodule leaf gall, curved leaf gall, and the swelling branch gall (Figure 1). The four galls were formed in different clones. The type of gall with the highest number of clones infested was the large nodule leaf gall, which was 21 clones with 53 infested plants (Table 1) or with the proportion of 56% (Figure 2A). However, the highest number of nodules formed was small leaf nodules, which were 1509 nodules (Figure 2B). This was because the insects causing gall, in the formation of nodules, one image can form more than one nodules.

The type of gall with the least number of infested clones and the least infested plants was the swelling branch gall which attack the branches of eucalyptus plants. Swelling branches were only formed on two eucalyptus clones (Table 1) with a percentage of 8%. The characteristics formed and insects causing gall were different even though they were formed in the same parts.

Type of Gall Large nodule leaf gall. Large nodule leaf galls were formed in 21 eucalyptus clones which have the characteristics of nodules formed 1–2 mm in diameter, red to pink in color, and clustered. Large nodule leaf gall was caused by *Fergusonina* sp. (Diptera: Fergusoninidae). Insects that causing gall in the formation of gall in eucalyptus were associated with nematodes *Fergusobia* sp. (Taylor & Davies, 2010). Large nodule leaf galls become a type of gall that attacks lots of eucalyptus in the observation plot due to eucalyptus that grows naturally around the observation plot. Many large nodule leaf galls were formed due to *Fergusonina* sp. and population of *Fergusonina* sp. that came out during maintenance with the total of 6 imago.

The clones with the most number of infested plants with large nodule leaf gall during 16 observations were C32 clones with 9 plants infested (Figure 3A), whereas the largest number of nodules formed was in the C48 clones (Figure 3B). This is because in one C48 clone plant, *Fergusonina* sp. attacked the same plants in every week of observation and attacked almost all leaves that grow on these plants with a large number of nodules formed. In C32 clone, every time, *Fergusonina* sp. attacked different plants and only attacked a few leaves that grow with only a small number of nodules formed.

Small Nodules Leaf Gall. Small nodules leaf galls attacked 10 eucalyptus clones planted during observation. The characteristics were pink in color, measuring 0.5–1 mm in diameter, single in number, and flat. Small nodules leaf galls were caused by insect *Ophelimus* sp. (Hymenoptera: Eulophidae). *Ophelimus* sp. ihas been reported to be the cause of gall on eucalyptus in Indonesia precisely in North Sumatra

Figure 1. Symptoms of gall formed on several clones of eucalyptus plants. (A) Small nodules; (B) Large nodules; (C) Curved leaves; (D) Swelling branches.

Table 1. Number of eucalyptus clones and plants infested

Type of gall	Number of infested clones	Number of infested plants
Large nodules leaf gall	21	53
Small nodules leaf gall	10	22
Curved leaf gall	6	12
Swelling branch gall	2	8

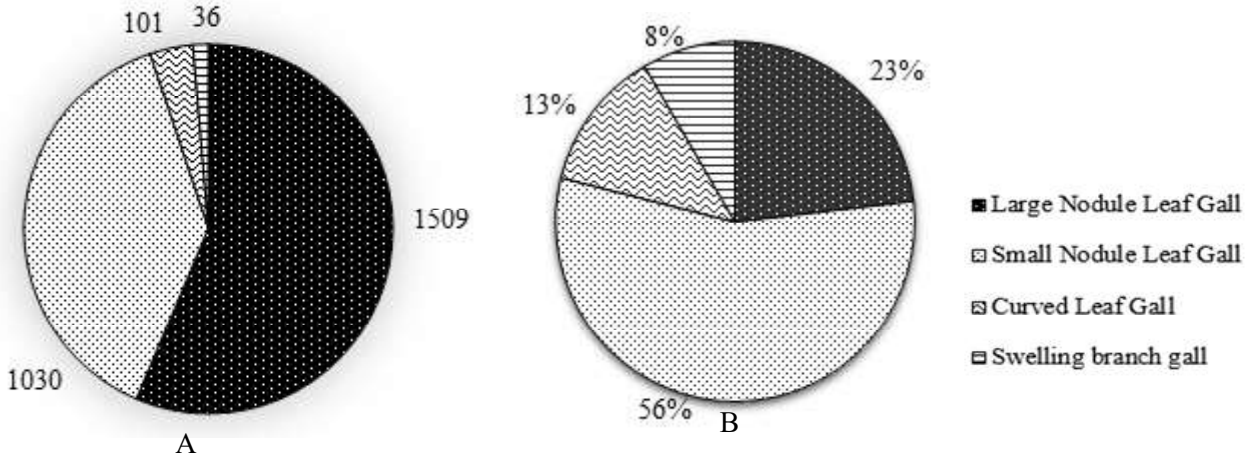

Figure 2. (A) Infested plant, (B) Number of nodules formed

(Syawaluddin, 2017) and (Lawson *et al.*, 2012) in East Java.

