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Pests of mandarin orange and its importance in Sikkim, India

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ABSTRACT: Mandarin orange (*Citrus reticulata* Blanco) is a major cash crop in Sikkim and in this paper the pests of mandarin orange obtained through inputs from farmers of Sikkim are documented with symptoms of pest attack and prevalence of important pests. Citrus long horned beetle (*Anoplophora versteegi*) was the most destructive pest followed by stem borer Japanese beetle (*Popillia japonica*) and four Hemipterans (*Planococcus citri, Toxoptera aurantii, Toxoptera citricidas and Diaphorina citri*) collectively called *laikira*. These pests were common across all sites as compared to other pests. This work can serve as a baseline for future researchers as well as government agencies to engage in management of these pests.

KEYWORDS: Sikkim mandarin orange, pests, prevalence, infestation

INTRODUCTION

Sikkim is India's first organic state and more than 67% of the total population depend on agriculture for livelihood (Joshi, 2004). Out of 7096 sq km area of Sikkim, mandarin orange is cultivated in approximately 12380 hectares. Native orange is grown in all the four districts of Sikkim between 600 – 1500 meters above mean sea level. There has been a three-fold increase in area under orange (4250 to 12340 hectares) between 2001-2002 and 2015-2016. It contributes significantly to the rural economy as more than 12000 farming families are directly dependent on orange for their livelihood.

The importance of orange as a cash crop has amplified due to the drastic decline of large cardamom (*Amomum subulatum*) which was the most successful cash crop in Sikkim till 2000. The area under cultivation of large cardamom had increased by 2.3 times between 1980 and 2000. Since early 2000, the area under *Amomum subulatum* declined by almost 50% (Sharma and Dhakal, 2011). Large cardamom yield declined drastically in the last decade due to fungal diseases, pests and decline in its major pollinator *Bombus sp* (Savory *et al.*, 2014; Sharma *et al.*, 2016; Sinu and Shivanna, 2007).

Orange cultivation has also begun to see a decline in terms of acreage as well as productivity. The emergence of diseases such as citrus dieback, powdery mildew, root/foot rot, shoot mould, anthracnose, red rust, scab, *Tristeza* virus - vascular

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borne disease, colonization of ants in citrus plant have been reported in recent years in orange orchards across Sikkim (Sharma and Dhakal, 2011). Pests have been known to affect productivity of crops since the dawn of agriculture with farmers constantly looking for methods to protect their crops from various organisms (Oerke, 2006). Insect pests are major competitors with human for the fruits of agricultural production and the damage caused by them is a primary factor in the reduced productivity of crop species (David Pimental, 1976); Metcalf, 1996; Oerke, 2006). Early detection and control of pest species are extremely important if large outbreaks of major cash crops are to be avoided.

Lack of reliable information on major insect pests and their spread is a major stumbling block for containing insect pests in Sikkim. This assumes additional importance when the crop in question is critical to people's livelihoods (Sharma *et al.,* 2000; Subba, 2009). In this paper, a first-hand knowledge on prevalence of insect pests across the distributional range of orange in Sikkim was attempted.

MATERIALS AND METHODS

Study Area:

Sikkim, located in Eastern Himalayan region is a biodiversity hotspot with a geographical area of 7096 sq km area. Approximately 9% of the total geographical area is dominated by cultivated area which can be seen interspersed between human habitations and forest patches. They grow various crops like large cardamom (*Amomum subulatum*), mandarin orange, ginger, variety of vegetables, cereals and pulses. With slow or little hope of large cardamom rejuvenation, government started rejuvenating orange orchards, expanding its cultivation in the area. This study was conducted in mandarin orange orchards (Fig. 1) covering East, West and South districts of Sikkim. Semi-structured interviews were conducted with 81 orange growers in Southern Sikkim.

