Adoxophyes orana

Figure 1. *Adoxophyes orana* adult male. Courtesy of Todd M. Gilligan and Marc E. Epstein, CSU, Bugwood.org.

Scientific Name
Adoxophyes orana Fischer von Roeslerstamm

Synonyms:
Adoxophyes reticulana, Capua reticulana, Cacoecia reticulana, Capua orana, Tortrix orana, Tortrix reticulana, Capua congruana, Adoxophyes tripsiana, Adoxophyes fasciata, Adoxophyes congruana, and *Acleris reticulana.*

Common Name
Summer fruit tortrix, reticulated tortrix, apple peel tortricid

Type of Pest
Moth

Taxonomic Position
Class: Insecta, **Order:** Lepidoptera, **Family:** Tortricidae

Reason for Inclusion in Manual
CAPS Target: AHP Prioritized Pest List – 2006 through 2013

Pest Description
Eggs: Females lay yellow egg masses of 30 to 50 eggs [3 to 10 mm ($^{1}/_{8}$ to $^{3}/_{8}$ in.) in diameter] on the surfaces of the leaves in early spring (Fig. 2). The eggs are easily observed in the inner parts of the tree top (Dickler, 1991). The greenish larvae hatch and leave behind transparent egg shells (CABI, 2012).

Larvae: Mature larvae are 18 to 22 mm ($^{11}/_{16}$ to $^{7}/_{8}$ in.) long and greenish in color with light hairs and warts (Fig. 2). The head is light brown to brownish yellow (sometimes somewhat spotted due to white blotches on the first, second, and sixth stemmata in fresh specimens) as is the thoracic shield and the anal shield. The anal comb is very fine and long with light colored teeth. The thoracal legs are brown to black. The head is long and wide. Abdominal and anal prolegs are greenish (Sakamaki and Hayakawa, 2004; CABI, 2012). When disturbed, the larvae spin a silken thread and descend to escape. This thread is also a possible method for movement via wind.

Figure 2. Left:*A. orana* larva; Right: *A. orana* egg mass. Photos courtesy of Coutin R./OPIE.

<u>Pupae</u>: The pupae of *A. orana* are initially greenish brown to light brown but become dark brown towards the time of adult emergence. The length is between 8 and 11 mm ($^{5}/_{16}$ to $^{7}/_{16}$ in.). Sakamaki and Hayakawa (2004) found lengths between 8.5 and 12 mm ($^{5}/_{16}$ to $^{1}/_{2}$ in.). The posterior margin of abdominal segments 2 to 8 of the pupae contains very small bristles. These bristles cannot be distinguished with a regular magnifying glass and are hence visible as a line. The specific forkshape of wing veins 7 and 8 is already visible in the pupal stage.

<u>Adults</u>: Adults (Fig. 1, 3) range from a dull grayish brown (female) to yellowish brown (male) with a variable dark-brown marking pattern and a 15 to 19 mm ($^{9}/_{16}$ to $^{3}/_{4}$ in.) (male) or 18 to 22 mm ($^{11}/_{16}$ to $^{7}/_{8}$ in.) (female) wingspan (Bradley et al., 1973). Dickler (1991) reports the wing span of the adult moth measuring from 16 to 22 mm ($^{5}/_{8}$ to $^{7}/_{8}$ in.). Adult males are smaller and more brightly colored than adult females.

A very specific characteristic of *A. orana* is the fork-shaped structure of the wing veins 7 and 8. The forewing of the female is rather dull grayish brown, while in the male the coloration is brighter and is a yellowish brown. Sexual dimorphism is pronounced; antenna of male shortly ciliate, forewing with broad costal fold from base to about one-third, markings usually conspicuous, contrasting with paler ground color; female usually larger, antenna minutely ciliate, forewing without costal fold, with darker general coloration and less contrasting markings (Bradley et al., 1973).

Biology and Ecology

Two generations occur per year in central Europe in apple orchards. The generations may overlap. A partial third generation is possible if warm temperatures persist in the fall. In Belgium, the generations usually occur from the end of May until the beginning of August and from August until mid-September. Cross (1994) describes the life cycle of the summer fruit tortrix in the United Kingdom. The first generation of larvae hatch from batches of eggs laid on the undersides of leaves in mid-June. The larvae graze on leaves and characteristically feed within a protective silk mesh. After undergoing five larval instars, the larvae pupate. The adult moths fly on warm August evenings and lay their eggs directly on the surface of fruit and leaves. The second generation of larvae hatches in August and feeds mainly on the fruit. They overwinter as second or third instars in silk cocoons in crevices in the bark. They become active again in the warmer spring months and pupate to emerge as moths in May and June (Cross, 1994).

