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Hymenopteran parasitoids and dipteran predators of *Diuraphis noxia* in the west-central Great Plains of North America: Species records and geographic range

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Abstract. Parasitoids and predatory flies were sampled in the wheat production region of the west-central Great Plains (southeastern Wyoming, western Nebraska, and north-central Colorado) of North America using plant material infested with the Russian wheat aphid, *Diuraphis noxia* (Mordvilko) (Hemiptera: Aphididae). Samples were taken April through October in 2001 and 2002, which was 15–16 years after first detection of *D. noxia* and 5–6 years after the last release of natural enemies for its control in this region. The natural enemies detected were (in order of high to low detection frequencies across three states and 2 years): *Aphelinus albipodus* Hayat and Fatima (Hymenoptera: Aphelinidae), *Eupeodes volucris* Osten Sacken (Diptera: Syrphidae), *Lysiphlebus testaceipes* (Cresson) (Hymenoptera: Braconidae, Aphidiinae), *Leucopis gaimarii* Tanasijtshuk (Diptera: Chamaemyiidae), *Aphidius avenaphis* (Fitch), *Aphidius matricariae* Haliday, *Diaeretiella rapae* (M'Intosh), *Aphidius ervi* Haliday, *Praon yakimanum* Pike and Starý (Hymenoptera: Braconidae, Aphidiinae), and *Aphelinus asychis* Walker (Hymenoptera: Aphelinidae). The results confirmed establishment of one of the 10 exotic parasitoid species released for *D. noxia* control (*A. albipodus*) in the west-central Great Plains. It is unknown whether detection of *A. asychis*, *A. matricariae*, and *D. rapae* can be attributed to exotic introductions or preexisting populations. Other species detected in this study have been previously documented from the western US, although the recognized distributions have expanded for *A. avenaphis*, *L. gaimarii*, and *P. yakimanum* compared to the first few years after initial detection of *D. noxia*. Thus, there is definitive establishment of one exotic introduced for *D. noxia* and considerable range expansion of preexisting species that prey upon *D. noxia*.

Key words: Aphelinidae, biological control, Braconidae, Chamaemyiidae, natural enemies, Russian wheat aphid, Syrphidae

Introduction

The invasion and spread of the Russian wheat aphid, *D. noxia* (Mordvilko) (Hemiptera: Aphididae), in North America prompted a classical biological control effort from 1987 to 1994 (Prokrym et al., 1998). More than 15 million parasitoids and predators were released in 16 states and two Canadian provinces (Tanigoshi et al., 1995; Prokrym et al., 1998). In the west-central Great Plains (encompassing southeastern Wyoming, western Nebraska, and north-central Colorado, USA), 10 species of parasitoids and three species of predatory flies were released (Mohamed et al., 2000; Brewer et al., 2001; Burd et al., 2001). They were *Aphelinus albipodus* Hayat and Fatima, *Aphelinus asychis* Walker, *Aphelinus varipes* (Forester) (Hymenoptera: Aphelinidae), *Aphidius colemani* Viereck, *Aphidius matricariae* Haliday, *Aphidius picipes* (Nees), *Aphidius rhopalosiphi* DeStefani, *Diaeretiella rapae* (M'Intosh), *Ephedrus plagiator* (Nees), *Praon gallicum* Starý (Hymenoptera: Braconidae, Aphidiinae), *Eupeodes nuda* (F.), *Sphaerophoria scripta* (L.) (Diptera: Syrphidae), and *Leucopis ninae* Tanasijtshuk (Diptera: Chamaemyiidae).

Before the *D. noxia* biological control program, *D. rapae* and *A. varipes* were reported parasitizing, but not controlling, *D. noxia* in the west-central Great Plains (Wraight et al., 1993). After the releases, *A. albipodus* and *D. rapae* were the most frequently detected species parasitizing *D. noxia* between 1993 and 1998, and other aphid parasitoid specimens were rarely collected (Brewer et al., 2001). Syrphids and *Leucopis* sp. were collected in both pre- and post-release surveys in the region (Wraight et al., 1993; Mohamed et al., 2000).

