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Regional Assemblages of *Lygus* (Heteroptera: Miridae) in Montana Canola Fields

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ABSTRACT: Sweep net sampling of canola (*Brassica napus* L.) was conducted in 2002 and 2003 to determine *Lygus* (Heteroptera: Miridae) species composition and parasitism levels in four regions of Montana. Regardless of region or seasonal change, *Lygus elisus* (Van Duzee) was the dominant species in all canola fields sampled, averaging 60–99% of the total adult populations. *Lygus borealis* (Kelton), *Lygus keltoni* (Schwartz) and *Lygus lineolaris* (Palisot) were detected at much lower levels. Total lygus population density was greatest in the southwest and central regions. The northeast and southwest regions had the greatest lygus species diversity. The proportion of *L. elisus* increased from early to late crop maturity stages in the southwest and central regions while there was no change in northeast and southwest canola production regions. Nymphal stages III–V were dissected to detect parasitism in 2003 only. Parasitism was found to be negligible in the dissection of 1,230 nymphs. *Lygus* population densities in canola indicate the potential for economic impact on Montana canola, especially in years when moisture is limited.

KEY WORDS: *Lygus*, canola, biological control, economic threshold

Canola is a relatively new crop in Montana, planted to increase crop diversity, decrease overall economic risk and improve sustainability. Canola, a cool season oilseed crop and a relatively high water user, could become important in Montana not only as a profitable cash crop, but also for expanding weed management options and diversifying rotations with wheat and barley, crops that require similar machinery and have complimentary fertilizer requirements (Fereidoon, 1990). Alternating cereal grains with canola can disrupt disease, weed, and insect cycles (Johnston *et al.,* 2002). However, planted canola acreage peaked at 65,000 acres in 2000, and has since declined to under 10,000 acres in 2009 (Montana Agricultural Statistics Service, 2009). Declining acreages are related to drought conditions that have plagued Montana farmers in the early 2000's but also to pest management issues including herbicide carry-over problems from cereals, plant diseases such as brown girdling root rot, and insect pests.

Lygus spp. (Heteroptera: Miridae) are well-known pests of seed alfalfa, cotton, and crucifers, including canola and mustard (*B. juncea*) (Lamb, 1989; Butts and Lamb, 1991a; Braun *et al.,* 2001). Lygus bugs are polyphagous, specializing on meristematic and reproductive tissues. Feeding by adults and older nymphs causes canola buds and flowers to abscise and seeds to darken and shrivel. Thus, lygus feeding can significantly reduce seed weight, viability and seed yield (Butts and Lamb, 1991b). Lygus have been a considerable pest of canola in the northern U.S. and Canadian prairie production regions (Blodgett and Johnson, 2006). A 1982 survey of three canola production regions in Alberta, Canada (north, central and

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south) found seed losses ranged from 2 to 7% (Butts and Lamb, 1991a). A widespread outbreak in Alberta, Canada 1998 resulted in 400,000 ha of canola treated with insecticide and high populations occurred for several years (Braun *et al.,* 2001; Carcamo *et al.,* 2002).

There are 31 North American *Lygus* species that vary in occurrence by region, year, and crop (Leferink and Gerber, 1997; Butts and Lamb, 1990; Braun *et al.,* 2001; Carcamo *et al.,* 2002). *Lygus* species composition was found to vary among Alberta canola production regions (Carcamo *et al.,* 2002) and has shifted since earlier studies were conducted in the 1980's (Butts and Lamb, 1991a). *Lygus elisus* (van Duzee) dominated boreal (northern) canola production regions of Alberta from the early 1980's until 1990 (Butts and Lamb, 1991a; Schwartz and Foottit, 1992). Although lygus bugs were at very low population densities in 1993 and 1994, a 1995 survey reports *L. borealis* (Kelton) and *L. lineolaris* (Palisot de Beauvois) were abundant in both alfalfa and canola with *L. elisus* rarely reported (Carcamo *et al.,* 2002) in the Alberta, Canada. A survey conducted during 1998–2002 (Carcamo *et al.,* 2002) found a species shift to *L. lineolaris* dominating collections in both boreal and parkland (east central) regions of Alberta. Currently the northern (boreal) assemblage is dominated by *L. lineolaris* with low occurrence of *L. borealis*, *L. elisus* and *L. keltoni*; southern (grassland) assemblage is dominated by *L. keltoni* with frequent occurrence of *L. elisus* and *L. borealis*; and parkland region variable for species composition but with little presence of *L. elisus* (Carcamo *et al.,* 2002).

