16 SWALLOW-WORTS

L. Tewksbury,[1] R. Casagrande,[1] and A. Gassmann[2]

[1]Department of Plant Sciences, University of Rhode Island, Kingston, Rhode Island, USA
[2]CABI Bioscience Centre Switzerland, Delémont, Switzerland

PEST STATUS OF WEED

There are three European species of swallow-worts found in North America: *Vincetoxicum nigrum* (L.) Moench (black swallow-wort), *Vincetoxicum rossicum* (Kleo.) Barb. (pale swallow-wort or dog strangling-vine), and *Vincetoxicum hirundinaria* Medik. (white swallow-wort) (Sheeley and Raynal, 1996). Swallow-worts are in the family Asclepiadaceae. *Vincetoxicum nigrum* and *V. rossicum* now are naturalized in northeastern North America, and both are invasive in natural areas and abandoned pastures (Lawlor, 2000). Swallow-worts are found in gardens and fields, along fencerows, roadways, grassy slopes, wooded edges, and streambanks. Tangled masses of swallow-wort vines shade and suppress native plants (Sheeley and Raynal, 1996). In Rhode Island, heavy growth of *V. nigrum* reduces the effectiveness of electric fences around pastures (Minto, pers. comm.). Loss of native plant species reduces habitat value for wildlife (Christensen, 1998). *Vincetoxicum hirundinaria* occurs sparsely in the northeast (Gleason and Cronquist, 1963), and Sheeley and Raynal (1996) suggest that this species is not well established in North America.

Nature of Damage

In central New York, *V. rossicum* forms dense monospecific stands in shrubby areas with a history of disturbance, and in the understory of successional woodlands (Lawlor, 2000). Near Windsor, Vermont, Lawlor (2000) observed *V. nigrum* out competing a population of a federally endangered endemic species, Jesup's milkvetch, *Astragalus robbinsii* (Oakes) Gray var. *jesupii* Egglest. and Sheldon. She also observed that *V. rossicum* is overgrowing the federally listed Hart's tongue fern, *Phyllitis scolopendrium* (L.) Newman at Split Rock, near Onadaga, New York. *Vincetoxicum rossicum* is threatening the only New England population of *Asclepias viridiflora* Raf. in Connecticut, an endangered species in that state (Mehrhoff, pers. comm.).

Loss of native plant species may reduce biodiversity and delay or redirect succession (Lawlor, 2000), as well as reduce the value of habitat to wildlife (Christensen, 1998). Cows and sheep in pastures will eat swallow-worts, and control their growth, but swallow-worts spread rapidly in abandoned pastures in New York (Lawlor, 2000) and Rhode Island (Casagrande, unpubl.). Swallow-worts are important weeds requiring management in tree plantations in New York (Lawlor, 2000), and in Rhode Island nurseries (Casagrande, unpubl.).

Current control measures have not been adequate to alleviate harmful effects of swallow-worts. Lawlor (2000) evaluated a number of control techniques used against *V. rossicum*. Her recommendations include mowing or hand pulling just as pods are beginning to form to minimize seed production. For herbicidal control, repeated applications are necessary. Christensen (1998) conducted experiments in Ontario to evaluate the effectiveness of herbicide control techniques for *V. rossicum*. Two applications of glyphosate were necessary (in mid-June and early August) to achieve greater than 90% reduction of *V. rossicum*. Following treatment with herbicide, another invasive plant, *Melilotus alba* Medicus (sweet white clover), replaced *V. rossicum* as the dominant plant. Repeated mowing is not successful in reducing the amount of cover of *V. rossicum* (Kirk, 1985).

Geographical Distribution

Gray (1868) first reported *Vincetoxicum nigrum* as escaping from gardens in Cambridge, Massachusetts. According to Pringle (1973), Scoggan (1979), and Sheeley and Raynal (1996), the distribution of *V. nigrum* currently extends west from the Atlantic coast to southeastern Ontario and south to southern Penn-

sylvania and Missouri. There is a record of *V. nigrum* from California in the USDA PLANTS Database (Fig. 1). Swallow-worts are commonly found in pastures and natural sites in these areas.

