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In this cluster are the combined studies under the fields of **Ecology** and **Plant Allelopathy**.
Ecology is a field of study that studies the interactions among organisms and their environment.
Plant Allelopathy is a field of study under **Ecology** that tackles how one plant may affect the growth of another due to the presence of allelochemicals.

Allelopathic effects of *Zingiber officinale* (ginger) leaf extracts on the germination of *Vigna radiata* (mung beans)

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Abstract

Allelopathy is a biological mechanism in which allelochemicals from one organism may influence the growth and development of other plants. It has been found that *Zingiber officinale* allelochemicals such as flavonoids, tannins, and phenols may influence the growth of *Vigna radiata*. This research investigated the allelopathic effects of *Zingiber officinale* leaf extracts on the seed growth of *Vigna radiata*. The *Zingiber officinale* leaf extracts 0.10 g/mL, 0.15 g/mL, and 0.20 g/mL were obtained by aqueous maceration of the sun-dried *Zingiber officinale* leaves and were applied to the seeds. Germination parameters were recorded every day for seven days. A significant difference was recorded between the germination percentage, germination rate, and inhibitory rate of the control and treatment groups. Results show that *Zingiber officinale* leaf extracts at 0.10-0.20 g/mL ratio inhibit the growth of *Vigna radiata* seeds.

Introduction. - The response of a plant to the presence of other plants and the factors that may influence a behavioral change in a plant is one of the topics of interest when learning plants' behaviors. This particular phenomenon is referred to as allelopathy. It is a biological mechanism in which biochemicals from an organism may influence the germination, growth, survival, and reproduction of other organisms [1].

Allelopathic effects of selected plants can be attributed to the presence of phenolic compounds such as flavonoids, tannins, and phenols, which can interfere with the activities of respiratory enzymes in seed germination and cause an inhibitory effect on its germination. This causes the alteration in the activities of the growth hormone Gibberellic acid which is responsible for the stimulation of seed germination [2]. Allelochemicals escape from plants in different ways such as leaching, volatilization, decomposition, and exudation [3].

Vigna radiata legume crops are prevalent in Southeast Asia and have varying uses, ranging from industrial to agricultural benefits. It is widely used as a food crop due to its high protein content [5]. The proteins and lipids are found to be high in the embryo, while the starch and crude fiber are concentrated in cotyledons and seed coats, respectively [6]. Moreover, *Vigna radiata* are reasonably priced in the market due to their relative ease of cultivation which may be caused by factors such as early maturity and resilience to drought, among others [7].

Allelopathic effects of some plants on *Vigna radiata* have already been conducted. These include the allelopathic effects of sorghum water extract which stimulated the growth of *Vigna radiata* due to the presence of phenolic compounds [8]. Another study was conducted by Hossain et al. [9], that utilized *Moringa oleifera* extracts that suppressed the growth yield parameters of *Vigna radiata*. On the other hand, *Vigna radiata* are also known to have allelopathic potential on other plants as explained by a study conducted by Nwoagu and Muogbu [4] in 2015.

Zingiber officinale is an important horticultural crop in tropical Southeast Asia. However, the main problem with *Zingiber officinale* culture is that *Zingiber officinale* is not suitable for continuous cropping and *Zingiber officinale* yields are low when this species is cultivated consecutively for years on the same land [10]. It is a heavy nutrient-demanding crop. Growing it with other crops is bound to exert some pressure on the nutrient pool of the soil.

Zingiber officinale leaf extracts exhibit inhibitory effects on the growth of other plants [11]. Stems and leaves of *Zingiber officinale* are known to exhibit stronger phytotoxicity, which adversely affects different growth parameters of soybean and chive [12]. Meanwhile, for other species such as sunflower and wild barley, it has been reported that allelochemicals from sunflower which inhibit the growth of wild barley at some concentrations might stimulate the growth of the wild barley at different concentrations [13]. Even if *Vigna radiata* have stimulatory effects on the growth of *Zingiber officinale* as reported by Nwaogu and Muogbo [4], the effect of *Zingiber officinale* on the growth of *Vigna radiata* has not yet been determined. With previous studies suggesting inhibitory effects of *Zingiber officinale* leaf extracts on other plants, the study hypothesize that *Zingiber officinale* leaf extracts will inhibit the growth of *Vigna radiata* .

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The established notion that *Vigna radiata* was able to stimulate the growth of *Zingiber officinale* plants prompted the conduct of the study by determining the effects of *Zingiber officinale* to *Vigna radiata*. The results of this research would be able to help in assessing whether *Vigna radiata* and *Zingiber officinale* could be planted together. The allelopathic activity between the two plants would serve as a great research endeavor for future studies. Also, the study aimed to raise awareness on how to efficiently utilize crop wastes by learning their implications for the environment, particularly on other plants.

This research aimed to investigate the allelopathic effects of *Zingiber officinale* leaf extracts on the germination of *Vigna radiata* seeds. It specifically aimed to:

(i) determine the germination percentage, germination rate, mean germination time, and inhibitory rate of *Vigna radiata* seeds treated with different ratios of *Zingiber officinale* leaf extract (0.10 g/mL, 0.15 g/mL and 0.20 g/mL) and distilled water (negative control);

(ii) determine the optimal ratio of the *Zingiber officinale* extract that could either enhance or inhibit the growth of *Vigna radiata* seeds during germination;

(iii) identify whether *Zingiber officinale* leaf extract has a positive or negative allelopathic effect on *Vigna radiata* seeds; and

(iv) determine significant differences between the germination percentage, germination rate, mean germination time, and inhibitory rate of the different treatment and control groups.

Methods. *Zingiber officinale* leaf extract was prepared by drying, cutting, grinding, screening, and maceration of the leaves. Meanwhile, the *Vigna radiata* seeds were subjected to a float test to identify viable seeds and were then distributed to the Petri dishes. Distilled water and the *Zingiber officinale* leaf extracts were applied to the control and treatment groups, respectively. The germination parameters of the *Vigna radiata* seeds were then recorded daily for seven days. The gathered results were then subjected to data analysis using One-way ANOVA and Tukey-Kramer Test. Personal protective equipment was also utilized throughout the conduct of their study. The data gathering procedures lasted for approximately two to three weeks.

Obtaining and verifying plant samples. The two main components of the study namely, *Zingiber officinale* leaves and *Vigna radiata* seeds were acquired from a single farm and from the local market in Jaro, Iloilo respectively, and were verified by the Department of Agriculture.

Drying, grinding, and screening of Zingiber officinale leaves. The acquired *Zingiber officinale* leaves were washed properly with distilled water to remove the impurities. Afterwards, the washed leaves were sun-dried on a threshing floor or any flat land surface for seven days. Drying techniques make the structural cell more fragile and facilitate subsequent grinding [14]. The dried leaves were chopped into 1 cm long pieces. The chopped leaves were converted into powder form with the help of an electric grinder. The next step was the screening of the *Zingiber officinale* leaves using a 0.5 mm screen mesh to yield more homogenized particles for efficient extraction to occur because the solvent must make contact with the target analytes [15].

Maceration and filtration. For the making of the aqueous leaf extracts, the screened *Zingiber officinale* leaves were weighed using a digital weighing scale. Then, 21.50 grams, 32.25 grams, and 43.00 grams of *Zingiber officinale* leaves in glass bottles were soaked in 215 mL of distilled water each forming extract ratios of 0.10 g/mL, 0.15 g/mL and 0.20 g/mL respectively. Then, the glass bottles were sealed and kept in a refrigerator (4℃) for 24 hours. After 24 hours, the extracts were filtered using a funnel with two layers of cheesecloth followed by Whatman No. 1 filter paper.

Storage. The filtered leaf extracts were stored inside dark, glass bottles before it was applied to the *Vigna radiata* seeds and kept in the refrigerator at a low temperature to prevent bacteria from growing. During transport, it was stored in an icebox to maintain the low temperature.

