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DISTRIBUTION OF *UROPHORA AFFINIS* AND *U. QUADRIFASCIATA*
(DIPTERA: TEPHTRITIDAE) FOR BIOLOGICAL CONTROL OF SPOTTED
KNAPWEED (*CENTAUREA MACULOSA*) AND DIFFUSE KNAPWEED
(*CENTAUREA DIFFUSA*) IN MICHIGAN

R. F. Lang¹, R. D. Richard¹, J. Winkler² and G. Wheeler³

ABSTRACT

Urophora affinis (Diptera: Tephritidae) and *U. quadrifasciata* (Diptera: Tephritidae) are two seedhead flies approved for release in the United States in 1971 and 1988, respectively for biological control of spotted and diffuse knapweed. United States Department of Agriculture, Animal Plant Health Inspection Service, Plant Protection Quarantine (APHIS) released a mixture of 4,000 adult *U. affinis* and *U. quadrifasciata* in Isabella County, Michigan, in 1994. No *Urophora* species were found in pre-release samples in seven counties in 1993. Samples collected in three counties in 1994, prior to the APHIS release, detected *U. quadrifasciata* in Menominee County. Surveys from 1998 to 2000 found *U. affinis* in 23 counties around and including Isabella County. *Urophora affinis* was also found in Schoolcraft County in northern Michigan. *Urophora quadrifasciata* was found in 86 samples in 83 counties and *U. affinis* in 42 samples in 24 counties from surveys taken in 1998 to 2000. *Centaurea maculosa* (Compositae) (spotted knapweed) was found to be present in all 83 counties and *C. diffusa* (Compositae) (diffuse knapweed) in two Michigan counties.

Spotted and diffuse knapweed are invasive plants that spread and reproduce by seed (Watson and Renney 1974). *Urophora affinis* Frauenfeld and *U. quadrifasciata* (Meig.) are beneficial insects introduced into North America to reduce seed production of these plants. *Urophora affinis* and *U. quadrifasciata* females oviposit on flower bracts, eggs hatch and larvae feed forming galls that distort plant tissues destined to produce seed. As a result of this feeding spotted knapweed seed production is reduced by 2.4 seed with each *U. affinis* gall produced and 1.9 seed with each *U. quadrifasciata* gall (Harris 1980). *Urophora* galls form a metabolic sink reducing plant reserves and the number of flower heads in diffuse knapweed (Harris 1980). The two *Urophora* species partially reduce seed production but have not been shown to decrease the density of spotted and diffuse knapweed in North America (Müller-Sharer 1993). These two tephritid flies are a part of a complex of species attacking the knapweed throughout the season in various locations on the plant causing lower knapweed vitality and health.

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Urophora affinis and *U. Quadrifasciata* were released in British Columbia, Canada in 1972 and Quebec, Canada in 1979 (Harris 1980, Harris and Myers 1984). In 1987, the United States Department of Agriculture, Animal Plant Health Inspection Service, Plant Protection Quarantine (APHIS) began implementing systematic and major releases of biological control agents for spotted and diffuse knapweed beginning in the western United States. *Urophora affinis* was approved for release in the United States 1 October 1971 and *U. quadrifasciata* was approved 9 August 1988 as biological control agents of spotted and diffuse knapweeds (Zwölfer 1970) (Reese and Story 1991).

Urophora affinis was released in Montana and Oregon in 1973 and shortly thereafter, in California, Idaho, and Washington (Maddox 1979). By 1978, *U. affinis* was released in the eastern United States and reported established in New York, Pennsylvania, and Virginia (Wheeler and Stoops 1996). APHIS released *U. affinis* from 1987 to 1996 into 97 counties in 14 Midwestern and western states. Establishment was confirmed in all 14 states (Lang et al. 1997).

Urophora quadrifasciata migrated from established populations in British Columbia, Canada into the United States and were recovered in Idaho in 1980 (Gillespie 1983) and in Montana in 1981 (Story 1985). *Urophora quadrifasciata* present in field collected spotted knapweed seedheads from British Columbia was released by USDA - ARS personnel in New York and Maryland in 1983 (Wheeler 1995, Wheeler and Stoops 1996). *Urophora quadrifasciata* is now established in 11 eastern states (Hoebeke 1993, Wheeler 1995). Pre-release sampling found established populations of *U. quadrifasciata* in Washington (1988), Indiana (1997), Michigan (1994), Minnesota (1989), and Wyoming (1991) (Lang et al. 1997). APHIS released *U. quadrifasciata* from 1988 to 1996 into 97 counties in 14 Midwestern and western states. Establishment was confirmed in all 14 states (Lang et al. 1997). Pre-release sampling found established populations of *U. quadrifasciata* in Washington (1988), Indiana (1997), Michigan (1994), Minnesota (1989), and Wyoming (1991) (Lang et al. 1997). By 1994, biological control agents including *U. affinis* and *U. quadrifasciata* had been released by APHIS as far east as Indiana and Michigan (Lang et al. 1997).

