

Research Article

**MORPHOMETRICS OF ADULT CHINESE CITRUS FLY
Bactrocera minax (Enderlein) (Diptera: Tephritidae) IN NEPAL**

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ABSTRACT

Morphometric study of adult Chinese citrus fly, *Bactrocera minax* (Enderlein) was carried out on May, 2020 at Sindhuli, Nepal. The mean body length of female recorded significantly higher, 14.29 ± 0.20 mm, than male, 12.52 ± 0.26 mm, with the mean difference of 1.77 mm ($p = \leq 0.001$). Females had a wider body (3.90 ± 0.06 mm) compared to males (3.39 ± 0.05 mm) ($p = \leq 0.001$) which differed significantly by 0.51 mm. Adult female possessed a wider wingspan, i.e. 23.51 ± 0.23 mm significantly different than adult male, i.e. 22.80 ± 0.19 mm with the mean difference of 0.71 mm ($p = \leq 0.05$). Similarly, the average wing length measured 8.82 ± 0.13 mm in male and 9.05 ± 0.11 mm in female with the mean difference of 0.23 mm. The ovipositor length recorded 4.52 ± 0.12 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, citrus, morphometrics, Nepal

INTRODUCTION

The Chinese citrus fly, *Bactrocera minax* (Enderlein) is a major citricultural pest species in China, Bhutan, India and Nepal which belongs to order Diptera and family Tephritidae (Adhikari *et al.*, 2020; Chauhan *et al.*, 2019; Dong *et al.*, 2014; White and Wang, 1992). The size of adults and other stages of *B. minax* is larger than other fruit fly species, oligophagus in food habit, univoltine in life cycle and is never attracted to para-pheromones like other common frugivorous *Bactrocera* species (Adhikari and Joshi, 2016-2018; Xia *et al.*, 2018). Therefore, this is a unique fruit fly species among horticultural pests. Major limiting biotic factors in sweet orange production in Nepal include various insect pests and diseases, and *B. minax* is one of them, causing substantial damage in sweet orange production in Nepal (Adhikari and Joshi, 2016-2018). Evidence suggests that this species

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has originated in the high temperate Southern Yunnan-Guizhou Plateau and dispersed throughout China's waterways systems (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, ultimately to Nepalese citrus orchards in the eastern middle mountain regime of the country. Its first record was made in the citrus orchard of Helambu, Sindhupalchowk district in December 1984 (Joshi and Manandhar, 2001; Adhikari and Joshi, 2016-2018). During 1990, a problem of maggots of this pest was observed on sweet orange in the citrus orchards in the eastern middle mountain region of Nepal. Based on the authentic identification of the Museum of Entomology, Florida, USA in 2007, the sweet orange decline was confirmed in the Dhankuta citrus orchards within the premises of National Citrus Research Program, Paripatle, Dhankuta, Nepal due to occurrences of *B. minax* (Joshi, 2019; Paudyal *et al.*, 2016; and Sharma *et al.*, 2015).

Biology and behavior including morphological traits of fruit fly species are highly affected by climate factors (Dominiak *et al.*, 2006). The most fundamental requirement for successful pest management is to ascertain pest identity and obtain knowledge on its habitat and behavior prior to applying any pest management strategy. Similar to other fruit fly species, the information on morphological characteristics of *B. minax* is helpful for its proper field diagnosis to execute appropriate management measures. This paper highlights the morphometrics of adult *B. minax* as a basis of its para taxonomy for its proper diagnosis.

MATERIALS AND METHODS

Rearing maggots for adult emergence

Maggots infested sweet orange fruits of cultivar Sindhuli Local were collected during the peak infestation period on the first week of November 2019 at Golanjor-5, Khaniyakharka, Sindhuli. The infested fruits were sliced, opened by a knife and maggots were allowed to exit from fruits. Maggots were obtained from the infested fruits and were reared (n = 200) in room condition (average temperature 18.35°C and relative humidity 74.04%) at the premises of Prime Minister Agriculture Modernization Project, Project Implementation Unit, Sindhuli Contact Office, Sindhulimadi. Twenty matured larvae were placed in the plastic jar (dimension: height = 15 cm, perimeter 10 cm) filled with the garden soil (20.65% moisture, loamy soil) up to 12 cm height which was replicated 10 times. Jar opening was tightened with muslin cloth and rubber band to avoid larval escape from the container. Pupae were examined and counted by gently stirring the soil after two months and placed in the same containers, again fastened with a piece of nylon mesh. Twenty five randomly selected freshly emerged adults (n = 162) out of pupae (n = 173) were collected for the measurement of major morphometrics parameters like length and breadth of adult flies, wingspan, length of wing and ovipositor on May, 2020 at Sindhuli, Nepal. Twenty-five replicates of each parameter were measured and recorded.

