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Association of Insect Fauna with the Flowers of the *Zea mays* (Sweet corn variety AKSH4) in Southern Part of West Bengal

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Abstract

This particular variety of maize, AKSH4, is juicy and sweet compared to the native variety. Insects are more attracted to the crop, and hence this variety is more dependent on insects rather than wind for its pollination. This is a preliminary report on the association of different insect groups with the maize flowers as foragers and pollinators. Insects associated with this variety showing both foraging and pollinating activity at different time periods of the day belong to the orders Hymenoptera, Coleoptera, Orthoptera, and Hemiptera. Altogether, 18 species of four orders of insects were observed during this study. The study was conducted on agricultural land near Saratnagar (Lat: 22.634; Log: 88.395) of district North 24 Parganas of Southern part of West Bengal region, from December 15th to April 20th, 2022-2023. The plants were approx. 6-7 ft in height. The number of insect populations belonging to the order Coleoptera is reported to be the most abundant, efficient and active diurnal and nocturnal foragers/ pollinators whereas the order Hymenoptera was found to be the next active and efficient visitors/pollinators in this study. The total number of visitors/pollinators was highest at 6-10 am, followed by 11-03 pm, 3-8 pm and 9-12 pm. It is also evident from the study that this difference in the foraging and pollinating activity, along with other unique behaviour of different insect orders, varied because of the variation in temperature, relative humidity and photoperiod that affect the number of insects visiting the corn plant.

Keywords: *AKSH4; Diurnal; Nocturnal Insect Foragers; Pollinators; Zea mays*

Introduction

Zea mays, belonging to the family Poaceae, basically known as corn, is a monocotyledon flowering plant. *Zea mays* is a protandrous and monoecious species (Vincent*,* 2002) with a staminate inflorescence, also known as a tassel top (produces pollen (Fig.1)) of the plant and is a hermaphrodite or monoecious plant species. Its inflorescence is a staminate with one or more of the middle nodes with a pistillate inflorescence in the axil. Nielsen (2010) opined that the early developmental stage flowers are bisexual, and in the latter stage some gametic changeover occurs; the female gynoecia of the male flowers and the male components (stamens) of the female flowers were dissociated, resulting in tassel (male) and ear or cob (female) development. Each egg on the cob gives rise to silks, which are hairy elongated stigmas appearing near the top of the ear, identifying characteristics of this particular species. The quantity of pollen is a central factor in ensuring the efficiency of controlled pollinations, and the data obtained by comparing traditional varieties with modern

hybrids of maize showed that an increase in pollen production is determined by the increase in branching of the male inflorescence (Landoni *et al*., 2024).