The respondents were chosen to accommodate orchards of different sizes from a larger group that comprised all orange farmers in these three districts. The interviews were conducted in the local language and recorded using a digital voice recorder with prior permission from the farmers or the responses were directly transcribed on to a note pad. Prior to this, two years were spent in the field conducting ecological research and building rapport with the locals. The first section of the questionnaire had questions typically on the farmer's household data and agricultural data with emphasis on pests of orange were recorded. Information on pests, symptoms on the plants after pest attacks and approximate time line of pest attack were recorded.

Farmers were requested to show us the pest attacks in their orchards. Since the entire range of pests were not available throughout the year, photographic evidence of the pest or affected part of the plant were taken (where possible). A preliminary list of pests was prepared after the interview and field visits, which was verified through secondary literature survey, communication with taxonomists and photographic identification of the pests by the farmers themselves.

RESULTS AND DISCUSSION

There were 13 different pest species affecting orange. They belonged to 12 families from four taxonomic orders namely Coleoptera, Diptera, Hemiptera and Lepidoptera (Table 1).

Sampled orchards were infested by more than one pest at any given time of the year. Farmer's input and field survey highlighted that these pests were found to attack different parts of orange such as leaves, trunk, branch, roots and fruits. All the pests reported in this study have been found to heavily impact *Citrus* production across the world (Cerda et al., 2017; Parsa et al., 2014; G. Sharma and Dhakal, 2011). However, their abundance and attack intensity varied across sites. The intensity of attack also varied in a given year. For example, most prevelent pest Japanese beetle (*P. japonica*) was highlighted. It was found throughout the year but its abundance and attack intensity was more in spring and monsoon. On the other hand citrus long-horned beetle (*A. versteegi*) emerged in March –

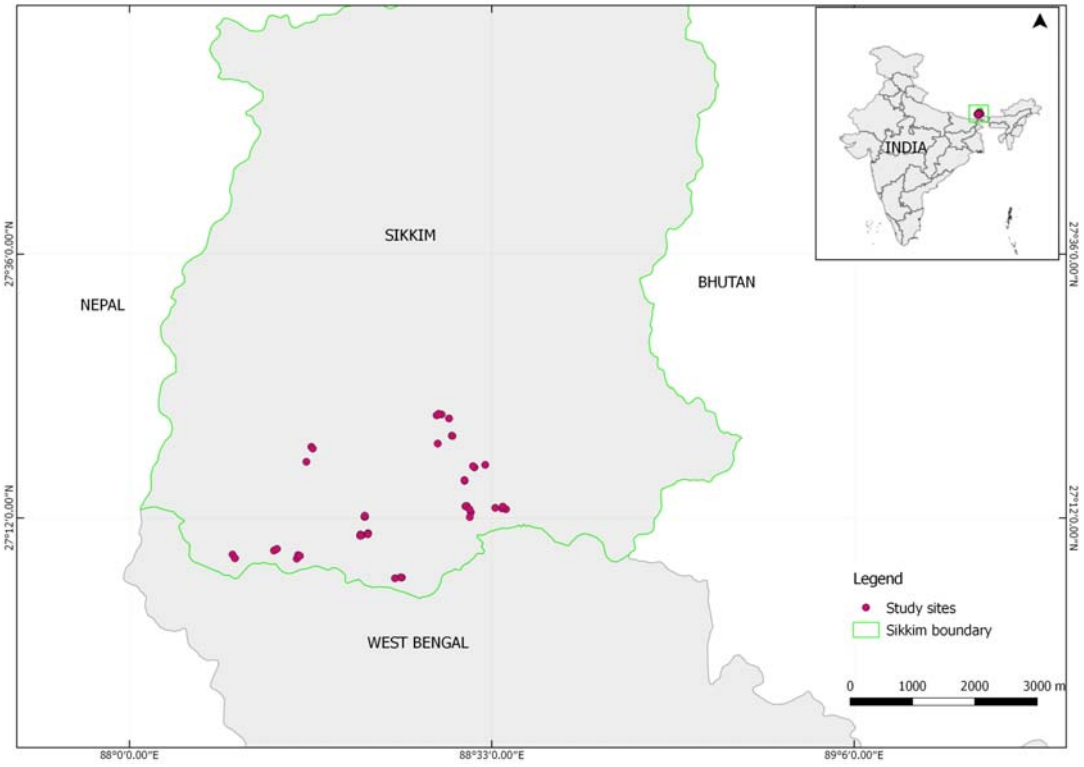

Fig. 1. Map shows location of Sikkim in India and study sites highlighted by dots

