

Receded Sweet Orange Losses From Chinese Citrus Fly, *Bactrocera Minax* (Enderlein) in Sindhuli Citrus Orchards: Lesson From Area Wide Control Program

Debraj Adhikari¹, Resham Bahadur Thapa¹, Samudra Lal Joshi², Jason Jinping Du³
and Umesh Kumar Acharya²

¹Agriculture and Forestry University, Nepal

²Nepal Agricultural Research Council, Nepal

³Beijing Ecoman Biotech Co. Ltd., China

Corresponding author's e-mail: adhikari.debraj@gmail.com

Abstract

*Citrus is an important fruit commodity in the mid-hills of Nepal. Fruit flies are the most important pests in the horticultural fruits of tree and vegetable origins. These days, among fruit flies, Chinese citrus fly (CCF), *Bactrocera minax* is becoming an important economic pest of citrus in Nepal. It was first reported in 2007 in sweet orange at Paripatle, Dhankuta, one of the eastern citrus growing hilly districts of Nepal. However, CCF is seemed to be extending to central and western hilly citrus orchards. It invaded economically for the first time in sweet oranges in the Sindhuli citrus orchards in 2014 resulting in 17 % fruit losses that increased to 35 % in 2018. The formalizing of Area-Wide Control Program (AWCP), in 2019, for the first time, for CCF management reduced its fruit loss rampages to the never-ever recorded lowest level, 15 %. AWCP along with technically proper understanding of its different stages in life-cycle, behavior in each stage and a proper AWCP managerial implementation made the entire CCF managing program a success.*

Keywords: AWCP, Fruit fly, Fruit loss, Sweet orange, Sindhuli

INTRODUCTION

The significance of fruit flies as pests in Nepal has been noticed since the commercialization of agriculture in the country. In context to Nepal-China agreement in 2012 to export citrus fruits from Nepal to China with due consideration of insect quarantine regulations (Nepal China Agreement, 2012) switched on a protocol based regular fruit fly surveillance in the citrus orchards of Sindhuli and Syangja districts (PPD, 2014). Sharma et al. (2015) reported

ten fruit fly species (*Bactrocera cucurbitae*, *B. dorsalis*, *B. zonata*, *B. tau*, *B. scutellaris*, *B. minax*, *B. caudatus*, *B. diversus*, *B. correcta* and *B. yoshimotoi*) from Nepal. Similarly, *B. tuberculata* and *B. artifacae* were caught in methyl eugenol and cue lure traps, respectively, in Dhankuta, Nepal (Bhandari et al., 2017). Thus, including *B. tsuneonis*, *B. nigrofemoralis*, *B. latifrons*, *Dacus longicornis* and *D. ciliates*, an accession of fruit flies in Nepal has been escalated to 17 species (Adhikari et. al., 2019). But, in 2007, species status change in

B. tsuneonis to *B. minax* (Paudyal et al., 2016; Joshi, 2019) retracted the Nepalese fruit fly species accession to 16 in number.

The Chinese citrus fly (CCF), *Bactrocera minax* (Enderlein) (Diptera: Tephritidae), is one of the most destructive insect pests of citrus in the Asian region from southwestern China to Nepal, India (Sikkim, West Bengal) and Bhutan (Bhandari et al., 2017, Wang et al., 2016 and Drew et al., 2013). CCF, as an oligophagous pest, feeds exclusively in citrus fruits (Xia et al., 2018), and prefers tight skinned to loose skinned citrus fruits in Nepal. Presently, it is distributed exclusively in the citrus orchards located in the eastern hilly areas to central hilly areas of the country. However, before its taxonomic status becomes clear, *B. dorsalis* was incriminated for the sweet oranges losses in the eastern hilly citrus orchards of the country. The proper taxonomic identity of the big bodied fruit fly infesting sweet oranges in Dhankuta citrus orchards is known as *B. minax* in 2007 by virtue of identification cooperation of the Museum of Florida, Gainesville, USA (Steek, 2007). Pursuing an extensive fruit fly survey of citrus orchards of eastern and western hill districts, namely Dhankuta, Tehrathum, Gorkha, Lamjung and Syangja disclosed *B. minax* extension to Tehrathum citrus orchards while none of the infested citrus fruit samples from other districts except Dhankuta yielded this fruit fly (NCRP, 2011). The harshness of *B. minax* in the eastern citrus orchards is still continued (Acharya and Adhikari, 2019) while *B. minax* originated problem is extending to the citrus orchards of central and western Nepal (Joshi, 2019). Brooding on the present and the past national *B. minax* situations indicated it incurred sweet orange and mandarin losses have been escalating since 2014 in the country (Adhikari and Joshi, 2018). Thus, the circumstances urge its strong legal approach at the first hand, and simultaneously gearing on the system approach

