A Survey of Five Stem-Feeding Insect Pests of Wheat in the Northern Great Plains[1]

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Abstract The wheat stem sawfly, *Cephus cinctus* Norton, the wheat stem maggot, *Meromyza americana* Fitch, the Hessian fly, *Mayetiola destructor* (Say), the wheat jointworm, *Tetramesa tritici* (Fitch), and the wheat strawworm, *Tetramesa grandis* (Riley), have long been considered wheat pests in the northern Great Plains. This paper reports results of surveys for these pests conducted over 3 yrs in parts of Montana (10 counties), North Dakota (14 counties), South Dakota (1 county), Nebraska (4 counties) and Wyoming (1 county). Fields were randomly selected and a mean of 191 stems were sampled from each field. The percentage of stems infested with each pest was recorded. The percentage of parasitized wheat stem sawfly larvae also was noted. The wheat stem sawfly, wheat stem maggot, and Hessian fly were the most commonly encountered pests, recorded in nearly every county. Wheat stem sawfly density was twice that of wheat stem maggot (7% vs 3.2%) in infested fields. Wheat stem sawfly densities exceeded 10% in 4 counties: Daniels and Wibaux in MT, Golden Valley, ND and Goshen, WY. Wheat stem sawfly parasitism was low and positively correlated with sawfly infestation. Wheat stem maggot infestations were low (<11% for all fields), averaging 3.2% among infested fields. Hessian fly densities were much lower (2.2% among infested fields) than reported elsewhere in the U.S. The wheat jointworm and strawworm were absent from most fields and only occasionally found at low levels (<1% and <3.5% respectively, among infested fields). This information will help to prioritize wheat insect pest management research and extension programs in this region.

Key words wheat stem sawfly, *Cephus cinctus*, wheat stem maggot, *Meromyza americana*, Hessian fly, *Mayetiola destructor*, wheat jointworm, *Tetramesa tritici*, wheat strawworm, *Tetramesa grandis*, survey

Wheat is one of the most widely grown crops in the United States, and specifically in the northern Great Plains. A number of insects feed within the stem or leaf sheath of the developing wheat plant. Among the most important are the wheat stem sawfly, *Cephus cinctus* Norton (Hymenoptera: Cephidae), the wheat stem maggot, *Meromyza americana* Fitch (Diptera: Chloropidae), the Hessian fly, *Mayetiola destructor* (Say) (Diptera: Cecidomyiidae), the wheat jointworm, *Tetramesa tritici* (Fitch) (Hymenoptera: Eurytomidae), and the wheat strawworm, *Tetramesa grandis* (Riley) (Hymenoptera: Eurytomidae) (Morrill 1995).

Each of these insect species has caused substantial damage to wheat in some years and locations. Despite their historical importance, there has been little effort to

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assess the impact and distribution of these species in the past 50 years. Staff reductions in state and federal research and extension programs, along with changing research priorities and interests, have contributed to the lack of survey information on anything but newly invasive or widespread pests. This is unfortunate for at least two reasons: relatively low populations of common, widely distributed pests that inflict small individual yield impacts can still produce large economic impacts over wide areas. And, second, with the reduction in research investments in general, and entomology in particular, research needs and opportunities must be prioritized. In this paper we report the results of wheat pest insect surveys conducted in selected counties of Montana, North Dakota, South Dakota, Nebraska and Wyoming. This type of information is needed to set and justify research and extension priorities.

Materials and Methods

The incidence and distribution of the wheat stem sawfly, the wheat stem maggot, the Hessian fly, the wheat jointworm, and the wheat strawworm were determined by surveying eastern Montana (10 counties), western North Dakota (14 counties), northwestern South Dakota (1 county), eastern Wyoming (1 county) and western Nebraska (4 counties) in 1999-2001 (Fig. 1). The survey was conducted during July and August, and samples were collected from each location in 1 of the 3 years. Cereal grain fields, primarily wheat, were selected randomly, on an *ad hoc* basis, and the number of sample sites within a county varied from 1-29. The type of wheat (spring, winter, or durum) being grown was recorded at each of the 229 fields sampled.

