Paphayompittayakom School, Thailand

HOW DOES LIGHT INFLUENCE TERMITE BIOLOGY *Leading to Sustainable* CULTIVATION STRATEGIES?

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Influence of Light on Termite Biology: Toward Sustainable Cultivation Strategies

by

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ABSTRACT

The study investigated the influence of various light colors on termite quantity and fungal growth. A total of 192 termites were utilized, including worker termites, soldier termites, and nymph/larvae. Twenty-four termites with a consistent weight of 32 grams per box were housed in separate compartments, each exposed to a unique color: purple, indigo, blue, green, yellow, orange, red, and natural light.

In the pursuit of understanding how light frequency, intensity, and temperature affect both termite quantity and weight, as well as fungal growth, the researchers measured humidity and temperature within each culture box, conducted termite population counts, and calculated the percentage of fungal content.

The results revealed statistically significant differences, at a 0.05 significance level in the weight of the breeding boxes, termite quantity, and the percentage of fungal content within the boxes exposed to different light colors. The number of termites was found to have a significant correlation with the frequency and intensity of light, as well as the temperature inside the box at a 0.05 significance level. Similarly, the percentage of fungal content within the boxes showed significant relationships with both the quantity of termites and the temperature inside the box at a 0.05 significance level.

INTRODUCTION

Termites *(Microcerotermes* sp.*)* are recognized for their economic significance and play a dual role as both creators and destroyers within ecosystems. As crucial components of forest societies, these insects hold a pivotal position due to their reliance on cellulose for sustenance — cellulose being a primary component of wood. Although their contribution to the natural environment is vital, the existence of termites presents significant challenges for human habitats.

Termites use the fungus to break down cellulose and lignin from wood scraps in their nests, transforming them into sugar molecules. The fungus, in return, thrives within termite nests, utilizing chemicals produced by the termites. In Thailand, termites from the family *Termitidae* are categorized into 15 species distributed among five genera – *Odontotermes* (8 species), *Macrotermes* (4 species), *Hypotermes* (1 species), *Ancistrotermes* (1 species), and *Microcerotermes* (1 species).

Edible termite mushrooms *(Termitomyces* sp.*)* are highly sought after for their rarity and delectable flavor, resulting in market prices ranging from 80 to 500 Baht per kilogram. The price fluctuates based on the mushroom's characteristics, such as its growth stage and the location of sale. Consequently, termite mushrooms have emerged as economically valuable fungi.

In light of this economic significance, researchers are keen on investigating how different light colors impact the population of termites and the growth of termite mushrooms.

Recognizing the multifaceted challenges posed by termites, the research team seeks to answer the following questions:

1. How does the frequency, intensity, and temperature of various colors of light impact the quantity and weight of termites?
2. In what manner does the frequency, intensity, and temperature of various colors of light affect the growth of the fungus?
3. Is there a relationship between the frequency, intensity, temperature, weight inside the culture box, termite population, and the growth of the fungus? If there is, how is this relationship manifested?

By addressing these research questions, the study aims to provide valuable insights for those dealing with termite infestations, individuals seeking effective breeding strategies for termites, and individuals interested in the cultivation of termite mushrooms in a novel light.

METHODS

The following materials were used for the experiment:

- 192 termites
- 27-28 grams of termite nests
- 7 LED strips
- 5 rolls of electrical/insulating tape
- scissors or cutter
- 8 plastic boxes or food containers, each measuring 17 x 11.5 cm

Equipment for measuring factors:

- Light intensity meter for measuring the intensity of various light colors.
- Air thermometer for measuring the air temperature in the observation room.
- Digital thermo-hygrometer for measuring the temperature and humidity inside the culture boxes.
- Visible Light Spectrum Chart for reference as a guide for light frequency.
- Weighing scale for weighing the termites.

These steps were taken to conduct a study on the life cycles and habitats of termites and investigate the impact of various light conditions on their behavior and dynamics over a 15-day observation period.

1. **Life Cycle and Habitat Investigation**: Initiated on January 6, 2024, the researchers studied and gathered information regarding the life cycle and habitat of termites. Factors influencing them were carefully examined and considered.

2. **Experimental Site Preparation**: The experiment was conducted at a student's residence in Ban Phrao, Pa Phayom, Phatthalung, Thailand.

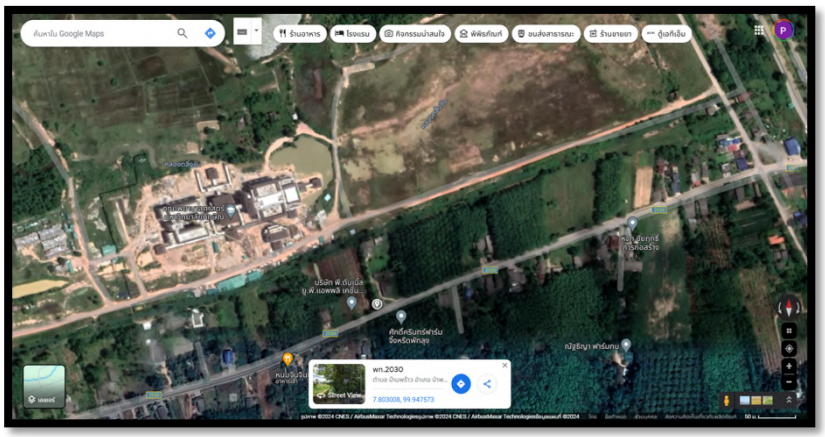


Figure 1: Map of the termite sampling area located at 7.803008° N, 99.947573° E, with an elevation of 23 meters, in Village No. 2, Ban Phrao Subdistrict, Pa Phayom District, Phatthalung, Thailand.

