KEY TO LARVAE OF *CASTANEA*-FEEDING OLETHREUTINAE FREQUENTLY INTERCEPTED AT U.S. PORTS-OF-ENTRY
(LEPIDOPTERA: TORTRICIDAE)

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Abstract – At least six species of olethreutine moths are common pests of chestnut (*Castanea* spp.) outside of the United States. Three are native to, or naturalized in the Mediterranean Region of Europe: *Pammene fasciana* (L.), *Cydia splendana* (Hübner) and *Cydia fagiglandana* (Zeller). Three are native to the Far East: *Eucoenogenes aestuosa* (Meyrick), *Cydia kurokoi* (Amsel), and *Cydia glandicolana* (Danilevsky). Commercial chestnuts imported into the U.S. from these regions are fumigated routinely to prevent entrance of these and other pests. However, larvae of these species frequently are encountered by agricultural inspectors at ports-of-entry in personal baggage and other cargo. A key to the larvae of these six species is presented, along with summary descriptions and select references on their biology, detection, and control in association with chestnuts.

Key words: chaetotaxy, chestnuts, China, *Cydia*, distribution, *Eucoenogenes*, Europe, Fagaceae, Far East, immature stages, India, introductions, invasive species, Iran, Italy, Japan, Korea, larvae, Nearctic, Netherlands, New Zealand, *Pammene*, Portugal, Russia, Spain, Turkestan, United Kingdom, Valsaceae.

The American chestnut (*Castanea dentata* (Marsh) Borkh.; Fagaceae) formerly was one of the most common forest trees in eastern North America, ranging from Maine to Michigan and south to Louisiana. It was prized for its lumber and nuts. In about 1904, a disease known as chestnut blight, caused by a fungus (*Cryphonectria parasitica* (Murrill) Barr; Valsaceae), was inadvertently introduced into New York. It spread rapidly throughout the eastern United States virtually eliminating the species as a canopy tree by the mid 1930s (Anagnostakis, 1972). Subsequently, several foreign chestnut trees were introduced into the United States, including the European chestnut (*Castanea sativa* Mill.), the Japanese chestnut (*Castanea crenata* Siebold & Zucc.), and the Chinese chestnut (*Castanea mollissima* Blume). These three species are comparatively tolerant or resistant to chestnut blight.

Domestic production of chestnuts does not meet U.S. demands; consequently, each year tons of commercial chestnuts are imported from abroad. Based on data from the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) (pers. comm.), in 1998 approximately 2,872,006 kilograms (over 3,000 tons) were imported, primarily from Northern Hemisphere countries. The main geographic sources were the Mediterranean Region of Europe (Spain, Portugal, and Italy) and the Far East (China and Korea) (Table 1). Imported chestnuts are treated routinely with methyl bromide to prevent the entry into the United States of non-native weevils (Coleoptera: Curculionidae) and moths (primarily Tortricidae). However, based on inspections of personal baggage and other cargo, it is likely that hundreds of kilograms of chestnuts enter this country illegally, undetected, and untreated every year (Table 2).

The larvae of several Olethreutinae (Tortricidae) are encountered by APHIS personnel when untreated chestnuts are intercepted at quarantine facilities at U.S. ports-of-entry. Historically, most of these larvae have been identified as either *Pammene fasciana* (Linnaeus) or *Cydia splendana* (Hübner); Weisman's (1986) key, widely used by APHIS personnel, includes *P. fasciana* (from Europe), *C. splendana* (from Europe), and *Cydia* spp. (from Europe and Asia). Recent work has shown that none of the three major European pests of chestnuts is found in Asia, where three other species frequently infest this crop (Komai & Ishikawa 1987). The purpose of this paper is to present a key to the larvae of the six *Castanea*-feeding Olethreutinae frequently intercepted at U.S. ports-of-entry, along with brief descriptions of the larvae and select references to information on biology, detection, and control of these species in association with chestnuts.