Each sample site was geo-referenced, and a mean of 191.7 (range 60-366) stems were collected. Stems were sampled by walking in a line perpendicular to the field margin nearest the road. Plants were randomly selected and uprooted at approximately 3 m intervals from the field border to approximately 100 m into the field

Stems were held in a cooler for transport to the laboratory, where they were split and examined. The number and location of specific wheat pests were recorded. In addition, for the wheat stem sawfly the presence of the predominant parasitoids *Bracon cephi* (Gahan) and *B. lissogaster* Muesebeck (Hymenoptera: Braconidae) was assessed. The two species are biologically similar, both are larval koinobionts, and their presence is easily detected, even as eggs, attached to the paralyzed host larva. Because of the difficulty of accurately separating the two species (Runyon et al. 2001), they are hereafter referred to as *Bracon* spp.

County, state and regional means for each pest were calculated (SAS Institute 2005). Analysis of variance (PROC GLM; SAS Institute 2005) was used to compare the abundance of each pest on the different wheat types (spring, winter, durum). There were no significant differences among wheat types for any pest except jointworm. The significant variation in wheat jointworm densities observed among the three types of wheat is difficult to interpret and may be an artifact because this species was only found in 9 of the 229 fields surveyed. Correlation and simple linear regression were used to investigate the relationship between wheat stem sawfly infested stems and parasitism levels. Associations among the different pests were evaluated using multiple correlation analysis.

Results and Discussion

Wheat stem sawfly, wheat stem maggot and Hessian fly are widely distributed across the northern Great Plains (Table 1). Wheat stem sawfly and wheat stem

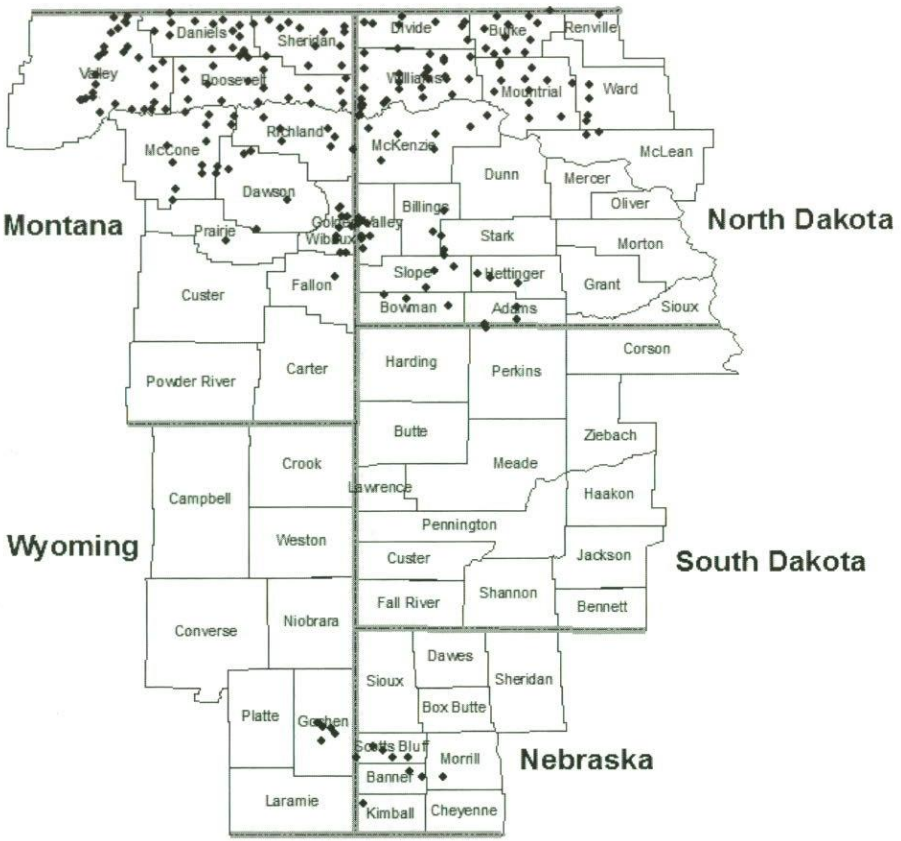

Fig. 1. Sample site locations for wheat insect pest survey, 1999-2001.

