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Periphyton Community Structure on Natural and Artificial Substrate in the Namu Sira-Sira River, Langkat Regency, North Sumatra

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Abstract

Periphyton is one of components biotic, living attached to various substrates has an important role in providing primary productivity of waters. The purpose of this study was to determine the identification of species, the structure of the periphyton community in natural and artificial substrates, the water quality of the Namu Sira-sira River in Langkat Regency. The data collection method was carried out using the "Purposive Random Sampling" method at three stations according to community activities in the research area. The results of the study obtained species found in natural substrates were 25 species and artificial substrates were 27 species. The community structure including the diversity index (H ') is included in the medium category with a value of 2.48 on natural substrates and artificial substrates with a value of 2.50. The uniformity index value (E) on natural substrates is 0.89 and artificial substrates are 0.90 categorized as high because the distribution of species in each station is even. Periphyton communities on natural substrates have advantages in terms of abundance and diversity compared to artificial substrates due to the complex interactions between environmental factors, substrate quality, and ecological processes that support their growth.

Keywords: *Community Structure; Namu Sira-Sira River; Perifyton; Substrate*

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INTRODUCTION

Periphyton is a collection of microorganisms that are animals and plants that are generally micro-sized. Periphyton is classified into animal groups which generally consist of Protozoa and Rotifera (amoeba, Rotaroria worms and crayfish), plant group periphyton consists of microalgae, for example Bacillariophyceae, Cholorophyta, Cyanophyta and Rhodophyta (Kono et al., 2021). Periphyton can reproduce asexually by dividing. This division can occur longitudinally or transversely, producing daughter cells that are the same or different in size (Wulandari, 2020). The development of periphyton populations is influenced by the aquatic environment such as light, temperature and nutrient availability (Lestari et al., 2021). In addition, the growth and development of periphyton needs to use a good substrate (Fauziah et al., 2019). According to Pratiwi et al., (2018), the presence of substrate can affect the growth of periphyton.

According to Rahardjanto (2019) states that based on the substrate can be divided into two, namely natural substrates and artificial substrates. Natural substrates such as wood, plant stems and rocks found around the river with irregular surfaces and have a porous texture so that the periphyton attachment process in the substrate becomes stronger. Artificial substrates are substrates that are deliberately made by humans with a flatter surface, so that periphyton tend to be less attached to the substrate, for example the deliberate placement of ceramics in the river. Substrates provide benefits to periphyton in various aspects, ranging from food sources, places to live, reducing pollution to reducing nutrient and oxygen content in the water (Pratiwi et al., 2018).

Good river water quality can be seen from the balanced pH of the water ranging from 6.5 to 8.5 and the absence of pollution such as unpleasant odors or unnatural water colors (Alfatihah et al., 2022). Water quality also greatly affects periphyton abundance. A high abundance of periphyton will be an indicator of good water quality for the river and if the abundance of periphyton is low, it can indicate a problem with water quality in the river. Good water quality for periphyton includes balanced nutrient levels and sufficient water clarity for lighting, so as to support the growth and metabolic activities of periphyton. Periphyton can live in various species of waters, such as marine waters and fresh waters, for example ponds, reservoirs, lakes and rivers (Mirna et al., 2020).

From observations that have been made in the Namu Sira-sira River, it is known that in the upstream part there is river excavation, the middle part becomes a tourist spot and the downstream part is a dam. This disturbs the habitat of river biota, especially the abundance of periphyton. According to Siagian (2018) Periphyton abundance is higher in natural substrates than in artificial substrates. This is because in natural substrates, living periphyton will be easier to find than in artificial substrates. Seeing the important role of periphyton in waters and the absence of information on the abundance of periphyton on natural and artificial substrates in the Namu Sira-sira river.

METHODS

Time and Place of Research

The research was conducted in May - June 2024 along the Namu Sira-Sira river in Langkat Regency which is divided into 3 research stations namely station 1 is on the beach lubuk mas still natural not used as a tourist spot located at 30 26.1 'U - 980 28.8 'East, station 2 is in the bathing area located at 30 26.1 'LU - 980 29.1 'East, station 3 is in the dam located at 30 26.4 'LU - 980 29.1 'East. Identification and testing of physico-chemical parameters were carried out at PT Shafera Enviro Laboratory Pancur Batu, Medan Tuntungan.

