Biological Control Operations On Alligatorweed

EDWARD O. GANGSTAD

Botanist, Office of the Chief of Engineers, Washington, D.C. 20314

ABSTRACT

Insects have been used successfully as a form of biological control to suppress alligatorweed [*Alternanthera philoxeroides* (Mart.) Griesb] in Florida and other states of the Southeast under the U.S. Army Corps of Engineers aquatic control program in cooperation with the Division of Entomology Research of the United States Department of Agriculture. The alligatorweed flea beetle (*Agasicles hygrophila* Selman & Vogt) was the first host-specific insect to be introduced. Other insects, alligatorweed thrips (*Amynothrips andersoni* O'Neill) and a stem-boring moth (*Vogtia malloi* Pastrana) are also host-specific and have been introduced for alligatorweed control. Infestations of alligatorweed are reduced to a negligible population in most situations in the southeastern states where these insect controls have been released.

INTRODUCTION

The initial responsibilities and interests in aquatic plant control by the Corps of Engineers arose from the widespread and profuse growths of alligatorweed and waterhyacinths [*Eichhornia crassipes* (Mart.) Solms.] that limited navigation in rivers and harbors of the southern states. When these aquatic plant infestations constitute a serious economic threat to navigation, flood control, drainage, agriculture, water quality, and related purposes, control projects are authorized within budgetry limitations set by the Congress of the United States in 1965. Mechanical methods were used during the first phase of this program (6) and chemical methods were used in the second phase (2,7). This paper deals with biological control as a third phase (1,2,3,4,5,8).

EXPLORATION FOR NATURAL ENEMIES

A research agreement was initiated by the Corps of Engineers in 1959 with the United States Department of Agriculture, Division of Entomology Research, to conduct explorations in South America for natural enemies of alligatorweed. George B. Vogt, research entomologist with the Systematic Entomology Laboratory, Washington, D.C. made the original survey and observed a flea beetle on alligatorweed in its natural habitat. A research laboratory was set up in Argentina for further research. The principal and immediate objective of the research program was to determine whether or not the alligatorweed flea beetle could complete its life cycle on any plant except its normal host. All evidence from these studies indicated that the alligatorweed flea beetle is an obligatory monophagous insect, and is the principal suppressant of alligatorweed in its native habitat.[1]

HOST SPECIFICITY

Laboratory feeding studies were conducted on *Polygonum, Fagopyrum, Rheum, Chenopodium, Atriplex, Amaranthus,* and *Alternanthera*. These feeding tests also included *Oryza, Nasturtium,* and *Nymphaea*. *Atriplex hastata* L. was the only species other than alligatorweed which was fed upon by the beetle and this species did not permit completion of the life cycle. In the feeding experiments with *A. hastata* both larval and adult flea beetles fed on the test plant. In two of the experiments, larvae fed on the leaves of *A. hastata* and development at first appeared to be normal when compared with the controls. However, by the 3rd day of the tests, the larvae became restless and exhibited migratory tendencies. Some of the larvae died. At the end of the 8th day all larvae were dead. In the third larval test, feeding was also evident and three of the five larvae completed their development and pupated in a glass tube. Two of these pupae died but the third pupa was metamorphosed to an abnormal, malformed adult which died within a few hours. In the experiments with adults, feeding was observed in all three experiments but was confined to the stems of the plant. As a result of this feeding, the adults lived an average of 21.7 days but showed abnormal behavior and died without producing eggs. In fact, dissection of the females subsequent to death demonstrated no ovarian development. Furthermore, *A. hastata* does not have a hollow stem, required in nature as a site for pupation. Observations of the plant under growing conditions have failed to demonstrate feeding by either larvae or adults of the flea beetle (3,4,5,8). Plants which were resistant to attack of the alligatorweed flea beetle are given in Table 1.

INSECT INTRODUCTION

The decision was made that this flea beetle was the most promising biocontrol for alligatorweed, and the insect

TABLE 1. PLANTS WHICH ARE RESISTANT TO ALLIGATORWEED FLEA BEETLE ATTACK.

I. POLYGONACEAE (Buckwheat family)
- A. *Polygonum:*
  1. *P. aviculare* L.—Common or yard knotweed; Annual.
  2. *P. hydropiperoides* Michx.—Mild water pepper; Perennial.
  3. *P. punctatum* Elliot.—Water smartweed; Perennial.
  4. *P. densiflorum* Mesin.—(densely flowered); Perennial.
- B. *Fagopyrum:*
  1. *F. sagittatum* Gilib.—Common buckwheat.
- C. *Rheum:*
  1. *R. rhaponticum* L.—Rhubarb; Perennial.