Preparation of research set-up. Prior to the start of the experiment, *Vigna radiata* were subjected to a seed viability test via the seed float test. A total of 120 viable *Vigna radiata* seeds and 12 Petri dishes (9 cm diameter) were surface sterilized with water: bleach (10:1) solution. The surface-sterilized seeds were evenly distributed into 12 Petri dishes that each contain 10 *Vigna radiata* seeds.

An improvised germination chamber was created by using a box container made of ¼ plywood with dimensions 90 cm by 45 cm by 60 cm. The lid of the box was drilled with holes at the top side. A 20 watts-fluorescent lamp (60 cm length) was attached at the top and was used as the source of diffused light and heat for the *Vigna radiata* seeds. Additionally, a lux meter was placed inside to monitor the temperature and light inside the growth chamber.

Maintenance and application of Zingiber officinale leaf extract and distilled water. The germination test was carried out in sterile Petri dishes with a kitchen towel acting as a soil substitute for the *Vigna radiata*. Then, 10 mL of *Zingiber officinale* leaf extracts was administered only during the first day on each Petri dish. The *Vigna radiata* seeds were immersed in the *Zingiber officinale* leaf extracts for seven days. Then, 90 of the 120 seeds were treated with *Zingiber officinale* leaf extract; 30 seeds for each of the three treatment groups (0.1 g/mL, 0.15 g/mL, and 0.20 g/mL) of the leaf extracts. The remaining 30 seeds were treated with 10 mL of distilled water. The seeds were watered at around 7:00 in the morning to allow the water to run down into the roots without too much water loss due to evaporation [16]. Approximately 10 mL of distilled water was added everyday to each replicate of all control groups to moisten the sterilized seeds [2]. Then, the Petri dishes were kept in a growth chamber, maintaining an average temperature of 27.5℃ for 12 hours for seven days.

Determination of seed growth parameters. The morphological parameters of *Vigna radiata* were determined every day for a span of seven days. These parameters include the following: germination percentage, germination rate, mean germination time, and inhibitory rate of *Vigna radiata* seeds [17].

$$Germination\ Percentage = \frac{total\ number\ of\ seeds\ germinated}{total\ number\ of\ seeds\ in\ the\ test} \times 100$$

$$Mean\ Germination\ Time = \frac{\sum_{i=1}^{k} n_i t_i}{\sum_{i=1}^{k} n_i}$$

$$Germination\ Rate = \frac{1}{MGT}$$

$$Inhibitory\ Rate = 100 - \frac{E_2 \times 100}{E_1}$$

where:
E_2=germinated treatment plants
E_1=germinated controlled plants
t_i=time from the start of the experiment to the ith day
n_i=number of seeds germinated in the ith time
k: last time of germination

Data Analysis. The data collected were analyzed using Microsoft Excel's Data Analysis function. The parameters were obtained by tabulating the mean of the replicates of the control and experimental groups and analyzing the means of these four groups. To further examine the results of the study, the gathered parameters in the three treatment groups were compared with the parameters obtained in the control group. Thus, one-way ANOVA with a significance level of $p \leq 0.05$ was used to examine the data. The computation for these values was done in Microsoft Excel 2019. For the post-hoc analysis tool, the Tukey-Kramer Test from Real Statistics add-in in Microsoft Excel 2019 was used to take into account unequal plant samples because some seeds died along the process.

Safety Procedure. The personal protective equipment (PPE) were worn which includes the following: laboratory gown, eye shield, surgical mask, gloves, and other protective equipment deemed necessary in the conduct of the research study. Long sleeves and long pants were also worn for additional protection. Disinfectant spray was done before and after working on the experimental area to prevent contamination.

Results and Discussion. - During the seven days of germination, there was a significant difference in terms of the germination percentage, germination rate, and inhibitory rate of the control and treatment groups. However, no significant difference in the mean germination time of the treatment and control group was found.

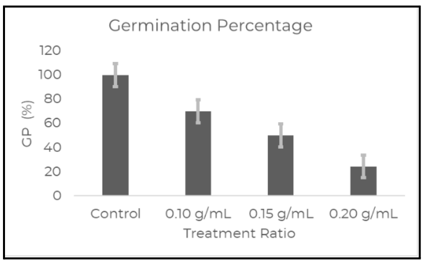
The 0.1 g/mL extract exhibited the least negative allelopathic effect of the leaf extract at 70% germination percentage while the highest negative allelopathic effect was observed at 0.20 g/mL extract with a 24.4% germination percentage.

Table 1. The Germination Percentage (GP), Mean Germination Time (MGT), Germination Rate (GR), and Inhibitory Rate (IR) of *Vigna radiata* seeds in the control and treatment groups.

Parameters	Different Concentrations of *Zingiber officinale* Leaf extract (g/mL)			
	Control	0.10	0.15	0.20
GP (%)	100.00 ±9.51	70.00 ±9.51	50.00 ±9.51	24.44 ±9.51
MGT (days)	1.79 ±0.26	1.88 ±0.26	1.93 ±0.26	1.37 ±0.40
GR (seeds/day)	0.61 ±0.08	0.68 ±0.08	0.58 ±0.08	0.15 ±0.11
IR (%)	0.00 ±8.20	31.11 ±9.30	48.89 ±9.30	75.56 ±8.20

Notes. Sample size = 30 seeds

A.1. Germination parameters from control and treatment groups. Of the three treatment groups, the 0.1 g/mL leaf extract showed 70% germination percentage. The lowest germination percentage among the treatment groups was recorded in the 0.20 g/mL extract with 24.4% germination percentage. Meanwhile, the control group had a germination percentage of 100%. As for its mean germination time, the 0.15 g/mL extract exhibited the highest mean germination time among all treatment groups with a value of 1.93 days. Meanwhile, the 0.20 g/mL extract has the lowest mean germination time value of 1.37 days. Additionally, the control group recorded a mean germination time value of 1.79 days. Following this, the 0.1 g/mL extract showed the highest germination rate among the three concentrations, with a value of 0.68. While the 0.20 g/mL extract showed the least germination rate with a value of 0.15. Meanwhile, the control group had a germination rate of 0.61. For the inhibitory rate, treatment 0.20 g/mL extract showed the highest inhibitory rate among all treatment groups with a value of 75.56 while treatment 0.1 g/mL extract had the lowest inhibitory rate with a value of 31.11. The results show a decreasing trend for the germination percentage and germination rate as the amount of the *Zingiber officinale* leaf extracts increased. While the trend of the inhibitory rate increased as the amount of the *Zingiber officinale* leaf extracts also increased.



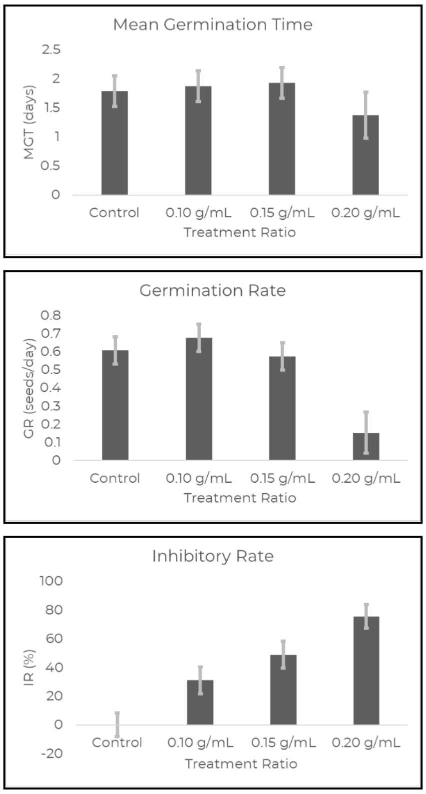


Figure 1. Germination percentage, mean germination time, germination rate, and inhibitory rate of *Vigna radiata* seeds (n=30) in different extract ratios 0.10 g/ml, 0.15 g/ml and 0.20 g/ml with significance level of $p \leq 0.05$.

