

**ESTABLISHMENT OF *UROPHORA AFFINIS* ON SPOTTED KNAPWEED IN
PENNSYLVANIA, WITH NEW EASTERN U.S. RECORDS OF
U. QUADRIFASCIATA (DIPTERA: TEPHRITIDAE)**

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Abstract.—The Old World tephritid *Urophora affinis* (Frauenfeld) is a gall-inducing seedhead fly released in western and eastern North America for the biological control of knapweeds, *Centaurea* spp. (Asteraceae). Its establishment and spread in the West are well documented, but recoveries in the East have been few: in New York near release sites in Essex and Warren counties and at unspecified localities in Quebec and Virginia (presumably at or near release sites). *Urophora affinis* is reported as a new state record from Pennsylvania (7 counties), and its establishment in central New York State is recorded. *Urophora quadrifasciata* (Meigen), another Palearctic species introduced for knapweed control, is recorded for the first time from Maryland, Virginia, and West Virginia, and its known range in Pennsylvania is extended.

Key Words: Insecta, Tephritidae, seedhead flies, distribution, spotted knapweed, biological control

The tephritid genus *Urophora* includes about 100 species whose larvae are nearly always associated with plants of the Asteraceae. Eight species are indigenous to the Nearctic Region, and three Eurasian species—*U. affinis* (Frauenfeld), *U. quadrifasciata* (Meigen), and *U. sirunaseva* (Hering)—have been introduced to North America for the biological control of adventive knapweeds, *Centaurea* spp. (White and Korneyev 1989, Turner et al. 1994). Several members of this composite genus infest rangelands and pastures in western North America (Watson and Renney 1974, Maddox 1979, Strang et al. 1979, Harris and Myers 1984, Müller-Schärer and Schroeder 1993). The most economically important species in the West are diffuse knapweed, *C. diffusa* Lam., and spotted knapweed, *C. biebersteinii* DC. (= *C. maculosa* of Amer-

ican authors) (Harris and Myers 1984, Müller et al. 1988, Kartesz 1994). Spotted knapweed is also common in the Northeast (USDA 1971, Gleason and Cronquist 1991).

Urophora affinis and *U. quadrifasciata* are seedhead flies whose larvae feed in buds and in flower heads of their herbaceous hosts, with females of *U. affinis* ovipositing in smaller heads than those of *U. quadrifasciata*. Larvae of the two species are able to coexist in capitula of their hosts (Berube 1980, Harris 1980a, Shorthouse 1990). The mostly univoltine *U. affinis* induces a complex gall from tissues of the ovary and receptacle; the thinner, more simple gall of *U. quadrifasciata*, a predominantly bivoltine species, is restricted to tissues of the ovary wall (Shorthouse 1978a, b, 1990, Story et al. 1992). Galls of *U. af-*

finis are greater energy sinks than those of *U. quadrifasciata*, reducing seed production even in uninfested capitula (Harris 1980b, Myers and Harris 1980, Shorthouse 1990). Despite negative interaction between these biological control agents, their effects on host plants are complementary, and knapweed seed is reduced more in areas where the flies coexist (Berube 1980, Harris 1980b, Myers and Harris 1980, Harris and Myers 1984).

Following initial releases of both tephritids in British Columbia in the early 1970s, their establishment in that province and the western United States (Washington to California plus Idaho and Montana) has been well documented (Maddox 1979, 1982, Harris and Myers 1984, Story et al. 1987, Julien 1992, Foote et al. 1993, Hoebeke 1993, Müller-Schärer and Schroeder 1993). They were also released in eastern North America: *U. affinis* in Ontario (1970–1971), Quebec (1979–1980), Maryland, New York (1983), and Virginia (1985–1986); and *U. quadrifasciata* in Quebec (1979), Maryland, and New York (1983) (Harris and Myers 1984, Julien 1992, Hoebeke 1993). Postrelease monitoring in the East, however, has been less thorough than in western North America. Not until the early 1990s was the eastern establishment of either species reported. Based on surveys during 1990 to 1992 (Hoebeke 1993), *U. quadrifasciata* was found to be widespread from New England (Connecticut, Massachusetts, New Hampshire, Rhode Island, and Vermont) south to New York, New Jersey, and Pennsylvania. No specimens of *U. affinis*, however, were collected from *Centaurea* spp. during surveys for *U. quadrifasciata* in the Northeast, although recoveries had been reported at release sites in Essex and Warren counties, N.Y., in 1985 (Foote et al. 1993, Hoebeke 1993). The only other eastern records of *U. affinis* are Quebec and Virginia, cited without specific localities by Julien (1992).

