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MANAGEMENT OF CHINESE CITRUS FLY, *Bactrocera minax*, (ENDERLEIN) (DIPTERA: TEPHRITIDAE) IN KATHMANDU, NEPAL

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ABSTRACT

The research on management of Chinese citrus fly (*Bactrocera minax*) was conducted at a citrus orchard. The average pupal length and breadth was recorded 7.98±0.22 mm and 3.81±0.13 mm respectively. The average length and breadth of adult fly was recorded 8.20±1.00mm and 4.5±0.00mm respectively. The average citrus fruit loss (%) due to Chinese citrus fly in 2021 at Chhahari Retreat, Kathmandu was 86.80%. It revels this is one of the serious pest in citrus fruits there. So, this action research was performed to manage the problem. AWCP (Area-wide control program) is practiced for the management of Chinese citrus fly by using spot application of protein bait. Lethal protein bait having 25% protein hydrolysate and 0.1% abamectin (Great Fruit Fly Bait) was used in spot application (one spot among 3 productive citrus trees) in weekly interval for 12 weeks. Following the AWCP, fruit loss was reduced to 27.68% in 2022 harvest. The overall fruit loss (%) was reduced by 59.12 % compared to year 2021 ($p<0.001$) by the spot application of protein bait.

Key words: *Bractrocera minax*, protein bait, sweet orange, spot application

INTRODUCTION

Citrus has a big impact on how people get their nutrients and how much money producers in Nepal make. Citrus fruit cultivation, in particular the SUNTALA (Mandarin) and JUNAR (Sweet Oranges) varieties, has been practiced in Nepal for generations. Citrus is one of Nepal's major fruit products in terms of area covered, output, and export potential. In fact, Nepal is one of the centers for citrus diversity, and many different species of citrus are grown here (Adhikari and GC,

2020). It is grown in more than 50 districts in Nepal (Adhikari and GC, 2020). In recent years, the Chinese Citrus Fly (CCF), *Bactroceraminax*(Enderlein) (Diptera: Tephritidae), has emerged as a significant threat to the production of the citrus fruits with tight skin, such as sweet Oranges, lemon, and lime as well as loose skinned mandarin fruit. Originating in China, it appears that this invasive species migrated into north-eastern Nepal through India and Bhutan (Adhikari et al., 2020).

Chinese citrus fly is one of the major pests of citrus in Nepal. The pest is more problematic in the eastern part of the country, Nepal. Because of its bigger size and univoltine life cycle, as well as its oligophagous feeding behavior and exclusive feeding on citrus fruits, this pest is unlike any other. It is not attracted by para-pheromone lures, cue lures, or methyl lures (Chen and Xie, 1955). Because of the difficulties associated with the control of this pest by chemical insecticides, farmers had experienced great losses in Sweet Oranges (Wang et al., 2018).Chinese citrus fruit fly is one of the major pests of citrus and is a big threat to commercial citrus farming. This fruit fly can cause (30-100%) reduction in yield of citrus (Sharma et al., 2015). The fly prefers to swoop down on its prey. Insects attack practically all citrus fruits, including sweet Oranges (Xia et al., 2018). Sex pheromones and parapheromones can be used to track most fruit flies; however, *Bactrocera minax* is not known to be attracted to any male lure (Drew et al., 2006, Zhou et al., 2012). Climate conditions have a significant impact on fruit fly species' biology, behavior, and morphological features (Dominiak et al., 2006). Identifying the pest and learning about its habitat and behavior before implementing any pest management strategies is the most fundamental necessity for successful pest management. The males of this species of *Bactrocera* are not drawn to any known chemical lures, in contrast to the majority of pest species. Protein bait traps (either protein hydrolysate or protein autolysate) can be used to monitor both sexes, however they also catch a lot of unrelated insects. The recurrent high infestation levels of *B. minax* in China highlight the need for a deeper comprehension of its biology and ecology in order to create and use more effective management techniques. Through open field surveys and video recordings, we investigated the eating and mating behaviors of *B. minax* in situ (Citrus orchards and surrounding ecosystems) as part of the development of a sterile insect method program against this pest (Dong et al., 2014).

