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The wheat stem sawfly – a nursery tale from the shortgrass prairie

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The wheat stem sawfly *Cephus cinctus* Norton (Hymenoptera: Cephidae; Fig. 1), is a major pest of spring wheat in the southern Canadian prairies and the northern plains of the United States (Weiss and Morrill 1992; Fig. 2). In the Canadian population, which is adapted to spring wheat, oviposition occurs in late June and early July when the female (Fig. 3) inserts an egg into the elongating internode of a wheat stem. Stems from which the head has yet not emerged (the boot stage) are preferred (Holmes and Peterson 1960). The larva (Fig. 4) feeds within the stem until the plant is nearly mature. It then girdles the stem at ground level, plugs the pith cavity and overwinters in the lower part of the stem (the stub). In the spring the overwintered larvae pupate

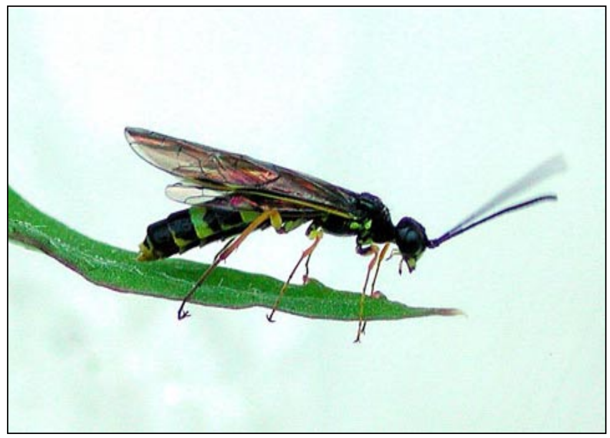

Fig. 1. Male wheat stem sawfly - a historical pest of wheat that has resurged in the prairies (photo by H. Goulet).

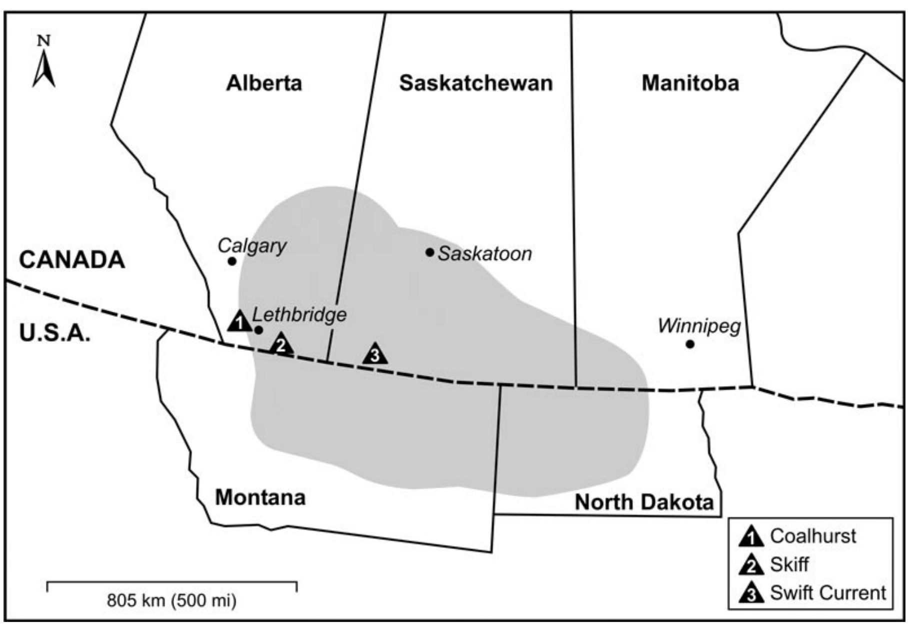

Fig. 2. Area within the Northern Great Plains of North America where the wheat stem sawfly has historically caused the most economic damage.

Fig. 3. Female wheat stem sawfly in the act of laying an egg on a wheat stem (photo by B. Beres).

and the adults begin emerging from the stubs about the middle of June.

