

Success of an exotic gallmaker, *Dryocosmus kuriphilus*, on chestnut in the USA: a historical account

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Dryocosmus kuriphilus, a cynipid gall wasp of Asian origin, was accidentally introduced into North America in 1974. The gall wasp attacks chestnut and causes rounded galls that reduce shoot elongation and fruit production, and cause twig dieback. Its geographic range in the eastern USA has expanded northward since its introduction, and now encompasses nearly 1.5 million square kilometres. Movement of infested plant material has allowed the establishment of separate satellite populations well removed from contiguous populations. The cryptic nature of the insect, lying within dormant buds for much of the year, makes the effectiveness of plant inspections questionable. An introduced parasite, *Torymus sinensis*, has successfully moved with expanding *D. kuriphilus* populations, and several native parasitoids are exploiting this exotic gallmaker.

Distribution and Dispersal

The Asian or Oriental chestnut gall wasp, *Dryocosmus kuriphilus* (Hymenoptera: Cynipidae), is a native of China. It was first reported outside its native geographic range in Japan in 1941 and on the Korean Peninsula in 1961, where it was initially managed through the use of resistant chestnut, *Castanea* spp., varieties. Adult gall wasps lay eggs in chestnut buds in early summer; larvae remain dormant until buds expand the following spring. Gall wasps induce the formation of greenish red, 8–15 mm diameter leaf and twig galls that suppress shoot elongation, reduce fruiting, and cause twig dieback. Severe infestations can result in mortality of young trees (Payne *et al.*, 1975; Anagnostakis & Payne, 1993).

The first report of the gall wasp's appearance outside Asia was in 1974 when it was reported on Chinese chestnut, *C. mollissima*, in Fort Valley (Peach County), Georgia, USA (33.5 N, 83.8 W) after being imported on infested plant material by a private grower side-stepping quarantine restrictions. The second report of its occurrence, in 1975, was also on Chinese chestnut in Peach County, 19.6 km north-east of the original introduction at the Southeast Fruit and Tree Nut Research Farm (United States Department of Agriculture Agricultural Research Service) (Fig. 1).

In 1976 the distribution included three adjacent counties north and east of Peach County, and the list of affected plant material included Japanese, *C. crenata*, and European, *C. sativa*, chestnuts. In 1979 the infestation covered portions of 10 counties, and was expanding northward at a rate of 25 km per year. In 1982 the host range expanded to include chinquapin, *C. pumila*, which the gall wasp rarely infests (J. Payne, pers. comm.).

By 1983 the gall wasp infestation had travelled 167 km west to Auburn, Alabama, and 137 km south to Tifton, Georgia (18.5 and 15.2 km per year, respectively), and was devastating the chestnut industry in southeast USA (Anagnostakis & Payne,

1993). In 1992 the gallmaker was successfully reared on cultivated American chestnut, *C. dentata*, in Peach County, and in 1993 was first reported on naturalized American chestnut in the Chattahoochee National Forest in Union County in northern Georgia, 300 km north of the original infestation (Fig. 1).

The range of the gall wasp continued to expand north-easterly along the Appalachian Mountains through the states of Tennessee and North Carolina, reaching the site of the American Chestnut Foundation Research and Breeding Farm in Meadowview, Virginia (Washington County) in 2001, 624 km from the initial introduction (23 km per year). In Meadowview the gall wasp readily infested Chinese and American chestnuts, and their hybrid crosses. The following year (2002) the gall wasp was also reported on Chinese chestnut in Wise County, Virginia.