The purpose of this paper is to document the distribution and establishment of *U. affinis* and *U. quadrifasciata* in the state of Michigan.

MATERIALS AND METHODS

Spotted knapweed infestations to be sampled were visually sought in each county. The goal was to find and sample a minimum of two knapweed infestations per county. Spotted knapweed seedheads were hand collected by walking through the spotted knapweed infestation and collecting one to two seedheads per plant. Sampling each site consisted of collecting approximately 200 seedheads to check for the presence and extent of infestation of *U. affinis* and *U. quadrifasciata* in the knapweed seedheads (Lang et al. 1997). One or more samples of spotted knapweed seedheads were collected from each county in the state of Michigan by APHIS, Michigan Department of Agriculture personnel, and volunteers from the Nature Conservancy in Michigan from 1993 to 2000. A minimum of one sample was taken in each county to document the distribution of *U. affinis* and *U. quadrifasciata*. The seedheads were collected from October to June. The collected seedheads were placed in a ziplock bag and shipped to the APHIS Bozeman Biological Control Laboratory in Bozeman, Montana, for dissection and determination of presence or absence of *U. affinis* and *U. quadrifasciata* galls. *Urophora affi-*

nis galls are hard lignified galls formed from the receptacle (Zwölfer 1970). *U. quadrifasciata* galls form from the seed ovary and are not lignified but paper thin (Reese and Story 1991). The data recorded were the average number of *U. affinis* and *U. quadrifasciata* galls present in 50 seedheads from each sample and the percent of seedheads infested by each of the two *Urophora* fly species.

Voucher specimens of *U. affinis* and *U. quadrifasciata* for each county are preserved at Museum of Zoology University of Michigan, APHIS Bozeman Biological Control Laboratory, Bozeman, Montana, Montana State University Entomology Collection, and the Michigan Department of Agriculture. *Urophora* flies that were allowed to emerge from collected knapweed seedheads were killed and preserved in 70 percent alcohol and shipped for identification and confirmation to APHIS Biological Control Station, Bozeman, Montana. The results of this emergence sampling from spotted and diffuse knapweed seedheads for *U. affinis* and *U. quadrifasciata* are entered in Table 1 as present for the *Urophora* flies found in the sample and unknown for the percent of the spotted and diffuse knapweed seedheads attacked.

RESULTS AND DISCUSSION

Pre-release surveys for *U. affinis* and *U. quadrifasciata* on spotted knapweed were taken in 1993 in state of Michigan, counties of Chippewa, Clare, Gladwin, Isabella, Delta, Dickinson, and Mackinac. No *U. affinis* or *U. quadrifasciata* galls were found in the samples (Table 1). Pre-release surveys were repeated April 1994 in the counties of Chippewa, Isabella, and Menominee. A healthy population of *U. quadrifasciata* was discovered in Menominee County with an average of 0.60 galls per seedhead and 36 percent of the seedheads were infested (Table 1). There were no *Urophora* flies detected in the other surveyed counties. APHIS released a mixture of 4000 *U. affinis* and *U. quadrifasciata* at one site in Isabella County on 17 July 1994. This is the only release of *Urophora* flies made in Michigan by APHIS. Subsequent monitoring from 1995 through 2000 indicated that this release resulted in establishment of *U. affinis* and *U. quadrifasciata* in Isabella County (Table 1).

The survey of spotted and diffuse knapweed for *U. affinis* and *U. quadrifasciata* in the state of Michigan resulted in finding spotted knapweed in all 83 counties and diffuse knapweed in two counties. *U. quadrifasciata* were present in samples taken from 1998 to 2000 in 86 samples from 83 counties and *U. affinis* were present in 42 samples from 24 counties (Table 1). *U. quadrifasciata* were found in diffuse knapweed surveyed in two counties, Leelanau in 2000 and Ostego in 1998 (Table 1). The population origin of *U. quadrifasciata* may have immigrated and dispersed throughout the state of Michigan from established populations in Canada, Wisconsin, Indiana, and the 1994 USDA, APHIS release in Isabella County, Michigan (Harris 1980, Harris and Myers 1984, Lang et al. 1997). *U. affinis* were found in spotted knapweed samples in 23 counties surrounding Isabella County. *U. affinis* were also found in Schoolcraft County (Table 1). The surveys of spotted knapweed for *U. affinis* from 1998 to 2000 resulted in population expansion of *U. affinis* populations consistent with APHIS findings from other monitored state release sites (Lang et al. 1997). Surveys in 1993 to 2000 show dramatic increase in distribution of *U. quadrifasciata* populations in the state of Michigan (Table 1). Seven counties were surveyed in 1993 and no *U. affinis* or *U. quadrifasciata* were found (Table 1). APHIS surveys found *U. quadrifasciata* were present in the state of Michigan in 1994 prior to the USDA, APHIS release. Spotted knapweed seedheads collected in Menominee County on 20 June 1994 averaged 0.60 *U.*

Table 1. *Urophora affinis* and *U. quadrifasciata* distribution survey in Michigan (all counties) (1993 to 2000).

