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Submission date: 05-Apr-2023 09:38PM (UTC-0500)

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Community of eaglewood *Gyrinops versteegii* (Gilg.) Domke and the diversity of plant species associated in western Lombok forest

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ABSTRACT

The association between plant life is determined by the need of sun light, humidity and air temperature. This physic conditions shape the character canopy constituent species association between eaglewood with other plants in the community. This study aims to determine the diversity of plant species associated with eaglewood trees in western Lombok forest. The study population was seen in the forest areas of western Lombok image area of 46357.86 ha. Footage designed by the method of delineation where the existence of eaglewood. Analysis to determine the association of eaglewood with other plants used SPASSOC.BAS (software of GW-BASIC version 3.22 software). The results showed that the community of *G. versteegii* in the western Lombok forest portrayed on plants species associated with it. Species of plants that associated with *G. versteegii* influenced by the variety and rate of growth of *G. versteegii*.

Key words: Association, gaharu, eaglewood, *Gyrinops versteegii*, Lombok Island.

1. Introduction

Association can be defined as a vegetation unit derived from a number of samples of vegetation or releves which has the same number of total species. Individual members of the association, namely, a real community, can be known in the field by the presence of certain species of diagnostic groups. Asosiasi spesies are the species composition of character "(ie, species unique to the association-type), but also by some" species that distinguishes "(Mueller-Dombois, and Ellenberg, 1974).

On the basis of the type of character species are distinguished:

1. The character of local species; with a variety of diagnostic validity tight and limited (for example, can be used to mountain valleys, an island, or the environment of the countryside).

2. The character of territorial species; which have greater validity, naturally defined areas (e.g. Vienna basin, southwestern lowland Germany or Ireland).

3. The character of absolute species; who had diagnostic validity without geographical restrictions (Mueller-Dombois, and Ellenberg, 1974).

Eaglewood are found on the island of Lombok has a local name Ketimunan (*Gyrinops versteegii* (Gilg.) Domke) included belong to sub family Aquilarioideae (Domke, 1934) and family Thymelaeaceae (Hou, 1960). One of the 22 species of tree aloes pig producer in Indonesia which is naturally found only in the Lesser Sunda Inlands, Moluccas and Papua (Ding Hou (1960 and 1964), Gunn et al. (2004), Ng et al. (1997), Mulyaningsih and Yamada (2008), and Eurlings and Gravendeel, 2005).

The existence of agarwood trees in natural forests are very hard to find its existence, rare even tend to worry now (Mulyaningsih, 2014). Likewise, also on the island of Lombok, the scarcity of eaglewood in natural forests has been started in 2000 (Mulyaningsih, 2005).

Tragically, based on direct observations in the field, although the condition is rare and is protected by conservation laws (Anonymous, 2006). Eaglewood illegal felling of trees continues, to obtain natural agarwood that it is very expensive to reach IDR 500 million / kg at current (Communication with several collectors and businessmen agarwood on Halmahera Island, March 2015).

In the natural forest, eaglewood trees usually coexist with the specific of plant species, such as *G. versteegii* coexist with *Arenga pinnata*, *Ficus rumphii*, *Syzigium polyanthum*, *Dracontomelon dao*, *Albizia procera*, *Calophyllum inophyllum*, *Pterospermum javanicum*, *Calophyllum inophyllum*, *Lansium domesticum* Langsat group, *Swietenia macrophylla* and others. To ensure that the relationships (associations) between *G. versteegii* with these trees it is necessary to study. This study aims to determine the diversity of plant species association with eaglewood in western Lombok forest.

2. Methodology

The research location is geographically located at the research area coordinates: 8°15'-8°40' South Latitude and 116°00'-116°20' East Longitude (Figure 2). Meanwhile, according to the administrative area, the research area covers three regions, namely West Lombok, North Lombok and Central Lombok, consisting of seven districts and seven villages. The sampling was

designed using the method of delineation of the eaglewood location.

Morphological diversity of data obtained from the collection of plant specimens that are within the sampling unit and the herbarium specimens. Its were stored in Herbarium Bogoriensis in Bogor as well as literature.

Ecological data collected by making sampling units measuring 20 m x 20 m, The sampling was designed using the method of delineation of the aloes trees location.

This is intended to obtain the location of eaglewood in natural forests and vegetation present in the plots are really describe the condition of the habitat of the gaharu tree. Furthermore, in each plot footage was created sub-plots measuring 10 m x 10 m (for the recording of the data rate of the pole), sub plot 5 m x 5 m (for the sapling level), and the sub-plot 2 m x 2 m (for seedlings). All sub-sub plots were made by nesting on the plot shots 20 m x 20 m (Figure 1).

To obtain a picture related to natural regeneration for eaglewood, then conducted the survey of all the individuals of that species (seedling, sapling, pole and the tree) contained in footage plots measuring 20 m x 20 m. It is intended to obtain complete data in the observation plots.

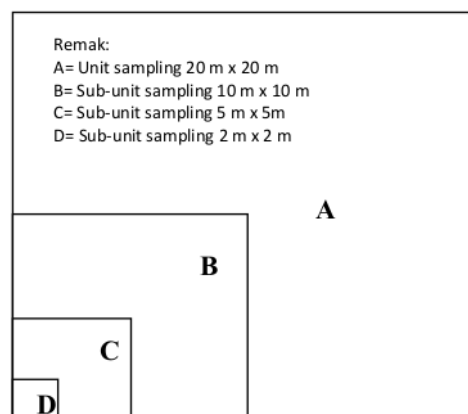


Figure. 1. Layout of sub-unit sapling in

each sampling unit of 20 m x 20 m)

The grouping or classification of ecological units was based on the structure and the location of eaglewood in the ecological unit by using an ordination analysis (Ludwig and Reynolds, 1988; Mueller-Dombois, and Ellenberg, 1974). Analysis to determine the association of eaglewood with other plants used SPASSOC.BAS (software of GW-BASIC version 3.22 software).