Here, we sampled for hymenopteran parasitoids and dipteran predators across the west-central Great Plains 15–16 years after the first detection of *D. noxia* (Halbert and Stoetzel, 1998) and 5–6 years after the last release of exotic parasitoids (Brewer et al., 2001). Our objectives were to sample for parasitoids and predatory flies released in the *D. noxia* biological control program, detect other species utilizing *D. noxia*, and note the geographic range of these natural enemies. We compared these findings to previous reports of aphid natural enemies on small grains in the Great Plains and western states.

Materials and methods

Farm sites

Parasitoids and predatory flies were sampled in 2001 and 2002 at 16 farm sites scattered throughout the 14,000 km^2 region of contiguous

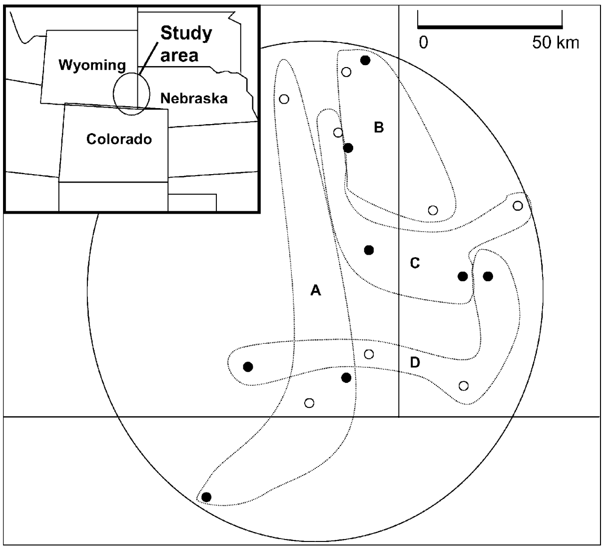

Figure 1. Locations of 16 farm sites where natural enemies of *Diuraphis noxia* were sampled. Each site consisted of cropping area and adjacent grassland where pots of *D. noxia*-infested wheat were placed to attract natural enemies. At least one wheat and one fallow strip were sampled at every site. A sunflower strip was also sampled in every site where it was present. For data analyses, farm sites were aggregated into four areas (A, B, C, and D) within the study region. ●, wheat-sunflower-fallow rotation; ○, wheat-fallow rotation.

wheat production in southeastern Wyoming, western Nebraska, and north-central Colorado, USA (the west-central Great Plains) (Figure 1). These sites were characterized by high elevation (1,280–1,830 m above sea level) and low seasonal rainfall with annual precipitation averaging 400 mm for the last 50 years (High Plains Climate Center, University of Nebraska, Lincoln). Each farm site consisted of a cropping area and an adjacent grassland area. The cropping area was a series of spatially alternating crop and fallow strips, 30–160 m wide and 0.25 to several kilometers in length. The crop strips included wheat (*Triticum aestivum* L.) at all sites, which was sown in September and harvested the following July. Some growers planted additional strips of a spring grain such as sunflower (*Helianthus annuus* L.) (8 sites), oats (*Avena sativa* [L.]) (2 sites), corn (*Zea mays* L.) (1 site), and proso millet (*Panicum miliaceum* L.) (1 site), in rotation with the wheat and fallow strips. The different crop rotations were scattered throughout the study area (Figure 1). A full explanation of the wheat agroecosystem of this dryland cropping region is available (Peterson et al., 1996). Grasslands were commonly found in the proximity of wheat and are known to affect biological control of aphids in adjacent small grain fields (Vorley and Wratten, 1987); therefore, grasslands adjacent to the cropping area were included in our sampling. Insecticides had not been used at any of the sites during the last 5 years except for sunflower pest control.

Sampling procedures

At each farm site, natural enemies were sampled using *D. noxia*-infested wheat to attract ovipositing parasitoids and predatory flies (Milne, 1995; Tanigoshi et al., 1995; Brewer et al., 2001). Samples were taken from the first three strips of the production field and the adjacent grassland. Sampling was conducted five times each year, at approximately equal intervals between late April and early October.

