1996 Entomology Project Report
Laboratory Services Division
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Biology and Distribution of the Apple Tortrix - *Archips fuscocupreanus* (Lepidoptera: Tortricidae) in Washington State, a Polyphagous Leafroller Pest New to North America

ERIC LAGASA, DAVID HARTLEY[1], AND MINDY ALLEN[2]

BACKGROUND

The apple tortrix (AT), *Archips fuscocupreanus* Walsingham, was first found in North America in 1995, during a Washington State Department of Agriculture (WSDA) exotic pest survey of western Washington State. AT was previously known to occur only in Japan and Korea, where it is an economic pest of apple, pear, and mulberry and also feeds on a broad range of native and introduced plants (Oku 1967).

Adult male specimens of AT were first detected as a "non-target" catch in a 1995 WSDA pheromone trap delimiting survey for cherry ermine moth (CEM), *Yponomeuta padellus* (L.), another recently discovered exotic defoliator species introduced into the Pacific Northwest. Initial identification of AT was provided by J. Powell, of the Essig Museum, UC Berkeley, and subsequently confirmed by D. Adamski, at the USDA Systematic Entomology Laboratory in Washington D.C.

Information on AT biology and economic status is scarce, largely because of its limited distribution (Japan, Korea). Available literature describes AT as one of the 3 or 4 more important species of leafrollers in Japan and subject to control in commercial apple production on a continuing basis. In general, it is a small moth in the leafroller family Tortricidae, with larval "leafrolling" habits similar to many other leaf and fruit damaging pest species in this large family. A summary of AT biology from the Japanese literature includes the following:

- AT is univoltine (one generation per year) and overwinters in the egg stage on the tree in protected areas, primarily on trunks and branches.
- Eggs hatch from early April to early May.
- Larvae feed until mid May to mid June, then pupate on the lower extremities of the tree or in the soil near the trees.
- Adults begin to appear in mid June to early July. Mating takes place and eggs are laid in mid to early July. Eggs overwinter and hatch the next spring.

After AT was identified as a "non-target" catch in the 1995 cherry ermine moth (CEM) survey, examination of available traps found AT in traps from 5 counties in Western Washington (Whatcom, Snohomish, King, Pierce, and Thurston). Unfortunately, some traps that did not capture CEM had been discarded prior to the discovery of AT, making the 1995 catch data somewhat disjunct and incomplete. Regardless, the 1995 survey clearly demonstrated that AT is well established in Western Washington, with over 950 moths counted in CEM traps. Sites and catch numbers for the 1995 AT collections are summarized in Table 1.

[1,2] Project Staff, Laboratory Services Division, WSDA, Olympia, Washington 98504-2560

