Pollination Ecology of *Commelina Communis* (Commelinaceae)

J H Wei[1], L D Liu[1,*], L Zhang[1], J Sun[1] and C C Pan[2]

[1] School of Life Sciences, Ludong University, Yantai, Shandong, 264025, China;
[2] Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou, Gansu, 730000, China.

Corresponding author and e-mail: L D Liu, liulinde@live.cn

Abstract. The floral biology, pollen/ovule ratio, pollen viability, flower visitors, pollination process and fruit set of *Commelina communis* were observed, measured and recorded in Kunyu Mountain, Shandong Province. The main results were as follows: The flowers of *C. communis* came into blossom at 3:00~5:00am, full-blossom before 6:00 and petal-shut at 12:00~13:00. The life-span of single flower of *C. communis* was about nine hours. In the four hours after flowering, the pollen viability was higher than 92%; six hours later, no pollen viability was detected. The P/O was 321±13. The results showed that *C. communis* was facultative autogamous. *C. communis* was pollinated by at least 4 species, of which syrphid fly was the main flower visitor. Fruit set of the completely netted flowers accounted for 92.7% of that under natural conditions. These indicated that self-pollination predominated in *C. communis*, xenogamy just played an auxiliary role in the breeding system.

1. Introduction

Commelina communis L. (Commelinaceae) is an annual, monoecious plant that is native to temperate northeast Asia [1]. *C. communis* flowers are zygomorphic with three blue petals. *C. communis* flowers can be divided into two types according to the existence of fertile stigmas or not: perfect flowers and staminate flowers. Each *C. communis* flower contains three types of stamen: long(L), medium(M) and short(S) typed stamens. The L-anther and M-anther produce fertile pollen; the S-anther produce pollen of weak vitality [2]. The pollination ecology of *C. communis* was studied by Song [3]. Song believed that the pollination syndrome of *C. communis* was autogamy and the mainly flower visitor (*Lasioglossum* sp.) was the pollen thief. Morita [2] considered that *C. communis* was self-compatible and could have delayed autogamy and bud pollination. Here we reported the pollination ecology of *C. communis* in China once again.

2. Materials and methods

2.1. Study sites

The study site was located on Kunyu Mountain (37º14´51.5"N and 121º46´16.3"E) in the eastern end of Jiaodong Peninsular at an average altitude of 923m above sea level in Shandong Province, PR China. This region is characterized by a temperate and monsoonal climate with four clearly distinct seasons. The annual precipitation is 815.6mm; the average temperature is 11°C. Vegetation is typical carpophylile.

Wei, J., Liu, L., Zhang, L., Sun, J. and Pan, C.
Pollination Ecology of Commelina Communis (Commelinaceae).
In *Proceedings of the International Workshop on Environmental Management, Science and Engineering (IWEMSE 2018)*, pages 539-544
ISBN: 978-989-758-344-5

2.2. Floral biology
In the field, flowering period, flower lifespan, anther dehiscence was revealed. The stigma of buds was cut off to examine the existence of pollen or not under microscope.

2.3. P/O
The perfect flowers were chosen to measure the pollen-ovule ratio. The P/O ratio was estimated according to the method of Cruden [4]. The number of pollen grains was estimated basing on the method of Anderson [5].

2.4. Pollen viability
The pollen viability was measured by TTC staining method. 20 flowers were chosen and scattered the pollens on a clean glass slide. A drop of 0.5% TTC was quickly added and keep the slide at 37°C in the dark for up to 2h. Then, three fields were randomly observed under an optical microscope, and 100 pollen grains were observed in each field. The number of pollen grains that were dyed red (active) was counted and averaged.

2.5. Observations and collection of flower visitors
Flower visitors observations were carried out in the field during 8-10, August 2008. We observed the area for 30 minutes every hour from 05:00 to 13:00. During observation periods, the species of each flower visitor, the number of visits made by each flower visitor were recorded. The flower visitors were captured and sent to specialists at Ludong University, Yantai, China, for identification.

2.6. Bagging experiments
To examine self-compatibility and contributions of autogamy in fruit set, two treatments for pollination experiments were conducted: (1) open pollination- flowers were labeled and left unbagged; (2) natural self-pollination- buds were bagged with nylon net. Two weeks later, remove the net away to observe if there was any fruit-set and counted.

2.7. Statistical analysis
A goodness of fit analysis was performed to test if the proportion in fruit set result in completely netting deviated significantly from the natural conditions.

3. Results

3.1. Floral biology
The flowers of *C. communis* are zygomorphy. The flowers began to blossom at 3:00~5:00 and in full-blown before 6:00. Before wilting, the flower lasted about nine hours. At 9:30am, flowers began to wilt. At 11:00~11:30, most flowers wilted, the pistils and long stamens rolled up, and flowers closed up again at 12:00~13:00. The anther dehisced before the opening of the petals. When the petals were about to open, pollen were found distributed on the stigmatic surface. Thirty hours later, most of *C. communis* flowers turned into fruits, others shed.

3.2. P/O
As shown in Table 1, P/O of *C. communis* was 321±13. The breeding system was facultative autogamous based on the criteria established by Cruden [4]. Our result was in line with that of other reports.

