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FLOWER SHAPE, SIZE AND COLOR PREFERENCES OF FOUR POLLINATORS (INSECTA: APIDAE) IN SELECTED AREAS OF DHAKA CITY

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ABSTRACT: The flower shape, size and color preferences of four bee species belonging to the family Apidae was observed. The observed species were *Apis cerana* Fabricius, *Apis dorsata* Fabricius, *Apis florea* Fabricius, and *Xylocopa aestuans* Linnaeus. The bees were observed and collected from two areas of Dhaka city- Curzon Hall and Ramna Park from February 2022 to December 2022. During the study period it was observed that the abundance of *A. florea* was the highest (about 35.18% of the total population) and *X. aestuans* was the least (about 10.26% of the total population). Preference over a particular size was an important attribute among pollinators. Flowers with mean diameter greater than 50 mm (*Dahlia* sp., *Couroupita guianensis*, *Tagetes* sp. *Calendula officinalis*, *Mesua ferrea*) were more visited by the pollinators. Flowers of different shapes were examined in the study and pollinators showed different preferences for different shaped flower. *A. cerana* mostly preferred rounded and rotate shaped flowers (*Dahlia* sp. 45% and *C. sulphureus* 41.16%). *A. florea* had a preference towards the star shaped flower (*L.indica*, 69.39%) followed by globe shaped flower (*Tagetes* sp., 50.70%). *A. dorsata* had a choice over trumpet shaped flower (*Tecoma stans*, 35.5%), followed by rounded shaped flower (*Dahlia sp.* 22%). *X. aestuans* had preferred orchid shaped flower the most (*Bauhinia* sp., 30.45%) followed by cruciate shaped flower (*M. ferrea*, 22.91%). Preference for any particular color was also examined in the study. Among them, *A. cerana* preferred the red color most (about 45% relative abundance in *Dahlia* sp.) followed by the color orange (about 41.16% relative abundance in *C. sulphureus*). *A. dorsata* preferred the yellow color the most (35.5% relative abundance in *T. stans*) followed by the color red (22% in *Dahlia* sp.). *A. florea* had a preference for color pink (69.39% in *L. indica* and 46.45% in *C. guianensis*) followed by the color orange (*Tagetes* sp., 51.61%). *X. aestuans* preferred the purple color most in the study (30.45% in *Bauhinia* sp.). The correlation between proboscis length of pollinators and different floral parameters of flowers were also investigated. The results showed that those parameters were not significantly correlated.

Key words**:** Pollinators, preferences, flower shape, size, color.

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INTRODUCTION

Pollinators show preferences over certain morphological cues of flowers that they prefer to pollinate. These preferences influence how often pollinators visit flowers and collect pollen and nectar. Because of this, most plant species create spectacular flowers and elaborate floral displays to draw pollinators (Brunet,2015). The diversity of flowering plant has also been greatly influenced by interactions with animal pollinators (Fenster *et al.*, 2004).

In order to discriminate between different flowers, pollinators use a number of morphological signals, such as flower size, form, color (Giurfa *et al.* 1995). These attributes are thought to be enticing to pollinators (Brunet, 2015). It is also well established that floral morphology influences both the number of pollinators which approach flowers and their visitation rates (Fenster *et al.* 2004). Among them, honey bees are thought to be one of the most effective pollinators. They belong to the genus *Apis* under the order Hymenoptera. In Bangladesh, the recorded honey bee species are- *Apis cerana*, *Apis dorsata*, *Apis florea* and *Apis mellifera* (Akter *et al.* 2019). Large carpenter bee is another efficient pollinator. This species belongs to the genus *Xylocopa* in the order Hymenoptera.

The present study has investigated on preference for floral shape, size and colors of different pollinator species and their association with their related flowering plants. Co-relation between different floral structures (e.g. corolla tube length, capitula diameter) and the proboscises of honey bees was attempted to establish. There is no published information available on the floral association of the pollinators in Dhaka city. Therefore, this study attempts to investigate some of the pollinator's preferences over different flowering plants.

