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The diversity of flora at the Late Pliocene era in the Cisubuh Formation based on palynological data

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ABSTRAK
Bukti palinologi berupa serbuk sari bunga dan spora tumbuhan Pteridophyta dari masa lampau memberikan ciri-ciri keanekaragaman tumbuhan. Penelitian ini bertujuan untuk mengetahui keanekaragaman flora pada masa lampau berdasarkan bukti palinologis berupa polen dan spora (palynomorph) yang tersimpan dalam sedimen di Formasi Cisubuh. Penelitian ini terdiri dari dua tahap, yaitu pengambilan sampel di lapangan, dan observasi laboratorium. Sebanyak 16 sampel Formasi Cisubuh di kawasan Rengasdengklok, Jawa Barat Indonesia telah diidentifikasi kandungan fosilnya. Enam puluh tujuh palinomorf telah diidentifikasi, terdiri dari 53 taksa polen dan 14 jenis spora. Dari 67 taksa palinomorf, 40 adalah polen arboreal, 12 adalah polen non-arboreal, dan 15 adalah Pteridophyta. Umur geologi Formasi Cisubuh adalah Pliosen Akhir yang ditunjukkan oleh ditemukannya serbuk sari *Dacrycarpidites australiensis* dan tanpa keberadaan spora *Stenochlaenidites papuanus*. Berdasarkan bukti palinologi, keanekaragaman flora pada setiap lapisan sedimen Formasi Cisubuh menunjukkan kemiripan yang tinggi (87%).

***Kata kunci*:** Palinomorf, Miosen Tengah, keanekaragaman, polen arboreal

ABSTRACT
Palynological evidence on past time gives features on plant diversity. The objective of this research was to determine the flora diversity in the past based on the palynological evidence in the form of pollen and spores (palynomorphs) that stored in sediments in the Cisubuh Formation. This research consisted of two stages, field sampling, and laboratory observation. A total of 16 samples on Cisubuh Formation on Rengasdengklok area, West Java Indonesia have been identified for their fossil content. Sixty-seven palynomorphs have been identified, comprised of 53 pollen taxa and 14 type of spores. Of the 67 palynomorph taxa, 40 were arboreal pollen, 12 were non-arboreal pollen, and 15 were Pteridophytes. The geological age of Cisubuh Formation was Late Pliocene, as indicated by *Dacrycarpidites australiensis* and without the presence of *Stenochlaenidites papuanus*. Based on the palynological evidence, the flora diversity in each layer sediment of the Cisubuh Formation showed high similarity (87%).

***Keywords*:** Palynomorph, middle Miocene, diversity,arboreal pollen, non-arboreal pollen

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Introduction

Palynological data (palynomorphs: pollen and spores) can reveal the history of plant life in the past. Palynological data is very important because it is a valid proof of the existence of plants in the past. Palynology evidence can be used to trace the plants that produce pollen or spores so that the diversity (biodiversity) of plants in the past can be known. Palynological analysis of sedimentary rocks can reveal flora diversity in a geological period. Plants diversity (biodiversity) is a representation of the number of plant species found in an area at a particular time. The higher the number of species shows the higher the biodiversity. Low biodiversity shows vulnerability to disturbances in ecosystem balance, while higher biodiversity shows ecosystem stability (Magurran, 1988; Nugroho, 2018).

The lithology of the Cisubuh Formation consists of marine claystone with poor hardness and is sometimes inserted by sandstones and limestones. The middle part is the intersection of claystone, siltstone, and sandstone with a thin insert of limestone. Marine fauna is often found at the bottom of the Cisubuh Formation and decreases to the top. This shows that the lower Cisubuh Formation is deposited in the inner neritic environment and upward gradation becomes litoral-paralic (Arpandi and Padmosukismo, 1975; Pertamina, 1996; Isnaniawardhani and Sunardi, 2014). The Cisubuh Formation was deposited at the age of Late Miocene to Plio-Pleistocene (Sudjatmiko, 1972; Pringgoprawiro et al., 1977; Sujanto and Sumantri, 1977; Martodjojo, 2003; Jambak et al., 2015). The Cisubuh Formation clay rock contains many foraminifera planktons whose ages are Mio-Pliocene or in the N17-N18 zone according to Blow's zoning, 1969 (Pringgoprawiro et al., 1977 in Praptisih, et al.,

(2012). However, so far the research on flora biodiversity in the Cisubuh formation has not been disclosed. The objective of this research was to determine the flora diversity in the past based on the palynological evidence in the form of pollen and spores (palynomorphs) that were stored in sediments in the Cisubuh Formation.