TABLE 1. 1995 Apple Tortrix Collection Sites in Western Washington

#	Sample or Trap Site #	# AT in Trap	Date Trap Placed	Date Trap Removed	Host	County	Location	Address
1	409-1026	35	6-Jun	5-Jul	h	King	Seattle	20219 Fremont Ave. N.
2	409-1031	8	29-Jun	17-Jul	h	King	Seattle	17011 Freemont Ave. N
3	409-1033	8	6-Jun	5-Jul	h	King	Seattle	312 N. Greenwood Dr.
4	409-1034	15	6-Jun	17-Jul	h	King	Seattle	Innis Arden & Greenwood
5	409-1035	9	6-Jun	31-Jul	h	King	Seattle	15248 Greenwood Ave. N.
6	409-1037	6	6-Jun	17-Jul	h	King	Seattle	13310 Greenwood Ave. N.
7	409-1039	30	6-Jun	5-Jul	h	King	Seattle	10712 Greenwood Ave. N.
-	409-1039	3	5-Jul	17-Jul	h	King	Seattle	10712 Greenwood Ave. N.
8	409-1040	28	6-Jun	5-Jul	c	King	Seattle	9501 Greenwood Ave. N.
9	409-1041	14	6-Jun	17-Jul	c	King	Seattle	7700 Meridian Ave. N.
10	409-1042	35	6-Jun	29-Jun	c	King	Seattle	8226 Meridian Ave. N.
11	409-1044	28	6-Jun	17-Jul	c	King	Seattle	9055 Meridian Ave. N.
12	409-1046	20	6-Jun	5-Jul	h	King	Seattle	12212 Corliss Ave. N.
13	409-1048	12	6-Jun	5-Jul	h	King	Seattle	12826 Meridian Ave. N.
-	409-1048	1	5-Jul	28-Aug	h	King	Seattle	12827 Meridian Ave. N.
14	409-1049	9	6-Jun	14-Aug	h	King	Seattle	13732 Meridian Ave. N.
15	409-1050	25	6-Jun	6-Jul	c	King	Seattle	14826 Meridian Ave. N.
16	409-1051	25	6-Jun	6-Jul	c	King	Seattle	15733 Meridian Ave. N.
17	409-1052	7	6-Jun	6-Jul	h	King	Seattle	16515 Meridian Ave. N.
-	409-1052	2	6-Jul	17-Jul	h	King	Seattle	16515 Meridian Ave. N.
18	409-1055	26	6-Jun	17-Jul	h	King	Seattle	1653 N 199th St.
19	409-1057	28	7-Jun	6-Jul	c	King	Seattle	2217 N.E. 135th St
20	409-1064	17	7-Jun	29-Aug	c	King	Seattle	13559 17th Ave. N.E.
21	409-1067	20	7-Jun	6-Jul	h	King	Seattle	143rd & 20th Ave. N.E.
22	409-1069	23	7-Jun	6-Jul	c	King	Seattle	1742 N.E. 146th St.
23	409-1072	17	7-Jun	18-Jul	h	King	Seattle	1540 N.E. 148th St.
24	409-1081	8	7-Jun	18-Jul	h	King	Seattle	16921 22nd Ave. N.E.
25	409-1082	16	7-Jun	1-Aug	c	King	Seattle	1802 170th Ave. N.E.
26	409-1105	1	8-Jun	22-Aug	c	Thurston	S. Tumwater	1020 93rd Ave. S.W.
27	409-1143	6	13-Jun	24-Jul	c	Thurston	N.E. Lacey	1667 Draham
28	409-1160	26	14-Jun	8-Aug	c	Thurston	S.E. Olympia	3111 Boulevard
29	409-1162	29	14-Jun	8-Aug	h	Thurston	E. Olympia	Karen Frazier Rd. & Fones Rd.
30	409-1164	26	14-Jun	25-Jul	h	Thurston	E. Olympia	Elizabeth Rd. @ Chambers Lk.
31	409-1165	27	14-Jun	25-Jul	h	Thurston	E. Olympia	14th Ave. & Golf Club Rd.
32	409-1169	20	14-Jun	25-Jul	c	Thurston	E Lacey	Vine Maple & Steilacoom Rd.
33	409-1186	30	15-Jun	22-Aug	c	Thurston	Olympia	22nd Ave. & Fir St.
34	409-1194	9	15-Jun	24-Jul	c	Thurston	N. Olympia	Tullis St. & Mitchell Ave.
35	409-1195	14	15-Jun	24-Jul	h	Thurston	N. Olympia	Tullis st. & Leavenworth Ave.
36	409-1275	15	21-Jun	27-Jul	h	Pierce	Steilacoom	Union Ave. & Martin
37	409-1276	28	21-Jun	23-Aug	h	Pierce	Steilacoom	Lafayette & Balch
38	409-1278	25	21-Jun	23-Aug	h	Pierce	Steilacoom	8304 97th St.
39	409-1288	17	21-Jun	27-Jul	c	Pierce	Tacoma	6226 Oakes St.
40	409-1289	45	21-Jun	27-Jul	c	Pierce	Tacoma	4908 Oakes St.
41	409-1290	37	21-Jun	23-Aug	h	Pierce	Tacoma	4306 Pine St.
42	409-1294	30	21-Jun	27-Jul	h	Pierce	Tacoma	2404 Alder St. (& 24th St.)
43	409-1302	34	21-Jun	23-Aug	c	Pierce	Tacoma	2830 Orchard St. (& Center St.)
44	409-1346	2	3-Jul	26-Jul	h	Pierce	Tacoma	S. 53rd St. & D St.
45	409-1349	24	3-Jul	23-Aug	c	Pierce	Tacoma	8021 S. "D" St.
46	409-1351	19	3-Jul	9-Aug	c	Pierce	Tacoma	9611 Sheridan Ave.
47	409-1352	9	3-Jul	9-Aug	h	Pierce	Tacoma	1424 S. 88th St.
48	409-1355	3	3-Jul	26-Jul	h	Pierce	Tacoma	1118 S. 62nd St.
49	630-s-0016	3	22-Jun	29-Jun	a	Whatcom	Bellingham	2710 McKenzie
50	630-s-0164	1	13-Jul	20-Jul	a	Whatcom	Bellingham	2614 Donovan
51	630-s-0144	1	21-Jun	17-Jul	h	Snohomish	Clearview	Clearview Station
52	630-s-0203	1	20-Jun	24-Jul	h	Snohomish	Marysville	3611 71st Ave. N.E.
53	630-s-0207	4	21-Jun	25-Jul	h	Snohomish	Clearview	15402 131st St.
54	630-s-0325	2	25-Jun	15-Aug	h	Snohomish	Clearview	Hwy. 9 & SR 524
Total AT =		963	Host codes; h - Ornamental hawthorne tree, c - Cherry tree, a - Apple tree					