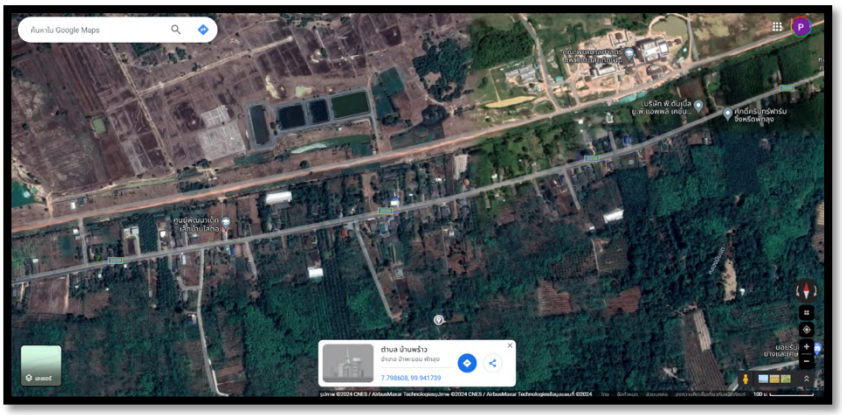


Figure 2: Map of the termite culture area located at 7.798608°N, 99.941739 °E with an elevation of 33 meters, in Village No. 2, Ban Phrao Subdistrict, Pa Phayom District, Phatthalung, Thailand.

3. **Box Design for Rearing, LED Strips Installation, and Experimental Planning**: Culture boxes were designed for rearing termites. Installed colored LED strips on 7 box lids and wrapped the outer surfaces of the 7 box containers with electrical tape. One box container was left unwrapped.

Figure 3: Culture boxes with LED strips

4. **Light Intensity and Frequency Measurement**: The intensity and frequency of light in different colors (purple, indigo, blue, green, yellow, orange, red, and natural light) were measured.

5. **Collection of Termite Colonies**: Termite colonies were located, and termite nests along with termites were collected for the experiment.

Figure 4: Termite nests.

6. **Placement of Termites in Eight (8) Boxes**: 24 Termites and termite nests were placed in each culture box, ensuring uniform weight (32 grams per box including the weight of the culture box and the box lid, but excluding the LED strips). A weighing scale was used.

Figure 5: Termites that were separated from their nests.

7. **Experiment Setup**: All eight culture boxes were prepared and arranged. Lights were turned on over the 7 culture boxes with LED strips, and data (temperature, humidity, and weight) were recorded. Changes in termite colonies, individual termites, and termites molds were closely monitored. Additionally, data for the culture box with one container left unwrapped were recorded to account for any variations in the experimental conditions.

8. **Light Exposure:** Termites were exposed to light for 6 hours per day, from 6:00 pm to 12:00 am. After completing 6 hours, lights were turned off on the 7 culture boxes. At 6 am and 6 pm, the culture boxes were examined, changes in the number of termites and the amount of termite molds were observed, and data (temperature, humidity, and weight) were recorded. This process continued for 15 days, from January 18 through February 1, 2024.

Figure 6: Hyphae of termite fungi that developed inside the culture box.

9. **Data Analysis and Presentation**: After 15 days, the recorded data were analyzed, summarized, and presented to the research advisor for evaluation and discussion which ended on February 14, 2024.

Data Analysis

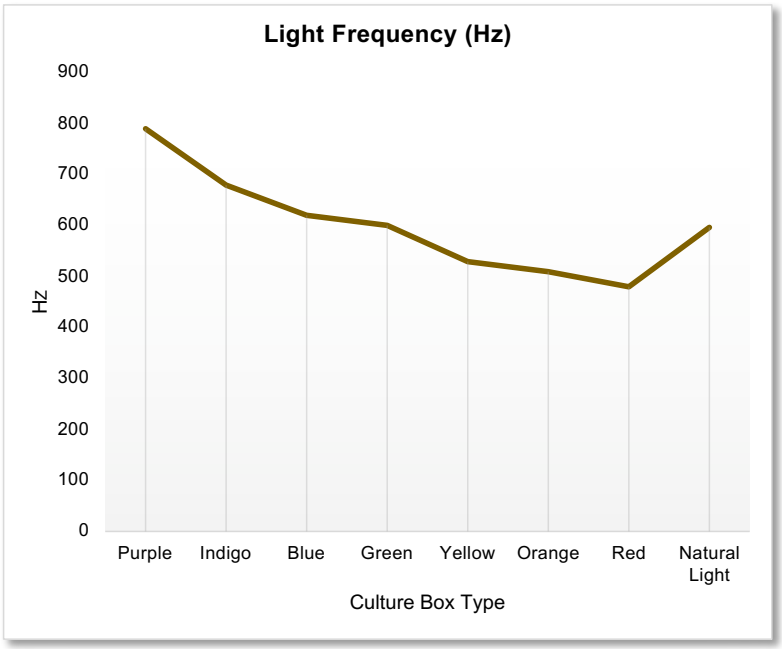
Researchers utilized various statistical data analyses to examine the collected data, including the calculation of means and Analysis of Variance (ANOVA) for temperature, weight of the culture boxes, termite count, and termite fungus growth. Additionally, correlation coefficients were performed to examine the relationships among light frequency, light intensity, temperature, weight of culture boxes, termite count, and fungal growth.