The mostly formed clones by small leaf nodules were C53 clones with the most number of nodules formed compared to other clones (Figure 4). The thing causing C53 clone was the clone formed by the small nodule leaf gall was probably due to breeding species when the crossing is on species that is susceptible to *Ophelimus* sp.

Curved Leaf Gall. Curved leaf gall has slightly different characteristics from the other two types of gall. The characteristics of the curved leaf gall was the formation of nodules on the leaf which causes the shape of the leaf to be curved. This type of gall was only formed on six eucalyptus clones planted with a large number of plants attacked by C53 clones.

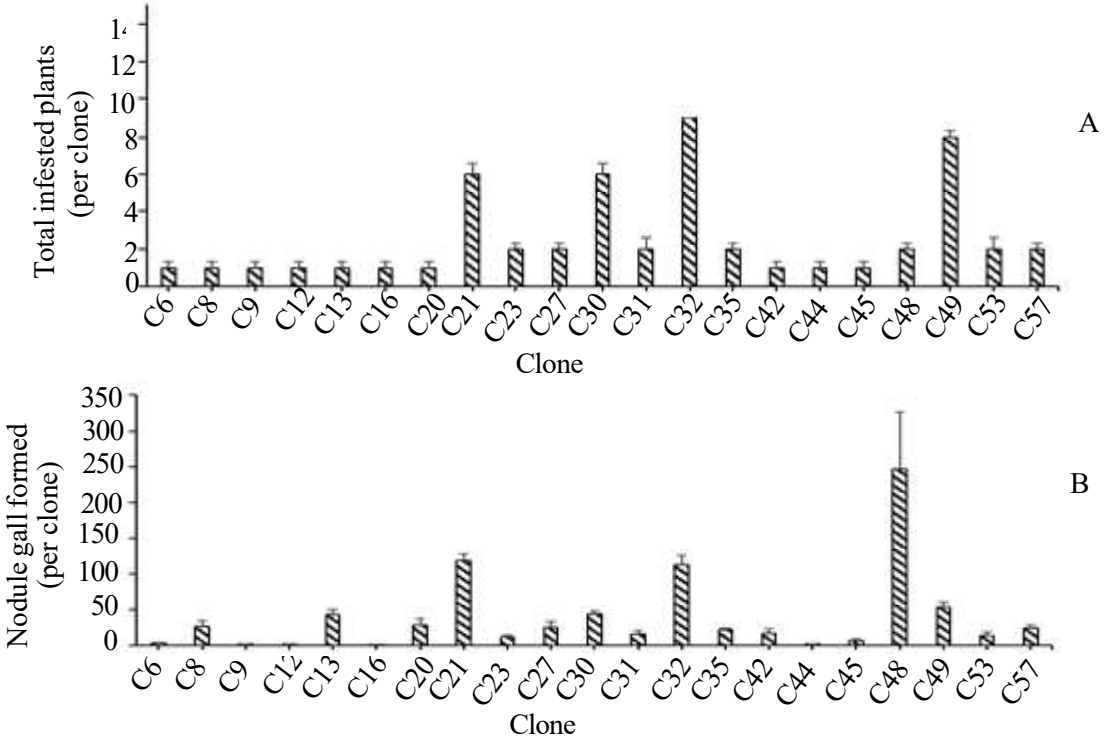

Figure 3. The clones were infested with large nodule leaf gall for 16 observations. (A) Total infested plants (x±SE); (B) Nodule gall formed (x±SE)

