Tortrix viridana

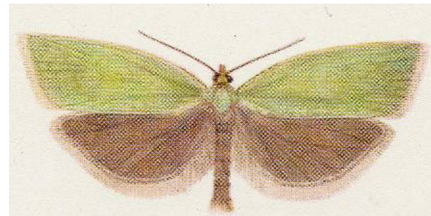

Fig. 1. Drawing of male *Tortrix viridana*.
[Image reproduced from Bradley et al. (1973)]

Scientific Name

Tortrix viridana (Linnaeus)

Synonyms:
Phalaena viridana Linnaeus
Heterognomon viridana Barrett 1905
Tortrix viridana Pierce & Metcalfe 1922

Common Names

Green oak tortrix, oak leaf roller, oak roller moth

Type of Pest

Moth, leafroller, defoliator

Taxonomic Position

Kingdom: Animalia, **Phylum:** Arthropoda, **Order:** Lepidoptera,
Family: Tortricidae, **Subfamily:** Tortricinae

Reason for inclusion in manual

Exotic Forest Pest Information System – classified as a very high risk pest with the potential to attack oaks
CAPS Priority Pest (FY 2008 – FY 2013)

Pest Description

Eggs: "Pale yellow at first, becoming orange-brown later, lenticular, delicately sculptured, usually covered by green scales from the upper surface of the forewings" (Bradley et al. 1973).

Larvae: "Head shining blackish brown or black; prothoracic plate varying from light greenish brown to green or grey, sometimes mottled with brown, a narrow whitish medial sulcus, posterior margin edged with black, anterior margin sometimes with a whitish border, the coloration and markings being exceedingly variable (in early instar larvae the prothoracic plate is usually entirely black); abdomen light olive-green, greyish green in early instars, integument strongly shagreened; pinacula dark brown or black; anal plate dark brown or green; anal comb usually with 8 prongs; thoracic legs shining black" (Fig. 2) (Bradley et al. 1973).

Fig. 2. Larva of Tortrix viridana on outer surface of rolled leaf
[Image from Milan Zubrick, #1370047, www.invasive.org]

Pupae: “Varying from brown to black” (Fig. 3) (Bradley et al. 1973).

Fig. 3. Pupa of *Tortrix viridana* within folded oak leaf.
[Image from Petr Kapitola, #UGA2112047, www.insectimages.org]

Males and females with a wingspan of “17-24 mm; males under 17 mm are known, the smallest being an individual from Oxshott (Surrey) [UK] with a wing span barely 13 mm, but such undersized specimens are rare. Sexual dimorphism not pronounced; antenna of male weakly dentate, densely ciliate, cilia less than width of flagellum, posterior margin of flagellum thinly clad with whitish scales; female usually with abdomen stouter and wings broader, antenna filiform, sparsely ciliate, more densely clad with whitish scales” (Bradley et al. 1973).

“Male. Forewing light green (viridine), darker basally, delicately strigulate distally, head, thorax, patagium and tegula concolorous, vertex and patagium often tinged with yellow; labial palpus whitish, suffused with fuscous exteriorly; whole of costal margin of forewing narrowly edged with whitish yellow, base of costa sometimes suffused with fuscous; dorsal scale-tuft tinged with yellow; cilia whitish, a pale green sub-basal line. Hindwing light grey; cilia whitish, with a grey sub-basal line around apex and along termen” (Fig. 1) (Bradley et al. 1973).

"Female. Similar to male" (Fig. 4) (Bradley et al. 1973).

"Variation. This species shows little variation except in the depth and intensity of the green coloration of the forewing and in the strength of the strigulation. Specimens are sometimes found in which the green coloration is replaced by dull yellow or primrose yellow; these apparently represent a recurring genetical form and are not due to abrasion or discoloration" (Bradley et al. 1973).