The subsequent table shows the analysis results obtained from the study:

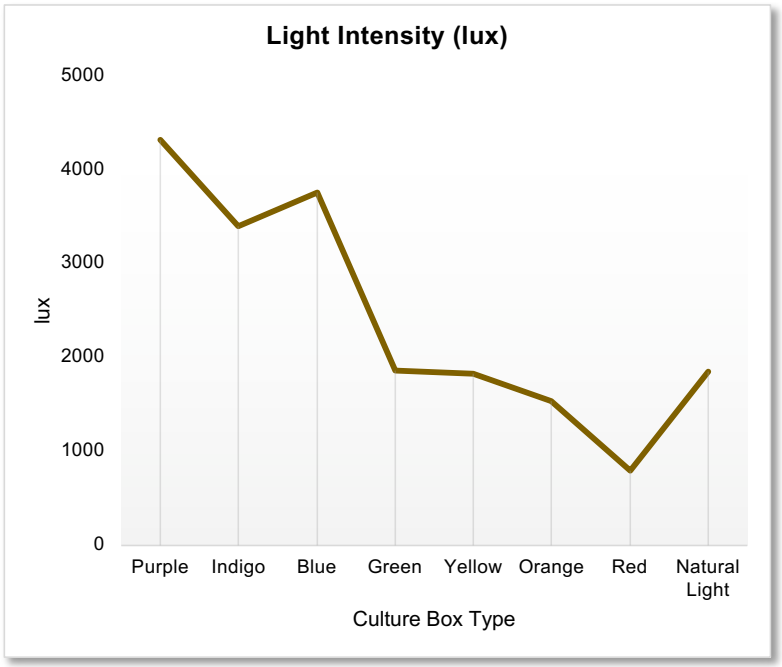
Table 1: Light Characteristics and Environment Conditions in Various Culture Box Type

Culture Box Type	Light Frequency (Hz)	Light Intensity (lux)	Avg. Relative Humidity Inside Culture Box (%)	Avg. Temperature Inside Culture Box (℃)	Avg. Weight of the Culture Box (g)
Purple	790	4317.66	99	20.91	38.17
Indigo	680	0.66	99	20.78	37.73
Blue	620	3755.66	99	20.84	36.30
Green	600	1856.33	99	20.79	37.80
Yellow	530	1820.66	99	20.93	37.90
Orange	510	1539.00	99	20.79	38.80
Red	480	797.33	99	20.89	37.90
Natural Light	597	1850.00	99	21.02	36.70

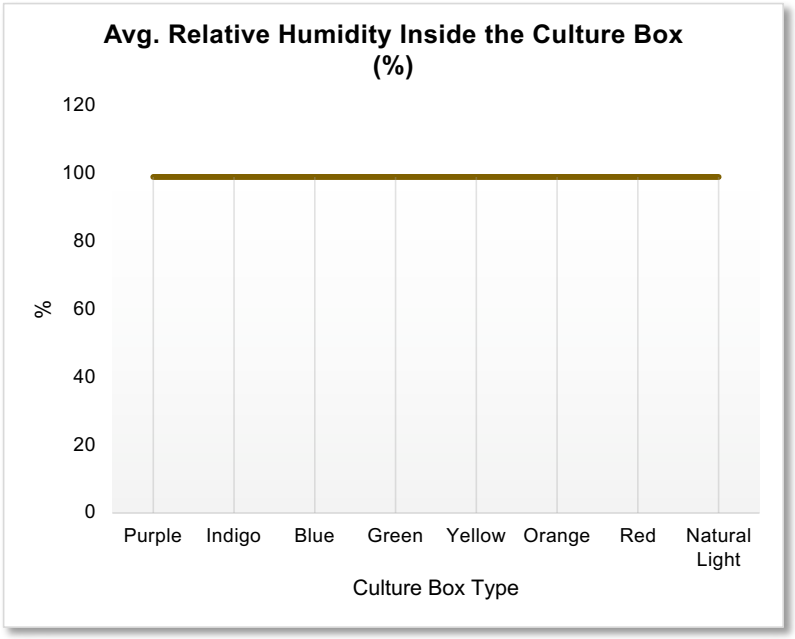
The result shows that the culture box exposed to red light demonstrated the lowest frequencies and intensities among all light sources, showcasing potential efficacy in reducing termite populations. Conversely, the culture box exposed to green light exhibited intermediate frequencies and intensities comparable to natural light. Notably, the culture box with green light maintained a lower average temperature inside the box, suggesting optimal conditions for the fungal growth compared to other light sources.