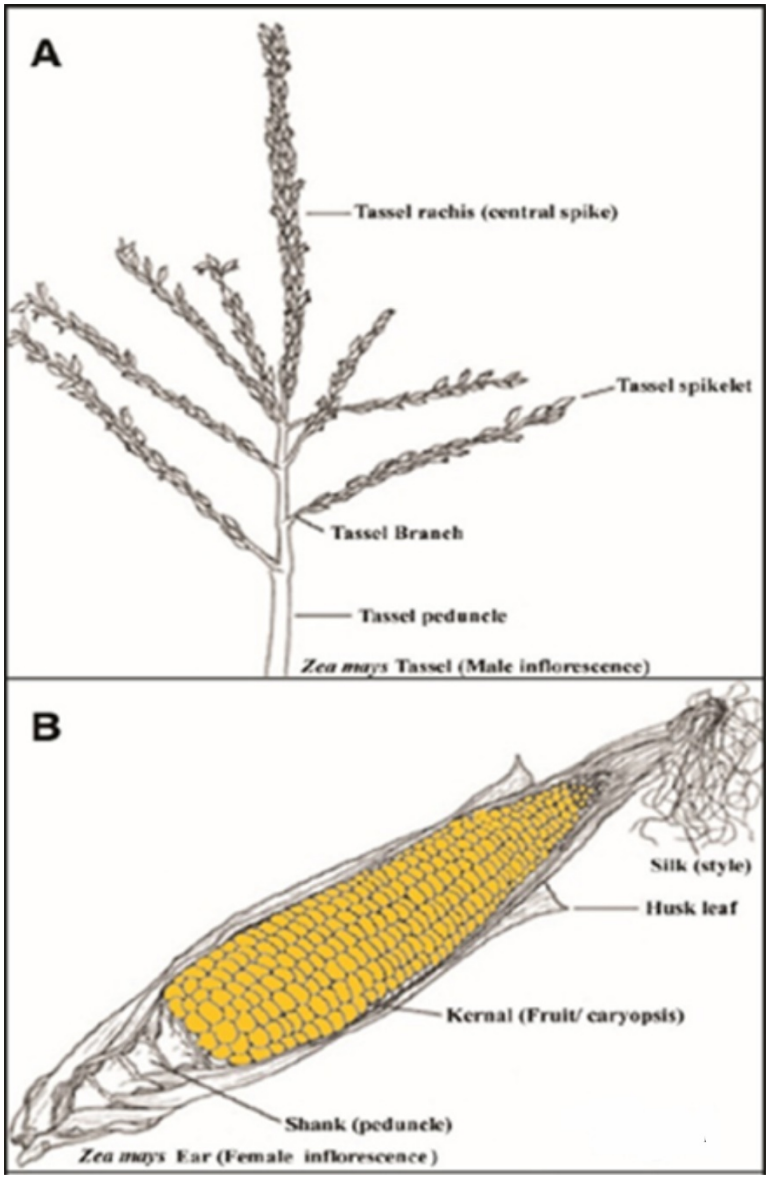

Figure 1: Male and Female Flower Part of Zea mays

According to Aldrich, Scott and Hoeft (1986) the tiny pollen grains of maize are carried by wind action to the silks (anemophilous), of the same plant or on a different plant. The pollen then travels down through the silk to fertilise an egg to form a kernel. Ollerton *et al*. (2019) and Asar, Ho and Sauquet (2022), who assessed during their premium research that, Pollination is a fundamental ecological process that influenced the diversification of many

seed plant families throughout evolutionary history. However, the variety of maize under experiments, the variety of AKSH4 maize plant produces a juicier and sweeter variety than other native varieties, which attract more insects, which intended this variety to be more inclined to insect pollination rather than wind (entomophily). Maize thereby plays a diverse and dynamic role in global agri-food systems and food/nutrition security (Poole, Donovan & Erenstein, 2021).

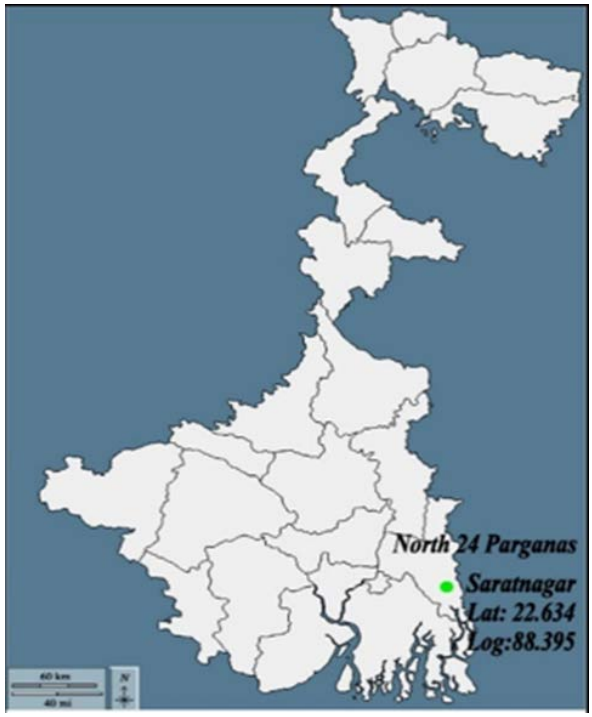

Figure 2: Location of the Area at North 24 Parganas of Southern Region of West Bengal

The present study describes the fact that both diurnal and nocturnal insects of various Orders play important roles in foraging (aggregation, collecting pollen, mating, predation), which in turn pollinates corn plants. This research is the pioneer to study the nocturnal floral visitors/pollinators of corn, *Zea mays*, in the Indian context and also to identify associated insects, those that act as foragers and pollinators. The extended study reveals the nature of those insects as diurnal and nocturnal pollinators, their behaviour along with their peak foraging period. The inference of this work also indicated that their behaviour varies with temperature, relative humidity and photoperiod. Altogether, 18 species of four orders of insects were collected as foragers and pollinators of *Zea mays* during this study (Tables 1 & 2).