April but was most abundant in May – August. Increase in pest abundance and attach intensity is more during monsoon season which begins roughly by late May and last till September end. With no chemical input, organic farming has been proven to have a positive impact on biodiversity as well as human well-being (Holzschuh *et al.*, 2008). However, this transition to organic agriculture brings with it a different set of challenges that includes pest management (Zehnder *et al.*, 2007) which were reported by farmers in our field sites also. Ever since Sikkim adapted its 'organic mission', both the state agencies as well as farmers are exploring ways to deal with pests and diseases in organic ways. As highlighted by Gopi *et al.* (2016)), from table salt to cow urine, cow dung, kerosene and local plants like *Eupatorium, Artemisia vulgaris* mixed with cow urine is being used as sprays to combat pest and diseases. The state agencies are engaging farmers in trainings and workshops to deal with pests and diseases naturally.

With changing climate, the abundance and intensity of pest and disease attacks have been reported to increase globally (Rosenzweig *et al.*, 2001). Farmers in Sikkim also expressed the idea that pest abundance, diversity and attack intensity has increased due to climate change induced erratic weather patterns - prolonged dry period followed by torrential short bouts of rain. This definitely deserves scientific exploration and validation in the future. However, studies across the world mention that due to their invasive nature, many pests are known to have adapted well to a diversity of climatic zones affecting numerous agricultural as well as wild plants (Kirk and Terry, 2003; Sharov and Liebhold, 1998). Pests recorded in this study for example, fruit fly (*B. dorsalis*) is a widely distributed invasive species with its origin in tropical Asia that has now spread across the globe. It has also been reported as pest of *C. reticulata* (Chen and Ye, 2007; Hui, 2001). The highly destructive mealy bug (*Planococcus citri*) is easily dispersed by wind