Material and Methods

The research sample was in the form of drilling sedimentary rocks in the Pasirputih Sub Basin in North West Java. Determination of the number of rock samples that will be analyzed using the stratified random sampling method. The research was carried out in two stages: field research and laboratory research. Field research includes sampling sedimentary rocks and lithological descriptions, while laboratory research includes the preparation of 16 samples of sedimentary rocks (RDL code) for preparation of palynological microscopic preparations. Palynology preparation using Moore's method, et al. (1991): fifty grams of rock samples soaked with 50% HCl to remove carbonate and then neutralized with distilled water. The neutral samples were soaked again with 40% hydrofluoric acid (HF) to remove silicate, after that they were neutralized again. Then they were soaked with 50% hydrochloric acid (HCl), and they have neutralized again. After the oxidation using nitric acid (HNO3) was done, the samples were neutralized again. To remove humic acid rock samples in 5%, KOH was soaked in hot conditions and neutralized again. The results are then filtered with a 250-50µm stratified nylon filter, after which a slide is made which is a microscope preparation with mounting slides using an attachment. The parameters observed in identifying palynological data are the characteristics and characteristics of fossil pollen and spores. The identification results were analyzed using the PAST-Palaeontological Statistics program, ver.0.99.

The descriptive analysis in the form of identification of types, properties, and characteristics of pollen and spores using binocular microscope magnification 250X, 400X, and 1000X. The microscope used is the Olympus photomicroscope type CX-41. The references used to identify pollen, and spore types include Erdtman (1952), Huang (1972), Faegri and Iversen (1989), Moore, et al. (1991), Punt, et al. (1994), and PalDat site. online at www.paldat.org (Anonim, 2005)

Determination of the relative age of the Cisubuh Formation is based on palynological data using stratigraphic interval zones with palynological zone criteria (Rahardjo et al., 1994). Calculation of the Diversity Index and Similarity Index is based on the presence and absence and the number of types of palynomorphs found in each stratum of sedimentary rocks. Diversity index to show the stability of a community and calculated using the Simpson-Diversity Index equation (Odum, 1993). On finite samples with the following formula:

$$D' = \sum_{j=1}^{S} \frac{ni\,(ni-1)}{N(N-1)}$$

D '= Index of Simpson Diversity
ni = Number of individuals of the first type
N = Total number of individuals
s = Number of taxa

The criteria used ranged from 0 to 1 with the criteria: Index values whose values close to 1 mean that species diversity is high, on the contrary, if the index value is close to 0 indicating the low diversity of species owned by a community (Odum, 1993). Sorensen Similarity Index is determined based on binary data in the form of the presence and absence of a taxon in all observed samples. Similarity index (IS) can illustrate the similarity of pollen and spore fossils found between sedimentary rock layers in different time periods and calculated using the Sorenson index (Ludwig & Reynolds, 1988; Krebs, 2002).

$$Ss = 2a / (2a + b + c)$$

Ss = Sorenson Similarity Index
A = The same number of the taxon in samples I and II
B = Amount of taxon which is only found in sample I
S = Amount of taxon which is only found in sample II
This index value ranges from 0 (no similarity) to 1 (highest similarity (Krebs 1999, 2002), with the following criteria:
IS <0.25 = very low
0.25-0.50 = low
0.50-0.75 = high
IS = 0.75-1 = very similar

Results and Discussion

The results of the identification of pollen and spore fossils that have been identified in the study location found 67 types of palynomorphs which were divided into 53 types of pollen and 14 types of spores. The data can be divided into palynomorphs: tree ablution (AP) found in 40 types, non-tree habitus (NAP) consisting of shrubs and herbs there are 12 types, and 15 types are spores from ferns (Pteridophyta) (Figure 1, 2).

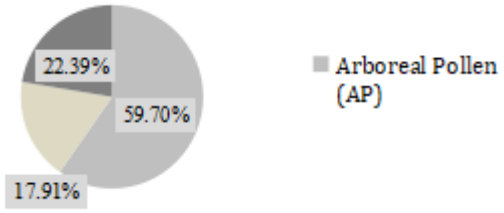

Figure 1. Percentage of fossil pollen and spores based on the plant habitus group that produces it