County	Year and Month	Avg. no. of <i>U. affinis</i> galls per seedhead	% of Seedheads attacked by <i>U. affinis</i>	Avg. no. of <i>U. quadrifasciata</i> a galls per seedhead	Seedheads attacked by <i>U. quadrifasciata</i>	Township	Location
Alcona	1998 Apr.	0.00	0%	present	unknown	Mitchell	Lat.44° 42.255' N Long.83° 48.042' W
	Alger	1998 Feb.	0.00	0%	present	Rock River	Lat.46° 19.952' N Long 86° 52.063' W
	2000 Mar.	0.00	0%	2.40	76%	Mathias	Lat.46° 10.654' N Long.86° 58.824' W
Alpena	2000 Apr.	0.00	0%	3.80	98%	Rock River	Lat.46° 19.447' N Long.86° 53.241' W
	1998 Apr.	0.00	0%	present	unknown	Long Rapids	Lat.45° 10.689' N Long.83° 41.423' W
	1998 Apr.	0.00	0%	2.12	76%	Casco	T1N R16W Sec 12
Allegan	1998 Apr.	0.02	2%	1.18	50%	Clyde	T2N R15W Sec 29
	1998 Apr.	0.028	20%	2.64	84%	Manlius	T3N R15W Sec 17 NW 1/4
	1998 Apr.	present	unknown	present	unknown	Otsego	Lat.42° 26.462' N Long.85° 39.420' W
Antrim	1998 Jan.	0.00	0%	present	unknown	Star	Lat.44° 58.467' N Long.84° 58.191' W
	2000 Mar.	0.00	0%	1.56	60%	Mancelona	Lat.44° 52.460' N Long.85° 04.545' W
	2000 Mar.	0.00	0%	0.80 (DK)	46%	Mancelona	Lat.44° 52.460' N Long.85° 04.545' W
Arenac	2000 Mar.	0.00	0%	2.34	64%	Turner	Lat.44° 06.627' N Long.83° 48.523' W
Baraga	2000 Mar.	0.00	0%	2.30	74%	Covington	T48N R34W Sec 22
Barry	1998 Apr.	0.00	0	present	unknown	Barry	Lat.42° 28.701' N Long.85° 25.388' W
	2000 Apr.	0.50	34%	0.74	44%	Castleton	Lat.42° 33.763' N Long.85° 06.063' W
	2000 Mar.	0.00	0%	2.72	58%	Kawkawlin	Lat.43° 41.107' N Long.84° 01.704' W
Bay	2000 Mar.	0.08	8%	3.04	74%	Williams	Lat.43° 36.464' N Long.84° 05.391' W
	1998 Feb.	0.00	0%	present	unknown	Benzonia	Lat.44° 36.361' N Long.86° 06.145' W
	1999 Oct.	0.00	0%	2.36	72%	Lake	T26N R16W Sec 4
Benzie	2000 Apr.	0.00	0%	1.94	74%	Blaine	Lat.44° 34.122' N Long.86° 12.067' W
	2000 Apr.	0.00	0%	1.04	40%	Colfax	Lat 44° 31.518' N Long.85° 52.698' W
	2000 Apr.	0.10	10%	1.46	64%	Bainbridge	T4S R17W Sec 23
Berrien	1999 Feb.	0.04	4%	2.42	78%	Hagar	T3S R18W Sec 23
	2000 Apr.	0.00	0%	2.20	74%	Quincy	T6S R5W Sec 20
	2000 Apr.	0.00	0%	present	unknown	Bedford	T1N R8W Sec 19
Branch	1999 Feb.	0.00	0%	present	unknown	Bedford	T1N R8W Sec 19
	2000 Apr.	0.68	46%	1.42	56%	Convis	Lat.42° 24.932' N Long. 85° 00.334' W
Calhoun	2000 Apr.	0.00	0%	3.52	76%	Tekonsha	T4S R6W Sec 34

