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Attack of *Urophora Quadrifasciata* (Meig.) (Diiptera: Tephritidae) A Biological Control Agent for Spotted Knapweed (*Centaurea Maculosa* Lamarck) and Diffuse Knapweed (*C. Diffusa* Lamarck) (Asteraceae) by a Parasitoid, *Pteromalus* Sp. (Hymenoptera: Pteromalidae) in Michigan

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ATTACK OF *UROPHORA QUADRIFASCIATA* (MEIG.) (DIIPTERA: TEPHRITIDAE) A BIOLOGICAL CONTROL AGENT FOR SPOTTED KNAPWEED (*CENTAUREA MACULOSA* LAMARCK) AND DIFFUSE KNAPWEED (*C. DIFFUSA* LAMARCK) (ASTERACEAE) BY A PARASITOID, *PTEROMALUS* SP. (HYMENOPTERA: PTEROMALIDAE) IN MICHIGAN

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ABSTRACT

Urophora quadrifasciata (Meig.) a seedhead fly released in North America for biological control of *Centaurea maculosa and C. diffusa* is parasitized by a *Pteromalus* sp. Parasitism up to 60% of *U. quadrifasciata* was found in samples of seed heads of *C. maculosa and C. diffusa* collected from 54 of the 59 counties sampled in Michigan and in one sample of *C. maculosa* seed heads from Hennepin County, Minnesota. Parasitism of *U. quadrifasciata* has rarely been reported.

Urophora quadrifaciata (Meigen) (Diptera: Tephritidae) was imported from Eurasia and released in British Columbia, Canada in 1972 as a biological control agent for *Centaurea maculosa* Lamarck and *C. diffusa* Lamarck, spotted and diffuse knapweeds, respectively (Harris 1986). Populations of *U. quadrifasciata* apparently migrated into the Western United States from British Columbia; *U. quadrifasciata* was detected in northern Idaho in 1980 (Gillespie 1983) and later in Montana in 1981 (Story 1985). *Urophora quadrifasciata* populations were subsequently confirmed in California, Oregon and Washington (Maddox 1979). *Urophora quadrifasciata* was released in Quebec, Canada in 1979 and in Massachusetts and New York in 1983 (Wheeler 1995). *Urophora quadrifasciata* was also released by United States Department of Agriculture, Animal Plant Health Inspection Service (APHIS) and other agencies from 1987 to 2002, and is now established throughout the northern United States and Canada (Lang et al. 1997, Hoebeke 1993, Story 1985, Wheeler 1995, Wheeler and Stoops 1996, Harris and Myers 1984, Reese and Story 1991). In 1994, APHIS made a mixed release of *U. affinis* Frauenfeld (Diptera: Tephritidae) and *U. quadrifasciata* in Isabella County, Michigan (Lang et al. 1997).

We began in 2002 to conduct a state-wide survey to determine the distribution of *Urophora spp*. in Michigan. It became apparent that parasitism was significant among Michigan populations of *U. quadrifasciata.* The scope of this study was to survey as many counties as possible to determine if parasitism of *U. quadrifasciata* and *U. affinis* was general throughout Michigan.

Parasitoids attacking *Urophora spp*. were previously surveyed in Montana, Washington, Minnesota, South Dakota, Arizona, Wisconsin, Nebraska, and Wyoming from 1988-1997. Three species of parasitoids attacking *U. affinis* in Montana and Washington were collected during these surveys including *Microdontomerus anthonomi* (Crawford) (Hymenoptera: Torymidae) (n = 7), *Mesopolobus* sp. (Hymenoptera: Pteromalidae) (n = 1), and *Pteromalus* sp. (Hymenoptera: Pteromalidae) (n = 8). There were no parasitoids collected from *U. quadrifasciata* (Lang and

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Richard 1998, Turner et al. 1990). In 1985 Peter Harris reared three Parasitoids from *U. quadrifasciata* identified as *Crataepiella trypetae* Gradwell (Hymenoptera: Pteromalidae) by Carl Yoshimoto (Ottawa) (personal com. Peter Harris). Surprisingly reports of parasitoids attacking *U. quadrifasciata* in Canada or the United States are rare (Myers and Harris 1980, Harris and Shorthouse. 1996). This paper documents the occurrence and relative severity of parasitism of *U. quadrifasciata* in Michigan.

