BioOne COMPLETE

Morphometry of Compound Eyes of Three Bactrocera (Diptera: Tephritidae) Species

Authors: Xue, Huangwa, Zheng, Lixia, and Wu, Weijian

Source: Florida Entomologist, 98(2) : 807-809

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.098.0266

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 19 Apr 2024
Terms of Use: https://bioone.org/terms-of-use

Morphometry of compound eyes of three *Bactrocera* (Diptera: Tephritidae) species

Huangwa Xue[1], Lixia Zheng[1,2], and Weijian Wu[1,]*

Bactrocera cucurbitae (Coquillett) (Diptera: Tephritidae), *Bactrocera dorsalis* (Hendel) and *Bactrocera tau* (Walker) are distributed widely in temperate, sub-tropical, and tropical regions of the world (Christenson & Foote 1960), and they infest a broad range of fruit and vegetable species (Hu et al. 2010). Compound eyes are important visual sensory organs with the capacity to distinguish colors and shapes (Briscoe & Chittka 2001), detect moving objects, and perceive the plane of polarized light (Horvath & Varju 2003). For a number of years various colors have been used as visual cues to trap fruit flies. For example, yellow traps were used for monitoring and controlling of *B. dorsalis* (Alyokhin et al. 2000). Moreover, Wu et al. (2007) demonstrated that *B. dorsalis* was attracted to green stimuli (spectra: 500-570 nm). Xue & Wu (2013) reported that the spectrum between 520-560 nm was more attractive to *B. cucurbitae* than either 480-500 nm or 560-600 nm. This study aimed to acquire additional relevant knowledge by morphometric investigations of differences between males and females and between the 3 species of various morphological features, including eye size, facet size, and numbers of ommatidia and ommatrichia.

Samples consisted of 20 individuals (10 males and 10 females) for each of the 3 *Bactrocera* species: *B. cucurbitae*, *B. tau* and *B. dorsalis*. Insects used in this study were obtained from laboratory colonies maintained at the Laboratory of Insect Ecology, South China Agricultural University, Guangzhou, China. Insects were reared in a cage (30 × 30 × 30 cm), fed artificial diet (yeast extract mixed with dextrose at a 1:3 ratio) and maintained at 28 ± 1.5 °C, 75-80% RH and 14:10 h L:D. Flies were killed by placing them in a freezer for 20 min, and then images were obtained using a dissection microscope (Zeiss, SteRED Discovery V12) connected to a computer. The heads of fruit flies were then dissected from the body by a sharp blade under the same dissection microscope. The specimens were fixed to aluminum stubs with conductive adhesive, and sputtered with gold for observation at 20 kV using a XL-30 ESEM scanning electron microscope.

The left compound eyes were observed and measured. Printed images were magnified, and optical microscope images were used to obtain measurements of dorso-ventral distance (eye width) and anterior-posterior distance (eye length) of the compound eyes, and the SEM images were used to obtain measurements of individual square ommatidium area per eye using a slide caliper (GB/T1214.1-1214.4, Shanghai Hengsheng Tools Co., Ltd., Shanghai, China). Additionally, we counted the numbers of ommatrichia and ommatidia using optical microscope images from the computer directly. Sexual dimorphism in the morphological traits was assessed in each species using the Mann-Whitney *U*-test ($P < 0.05$), while the general linear model (GLM) procedure and a least significant difference (LSD) multiple comparison separation test were used to test for morphological differences among species. Statistical analyses were performed with SPSS 11.0.

The compound eyes of *B. cucurbitae*, *B. tau* and *B. dorsalis* were found to be ellipsoid in shape (Fig. 1). Each compound eye was comprised of a large number of ommatidia, which were packed closely together in a hexagonal and square arrays. The ommatidia at the center and posterior edge of the compound eyes were square, others were hexagonal. The ommatidia of the dorsal region were hexagonal and they were larger than the square ommatidia (Fig. 2). There were a several differences in morphological parameters between the sexes of the 3 species. The eyes of *B. dorsalis* females were wider than those of the males (799.48 ± 15.14 µm and 753.01 ± 17.76 µm, respectively), *B. cucurbitae* females had smaller individual square ommatidium area than males (376.7 ± 5.03 µm and 391.7 ± 5.26 µm, respectively), and *B. tau* females had more ommatidia than males (3,904.12 ± 42.1 and 3,630.44 ± 39.9, respectively). There were no differences between the sexes in the other parameters measured.