Before using the key, non-tortricid Lepidoptera can be eliminated by the following characters (also see Fig. 1). All tortricids infesting *Castanea* have a trisetose L-group on the prothorax (Fig. 1, T1); species with a bisetose L-group may be Pyrlaoidea, Noctuoidea, or Carposinidae. All tortricid larvae have L1+L2 close together on abdominal segments 1-8, usually on the same pinaculum (Fig. 1); in Tineoidea and Yponomeutoidea the Ls are distant from each other. Finally, in all tortricid pests of *Castanea* (and Tortricidae in general), SD1 is located anterior or only slightly dorso-anterior to the spiracle on abdominal segment 9; this is in contrast to the condition in most Gelechioidea where it is dorsal to the spiracle.

TABLE 1. Chestnut imported into the United States for fiscal year 1998. Source: USDA/APHIS/PPQ, Riverdale, Maryland.

COUNTRY	# SHIPMENTS	KILOGRAMS
China	6	41,454
Italy	112	1,526,252
Korea	67	1,083,872
Netherlands	2	6,000
New Zealand	1	180
Portugal	15	55,208
Spain	8	159,040
TOTAL	**211**	**2,872,006**

TABLE 2. Number of interceptions of illegally imported *Castanea* infested with Olethreutinae larval sent to USDA for identification. Source: USDA, Systematic Entomology Laboratory database (SELIS).

COUNTRY	# 1998	# 1999	# 2000
Bosnia	1	0	0
China	0	0	1
Fiji	1	0	0
France	0	0	4
Germany	0	1	1
Greece	4	3	1
Iran	0	0	1
Italy	13	5	4
Japan	0	0	1
Korea	11	6	3
Macedonia	1	0	0
Portugal	4	0	0
Romania	1	2	0
Singapore	0	1	0
Turkey	0	0	2
TOTALS	**36**	**18**	**18**

KEY TO LARVAE OF *CASTANEA*-FEEDING OLETHREUTINAE

1 From Europe (primarily Portugal, Spain, Italy, Greece)...........2
1' From Asia (primarily Korea, Japan, China)..............................4
2 Anal fork present (Fig. 2), pinacula extremely large, dark.... ....*Pammene fasciana*
2' Anal fork absent, pinacula usually moderately small................3
3 Body whitish, pinacula mostly concolorous with body; distance between Vs on A9 slightly to conspicuously greater than that between Vs on A8 (Fig. 3b); number of crochets on prologs usually less than 18......................................*Cydia splendana*
3' Body reddish white, pinacula red; distance between Vs on A9 usually about the same as (sometimes slightly greater than) that between Vs on A8 (Fig. 3a); number of crochets on prologs usually more than 18.......................*Cydia fagiglandana*
4 SV-group on A9 bisetose (Fig. 4a); head dark brown, often with darker maculations; crochets biordinal..*Eucoenogenes aestuosa*
4' SV-group on A9 unisetose (Fig. 4b), head yellowish brown, without maculations; crochets mostly uniordinal......................5
5 Body red, pinacula inconspicuous, concolorous with body; 19-26 crochets on abdominal prolegs..........*Cydia glandicolana*
5' Body whitish, pinacula conspicuous, darker than body; 25-35 crochets on abdominal prolegs.............................*Cydia kurokoi*

BRIEF DESCRIPTIONS OF *CASTANEA*-FEEDING LARVAE

The following descriptions are based on a combination of published literature and personal examination of larvae by the authors. Additional details of the morphology and biology of European species can be found in Swatschek (1958) and Bradley *et al*. (1979), and the Asian species in Komai and Ishikawa (1987). Terminology for larval characters follows Stehr (1987). The SV formula (i.e., SV-group) refers to abdominal segments 1, 2, 7, 8, and 9.