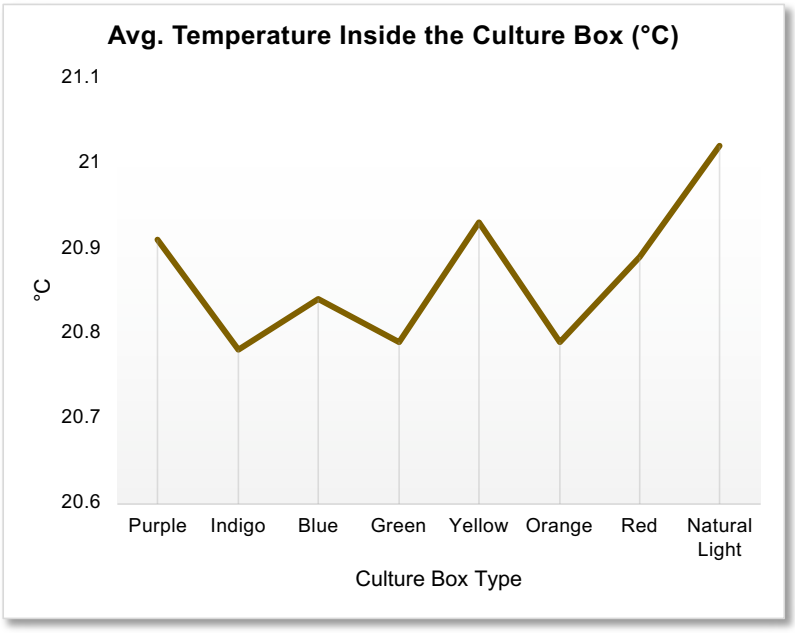
Graph 1: Illustrates the light frequencies for various types of culture boxes.



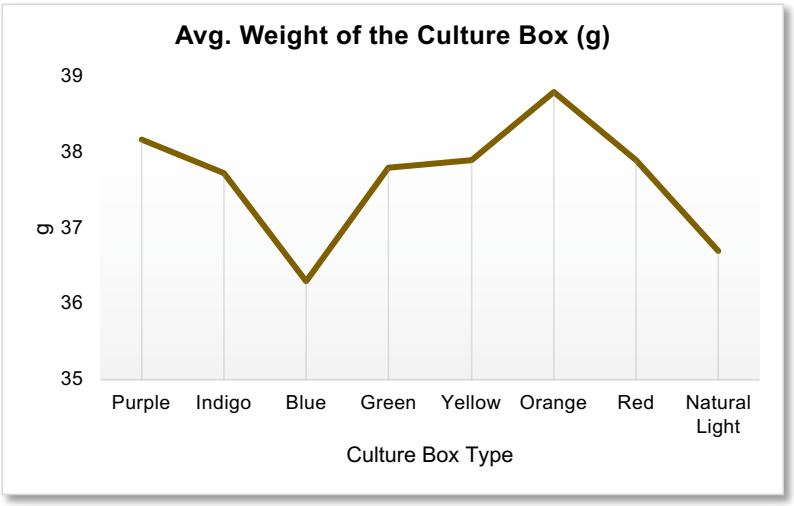
Graph 2: Illustrates the light intensity for various types of culture boxes.



Graph 3: Illustrates the average relative humidity inside the culture boxes for various colors.



Graph 4: Illustrates the average temperature inside culture boxes for various colors.

