Evaluation on floral visitors of *Zingiber spectabile* (Zingiberaceae) at Gua Ikan, Kelantan, Peninsular Malaysia

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Evaluation on floral visitors of *Zingiber spectabile* (Zingiberaceae) at Gua Ikan, Kelantan, Peninsular Malaysia

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Abstract. Insects are the well-known pollinators of angiosperm plants. However, the discovery of specific insect pollinators of a specific plant is still lacking in many angiosperms. Family Zingiberaceae which is also known as a ginger family, is one of the least explored angiosperms in the aspect of plant-pollinator interaction. Hence, this study was conducted to understand the interaction between *Zingiber spectabile* and pollinators. The aims of the study are i) to determine the floral blooming period of *Z. spectabile*; ii) to identify floral visitor of *Z. spectabile*; iii) to identify the insect pollinators of *Z. spectabile*. The study was conducted in the limestone forest of Gua Ikan (Dabong, Kelantan) in September 2020. Direct observation method was used to achieve the above-mentioned objectives. Observation was performed from 0700 hours to 2000 hours. A floral visitor was counted as pollinator when the insect touches the sexual organs of the flower. This study reveals that flower of *Z. spectabile* have a lifespan of less than a day. Flower opening (anthesis) starts at 1000 hours while flower closure time starts at 2000 hours. An inflorescence of *Z. spectabile* produce one to three flowers per day. Insect order Coleoptera, Diptera, Hemiptera, Hymenoptera and Lepidoptera are the common floral visitors of the *Z. spectabile*. However, among the floral visitors, order Diptera, Hemiptera and Lepidoptera were found to play the role of pollinator for *Z. spectabile*. This study reveals the fundamental information about pollinators of *Z. spectabile*. Further detailed study is recommended to reveal the effects of floral scent in attracting the pollinators as further evaluation of Zingiberaceae-pollinator interaction.

1. Introduction

Plant-pollinator interaction is a mutualistic relationship between plants and animals which benefit both organisms [1]. There is presence of general and plant specific pollinator depending on the plant species [2]. Previous studies have proven that continual survival of plants especially angiosperms was ensured by the plant-pollinator interaction [3]. Family Zingiberaceae is one of the angiosperm family that less

studied for plant-pollinator interaction. In Peninsular Malaysia, there are 160 species of gingers have been recorded [4-9]. However, specific pollinators for species of Zingiberaceae is still unknown for many species. Studies also has proven that floral anthesis is correlated with the presence of floral visitors [10]. Lacking of the information in floral anthesis in Zingiberaceae also caused less understanding of Zingiberaceae-pollinator interaction.

The Zingiberaceae-pollinator interaction has begun to explored in few parts of the world such as Borneo (Malaysia) [11,12], India [10], Indonesia [13] and Thailand [14]. Floral visitors and pollinators vary between the species [11]. Previous studies show that insects and birds are the major floral visitor and pollinators of Zingiberaceae. Exploration on more ginger species will reveal more specific information regarding Zingiberaceae-pollinator interaction. Hence, this study is focused on one of the well-known ginger species in Malaysia, the Beehive ginger, *Zingiber spectabile.*

Flower of *Z. spectabile* is hermaphroditic (bisexual) where each flower contains the male (anther) and female (stigma) organs [4]. The flower resembles an Orchids. Dull yellow to reddish orange 'beehive-like' inflorescence that contain purple with yellow spots flower is the key identification of this species from other gingers. Scientific information on flower blooming and floral visitors for *Z. spectabile* is still lacking especially in Malaysia. Therefore, this study aims i) to determine the floral blooming period of *Z. spectabile*; ii) to identify floral visitor of *Z. spectabile*; iii) to identify the insect pollinators of *Z. spectabile*. The information from this study will provide more understanding on the Zingiberaceae-pollinator interaction that contributing in continual survival of Zingiberaceae in the wild.