Cass	2000 Apr.	0.00	0%	1.62	64%	La Grange	T6S R15W Sec 36
Charlevoix	1998 Feb.	0.00	0%	present	unknown	Hayes	Lat.45° 22.167' N Long. 85° 08.708' W
	2000 Mar.	0.00	0%	2.38	80%	Hayes	Lat.45° 21.790' N Long. 85° 10.251' W
Cheboygan	1998 Feb.	0.00	0%	present	unknown	Koehler	Lat.45° 24.818' N Long. 84° 36.198' W
	1999 Feb.	0.00	0%	3.36	82%	Munro	T37N R3W Sec 24
Chippewa	2000 Mar.	0.00	0%	1.94	78%	Mackinaw	Lat.45° 96.165' N Long.84° 43.588' W
	1993 May	0.00	0%	0.00	0%	Superior	T46N R4W Sec 28
	1994 Apr.	0.00	0%	0.00	0%	Superior	T46N R4W Sec 28
	1998 Feb.	0.00	0%	present	unknown	Trout Lake	Lat.46° 12.239' N Long.85° 01.205' W
	2000 Apr.	0.00	0%	1.34	48%	Soo	Lat.46° 17.149' N Long.84° 12.557' W
	2000 Apr.	0.00	0%	2.42	86%	Sugar Island	Lat.46° 29.118' N Long.84° 09.341' W
	2000 Apr.	0.00	0%	1.08	50%	Sugar Island	Lat.46° 23.707' N Long.84° 12.479' W
Clare	2000 Apr.	0.00	0%	4.60	96%	Chippewa	Lat.46° 20.482' N Long.85° 02.258' W
	1993 Feb.	0.00	0%	0.00	0%	Arthur	T18N R3W Sec 3
	1998 Jan.	0.00	0%	present	unknown	Hatton	Lat.43° 54.375' N Long.84° 46.764' W
	1999 Feb.	0.00	0%	1.36	44%	Hayes	T19N R4W Sec 34
	2000 Apr.	0.12	12%	2.68	78%	Surrey	Lat.43° 52.070' N Long.84° 55.000' W
Clinton	1999 Oct.	0.78	50%	0.56	32%	Bath	T5N R1W Sec 26
	2000 Apr.	1.12	52%	1.98	66%	Bingham	Lat.43° 01.691' N Long.84° 33.739' W
Crawford	1998 Jan.	0.00	0%	present	unknown	Beaver Creek	Lat.44° 32.422' N Long.84° 46.232' W
	1999 Feb.	0.00	0%	2.58	72%	Grayling	T26N R3W Sec 5
Delta	2000 Mar.	0.00	0%	1.02	40%	Beaver Creek	Lat.44° 32.422' N Long.84° 46.232' W
	1993 May	0.00	0%	0.00	0%	Masonville	T41N R21W Sec 28 SW1/4
	1995 Jun.	0.00	0%	0.14	10%		Lat.45° 54' 59.5" N Long.86° 55' 59.4" W
	1995 Jun.	0.00	0%	0.08	6%		Lat.45° 44' 46.6" N Long.87° 05' 20.4" W
	1998 Feb.	0.00	0%	present	unknown	Brampton	Lat.45° 55.654' N Long.86° 58.466' W
	2000 Mar.	0.00	0%	2.62	76%	Wells	T39N R22W Sec 29
	2000 Mar.	0.00	0%	3.10	90%	Brampton	Lat.45° 55.654' N Long.86° 58.466' W
Dickinson	1993 May	0.00	0%	0.00	0%	Breitung	T41N R30W Sec 27 NE 1/4
	1995 May	0.00	0%	0.00	0%		Lat.45° 55' 49.1" N long.88° 02' 11.3" W
	1995 May	0.00	0%	0.64	30%		Lat.45° 47' 5.09" N Long.87° 52' 32.8"
	2000 Mar.	0.00	0%	3.64	90%	Felch	
Eaton	2000 Mar.	0.00	0%	2.58	88%	Breen	Fordville Rd
	2000 Apr.	1.08	60%	2.88	76%	Eaton	Lat.42° 34.504' N Long.84° 49.272' W

(Continued)

Table 1. (Continued)