Here we give the first records of *U. affinis* from Pennsylvania, document its es-

tablishment in central New York, and speculate on the origin of these populations. We also provide the first records of *U. quadrifasciata* from Maryland, Virginia, and West Virginia, and extend its previously recorded distribution in Pennsylvania.

METHODS

Urophora affinis.—The first Pennsylvania specimens were collected at Tamaqua (Schuylkill Co.), Pa., on 23 June 1994. In late June we began surveying spotted knapweed colonies observed within 50–60 km of the detection site in an attempt to delimit the fly's distribution in eastern Pennsylvania. Capitula of knapweed growing on shaly roadside banks, in road maintenance or construction spoils, along railroad rights-of-way, in urban vacant lots, and in other disturbed sites were swept with a standard insect net. The number of sweeps varied with colony size but usually consisted of at least several hundred. Any *U. affinis* adults observed were collected for laboratory verification of tentative field identifications. Our surveys apparently were initiated before adult populations had begun to decline, based on the presence of greater numbers of males than females, or at least about equal numbers of both sexes; males tend to emerge earlier (Story and Anderson 1978). Surveys continued until late August, although no adults were seen after mid-July. Similar, but less extensive, sampling of knapweed was conducted in 1994 in north-central Pennsylvania (A.G.W., C.A.S.) and in central and south-central New York (E. R. Hoebeke, A.G.W.). In 1995, additional delimiting surveys were made in eastern Pennsylvania (A.G.W.).

Urophora quadrifasciata.—Spotted knapweed was sampled during 1994–1995 in portions of Maryland, Virginia, and West Virginia—states from which this tephritid's establishment had not been previously recorded. Limited sampling was also conducted in several western Pennsylvania counties where this species had not been found in earlier surveys (Hoebeke 1993).

