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Life history and pheromone response in *Pissodes schwarzi* Hopk. (Coleoptera: Curculionidae)

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ABSTRACT

Pitfall traps baited with live *Pissodes schwarzi* Hopk. males plus pine sections captured 46 female *P. schwarzi* from 1 June to 1 September, 1989, indicating the presence of a male-produced sex pheromone. No weevils were captured in unbaited traps, or those baited with females on pine or pine sections alone. Seasonal response of *P. schwarzi* females to the male-baited pitfall traps indicated peak periods of activity in early June, representing overwintered adults, and mid- to late July, corresponding to the emergence of new adults. Development time of *P. schwarzi* varied depending on oviposition location on the tree. Overwintered brood adults began to oviposit in May and continued through August.

INTRODUCTION

The Yosemite bark weevil, *Pissodes schwarzi* Hopk., attacks and breeds in the bole, root collar and large roots of stressed or dying trees (Wood 1964; Stevens 1966). Hopkins (1911) and

Smith and Sugden (1969) list its hosts as *Larix occidentalis* Nutt. (western larch), *Picea engelmannii* Parry ex Engelm. (Engelmann spruce), *P. glauca* (Moench) Voss. (white spruce), *P. mariana* (Mill.) B.S.P. (Black spruce), *P. pungens* Engelm. (blue spruce), *Pinus ponderosa* Laws. (ponderosa pine), *P. albicaulis* Engelm. (whitebark pine), *P. contorta* Dougl. (lodgepole pine), *P. flexilis* James (limber pine) and *P. monticola* Dougl. (western white pine). In British Columbia, *P. schwarzi* is commonly found in lodgepole pine infected with comandra blister rust, *Cronartium comandrae* Pk. (Furniss and Carolin 1977) or other damaging agents.

Host selection by another root-inhabiting *Pissodes*, *P. nemorensis*, has been shown to be pheromone mediated (Fontaine and Foltz 1982). Males release grandisol and grandisal, originally found in the boll weevil, *Anthonomus grandis* Boheman (Tumlinson *et al.* 1969), which attract both males and females (Phillips *et al.* 1984). Both *P. schwarzi* and *P. nemorensis* exhibit similar habits, attacking boles and root collars of young trees. This study investigates the hypothesis that *P. schwarzi* produces an aggregation pheromone and describes some aspects of the weevil's life history and habits.

MATERIALS AND METHODS

Pitfall traps modified slightly from those used to catch *Hylobius abietis* (L.) (Tilles *et al.* 1986a,b; Nordlander 1987) were constructed from 30 cm lengths of PVC plastic drainpipe with a 10 cm inside diameter. The pipes were inserted into the soil so that 8 equidistant holes (6 mm diam.) drilled around the circumference at mid-point of the pipe were at ground level. A thin coating of Tanglefoot® was applied every 3 weeks to the above-ground portion of the trap to catch any responding weevils that might climb the trap. Experimental traps all had a 4-5 cm long section of fresh lodgepole pine wrapped in a fine mesh fabric and suspended at ground level inside the trap. The four treatments were: 1) one male inside the mesh fabric on a pine section; 2) one female inside the mesh fabric on a pine section; 3) pine alone; and 4) an unbaited control. The bait weevils were collected 20 May 1989 on lodgepole pines infected with comandra blister rust. Responding weevils that entered the holes in the trap fell into the bottom of the trap where a plastic dish filled with anti-freeze fluid would trap and kill the insects. The inside of the traps were coated weekly with Tri-flo® (teflon lubricant) to keep responding weevils from climbing up the inside walls and escaping.

The traps were placed in a naturally-regenerated stand of lodgepole pine (average age 12 years) at Ellis Creek located in the montane spruce zone (Table 1) (Lloyd *et al.* 1990), 15 km east of Penticton, B.C. The stand was juvenile-spaced in 1983 and had sustained about 35% infection by *C. comandrae*. Approximately one third of the infected trees, or 10% of the trees in the stand, showed past or current evidence of *P. schwarzi* infestation.