Three to four generations occur in northern Greece in peach orchards. *Adoxophyes orana* overwinters in bark crevices as a third instar and emerges in the spring to feed on flower buds (Milonas and Savopoulou-Soultani, 2000). Larval activity begins in early spring (March) and is completed by the end of April. *Adoxophyes orana* has a facultative diapause that occurs in response to decreasing photoperiods at the end of October (Milonas and Savopoulou-Soultani, 2004). Each year adult activity occurs in early May or after 418 degree days have accumulated from February 1st, when diapauses development is completed (Milonas and Savopoulou-Soultani, 2006). Two additional adult flights occur during July and from late August until mid-September.

Figure 3. Top: Adult *A. orana* (female top, male bottom). Courtesy of Coutin R./OPIE. Bottom: An *A. orana* adult male feeding on a host leaf. Note the prominent costal folds. Courtesy of Jae-Cheon Sohn, Bugwood.org

Flight periods last for approximately four weeks (Barel, 1973). Moths fly at temperatures above 12°C (54°F) and are typical night fliers with maximum activity around midnight (Minks and Noordink, 1971). Males precede females in flight by a few days and may disperse up to 400 meters (1,300 feet). Female dispersal is limited (Barel, 1973). Mating occurs at night or in the early morning hours about a day after emergence (De Jong et al., 1971; Whittle, 1985; Van der Kraan and van der Straten, 1988; He et al., 1996). *Adoxophyes orana* typically mates once (50 to 60% of the time) but can mate two or more times (Minks and Noordink, 1971).

The number of eggs per female is quite variable and temperature dependent (Charmillot et al., 1984). Charmillot et al. (1984) found that females produced on average 271.1 eggs in a 25°C (77°F) temperature cabinet and 328.6 eggs in an insectary. Janssen

(1958) observed similar numbers; while De Jong and Van Dieren (1974) recorded 160 to 329 eggs per female. Van der Kraan and ver der Straten (1998) conducted a study where egg production ranged from 20 to 560, with an average of 292. Although the temperature development threshold is 10.6°C (51°F) for eggs (De Jong et. al., 1965), most eggs are laid at temperatures above 13°C (55°F) (Ankersmit et al., 1976). Egg mortality is common at temperatures at or below 13 to 14°C (55 to 57°F) (Ankersmit et al., 1976). On average the lifespan of the females ranged from 3 to 22 days (14.6 days on average) (van der Kraan and van der Straten, 1988).

Figure 4. Top: Damage to apple epidermis showing "gnawed" appearance. Bottom: Damage to pear foliage and fruit. Photos courtesy of R. Coutin/OPIE.

According to Charmillot and Megevand (1983), laboratory and field tests have shown that the threshold temperature for eggs is 10°C (50°F), while those for summer and overwintering larvae are 7 to 8°C (45 to 46 °F) and 10°C, respectively. The threshold for development of pupae is slightly over 10°C. The duration of embryonic and pupal phases is 90 degree days above 10°C. The summer larval phases last an average of 430 degree days above 7°C (Charmillot and Megevand, 1983). Milonas and Savopoulou Soultani (2000) examined the effect of temperature (14, 17, 21, 25, and 30°C (57, 63, 70, 77, and 86°F)) on development, survival, fecundity, and longevity on *A. orana.* The optimal temperature for development was 25°C (77°F). Total developmental time ranged from 50.2 days at 14°C (57°F) to 20.7 days at 25°C (77°F). On average, 333.3 degree days were required for total larval development. The mean longevity for females was 13.5 days at 14°C and 7.6 days at 30°C (86°F); whereas for males mean longevity ranged from 14.9 days at 21°C (70°F) and 7.9 at 30°C. Females laid the fewest eggs (70.6) at 14°C. Extreme temperatures had a negative effect on all life table parameters.