These results are in line with the principle that allelochemicals that inhibit the growth of some plant species at certain concentrations might stimulate the growth of the same or different plant species at different concentrations [13]. For instance, the shoot extracts of cannabis in high concentrations was reported to have an inhibitory effect on the germination indices while root extracts had no statistically significant effect on the germination of lettuce seeds [18]. Additionally, phenolic compounds, one of the allelochemicals found in *Zingiber officinale* leaves, are reported to have stimulatory effects on seed germination and seedling growth of plants at low concentrations but resulted in a decrease in germination parameters at higher concentrations [18]. Also, some *Vigna radiata* seeds in the treatment with 0.10 g/mL extract (21.5 g/215 mL) were able to germinate for a few days and slowly disintegrated. This might be due to the direct contact of the root with the inhibitory chemicals as described with various crops and weeds [2]. Hence, roots are generally the first point of contact with chemical compounds which explains that any abnormal growth in the root is an obvious sign of chemical toxicity by allelopathic plants [12]. Similar observations were reported by [19] wherein it was discovered that the effect of allelochemicals in *E. coccinea* may have led to the metabolic impairment of *Vigna radiata*. Thus, the formation of the natural root was significantly affected.

A.2. Optimal ratio of the Zingiber officinale leaf extract. The least negative allelopathic effect of the seed extract was observed in the 0.1 g/mL extract while the highest negative allelopathic effect was observed in the 0.20 g/mL extract. As such, the 0.20 g/mL extract is the optimal ratio of the extract among the three treatment groups which would inhibit the growth of *Vigna radiata* seeds because it has the highest inhibitory rate. Given as well as there exists a significant difference between the control and treatment groups in the germination percentage as well as the inhibitory rate.

Allelopathy is often due to the synergistic activity of allelochemicals rather than single compounds. Thus, the response of the *Vigna radiata* seeds to the *Zingiber officinale* leaf extracts may be attributed to the reaction of the various allelochemicals in the leaf extracts among each other and their implications to the growth of the *Vigna radiata* [18]. The increase in the amount of these allelochemicals increased the allelopathic activity in the *Vigna radiata*. As such, treatment 0.20 g/mL extract (43. 00 g/ 215 mL), which contained more *Zingiber officinale*-leaf-powder: water ratio, caused more negative allelopathic effects on the *Vigna radiata* seeds.

A.3. The allelopathic effect of the Zingiber officinale leaf extract. The application of *Zingiber officinale* leaf extracts 0.1 g/mL, 0.15 g/mL and 0.2 g/mL on *Vigna radiata* caused a significant decrease in the germination percentage, and germination rate of the *Vigna radiata* seeds. These results indicated a negative allelopathic effect on the growth of *Vigna radiata* seeds. The *Zingiber officinale* leaf extracts in all three treatment groups showed negative allelopathic effects on the germination of *Vigna radiata* seeds in contrast to the control group, and no extracts have stimulatory effects on the growth of the seeds.

Zingiber officinale leaf extracts have previously shown inhibitory effects on the growth of other plants [11]. Stems and leaves of *Zingiber officinale* are known to exhibit stronger phytotoxicity, which adversely affects seed germination, seedling growth, water uptake, and lipase activity of soybean and chive [12]. Moreover, *Vigna radiata* in the study were at germination stage supporting its sensitive response to the concentration of bioactive compounds in their surroundings [19].

A.4. Significance of the growth parameters. The p-values of the germination percentage, germination rate, and inhibitory rate are 3.28×10^{-5}, 2.31×10^{-5}, and 3.07×10^{-6}, respectively, which are less than or equal to 0.05 showing a significant difference among the treatment groups. Meanwhile, the mean germination time does not have a significant difference present as it has a p-value of 6.96×10^{-1}.

By conducting the Tukey-Kramer test, the inhibitory rate showed a significant difference between the control group and all the treatment groups. For the germination percentage, significant results are found between the control and treatment 0.15 g/mL extract results, as well as between the control and treatment 0.20 g/mL extract results. Finally, for the germination rate, there are significant results between the control and treatment 0.20 g/mL extract groups as well as with the 0.1 g/mL extract and 0.20 g/mL extract .

Limitations. The study is limited to observing whether *Zingiber officinale* leaf extracts inhibited or promoted the growth of *Vigna radiata* through the observance of germination parameters namely inhibitory rate, germination percentage, mean germination time, and germination rate.

Additionally, the results of the data analysis may be subject to error due to uneven sample size caused by the death of some *Vigna radiata* seeds while some ceased to grow after the fifth day of the data gathering. This brings several concerns that were addressed, such as making a germination chamber to cater to the growth of *Vigna radiata*. However, the effects of other *Zingiber officinale* extract ratios on the growth of *Vigna radiata* seeds could not be determined. Thus, the gathered result about the optimal ratio of treatment provides limited knowledge because the extract ratios used in the study were limited to 0.1 g/mL, 0.15 g/mL and 0.20 g/mL *Zingiber officinale* leaf extracts. Due to the unavailability of laboratory equipment, other parameters were not controlled, specifically, the moisture content of *Vigna radiata*. Furthermore, the study was not able to conduct phytochemical analysis. Thus, the specific allelochemicals found on the *Zingiber officinale* leaves were not determined.

Conclusion. - The results showed that the growth of *Vigna radiata* seeds during germination revealed that germination rate, germination percentage, and mean germination time were suppressed in treatments containing different ratios of *Zingiber officinale* leaf extracts. Germination percentage, germination rate, and inhibitory rate of *Vigna radiata* seeds between and among the control groups and treatment groups showed significant differences. The 0.20 g/mL extract showed the highest inhibitory rate. Thus, treatment 0.20 g/mL extract is considered the optimal ratio of extract that could inhibit the growth of *Vigna radiata* seeds. It can be concluded that *Zingiber officinale* leaf extracts have a negative allelopathic effect because it was able to inhibit the growth of *Vigna radiata* seeds. Thus, *Zingiber officinale* should not be co-planted with *Vigna radiata* seeds.

Recommendations. - It is recommended that a larger sample size is also recommended to obtain an accurate and discrete significance difference. The study could also be extended throughout the life cycle of *Vigna radiata* to gather data about other parameters such as morphological features. It is also recommended that future studies explore other treatment ratios for the study. The experiment may also be replicated in laboratory and field conditions that are ideal for the growth of *Vigna radiata* seeds in contrast to the improvised germination chamber used in the study. Also, further tests for the *Zingiber officinale leaf* extracts are recommended such as the conduct of phytochemical screening to determine the relative abundance of allelochemicals in *Zingiber officinale*.

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The relationship between urbanization indicators and the *Passer montanus* bird count in urban and urban sprawl areas in Iloilo and Bacolod, Philippines

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urban adapter

Abstract

Urbanization leads to the depletion of vegetation that provides food, habitat, and breeding grounds for *Passer montanus*. Data was collected from Bacolod City and Iloilo, Philippines, using citizen science to assess the *P. montanus* bird count in relation to urbanization indicators. The distances of the participants' residences from the city center and nearest main road were determined. Point count was performed while observing *P. montanus* that perched, people, moving vehicles, and predominant vegetation type seen during the observation period. Through R-4.1.2 Programming, the Eta coefficient test showed a weak association between *P. montanus* and the predominant vegetation type. The Spearman correlation indicated that the species and vehicles were moderately correlated while the rest of the data pairs had no significant correlation. In urban environments, urban adapters, *P. montanus*, persist. The species is tolerant of humans and moving vehicles and has no specific vegetation that serve as forage sites.

Introduction. - *Passer montanus*, also known as Maya, originated from the common day West Germany and is considered one of the most common birds in the Philippines by The Haribon Foundation [1]. This species is often seen in thick hedgerows and bushy parks [2]. Habitat sites for *P. montanus* are located in residential areas, suburban areas, parks, and gardens [3,4].