County	Year and Month	Avg. no. of <i>U. affinis</i> galls per seedhead	% of Seedheads attacked by <i>U. affinis</i>	Avg. no. of <i>U. quadrifasciata</i> a galls per seedhead	Seedheads attacked by <i>U. quadrifasciata</i>	Township	Location
Emmet	1998 Feb.	0.00	0%	present	unknown	Resort	Lat.45° 21.984' N Long.84° 59.723' W
	2000 Mar.	0.00	0%	0.80	50%	McKinley	Lat.45° 33.662' N Long.84° 47.028' W
Genesee	1999 Oct.	0.34	22%	2.30	72%	Flint	I-96 @ exit 133
Gladwin	1993 Feb.	0.00	0%	0.00	0%	Sherman	T20N R2W Sec 24
	2000 Mar.	0.14	10%	1.28	58%	Tobacco	Lat.43° 49.487' N Long.84° 23.785' W
Gogebic	2000 Mar.	0.02	2%	2.48	72%	Grout	Lat.43° 59.278' N Long.84° 33.920' W
	1999 Nov.	0.00	0%	0.72	42%	Wakefield	T47N R44W Sec 30
Grand Traverse	2000 Mar.	0.00	0%	2.90	82%	Watersmeet	T45N R39W Sec 28
	1998 Jan.	0.00	0%	present	unknown	Fife Lake	Lat.44° 35.445' N Long.85° 21.200' W
Gratiot	2000 Mar.	0.00	0%	0.64	34%	Fife Lake	Lat.44° 30.749' N Long.85° 20.545' W
	2000 Mar.	0.00	0%	1.34	58%	Fife Lake	Lat.44° 30.749' N Long.85° 20.545' W
	2000 Mar.	0.00	0%	0.80	32%	Fife Lake	Lat.44° 35.445' N Long.85° 21.200' W
	2000 Mar.	0.74	48%	1.88	78%	Pine River	Lat.43° 24.584' N Long.84° 39.987' W
Hillsdale	1998 Jun.	0.00	0%	present	unknown	Somerset	T5S R1W Sec 7
Houghton	2000 Mar.	0.00	0%	2.48	82%	Duncan	Unknown
Huron	2000 May	0.00	0%	1.66	70%	Verona	Lat.43° 48.100' N Long.82° 56.469' W
	2000 May	0.00	0%	0.48	30%	Sebewaing	Lat.43° 43.980' N Long.83° 27.599' W
Ingham	1998 Apr.	0.00	0%	1.32	70%	Alaiedon	T3N R1W Sec 31
	2000 Apr.	0.18	16%	0.40	26%	Meridian	T4N R1W Sec 19
	2000 Apr.	0.34	30%	1.08	56%	Lansing	Lat.42° 43.152' N Long.84° 29.780' W
	2000 Apr.	0.26	24%	1.26	52%	Vevay	T2N R1W Sec 6
Ionia	1998 Apr.	0.00	0%	present	unknown	Otisco	Lat.43° 05.109' N Long.85° 11.781' W
	2000 Apr.	1.56	72%	0.86	40%	Berlin	Lat.42° 52.809' N Long.85° 04.322' W
Iosco	2000 Mar.	0.00	0%	1.96	62%	Plainfield	Lat.44° 22.856' N Long.83° 49.445' W
	2000 Mar.	0.00	0%	2.24	72%	Reno	Lat.44° 15.440' N Long.83° 48.233' W
Iron	1999 Nov.	0.00	0%	1.28	52%	Mastodon	Lat.46° 03.337' N Long.88° 20.346' W
	2000 Mar.	0.00	0%	3.06	86%	Hematite	Unknown
	2000 Mar.	0.00	0%	1.14	46%	Mansfield	Sagola

Isabella	1993 Feb.	0.00	0%	0.00	0%	Fremont	T13N R5W Sec 14
	1994 Mar.	0.00	0%	0.00	0%	Fremont	T13N R5W Sec 14
	1994 Jul. 17		Released	N/A	Released	N/A	Fremont T13N R5W Sec 14
*	1994 Nov.	0.22	12%	0.00	0%	Fremont	T13N R5W Sec 14
	1995 Feb.	0.00	0%	0.00	0%	Fremont	T13N R5W Sec 11
	1995 Feb.	0.00	0%	0.00	0%	Fremont	T13N R5W Sec 22
	1995 Feb.	0.00	0%	0.00	0%	Lincoln	T13N R4W Sec 18
	1995 Feb.	0.00	0%	0.00	0%	Fremont	T13N R5W Sec 23
	1995 Feb.	0.00	0%	0.00	0%	Fremont	T13N R5W Sec 15
	1995 Feb.	0.00	0%	0.00	0%	Fremont	T13N R5W Sec 4
	1995 Feb.	0.00	0%	0.00	0%	Fremont	T13N R5W Sec 14
	1995 Feb.	0.00	0%	0.06	4%	Lincoln	T13N R4W Sec 7 NE 1/4
	1995 Feb.	0.00	0%	0.00	0%	Lincoln	T13N R4W Sec 7 SE 1/4
	1995 Feb.	0.00	0%	0.00	0%	Lincoln	T13N R4W Sec 7 NW 1/4
	1995 Feb.	0.00	0%	0.00	0%	Lincoln	T13N R4W Sec 6 NE 1/4
	1996 Mar. *	0.14	14%	0.02	2%	Fremont	T13N R5W Sec 14
	1996 Mar.	0.00	0%	0.00	0%	Fremont	T13N R5W Sec 11
	1996 Mar.	0.00	0%	0.00	0%	Fremont	T13N R5W Sec 15
	1996 Mar.	0.00	0%	0.00	0%	Fremont	T13N R5W Sec 23
	1997 May	0.04	4%	0.12	10%	Fremont	T13N R5W Sec 15
	1997 May	0.00	0%	0.50	28%	Fremont	T13N R5W Sec 7
	1997 May	0.02	2%	0.00	0%	Fremont	T13N R5W Sec 11
	1997 May	0.00	0%	0.14	10%	Fremont	T13N R5W Sec 22
	1997 May	0.00	0%	0.36	10%	Lincoln	T13N R4W Sec 18
	1997 May*	2.68	80%	0.12	6%	Fremont	T13N R5W Sec 14
	1998 Jan.	0.00	0%	present	unknown	Union	Lat.43° 37.368' N Long.84° 46.107' W
	1998 Mar.	0.00	0%	present	unknown	Coe	Lat.43° 31.503' N Long.84° 41.812' W
	1998 Nov.*	4.72	98%	0.54	20%	Fremont	T13N R5W Sec 14
	1998 Nov.	0.28	22%	1.92	66%	Lincoln	T13N R4W Sec7
	1998 Nov.	0.24	22%	2.22	80%	Fremont	T13N R5W Sec 15
	1998 Nov.	0.12	10%	2.36	88%	Fremont	T13N R5W Sec 4
	2000 Feb.	0.26	18%	1.16	50%	Broomfield	Lat.43° 35.018' N Long.85° 05.107' W
Jackson	1998 Jun.	0.00	0%	present	unknown	Hanover	T4S R2W Sec 22
Kalamazoo	1998 Apr.	0.00	0%	present	unknown	Comstock	Lat.42° 14.856' N Long.85° 31.840' W
	1999 Oct.	0.00	0%	1.52	54%	Charleston	T2S R9W Sec 16