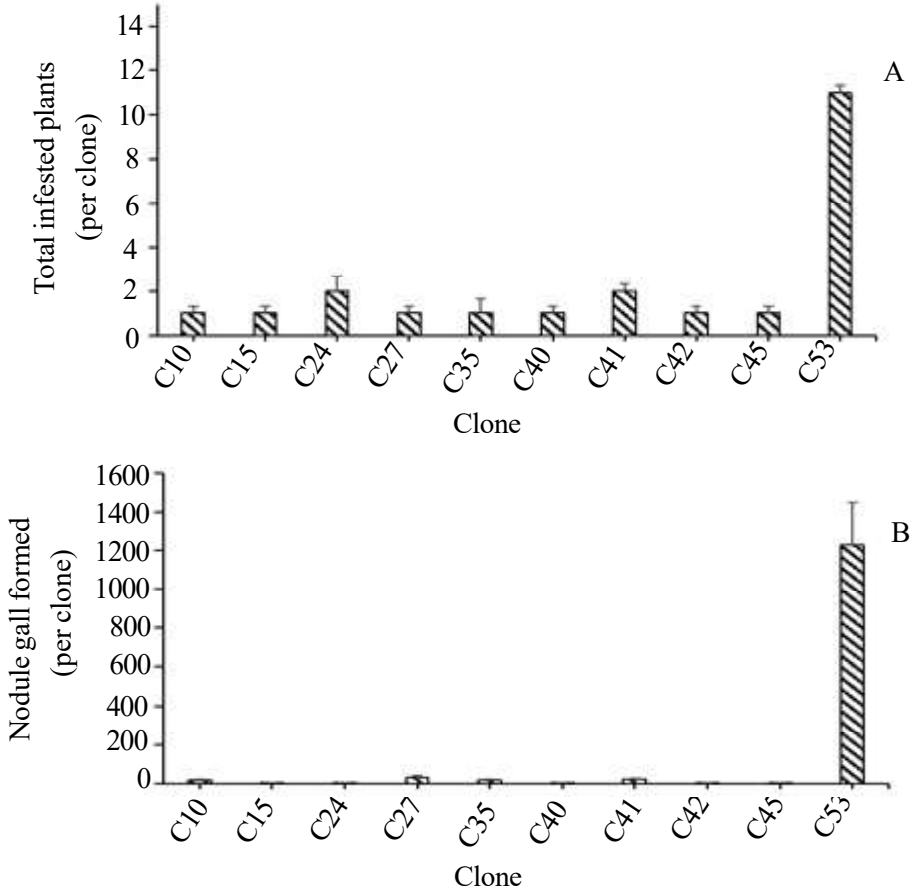

Figure 4. The clones were infested with small nodule leaf gall for 16 observations. (A) Total infested plants (x±SE); (B) Nodule gall formed (x±SE)

This type of gall is formed on the eucalyptus branches with the characteristics of the affected branches being brown nodules. The reason for the swelling of the branch was Leptocybe invasa (Hymenoptera: Eulophidae). This insect has never been reported found in Indonesia but has been widely reported to attack eucalyptus in Australia, South Africa and China (Dittrich-Schroder *et al*., 2012; Zhu *et al*., 2012; Mendel *et al*., 2004). Only two of these gall clones were formed, which are C47 and C48 with the highest number of plants affected and the number of nodules formed was C47 (Figure 6).

Clone Resistance Level. The resistance rate of eucalyptus clones can be influenced by several factors including the environment and the resistance of crossed plant clones (Fernandes & Price, 1992). Not all eucalyptus plant clones planted in the observation plot were all formed by four types of gall. There were 27 clones or 47% of the planted clones which did not form gall during 16 observations (Figure 7).

Eucalyptus clones did not only form one type of gall but one clone can form more than one type of gall. Based on observations, there were 23 clones (Table 2) or 40% of clones formed only one type of gall (Figure 7), while the number of clones formed by two types of gall was 5 clones (Table 2) or 9% (Figure 7). Only 2 clones formed the most of gall types (3 gall types), C35 and C53 that were included in the vulnerable category (Table 2). This is because the two clones are likely to originate from the crossing of two eucalyptus species that are susceptible to insects causing gall. None of the 30 clones forming gall consisted of 4 types of gall.

Observation of the resistance rate of the clones based on the number of plants attacked by getting 3 categories of resistance, namely resistant, moderate, and