Cydia splendana **(Hübner)**
Head light yellowish brown; prothoracic and anal shields yellow; body grayish green or yellowish white, pinacula concolorous with body. SV-group 3:3:2:1:1; crochets on prolegs uniordinal, 15-19; crochets on anal proleg 7-9; L3 sometimes slightly separated from L2+L1 pinaculum on A9; distance between Vs usually slightly greater on A9 than on A8 (Fig. 3b); D2s often on separate pinacula on A9; anal fork absent. Although reported from chestnuts world-wide, Komai and Ishikawa (1987) present compelling evidence that this species is restricted primarily to Europe (ranging east to northern Iran and the Ural Mountains) and does not occur in the Far East. As with most of the species treated here, it has been recorded from *Quercus* spp. (Fagaceae) as well as *Castanea* (Bradley *et al*., 1979).
References: Swatschek (1958), Bradley *et al*. (1979), Rotundo

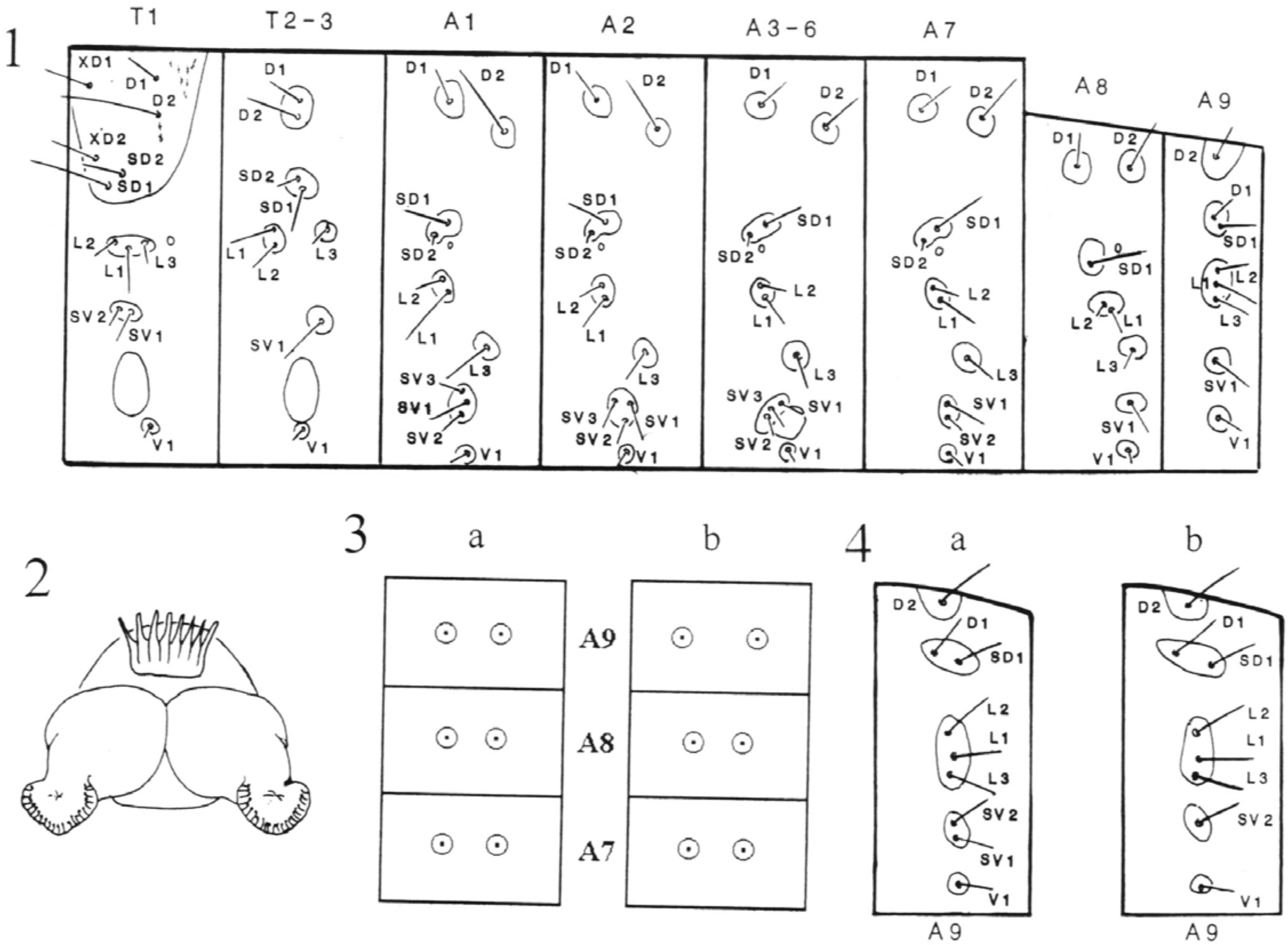

Fig. 1-4. Features of the larvae of *Castanea*-feeding Olethreutinae. 1, Chaetotaxy of *Cydia gladicolana* (from Komai & Ishikawa, 1987); 2, Last abdominal segment of *Pammene fasciana* illustrating presence of anal fork; 3, Venter of abdominal segments 7, 8, and 9 illustrating relative positions of V setae: setae about as far apart on A9 as on A8 (3a) and setae farther apart on A9 than on A8 (3b); 4, Lateral view of abdominal segment 9 illustrating two (4a) versus one (4b) seta in the SV-group.

and Giacometti (1986), Komai & Ishikawa (1987), Rotundo *et al*. (1988), Onucar & Ulu (1989), Rotundo and Tremblay (1993), Antonaroli (1995a), Debouzie *et al*. (1996), Den Otter *et al*. (1996), Tsankov *et al*. (1996), Martin *et al*. (1998).

