



Chinese citrus fly, *Bactrocera minax* (Enderlein) (Diptera: Tephritidae) in Sikkim: a study on its morphometrics

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ABSTRACT: A study on the morphology of adult Chinese citrus fly, *Bactrocera minax* was carried out on April 2023, at State Bio-control Lab, Agriculture Department, Gangtok, Sikkim. The mean body length of female recorded significantly higher, i.e. 11.28 ± 0.18 mm, than male, i.e. 10.10 ± 0.25 mm, with the mean difference of 1.17mm ($p = \leq 0.01$). Female had a wider body (3.60 ± 0.06 mm) compared to male (3.09 ± 0.10 mm) ($p = \leq 0.01$) which differed significantly by 0.51mm. Adult female possessed a wider wingspan, i.e. 23.30 ± 0.26 mm significantly different than adult male, i.e. 22.25 ± 0.4 mm with the mean difference of 1.04 mm ($p = \leq 0.01$). Similarly the average wing length measured 8.65 ± 0.21 mm in male and 10.26 ± 0.06 mm in female with the mean difference of 1.61mm. The ovipositor length recorded 4.00 ± 0.20 mm. This information is useful to distinguish between Chinese citrus fly and other fruit fly species of citrus orchards and useful in planning of the suitable management options.

Keywords: Adult, *Bactrocera minax*, fruit fly, morphometrics, Sikkim mandarin

INTRODUCTION

Mandarin orange (*Citrus reticulata* Blanco) a highly polyembryonic species belonging to family Rutaceae is the most common among Citrus fruits grown in India. It occupies nearly 50% of the total citrus area in India. Mandarin group includes all types of loose jacket oranges commonly called as Santra or mandarin such as Nagpur Santra, Coorg Santra, the Khasi Mandarin, Sikkim Mandarin etc. Sikkim Mandarin is a commercially desirable ecotype of mandarin group native to Sikkim. It is the most important traditional fruit of Sikkim and is similar to Nepal or Assam or Darjeeling or Khasi mandarin. Insect pests are one of the major constraints for increasing the production and productivity of crops.

A large number of insect pests attack mandarin right from immature fruiting stage and continue till harvest of the fruit. Among them, Chinese citrus fly *Bactrocera minax* (Enderlein) (Diptera: Tephritidae) is a major pest causing both qualitative and quantitative loss. The Chinese citrus fly is a major citricultural pest species in China, Bhutan, India and Nepal (Adhikari *et al.*, 2020; Chauhan *et al.*, 2020; Dong *et al.*, 2014; White and Wang, 1992). It had been reported to be well distributed to a wide range of temperate regions of Asia, including Nepal, Bhutan,

China and India (West Bengal and Sikkim) (Fan *et al.*, 1994, Dorji *et al.*, 2006, Drew *et al.*, 2006; Jha *et al.*, 2019). The size of adults and other stages of *B. minax* is larger than other fruit fly species like *Bactrocera dorsalis* (Hendel), *B. zonata* (Saunders), *Zeugodacus cucurbitae* (Coquillett) etc., they are oligophagus in food habit, univoltine in life cycle and is never attracted to parapheromones like other common frugivorous *Bactrocera* species (Adhikari *et al.*, 2020; Adhikari and Joshi, 2018; Xia *et al.*, 2018). Therefore, this is a unique fruit fly species among horticultural pests.

Evidence suggests that this species has originated in the high temperate Southern Yunnan Guizhou Plateau and dispersed through China's waterways system (Xia *et al.*, 2018). Because of its flying capacity to great distances, this insect has made its way from China through Bhutan, Sikkim, India and extended to citrus orchards in the eastern middle mountain regime of Nepal (Adhikari *et al.*, 2022b). Biology and behavior including morphological traits of fruit fly species are highly affected by climate factors (Dominiak *et al.*, 2006). The female fruit flies puncture the peel and lay eggs into the soft and tender fruits (Zhang 2007). Maggots feed inside the developing fruits causing rapid decay, which later becomes inedible and finally dropped prematurely (Wang *et al.*, 2009).

The maggots of *B. minax* were found escaped out of the fruits while attached to the tree and pupate in the soil. The lifecycle of this species is reported to be one of the longest amongst *Bactrocera* spp. (Adhikari *et al.*, 2021; Li *et al.*, 2019). Effective management of this dreaded pest is very much difficult due to its concealed feeding habit and typical life history.

The farmers of Sikkim (a Himalayan state of India), practices organic farming system, as the entire state is organically certified following all the guidelines of NPOP (National Programme of Organic Farming). Due to complete ban on synthetic pesticides, there has been upsurge in the many pests, including the fruit fly population. Over the last 5-6 years, fruit drop in *C. reticulata* due to infestation of fruit fly is also increased with damage extent ranging from 50-70%. So far, *B. minax* is not reported to be the major pest for causing the fruit drop in the state of Sikkim. Recommended management practices like use of methyl eugenol trap, dumping of fallen fruits and orchard sanitation have been practiced by the farmers for management of fruit drop, considering the species of *Bactrocera*. However, the *B. minax* cannot be managed by the above practices. Due to lack of in depth knowledge on the characteristics of *B. minax*, and the identification of the pest there is high implication on the management practices.