to its area-wide monitoring and management to reduce the *B. minax* citrus losses within an economic level. This paper highlights an abridged status of the sweet orange losses in citrus orchards of Sindhuli district since the inception of Chinese citrus fly, *B. minax*, its time bound different life stages in univoltine life cycle pattern, and lessons learned from its area-wide control program using protein hydrolysate lethal lure bait.

METHODOLOGY:

This paper is prepared based on the information derived from different published (journals, proceedings, edited books with contributed articles and internet) and unpublished scientific papers and authentic popular articles on Chinese citrus fly, *B. minax* in the country and abroad.

Area-wide control approach was adopted using Beijing Ecoman Biotech Co. Ltd manufactured Great Fruit Fly Bait.

RESULTS AND DISCUSSION:

Sweet Orange Losses from Chinese Citrus Fly, *Bactrocera minax* (Enderlein) in Sindhuli district

The production and productivity of sweet orange in Sindhuli district are observed in an increasing trend as per the total area covered and productive area of sweet orange cultivation (Table 1). The average sweet orange losses due to Chinese citrus fly (*Bactrocera minax*) in Sindhuli has been observed to be in an increasing trend since its first survey in 2014 and extended to 2018 to the tune of 17% to 35%, respectively. A very hopeful and encouraging break in the loss trend to 15% was obtained in 2019 by virtue of area-wide control program using protein hydrolysate lethal lure bait (Great Fruit Fly Bait) (Figure 1).

Year of Production	Total area (ha)	Productive area (ha)	Production (mt)	Productivity (mt/ha)
2014	1110	623	7218	11.58
2015	1210	641	7698	12.00
2016	1221	661	7937	12.01
2017	1325	716	8613	12.03
2018	1327	720	8820	12.25
2019	1345	725	8881	12.25