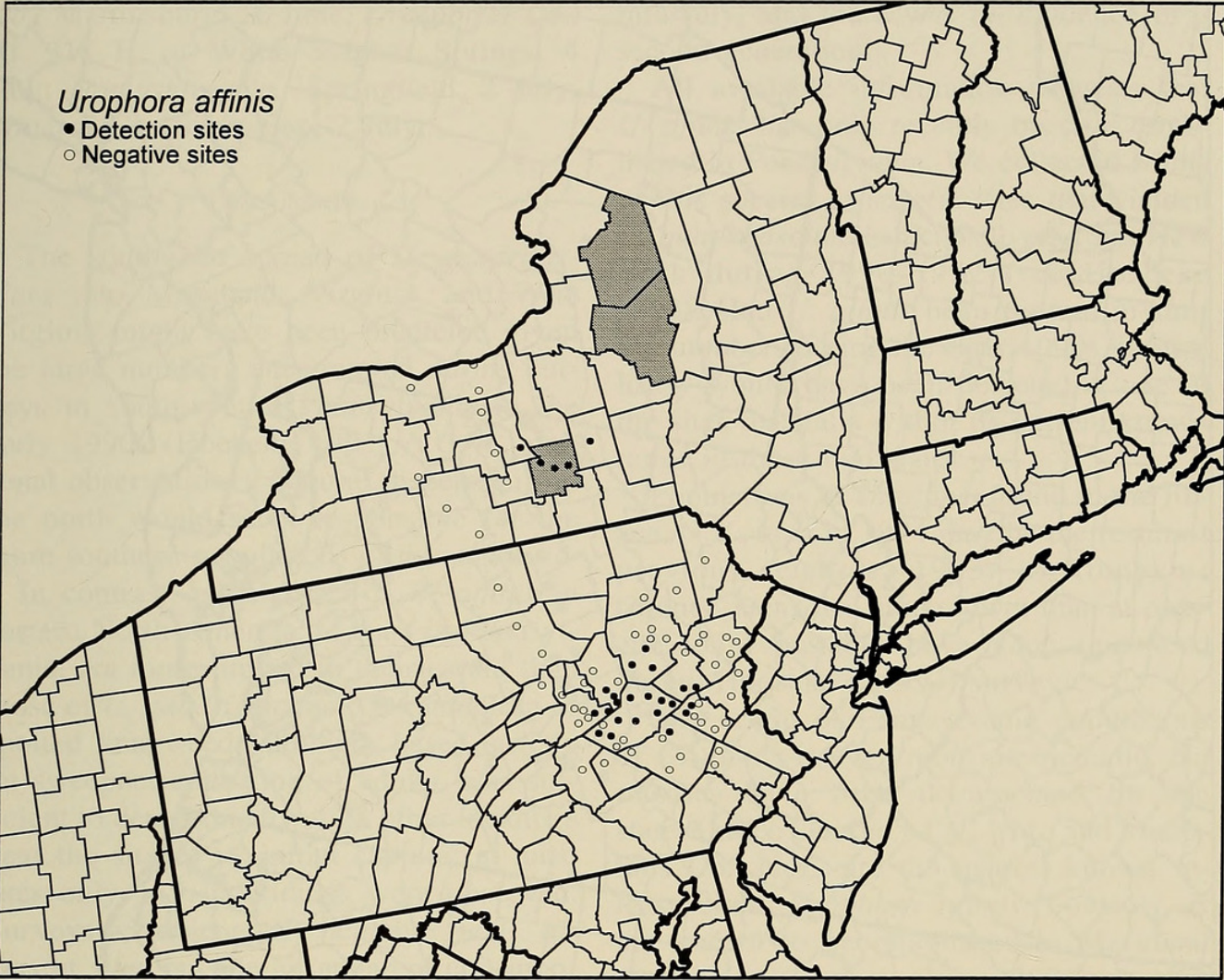


Fig. 1. Known distribution of *Urophora affinis* in New York and Pennsylvania. Shading indicates counties in which biological control releases were made; release sites in eastern Canada, Maryland, and Virginia are not shown.

Voucher specimens of both species have been deposited in the Cornell University Insect Collection, Ithaca, NY (CUIC) and Pennsylvania Department of Agriculture Insect Collection (PADA); specimens of *U. affinis* have been deposited at the National Museum of Natural History, Washington, DC (USNM).

RESULTS

Urophora affinis.—The following records, representing the first for Pennsylvania and first for New York except recoveries at release sites in the Adirondacks, extend the known distribution of *U. affinis* in eastern North America (Fig. 1). All Pennsylvania collections were made by the authors in 1994 (except Northumberland Co.,

1995) from *Centaurea biebersteinii*. New York collections were made in 1994 by E. R. Hoebeke from the same plant species.

NEW YORK: *Cortland Co.*, Cortlandville, 2 July; *Seneca Co.*, 1 mi. N. of Interlaken, 3 July; *Tompkins Co.*, Dryden, Ithaca, and Taughannock Falls State Park, 2–4 July. PENNSYLVANIA: *Berks Co.*, Hamburg, 5 July; *Carbon Co.*, Bowmantown, 11 July; Jim Thorpe, 23 June; *Columbia Co.*, Aristes, Centralia, and 6 mi. S. of Numidia, 1 July; *Lehigh Co.*, Jacksonville, New Tripoli, 5 July; *Luzerne Co.*, Rt. 81 nr. Dorrance exit, 30 June; Hazleton, 23 June; Nescopeck, 27 June; *Northumberland Co.*, Coal Twp. N. of Shamokin, 13 June; Mount Carmel, 6 July; *Schuylkill Co.*, NE. of Barnesville, 30 June; Frackville, 23 June;