***Cydia fagiglandana* (Zeller)**

Head light brown; prothoracic and anal shields reddish yellow; body whitish, with orange-to-red, suffused, longitudinal stripes, pinacula orange to red. SV-group 3:3:2:1:1; crochets on prolegs uniordinal, 18-21; crochets on anal proleg 11-14; L3 sometimes slightly separated from L2+L1 pinaculum on A9; distance between Vs about the same on A9 as on A8 (Fig. 3a); D2 pinacula not completed fused to each other on A9; anal fork absent. This species is a common pest of *Castanea*, *Fagus*, and *Quercus* (all Fagaceae) throughout much of Europe, ranging south to northern Iran and east to the Trans-Caucasus and the mountains of Turkestan (Bradley *et al*. 1979; Kuznetsov, 1987).

References: Swatschek (1958), Bradley *et al*. (1979), Rotundo and Giacometti (1986), Rotundo and Tremblay (1993), Antonaroli (1995b), Den Otter *et al*. (1996), Soria and Ocete (1996), Martin *et al*. (1998).

***Cydia glandicolana* (Danilevsky)**

Head yellowish brown; prothoracic shield pale yellowish brown, mottled with yellowish brown along posterior margin; anal shield pale yellowish brown, usually without mottling; body yellowish, tinged with red, with inconspicuous, concolorous pinacula (discernible only in mounted specimens viewed under a microscope). SV-group 3:3:2:1:1; crochets on prolegs uniordinal, 19-26 (rarely with fewer); crochets on anal proleg 10-12; on A9, L3 on separate pinacula from L2+L1, or all three L setae on a common pinaculum, or L3 absent (rarely); distance between Vs greater on A9 than on A8 (Fig. 3b); D2 pinacula completely fused to each other on A9; anal fork absent. This species is a major pest of chestnuts in China but has never been found infesting chestnuts in Japan, although the larvae are common in acorns of oaks (*Quercus* spp.) (Komai and Ishikawa, 1987).

References: Komai and Ishikawa (1987), Byun *et al*. (1998).