maggot were present in more than half of all fields surveyed. Hessian fly was found in 38% of the fields surveyed whereas the two eurytomid species were found in less than 20% of the fields sampled. The wheat stem sawfly was found at the highest levels of infestation (calculated for each field as number of stems infested with a specific pest / total number of stems × 100), up to 83%. Peak infestation levels for the other pests were below 11% except for the wheat strawworm which reached nearly 21% in one field (Table 1). Among infested fields, wheat stem sawfly infestation averaged nearly 7%, more than double that of the other pests.

Disaggregating the data by county provides information on the relative importance of individual pests in specific locations (Table 2). In the U.S., the wheat stem sawfly has generally been considered a pest primarily in Montana and North Dakota (Davis 1952). The survey data support this with all but one county in Montana and North Dakota recording the sawfly. A new finding however, is the surprisingly high infestations in Goshen Co., Wyoming, and Scottsbluff and Banner counties in Nebraska. The wheat stem sawfly was observed in these counties in earlier surveys (Davis 1953,

Table 1. Incidence of five wheat pests in the northern Great Plains, 1999-2001

Pest	Infested fields (%)*	Infestation level** among infested fields (range)	Infestation level** among infested fields (mean)
Wheat stem sawfly	54%	0.4-82.6%	6.95%
Wheat stem maggot	62%	0.4-10.6%	3.19%
Hessian fly	38%	0.4-8.9%	2.15%
Wheat jointworm	3%	0.5-1.3%	0.77%
Wheat strawworm	17%	0.4-20.7%	3.34%

* Number of fields in which each pest was found/total number of fields (n = 299) * 100.

** Calculated for each field: number of infested stems/total number of stems sampled * 100.

Wallace and McNeal 1966), but the magnitude of the infestations, exceeding 3% in Banner and Scottsbluff counties, and exceeding 13% in the adjacent Goshen Co., has not been reported previously.

The highest infestation was found in Golden Valley Co., North Dakota, with a mean infestation of more than 19%. The last geographically extensive surveys for the wheat stem sawfly, conducted in the early 1950s, reported higher infestations in Montana than in North Dakota (Davis 1952, 1953). These surveys found high, but not the highest, infestation levels in Golden Valley Co. Our survey also found, with the exception of Wyoming where only one county was sampled, that the counties of Montana had the highest mean infestation (4.5%) of wheat stem sawfly.

Two species of parasitoids, *Bracon cephi* (Gahan) and *B. lissogaster* Muesebeck, attack wheat stem sawfly larvae in the northern Great Plains (Runyon et al. 2001). These species have a similar biology and impact on wheat stem sawflies. In addition they are difficult to separate and have likely been confused in the literature. Most authors refer to the cumulative impact of *Bracon* spp. on *C. cinctus* populations. In some areas this impact can be considerable. Morrill et al. (1994) reported parasitism of more than 70% in Pondera Co. in north central Montana. The impact of these natural enemies varies across time and locations. At two locations within Pondera Co. parasitism levels varied from 15-98% from 1994-1997 (Morrill et al. 1998).