Damage

Visible damage is similar on all stone fruit hosts. External feeding is visible on leaves and fresh growth of twigs. Feeding can deform leaves and create areas with necrosis (dead tissue). Damaged flesh heals leaving 'corky' scars (Fig. 4). Leaves may appear wilted, yellow, shredded, or dead. Leaves are likely to be rolled or folded and held together with silk webbing. Larval feeding on new growth of twigs will leave lesions. If the insect is feeding on flowers, external feeding damage and silk webbing will be evident. In all areas where the insect has fed, frass (excrement) should also be visible. Typically, *A. orana* spins a leaf against a fruit. The larva is often found in between these two plant structures, and fruit damage is mostly found where a leaf is attached to the fruit (CABI, 2012).

On apples, it can be expected that damage from the first generation will result in large deep holes, whereas the second generation produces small holes of less than 5 mm (0.20 in.) in diameter (CABI, 2012).

Summer [LJ1]generatio[MDZ-A2]n larvae feed extensively and severely damage fruit. Feeding on fruits or pods causes scabs or pitting, and frass may be present. On fruit crops, larvae prefer to feed sheltered under a leaf bound to fruit and silk.

Pest Importance

The summer fruit tortrix moth has become a serious pest in peach and cherry orchards in northern Greece in the last 20 years (Milonas and Savopoulou-Soultani, 2006). In central and northern Europe, it is considered to be an important pest of apple orchards. *Adoxophyes orana* is not host-specific as it reportedly feeds and develops on more than 50 plant species in multiple families. Potential host plants, both cultivated and wild, are common in the United States and often occur at high densities (Davis et al., 2005).

The larvae feed on both foliage and fruit. Damage to foliage is insignificant, but damage to fruit can be serious. *Adoxophyes orana* can cause damage to more than 50% of fruit in an infested orchard. Well-managed orchards with a lot of young shoots can be particularly infested. Secondary fungal infection is also common where insect damage has occurred.

A. orana is listed as a harmful organism in the following ten countries: Canada, Chile, Colombia, Ecuador, India, Israel, Japan, Peru, Taiwan, and Thailand (USDA-PCIT, 2014). There may be trade implications with these countries if this moth becomes established in the United States.

Known Hosts

Although the host range includes more than 50 plant species in multiple families, *A. orana* feeds preferentially on apples, pears, stone fruit, and other Rosaceous hosts.

Major hosts

Cydonia oblonga (quince), *Malus* spp. (apple), *Prunus armeniaca* (apricot), *Prunus avium* (sweet cherry), *Prunus domestica* (plum), *Prunus persica* (peach), *Pyrus* spp. (pear), and *Rubus* spp. (raspberry).

Minor hosts

Acer spp. (maple), *Alnus* spp. (alder), *Arachis hypogaea* (peanut)**,** *Beta* spp. (beet), *Betula* spp. (birch), *Carpinus* spp. (hornbeam), *Castanea crenata* (Japanese chestnut), *Castanopsis fissa* (evergreen chinkapin), *Chenopodium album* (lambsquarters), *Citrus* spp. (citrus), *Convolvulus arvensis* (field bindweed), *Corylus* spp. (hazelnut), *Cotoneaster dielsianus* (cotoneaster), *Crataegus* spp. (hawthorne), *Dimocarpus longan* (longan)**,** *Diospyros* spp. (persimmon), *Eriobotrya* spp. (loquat), *Fagus sylvatica* (beech), *Ficus* spp. (fig), *Forsythia suspensa* (forsythia), *Fragaria* spp. (strawberry), *Fraxinus* spp. (ash), *Glycine max* (soybean), *Gossypium* spp. (cotton), *Humulus* spp. (hops), *Laburnum* spp. (laburnum), *Ligustrum spp.* (privet), *Litchi chinensis* (litchi), *Lithocarpus glaber* (Japanese oak), *Lonicera* spp. (honeysuckle), *Malus* spp. (crabapple), *Medicago* spp. (alfalfa), *Menyanthes trifoliate* (buckbean), *Morus* spp. (mulberry), *Olea* spp. (olive), *Parrotia* spp. (ironwood), *Physalis peruviana* (Peruvian groundcherry), *Pistacia* spp. (pistachio), *Populus* spp. (poplar), *Potentilla* spp. (cinquefoil), *Prunus cerasus* (sour cherry), *Prunus padus* (European bird cherry), *Prunus salicina* (Japanese plum), *Prunus triloba* (almond tree), *Punica* spp. (pomegranate), *Quercus* spp. (oak), *Rhododendron catawbiense* (Catawba rosebay), *Ribes* spp. (currant), *Rosa* spp. (rose), *Rubus* spp. (blackberry), *Rumex* spp. (dock), *Salix* spp. (willow), *Solanum* spp. (nightshade), *Sorindeia juglandifolia* (damson), *Symphoricarpos* spp. (snowberry), *Syringa* spp. (lilac), *Tilia* spp. (basswood), *Ulmus* spp. (elm), *Urtica* spp. (nettle), *Vaccinium* spp. (blueberry), *Vicia faba* (faba bean)*,* and *Vitis vinifera* (grapevine) (Davis et al., 2005; CABI, 2012).