In the Philippines, urbanization resulted from the merging of urban and agricultural land use due to the continuous development of topography [5]. It has been linked to the construction of pavements and buildings, depleting vegetation that may serve as food, habitat, and breeding grounds for birds, in turn contributing to the decline of their kind in urban areas [6]. Urban sprawl is indicated by the changes in the land-use pattern toward urban development [7]. It can be low-density residential development wherein houses are suddenly present in areas that were previously rural landscapes [8]. In this study, it signifies the growth of urbanization from lower city densities and undeveloped areas.

Research conducted in countries such as China [4], Israel [8], the Czech Republic [3], and Poland [9] on *P. montanus* imply the decline of the species population in highly urbanized areas. Because these birds rely on vegetation for food and habitat, their abundance is high in residential and suburban areas, low buildings, parks, and university campuses with a low degree of urbanization [3,4]. Skorka et al. [9] found that their abundance was high in areas away from the city center and with many streets. The species might be associated with diverse and mixed habitat composition, where they can find suitable foraging and nesting conditions [3]. Urban adapters, inclusive of both native and non-native animals, are predominant in intermediate urbanization level communities [10] because of humans and the many elements that come with their presence such as cultivated plants and garbage that they make available in the environment [11].

In this study, citizen science was used to gather data regarding the bird count of *P. montanus* by enlisting volunteers localized within the sampling sites. Citizen science targets the public across a wide range of localities to participate in data collection for projects [12]. Thus, the bird to be surveyed should essentially be familiar to the public. *Passer montanus* was chosen because it fits this criteria [1]. Citizen science is actively used in ecological projects and has been quite successful in providing information for bird monitoring projects, as bird-watching is popular with the general majority.

As far as can be determined, there have been no studies concerning the *P. montanus* bird count in urban and urban sprawl areas in Iloilo Province and Bacolod City. The mentioned sampling sites were chosen because they undergo urbanization and consist of a mixture of urban and urban sprawl areas. It is hypothesized that the number of *P. montanus* is positively correlated to the distance of the residence from the main road and city center and the predominant vegetation type, while it is negatively correlated to the number of people and moving vehicles.

The findings of this study can be used in bird-related studies concerning ecological habitats

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in response to urbanization. It could be used as a basis for projects focusing on preserving the habitat of birds by providing details on the type and characteristics of areas where birds would thrive and the possible important food and nest sites for birds within the city. Information regarding the association of animals and urban areas is essential to finding ways to manage wildlife in cities.

This study aims to assess the *P. montanus* bird count in residences of selected urban areas and urban sprawl areas of Iloilo Province and Bacolod City using citizen science. It specifically aimed:

(i) To determine the maximum number of *P. montanus* that perched within the participants' range of sight for thirty (30) minutes during the late afternoon (4:00 - 6:00 PM).

(ii) To determine the predominant vegetation type in the participants' observation area.

(iii) To determine the correlation between the maximum number of *P. montanus* observed in different sampling sites and the distance of the residence from the city center, the distance from the nearest main road, the number of people, and the number of moving vehicles using Spearman's rank correlation coefficient, and.

(iv) To determine the association between the maximum number of *P. montanus* in different sampling sites and the predominant vegetation type in the observation area using the Eta coefficient test.

Methods. - Data was collected using citizen science. Each participant performed a point-count bird survey. The researchers acquired each participant's residence coordinates used in calculating the distance of each residence to the nearest main road and city center. The participants provided the predominant vegetation type in their observation area.

Citizen Science Management. The researchers recruited participants through social media and partnered with the Department of Education. Citizen scientists voluntarily participated and were chosen through the following established criteria: (1) Participants were nine to 49 years old, (2) resided in Iloilo Province and Bacolod City, and (3) scored four out of five in the evaluation that assessed their skills in identifying *P. montanus*. The researchers distributed a copy of supplemental guides with a photo and description of the characteristics of the species based on the Birds in The City field guide created by The Haribon Foundation [13], and additional instructions. Optional orientation sessions were conducted through Zoom Meetings. Data was submitted to the submission link or other provided contact details.

Sampling Sites. The chosen sampling sites were Iloilo Province and Bacolod City. Each location was classified into two categories, namely urban areas and urban sprawl areas based on urbanization indicators, available data from the 2018 Iloilo Province Profile, and the Enhanced Provincial Development and Physical Framework Plan from the Province of Iloilo, containing a map identifying each municipalities' urbanization level. Bacolod City was classified as urban based on the Bacolod City Profile on the PhilAtlas website.

Passer montanus. *P. montanus*, a resident species in the Philippines, is known to locals as Maya and is one of the most common birds in the country [1]. An adult *P. montanus* is a "chunky sparrow with a chestnut crown, black throat, and a distinctive white cheek and black ear patch" [20]. Both male and female species share these characteristics and are similar in appearance. The species forages food on the ground, trees, and plants, usually in the form of gleaning and picking. In the Philippines, they may feed on rice [21].

Point Count Survey. The bird survey was conducted on any day of the week for 30 minutes between 4:00 P.M. to 6:00 P.M. The point count method is a purposeful bird survey method adapted from Paker et al. [8] where the point counts' surroundings are included in the study. In each residence, a single stationary observation point was determined. The participants stood on the point of observation with the best vantage point, where their range of sight is maximized. *P. montanus* was observed quietly in the observation point for thirty (30) minutes at a 180° angle or a half-circle. Other than the option of doing the survey outdoors, the participants were allowed to do it indoors, by looking out a window or by standing on a balcony, as long as they could have a good vantage point. Only the maximum number of perched birds that landed at any one time within the timeframe was noted. Perched means "to alight, settle, or rest on a perch, a height, or a precarious spot" [14]. Once the bird rested on a spot, it is considered perching. During observation, the number of individuals and moving vehicles that were seen in the observation area was accounted for.

Vegetation Type. The participants provided the predominant vegetation type of their observation area which refers to the plant type that covers most of the vicinity or is bountiful within the area. In the case of an equal distribution of plant types, the type recorded is the largest in size and is capable of outcompeting other plants by "controlling the availability of light, water, and other resources" [22].

Data Analysis. Two variables were correlated with each other at a time, these are: (1) the number of birds and distance of the residence from the city center, (2) the number of birds and distance of the residence from the nearest main road, (3) the number of birds and the number of people, and (4) the number of birds and the number of moving vehicles using Spearman's rank correlation coefficient. Moreover, the Eta Coefficient test was used to associate the predominant vegetation type with the number of birds. All statistical analyses were performed using R-4.1.2 Programming software.

Safety Procedure. The participants did not perform the activity: (1) when it rained, (2) during calamities, and (3) when participants were not in the proper condition. They were advised to apply sunscreen, wear caps, and check their surroundings. Moreover, the study complied with the Data Privacy Act of 2012 or RA 10173 when dealing with the personal information of the participants.

Results and Discussion. - There were fifty-eight (58) participants who submitted complete data. Thirty-four are from Bacolod City and 24 are from all throughout Iloilo Province, such as Iloilo City (10.702561, 122.568579), Guimbal (10.667642, 122.299627), Miagao (10.668020, 122.197836), and Calinog (11.144736, 122.514609). Moreover, 13 of the participants from Iloilo Province are from urban sprawl areas, while the rest are from urban areas as shown in Figure 1.

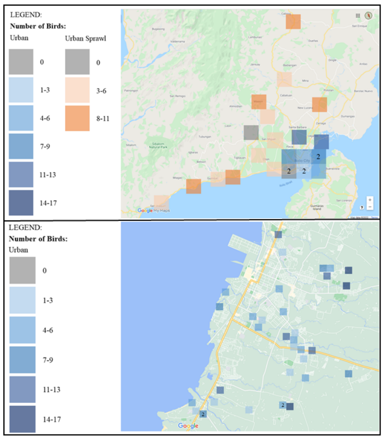

Figure 1. Map of the *P. montanus* bird count in urban areas and urban sprawl areas in Iloilo Province (above) and Bacolod City (below).