4. Results and Discussion

Based on the analysis ordinate obtained six ecological communities of plants, namely: (1) ecological communities of *G. versteegii* (Gilg.) Domke var. *fructiquadratus* T.M., D.M., S. & I.Y. var. nov.; (2) ecological communities of *G. versteegii* (Gilg.) Domke var. *brunniluteolus* T.M., D.M., S. & I.Y. var. nov.; (3) ecological communities of *G. versteegii* (Gilg.) Domke var. *longistipitis* T.M., D.M., S. & I.Y. var. nov.; (4) ecological communities of *G. versteegii* (Gilg.) Domke var. *brevistipitis* T.M., D.M., S. & I.Y. var. nov. and *G. versteegii* (Gilg.) Domke var. *tubuliformis* T.M., D.M., S. & I.Y. var. nov.; (5) the ecology of plant communities moisture areas (6) the ecology of plant communities dry areas. Sixth ecology of plant communities mentioned above, is illustrated in the map below (Figure 2).

Species of plants associated with *G. versteegii* var. *brevistipitis* at seedling stage.

Interactions between species into the lime light very important in the ecology of species. In a particular community, there are a number of biotic and abiotic factors affecting the distribution, abundance and species interactions. Depending on whether the two species choose the same habitat or avoid it, because it has some attraction to

shared or reject it, or no interaction whatsoever, which will generate a specific pattern on interspecific associations.

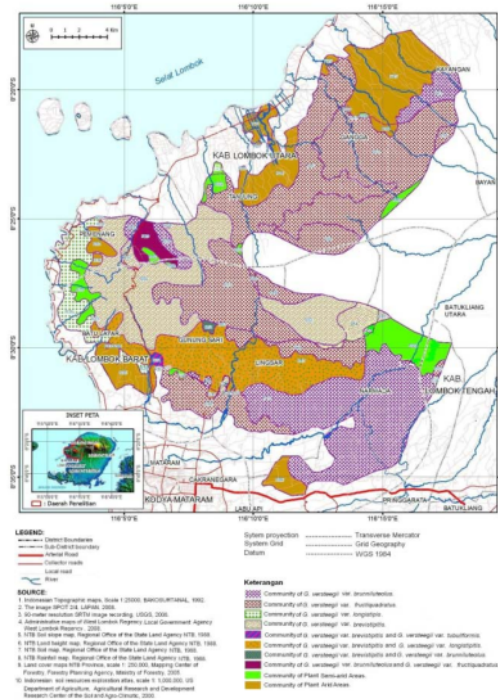


Figure. 2. Map of *G. versteegii* communities ecology in the western Lombok forest.

This association can be positive, negative, or no (no association). To measure the degree of association of the relationship between species used Ochiai Index (OI), Dice Index (DI) and Jaccard Index (JI). This technique is based on the presence or absence of species in ecological unit, i.e. by measuring how often the two species are found in the same location. In general, the relationship between the two species, because: 1. The two species choose the same habitat or avoid certain habitat factors; 2. The two species have common requirements abiotic and biotic environment are the same;

3. One or both species have an affinity for each other, either attraction or rejection (Ludwig & Reynolds, 1988)

True positive associations found in the couple *G. versteegii* var. *brevistipitis* with *Sandoricum koetjape* and *G. versteegii* var. *brevistipitis* with *Baccaurea racemosa* shown in the high association index: IO = 81.6%, ID = 80% and IJ = 66.7% for the first pair and the IO = 70.7%, 66.7% and ID = IJ = 50% for couples to two. *Thespesia populnea* and *Leucauca glauca* true negative association indicated by the Chi Square (X^2) = 2.222 and 5.000 > W test = 1.808. Figure 3. shows the results of the index associations that partner *G. versteegii* var. *fructiquadratus* true positively associated with *Hypobatrachum roxburghii* right index results indicated a high association namely: IO = 81.6%, ID = 80% and IJ = 66.7%.

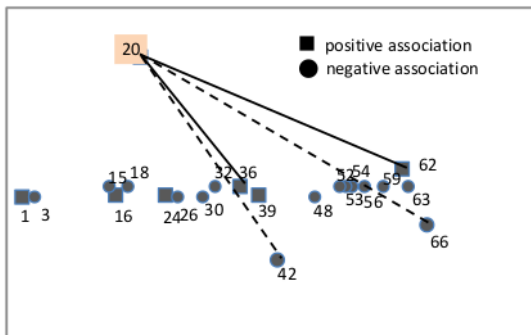


Figure 3. Diagram Plexus for the association between *G. versteegii* var. *brevistipitis* with 21 other plants in the forest seedlings in western Lombok in the seedling level. Species that are connected by a hyphen is positively associated right and connected with broken lines is true negative association. **Description:** (20). *G. versteegii* var. *brevistipitis*, (62). *S. koetjape*, (36). *B. racemosa*, (24). *Eugenia malaccensis*, (39). *Harpullia cupanioides*, (16). *L. domesticum* Langsat group, (54) *Calophyllum inophyllum*, (56) *Mangifera* sp., (53) *C.*

soulattri, (63) *Chisocheton pentandrus*, (15) *L. domesticum* Cluring group, (32) *Diospyros montana*, (52) *Artocarpus heterophyllus*, (18) *Metadina trichotoma*, (59) *Nephelium lappaceum*, (66) *T. populnea*, (42) *L. glauca*, (1) *A. pinnata*, (30) *S. polyanthum*, (3) *P. javanicum*, (26) *Pavetta indica* forma *montana* and (48) *S. macrophylla*.

