How does spittlebug oviposition affect shoot growth and bud production in two willow species?

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We measured the effects of oviposition by the spittlebug Aphrophora pectoralis on shoot growth and bud production in two willow species, Salix miyabeana and Salix sachalinensis. In autumn, adult females of A. pectoralis insert their ovipositor into the apical region of 1-year-old shoots, resulting in the death of most shoot tips within 1 week. Consequently, an increase in the number of dead buds and a decrease in the number of vegetative buds on 1-year-old shoots was recorded. In the following spring, the growth of current-year shoots was greatly increased on 1-year-old shoots damaged by spittlebug oviposition. Furthermore, spittlebug oviposition increased the production rate of vegetative buds in both S. miyabeana and S. sachalinensis. However, no impact on the production rate of reproductive buds was detected in either willow. We conclude that the compensatory growth of current-year shoots and an increase in vegetative buds in the two willow species was caused by oviposition of A. pectoralis.

Key words: Aphrophora pectoralis; apical dominance; compensatory shoot growth; Salix miyabeana; Salix sachalinensis.

INTRODUCTION

A wide variety of plant defense strategies have evolved against herbivorous insects and mammals (Coley et al. 1985; Myers 1988; Karban & Myers 1989), including physical defense using trichomes and tissue hardness (Hoffman & McEvoy 1986; Gross & Price 1988; Tuberville et al. 1996) and chemical defense using phenolic compounds, tannins and mustard oil (Feeny 1970; Erickson & Feeny 1974; Rowell-Rahier 1984; Schultz 1988; Clausen et al. 1991; Raupp & Sadof 1991; Julkunen-Tiitto et al. 1995). Furthermore, recent studies have emphasized that plants have evolved not only avoidance strategies to herbivory, but also tolerance strategies (van der Meijden et al. 1988; Mauricio et al. 1997). A compensatory response is one of the major tolerance strategies of woody plants (McNaughton 1983; Hartnett 1989; Belsky et al. 1993). It is the ability of plants to partially or fully compensate for the loss of plant tissue, and is a common plant response following herbivory (Dyer & Bokhari 1976; McNaughton 1979; Inouye 1982; Heichel & Turner 1983; Paige & Whitham 1987; Roininen et al. 1994).

Many studies have examined the effects of herbivory on leaves and fruits (Feeny 1970; Haukioja & Niemelä 1979; Paige & Whitham 1987; Karban & Myers 1989; Bergelson & Crawley 1992; Tuberville et al. 1996; Mauricio et al. 1997; Fox et al. 1998). However, herbivorous insects utilize plants not only as a food resource, but also for mating, oviposition and as a shelter from predators, parasitoids and unfavorable climatic conditions (Damman 1987; Denno et al. 1990; Cappuccino 1993; Larsson et al. 1997). These non-feeding activities of herbivorous insects may also influence the growth and reproduction of host plants in the same way that herbivory does (Craig et al. 1986; Sacchi et al. 1988). For example, a bud-galling midge, Rabdophaga sp., reduced bud numbers and shortened the shoot length of the willow, Salix
exigua Nutt. (DeClerck-Floate & Price 1994). However, little attention has been paid to the effects of non-feeding behavior by herbivorous insects on host plants.

The spittlebug Aphrophora pectoralis Matsumura is a xylem-sucking insect that utilizes willows (Komatsu 1997). In autumn, adult females insert their ovipositor for egg laying into the apical region of shoots that grow in the current year. Because of the mechanical damage this action causes the upper part of most of the affected shoots dies within 1 week. Recent studies have revealed changes in the patterns of plant growth following herbivory on the upper part of the shoots in several woody plants (Whitham & Mopper 1985; Mopper et al. 1991). Thus, shoot growth and bud production in succeeding years may be influenced by the oviposition behavior of the spittlebug.

The purpose of this study was to determine the effects of oviposition by the spittlebug A. pectoralis on shoot growth and bud production of two willow species, S. miyabeana Seemen and S. sachalinensis Fr. Schm. We used the number of buds and shoot length as a measure of plant response to damage caused by spittlebug oviposition because willows are regarded as aggregations of repeated units or modules, such as shoots (Tuomi & Vuorisalo 1989). We investigated whether spittlebug oviposition in autumn 1998 affected: (i) the number of dead and vegetative buds in mid May 1999; (ii) the length of current-year shoots and the number of leaves in early September 1999; (iii) the number of new buds produced in early September 1999; and (iv) the production rates of vegetative and reproductive buds in early May 2000. In addition, we investigated the relationship between the position and the length of current-year shoots in early September 1999.

METHODS

Study site

The study was conducted on the banks of the River Ishikari in Hokkaido, northern Japan (43°11′N, 141°24′E). At this site, six willow species (S. miyabeana, S. sachalinensis, Salix integra Thunb, Salix hultenii Floderus, Salix subfragilis Anders and Salix pet-susu Kimura) grow sympatrically. S. miyabeana and S. sachalinensis are the most and second most abundant species, respectively, in this area (Ishihara et al. 1999).

Spittlebug

The spittlebug A. pectoralis is a herbivorous insect that utilizes willows (Komatsu 1997). In general, spittlebugs suck xylem sap from the host plants (Kuenzi & Coppel 1985; Owen 1988). A. pectoralis overwinters in an egg stage. Hatching of overwintered eggs begins in mid May, just before the beginning of shoot elongation in the willows (Nozawa & Ohgushi 2002). Nymphs produce spittle in which they live and feed and this spittle protects them from natural enemies, desiccation and high temperatures (Marshall 1966; Whittaker 1970; Kuenzi & Coppel 1985). Young nymphs tend to aggregate, but this aggregative behavior is reduced as they mature. Adults begin to emerge from late June and mating and oviposition occur from early August to mid October. Adult females insert their ovipositors into the upper part of shoots that grow in the current year and lay eggs inside these shoots. The upper part of any shoot that receives eggs will die within 1 week as a result of mechanical damage. We term a shoot that began to grow in the year of the study (1999) a current-year shoot and a shoot that began to grow in the previous year (1998) a 1-year-old shoot.

Host plants

Salix miyabeana and S. sachalinensis are common willow species in Hokkaido, northern Japan. Both willows grow along riversides or in open areas. The two species are dioecious deciduous trees. Salix miyabeana grows to 3–5 m in height and S. sachalinensis up to 10–15 m in height. They flower from April to early May in Hokkaido; the female trees develop their inflorescences during May and disperse their seeds in mid June. Vegetative budbreak occurs when the catkins are blooming and leaf expansion and shoot elongation continue until mid July. Secondary leaf expansion and shoot elongation occasionally occurs after September. Most leaves senesce by late October and new buds appear on the leaf axils at that time.