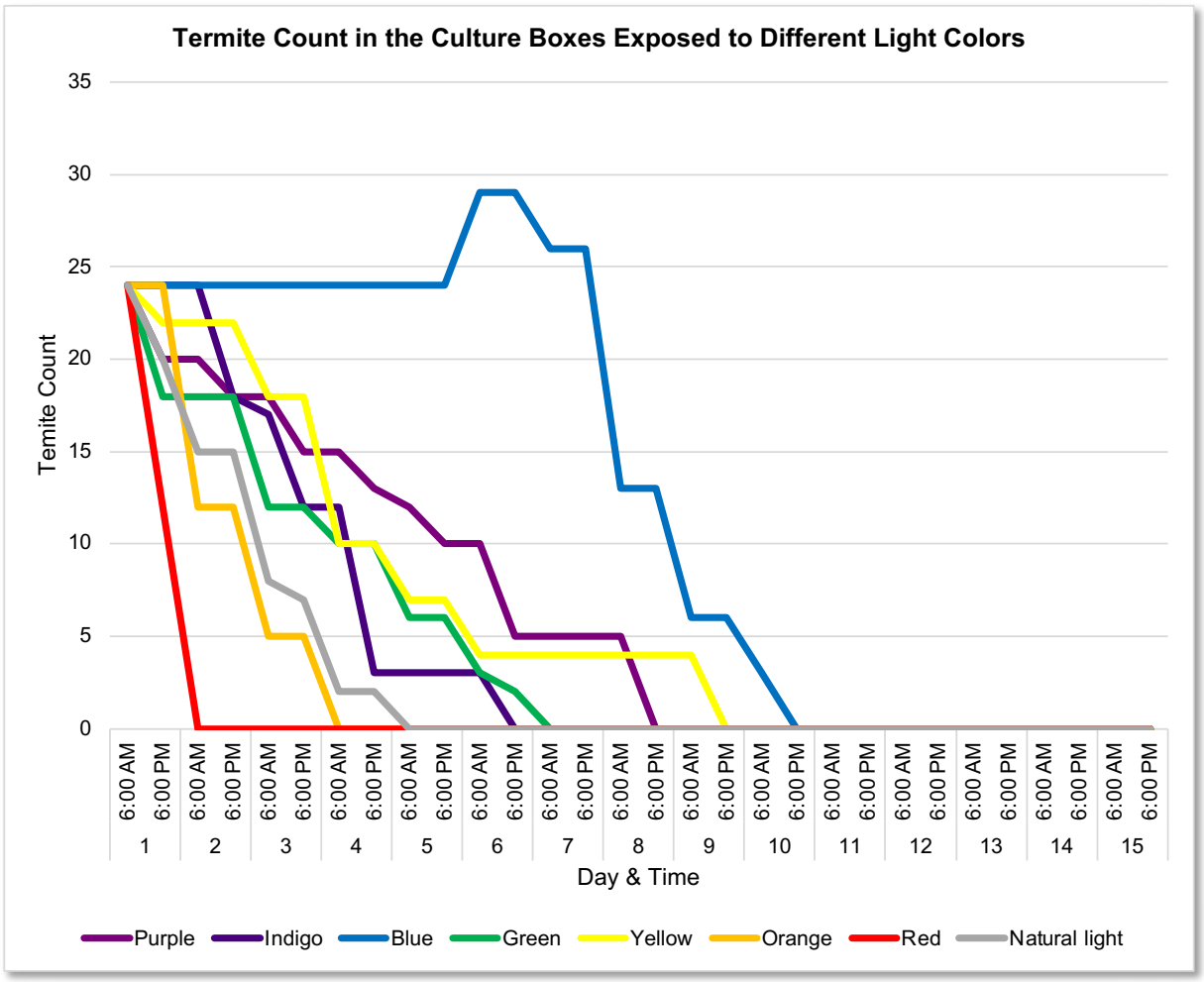


Graph 5: Illustrates the average weight of the culture box.

Table 2: Comparative Analysis of Termite Count in the Culture Boxes Exposed to Different Light Colors

Day	Time	Termites Count in the Culture Boxes Exposed to Different Light Colors							
		Purple	Indigo	Blue	Green	Yellow	Orange	Red	Natural light
1	6:00 AM	24	24	24	24	24	24	24	24
	6:00 PM	20	24	24	18	22	24	12	20
2	6:00 AM	20	24	24	18	22	12	0	15
	6:00 PM	18	18	24	18	22	12	0	15
3	6:00 AM	18	17	24	12	18	5	0	8
	6:00 PM	15	12	24	12	18	5	0	7
4	6:00 AM	15	12	24	10	10	0	0	2
	6:00 PM	13	3	24	10	10	0	0	2
5	6:00 AM	12	3	24	6	7	0	0	0
	6:00 PM	10	3	24	6	7	0	0	0
6	6:00 AM	10	3	29	3	4	0	0	0
	6:00 PM	5	0	29	2	4	0	0	0
7	6:00 AM	5	0	26	0	4	0	0	0
	6:00 PM	5	0	26	0	4	0	0	0
8	6:00 AM	5	0	13	0	4	0	0	0
	6:00 PM	0	0	13	0	4	0	0	0
9	6:00 AM	0	0	6	0	4	0	0	0
	6:00 PM	0	0	6	0	0	0	0	0
10	6:00 AM	0	0	3	0	0	0	0	0
	6:00 PM	0	0	0	0	0	0	0	0
11	6:00 AM	0	0	0	0	0	0	0	0
	6:00 PM	0	0	0	0	0	0	0	0
12	6:00 AM	0	0	0	0	0	0	0	0
	6:00 PM	0	0	0	0	0	0	0	0
13	6:00 AM	0	0	0	0	0	0	0	0
	6:00 PM	0	0	0	0	0	0	0	0
14	6:00 AM	0	0	0	0	0	0	0	0
	6:00 PM	0	0	0	0	0	0	0	0
15	6:00 AM	0	0	0	0	0	0	0	0
	6:00 PM	0	0	0	0	0	0	0	0

The result shows the termite mortality in culture boxes exposed to different light colors. This indicates distinct patterns: the culture box exposed to red light exhibited the swiftest decline in termite population, with a mortality rate observed within 2 days. In contrast, the culture box with blue light demonstrated a prolonged time frame, taking 10 days for a substantial decrease in termite numbers. This information contributes valuable insights into the varied effects of light colors on termite mortality rates over time.