Based on second plexus diagram above it can be concluded that the seedlings, *G. versteegii* var. *brevistipitis* positively associated true with trees of *S. koetjape* and *B. racemosa*. This means that both the tree coexist mutually benefit. Additionally *G. versteegii* var. *brevistipitis* with tree *S. koetjape* and *B. racemosa* have the same habitat.

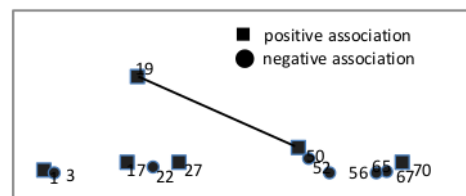


Figure 4. Plexus diagram for the association between *G. versteegii* var. *fructiquadratus* with 11 other plants in the seedling stage in western Lombok forest. Type associated with the line is positively associated correctly. **Description:** (19) *G. versteegii* var. *fructiquadratus*, (50) *H. roxburghii*, (70) *Litsea glutinosa*, (17) *Heritiera* sp. (27) *Punica granatum*, (1) *A. pinnata*, (22) *Eugenia aquea*, (67) *Pometia* sp., (52) *A. heterophyllus*, (56) *Mangifera* sp., (3) *P. javanicum* and (65) *Sandoricum sapindina*.

So that both the tree can also be used as an indicator of the existence of *G. versteegii* var. *brevistipitis*. However contrary tree *L. glauca* and *T. populnea* have a true negative association against *G. versteegii* var. *brevistipitis*. The presence of both the tree among the trees *G. versteegii* var. *brevistipitis* can be detrimental to the

growth of trees *G. versteegii* var. *brevistipitis*. *L. glauca* has a tiny leaf and canopy structure does not make the meeting so that the intensity of light can penetrate to the ground.

This causes the soil surface becomes dry conditions are not favorable for the survival of *G. versteegii* var. *brevistipitis*. *T. populnea* has a canopy that is too tight, shallow rooting and greedy for nutrients so it can inhibit the trees growth of *G. versteegii* var. *brevistipitis*. *G. versteegii* var. *fructiquadratus*, absolutely positively associated with *H. roxburghii*. This tree has leaves that are not so dense, so sunlight can reach to two species of the tree canopy. This tree can be used as indicators of habitat *G. versteegii* var. *fructiquadratus*.

The plants species associated with *G. versteegii* var. *brevistipitis* at sapling stage.

Species of plants associated with *G. versteegii* at the level of sapling. At sapling level, there are four diverse population agarwood trees namely: *G. versteegii* var. *fructiquadratus*, *G. versteegii* var. *brunniluteolus*, *G. versteegii* var. *brevistipitis* and *G. versteegii* var. *longistipitis*. Results of variance ratio test, chi-square and association index on sapling level shown in (Figure 5).

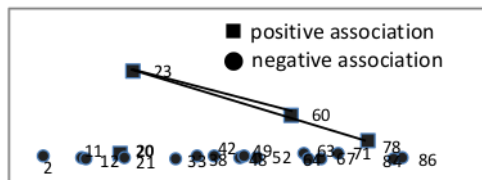


Figure 5. Plexus Diagram for the association between *G. versteegii* var. *fructiquadratus*, with 19 species of other plants at a rate of sapling in the forest in western Lombok. Type associated with a hyphen true positively associated. **Description:** (23) *G. versteegii* var. *fructiquadratus*, (78) *Chisocheton pentandrus* (60). *H. roxburghii*,

(20) *Heritiera* sp., (71) *Mangifera* sp., (63) *Gnetum gnemon*, (2) *Garcinia divida*, (49) *A. fuliginosa*, (42) *Dracontomelon costatum*, (38) *Cinnamomum zeylancum*, (21) *Durio zibethinus*, (48) *Coffea arabica*, (11) *Planchonella nitida*, (86) *Litsea glutinosa*, (52) *Pentaspadon* sp., (12) *Theobroma cacao*, (67) *C. soulattri*, (33) *P. granatum*, (84) *Timonius* sp. and (64) *Garcinia dulcis*.

From the results of the analysis obtained *G. versteegii* var. *fructiquadratus* absolutely positively associated with *H. roxburghii* shown on a high association index namely: $IO = 100\%$, $ID = 100\%$ and $IJ = 100\%$, and the couple *G. versteegii* var. *fructiquadratus* absolutely positively associated with *C. pentandrus* with an index value of association: $IO = 70.7\%$, $ID = 66.7\%$ and $IJ = 50\%$.

Results of variance ratio test, chi-square and association index for *G. versteegii* var. *brunniluteolus* sapling at the level shown in (Figure 6). True positive associations found in the couple *G. versteegii* var. *brunniluteolus* with *C. inophyllum* and *G. versteegii* var. *brunniluteolus* with *M. indica* shown on a high association index namely: $IO = 100\%$, $ID = 100\%$ and $IJ = 100\%$ as well as on partner *G. versteegii* var. *brunniluteolus* with *C. arabica* and couples of *G. versteegii* var. *brunniluteolus* with *P. guajava* the association index: $IO = 70.7\%$, $ID = 66.7\%$ and $IJ = 50\%$.

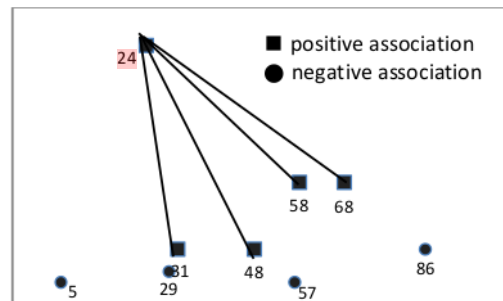


Figure 6. Plexus Diagram for the association between *G. versteegii* var. *brunniluteolus* with 8 other species at the rate of sapling in the forest in western Lombok. Type associated with a hyphen is true positively associated. **Description:** 24. *G. versteegii* var. *brunniluteolus*, 58. *M. indica*, 68. *C. inophyllum*, 31. *Psidium guajava*, 48. *C. arabica*, 29. *E. aqua*, 86. *Litsea glutinosa*, 57. *S. macrophylla* and 5. *Bambusa* sp.

