J. Aquat. Plant Manage. 22: 57-61

The Impact of *Neochetina eichhorniae* on Waterhyacinth in Southern Louisiana

RICHARD A. GOYER AND JOHN D. STARK[1]

ABSTRACT

Feeding by adult *Neochetina eichhorniae* Warner had a significant impact on waterhyacinth plant vigor and reproduction in as short a time as one month under restricted field conditions. Treatments of one weevil/plant had an adverse effect on plant height and the number of reproductives. Treatments ranging from one to four weevils/plant also significantly increased the number of dead leaves/plant. Plant root length, the number of live leaves and total dry weight (biomass) were adversely effected by treatments of four weevils/plant. Feeding by adult and larval *N. eichhorniae* on waterhyacinth plants in southern Louisiana caused a reduced plant reproductive rate and vigor as well as plant death. Areas previously infested with waterhyacinth became occupied by several semi-aquatic plant species that flourished on the decaying mat. Open water returned, at least temporarily, to one site.

Key words: weevils, *Eichhornia crassipes,* plant vigor, aquatic weeds, biocontrol.

INTRODUCTION

Waterhyacinth, *Eichhornia crassipes* (Mart.) Solms is a perennial, mat-forming aquatic plant, native to Brazil, that now grows in nearly all countries with environments favorable for its development. By 1979 approx. 0.6 million hectares of Louisiana's water and wetlands were infested (4). In addition to obstructing water flow, this weed pollutes the water through rapid growth and decomposition, creates microenvironmental conditions toxic to fish and waterfowl, and reduces boating, fishing and other recreational activities.

For these reasons, searches were conducted for a biological, self-perpetuating, economical control method. Among other organisms, a weevil, *Neochetina eichhorniae* Warner, was determined to be host-specific on waterhyacinth (5) and, after quarantine procedures were carried out, the weevil was mass-reared and released in Florida by the USDA in 1972. Successful establishment of the weevil in Florida led to subsequent mass-rearing and release of the weevil in Louisiana by the Louisiana Department of Wildlife and Fisheries (4). Several field "nursery" areas were established and, begining in 1974, infested plants were distributed throughout the state.

The objective of our study was to determine the weevil's ability to suppress waterhyacinth in southern Louisiana under both restricted and natural field conditions.

[1]Professor, and Former Research Assistant, Department of Entomology, Louisiana Agriculture Experiment Station, Louisiana State University Agricultural Center, Baton Rouge, LA 70803.

MATERIALS AND METHODS

Restricted Field Studies. Concurrently with evaluating the impact of *N. eichhorniae* weevils under natural field conditions, preliminary testing during the summer of 1980 was conducted to determine the effects of several densities of adult weevils under restricted conditions. Three livestock watering troughs (cap. 2423 liters), filled with water from a nearby ditch were utilized for these tests. Each trough was lined with visquene prior to filling so that the plants would not be influenced by any mineral deposits other than these in the "natural" water. Each tank was fitted with an elevated, compartmentalized 80-mesh screen top to prevent weevil escape or movement among treatments.

Seven uninfested, erect, pre-flowering stage waterhyacinth plants (Stage II) (1) were introduced into four equal-sized compartments in each tank (total of 28 plants/tank) on 29 September 1980. All plants had been field collected and then isolated at a greenhouse facility. Isolation procedures involved spraying all plants every two weeks for at least six weeks with carbaryl 50 wp (2.5 g/l) to kill any adult weevils present. The experimental design was a completely randomized block design with three replications. Treatments were: one weevil/plant, two weevils/plant, four weevils/plant, and control (no weevils). All adult weevils[2] were previously field collected from waterhyacinth growing in Bayou Morgan City (near Morgan City, La.). After one month all plants were removed and height of the tallest leaf, root length, number of live leaves, number of dead leaves (those with brown pseudolamina), number of feeding scars, dry plant weight, and the number of daughter plants recorded. An analysis of variance was conducted on all results to determine if differences among treatment means existed. Duncan's New Multiple Range Test was utilized to separate significant treatment effects.