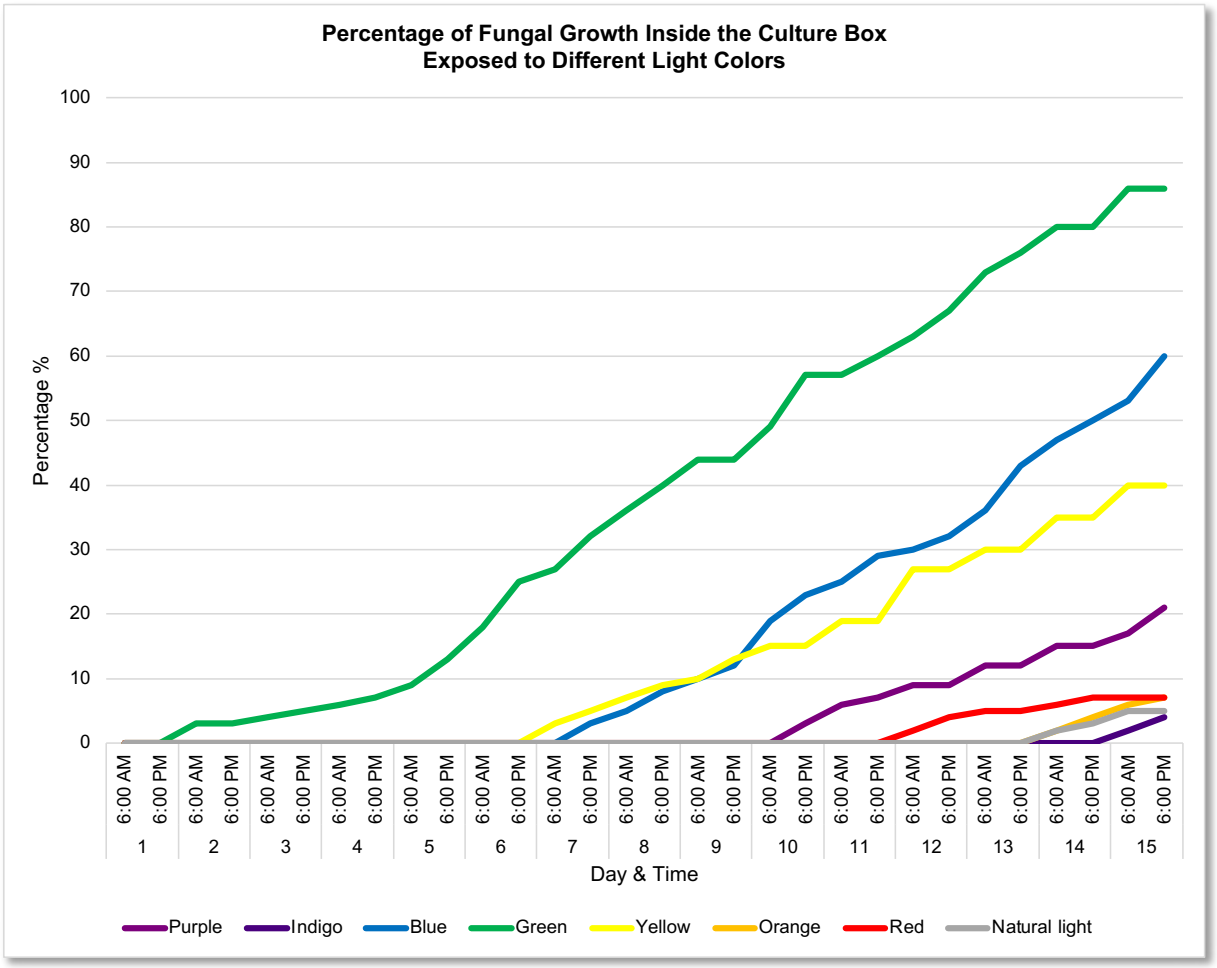


Graph 6: Illustrates the termites count in culture boxes exposed to different light color.

Table 3 : Comparative Analysis of Fungal Growth Percentage Inside the Culture Box Exposed to Different Light Colors

Day	Time	Percentage of Fungal Growth Inside the Culture Box Exposed to Different Light Colors							
		Purple	Indigo	Blue	Green	Yellow	Orange	Red	Natural light
1	6:00 AM	0	0	0	0	0	0	0	0
	6:00 PM	0	0	0	0	0	0	0	0
2	6:00 AM	0	0	0	3	0	0	0	0
	6:00 PM	0	0	0	3	0	0	0	0
3	6:00 AM	0	0	0	4	0	0	0	0
	6:00 PM	0	0	0	5	0	0	0	0
4	6:00 AM	0	0	0	6	0	0	0	0
	6:00 PM	0	0	0	7	0	0	0	0
5	6:00 AM	0	0	0	9	0	0	0	0
	6:00 PM	0	0	0	13	0	0	0	0
6	6:00 AM	0	0	0	18	0	0	0	0
	6:00 PM	0	0	0	25	0	0	0	0
7	6:00 AM	0	0	0	27	3	0	0	0
	6:00 PM	0	0	3	32	5	0	0	0
8	6:00 AM	0	0	5	36	7	0	0	0
	6:00 PM	0	0	8	40	9	0	0	0
9	6:00 AM	0	0	10	44	10	0	0	0
	6:00 PM	0	0	12	44	13	0	0	0
10	6:00 AM	0	0	19	49	15	0	0	0
	6:00 PM	3	0	23	57	15	0	0	0
11	6:00 AM	6	0	25	57	19	0	0	0
	6:00 PM	7	0	29	60	19	0	0	0
12	6:00 AM	9	0	30	63	27	0	2	0
	6:00 PM	9	0	32	67	27	0	4	0
13	6:00 AM	12	0	36	73	30	0	5	0
	6:00 PM	12	0	43	76	30	0	5	0
14	6:00 AM	15	0	47	80	35	2	6	2
	6:00 PM	15	0	50	80	35	4	7	3
15	6:00 AM	17	2	53	86	40	6	7	5
	6:00 PM	21	4	60	86	40	7	7	5

The result shows that the culture box exposed to green light exhibited the highest percentage of the fungal growth inside the box on the 15th day. This findings suggests that the fungal growth thrives under optimal growth conditions, particularly in response to the moderate frequency and intensity of green light.