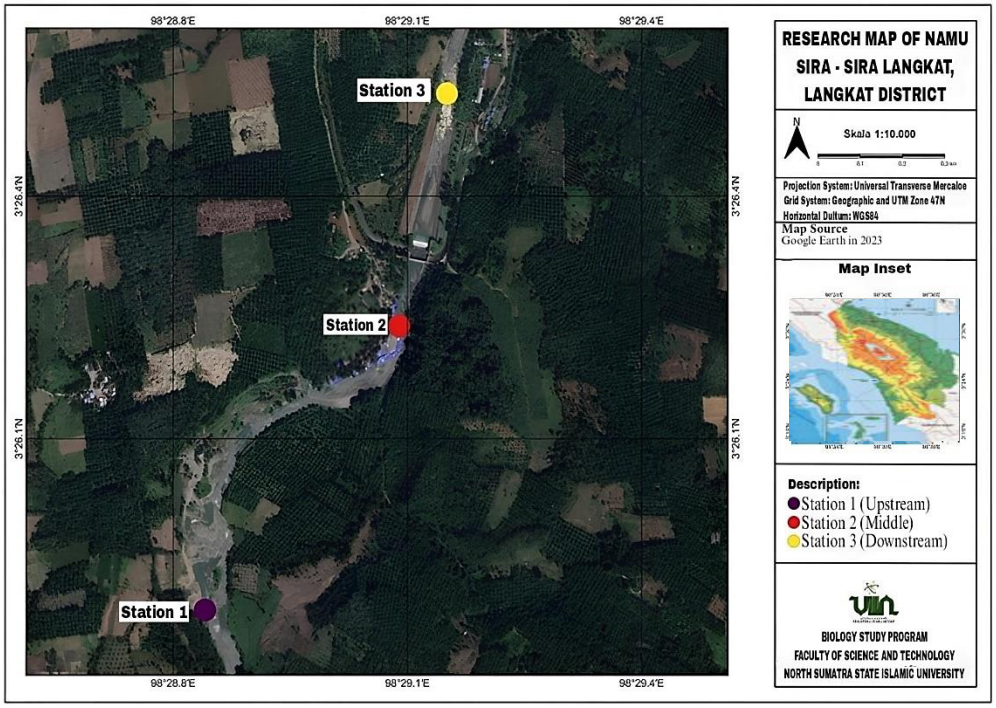

Figure 1. Sampling Location Map

Tools and Ingredients

The tools used in this study are 30 x 30 cm iron, thermometer, pH meter, NZ1903S Euromex Stereo Nexius Zoom Trinocular Microscope, 1 liter water sample bottle, sample bottle, label paper, coolbox, toothbrush, ceramic, stationery, marker, digital camera, raffia rope, dropper, ping pong ball, secchi disc and identification book from the website (Bugguide, 2019). The materials used in this study were 10% lugol, 100ml aquadest, water samples measured based on physical and chemical parameters, substrate samples and Periphyton as Biological parameters identified as bioindicators of water quality.

Research Procedure

Prior to the research, ceramics were placed on the surface of the river at 3 points at each research station with a time interval of 1 month. Each point contained

natural substrate and artificial substrate. Sampling was done 3 times with an interval of 1 week. Periphyton sampling on natural substrates and artificial substrates was carried out at 3 stations, namely upstream, middle and downstream. Each station has 6 points, where each point has 3 replicates. It can be concluded that all stations have 18 replicates. Periphyton sampling was carried out with iron measuring 30 x 30 cm and ceramics. The positioning of iron and ceramics is done on the surface of the river. Each substrate contained in the plot is taken, the surface of the substrate such as rocks and ceramics that are in the plot brushed or scraped using a toothbrush, periphyton samples are inserted into a sample bottle that has contained 100 ml of distilled water, done repeatedly until the distilled water in the sample bottle becomes cloudy, then the sample is preserved by giving 3-5 drops of lugol and the final stage the sample bottles were labeled and duct-taped then put into a coolbox and taken to PT Shafera Enviro Laboratorium for identification. Water sampling for chemical physics analysis was conducted directly at the research site. The physico-chemical parameters measured include temperature, pH, BOD, DO, current velocity and oxygen saturation.