II. CHENOPODIACEAE (Goosefoot family)
- A. *Chenopodium:*
  1. *C. macrospermum* Hook. F. Var. farinosum (Wats.)—Annual.
  2. *C. ambrosioides* L.—Mexican tea; Short lived perennial.
- B. *Atriplex:*
  1. *A. hastata* L. saltbush; Annual.
  2. *A. hortensis* L.—Garden orache; Annual.
  3. *A. semibaccata* R. Br.—Australian saltbrush; Perennial.

III. AMARANTHACEAE (Pigweed family)
- A. *Amaranthus:*
  1. *A. deflexus* L.—Low amaranth: Annual.
  2. *A. standleyanus* Parodi—Annual.
  3. *A. lividus* L. Var. *ascendens* (Lois.) Thell.—Annual.
- B. *Alternanthera:*
  1. *A. bettzichiana* (Reg.) Standl.—Ornamental Perennial.
  2. *pungens* H.B.K.—Yerva Del Pollo; Perennial.
  3. *A. repens* (L) Kuntze.—Perennial.

IV. MISCELLANEOUS
  1. *Oryza sativa* L.—Rice; Annual. (Gramineae).

was brought, under quarantine, to the research laboratory in Albany, California for further study in 1963. The first release was made in South Carolina in 1964 at the Savannah National Wildlife Refuge under conditions which appeared to be similar to those in South America. These early results were not very impressive. The first successful biological control was observed in the Ortega River, near Jacksonville, Florida in 1965. Most of the alligatorweed flea beetles distributed in the United States have come from this area (1). Conditions in Florida were apparently more favorable than elsewhere. Successful control, however, may have been due in part to the effects of (2,4-dichlorophenoxy)acetic acid (2,4-D) on the alligatorweed mat from incidental treatment of waterhyacinth, shortly after release of the beetle.[2]

DISTRIBUTION IN SOUTHEASTERN UNITED STATES

During May 1965, two trips were made into southeastern United States to distribute the alligatorweed flea beetle and to initiate evaluation studies. The first trip was made by Dr. W. H. Anderson U.S. Department of Agriculture, on 7 to 12 May. His primary objective was to release beetles at selected localities in Georgia, South Carolina, and North Carolina. On 9 May, with Messrs. Charles Zeiger and James McGeehee of the Corps of Engineers, Jacksonville, he visited the original release site on the Ortega River. The alligatorweed infestation at this site showed no evidence of recovery; there were only scattered plants growing along

[1]Vogt, G. B. 1973. Exploration for natural enemies of alligatorweed and related plants in South America. Aquatic Plant Control Program Tech. No. 3, Biological Control of Alligatorweed, U.S. Army Engineers Waterways Exp. Sta., Vicksburg, Miss. pp. B1-B66.

[2]Weldon, L. W., R. D. Blackburn, W. C. Durden. 1973. Evaluation of *Agasicles* n. sp. for biological control of alligatorweed. Aquatic Plant Control Program Tech. Rep. No. 3. Biological Control of Alligatorweed, U.S. Army Engineers Waterways Exp. Sta., Vicksburg, Miss. pp. D1-D54.

the banks and a few small floating islands that had drifted in from the river. At another site on Black Creek south of Jacksonville, where there was a considerable amount of alligatorweed in small as well as extensive patches along the banks, all plants were found to be under heavy attack. Some of the patches were entirely brown with the stems prone and badly chewed.

Additional releases were made at the Jim Woodruff Reservoir in Georgia and Florida, at three sites near Mobile, Alabama, at Gulfport and Yazoo City, Mississippi, at two sites on the Dam B Reservoir near Jasper, Texas, and at three sites in the J. D. Murphree Wildlife Area near Port Arthur, Texas. The general distribution is summarized in Table 2.

TABLE 2. DISTRIBUTION OF ALLIGATORWEED FLEA BEETLES IN NORTH AND SOUTH CAROLINA, GEORGIA, FLORIDA, ALABAMA, MISSISSIPPI, TAXAS, AND TENNESSEE.