Keeping in view the facts, present investigation is envisaged to study the morphological traits/characteristics of Chinese citrus fly, *Bactrocera minax* which will help in field diagnosis to differentiate it from the other fruit fly species of citrus orchards and in turn, it will be useful in planning of the suitable management options.

MATERIALS AND METHODS

The present study was conducted during 2022-23 at State Bio-control Lab, IPM, Agriculture Department, Gangtok, Sikkim, India (27.310576 Latitude and 88.597589 Longitude). Citrus fruit drop led by Chinese citrus fly infestation was reported from Beng-Bhirkuna, Khamdong, East Sikkim (27.26° N Latitude, 88.48° E Longitude, Altitude 1148 meters) and infested fruits of Sikkim mandarin (Local cultivar) were collected from the orchard during the last week of November, 2022. The collected samples were then brought to the laboratory.

Then the collected samples were carefully opened and maggots were taken out from the infested fruits. Maggots were then reared (n=100) in room condition (average temperature 9-10° C and relative humidity 90%) at IPM Lab. Maggots were then placed in glass jar filled with soil upto the height of 5cm height and mouth of glass jar was tightened with muslin cloth and rubber band to prevent the escape of maggots and maggots were replicated 10 times. Fully mature larvae transformed into pupae within one month and pupae were counted by gentle stirring the soil and placed in the same glass jar and covered with muslin cloth and partially filled with moist sand. Emergence of adult were also recorded. Adults emerged after four-five months and ten numbers of randomly selected freshly emerged adults were taken for study of major morphometrics parameters like length and breadth of adult flies, wingspan, length of wing and ovipositor on May, 2023 at IPM Lab, Tadong and others were preserved as specimen in the laboratory. Ten replicates of each parameter were measured and recorded.

Measurement of adult flies

Calibrated digital Vernier Caliper (Serial No: B22036450, Model No. CD-8"ASX) was used to measure body length, breadth, wingspan and length of wing of both male and female individually, and female fly ovipositor. The breadth of adult fly was recorded measuring the mesothorax portion. Apical tip to tip of forewings including the thorax was measured to compute wingspan, length of wing was calculated from joint part of the wing to apical tip of the wing. Similarly, the length of ovipositor was measured from joint portion at abdomen to the tip of the ovipositor (Roccia *et al.*, 2013). In addition to the above parameters, body shape and color were also recorded. Statistical Analysis was done by using SAS Software to study the mean comparison of

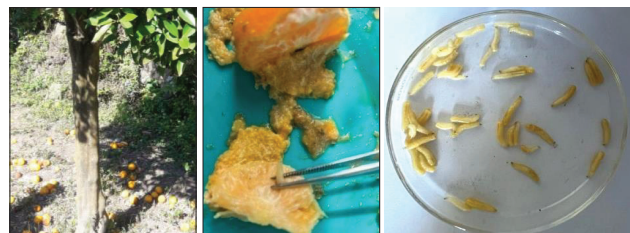


Fig. 1. Collection of infested fruits from the field to study the life cycle of *B. minax*

Table 1. Body length and breadth of adult *B. minax*

Sex	Length (mm)		Breadth (mm)	
	Range	Mean \pm SE	Range	Mean \pm SE
Male (n = 25)	9.44 -11.65	10.10 \pm 0.25	2.66-3.56	3.09 \pm 0.10
Female (n = 25)	10.34 -11.88	11.28 \pm 0.18	3.32-3.96	3.60 \pm 0.06

Table 2. Wingspan and length of adult *B. minax*

Sex	Wingspan (mm)		Length of wing (mm)	
	Range	Mean \pm SE	Range	Mean \pm SE
Male (n = 25)	20.54 -23.98	22.25 \pm 0.40	7.93 – 9.88	8.65 \pm 0.21
Female (n = 25)	21.59-24.12	23.30 \pm 0.26	9.87 – 10.53	10.26 \pm 0.06

body size (length and breadth) and wing length and wing span of the adult male and female.

RESULTS AND DISCUSSIONS

Body size of *B. minax*

The Chinese citrus fly, *B. minax* is the largest one among horticultural fruit fly pests (Xia *et al.*, 2018) and other Bactrocera species. The length of body of adult male ranged from 9.44 mm to 11.65 mm; with a mean of 10.10 \pm 0.25 mm (Table 1) whereas the average body length of an adult female fly was recorded to the tune of 11.28 \pm 0.18 mm, with a range of 10.34 to 11.88 mm. The body length of male and female adult flies was significantly different, (mean difference = 1.17mm, t Value = 3.72, $p \leq 0.01$).