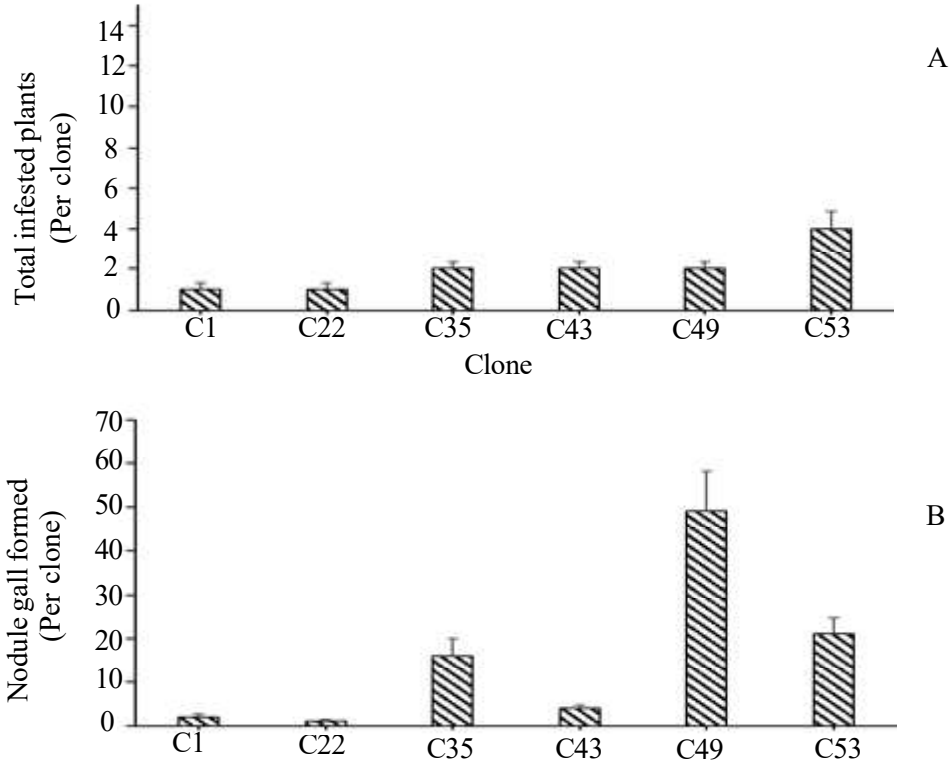

Figure 5. The clones were infested with curved leaf gall for 16 observations. (A) Total infested plants (x±SE); (B) Nodule gall formed (x±SE)

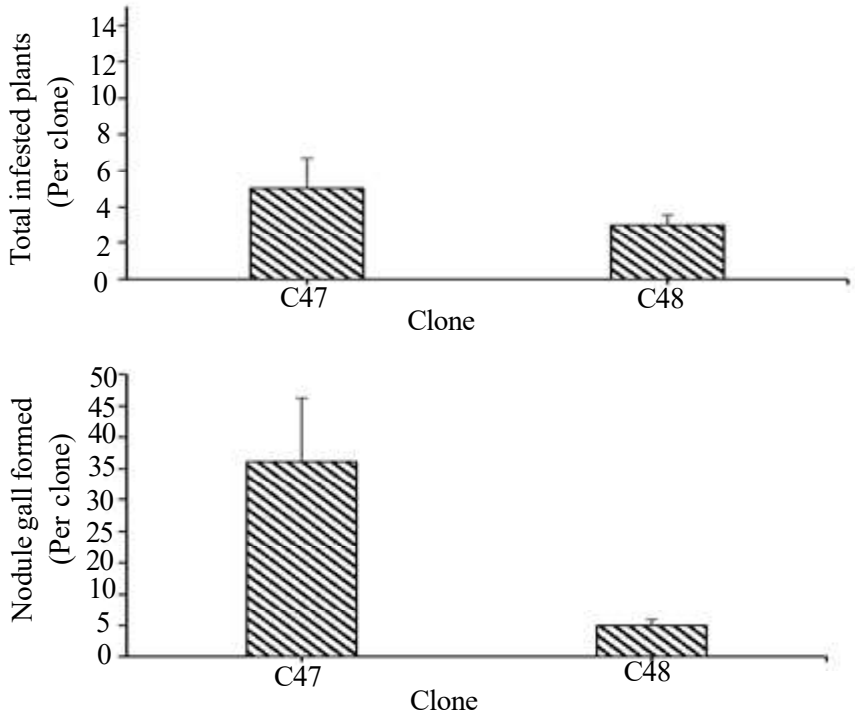

Figure 6. The clones were infested with swelling branch gall for 16 observations. (A) Total infested plants (x±SE); (B) Nodule gall formed (x±SE)