In Saskatchewan, between 1926 and 1958, the wheat stem sawfly caused more damage (Fig. 5) to wheat crops than did grasshoppers (McGinnis and Kasting 1967). It was realized early on that host plant resistance would be the best defence against this insect and in the late 1950's attempts were initiated to establish a wheat stem sawfly nursery (Fig. 6A) near Lethbridge, Alberta to facilitate the assessment of level of resistance in wheat breeding lines (Peterson et al. 1968). In the original establishment of the nursery by Peterson et al. (1968) three methods of introduction were used: 1) infested stubs were collected in fall, stored overwinter at 10°C, and transplanted in the nursery the following spring, 2) adult sawflies were collected with sweep nets in June from infested fields and immediately transported to the nursery, and 3) stubs containing larvae were collected in the fall and immediately transplanted in the nursery.

Although the first crop year of the nursery was 1959, a useful sawfly population was not established until 1965. The population of the nursery remained more or less stable from 1965 through 1991, but in 1992 a severe spring drought led to late crop emergence which resulted in a phenological asynchrony between the appropriate crop stage and sawfly oviposition. As a consequence the sawfly population was essentially eliminated. In response to the recent resurgence of the wheat stem sawfly, research on this insect has been renewed and there was a need to re-establish the nursery (Fig. 6B). Our objective was to assess a novel method additional to the Peterson et al. (1968) methods used in the establishment of a sawfly nursery.

For our first attempt to repopulate the nursery in 1999 adult sawflies were collected on July 9, 12, and 22 from infested fields at Vulcan, Alberta. They were caught with sweep nets, and placed in partially inflated plastic bags, with about 50 in each bag, and transported in cold chests to the nursery for release the same day. A sample of three bags on each date was kept for determination of the sex ratio. The estimated number of sawflies and percent females in the collections was: July

Fig. 4. Larvae of wheat stem sawfly being attacked by the juvenile stage of *Bracon cephi* (top), an important parasitoid found throughout the range of *Cephus cinctus* (photo by C. Barlow).

9: 4,800, 9.3%; July 12: 6,000, 19.1%; July 22: 4,000, 52.7%. Assessment of the subsequent level of infestation in the fall of 1999 and 2000 by visually rating the % of stems cut, a methodology validated by Holmes et al. (1968), indicated that the reintroduction had failed (Table 1) i.e. <5.0% stems cut. The other method (referred to herein as # 4) conducted in 2001 differed from Peterson et al. (1968). About 10,000 wheat stubs were dug from a severely infested wheat field at Skiff, Alberta on April 18 and 19 and immediately replanted at the nursery in a shallow trench along the western edge of the strips where the test lines of wheat, grown as single rows in a randomized complete block design with four replicates, were to be planted. In the fall of 2001 the overall cutting level in the test lines was 19%, which enabled a rating of the resistance levels in breeding lines and candidate cultivars for the first time since 1991. By 2003, without further augmentation, the cutting level increased to an overall mean of 57% (Table 1).

Weather conditions, especially precipitation, can undoubtedly affect the success of artificial infestations. Peterson et al. (1968) reported that following their introductions over a period of four consecutive generations the infestation levels were still low, which they attributed to the below average annual and growing season precipitation during the first three years (Table 1). There were no artificial attempts to populate the nursery in 1963 and 1964, and despite more favourable weather conditions, Peterson et al. (1968) report the population remained low. It was not until the sixth year of establishment that the population rose to a level that Peterson et al. (1968) describe as being high enough to create an adequate infestation the following year i.e. 40 % stubs cut or containing live larva (Table 1). In our study, precipitation did not appear to have much effect on establishment success. Precipitation was near normal in 1999 when we used the adult transfer method (2) and the weather was moderate for several weeks afterwards. However, in spite of apparently favourable conditions the infestation levels that fall and again in 2000 were very low. Although the spring transfer of stubs (4) in 2001 was done in a very dry year the population successfully established. The conditions were more severe than the drought of 1960 (Table 1) in which Peterson et al. (1968) report the dry soil conditions likely inhibited adult emergence from their transplanted stubs. Cutting of stems in 1960 was 10.5 % compared to 19 % in 2001. Our method (4) also proved to be more effective in rapidly creating an adequate population. Using the spring stub transplant method we achieved the minimum infestation threshold of 15-20% (Peterson et al. 1968) that same year, and reached the desirable infestation threshold level of 40% (Peterson et al.,1968) by Year 2 (Table 1). Peterson et al. (1968) were not able to populate the nursery to an adequate level until Year 6. The higher success rate for our stub transplant method is likely