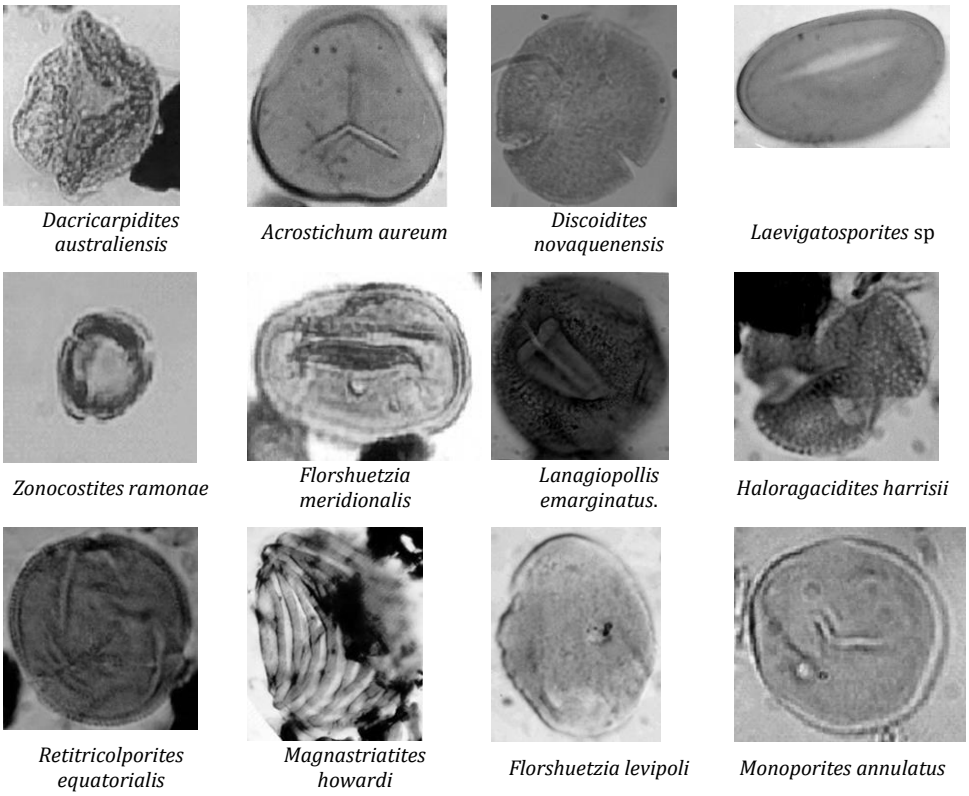

Figure 2. Several types of palynomorphs found in the sediment of the Cisubuh Formation

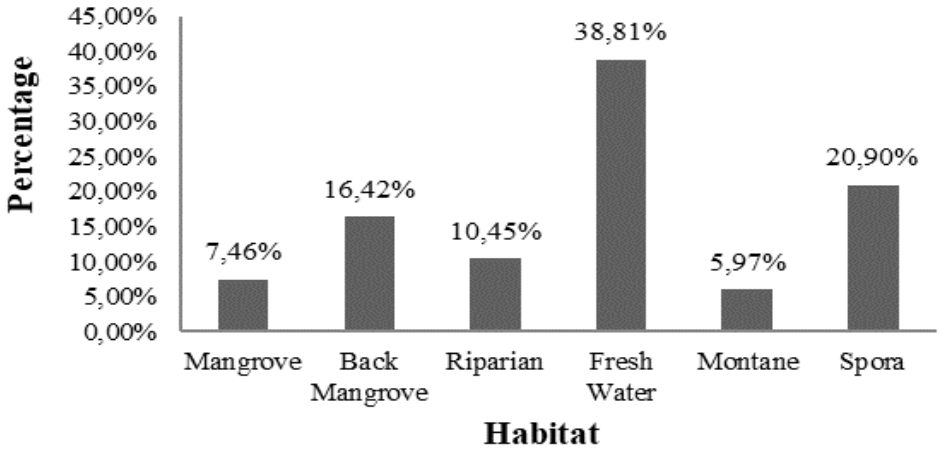

Figure 3. Percentage of fossil pollen and spores based on the plant habitat group that produces it

Based on the identified palynomorphs habitat, it is divided into five types of mangrove species, 11 species of back mangroves, seven types of riparian markers, 26 types of freshwater habitat, four types of montane species, and 14 types of Pteridophyta groups (Figure 3). On river sediment in the surrounding research area, the highest palynomorphs in freshwater habitat occurred due to the runoff process which finally deposited. Determination of the relative age of the Cisubuh Formation based on palynological data showed a Late Pliocene age. This prediction was based on the presence of *Dacricarpidites australiensis* without the presence of *Stenochlaenidites papuanus* (including in the *Dacricarpidites australiensis* Zone) (Rahardjo et al., 1994). The Simpson index value based on the type of palynomorph found has a mean of 0.93 (Table 1), including high criteria (Odum, 1993).

Table 1. Simpson Diversity Index Value of the palynomorphs found in the sediment of the Cisubuh Formation.