From May to July 2018, the AWCP was implemented in Nepal by Junar Super-zone, Sindhuli under the Prime Minister Agriculture Modernization Project (PMAMP). The main components of the AWCP were the use of protein bait called Great fruit fly bait (Protein hydrolysate 25+0.1 percent Abamectin) as spot

applications underside of the 0.5 to 1 m^2 leaf for 10 times at a weekly interval, in accordance with the protocol developed by Ecoman Biotech, China. It's interesting to note that from 56.7 percent in 2017, the average fruit loss attributable to the fly dropped to 10.90 percent in 2018. While 6 percent of the infestation in the 10.90 percent of the population was brought on by causes other than the CCF, water stress, nutritional problems, and bug infestations (Adhikari et al., 2020). Unsuitable orchard management techniques enhance the likelihood of a fruit fly; as a result, routine training/pruning operations and a balanced fertilizer dose are advised. A balanced fertilizer DOSE SERVES TO REVITALIZE THE ORCHARD WHILE TRAINING AND PRUNING REMOVE THE INSECT'S HABITAT (GAUTAM et al., 2019). Maintaining field sanitation lowers the fly incidence from 50% to 100% to 1% (Xia et al., 2018). After pollination and the development of little fruits, fruit can be bagged with wax-coated or oil-soaked paper to assist prevent fly assault and spread. According to reports, the brown paper bag worked well to keep fruit flies under control (Sarker et al., 2009). Another approach to stop future spread is proper disposal of contaminated fruits. To prevent the spread of the pest, it can be buried deeply, tightly packaged in polythene plastic, submerged in water, burned, and fed into the hooper of a gas plant powered by FYM. Fruits that are contaminated (fallen fruit) must be collected and buried at least 30 cm below the surface, in a trench that is between 1 and 1.5 meters deep.The general objective of the study is to know the morphology and management of Chinese citrus fly. To measure the diameter of fruit, know the morphological characters of Chinese citrus fly, assess the damage in 2021 and 2022 after protein bait application are other specific objectives.

MATERIALS AND METHODS

Site selection

The site was selected on the basis of the availability of a problematic citrus orchard in Kathmandu. The problematic citrus orchard was purposefully selected for the study. Compatibility with the field owners was taken into account as well. The cost of the total project was considered and the distance to the field was taken into consideration as well. The study area was confined to the Kathmandu district at Chhahari Retreat, Budanilkantha. The orchard is situated at 1485.17-meter masl and thelatitude and longitude was 27.7863210 degree N, 85.3542847 degree E respectively. The research was done from3rd May, 2022 till 19th July, 2022.

Record of citrus fruits in the orchard and measurement of morphological characteristics of pupae and adults

Manual Vernier Caliper was used to measure the breadth of the fruit for research. This measurement was taken so that the spraying could be started at the optimum time i.e. when the average fruit size of the orchard is 10-15 mm. Manual Vernier Caliper was used to measure body length, breadth, wingspan of the fruit fly, the length and breadth of pupae. The breadth of the adult fly was recorded by measuring the mesothorax portion. Apical tip-to-tip of forewings including the thorax was measured to compute wingspan. In addition to the aforementioned variables, information on body type and color was gathered. Puape (n=23) was collected from the site (Chhahari resort) on 1st May, 2022. The pupae were carefully placed in a transparent plastic container covered with thin muslin cloth for ventilation purposes. From the pupae collected, 2 adult flies emerged which were used to measure major morphometrics parameters like length and breadth of adult flies, and wingspan at Chhahari Retreat, Kathmandu.