Also in 2002, a distinctly separate gall wasp infestation was reported in Broadview Heights, Ohio (Cuyahoga County), north of the expanding southern populations by a distance of 643 km (Stehli, 2003). This isolated population was initially restricted to three Chinese chestnuts planted near homes in a suburban environment. This population extended 41 km east in 2005, reaching Mantua, Ohio (Portage County), where it was reported infesting Chinese chestnuts cultivated for nut production. An additional isolated northerly infestation was reported on the border of the states of Maryland and Pennsylvania in mid-2006, 540 km east of the Ohio infestations, and 630 km north of the northern edge of the southern infestation. Finally, in late 2006 the gall wasp was reported in Somerset County Pennsylvania, approximately equidistant between the Ohio and Maryland/Pennsylvania infestations, again on Chinese chestnuts grown for nut production.

Meanwhile, the gall wasp infestation in the south pushed westward, and in 2003 reached Bowling Green, Kentucky (Warren County), where it was infesting naturalized American chestnut in a forest setting (Cooper & Rieske, 2007). This site

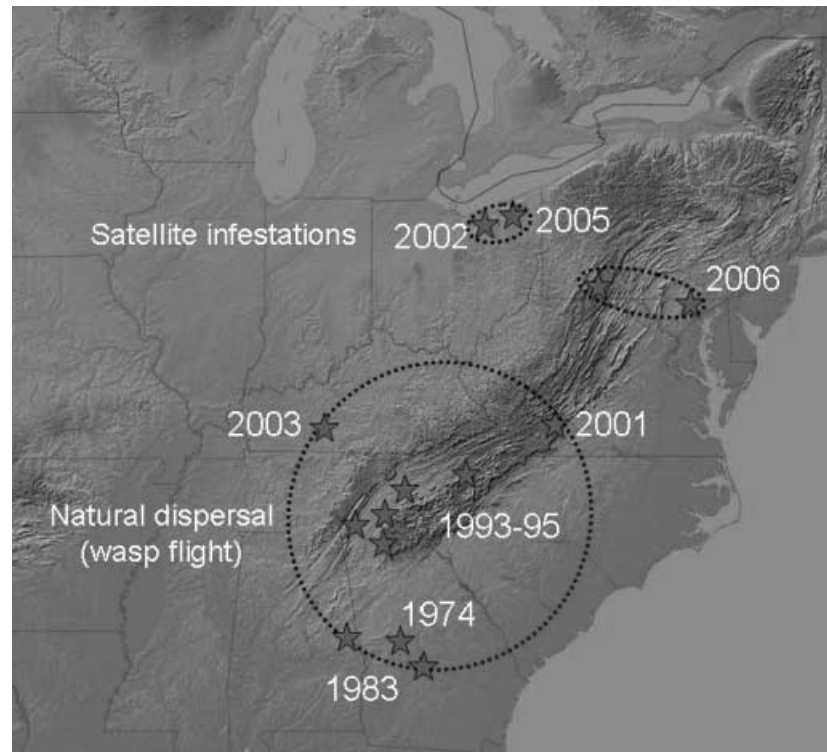


Fig. 1 Distribution and dispersal pattern of *D. kuriphilus* in eastern North America (map adapted from <http://birrell.org/andrew/relief/Maps/>).

is 506 km west of Meadowview, Virginia, and lies at the extreme western edge of the natural range of American chestnut prior to its devastation from the chestnut blight fungus, *Endothia parasitica*.

Currently there appears to be at least two distinct geographic populations of the gall wasp in the eastern USA. The southerly populations of *D. kuriphilus*, originating from the initial introduction in south central Georgia in 1974, expanded north-easterly at a rate of 23 km per year through 2001. This persistent expansion is likely occurring by wasp flight on naturalized American chestnut, augmented by north-easterly winds common in the region during periods of adult wasp activity.

In contrast, the northern populations in Ohio are well beyond the projected dispersal by natural flight, and likely resulted from transport of infested plant material (Cooper & Rieske, 2007). The gall wasp occurrences in Maryland and Pennsylvania are potentially eastward expansions of the isolated northern population from Ohio, or perhaps separate introductions on infested plant material. Alternatively, north-easterly winds could have carried adult gall wasps from the southern population considerably greater distances than expected from wasp flight alone.