Between 21-23 May 1989, 60 traps were placed in 4 rows of 15 traps each, spaced about 12 m apart, with 15 m between rows. Treatments were assigned in 15 systematic, repetitive complete blocks, beginning at the start of the first row and ending at the last trap of the fourth row.

Table 1

Description of biogeoclimatic zones and subzones sampled in this study. Zones are generally named after one or two dominant climax tree species and two lower-case alphabetic characters are used to denote climatically based subzone names (Lloyd *et al.* 1990; Meidinger and Pojar 1991). The single numeric character following a subzone's alphabetic character indicates a variant, numbered geographically from south to north.

Characteristics	IDFdm1	MSdm1	ESSFdc1
Site	Okanagan Falls	Ellis Creek	Daves Creek
Zone	Interior Douglas-fir	Montane spruce	Engelmann spruce-subalpine fir
Subzone	dry, mild	dry, mild	dry, cold
Elevation (m)	560-1,300	1,300-1,600	1,600-1,950
Annual mean temperature (°C)	3.8	3.2	2.0

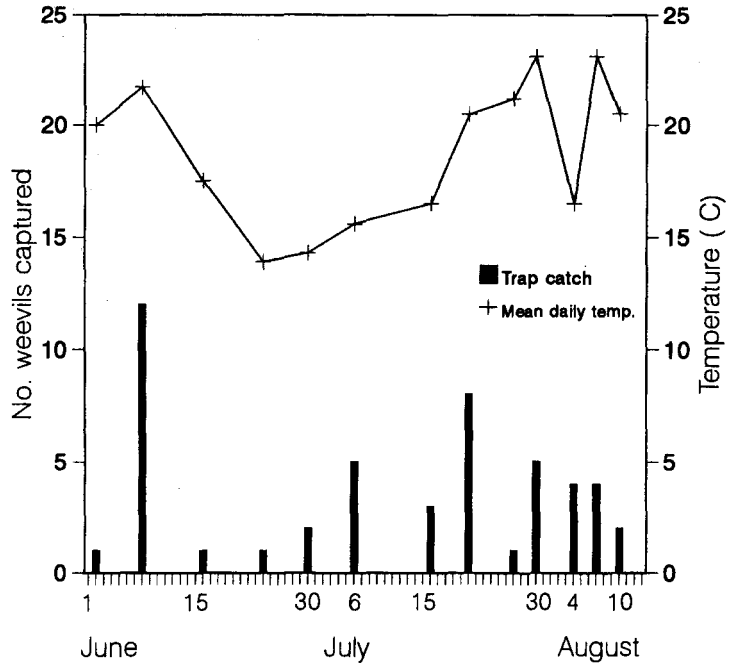


Figure 1. Numbers of *Pissodes schwarzi* caught in pitfall traps, by collection date, from June 1 to September 1, 1989, and corresponding average daily temperature for each period of elapsed time between collection dates. All pitfall traps were located in the Ellis Creek drainage.

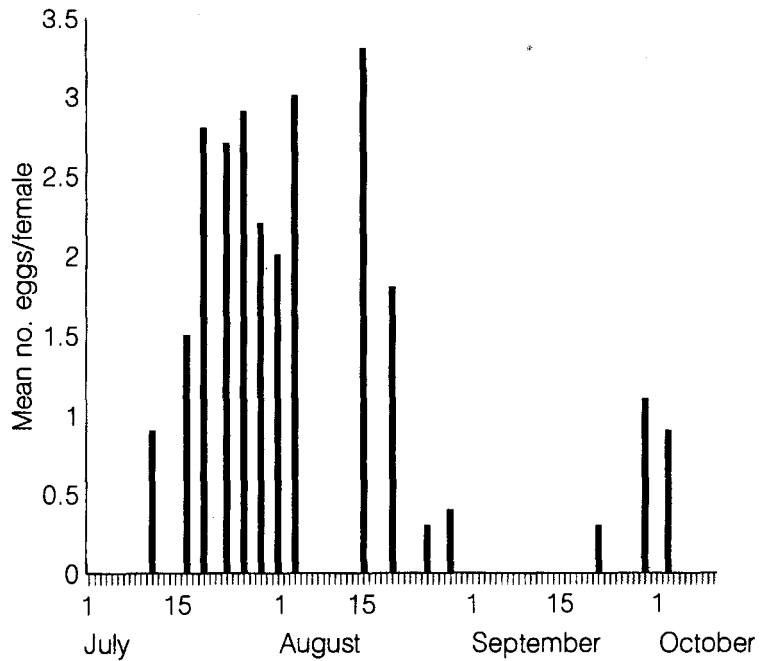


Figure 2. Seasonal trend in numbers of eggs laid by newly emerged *Pissodes schwarzi* females per 3-7 day periods, from July through October, 1989.