The *D. noxia*-infested wheat was prepared in circular plastic pots (16 cm diameter and 17 cm height) filled half with vermiculite as a bottom layer for moisture retention and half with soil. The winter wheat cultivar Buckskin was seeded at the rate of ≈200 seeds (≈60% viability) per pot to form a dense wheat layer. The potted plants were grown in the greenhouse (10–27 °C under natural sunlight) to the one- to two-leaf stage. The seedlings were sprayed with a short-residual insecticide (1100 Pyrethrum TR, Whintmire Micro-Gen Research Laboratories Inc, St. Louis, MO, USA) to eliminate insect contaminants. After 1 or 2 days, the plants were infested with laboratory-maintained *D. noxia* (roughly 100 aphids per pot) using the method of Brewer et al. (2001) and covered with organdy fabric. After 3–4 days to allow further increase in aphid numbers, covers were removed and pots were taken to the farm sites. To check for possible contaminating aphid parasitism in the greenhouse, four extra pots with fabric covers were left in the greenhouse during each sampling period.

A total of 32 pots of *D. noxia*-infested wheat was placed at each farm site along two line transects. The two line transects were parallel and ≈160 m apart from each other and were ≥50 m away from field edges running perpendicular to the long axis of the crop strips. The transects stretched up to 400 m into the cropping area across the first three strips, always including at least one wheat and one fallow strip, and extended the opposite direction up to 150 m into the adjacent grassland. Eight pots were placed in the grassland and 24 in the cropping area.

The top of each pot was covered with a flat plastic mesh sheet with a hole size of 6 mm × 6 mm (model xv1170, Internet, Inc, Minneapolis, MN, USA) to protect the plants from most grasshopper feeding, while allowing parasitoids and predatory flies access to the plants and aphids. Pots were buried into the ground up to the rim to aid moisture retention (Ahern and Brewer, 2002). To maximize the chance of capturing natural enemies, the pots were left in the farm sites as many days as possible, 2–7 days, until plant wilting was anticipated. Therefore the exposure period varied considerably across the season but was consistent across farm sites during each sampling period. After exposure to natural enemies, all pots were transported to the greenhouse, covered with organdy, and incubated for approximately 1 week, allowing parasitoids to pupate (Ahern and Brewer, 2002). The same incubation period was satisfactory in allowing predatory flies to develop from oviposited eggs in the aphid-infested plant material.

After incubation, foliage in each pot was clipped at the base and placed in an emergence canister attached with a collection vial (Prokrym et al., 1998; Ahern and Brewer, 2002) to capture emerging parasitoids and predatory flies. The canisters were maintained at room temperature (≈24 °C) and ≈70% RH under a constant light for 2 weeks. The contents of the collection vials were examined under a dissection microscope for species identification using keys and other materials found in Vockeroth (1992), Tanasijtshuk (1996), and Pike et al. (1997). The contents of the canisters also were examined to further maximize the likelihood of detecting parasitoids and predatory flies associated with *D. noxia*.

Data analysis

The experiment was arranged in randomized block design in which the 16 farm sites were grouped into four blocks of four sites each based on geographic proximity of sites and scatter of the wheat-fallow and wheat-sunflower-fallow rotations (Figure 1). Detection frequency (number of aphid-infested pots where the natural enemy was detected divided by the total number of pots) was compared among natural enemy species across the 16 farm sites and all sampling periods within each year. The data set was fit to a logistic regression model (PROC GENMOD, SAS Institute, 2000) in which detection frequency was the dependent variable and the block factor and the listing of all natural enemies collected during the year were the class variables. If significant differences among species were detected in the model, pair-wise Wald chi-square tests were used for mean separation of detection frequency among natural enemies (PROC GENMOD, SAS Institute, 2000).

In the second analysis, the proportion of sites (16 sites over three states) where the natural enemy was detected, was compared among natural enemy species across all sampling dates during the two study years. The data set was fit to a logistic regression model in which the proportion of sites was the dependent variable and the block factor and the listing of all natural enemies collected during the two study years were the class variables (PROC GENMOD, SAS Institute, 2000). If significant differences among species were detected in the model, pairwise Wald chi-square tests were used for mean separation of proportion of sites where detection occurred among natural enemies (PROC GENMOD, SAS Institute, 2000).