MATERIAL AND METHODS

The research was conducted from February 2022 to December 2022. The study areas were Curzon Hall of University of Dhaka and Ramna park. The bees were observed and collected during day time usually between (8 a.m to 1 p.m). Cloudy and rainy days were avoided. Number of pollinators coming around these observation sites were counted visually and recorded with respect to each observation site and each species respectively. To observe the foraging behavior and their preferences, respective walks around the study areas had been undertaken. During study period the visit numbers and the duration of each visit was recorded. The maximum and minimum time of foraging on a flower was recorded using stop watch. To measure the floral parameters, fresh specimens were collected and taken to the laboratory for further measurements. Diameter of flower, diameter of capitula, corolla tube length, corolla tube diameter were

measured with the help of centimeter scale and digital caliper. Each of the measurements were recorded for calculation. The length of the honey bee proboscis was measured by capturing them during the study period. First, the honey bee was killed using aerosol. Then the head part was dissected and the proboscis was removed. The proboscis length was measured using a digital caliper from prementum to glossa. The whole length was regarded as proboscis length. The date of observation, study area, name of pollinators, name of plants, date and time of the observation were recorded during observation. The procedure described in (Akter *et al.* 2019) was used to identify pollinators. The plants described in the study were identified with the help of (Rahman, 2015). Camera was used to take photographs of pollinators and their related plants.

RESULTS AND DISCUSSION

In this study, three species of honey bees and one species of large carpenter bee have been examined to determine their preferences over different flowering plants. These species are: *A. cerana*, *A.dorsata*, *A.florea* of the genus *Apis* and *X.aestuans* of the genus *Xylocopa*.

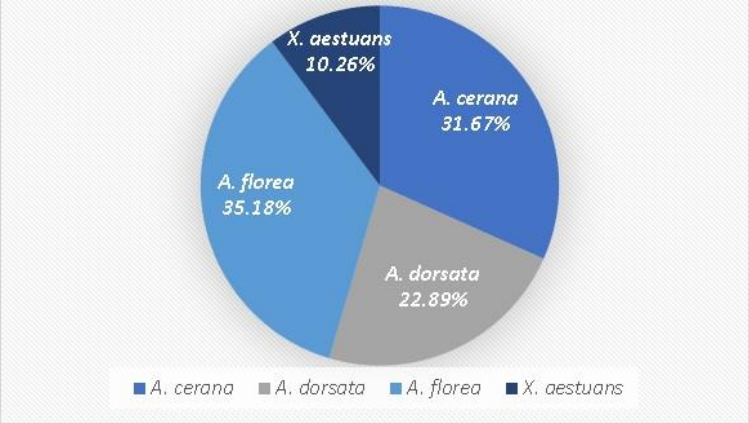

Fig. 1 Percentage of pollinators species throughout the study period.

Among the 28,165 pollinators observed in the study, honey bees were dominant. The dwarf honey bee, *A. florea* was found in greater numbers than the other pollinators species. *A. cerana*, slightly less than *A. florea* was second most abundant species. Among all the honey bee species *A.dorsata* had the relative abundance of 22.89%. The large carpenter bee. *X.aestuans* was the least abundant species that was found in the study. The relative abundance of this species was very poor compared to the other pollinators species. It covered only 10% of the total pollinators (Fig.1)