1996 APPLE TORTRIX SURVEY

Several field projects to evaluate the biology and distribution of AT in Western Washington were conducted in 1996. The field work was severely complicated by the inability to identify immature stages of AT. Very little information on identification of immature stages of AT was found in the available technical literature, and none exists specifically to separate AT larvae from other North American or European tortricid species. This was a particular problem because several similar indigenous and introduced exotic (European) leafroller species are common and abundant in the same areas of Western Washington where AT was found. As a result, it was necessary to rear immature stages of AT to the (identifiable) adult stage to interpret survey and biological observations conducted during the larval season. Development of diagnostic characters to identify AT immature stages became a primary focus of field and laboratory work.

1996 Project Objectives

1. Identify diagnostic (identification) characters for AT larvae, pupae, and adults.
2. Evaluate the biology of AT in the Olympia area, including host plants, phenology, feeding characteristics, and relative prevalence.
3 Monitor AT population change at eight Olympia area trap sites that were positive in 1995.
4. Establish (delimit) AT distribution in Western Washington.
5. Assess what parasitoids are present and the percent parasitism in AT populations in the Olympia area.

Methods

Beginning in April, apple trees and other host plants in the vicinity of several 1995 AT catch sites in Thurston county (greater Olympia area) were periodically inspected and leafroller larvae or pupae encountered were collected These sites were mostly unsprayed trees and shrubs in residential yards or vacant lots in residential areas. Apple trees were a primary focus of the survey, receiving about 1/3 of available inspection and collection time.

Table 1. Host plants examined and sampled for AT in the Olympia area, in order of emphasis (by column):

apple	hawthorn	horse chestnut
cherry	azalea	chestnut
plum	rhododendron	alder
filbert	rose	potentilla
pear	blackberry	strawberry
maple	dogwood	poplar
English laurel	quince	
cascara	raspberry	

Larvae were placed in individual containers on either host plant leaves or artificial diet for rearing to adult. Host, and developmental phenology data was recorded for each specimen as well as descriptive information on potential diagnostic characters such as color and patterns on head capsule, pro-thoracic plate, and body. Shed larval skins and pupal cases were kept with emerged adults or parasitoid specimens for species diagnosis.