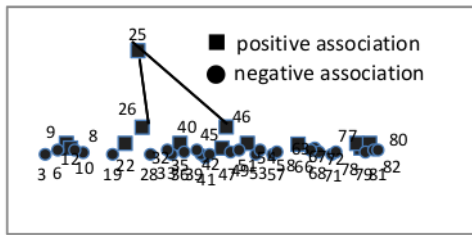


Figure 7. Plexus Diagram for the association between *G. versteegii* var. *brevistipitis* with 39 other plant species at a rate of sapling in the forest in western Lombok. Type associated with a hyphen is true positively associated. **Description:** (25) *G. versteegii* var. *brevistipitis*, (26) *G. versteegii* var. *longistipitis*. (46) *Diospyros sundaica*, (63) *G. gnemon*, (35) *Citrus reticulate*, (77) *S. koetjape*, (80) *T. populnea*, (51) *Ficus septica*, (8) *Hypobathrum* sp., (22) *Metadina trichotoma*, (67) *C. soulattri*, (78) *C. pentandrus*, (9) *Eurya acuminata*, (45) *Harpullia cupanioides*, (41) *B. racemosa*, (19) *L. domesticum* Langsat group, (57) *S. macrophylla*, (71) *Mangifera* sp., (3) *P. javanicum*, (33) *P. granatum*, (40) *S. nervosum*, (42) *Dracontomelon costatum*, (53) *Syzygium microcymum*, (28) *F. rumphii*, (68) *C. inophyllum*, (58) *M. indica*, (79) *S. sapindina*, (36) *C. zeylanicum*, (47) *Syzygium* sp., (72) *Villebrunea rubescens*, (12) *T. cacao*, (32) *Anacardium occidentale*, (49) *Ardisia fuliginosa*, (54) *Schoutenia ovata*, (66) *A. heterophyllum*, (81) *Pometia* sp., (82) *Mimosops elingi*, (6) *Hypobathrum microcarpum*, (39) *Diospyros montana* and (10) *Dilenmia indica*.

In the association between *G. versteegii* var. *brevistipitis* with 39 other plant species at a rate of sapling, the results of variance ratio test, chi-square and association indexes are shown in (Figure 7). *G. versteegii* var. *brevistipitis* true positive association with *G. versteegii* var. *longistipitis* and *D. sundaica* show in association index is quite high, namely: **IO = 70.7%**, **ID = 66.7%** and **IJ = 50%** on the second pair.

Associations between *G. versteegii* var. *longistipitis* with 16 other plants species at a rate of sapling, the results of variance ratio test, Chi-square and association indexes are shown in (Figure 8). *G. versteegii* var. *longistipitis* true positive association with *G. versteegii* var. *brevistipitis* and *H. cupanioides* shown in association index is high enough that: **IO = 100%**, **ID = 100%** and **IJ = 100%** in both partners, as well as on partner *G. versteegii* var. *longistipitis* true positive associated with *Gymnacranthera farquhariana* and *Syzygium racemosa* show in association index is high enough that: **IO = 70.7%**, **ID = 66.7%** and **IJ = 50%** on the second pair.

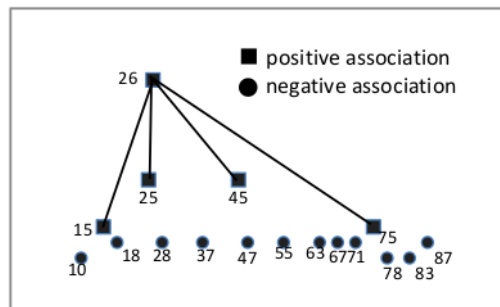


Figure 8. Plexus diagram for the association between *G. versteegii* var. *longistipitis* with 16 other plants species at a rate of sapling in the forest in western Lombok. Species that are connected by a hyphen is true positively

associated. **Description:** (26) *G. versteegii* var. *longistipitis*, (25) *G. versteegii* var. *brevistipitis*, (45) *H. cupanioides*, (15) *G. farquhariana*, (75) *S. racemosa*, (41) *S. polyanthum*, (55) *A. edulis*, (9) *A. scholaris*, (69) *A. heterophyllus*, (67) *C. soulattri*, (16) *T. cacao*, (63) *G. gnemon*, (62) *S. macrophylla*, (80) *N. lappaceum*, (33) *Eugenia malaccensis* and (78) *Dysoxylum parasiticum*.

Species of plants associated with *G. versteegii* at levels pole.

At the level of sapling, based on the variance ratio test, Chi-square and association index showed a positive association between *G. versteegii* with plants species. Each population of *G. versteegii* in his community have specific plant species as shown below. *G. versteegii* var. *fructiquadratus*, absolutely positively associated with *H. roxburghii*, *C. pentandra*. *G. versteegii* var. *brunniluteolus* absolutely positively associated with: *C. inophyllum*, *M. indica*, *C. arabica* and *P. guajava*. *G. versteegii* var. *brevistipitis* true positively associated *G. versteegii* var. *longistipitis* and *D. sundaica*. *G. versteegii* var. *longistipitis* true positively association with *G. versteegii* var. *brevistipitis*, *G. farquhariana*, *S. racemosa* and *H. cupanioides*.