	Taxa_S	Individuals	Dominance_D	Simpson_1-D
RDL 1	27	161	0.15	0.86
RDL 2	38	207	0.10	0.90
RDL 3	42	207	0.07	0.93
RDL 4	42	192	0.06	0.94
RDL 5	34	202	0.09	0.91
RDL 6	40	207	0.08	0.92
RDL 7	40	211	0.06	0.94
RDL 8	40	208	0.07	0.93
RDL 9	39	210	0.07	0.93
RDL 10	41	213	0.08	0.92
RDL 11	50	217	0.07	0.93
RDL 12	47	210	0.04	0.96
RDL 13	46	208	0.06	0.94
RDL 14	48	213	0.04	0.96
RDL 15	48	204	0.04	0.96
RDL 16	47	207	0.05	0.95
Average	41.81	204.81	0.07	0.93

Note: RDL 1: the oldest sediment layer

Sorensen Similarity Index shows the level of similarity of flora present in all samples observed (Table 2). Similarity index values found ranged from 53% - 87% with an average of 74%. The lowest similarity index was recorded between RDL 5 and RDL 13 because only 21 species occurred in both samples. Meanwhile, the highest index was counted between RD 12 and RD 16 with 41of 67 species were coexisted. The mean value characterizes the similarities between the observed sample layers including high criteria (Krebs, 1999, 2002). The value of the high similarity index shows that the presence of palynomorph has a high similarity between each sample of a sediment layer, meaning that habitat and environmental conditions at that time were stable so that the flora community in the habitat developed relatively consistent and did not have major changes in their flora composition.

Table 2. Sorensen Similarity Index Value of the palynomorphs found in the sediment of the Cisubuh Formation.

	RDL 1	RDL 2	RDL 3	RDL 4	RDL 5	RDL 6	RDL 7	RDL 8	RDL 9	RDL 10	RDL 11	RDL 12	RDL 13	RDL 14	RDL 15	RDL 16
RDL 1	1.00	0.62	0.61	0.58	0.62	0.66	0.66	0.57	0.58	0.59	0.60	0.62	0.58	0.61	0.59	0.57
RDL 2	0.62	1.00	0.70	0.75	0.67	0.72	0.77	0.72	0.75	0.73	0.68	0.68	0.62	0.74	0.70	0.73
RDL 3	0.61	0.70	1.00	0.71	0.66	0.76	0.71	0.71	0.64	0.67	0.70	0.70	0.70	0.73	0.73	0.74
RDL 4	0.58	0.75	0.71	1.00	0.74	0.66	0.68	0.68	0.74	0.75	0.74	0.70	0.66	0.78	0.73	0.72
RDL 5	0.62	0.67	0.66	0.74	1.00	0.68	0.62	0.57	0.63	0.67	0.60	0.59	0.53	0.66	0.63	0.59
RDL 6	0.66	0.72	0.76	0.66	0.68	1.00	0.73	0.73	0.68	0.77	0.76	0.74	0.72	0.77	0.75	0.76
RDL 7	0.66	0.77	0.71	0.68	0.62	0.73	1.00	0.78	0.78	0.72	0.73	0.67	0.67	0.77	0.70	0.74
RDL 8	0.57	0.72	0.71	0.68	0.57	0.73	0.78	1.00	0.73	0.74	0.71	0.69	0.72	0.77	0.77	0.74
RDL 9	0.58	0.75	0.64	0.74	0.63	0.68	0.78	0.73	1.00	0.73	0.70	0.72	0.71	0.76	0.74	0.79
RDL 10	0.59	0.73	0.67	0.75	0.67	0.77	0.72	0.74	0.73	1.00	0.73	0.80	0.76	0.76	0.79	0.80
RDL 11	0.60	0.68	0.70	0.74	0.60	0.76	0.73	0.71	0.70	0.73	1.00	0.80	0.77	0.82	0.73	0.78
RDL 12	0.62	0.68	0.70	0.70	0.59	0.74	0.67	0.69	0.72	0.80	0.80	1.00	0.84	0.78	0.82	0.87
RDL 13	0.58	0.62	0.70	0.66	**0.53**	0.72	0.67	0.72	0.71	0.76	0.77	0.84	1.00	0.72	0.79	0.77
RDL 14	0.61	0.74	0.73	0.78	0.66	0.77	0.77	0.77	0.76	0.76	0.82	0.78	0.72	1.00	0.81	0.86
RDL 15	0.59	0.70	0.73	0.73	0.63	0.75	0.70	0.77	0.74	0.79	0.73	0.82	0.79	0.81	1.00	0.86
RDL 16	0.57	0.73	0.74	0.72	0.59	0.76	0.74	0.74	0.79	0.80	0.78	**0.87**	0.77	0.86	0.86	1.00

Conclusions

From the data records of fossil palynomorphs in the Cisubuh Formation can be concluded that there are 67 types of palynomorphs consisting of 53 types of pollen and 14 types of spores. The presence of *Dacricarpidites australiensis* pollen without the presence of *Stenoclaenidites papuanus* spores indicates the age of the Cisubuh Formation belongs to the Late Pliocene era. The palynological evidence shows that the flora diversity in each layer of sediment of the Cisubuh Formation showed high similarity (87%).

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