Fig. 5. Wheat stem sawfly damage to spring wheat near Foremost, Alberta near the middle of August in 2004; note the heavier damage along the edges of the field (photo by T. Dickinson).

Table 1. Percentage of stems cut by sawflies and associated precipitation data. Data for 1960-66 from Peterson et al. (1968)

			Precipitation	
Year	Repopulation method	Percentage of stems cut by sawflies	Yearly total (cm)	Total for April, May and June (cm)
1960	1, 2	10.5	28.4	12.3
1961	1	14.5	37.0	11.0
1962	1, 3	19.0	28.1	9.0
1963	none	16.5	42.5	19.9
1964	none	17.0	44.7	23.3
1965	none	63.0	53.5	22.6
1966	none	78.5	52.1	22.3
1987	none	19.9	36.8	9.2
1988	none	6.8	22.6	6.7
1989	none	26.8	43.4	13.2
1990	none	47.8	32.4	15.2
1991	none	32.2	39.8	19.7
1992	none	<1.0	37.6	12.8
1999	2	<5.0	34.1	16.5
2000	none	<5.0	27.6	9.0
2001	4	19.0	17.6	9.7
2002	none	47.0	63.4	33.1
2003	none	57.0	n/a	18.1
Long term average 1902 – 2002			40.0	16.0

1. stubs collected in fall, stored overwinter and transplanted to site in spring
2. adult sawflies collected and immediately transported to site
3. stubs collected in fall and immediately transplanted to site
4. stubs collected in spring and immediately transplanted to site

Figure 6. Lethbridge Research Centre wheat stem sawfly nursery:
(A) shortly after original establishment (Peterson et al. 1968);
(B) in July 2003 (photo by B. Beres).

because we collected the stubs in the spring after they had overwintered in a natural and undisturbed environment.

Our results are consistent with the conclusion of Peterson et al. (1968) that transplanting of stubs containing diapausing larvae is a more effective method of populating a sawfly nursery than is the importation of adults. Furthermore, our success with spring transplantation of stubs, even in a drought year, indicates that it is best to let the diapausing larvae overwinter undisturbed in their normal habitat. In addition, we were able to repopulate the nursery to a desirable level by Year 2 using this method. The low success rate observed by Peterson et al. (1968) when they transplanted stubs in the fall can be attributed to an increased exposure to adverse environmental conditions.

The only caveat to the transplant method is the accidental introduction of a parasitoid. Larvae that have been parasitised by natural enemies may also be transplanted. We have observed the parasitoid, *Bracon cephi* (Figs. 7 and 4), emerging in the lab from material collected at the nursery (Cárcamo and Beres unpublished data). It is not possible to determine if the parasitoid was imported with the plant material or whether it migrated to the site as sawfly populations increased.

The empirical testing of the level of resistance to wheat stem sawfly in candidate cultivars and germplasm lines of bread and durum wheats

Fig.7. Adult of *Bracon cephi*, an important parasitoid of *C. cinctus* (photo by H. Goulet).

require a site that will provide a high and uniform level of exposure to the sawfly. In recent years, this has only been accomplished by moving to off-station sites where sawfly infestation was severe the previous year. However, off-station sites are more expensive, labour intensive, and sometimes difficult to manage. With the successful re-population of the Lethbridge wheat stem sawfly nursery we now have a core site for several on-going research projects on this important insect pest.

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