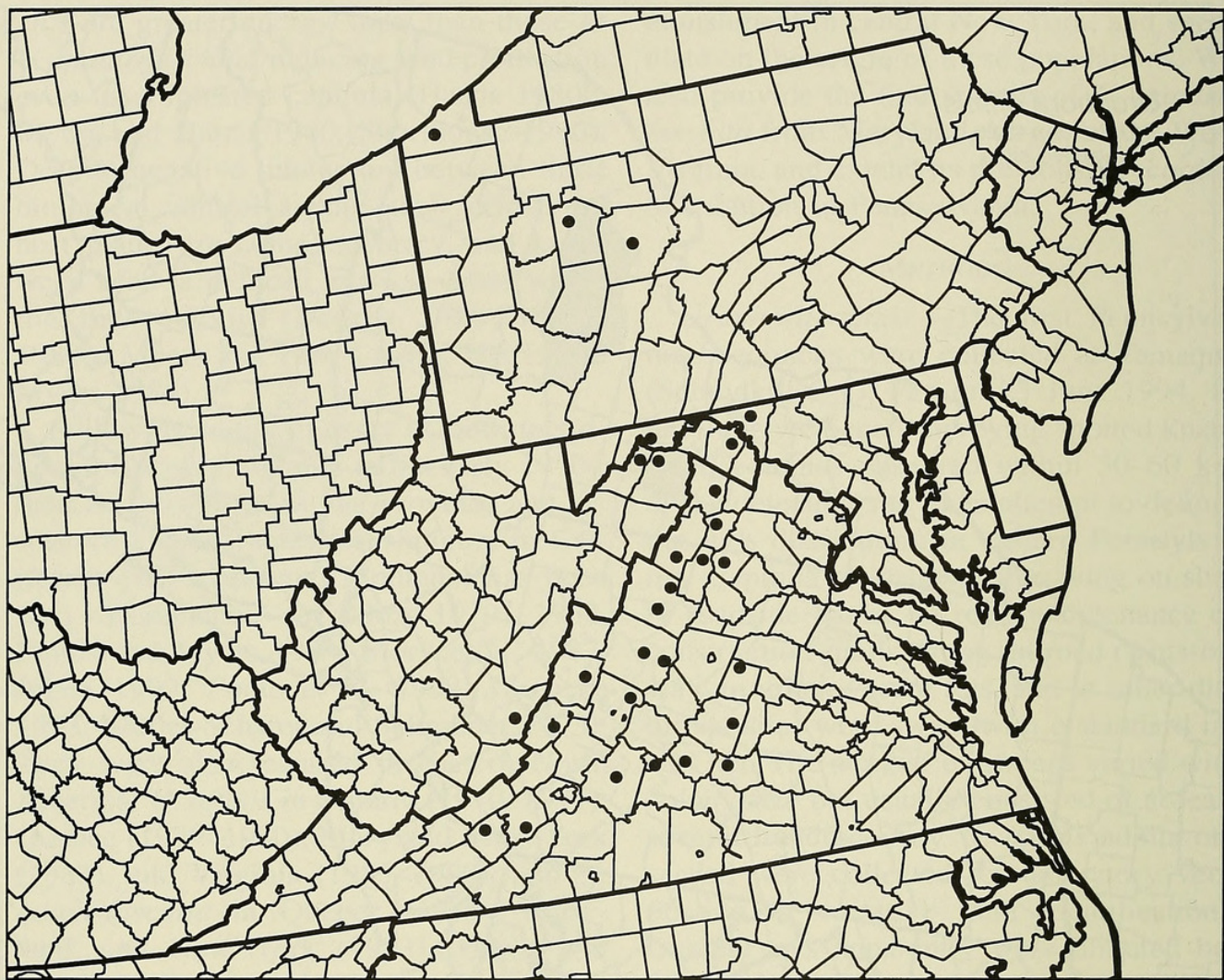


Fig. 2. New records of *Urophora quadrifasciata* in eastern United States.

