

# Visualizing the Mesothoracic Spiracles in a Bark Beetle: *Hypothenemus hampei* (Coleoptera: Curculionidae)

FERNANDO E. VEGA,<sup>1,2</sup> GARY BAUCHAN,<sup>3</sup> FRANCISCO INFANTE,<sup>4</sup>  
JORGE M. VALDÉZ-CARRASCO,<sup>5</sup> AND ROGER BEAVER<sup>5,6</sup>

Ann. Entomol. Soc. Am. 108(3): 446–448 (2015); DOI: 10.1093/aesa/sav016

**ABSTRACT** In a low-temperature scanning electron microscopy study aimed at determining whether the coffee berry borer [*Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae)] possesses mycangia, we fortuitously detected the mesothoracic spiracles, which are usually concealed. The mesothoracic spiracles are ventrolaterally located in the intersegmental membranes between the prothorax and mesothorax, and contain a large number of setae. This is the first study that includes photographs of the mesothoracic spiracles in a bark beetle.

**KEY WORDS** broca del café, coffee berry borer, pygmy borers, Scolytinae

The coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae: Scolytinae), is the most economically important insect pest of coffee (Vega et al. 2015a) and has been the subject of scientific study for over 100 years (Infante et al. 2014). Despite several papers that have been published on the insect, recent low-temperature scanning electron microscopy (LT-SEM) studies, originally aimed at determining if the coffee berry borer possesses mycangia, have brought to the forefront the biological complexity and morphological intricacies of the coffee berry borer, a member of the tribe Cryphalini, also known as pygmy borers.

In the first study, Vega et al. (2014) observed a reduction in the number of facets in the compound eyes of male coffee berry borers, which led to studies aimed at elucidating the optomotor responses of male vs. female insects. In the second study, Vega et al. (2015b) observed the presence of a spine in the vestigial wings of some male coffee berry borers, whose function remains unknown, although it is possible that it might be involved in acoustic communication. Here, we report on the mesothoracic spiracles in the coffee berry borer. We have been unable to locate any published

photographs that depict these spiracles in a bark beetle. One reason for this might be that as Ritcher (1969a) reported for the Scarabaeoidea, the mesothoracic spiracles “have been ignored by most morphologists and taxonomists because these spiracles are concealed and difficult to observe without dissection.” It is worth noting that we were unable to find mycangia and that the only member in the genus *Hypothenemus* with confirmed mycangia is *Hypothenemus curtippennis* (Schedl) (Beaver, 1986, Vega et al. 2015a).

## Materials and Methods

Insects were dissected from coffee berries (*Coffea arabica* L.) collected in the field near Tapachula, Chiapas, Mexico. A batch of live insects was sent to Maryland for the LT-SEM work; specimens were processed as described by Vega et al. (2014). Another batch of insects was used to identify the different parts of the spiracles. The area surrounding the spiracles was dissected with a scalpel, dyed with Congo red, mounted on a microscope slide, and photographed.

## Results and Discussion

The initial detection of the ventrolaterally located mesothoracic spiracles was the result of an insect exhibiting a pose that allowed observing the ventral intersegmental membranes between the prothorax and mesothorax (Fig. 1a,b). According to Comstock (1948) “each pair of spiracles is attributed to the segment in front of which it is normally situated”; therefore, based on these spiracles being located in front of the mesothorax, they are referred to as mesothoracic spiracles.

An interesting feature of the mesothoracic spiracles in the coffee berry borer is the presence of setae that extend outward from the spiracular opening

<sup>1</sup>Sustainable Perennial Crops Laboratory, U. S. Department of Agriculture, Agricultural Research Service, Bldg. 001, Beltsville, MD 20705.