(Continued)

Table 1. (Continued)

County	Year and Month	Avg. no. of <i>U. affinis</i> galls per seedhead	% of Seedheads attacked by <i>U. affinis</i>	Avg. no. of <i>U. quadrifasciata</i> a galls per seedhead	Seedheads attacked by <i>U. quadrifasciata</i>	Township	Location	
Kalkaska	1998 Jan.	0.00	0%	present	unknown	Boardman	Lat.44° 38.510' N Long.85° 17.789' W	
	2000 Mar.	0.00	0%	1.92	76%	Garfield	Lat.44° 34.994' N Long.85° 07.955' W	
Kent	1998 Apr.	present	unknown	present	unknown	Solon	Lat.43° 15.108' N Long.85° 34.109' W	
	2000 Apr.	0.90	50%	0.60	32%	Solon	Lat.43° 13.080' N Long.85° 34.414' W	
Keweenaw	2000 Mar.	0.00	0%	4.44	92%	All Ouez	T57N R32W Sec 32	
	2000 Apr.	0.00	0%	1.78	66%	Eagle Harbor	Lat.47° 26.180' N Long.87° 57.962' W	
Lake	1998 Jan.	0.00	0%	present	unknown	Dover	T20N R11W Sec 23	
Lenawee	1998 Jun.	0.00	0%	present	unknown	Cambridge	T5S R2E Sec 24	
Lapeer	1999 Oct.	0.02	2%	3.46	84%	Imlay	T7N R12E Sec 29	
Leelanau	1998 Jan.	0.00	0%	present	unknown	Leland	Lat.44° 58.988' N Long.85° 44.180' W	
	1999 Oct.	0.00	0%	1.56	52%	Leelanau	T32N R11W Sec 22	
	1999 Oct.	0.00	0%	1.32	50%	Cleveland	T29N R13W Sec 9	
	2000 Mar.	0.00	0%	1.78	62%	Leelanau	Lat.45° 12.520' N Long.85° 32.693' W	
	2000 Mar.	0.00	0%	0.72 (DK)	40%	Centerville	Lat.44° 54.874' N Long.85° 47.243' W	
	2000 Mar.	0.00	0%	1.46	72%	Centerville	Lat.44° 54.874' N Long.85° 47.243' W	
	2000 Apr.	0.00	0%	2.04	80%	Glen Arbor	T30N R15W Sec 4	
	2000 May	0.00	0%	3.04	88%	Leland	T31N R14W Sec 3	
	Livingston	1998 Apr.	0.00	0%	1.60	70%	Handy	T3N R3E Sec 14
		1998 Apr.	0.00	0%	2.00	72%	Unknown	M-96, Howell Exit (#137)
Luce	1998 Feb.	0.00	0%	present	unknown	Columbus	Lat.46° 20.142' N Long.85° 47.531' W	
	2000 Apr.	0.00	0%	1.82	74%	Columbus	Lat.46° 20.300' N Long.85° 44.703' W	
Macomb	1999 Feb.	0.00	0%	present	unknown	Chesterfield	T3N R14E Sec 20	
Mackinac	1993 May	0.00	0%	0.00	0%	Moran	T41N R5W Sec 25 NW 1/4	
	1998 Feb.	0.00	0%	present	unknown	Moran	Lat.45° 51.447' N Long.84° 46.981' W	
	2000 Mar.	0.00	0%	2.52	84%	Garfield	Lat.46° 05.701' N Long.85° 27.075' W	
Manistee	2000 Mar.	0.00	0%	2.54	88%	Moran	Lat.45° 50.968' N Long.84° 43.326' W	
	1998 Jan.	0.00	0%	present	unknown	Norman	Lat.44° 13.515' N Long.85° 51.193' W	
	2000 Mar.	0.00	0%	1.76	66%	Bear Lake	Lat.44° 23.152' N Long.86° 07.159' W	