Methodology

The study was conducted on agricultural land near Saratnagar (Lat: 22.634; Log: 88.395) of district North 24 Parganas of Southern part of West Bengal region (Figure 2), from December 15th to April 20th, 2022-2023. The plants were approx. 6-7 ft in height. The seeds of corn

were very sweet and juicy. Variety AKSH4 was sown for seed production on December 1st, 2022, in three plots measuring each 35 m x 35 m. Sweep net of about 20 cm radius was used to collect visiting and pollinating insects at different time periods, viz. 6-7 am, 8-9 am, 10-11 am, 12-1 pm, 2-3 pm, 4-5 pm, 6-7 pm, 8-9 pm and 10-12 pm. Record of daily mean temperature and relative humidity were collected from the local meteorological laboratory (Avg. temperature 24°C, RH 50%). The methods for collection, killing, preservation, setting and pinning of the insects were adopted from the manual of the Zoological Survey of India (Jonathan, Tikader & Kulkarni, 1986). The collected specimens were identified from the Zoological Survey of India, Kolkata. The correlation coefficient of different species of various orders with temperature and relative humidity was calculated using the most widely used Pearson's correlation coefficient method. The correlation coefficient of different species of various orders with temperature and relative humidity was calculated using Pearson's correlation coefficient method.

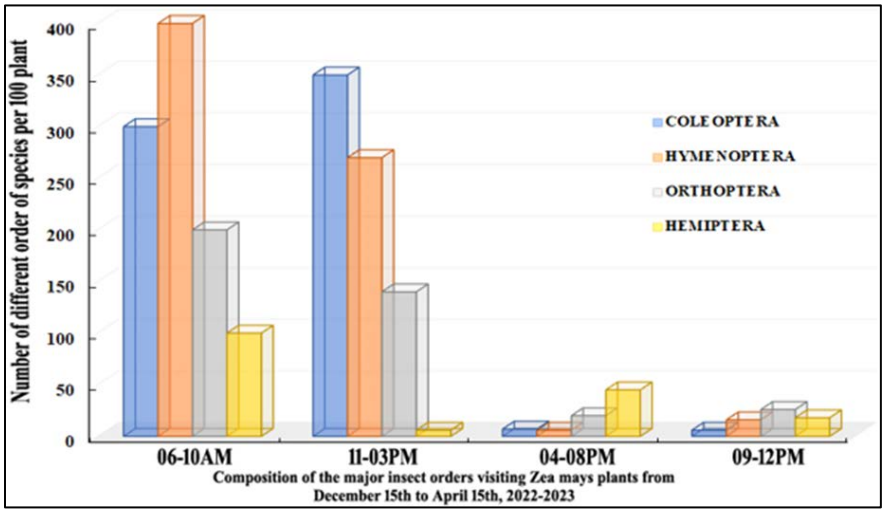

Figure 3: Composition of Different Insect Orders Visiting Maize Plant During Various Time Schedules

Results

In the present study, a total of 18 species under four Orders were observed to be associated with the flowers of maize crops (Table 1 & 2). The study reveals that most of the insects in relation to this crop pollinator activated condition are more active in daytime. Families Scarabaeidae, Elateridae and Coccinellidae of the order Coleoptera (one from each family) and family Tettigoniidae of the order Orthoptera (3 species) were found to be foragers of maize with nocturnal activity in *Zea mays*. Casual visitors like Two species of the family Pentatomidae and one species from the family Capsidae under the order Hemiptera were identified as pollinators of *Zea mays* (Fig.3). All these insects had been reported to show correlation with temperature and humidity. A representative correlation curve revealed a high correlation value, r=0.75, with temperature for order Coleoptera, and a high correlation

value, r=0.94 and 0.86, for Hymenoptera and Orthoptera, respectively, with humidity. The other correlation values (r) were calculated (Figure 4).