Results

Eight parasitoid and two predatory fly species were detected attacking *D. noxia* in nearly 4,900 pots of *D. noxia*-infested wheat set in the wheat agroecosystem of the west-central Great Plains in 2001 and 2002 (Table 1). It should be noted that frequencies of parasitoids detected might have been somewhat underestimated because of the opportunity for intraguild predation (i.e., aphid predators feeding on parasitized aphids) in the pots during incubation period after pots were retrieved from the field (Mayhöfer and Klug, 2002). Sixty seven specimens of encyrtid and pteromalid secondary parasitoids were collected, representing 0.75% of 8,887 primary parasitoids recovered in 2001 and 2002. Eleven specimens of syrphid parasitoids (Ichneumonidae: Diplazontinae) were found in 2001 samples, representing 0.53% of 2,091 syrphids collected in 2001. We focused on the primary parasitoids because of low representation and difficulties in identification of the secondary parasitoids.

Frequency of detection differed significantly among natural enemies attacking *D. noxia* in both years (2001: n = 2,356, $\chi^2 = 2{,}578$, df = 9, $p < 0.0001$; 2002: n = 2,521, $\chi^2 = 1{,}062$, df = 7, $p < 0.0001$, Table 1). Detection of species between years did not differ by more than 4%, with the exception of *Eupeodes volucris* Osten Sacken (Diptera: Syrphidae), which was much more common in 2001 than in 2002 (Table 1). In order of season-long prevalence (high to low) summed over the 2 years, the natural enemies detected were *A. albipodus*, *E. volucris*, *Lysiphlebus testaceipes* (Cresson), (Hymenoptera: Braconidae, Aphidiinae), *Leucopis gaimarii* Tanasijtshuk (Diptera: Chamaemyiidae), *Aphidius avenaphis* (Fitch), *Aphidius matricariae* Haliday, *D. rapae*, *Aphidius ervi* Haliday, *Praon yakimanum* Pike and Starý (Hymenoptera: Braconidae, Aphidiinae), and *A. asychis* (Table 1).

Natural enemies of *D. noxia* differed significantly in the number of sites where they were detected over the two study years (n = 16, $\chi^2 = 52$, df = 9, $p < 0.0001$, Table 2). Three species (*A. albipodus*, *L. testaceipes*, and *E. volucris*) were detected in all 16 sites scattered in the three states (Table 2). Seven other species were not found in north-central Colo-

Table 1. Parasitoids and predatory flies of *D. noxia* detected in southeastern Wyoming, western Nebraska, and north-central Colorado, and notes on previous collections in western USA

Natural enemies (order, family, species)	Frequency of detection (%)[a]		History[b]	Western states where previously detected
	2001	2002		
Hymenoptera				
Aphelinidae				
Aphelinus albipodus	16.34 ± 0.76 d	13.21 ± 0.67 f	Introduced[c]	CO[d], KS[d], MT[d], NE[d], WY[d]
Aphelinus asychis	0.04 ± 0.04 a	not detected	Exotic[e] and Introduced[c]	CA[f], CO[d], KS[d], NE[d], WA[g], WY[d]
Braconidae				
Lysiphlebus testaceipes	4.16 ± 0.41 c	5.67 ± 0.46 e	Endemic[h]	Common throughout the US[h]
Aphidius avenaphis	0.35 ± 0.16 ab	0.55 ± 0.15 bc	Endemic[h]	CA[h], ID[i], WA[g]
Aphidius ervi	0.04 ± 0.04 a	0.20 ± 0.09 ab	Pre-existing[j]	ID[k], KS[h], NE[h], OR[h], WA[h], WY[l]
Aphidius matricariae	0.14 ± 0.10 a	0.60 ± 0.15 c	Pre-existing[m] and Introduced[c]	CA[m], ID[m], WA[m], WY[l]
Diaeretiella rapae	0.13 ± 0.07 a	0.20 ± 0.09 ab	Endemic[h] and Introduced[c]	Common throughout the US[h]
Praon yakimanum	0.08 ± 0.06 a	not detected	Endemic[g]	WA[g]
Diptera				
Chamaemyiidae				
Leucopis gaimarii	0.77 ± 0.23 b	1.63 ± 0.25 d	Endemic[n]	ID[n], UT[n], WA[n]
Syrphidae				
Eupeodes volucris	24.46 ± 0.89 e	0.08 ± 0.06 a	Endemic[o]	Common throughout the western US[o]