Hegins, 29 June; Llewellyn, 7 July; N. of Mahanoy City, 27 June; New Ringgold, 5 July; Pottsville, 7 July; Tamaqua, 23 June, 7 July; Rt. 209 N. of Tamaqua, 23 June; Tremont, 7 July.

Urophora quadrifasciata.—The known eastern distribution is extended to include Maryland, Virginia, and West Virginia, as well as additional counties in western Pennsylvania (Fig. 2). All collections were made in 1994–1995 by A.G.W. from *C. biebersteinii*.

MARYLAND: *Allegany Co.*, Oldtown, 2 July; *Washington Co.*, Hagerstown, 26 June; Hancock, 2 July. PENNSYLVANIA: *Clearfield Co.*, Rt. 879 NE. of Clearfield, 12 July; *Erie Co.*, Rt. 832 nr. junc. Rt. 90, SW. of Erie, 13 July; *Jefferson Co.*, Brookville, 12 July. VIRGINIA: *Alleghany Co.*,

Covington, 26 June; *Appomattox Co.*, Rt. 460, Spout Springs, 3 July; *Augusta Co.*, Staunton, 25 June; Waynesboro, 3 July; *Bath Co.*, Rt. 39 E. of Millboro Springs, 3 July; *Bedford Co.*, Bedford, 3 July; *Buckingham Co.*, Sprouses Corner, 4 July; *Campbell Co.*, Lynchburg, 3 July; *Fluvanna Co.*, SW. of Zion X-Roads, 4 July; *Frederick Co.*, Winchester, 26 June; *Montgomery Co.*, Christiansburg, 26 Aug.; *Page Co.*, Luray, 7 Aug.; *Prince Edward Co.*, nr. Prospect, 3 July; *Pulaski Co.*, Dublin, 3 July; *Rappahannock Co.*, Rt. 211 nr. Thornton Gap and Page Co. line, 7 Aug.; *Rockbridge Co.*, Fairfield, 3 July; *Rockingham Co.*, Broadway, 25 June; Harrisonburg, 4 July; *Shenandoah Co.*, Mount Jackson, 26 June; *Warren Co.*, Rt. 55, 3 mi. E. of Strasburg, 7 Aug. WEST VIRGINIA: *Berkeley*

Co., Martinsburg, 26 June; *Greenbrier Co.*, Rt. 311 E. of White Sulphur Springs, 4 July; *Hampshire Co.*, Springfield, 2 July; *Mineral Co.*, Short Gap, 2 July.

DISCUSSION

The southward spread of *U. quadrifasciata* into Maryland, Virginia, and West Virginia might have been predicted given the large numbers encountered during surveys in south-central Pennsylvania in the early 1990s (Hoebeke 1993, A.G.W., personal observations). Natural dispersal from the north would seem responsible for the more southern populations of this tephritid.

In contrast, populations of *U. affinis* in eastern North America, at least in Pennsylvania, are more limited in their extent than those of *U. quadrifasciata*. Our sampling of spotted knapweed, although based strictly on sweepnet collecting of adults, was sufficient to detect this fly at 22 other localities near the site of its initial capture; at most sites only 1–5 individuals were observed. Surveys were generally negative for *U. affinis* at sites outside an apparent core population centered in Schuylkill Co. (Fig. 1), even though the size of knapweed colonies and sampling intensity were equivalent. Negative localities are shown in Fig. 1 only if there seemed to be a reasonable chance of collecting adults (until about mid-July). We also failed to detect populations in northern Pennsylvania and south-central New York, as well as in Maryland, Virginia, and West Virginia.

