Pollinators of Sikkim Mandarin Orange Citrus reticulata (Sapindales: Rutaceae)

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NOTE

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Pollinators of Sikkim Mandarin Orange *Citrus reticulata* (Sapindales: Rutaceae)

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Sikkim Mandarin Orange (*Citrus reticulata* Blanco, 1837) is a member of the Rutaceae family and a commercially desirable variety of the mandarin group native to Sikkim. The Sikkim Mandarin Orange (SMO) growing area lies at an altitudinal range of 700–1,500 m and it is an annual flowering plant. Mandarin orange is dependent on bees for its pollination and pollinators help in higher yield and increased fruit set (ICIMOD 2003). Irrespective of large cardamom yield decline due to pollinator deficiency in Sikkim (Sinu & Shivanna 2007), till date there exists no systematic study on the range of pollinators for SMO. This study aims to bridge this gap especially when a large proportion of farmers are dependent on the SMO for cash income.

Our study area spanned the East, West and South districts of Sikkim. The southern part of the state, which lies in the altitude range of 600–1500 m provides an ideal climate for SMO cultivation (DHCCD 2015). Data was collected across 72 SMO orchards from 2011 to 2013. These orange orchards were selected within an altitudinal gradient of 700–1,452 m and were spread across 316km^2 (Fig. 1).

Pollinator visitation: At each site, 150 flowers were tagged and observed from 08.00–17.00 h to record insect species that visit them. Intra-floral foraging behavior of each insect species was carefully observed to note whether it is a pollinator or a forager. SMO bear self-fertile, bisexual flowers and pollen movement is facilitated by pollinators. Transparent plastic bags were used to trap insects visiting the flowers to avoid any fruit loss during their collection. Collected samples were preserved in 70% ethanol and subsequently identified in the laboratory. Insects which were not seen touching the flower reproductive parts were not collected for identification.

We recorded 24 species of insects during the study period (2011–2013). Common Honey Bee *Apis cerana* was the most dominant pollinator followed by hoverflies belonging to eight genera, namely, *Episyrphus* sp., *Melanostoma* sp., *Ischiodon* sp., *Eristalis* sp., *Eristalinus* sp., *Scaeva* sp., *Episyrphus* sp., and *Eupeodes* sp. (Image 1,2) . This was followed by stingless bees (Hymenoptera), seed bug (Hemiptera), and beetles (Coleoptera) that were sparse visitors. Recorded insects were both pollen and nectar feeders. Bees (Hymenoptera) and hoverflies (Diptera) visited flowers in groups while most of the

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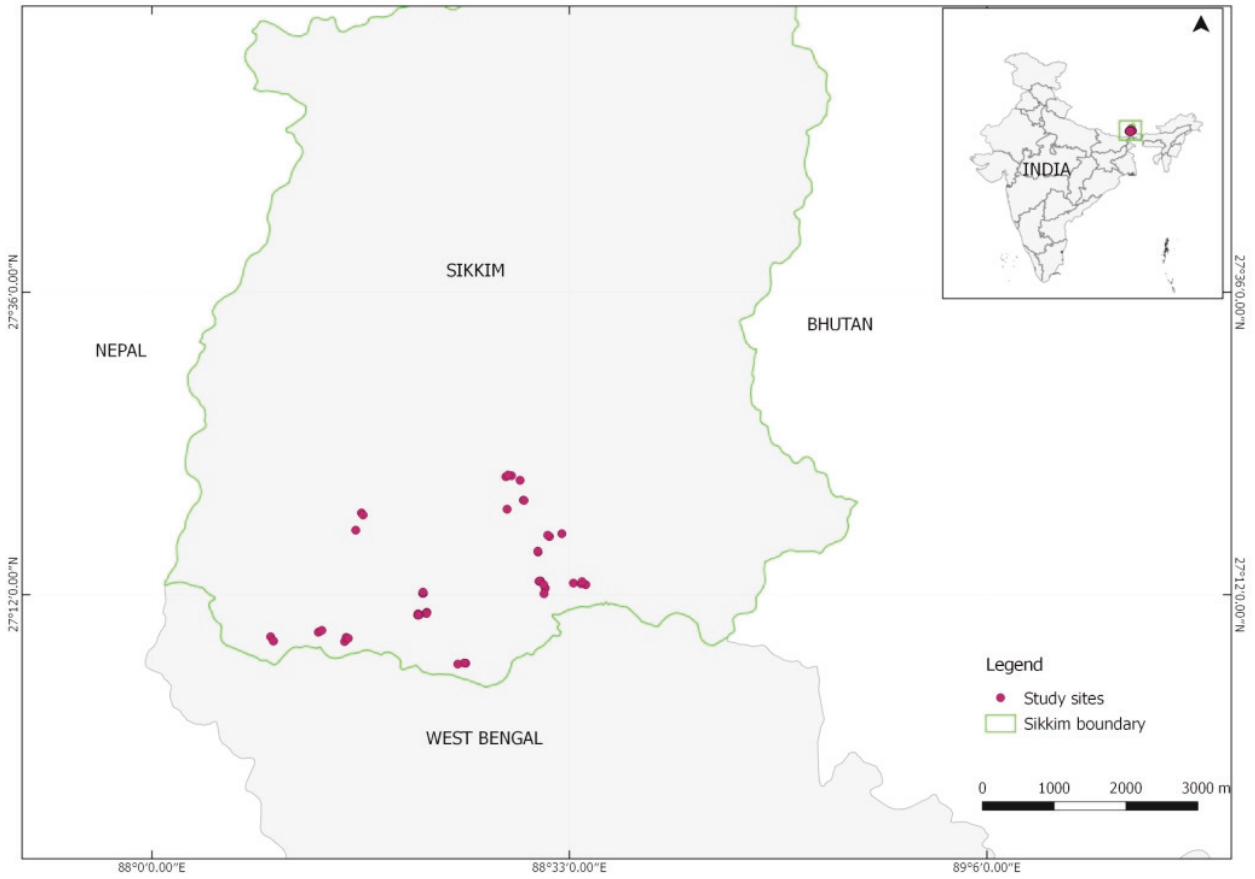

Figure 1. Location of orchards (in red dots) within the northeastern Indian state of Sikkim.

beetles and seed bugs visited individually. All the insects landed on the petal and foraged for pollen placed on top of the flower and nectar at the flower base. In this process all the insects invariably touch both anther and stigma of SMO flower. An insect visitor was called a pollinator when the ventral side of insect's body containing pollen load touched the reproductive part of flowers.