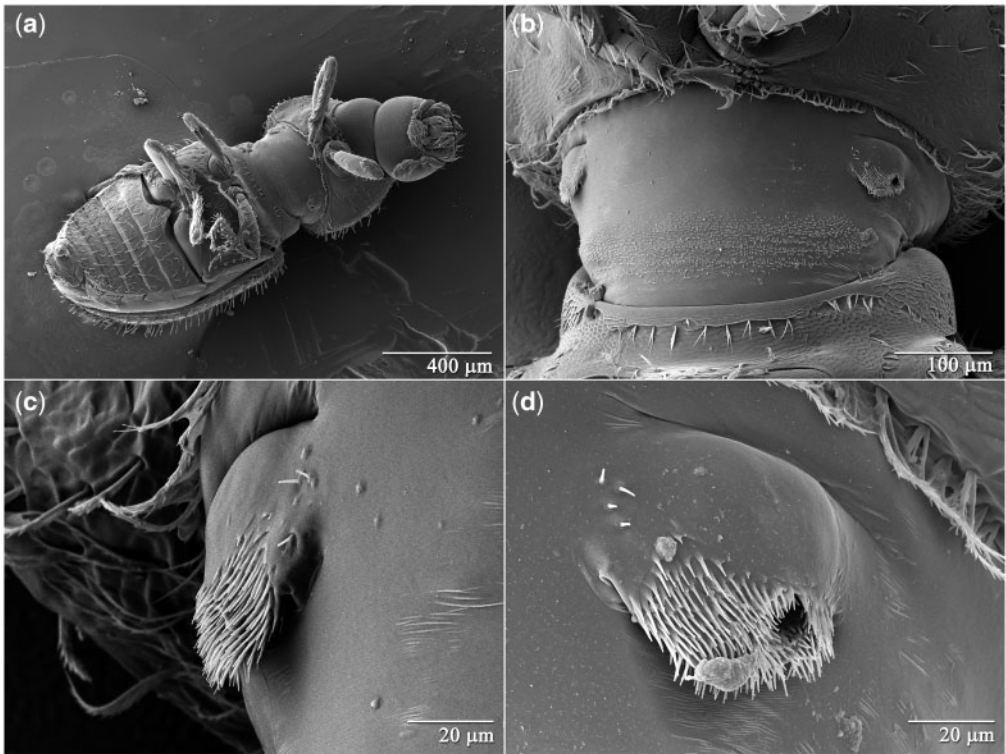
<sup>2</sup>Corresponding author, e-mail: Fernando.Vega@ars.usda.gov.

<sup>3</sup>Electron and Confocal Microscopy Unit, U. S. Department of Agriculture, Agricultural Research Service, Bldg. 012, Beltsville, MD 20705.

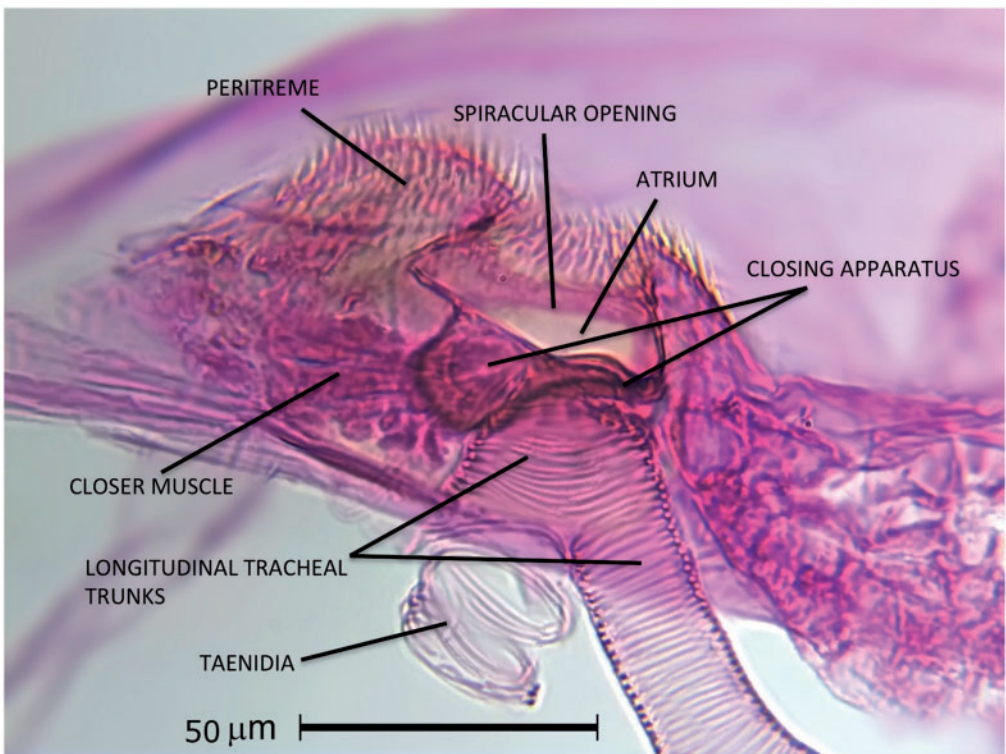
<sup>4</sup>El Colegio de la Frontera Sur (ECOSUR), Carretera Antigua Aeropuerto Km. 2.5, Tapachula, 30700 Chiapas, México.