MATERIALS AND METHODS

Two hundred *C. maculosa* or *C. diffusa* seed heads were collected from each of 106 sites in 59 counties in Michigan in late winter and early spring of 2002. The *Centaurea* sites sampled varied from a few plants to large infestations. Samples were collected from one to two *Centaurea* infestations per county including as many counties as possible in one summer as time would permit. *C. maculosa* and *C. diffusa* seed heads were hand collected by walking through the *Centaurea* infestation and collecting one or more seed heads per plant. If a spray of seed heads was included in a sample, two to four seed heads from various parts of the spray would be broken off and dissected to check for parasitoids. The seed heads were not collected from a predetermined location on each plant. The two diffuse samples included in the study from Missaukee County, Norwich township and Otsego County, Elmira township were from mixed stands of *C. maculosa* and *C. diffusa* plants (Table 1). Fifty seed heads from each sample of 200 seed heads were dissected to count *U. affinis* and *U. quadrifasciata* galls and observe any evidence of parasitism. Parasitoid larvae and pupae recovered from the *U. quadrifasciata* galls in the dissected seed heads were placed in gel capsules for rearing to adults. The remaining seed heads from the samples were individually placed in 30 ml clear plastic cups to collect additional eclosed parasitoid adults for identification. These samples were kept at room temperature. The cups were opened after 3 months and the contents examined. When parasitoid adults were found, the seed head was dissected to confirm the identification of the host. Adult parasitoids that emerged from U. *quadrifasciata* puparia or that completed their development in gel capsules were mounted and sent to the United States Department of Agriculture, Agriculture Research Service, Systematic Entomology laboratory (Beltsville, Maryland) for identification. Voucher specimens are retained at the United States Department of Agriculture, Animal Plant Health Inspection Service, Center for Plant Health Science and Technology laboratory in Fort Collins, Colorado.

RESULTS

Establishment of *U. quadrifasciata* was previously confirmed in all 83 counties in Michigan (Lang et al 2001). Prerelease sampling of *C. maculosa* and *C. diffusa* in Michigan by USDA APHIS personal in 1993 in of Chippewa, Clare, Gladwin, Isabella, Delta, Dickinson, and Mackinac Counties yielded no *Urophora spp*. in seed head samples. In 1994 prerelease surveys for *U. affinis* and *U. quadrifasciata* were conducted in Chippewa, Isabella and Menominee Counties; *U. quadrifasciata* was found in Menominee County, with 36 percent of the seed heads infested and an average of 0.60 galls per seedhead (Lang et al 2001). In 2000 a few eclosed parasitoids were observed in bagged spotted or diffuse knapweed seed head samples from Michigan (J. Winkler, pers. comm.). In 2002, spotted and diffuse knapweed samples from Michigan exhibited parasitism rates of *U. quadrifasciata* as high as 60% (Table 1). Parasitism of *U. quadrifasciata* was found in 54 of 59 counties (92%) sampled (Table 1). In 2002 five adult *Pteromalus* sp. from *U. quadrifasciata* were found in one sample of *C. maculosa* seed heads from Hennepin County, Minnesota in an APHIS *Urophora* spp. monitoring survey. There were no parasitoids found in *U. affinis* galls. The parasitoids from *U. quadrifasciata* were identified as *Pteromalus* sp. by Dr. E. Eric Grissell of the

Table 1. Percent of *Urophora quadrifasciata* Parasitized by *Petermalus* sp.