Graph 7: Illustrates the fungal growth percentage inside the culture boxes exposed to different light colors.

Table 4: ANOVA Analysis of Fungal Growth, Termite Count, Temperature, and Weight in the Culture Boxes

ANOVA (Analysis of Variance)						
Source of Variation		Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F	Sig.
Fungal Growth	Between Groups	36733.229	7	5247.604	27.823	.000*
	Within Groups	43757.233	232	188.609		
	Total	80490.463	239			
Termite Count	Between Groups	2734.263	7	390.609	6.247	.000*
	Within Groups	14506.033	232	62.526		
	Total	17240.296	239			
Temperature	Between Groups	1.504	7	.215	.138	.995
	Within Groups	360.116	232	1.552		
	Total	361.620	239			
Weight	Between Groups	134.029	7	19.147	13.558	.000
	Within Groups	327.633	232	1.412		
	Total	461.662	239			

*Statistically significant at the .05 level (Sig. ≤ .05)

The results demonstrate statistically significant differences in both the termite count and the percentage of fungus within the culture boxes across various light colors, reaching a significance level of 0.05.

Table 5 : Correlation Analysis of Light Frequency, Light Intensity, Fungal Growth, Termite Count, Temperature, and Weight in the Culture Box

Correlations							
Source of Variation		Light Frequency	Light Intensity	Fungal Growth	Termite Count	Temperature	Weight
Light Frequency	Pearson Correlation	1	.904**	-.003	.158*	.000	-.068
	Sig. (2-tailed)		.000	.962	.014	.996	.296
	N	240	240	240	240	240	240
Light Intensity	Pearson Correlation	.904**	1	.027	.279**	.006	-.156*
	Sig. (2-tailed)	.000		.674	.000	0.931	.016
	N	240	240	240	240	240	240
Fungal Growth	Pearson Correlation	-.003	-0.027	1	-.284**	-.177**	-0.035
	Sig. (2-tailed)	.962	0.674		.000	0.006	.585
	N	240	240	240	240	240	240
Termite Count	Pearson Correlation	.158*	.279**	-.284**	1	.491**	-.356**
	Sig. (2-tailed)	.014	.000	.000		.000	.000
	N	240	240	240	240	240	240
Temperature	Pearson Correlation	.000	-.006	-.177**	.491**	1	-.510**
	Sig. (2-tailed)	.996	.931	.006	.000		.000
	N	240	240	240	240	240	240
Weight	Pearson Correlation	-.068	-.156*	-.035	-.356**	-.510**	1
	Sig. (2-tailed)	.296	.016	.585	.000	.000	
	N	240	240	240	240	240	240

* Correlation is significant at the 0.05 level

The results reveals statistically significant effects of light frequency, light intensity, and temperature inside the culture box on termite count, supported by significance levels below 0.05. Furthermore, the temperature inside the culture box and the termite count demonstrate a significant impact on the percentage of fungal growth within the culture box area, with significance levels below 0.05.

CONCLUSION

In conclusion, our comprehensive investigation into the interplay of light frequency, intensity, and temperature within the culture box has revealed significant insights into the intricate dynamics of termite behavior, fungal growth, and their interrelationships. The three key findings outlined below not only contribute to the understanding of termite biology but also present practical implications for novel approaches to termite cultivation and sustainable resource utilization. The outcomes emphasize the intricate nature of ecological interactions and offer a foundation for further exploration in the realms of entomology and environmental science.

1. The impact on termite quantity and weight is influenced by light frequency, light intensity, and temperature inside the culture box. Different colors of light yield varying results. The culture box exposed to red light demonstrated optimal efficacy in reducing termite quantity. In contrast, the culture box exposed to blue light exhibited lower effectiveness in diminishing termite numbers, suggesting its potential application for termite cultivation as a novel protein source in the insect diet.

2. The growth of the fungus is influenced by the temperature inside the culture box, which, in turn, is affected by the color of light. Different colors of light produce varied effects on the growth of the fungus. The culture box exposed to green light proves to be the most effective in cultivating the fungal growth. Moreover, the researchers believe that this outcome adds valuable data for cultivating the nutritional value of termite mushrooms found in Southern Thailand.

3. Light frequency, light intensity, and temperature inside the culture box are correlated with the quantity and weight of termites. Additionally, the temperature inside the culture box is linked to the growth of the fungus, and there is a relationship between termite population and fungal growth. A negative correlation is observed, indicating that as the termite population decreases, the fungus tends to increase.

This study serves as a valuable resource for farmers seeking to manage termite populations for income generation and for students interested in the study of termites and fungi within termite nests. By adapting note-taking research to existing scientific tools in schools and the GLOBE protocol, our experiment opens avenues for further development and application in line with established scientific methodologies.

It's important to note that our experiment employed LED strips with all seven colors (purple, indigo, blue, green, yellow, orange, and red) which were purchased online. While the light intensity values may vary, future research is encouraged to utilize stable lights adhering to standardized norms for improved reliability.

