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Population dynamics of Auricularia delicata fruit bodies in Bingungan forest, Turgo D. Prasetiya and T. Aminatun1 1Department of Biology, Yogyakarta State Universiy, Yogyakarta, Jl. Colombo No.1, 55281, Indonesia dwiki412fmipa@student.uny.ac.id Abstract. We have already done describing clearly enough about the particular substrates as Auricularia delicata habitat. Along with that research, another study was population dynamics of Auricularia delicata fruit bodies, among density and all measured environmental factors (temperature, air humidity, light intensity, pH, and water content of the substrates) which were carried out in Bingungan forest for eight months, 136 sampling from rainy season began to early dry season. Those data were analyzed using time series analysis which visualized in FIR (Finite Impuls Response) graphs and discriminant analysis (LDA) to classify similarity among plots and samplings. The population dynamics of Auricularia delicata fruit bodies might be modeled using GEE (Generalized Estimating Equation) analysis for forecasting purpose. Therefore, we have representation about when the best timing of Auricularia delicata did fruiting process in what conditions really were. Keywords: Auricularia delicata, Population Dynamics, Environmental factors, GEE Introduction Auricularia delicata is edible mushroom included macrofungi group with jelly and gelatin texture. This macrofungus is closed to the others jelly-textured fungi such as ear mushrooms (Auricularia spp.). In the research report of Prasetiya et al.[1]. Auricularia delicata has the jelly texture like seaweed. It is colored white cream, yellow to dark brown on the margin and then more brown or orange in the middle surface. The margin of this macrofungi is wavy. The pileal bottom surface is patterned irregularly, stemless, has fruit body thickness 0.1-0.2 cm, and width 0.5 - 6.5 cm. In term of the fruiting process, all of the macrofungi are affected by environmental factors changes. Ohenoja[2] explained that within a geographic region fruiting process is influenced by elevation and latitude and their effects to the climatic factors such as humidity, temperature, and precipitation. In this research, we concerned primarily with the effects of environmental factors changes on fungal fruiting of Auricularia delicata. However, fungi often can tolerate particular wide range of suboptimal factors if all others are near optimal, but a combination of suboptimal factors can prevent fungal growth and development[4]. Xing-Hong et al.[3] have determined optimum several conditions such as temperature, pH, water content and chemical compounds of substrates in purpose to optimize Auricularia delicata fruit bodies production in cultivation sector in China. Maintaining and restoring desired wood decay-associated macrofungi can be quite enough as a challenge for management given the problems of detectability, variable dispersal, log down pattern and distribution and lack of scientific information on species-life histories and habitat requirements [5][6]. Within describing clearly enough about particular substrates as Auricularia delicata habitat and Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI. Published under licence by IOP Publishing Ltd 1 studying population dynamics of Auricularia delicata fruit bodies, among density and all measured environmental factors (temperature, air humidity, light intensity, pH, and water content of the substrates) from the rainy season to the early dry season will give the first basic data to maintain Auricularia delicata' living ecosystem . Methods 2.1 Determination of permanent plots. The plots were determined based on the type of substrates which overgrown with Auricularia delicata' fruitbodies. Plots determination was done by substrate based sampling