Periphyton samples were observed by dripping water samples onto a glass object then placed on the object table and observed through the eyepiece of a light microscope. Periphyton that already known genus then counted the total number in each sample bottle. The identification of periphyton used the identification reference book from PT. Shafera Enviro Laboratorium and used the website of PT Shafera Enviro Laboratorium, Bugguide (2019).

Data Analysis

Diversity Index

Diversity index shows the level of distribution of individuals in a station or sample ecosystem according to the criteria calculated based on the Shanon Wiener index. If the value of H >3 then the level of diversity is high, and 1< H< 3 shows moderate diversity, and H < 1 shows a low diversity value (Barus, 2020). Diversity Index Calculation (Trianto et al., 2020).

$$H' = - \sum_{i=1}^{n} Pi \; In \; Pi$$

Description :
H' = Diversity index.
Pi = ni/N (number of individuals of a species/total number of individuals of all species).
Ni = number of individuals of each species.
N = total number of individuals of all species.

Abundance Index

Abundance Index (Ario et al., 2019),

$$K = \frac{ni}{Ac} x \frac{At}{Vs} x \frac{Vt}{As}$$

Description:

K = Periphyton abundance (individuals/cm2)
ni = Number of periphyton found
At = Area of cover glass (20x20) mm2 = 324
Vt = Volume of periphyton sample water (ml) = 100 ml
Ac = Field of view area (cm2) = 3.06
As = Area of scraped substrate 30 x 30 cm = 900 cm2
Vs = Volume of observed sample

Uniformity Index

Uniformity Index (Hendrayana et al., 2020),

$$E = \frac{H'}{H'max} = \frac{H'}{In\ s}$$

Description :
E = Uniformity index
H' = Shannon - Wiener diversity index
Hmax = In s
S = Number of species

Shannon - Wienner uniformity index uniformity category (Hendrayana et al., 2020).
$0 \leq E < 0,4$ = Low Uniformity
$0,4 \leq E < 0,6$ = Medium Uniformity
$0,6 \leq E \leq 1,0$ = High Uniformity

The closer the value to 0, the smaller the population uniformity, between the distribution of the number of individuals of each species is not equal and there is a tendency for one species to dominate. Conversely, the closer the value is to 1, the distribution tends to be even and there is no dominating species.

RESULTS AND DISCUSSION

Periphyton Species on Natural and Artificial Substrates

Based on the results of research conducted in the Namu Sira-sira River, 25 species were found on natural substrates, 27 species on artificial substrates, 8 orders, 19 families. Identification can be seen in table 1. In table 1, it can be seen that the class of the highest order is Bacillariophyceae. Bacillariophyceae has the ability to adapt to strong and slow currents because the Bacillariophyceae group has a tool to stick to the substrate in the form of a gelatinous stalk because this group has high adaptation and survival to various water conditions including extreme conditions. According to Pane & Harahap (2023) stated that Bacillariophyceae or diatoms are generally most commonly found as a dominant or subdominant primary producer group except in muddy rivers. Most members of the Bacillariophyceae class have cytoplasm which contains mucopolysaccharides that are able to secrete adhesive liquid to stick and the Bacillariophyceae group is able to adapt to changes in environmental factors.

Table 1. Periphyton Species On Natural And Artificial Substrates in Namu Sira-sira River Waters