Vincetoxicum rossicum is distributed from the Atlantic coast west to southern Michigan and northern Indiana, and from southern Ontario, Canada, south through southern Pennsylvania (Pringle, 1973; Scoggan, 1979; Sheeley and Raynal, 1996) (Fig. 2). Moore (1959) reported that *Cynanchum medium* had been collected frequently since 1889 in Ontario, Canada. *Cynanchum medium* is a synonym of *V. rossicum* (Sheeley and Raynal, 1996). Collections of *V. rossicum* have come primarily from roadsides and wild areas (Sheeley and Raynal, 1996).

Vincetoxicum hirundinaria was first recorded in North America in Gray's Manual (Robinson and Fernald, 1908) as *Cynanchum vincetoxicum*. There are records of *V. hirundinaria* from New York, Michigan, and Montreal. The USDA PLANTS Database has only the New York record for the United States (Fig. 3). However, there are no reports of well-established populations of *V. hirundinaria* in North America (Sheeley and Raynal, 1996).

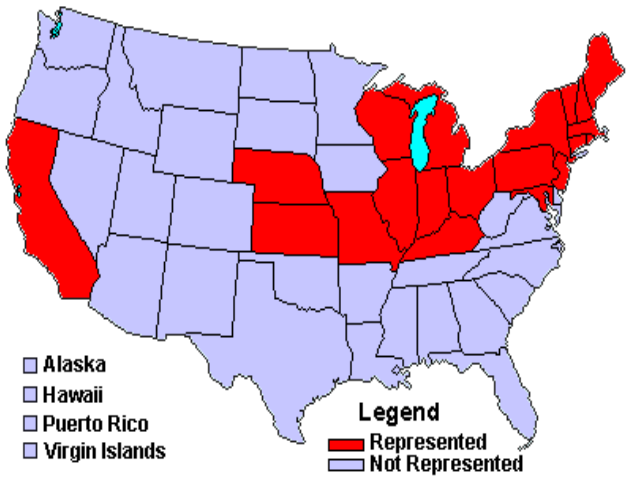

Figure 1. Distribution of *Vincetoxicum nigrum* in the United States. (USDA PLANTS Database.)

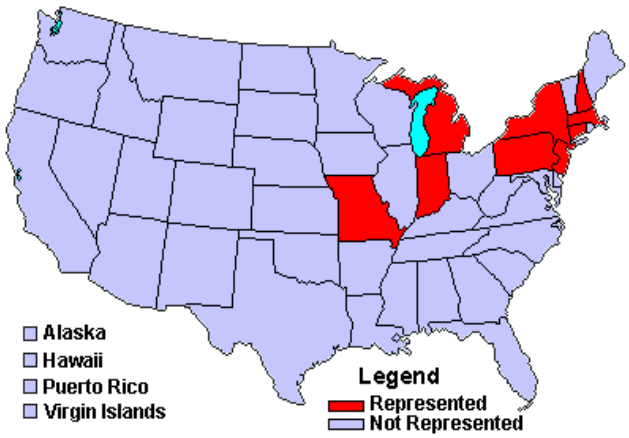

Figure 2. Distribution of *Vincetoxicum rossicum* in the United States. (USDA PLANTS Database.)

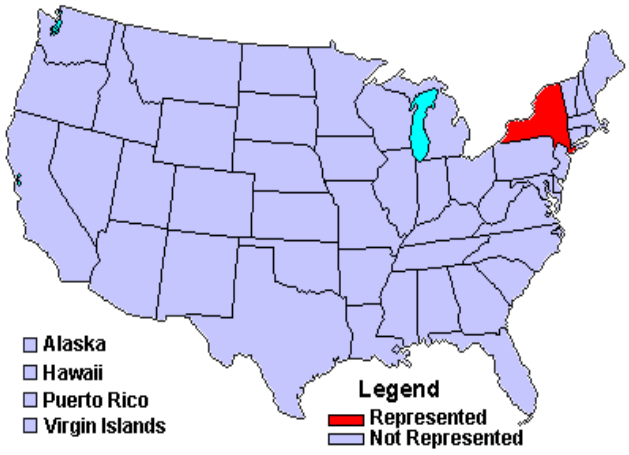

Figure 3. Distribution of *Vincetoxicum hirundinaria* in the United States. (USDA PLANTS Database.)