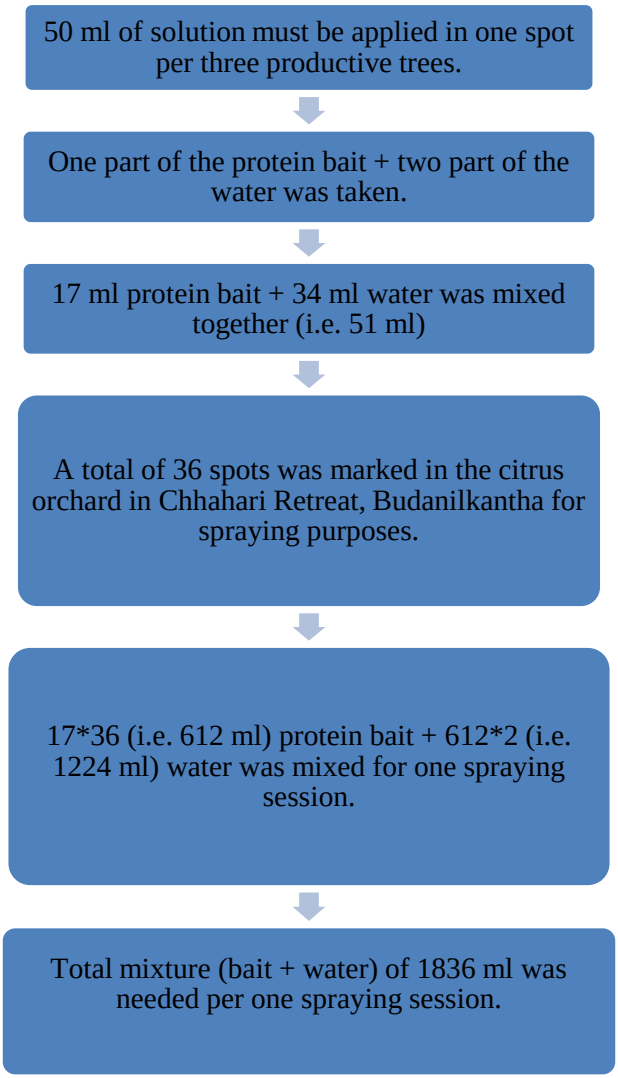
Damage assessment of citrus fruit in 2021 and protein bait application and damage assessment on 2022

The damage assessment of the citrus fruit in 2021 was done by questioning the owner of the orchard about the loss of each specific tree that we had marked. Pieces of colorful ribbons were used to mark the trees. Protein bait and water were combined in a ratio of one part protein bait to two parts water to create an aqueous bait solution for treatment. Thus, the prepared aqueous bait solution was sprayed @ 50 ml solution over 0.5 to 1 m^2 area under the leaves in one among three productive Sweet Oranges trees at the location in the weekly intervals, which was repeated 10-12 times (Ecoman-Biotech, 2018). A total of 12 spraying sessions was performed for research purposes at Chhahari Retreat, Budanilkantha at weekly interval. Application of protein bait during rainfall was avoided as the solution could be washed away by the rain. Proper precautions were taken during the application of protein bait solution in the citrus orchard and sanitation was maintained as well. The application of the solution was done through Knapsack sprayer. For preparing the solution, we used mixture of water and bait in the ratio of 2:1. The protein bait used (Great Fruit Fly Bait) contained 25% protein hydrolysate and 0.1% abamectin.

Data Analysis

The diameter of the fruits recorded was used to analyze the minimum, maximum, S.D., S.E., with the help of Ms. Excel to get the optimum time to start the spot

application of protein bait spray. The varieties of citrus trees and the number of productive and non-productive trees recorded were sorted in the form of pie-chart and bar graph respectively. The mean and range of the adult fly (length and breadth) as well as the wing span was analyzed from Ms. Excel.



Photograph 1. Protein bait spot

Photograph 2: Spot application of protein bait

RESULTS AND DISCUSSION

Record of citrus fruits in the orchard

Citrus fruit diameter measurement in Chhahari Retreat, Budanilkantha

We measured citrus fruits in the orchard on 15/01/2079 B.S. This measurement helped us to spray the protein bait at the optimum time. The average fruit size was 9.78 mm from the total of 30 fruits that we measured. Figure 1 is a pie-chart showing the percentage of different citrus trees present in the orchard at Chhahari Retreat, Budanilkantha. This pie-chart helps us know varieties and percentage of citrus trees avaliable in orchard as well.

