

Reprinted from: *Leafy Spurge, Monograph series of the Weed Science Society of America*. ed. Alan K. Watson, 1985. Chapter 2 (3):7-13.

Published by: Weed Science Society of America. <http://www.wssa.net/>

Origins of leafy spurge in North America

P. H. DUNN

Research Entomologist, USDA Biological Control of Weeds Laboratory, Europe, c/o American Embassy Agriculture, APO New York 09794.

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I. Introduction

Leafy spurge is an important weed in North America. It is found in six provinces in Canada and 26 states of the United States, where 144 different counties have infestations greater than 500 acres (202.5 ha) (9). Noble *et al.* (22) estimated the North American infestation to be approximately 2.5 million acres (1,011,750 ha). It has also been reported as a roadside weed of minor importance near Ecatapec in the state of Mexico (D. F.), Mexico (E. A. Luna, personal communication). Early workers with leafy spurge recognized it as a plant of European origin, probably introduced into North America with commerce. Batho (3) noted that it was most likely introduced into Minnesota with oats from Russia.

While early workers noticed differences between plant populations, the weed was by and large considered to be a single, quite variable species, the name alternating between *Euphorbia esula* and *E. virgata*, depending on who was writing about it. Later examination of herbarium specimens from across North America has shown that leafy spurge is not a single species but an aggregation of closely related (and perhaps hybridized) taxa

whose relationships must be clarified before effective biological or chemical control can take place.

The fact that leafy spurge is an alien weed with a large group of natural enemies in Europe makes it an excellent candidate for biological control (17, 18). At the outset, the biological control of this weed seemed like a straightforward project of introducing insects from leafy spurge in Europe and colonizing them on the weed in North America. Thus, investigators working in biological control became aware of the taxonomic problem and the plant's variability with the discovery that insects collected in Switzerland and Austria would not accept North American leafy spurge (17).

It also became obvious that to find useful candidate insects for biological control, insects with a broader host-plant spectrum would need to be found or natural enemies must be collected overseas from the same leafy spurge types that occur in North America. To do the latter, it is of paramount importance to determine the origins of leafy spurge in North America.

II. History

According to Britton (6), the first specimen of leafy spurge in the United States was collected by William Oakes in 1827 at Newbury, Massachusetts. The herbarium of the Missouri Botanical Garden at St. Louis also houses a later collection (1842) by Oakes (M. R. Crosby, personal communication). The first record from Canada was from Huron County, Ontario in 1899 (5). While these specimens establish an early entry into North America, they do not pinpoint how or from where they arrived. At the beginning of this study it was believed that leafy spurge entered North America as ballast plants and then spread westward.

In 1933 Hanson and Rudd (16) mapped the distribution of leafy spurge in the United States and reported three centers of infestation, one on the east coast, a major infestation in the north-central states, and small scattered infestations in the western states of Montana, Idaho and Washington.

In a more recent survey by Dunn (9) the same pattern was found to exist, but the infested areas were larger and more dense than those reported by Hanson and Rudd. When the distribution pattern became known, the earlier idea of a simple westward migration of leafy spurge was discarded, because it did not provide a credible explanation for the large infestations of leafy spurge that were centered in the north-central plains states of the United States and the southern-central provinces of Canada that had no connection with the Atlantic seaboard.

III. Modes of introduction

Ballast. In trading with America in the 1600's and 1700's, ships from Europe brought manufactured goods, which took up little space and provided little weight. It was therefore necessary to carry soil or other heavy material (ballast) in the ships' holds to provide stability at sea. The soil ballast was dumped on the shore near the ports in America, and for the return trip to Europe the ships were ballasted with cargoes of raw materials, such

as lumber and tobacco. Seeds of many European plants were in the soil that was used for ballast and many exotic weeds entered North America in this way.

