Host Plant Quality and Male Wheat Stem Sawfly (Hymenoptera: Cephidae) Fitness[1]

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Abstract The size of male *Cephus cinctus* Norton (Hymenoptera: Cephidae) adults did not significantly increase with the size of host stems in which larvae developed. Larger adult male sawflies had higher longevity. There was no statistically significant relationship between wing length and the emergence date, mating success, or dispersal from overwintering sites. The relation of host plant quality and sawfly fitness was less apparent for male adults than that which we previously reported for females.

Key Words Wheat stem sawfly, *Cephus cinctus,* host quality, insect fitness

Host plant vigor, stem diameter, and seed size affect phytophagous female insect size, fecundity, and abundance (Mopper and Whitham 1992, Craig and Mopper 1993, Smith et al. 1995, McMillin and Wagner 1998, Morrill et al. 2000). The relationship between host quality and male fitness is more difficult to quantify (Charnov 1982) and has received less attention. Therefore, we investigated the interaction between host plant quality and some factors that influence fitness of male wheat stem sawflies, *Cephus cinctus* Norton (Hymenoptera: Cephidae) (called "sawfly" hereafter).

The sawfly is univoltine. Adults emerge in the spring, and eggs are deposited in stems of wheat and other grass hosts (Youtie and Johnson 1988). Larvae feed and complete their development within the stems. Larvae overwinter in lower stem sections, or "stubs". Pupation occurs within the stubs in the spring after obligatory larval diapause is completed (Ainslie 1920).

Ovipositing sawflies select larger-diameter stems (Morrill et al. 1992). Inadequate stem size, especially during periods of marginal moisture availability, precludes larval survival in many species of wild grasses (authors, unpub.).

The gender of sawfly progeny is determined by selective fertilization at the time of oviposition, in a fashion similar to other haplo-diploid Hymenoptera (Flanders 1946). Females are more likely to be produced in larger stems (Wall 1952, Morrill et al. 2000). Female adults from the largest stems have greater longevity and higher fecundity (Morrill et al. 2000).

In this project, we used wheat stem diameter as an indicator of host quality. Wing length, longevity, mating success, and dispersal were indicators of male sawfly fitness.

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Materials and Methods

Sawflies for laboratory trials were reared from larvae-infested wheat stubs that were obtained from post-harvest fields in Broadwater Co. (north of Three Forks: 46° 25.500′, 111° 385.500′), Chouteau Co. (east of Brady: 48° 00.107′, 111° 14.911′), and Stillwater Co. (east of Rapelje: 45° 59.308′, 109° 16.497′), Montana. All fields were hollow-stemmed winter wheat of undetermined variety. The stubs were collected in September, stored at 3° C for >4 months to permit completion of larval diapause, and then were placed in individual 7 × 3 cm diam glass shell vials that were stoppered with moistened cotton plugs. Vials were inspected daily, and dates of sawfly emergence and death were recorded.

Mesothoracic wing length was used as an indicator of body size. Sawfly bodies are soft and begin to desiccate and shrink after death. However, wing lengths are stable and are good indicators of body sizes (Morrill et al. 2000). Wings were removed and tip to base measurements were determined with a digital caliper.

The upper end of infested stubs were measured with a caliper. Minimum and maximum dimensions of oval-shaped stubs were averaged. The stubs the result of circular notches that are cut around the inside perimeter of stems. The weakened stems break, or "lodge", and fall to the ground prior to harvest. The stubs are filled with soft plugs through which adults later emerge. Infested stubs are easily identified by these characteristics.

Stub diameter and wing length. Wing lengths of 71, 99, and 21 male sawflies were measured from fields in Chouteau, Broadwater, and Stillwater counties, respectively. The relationship of wing size and stub diameter at each location was estimated by using linear regression.

Longevity and wing length. Wing lengths of male sawflies that survived for >4 d were measured for each location. Several wasps died due to entrapment in the cotton plugs and were discarded. The relation between size and survival was determined with linear regression.