method [7]. Bingungan forest had been explored, then each coordinate point and elevation of the plot that used as permanent plots were recorded in a notebook and made into a distribution map (plots coded as D01, D02, D03, D04, D05, D06, D07, D08, and D09). 2.2 Monitoring population dynamics of Auricularia delicata. The population of Auricularia delicata calculated in each plot was Auricularia delicata density of fruit bodies . 2.3 Measuring microclimates and substrate retrieval. The microclimate conditions of each plot that were measured directly at each sampling include air temperature, light intensity, and air humidity. The substrates which overgrown with Auricularia delicata fruit bodies were taken about ± 10 grams to be analyzed for pH and wood water content. 2.4 Data Analysis. Those collected data were analyzed using time series analysis which visualized in FIR (Finite Impuls Response) graphs and discriminant analysis (LDA) to classify similarity among plots and samplings. The population dynamics of Auricularia delicata fruit bodies might be modeled using GEE (Generalized Estimating Equation). Results and Discussion 3.1 Population dynamics along with measured environmental variables. Firstly, the fluctuated data are presented in the form of FIR graphs in Figure 1, 2, 3, 4, 5, and 6 to see the trends of fruit bodies' density of Auricularia delicata and all measured environmental factors during monitoring from October 2017 – May 2018 in 136-time sampling. Figure 1.Fruit bodies density trend of Auricularia delicata in 136 time sampling ranged from 0 (min) – 640 (max) Figure 2.Temperature changes trend in 136 time sampling ranged from 17°C (min) – 27°C (max) Figure 3.Humidity changes trend in 136 time sampling ranged from 44% (min) - 90% (max) Figure 4. Light intensity changes trend in 136 time sampling ranged from 21,1 lux (min) – 48.500 lux (max) Figure 5. Water content changes trend in136 sampling ranged from 16,8% (min) – 452,6% (max) Figure 6. pH changes trend in 136 time sampling ranged from 4 (min) – 7,5 (max) Both from the observational data and the graphs during rainy season until early dry season, the number of Auricularia delicata fruit bodies in density experienced fluctuation. The highest fruit bodies population of Auricularia delicata in 2017 occurred at the 101st sampling with the number of fruit bodies production reached 640 on the plot D04 whose substrate included decay class 4; environmental factors measured at the sampling were 20°C at temperature, 79% at air humidity, 33 lux at light intensity, 5.8 at pH and 136.33% at water content with severe weather condition, which was likely raining to occur in the morning or night, previously. From Figure 1, it can be seen that the most fruit bodies of Auricularia delicata were produced in April until May 2018 as the early dry season; the production of these fruit bodies ranged from 120 to 640 in the plots where substrates included as category of decay classes 3 and 4, namely plots D01, D02, D03, D04, D05, D08 and D09, while in the living tree plots that were D06 and D07 only a few number of fruit bodies production which did not reach 20 in density. 3000 2848 2500 2000 1800 1599 1500 Density 1000 985 677 702 Rainfall (mm) 577 567681 500 389 471 454 475 228 89 146 0 / Figure 7. Auricularia delicata fruit bodies dynamics against rainfall by per month Figure 7 showed the population dynamics of Auricularia delicata fruit bodies against rainfall. The most fruit production occurred in March April as the early dry season; the total fruit of sampling production reached 1800 and 2800 with rainfall values of 89 mm and 146 mm, even in January (still included in rainy season) the total production of fruit bodies reached 1599 with rainfall value of 475 mm. In addition to determining the highest production of fruitbodies every month, the best sampling can also be determined by using the discriminant analysis to obtain a classification of sampling that has similar conditions in which plots were in Figure 8, so we could find out the optimum environmental factors that affected the highest production of Auricularia delicata fruit bodies in Table 1. Figure 8. Discriminant analysis (LDA) graph, adjacent coordinate points showed similar sampling condition and each symbol represented each plot Table 1. Discriminant analysis classification, the same number shows similar sampling condition Sampling /plots D01 D02 D03 D04 D05 D06 D07 D08 D09 Oct-14 Oct-28 Nov- 12