Fig. 4. Male (right) and female (left) of *Tortrix viridana* on an oak leaf.
[Image from Louis-Michel Nageleisen, #UGA2101020, www.insectimages.org]

Biology and Ecology

Tortrix viridana typically has one generation per year, but two are possible in warmer climates (Bogenschütz 1991). Moths are active from late April to early July in Europe and Eurasia. The life span for adults is approximately one week. Moths are active during the day and may be found in large numbers in the upper portion of tree crowns. Mating occurs during the afternoon and evening; however, the species may be able to reproduce parthenogenetically (Du Merle 1999a). Adults are capable of utilizing winds to disperse up to 100 km [~62 mi] (Du Merle and Pinguet 1981, Schneider 1984, Winter 1984, Bogenschütz 1991, reviewed in Ciesla 2003). The sex ratio for *T. viridana* is 1:1. One female may deposit 50-60 eggs, usually in clutches of 2-3 eggs that partially overlap (reviewed in Horstmann 1977, Bogenschütz 1991, Markov 1993). Egg masses are deposited in a lustrous, sticky substance on bark, leaf scars or near buds on small shoots (2 year old growth; 1-3 cm diameter) (Speight 1985, Bogenschütz 1991, Markov 1993).

Fecundity and development of *T. viridana* are affected by food (quantity and quality) and temperature (Bogenschütz 1991, Markov 1993). Overcrowding or reduced food quality results in fewer, smaller adults and reduced oviposition rates. Because males require less food than females during larval development, they pupate and emerge earlier in the year (Bogenschütz 1991). When food is scarce, females are more likely than males to die from starvation, which alters the sex ratio (Bogenschütz 1991).

Eggs enter diapause and overwinter (Fazeli and Abai 1990). Diapause begins in the spring or early summer and ends in late fall-early winter (Du Merle 1999b). Temperatures must drop to at least 8°C [~46°F] for eggs to satisfy cold requirements.

Although the effect of days colder than 8°C on the duration of diapause has not been quantified, diapause will end relatively sooner in areas with colder climates (Du Merle 1999b). Eggs must experience 60-100 days at 8°C [~46°F] to break diapause (Du Merle 1999b). Once diapause has broken, embryos within eggs will begin to develop once temperatures reach about 10°C [50°F] and will hatch when 200 degree days [°C] have accumulated (reviewed in Bogenschütz 1991).

Larvae hatch in the spring of the year after eggs were laid (Du Merle 1982, Speight 1985, Ivashov et al. 2002). Hatch occurs near the time of budbreak (Speight 1985, Ivashov et al. 2002), typically in April or early May (Bradley et al. 1973). Newly hatched larvae feed on opening buds, young leaves, flowers and new shoots (Speight 1985, reviewed in Ciesla 2003). Larvae develop through five instars, and insects remain as larvae for 20-40 days depending on temperature (Speight 1985, Fazeli and Abai 1990, Tiberi and Roversi 1990, Bogenschütz 1991, reviewed in Ciesla 2003, reviewed in CAB 2006). Early instars are vulnerable to cold temperatures. A spring freeze with temperatures at -6°C [21°F] will kill nearly 30% of the population (reviewed in Bogenschütz 1991). When food becomes scarce, larvae will hang from a silken thread and disperse by ballooning (reviewed in CAB 2006). If hatching does not coincide with budbreak, larvae will survive for about 10 days under spring conditions. If food cannot be found in that time, larvae will die from starvation (Speight 1985, Hunter 1990, Bogenschütz 1991, Markov 1993) or simply fail to develop as a result of reduced nutritional quality of leaves or host plant resistance mechanism (protease inhibitor) (Hunter 1990, 1997, Ivashov et al. 2001, 2002). For these reasons, early hatched larvae are more likely to complete development than those that hatch later in spring (Ivashov et al. 2001).

Pupation occurs in rolled leaves spun together with silk. The duration of the pupal stage generally lasts 2-3 weeks, depending on temperature (Bogenschütz 1991, reviewed in CAB 2006).

See ‘Known Hosts’ for a listing of the plants that can be attacked by *T. viridana* and ‘Pest Importance’ for a discussion of the potential economic impact.

Damage

Tortrix viridana larvae feed on buds, foliage, flowers, and new shoot growth of oaks and other deciduous trees and shrubs. The insect may cause significant defoliation (see ‘Pest Importance’). Developing larvae will roll leaves to create protected feeding sites and to pupate (see ‘Biology and Ecology’).