Parasitism levels found in this survey were low and did not approach the levels reported by Morrill et al. (1994, 1998). No parasitized wheat stem sawfly larvae were found in half of the counties where the wheat stem sawfly was present (14 of 28) and, of 127 fields with wheat stem sawfly, only 32 contained parasitized larvae. In the states in which more than one county was surveyed (Table 2), parasitism levels were higher in Montana (6.9%) and Nebraska (7.7%) than in North Dakota (3.1%). There was a significant positive correlation between wheat stem sawfly infested stems and parasitized wheat stem sawfly larvae ($n = 127$; $P < 0.0001$). Linear regression of parasitized wheat stem sawfly larvae on wheat stem sawfly-infested stems was significant ($n = 127$; $F = 94.72$; $P < 0.001$). Despite the low parasitism levels, higher sawfly infestations supported higher parasitism levels. Mean wheat stem sawfly infestation was 5.4% where no parasitoids were found versus 15.1% infestation among fields where parasitized larvae were observed. The significant regression line ($r^2 = 0.429$) suggests that parasitism levels are insufficient to keep wheat stem sawfly populations below damaging levels. For example, at an infestation level of 80%,

Table 2. Incidence of five wheat pests and a wheat stem sawfly parasitoid in different counties across the northern Great Plains, 1999-2001

State/county	Number of sites	Number of stems**	Infested stems (%)*					Parasitized sawfly (%)***
			Wheat stem sawfly	Wheat stem maggot	Hessian fly	Jointworm	Strawworm	
North Dakota								
Adams	3	726	1.7	2.1	12.0	0	0	0
Billings	2	377	2.1	0.5	0	0	0	0
Bowman	4	910	0.9	2.4	2.6	0	0	12.5
Burke	13	2539	0.8	0.8	0.0	0	0.2	4.8
Divide	9	1499	0.2	0.2	0.3	0	0	66.7
Golden Valley	8	1356	19.1	3.8	0.9	0	0.3	1.9
Hettinger	2	460	0.2	3.5	1.5	0	0	0
McKenzie	7	1320	1.6	2.5	1.3	0.1	0	0
McLean	3	560	0.5	2.1	0	0	0	0
Montrail	11	2079	0.4	2.1	0	0	0.4	0
Slope	3	655	0.2	2.7	2.3	0.3	0.2	100
Stark	3	682	0.1	2.6	1.0	0	0	0
Ward	4	789	0.4	3.0	2.0	0	0	33.3
Williams	29	5600	1.1	3.1	0.8	0	0.1	3.1
ND total	101	19552	2.1	2.3	1.2	0	0.1	3.1
Montana								
Daniels	15	2876	11.4	0.5	0.7	0	0	11.0
Dawson	8	1455	3.5	3.3	0.5	0.2	2.7	0
Fallon	1	309	0.3	1.9	1.0	0	0	0
McCone	13	2667	1.6	2.2	1.1	0	0.8	4.8
Prairie	1	154	0.6	5.2	0.0	0	0.6	0
Richland	7	1548	0.0	3.5	0.3	0	0.1	0

Table 2. Continued.

State/county	Number of sites	Number of stems**	Infested stems (%)*					Parasitized sawfly (%)***
			Wheat stem sawfly	Wheat stem maggot	Hessian fly	Jointworm	Strawworm	
Roosevelt	17	3612	0.5	2.5	0.6	0	0	0
Sheridan	14	2653	0.5	0.7	0.5	0	0	0
Valley	26	4678	7.3	2.2	0.5	0.1	0.7	3.5
Wibaux	10	1520	11.8	1.6	1.0	0	0.4	9.4
MT total	112	21670	4.5	1.9	0.6	0.02	0.5	6.9
South Dakota								
Perkins	1	191	2.6	1.0	8.9	0	0	0
Wyoming								
Goshen	6	10648	13.9	2.8	0	0	4.3	0.7
Nebraska								
Banner	2	269	3.0	0	1.1	0	5.9	12.5
Kimball	1	170	1.4	0.5	0.6	0	5.7	0
Morrill	1	209	0	0	0	0	0	0
Scottsbluff	5	771	3.6	0.8	0.1	0	3.6	7.1
NE total	9	1419	2.7	0.5	0.4	0.1	3.9	7.7

* Total number of infested stems/total number of stems * 100.
** Total number of stems from all sample sites.
*** Percentage of wheat stem sawfly larvae parasitized by *Bracon* spp.

parasitism levels are <5%. This assumes that *Bracon* spp. respond to wheat stem sawfly in a density-independent manner. Many parasitoids respond to host densities in a density-dependent fashion, and *Bracon* spp. may also. More detailed behavioral and ecological studies are needed to better understand the impact of natural enemies on wheat stem sawfly population dynamics.