Nov- 26 Dec-09 Dec-23 Jan-06 Jan-20 Feb-03 Feb- 18 Mar- 04 Mar-17 Apr- 01 Apr- 15 May- 06 May- 19 5 5 2 5 5 5 2 2 3 1 8 3 1 8 3 8 5 6 5 8 9 4 8 2 8 8 3 4 3 2 3 6 6 4 7 6 2 2 2 3 2 6 1 2 8 4 7 9 5 9 9 4 4 8 5 3 7 1 5 6 2 2 2 2 5 6 5 9 2 4 5 2 1 2 4 4 1 6 4 6 5 1 5 6 4 7 3 6 3 6 4 2 6 1 5 2 8 6 7 7 6 2 9 9 6 2 9 9 7 3 5 5 6 8 3 5 5 5 8 8 1 5 6 4 4 6 2 7 9 6 2 9 2 2 7 9 From Table 1, we could find out the optimum conditions of Auricularia delicata fruit bodies production by matching all data of environmental factors and density. Based on the discriminant analysis, the group with number 4 was the best sampling conditions which refer to a large number of fruit bodies produced. Followed the group with number 1 as the second best sampling condition group. Whereas the worst sampling condition group was indicated by the group with number 6. In the study of Xing Hong et al.[3] stated that the optimum temperature of cultivation condition for Auricularia delicata growth ranged between 24°C and 32°C, and the optimum pH ranged between 5.5 and 6.0. Whereas from the results of this study indicate that the optimum environmental conditions for the formation of fruit bodies of Auricularia delicata consist of temperature between 17°C and 24°C; light intensity between 33 lux and 4580 lux; humidity between 60-85%; pH between 5.5-7; water content between 40.12% and 315.41%. Deacon[4] stated that most mesophilic fungi which mean it can grow at a temperature ranges of 10°C-40°C, and the best growth at room temperature range of 22°C- 25°C, so it can be concluded that Auricularia delicata is a mesophilic fungus that can grow on the temperature range of 17°C-27°C. 3.2 Modeling with Generalized Estimating Equation (GEE) To find out which environmental factors were the most significant in influencing Auricularia delicata fruit bodies of density, a statistical analysis approach using GEE had been. This method is appropriate to be used when the residuals of a linear regression are not normally distributed, Poisson distribution will be applied[8]. The Procedural analysis in this research is to determine QIC (Quasi-likelihood under Independence Model Criterion) and choosing the best correlation structure based on the smallest QIC value. Then the final mathematics model has to be formed. Table 2.Summary of QIC values Correlation Structure Independent AR(1) Exchangeable 5-Dependent QIC Values 17126,556 17317,651 18078,007 26898,730 Table 2 shows that the smallest QIC is 17126,556 which is an independent correlation structure, so it can produce the most efficient estimator compares to other correlations. The structure of independent correlation shows that the time data between observations does not show a correlation. Table 3. Paramaters estimation based on independent correlation structure Parameter B Std. Error 95% Wald Confidence Interval Lower Upper Wald Chi-Square Hypothesis Test df Sig. (Intercept) Temperature Light intensity Humidity pH Water content Time (Scale) -.487 -.026 -3.403E-6 .012 .335 .004 .177 1 3.1031 .0422 2.2843E-5 .0158 .1368 .0016 .0513 -6.569 -.108 -4.817E-5 -.019 .067 .001 .077 5.595 .057 4.137E-5 .043 .603 .007 .278 .025 .369 .022 .598 5.989 6.497 11.923 1 1 1 1 1 1 1 .875 .544 .882 .439 .014 .011 .001 Dependent Variable: Density_Auricularia_delicata Model: (Intercept), Temperature, Light_Intensity, Humidity, pH, Water_Content, Time At the very least, from the results of the GEE analysis in Table 3, we get information that environmental factors that had the most significant effect on changes in the population dynamics of Auricularia delicata fruit bodies were pH and wood water content. In the fungal physiology, pH plays an important role in germination of spores, mycelia growth, enzyme activity (wood degradation) and fruit bodies formation. The wood fungi have optimum environmental pH conditions range from 5-6 and it can survive in the range of pH 2.5 – 9[9]. Basically, wood-decaying fungi are able to change the pH state in the external environment due to metabolic activity[4], such as white-rot fungi accumulate acidic oxalate acids in relation to enzymatic degradation of lignin by lignin peroxidase and manganese peroxidase. Brown-rot fungi form oxalic acid as a catalyst in the process of hydrolysis of the degradation of polysaccharide compounds in wood. The acid released compounds can increase porosity in wood tissue for hyphae enzymes, and molecular substances can