BACKGROUND INFORMATION ON PEST PLANT

Taxonomy

Swallow-worts are members of the family Asclepiadaceae**.** The generic placement of the European and North American swallow-wort species is dynamic. The generic names *Cynanchum* and *Vincetoxicum* have been applied in North American and European literature. Black swallow-wort has been known as *Cynanchum nigrum* (L.) Pers. or *Vincetoxicum nigrum* (L.) Moench. (Kartesz and Gandhi, 1991). We use the scientific nomenclature of Sheeley and Raynal (1996) for the three swallow-wort species introduced into North America: *Vincetoxicum nigrum*, *Vincetoxicum rossicum*, and *Vincetoxicum hirundinaria*. Recent molecular evidence indicates that both *Vincetoxicum* and *Cynanchum* are valid genera and that the European species presently in the northeastern United States are all in the genus *Vincetoxicum* (W. D. Stevens, pers. comm.). These are apparently the only three species of *Vincetoxicum* present in North America. In Europe, there are 18 native species of *Vincetoxicum* (with

nine subspecies of *V. hirundinaria*) and one native species of *Cynanchum* (*C. acutum* L.) (Heywood, 1972) (Table 1).

Biology

Swallow-worts are herbaceous perennials in the family Asclepiadaceae that grow into twining vines (Fig. 4). In one season a vine can grow 1 to 2 m. In New York, flowering begins in late May, peaks in mid-June and ends in mid-July (Lumer and Yost, 1995). Flowers (Fig. 5), which have the scent of rotting fruit, each remain open for six to eight days. The fruit pods (Fig. 6) release seeds from mid-August to early October (Lumer and Yost, 1995). *Vincetoxicum nigrum* spreads clonally from deep rhizomes (Lumer and Yost, 1995). *Vincetoxicum rossicum* moves into new

Table 1. Native *Cynanchum* and *Vincetoxicum* Species in Europe (Heywood, 1972)

Species	Native	Main Countries / Area
Cynanchum acutum L.	Yes	Albania, Bulgaria, France, Greece, Italy, Romania, Portugal, Spain, Yugoslavia, S. Russia
Vincetoxicum canescens (Willd.) Decne	No (from S.W. Asia)	Greece
V. fuscatum (Hornem.) Reichenb.	Yes	Albania, Bulgaria, Greece, Yugoslavia, S. and E. Russia, Turkey
V. hirundinaria subsp. *adriaticum* (G. Beck) Markgraf	Yes	N. W. Yugoslavia
V. hirundinaria subsp. *contiguum* (Koch) Markgraf	Yes	W. Yugoslavia
V. hirundinaria subsp. *hirundinaria*	Yes	All Europe except Portugal and Spain
V. hirundinaria subsp. *intermedium* (Loret and Barr.) Markgraf	Yes	S. France, N. E. Spain
V. hirundinaria subsp. *jailicola* (Juz.) Markgraf	Yes	S. Ukraine
V. hirundinaria subsp. *lusitanicum* Markgraf	Yes	N. W. Portugal, N. Spain
V. hirundinaria subsp. *nivale* (Boiss. and Heldr.) Markgraf	Yes	Balkan
V. hirundinaria subsp. *stepposum* (Pobed.) Markgraf	Yes	C. and S. Russia, Ukraine
V. huteri Vis. and Ascherson	Yes	Albania, Yugoslavia
V. juzepczukii (Pobed.) Privalova	Yes	S. Ukraine
V. nigrum (L.) Moench	Yes	France, Italy, Portugal, Spain
V. pannonicum (Borhidi) J. Holub	Yes	Hungary
V. rossicum (Kleopow) Barbarich	Yes	Ukraine, S. E. Russia
V. scandens Sommier and Levier	Yes	S. and E. Ukraine, S. Russia
V. schmalhausennii (Kusn.) Markgraf	Yes	S. Ukraine
V. speciosum Boiss. and Spruner	Yes	Albania, Bulgaria, Greece, Yugoslavia, Turkey
V. vincetoxicum subsp. *cretaceum* (Pobed.) Markgraf	Yes	S. E. Russia, S. and E. Ukraine

Figure 4. *Vincetoxicum nigrum* vine on pasture fence. (Photograph by H. Faubert.)

Figure 5. *Vincetoxicum nigrum* flower. (Photograph by R. A. Casagrande.)

