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Observations of the Biology of *Phasgonophora Sulcata* (Hymenoptera: Chalcididae), a Larval Parasitoid of the Twolined Chestnut Borer, *Agrilus Bilineatus* (Coleoptera: Buprestidae), in Wisconsin

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OBSERVATIONS ON THE BIOLOGY OF *PHASGONOPHORA SULCATA* (HYMENOPTERA: CHALCIDIDAE), A LARVAL PARASITOID OF THE TWOLINED CHESTNUT BORER, *AGRILUS BILINEATUS* (COLEOPTERA: BUPRESTIDAE), IN WISCONSIN[1]

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ABSTRACT

Phasgonophora sulcata Westwood was the principal larval parasitoid of *Agrilus bilineatus* (Weber) during a study conducted in a natural oak-hardwood forest in the Kettle Moraine State Forest, Jefferson County, Wisconsin. Mean percent larval parasitism was 10.5%. Mean *A. bilineatus* and *P. sulcata* densities were, respectively, 53.0 and 6.1 adults per square meter of bark. The theoretical developmental threshold temperatures for overwintering *A. bilineatus* and *P. sulcata* larvae were 17.8° and 19.1°C, respectively. The peak flight period of *P. sulcata* (9 July 1980) occurred ca. 3 weeks after the *A. bilineatus* peak flight (18 June 1980) at about the time of peak *A. bilineatus* egg eclosion. The *P. sulcata* sex ratios (males:females) for laboratory-reared and field-captured adults were 1:1.35 and 1:3.22, respectively.

Phasgonophora sulcata Westwood (Fig. 1) is the principal larval parasitoid of the twolined chestnut borer, *Agrilus bilineatus* (Weber), in New York and Pennsylvania (Cote and Allen 1980). *P. sulcata* also is the principal larval parasitoid of the bronze birch borer, *Agrilus anxius* Gory (Barter 1957), and the bronze poplar borer, *Agrilus liragus* Barter & Brown (Barter 1965), and it accounted for 1–8% and 2–20% parasitism, respectively, in New Brunswick. We present here observations on the biology of *P. sulcata* recorded during a life-history study of *A. bilineatus* in a natural oak-hardwood forest in the Kettle Moraine State Forest, Jefferson County, Wisconsin, in 1980.

MATERIALS AND METHODS

Percent larval parasitism, borer density, and parasitoid density were determined by rearing *A. bilineatus* and *P. sulcata* adults from naturally infested bark. Approximately 10 m^2 of bark were collected from the lower boles (1–5 m) of three northern red oaks, *Quercus rubra* L., and two black oaks, *Quercus velutina* Lam., in April and May. The bark was divided equally into 10 emergence cages, maintained at room temperature, and checked daily for adults. The number of reared adults per sample was recorded by species. All *P. sulcata* exit holes were traced back into the bark by splitting with hammer and chisel to determine if they had originated from an *A. bilineatus* pupal chamber.

The theoretical developmental threshold temperatures for overwintering *A. bilineatus* and *P. sulcata* larvae were determined. Approximately 3 m^2 of infested bark were collected on 1 January from the lower boles of two northern red oaks and returned to the laboratory. The bark was placed into four emergence cages and each was maintained separately in environ-

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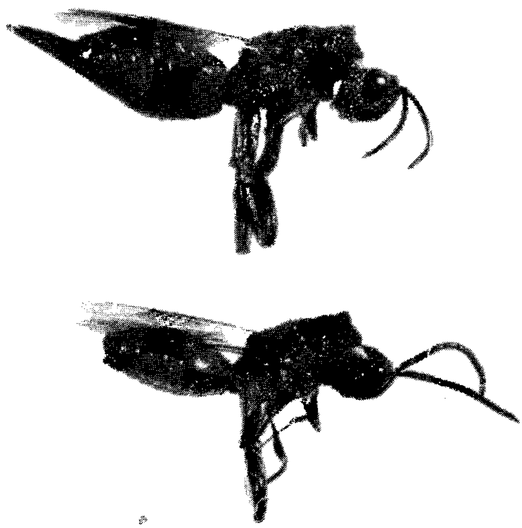

Fig. 1. *Phasgonophora sulcata* adults (×6.3): female (top), male (bottom).

mental chambers at 20°, 24°, 28°, and 30°C. Adults were removed daily and the number of days to emergence was recorded. Mean developmental time in days was calculated by species for each temperature. The developmental threshold temperatures and their respective linear equations were determined from the 24° and 28°C data.

The adult flight period was investigated by trapping adults on Tree Tanglefoot®-coated, 20-cm-wide polyethylene bands, stapled at breast height (1.3 m) around the trunks of six northern red oaks, four black oaks, and seven white oaks, *Quercus alba* L., beginning on 30 May. All trees were stressed to increase their attractiveness to *A. bilineatus* adults by basal girdling with a chain saw on 4 June. *A. bilineatus* and *P. sulcata* adults were removed and counted weekly from 4 June through 17 September.

The sex ratio and sex factor for all laboratory-reared and field-captured *P. sulcata* adults were calculated. Reared adults were those recovered from the developmental-rate and percent-parasitism studies; field-captured adults were those recovered from the flight-period study.