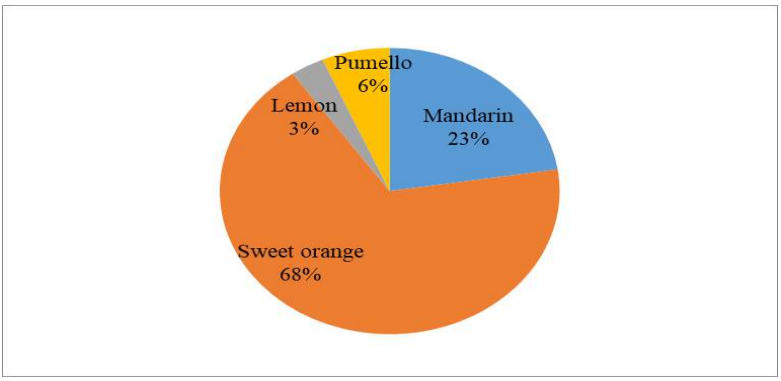


Figure 1. Types of citrus fruit in percentage

Figure 2 tells us the number of productive and non-productive citrus tree varieties present in the orchard at Chhahari Retreat, Budanilkantha. The non-productiveness of citrus tress was confirmed when it was not producing any fruit for more than a year.

Body size of *B. minax*:
The adult body ranged from 9.2 mm to 7.2 mm in length with a mean of 8.20±1.00 mm and 4.5mm in breadth with a mean of 4.50±0.00 mm. However, the average body length (12.52 ± 0.26 mm and 14.29 ± 0.20 mm), breadth (3.39 ± 0.05 mm and 3.90 ± 0.06 mm) and wingspan (22.80 ± 0.19 mm and 23.51 ± 0.23 mm), male and female respectively was measured in the morphological study of adult

Chinese citrus fly, Nepal (Adhikari 2022). Only two adults was taken for measurement due to the high mortality rate of pupa.

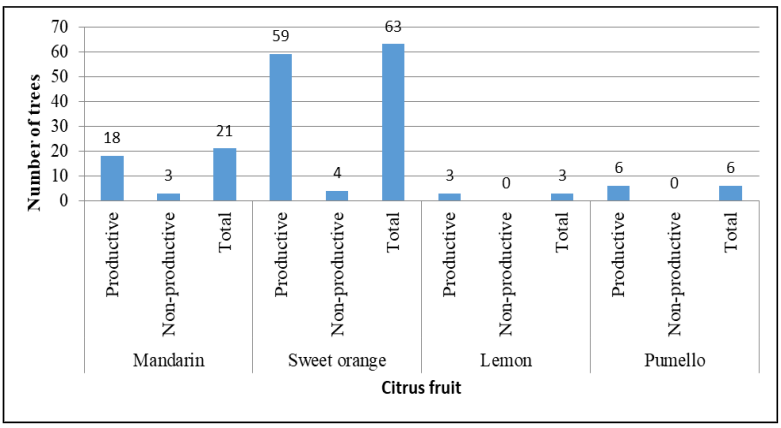


Figure 2- Citrus orchard detail in graph

Wing span of ***B. minax*****:**
The pupae ranged from 9.9 to 5.4 mm in length with a mean of 7.98±0.22mm and the breadth of pupae ranged from 5.3-2.4 mm with a mean of 3.81±0.13 mm. The actual wingspan ranged from 11.7-11.5 mm with a mean of 11.60±0.10 mm.