Field Study Areas. Two areas in southern Louisiana were chosen as study sites from a list of areas where *N. eichhorniae* infested plants were released by the Army Corps of Engineers and the Louisiana Department of Wildlife and Fisheries. These areas were accessible and were different ecologically. The first area was a partially impounded bayou near Whitehall (Livingston Parish) and the second was Bayou Morgan City (Assumption Parish). The Whitehall area is a shaded cypress swamp with relatively little waterflow during most of the year. Great fluctuations in water level occur in Spring due to rainfall patterns and back up from the nearby Amite River. The area was heavily in-

[2]A random sample of 300 weevils taken from field study areas were identified by Dr. D. R. Whitehead, USDA, Beltsville, MD., as *N. eichhorniae.* No *N. bruchi* were recovered. Voucher specimens are deposited in the L.S.U. Entomological Museum.

fested with waterhyacinth at the start of our investigation. Bayou Morgan City is a much larger, slowly moving, open water system. Waterhyacinth plants were present along the edge of the bayou and in concentrated amounts at the mouth of inlets when the study was initiated. The plant population frequently built up to cover the central portion of the bayou during the summer.

Experimental Data Collected. The Whitehall and Morgan City plots were visited at two-week intervals from 6/7/79 to 8/27/80 except for a few dates during winter and flooded conditions. Twenty-five plants/plot were examined in the field and all life stages of *N. eichhorniae* collected and counted. The 25 sample plants were chosen as randomly as possible, however movement through dense waterhyacinth mats, especially late in the summer was difficult. Therefore, plants were taken from a relatively small area (0.10 ha) on each sample date at each plot.

From 2/21/80 to 8/27/80 sampling procedures were changed to facilitate more accurate determination of weevil numbers and to obtain several plant measurements. Twenty-five plants were selected at random at each site as before, but were placed collectively in plastic bags, sealed and transported to the laboratory. The numbers of adults, larvae, and pupae, plant height, root length, number of live leaves, number of dead leaves, wet root weight, and wet weight of leaves and stems were recorded for each of the 25 plants. A subsample of five of the 25 plants collected at each site was selected at random, and the total number of feeding scars/plant recorded. The number of feeding scars later was compared with the number of adults to determine if the number of feeding scars present in the field was indicative of the adult population. The number of feeding scars also was compared with plant density to determine if adult feeding was related to reductions in plant density. Plant density was determined at each site from 2/21/80 to 8/27/80 by counting the number of plants (including daughter plants) in three randomly selected 1 m^2 areas.

RESULTS AND DISCUSSION

Restricted impact tests indicated that after 30 days significant differences existed among plant height means for all treatments (Table 1). The tallest plants were present in the control, followed by treatments of one, two, and four weevils/plant, respectively. Mean root length/plant was not significantly different among the control, one, and two weevils/plant, but was significantly different between four weevils/plant and all other treatments. No significant difference existed among the mean number of live leaves/plant among the control, one, and two weevils/plant and all other treatments. The mean number of dead leaves/plant was not significantly different when treatments of one and two weevils/plant were compared, but significant differences existed between the control, one and two weevils/plant, and four weevils/plant. Analysis of the data indicated that significant differences in the number of feeding scars/plant existed between all treatments. The greatest mean number of feeding scars was present in treatments of four weevils/plant, followed by two, one and the control, respectively. No significant differences existed among mean dry plant weight of the control, one, and two weevils/plant but a significant difference existed between four weevils/plant and all other treatments. The greatest number of reproductives/plant (daughter plants) occurred in the control followed by one, two, and four weevils/plant, respectively. Comparable results were reported in Australian studies (2).

Field Study. At both field areas the adult population increased over time as indicated by adult numbers and a corresponding increase in feeding scars/plant (Fig. 1). A positive correlation was found between feeding scars/plant and plants/m^2 at the Whitehall plot (Fig. 1a,b). This was exactly the opposite of what might be expected. However, because spring high water removed the damaged plants from this plot, plant density increased substantially as the waterhyacinth became re-established. Normal high water levels in the Spring of 1980 washed away the hyacinth mat at the Whitehall plot from 3/20/80 to 5/15/80. Spring high water occurs annually at this plot due to its close proximity to the Amite River. The weevil populations at this plot, apparently, had been increasing for several seasons. When densities of six to eight weevils/plant were reached in 1980 (3), cumulative impact had almost destroyed the mat, and it was broken up and dispersed by the high water. The vigor of new plants coupled with their inherent high reproductive rate prevented rebounding adult weevil populations from reducing plant density during a single season. As the density of waterhyacinth plants increased after spring high water, the weevil population increased causing a corresponding increase in the number of feeding scars (Fig. 1a,b,d).