In urban areas, as many as seventeen (17) were counted, while in urban sprawl areas, eleven (11) birds were the highest bird count. Both areas included participants with no birds counted. The squares with "2" represent two data points, having two different participants' observation areas (Figure 1).

The Eta correlation coefficient, between the two variables: number of birds and predominant vegetation type, resulted in η=0.27 Eta Coefficient test statistic indicating a weak association (Table 1). Thus the null hypothesis, stating that there is no association between the number of *P. montanus* and the predominant vegetation type, is rejected.

Table 1. The calculated Spearman rank correlation coefficient and Eta coefficient test statistic for the number of *P. montanus* and urbanization indicators.

Variables	Calculated coefficient
Predominant vegetation type and the number of *P. montanus*	Eta coefficient test statistic (η): 0.27
Distance of the residence from the city center and the number of *P. montanus*	Spearman rho (r_s): 0.04 (P=0.75)
Distance of the residence from the nearest main road and the number of *P. montanus*	r_s: 0.02 (P=0.86)
Number of people and the number of *P. montanus*	r_s: 0.19 (P=0.16)
Number of moving vehicles and the number of *P. montanus*	r_s: 0.31 (P=0.02)

Accordingly, the number of birds observed in the observation areas having trees as the predominant vegetation type is more variable compared to the other types (Figure 2). The upper quartile and median of trees are higher than the other types, indicating that there is a higher number of birds observed in areas with trees as the predominant type. However, since the Eta Squared, which is 0.07, represents only 7% of the variance of the number of birds can be attributed to the vegetation type, the spread of the data is not highly associated with the vegetation. This further shows the weak association between the two variables.

Forty-five people reported having trees as their predominant vegetation type, while the other 13 reported other types including shrubs, herbs, grass, ferns, and succulents.

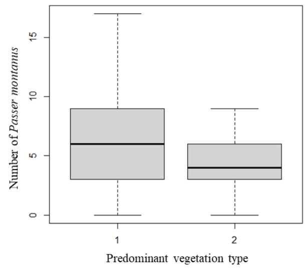

Figure 2. Correlation between the predominant vegetation type and number of *P. montanus* (1=trees, 2=other vegetation types).

Among all the pairs of variables, only the number of birds and the number of moving vehicles have a moderate relationship with a Spearman rho of rs=0.31, while the rest have a negligible relationship (rs<0.2) (Table 1). Figures 4 to 7 display the scatter plots of the number of *P. montanus* and the variables. As seen, there is no visible linear relationship as the points lie randomly on the graph.

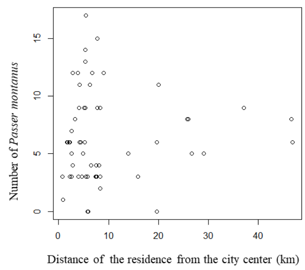

Figure 3. The relationship between the distance of the residence from the city center and the number of *P. montanus.*

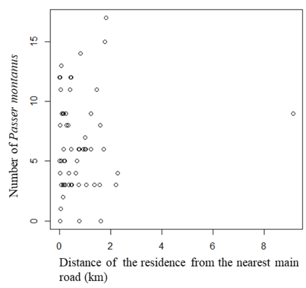

Figure 4. The relationship between the distance of the residence from the nearest main road and the number of *P. montanus.*

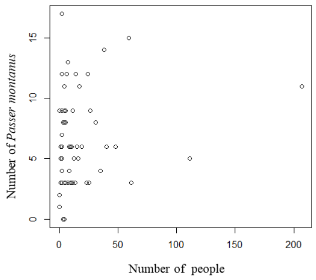

Figure 5. The relationship between the number of people and the number of *P. montanus.*

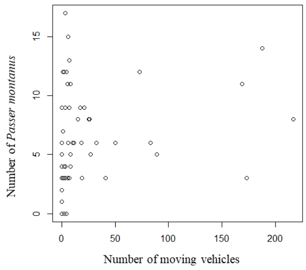

Figure 6. The relationship between the number of moving vehicles and the number of *P. montanus.*

In the sampling sites, it was observed that in urban environments, where there is habitat fragmentation and human disturbance, urban adapter species, particularly *P. montanus*, persist. Urban adapters are found in urban communities [11] and are predominant in these areas [10]. This is further supported by the gathered data, wherein the highest bird count of seventeen (17) was observed in the urban area with the coordinates: 10.672679, 122.995988 (Barangay Estefania, Bacolod City). Urban adapters take advantage of the resources provided by humans but do not depend on them [15].

Urbanization causes severe habitat fragmentation wherein the urban patches have discrete and high-contrast edges. According to Yuan & Lu [16], habitat fragmentation and disturbance caused by humans increase the number of urban adapters due to the diverse vegetation of the smaller areas, increasing the habitat's heterogeneity and attracting some bird species. In Iloilo and Bacolod, habitat fragmentation can be observed as wide areas of land, typically, vegetation areas, are transformed into smaller patches isolated from each other by deforestation or the construction of roads. Roads such as San Rufino Street (10.818954, 122.432563) in Alimodian, and Aleosan Road (10.780912, 122.465202) in San Miguel, Iloilo are mainly seen to divide the vegetation areas into smaller total areas. The bird count reported in these areas are six and five, respectively. Additionally, in some, small-scale deforestation occurred such as in Batuan Ilaya, Oton (10.742100, 122.429908), and M.V. Hechanova, Jaro, Iloilo (10.747357, 122.567027) to build the residences that can be seen now. The participants in both areas observed a bird count of three birds.

Our results show that *P. montanus* persists in urban and urban sprawl areas in the sampling sites with different built-up areas and vegetation coverage. In the study of Peh et al. [17], the term "persistent" was used to describe the species present in mixed-rural habitat observation areas. Even if only one bird was detected, the species was still classified as persistent since low abundance does not necessarily mean a negative species-habitat relationship [17].

The species has variable nesting habits, making them more resilient in adapting to environments [18]. Hollows of buildings may be important nesting spots in urban areas; areas with urban infrastructures and low-rise buildings including residences near Lacson Street (10.683290, 122.956049) and Araneta Avenue (10.638403, 122.931227) in Bacolod City, while gardens in residences may serve as foraging sites such as in the case of some participants living in subdivisions in Barangay Mansilingan (10.617908, 122.971113) and Barangay Estefania (10.669764, 122.987048) in Bacolod City.

Additionally, *P. montanus* is not a suitable biological indicator for urbanization in the sampling sites. Biological indicators are organisms associated with their environment. Their presence is indicative of the existence of certain conditions [19]. Based on the gathered data, *P. montanus* was observed in relatively high numbers in both urban and urban sprawl areas.

According to Yuan & Lu [16], vegetation within the area supports bird presence because they utilize it as habitat and food. In the study, however, despite the evidence that most of the participants reported having trees as the predominant type, it was found that there is no specific vegetation type that usually serves as the species' food and nest sites in the observation areas. As urban adapters, the *P. montanus* observed may have no specific preference for the vegetation they use for nesting and food. Their diet includes a variety of seeds and insects. In urban areas, they consume flowers, leaf buds, plant shoots, and even insects [20]. In the Philippines, *P. montanus* feeds on rice and seeds [21]. This supports the claim that it likely has a diverse diet that varies in different locations because of learned behavior and adaptation, and by relying on locally abundant food [22].

Some participants reported having a zero bird count. This is not due to human disturbance, as the participants observed only around 0-4 moving vehicles and people, which is lower compared to other reported data. Participants said that it may be due to their chosen time. Before the time started, birds can be seen perching. But, when the time started, no perched birds were observed. Because of the varying observation times, environmental factors such as the weather conditions not considered in the study may have affected the bird count.

The results of this study indicate that the *P. montanus* bird count has no relationship with the number of people. The birds may have adapted to the presence of humans. Studies show *P. montanus* could adapt to human environments and even increase in number; however, they are unable to adapt to the rapid expansion of urban development as it decreases vegetation coverage [16, 4].