Fig. 5. Foliar feeding damage caused by *Tortrix viridana*.
[Image from Petr Kapitola, www.insectimages.org]

Feeding damage by *T. viridana* larvae is similar to that caused by other polyphagous defoliators. Evidence of the pest includes heavy defoliation in oak crowns; rolled leaves of host trees spun with silk webbing; feeding damage on buds, foliage and flowers of host trees.

If larvae feed on developing buds, the buds will assume a conical shape; webbing from bud to bud will be present, and a blackened exit hole (Bogenschütz 1991). The entire crown may be covered with webbing during severe outbreaks.

If infestations last several years, trunks will be shorter, bent and tapered. Epicormic shoots may form (Bogenschütz 1991).

Pest Importance

Tortrix viridana is considered a pest of economic importance in Europe, Russia and the Near East where periodic outbreaks have contributed to extensive oak defoliation and decline (Fazeli and Abai 1990, Hunter 1990, Tiberi and Roversi 1990, Markov 1993). In Spain, this pest has been a significant pest of oak; larval feeding damage to tender bark and new shoots has resulted in reduced flowering and fruiting (acorn production) (reviewed in Ciesla 2003). In Poland, *T. viridana* and other defoliators have impacted over 650 thousand ha [>1½ million acres] and prompted control measures (Stocki 1994). *Tortrix viridana* can cause serious damage to oak forests, particularly when egg hatch occurs early in spring and conditions for larval development are optimal (Ivashov et al. 2001). Larval density may vary from 1-2 per bud, and up to 12 per bud in heavy infestations. The final two larval instars are the most damaging (reviewed in CAB 2006).

Larvae are considered largely monophagous feeders of oaks, particularly new foliage and buds; however, this pest may feed on a variety of ornamental trees and shrubs (see ‘Known Hosts’) (Bogenschütz 1991, Du Merle 1999b). Population size can vary from year to year (see ‘Biology and Ecology’), but in its native range, the insect is attacked by several natural enemies which may hold populations in check (reviewed in Ellis 1946, reviewed in Horstmann 1977, Hunter et al. 1997). Thus, the potential economic impact in the United States in the absence of natural enemies is uncertain.

The economic impact of *T. viridana* is difficult to measure especially because this pest typically occurs with other primary defoliators (including *Erannis defoliaria* and *Operophthera brumata*) and secondary pests (Speight 1985, reviewed in Ciesla 2003, reviewed in CAB 2006). Considerable defoliation can occur without causing significant damage (Mattson and Addy 1975, Furniss and Carolin 1977, Drooz 1985). However, heavy defoliation repeated over a period years can cause decline of tree health, reduced growth rates, attraction of secondary pests, and tree death (Furniss and Carolin 1977, Drooz 1985, Speight 1985, Rubtsov 1996).

Tortrix viridana is not known to occur in the United States. Risks associated with *T. viridana* have been evaluated for North American forests. The insect was considered of high risk, but this rating was very uncertain (Ciesla 2003). The potential for environmental impact was considered high, but the potential for establishment, spread and economic-impact were each rated moderate.

Known Hosts

Larvae of *T. viridana* are reported predominantly as feeders of oak foliage, but may also feed on other tree and woody plant species. *Tortrix viridana* has a preference for *Quercus robur* and *Q. pubescens* (Novotný et al. 1990).

Hosts	**References**
Acer sp. (maple)	(Zhang 1994, Meijerman and Ulenberg 2000, Ciesla 2003, CAB 2006)
Acer monspessulanum (Montpellier maple)	(CAB 2006)
Carpinus sp. (hornbeam)	(Zhang 1994, Meijerman and Ulenberg 2000, Ciesla 2003)
Carpinus betulus (hornbeam)	(CAB 2006)
Corylus avellana (hazel)	(CAB 2006)
Fagus sp. (beech)	(Zhang 1994, Meijerman and Ulenberg 2000)
Fagus sylvatica (beech)	(Ciesla 2003)
Fraxinus angustifolia (narrow-leaved ash)	(CAB 2006)
Juniperus sp. (juniper)	(CAB 2006)
Picea abies (common spruce)	(CAB 2006)
Populus sp. (poplar)	(Zhang 1994, Meijerman and Ulenberg 2000, Ciesla 2003)