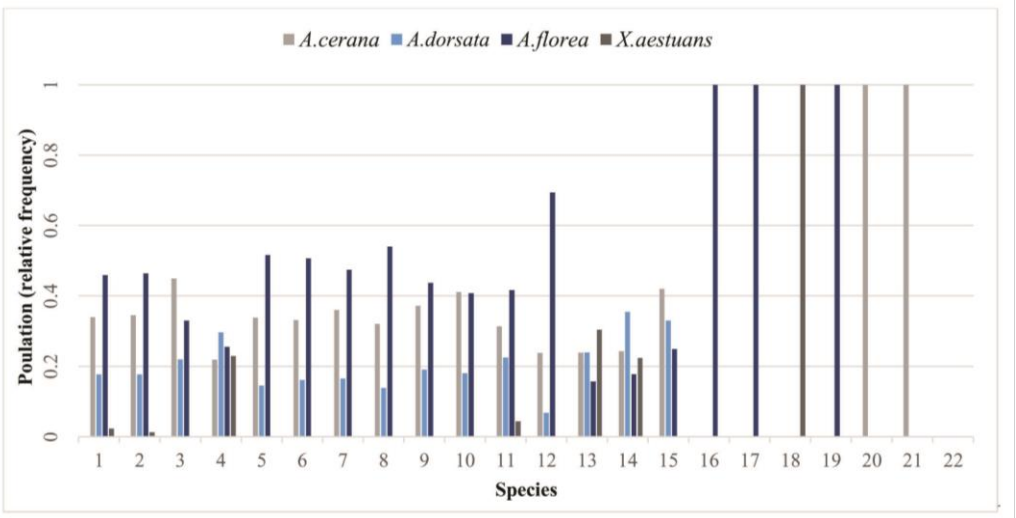

Fig. 2. Relative frequency (%) of total individuals of each species in each flower. Here, 1=*C.guianensis* (red), 2=*C.guianensis* (pink), 3=*Dahlia* sp. 4=*M.ferrea*, 5=*Tagetes* sp. (orange), 6= *Tagetes* sp.(yellow), 7=*C.officinalis* (yellow), 8=*C.officinalis* (orange), 9=*C.sulphureus* (yellow), 10=*C.sulphureus* (orange),11=*Q.indica*, 12=*L.indica*, 13=*Bauhinia* sp., 14=*T.stans*, 15=*G.globosa* , 16= *Acmella* sp.,17= *C.rutidosperma* , 18= *I.purpurea* , 19= *P.grandiflora* ,20= *Pentas* sp.,21= *S.splendens*.

From the relative abundance of pollinators in each flower (Fig.2), it is shown that, most of the flowers were visited by three honey bee species – *A.dorsata*, *A. florea* and *A. cerana*. Only 6 species of flowers were visited by *X. aestuans*. They are – *C. guianensis* (red & pink), *M. ferrea*, *Q. indica*, *Bauhinia* sp., *I. purpurea* and *T. stans* whereas, *I. purpurea* was solely visited by this pollinator. *A. florea* dominated most of the flowers in the study. *A. cerana* appeared to be the second most abundant pollinator after *A. florea*. Though, it was most abundant in two flowers – *Dahlia* sp. and *C. sulphureus* (orange). *A. dorsata*, which was also less abundant than the other honey bees appeared to be the most abundant in case of *M. ferrea* and *T.stans*. Among other flowers, relative abundance of *A. dorsata* remained less than 30%. *A. florea* had the smallest size among the pollinators and this acted as an advantage as they were able to forage flowers of different shapes and sizes. Being small, it appeared to be visiting the flowers for a longer time as well (Table 2). Among all the flowers studied, *M. ferrea* had more or less equal distribution of frequency where all the pollinators foraged.

Foraging preferences of pollinators: While foraging, pollinators showed preferences for different attributes of flowers. The flowers they foraged on, their shape and foraging time are presented in Table 1. From Table 2, it appears that, average time for foraging varied from flowers to flowers in every pollinators. In case of *A. cerana*, *A. dorsata* and *A. florea* the maximum amount of time was spent in red colored rounded shaped *Dahlia* sp. The time spent foraging was

highest in *A. florea* (average 155s) and lowest in *A. dorsata* (average 47.5s).In case of *X. aestuans*, it spent maximum foraging time in white colored cruciate shaped *M. ferrea* followed by *C. guianensis* and *T. stans*.

Foraging preference of A. dorsata: A. dorsata preferred flowers that had mean diameter larger than 50mm for example: *Dahlia* sp. *C.guianensis*, *M.ferrea* also flowers mean diameter less than 50 mm, for example: *C. sulphureus* and avoided flowers that were too small and which were foraged by *A. florea* (*P. grandiflora*, *Acmella* sp., *C. rutidosperma*) (Table 1).This finding is supported by Ali *et al.* (2011) who also reported that *A. dorsata* do not visit the flowers which are most preferred by *A. florea*. Since, larger flowers will be rich in calory in comparison to small flowers, it seemed that *A. dorsata* preferred flowers with high calory. Similar findings were also found in Navarro and Medel (2009), in their studies showed that the amount of nectar production is positively correlated with flower size. *A. dorsata* had a choice over trumpet shaped flower (*T. stans*) followed by rounded shaped flower (*Dahlia* sp.). It preferred yellow color the most followed by the color red.