Lygus bug parasitoids, *Peristenus* spp. have been studied and are responsible for substantial parasitism rates in strawberries in New York, USA (Tilmon and Hoffman, 2002) and alfalfa in New Jersey, USA (Day *et al.,* 1990), Alberta, Canada (Jones, 2000), and Canadian prairie region (Braun *et al.,* 2001). The native parasitic wasp *Peristinus pallipes* (Hymenoptera: Braconidae) oviposits into lygus bug nymphs and can be responsible for up to 83% parasitism in alfalfa (Jones, 2000). However, these parasitoids seem to be less effective on lygus in canola, accounting for only 0–5% parasitism (Braun *et al.,* 2001). Currently, impacts and availability of biological controls for lygus bugs in Montana canola are not well known. The objective of this study was to determine the lygus bug species composition, seasonal occurrence and parasitism levels of lygus bugs in canola in four production regions of Montana.

Materials and Methods

Field sampling was conducted in four regions of Montana where canola production is important; northeast (NE; Sheridan, Daniels and Roosevelt Counties), southwest (SW; Broadwater and Gallatin Counties); central (C; Fergus County), and northcentral (NC: Hill County). In the northeast 8 and 4 fields, in the southwest 5 and 3 fields, in the central 7 and 4 fields and in the north central 4 and 8 fields were sampled in 2002 and 2003, respectively. Weekly samples, consisting of 25 or 100, 180° sweeps were taken with a standard 38 cm diameter sweep net beginning in early June and continuing until mid-August. Larger sweep samples (100 sweeps per field) were taken in the early season when lygus bug numbers were low, decreasing to 25 sweep samples per field later in the season when lygus numbers had substantially increased. Two samples per field were collected at each sampling date. Data collected from each site were averaged and then normalized to 50 sweeps per field. Crop stage

Table 1. Change in proportion of *L. elisus* from early to late stages of canola development in four regions of Montana. Proportions of *L. elisus* (central value) include 95% confidence intervals: lower bound (LB) and upper bound (UB).

		Proportion of *L. elisus*		
Region	Stage	LB	Central Value*	UB
NE	Early	0.5227	0.7279[a]	0.8920
	Late	0.6070	0.7296[a]	0.8367
SW	Early	0.5487	0.6578[a]	0.7589
	Late	0.7625	0.8493[b]	0.9198
C	Early	0.8713	0.9211[a]	0.9595
	Late	0.9531	0.9721[b]	0.9863
NC	Early	0.7911	0.9237[a]	0.9928
	Late	0.8174	0.9227[a]	0.9852

* Central values sharing the same letter within a region are not statistically different ($P > 0.05$) using Tukey's simultaneous comparisons test.

was assessed using a numeric value to indicate developmental stage of the crop: 50, flower bud development; 60, flowering; 70, pod development, and 80, pod development and seed ripening, similar to Growth Stages 5, 6, 7, and 8 from McGregor (1981).

Sweep samples were transferred to self-sealing plastic bags and refrigerated in the laboratory until lygus adults and nymphs were sorted from other insects and placed in labeled vials for subsequent processing. Adults were counted and identified to species according to Schwartz and Foottit (1998), who advocate using variation in head and pronotal structure, coloration, punctation, and vestiture, to separate the species. Several adults were mounted on points for further reference, while others were stored in plug vials with locality labels attached. Representative adult specimens were sent to Dr. Michael D. Schwartz, (Agriculture and Agri-Food Canada, Ottawa, Canada), to confirm the identifications. Voucher specimens were deposited in the Montana State University Entomology Museum. All lygus nymphs were counted, identified to stages III–V and stored in labeled plug vials with 70% ethanol and dissected for parasitism consistent with Day (1990). Parasitism data were not collected in 2002.