The study identified beetles from different families, like Coccinellidae and Lycidae activated more during daytime, and Scarabaeidae and a species belonging to the order Elateridae during night, acting as visitors which also act as pollinators. It has also been observed that Coccinellidae, especially Oenopia sp. (~10-12/plant) and Lycidae (~3-4 /plant) preferred to visit between 6 am -3 pm. Their act of eating the pollen grains created aggregation of those insects on the tassels of the corn from the base to the tip. Insects of the family Lycidae aggregate for mating, observed during this study. They split open the bilobed anthers with their strong mandibles, thereby exposing the pollen grains.

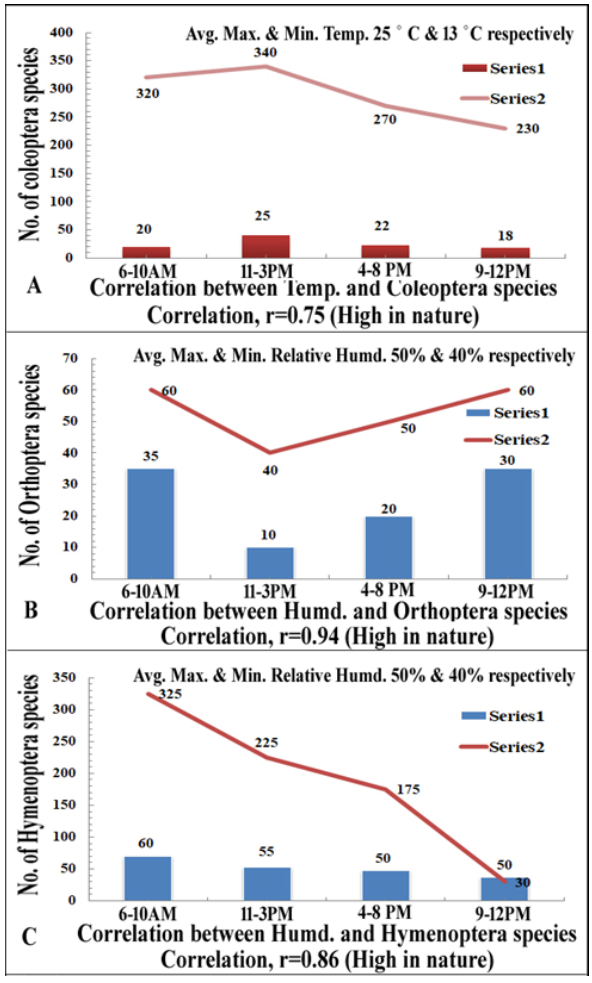

Figure 4: (A) Correlation between Temperature and Number of Species Under Order Coleoptera; (B) Correlation between Humidity and Number of Species Under Order Orthoptera; (C) Correlation between Humidity and Number of Species Under Order Hymenoptera

During this activity their upper and lower surfaces of the body, the appendages, antennae and the mouth parts, to a large extent, get smeared with lots of pollen grains. It has also been observed that they usually spend at least 20-30 minutes on such condition.

The pollen grains as a result showered at a huge number from the tassels and dropped on the glossy and shiny silks of the same plant as well as nearby plants.

During the night from 6 to 10 pm, quite a number of coleopteran species from families Scarabaeidae (~3-4/plant) and Elateridae (~1-2/plant) were observed to visit the plants, which might be helping in pollination of this variety of maize. Honeybees were found to be effective pollinators. It was observed that their preferable time for foraging was 7am till 11am, and they spent at least 20-25 seconds per plant. Two different species of bees were observed; the bigger one, Apis megapis dorsata were more in number (~8-10/ plant) than the smaller one, Apis cerana indica (~6-7/plant). During their foraging activity pollen grains got deposited on the silks of the female part of the plant, and thus it helped in pollination, but honeybees, especially in this case, removed large quantities of pollen and deposited very little pollen on the stigmas because much of the amount of pollen grains got wasted. Their activities and population generally decreased after 12 noon till they again visited the field after 2.30pm and remained till 5pm.