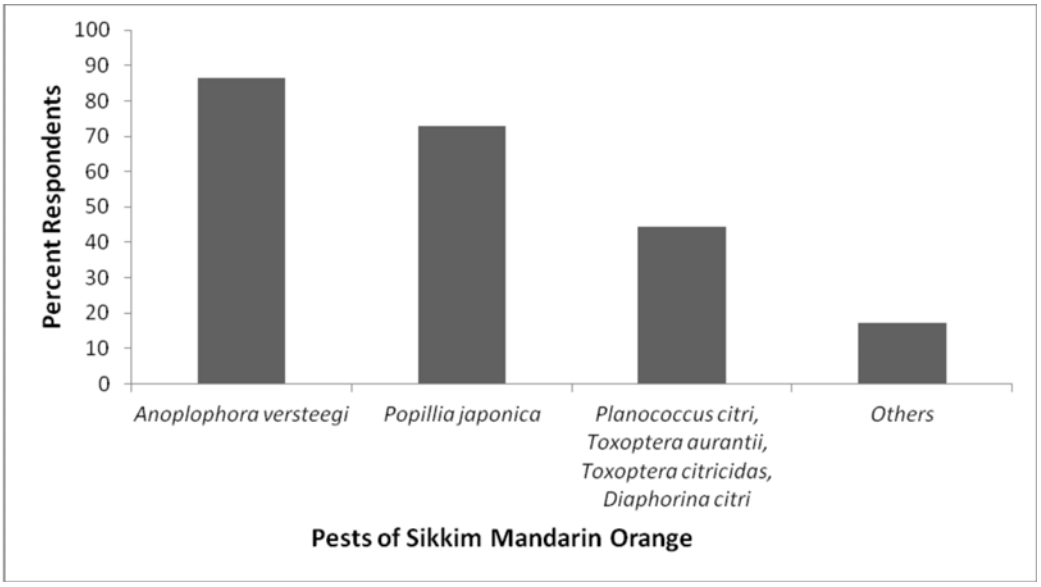

Fig. 2. Pest of orange ranked by farmers as most destructive to the crop

(Cornwell, 1960) making their spread across plants and even orchards easy. Integrated management of these pests requires an understanding of the diversity, abundance and intensity of pest attack after which control measures can be planned. The present study makes an effort to fill that gap by identifying the important pests of orange from the organically managed orchards of Sikkim.

All the pests listed from Sikkim are known to damage crops globally (Dedryver *et al.*, 2010; Mitchell, 1984; Pollard *et al.*, 1986) and will impact the economic benefit people derive from the cultivation of oranges. Farmers reported decrease in yield of oranges due to pest attacks, a research aspect which deserves more attention. Amongst the symptoms mentioned in the table, farmers highlighted yellowing of leaves and eventual death of plant as well as fruit fall caused by these pests as a major economic setback to them. As reported by Gu and Pomper (2006), attacks by Japanese beetle (*P. japonica*) and citrus long-horned beetle (*A. versteegi*) were cited as the main pests leading to crop loss by farmers. Based on interview results, we found that approximately 85% respondents reported citrus long horned beetle as the most destructive pest. This was followed by stem borer Japanese beetleas reported by 72% respondents and four Hemipterans (*P. citri, Toxoptera aurantii, Toxoptera citricidas and Diaphorina citri*) collectively called *laikira* by the farmers was reported to be destructive by 45% respondents. These pests were common across all sites as compared to others which were reported to be harming the crop by 18% respondents (Fig. 2).

Identification of the specific pest responsible for the damage was not always possible by the farmers because of similar and overlapping symptoms caused by different pests. Attempts were made to verify the identity of the pest through photographs and consultation with other experts but it was not possible to identify all the pests for all locations. An additional issue was that the farmer's usage of local terms for pests were generic in nature and not necessarily unique for each species. This highlights two important factors, one that some of these pests are considerably new to farmers or have increased in the recent past such as red scale (*Aonidiella aurantii*) and Japanese beetle. Secondly, having no knowledge about pests which is affecting their crop may also act as an obstacle in managing them later (Parsa *et al.*, 2014). The information generated by this work can be used as a baseline by other researchers to address distribution of the pest in the landscape and also investigate their

Table 1. Pests of Sikkim mandarin orange

Sl No	Scientific name	Local name	Common Name	Order	Family	Distribution	Symptom
1	*Popillia japonica*	*Padhera*	Japanese beetle	Coleoptera	Scarabaeidae	throughout the year, more abundant in spring and monsoon	Adult feed on foliage causing leaf skeletonization.
2	*Anoplophora versteegi*	*Singh kira*	Citrus long-horned beetle	Coleoptera	Cerambycidae	Emerges in March - April but is most abundant during May - August	Insects cause damage to leaves, roots, trunk and twigs. Feeding on leaves and petioles can result in yellowing or drooping of leaves. The major damage occurs in the roots, trunk and twigs by the larvae which burrow into the wood restricting water and nutrient transport and also secondary infection. Primary signs of infestation include round emergence holes, piles of sawdust and excreta and oozing sap
3	*Bactrocera dorsalis*	*Kanchi kira*	Fruit fly	Diptera	Tepthritidae	Primarily in summer	Attacks the fruit and the symptoms include black and brown lesions on the fruit, signs of internal feeding and premature fruitfall.
4	*Planococcus citri*	*Fusre lai kira*	Mealy bug	Hemiptera	Pseudo-coccidae	Spring and early summer	White cottony masses of eggs are deposited on trunks and stems of citrus plants. Wax and honeydey secreted by the insect nymphs are visible indicators of infestation. Infestation also leads to wilted distorted yellowed leaves, premature leaf drop, stunted growth and even death of infested plant parts or the entire plant in some cases. Fruit drop can result from mealybugs feeding near the buttonof oranges with oranges developing hard lumps and discoloured, poor quality fruit.
5	*Toxoptera aurantii*	*Kalo lai kira*	Black aphid	Hemiptera	Aphididae	Thrives at higher temperatures. Available throughout the year	Aphids sucking sap cause deformations on the plants causing curled and shriveled leaves and occasionally forming galls. Primarily attacks the tender young shoots, flower buds and the undersides of young leaves and avoid tougher plant tissues. Also secrete honeydew which can promote the growth of sooty fungus mould which can blacken the leaves, decreasing photosynthetic activity