Since the Morgan City plot consisted of waterhyacinth mats undisturbed by flooding, this plot gave a reasonable estimate of the effect of adult feeding on plant density. A negative relationship existed between the number of feeding scars and plant density at Morgan City indicating that decreasing density of waterhyacinth plants at this plot was closely correlated with increasing number of adult feeding scars. At the end of the 1980 growing season the water-

TABLE 1. IMPACT OF *Neochetina eichhorniae* ON STAGE II WATERHYACINTH UNDER RESTRICTED FIELD CONDITIONS, BEN HUR FARM, LOUISIANA STATE UNIVERSITY, 9/29/80-10/29/80.

No. weevils per plant	Plant Height (cm)	Root Length (cm)	No. of Live Leaves	No. of Dead Leaves	No. of Feeding Scars	Dry Plant Weight (g)	No. of Reproductives
0 (control)	22.10 a[1]	30.68 a	8.67 a	0.90 c	0.00 d	3.16 a	1.86 a
1	20.00 b	30.47 a	9.14 a	1.71 b	144.14 c	3.15 a	1.19 b
2	19.23 c	30.96 a	8.62 a	1.95 b	334.33 b	3.17 a	0.67 c
4	16.18 d	28.46 b	2.19 b	7.90 a	805.29 a	2.50 b	0.10 d

[1]Means within columns followed by different letters are significantly different (0.05) according to Duncan's Multiple Range Test.