The adult female fly has a wider body width, i.e. 3.60 \pm 0.06 mm (ranging from 3.32 to 3.96 mm) significantly different than adult male fly, measuring 3.09 \pm 0.10 mm (ranging from 2.66 to 3.56 mm) (Table 1). The matured male and female flies significantly varied in breadth (mean difference = 0.51mm, t Value = 4.09, $p \leq 0.01$). Whereas, Adhikari *et al.*, 2022a measured bigger body size viz. body length of male (12.52 mm) and female (14.20 mm), and width of body 3.30 mm and 3.90 mm of male and female respectively in Nepal. The difference in locality and the type of citrus fruit they consumed might have been the reason for variation in body size of same species of fruit fly.

Wingspan and wing length of adult *B. minax*

The adult female has a larger wingspan (23.30 \pm 0.26 mm) ranging from 21.59 mm to 24.12 mm which is significantly different from adult male fly (22.25 \pm 0.40 mm) ranging 20.54 mm to 23.98 mm (Table 2). The wingspan of adult flies differed between male and female,

Table 3. Length of ovipositor of *B. minax*

Length of ovipositor (mm) (n = 10)	
Range	Mean \pm SE
3.07-4.87	4.00 \pm 0.20

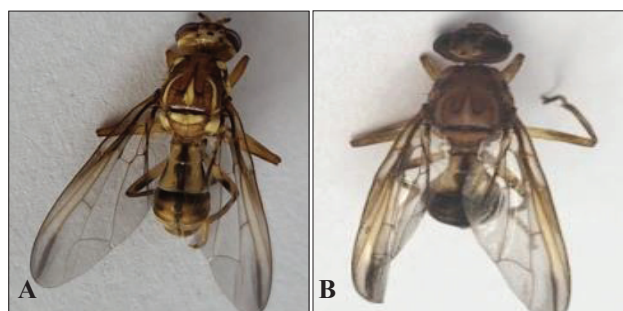
(mean difference = 1.04mm, t Value = 2.16, $p \leq 0.01$). The adult female fly wings measured 10.26 \pm 0.06 mm long, ranging from 9.87 mm to 10.53 mm, compared to male, which measured 8.65 \pm 0.21mm, ranging from 7.93 mm to 9.88 mm. The mean difference was 1.61mm in this case. In general, the wing length of different fruit fly species varies from 2 to 8 millimetres (White, 1988; Drew, 1979).

Length of ovipositor of adult *B. minax*

The ovipositor length of female varied from 3.07 mm to 4.87 mm, with an average of 4.00 \pm 0.20 mm (Table 3). Adhikari *et al.*, 2022a reported that the average length of ovipositor of female *B. minax* approximately 4.52 mm.

Shape and color of *B. minax*

Adult *B. minax* is clearly different from other species of Bactrocera. Face fulvous with elongate black spot on each furrow. It has an elongate oval and petiolate abdomen which is bigger sized (larger Dacus

**Fig. 2. Adult emergence from pupa****Fig. 3. Adults of *B. minax* (A: Male, B : Female)**

like) species among other horticultural pest species of *Bactrocera*. The body of adult fly is red-brown in color which has yellow colored lateral and medial vittae and distinct T-pattern on the abdomen as well as broad costal band well overlapping R 4+5 with a dark spot at the apex of wing (Fig. 3). This fly is brownish in color with yellow markings, with a black band along the outer border of their wings, and a wasp-like look (Chen and Xie, 1955). Drew *et al.*, 2007 described a morphological description of the adult Chinese citrus fly, noting that the fly is likely the biggest of all *Bactrocera* species. Ecological situation may be a key factor that influence in the morphological characteristics such as body shape and size of fruit flies within the species (Zhou, 2020). The larval diet and nutritional content are thought to be the most critical variables determining juvenile growth and eventual adult body size. In fruit flies, body size is an indication of fitness, with larger males and females having higher mating success and egg production, respectively (Newman *et al.*, 2021).

CONCLUSION

It was observed that *B. minax* has sexual dimorphism in body size. The body length (10.10 ± 0.25 mm and 11.28 ± 0.18 mm), breadth (3.09 ± 0.10 mm and 3.60 ± 0.06 mm) and wingspan (22.25 ± 0.4 mm and 23.30 ± 0.26 mm) and length of wing (8.65 ± 0.21 mm and 10.26 ± 0.06 mm), respectively of male and female Chinese citrus fly. The length of ovipositor was measured 4.00 ± 0.20 mm in this study. Sikkim's farmers call the fruit fly as "KANJI KIRA," which is a local term for smaller insects. The Chinese citrus fly is larger than other fruit fly species as far as size concerned. However "JETHI KIRA" would be an ideal local name of this fruit fly, which will also illustrate its behaviour, including its univoltine life cycle and oligophagous nature. This fruit fly is not attracted to parapheromone lure traps.

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