***Cydia kurokoi* (Amsel)**

Head yellowish brown; prothoracic and anal shields pale yellowish brown, mottled with yellowish brown; body whitish, with conspicuous, darker pinacula. SV-group 3:3:2:1:1; crochets on prolegs uniordinal, 25-35; crochets on anal proleg 11-17; all three L setae on a common pinaculum on A9; D2 pinacula completely fused to each other on A9; distance between Vs greater on A9 than on A8 (Fig. 3b); anal fork absent. This species occurs in China, Korea, and Japan; it is a common pest of chestnuts in Japan (Komai and Ishikawa 1987).

References: Komai and Ishikawa (1987), Byun *et al*. (1998).

***Pammene fasciana* (Linnaeus)**

Head light brown or yellow, with slightly darker mottling; prothoracic shield whitish with dark dots; anal shield brown with darker brown dots; body whitish, with large, gray-brown pinacula. SV-group 3:3:2:2(1):1; crochets on prolegs uniordinal (or irregularly biordinal), 30-33; crochets on anal proleg 21-22; D2 pinacula completely fused to each other on A9; all three L setae on a common pinaculum on A9; distance between Vs greater on A9 than on A8 (Fig. 3b); anal fork present (Fig. 2). This species ranges from Great Britain to Russia; the larvae have been reported from *Quercus*, *Fagus*, and *Castanea*.

References: Swatschek (1958), MacKay (1959) (as *H. juliana*), Bradley *et al*. (1979), Rotundo and Giacometti (1986), Mansilla and Salinero (1993), Rotundo and Tremblay (1993), Antonaroli (1995b), Martin *et al*. (1998).

***Eucoenogenes aestuosa* (Meyrick)**

Head dark brown, often with darker maculations; prothoracic and anal shields dark brown; body grayish yellow, with inconspicuous, concolorous pinacula; D2s and D1+SD1 pinacula large, fused or almost fused on A9; crochets on prolegs biordinal, 37-44; crochets on anal proleg 28-30; SV-group 3:3:2:2:2; all three L setae on a common pinaculum on A9; distance between Vs about the same on A9 as on A8 (Fig. 3a); anal fork absent. This species occurs in northern India, China (Yunnan Province), Korea, and Japan (Komai and Ishikawa, 1987), and is the dominant pest of chestnuts in northern Japan (Takamura, 1974). The larvae are considerably more active than those of other *Castanea*-feeding Olethreutinae.

References: Takamura (1974), Komai and Ishikawa (1987), Byun *et al*. (1998).