Densities of *U. affinis* adults in Pennsylvania were not assessed, but field estimates indicated that at least during late June to mid-July they were typically outnumbered 10–20:1 by *U. quadrifasciata*. Only at Pottsville on 7 July 1994 was *U. affinis* dominant: about 100 adults vs 4–5 of *U. quadrifasciata*; by late July the latter species was abundant and no *U. affinis* were found. Tamaqua was the only other site at which more than 10 *U. affinis* adults were observed. No *U. affinis* were seen after

mid-July, and there was no evidence of a second generation.

All available information suggests that *U. affinis* has only recently become established in Pennsylvania. We collected adults of this species at several sites that yielded *U. quadrifasciata* in Pennsylvania and New York during 1990–1992 (see Hoebeke 1993). Had *U. affinis* been present in similar numbers during the early 1990s, it most likely would have been detected at one of the sites that falls within its current known range in those two states.

Populations of *U. affinis* found in the Ithaca, N.Y., area in 1994 may be the result of previous releases (1983) in Tompkins County. Densities much lower than at present could possibly have gone unnoticed during Hoebeke's (1993) surveys.

The origin of Pennsylvania populations of *U. affinis* is even more problematic. No releases have been documented for the state; Prince George's Co., Md., and Tompkins Co., N.Y., are the nearest known release sites. *Urophora affinis*, however, is not known to be established in Maryland (P. W. Tipping, pers. comm. 1994), and we did not find it in that state in 1994 during limited sampling of spotted knapweed in Allegany and Washington counties. If populations in eastern Pennsylvania are the result of natural dispersal from central New York, the fly could be expected to occur in the intervening area. It was not, however, found immediately north and northwest of Schuylkill Co., Pa.; nor was it detected at various other sites in New York and Pennsylvania (Fig. 1).

Urophora affinis (and *U. quadrifasciata*) can be purchased from suppliers of biological control agents, but because there is little interest in controlling spotted knapweed in the East (N. Poritz, pers. comm. 1994), the possibility of this tephritid's establishment from releases by private citizens or local governments seems unlikely. Other alternatives are long-distance aerial transport, either active or passive, from established populations in New York or Virginia, or

through the accidental introduction of infested knapweeds via commerce.

Regardless of their origin, the eastern North American populations of *U. affinis* provide an additional opportunity to evaluate long-term interactions with *U. quadrifasciata*. In the West, the latter biocontrol agent initially spread more rapidly, colonizing even remote knapweed stands (Harris 1980a, Harris and Myers 1984, Story et al. 1987, Story et al. 1992). But *U. affinis* proved the more persistent of the two species and has generally become dominant at sites where they co-occur. This is also the case in Europe (Berube 1980, Story et al. 1992).

Urophora quadrifasciata disperses more readily than *U. affinis* (but does not show greater flight propensity or endurance in laboratory studies [Roitberg 1988]) and has potential for more rapid population increase. These advantages tend to be offset by the lack of unopened inflorescences available in late summer. In contrast, the univoltine *U. affinis* emerges when flower buds of its hosts are abundant, and it consequently has less pressure to disperse. Its attacks on knapweed retard further development of capitula, placing the mainly bivoltine, later-emerging *U. quadrifasciata* at a competitive disadvantage (Berube 1980, Harris and Myers 1984, Story et al. 1992).

These seedhead flies by themselves cannot be expected to reduce host plant densities in the East. They have not done so in western North America (Harris and Cranston 1979, Harris 1980a, Maddox 1982, Story et al. 1989), and a "cumulative stress" approach combining biological control with other management techniques will be needed to achieve successful control (Müller-Schärer and Schroeder 1993). Nevertheless, these tephritids should be considered beneficial in the East, their combined attacks on spotted knapweed likely resulting in reduced seed production similar to that documented in the West (Harris 1980a, 1984; Harris and Myers 1984). Their populations should be monitored to determine

whether *U. affinis* becomes the dominant tephritid species in most eastern knapweed stands.

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