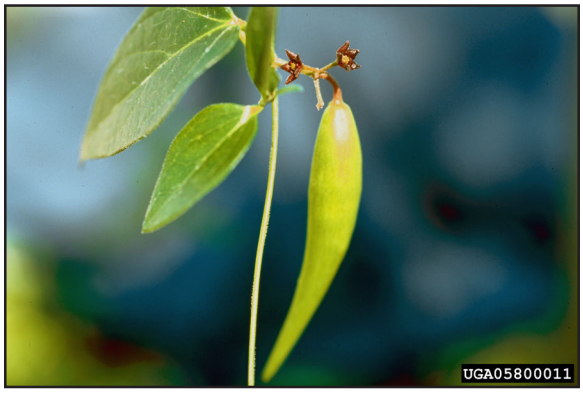

Figure 6. *Vincetoxicum nigrum* seed pod. (Photograph by R. A. Casagrande.)

sites by seed (Christensen, 1998). Like other members of the family Asclepiadaceae, these species have parachute-lifted seeds that are carried by wind. *Vincetoxicum rossicum* is very successful in areas of shallow soil over limestone bedrock (Lawlor, 2000). Swallow-worts growing in shaded areas have thinner stems and tendrils; larger, darker, thinner leaves; fewer roots; and fewer, paler flowers than plants growing in sunny areas (Christensen, 1998).

Analysis of Related Native Plants in the Eastern United States

There are no native species in the genus *Vincetoxicum* in North America. There are fourteen species of native plants listed in the genus *Cynanchum* in the United States (The Biota of North America Program, 2001) (Table 2). Most have a very limited distribution; nine of the fourteen have been recorded in only one state. One species, *Cynanchum laeve* (Michx.) Pers., is found in 26 states. The family Asclepiadaceae in North America includes more than 80 species of milkweeds, in the genus *Asclepias* (USDA, NCRS, 1999). *Asclepias syriaca* L., common milkweed, is a preferred food source for larvae of the monarch butterfly (*Danaus plexippus* L.) (Hartzler and Buhler, 2000).

Haribal and Renwick (1998) found that female monarch butterflies (Fig. 7) oviposit on black swallow-wort (*V. nigrum*) in choice tests in the laboratory; however, resulting larvae were not able to complete development on this plant. Dacey and Casagrande (pers. obs.) found that monarchs readily oviposit on *V. nigrum* in the laboratory and in large cages in the field. In both cases, when monarchs were given a choice of ovipositing on common milkweed (*A. syriaca*) or black swallow-wort, they laid approximately 25% of their eggs on the swallow-wort, and all of the resulting larvae died. Dacey and Casagrande (pers. obs.) found eggshells as evidence of monarch oviposition on black swallow-wort in uncaged field populations of swallow-wort and milkweed.

It is not clear what impact *V. nigrum* may be having on populations of monarch butterflies in nature. Haribal and Renwick (1998) note that in some locations in the United States, *V. nigrum* has replaced much of the native vegetation, including the *Asclepias*

Table 2. Native *Cynanchum* Species in North America

Species	Common Name	States
Cynanchum angustifolium Pers.	Gulf Coast swallow-wort	AL, FL, GA, LA, MS, NC, SC, TX
C. arizonicum (Gray) Shinners	Arizona swallow-wort	AZ, NM
C. barbigerum (Scheele) Shinners	Bearded swallow-wort	TX
C. blodgettii (Gray) Shinners	Blodgett's swallow-wort	FL
C. laeve (Michx.) Pers.	Honeyvine	AL, AR, DE, FL, GA, IA, ID, IL, IN, KS, KY, LA, MD, MI, MS, NC, NE, NY, OH, OK, PA, SC, TN, TX, VA, WV
C. ligulatum (Benth.) Woods.	Mexican swallow-wort	AZ
C. maccartii Shinners	Maccart's swallow-wort	TX
C. northropiae (Schlechter) Alain	Fragrant swallow-wort	FL
C. pringlei (Gray) Henrickson	Pringle's swallow-wort	TX
C. racemosum (Jacq.) Jacq.	Talayote	TX
C. racemosum var. *unifarium* (Scheele) E. Sundell		TX
C. scoparium Nutt.	Leafless swallow-wort	FL, GA, MS, SC
C. utahense (Engelm.) Woods	Utah swallow-wort	AZ, CA, NV, UT
C. wigginsii Shinners	Wiggins' swallow-wort	AZ

spp., hosts for monarch butterfly larvae. Milkweeds are used as host plants by at least eight other native North American insects (Arnett, 1985; Palmer, 1985; McCauley, 1991). There is no literature on whether these native insects are able to successfully use *Vincetoxicum* species as host plants or whether, as with monarchs, they are threatened by these invasive plants.

