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RELEASE OF PREDATORS OF THE BALSAM WOOLLY APHID IN NORTH CAROLINA

The balsam woolly aphid, Chermes piceae Ratz. (Homoptera: Chermidae), was accidentally introduced into North America from Europe about 1900 (Balch 1952). The aphid is now a serious pest of Fraser fir, Abies fraseri (Pursh) Poir., in the Southern Appalachians. Since its discovery in North Carolina in 1957 (Speers 1958), the aphid has killed thousands of trees annually. Fraser fir is an especially valuable aesthetic resource along the Blue Ridge Parkway, in the Great Smoky Mountains National Park, and Mt. Mitchell State Park where it is viewed by millions of persons annually.

The balsam woolly aphid may possibly be controlled with insect predators which are its natural enemies in Europe, as well as by predators that feed on closely related aphid species in other areas of the world.

The first introductions of foreign insect predators to aid in control of the balsam woolly aphid in North Carolina were made in 1959 and 1960 (Amman 1961). Since then an additional 15 species of predators were tried in the field and laboratory (table 1). Two species were received from Germany and 13 species from India and Pakistan.[1]

Predators were released in the field in cloth or wire-screen cages placed around the trunks of Fraser fir trees moderately to heavily infested with the aphid. Predators tested in the laboratory were released in cages containing heavily infested fir bolts, the ends of which were placed in damp sand to maintain the bark moisture.

Coleoptera

Seven species of beetles were released; all were coccinellids. Adults of Adalia tetraspilota Hope, Adonia variegata Goeze, Ballia eucharis Muls., Calvia sp., and Oenopia sauzeti Muls. fed on the balsam woolly aphid. Adalia tetraspilota, Adonia variegata, Ballia dianae, Calvia sp., and Harmonia breiti Mader were observed in copula. However, no egg laying was observed nor were any progeny recovered.

Observation at the Bent Creek Laboratory indicated that Adalia, Adonia, Calvia, and Oenopia, like many other coccinellids, overwinter as adults in the duff of the forest floor. Adults of these species were placed in cages containing infested fir bolts surrounded with pine chips 3 inches deep. The cages were placed outside. By October 23, 1961, none of the insects was visible in the cages; on January 18 examination showed that all of the adults had burrowed under the pine chips. Adonia and Oenopia were dead; several Adalia and Calvia were alive. The average minimum temperature for December 1961 was 28.1° F., with a low of 9° F. on December 30. The average minimum temperature in January 1962 was 24.2° F., with a low of minus 4° F. on January 12. The low occurred 6 days before the insects were brought into the laboratory for examination. Considerable cold tolerance by both species of beetles is indicated. Failure to establish Adalia and Calvia in the field may be because of the small numbers released. The other species of beetles may be unable to withstand the cold temperatures, and to change from their native prey species to the balsam woolly aphid.

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[1] In 1959 and 1960 predators were made available by the Commonwealth Institute of Biological Control, Canada Department of Agriculture and the Agricultural Research Service of the U. S. Department of Agriculture. Since 1960, the predator introductions were financed by the U. S. Forest Service through Public Law 480.

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Table 1.--Predators released for control of the balsam woolly aphid in North Carolina, 1961-1963

Species	Origin	Released		Year
		Field	Laboratory	
		- - - Number - - -		
Coleoptera				
Coccinellidae				
Adalia tetraspilota Hope	Pakistan	65	19	1961
Adonia variegata Goeze	India	15	16	1961
Ballia dianae Muls.	India	205	0	1961
Ballia eucharis Muls.	India	74	0	1961
Calvia sp.	India	55	10	1961
Harmonia breiti Mader	India	50	0	1961
	Pakistan	81	0	1961
Oenopia sauzeti Muls.	India	90	16	1961
Diptera				
Chamaemyiidae				
Leucopis griseola (Fallen)	Germany	126	20	1961
Leucopis sp.	India	0	77	1962
	India	652	207	1963
Syrphidae				
Metasyrphus lunulatus (Meigen)	Germany	50	0	1961
Hemiptera				
Anthocoridae				
Tetraphleps nr. pilipes	Pakistan	457	0	1963
Tetraphleps sp.	India	0	268	1963
	Pakistan	128	176	1963
Neuroptera				
Chrysopidae				
Chrysopa sp.	India	569	145	1961
	India	53	37	1962
Chrysopa sp. (light green)	India	14	30	1962
Hemerobiidae				
Hemerobius sp.	India	26	0	1961
	India	0	6	1962
	India	315	1,088	1963

Diptera

Three species of flies were introduced during the 3-year period. However, mating and egg laying were not observed and progeny were not recovered. The adults died from 10 days to 2 weeks after release. Possibly not all conditions were present in the cages for feeding, mating, and egg laying by the adults.