Class	Ordo	Family	Species	Natural Substrate A1	Artificial Substrate B1
Bacillaariophyceae	Centrales	Bacillariaceae	*Nitzschia* sp.	125	111
		Cymbellaceae	*Cymbella* sp.	1.179	952
		Naviculaceae	*Navicula* sp.	727	573
		Surirellaceae	*Surirella* sp.	294	261
		Pinnulariaceae	*Pinnuralia* sp.	66	99
		Stauroneidace	*Stauroneis* sp.	73	121
		Cocconeidaceae	*Cocconeis* sp.	195	99
		Pleurosigmataceae	*Gyrosigma* sp.	161	84
		Achnanthaceae	*Achnanthes* sp.	121	139
		Rhopalodiaceae	*Rhopalodia* sp.	73	48
Chlorophyceae	Chlorococcales	Selenastraceae	*Ankistrodesmus* sp.	172	51
		Scenedesmaceae	*Scenedesmus* sp.	18	66
			Chaetophora sp.	0	15
			Pediastrum sp.	15	0
Coscinodiscophyceae	Coscinodiscales	Melosiraceae	*Melosira* sp.	0	18
Cyanophyceae	Chrococcales	Oscillatoriaceae	*Oscilatoria* sp.	429	250
			Phormodium sp.	73	44
Fragilariophyceae	Flagilaris	Fragillariaceae	*Fragillaria* sp.	227	209
			Synedra sp.	709	716
			Diatoma sp.	114	150
Mediophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia* sp.	26	26
Ulvophyceae	Bryopsidales	Ulotrichaceae	*Ulothrix* sp.	312	136
		Cladophhoraceae	*Cladophora* sp.	235	187
Zygnemophyceae	Zygnema	Zygnemataceae	*Cosmarium* sp.	51	77
			Euastrum sp.	0	55
			Micrasterias sp.	0	11
			Spirogyra sp.	169	235
			Zygnema sp.	7	0
			Closterium sp.	55	73
		Total		**5.656**	**4.806**

The class with the lowest order is Coscinodiscophyceae, due to the lack of availability of nutrients that can be obtained. According to Padang et al., (2020) Coscinodiscophyceae can adapt well to environments rich in ions such as sodium, potassium, magnesium, and chloride. Coscinodiscophyceae are not commonly found in river waters because river waters are calm and do not have suitable water quality for them. Coscinodiscophyceae play a role in primary production through photosynthesis, which is the main food source for many other organisms in aquatic ecosystems, in addition Coscinodiscophyceae are also environmental indicators because they are sensitive to changes in environmental conditions.

Centrales is the order of the highest family due to its specific life traits and distribution. Periphyton belonging to the order Centrales, live on the bottom of the water and play an important role in sediment stabilization. They also act as deposit feeders and decomposers of organic matter, so their abundance may increase at sites with high organic matter content (Arsad et al., 2021).

The order of the lowest family is Coscinodiscales. According to Astriana et al., (2022) Coscinodiscales can adapt to environmental changes, such as changes in nutrient availability and physical water conditions. This allows them to survive and thrive in a variety of environments. The family of the most abundant species is Zygnemataceae. Clear and rocky waters often have adequate nutrient availability, which allows Zygnemataceae to proliferate and spread widely. In line of Abizar & Rahmah (2020) that Zygnemataceae family is a tribe of green algae that has high species diversity and wide distribution in various water conditions including the Namu Sira-sira River.

The Namu Sira-sira river has many rocks and is used as a natural substrate for periphyton life. In artificial substrates, namely ceramics, which are used as periphyton as well as a place to live from periphyton. 29 species were found in periphyton in natural substrates and artificial substrates. In the artificial substrate there were 25 species found with a total of 5,656 individuals, while in the artificial substrate there were 27 species found with a total of 4,806 individuals. The natural substrate has a higher total number of individuals compared to the total number of individuals in the artificial substrate. This is because the natural substrate (rock) has a rough rock surface, causing periphyton to survive more strongly on the sidelines of the rock so that it is not easily carried away by the current and accroding to Arsad et al., (2021) periphyton also get nutrients from the surrounding water or microbial regeneration in the periphyton community. Dharmaji et al., (2021) Periphyton communities in natural substrates have advantages in terms of abundance and diversity compared to artificial substrates due to complex interactions between environmental factors, substrate quality, and ecological processes that support periphyton growth.

Pediastrum sp. and *Zygnema* sp. were not found in artificial substrates, this is because natural substrates provide the necessary nutrients for their growth and reproduction, while artificial substrates lack the availability of nutrients. Masithah (2023) *Pediastrum* sp. often form colonies that help them float and get enough light for photosynthesis. *Zygnema* sp. have a filamentous shape which allows them to adapt to water currents.

Chaetophora sp., *Melosira* sp., *Euastrum* sp. and *Micrasterias* sp. were not found on the natural substrate, as these species require certain nutrients to develop properly.

Hertika et al., (2021) If the natural substrate does not provide sufficient nutrients, such as nitrogen and phosphorus, then their growth will be inhibited. Morphological characteristics of *Chaetophora* sp., *Melosira* sp., *Euastrum* sp., and *Micrasterias* sp. that allow them to adapt well to artificial substrates include filamentous structure, distinctive cell shape, and the ability to photosynthesize efficiently.