Table 1. The P/O ratios for *Commelina communis*.

Stamens no./flower	Pollen grain no./anther	Pollen grain no./flower	Ovule no./flower	P/O ratio
6	1285±53	7714±317	4	321±13

3.3. Pollen viability

The pollen viability gradually decreased with the progress of flower life. The pollen viability of *C. communis* was higher than 92% at the beginning of flowering, and could last about four hours. Four hours later, the pollen viability of *C. communis* brought down quickly. The fifth hour after blooming, the pollen viability of *C. communis* decreased to 23.9%. After the sixth hour, no pollen viability of *C. communis* could be detected (Figure 1).

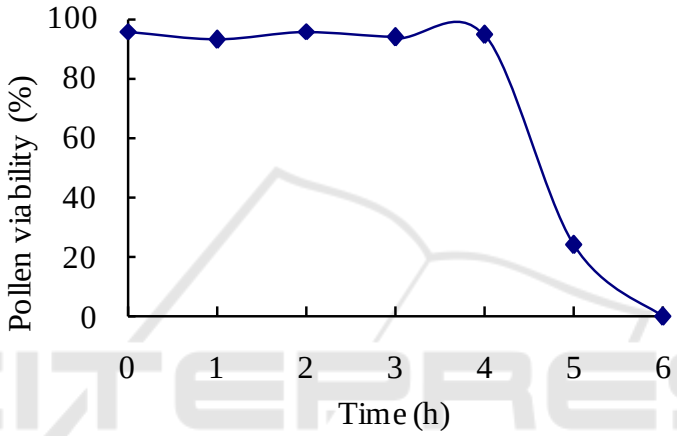

Figure 1. Pollen viability of Commelina communis on sunny days.

3.4. Flower visitors

At least four insect species were observed to visit the flowers of *C. communis* (Table 2). Most visits to flowers occurred before 8:30, no visits were observed after 8:30 (Figure 2). Syrphid flies were the most common visitors, the others belonged to Hymenoptera were occasional visitors. As usual, syrphid flies hovered several times above the flowers before foraging, and then landed on the fertile anthers to graze pollen. All the visitors were concentrated towards gathering pollen because no nectar was found in the flowers of *C. communis*. Pollen was the only rewards for visitors. The anthers of the long stamens could touch the stigmatic surface when visitors were landing and foraging on perfect flowers.

Table 2. Floral visitors and their rewards on flowers of *Commelina communis*

.Order	Family	Genus	Species	Reward
		Habropoda		Pollen
Hymenoptera	Apoidea	*Halictus*	*Lasioglossum calceatum*	Pollen
		Amegilla	*Amegilla parhypate*	Pollen
Diptera	Syrphid			Pollen

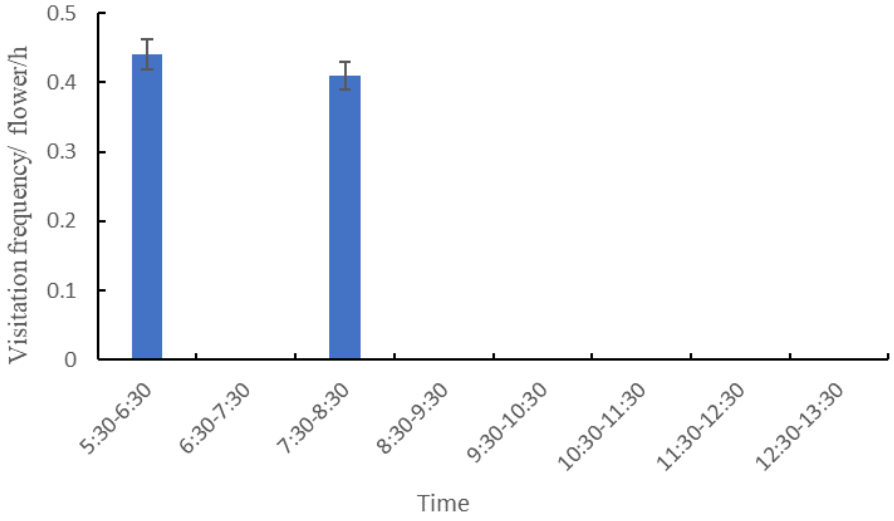

Figure 2. Visitation frequency of all insects to *Commelina communis*.

3.5. Bagging experiments

Fruits were produced by perfect flowers but staminate ones. Under natural conditions, fruit set was 53.4±6.3%. In the completely netted flowers, fruit set was 49.5±6.2%, accounting for 92.7% of that under natural conditions. These results suggested that autogamy played a dominant role in fruit production in *C. communis*.

3.6. Conclusions

Our results indicate that the pollen viability of *C. communis* gradually decreased with the progress of anther dehiscence; 6h later, most pollen grains lost their viability. P/O ratio was 321±13. According to Cruden, *C. communis* was facultative autogamous. Fruit set of the completely netted flowers accounted for 92.7% of that under natural conditions. Autogamy played a dominant role in fruit production in *C. communis*.

