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## Color Attraction of the Crepuscular Hawk Moth (*Nephele hespera*) (Lepidoptera: Sphingidae)

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**Abstract** The crepuscular hawk moth (*Nephele hespera*) belongs to the family Sphingidae, subfamily Macroglossinae. Hawk moths is known as a pollinator in nature. It is a stenophagous organism which the larva feed only young karunda leaves (*Carissa carandas* L.). The objectives of this study is to investigate the color and structure of karunda flowers (n=30), crepuscular hawk moths' proboscis, and the color of artificial flowers attraction and amount of 25% honey solution uptake of the hawk moths. The results showed that karunda's flowers were white color with a tubular shaped flowers (averaged 19.20±1.16 mm long). The proboscis length of the male and female hawk moth was 46.03±2.33 and 44.03 ± 2.08 mm, respectively. The uptake of honey solution from violet, yellow, pink, white and chartreuse green of artificial flowers was 0.51±0.04, 0.53±0.08, 0.55±0.09, 0.60±0.15 and 0.64±0.12 ml/adult, respectively. The frequency visit of adult hawk moths to various colors of artificial flowers was presented in order from high to low was as follows: chartreuse green, white, yellow, pink and violet.

**Keywords:** *Nephele hespera*, *Carissa carandas* L, Color attraction, proboscis

### Introduction

Crepuscular hawk moths are significant pollinators in tropical regions (Johnson and Martins, 2013) and the flower scent is an important factor which served as a mediatory tool during pollen is transferred between flowers (Kessler *et al.*, 2015) These moths have the long and flexible proboscis with olfactory receptor at the end of their proboscis (Bauder *et al.*, 2010) for sucking the nectar. The spur that is longer could perfectly satisfy the demand of insects and additionally increase the opportunities of pollination in another ways (Suetsugu *et al.*, 2015).

The stimuli for host selection of foraging crepuscular hawk moths was stimulus of flower scent including their behaviors which determine their

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selection. Flowers'scent is the most effective stimuli of flowers for attracting the insects. (Riffell and Alarcon, 2013). Ipomopsis is a flowering plants changing it color from red to pink-white. The crepuscular hawk moth consume it nectar as a pollination. The appropriate flower color for these moths is light color (Paige and Whitham, 1985). Flowers emitted varieties sense and nectar to attract pollinators. Moreover, shape of flowers exhibit the coevolution between the moths and the flowers. The moth like the deep spurs and narrow petals flowers. The scents and shape of flowers play an important role as attracting the moth. Apart from these mentioned, the patterns and shapes of their petals should be taken into account (Gaskett *et al.*, 2012).

The purposes of this research is to deliberately study about the structure of karanda flower, colors which is attracting the crepuscular hawk moth and the amounts of honey solution consuming by the moth. This insect is one of the main pollinator in the ecosystems. There are few studies on this species of hawk moth.

## **Materials and methods**

### ***The structure of the *Carissa carandas* L***

*C. carandas* were collected and measured the flower sizes.

### ***Proboscis of *N. hespera****

Take 30 samples of males and females to measure the length of proboscis.

### ***Study on the color attraction of the crepuscular hawk moth and Amount of nectar uptake by the adults crepuscular hawk moth***

After the hawk moth hatched out of the pupa, it was transferred to a rearing cage (40x60x40 cm). Inside the cage, 5 artificial flowers: white, pink, violet, yellow and chartreuse green were embedded with equal distance on the circumference(6 cm diameter) stage. The flower has 4 cm corolla tube filled up with 1.1 ml of 25% honey solution. The flower color that the moth selected and the amount of honey solution uptake was recorded.