Fruit damage assessment
In a non-AWCP condition, the highest CCF mean sweet orange fruit damage % in 2021 was 86.80 % in Chahari Retreat, Budanilkantha. Hence, with AWCP in 2022, the mean fruit damage receded remarkably in comparison to without AWCP in 2021. The recession in mean fruit damage in 2022 is obviously an impact of AWCP with applications of the Great Fruit Fly Bait in the citrus orchard. The clearly declining mean fruit damage percentages in 2022 by virtue of AWCP's handling of B. minax in citrus orchards was statistically confirmed using the Student's "t-test" to determine the effectiveness of the AWCP management against CCF in the citrus orchard of Chahhari Retreat, Budanilkantha. The mean fruit damage (MFD) 86.80% in 2021 was reduced to 27.68% (very highly significant; $p \leq 0.0000$). Chinese citrus fly management strategies can vary in their efficacy depending on the location of the orchards, the vegetation in the area, the sprayers' ability to apply spot treatments, and other managerial factors. Van Schoubroeck (1999) emphasized the necessity of management and monitoring methods for the growth of successful IPM practice.

Table 1. Student's t-test for fruit damage assessment

Particulars	Variable 1 (2021)	Variable 2 (2022)
Mean fruit damage percentage (%)	27.680000	86.800000
Variance	16.310000	34.083333
Observations	25.000000	25.000000
Pearson Correlation	0.110628	
Hypothesized Mean Difference		
df	24.000000	
t Stat	39.639483)	
t-test for mean fruit damage % P(T<=t) one-tail	0.000000	
t Critical one-tail	1.710882	
t-test for mean fruit damage % P(T<=t) two-tail	0.000000	
t Critical two-tail	2.063899	

RESULTS AND DISCUSSION

Chinese Citrus Fly (CCF), *Bactroceraminax* (Enderlein) (Diptera: Tephritidae), has emerged as a significant threat to the production of the citrus fruits with tight skin, such as sweet oranges, lemon, and lime as well as loose skinned mandarin fruit. Originating in China, it appears that this invasive species migrated into north-eastern Nepal through India and Bhutan (Adhikari et al., 2020). This study helps us know about citrus fruits, fruit flies, Chinese citrus fly in detail. We learn about mapping and labelling of an orchard, measuring the diameter of fruits through this research. Morphological study of the Chinese citrus fly and its management by spot application of protein bait is done during this study. The detailing of the citrus orchard by recording the varieties of citrus trees along with the number of productive or non-productive (each variety) is done. Rearing of pupae is done during the study where the length, breadth, and range of pupae (n=23) is recorded. Similarly, adults (n=2) are taken to measure their length, breadth, range as well as their wing span. The shape, size, and color of the adult is studied in detail. The loss of citrus fruit in the past year is recorded along with their average, minimum, and maximum. Lethal protein bait having 25% protein hydrolysate and 0.1% abamectin is used in spot application (one spot among 3 productive citrus trees) in weekly intervals for 12 weeks (Ecoman-Biotech, 2018). As abamectin is registered to manage ornamental insect pests, spinosad would have been a better killing agent for Chinese citrus flies but due to the unavailability of protein bait consisting of spinosad at that time abamectin was

used. The average citrus fruit loss (%) due to Chinese citrus fly in 2021 at Chhahari Retreat, Kathmandu is minimized as a result of protein bait application in 2022. AWCP (Area-wide control program) is used in the management of Chinese citrus fly by maintaining sanitation and spot application of Protein bait.

CONCLUSION

This study helps us in the identification of the Chinese citrus fly from its pupal stage to its adult stage. We got to know that precautions are very necessary for the management of *Bractrocera minax* and field sanitation to control maggots along with spot application of protein bait are major management strategies in controlling them and starting the treatment process early is highly recommended to have any chance of controlling its damage. As we already know the losses caused by Chinese citrus flies at Chhahari Retreat, Kathmandu in 2021 by questioning the owner about losses in all 25 citrus trees that we had marked. In order to know the impact we have made on preventing citrus production loss, in 2022 similar questioning was done to the farmers from which we got to know that the overall fruit loss (%) was reduced by 59.12 % compared to year 2021 by the spot application of Great fruit fly bait (25 % Protein hydrolysate + 0.1 % Abamectin).

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