Foraging preference of A.cerana: From the recorded choice of *A. cerana*, it was found that, this species foraged on flowers with a mean diameter greater than 50 mm and a mean diameter less than 50 mm except for the extremely small flower – *Acmella* sp. and *C. rutidosperma*. Though, many researches indicate the preference for larger size of flower, some agree that opposite could also be found. For instance, Stang, Klinkhamer, and van der Meijden (2006) did not discover a correlation between floral display space and the number of pollinator species in a Spanish Mediterranean community. Stanton *et al.* (1987) also showed no correlation between flower size and behavior of small bee in pollination in *R. raphanistrum* (Brassicaceae).

In case of shape, *A.cerana* mostly preferred rounded and rotate shaped flowers (e.g. *Dahlia* sp. and *C. sulphureues*). It also foraged on other different shaped flowers- bell shaped, rosaceous, globe shaped and so on. Though the size of proboscis of *A. cerana* was in between *A. dorsata* and *A. florea*, it foraged all the bell shaped flowers except *I. purpurea*. This finding is supported by Waelti *et al.* (2009) who showed that, pollinators with elongated tubular mouthparts tend to frequent tubular shaped flowers. Since, production of pollen and nectar is correlated with the corolla shape, pollinators would prefer the shape according to their calorie needs (Go´mez *et al.* 2014). The foraging of *A.cerana* in different shaped flower indicates toward an average calory need that is mitigated by all the flowers it visit. In terms of color, *A. cerana* preferred the red color most (e.g. *Dahlia* sp.) followed by the color orange (e.g.*C. sulphureus*). *A. cerana* also foraged on different colors of flowers. This finding is supported by Saiz *et al.* (2016) who found that a group of naive *A. cerana* showed slight preference to the

yellow color and the other not. Although, several studies have described spontaneous color preferences in bees (Lunau 2005; Giurfa *et al.* 1995;).

Foraging preference of A. florea: In terms of shape, *A. florea* had a preference towards the star shaped flower (e.g. *L. indica*) followed by globe shaped flower (*Tagetes* sp., 50.70%). In terms of color, *A. florea* had a preference over color pink (e.g. 69.39% in *L. indica* and 46.45% in *C. guianensis*) followed by the color orange (e.g. *Tagetes* sp.). *A. florea* was the most general pollinators in terms of size of flower. It foraged on the longest diameter of *Dahlia* sp. and the smallest diameter of *Acmella* sp. where other pollinators could not forage on. Sajjad *et al.* (2011), in their study compared the floral size preferences between *A. dorsata* and *A. florea* and found that *A. florea* foraged on most of the flowers of varied size and *A. dorsata* avoiding the smaller ones. He concluded that, *A. florea* due to their vast choices, could exploit resources more than *A. dorsata*. This study supports the idea of our investigation where *A. florea* foraged on almost every flower except two- *S. splendens* and *I. purpurea*.

Foraging preferences of X. aestuans: X. aestuans had preferred orchid shaped flower the most (e.g. *Bauhinia* sp.) followed by cruciate shaped flower (*M. ferrea*). It also preferred the purple color most in the study (e.g. *Bauhinia* sp). It can also be said that it was the least general pollinators in the study preferring only flowers with large calory reward. Highly prefers the large sized flowers that contain high energy content. A study conducted by ven der Pijl (1954) showed that, when there are many plants blooming at the same time, large carpenter bee will forage on flowers that offer reward the most qualitative and quantitive reward.

Table 1. Measurements of floral parameters

Plant name		**Mean capitulum diameter (mm)**	**Mean diameter of flower (mm)**
Scientific name	Botanic name		
Acmella sp.	Panicled spot flower	5.87	-
Calendula officinalis	Pot marigold	15.25	56.58
Cosmos sulphureus	Sulphur cosmos	12.34	48.22
Courpourita guianensis	Cannonball tree	29.5	74.7
Dahlia sp.	Dahlia	43.51	177.2
Euphorbia milii	Crown of thorn	2.8	28.5
Gomphrena globosa	Globe amaranth	-	22.5
Lagerstomea indica	Cape myrtle	-	27.5
Mesua ferrea	Ceylon ironwood	28.6	58.4
Pentas sp.	Star flower	1.78	18.5
Portulaca grandiflora	Moss rose	-	40.5
Quisqualis indica	Rangoon creeper	-	12
Tagetes sp.	Marigold	-	59.94