At approximately weekly intervals from 1 June to 1 September 1989, captured weevils were collected, and the pine, and weevil baits if necessary, were replaced. Captured weevils were separated by sex (Harman and Kulman 1966).

To study the bionomics of *P. schwarzi*, 5 to 8 infested pine roots were collected at approximately weekly intervals from 1 June to 23 August 1988 from 3 sites, located in three different biogeoclimatic zones and subzones, in the Penticton area (Okanagan Falls, Daves Creek, and the trapping site, Ellis Creek) (Table 1). The roots were subdivided into bole, root-ball, and lateral roots, and dissected; the numbers of weevils in each life stage, as well as empty chip cocoons were recorded.

Infested roots were collected from Ellis Creek on 21 May 1989 and the adults were allowed to emerge in the laboratory. The weevils used in the study emerged between 9-20 June 1989. Oviposition by emergent weevils was studied by placing 39 male-female pairs of *P. schwarzi* on 6 cm lengths of fresh pine in a 15 x 2.5 cm petri dish on 21 June, 1989. The 39 petri dishes containing the weevils were kept in a screen house under natural light:dark and temperature conditions. The pine was replaced every 3-5 days and assessed for oviposition. Observations from dissections and the trapping study were related to weather recorded by the B.C. Forest Service about 2 km from the Ellis Creek site, at the same elevation.

RESULTS AND DISCUSSION

Forty-eight *P. schwarzi* were captured throughout the summer in traps baited with males on pine sections (two of these were captured in the Tanglefoot). No weevils were captured in unbaited traps, or those baited with females on pine or pine sections alone. Forty-six of the *P. schwarzi* captured were females, indicating a male-produced sex pheromone. The lack of response to all but the males-on-pine treatment suggests that *P. schwarzi* does not respond to an attractive tree trunk silhouette for visual orientation, with or without host volatiles, similar to results obtained with *H. radicus* Buchanan (Hunt and Raffa 1989). Three *Hylobius warreni* and one *Magdalis* sp. were caught in response to the male-on-pine treatment.

The seasonal response of female *P. schwarzi* to the male-baited pitfall traps indicates peak periods of activity in early June and mid- to late July (Fig. 1). Trap catches were generally highest in warm weather. The first seasonal peak probably represents overwintered adults, and the second peak newly emerged adults. Adults were collected from around the boles of stressed pines on 10 May 1989 and all 6 of the females collected were ovipositing. These females when paired with males laid 4.1 ± 0.3 eggs per day (mean + S.E.) from 10 May to 1 June 1989.

Dissections of infested roots collected periodically from the three locations throughout the summer revealed a fairly high frequency of larvae in the host from early June, to the end of August. The frequency of pupae increased from late June through late July, and decreased in August. The frequency of adults in the host varied only slightly between sites, and generally increased from late July to early August. Separation of larval instars visually into early versus late disclosed that late instars were most frequent in early June and August, and early instars from mid-June through late July, corresponding to the observed activity of overwintered adults in the field. As also noted by Stevens (1966), all developmental stages were represented during July and August. However, in B.C. overwintered adults can be found mating, feeding and ovipositing on boles as early as May and this has been observed to continue through August, as opposed observations in California (Stevens 1966) where the first sign of oviposition was noticed in July. Because of the protracted oviposition period, overwintering larvae of all stages may be encountered (Stevens 1966; personal observations).