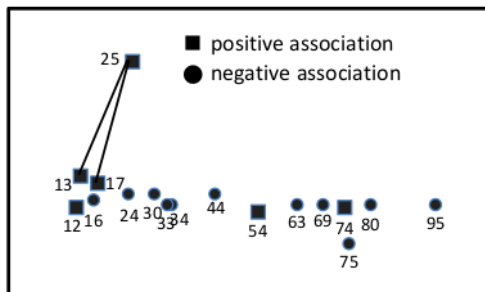


Figure 9. Plexus diagram for the association between *G. versteegii* var. *fructiquadratus* with 16 other plants species at the level of the poles in the forest in western Lombok. Type associated with a hyphen is true

positively associated and which are connected with broken line are true negative association. **Description:** (25) *G. versteegii* var. *fructiquadratus*, (13) *Planchonella nitida*, (17) *Erythrina orientalis*, (74) *Mangifera* sp., (54) *D. costatum*, (12) *Garcinia opura*, (44) *M. trichotoma*, (30) *F. rumphii*, (24) *D. zibethinus*, (34) *A. occidentale*, (63) *M. indica*, (69) *A. heterophyllus*, (80) *N. lappaceum*, (33) *E. malaccensis*, (95) *L. glutinosa*, (75) *Areca catechu* and (16) *T. cacao*.

At the poles there are four varieties of eaglewood namely: *G. versteegii* var. *fructiquadratus*, *G. versteegii* var. *brunniluteolus*, *G. versteegii* var. *brevistipitis* and *G. versteegii* var. *longistipitis*. Results of variance ratio test, Chi-square and association index on the association between *G. versteegii* var. *fructiquadratus* with 16 plants species. Figure 9 shows *G. versteegii* var. *fructiquadratus* true positive association with *P. nitida* and *E. orientalis* show in association index is quite high, namely: $IO = 81.6\%$, $ID = 80\%$ and $IJ = 66.7\%$ and $IO = 70.7\%$, ID and $IJ = 66.7\% = 50.0\%$.

Results of variance ratio test, Chi-square and association index on the association between *G. versteegii* var. *brunniluteolus* with 7 other plants species at the level of the pole. Figure 10 shows *G. versteegii* var. *brunniluteolus* true positive associations with *A. heterophyllus*, *Alstonia spectabilis* designated on the value of $X^2 = 3.000 > VR$ index and the index is high enough associations: $IO = 1.6\%$, $ID = 80\%$ and $IJ = 66.7\%$ for the second pair.

Additionally *G. versteegii* var. *brunniluteolus* also associated with *G. gnemon* and *D. zibethinus* the association index: $IO = 70.7\%$, $ID = IJ = 66.7\%$ and 50.0% . *G. versteegii* var. *brunniluteolus* true positive association with *A. heterophyllus*, *A. spectabilis*. *G. versteegii* var. *brunniluteolus* true positive association with *G. gnemon*, *D.*

zibethinus, *A. heterophyllus* and *A. spectabilis*.

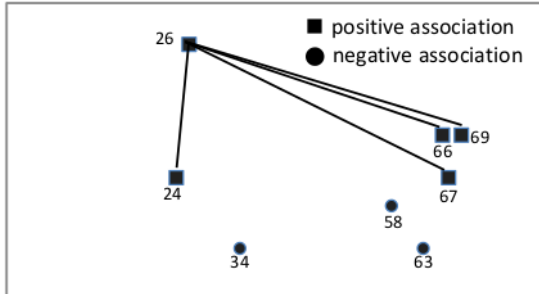


Figure 10. Plexus diagram for the association between *G. versteegii* var. *brunniluteolus* with 7 other plants species in the forest in western Lombok. Species that are connected by a hyphen is true positively associated and connected with broken line is true negative association. **Description:** (26) *G. versteegii* var. *brunniluteolus*, (69) *A. heterophyllus*, (66) *A. spectabilis*, (67) *G. gnemon*, (24) *D. zibethinus*, (34) *A. occidentale*, (63) *M. indica* and (58) *C. Arabica*.

Results of variance ratio test, Chi-square and association index on the association between *G. versteegii* var. *brevistipitis* with 25 other plants species at the level of the pole. Figure 11 shows the couple *G. versteegii* var. *brevistipitis* with *Horsfieldia* sp. positively associated correctly shown on the value of $X^2 = 5.000 > VR$ index and the index is high enough associations: $IO = 81.6\%$, $ID = 80\%$ and $IJ = 66.7\%$ and couples *G. versteegii* var. *brevistipitis* with *Bambusa* sp. the association index: $IO = 70.7\%$, $ID = 66.7\%$ and $IJ = 50.0\%$.

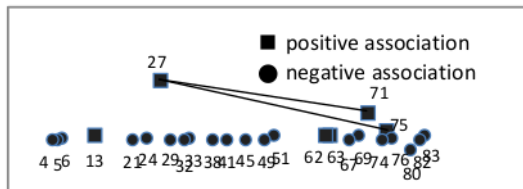


Figure 11. Plexus diagram for the association between *G. versteegii* var. *brevistipitis* with 25 other plants species at the poles level, in the forest in the western part of Lombok. Species that are connected by a hyphen is absolutely positively associated. **Description:** (27) *G. versteegii* var. *brevistipitis*, (71) *C. inophyllum*, (75) *A. catechu*, (63) *M. indica*, (62) *Sterculia macrophylla*, (13) *P. nitida*, (80) *N. lappaceum*, (51) *B. racemosa*, (69) *A. heterophyllus*, (83) *S. koetjape*, (24) *D. zibethinus*, (76) *Villebrunea rubescens*, (33) *E. malaccensis*, (6) *D. rigida*, (67) *G. gnemon*, (74) *Mangifera* sp., (41) *S. polyanthum*, (5) *P. javanicum*, (32) *Meliosa ferruginea*, (38) *C. reticulate*, (45) *Diospyros montana*, (49) *Canarium littorale*, (4) *G. divida*, (21) *L. domesticum* Cluring group, (29) *C. corniculata* and (82) *Paraserianthes falcataria*.