16 farm sites scattered in the three states (Figure 1) were sampled five times in 2001 and five times in 2002. The samples were combined across 16 sites in each year to calculate detection frequencies shown above. In August and September samples of 2001, there were *Aphidius* parasitoids present in control pots that were not exposed to parasitoids in the field, indicating that field samples were possibly contaminated with *Aphidius* that were present in the greenhouse. Therefore, *Aphidius* species found during those two sampling dates were excluded from the data set.

[a] % of pots where species was detected ± SE. Different letters in a column indicate a significant difference by pair-wise Wald chi-square tests at $\alpha = 0.05$.

[b] History of species recoveries: Introduced: species introduced for *D. noxia* biological control, Exotic: species introduced to North America prior to *D. noxia* biological control effort, Endemic: species native to North America, Pre-existing: species was documented from the US prior to the *D. noxia* biological control effort; it is not clear whether the existing populations originated from populations endemic to North America or from exotic introductions to the US in 1960s or earlier.

[c] Prokrym et al. (1998); [d] Burd et al. (2001); [e] Jackson et al. (1971), van den Bosch et al. (1957), and Mackauer (1968); [f] Bernal et al. (1993); [g] Pike et al. (1997); [h] Krombein et al. (1979); [i] Bosque-Pérez et al. (2002); [j] Mackauer and Finlayson (1967) and González et al. (1995); [k] Feng et al. (1992); [l] Brewer et al. (2001); [m] Schlinger and Mackauer (1963); [n] Tanasijtshuk (1996); [o] Heiss (1938).

Table 2. Geographic variability in occurrence of *D. noxia* parasitoids and predatory flies in southeastern Wyoming (WY), western Nebraska (NE), and north-central Colorado (CO) across 16 farm sites in the region, 2001 and 2002

Natural enemies (order, family, species)	No. of sites where detected				% of sites where detected
	WY (10)[a]	NE (5)[a]	CO (1)[a]	Overall (16)[a]	
Hymenoptera					
Aphelinidae					
Aphelinus albipodus	10	5	1	16	100 c
Aphelinus asychis	1	0	0	1	6 a
Braconidae					
Lysiphlebus testaceipes	10	5	1	16	100 c
Aphidius avenaphis	3[b]	4[b]	0	7	44 ab
Aphidius ervi	4	0	0	4	25 ab
Aphidius matricariae	4	5	0	9	56 bc
Diaeretiella rapae	4	0	0	4	25 ab
Praon yakimanum	2[c]	0	0	2	13 a
Diptera					
Chamaemyiidae					
Leucopis gaimarii	8[b]	4[b]	0	12	75 c
Syrphidae					
Eupeodes volucris	10	5	1	16	100 c

16 farm sites were sampled five times in 2001 and five times in 2002. All samples were combined across 2 years. Different letters in the column of % of sites where detected indicate a significant difference by pair-wise Wald chi-square tests at $\alpha = 0.05$.
[a] Number of sites sampled; [b] First recovery record in Wyoming and Nebraska; [c] First recovery record in Wyoming.

rado, although the state was represented by only one farm site. Three species (*A. avenaphis*, *A. matricariae*, and *L. gaimarii*) were found in Wyoming and Nebraska only and four species (*A. asychis*, *A. ervi*, *D. rapae*, and *P. yakimanum*) were detected in Wyoming only (Table 2).