Developmental time varied depending on the oviposition site on the tree. The preferred oviposition site was the lower bole (>80%) with the remainder occurring equally in the root-ball and lateral roots. Developmental time in the bole can be as much as a year shorter than in the root ball or lateral roots due to higher above-ground temperatures (personal observation). Some infested trees were identified and checked periodically throughout the summer to observe development in the field. Weevils developed and emerged from the above-ground portions of the trees whereas many weevils in the below-ground portions of the trees overwintered as larvae or pupae for a second winter. About 50% of infested trees that were dissected from the three sites

had empty chip cocoons, from which adults had already emerged and the majority of the emergence was from the bole. The collections made from Daves Creek (ESSF), had >90% of the cocoons located in the above ground portion of the bole. This could be due to a preference for ovipositing on the bole in the cool temperature regime in this biogeoclimatic zone.

From 12-18 July 1989, 22 to 28 days after being placed on host sections in petri dishes, the females began ovipositing and continued until 2 Oct. (Fig. 2). There appeared to be a major peak in late July through August, and then a lesser one in October. Weevils could be found ovipositing on boles in the field until late September in 1989. The mean number of eggs laid per female (\pm S.E.) was 22.6 ± 1.82 , with a maximum of 92 eggs laid by one female. There were up to 5 eggs deposited per puncture; however, of the 904 oviposition punctures examined, 86% contained 1 egg and 12%, 2 eggs.

According to Stevens (1966) mating occurs on the foliage, with oviposition taking place throughout the summer. Our observations and data (Fig. 2) support Stevens (1966) observation regarding oviposition; however, mating was only observed on the bole of lodgepole pine. Mating locations may differ between geographic areas or climatic regimes, or perhaps Stevens (1966) observed *Pissodes terminalis* mating on the foliage and did not distinguish it from *P. schwarzi*.

Aggregation pheromones were reported for *P. nemorensis* by Booth and Lanier (1974). Males produced a pheromone that when deployed with host odors attracted conspecific males and females (Booth *et al.* 1983). *P. strobi* and *P. nemorensis* both produce grandisol (*cis*-2-isopropenyl-1-methylcyclobutaneethanol), and its corresponding aldehyde, grandisal, which act together as aggregation pheromones for *P. nemorensis* (Booth *et al.* 1983; Phillips and Lanier 1986). Phillips and Lanier (1986) found that male *P. strobi* produce an unknown allelochemical that interrupts the response of *P. nemorensis* to its natural or synthetic aggregation pheromone. Although Booth and Lanier (1974) postulated that *P. strobi* uses a male-produced aggregation pheromone, repeated field tests have indicated that grandisol and grandisal are not pheromones for *P. strobi* (Booth and Lanier 1974; Phillips 1981; Booth *et al.* 1983). We hypothesize that a similar relationship to that between *P. nemorensis* and *P. strobi* could occur between the lodgepole terminal weevil, *P. terminalis* Hopping, and *P. schwarzi*, which spatially occupy similar host sites.

Commonly, *P. schwarzi* infests trees stressed by rusts, *Cronartium comandrae*, root rots and other insects, such as *Cylindrocopturus* spp. (Coleoptera: Curculionidae) (Wood 1964; Stevens 1966; Coulson and Franklin 1970), which are in themselves damaging or fatal. Therefore, *P. schwarzi* is not economically important at present, but with increasingly intensive silvicultural practices, e.g. spacing, and the probable onset of climatic warming trends, *P. schwarzi* could well emerge as a problem in some circumstances, particularly because of its tendency to infest apparently drought-stressed trees (personal observation).

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NOTES

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A versatile wind-resistant insect cage

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ABSTRACT

Ecological field studies often require cages that can withstand adverse weather conditions such as high winds, without greatly altering environmental conditions within them. A large field cage was designed, fabricated and tested for predator-prey studies on raspberry plantings. It consisted of a wood base and screening suspended with loops of canvas from a framework of PVC pipe. The cage withstood gusts above 70 km/h, did not appreciably alter temperature or RH, but did reduce light by 40% and rainfall by 25%. The cage design is simple and can be adapted to many experimental situations.

INTRODUCTION

Field cages have traditionally been designed with vertical walls and right-angled corners (e.g. Fay and Meats 1987; Grant and Shepard 1985; and Savinelli *et al.* 1988). This shape provides ample standing room. However, rectangular cages have stability problems, particularly in