Because of the proximity to the seacoast of the earliest recorded leafy spurge plants, one would suspect they entered in ballast. A specimen of leafy spurge (now at the Missouri Botanical Garden herbarium) was collected August 2, 1877 by John H. Redfield and annotated "collected from ballast at Greenwich Point, Philadelphia." While this collection was not as early as those of Oakes, the annotation citing a ballast dump as a collection site provides good evidence to support the hypothesis that the rather disperse east coast infestation was the result of multiple introductions in ballast soil carried in the ships from Europe to North America, then dumped on the American shore.

Mennonites. In a search for some clue to explain the widely separated infestations in North America, this sentence was noticed in the 1933 paper by Hanson and Rudd, "In Manitoba the weed occurs in the settlements of Russian Mennonites who may have brought the seed with them from Russia" (16). This statement opened a new avenue of possibilities to explain the dense north-central infestation of leafy spurge.

Cornelius Krahn (20), a Mennonite historian, recounted that many Mennonites chose to leave Russia rather than be conscripted into the Czar's army, and they migrated to Canada and the United States in the decade of 1870-1880. In 1874 about 18,000 Mennonites came to North America, settling in Manitoba, North and South Dakota, Minnesota, Nebraska, and Kansas. These settlers and their heirs kept excellent records of their movements; so it was easy to find the names of the villages in Russia from where they came. The majority of those who settled in North America in this wave of immigration came from the villages of Chortitsa and Molotschna, near the mouth of the Dnieper River in the Ukraine (20). Concerning their settlement in the New World, Krahn (20) wrote: "When the Mennonites arrived in the prairie states and provinces, they brought with them, along with their household goods and furniture, various seeds they had been planting on the steppes of the Ukraine, including smaller quantities of varieties of wheat."

By using Hanson and Rudd's observations on the distribution of leafy spurge in the United States and Krahn's description of their move, it can be inferred that leafy spurge was introduced into North America by this immigration of 18,000 people from Russia in 1874, as well as in ballast from Europe.

Seedgrain. Additional reports of introductions of leafy spurge into North America were also found. For example, Batho (3) wrote, "The state of Minnesota attributes its (leafy spurge) introduction into southwestern Minnesota to a bushel of oats brought in about 1890 from southern Russia." Since this 1890 introduction date was 20 years after the Mennonite immigration, it was another introduction report whose source should be investigated. However, this introduction was made before the U.S.D.A. Department of Plant Introduction had complete records, and the source of the introduction and the origin of the oats is unknown.

Further examination of early plant introduction literature led to the name Mark Alfred Carleton. Carleton (7) was a cereal plant explorer for the U.S.D.A. and in 1898 and 1899 he made trips to Russia, where he studied grain production in detail and brought 13 kinds of wheat, 4 kinds of oats, 6 varieties of millet and 2 kinds of emmer (*Triticum dicoccum*) to the United States. Carleton's trip report described how seeds were cleaned in Russia at

that time: "The operations of cleaning grain are very primitive and very bad. For this reason it is impossible to obtain seed grain that is pure and free of weed seeds, unless it is all cleaned over again by some reliable seed firm. Even then it is often found that certain varieties require further cleaning on reaching this country." However, Carleton (7) noted that "in cases where great care was exercised, excellent work has been performed by the use of these simple circular sieves, though the operation is, of course, exceedingly slow."

The first statement lends support to the probability that much of the grain introduced from Russia as seed grain was most likely contaminated by weed seeds. Carleton (7) also stated, "Wherever Russian oats have already been introduced into this country, they have become very popular sorts, as the best oat districts in Russia and Siberia generally possess a climate a little drier and colder than the corresponding oat districts in this country." thus indicating that there had been introductions of Russian seed grain before his 1898-1899 trip to Russia. This could account for the 1890 introduction of oats mentioned by Batho, and Carleton's description of seed cleaning certainly makes a shipment of any size suspect as far as contamination with weed seeds is concerned.