RESULTS AND DISCUSSION

A total of 530 *A. bilineatus* and 61 *P. sulcata* adults were reared from10 m^2 of bark. Mean percent larval parasitism ($\bar{x} \pm$ SE; range) was 10.5% ± 2.1; 2.1–25.0%. *A. bilineatus* and *P. sulcata* mean overwintering densities ($\bar{x}/m^2 \pm$ SE; range) were 53.0 ± 6.9; 27–101 and 6.1 ± 1.4; 1–16, respectively. Also reared were three unidentified braconids (Hymenoptera); one *Tenebroides corticalis* (Melsheimer), (Coleoptera: Trogositidae); and one *Cymatodera bicolor* (Say), (Coleoptera: Cleridae).

The theoretical developmental threshold temperatures for overwintering *A. bilineatus* and *P. sulcata* larvae were 17.8° and 19.1°C, respectively. Their respective linear equations were $Y=0.00475X-0.0845$ for *A. bilineatus* and $Y=0.0036025X-0.06892$ for *P. sulcata*; Y repre-

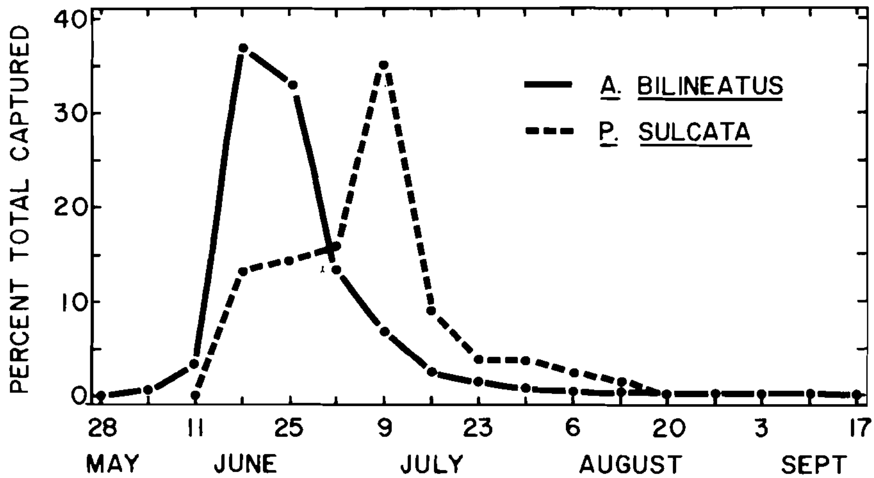

Fig. 2. The 1980 adult flight periods for *Agrilus bilineatus* (n=12,987) and *Phasgonophora sulcata* (n=76) in the Kettle Moraine State Forest, Jefferson County, Wisconsin.

Table 1. Mean developmental time in days for overwintering *Agrilus bilineatus* and *Phasgonophora sulcata* larvae to complete development in overwintering sites in oak bark and emerge as adults at 20°, 24°, 28°, and 30°C.

Temperature (°C)	Mean Developmental Time in Days *Agrilus bilineatus* $\bar{x} \pm SE$	$1/\bar{x}$	(n)	*Phasgonophora sulcata* $\bar{x} \pm SE$	$1/\bar{x}$	(n)
30°	19.2 ± 0.22	0.0521	(82)	25.8 ± 0.40	0.0388	(21)
28°	20.6 ± 0.26	0.0485	(17)	31.3 ± 0.47	0.0320	(7)
24°	33.9 ± 0.40	0.0295	(7)	57.0 ± 0.58	0.0175	(3)
20°	83.6 ± 2.03	0.0120	(9)			(0)

sents 1/(mean developmental time in days) and X represents temperature (C°). Mean developmental times for overwintering *A. bilineatus* and *P. sulcata* larvae are shown in Table 1. *A. bilineatus* consistently completed development and emerged before *P. sulcata*. *A. bilineatus* overwintered in pupal chambers in the outer bark as mature fourth instar larvae. *P. sulcata* overwintered within its host; however, the overwintering parasitoid life stage was not determined. Parasitized *A. bilineatus* larvae constructed normal pupal chambers and positioned themselves normally within the chamber. *P. sulcata* probably overwintered as early instar larvae since no host disfigurement or discoloration was observed until late April in field-collected specimens; then parasitized larvae turned from milky white to golden yellow and failed to pupate. *A. bilineatus* larvae constructed a passage for subsequent adult emergence from their pupal chamber to within 1–2 mm of the bark surface and packed it with frass before overwintering. *P. sulcata* adults exited via those passages; they constructed a circular exit hole that is distinct from the larger D-shaped *A. bilineatus* exit hole.

The peak flight period of *P. sulcata* (9 July 1980) occurred ca. 3 weeks after *A. bilineatus* peak flight (18 June 1980) (Fig. 2). A similar flight pattern was observed from sticky-trap catches on oaks that were girdled on 17 April 1980 in the same area (J. O. Haanstad, pers. comm.). The delayed peak flight of *P. sulcata* with respect to *A. bilineatus* may be a result of differences in their developmental threshold temperatures. The *P. sulcata* peak flight period occurred at about the time of peak *A. bilineatus* egg eclosion. *A. bilineatus* females oviposited in bark cracks and crevices on the bark surface; *P. sulcata* females were observed entering bark cracks and ovipositing near *A. bilineatus* eggs.

The *P. sulcata* sex ratio (males:females) and sex factor (females/males+females) were, respectively, 1:1.30 and 0.57 (n=92) for laboratory-reared adults and 1:3.22 and 0.76 (n=76) for field-captured adults. *P. sulcata* females were more active than males on the bark surface; this probably explains in part the relatively high proportion of captured females.

P. sulcata was the principal larval parasitoid of *A. bilineatus* in this study. The behavior and biology of *P. sulcata* allow it to be an effective parasitoid of *A. bilineatus*.

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