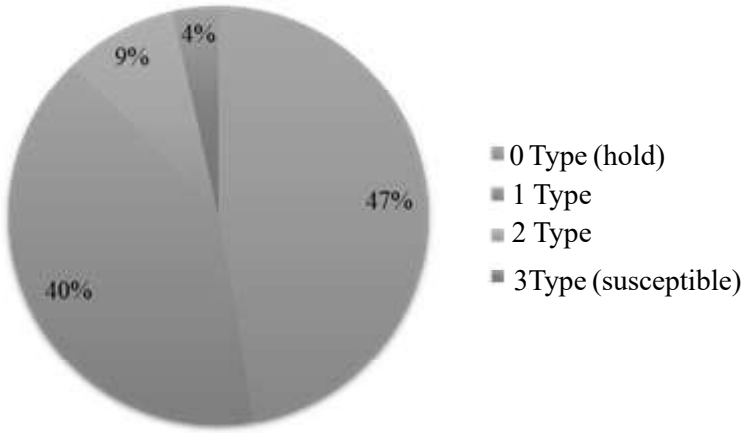

Figure 7. The proportion of clone resistance rate is based on the number of types of gall formed

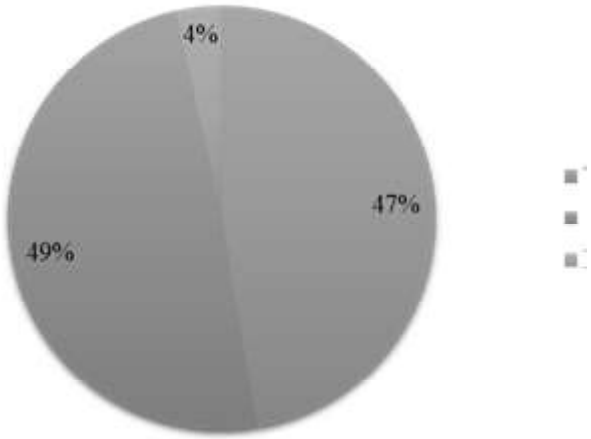

Figure 8. Proportion of clone resistance rate is based on the number of plants attacked by insects causing gall

Table 2. Number of types of gall formed in the clone

	Number of type of gall			
	0	1	2	3
Clones	C2, C3, C4, C5, C7, C11, C14, C17, C18, C19, C25, C26, C28, C29, C33, C34, C36, C37, C38, C39, C46, C50, C51, C52, C54, C55, C56	C1, C6, C8, C9, C10, C12, C13, C15, C16, C20, C21, C22, C23, C24, C30, C31, C32, C40, C41, C43, C44, C47, C57	C27, C42, C45, C48, C49	C35, C53
Total of Clones	27	23	5	2
Category	Resistant	Moderately resistant	Medium	vulnerable

vulnerable. The result was that 47% of the clones were those resistant or had no purity in the clone. At the same time, only 4% of the clones included in the clone that were susceptible to be attacked by insects causing gall (Figure 8), ie C49 clones with 8 plants attacked and C53 with 13 plants attacked. The differences in the types of clones classified into the vulnerable category can be caused because there were more insects causing gall like the morphology of plants in C35 clones than C49 clones.

CONCLUSION

The types of gall formed were four types. One of the four types had been reported to be found in Indonesia. The type of gall that attacked many eucalyptus plant clones was the type of gall with a large nodule leaf gall caused by *Fergusonina* sp. (Diptera: Fergusoninidae). There were two clones included as vulnerable clones based on the number of gall types formed, namely C35 and C53. There were 27 clones which did not form gall at all, which could be cultivated as an effort to control the insects causing gall in eucalyptus plants.

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REFERENCES

Berry JA & Withers TM. 2002. New gall-inducing species of ormocerine pteromalid (Hymenoptera: Pteromalidae: Ormocerinae) described from New Zealand. *Aust. J. Entomol*. 41(1): 18–22.

Boucek Z. 1977. Descriptions of Tachinobia gen. n. and three new species of Tetrastichinae (Hymenoptera: Eulophidae), with a tentative key to genera. *Bull. Entomol. Res.* 67(1): 17–30.

BPS. 2015. *Statistik Produksi Kehutanan 2015.* Badan Pusat Statistik, Jakarta.

BPS. 2016. *Statistik Produksi Kehutanan 2016.* Badan Pusat Statistik, Jakarta.

BPS. 2017. *Statistik Produksi Kehutanan 2017.* Badan Pusat Statistik, Jakarta.

CABI. 2005. *Forestry Compendium, 2005 edn*. (CD version). CAB International, Wallingford.