There were some differences in eye morphology among the 3 species (Table 1). *Bactrocera dorsalis* had a smaller eye width and a smaller individual square ommatidium area than the other 2 species, and the largest number of ommatrichia. *Bactrocera tau* had the smallest number of ommatrichia, and the number in *B. cucurbitae* was intermediate. In all 3 species, the ommatrichia were either straight or curved hairs with blunt-tips. They were commonly located in basal sockets and sparsely distributed between the ommatidia.

In conclusion, we provided an extensive description of morphometric characters of the compound eyes of *B. cucurbita*, *B. dorsalis* and *B. tau*. The different morphometric characters among the 3 species of fruit flies may serve different functions. In arthropods, the size, shape, color, ommatidium number and surface texture of the compound eye influence many features of the visual field including its dimensions, acuity and sensitivity (Rutowski 2000). Differences in the morphology of the compound eye, which affect the visual field, should be expressed in differences in behavior, life style and habitat preferences that make different demands on the visual system (Horridge 1977; Warrant & McIntyre 1993; Land 1997). The findings of this study suggest that the 3 species of fruit flies may have the same spectral sensitivities of their photoreceptors. Since *B. cucurbita* and *B. dorsalis* were both attracted to colored paper with a spectrum between 520-560 nm (Wu et al. 2007; Xue & Wu 2013), presumably that the color preference of the *B. tau* also would be close to 520-560 nm. Our results can be helpful in exploring the relationship among the ultrastructural features of

[1]Laboratory of Insect Ecology, South China Agricultural University, Guangzhou 510642 China
[2]College of Agronomy, Jiangxi Agricultural University, Nanchang 330045 China
[*]Corresponding author; E-mail: weijwu@scau.edu.cn

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 19 Apr 2024
Terms of Use: https://bioone.org/terms-of-use