An increase in main roads results in high vehicle flux. There was no association between the bird count and the distance of the residences from the nearest main road. According to the study of Zhang & Zheng [4], city centers and main roads may not be suitable environments for *P. montanus* due to the high human population and vehicle flux, nevertheless, some participants were able to report a high bird count despite residing near or even by the main road such as those residing near Lacson Street and Negros South Road (9.295563, 123.300249) in Bacolod City. This may be due to the presence of alternative sites for nesting and foraging, such as hollows in buildings and decorative trees. According to the study of Yuan & Lu [16], as the density of roads increases, there is a decrease in vegetative composition, which may negatively affect the species, suggesting that mixed areas having artificial surfaces and city green and less disturbance are suitable environments for the birds. Most of the observation areas in this study are mixed areas including Estefania in Bacolod and Pavia (10.760336, 122.525959) in Iloilo.

Based on the results, the number of birds and number of moving vehicles have a moderate relationship. The surveyed species are tolerant of vehicles because in some areas with high vehicle flux, *P. montanus* can still be seen. The bird may also perch in taller buildings farther from the ground where there are moving vehicles, where disturbance and noise pollution brought by the vehicles is reduced. This can be observed in residences near Iloilo City Proper (10.695209, 122.564690). However, in urban sprawl areas farther from the city center, the cars may enter the observation area in intervals and do not produce loud sounds, as observed by a participant in Pavia, Iloilo.

Limitations. The study did not account for meteorological conditions during the bird survey. Furthermore, due to restrictions at the time of the study, the survey is restricted to the participants' residences. The data is also not widely distributed geographically and is mostly concentrated within urban areas since prospective participants from rural areas are difficult to contact. Thus, no data was gathered from rural areas which were initially included in the scope to be studied. Communication barriers and data quality were the major limitations since the participants conducted the bird survey without the researchers' supervision. Nonetheless, supplemental guides were provided to aid the participants. Lastly, research conducted on the relationship of *P. montanus* and urbanization dealt with the abundance of species, while this study focused on the *P. montanus* bird count.

Conclusion. In urban environments in Iloilo Province and Bacolod City where there is habitat fragmentation and human disturbance, urban adapter species, particularly *P. montanus*, persist. In urban areas, as many as seventeen were counted, while in urban sprawl areas, eleven birds were the highest bird count observed. There is no specific vegetation type that usually serves as the species' food and nest sites in the observation areas. The species is also tolerant of the presence of humans and to moving vehicles. Mixed areas with artificial surfaces and city green are important sites for the species. Thus, the conservation of diverse patches with vegetation, serving as foraging sites, and buildings, for nest sites, are essential for *P. montanus* to establish populations in urban areas.

Recommendations. - Further research should be conducted on the relationship between specific plant groups and *P. montanus*. In the study, only vegetation type categories based on the physical characteristics of the plants were considered. The researchers also recommend studying a broader scope of the geographical area to better understand the relationship between *P. montanus* or other species to varying land characteristics, namely in urban, urban sprawl, and rural areas. Lastly, the researchers may consider the weather conditions during the survey. The research may be used to conduct studies in other birds, especially those endemic in the country. A longer duration should also be considered, especially when citizen science is involved and if there will be more than one observation.

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Effects of different colors of LED light as an artificial light source on the Growth of *Abelmoschus esculentus* var Smooth Green seedlings

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Abstract

Artificial lighting, including high-pressure sodium lamps, fluorescent lamps, and light-emitting diodes (LEDs), has been used to aid in the growth of many plants. However, there is still limited knowledge as to the effects of red, blue, and green LED lights on the growth of *Abelmoschus esculentus* var. smooth green. Thus, the effects of LEDs as an artificial light source on the plant height and root length of *Abelmoschus esculentus* var. smooth green have been examined in this study. Seedlings that were germinated for 14 days were tested in four separate setups: three treatments and one control. Results showed that at the end of the 14-day LED light treatment from 6:00 AM to 6:00 PM, the plant mortality percentage was 100% in all treatment groups. As a result of the limited amount of data gathered, the researchers were unable to conduct data analysis.

Introduction. - For many years, light sources have been deeply studied in the biological and horticultural sciences. Along with the large number of genes affected by the light under which plants are grown [1], photosynthetic phenomena heavily rely on these light sources. However, as there are regions wherein sunlight, the natural light source, is insufficient for optimal growth, total plant growth and yield have been affected [1,2]. In order to resolve these issues, artificial light sources such as high-pressure sodium lamps, fluorescent lamps, and light-emitting diodes (LEDs) have been developed and studied.

While a number of artificial light sources have been developed, research by Hamamoto and Yamazaki (2009)[3], Lu *et al.* (2012)[4], Darko *et al.* (2014)[5], and Degni *et al.* (2019)[6] claimed that LEDs provide more benefits compared to the other artificial light sources due to their high energy efficiency, long lifetime, cool emitting surface, low power consumption, and high photosynthetic active radiation (PAR). A portion of the light spectrum called high photosynthetic active radiation (PAR), which has wavelengths between 400 and 700 nm, is used by plants to undertake photosynthesis. The control over spectral composition and light intensity to match plant photoreceptors also allows the improvement and increase in growth, morphology, and other physiological processes of various plant species, including lettuce, potato, pepper, radish, green vegetables, and some other plants [1]. Moreover, according to Darko *et al.* [5], LED technology has been predicted to replace fluorescent and high-intensity discharge (HID) lamps in horticultural systems and to modify controlled growth environments for plants. These benefits brought about by LED artificial light sources led to the development of numerous research as to its effects on various plant species, as mentioned above.

LEDs as artificial light sources have been studied for over two decades. In a study by Bula *et al.* [7], lettuce (*Lactuca sativa* L. 'Grand Rapids') plants were maintained under the LED irradiation system at a total PPF of 325 $\mu mol \cdot s^{-1} \cdot m^{-2}$ for 21 days in order to test the effects of using LED as a radiation source for plants and compare them to that of the cool-white fluorescent lamps, which were more widely used at that time. The changes in plant growth responses, phase transitions, and pigment accumulation of *Brassica juncea* (vegetable mustard), *Lactuca sativa* (lettuce), *Ocimum gratissimum* (clove basil), *Coleus blumei*, and *Tagetes patula* (French marigold) have also been observed in different light environments composed of red and blue LED lights with the peak wavelengths of 460, 635, and 660 nm [8]. Moreover, *Lycopersicum esculentum* L. cv. MomotaroNatsumi (tomatoes) , *Brassica oleracea* L. cv Winterborn (kale plants), *Allium cepa* L. (onions), *Spinacia oleracea* (spinaches), *Capsicum annuum* L. (sweet peppers) , *Brassica campestris* L. (Chinese cabbages) and *Cucumis sativus* L. (cucumbers) have also been studied in red, blue and green LED sources of various combinations and wavelengths as the changes in their physiology such as the reduction of nitrate content, higher chlorophyll content and promoted petiole elongation, increased in leaf area, fresh and dry weight and more were recorded and analyzed [9-14,4]. Different LEDs have different colors, but green, red, and blue are commonly studied. Furthermore, LED lights designated at 3 and 5 watts are commonly used in simulated growing environments for crops these days [15]. The previous research [4,5,1] has established knowledge about the effects of these lights on numerous species of plants—ranging from fruits, vegetables, and even

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flowers—and has proved that each kind of light may have varying effects on the characteristics of the species and that there is no universal formula for it.