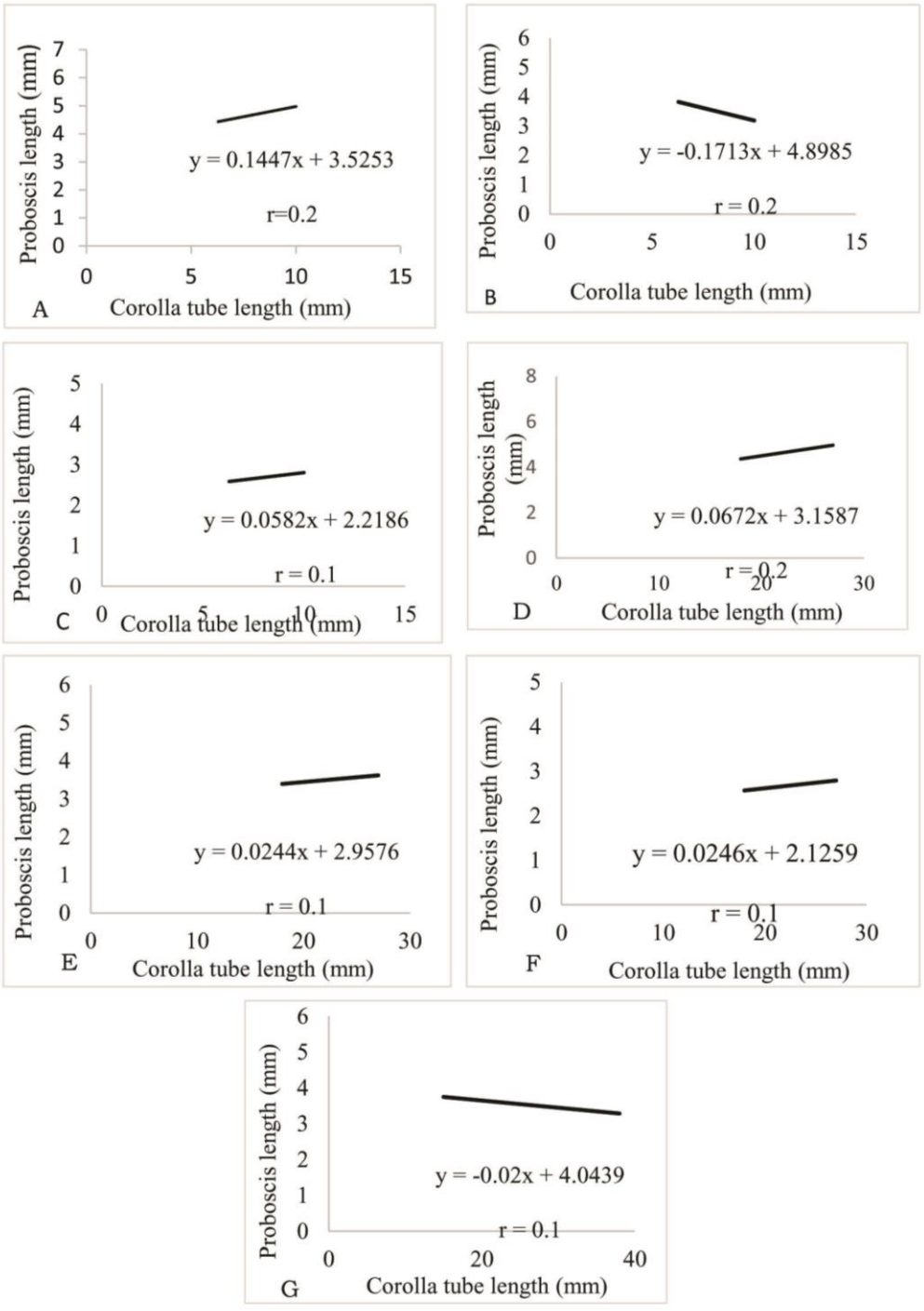

Fig. 3. Relation between proboscis length of honey bees with tubular shaped flowers. A. *A.dorsata*, B. *A.cerana*, C. *A.florea* with *Bauhinia* sp., D. *A.dorsata*, E. *A.cerana*, F. *A.florea* with *T.stans*, G. *A.cerana* with *S.splendens*