1996 Project Methods (Cont.)

Most adult male specimens and some females of suspect AT and other leafroller species reared were dissected to prepare diagnostic slide mounts of genitalia for species determination. Additionally, once adult identifications were determined, the associated larval mandibles and anal combs from the preserved shed skins were also slide mounted for diagnostic evaluation.

The pheromone trap survey used Pherocon 1-C® type traps, baited with CEM pheromone (z-11-tetradecenyl acetate) in septa lures provided by USDA APHIS Otis Methods Lab. Traps were hung in early June, primarily in cherry and hawthorn trees (CEM hosts), and inspected approximately every two weeks through August. The 1996 Olympia area traps sought to replicate the 1995 methods as much as possible, using the same type of trap and lure, placed at the same sites by the same trapper.

Traps from several other exotic pest surveys conducted concurrently were also inspected for AT. Blacklight collection of adult moths was also conducted periodically during adult flight.

Results

Diagnostic Characters for AT

Species level identification of larvae and adults of many leafroller species is relatively difficult due to a pronounced variability of coloration and marking patterns among individuals of the same species. The variation between individuals is further complicated by changes in color and patterns that occur in larvae as the developmental stages mature.

To date, only AT adult males collected have been definitely identified to species. Distinctive ventral lobes on the lateral valves of the male genitalia are the unique diagnostic character that make this possible. Most male AT identified can also be distinguished from other similar leafrollers species by a combination of (variable) characters, including; overall wing color and pattern, length of the costal fold (a fold in the leading edge of the fore wing), and color of pupal case.

Identification of AT in the Olympia area was particularly difficult due to the abundant presence of two species of leafrollers very similar to AT, the oblique-banded leafroller (OBLR), *Choristoneura rosaceana* (Harris), and the filbert or European leafroller (EL), *Archips rosanus* L.. All three similar species were present on many of the same host plants, and in the same larval stages at the same time. Adult moths of the two *Archips* species reared in this project, *fuscocupreanus* (AT) and *rosanus* (ET), were essentially identical in overall appearance. Adult males can only be differentiated by the microscopic characters mentioned above, length of costal wing folds and minor differences in genitalia.

No definitive diagnostic character has been found to decisively identify larvae, pupae, or adult female AT at this time, although several are being studied. One interesting and consistent difference noted between the three common look-alike species in this project was the color of shed pupal cases. The shed pupal cases of AT are a medium brown, while those of ET are more straw-colored, and pupal cases of OBLR are a very dark brown

Diagnostic Characters for AT (Cont.)

Pupal case coloration was used in this project to identify (separate) reared female moths, based on individual specimen comparisons with a large set of identified males from the same collection sites. As a independent diagnostic character, pupal case color has limited value.

Interestingly, a distinctive and potentially significant character being studied has been found in larval mandibles. Preliminary examination of the mandibles of mature AT larvae and a number of other leafroller species (in addition to those reared in this project) has found a clear and consistent difference in pattern and degree of pigmentation. The mandibles of AT larvae examined are darkly pigmented in the basal half, quite different from the pigmented edges or uniformly colored mandibles of other species. However, much more study is needed before the consistency and value of the character is established. Hopefully, results of this work and a detailed description of the applied diagnostic characters mentioned in this project report will be provided in a methods report or new pest technical bulletin at a later date.

Biology of AT in the Olympia Area

AT was reared from 9 of the 22 different shrub and tree hosts surveyed, more than any other species of leafroller collected in this project. AT hosts included; apple, azalea, cherry, English laurel, cascara, filbert, maple, potentilla, and Asian pear.

AT was one of three leafroller species that were fairly abundant on several host trees in the Olympia area in 1996. The other common species were the European leafroller (EL), *Archips rosanus*, and oblique-banded leafroller (OBLR), *Choristoneura rosaceana*. Damage from these three species was conspicuous in some areas of Olympia in late May and June, particularly on apple and English laurel (*Prunus laurocerasus)*.