Marquette	1998 Mar.	0.00	0%	present	unknown	Marquette	Lat.46° 33.965' N Long.87° 23.399' W
	2000 Mar.	0.00	0%	3.06	86%	Marquette	Lat.46° 33.710' N Long.87° 23.342' W
	2000 Mar.	0.00	0%	3.22	88%	West Branch	Lat.46° 22.615' N Long.87° 16.285' W
Mason	1998 Feb.	0.00	0%	present	unknown	Grant	Lat.44° 09.150' N Long.86° 17.993' W
	1998 Apr.	0.00	0%	2.48	80%	Amber	T18N R17W Sec 28
Mecosta	1998 Apr.	0.00	0%	1.16	50%	Riverton	T17N R17W Sec 31
	1998 Feb.	0.02	2%	1.76	72%	Morton	T14N R8W Sec 15 SW 1/4
	1998 Feb.	0.00	0%	1.86	74%	Millbrook	T13N R7W Sec 9 SE 1/4
	1998 Apr.	0.00	0%	2.94	76%	Mecosta	T14N R10W Sec 22 SE 1/4
	1998 Apr.	0.00	0%	present	unknown	Green	Lat.43° 44.710' N Long.85° 31.968' W
Menominee	2000 Feb.	0.04	4%	1.00	46%	Sheridan	Lat.43° 39.542' N Long.85° 08.805' W
	1994 Jun.	0.00	0%	0.60	36%	unknown	T36N R24W Sec 20
	1994 Sept.	0.00	0%	0.04	4%	unknown	T34N R27W Sec 27
	1995 May	0.00	0%	0.08	6%	unknown	Lat.45° 43' 05.0' N Long.87° 36' 25.4" W
	1995 Jun.	0.00	0%	0.04	4%	unknown	Lat.45° 42' 10.1' N Long.87° 20' 45.5" W
	2000 Mar.	0.00	0%	1.44	54%	Gourley	T37N R25W Sec2
Midland	2000 Mar.	0.00	0%	2.00	74%	Lake	T35N R28W Sec 23
	2000 Mar.	0.63	36%	2.10	66%	Midland	Lat.43° 39.254' N Long.84° 12.330' W
Missaukee	2000 Mar.	0.06	6%	2.16	68%	Edenville	Lat.43° 46.755' N Long.84° 24.406' W
	1998 Jan.	0.00	0%	present	unknown	Butterfield	Lat.44° 19.868' N Long.84° 56.694' W
	2000 Mar.	0.00	0%	1.70	58%	Forest	Lat.44° 25.149' N Long.85° 08.181' W
Monroe	2000 Apr.	0.00	0%	1.16	62%	Whiteford	T8S R6E Sec 11
Montcalm	1998 Feb.	0.74	44%	2.22	90%	Reynolds	T12N R10W Sec 27 SE 1/4
	1998 Feb.	0.72	30%	1.62	66%	Pine	T11N R8W Sec 4 NW 1/4
	1998 Feb.	0.30	26%	0.72	28%	Cato	T12N R8W Sec 17 NE 1/4
	1998 Apr.	present	unknown	present	unknown	Pierson	Lat.43° 27.733' N Long.85° 29.105' W
Montmorency	1998 Apr.	0.00	0	present	unknown	Vienna	Lat.44° 57.754' N Long.84° 16.804' W
	2000 Mar.	0.00	0	0.94	40%	Vienna	Lat.44° 57.693' N Long.85° 16.748' W
Muskegon	1998 Apr.	0.16	14%	2.16	82%	Whitehall	T12N R17W Sec 26
	1998 Apr.	1.10	46%	1.40	62%	Fruitport	T9N R16W Sec 24
	2000 Feb.	0.48	38%	1.00	58%	Dolton	Lat.43° 19.316' N Long.86° 14.335' W
Newaygo	1998 Feb.	0.04	4%	4.40	90%	Big Prairie	T13N R11W Sec 29 NW 1/4
	1998 Feb.	4.58	98%	0.44	26%	Croton	T12N R11W Sec 29 NW 1/4
	1998 Apr.	0.00	0%	present	unknown	Barton	Lat.43° 44.580' N Long.85° 38.792' W

(Continued)

Table 1. (Continued)