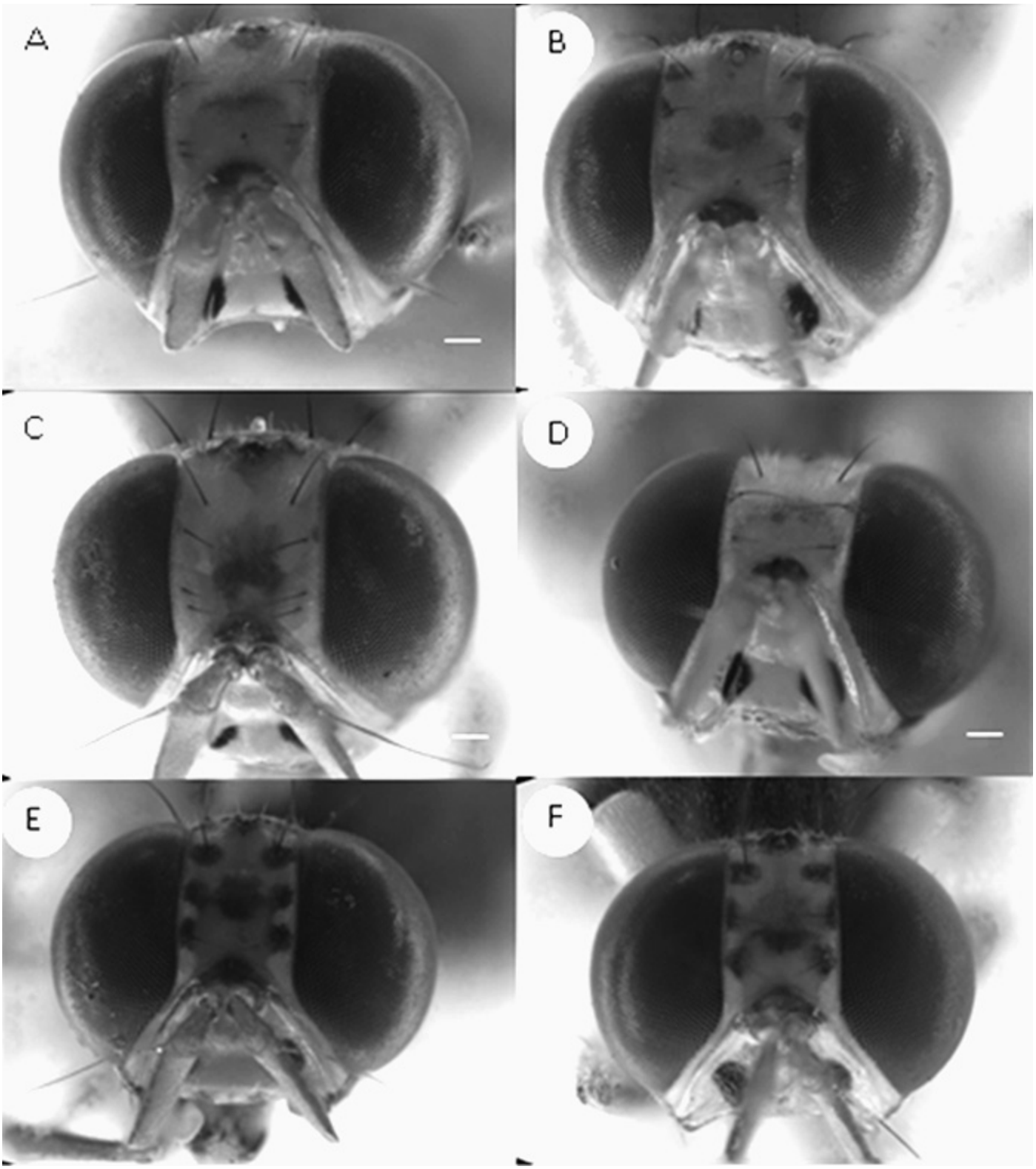

Fig. 1. Light micrographs of the compound eyes of the 3 *Bactrocera* species. Scale bar = 100 µm. A: Female *B. cucurbitae* B: Male *B. cucurbitae* C: Female *B. tau* D: Male *B. tau* E: Female *B. dorsalis* F: Male *B. dorsalis.*

compound eyes, physiological mechanisms and phototaxis and other behaviors.

We are grateful to Ms. Xin-Fang Chen (Instrumental Analysis and Research Center of South China Agricultural University) for the assistance with SEM. This study was supported by the Special Fund for Agro-Scientific Research in the Public Interest of China (grant no. 201103026-4, 2011-2015), and the Science and Technology Planning Project of Guangdong, Province, China (grant no. 2012A020602034).

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 19 Apr 2024
Terms of Use: https://bioone.org/terms-of-use

Table 1. Morphological parameters of the compound eyes (mean ± SE) of laboratory-reared adult *Bactrocera cucurbitae*, *Bactrocera tau* and *Bactrocera dorsalis* obtained by environmental scanning electron microscopy (ESEM) (n = 20).

Species	Number of ommatidia	Eye width (μm)	Eye length (μm)	Individual square ommatidium area (μm²)	Number of ommatrichia
B. cucurbitae	3693.70 ± 38.66 a	819.55 ± 13.70 a	1283.92 ± 12.39 a	384.21 ± 3.93 a	137.10 ± 2.60 b
B. tau	3767.25 ± 42.22 a	822.05 ± 11.13 a	1291.13 ± 17.49 a	380.78 ± 8.85 a	117.40 ± 3.40 c
B. dorsalis	3751.80 ± 37.84 a	776.25 ± 12.55 b	1268.92 ± 11.20 a	290.45 ± 3.15 b	147.50 ± 4.50 a
F	0.958	4.246	0.659	83.196	18.352
P	0.390	0.019	0.521	0.000	0.000

Means with same letters in a column are not significantly different (GLM, LSD, $P < 0.05$).