## Results and Discussion

### *The structure of the Karanda flower*

**Flower:** The inflorescence is a bunch. The cyme sub-inflorescence is a bouquet of flowers with 3 white color flowers. The lower petals are attached to the tube. The petals at the end of the flowers are divided into 5 petals. The petals are pink with the length of 16.00-21.00 mm (average  $19.20 \pm 1.16$  mm), which is a half time the proboscis length of the hawk moth. The petals of each petal have the broadest margin of 4.50-7.00 mm ( $5.67 \pm 0.59$ ) and petals 8.50-12.00 mm (average  $10.57 \pm 1.03$ ). The pedicel is 2.50- 6.00 mm (average  $3.81 \pm 0.98$ ) (Table 1) (Figure 1). It is a complete flower with both male and female stamens in the same flower. And five stamens attached to the flower petals. The anthers filament is very short and one pistil is lower than the stamens. The stamen is 9.50-10.00 mm long. The *C. carandas* is considered to be the only host plant of the crepuscular hawk. It is evident that plants have evolved together with insects (Suetsugu *et al.*, 2015). *Vanda falcata* grows in the longer shape of flower stem to response to the insect's mouthpart and increase the chances of pollination. In addition, the smell of flowers is important to attract the population of butterflies. Orchid flowers in the evening release floral fragrance. (Taneda *et al.*, 2009), which induces uterine pollination. In addition to finding food of butterflies, they use color or stimuli such as the smell of flowers and learning behavior (Riffell and Alarcon, 2013). Only a few hawk moth are developed to suck in a long stem flower to obtain the nectar (Bauder *et al.*, 2010).

### *A proboscis of N. hespera*

The proboscis of male is slightly longer than the females. Male's proboscis length was 42-51 mm (average  $46.03 \pm 2.33$  mm) (Figure 2). 42-48 mm (average  $44.03 \pm 2.08$ ) female's proboscis (Figure 3). The adult of the *N. hespera* is a noctuidae with large eyes. The evolution of the selection of food plants by the study found that the *N. hespera* with a Proboscis length of 8 half the length of the petal of the *C. carandas*. The results of this study are consistent with research (Darwin, 1862; Johnson & Steiner, 1997; Alexandersson & Johnson, 2002; Johnson *et al.*, 2002; Borrell, 2005; Pauw *et al.*, 2009; Krenn, 2010). Hawk moths have evolved in adaptation to acquire food resources, such as nectar, flowers hidden in deep petal vesicles.

***The color attraction of the crepuscular hawk moth and amount of nectar uptake***

Color attraction to hawk moth and amount of nectar uptake by the adults crepuscular hawk moth from 5 artificial flowers: yellow, white, chartreuse green, pink and violet. in a rearing cage size 40x60x40 cm. It was found that the hawk moth sucked honey solution from artificial flowers during the night and early in the morning. From the observation, the hawk moth acquired the honey solution in two positions: one landing on the flowers and use its proboscis to take up the solution (Figure 4-5) and the other is hovering and fluttering, then extend its proboscis to get the honey solution.

Amount of nectar uptake by the *N. hespera*, The highest volume uptake was found from chartreuse green artificial flower  $0.64 \pm 0.12$  ml, flowered by white, pink, yellow and violet flowers  $0.6 \pm 0.15$ ,  $0.55 \pm 0.09$ ,  $0.53 \pm 0.08$  and  $0.51 \pm 0.05$  ml, respectively (Table 2). The similar results were illustrated in Figure 6, the most frequent visit of the karanda hawk moth to artificial flowers was chartreuse green. This indicated that color of flower effect on this hawk moth host selection. However, the smell of sweet nectar in flowers is an important stimulus to attract butterflies as well. In addition to finding food of *N. hespera*, both color and smell of flowers including learning behaviour are the choice decision of nectar uptake from the flowers (Riffell and Alarcon, 2013). During the night, the white or soft flower reflects well in the 400 to 800 nm spectrum, which attract to hawk moth more than the solid colors (Paige and Whitham, 1985).