Table 2. Foraging time of pollinators in different flowers

Observed flower (scientific name)	Shape of flower	Color of flower	*A.cerana* Duration of visits per flower (seconds)			*A.dorsata* Duration of visits per flower (seconds)			*A.florea* Duration of visits per flower (seconds)			*X.aestuans* Duration of visits per flower (seconds)		
			Min.	Max.	Average	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.	Average
Acmella sp.	Disk shaped	Yellow							2	25	13.5			
Bauhinia sp.	Orchid shaped	Light purple	4	12	8	2	15	8.5	2	18	10	3	12	7.5
Calendula officinalis	Rotate	Orange	5	20	12.5	5	15	10	4	40	22			
Calendula officinalis	Rotate	Yellow	4	25	14.5	5	10	7.5	5	45	25			
Cleome rutidosperma	Diamond shaped	Blueish white							2	15	8.5			
Cosmos sulphureus	Rotate	Yellow	3	20	11.5	2	20	11	5	35	20			
Cosmos sulphureus	Rotate	Orange	3	22	12.5	2	15	8.5	4	40	22			
Couroupita guianensis	Rosaceous	Red	4	15	9.5	3	10	6.5	4	35	19.5	5	10	7.5
Couroupita guianensis	Rosaceous	Light pink	3	12	7.5	4	10	7	5	30	17.5	5	15	10
Dahlia sp.	Rounded	Red	10	120	65	5	90	47.5	10	300	155			
Gomphrena globosa	Globe shaped	Purple	5	20	12.5	5	15	10	3	15	9			
Ipomoea purpurea	Funnelform	Purple										5	12	8.5
Lagerstroemia indica	Star shaped	Pink	2	10	6	5	12	8.5	2	10	6			
Mesua ferrea	Cruciate	White	2	20	11	2	20	11	12	120	66	3	20	11.5
Portulaca grandiflora	Saucer shaped	Purple							3	20	11.5			
Pentas sp.	Salvershaped	Light pink	5	60	32.5									
Quisqualis indica	Stellate	Red , pink	2	10	6	3	10	6.5	2	15	8.5	3	10	6.5
Salvia splendens	Tubular	Red	3	40	21.5									
Tagetes sp.	Globe shaped	Yellow	3	12	7.5	2	10	6	5	30	17.5			
Tagetes sp.	Globe shaped	Orange	3	14	8.5	2	10	6	4	35	19.5			
Tecoma stans	Trumpet shaped	Yellow	4	10	7	5	40	22.5	3	10	6.5	5	15	10

Fig 4. Pollinators foraging in different flowers. *A.florea* in a.,b.*C.guianensis*, c. *A.dorsata*, d. *A.cerana*, e.*A.florea* in *Dahlia* sp. f. *A.dorsata*, g. *X.aestuans*, h. *A.florea* in *M.ferrea*, i. *A.dorsata*, j. *A.cerana* in *C.sulphureus*, k. l. *A.florea* in *C.officinalis*, m. *A.cerana* in *Bauhinia* sp. n. o. *A.florea* in *Tagetes* sp. *A.florea* in p. *P.grandiflora*, q. *G.globosa*, r. *Acmella* sp.s. *C.rutidosperma*, *A.cerana* in t. *Pentas* sp. u. *S.splendens*, v. *Ixora* sp. w. *A.florea* in *Ixora* sp.

Table 3. Proboscis length of honey bees

Name of honey bee species	Average length of proboscis (mm) N=35	Standard deviation
Apis dorsata	4.68 mm	0.741937
Apis cerana	3.52 mm	0.662653
Apis florea	2.67 mm	0.41543

Table 4. Measurements of floral parameters

Plant name		Mean corolla tube length (mm)	Mean throat diameter length (mm)
Scientific name	Botanic name		
Bauhinia sp.	Orchid tree	8mm	1.5 mm
Tecoma stans	Yellow bell flower	21.7 mm	25mm
Salvia splendens	Scarlet sage	30mm	7.8 mm
Ipomoea purpurea	Morning glory flower	71.63 mm	75mm

Relation of proboscis length of honey bees with corolla tube length of flowers: Relationships between the proboscis length of three honey bee species and corolla tube length of the specific flowers are presented in Figure:2. Results indicate that, proboscis length of three honey bees did not strongly correlated with the corolla tube lengths of flowers. It can be interpreted this way- since the honey bees can enter the tubular portion of the corolla themselves, their proboscis did not show any strong relation. They do not have to probe their tongues from the outside of flowers when they can readily enter the flower tube.