The seed samples Carleton brought with him from Russia were fairly small, from ¼ bushel (8.8 L) to 1 bushel (35.24 L.). Because of his interest in weed-free seeds, they were probably clean. However, in 1900, on the heels of Carleton's exploration, Bernard Warentkin, an important Mennonite leader, brought 15000 bushels (528.6 m³) of "Crimean" wheat from the old Mennonite colony at Molotschna. If one recalls Carleton's description of seed cleaning of that time, it is unlikely that the 15000 bushels were weed-free. In addition, Carleton (8) notes that fresh shipments of wheat seeds from the Crimea and Ukraine were made from time to time following the shipment made in 1900.

I regard all these shipments as suspect of being contaminated with weed seeds, especially since I had the opportunity, in the summer of 1979, to visit and collect leafy spurge plants at the villages of Molotschna and Chortitsa and surrounding area. Some of these collections were made on and in wheat fields. The leafy spurge plants collected there were compared with leafy spurge plants from 12 states in the United States by Alan Radcliffe-Smith at the Royal Botanical Gardens, Kew. Radcliffe-Smith's findings were that three of the four taxa of leafy spurge were common to the United States, *Euphorbia virgata* Waldst. & Kit., *E. × pseudovirgata* (Schur) Soó, and *E. virgata* Waldst. & Kit. cf. var. *orientalis* Boiss. (*E. boissieriana*) Woron.) Prokh.)

These findings are strong circumstantial evidence that leafy spurge was introduced into North America by the Mennonites during their immigration and later as a contaminant in large shipments of seed grain.

Smooth Brome Grass. Another possible source of leafy spurge introduction surfaced in a 1932 Manitoba Department of Agriculture Bulletin in which Batho (4) wrote "...leafy spurge is evidently introduced into new areas by seeds. Some farmers believe their infestations have come from brome grass seed."

A tracing of the origin of smooth brome grass (*Bromus inermis*) in Canada led to an account of James Fletcher's 1893 testimony on the virtues of this grass before an agricultural committee of the House of Commons at Ottawa. He stated that brome grass had been "...imported from Germany five to six years ago" (which would be about 1887-88) (11). William Saunders' 1897 testimony before the same committee noted that 10 years

previously (1887) "... several pounds each of the seeds of all the grasses grown to advantage in northern Europe for hay and pasture and especially those grown north of Riga, Russia ..." were ordered from a seed dealer in Riga (23). Awnless (or smooth) brome (*Bromus inermis*) was one of these grasses that grew exceedingly well. Saunders also remarked, "The seeds men also have imported it (brome grass) in large quantities and sold it readily."

Again in 1897, James Fletcher's testimony supported the Russian origin of the brome grass seed when he stated, "I might mention that it was our own Canadian farms which introduced this grass into American agriculture. Several samples were imported from Russia at the beginning of the experimental farm work. Since then it has been distributed in small packages all over the country, wherever we thought it would be useful." (12).

If leafy spurge was associated with brome grass, it may well have been introduced into Canada a second time and widely distributed during this flurry of activity with brome grass by both government and private agencies.

The introduction of smooth brome grass into the United States seems to predate the Canadian introduction by a few years. Anderson (1) wrote: "So far as can be determined from the available records, brome grass, presumably of Hungarian origin, was first introduced into the United States about 1880 by the California Agriculture Experiment Station from Volmorin, Andrieux and Co. of Paris. By 1884 the California station offered packets of seed to farmers and others for planting." It is doubtful if leafy spurge was distributed with these seeds because, according to Dwinelle (10), Hungarian brome grass (*Bromus inermis*) was from seed imported by the University from Europe, commended by the French, as adapted to dry soils. He also wrote, "Our experience indicates that it will do well here, either with or without moderate irrigation." This grass was available in 4-oz packages at 5 cents in stamps per package.

One is left with the impression that only a small quantity of seed was imported from France and that it was grown experimentally until enough seed could be produced for a moderate distribution. It is doubtful if the 4-oz packages were contaminated, which would eliminate Hungary as a source of leafy spurge through brome grass seed contaminants.