County	Township	Location	Number of seedheads infested by *Urophora quadrifasciata* (n=50)	Number of *Urophora quadrifasciata* galls in the sample (n=50)	Percent *Urophora quadrifasciata* parasitized
Alcona	Hayes	Lat.44°42.956´N Long.83°18.004´W	15	22	9%
Alcona	Mitchell	Lat.44°42.255´N Long.83°48.042´W	14	33	12%
Allegan	Ostego	Lat.42°26.962´N Long.85°39.420´W	14	42	0%
Allegan	Wayland	Lat.42°40.495´N Long.85°39.194´W	19	59	3%
Alpena	Alpena	Lat.45°08.024´N Long.83°25.932´W	25	39	33%
Alpena	Long Rapids	Lat.45°10.689´N Long.83°41.923´W	22	37	35%
Antrim	Mancelona	Lat.44°52.398´N Long.85°04.626´W	27	52	15%
Antrim	Star	Lat.44°58.466´N Long.84°57.184´W	12	20	5%
Antrim	Warner	Lat.45°04.488´N Long.84°53.914´W	37	71	4%
Baraga	Baraga	Lat.46°47.410´N Long.88°28.482´W	39	88	3%
Baraga	Covington	Lat.46°32.811´N Long.88°32.056´W	40	92	0%
Barry	Barry	Lat.42°28.701´N Long.85°25.394´W	5	5	0%
Barry	Castleton	Lat.42°36.210´N Long.85°07.701´W	13	21	19%
Barry	Hastings	Lat.42°36.698´N Long.85°16.182´W	15	23	4%
Benzie	Benzonia	Lat.44°36.360´N Long.86°06.068´W	24	52	4%
Benzie	Blaine	Lat.44°34.074´N Long.86°12.042´W	13	20	5%
Benzie	Colfax	Lat.44°31.624´N Long.85°52.661´W	8	10	20%
Benzie	Crystal Lake	Lat.44°41.386´N Long.86°15.075´W	17	35	37%
Branch	Ovid	T7S R6W Sec 3NE	31	129	4%
Calhoun	Bedford	Lat.42°22.021´N Long.85°17.870´W	8	13	0%
Calhoun	Convis	T1S R6W Sec 26SW	15	22	9%
Cass	Marcellus	Lat.42°01.628´N Long.85°48.702´W	23	55	40%
Charlevoix	Boyne Valley	Lat.45°10.180´N Long.84°45.915´W	22	57	11%
Charlevoix	Hayes	Lat.45°22.167´N Long.85°08.708´W	18	28	25%
Charlevoix	Hayes	Lat.45°21.790´N Long.85°10.251´W	12	18	17%
Cheboygan	Koehler	Lat.45°24.659´N Long.84°36.176´W	28	62	18%
Cheboygan	MacKinaw	Lat.45°46.165´N Long.84°43.588´W	23	40	30%
Clare	Hatton	Lat.43°54.204´N Long.84°46.704´W	37	92	22%

Table 1. (Continued)