penetrate the deepest parts of the tissue for degradation[9]. As wood degradation by fungi involves several enzymes, which are active in an aqueous environment, and because hyphae consist of up to 90% of water, wood fungi need water indeed. Water is also used for the uptake of nutrients, the transport within the mycelia and as a solvent for metabolism. Without water, the metabolism rests. Water moisture content which can occur by five ways: rainfall, absorption from the air, capillary penetration of water into the wood in ground contact or in buildings by condensation on wood surfaces, water transport by the mycelium, and water formation by fungal metabolism. It has been known also about the fungal loss of water by evaporation as an effect of temperature, humidity, matrix potential as well by water transport via mycelia[12]. The minimum condition for decaying wood by rotting fungi is near the fiber saturation point of about 30% wood water content [9]. Light intensity might have no significance for fungi because fungi are a carbon-heterotrophic organism. A requirement for light occurs particularly with respect to the initiation of reproduction and the ripening of the fruit bodies. Light is only the signal that the mycelia have reached the (irradiated) surface, where there the spores can be produced in an environment suitable for spore release [10]. Humidity and air temperature are interconnected factors, if the temperature rises the humidity will decrease, while when the temperature drops the humidity will rise. Macrofungi can grow in the humidity range of 65% -100%. The general minimum humidity for the growth of fungi is 70%, although there are several types of fungi that can grow at 65% humidity the growth is very slow. Air humidity in the Bingungan Forest area range from 58-89%, this condition was in accordance with the needs of the macrofungi to grow[11]. However, in this case, humidity was not significant to changes in population dynamics of Auricularia delicata fruit bodies. Conclusion There are a number of conclusions that can be drawn, including: the optimum environmental conditions for the formation of the fruit bodies of Auricularia delicata consist of temperature between 17° C and 24° C; light intensity between 33 lux and 4580 lux; humidity between 60-85%; pH between 5.5-7; water content between 40.12% and 315.41%. But only pH and water content of the substrate had a significant effect on the population dynamics of Auricularia delicata fruit bodies. The highest fruit bodies' production occurred in April and May 2018, with low rainfall of 89 mm and 146 mm in the early dry season.. Acknowledgments We acknowledge to our best colleagues Junita Kurniawati and Suryo Arif Setyawan, also we are very grateful to Bapak dan Ibu Musimin as Turgo citizen which had taken care of us along this research. References [1] Prasetiya D, Kurniawati J, Mutiarani Y P, Salim I, Aminatun T 2017Eksplorasi Keanekaragaman Makrofungi Edible dan Non-Edible di Kawasan Hutan Hujan Tropis Turgo Merapi Research Report of PKM DIKTI-2017 Yogyakarta State University (Unpublished). [2] Xing-Hong W, Chaobin Z, Pedro F, and Changhe Z 2016 Screening and Characterization of Auricularia delicata Strain for Mushroom Production under Tropical Temperature Conditions to Make Use of Rubberwood Sawdust. Research Journal of Biotechnology. 11, 11: 26-37. [3] Ohenoja E 1993 Effect of Weather Conditions on The Larger Fungi at Different Forest sites in Nothern Finland in 1976-1988 Acta Universitatis Ouluensis243:1-69. [4] Deacon J W 2006 Fungal Biology (USA: Blackwell Publishing Ltd). [5] Molina R, Pilz D, Smith J, Dunham S, Dreisbach T, O'dell T and Castellano M 2001 Conservation and Management of Forest Fungi in The Pacific Northwestern United States: An Integrated Ecosystem Approach. (USA: Department of Agriculture United States, Forest Service, Pacific Northwest Research Station, Portland, Oregon). [6] O'Dell TE, Smith JE, Castellano M, LuomaD 1996 Diversity and conservation of forest fungi. In Managing forest ecosystems to conserve fungus diversity and sustain wild mushroom harvests (Gen. Tech. Rep. PNW-GTR-371. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station) p 5-18. [7] Schimt J P and Lodge D J 2004 Classical Method and Modern Analysis for Studying Fungal Diversity (Boca Raton, FL: Marcel Dekker Inc). [8] Kindt R and Coe R 2005Tree

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