Dittrich-Schroder G, Wingfield MJ, Hurley BP, & Slippers B. 2012. Diversity in Eucalyptus susceptibility to the gall-forming wasp *Leptocybe invasa*. *Agr. Forest Entomol*. 14(4): 419–427.

Fernandes GW & Price PW. 1992. The adaptive significance of insect gall distribution: survivorship of species in xeric and mesic habitats. *Oecologia*. 90(1): 14–20.

Franco JC, Garcia A, & Branco M. 2016. First report of *Ephichrysocharis burwelli* in Europe, a new invasive gall wasp attacking eucalypts. *Phytoparasitica*. 44(4): 443–446.

Goud KB, Kumar NK, Vastrad AS, Bhadragoudar M, & Kulkarni HD. 2010. Screening eucalyptus genotypes against gall wasp. Leptocybe *invasa* Fisher and La Salle (Hymenoptera: Eulophidae). *Karnataka J. Agric. Sci.* 23(1): 213–214.

Kolesik P, Taylor GS, & Kent DS. 2002. New genus and two new species of gall midge (Diptera: Cecidomyiidae) damaging buds on Eucalyptus in Australia. *Aust. J. Entomol.* 41(1): 23–29.

Lawson S, Griffiths M, Nahrung H, Noack A, Wingfield M, Wilcken C, Slippers B, Lo N, Thu PQ, Lee SS, Lelana NE, Ketphanh S, Zhou X, & Eungwijarnpanya S. 2012. *Biological Control of Eucalypt Pests Overseas and in Australia.* ACIAR, Australia.

Mawardi S & Suhendi D. 2004. *Dasar - Dasar Pemilihan Bahan Tanam Unggul dalam Kaitannya dengan Manajemen Produksi dan Mutu dalam Materi Kursus Budidaya dan Pengolahan Hasil Tanaman Perkebunan*. PUSLIT KOKA, Jember.

Mendel Z, Protasov A, Fisher N, & La Salle J. 2004. Taxonomy and biology of *Leptocybe invasa* gen. & sp. n. (Hymenoptera: Eulophidae), an invasive gall inducer on *Eucalyptus*. *Aust. J. Entomol*. 43(2): 101–113.

Nair KSS. 2000. *Insect Pest and Diseases in Indonesia Forests: an Assessment of The Major Threats, Research Efforts and Litterature*. CIFOR, Bogor.

Nair KSS. 2007. *Tropical Forest Insect Pests: Ecology, Impact, and Management*. 1 edition. Cambridge University Press, New York.

Nambiar EKS & Harwood CE. 2014. Productivity of acacia and eucalypt plantations in Southeast Asia. 1. Bio-physical determinants of production: oppurtunities and challenges. *Int. Forest Rev*. 16(2): 225–248.

Schauff ME & Garrison R. 2000. An introduced spesies of *Ephichrysocharis* (Hymenoptera: Eulophidae) producing galls on Eucalyptus in California with notes on the described species and placement of the genus. *J. Hymenoptera Res*. 9(1):176–181.

Sharma A, Raman A, Taylor GS, Fletcher MJ, & Nicol HI. 2015. Feeding and oviposition behaviour of a gall inducing species of *Glycaspis* (*Synglycaspis*) (Hemiptera: Psylloidea: Aphalaridae) and development of galls on the leaves of *Eucalyptus macrorhyncha* (Myrtaceae) in central western New South Wales, Australia. *Eur. J. Entomol*. 112(1): 75–90.

Syawaluddin. 2017. Serangga yang Berasosiasi dengan Puru Daun Eukaliptus di Sumatera Utara. *Tesis.* Intitut Pertanian Bogor, Bogor.

Taylor GS & Davies KA. 2010. The gall fly, *Fergusonina lockharti* Tonnoir (Diptera: Fergusoninidae) and description of its associated nematode, *Fergusobia brittenae* sp. nov. (Tylenchida: Neotylenchidae). *J. Nat. Hist*. 44(15-16): 927–957.

Thu PQ, Dell B, & Burgess TI. 2009. Susceptibility of 18 eucalypt species to the gall wasp *Leptocybe invasa* in the nursery and young plantations in Vietnam. *ScienceAsia*. 35(2): 113–117.

Zhu FL, Ren SX, Qiu BL, Huang Z, & Peng ZQ. 2012. The abundance and population dynamics of *Leptocybe invasa* (Hymenoptera: Eulophidae) galls on *Eucalyptus* spp. in China. *J. Integr. Agric*. 11(12): 2116–2123.