Discussion

Parasitoids

The diversity of *D. noxia* parasitoids identified in this study differed from previous records of parasitoids in the west-central Great Plains. *Aphelinus albipodus*, one of the 10 parasitoid species released for

D. noxia control in the west-central Great Plains, was the only exotic species definitely established in the region as a result of the release effort. The aphelinid was frequently detected in this (Table 1) and previous post-release surveys (Brewer et al., 2001; Burd et al., 2001), indicating that the parasitoid is adapted to the dryland wheat agroecosystem (Ahern and Brewer, 2002). The parasitoid was also detected in the previous post-release surveys in eastern Colorado, Kansas, and Montana (Elliott et al., 1995; Burd et al., 2001).

Five exotic braconids released for *D. noxia* control in the west-central Great Plains (*A. colemani*, *A. picipes*, *A. rhopalosiphi*, *E. plagiator*, and *P. gallicum*) were not recovered in this or previous post-release surveys (Mohamed et al., 2000; Burd et al., 2001), although small numbers of unidentified *Ephedrus* sp. and *Praon* sp. were reported previously (Brewer et al., 2001).

In this study, four braconids recovered (*A. avenaphis*, *A. ervi*, *L. testaceipes*, *P. yakimanum*) were either native or long-time residents of North America (Mackauer and Finlayson, 1967; Krombein et al., 1979; Pike et al., 1997) and were not introduced for *D. noxia* control (Prokrym et al., 1998). In comparison, during and within a few years after the release program for *D. noxia* control, two native or resident parasitoids (*A. ervi* and *L. testaceipes*) were recovered (Brewer et al., 2001; Burd et al., 2001). These results indicate increased occurrence of native and resident parasitoid species utilizing *D. noxia* as a host.

Aphelinus asychis, *A. matricariae*, and *D. rapae* were detected in this (Table 1) and previous post-release surveys (Mohamed et al., 2000; Brewer et al., 2001; Burd et al., 2001). These parasitoids were released in the west-central Great Plains for *D. noxia* control (Prokrym et al., 1998) and were also known to occur in the western US before the releases (Schlinger and Mackauer, 1963; Krombein et al., 1979; Feng et al., 1992; Bernal et al., 1993). Because the strains of these three species are morphologically indistinguishable, it cannot be determined whether the recovery of these parasitoids in the post-release sampling (Mohamed et al., 2000; Brewer et al., 2001; Burd et al., 2001), including this study, was attributable to exotic introductions or preexisting populations in the western US.

Similarly, exotic strains of *A. varipes* were released in Colorado for *D. noxia* control between 1991 and 1993 (Burd et al., 2001) although a native *A. varipes* was detected parasitizing *D. noxia* in north-central Colorado before the exotic introductions (Wraight et al., 1993). The aphelinid was recovered in the previous post-release surveys conducted in southeastern Colorado, Oklahoma, and northeastern Wyoming (Burd et al., 2001) but was not detected in this or previous post-release surveys conducted in west-central Great Plains (Mohamed et al., 2000; Brewer et al., 2001; Burd et al., 2001).

This study documented the first record of *P. yakimanum* in the west-central Great Plains. Previously the parasitoid was known to occur only in Washington state (Pike et al., 1997). Only two incidences of *D. noxia* parasitism by *P. yakimanum* were recovered, both from Goshen Co, Wyoming. Also, *A. avenaphis* was infrequently detected and not previously known in this region (Wraight et al., 1993; Mohamed et al., 2000; Brewer et al., 2001; Burd et al., 2001). The parasitoid was previously reported from California, Idaho, and Washington (Krombein et al., 1979; Pike et al., 1997; Bosque-Pérez et al., 2002).

Aphidius ervi had been previously reported from several western states (Idaho, Kansas, Nebraska, Oregon, Washington, and Wyoming) (Krombein et al., 1979; Feng et al., 1992; Brewer et al., 2001) and from the eastern US (Mackauer and Finlayson, 1967). *Aphidius matricariae* had been previously documented in California, Idaho, Washington, and Wyoming (Schlinger and Mackauer, 1963; Pike et al., 1997, 2000; Brewer et al., 2001). *Diaeretiella rapae* and *L. testaceipes* are widely distributed in the US (Krombein et al., 1979).