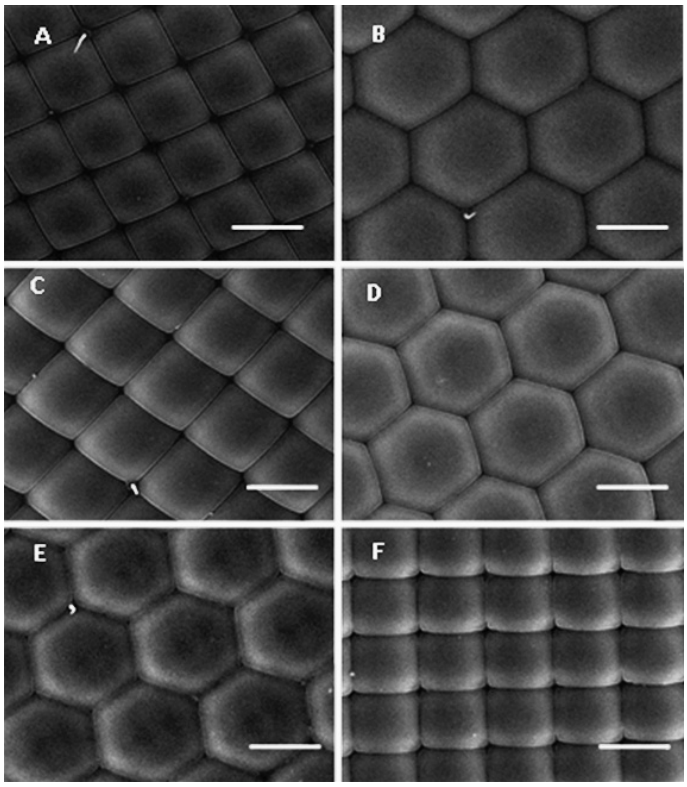

Fig. 2. SEM micrographs of the compound eye of 3 *Bactrocera* species showing the shapes of the ommatidia (square and hexagonal), central region (A, C, E) and dorsal region (B, D, F). Scale bar = 20 μm A, B: *B. cucurbitae* C, D: *B. tau* E, F: *B. dorsalis.*

Summary

We investigated the external morphology, eye size, facet size, and numbers of ommatidia and ommatrichia of the compound eyes of *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae), *Bactrocera tau* (Walker) and *Bactrocera dorsalis* (Hendel) using light and scanning electron microscopy. There significant differences were found between females and males and between the 3 *Bactrocera* species. The results contribute to the further exploration of the relationship between the ultrastructural dimensions of the compound eye features and the visually-based behaviors of these 3 *Bactrocera* species.

Key Words: scanning electron microscopy; morphometric measurements; ultrastructure; fruit fly

Sumario

Investigamos la morfología externa, el tamaño de los ojos, el tamaño de las facetas y el número de ommatidia y ommatrichia de los ojos compuestos de *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae), *Bactrocera tau* (Walker) y *Bactrocera dorsalis* (Hendel) usando microscopía de luz y electrónica de barrido (SEM). No se encontraron diferencias significativas entre las hembras y los machos de las 3 especies de *Bactrocera*. Los resultados contribuyen a la investigación adicional de las relaciones entre las dimensiones ultraestructurales de las características de los ojos compuestos y el comportamiento basado en lo visual de estas 3 especies *Bactrocera*.

Palabras Clave: microscopía electrónica de barrido; mediciones morfométricas; ultra estructura; mosca de la fruta

References Cited

Alyokhin AV, Messing RH, Duan JJ. 2000. Visual and olfactory stimuli and fruit maturity affect trap captures of oriental fruit flies (Diptera: Tephritidae). Journal of Economic Entomology 93: 644-649.

Briscoe AD, Chittka L. 2001. The evolution of colour vision in insects. Annual Review of Entomology 46: 471-510.

Christenson LD, Foote RH. 1960. Biology of fruit flies. Annual Review of Entomology 5: 171-192.

Horridge, GA. 1997. The compound eye of insects. Scientific American 237: 108-120.

Horvath G, Varju D. 2003. Polarized light in animal vision-polarization patterns in nature, pp. 131-176. Springer Verlag, Berlin Heidelberg, New York.

Hu F, Zhang GN, Jia FX, Dou W, Wang JJ. 2010. Morphological characterization and distribution of antennal sensilla of six fruit flies (Diptera: Tephritidae). Annals of the Entomological Society of America 103: 661-670.

Land MF. 1997. Visual acuity in insects. Annual Review of Entomology 42: 147-177.

Rutowski RL. 2000. Variation of eye size in butterflies: inter- and intraspecific patterns. Journal of Zoology 252: 187-195.

Warrant EJ, McIntyre PD. 1993. Arthropod eye design and the physical limits to spatial resolving power. Progress in Neurobiology 40: 413-461.

Wu WY, Chen YP, Yang EC. 2007. Chromatic cues to trap the oriental fruit fly, *Bactrocera dorsalis*. Journal of Insect Physiology 53: 509-516.

Xue HW, Wu WJ. 2013. Preferences of *Bactrocera cucurbitae* (Diptera: Tephritidae) to different colors: A quantitative investigation using visual wavelengths. Acta Entomologica Sinica 56: 161-166.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 19 Apr 2024
Terms of Use: https://bioone.org/terms-of-use