Lygus Densities by Region

Economic thresholds for lygus bugs have been established for canola growth stage 70, between the end of flowering and early pod ripening stages (Jones, 2000). Thus, only total counts of nymphs III–V and adults at stage 70, were used to analyze population differences among regions. The numbers of lygus bugs per field were averaged to account for multiple samples within a single field (Table 1). A General Linear Model (GLM) was used to test differences among regions with an analysis of variance (ANOVA). Counts from each field were log transformed for the analysis using: $X = \log(N + 1)$ to reduce heteroscedasticity, where there were unequal variances, and also to transform zero values of total lygus bugs. *Lygus* spp. densities were tested for differences between years and among regions. Lygus bug densities within a region were compared using Tukey simultaneous tests at the 95% confidence level. The numbers of lygus bugs per sweep within regions were then back transformed using the inverse log to compare total numbers to the economic threshold of 1.5 lygus bugs per sweep.

Species Composition Among Regions

Species composition was analyzed among regions to identify differences of species diversity by location. The proportions of species (x) to total adults (n) from each field site were transformed according to Anscombe (1948) for distributions that include an entire range of proportions (i.e., $0/n$ through n/n):

$$X' = \arcsin\sqrt{[(x+3/8)/(n+3/4)]}$$

This gave weighted results based on the sample size so that an accurate mean for *L. elisus* could be calculated. Samples with no adults were excluded from the analysis. The analysis was performed on the mean proportions of *L. elisus* at crop stage 70 using PROC GLM (Statistical Analysis System, SAS Institute, Research Triangle Park, NC) and a test level of $\alpha = 0.05$ and 95% confidence level Tukey tests to identify differences among regions. Confidence intervals for the proportions of species were calculated from the transformed data using a t-value corresponding to the correct degrees of freedom: mean $\pm$ $t_{\alpha,df}$ (SE). Means and confidence intervals were back transformed using $[\sin(X')]^2$.

Species Composition

Stages of canola were categorized into either early (stages 50 and 60) or late (stages 70 and 80) and the means were calculated within region to examine a possible seasonal effect on adult *Lygus* species proportions. Samples with no adults present were excluded from the analysis. The Anscombe transformation (above) was used for data from each field site, and 95% confidence levels were calculated using the appropriate t-value. The means and confidence values were again back transformed using $[\sin(X')]^2$.

Data was analyzed using MINITAB (Release 13.1, Minitab Inc., 2000) to assess species complex, seasonal occurrence, and regional differences within Montana.

Results

For the combined 2002 and 2003 field seasons, over 3,000 lygus bug nymphs and adults were collected from canola in the four Montana production regions. Generally, lygus bug populations increased as canola developed through the flowering stages, with few bugs observed or collected prior to this stage, bolting to the beginning of flower plant stages. The dominant species across both years and all crops sampled was overwhelmingly *L. elisus*, averaging from 60 to 99% in each field throughout the season (Figure 1). *Lygus borealis*, *L. keltoni*, and *L. lineolaris* were also commonly observed, but in much lower numbers ca. 9%. A few individuals of *L. rugulipennins*, *L. shulli*, and *L. solidaginus* were also collected ca. 0.1%. Due to the dominance of *L. elisus* and low numbers of other species present, it was not feasible to analyze species compositional differences among regions. However, a non-transformed assemblage chart is presented (Fig. 1) of species composition from each region, indicating greater *Lygus* species diversity from the northeast and southwest regions. The northeast non- *L. elisus* species were composed of 11% *L. borealis*, 6% *L. lineolaris*, and 3% *L. keltoni*. The southwest region was composed of 7% *L. keltoni*, 5% *L. lineolaris*, 1% *L. borealis*. Northcentral and central regions had a striking lack of species diversity.

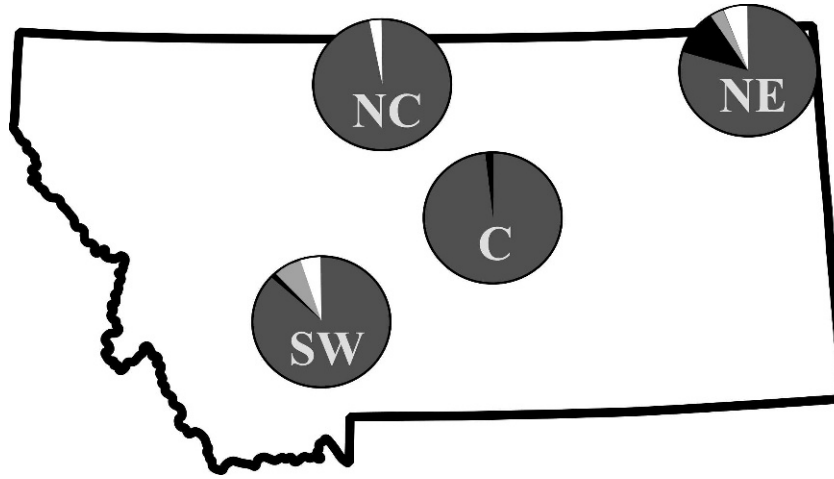

Fig. 1. Montana *Lygus* species composition by region: NE, northeast; SW, southwest; C, central; NC, north central. Shades of gray are representative of individual lygus species: gray, *L. elisus*; black, *L. borealis*; light gray, *L. keltoni*; white, *L. lineolaris*.