Table 1: List of Diurnal Insect Foragers and Pollen Collectors on *Zea mays* in Saratnagar, West Bengal

Order	Family	Species	Time for foraging/pollination	Habit
Coleoptera	Coccinellidae	*Oenopia* sp.	7am-2pm	Diurnal
		Harmonia arcuata	7am-2pm	Diurnal
		Coccinella septempunctata	7am-2pm	Diurnal
		Menochilus sexmaculatus	7am-2pm	Diurnal
		Chilocorus sp.	7am-2pm	Diurnal
	Lycidae	Unidentified	7am-2pm	Diurnal
Hymenoptera	Apidae	*Apis megapis dorsata*	7am-11am	Diurnal
		Apis cerana indica	8am-11am	Diurnal
		Apis mellifera	7am-12pm	Diurnal
Hemiptera	Pentatomidae	*Nezara viridula*	9am-2pm	Diurnal
		Agonoscelis nubile	9am-2pm	Diurnal

A few diurnal species of bugs, viz. Nazara viridula and Agonoscelis nubile and the nocturnal species Megacoelum stramineum were also observed to visit for foraging, but no pollen grain was seen adhered to their bodies. From 3 pm onwards the activity of diurnal foragers and pollinators gradually decreased. After 4 pm some grasshoppers (~2-3/plant) of the family Tettigoniidae were found to visit the fields mainly for foraging. After 6 pm, their abundance increased (~3-4/plant). They were observed to be strong and powerful nocturnal visitors, though less abundant. They were observed to prefer a quiet, cool and dark ambience for foraging. They visited and sat on the tassels till late at night by hugging the thin, slender

tassels with the help of their strong fore and hind legs. With the help of their strong mandibles, they chewed and opened the anthers and thereby exposed the pollen grains. As a result, the pollen grains got dusted in large numbers on their thorax, forewings, ventral surface of the abdomen, the jointed appendages (specially the forelegs), the antennae and the mouth parts. The entire activity in each instance took about 15-20 minutes, and after that, they jumped/walked away to visit the nearby plants.

During the night from 7 pm onwards, it was observed quite often that the upper part of the maize plants bearing the dangling tassels got affected by a large number of aphids, where they probably came for foraging or for taking a rest. However, during daytime these aphids were less visible on the plants. It was observed that these aphids during the night attracted a large number of black ants (Camponotus sp.). These aphids were observed to excrete sugar-rich fluid for the ants and in return got protection from them against predators. This symbiotic association continued till 1-2 hrs. During this interaction these black ants got showered with large amounts of pollen grains, but their little active movement on the plants indicates them simply as visitors.

Table 2: List of Nocturnal Insect Foragers and Pollen Collectors on Zea mays in Saratnagar, West Bengal

Order	Family	Species	Time for foraging/pollination	Habit
Coleoptera	Elateridae	Unidentified	6am-10pm	Nocturnal
	Scarabaeidae	Unidentified	6am-10pm	Nocturnal
Hymenoptera	Formicidae	Camponotus sp.	7pm-10pm	Nocturnal
Hemiptera	Capsidae	Megacoelum stramineum	7pm-10pm	Nocturnal
Orthoptera	Tettigoniidae	Ducetia japonica	4pm - 10pm	Nocturnal
		Atractomorpha sp.	4pm - 10pm	Nocturnal
		Euconocephalus sp.	4pm - 10pm	Nocturnal

Discussion

In the case of maize plants, though anemophily is the most commonly reported phenomenon, the role played by the insect visitors in the pollen collection and pollination process needs to be looked into. The number of major insect Orders with respect to the time schedule, when they often visited the maize plant for foraging and pollination is shown (Table 1 & 2). It was reported by Fonseca *et al*. (2003) that although bees and other insects visit male tassels of maize plants for foraging, they have a small role in pollination because female flowers are little attractive for pollinating insects. It was even observed by Poehlman and Sleper (1995) that generally anthers will not open in cool and humid weather, thereby trapping the pollen within. Herrero and Johnson (1980) reported that prolonged exposure to temperatures above 32°C can even reduce pollen germination of many genotypes in maize to levels near zero. Hence, in such situations, pollination in maize by wind is not that

effective, and it has to depend on some biotic pollen dispersal agents like insects for effective pollination.