Hosts	References
Quercus spp. (oak)	(Ellis 1946, Ortiz and Templado 1976, Speight 1985, Tiberi and Roversi 1990, Van der Geest and Evenhuis 1991, Markov 1993, Zhang 1994, Du Merle 1999b, Meijerman and Ulenberg 2000, Matosevic 2001)
Quercus canariensis (Algerian oak)	(CAB 2006)
Quercus cerris (European turkey oak)	(Zhang 1994, CAB 2006)
Quercus faginea (Lusitanian oak)	(CAB 2006)
Quercus frainetto (Hungarian oak)	(CAB 2006)
Quercus iberica	(CAB 2006)
Quercus ilex (holm oak)	(Du Merle and Pinguet 1981, Du Merle 1982, Van der Geest and Evenhuis 1991, Du Merle 1999b, Ciesla 2003, CAB 2006)
Quercus imeretina	(CAB 2006)
Quercus petraea (durmast oak)	(Horstmann 1977, Hunter 1990, Van der Geest and Evenhuis 1991, Stocki 1994, Ciesla 2003, CAB 2006)
Quercus pubescens (downy oak)	(Du Merle and Pinguet 1981, Du Merle 1982, Novotný et al. 1990, Du Merle 1999b, CAB 2006)
Quercus pyrenaica (black oak)	(Van der Geest and Evenhuis 1991, CAB 2006)
Quercus robur (common oak)[1]	(Horstmann 1977, Winter 1984, Hunter and Willmer 1989, Hunter 1990, Novotný et al. 1990, Van der Geest and Evenhuis 1991, Stocki 1994, Rubtsov 1996, Hunter et al. 1997, Ciesla 2003, CAB 2006)
Quercus rubra (northern red oak)	(Van der Geest and Evenhuis 1991, Stocki 1994)
Quercus sessiliflora	(Du Merle 1999b)
Quercus suber (cork oak)	(Van der Geest and Evenhuis 1991, Du Merle 1999b, Ciesla 2003, CAB 2006)
Quercus trojana (Macedonian oak)	(CAB 2006)
Rhododendron sp.	(Zhang 1994)
Rubus idaeus (raspberry)	(Meijerman and Ulenberg 2000, CAB 2006)
Salix sp. (willow)	(Zhang 1994, Meijerman and Ulenberg 2000)
Urtica sp. (nettle)	(Meijerman and Ulenberg 2000)
Vaccinium sp. (blueberry)	(Zhang 1994, Meijerman and Ulenberg 2000)

1. Rubtsov (1996) recognized two "phenoforms": late oaks (*Quercus robur* var. *tardiflora*) and early oaks (*Quercus robur* var. *praecox*)

Known Distribution

Tortrix viridana is reported from:

Africa: Algeria, Morocco, and Tunisia; **Asia:** Azerbaijan, Cyprus, Georgia, Iran, Israel, Syria, Russia, Tajikistan, and Turkey; **Europe:** Albania, Andorra, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, and United Kingdom

(Ortiz and Templado 1976, Arn et al. 1979, Knauf et al. 1979, Du Merle and Pinguet 1981, Du Merle 1982, 1999b, Schneider 1984, Winter 1984, Speight 1985, Hunter and Willmer 1989, Fazeli and Abai 1990, Hunter 1990, Novotný et al. 1990, Tiberi and Roversi 1990, Markov 1993, Stocki 1994, Rubtsov 1996, Hunter et al. 1997, Meijerman and Ulenberg 2000, Matosevic 2001, Ciesla 2003, Zhang 1994, CAB 2006, Aarvik 2011, CABI 2012).

Pathway

This species has been intercepted five times at U.S. ports of entry. All five inteceptions occurred at airports. This species has only been intercepted once on plant material (*Quercus* sp.); the other inteceptions occurred on miscellaneous material. Most of the interceptions originated on material from Germany (3) (AQAS 2013, queried January 30, 2013). Ciesla (2003) states that pupae could move through exports of logs or other wood products while eggs could move on nursery stock.

If this species were to be introduced into the United States, natural spread could occur through short distance flight of adults or air current movement of larvae (Ciesla 2003).