Leafrolling and feeding damage from AT larvae was not found to be distinctive from the other species present, although data was not collected to evaluate differences in leaf refuge forms. Somewhat distinctive variations of longitudinal (cigar style) "rolling", oblique or lateral "folding", and fluted "gathering" of leaves to construct refuges were noted. The local refuge building habits of AT will be much easier to determine once larval identification characters are established.

The pupation, and adult emergence timing of AT also coincided with that of the other two common species, with average dates for those events occurring within 4 days for all three species. Average pupation and adult emergence dates for AT were June 6th and June 17th respectively.

All together, one hundred fifty four adult leafroller moths, comprised of eight species, were reared and identified in this Olympia area project. Species, numbers collected, and a summary of host plants and phenology (development) dates is presented in table 2.

Table 2. Leafroller Species Reared in 1996 from Various Host Plants in the Vicinity of 1995 Apple Tortrix Catch Sites - Olympia Area, Thurston Co., Washington.

Species	# Reared	% of Total	Host Plants (#)	Ave. Pupation*	Ave. Eclosion*
Archips fuscocupreanus (AT)	63	42 %	apple (44) azalea (3) cascara (3) filbert (5) maple (3) potentilla (1) cherry (2) Asian pear (1) English laurel (1)	8 June	18 June
Archips rosanus (EL)	63	42 %	apple (50) cascara (4) chestnut (1) filbert (5) horse chestnut (2) potentilla (1)	6 June	18 June
Choristoneura rosaceana (OBLR)	15	10 %	apple (10) dogwood (1) filbert (3) maple (1)	9 June	22 June
Croesia holmiana	6	4 %	apple (6)	2 July	7 July
Batodes (Ditula) angustiorana	5	3 %	apple (5)	9 June	21 June
Spilonota ocellana	1	1 %	apple (1)	28 June	7 July
Acleris sp.	1	1 %	apple (1)	24 June	29 June
Pandemis sp.	1	1 %	apple (1)	31 May	3 June
Total # reared -	150				

* - Pupation and eclosion dates are under laboratory conditions (i.e. field collected larvae reared to adult in lab).

Clearly AT is currently a significant element (42% of total) of a fairly diverse and abundant leafroller fauna in the Olympia area. However, these 1996 project results should be recognized as a preliminary (and very limited) evaluation of the local biology of this exotic pest. These results suggest AT is well suited to local (S.E. Puget Sound area) conditions and feeds on a significant range of ornamental and fruiting host plants.

Olympia Area Population Monitoring 1995 / 1996, Trap Catch Comparisons

A very important aspect of the pheromone trap surveys for AT was the evaluation of species caught using this (CEM) pheromone lure, particularly given the difficulty of identifying similar species known to be present in the target survey area. The 1995 trap data represented counts of "AT-like" moths in CEM traps, but was compiled before the similarity of AT and EL adults was recognized. Fortunately, a close review of the 1996 Olympia area trap catch, at sites where AT and EL were equally abundant (based on larval rearing results), found the catch to be almost exclusively AT. Approximately 250 male moths, caught with CEM lure in the Olympia area, were identified using the costal wing fold character discussed earlier. Only 1 EL was found in this large sample, suggesting that the CEM lure is very specific for these *Archips* species, attracting only AT.

Olympia Area Population Monitoring (Cont.)

Ten survey sites where AT was caught in the Olympia area in 1995 were re-trapped in 1996. The total number of AT caught in 1996 was higher than in 1995, but the changes by site were mixed, with 4 sites showing an increase and 6 a decrease in catch. A clear overall trend of population change is not evident in the limited data collected in this study. Factors limiting the significance of catch comparison between years include different trap check intervals and seasonal weather. Another interesting observation affecting the comparative value of catch data was the frequent evidence of bird and insect (primarily yellow jacket) predation on moths in the traps, including feathers, dead yellow jackets, missing moth parts, and disturbed stickum.

The trap data does provide good information on adult flight of AT, which extended from late June to early August in the Olympia area in 1996. Peak flight was sometime near mid-July, but flight was not particularly synchronized. In general, trap catch showed a gradual increase and decrease in flight over the flight period recorded (about six weeks). A comparison of yearly catch and the 1996 catch timing is presented in table 3.