**Table 1.** Floret sizes in mm of the karanda

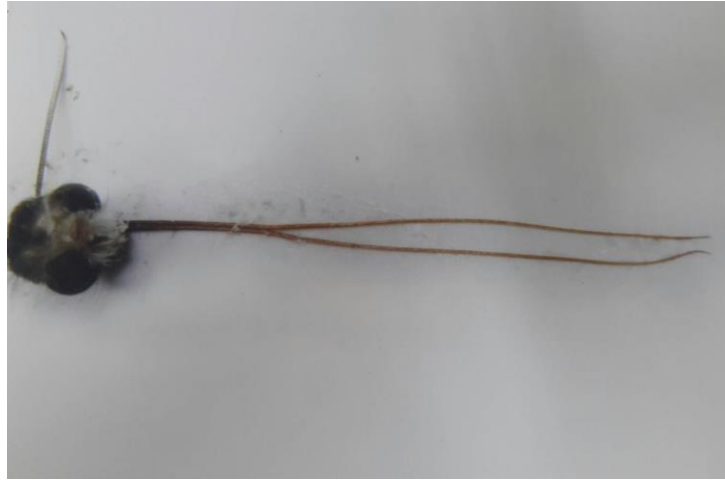
Pedicel length	Corolla tube length	Petal	
		Width	Length
3.81±0.98	19.20±1.16	5.67±0.59	10.57±1.03



**Figure 1.** Flowers of the karanda



**Figure 2.** A male proboscis of the crespuscular hawk moth ( $46.03 \pm 2.33$  mm long)



**Figure 3.** A proboscis length of adult female *N. hespera* ( $44.03 \pm 2.08$  mm long)



**Figure 4.** The hawk moth using its proboscis for honey solution uptake

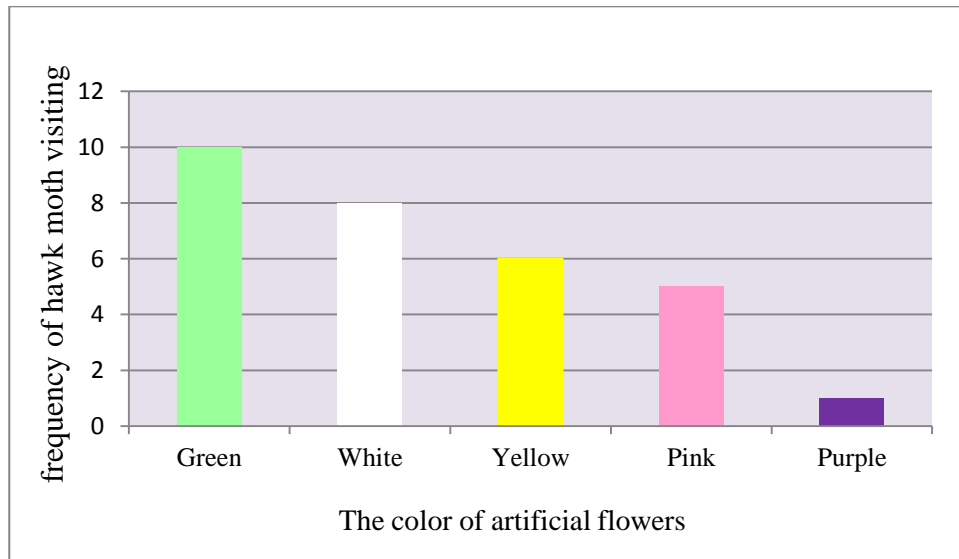


**Figure 5.** Landing position of crepuscular hawk moths

**Table 2.** Amount of nectar uptake by the crepuscular hawk moth

Color of artificial flowers	Amount of 25% honey solution uptake <sup>1</sup> (ml)	Range(ml)
Yellow	0.53±0.08c	0.5-0.7
White	0.60±0.15ab	0.5-0.9
green	0.64±0.12a	0.5-0.9
Pink	0.55±0.00bc	0.5-0.7
violet	0.51±0.00c	0.5-0.7
%C.V.	17.96	

<sup>1</sup>Means with the same letter are not significantly different from each other (P>0.05 ANOVA followed by LSD)



**Figure 6.** Frequency of hawk moth visiting associated with the color

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