Measurement of adult flies

Calibrated digital Vernier Caliper (BERRLION, No: 070501150) (Fig. 1) was used to measure body length, breadth, wingspan and length of wing of both male and female individually, and female fly ovipositor. Fig. 2 shows the adult *B. minax* using Vernier Caliper from the top of the head to the tip of the abdomen, and the adult fruit fly body length was measured. 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.



Fig. 1. Vernier Caliper (BERRLION, No: 070501150)

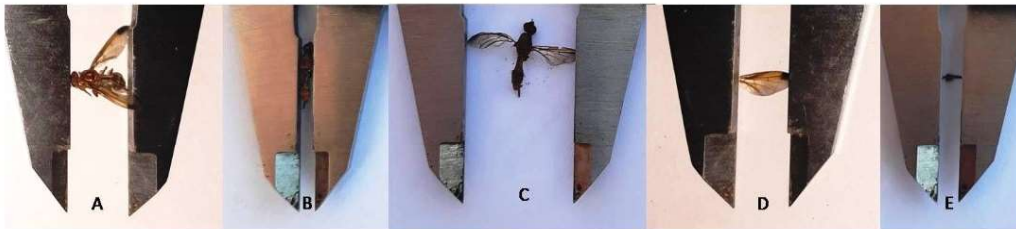


Fig. 2. Measurement of adult fruit fly using Vernier Caliper
(A: Body length, B: Body breadth, C: Wingspan, D: Length of wing and E: Length of ovipositor)

Statistical analysis

Microsoft Excel (version 97-2003) was used to derive descriptive statistics like range, mean and standard error of mean and prepared necessary tables. Student's t-test was used for the mean comparison of body size (length and breadth) and wing of the adult male and female flies.

RESULTS AND DISCUSSION

Body size of *B. minax*

The size of plant feeder-herbivorous insects and their performance have been found to have a positive relationship, which is influenced by genetic and environmental factors, including the host plants they feed on (Hone, 1993). For the survival of the herbivorous insect, some of the parameters like fitness, and fecundity may be directly affected by host plants (Awmack and Leather, 2002; Smith and Hardman, 1986). The Chinese citrus fly, *B. minax* is the largest one among horticultural fruit fly pests (Xia *et al.*, 2018). The adult male body length ranged from 9.47 mm to 14.45 mm; with a mean of 12.52 ± 0.26 mm (Table 1) whereas the average body length of an adult female fly was recorded 14.29 ± 0.20 mm, with a range of 11.6 -16.10 mm. The length of male and female adult flies was significantly different, ($t(48) = 5.41, p = \leq 0.001$) with the mean difference of 1.77 mm. Drew (1979) reported the adult *B. minax* measuring 10 to 13.2 mm length without the female ovipositor. The adult female fly has a wider body width, i.e. 3.90 ± 0.06 mm (ranging from 3.34 to 4.24 mm) significantly different than adult male fly, measuring 3.39 ± 0.05 mm (ranging from 2.98 to 3.73 mm) (Table 1). The matured male and female flies significantly varied in breadth ($t(48) = 6.9, p = \leq 0.001$), with a mean difference of 0.51 mm.

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)	9.47 - 14.45	12.52 ± 0.26^b	2.98 - 3.73	3.39 ± 0.05^b
Female (n = 25)	11.61 - 16.10	14.29 ± 0.20^a	3.34 - 4.24	3.90 ± 0.06^a

Student t-test (≤ 0.001) obtained from the data within-column means with the same small letters are not significantly different between male and female. Values represent means of 25 replicates of fruit flies each. \pm = SE.

Wingspan and wing length of adult *B. minax*

The adult female has a larger wingspan (23.51 ± 0.23 mm) ranging from 21.55 mm to 25.45 mm which is significantly different from adult male fly (22.80 ± 0.19 mm) ranging 20.40 mm to 24.50 mm (Table 2). The wingspan of adult flies differed between male and female, ($t(48) = 2.39, p = \leq 0.05$) with the mean difference of 0.71 mm. The adult female fly wings measured 9.05 ± 0.11 mm long, ranging from 8.05 mm to 10.55 mm, compared to male, which measured 8.82 ± 0.13 mm, ranging from 7.78 mm to 10.23 mm. The mean difference was 0.23 mm in this case. Generally, fruit fly species vary in wing length from about 2 mm to 8 mm (White, 1988; Drew, 1979).

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

Sex	Wingspan (mm)		Length of wing (mm)	
	Range	Mean ± SE	Range	Mean ± SE
Male (n = 25)	20.40 - 24.50	22.80 ± 0.19 ^b	7.78 - 10.23	8.82 ± 0.13
Female (n = 25)	21.55 - 25.45	23.51 ± 0.23 ^a	8.05 - 10.55	9.05 ± 0.11

Student T-test (≤ 0.05) obtained from the data within-column means with the same small letters are not significantly different between male and female. Values represent means of 25 replicates of fruit flies each. \pm = SE.