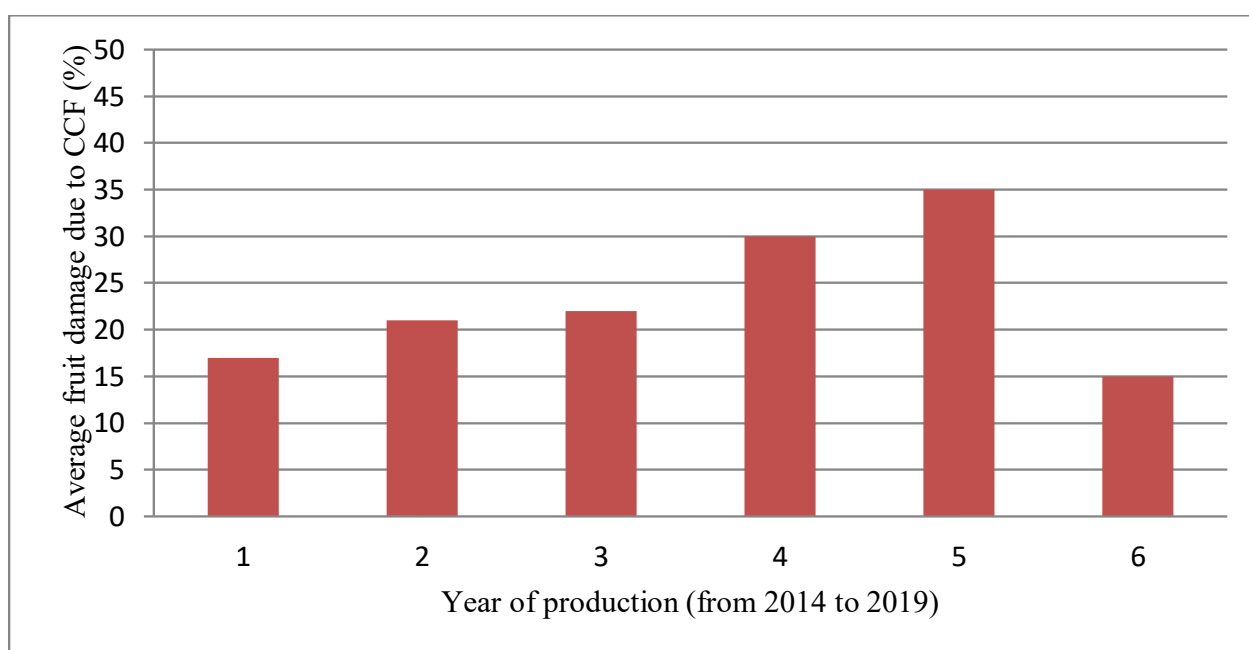


Figure 1. Average sweet orange fruit damage due to Chinese citrus fly (*B.minax*) in Sindhuli, Nepal.

Life-cycle of Chinese citrus fly in Sindhuli, Nepal

Chinese citrus fly (*B.minax*) is a univoltine fruit fly species. The life-cycle stages and behavior of this pest are important aspects to develop strategy to manage the pest. As per its problem observed in the sweet orange (*Citrus sinensis*) at Sindhuli district from 2014 to till date, the following presented chart represents the life-cycle stages in the different months of year (Figure 2). Similar life-cycle stages and time period are mentioned in China (Xia et al., 2018).

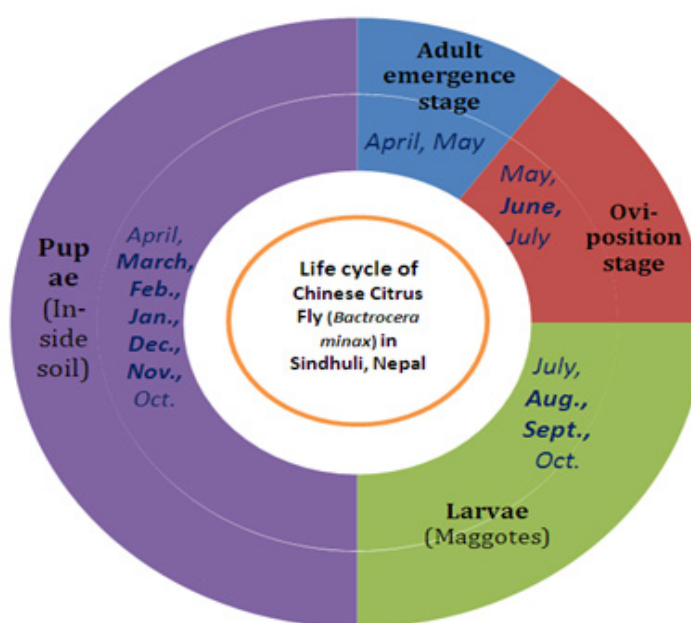


Figure 2. Life-cycle of Chinese citrus fly in Sindhuli, Nepal.

CCF adults are found to emerge from soil during April to May and remained active for oviposition after feeding proteinous food in May to July. Female adult laid eggs below the skin of the immature sweet orange. Eggs developed into maggots (larvae) and fed in pulp that ruined the quality of fruit. Maggots remained actively developing inside fruit from July to October. An infested fruit found to be lighter in weight compared to healthy fruit. Matured maggots made noticeable exit holes in the skin and escaped to soil down the fruit. Any immature maggots inside the fallen fruit to soil remained inside until mature stage. The mature maggots entered into soil and transformed in pupae that remained inside soil for around 6 months (October to April). Management strategy of this pest should be linked with the biology and immediate behavior of immature stages of CCF. Integrated management measures practiced against this pest achieved fruit losses reduction in the coordinated community mobilization in orchards.

Area-Wide Control Program of Chinese citrus fly

The concept of Area-Wide Control Program (AWCP) involved developing and integrating biologically-based pest control technologies into a comprehensive management package that yielded economically viable, environmentally friendly and sustainable management of

B. minax in the citrus orchard. Considering the peculiar characteristics of the pest management, measures should be implemented in a large area at a time simultaneously. AWCP to run included managerial and technical aspects. The managerial aspect consists of stakeholder’s consultation, clustering of orchards for spray plan, activity orientation to spray persons and orchard owners, and activity monitoring and feedback. At the other hand technical aspect included fruit loss assessment, monitoring adult fly emergence date in the orchards, initiating spot application of protein bait and maintaining sanitation in orchard to prevent maggots in infested fruits to go to pupation into soil.