SMO is an evergreen plant showing flowering response to early monsoon shower starting in the mid of February. Flowering period lasts for a month, from late February to early April. Orchards in the lower altitude starts flowering earlier followed by orchards in the higher altitudes. Flowers are white in colour with strong scent attracting a range of insects for pollination. Highlighting the importance of pollinators of the mandarin orange, in a study conducted by the International Center for Integrated Mountain Development (2003), pollination was seen to increase the yield of mandarin orange by four times compared to pollinator excluded flowers. Honey bee (*Apis* sp.) has been reported as a major pollinator of different varieties of *Citrus* sp. from across the world, for example, Mandarin orange *Citrus reticulata* in Nepal is pollinated by *A. cerana, A. dorsata, A. florea,* and *A. mellifera* (International Center for Integrated Mountain Development 2003). Kinnow *Citrus reticulata*, a hybrid between mandarin orange and sweet lime, was reported to be pollinated by *A. dorsata* and *A. florea* in Pakistan (Manzoorul-Haq et al. 1978). Results of our study show only *A. cerana* visited mandarin orange flowers, while *A. dorsata* or *A. florea*, which were recorded in other studies, were not observed even outside our experiment sites during the study period. Hoverflies, although not reported as pollinators of mandarin oranges earlier, are known to pollinate rapeseed oil (Jauker & Wolters 2008), apple (Solomon & Kendall 1970), and strawberries (Kendall et al. 1971). Both bees and flies visited flowers in groups and visited more than one flower at a time, possibly aiding in cross/sexual pollination (Raju et al. 2012). Visits by other taxa such as butterflies, stingless bees, and beetles to orange flowers were less in comparison to bees and flies. However, the importance of these wild pollinators in sustaining pollination of SMO needs further exploration.

Table 1. Pollinators of Sikkim Mandarin Orange.

	Order	Family	Sub family	Genus	Species	Altitude range	Forage collected
1	Coleoptera	Coccinellidae	Coccinellidae	*Oenopia*	*kirbyi* (Mulsant)	700–1400	nectar + pollen
2		Scarabaeidae	Rutelinae	*Anomala*	sp.	700–1400	nectar + pollen
3		Scarabaeidae	Citoniinae	*Clinteria*	sp.	700–1400	nectar + pollen
4		Chrysomelidae	Eumolpinae	*Chrysonopa*	sp.	700–1400	nectar + pollen
5		Chrysomelidae	Galerucinae	*Galerucinae*	sp.	700–1400	nectar + pollen
6	Diptera	Calliphoridae	Chrysomyinae	*Chrysomya*	sp.	1000–1400	nectar + pollen
7		Rhiniidae	Rhiniinae	*Rhinia*	sp.	0800–1400	nectar + pollen
8		Sarcophagidae	Paramacronychiinae	*Wohlfartia*	sp.	0800–1400	nectar + pollen
9		Syrphidae	Syrphinae	*Episyrphus*	sp.	0800–1400	nectar + pollen
10		Syrphidae	Syrphinae	*Melanostoma*	sp.	900–1400	nectar + pollen
11		Syrphidae	Syrphinae	*Ischiodon*	*scutellaris* (Fabricius)	0800–1400	nectar + pollen
12		Syrphidae	Eristalinae	*Eristalis*	*tenax* (Linnaeus)	0800–1400	nectar + pollen
13		Syrphidae	Syrphinae	*Scaeva*	*pyrastri* (Linnaeus)	900–1400	nectar + pollen
14		Syrphidae	Syrphinae	*Eupeodes*	*confrater* (Wiedemann)	900–1400	nectar + pollen
15		Syrphidae	Eristalinae	*Eristalinus*	*taeniops* (Wiedemann)	900–1400	nectar + pollen
16		Syrphidae	Syrphinae	*Episyrphus*	Viridaureus	900–1400	nectar + pollen
17		Syrphidae	Eristalinae	*Eristalis*	*basifemorata(*Brunetti)	700–1400	nectar + pollen
18	Hemiptera	Lygaeidae	Lygaeinae	*Spilostethus*	*pandurus* (Scopoli)	700–1400	nectar + pollen
19		Lygaeidae	Lygaeinae	*Graptostethus*	*incertus* (Walker)	700–1400	nectar + pollen
20		Largidae	Physopeltinae	*Physopelta*	*gutta gutta* (Burmeister)	700–1400	nectar + pollen
21	Hymenoptera	Halictidae	*Halictinae*	*Seladonia sp*	sp.	700–1200	nectar + pollen
22		Halictidae	Halictinae	*Lasioglossum*	sp.	700–1200	nectar + pollen
23		Apidae	Apinae	*Apis*	*cerana*	700–1500	nectar + pollen
24		Apidae	Apinae	*Tetragonula*	sp.	800–1200	nectar + pollen

Image 1. *Apis cerana* pollinating Sikkim Mandarin Orange flower.

Image 2. *Apis cerana* and *Eristalis* sp. visiting Sikkim Mandarin Orange flowers.

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