Wheat stem maggot was the most commonly encountered pest, found in 62% of the fields sampled (Table 1). Infestation levels were low (<11%) and fairly consistent across the survey area, averaging approximately 3.2% among infested fields. These levels are similar to the 1-3% infestations levels reported in eastern South Dakota by Gilbertson (1925), Kieckhefer and Morrill (1970), and more recently, Hesler and Kieckhefer (2000). The impact and significance of the wheat stem maggot does not appear to have changed substantially in 80 yrs, despite changes in farming practices and the deployment of new wheat cultivars.

Hessian fly occurred widely across the survey area, 38% of fields were infested (Table 1), but at low levels. Only two counties recorded infestation levels above 3%: Adams Co., North Dakota (12.0%) and Perkins Co., South Dakota (8.9%). In contrast, infestation levels in Georgia ranged from 4.8-86.5% (Buntin and Raymer 1989) and up to 95% in Oregon (Smiley et al. 2004).

The jointworm, *Tetramesa tritici*, was rare (found in 3% of fields) and present in low numbers in infested fields (<2% infested stems) (Table 1). Despite its low numbers, this species was widely distributed; it was present in two counties in each of North Dakota, Montana and Nebraska. This species was once considered the second most important wheat pest east of the Mississippi River (Phillips 1918). In the mid1930s it became more prevalent in the west (Knowlton 1932, Knowlton and Janes 1933) but has not been reported in the literature because that time. These survey results confirm its status as a noneconomic species.

The strawworm, *Tetramesa grandis*, was more common (found in 17% of surveyed fields) and present in higher densities (3.3% infestation among infested fields) than was *T. tritici* (Table 1). The strawworm was present at high levels (3.6-5.9%) in four counties: Goshen Co., Wyoming, and Banner, Kimball and Scottsbluff counties, Nebraska. In general, the wheat strawworm is insignificant and, like the wheat jointworm, poses no threat to wheat production in this region.

The only significant association among these insects was a significant positive correlation between the jointworm and strawworm (Table 3). All other associations were not significant. It is difficult to interpret the positive association of these two eurytomids. These two species have not been well-studied, particularly in the past 50 yrs, and there are no previous reports of this association.

Surveys are expensive, time consuming and provide only a snapshot of current pest populations. Geographically extensive surveys generally do not provide an accurate description of the field-level spatial variation in insect distributions. In addition, unless the same locations are sampled across several years, temporal variation in pest densities cannot be quantified. More detailed studies are needed to understand the complex dynamics of pest populations within a field and across seasons.

Despite their limitations, surveys provide a valuable assessment of the relative importance of different pests across a wide geographic scale. This type of information is lacking from experiment station studies and most multilocation trials. Utilizing this approach, our findings suggest that pest management efforts should be focused on wheat stem sawfly, particularly in areas such as the Nebraska Panhandle that have not typically been considered at-risk from this pest species. Wheat stem sawfly pest

Table 3. Correlation coefficient matrix for the incidence of five insect pests of wheat in the northern Great Plains, 1999-01

	Wheat stem sawfly	Wheat stem maggot	Hessian fly	Jointworm	Strawworm
Wheat stem sawfly	1.0000				
Wheat stem maggot	−0.0949	1.0000			
Hessian fly	−0.0434	0.0716	1.0000		
Joint worm	0.0213	−0.0551	−0.0210	1.0000	
Straw worm	0.0542	0.0396	−0.0215	0.1867*	1.0000

n = 229.
* $P < 0.005$.

management research has focused on developing resistant cultivars and cultural practices to reduce the impact of this pest (Berzonsky et al. 2003). It needs to be determined if wheat cultivars and production practices developed in Montana, North Dakota and Canada, are suitable for the Nebraska Panhandle and adjacent areas of Wyoming.

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