Pathogen or Associated Organisms Vectored

Adoxophyes orana is not known to be a vector and is not known to be vectored by another organism. Although the damage to the fruit is usually superficial, fungal pathogens can infect the damaged fruit through these wounds and significantly reduce fruit quality (CABI, 2012).

Known Distribution

Asia: Armenia, Azerbaijan, China, Georgia, Japan, and Korea. **Europe:** Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Lithuania, Netherlands, Norway, Poland, Romania, Russia, Serbia, Slovenia, Spain, Sweden, Switzerland, Ukraine, and the United Kingdom (Davis et al., 2005; CABI, 2012).

Pathway

Adoxophyes orana is liable to be transported on fruit or leaf material of hosts. It is not known to be transported on seed, bark, or root material (CABI, 2012). Currently, the import of *Malus* spp. plant material is allowed from Belgium, France, Germany, and the Netherlands, all countries known to have *A. orana*. Import of *Prunus* spp. plant material is also allowed from the Netherlands. In addition, the import of *Rubus* spp. plant material is currently allowed from the United Kingdom (USDA, 2013).

Since 2004, there have been 13 shipments of *Prunus* spp. plant material from the Netherlands. The largest of these shipments contained over 46,000 plant units. During this time, there have also been shipments of *Malus* spp. plant material from the Netherlands (112), France (59), Belgium (34), and Germany (23). These shipments contained a combined total of over 11.4 million plant units. There were also 16 shipments of *Rubus* spp. plant material from the United Kingdom (AQAS, 2014).

Since 2004, there have been interceptions at U.S. ports of entry of *Cydonia* spp. (3), *Malus* spp. (285), *Prunus* spp. (135), *Pyrus* spp. (10), and *Rubus* spp. (88) plant material intended for propagation from known host countries (AQAS, 2014). These interceptions came from 22 different known host countries. Most of the intercepted plant material was found in airline baggage and permit cargo, and a few were also found in mail.

Survey

CAPS-Approved Method*:

The CAPS-approved method is a trap and lure combination. The trap is a paper delta trap with 2 sticky sides. The lure is effective for up to 84 days (12 weeks).

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

Paper Delta Trap, 2 sticky sides, Brown
Paper Delta Trap, 2 sticky sides, Green
Paper Delta Trap, 2 sticky sides, Orange

The trap should be used with the ends left open. Trap color is up to the State and does not affect trap efficacy. The Lure Product Name is "*Adoxophyes orana* Lure."

IMPORTANT: Do not place lures for two or more target species in a trap unless otherwise recommended.

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

Survey Site Selection: Fruit trees in the family Rosaceae are the preferred host of this moth.

Time of year to survey: In European host countries, adults are present from late May to late June (first generation), late July to early September (second generation), and October (third generation).

*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:

Trapping: Several monitoring techniques have been developed and applied to *A. orana*. The most effective approach involves sex pheromone-baited traps. The sex pheromone is a blend of (*Z*)-9-tetradecenyl acetate and (*Z*)-11-tetradecenyl acetate (Tamaki et al., 1971; Meijer et al., 1972). These two compounds are most attractive to males in a 9:1 blend of (*Z*)-9:(*Z*)-11 isomers; *E*-isomers of either compound had a strong inhibitory effect (Minks and Voerman, 1973; Davis et al., 2005). The 9:1 pheromone blend is available commercially as Adoxomone (Murphy PheroconTM Summer Fruit Tortrix Moth Attractant) for use with Pherocon 1C traps. Den Otter and Klijnstra (1980) showed that male *A. orana* not only respond to the mixture of these components but also to its separate components. The authors speculated that that the sex pheromone released by females contains more than two components, because copulation behavior is not seen with the synthetic pheromone but readily occurs in the presence of virgin females. Guerin et al. (1986) identified twelve products related to the sex pheromone main components (*Z*)-9- and (*Z*)-11-tetradecenyl acetate (*Z*9-14:Ac and *Z*11-14:AC, respectively). These were the geometric isomers and the alcohols of the main components, (*Z*)-9-dodecnyl acetate, (*Z*)-11-hexadecenyl acetate, and saturated acetates of 12 to 22 carbons. The addition of either of the two alcohols to a blend of the two acetates augmented trap catch in the field (Guerin et al., 1986; Yang et al., 2009). Temperatures below 12°C (54°F) lower flight activity and also trap catches (Minks and Noordink, 1971).

Milonas and Savopoulou-Soultani (2006) installed three Pherocon pheromone traps during the vegetative period in peach, apple, cherry, and pear orchards in Greece. Traps were baited with sticky inserts loaded with synthetic sex pheromone. Traps were checked at weekly intervals, and pheromone lures and trap bottoms were changed every 4 weeks. Polyethylene caps treated with 100 µg of the pheromone blend remained effective for over 7 weeks (Minks and Voerman, 1973).

<u>Visual survey:</u> Visual sampling and beat sampling may also be used to inspect plants for eggs and larvae. Eggs may be observed on the stems and leaves; late instars may be found in the crown on new shoot growth; and pupal cocoons may be found in leaves, on stems, or in mummified pods/seeds. Both methods are time consuming. Visual sampling or beat sampling are not commonly recommended (Davis et al., 2005).

In the spring (end of April), *A. orana* can be surveyed by sampling flower clusters just before the bloom of apple. This sampling is labor intensive, because it is often necessary to examine a large number of clusters and because identification of the larvae is often difficult (Charmillot and Brunner, 1989). Sampling for the summer generation larvae is easier because the damage is easily visible when third instar larvae and older begin to roll the leaves. In Switzerland, the first damage on shoots is apparent from the end of June to the end of July about 200 degree days after the start of the first flight (Charmillot and Brunner, 1989). Fruit can also be sampled in August and September by looking for small holes in fruit from the feeding of the third instar larvae. A visual examination of about 2,000 fruit at harvest can be used to show damage from the first and second generation of *A. orana* (Charmillot and Brunner, 1989).

Trap placement: Milonas and Savopoulou-Soultani (2006) installed traps 2 m (6.5 ft) above the ground in a shaded part of the canopy.

Milonas and Savopoulou-Soultani (2006) cut two shoots at weekly intervals randomly from four sides (N, S, E, W) of trees during the vegetative period from April until October. Thirty-two trees were randomly chosen and eight 30-cm (11.81 in.) long shoots were cut from each tree from the beginning of plant development. Shoots were examined in the laboratory using a stereoscope. Ripe fruits were also sampled randomly from the orchard and examined in the laboratory for superficial damage caused by *A. orana* larvae.

Not recommended: Robinson light traps with 125W mercury vapor bulbs, 125 W black light bulbs, or 100W flood lights have been used. While sex pheromone traps attract males of a targeted species, light traps nonselectively draw in many flying insects.

Key Diagnostics/Identification

CAPS-Approved Method*:

Confirmation requires a morphological identification. Gilligan (2014) has developed a screening aid for use in the CAPS program. This aid will be posted on the CAPS website soon.

Adoxophyes orana may occur in mixed populations with other morphologically similar species, including other *Adoxophyes* species. Final identification is by dissection of male genitalic structures.

*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 Species

Adoxophyes orana very closely resembles two U.S. species, *Adoxophyes furcatana* and *A. negundana*, but there are slight differences in male genitalia. Any identification should be confirmed by an appropriately trained entomologist.

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Revisions

June 2014

1) Revised the **Pest Importance** section.
2) Revised the **Biology/Ecology** section.
3) Revised the **Pathway** section.
4) Updated the NAPPFAST map to a more recent Pareto risk map.
5) Revised the **Key Diagnostics/Identification** section based on Gilligan (2014).

August 2016

1) NAPPFAST map removed.