CONCLUSION

The findings of the study indicated that *A.florea* was the most abundant species followed by *A.cerana*, *A.dorsata* and *X.aestuans*. Pollinators mostly preferred red, pink, yellow and orange colored flowers. The study also indicated that, they had a preference towards larger flowers overall due to more resources and more space. The study found no significant correlation between the proboscis length of pollinators and corolla tube length of flowers. Further research on the preferences of pollinators will be required to increase knowledge about their choices.

LITERATURE CITED

AKTER, T., AKTHER, S., SULTANA, S., JHORNA, J.A. and BEGUM, S. 2019. The bees (Apocrita: Hymenoptera) of Dhaka city, Bangladesh. *Journal of Biodiversity Conservation and Bioresource Management*. **5**: 113-120.

ALI, M., SAEED, S., SAJJAD, A. and WHITTINGTON, A. 2011. In search of the best pollinators for canola (Brassica napus L.) production in Pakistan. *Applied Entomology and Zoology*. **46**. 353-361.

BRUNET, J. 2015 "The Effects Of Flower, Floral Display, And Reward Sizes On Bumblebee Foraging Behavior When Pollen Is The Reward And Plants Are Dichogamous," *Int. J. Plant Sci.* **176**(9): 811–819.

FENSTER, C., ARMBRUSTER, W., WILSON, P., DUDASH, M. and THOMSON, J. 2004. Pollination Syndromes and Floral Specialization. *Annu. Rev. Ecol. Evol. Syst.* **12**: 375-403.

GIURFA, M., NÚÑEZ, J., CHITTKA, L.1995 Color preferences of flower-naive honeybees. *J. Comp Physiol. A.***177**: 247–259.

GÓMEZ, J., MUÑOZ, P., JESUS, A., ABDELAZIZ, M., LORITE, J. and PERFECTTI, F. 2014. Evolution of pollination niches and floral divergence in the generalist plant Erysimum mediohispanicum. *Annals of botany*. **113**: 237-249.

LUNAU, K., GERTEN NÉE PAPIOREK, S., ELTZ, T. and SAZIMA, M. 2011. Avoidance of achromatic colours by bees provides a private niche for hummingbirds. *The Journal of experimental biology*. **214**: 1607-12.

NAVARRO, L., MEDEL, R. 2009. Relationship between floral tube length and nectar robbing in Duranta erecta L. (Verbenaceae). *Biological Journal of the Linnean Society*. **96**: 392 - 398.

RAHMAN, S. 2015. Ecological diversity of Flora and Fauna at Curzon Hall, University of Dhaka, Bangladesh. *International Journal of Recent Research in Life Sciences*. **2:** 36-40.

SAIZ, S.R. and BOSCH, J. 2016. "Pollinators show flower color preferences but flowers with similar colors do not attract similar pollinators," *Annals of Botany*. **118** : 249–257.

STANG, M., KLINKHAMER, P.G.L. and VAN DER MEIJDEN, E. 2006. Size constraints and flower abundance determine the number of interactions in a plant-flower visitor web. *Oikos*. **112**:111–21.

STANTON, M. L., and PRESTON, R. E. 1988. Ecological Consequences and Phenotypic Correlates Of Petal Size Variation In Wild Radish, Raphanus Sativus (Brassicaceae). *American Journal of Botany*. **75**(4): 528–539.

VAN DER PIJL, L. 1961. Ecological Aspects of Flower Evolution. II. Zoophilous Flower Classes. *Evolution*, **15** (1) : 44.

WAELTI, M. O., PAGE, P. A., WIDMER, A., and SCHIESTL, F. P. 2009. How to be an attractive male: floral dimorphism and attractiveness to pollinators in a dioecious plant. *BMC Evolutionary Biology*. **9**(1).

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