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REFERENCES CITED

Anagnostakis, S. A.
1972. Biological control of chestnut blight. *Science* (Washington), 215:446-471.
Antonaroli, R.
1995a. Trials of capture in the area near Moderna of *Cydia splendana* with sexual attractant. Comparison among dispensers. *Inform. Fitopatol.* (Bologna), 45:56-60.
Antonaroli, R.
1995b. Trials of capture in the area near Moderna of *Pammene fasciana* L. and *Cydia fagiglandana* Zeller, chestnut pests, with sexual attractants: 1992-1994. *Inform. Fitopatol*. (Bologna), 45:61-64.
Bradley, J. D., W. G. Tremewan, and A. Smith
1979. *British Tortricoid Moths*. Tortricidae: Olethreutinae. London: Ray Soc. 336pp.
Byun, B., Y. Bae, and K.-T. Park
1998. *Illustrated Catalogue of Tortricidae of Korea (Lepidoptera)*. *In* K.-T. Park (ed.), *Insects of Korea* [2]. Chuncheon: Korea Res. Inst. Biosci. Biotech., Ctr. Insect Syst. 317pp.
Debouzie, D., A. Heizmann, E. Desouhant, and F. Menu
1996. Interference at several temporal and spatial scales between two chestnut insects. *Oecologia* (Berlin), 108:151-158.
Den Otter, C. J., A. De Cristfaro, K. E. Voskamp, and G. Rotundo
1996. Electrophysiological and behavioural responses of chestnut moths, *Cydia fagiglandana* and *C. splendana* (Lep., Tortricidae) to sex attractants and odours of host plants. *J. Appl. Ent*. (London), 120: 413-421.
Komai, F., and K. Ishikawa
1987. Infestation of chestnut fruits in China with two species of the genus *Cydia* (Lepidoptera: Tortricidae). *Japan. J. Appl. Ent. Zool.* (Tokyo), 31:55-62.
Kuznetsov, V. I.
1987. Family Tortricidae (Olethreutidae, Cochylidae) – tortricid moths. *In* G. S. Medvedev (ed.), *Keys to the Insects of the European Part of the USSR. Volume IV. Lepidoptera. Part I*, 279-991. St. Petersburg: Nauka Publ.
Mansilla, J. P., and M. C. Salinero
1993. *Pammene fasciana* L. (Lep., Tortricidae) tortricido precoz del castano (*Castanea sativa* Mill.). *Bol. Sanidad Veget. Plagas* (Madrid), 19:151-157.
Martin, A., P. Baronio, N. Baldassari, and G. Rocchetta
1998. I lepidotteri tortricidi del castagno (*Pammene fasciana* (L.), *Cydia fagiglandana* (Zel.) e *Cydia splendana* (Hb.)) valutati come un'unica entità di danno. *Boll. Ist. Ent. Univ. Bologna*, 52:105-114.
MacKay, M. R.
1959. Larvae of the North American Olethreutidae (Lepidoptera). *Can. Ent*. (Ottawa), Suppl. 10. 338pp.
Onucar, A., and O. Ulu
1989. Faunistic survey studies in chestnut plantations and establishment of control measures against the infectious pest in nuts in Izmir. *Doga Turk Tarim Ormancilik Derg* (Ankara), 13:637-643.
Rotundo, G., and R. Giacometti
1986. Realta e prospettive di lotta alle tortrici delle castagne. *Inform. Agrar*. (Verona), 42:69-72.
Rotundo, G., C. Tonini, G. Guglielmetti, and A. Rotundo
1988. Identification of volatiles from leaves of *Castanea sativa* Miller and electroantennogram responses of *Cydia splendana* Hubn. (Lep., Tortricidae). *Ann. Fac. Sci. Agrar. Univ. Stud. Napoli Portici* (Naples), 21:20-38.
Rotundo, G., and E. Tremblay
1993. Electroantennographic responses of chestnut moths (Lepidoptera: Tortricidae) and their parasitoid *Ascogaster quadridentatus* Wesmael (Hymenoptera: Braconidae) to volatiles from chestnut (*Castanea sativa* Miller) leaves. *Redia* (Rome), 76:361-373.
Soria, F. J., and M. E. Ocete
1996. Principales tortricidos perforadores del fruto del alcornoque en la sierra norte de Sevilla. *Bol. Sanidad Veget. Plagas* (Madrid), 22: 63-69.
Stehr, F. (ed.)
1987. *Immature Insects*. [1]. Dubuque: Kendall/Hunt. 754pp.
Swatschek, B.
1958. *Die Larvalsystematik der Wickler (Tortricidae and Carposinidae)*. Berlin: Akad. Verlag. 269pp.
Takamura, N.
1974. Biology and control of the greenish chestnut moth, *Acroclita aestuosa* Meyrick. *Shokubutsu b_eki (Plant Protection)* (Tokyo), 28):419-424. [In Japanese]
Tsankov, G., P. Mirchev, and R. Giacometti
1996. Tortricoid moth males caught by trap baited with synthetic attractants set in sweet chestnut stands in the Belasitsa Mountains (Bulgaria). *Boll. Lab. Ent. Agrar. Silvestri* (Portici), 51:127-136.
Wiesman, D. M.
1986. Keys for the identification of some frequently intercepted lepidopterous larvae. U.S. Department of Agriculture, APHIS, PPQ, APHIS 81-47. [Unpublished]