Date of emergence and wing length. The wing lengths of 52 male sawflies from Broadwater Co. stubs were measured during the emergence period from 3 to 11 May. Mean daily wing lengths were compared with Kruskal-Wallis non-parametric one-way analysis of variance by using SigmaStat (Charland 1995).

Dispersal and wing length. The dispersal of male sawflies from a summer fallow field into a neighboring barley field was determined in Broadwater Co. Samples consisted of four replications of 40 sweeps with a 38 cm diam net at 2, 10, 20, 30, and 40 m from the field border 7 d after emergence began. One hundred twelve male wasps were captured. Unfortunately, subsequent insecticide application by the producer precluded further sampling. Mean wasp wing lengths from each location were compared with one-way analysis of variance.

Mating success and wing length. Sawflies mate near overwintering sites or in nearby vegetation. We used aspirators to collect 24, 12, and 44 mating pairs in the fallow wheat stubble field in Broadwater Co. on 12, 14, and 16 July, respectively. During these sampling dates, 80, 32, and 88 patrolling males were collected with a sweep net. The mean wing lengths of mating and patrolling sawflies were compared with a *t* test for the first two samples. Means on the third date were not normally distributed, therefore comparisons were made by using the Mann-Whitney rank sum test run with SigmaStat.

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Results and Discussion

Stub diameter and wing length. Stub diameters ranged 1.55 to 3.44 mm, and wing lengths ranged 2.40 to 7.96 mm. However, although there was a 2-fold range in host stem sizes and wing lengths, there was no statistically significant relationship between these factors. Values were $R = 0.058$, df = 70, $P = 0.024$ (Chouteau Co.), $R = 0.013$, df = 98, $P = 0.137$ (Broadwater Co.), and $R = 0.156$, df = 20, $P = 0.043$ (Stillwater Co.). This suggests that there was no advantage in male development in the largest, or highest quality stems. In contrast, female wasp wing length and body weight was positively related to host stub diameter (Morrill et al. 2000).

Longevity and wing length. Male sawflies lived for up to 11 d in the laboratory, well within the range expected for individuals in the field. Larger wasps lived longer. (Broadwater Co.: $R = 0.744$, days = $-26.95 + (5.13 \times$ wing length), df = 4, $P = 0.060$); Stillwater Co.: $R = 0.698$, days = $-24.3 + (5.21 \times$ wing length), df = 3, $P = 0.107$) Chouteau Co.: $R = 0.588$, days = $(-15.93 + (3.72 \times$ wing length), $P = 0.046$ (Fig. 1). The increase in longevity with larger body size was the most significant male fitness factor that we found. The apparent higher energy reserves in the larger individuals are important because sawflies are not known to feed. Males mate more than once, therefore longevity affects the incidence of encounters with females.

Date of emergence and wing length. Large males did not emerge earlier than small males during the 8-d emergence period (Kruskal-Wallis one-way analysis of

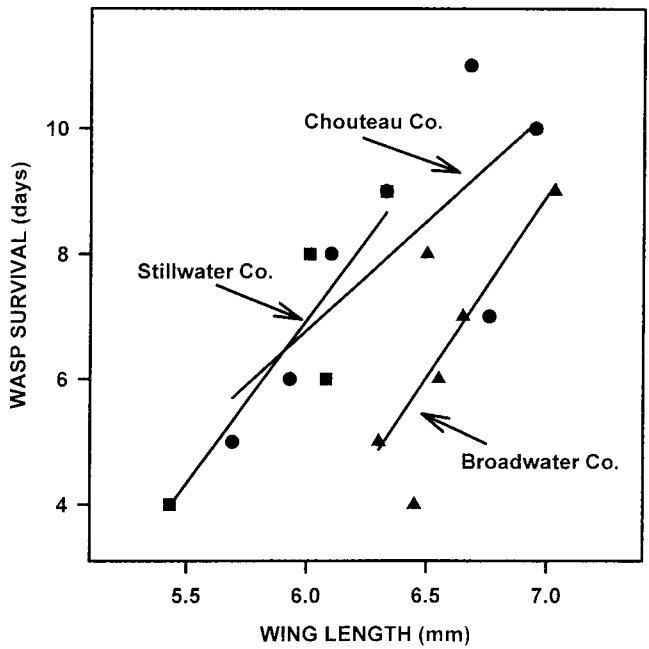

Fig. 1. Longevity of male wheat stem sawfly wasps from three localities in Montana relative to wing length.