Crop failures, natural disasters, insect pests, and diseases, as well as out-of-season supplies, have all contributed to a reduction in vegetable production as these are some of the major constraints to *Abelmoschus esculentus* quality and quantity [16,17]. Despite the knowledge on the effects of LED as an artificial light source to various plants such as strawberry [18], lettuce [19], tomato [4], there is still limited knowledge as to the effects of red, blue, and green LED lights on *Abelmoschus esculentus*, or more commonly known as okra, of the smooth green variety. According to Degni *et al.* [6] and Roy *et al.* [20], okra is a mineral-rich vegetable with anti-diabetic and therapeutic characteristics that is widely cultivated around the world in tropical, subtropical and warm temperature regions. Furthermore, it can tolerate a wide range of soil types, which is especially beneficial for countries with varying geological characteristics such as the Philippines. Okra seeds, which are a source of oil and protein, and okra pods, which are a significant source of dietary fiber, also offer diverse medical benefits [20]. Furthermore, as the plant maturity of okra only takes around 60-180 days after sowing, its importance is heightened in the food production industry. In addition to this, according to the Department of Agriculture, Philippine okra production will soon reach the Korean market as the Philippines begins exporting them for the 2021-2022 season after meeting both countries' agreed-upon conditions. Fresh okra had also already been exported to Japan prior to Korea exportation, which further proves its high economic potential as one of the countries' main exports.

In a study by Degni *et al.* [6], each light treatment was modified to provide a specified amount of light intensity to the okra samples, ranging from 455 nm to 635 nm. There are some existing research; however, the parameters that have been measured focus on germination rate and time [6] and reproductive responses such as position and number of flowers [3]. Thus, this study aims to determine the effects of using red, blue, and green LED lights as an artificial light source on the root length and plant height of *Abelmoschus esculentus* var. smooth green. Based on the findings of previous research [5,1,6], the researchers have come to hypothesize that the use of LED as an artificial light source shall increase the plant height and root height of the *Abelmoschus esculentus* var. Smooth green plants are grown under it. This study would aid in developing better *Abelmoschus esculentus* cultivation methods using artificial light sources in order to supply the required demand in different countries such as Brazil, India, Thailand, and the Philippines, where *Abelmoschus esculentus* is popular and also widely cultivated [21]. It could also aid in actualizing the economic potential of *Abelmoschus esculentus* as one of the Philippines' major exports especially to countries such as Korea and Japan. Moreover, local horticulturists may also be guided by this study into developing LED light treatment setups so that a better quality of okra plants may be produced.

This study aimed to measure the plant growth of the *Abelmoschus esculentus* var. smooth green (okra) plants under red, blue and green light-emitting diodes (LED) as the light source. It specifically aimed to:

(i) To measure the plant heights of the *Abelmoschus esculentus* var. smooth green plants in four different setups (plants under the white LED bulb are in one control group, while plants under green, blue, and red LED bulbs are considered as treatment group) after 14 days,

(ii) To measure the root lengths of the *Abelmoschus esculentus* var. smooth green plants in four different setups (plants under the white LED bulb are in one control group, while plants under green, blue, and red LED bulbs are considered as treatment group) after 14 days; and

(iii) To compare the plant height and root length of the *Abelmoschus esculentus* var. smooth green plants in four different setups (plants under the white LED bulb are in one control group, while plants under green, blue, and red LED bulbs are considered as treatment group).

Methods. - A total of 200 seeds were sowed throughout the 14-day germination period. Using random sampling, 60 samples were chosen from the total number of plants germinated. Three trials were conducted, each with fifteen repetitions of one control group and three treatment groups (blue, red, and green). Three set-ups were simultaneously conducted in Barangay Sto. Nino Sur, Arevalo, Iloilo City, Iloilo , Barangay Barangay Sohoton, Barotac Nuevo, Iloilo and Barangay Union, Nabas, Aklan using the same soil series. The samples were then monitored and watered regularly. For 14 days, the plants were under the control and treatment groups. After that, measurements of plant height and root length should be obtained. However, because the data was insufficient, no data analysis was performed.

Germination of Seeds. The *Abelmoschus esculentus* var. smooth green (okra) seeds from East-West Seed were used in this experiment. Each seed was sown in each of the cells of the two 100-cell germination trays, for a total of 200 seeds subject to germination. Then, the germination trays were placed in an area with little to no shade, such that the seeds could receive as much and as even light as possible. The seeds were monitored for 14 days and were watered with 25 mL daily.

Experimental Setup. Each member prepared a closed room to accommodate one trial of each treatment group and one trial of the control group. Then, four wooden tables of dimensions 0.5m x 1.0m x 1.5m were prepared, with a black cloth wrapped around the four posts on the edge. There was also a wooden bar running across the table along its horizontal, where a 5W LED light bulb that has a 25 cm vertical distance from the top of the pots, was hung from [4]. All of the bulbs were acquired from the same store. After the initial germination period of 14 days, the fishbowl randomization method was used to randomize the choosing of seedling samples to be transplanted. All setups used garden soil to fill each pot with a diameter of 9 cm and a height of 8 cm, where each seedling was transferred to. To avoid biases on the possible outcome of the experiment, the lottery or fishbowl randomization method was used in dividing the samples into control and treatment groups. There was a total of 1 control group and 3 treatment groups.

Measurements and Parameters. The parameters were measured after 14 days. The plant height was measured from the base of the root to the longest leaf tip using a vernier caliper in millimeters adapted from Preetha & Stanley [22]. For the root length, the seedlings were carefully lifted out of the tray to avoid damaging the roots. It was measured from the base to the end of the longest root using a vernier caliper in millimeters adapted from Shahid *et al.* [23].

Data Analysis. In testing the significance of the germination and seedling emergence parameters, the One-Way Analysis of Variance (One-Way ANOVA) and Fisher's Least Significant Difference (LSD) method shall be used to create confidence intervals between factor level means, with a level of significance of 0.05. In case of plant mortality during the experiment, the Tukey's Range test may also be used for the differences between the treatment means. Lastly, the software to be used for the above-mentioned procedures shall be Microsoft Excel (2016 Version).

Safety Procedure. Safety precautions were observed while conducting the study. Disorganized electrical wirings may cause electrocution, thus proper installment and monitoring of electrical materials were observed. High-energy blue light from the LED bulbs may also cause damage to the eyes, thus the researchers wore protective glasses and limited their exposure to the light. During the transplanting of seedlings, pathogenic bacteria in soil may cause infections, thus wearing protective gloves was observed. Lastly, each sharp edge of the experimental table was covered with foam to minimize potential risk for the researchers.

Results and Discussion. - This study aimed to determine the effects of different colors of LED light (red, blue and green) as an artificial light source on the plant growth of *Abelmoschus esculentus* var. smooth green seedlings. The root lengths and plant heights under the three treatment groups and one control group were collected after 14 days. However, after the collection of data, the researchers were not able to perform the data analysis procedures as the number of surviving sample populations was insufficient due to the 100% mortality rate in all plants under the treatment groups.

For each of the three trials of the three treatment groups, none of the 15 plants have survived. Thus, the mortality percentage of the *Abelmoschus esculentus* under the red, blue, and green LED light is 100%. Under the control treatment, there is only a mortality percentage of 53.33% as there had only been a total of 24 *Abelmoschus esculentus* from the three control setups that have survived. Due to the limited number of surviving sample populations from the control group, the data has been insufficient, and thus researchers have been unable to conduct the data analysis methods. The measurements of plant heights and root lengths recorded on plants grown in the control set-up are shown in the tables below (Tables 1-3).

Table 1. This table shows the measurements of plant height and root length recorded by Member 1 (Arsenal) on the plants grown in the control setup.

Member 1	
Plant Height (mm)	Root Length (mm)
166	38
164	24
157	11

Table 2. This table shows the measurements of plant height and root length recorded by Member 2 (Belicena) on the plants grown in the control setup.

Member 2	
Plant Height (mm)	Root Length (mm)
156	41
131	17
155	60
140	54
166	61
167	34
178	65
43	86
132	46
20	94

Table 3. This table shows the measurements of plant height and root length recorded by Member 3 (Gubaton) on the plants grown in the control setup.