Name and Address of Cooperator	Location of Site
	North Carolina
Mr. O. H. Johnson U. S. Army Engineer District, Wilmington Wilmington, N. C. Mr. Jessie Sessions Office of the State Entomologist State Department of Agriculture Wilmington, N. C.	(1) Chadbourn, released flea beetle in a farm drainage ditch about 1000 ft from the intersection of country roads 1560 and 1562 (2) At marker separating Brunswick and New Hanover Counties on (3) On property owned by Time Corp. (4) Lake Waccamaw (5) Vicinity of Wilmington
	South Carolina
Mr. Jack J. Lesemann Chief, Engineering Division U. S. Army Engineer District Charleston	(1) Lake Marion, Santee; southwestern shore between towns of Elloree and Lone Star. Released at bridge in swamp (halfway Swamp) (3) Ashepoo River where it crosses the eastern alternate of U. S. 17 (4) On the grounds of the Vegetable Breeding Laboratory at Charleston (5) Goose Creek Reservoir near building occupied by reservoir personnel (6) Edisto River, where U. S. Route 78 crosses river (7) Black River at Kingstree (8) Naval facility at Charleston
	Georgia
Mr. Angus K. Gholson Jim Woodruff Reservoir U. S. Army Corps of Engineers Chattahoochee, Fla.	(1) Savannah National Wildlife Refuge, Pool 3 (2) Mouth of Ebenezer Creek on Savannah River (3) Casey Canal, Savannah (4) Jim Woodruff Reservoir on Flint River arm
	Florida
Mr. Charles F. Zeiger U. S. Army Engineer District Jacksonville Jacksonville, Fla.	(1) Released on the Ontega River and approximately fifty other locations Florida
	Alabama
Mr. W. E. Ruland U. S. Army Engineer District, Mobile Mobile, Ala.	(1) Perch Creek—1, near church (2) Perch Creek—2, near bridge (3) Three Mile Creek, near bridge
Mr. George Allen U. S. Army Engineer District, Mobile Mobile, Ala.	(4) On canal crossing Halls Mill Road (5) On Black Warrior River at the Dempolis Reservoir (6) Gulf Shores, in the State Park
	Mississippi
Mr. Milton F. Parkman U. S. Army Engineer Division, Vicksburg, Miss.	(1) Yazoo River, Yazoo City (2) White Sand Creek, Prentiss (3) Keyser Bayou, Gulfport
	Texas
Mr. Robert N. Hambric Texas Parks and Wildlife Department Houston, Tex.	(1) Dam B. Reservoir: (a) *Site 1*—Walnut Ridge Park (b) *Site 2*—Bridge on Highway from Jasper to Livingston
Mr. Charles D. Stutzenbaker Texas Parks and Wildlife Department Port Arthur, Tex.	(2) J. D. Murphree Wildlife Area: (a) *Site 1*—Taylor Bayou Air-boat Trail (b) *Site 2*—Outside ditch, compartment 1, at hydro-flow gate
Mr. Clifford J. Novosad U. S. Army Engineer District, Galveston Galveston, Tex.	(c) *Site 3*—Mouth of Deering Slough
	Tennessee
Dr. Gordon E. Smith Tennessee Valley Authority Mussel Shoals, Ala.	(1) At Mussel Schoals and other locations in Tennessee

VEGETATIVE CONTROL

Throughout its lifestages, the flea beetle attacks the alligatorweed in different ways. The adults feed on surface leaves; females lay their eggs—1,000 or more—on the undersides of leaves; young larvae then feed on the undersurface of the leaf and, as mature larvae, chew their way into the stems. Larvae develop into adults within the stems, eat their way out, and return to the leaves to start the cycle again. Damage by the beetle and larvae either kills the alligatorweed outright, or weakens it, making it vulnerable to disease, competition from other aquatic plants, and wind and wave action.

The program for biocontrol of alligatorweed with the flea beetle has been generally satisfactory within the limits to be expected. The estimated acreage of infestation and acreage of chemical treatment of the Corps Program is summarized in Table 3. The acreage of infestation was

TABLE 3. ACREAGE OF INFESTATION AND CHEMICAL TREATMENT OF ALLIGATORWEED FOR 1963 TO 1973[1]

	Area of Infestation		Area of Treatment	
Year	1963 (acres)	1973 (acres)	1963 (acres)	1973 (acres)
South Atlantic Division				
Jacksonville (Fl)	2597	minor	50	none
Savannah (Ga)	1838	minor	50	none
Wilmington (NC)	428	3220	100	235
Charleston (SC)	30430	29710	750	750
Mobile (Al)	4813	225	50	109
Lower Mississippi Valley Division				
New Orleans (La)	55880	36275	19605	4000
Vicksburg (Mi)	none	200	none	200
Southwestern Division				
Galveston (Tx)	1200	8400	1200	300
Total Acreage	97186	78030	21805	5594

[1] Estimate of acreage by field crews:

reduced from 97,186 acres in 1963 to 78,030 acres in 1973. The acreage for treatment with herbicides was reduced from 21,805 acres in 1963 to 5,594 acres in 1973. The current results indicate that alligatorweed has been reduced to a negligible population in most infestations in the southeastern states where insect controls have been released.