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variance on ranks, df = 9, $P = 0.103$). It is common to find male sawflies several days earlier than females in the field (Ainslie 1920). Adults live for about 1 wk, therefore males that emerge too early would not survive throughout the period when receptive females are available.

Dispersal and wing length. Mean and SEM of male wing lengths were 6.65 mm ± 0.08, 6.231 mm ± 0.154, 6.20 mm ± 0.165, and 6.33 mm ± 0.154 for sawflies collected 2, 10, 20, and 30 m into the field that bordered the overwintering site. There was no statistically significant relation between wing size and distance (one-way ANOVA, $P = 0.64$, df = 82).

Sawfly dispersal is characterized by slow short duration flights that are within 0.5 of the ground. Flight activity begins in mid-morning and terminates at mid-day or when wind speeds exceed 5 km/h. Sawflies may have remained within patches of the large-stemmed perennial grass hosts that were part of the native prairie vegetation (Kemp et al. 1990), therefore long flights to find hosts and mates were not necessary. Dispersal ability may now be more important than previously because the current agricultural landscape that consists predominantly of alternate-year fallow, and wasps must disperse from overwintering sites to standing crops.

Mating success and wing length. There were no statistically significant differences in wing lengths of male wasps that were copulating with females and males that were patrolling ($t = -1.52$, df = 102, $P = 0.131$, $t = 0.84$, df = 42, $P = 0.40$, $t = 0.51$, df = 130, $P = 0.60$, for 12, 14, and 16 July, respectively) (Fig. 2). Male mating success apparently is due primarily to chance encounters with females.

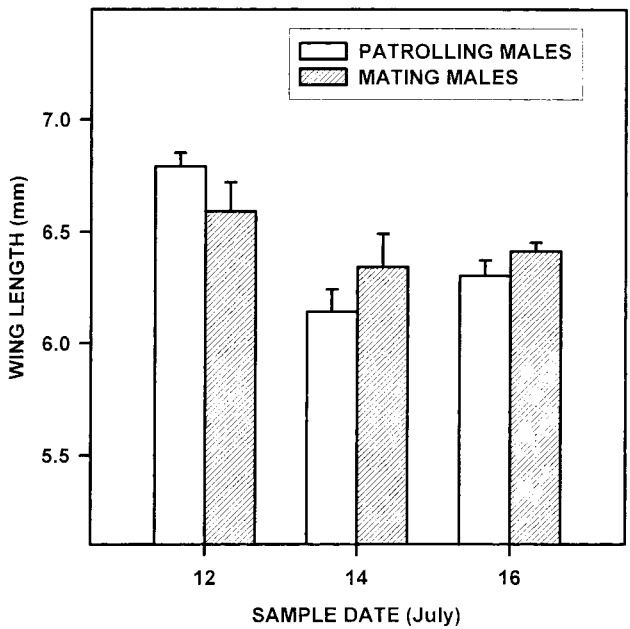

Fig. 2. Comparison of wing lengths of mating and patrolling male wheat stem sawflies in Broadwater Co. Bars indicate means and standard errors.

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Newly-emerged females climbed to the tops of nearby stems and waited for patrolling males. Female wasps appeared to mate only once. Those that did not mate shortly after emergence flew upwind to tall border grass where they encountered patrolling males. Females contain fewer than 50 eggs (Morrill et al. 2000), therefore repeated mating to accumulate high sperm numbers may be of little value.

Conclusions. Male fitness is difficult to quantify, as Charnov (1982) stated. Although larger males lived longer, and potentially encounter more females, the relationship between host size and insect size was subtle. Female wasps optimize host utilization by depositing fertilized eggs in the most suitable stems, as indicated by the more obvious response of female progeny to host quality.

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