Member 3	
Plant Height (mm)	Root Length (mm)
150	80
156	63
155	100
157	37
162	246
143	45
120	45
140	187
162	147
144	96
131	52

Limitations. As shown in figure 1, in all setups, the mortality of *Abelmoschus esculentus* plants in the treatment groups rises over time. The researchers have identified five possible factors which have affected the growth and eventual mortality of the *Abelmoschus esculentus* plants: light intensity, distance between the plant and LED bulb, daily weather conditions and temperature, amount of water, and lastly limitations in equipment. First, it is possible that the light intensity of the LED bulbs has been insufficient to support the growth of all 15 *Abelmoschus esculentus* plants in one setup. In a study by Liu *et al.* [24], 24 units of 3W LED bulbs had been used in one of the setups while on the other hand, in a study conducted by Sabzalian *et al.* [25], 1.0 W LED bulbs had been used. Each setup had been placed in each of the four growth cabinets, and each cabinet supported 120 of these 1.0W LED Lights. In another study by Lu et. al. [4], each unit of the LED bulb used had the wattage 18W. According to the above studies by Liu *et al.* [24], Lu *et al.* [4], and Sabzalian *et al.* [25], LED bulbs with different wattages were utilized in a set-up; however, according to a study conducted by Abeena *et al.* [15], 3 watts and 5 watts of LED light have also been commonly used in growing indoor plants or under simulated environments. Thus, this study utilized a 5-watt LED bulb per set-up. Since the distance between the bulb and the top of the pot had been adapted from the study by Lu et. al [4], it could be that the light intensity received by each plant had been insufficient as the higher wattage of the LED bulb, the higher the light intensity it produces. On the other hand, it is also possible that the distance between the light bulb and the plant had a major effect on the growth of the plant. As mentioned above, the distance between the bulb and the top of the pot of 25 cm had been adapted from the study by Lu et. al [4]. However, as the plant grows, its height also increases – which means that the plant had been constantly growing closer to the LED bulb, and that the closing distance might have caused the *Abelmoschus esculentus* samples to receive too much heat from the bulb then start to wither at around Days 4 to 8.

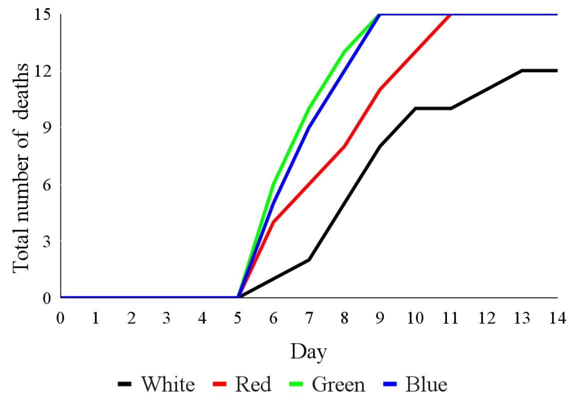

Figure 1(a). This graph shows the number of cumulative plant mortalities as recorded daily of Member 1 (Arsenal).

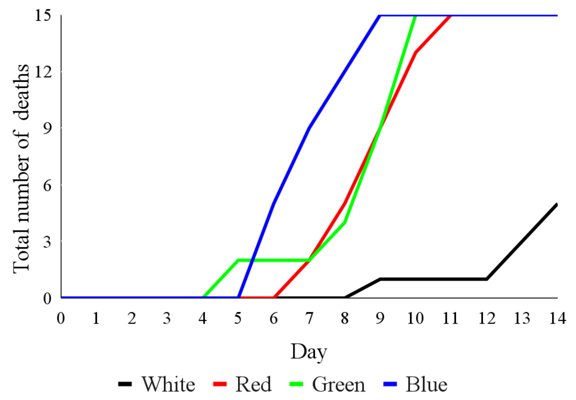

Figure 1(b). This graph shows the number of cumulative plant mortalities as recorded daily of Member 2 (Belicena).

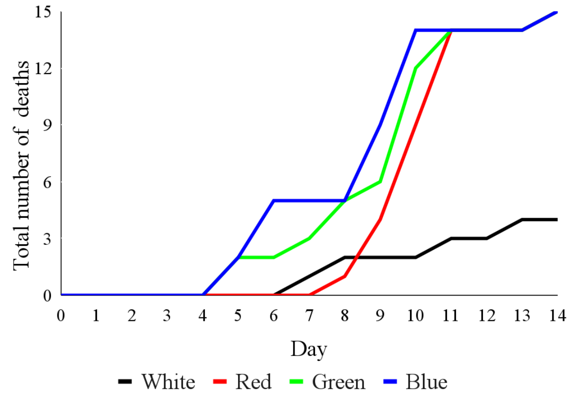

Figure 1(c). This graph shows the number of cumulative plant mortalities as recorded daily of Member 3 (Gubaton).

This is evidenced by the graphs above which shows the growth trend of the *Abelmoschus esculentus* in all setups. It could be observed that the mortalities had only started from around Day 4 to Day 8, and that by Day 14, all *Abelmoschus esculentus* under the treatment setups had already died. According to a study by Wang and Folta (2013), far-red light, which is the dominant wavelength, is what causes the most noticeable changes. Additionally, there are differences in the ways that the green, red, and blue wavebands affect the plant's growth and development. The wavelengths that most strongly stimulate photosynthesis are at the red end of the spectrum (600–700 nm), followed by the blue region (400–500 nm), and finally the green region (500-600 nm). As can be observed from the graphs, plants in the treatment setup with green LED died earlier than those in the setup with red and blue LED. Plants with withered leaves have been constantly monitored since the moment the stem breaks or falls, the plant is deemed to be dead. The dead plant's condition supports it as it wilts in the days that follow after it was declared dead until the 14-day period. The pale leaves and withering of the plants, which have been noticeable on the plants from the treatment groups, are indicators of overwatering and/or overexposure to light.

In the study by Liu *et al.* [24], the growth temperature had been set to 25±2 °C, which is similar to the outside average daily temperature. However, in another study by Degni *et al.* [6], the temperature had only been recorded daily but not controlled. Due to the difference in the researchers' setup locations, there might have been variations in the daily weather conditions which may have affected the growth of the *Abelmoschus esculentus* during the germination phase of the study.

Another factor that had also been considered is the amount of water that had been used for the plants. As adapted from the study by Lamont 1999[26], each plant has been watered with 25mL of water daily. However, after observing the soil by the end of 14 days, most of the pots with dead plants had wet to moist soil. Since *Abelmoschus esculentus* is a heat-loving crop, it is possible that the amount of water had been more than what is needed in the setup. Thus, the mortality of the plants might have also been affected.

Moreover, in studies conducted by Liu et al. [24] and Degni et al. [6], each light treatment has been adjusted to give a specific amount of light intensity of around 455 nm to 635 nm. The study included five treatment groups: blue, green, red, blue and green, and red and green. However, due to the limitations in the availability of equipment, the researchers have been unable to measure the light intensity received by the plants. This may have affected their growth, and have thus been one of the factors that led to such results.

Conclusion. - Based on the obtained results, it may be concluded that LED light as an artificial light source for *Abelmoschus esculentus* var. smooth green resulted in a 100% mortality percentage on all the treatment setups in this study.

Recommendations. - It is recommended to either use an LED light bulb with a higher wattage or use multiple light bulbs in each setup to increase the light intensity received by the plants. LED strips may also be used in place of LED bulbs as the light produced by the source is dispersed more evenly and consistently among the plants. Furthermore, it is recommended to measure and to determine the specifications of the LED bulbs to be used, such as light intensity, spectrum, and the area covered by the light, since these are some of the factors that may determine the output of the LED light sources. It is also recommended to test the effects of mixed colors and wavelengths, as different plants require specific conditions to obtain optimum growth. Aside from the LED parameters that may have influenced okra growth, other aspects to be considered are temperature and humidity of the setup environment, and the amount of water received by the plants could also be reduced. It is also recommended that a control set-up be in place under normal conditions.

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