Results of variance ratio test, Chi-square and association index on the association between *G. versteegii* var. *longistipitis* with 11 other plants species at the level of the pole. Figure 12 indicate a true positive associations found in the couple *G. versteegii* var. *longistipitis* with *S. polyanthum*, *Allophylus cobbe* and *A. scholaris* shown on a high association index, namely: $IO = 100\%$, $ID = 100\%$ and $IJ = 100\%$.

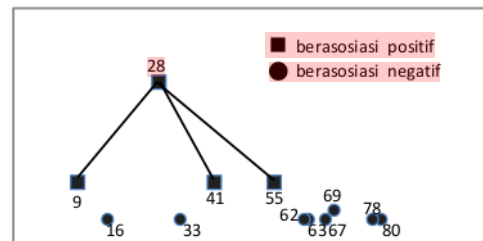


Figure 12. Plexus diagram for the association between *G. versteegii* var. *longistipitis* with 11 other plants species in the forest in West Lombok. Species that are connected by a hyphen is true positive association. **Description:** (28) *G. versteegii* var. *longistipitis*, (41) *S. polyanthum*, (55)

Allophylus cobbe, (9) *A. scholaris*, (69) *A. heterophyllus*, (67) *G. gnemon*, (16) *T. cacao*, (63) *M. indica*, (62) *S. macrophylla*, (80) *N. lappaceum*, (33) *E. malaccensis* and (78) *D. parasiticum*.

Species of plants associated with *G. versteegii* at tree level.

The positive association relationship between *G. versteegii* var. *fructiquadratus* with other trees at the tree level, based on the results of the variance ratio test, Chi-square and association index, showed a true negative association contained on the pair: *G. versteegii* var. *fructiquadratus* with *T. cacao*, and *A. heterophyllus* (the value of $X^2 = 4,000 > W$ value test). True positive associations found in the couple *G. versteegii* var. *fructiquadratus* with *C. nucifera* shown in the value of $X^2 = 4,000 > W$ test and the index values are fairly high association namely: IO = 100%, ID = 100% and 100% and the IJ = true positive associations are also present in pairs : *versteegii* var. *fructiquadratus* with *A. pinnata*; *S. macrophylla*; *D. dao*; *L. domesticum* Langsat group; *A. procera* and *P. valida* shown on a high association index, namely: IO = 81.6%, ID = 80% and IJ = 66.7%.

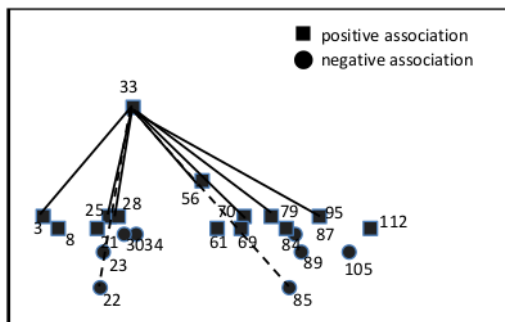


Figure 13. Plexus diagram for the association between *G. versteegii* var. *fructiquadratus* with 21 other plants species at the level of the tree, in the forest west part of Lombok. Species that are connected by a hyphen is

true positive association and broken lines a true negative association. **Description:** (33) *G. versteegii* var. *fructiquadratus*, (56) *Cocos nucifera*, (3) *A. pinnata*, (79) *S. macrophylla*, (25) *D. dao*, (28) *L. domesticum* Langsat group, (70) *A. procera*, (95) *P. valida*, (8) *P. javanicum*, (61) *Neonauclea calycina*, (69) *A. cobbe*, (84) *A. spectabilis*, (21) *Syzygium aromaticum*, (112) *Litsea angulata*, (23) *E. orientalis*, (105) *Toona sureni*, (89) *Palaquium javense*, (85) *G. gnemon*, (22) *T. cacao*, (87) *A. heterophyllus*, (34) *G. versteegii* var. *brunniluteolus* and (30) *D. zibethinus*.

Results of variance ratio test, Chi-square and association index on the association between *G. versteegii* var. *brunniluteolus* with 13 other plants species at tree level. True negative association found in pair *G. versteegii* var. *brunniluteolus* with *T. sureni* (value of $X^2 = 3,000 > W$ test) (Figure 13).

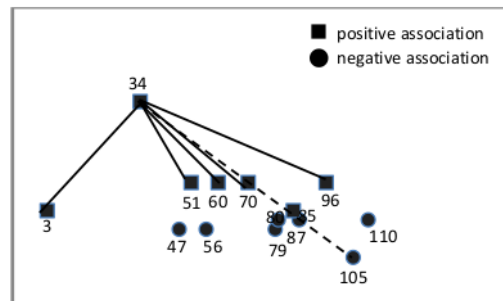


Figure 14. Plexus diagram for the association between *G. versteegii* var. *brunniluteolus* with 13 other plants species at the level of the tree, in a forest in western Lombok. Species that are connected by a hyphen is true positive association and broken lines a true negative association. **Description:** (34) *G. versteegii* var. *brunniluteolus* (51) *S. polyanthum*, (70) *A. procera*, (96) *N. lappaceum*, (60) *C. littorale*, (3) *A. pinnata*, (85) *G. gnemon*, (56) *C. nucifera*, (79) *S. macrophylla*, (47) *P. valida*, (105) *T. sureni*,

(80) *M. indica*, (87) *A. heterophyllus* and (110) *M. caesia*.