County	Year and Month	Avg. no. of <i>U. affinis</i> galls per seedhead	% of Seedheads attacked by <i>U. affinis</i>	Avg. no. of <i>U. quadrifasciata</i> a galls per seedhead	Seedheads attacked by <i>U. quadrifasciata</i>	Township	Location
Oakland	1998 Apr.	0.00	0%	2.88	72%	Novi	T1N R8E Sec 16
Oceana	1998 Apr.	0.00	0%	1.60	66%	Weare	T16N R17W Sec30
	2000 Feb.	0.00	0%	2.28	72%	Hart	Lat.43° 41.294' N Long.86° 23.084' W
Ogemaw	2000 Mar.	0.00	0%	0.42	26%	Rose	Lat.44° 25.316' N Long.84° 06.715' W
Ontonagon	1999 Nov.	0.00	0%	1.98	78%	Bergland	T48N R42W Sec 4
	2000 Mar.	0.00	0%	2.82	86%	Rockland	T50N R39W Sec 14
	2000 Mar.	0.00	0%	4.44	96%	Ontonagon	US 45/RR Tracks
Osceola	1998 Jan.	0.00	0%	present	unknown	Sherman	Lat.44° 08.757' N Long.85° 25.068' W
	2000 Feb.	0.00	0%	2.44	52%	Orient	Lat.43° 53.655' N Long.85° 03.867' W
Oscoda	1998 Apr.	0.00	0%	present	unknown	Comins	Lat.44° 43.512' N Long.84° 06.827' W
	2000 Mar.	0.00	0%	1.54	58%	Greenwood	Lat.44° 43.491' N Long.84° 16.980' W
Otsego	1998 Jan.	0.00	0%	present	unknown	Bagley	Lat.45° 01.100' N Long.84° 42.104' W
	2000 Mar.	0.00	0%	1.48 (DK)	76%	Elmira	Lat.45° 05.306' N Long.84° 48.922' W
	2000 Mar.	0.00	0%	1.58	58%	Elmira	Lat.45° 05.306' N Long.84° 48.922' W
	2000 Mar.	0.00	0%	1.88	72%	Charlton	Lat.45° 58.291' N Long.84° 27.333' W
Ottawa	1999 Apr.	1.28	58%	0.44	22%	Spring Lake	T8N R16W
	2000 Feb.	0.90	52%	1.22	46%	Spring Lake	Lat.43° 05.656' N Long.86° 12.682' W
Presque Isle	1998 Apr.	0.00	0%	present	unknown	Posen	Lat.45° 14.510' N Long.83° 41.047' W
Roscommon	1998 Jan.	0.00	0%	present	unknown	Roscommon	Lat.44° 11.770' N Long.84° 47.800' W
	1999 Feb.	0.00	0%	0.72	40%	Lyon	T24N R4W Sec 34
	2000 Mar.	0.00	0%	3.44	86%	Roscommon	Lat.44° 11.370' N Long.84° 47.728' W
Saginaw	1999 Jul.	0.00	0%	present	unknown	Buena Vista	Lat.43° 28.791' N Long.83° 54.298' W
St. Clair	1999 Oct.	0.00	0%	1.86	62%	Kimball	T6N R16E Sec 4
St. Joseph	2000 Apr.	0.00	0%	1.28	54%	Nottawa	T6S R10W Sec 19
Sanilac	2000 May	0.00	0%	3.16	80%	Argyle	Lat.43° 32.661' N Long.82° 56.157' W
Schoolcraft	1998 Feb.	0.00	0%	present	unknown	Mueller	Lat.46° 05.730' N Long.85° 56.876' W
	2000 Mar.	0.84	56%	2.36	84%	Thompson	Lat.45° 54.617' N Long.86° 28.649' W

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	2000 Mar.	0.00	0%	3.12	92%	Mueller	Lat.46° 04.759' N Long.85° 57.484' W
	2000 Apr.	0.00	0%	0.54	30%	Germfask	T45N R13W Sec 9
Shiawassee	1999 Oct.	0.98		46%	3.54	84%	Shiawassee T6N R3E
Tuscola	2000 May	0.00	0%	2.82	78%	Wisner	Lat.43° 34.984' N Long.83° 41.110' W
VanBuren	1999 Feb.	0.00	0%	1.36	63%	Hartford	T3S R16W Sec22
	2000 Apr.	0.00	0%	1.60	70%	Covert	T2S R17W
Washtenaw	1999 Oct.	0.00		0%	2.10	70%	Ann Arbor T2S R6E
	2000 Apr.	0.00	0%	1.26	64%	Ann Arbor	T2S R6E Sec 27
Wayne	1998 Apr.	0.00	0%	2.68	86%	Farmington Hills	Unknown
Wexford	1998 Jan.	0.00	0%	present	unknown	Cedar Creek	Lat.44° 24.376' N Long.85° 21.302' W
	2000 Apr.	0.00	0%	1.54	50%	Cedar Creek	Lat.44° 24.195' N Long.85° 26.227' W
	2000 Apr.	0.00	05	0.66	36%	Cedar Creek	Lat.44° 24.195' N Long.85° 26.227' W

* = The site of the original release in Isabella county.

DK= diffuse knapweed

quadrifasciata with 36 percent of the seedheads infested. The first USDA, APHIS release was made July 17, 1994. The surveys from 1998 to 2000 revealed many well-established populations of the two *Urophora* species in Michigan (Table 1). In conclusion, both species of knapweed seedhead flies are well-established throughout the state of Michigan.

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