Length of ovipositor of adult *B. minax*

The ovipositor length of female varied from 3.50 mm to 5.80 mm, with an average of 4.52 ± 0.12 mm (Table 3). Chen and Xie (1955) reported that the length of ovipositor of female *B. minax* approximately 6.5 mm.

Table 3. Length of ovipositor of *B. minax* (♀)

Length of ovipositor (mm) (n = 25)	
Range	Mean ± SE
3.50 - 5.80	4.52 ± 0.12

Shape and color of *B. minax*

B. minax has elongate oval and petiolate abdomen which is bigger sized (larger *Dacus* 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 (Figs. 3 and 4). Similar morphological features of the fruit fly are described in Plant Health Australia (2018) published “Australian Handbook for the Identification of Fruit Flies v3.1” and in Adhikari and Joshi (2016-2018). 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).

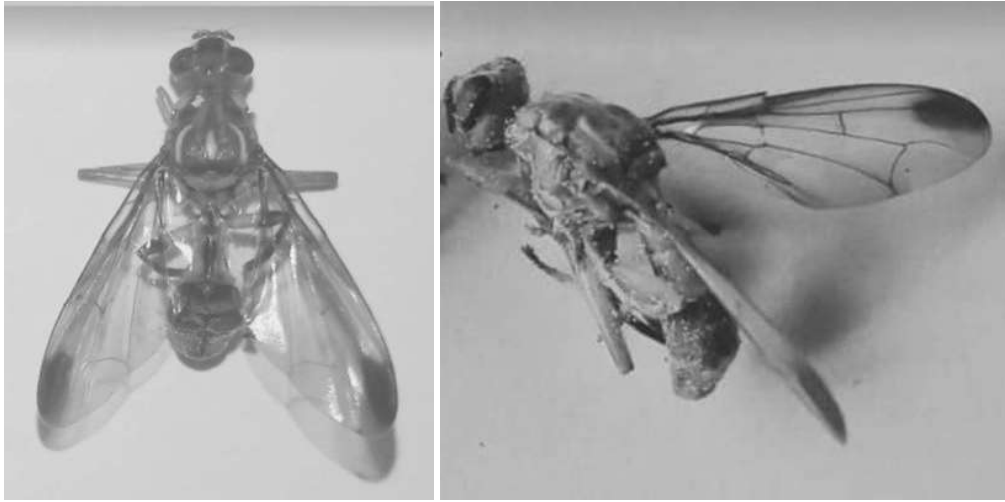


Fig. 3. Adult Chinese citrus fly (♂)

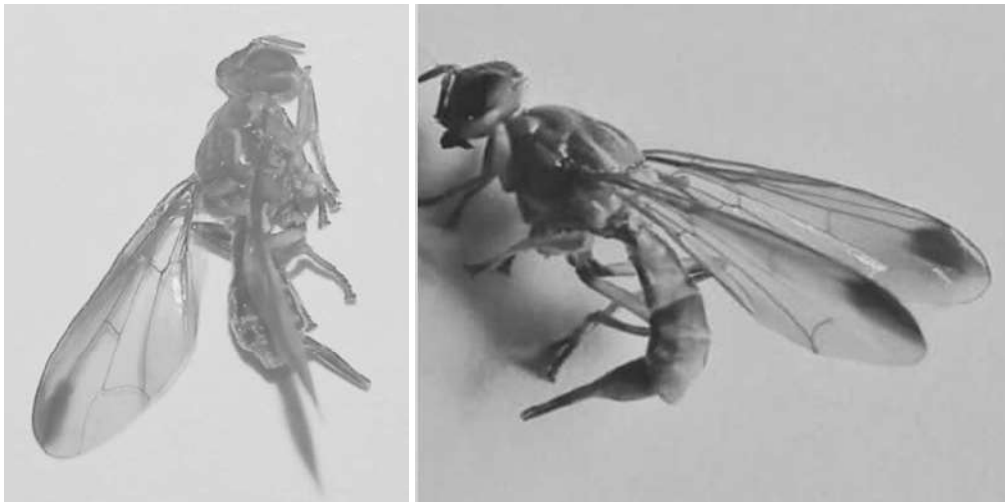


Fig. 4. Adult Chinese citrus fly (♀)

CONCLUSION

It was observed that *B. minax* has sexual dimorphism in body size. The 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) and length of wing (8.82 ± 0.13 mm and 9.05 ± 0.11 mm), respectively of male and female Chinese citrus fly. The length of ovipositor was measured 4.52 ± 0.12 mm in this study.

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