County	Township	Location	Number of seedheads infested by *Urophora quadrifasciata* (n=50)	Number of *Urophora quadrifasciata* galls in the sample (n=50)	Percent *Urophora quadrifasciata* parasitized
Clare	Surrey	Lat.43°52.051´N Long.84°54.962´W	17	23	17%
Clinton	Bingham	Lat.43°01.723´N Long.84°33.735´W	12	42	0%
Crawford	Beaver Creek	Lat.44°32.406´N Long.84°46.115´W	15	26	23%
Crawford	South Branch	Lat.44°30.648´N Long.84°28.315´W	9	13	23%
Crawford	South Branch	Lat.44°36.795´N Long.84°24.686´W	19	23	4%
Delta	Brampton	Lat.45°55.677´N Long.86°58.460´W	47	210	31%
Delta	Ford River	Lat.45°40.725´N Long.87°08.426´W	32	94	31%
Delta	Masonville	Lat.45°59.602´N Long.86°57.956´W	44	155	21%
Dickinson	Breitung	Lat.45°55.343´N Long.88°02.465´W	34	74	10%
Dickinson	Norway	Lat.45°47.509´N Long.87°52.328´W	41	109	17%
Eaton	Benton	Lat.42°37.121´N Long.84°44.862´W	15	82	17%
Eaton	Eaton	Lat.42°34.504´N Long.84°49.285´W	16	36	0%
Emmet	McKinley	Lat.45°33.662´N Long.84°47.028´W	9	21	52%
Emmet	Resort	Lat.45°21.984´N Long.84°59.723´W	12	17	24%
Gladwin	Bourret	T20N R2E Sec 7	15	32	34%
Gladwin	Grout	Lat.43°59.205´N Long.84°33.916´W	19	39	8%
Gladwin	Tobacco	Lat.43°50.597´N Long.84°24.991´W	7	10	20%
Gogebic	Wakefield	Lat.46°29.254´N Long.89°55.985´W	18	31	0%
Gogebic	Watersmeet	Lat.46°15.778´N Long.89°10.546´W	29	53	0%
Grand Traverse	Fife Lake	Lat.44°35.426´N Long.85°21.173´W	24	50	40%
Grand Traverse	Fife Lake	Lat.44°30.739´N Long.85°20.645´W	21	35	9%
Grand Traverse	Mayfield	Lat.44°33.349´N Long.85°39.237´W	18	37	3%
Grand Traverse	Peninsula	Lat.44°53.644´N Long.85°31.308´W	17	28	32%
Grand Traverse	Whitewater	Lat.44°46.806´N Long.85°21.180´W	6	16	13%
Gratiot	Emerson	Lat.43°17.523´N Long.84°35.022´W	20	84	12%
Houghton	Duncan	Lat.46°29.213´N Long.88°52.828´W	25	49	0%
Houghton	Torch Lake	Lat.46°58.817´N Long.88°28.087´W	33	79	1%
Ingham	Lansing	Lat.42°43.162´N Long.84°29.761´W	19	35	37%
Ionia	Berlin	Lat.42°52.875´N Long.85°04.556´W	15	35	6%

Table 1. (Continued)

County	Township	Location	Number of seedheads infested by *Urophora quadrifasciata* (n=50)	Number of *Urophora quadrifasciata* galls in the sample (n=50)	Percent *Urophora quadrifasciata* parasitized
Ionia	Orleans	Lat.43°05.115´N Long.85°04.510´W	10	15	0%
Iosco	Plainfield	Lat.44°22.856´N Long.83°49.445´W	14	18	6%
Iosco	Reno	Lat.44°15.440´N Long.83°48.223´W	21	18	17%
Iron	Hematite	Lat.46°18.506´N Long.88°28.052´W	24	56	0%
Iron	Mansfield	Lat.46°05.242´N Long.88°10.049´W	35	87	0%
Isabella	Broomfield	Lat.43°35.032´N Long.85°05.159´W	12	27	15%
Isabella	Coe	Lat.43°31.557´N Long.84°41.822´W	8	18	22%
Isabella	Union	Lat.43°37.345´N Long.84°46.054´W	8	24	8%
Kalkaska	Boardman	Lat.44°38.490´N Long.85°17.799´W	26	64	14%
Kalkaska	Garfield	Lat.44°34.994´N Long.85°04.910´W	30	54	6%
Kalamazoo	Charleston	Lat.42°18.362´N Long.85°23.419´W	11	19	11%
Kalamazoo	Comstock	Lat.42°14.879´N long.85°31.836´W	17	30	13%
Kalamazoo	Ross	Lat.42°24.349´N Long.85°23.662´W	5	7	0%
Kent	Byron	Lat.42°48.733´N Long.85°39.954´W	8	18	6%
Kent	Solon	Lat.43°13.112´N Long.85°34.306´W	12	22	27%
Lake	Peacock	Lat.44°02.816´N Long.85°50.665´W	9	19	16%
Lake	Pleasant Plains	Lat.43°50.923´N Long.85°51.109´W	9	15	20%
Leelanau	Centerville	Lat.44°54.886´N Long.85°54.886´W	9	14	7%
Leelanau	Cleveland	Lat.44°55.323´N Long.85°52.534´W	14	20	5%
Leelanau	Glen Arbor	Lat.44°52.253´N Long.86°02573´W	20	28	25%
Leelanau	Leelanau	Lat.45°09.988´N Long.85°37.257´W	7	9	33%
Leelanau	Leelanau	Lat.45°11.828´N Long.85°32.731´W	12	22	23%
Leelanau	Leland	Lat.44°59.069´N Long.85°44.207´W	16	26	12%
Leelanau	Leland	Lat.45°02.450´N Long.85°44.402´W	26	41	7%
Mackinac	Garfield	Lat.46°05.660´N Long.85°27.062´W	35	90	18%
Mackinac	Moran	Lat.45°51.477´N Long.84°47.002´W	31	92	22%
Manistee	Bear Lake	Lat.44°23.239´N Long.86°07.032´W	23	46	17%
Manistee	Norman	Lat.44°13.386´N Long.85°54.586´W	17	21	10%
Marquette	Skandia	Lat.46°23.156´N Long.87°14.439´W	49	181	25%