Figue 7. Monarch butterfly (*Danaus plexippus* L.). (Photograph by J. Dacey.)

HISTORY OF BIOLOGICAL CONTROL EFFORTS IN THE EASTERN UNITED STATES

Area of Origin of Weed

Vincetoxicum nigrum is native to southwestern Europe; *V. rossicum* is found in the Ukraine and southeast Russia; and *V. hirundinaria* is distributed throughout Europe (Heywood, 1972).

Areas Surveyed for Natural Enemies in North America

Only one insect, the tarnished plant bug (*Lygus lineolaris* [Palisot de Beauvois]), has been reported feeding on *Vincetoxicum* species in North America (Lawlor, 2000), but damage was minimal. Sheeley (1992) noted the lack of herbivores and pathogens in swallow-wort stands in upstate New York. Christensen (1998) also found no evidence of herbivory or disease in swallow-worts in Ontario. Christensen suggests that the toxic substances in swal-

low-worts repel herbivorous insects. It appears that none of the natural enemies known to be associated with swallow-wort in Europe have been accidentally established in North America.

Natural Enemies Found in Europe

There are several potential biological control agents associated with *V. hirundinaria* in Europe. In western and central Europe, two chrysomelids, *Chrysochus asclepiadeus* Pallas and *Chrysomela aurichalcea* ssp. *bohemica* Mann, are reported as specialists on *V. hirundinaria* (Mohr, 1966; Dobler *et al.*, 1998). The Russian literature indicates that there are several other species of chrysomelid beetles that feed on *Vincetoxicum* species in Russia and central Asia (Izhevski, pers. comm.). Five other species of specialist insects herbivorous on *V. hirundinaria* have been reported in Europe: the noctuid moth *Abrostola asclepiadis* (Denis and Schiff.) (Forare, 1995); two gall midges, *Contarinia vincetoxici* Kieffer and *Contarinia asclepiadis* (Giraud), which feed, respectively, on the flowerbuds and the pods of *V. hirundinaria* (Buhr, 1965); and two other seed-feeding species, the tephritid fly *Euphranta connexa* (Fabricius) (Solbreck and Sillen-Tullberg, 1986) and the lygaeid bug *Lygaeus equestris* (L.) (Kugelberg, 1977; Solberg and Sillén-Tullberg 1990). One weevil, *Otiorhynchus pinastri* Herbst, is believed to be monophagous on *V. hirundinaria* in Europe (Dieckmann, 1980; Kippenberg, 1981). The insect fauna of *V. nigrum* and *V. rossicum* in Eastern Europe and in Russia is confounded by the plant synonymy at both the specific and generic level. The potential for finding herbivores of swallow-worts seems great given the number of *Vincetoxicum* species recorded in Eurasia.

Two pathogens of *Vincetoxicum* spp. are recorded in the literature; *Peridermium pini* (Pers.) Lev., a stem rust that alternates between pine and other plants such as *Vincetoxicum* spp. and *Paeonia* spp. (Gibbs *et al.,* 1988), and *Cronartium asclepiadeum* (Willdenau) Fries (Gaumann, 1959).

BIOLOGY AND ECOLOGY OF KEY NATURAL ENEMIES

Little is known on the biology and ecology of natural enemies of swallow-worts. Some information is available on the following species.

Abrostola asclepiadis Schiff. (Lepidoptera: Noctuidae)

In Finland, Sweden, and Denmark, the larva of the noctuid moth *A. asclepiadis* is monophagous on *V. hirundinaria* (Forare, 1995). Adults fly in June and July. Development from egg to pupa takes about six weeks, leaving time for only one generation per year in Sweden. Further south in Europe, more than one generation occurs (Forare, 1995). Female moths can lay at least 255 eggs on the undersurface of *V. hirundinaria* leaves. Small shaded patches of host plants receive higher egg densities than large exposed ones (Forare, 1995). First and second instar larvae feed day and night, moving very little from where the eggs were deposited. Larger larvae are nocturnal and actively search for foliage, feeding mainly at the top of plants. Larvae complete development in August or September and pupate in the soil.