Sl No	Scientific name	Local name	Common Name	Order	Family	Distribution	Symptom
6	*Diaphorina citri*	*Lai kira*	Citrus Psylla	Hemiptera	Psyllidae	March - April	The nymphs are completely exposed and can be seen with the naked eye. White waxy secretions on the leaves are symptomatic while they exhibit a variety of other symptoms on the leaves, stems, twigs and fruits. Leaves show yellowing, fruits are underdeveloped and hard with low juice with most of the seeds being small and dark coloured.
7	*Aonidiella aurantii*	*Rato thople papra*	Red scale	Hemiptera	Coccidae	Variable	The insect feeds on sap and are found on all parts of the plant but are more noticeable on the fruit. Leaf discoloration, shoot distortion and leaf drop are the common symptoms. The bark of the trees may split and even result in death of the tree.
8	*Bemisia tabaci*	*Seto kira putali jasto*	Whitefly	Hemiptera	Aleyrodidae	Thrives in higher temperatures but prevalent throughout the year	At first, the damage consists of yellowish spots. The leaves demonstrate a yellow mosaic, with the green areas turning smaller over time. Twisting of stems and curling of leaves may occur, and the plants may become stunted. Heavily-infested leaves often wilt and fall off. In addition to direct feeding, all stages damage the plants through abundant production of honeydew, which encourages the growth of sooty moulds, and, most importantly, by the transmission of viruses. The nymphs excrete large quantities of honeydew, which is rich in carbohydrates and supports the growth of sooty mold, causing parts of the plant to turn black
9	*Toxoptera citricidas*	*Seto lai kira*	Citrus/white aphids	Hemiptera	Aphididae	Throughout the year but thrives. Outbreaks occur after rains when new buds and leaves emerge	Leaves show chlorosis
10	*Papilio spp.*	*Chirke putali*	Citrus butterfly	Lepidoptera	Papilionidae	July - Dec	Caterpillars can completely defoliate young trees and in the case of mature trees, the young leaves are destroyed

Sl No	Scientific name	Local name	Common Name	Order	Family	Distribution	Symptom
11	*Inderbella quadrinotata*	*Kath khane larva*	Bark-eating caterpillar, bark borer	Lepidoptera	Cossidae	Throughout the year, more abundant in monsoon	Damage most visible on the bark with the damage caused by the larva boring into the trunk and branches creating tunnels underneath. Dark brown masses consisting of wood particles and faecal matter are seen plastered on the barks of infected plants
12	*Phyllocnistis citrella*	*Pat khane kira*	Citrus leaf miner	Lepidoptera	Gracillaridae	Whenever new leaves appear	Damage of leaves through leaf mining by larvae
13	*Eudocima sp*	*Seto moth*	Moth	Lepidoptera	Noctuidae	May - Dec	Damage to leaves near the shoot tips and areas where the leaf is rolled

impact on crop losses which directly impacts thousands of farmers of Sikkim. The information will also serve as an important outreach material to the concerned government agencies to sensitize farmers about the array of pests and to train them in identifying pests. Since orange orchards are pivotal to the sustenance of rural communities of Sikkim, the farmers may be trained to report the pest incidence and share local traditional management practices they use to counter pest out breaks that have disasterous effect on orange production.

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