2. Methodology

2.1. Study Sample

This study was focused on *Z. spectabile* at limestone forest of Gua Ikan at Dabong, Kelantan. This site located at 5°21'16.10"N 102°1'36.26"E with an elevation of 53.3 m above sea level. The study was conducted in September 2020. There were two colonies of *Z. spectabile* recognised at the limestone forest with a distance of approximately 50 m between the colonies. This species identified with the presence of inflorescence from separate shoot than the rhizome, long peduncle, pouch-like yellow inflorescence bracts with incurved margin and purple flower with many small dots [4]. The study was conducted for both identified colony of *Z. spectabile*. One inflorescence was selected from each colony and observed for three days to achieve objectives of this study.

2.2 Floral Anthesis Observation

Floral anthesis observation was done using direct observation method. Incurved margin of inflorescence bracts that contain flower buds were marked with permanent black marker pen (ZEBRA, Japan) prior to the study. The marked inflorescence was observed from 0700 hours to 2000 hours to record the beginning and end of anthesis (flowering period). The stage of flower was recorded every one hour.

2.3 Floral Visitor Observation

The floral visitors of *Z. spectabile* was observed from 0700 hours to 2000 hours through direct observation method. Observation was done with a distance of 1.5 m from the flower to reduce disturbance around the flower and bias in the data. The flower visited with a short distance of 30 cm for every one hour to ensure movement of any smaller organism around the flower. An organism is counted as flower visitor when the visitor touched any parts of the flower. The floral visitors were identified to order level [15]. The visitor was classified as pollinator when the visitor touched the sexual organs (anther and stigma) of the flower [11].

3. Result and Discussion

Observation on the *Z. spectabile* flower reveals that an inflorescence could produce one to three flowers per day (Table 1). An inflorescence from Colony 1 and Colony 2 produced a total of five and seven flowers respectively for three days. Floral anthesis begins around 1000 hours (Table 2). A fully bloomed flower could be observed around 1100 hours while the flower starts to close at 2000 hours. According to [13], *Z. officinale* starts to bloom in the afternoon (around 1315 hours) at Bogor, Indonesia. The anthesis begins earlier for *Z. spectabile* compared to *Z. officinale*. Bloomed flower at marked bract was found to be withered in the next day morning. This scenario proved that lifespan of *Z. spectabile*'s flower is less than a day (24 hours). The lifespan is similar to other ginger species, for instance, 12-18 hours for *Z. officinale* [13] and one day for *Etlingera elatior* [10]. The precise wilt time of flower was unable to be confirmed in this study. Further 24 hours evaluation on the flower in the future could reveal the missing information in this study.

Table 1. Summary of flower observed in *Zingiber spectabile* colonies at Gua Ikan, Dabong, Kelantan.

	Colony 1	Colony 2
Day 1	1	2
Day 2	2	2
Day 3	2	3
Total flowers	5	7

Table 2. Beginning and end of anthesis for *Zingiber spectabile* at Gua Ikan, Dabong, Kelantan.

Time (hrs)	**Flower stage**
0700	Fully closed bud
0800	
0900	
1000	Opening of bud
1100	Fully bloomed flower
1200	
1300	
1400	
1500	
1600	
1700	
1800	
1900	
2000	Flower start to close

Insect order Coleoptera, Diptera, Hemiptera, Hymenoptera and Lepidoptera are the common floral visitors of the *Z. spectabile* (Table 3). No birds were recorded in this study. However, among the floral visitors, Diptera, Hemiptera and Lepidoptera were found to play the role of pollinator for *Z. spectabile* where only these orders touched the sex organ of the flower. The observation is contrast to the pollinator of other studied ginger species. Birds and bees are the recorded pollinators for gingers [10,11,12,14]. The pollinator of *Z. spectabile* also varies compared to other *Zingiber* spp. Order Hymenoptera (bees) are documented to pollinate *Z. longipedunculatum* at Borneo [11] while no pollinator recorded for Z. *officinale* at Indonesia [13]. The comparison of pollinator between the *Zingiber* spp. proves that pollinator varies between the species.