Lygus Density by Region

Although total numbers of lygus bugs collected in 2003 were greater than in 2002, the difference was not significant ($F = 1.27$; d.f. = 1, 34; $P = 0.269$). When data from the two years were combined, the overall effect of region on the abundance of lygus bugs was highly significant ($F = 28.17$; d.f. = 3, 34; $P < 0.01$). There were significant differences in lygus numbers among regions (Fig. 2); the northeastern region had significantly lower lygus densities compared with the other three regions (Table 2). Northcentral Montana had significantly higher lygus densities than the northeast, and significantly lower densities than southwest and central regions. The southwest and central regions had comparable lygus densities.

The central and southwest regions, on average exceeded or nearly exceeded, with 2.04 and 1.33 lygus per sweep, respectively, the economic threshold of 1.5 lygus per sweep (Blodgett and Johnson, 2006). The northeast and northcentral regions were well below the threshold population density for this stage of plant development. The northeast and northcentral regions each had one unusual observation with a large standardized residual (2.86 and 2.05 respectively), however we did not feel that it skewed the results of this analysis because these regions had the lowest number of total lygus and also the greatest field to field variability (Fig. 2). One field in the southwestern region had an extremely high population density that was viewed as an outlier and left out of the model. However, the results were unaffected because this region had the greatest lygus densities (Fig. 2).

Species Composition Among Regions

Although each region was dominated by *L. elisus*, there were significant differences in the proportion of secondary species. The proportion of *L. elisus* differed significantly among regions ($F = 15.11$; d.f. = 3, 36; $P < 0.01$) but not between years ($F = 2.28$; d.f. = 1, 36; $P = 0.141$). Post hoc contrast analysis indicates that the proportion of *L. elisus* in the northeastern and southwestern regions was

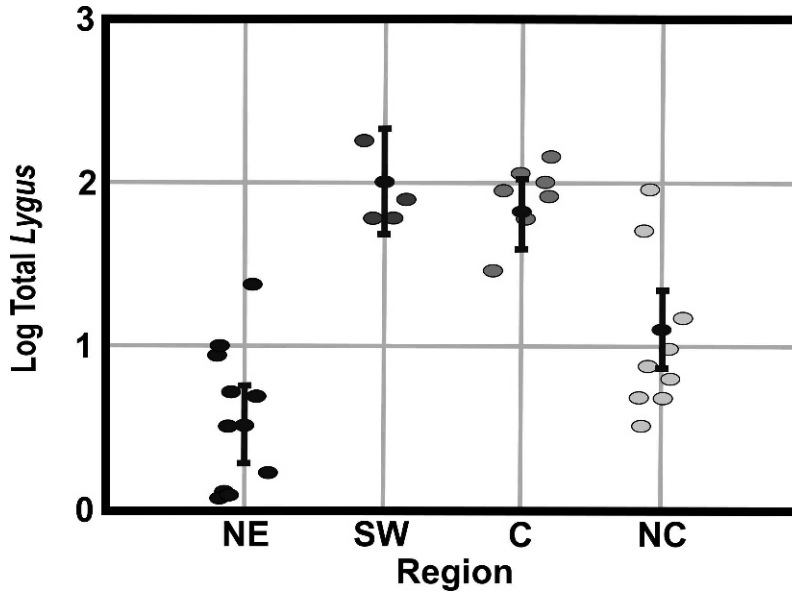

Fig. 2. Log total lygus numbers from individual fields sites within four Montana canola production regions with means and 95% confidence intervals.

significantly lower than central and northcentral regions (Table 3). Northeast Montana had greatest species diversity with a mean of 27% non-elisus, followed by the southwest with 15%. Canola fields sampled in north central and central Montana were almost entirely *L. elisus*, having very low numbers of other species (6% and 3% respectively) (Fig. 1).