Predatory flies

The exotic aphid predatory flies, *E. nuda*, *S. scripta*, and *L. ninae*, had been released in southeastern Wyoming from 1991 to 1995 and north-central Colorado in 1992 for *D. noxia* control (Mohamed et al., 2000, D.N. Grooms, personal communication). A small number of *L. ninae* was recovered a few years after its release in north-central Colorado (Mohamed et al., 2000). We did not detect any of the exotic species, but found the native syrphid *E. volucris* and the native chamaemyiid *L. gaimarii*. *Eupeodes volucris* is common in the western US (Jones, 1922; Heiss, 1938; Vockeroth, 1992) and had been previously collected in grassland and wheat fields of north-central Colorado (Kumar et al., 1976; Mohamed et al., 2000) and in western Nebraska (Wehr, 1922). Mohamed et al. (2000) collected four other syrphids occurring in north-central Colorado by sweeping wheat fields. Our method assured that detected syrphids could complete development on *D. noxia*. This study also reports the first records of *L. gaimarii* in Nebraska and Wyoming with the caveat that unidentified *Leucopis* specimens had been previously recovered in Colorado (Wraight et al., 1993; Hammon and Peairs, 1998). *Leucopis gaimarii* was previously reported from Washington, Idaho, and Utah (Tanasijtshuk, 1996), where it was known to attack

D. noxia prior to releases of the exotic *L. ninae* (Gaimari and Turner, 1996).

Comparisons with parasitoid diversity of other regions

The diversity of *D. noxia* parasitoids has been documented in the Pacific Northwest (Idaho and Washington), USA (Pike et al., 1997, 2000; Bosque-Pérez et al., 2002) after natural enemies of *D. noxia* were released. Parasitoids preying upon *D. noxia* were also surveyed in central Europe (Czech Republic) where *D. noxia* was first detected in 1995 (Starý, 1999). Numbers of *D. noxia* parasitoid species documented were seven in central Europe (Starý, 1999), 14 in the Pacific Northwest (Pike et al., 1997, 2000; Bosque-Pérez et al., 2002), compared to eight in this study. The only parasitoid species found in all three regions were *A. ervi*, *A. matricariae*, and *D. rapae*. The species unique to central Europe were *A. picipes*, *E. plagiator*, and *Praon volucre* (Haliday) (Hymenoptera: Braconidae, Aphidiinae) (Starý, 1999). The parasitoids of *D. noxia* unique to the Pacific Northwest but not the two other regions were *A. varipes*, *Ephedrus californicus* Baker, *Monoctonus washingtonensis* Pike and Starý, *Praon occidentale* Baker, and *Praon unicum* Smith (Hymenoptera: Braconidae, Aphidiinae) (Pike et al., 2000). All parasitoid species recorded in the west-central Great Plains were also detected in the Pacific Northwest. Generally, the braconid genera associated with *D. noxia* appeared similarly represented in these regions. In contrast, no *Aphelinus* species were reported from central Europe compared with three *Aphelinus* species detected in Pacific Northwest and west-central Great Plains combined. Predatory flies of *D. noxia* are much less known, precluding similar comparisons across regions.

Our results indicate definite establishment of one of 10 exotic parasitoids released for *D. noxia* control (*A. albipodus*). None of three dipteran predators released were recovered. Six to nine natural enemy species (*A. avenaphis*, *A. ervi*, *L. testaceipes*, *P. yakimanum*, *E. volucris*, *L. gaimarii*, and possibly indigenous or long-established strains of *A. asychis*, *A. matricariae*, and *D. rapae*) found in this study conducted 15–16 years after the detection of *D. noxia* were attributed to pre-existing populations. By comparison, three to six pre-existing species (*A. ervi*, *L. testaceipes*, *E. volucris*, and possibly indigenous or long-established strains of *A. asychis*, *A. matricariae*, and *D. rapae*) were found in previous post-release surveys conducted within 5–9 years after the first detection of *D. noxia* (Mohamed et al., 2000; Brewer et al., 2001; Burd et al., 2001). Thus, although definitive establishment of exotics introduced specifically for *D. noxia* is limited to one species, there has been considerable expansion of species numbers and geographic range of preexisting species that prey upon *D. noxia*.

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