It has been observed that this special hybrid variety of maize crops (AKSH4) is more attracted by insect visitors than the native variety of maize. This may be due to its juicy and sweet qualities of corn and so the particular variety is more dependent on insect pollination rather than wind pollination. Beetles are considered reliable and specific pollinators of several plants in the tropics by many entomologists. Pollination by beetles has been observed in some wild flowering plants from Himachal Pradesh (Kritika & Jaimala, 2017). Mouthparts in most of the coleopterans are perpendicular to the body axis; this position limits the length of the mouthparts, and they are able to lick up nectar from open flat blossoms (Roubik, 1995), though in the present case it was the juicy anthers that were the main target. Diurnal visitors from the families Coccinellidae and Lycidae under order Coleoptera were found in large numbers as visitors on maize. Of them, Oenopia sp. and one unidentified species of the family Lycidae were found to show unique behaviour of aggregation and copulation, respectively. Hawkeswood (2002) reported that the lycids are generally nectar feeders and also reported as effective pollinators of some Heathland plants of Australia. The aggregation had a modifying effect due to sudden temperature changes. Two species of honeybees from the family Apidae were noticed abundantly. Though Apis sp. were abundant, they deposited little pollen on the stigmas and quite an amount of pollen got wasted.

Comparatively, Coccinellid beetles were observed to carry more pollen during the present study. Regarding the effectiveness of each species of pollinator, it seems that it depends chiefly on two factors: their relative abundance among the pollinator "pool" and the efficiency with which they remove and deposit pollen. Insects of the family Tettigoniidae were observed to visit during the late afternoon that continued till late night. During their visit to the plant, their body parts got dusted with lots of pollen grains, and they were often seen to walk from one plant to another carrying the pollen, spending time exploring the shiny stigma, which was again a clear indication of pollination by these species. A recent work by Suetsugu and Tanaka (2014) showed that though katydids are not regular floral visitors, the juvenile katydid, *Ducetia japonica*, regularly visited and consumed the pollinia and anther caps of *Habenaria* (Orchidaceae). Therefore, orthopterans may be considered as effective nocturnal pollinators of *Zea mays*.

Conclusion

The comparison among different insect orders clearly revealed that insect populations, specially from the family Coccinellidae of the order Coleoptera, showed the highest population diversity, relative abundance and high correlation values with temperature and humidity, respectively. They were the most efficient and effective foragers present at all four time periods, i.e., 6-10 am, 11-3 pm (maximum numbers), 4-8 pm and 9-12 pm (minimum numbers) (Fig. 3). Besides this, all the coccinellid beetles reported during this study were predatory in nature, and they visited every part of the plant for searching their prey. They may be the slow mover but had a chance to help in the pollination process of maize.

Their serrated antennae and ridged elytra helped them to carry pollen, which had been observed during this study. Even scarabaeid beetles were also reported to show pollination during the night.

Next to Coleoptera, it is the *Apis megapis dorsata* of order Hymenoptera that was reported to be the most abundant, but their distribution, unlike Coleoptera, was not that uniform. Their number decreased in the afternoon, and after 3:00 pm, their abundance again increased and ultimately lasted till 5 pm. Though the number of bees in maize plants was less but they also play a vital role in pollination as they are the recognised effective pollinators of other angiospermic plant species.

During this study, it had been observed that katydids with their strong mandibles chewed and opened the anthers and thereby exposed the pollen grains. Lastly, it can be concluded that this is the first attempt to make an inventory of insect pollinators of *Zea mays*, AKSH4, which will certainly help future workers as baseline data on pollinators and pollination of *Zea mays.*

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