However, about 13 years later, another major introduction of smooth brome grass was made into the United States by N. E. Hansen who was a horticulturist and plant explorer for the U.S.D.A. working from the University of South Dakota at Brookings. In his career as a plant explorer he made three trips to Russia and Asia collecting new varieties of cold-hardy plants suitable for growing in the Northern Great Plains areas. During the expedition of 1897-98 Hansen (14) sent 12 tons of smooth brome grass seed from Penza province in the Volga Valley in Russia to the United States. Much later, in 1945, Hansen (15) wrote: "In the 1897-9 tour, I resolved to clear up the question of Hungarian or Austrian brome grass which was beginning to attract favorable notice in the Prairie Northwest. But this region was too far south, I figured, to give us anything of value. I soon found out that this seed, although it came from the regions mentioned, really was grown in the Volga River region of Russia and that the entire available crop of seed for that year, 1897, was about 12 tons. I cabled Secretary of Agriculture James Wilson and the reply came quickly, 'Buy 12 tons,' this was later widely distributed."

During an exploration for natural enemies of leafy spurge in Russia in 1979, I was unable to travel in Penza Province, the source of Hansen's large shipment of smooth brome grass seed. However, an entomologist in Penza collected insects on leafy spurge and sent them to me in Crimea. Several pieces of leafy spurge were in shipment to serve as food and a resting place for the insects. These plant pieces were pressed and later given to Alan Radcliffe-Smith, Royal Botanic Gardens, Kew, who ventured an identity as probably *E. virgata* var. *orientalis*.

IV. Spread of leafy spurge

Kennedy (19), in his discussion on smooth brome grass, acknowledges the earlier introduction of this grass by the University of California, then goes into some detail about the disposition of the fiscal year 1896-97 distribution of smooth brome grass seed by the U.S.D.A. Kennedy points out that 603 experimenters received brome grass seed from the U.S.D.A. and stated: "This distribution does not include the state experiment stations to some of which large quantities were sent. The packages sent out varied from one quart to 35 pounds. The larger part of this seed was purchased from Russia by the Secretary of Agriculture (Hansen's collection) and distributed by this division, or through the Section of Seed and Plant Introduction. Almost every state in the Union is represented in this distribution." The distribution list showed 42 states and Indian Territory (eastern Oklahoma).

Kennedy (19) also noted, "The states receiving the largest amounts of seed . . . were Kansas, Montana, Texas, Colorado, Nebraska, North Dakota, Washington, and Oregon in order named." Hanson and Rudd (16) reported leafy spurge in all those states except Kansas, Texas, and Oregon in 1933. A more complete survey by Dunn (9) in 1975 showed leafy spurge in all those states, except Texas.

In 1899, Lyon (21) gave a good account of how the brome grass seed was used in Nebraska, explaining that in the spring of 1899 "the Experiment Station received a consignment of *Bromus inermis* seed from the U.S. Department of Agriculture." This seed was presumably from the 12 tons received from Hansen, ex. Penza province, USSR, in February of that year. Three hundred seventy-five pounds of this seed were sown in a 15-acre field plot on the experiment station farm. Another 350 (plus) pounds were distributed, mostly to members of the Agricultural Students Association, in 17 counties throughout the state in 31 shipments of approximately 12.5 to 25 pounds, each to be used on one or one-half acre test plots. The trial was regarded as a moderate success, but of special interest is that 12 of the 17 counties that received smooth brome grass for trials are now infested with leafy spurge. While this evidence is highly circumstantial, it lends credence to the possibility that leafy spurge could have been introduced and distributed with smooth brome grass seed from Russia. Thus, when these events are considered along with the observation of Batho (3), "leafy spurge is being introduced into new areas by seeds. Some farmers believe that their infestations have come from brome grass seed," the events acquire significance.

The distribution of leafy spurge has been associated with alfalfa on more than one occasion. For example, Story (26), in talking to "old timers" about the origin of leafy spurge in Montana, found that in Judith Basin County "The plant was introduced in the early

1920's with some 'Cossack' alfalfa seed (a yellow-blossom dry land alfalfa) obtained from somewhere in Asia." From this statement it seemed obvious that if the source of Cossack alfalfa in Asia was found, we would possibly have the origin of another type of leafy spurge found in North America.