Diversity Index (H') and Uniformity Index (E)

Based on the Diversity Index (H') and Uniformity Index (E) periphyton obtained at each research station can be seen in Table 2.

Tabel 2. Diversity index and uniformity index values obtained at each research station

No.	Index	Natural Substrate	Artificial Substrate
		A	B
1.	**Diversty (H')**	2,48	2,50
2.	**Uniformity (E)**	0,89	0,90

Based on Table 2, it is known that the diversity of periphyton in a body of water can indicate the quality of these waters, the diversity of periphyton in the waters of the Namu Sira-Sira River is classified into unpolluted waters, it can be seen in table 2 that the range of diversity indices on natural substrates at all stations is 2.48 and artificial substrates is 2.50.

The size of the periphyton diversity of a water body is expressed as the number of species found in these waters, the greater the number of species, the higher the diversity value, the relationship between the number of species with the number of individuals can be expressed in the form of a diversity index. A community is said to have high species diversity if there are many species with a relatively even number of individuals of each species. If a community consists of only a few species with an uneven number of individuals, then the community has low diversity (Amrillah, 2023).

The Uniformity Index (E) of periphyton obtained at each research station can be seen in Table 2. Based on Table 2, the uniformity index (E) on natural substrate is 0.89 and artificial substrate is 0.90. Natural substrates and artificial substrates have a high uniformity index value, indicating the distribution of each individual is relatively even. Hertika et al., (2021) describe if the uniformity index approaches 0, the smaller the uniformity of a population and the distribution of individuals of each species is uneven, this can be caused by the tendency of a genus to dominate in the population. Conversely, if the uniformity index approaches a value of 1, the population shows uniformity in the number of individuals evenly distributed.

Abundance Index (K)

Based on Table 3, it can be seen that the highest abundance value of periphyton in natural substrates and artificial substrates is *Cymbella* sp.. This is because light enters the water body, and nutrients and carbon dioxide (CO2) gas are fulfilled to

photosynthesize, reproduce themselves and to breed. Dharmaji et al., (2021) said that the high abundance of periphyton in this species is due to its cosmophytic nature and high adaptability to the environment and is known to have the ability to survive changes in unfavorable environmental conditions, able to accumulate nutrients and store them as food reserves in the form of non-dissolved polymers. However, their excessive abundance can be harmful to aquatic biota and can produce toxins.

Table 3. Abundance index obtained on natural substrates and artificial substrates

Name	Species	Natural Substrate	Artificial Substrate
		A	B
Bacillaariophyceae	*Nitzchia* sp.	1.467	2.204
	Cymbella sp.	13.875	11.196
	Navicula sp.	8.557	6.741
	Surirella sp.	3.455	3.067
	Pinnularia sp.	776	1.167
	Stauroneis sp.	863	1.424
	Cocconeis sp.	2.290	1.165
	Gyrosigma sp.	1.898	992
	Achnanthes sp.	1.424	1.639
	Rhopalodia sp.	863	388
Chlorophyceae	*Ankistrodesmus* sp.	2.675	2.459
	Scenedesmus sp.	8.341	8.427
	Chaetophora sp.	1.337	1.769
	Pediastrum sp.	2.027	604
Coscinodiscophyceae	*Melosira* sp.	2.16	776
Cyanophyceae	*Oscillatoria* sp.	0	173
	Phormodium sp.	173	0
Fragilariophyceae	*Fragillaria* sp.	5.051	2.937
	Synedra sp.	863	518
	Diatoma sp.	302	302
Mediophyceae	*Biddulphia* sp.	3.671	1.596
Ulvophyceae	*Ulothrix* sp.	2.761	2.200
	Cladophora sp.	604	906
Zygnemophyceae	*Cosmarium* sp.	0	647
	Euastrum sp.	0	129
	Micrasterias sp.	1.984	2.765
	Spirogyra sp.	86	0
	Zygnema sp.	647	863
	Closterium sp.	0	216
	Total	**66.206**	**57.270**