Interestingly, the southern edge of the range of *D. kuriphilus* in the eastern USA has remained stable since 1983. Although this lies at the extreme edge of the naturalized range of American chestnut, suitable cultivated material should be adequate to sustain gall wasp populations. Clearly additional limiting factors have kept southward expansion in check.

Gall wasp associates

In 1977, three years after *D. kuriphilus* was first reported in North America, the parasitic wasps *Torymus sinensis*, *T. tubicola*, and *Megastigmus* sp. (Hymenoptera: Torymidae), which had successfully suppressed damaging gall wasp populations in Japan, were introduced into gall wasp infested orchards in Byron, Georgia (Payne, 1978). Within a short period, gall wasp populations in central Georgia declined and the incidence of galling dropped below acceptable levels. *Torymus sinensis* has moved with expanding gall wasp populations in eastern North America, and several native parasitoids successfully exploit *D. kuriphilus* (Cooper & Rieske, 2006; Cooper & Rieske, 2007). *T. sinensis* and *Ormyrus labotus* (Hymenoptera: Ormyridae) occur in frequencies great enough to influence gall wasp populations (Cooper & Rieske, 2007).

Conclusions

D. kuriphilus is poised to continue its rapid spread through eastern North America, either through natural movement or through movement of infested plant material. Natural dispersal by flight, augmented by wind currents, can easily be sustained on naturalized American chestnut, ornamental chestnuts, and chestnuts planted for nut production. Undoubtedly the intentional movement of infested plant material poses the greatest risk, allowing the establishment of separate satellite populations well removed from contiguous populations.

Interstate movement of *Castanea* spp. is regulated by only a few states, and the cryptic nature of the insect, lying within dormant buds for the majority of its life cycle, make the effectiveness of plant inspections questionable. Fortunately several natural enemies appear capable of exploiting *D. kuriphilus*, and management through natural means appears a viable and hopeful option.

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Succès d'un insecte exotique, *Dryocosmus kuriphilus*, sur châtaignier aux Etats-Unis: un historique

Dryocosmus kuriphilus, un cynips d'origine asiatique, a été accidentellement introduit en Amérique du Nord en 1974. Il attaque le châtaignier, et provoque des galles arrondies qui réduisent l'élongation des rameaux et la production de fruits, et cause un dépérissement terminal. Sa répartition géographique dans l'est des Etats-Unis s'est étendue vers le nord depuis son introduction et englobe désormais 1,5 millions de kilomètres carrés. Les mouvements de matériel végétal infesté ont permis l'établissement de populations satellites séparées bien éloignées des populations contiguës. La nature cachée de l'insecte, restant dans les bourgeons dormants la plupart de l'année, interroge sur l'efficacité des inspections de végétaux. Un parasite introduit, *Torymus sinensis*, s'est disséminé avec succès en suivant l'expansion des populations de *D. kuriphilus*, et plusieurs parasitoïdes indigènes exploitent ce cynips exotique.

Успех экзотической орехотворки *Dryocosmus kuriphilus* на каштане в США: исторический экскурс

Dryocosmus kuriphilus, галлообразующая орехотворка азиатского происхождения, была случайно завезена в Северную Америку в 1974 г. Орехотворка паразитирует на каштане и вызывает образование округленных галлов, которые приводят к сокращению роста веточек и производства плодов, а также к усыханию побегов. Начиная с акклиматизации ее географический ареал в восточной части США расширился к северу и теперь охватывает почти 1,5 млн. кв. км. Перемещение зараженного растительного материала привело к акклиматизации отдельных сопутствующих популяций, достаточно удаленных от смежных популяций. Скрытый характер развития насекомого, откладывающего яйца внутрь спящих почек в течение большей части года, позволяет усомниться в эффективности визуальных досмотров растений. Интродуцированный паразит *Torymus sinensis* успешно перемещался с расширением популяций *D. kuriphilus*, несколько автохтонных паразитоидов развивается на этой экзотической орехотворке.

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