Table 1. (Continued)

County	Township	Location	Number of seedheads infested by *Urophora quadrifasciata* (n=50)	Number of *Urophora quadrifasciata* galls in the sample (n=50)	Percent *Urophora quadrifasciata* parasitized
Mason	Amber	Lat.43°56.023´N Long.86°20.352´W	5	44	23%
Mason	Grant	Lat.44°09.123´N Long.86°17.997´W	12	15	7%
Mason	Riverton	Lat.43°49.166´N Long.86°23.592´W	18	35	9%
Mecosta	Green	Lat.43°44.673´N Long.85°32.055´W	13	21	0%
Mecosta	Millbrook	Lat.43°29.927´N Long.85°07.497´W	12	29	14%
Mecosta	Sheridan	Lat.43°39.542´N Long.85°08.805´W	17	27	4%
Menominee	Cedarville	Lat.45°30.061´N Long.87°17.468´W	31	70	14%
Menominee	Mellen	Lat.45°17.585´N Long.87°36.917´W	28	52	15%
Menominee	Meyer	Lat.45°42.833´N Long.87°35.946´W	30	72	4%
Midland	Edenville	Lat.43°46.368´N Long.84°24.444´W	17	28	11%
Midland	Larkin	Lat.43°39.398´N Long.84°14.931´W	28	39	0%
Missaukee	Butterfield	Lat.44°20.142´N Long.84°56.681´W	11	22	5%
Missaukee	Caldwell	Lat.44°21.308´N Long.85°12.979´W	29	76	25%
Missaukee	Norwich (DKW)	Lat.44°27.109´N Long.85°04.397´W	14	21	0%
Missaukee	Norwich (SKW)	Lat.44°27.109´N Long.85°04.397´W	14	23	4%
Montcalm	Belvidere	Lat.43°25.727´N Long.85°08.957´W	16	30	7%
Montcalm	Sidney	Lat.43°19.295´N Long.85°19.295´W	17	43	5%
Montcalm	Reyolds	Lat.43°23.626´N Long.85°30.142´W	7	18	0%
Montmorency	Vienna	Lat.44°57.693´N Long.85°16.748´W	30	50	20%
Muskegon	Dalton	Lat.43°19.316´N Long.86°14.335´W	5	11	0%
Muskegon	Casnovia	Lat.43°16.705´N Long.85°49.303´W	38	19	0%
Newaygo	Ashland	Lat.43°20.374´N Long.85°48.706´W	19	40	5%
Newaygo	Barton	Lat.43°44.581´N Long.85°38.693´W	10	22	14%
Newaygo	Merril	Lat.43°40.905´N Long.85°48.780´W	12	17	24%
Oceana	Hart	Lat.43°41.294´N Long.86°23.084´W	22	44	11%
Oceana	Weare	Lat.43°45.497´N Long.86°22.901´W	19	36	28%
Ogemaw	Rose	Lat.44°25.316´N Long.84°06.715´W	24	45	24%
Ontonagon	Carp Lake	Lat.46°49.062´N Long.89°34.044´W	26	56	0%

Table 1. (Continued)