LITERATURE CITED

1. Brown, J. L. 1973. *Vogtia malloi,* a newly introduced pyralid for the control of alligatorweed in the United States. PhD thesis. Univ. of Florida, Gainesville. 71 pp.
2. Gangstad, E. O., N. R. Spencer and J. A. Foret. 1975. Towards integrated control of alligatorweed. Hyacinth Contr. J. 13:30-33.
3. Hawkes, R. B., L. A. Andres, W. H. Anderson. 1967. Release and progress of an introduced flea beetle, *Agasicles* n.sp., to control alligatorweed. J. Econ. Entomol. 60:1476-77.
4. Maddox, D. M.. L. A. Andres, R. D. Hennessey, R. D. Blackburn. N R. Spencer. 1971. Insects to control alligatorweed, an invader or aquatic ecosystems in the United States. Bioscience 21:985-91.
5. Maddox, D. M., R. N. Hambric. 1970. Use of alligatorweed flea beetle in Texas: an exercise in environmental biology. Proc. S. Weed Sci. Soc 23:283-86.
6. Wunderlick, William E. 1964. Waterhyacinth control in Louisiana. Hyacinth Contr. J. 3:4-7.
7. Wunderlick, William E. 1966. Practical Suggestions for a large scale aquatic weed control project. Hyacinth Contr. J. 5:6-10.
8. Zeiger, C. F. 1967. Biological control of alligatorweed with *Agasicles* n. sp. in Florida. Hyacinth Contr. J. 6:31-34.

Ecological Studies of *Neochetina bruchi* and *N. eichhorniae* on Waterhyacinth in Argentina[1,2]

C. J. DELOACH[3]

Research Entomologist

and

Hugo A. Cordo

Ingeniero Agronomo

Biological Control of Weeds Research Laboratory, USDA-ARS

Hurlingham, Buenos Aires Prov., Argentina

ABSTRACT

Both *Neochetina bruchi* Hustache and *N. eichhorniae* Warner had three generations a year near Buenos Aires, Argentina. Peak populations of adults occurred in September, January, and April to May. Both species overwintered as adults, larvae, and pupae. The maximum rate of oviposition occurred in October and November, and the rate declined thereafter through the season. *Neochetina bruchi* was more abundant in spring and summer and *N. eichhorniae* in fall and winter. The two species oviposited and rested on different parts of the plant. The weevils damaged waterhyacinth [*Eichhornia crassipes* (Mart.) Solms.] throughout the year, but maximum damage was done during the summer, when an average of 130 feeding spots per leaf were made by the adults and 30% of the petioles were damaged by tunneling of the larvae. The two species may be able to co-exist because of a shift in the abundance of their preferred ovipositional sites, caused by the seasonal development of the plants. The two species would probably complement each other if introduced into another country for biological control of waterhyacinth.

[1]Coleoptera: Curculionidae: Bagoini.

[2]This research was supported by funds from the Office of the Chief of Engineers, Water Resources Division, District of Civil Works, Washington. D. C.

[3]Present address: Grassland-Forage Research Center, USDA-ARS, Temple, Texas 76501.

INTRODUCTION

In Argentina, waterhyacinth occurs in slow moving streams, canals, lakes, and lagoons in the humid region from the northern border of the country south to the delta of the Río Paraná at Buenos Aires. The plant usually grows only a few meters out from the shoreline though it is occasionally abundant enough to block small waterways. The lush growth that completely covers bodies of water in the southeastern United States does not usually occur in Argentina because of the combined attack of its natural enemies. Severe damage is done by several species of insects that feed on the leaves or bore in the petioles and crowns, and by mites and snails.

The two species of weevils, *Neochetina bruchi* and *N. eichhorniae* are among the four or five most promising organisms for introduction into the United States to control waterhyacinth (1, 2). The two species are very similar in appearance, but *N. bruchi* is slightly larger and lighter brown than *N. eichhorniae* and often has a tan chevron across the elytra; DeLoach (3) and Warner (11) give descriptions and keys for their identification. Perkins (7, 10) made earlier observations on the biology of both species; he found that *N. eichhorniae* would not attack economically important plants and subsequently released it in the field in Florida (8). DeLoach (4) and Perkins and Maddox (9) subsequently found that *N. bruchi* was also sufficiently