4. Discussion

Mutualism was formed between plants and their pollinators in the million years' coevolution. The plants benefit from pollinators when they are foraging on the flowers. Many factors such as floral color, shape, floral size and density, and the distribution of nectar rewards can affect the foraging behavior of a pollinator [6-9]. In this species, flowers without petals received fewer approaches by flower visitors. The removal of S- and M- anthers did not decrease the approach frequencies of flower visitors [10]. So it was the floral color and shape attracting the insects, and the aim of flower visitors was pollen because no nectar was produced in this species.

The reliability of using pollen/ovule ratio and outcrossing index as directive parameters of breeding system was ever doubted. But these were extensive used [11-15]. In these studies, the results of P/O, OCI were consist with that of bagging experiments. In this paper, these two parameters were also adopted to test the breeding system of *C. communis*, but the results were contradict with that of bagging experiments.

The flowers of *C. communis* are zygomorphy. Bilateral symmetry in flowers was evolved from radial symmetry [16-17]. The appearance of zygomorphy has led to the evolution of highly specialized pollination systems seen in advanced families [18]. In *C. communis*, at least four species were observed. But syrphid fly was the most common flower visitor and could carry pollen on their

body. The other visitors' appearance was very occasional. So we also believed *C. communis* was syrphid fly-pollinated on Kunyu Mountain.

Species with zygomorphic flowers which were more commonly found in the Commelineae were self-compatible [19]. Our results indicated that the pollination syndrome of *C. communis* was mainly autogamy. Entomophily played a minor role in fruit production in this species. Autonomous self-pollination had been classified into three types [20]: prior self-pollination, competing self-pollination and delayed self-pollination. Delayed self-pollination provides an opportunity for cross-pollination prior to flowers self-pollinating [21]. Pollination was completed only when pollen with viability reached to receptive stigma. In *C. communis*, pollen viability was disappeared after six hours of flowering. So, delayed self-pollination could not occur even when the flowers closed up again in the noon. In the mating system of *C. communis* existed both selfing (prior pollination) and outcrossing simultaneously. Several studies show that the corolla of *C. communis* and associated structures may attract pollinators and pollinators might influence the size of floral organs [22-24]. However, autogamy predominated in *C. communis*, xenogamy just played an assistant role in the breeding system. This was different from that of Morita and Nigorikawa [2].

In the experiment, we found the staminate flowers could not set fruits although pollen was found on the stigma surface. This needs for further study.

Acknowledgements

This work was financially supported by the National Natural Science Foundation of China (41773086, 31400392) and China Postdoctoral Science Foundation funded project (2015T81068, 2014M552516).

References

[1] Ushimaru A, Itagaki T and Ishii S H 2003 *Evolutionary Ecology Research* 5 4
[2] Morita T and Nigorikawa T 1999 *Natural history of flowers Hokkaido* (Japan: Sapporo University Press) p 227-242
[3] Song Y P 2014 *A Study on the adaptive significance of heteranthery in Commelina communis (Commelinaceae)* Changsha: Central South University
[4] Cruden R W 1977 *Evolution* 31 1
[5] Anderson G J, Bernardelb G and Stuessy T F 2001 *American Journal of Botany* 88 2
[6] Waddington K D 1981 *Pollination Biology: Foraging behavior of pollinators* (Florida Academic Press) p 213-235
[7] Waser N M and Price M V 1981 *Evolution* 35 2
[8] Galen C and Plowright R C 1985 *Canadian Jounal of Botany* 63 3
[9] Mitchell R J 1993 *Evolution* 47 1
[10] Ushimaru A, Watanabe T and Nakata K 2007 *American Journal of Botany* 94 2
[11] Liu L D, Zhu N and Shen J H 2002 *Acta Ecol Sin* 22 7
[12] Liu L D, Zhang P, Zhang L, Chen L and Gao Y B 2004 *Acta Bot Boreal-Occident Sin* 24 8
[13] Liu L D, Zhang L, Gao C M, Tang H T and Gao B Y 2006 Journal of Desert Research 26 5
[14] Zhang R B, Dou Q L, He P, Xiao Y A, Liu Y and Hu S J 2006 *Guihaia* 26 3
[15] Xiao Y A, He P and Li X H 2004 *Acta Phytoecol Sin* 28 3
[16] Stebbins G L 1974 *Journal of Ecology* 65 2
[17] Gifford E M, Foster A S 1989 *Taxon* 38 613
[18] Neal P R, Dafni A and Giurfa M 1999 *Annual Review of Ecology and Systematics* 160 S6
[19] Owens S J 1981 *Annals of Botany* 47 5
[20] Lloyd D G and Schioen D J 1992 *International Journal of Plant Sciences* 153 3
[21] Sun S G, Guo Y H, Gituru W R and Huang S Q 2005 *Plant Systematics & Evolution* 251 2-4
[22] Faden R B 1992 *Annals of the Missouri Botanical Garden* 79 1

[23] Ushimaru A, Itagaki T and Ishii H S 2003 *Plant Species Biology* 18 2-3
[24] Hardy C R, Sloat L L and Faden R B 2009 *American Journal of Botany* 96 7