This source of Cossack alfalfa was located. In describing one of his explorations Hansen (15) wrote: "I also brought a natural hybrid (sand lucerne) from Russia in 1906, only half of a teaspoon full of seed, which I named 'Cossack' alfalfa. Ten years later the farmers in South Dakota raised 60,000 pounds of 'Cossack' seed." It is unlikely that the half teaspoonful of seed contained anything but alfalfa seed; hence, apparently no new leafy spurge type was introduced with it. However, Hansen's (15) description of the production and distribution of 60,000 pounds of Cossack alfalfa seed in the subsequent 10 years (up to about 1917) suggests that there was a connection between some of the Montana infestations described by Story (26) and South Dakota. The Dakotas are named as a source of leafy spurge in four of the Montana counties and 'Cossack' alfalfa was indicated in the fifth.

Another reason for associating leafy spurge with alfalfa arises from the popularity of using an alfalfa-brome grass mix for sowing. When discussing such a mixture, Hansen (15) stated "...it has become widely popular. In Iowa, Wisconsin, and many other states an alfalfa brome grass mixture is now much used. The alfalfa roots' nitrogen-bearing nodules feed the brome grass and keep it from getting sod bound." Anderson (1) also mentioned that brome grass was commonly sown in a mixture of alfalfa and red and white clover seeds, along with native grasses.

Leafy spurge has also been associated with oats on several occasions in the literature. For example, Batho (3) reported that leafy spurge was introduced into Minnesota in oats and Bakke (2) described how oat seeds at a farm in Haywarden, Iowa had as many as 200 leafy spurge seeds per bushel. A Mennonite historian, John D. Unruh, wrote in a personal communication: "In my own community, Childstone township in Turner County (South Dakota), we first became aware of this pest shortly before World War I. An uncle of mine bought some seed oats from someone in the Dolton (Turner County) area and we generally attributed the introduction (of leafy spurge) to this incident." While these alfalfa-oat associations with leafy spurge contribute little to the information on the introduction of leafy spurge, they do contribute to our understanding of how leafy spurge was probably spread within the United States and Canada after its introduction and establishment.

V. Routes of travel

Selleck (24) studied the introduction of leafy spurge into North America and has cited numerous examples of its early distribution in Canada. In Saskatchewan, Selleck found a strong correlation between some of the worst infestations in the province and a trail used by traders and settlers in the prerailroad period ending in 1895. He also points out that leafy spurge infestations adjacent to the railroads suggest that railroads have contributed to the distribution in Canada. Other agents of long-distance dispersal include agricultural machinery, animals, birds, moving water and transport of contaminated seed and feed-stuffs (24, 25).

Forbes (13) reported that the leafy spurge-alfalfa relationship was also well known in Canada. The province of Manitoba, realizing that leafy spurge was commonly spread in hay, passed a law making it “illegal to offer hay for sale containing any part of leafy spurge,” and “illegal to transport on any public road hay that contains any part of a leafy spurge plant.” Careless threshing and cultivation practices, as well as movement of contaminated machinery along roads, was also implicated in the spread of leafy spurge.

VI. Conclusions

By searching the literature, and through correspondence, it was possible to ascertain the four most probable ways leafy spurge was introduced into North America. The four modes of introduction of leafy spurge into North America were: 1) in ship ballast, 2) in seed stocks of Mennonite immigrants, 3) in cereal seed introductions, and 4) in brome grass seed introductions. In addition, the two most probable areas of origin (the Ukraine and the Penza Province in the Volga Valley of Russia) and the two general areas of origin (Russia and Europe) have been determined. From the evidence presented here, the leafy spurge of European origin is primarily found along the east coast of North America, whereas the leafy spurge that has infested the central Great Plains areas common to Canada and the United States is probably of Russian origin.

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