County	Township	Location	Number of seedheads infested by *Urophora quadrifasciata* (n=50)	Number of *Urophora quadrifasciata* galls in the sample (n=50)	Percent *Urophora quadrifasciata* parasitized
Ontonagon	Stannard	Lat.46º31.965´N Long.89º09.460´W	35	53	2%
Osceola	Orient	Lat.43º53.621´N Long.85º08.860´W	5	7	0%
Osceola	Sherman	Lat.44º08.763´N Long.85º25.087´W	29	63	13%
Oscoda	Comins	Lat.44º43.512´N Long.84º06.827´W	22	39	28%
Oscoda	Greenwood	Lat.44º43.491´N Long.84º16.980´W	14	26	8%
Otsego	Bagley	Lat.45º01.090´N Long.84º42.235´W	12	24	8%
Otsego	Charlton	Lat.44º58.311´N Long.84º27.350´W	23	42	14%
Otsego	Elmira (DKW)	Lat.45º05.209´N Long.84º49.001´W	29	56	39%
Otsego	Elmira (SKW)	Lat.45º05.209´N Long.84º49.001´W	28	55	20%
Ottawa	Spring Lake	Lat.43º05.656´N Long.86º12.682´W	13	25	8%
Presque Isle	Posen	Lat.45º14.510´N Long.83º41.047´W	24	52	31%
Roscommon	Lyon	Lat.44º28.526´N Long.84º47.216´W	30	64	6%
Roscommon	Roscommon	Lat.44º11.809´N Long.84º47.730´W	12	27	4%
Schoolcraft	Mueller	Lat.46º05.616´N Long.85º56.952´W	44	170	9%
Schoolcraft	Thompson	Lat.45º54.206´N Long.86º20.176´W	45	144	19%
St. Joseph	Lockport	Lat.41º58.199´N Long.85º31.792´W	0	0	0%
St. Joseph	Mendon	Lat.42º02.343´N Long.85º31.147´W	7	12	0%
Van Buren	Porter	Lat.42º08.731´N Long.85º51.183´W	12	25	60%
Wexford	Antioch	Lat.44º24.608´N Long.85º41.901´W	14	23	17%
Wexford	Cedar Creek	Lat.44º24.343´N Long.85º21.482´W	15	32	13%
Wexford	Cedar Creek	Lat.44º24.195´N Long.85º26.227´W	13	19	5%
Wexford	South Branch	Lat.44º11.064´N Long.85º48.021´W	17	32	16%

United States Department of Agriculture, Agriculture Research Service, Systematic Entomology Laboratory in Beltsville, Maryland. Dr. Grissell could not find any comparable identified specimens in the U. S. National Collection and noted that the genus *Pteromalus* is poorly known and needs to be revised. Several hyperparasites collected from the seed head samples were identified as *Macroneura vesicularis* Retzius (Hymenoptera: Eupelmidae); this wasp attacks many hosts.

DISCUSSION

Parasitoid attack on *U. quadrifasciata* in Michigan is considerable and widespread. *Pteromalus* sp. belong to the Pteromalidae family which is wide spread throughout North America. Pteromalidae are parasitic and attack a wide variety of hosts (Borror et al 1976, Gordh 1979). *Pteromalus elevatus* (Walker), an introduced parasitoid attacks many Tephritidae gall formers including *Urophora cardui* (Linnaeus) a stem galler on *Cirsium arvense*, *U. jaceana* Hering, a gall former in *Centaurea nigra* (black knapweed) flower heads and *U. stylata* (Fabricius) a gall former in *Cirsium vulgare* flower heads. *Pteromalus musaeus* (Walker) attacks *Terellia serratula* (Linnaeus), a gall inducer in *C. vulgare* flower heads and *Pteromalus caudiger* (Graham) attacks *Tephritis conura* Loew in *Cirsium heterophyllum* flower heads (Hoebeke and Wheeler 1996, Peschken and Derby 1997, Redfern et al. 1992). The *Pteromalus* sp. we found parasitizing *U. quadrifasciata* in Michigan needs further study to determine the species, origin, hosts, distribution, damage to the *U. quadrifasciata* population and if the attack will be sustained. Additional surveys in surrounding states should be conducted to determine if this is a local phenomenon or if parasitism by *Pteromalus* sp. is common in all *U. quadrifasciata*-infested areas.

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