Potential Distribution within the United States

Based on where *T. viridana* has been reported worldwide, we predict that the species is most closely associated with biomes characterized as temperate coniferous forest or Mediterranean scrub. Collectively these two biomes account for 20% of the area within the contiguous United States. The biomes occur along the coastal west; Pacific northwest, higher elevations in the intermountain west, and coastal southeast. A specialized environment will be required for establishment of this insect because cold temperatures are of unique importance. The environment must provide an adequate number of chilling days for the insect to complete diapause; however, springs must be reliably warm to prevent young larvae from dying due to a spring freeze.

A recent risk analysis by USDA-APHIS-PPQ-CPHST illustrates the abundance of host material in the eastern as well as portions of the western United States.

Survey

CAPS-Approved Method*:
The CAPS-approved method is a trap and lure combination. The trap is a wing trap kit. The lure is effective for 28 days (4 weeks).

Any of the following Trap Product Names in the IPHIS Survey Supply Ordering System may be used for this target:

Wing Trap Kit, Paper
Wing Trap Kit, Plastic

The Lure Product Name is "*Tortrix viridana* Lure."

<u>IMPORTANT:</u> Placing lures for two or more target species in a trap should never be done unless otherwise noted here.

<u>Trap spacing:</u> When trapping for more than one species of moth, separate traps for different moth species by at least 20 meters (65 feet).

*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at http://caps.ceris.purdue.edu/.

Literature-Based Methods:
Visual sampling can be used to detect populations of *T. viridana,* but this method is not generally recommended. Severe infestations can cause extensive defoliation and stunting of trees (see 'Symptoms' above). However, many of these symptoms can be caused by other oak defoliators. Other established tortricids may also roll leaves. Infestations of *T. viridana* can be difficult to confirm because larvae tend to occupy the upper canopy (Bogenschütz 1991). Visual sampling for eggs is difficult and subject to errors.

Pheromones have been identified for *T. viridana* (El-Sayed 2005). Pheromone-baited traps are extremely useful to detect the presence of the species, but may have limited utility to accurately estimate population abundance (reviewed in CAB 2006). The primary component of the sex pheromone for *T. viridana* is (Z)-11-tetradecenyl acetate, which is an effective single-compound attractant for the species (Arn et al. 1979, Knauf et al. 1979). The pheromone for the red banded leaf roller, *Argyrotaenia velutinana*, is comprised of a 2:3 ratio of (Z)-11-tetradecenyl acetate and dodecyl acetate, which attracts *T. viridana* (Hrdý et al. 1979). This blend is available commercially. Novotný (1990) noted that (Z)-11-tetradecenyl acetate in a 9:1 ratio with (Z)-11-tertadecnol attracted two to five times as many males as (Z)-11-tetradecenyl acetate alone.

The pheromone is effective with several trap types (Novotný et al. 1990), Pherocon 1C traps are common (Hrdý et al. 1979). Trap color has no affect on the number of captured males (Schneider 1984). Traps should be attached to the trunk of a tree or hung from a branch, placing the trap at eye level, approximately 1.5 m [5 ft] above ground (Bogenschütz 1991). Pheromone should be dispensed from rubber septa loaded with 1 mg of attractant (Hrdý et al. 1979). Traps should be separated by at least 50 m [~160 ft] (Hrdý et al. 1979).

Traps baited with pheromone for *T. viridana* (presumably (Z)-11-tetradecenyl acetate though not specified) may also attract: *Ptycholoma lecheana*, *Archips xylosteana*, *Archips crataegana*, *Aleimma loeflingiana*, *Choristoneura hebenstreitella*, and *Croesia bergmanniana* (Tiberi and Roversi 1990).

Traps with the pheromone blend for red banded leaf roller may also attract *Aphelia paleana*, *Archips xylosteana*, *Argyrotaenia pulchellana*, and *Eupoecilia angustana* (Hrdý et al. 1979).

Key Diagnostics

CAPS-Approved Method*:

Confirmation of *T. viridana* is by morphological identification.

*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at http://caps.ceris.purdue.edu/.

Easily Confused Pests

This pest is easily identified, *Tortrix viridana* is bright green and there are no similar-looking species in North America. There are no similar-looking species in North America.

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