True positive associations found in the couple *G. versteegii* var. *brunniluteolus* with *S. polyanthum*, *A. procera*, *N. lappaceum* and *C. littorale* shown in (the value of Chi-Square = 3,000 > W_{test}) and a fairly high association index ie: IO = 100%, ID = 100% and IJ = 100% and a couple *G. versteegii* var. *brunniluteolus* with *A. pinnata* and couples *G. versteegii* var. *brunniluteolus* with *G. gnemon* ordi¹ed with a high enough value, namely: IO = 70.7%, ID = 66.6% and IJ = 50%

Results of variance ratio test, Chi-square and association index on the association between *G. versteegii* var. *brevistipitis* with 22 other plants species at tree level. True positive associations found in *G. versteegii* var. *brevistipitis* with *G. versteegii* var. *tubuliformis*, *S. polyanthum*, *B. racemosa*, *D. dao*, *F. rumphii* and *L. domesticum* Langsat group shown¹ in association index is quite high, namely: IO = 70.7%, ID = 66.7% and IJ = 50.0% (Figure 22).

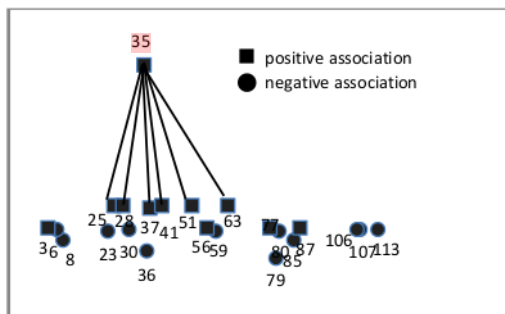


Figure 15. Plexus diagram for the association between *G. versteegii* var. *brevistipitis* with 22 other plants species at a rate of tree in a forest in western Lombok. Species associated with the line is a¹bsolutely positive association. **Description:** (35) *G. versteegii* var. *brevistipitis*, (37) *G. versteegii* var. *tubuliformis*, (51) *S. polyanthum*, (63) *B. racemosa*, (25) *D. dao* (41) *F. rumphii*, (28)

L. domesticum Langsat group, (56) *C. nucifera*, (87) *A. heterophyllus*, (3) *A. pinnata*, (77) *S. microcymum*, (36) *G. versteegii* var. *longistipitis*, (80) *M. indica*, (23) *E. orientalis*, (59) *C. odorata*, (79) *S. macrophylla*, (85) *G. gnemon*, (8) *P. javanicum*, (30) *D. zibethinus*, (107) *Artocarpus elasticus*, (106) *Alseodaphne* sp., (6) *G. divida* and (113) *Antidesma bunius*.

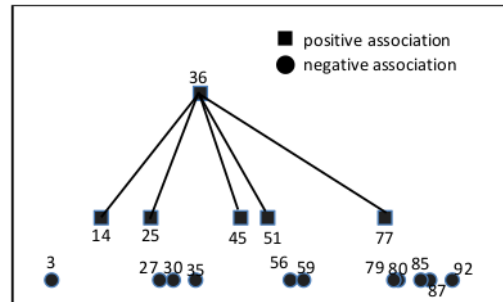


Figure 16. Plexus diagram for the association between *G. versteegii* var. *longistipitis* with 16 other plants species at a rate of trees in a forest in western Lombok. Species associated with the line is true positive association. **Description:** (36) *G. versteegii* var. *longistipitis*, (51) *S. polyanthum*, (25) *D. dao*, (37) *G. versteegii* var. *tubuliformis*, (28) *L. domesticum* Langsat group, (41) *F. Rumphii* and (63) *B. racemosa*. (77) *Syzigium microcymum*, (45) *E. malaccensis*, (14) *A. scholaris*, (56) *C. nucifera*, (80) *M. indica*, (35) *G. versteghii* var. *brevistipitis*, (87) *A. heterophyllus*, (3) *A. pinnata*, (85) *G. gnemon*, (30) *D. zibethinus*, (79) *S. macrophylla*, (59) *Cananga odorata*, (27) *L. domesticum* Cluring group and (92) *A. catechu*.

The association between *G. versteegii* var. *longistipitis* with 16 other plants species at tree level. True positive associations found¹ *G. versteegii* var. *longistipitis* with *S. polyanthum*, *D. dao*, *S. microcymum*, *E. malaccensis* and *A. scholaris* show¹ in association index is quite high, namely: IO = 100%, ID = 100% and IJ = 100% (Figure

14). *G. versteegii* var. *tubuliformis* found in one ecological unit with *G. versteegii* var. *brevistipitis* certainly *G. versteegii* var. *tubuliformis* also positively associated with tree species associated with *G. versteegii* var. *brevistipitis* (Figure 16).

On the growth rate of the trees there are true negatives associated tree species with eaglewood, especially on *G. versteegii* var. *fructiquadratus* and *G. versteegii* var. *brunniluteolus*. *G. versteegii* var. *fructiquadratus* absolutely positively associated with *Planchonella nitida*, *E. orientalis*. *Planchonella nitida* and *E. orientalis* has a canopy with a layout that is not so tight leaves and roots grow vertically. The conditions enable both the tree species can share the sunlight and nutrients as well as the association between the three species of these plants can create a fairly high humidity.

G. versteegii var. *brunniluteolus* true positive association with *A. pinnata* tree, *A. procera*, *S. polyanthum*, *C. littorale* and *N. lappaceum*. Palm trees have an upright canopy so sunlight can share with the adjacent plant species. Trees also strong roots can withstand erosion and has the ability to bind water so as to maintain soil moisture and the surrounding air (Hidayat, 2014; Nugroho, 2008). So also the tree *A. procera*, *S. polyanthum*, *C. littorale* and *N. lappaceum* have canopy structure with the layout leaves were not so tight. Such canopy structure can maintain air humidity and sunlight can share with other trees side by side.

G. versteegii var. *brevistipitis* true positive association with *G. versteegii* var. *tubuliformis* and *L. domesticatum* Langsat group, *D. dao*, *F. rumphii*, *S. polyanthum*, *B. racemosa*. *G. versteegii* var. *tubuliformis*, *L. domesticatum* Langsat group, *D. dao* canopy structure has an oval shape and layout has leaves that are not so tight. Such canopy structure can maintain air humidity and sunlight can share with other trees side by

side. *Ficus rumphii* have canopy structure has a rounded shape and layout leaves tightly enough, but the roots can store water, so that the soil and surrounding air humidity is maintained.