<sup>5</sup>Colegio de Postgraduados, Campus Montecillo, Apartado Postal 56230, Km. 36.5, Carretera México-Texcoco, Montecillo, Texcoco, Edo. de México, México.

<sup>6</sup>Roger Beaver, 161/2 Mu 5, Soi Wat Pranon, T. Donkaew, A. Maerim, Chiangmai 50180, Thailand.



**Fig. 1.** LT-SEM photographs of (a) ventral parts of a female coffee berry borer; (b) intersegmental membranes between the prothorax and mesothorax showing the ventrolaterally located mesothoracic spiracles; (c) close-up of right mesothoracic spiracle; (d) close-up of left mesothoracic spiracle. Note setae extending from spiracles.



**Fig. 2.** Various parts of the mesothoracic spiracle in the coffee berry borer.

(Figs. 1b-d, and 2), similar to those reported by Russo (1937–1938) for *Phloeotribus scarabaeoides* (Bernard) (Curculionidae: Scolytinae). Comstock (1948) proposed that the function of setae might involve the exclusion of particulate matter and several Scarabaeoidea examined by Ritcher (1969a) exhibit a “filter apparatus” in the spiracular opening itself, a condition that does not resemble that of the coffee berry borer. Klowden (2007) mentions that the setae, when present in the atrium, might also be involved in the reduction of water loss in addition to collecting particulate matter.

The various parts of the mesothoracic spiracles, including the peritreme, spiracular opening, atrium, closing apparatus, closer muscle, longitudinal tracheal trunks, and taenidia are depicted in Fig. 2. The respiratory system of bark beetle seems to have been nearly completely ignored in the literature, presumably because it was not thought to have any taxonomic significance. Ritcher (1969a,b) presented evidence indicating that various characters observed in the spiracles can be of value to differentiate genera and species of Scarabaeoidea. The comparison of mesothoracic spiracles in various genera and species of Scolytinae could reveal a novel character for species identification. To the best of our knowledge, this is the first article that includes photographs of the mesothoracic spiracles in a bark beetle.

### Acknowledgments

We thank Chris Pooley (U.S. Department of Agriculture–Agricultural Research Services [USDA-ARS]) for preparing Fig. 1.

### References Cited

- Beaver, R. A. 1986.** The taxonomy, mycangia and biology of *Hypothenemus curtippennis* (Schedl), the first known cryptine ambrosia beetle (Coleoptera: Scolytidae). *Insect Syst. Evol.* 17: 131–135.
- Comstock, J. H. 1948.** An introduction to entomology, 9th ed., revised. Comstock Publishing Company, Inc., Ithaca.
- Infante, F., J. Pérez, and F. E. Vega. 2014.** The coffee berry borer: The centenary of a biological invasion in Brazil. *Braz. J. Biol.* 74: S125–S126.
- Klowden, M. J. (2007).** Physiological systems in insects, 2nd ed. Academic Press, San Diego, CA.
- Ritcher, P. O. 1969a.** Spiracles of adult Scarabaeoidea (Coleoptera) and their phylogenetic significance. II. Thoracic spiracles and adjacent sclerites. *Ann. Entomol. Soc. Am.* 62: 1388–1398.
- Ritcher, P. O. 1969b.** Spiracles of adult Scarabaeoidea (Coleoptera) and their phylogenetic significance. I. The abdominal spiracles. *Ann. Entomol. Soc. Am.* 62: 869–880.
- Russo, G. 1937–1938.** V. Contributo alla conoscenza dei Coleotteri Scolitidi Fleotribo: *Phloeotribus scarabaeoides* (Bern.) Fauv. Parte Prima. Morfologia, anatomia e istologia. *Bollettino del R. Laboratorio di Entomologia Agraria di Portici* 1: 1–262.
- Vega, F. E., A. Simpkins, G. Bauchan, F. Infante, M. Kramer, and M. F. Land. 2014.** On the eyes of male coffee berry borers as rudimentary organs. *PLoS ONE* 9: e85860.
- Vega, F. E., F. Infante, and A. J. Johnson. 2015a.** The genus *Hypothenemus*, with emphasis on *H. hampei*, the coffee berry borer, pp. 427–494. *In* F. E. Vega and R. W. Hofstetter (eds.), *Bark beetles: biology and ecology of native and invasive species*. Academic Press, San Diego, CA.
- Vega, F. E., A. Simpkins, G. Bauchan, J. M. Valdéz-Carrasco, A. Castillo, and F. Infante. 2015b.** A mysterious wing spine in male coffee berry borers. *Fla. Entomol.* 98: 359–360.

*Received 25 November 2014; accepted 22 January 2015.*