References

Chomngam, K., & Tuengnok, N. (2018). Development of light-based insect traps. Retrieved from https://nuir.lib.nu.ac.th/dspace/bitstream/123456789/4866/1/KonkritChomngam.pdf

Kuekun, K. (6 August 2020). Vision and light. Retrieved from https://www.scimath.org/lesson-physics/item/9776-2019-02-21-06-15-23

Boonpong, N. (8 February 2021). Kingdom of Fungi. Retrieved from https://www.scimath.org/lesson-biology/item/11312-2020-02-18-04-05-10

Agricultural Ecology. (11 May 2023). Diversity of mushrooms. Tribute from the ecosystem. Retrieved from https://biothai.net/ecological-agriculture/5762

Somboonwong, P. (M.P.P.). Mushroom cultivation. Retrieved from https://researchex.mju.ac.th/agikl/index.php/knowledge/42-mushroom/107-muchroomn

Sueb Nakasathien Foundation. (March 13, 2020). Light pollution is a catastrophe that leads to the extinction of insects. Retrieved from https://www.seub.or.th/bloging/news/global-news/%E0%B8%A1%E0%B8%A5%E0%B8%A0%E0%B8%B2%E0%B8%A7 %E0%B8%B0%E0%B8%97%E0%B8%B2%E0%B8%87%E0%B9%81%E0%B8%AA%E0%B8%87%E0%B8%84%E0 %B8%B7%E0%B8%AD%E0%B8%A1%E0%B8%AB%E0%B8%B1%E0%B8%99%E0%B8%95%E0%B8%A0%E0%B8 %B1/

Ban Nai Grim School. (M.P.P.). Study about termites, tiny architects of nature and destructive pests. Retrieved from https://bannaigrim.ac.th/%E0%B8%95%E0%B8%B1%E0%B8%A7%E0%B8%9B%E0%B8%A5%E0%B8%A7%E0%B8 %81/

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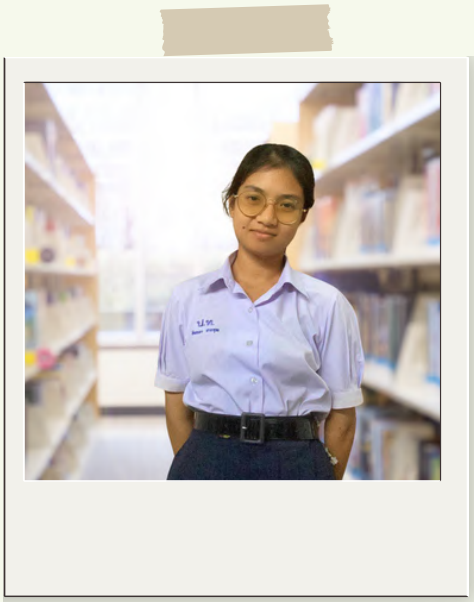
Director, Paphayompittayakom School

Appendices

researchers

Paphayompittayakom School, Thailand



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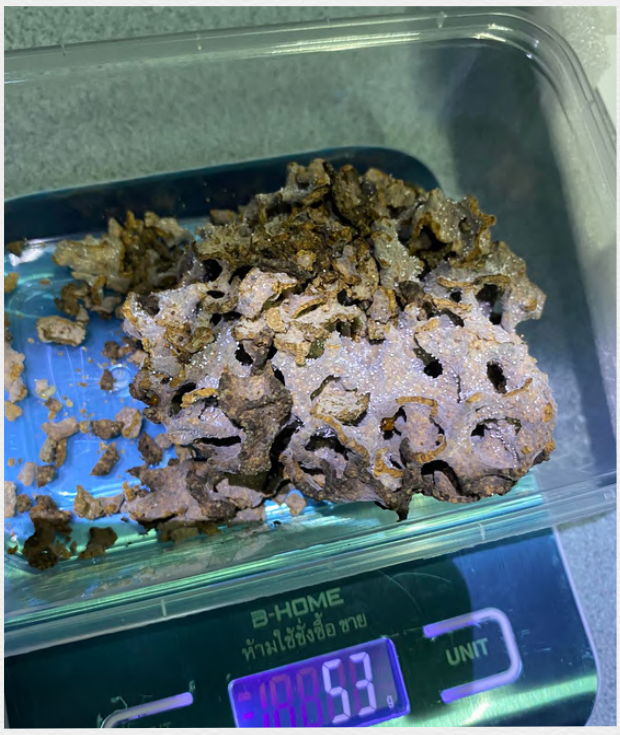
termite biology.



Researchers meticulously tally termite counts under varying light conditions. The LED-equipped culture box provides the stage for these experiments and the subsequent weighing of termite nests unveils the intricate influence of light on termite behavior and colonies.

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fungal growth.

Capturing a snapshot of thriving fungal growth in the culture box. Researchers keenly observe termites. Their diligent measurements extending to the precise monitoring of temperature and humidity, employing a digital thermo-hygrometer for comprehensive environmental insights.

research essentials.

A visual compilation showcasing the research materials, precise measurements of termite length, meticulously labeled culture box, and a detailed view of a culture box highlighting the percentage of fungal growth.

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faces behind the research

Paphayompittayakom School, Thailand

Pornpawit Tabchum · Kanatip Baolai · Rommel De La Cruz

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