In the natural substrate has a high abundance value with a total of 66,206 and in the artificial substrate has an abundance value with a total of 57,270. The high abundance of periphyton in this type is because it is cosmopholite and has a high adaptability to the environment and is known to have the ability to survive changes in

unfavorable environmental conditions, able to accumulate nutrients and store them as food reserves in the form of non-dissolved polymers. The high abundance is caused by sufficient light intensity, temperature and availability of nutrients. Temperature has a role as a regulator of metabolism and physiological functions of aquatic organisms, besides that temperature also has a major effect on accelerating or slowing the growth of aquatic organisms. The abundance of periphyton is influenced by the current, where the stronger the current, the more species obtained by periphyton, and vice versa, the lower the current speed, the fewer species obtained by periphyton (Kono et al., 2021).

The structure of the periphyton community is not always influenced by the relationship between species, but also by the relative abundance of organisms of the species. So that the relative abundance of an organism can affect a function of the community, the distribution of individuals between species in the community, can even have an influence on the balance of the community and ultimately affect the stability of the community (Mustofa, 2020).

According to Rahardjanto (2019) explained in general, periphyton species are sedentary for a long time and are able to respond to pollutants dissolved in water, so as to provide information about the actual quality conditions of a water body. The response shown is a change in the components of aquatic biota (periphyton), especially in its structure and function such as composition, number, and abundance. The abundance index (K) of periphyton obtained at each research station can be seen in Table 3.

Water Quality in Namu Sira-Sira River

The value of the Chemical Physics Factor of Waters at each research station can be seen in Table 4. Table 4 can be seen that the pH value of water does not occur significant differences, the pH of the water obtained is 6.7 the pH value in the waters of the Namu Sira-sira River is categorized as normal (Alfatihah et al., 2022). The value of dissolved oxygen is 8.5 mg/l, it is thought to be influenced by the movement of water masses with contact between the surface of the water and air high current velocity this affects the level of oxygen solubility and diversity of periphyton. The BOD5 value obtained is 0.2 mg/l, the BOD5 content of 5.0-15 mg/l is classified into moderately polluted waters and >15 mg/l is classified as heavily polluted waters (Barus, 2020).

Table 4. Water quality values in Namu Sira-sira River

No.	Parameter	Unit	Value
1.	pH	-	6,7
2.	DO	mg/l	8,5
3.	BOD	mg/l	0,2
4.	Temperature	°C	27,1
5.	Current Velocity	m/s	0,15
6.	Light Penetration	cm	82,00

The temperature obtained is 27.1 °C, temperature is one of the important environmental factors for the life of living things, the ideal temperature limit for periphyton growth is around 20 - 30 °C, while the temperature for the growth of aquatic biota is between 28 - 32 °C (Arsad et al., 2021). The current speed value obtained is 0.5 m/s, where the current contained in a body of water is divided into 5 categories, namely: very fast current (> 1m/s), fast (0.5 – 1.0 m/s), medium (0.25 - 0.5 m/s), slow (0.1 - 0.25 m/s) and very slow (< 0.1 m/s) (Astriana et al., 2022). The value of light penetration is around 82 cm, the turbid water category if the brightness value ranges from 0.25-1.00 m slightly turbid waters if it has a brightness value ranging from 1.00-5.00 m, while the clear water category has a brightness level value above 5.00 m (Fauziah et al., 2019).

CONCLUSIONS

This result shown that (1) Periphyton obtained on natural substrates amounted to 25 species with a total of 5,656 individuals. On artificial substrates, 27 species were found with a total of 4,806 individuals. (2) The diversity index value (H') on natural substrates is 2.48 and artificial substrates are 2.50 Namu Sira-sira River in Langkat Regency is included in the diversity value of the medium category. The value of the uniformity index (E) on natural substrates is 0.89 and artificial substrates are 0.90 categorized as high because the distribution of species at each station is evenly distributed. The highest abundance index value in the natural substrate is 66,206 and the artificial substrate is 57,270. Periphyton communities on natural substrates have an advantage in terms of abundance and diversity compared to artificial substrates due to complex interactions between environmental factors, substrate quality, and ecological processes that support periphyton growth. (3) Each value of physical and chemical water factors obtained at each research site is not much different, changes in physical and chemical water factors that are too significant will affect the existence of aquatic organism life systems, especially periphyton.

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