The most frequent floral visit (peak hour) for a total of six days of observation is at 1200 to 1259 hours and 1600 to 1659 hours with 16 and 15 visits of insects respectively (Figure 1). This situation

occurs after the flower fully opened and ready to be consumed by the insects and also in the evening during the active time of insects. Hemiptera noted to explore the flower bud even before opening of the bud. Hemiptera, Diptera, Lepidoptera, and Hymenoptera showed higher number of visits during the six days of observation. Lepidoptera observed to land on the lip and insert the proboscis into the corolla tube to collect nectar as similar been observed in *E. elatior* and other plant species [10, 16]. Hemiptera found to suck nectar from various part of the flower while Diptera collect pollen from anther by inserting body under the elongated anther crest. Less studies have discussed Diptera and Hemiptera as pollinators. Diptera have been recorded to pollinate more than 100 cultivated plant species [17] meanwhile Hemiptera recorded to pollinate *Macaranga tanarius* at Japan [18].

Table 3. Floral visitor and pollinator of *Zingiber spectabile* at Gua Ikan, Dabong, Kelantan.

Common Name	Insect Order	Floral Visitor	Pollinator
Beetle	Coleoptera	/	
Fly	Diptera	/	/
True bug	Hemiptera	/	/
Ant	Hymenoptera	/	
Skipper	Lepidoptera	/	/

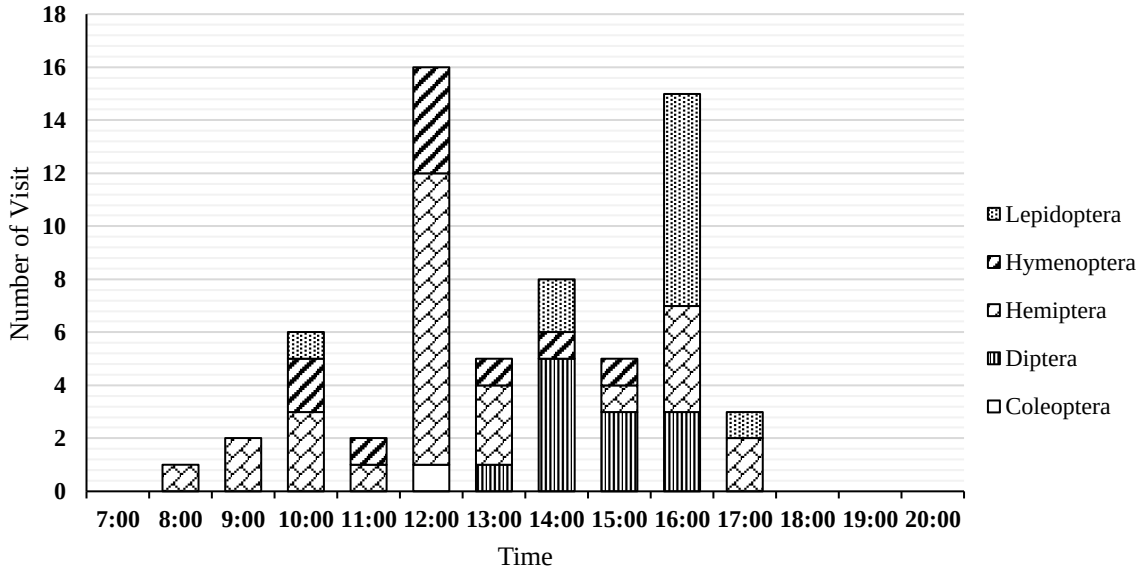

Figure 1. Number of visits for six days according time by floral visitor of *Zingiber spectabile* at Gua Ikan, Dabong, Kelantan.

4. Conclusion

Examination on floral blooming behavior and floral visitor of *Z. spectabile* reveals few fundamental information about the species. Flower of *Z. spectabile* have a lifespan of less than a day. Insect order Coleoptera, Diptera, Hemiptera, Hymenoptera and Lepidoptera are the common floral visitors of the *Z. spectabile*. Diptera, Hemiptera and Lepidoptera were found to play the role of pollinator for *Z. spectabile*. This study may the first scientific report of floral visitors and pollinators of *Z. spectabile*. Further detailed study is recommended to reveal the effects of floral scent in attracting the pollinators as further evaluation of Zingiberaceae-pollinator interaction.

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