Table 3. Olympia Area 1995/1996 AT Pheromone Trap Catch Results

Trap Site Number (1995 and1996 #)	1995 Catch Total at Site	1996 Catch Total at Site	Change in Catch '95 to '96	1996 Trap Check Date	# AT Caught
1105 / 1725	1	0	**-1**	29-Aug	0
1143 / 1726	26	38	**12**	28-Jun	4
				2-Jul	4
				10-Jul	8
				19-Jul	15
				5-Aug	7
1162 / 1727	29	24	**-5**	28-Jun	2
				3-Jul	2
				10-Jul	5
				26-Jul	11
				5-Aug	4
1164 / 1728	26	18	**-8**	2-Jul	4
				10-Jul	3
				26-Jul	10
				5-Aug	1
1165 / 1729	27	18	**-9**	3-Jul	4
				10-Jul	5
				26-Jul	9
1169 / 1730	20	3	**-17**	29-Aug	3
1143 / 1731	6	12	**6**	29-Aug	12
1186 / 1732	30	130	**100**	24-Jun	5
				3-Jul	15
				12-Jul	39
				19-Jul	11
				26-Jul	31
				5-Aug	27
				14-Aug	2
1194 / 1733	9	20	**11**	29-Aug	20
1195 / 1734	14	2	**-12**	29-Aug	2
TOTALS	187	265	**78**		

Distribution of AT in Western Washington, 1995 / 1996

As mentioned earlier, the 1995 CEM survey found AT in 5 counties in Western Washington: Whatcom, Snohomish, King, Pierce, and Thurston. Available resources in 1996 allowed for some additional delimiting survey, which added Skagit county (in northwestern Washington) to the infested list, but did not detect AT in Southwestern or Eastern Washington counties surveyed. Trap numbers and results for both years of survey are presented in Table 4.

Table 4. 1995*-1996 Trap Placement and Results for AT Survey in Washington State.

Year	County	Sites Trapped	# Catch Sites	Total AT	Ave. #AT/Site
1995*	Whatcom	86	2	4	2.0
	Skagit	27	0	0	
	Snohomish	52	4	8	2.0
	King	58	25	475	19.0
	Pierce	61	13	288	22.2
	Thurston	109	10	188	18.8
	Lewis	49	0	0	
	Cowlitz	0	0	0	
	Clark	0	0	0	
	Kittitas	49	0	0	
	Grant	90	0	0	
	Okanogan	46	0	0	
	1995 Totals -	-	-	963	
1996	Whatcom	44	1	4	4.0
	Skagit	35	1	1	1.0
	Snohomish	23	3	6	2.0
	King	0	0	0	
	Pierce	0	0	0	
	Thurston	10	9	265	29.4
	Lewis	6	0	0	
	Cowlitz	10	0	0	
	Clark	10	0	0	
	Kittitas	17	0	0	
	Okanogan	11	0	0	
	1996 Totals	166			

* 1995 data is incomplete (See Background)

A map of counties surveyed in Washington State and catch results is presented in Figure 1.

Parasitoids Reared from AT in the Olympia Area

To date only one parasitoid specimen has been identified from an AT host. Pending mandible identification assessment may add one or two additional parasitoids reared from AT. Based on the successful rearing of 63 adult AT from larvae, this survey would indicate a current parasitism rate in the Olympia area of 4% or less.

Pertinent Literature

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Report prepared by:

Eric LaGasa
State Entomologist
Washington State Department of Agriculture
Laboratory Services Division
P.O. Box 42560
Olympia, Washington 98504-2560
(360) 902-2063 FAX (360) 902-2094
eMail: elagasa@agr.wa.gov

David Hartley
Agricultural Technician (WSDA Project Position)
1024 S. Decatur St.
Olympia, Washington 98502

Mindy Allen
Laboratory Technician (WSDA Project Position)
2020 Stevens St.
Shelton, Washington 98584