Table 2. Major technical steps of AWCP of CCF

Understand the life-cycle of Chinese citrus fly: Univoltinism	One year life-cycle. All stages (adult, egg, larva and pupae) are bigger in size than other <i>Bactrocera</i> species.
Understand the behavior of different stages of the life-cycle of CCF.	Adult CCFs not attracted to male lures (methyl eugenol and cue lure). Eggs inside fruit. Maggots inside fruit until fully matured. Maggots leaving fruits to soil to transform into pupae. Immature maggots remain inside the fallen fruit to soil until fully matured.
Monitoring of CCF emergence date.	Netting in the orchard ground, and/or protein bait trap etc. during March, April and May as per the elevations of the orchard sites.
Protein bait preparation.	Mix 1 part of protein bait in 2 parts of water.
Spray program (Initiate the spray program within 10-15 days of CCF emergence.)	Spray 50 ml prepared protein bait solution in 0.5-1 m ² area underside leaves. Spray should apply on an assigned spot in one of the randomly selected trees among 3 productive trees for 10-12 times in a weekly interval.
Sanitation: (Prevent maggots to transform into pupae in soil in order to break CCF life-cycle.)	Infested fruits should be buried in the pit at least 30 cm deep into soil or burn or close air-tight inside a plastic bag or put into water tank/pond or into bio-gas plant or feed to livestock or keep fruits in processing to kill maggots inside.

AWCP includes eco-friendly pest management measures in contrary to traditional blanket pesticide spray. It reduces the use of chemical pesticides and helps maintaining sound ecosystem. In 2018, growers of Golanjor 4, Tinkanya, Sindhuli saved sweet oranges in orchards extending to 40 ha by adopting an Area-wide Control Program (AWCP) focusing on the life-cycle of CCF (Adhikari et al., 2020). AWCP helped mass female CCFs annihilation by virtue of female lure, the lethal protein bait, sprayed in a limited assigned spot (0.5 to 1 m²) on underside of leaves of one tree randomly selected among 3 productive sweet orange trees synchronizing with adult CCF female emergences in the orchard. Besides, collection and proper disposal of fallen maggot infested fruits on soil surface in an entire fruiting season also helped growers to break CCF life-cycle that checked fruit fly generation that could have infested in 2019 season's sweet oranges. Similarly, in 2019, Prime Minister Agriculture Modernization Project, Junar Superzone, Sindhuli took technical lead to initiate AWCP in citrus orchards, and a repercussion was a remarkable achievement in sound sweet orange production in Sindhuli that never occurred before.

CONCLUSION:

Area-wide Control Program (AWCP), an evolved crop protection idea, in true sense is not brand new in the globe. The success story of AWCP in citrus orchards against *B. minax* in China was a temptation to Nepal to test this approach with Chinese technology against *B. minax* pestilence in Sindhuli sweet orange orchards under the supervision of the Office of Sweet Orange Superzone. Pilot AWCP implementation in 2018 with remarkable reduction of fruit losses against *B. minax* in this area was very much encouraging to sweet orange farmers of Sindhuli. Economic cooperation of Sindhuli

sweet orange farmer aided with monetary benefit from Sweet Orange Superzone at Sindhuli practiced AWCP against *B. minax* in 2019 citrus fruiting season. A remarkable *B. minax* free sweet orange flooded into the Sindhuli market that ever occurred in the history of sweet orange production in this area. The ever escalating *B. minax* incurred fruit losses this year sealed at 15%, and that was a real achievement prized to farmers by virtue of AWCP implementation in Sindhuli citrus orchards. The result would have appeared even better if the citrus farmers would have cooperated openly to AWCP practice. The hitches from farmers were because of their low level literacy status, backwardness in socio-economic status, and low acreage holding in citrus farming.

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ERRATUM:

The title of the article has been appeared as “Receded sweet orange losses from Chinese citrus fly, *Bactrocera minax* (Enderlein) in Sindhuli citrus orchards: Lesson from area wide control program” in hard copy which should have read as “Receded sweet orange losses from Chinese citrus fly, *Bactrocera minax* (Enderlein) in Sindhuli citrus orchards: Lesson from area wide control program” and corrected accordingly in e copy of the manuscript.