Generalist predators and parasitoids cause most of the mortality of *A. asclepiadis* eggs in Scandinavia. Ants are the primary generalist predators, but chrysopid larvae, anthocorid bugs, and mites also have been observed feeding on *A. asclepiadis* eggs (Forare, 1995). Species of *Trichogramma* (Trichogrammatidae) and *Telenomus* (Scelionidae) parasitize *A. asclepiadis* eggs. First and second instars are attacked by the same predators as the eggs. Ants and predaceous pentatomid bugs attack larger larvae. Egg and larval predation are important in reducing the population size of *A. asclepiadis* (Forare, 1995). This is the primary reason why this insect has very little effect on its host plant population, although occasionally there are small outbreaks of the species, which may cause local defoliation (Forare, 1995).

Euphranta connexa (Fabr.) (Diptera: Tephritidae)

Larvae of the fly, *Euphranta connexa,* feed on the seeds within the developing pods of *V. hirundinaria,* attacking 50 to 100% of the pods. Pods attacked by *E. connexa* usually have most seeds destroyed and even undamaged seeds are more susceptible to fungal pathogens. *Euphranta connexa* is monophagous on *V. hirundinaria* and only has one generation per year. The polyphagous ichneumonid *Scambus brevicornis* (Gravenhorst) parasitizes *E. connexa* in Sweden, but does not appear to regulate its density (Solbreck and Sillen-Tullberg, 1986).

Lygaeus equestris (L.) (Heteroptera: Lygaeidae)

Lygaeus equestris is a seed-feeding bug that feeds on a number of plant species, but prefers *V. hirundinaria*. Both nymphs and adults of *L. equestris* feed on seeds of *V. hirundinaria*. *Lygaeus equestris* adults hibernate in crevices in rock walls and buildings from late August through late April or May (Solbreck and Sillén-Tullberg, 1990). In Sweden, it appears to have no serious natural enemies. Weather conditions and food resources limit the populations of *L. equestris* (Kugelberg, 1977).

Natural Enemies Subjected to Host Range Tests

No natural enemies of *Vincetoxicum* species have been subjected to host range screening.

Releases Made

No natural enemies of *Vincetoxicum* species have been released in North America.

RECOMMENDATIONS FOR FUTURE WORK

It is commonly recognized that invasive non-indigenous plants can displace native plants, sometimes also affecting populations of native animals that use these plants for food or shelter. Swallow-worts, which often grow as vines on other plants, are very effective competitors, often warranting control measures on this basis alone. Black swallow-wort is apparently unusual, however, in effectively serving as a sink for monarch butterfly eggs. These important native insects are stimulated to oviposit on swallow-wort, but larvae cannot survive. It is not known how many other native North American insects might also unsuccessfully (or successfully) use this new plant as a host. Laboratory and field cage studies, followed by field surveys in eastern United States, are needed to determine if this plant has the potential to harm populations of other native insects in addition to the monarch butterfly. Such research would also provide information on the effects of native insects on swallow-worts.

European research will lead to a better understanding of the potential for classical biological control of swallow-worts in North America. Swallow-worts are not considered weeds in Europe, presumably because of the complex of insects that feed upon them. There is a high probability that European herbivores can be found with the genus-level host specificity that would be required for consideration for North American introduction. European research will involve detailed literature and herbarium survey for distribution and taxonomy of *Vincetoxicum* herbivore records. Surveys for insects herbivorous on *Vincetoxicum* species should be conducted in western Europe, the Balkans, and southern Russia. All natural enemies found should be identified and evaluated. Once promising natural enemies are identified, biological studies and preliminary host range testing with critical North American Asclepiadaceae species will be needed. Host use evolution has been shown in the *Chrysochus* milkweed beetles in behavioral studies and population genetics (Dobler and Farrell, 1999). Parallel studies could be applied to the chrysomelids and other natural enemies associated with *Vincetoxicum* in Europe.

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