Species Composition and Parasitism

There were no significant differences in species composition from the early to late stages within northeast and north central regions when data from 2002 and 2003 were combined. The southwest and central regions had significant increases in the proportions of *L. elisus* from early to late crop stages (Table 1). A 19% increase of *L. elisus* was observed in late canola developmental stages of canola in the southwest region while the central region had a 5% increase in *L. elisus,* resulting in 85 and 97% *L. elisus*, respectively.

Table 2. Log means (SE) of total lygus and significance between regions.

Region	Log means (SE)*	Inverse log#	Lygus per sweep$^{\xi}$
NE	0.5086 (0.1247)[a]	3.23	0.06
SW	2.0083 (0.1664)[b]	101.93	2.04
C	1.8233 (0.1181)[b]	66.57	1.33
NC	1.0936 (0.1247)[c]	12.41	0.25

* Regions sharing a letter are not statistically different ($P > 0.05$) using Tukey's simultaneous comparisons test.

Inverse log gives the mean total lygus per 50 sweeps.

$^{\xi}$ Total number of lygus per sweep compared with economic threshold of 1.5 lygus per sweep, boldfaced indicates a cause of concern in these regions.

Table 3. Upper and lower boundaries of the central value proportion of *L. elisus* among regions using a 95% confidence interval.

Region	Proportions of *L. elisus*		
	LB	Central Value*	UB
NE	0.6972	0.7737[a]	0.8419
SW	0.8010	0.8549[a]	0.9016
C	0.9463	0.9744[b]	0.9923
NC	0.9007	0.9431[b]	0.9743

* Regional central values sharing the same letter are not statistically different ($P > 0.05$) using Tukey's simultaneous comparisons test.

Parasitism was not detected during the dissection of 1230 lygus nymphs collected from canola from the four regions of Montana sampled in this study.

Discussion

The poor canola yields that Montana farmers experienced the past ten years were attributed to generalized drought conditions, but lygus may also have played an important role. Hot, dry weather patterns, promotes more rapid insect development and exacerbates lygus injury to canola (Butts and Lamb, 1991a). Drought stress during the canola flowering stage reduces pod production and restricts the ability of plants to compensate for insect damage (Wise and Lamb, 1998a, 1998b). Results of this study found lygus populations in southwest and central Montana production regions near the economic threshold of 1.5 lygus per sweep (Fig. 2; Table 2) and it is likely that some fields within the region warranted lygus controls, emphasizing the need for monitoring lygus populations in Montana canola fields.

The four lygus species observed in Montana canola are thought to be equally destructive to reproductive tissues (Jones, 2000), although they have different host crop preferences. Regional variations in lygus species complex have been reported. In Saskatchewan, *L. lineolaris* was the dominant species on oilseeds (Schwartz and Foottit, 1992; Braun *et al.,* 2001), and was first detected in canola at early bud stage (late June to early July) reaching high population densities in mid-August (Braun *et al.,* 2001). In Alberta *L. lineolaris*, *L. borealis*, *L. elisus* and *L. keltoni* were the most common species, although *L. keltoni* was not found east of Alberta and *L. lineolaris* was rare in the mixed and short grass prairie (Schwartz and Foottit, 1998). In a survey of lygus species and parasitism from a variety of weed species and alfalfa in Colorado, the most abundant lygus species was *L. elisus* collected from flixweed (Cruciferae: *Descurainia sophia*) and alfalfa/flixweed mixtures, comprising about 97 and 90% of individuals, respectively (Demirel *et al.,* 2005).

Parasitism of lygus has the potential to be an important biological control method in canola, reducing pesticide use and producer costs. However, in our study, parasitism of nymphs stages III–V collected from canola across four regions of Montana was found to be negligible. Higher levels of parasitism have been reported in alfalfa (up to 70% parasitism), in contrast to very low rates (<1%) in nymphs collected from late season canola (Braun *et al.,* 2001).

In summary, *Lygus* population densities in canola likely have economic consequences for Montana canola producers, especially in years when moisture is limited. Population densities varied among canola production regions and crop

stage. Of the four primary species observed, *L. elisus* was the most abundant species in all regions and two of four regions, *L. elisus* proportion increased from early to late in the production season. Lygus parasitism was found to be negligible.

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