Hemiptera

Two species of Tetraphleps were received in 1963, and adults fed on eggs of the balsam woolly aphid under laboratory conditions. Adults of Tetraphleps nr. pilipes were released in a cage enclosing a small infested fir tree. Foliage is necessary for oviposition because Tetraphleps inserts its eggs into the needles of fir with the tip of the egg exposed. Eggs remain in diapause until the following spring (Ghani, Unpublished Report).[2] When the cage was removed 3 weeks later, several living adults could still be found. Eggs were not found.

[2] Ghani, M. A. Investigations on the predators of Adelges (an aphid) on fir. U. S. Dept. Agr., Agr. Res. Serv., Foreign Res. and Tech. Program Div. Rpt., 10 pp. 1962. [Unpublished Report.]

Neuroptera

Several hundred Chrysopa sp. larvae and adults were released in the field. Both larvae and adults fed on the balsam woolly aphid, but reproduction apparently did not occur.

In the laboratory, Chrysopa larvae were fed the balsam woolly aphid and other species of aphids. They readily fed on the cabbage aphid, Brevicoryne brassicae (L.), an aphid from rose (probably Macrosiphum rosae (L.)) and a species of Cinara from pitch pine. All predator larvae died before completing development. This may indicate a nutritional deficiency in these prey so that Chrysopa is unable to complete its development.

Hemerobius sp. adults and larvae fed on the balsam woolly aphid under both laboratory and field conditions. However, none of the larvae completed development, and mating and oviposition by adults were not observed. Failure to become established in the field may have been the result of the small numbers of predators released on each date.

Preliminary Evaluation of Predators Released in 1959 and 1960

A preliminary evaluation of the six species of predators released in 1959 and 1960 revealed that Aphidecta obliterata (L.) (Coleoptera: Coccinellidae), Aphidoletes thompsoni Möhn (Diptera: Cecidomyiidae), and Laricobius erichsonii Rosenh. (Coleoptera: Derodontidae) obtained from Germany can overwinter and reproduce in the Mt. Mitchell area, but that Leucopis obscura Hal. (Diptera: Chamaemyiidae) and Pullus impexus (Muls.) (Coleoptera: Coccinellidae) from Germany, and Scymnus pumilio (Muls.) (Coleoptera: Coccinellidae) from Australia may not have become established. Additional releases of predators first introduced in 1959-1960 are reported in table 2.

Table 2.--Additional releases of predators initially introduced for balsam woolly aphid control in North Carolina during 1959-1960[1]

Species	Origin	Released		Year
		Field	Laboratory	
		- - - Number - - -		
Coleoptera				
Coccinellidae				
Aphidecta obliterata (L.)	Germany	--	[2]800	1963
Derodontidae				
Laricobius erichsonii Rosenh.	Germany	12,287	--	1962
Diptera				
Chamaemyiidae				
Leucopis obscura Hal.	New England[3]	1,366	--	1962

[1] For initial releases see Amman 1961.
[2] Progeny of Aphidecta were released in the field.
[3] Introduced originally from Germany.

The small, yellow ladybird beetle, Aphidecta obliterata, has persisted since its release in 1960. Aphidecta was recovered from the upper bole and branches of three infested trees that were felled in 1963. When caged on an infested fir tree in 1963, Aphidecta almost completely eliminated the aphids from the caged portion of the bole. This coccinellid should be a valuable addition to the predator complex of the aphid.

Aphidoletes thompsoni was introduced in 1959. The orange larva of this small fly has been found in small numbers each year at distances up to $\frac{1}{2}$ mile from release sites, but the population remains at a low level.

Laricobius erichsonii is the most promising of the predators. This small, dark brown beetle has increased considerably since its initial release in 1959 and has shown the ability to reduce greatly a balsam woolly aphid population under caged conditions. Because of its exceptional promise, 12,287 Laricobius adults were released in 1962 along the Black Mountain Range in the Mt. Mitchell area in a pilot control test. Laricobius was found the following year in 7 of the 13 release sites used for the test.

Eggs and a few old adults of Pullus impexus, a small, orange coccinellid beetle, were able to overwinter after release of the beetle in 1960. Larvae completed development in 1961; however, this species was not recovered in either 1962 or 1963.

Leucopis obscura Hal., a small fly from Germany, was established in New England to aid in the control of the balsam woolly aphid (Dowden and Crosby 1958). Two shipments were received from the Maine Forest Service and the Northeastern Forest Experiment Station for release on Mt. Mitchell. It was thought that little difficulty would be encountered in establishing Leucopis, because it became established so easily in both the Northeast and Northwest, but after two releases this fly has yet to be recovered.

Scymnus pumilio, a very small, black coccinellid introduced from Australia, was never recovered.

Studies to evaluate the effectiveness of species of predators in controlling the balsam woolly aphid in North Carolina are continuing. Species which appeared promising during the first release but failed to become established, such as Pullus impexus, will be introduced a second time, and additional species of predators will be tested against the aphid as they become available.

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