G. versteegii var. *brevistipitis* true positive associated with *A. scholaris*, *S. polyanthum*, *D. dao*, *E. malaccensis* and *S. microcymum*. The species has a canopy structure with the layout of the leaves were not so tight. Such canopy structure can maintain air humidity and sunlight can share with other trees side by side.

At the tree level, based on test results ratio variants, chi-square and association index showed a true positive association is also true negative association between *G. versteegii* with plant species. Such as the following shows that every group in *G. versteegii* have specific species in the association.

So at the tree level, based on test results ratio variants, Chi-square and association index showed a true positive association and also true negative association between *G. versteegii* with plant species. Such as the following shows that every group in *G. versteegii* have specific species in the association.

1. *G. versteegii* var. *fructiquadratus* true negatives associated with *T. cacao*, and *A. heterophyllus*. On the other hand *G. versteegii* var. *fructiquadratus* absolutely positively associated with *C. nucifera*, *A. pinnata*, *S. macrophylla*, *D. dao*, *L. domesticum* Langsat group, *A. procera* and *P. valida*.

2. *G. versteegii* var. *brunniluteolus* true negative associated with *T. sureni*. In contrast to the species *S. polyanthum*, *A. procera*, *N. lappaceum*, *A. pinnata*, *G. gnemon* and *C. littorale* true positive association with *G. versteegii* var. *brunniluteolus*.

3. *G. versteegii* var. *brevistipitis* true positive association with *G. versteegii* var. *tubuliformis*, *S. polyanthum*, *B. racemosa*, *D.*

dao, *F. rumphii* and *L. domesticum* Langsat group.

4. *G. versteegii* var. *longistipitis* with *S. poly-anthum*, *D. dao*, *S. microcymum*, *E. malaccensis* and *A. scholaris*.

Plant species that became associated with *G. versteegii* broadly has the character structure of the canopy with the layout leaves were not so tight. The canopy structure can maintain air humidity and sunlight. It can share with other trees side by side, or roots can store water to maintain soil moisture and air in the vicinity. This plant species is essential for maintaining the ecological functions of ecosystems *G. versteegii* remained stable. In addition plant species that can be used as an indicator of ecosystem ecology unit of *G. versteegii*. It can also be used as a reference in the domestication *G. versteegii*. One of the causes of the differences in the association of plant species on each varieties *G. versteegii* and growth rate because of differences in geography of ecological unit. The following are presented in table 1 plant species associated with *G. versteegii*.

The existence of a ecosystem community garahu tree together with other plants species. There is a positive or negative association. According Kimmins (1997), the presence of other species may be important for food and / or shelter, or perhaps the main threat in terms of disease, predation, parasitic or competition. Beneficial or harmful relationship may exist between organisms of the same size. Interspecific relationships that do not always appear to be the major factor controlling the performance or even the existence of species in a particular ecosystem.

Table 1. Species of plants associated with *G. versteegii*

	The type of association in <i>G. versteegii</i> :
	1. var. <i>fructiquadratus</i> ;
	2. var. <i>Brunniluteolus</i> ;

No	Plant species	1	2	3	4
	3. var. <i>longistipitis</i> ; 4. var. <i>brevistipitis</i>				
SEEDLING					
1	<i>H. roxburgii</i>	+			
2	<i>S. koetjape</i>				+
3	<i>L. glauca</i>	-			
4	<i>T. populnea</i>	-			
SAPLING					
1	<i>H. roxburghii</i>	+			
2	<i>C. inophyllum</i>		+		
3	<i>G. versteegii</i> var. <i>brevistipitis</i>	.		+	
4	<i>G. versteegii</i> var. <i>longistipitis</i>	.			+
5	<i>C. Pentandrus</i>	+			
6	<i>M. indica</i>		+		
7	<i>G. farquhariana</i>			+	
8	<i>D. Sundaica</i>				+
9	<i>C. arabica</i>		+		
10	<i>S. Racemosa</i>			+	
11	<i>P. guajava</i>		+		
12	<i>H. cupanioides</i>			+	
POLE					
1	<i>P. nitida</i>	+			
2	<i>G. gnemon</i>		+		
3	<i>S. polyanthum</i>			+	
4	<i>Horsfieldia</i> sp				+
5	<i>E. Orientalis</i>	+			
6	<i>D. zibethinus</i>		+		
7	<i>A. cobbe</i>			+	
8	<i>Bambusa</i> sp				+
9	<i>A. heterophyllus</i>		+		
10	<i>A. Scholaris</i>			+	
11	<i>A. spectabilis</i>		+		
TREE					
1	<i>C. nucifera</i>	+			
2	<i>S. polyanthum</i>		+	+	+
3	<i>A. pinnata</i>	+	+		
4	<i>A. procera</i>	+	+		
5	<i>D. dao</i>	+		+	+

6	<i>B. racemosa</i>				+
7	<i>S. macrophylla</i>	+			
8	<i>N. lappaceum</i>		+		
9	<i>S. microcymum</i>			+	
10	<i>E. malaccensis</i>			+	
11	<i>F. rumphii</i>				+
12	<i>L. domesticum</i> Langsat group	+			+
13	<i>G. gnemon</i>		+		
14	<i>A. scholaris</i>			+	
15	<i>C. littorale</i>		+		
16	<i>P. valida</i>	+			
17	<i>T. cacao</i>	-			
18	<i>T. sureni</i>	-			
19	<i>A. heterophyllus</i>	-			

1. Conclusion

The results showed that the community of eaglewood trees can be illustrated on *G. versteegii* on plant species diversity associated with it each level of eaglewood growth and *G. versteegii* varieties of plant species has a specific association.

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