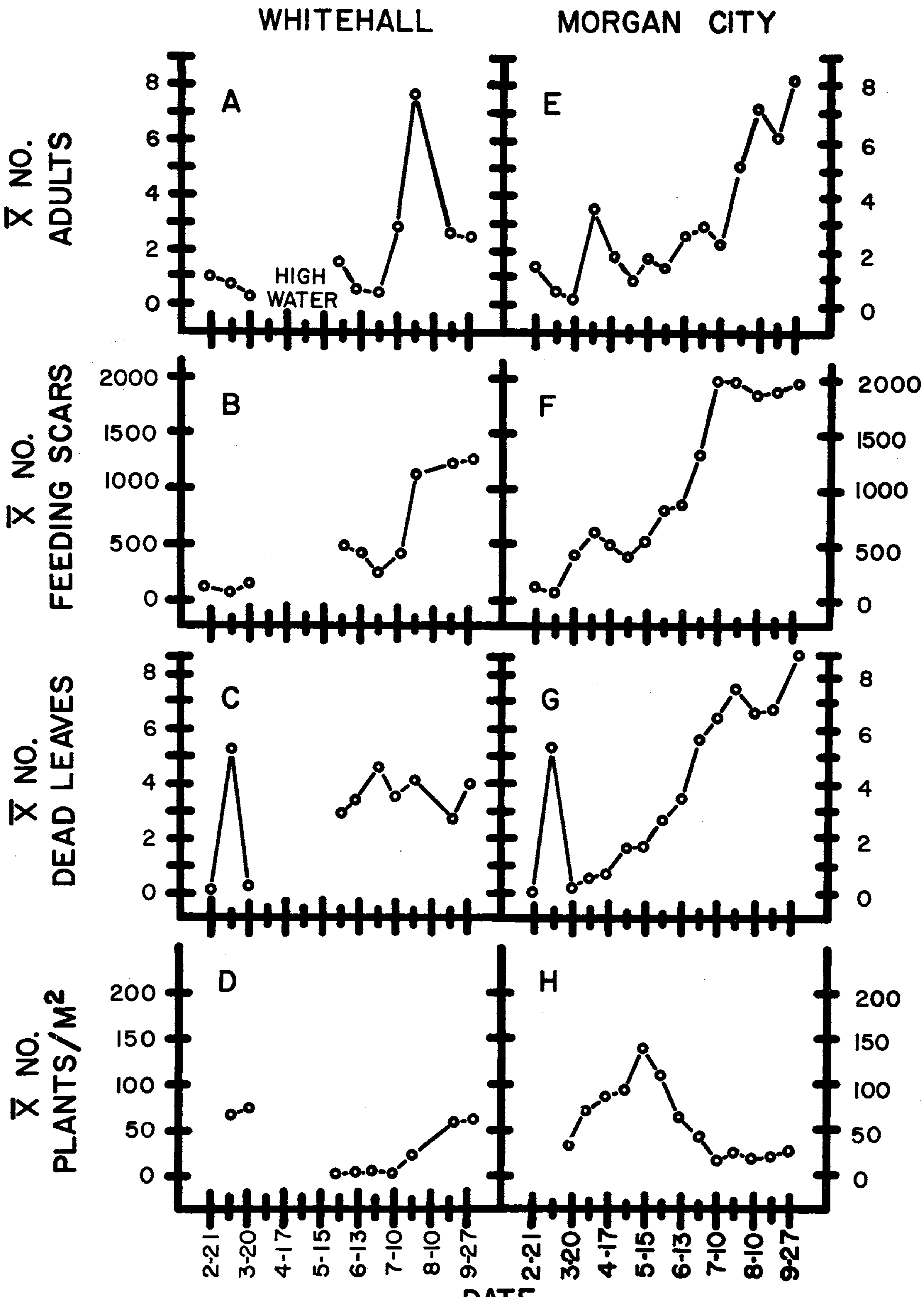

Figure 1. Relationship of *Neochetina eichhorniae* and waterhyacinth, southern Louisiana, 1980. X̄ are per plant.

hyacinth mats were very stressed and visual observations revealed that adult and larval feeding was extensive. Waterhyacinth leaves were turning brown and curling up. Many plants were dying without any apparent involvement by *Cercospora* sp. or abiotic factors. By 1981 waterhyacinths were completely absent from the entire bayou.

No significant correlation existed between plants/m^2 and the number of adults/plant at Whitehall in 1980. Reductions in plant density at Whitehall in 1980 were difficult to determine because waterhyacinth was in the process of reestablishing this area. The extremely high reproductive rate of waterhyacinth enabled the plant to cover open water surfaces very rapidly and a lag in the weevil population occurred at this plot. Plant reproduction probably occurred much more rapidly than weevil-inflicted damage. No plants were collected in this plot on 5/30/80 (just after the removal of the mat by high water); however, by 8/27/80 there were 59 plants/m^2 (Fig. 1d). Plant density levels of 72 plants/m^2 had been present prior to the removal of the mat. This density level was not re-attained at the Whitehall site during the summer of 1980.

A negative relationship existed between plants/m^2 and the number of adults/plant at Morgan City (Fig. 1e,h). Plant density increased from 31 plants/m^2 on 3/20/80 to 136 plants/m^2 on 5/15/80. The number of plants/m^2 dropped off sharply to 20 on 7/10/80 and the plant density remained at a low level until the end of the study. At the same time, populations of adult *N. eichhorniae* increased from 0.1 adults/plant on 3/20/80 to 1.7 adults/plant on 5/15/80, 2.4 adults/plant on 7/10/80, and 8.0 adults/plant on 8/27/80. In theory, plant density should increase in spring and summer to a maximum density/surface area of water. Density should level off and begin to decline when temperatures fall in winter. However, plant density reached a peak in late spring (5/15/80) and then declined rapidly concurrently with adult weevil population increases. The highest population of adults present before the sharp decline in plant density on 5/15/80 was 1.4 adults/plant. This does not necessarily indicate that levels of 1.4 adults/plant can control waterhyacinth in the field. A cumulative effect over several seasons of adult and larval feeding was probably responsible for the decline in the waterhyacinth mat. Adult weevil populations reached ca eight adults/plant by the end of September 1979 at Morgan City and again in August 1980 (6). This level appeared to severely damage waterhyacinth mats.

There was a comparable trend between the number of dead leaves/plant and the number of adults/plant at both Whitehall and Morgan City (Fig. 1a,c,e,g). There were no dead leaves present at Morgan City on 3/20/80 but by 8/27/80 there were 9.1/plant. This far exceeds the "normal" increase in dead leaves. During this time period a similar increase in the number of adults occurred in this plot. The number of dead leaves corresponded very closely with the trend indicated by that of the adult weevil population data.

The waterhyacinth mats at the Morgan City site declined dramatically during the 1980 growing season. Adult weevil damage was so severe that leaves curled up, turned brown and plants shrivelled up and died. Leaf drop occurred due to petiole girdling by adult weevils. Large sections of the mat at both areas started to decay and sink (Fig. 2) resulting in the establishment of several species of aquatic and semi-aquatic plants. The semi-aquatic plants growing in or on the decaying mat were the most predominant group: cyperus sedge (*Cyperus* sp.), smartweed (*Polygonum punctatum* Ell.), water pennywort (*Hydrocotyle umbellata* L.), water orchid (*Habenaria repens* Nuttall), primrose willow (*Ludwigia decurrens* Walt.), and an unidentified

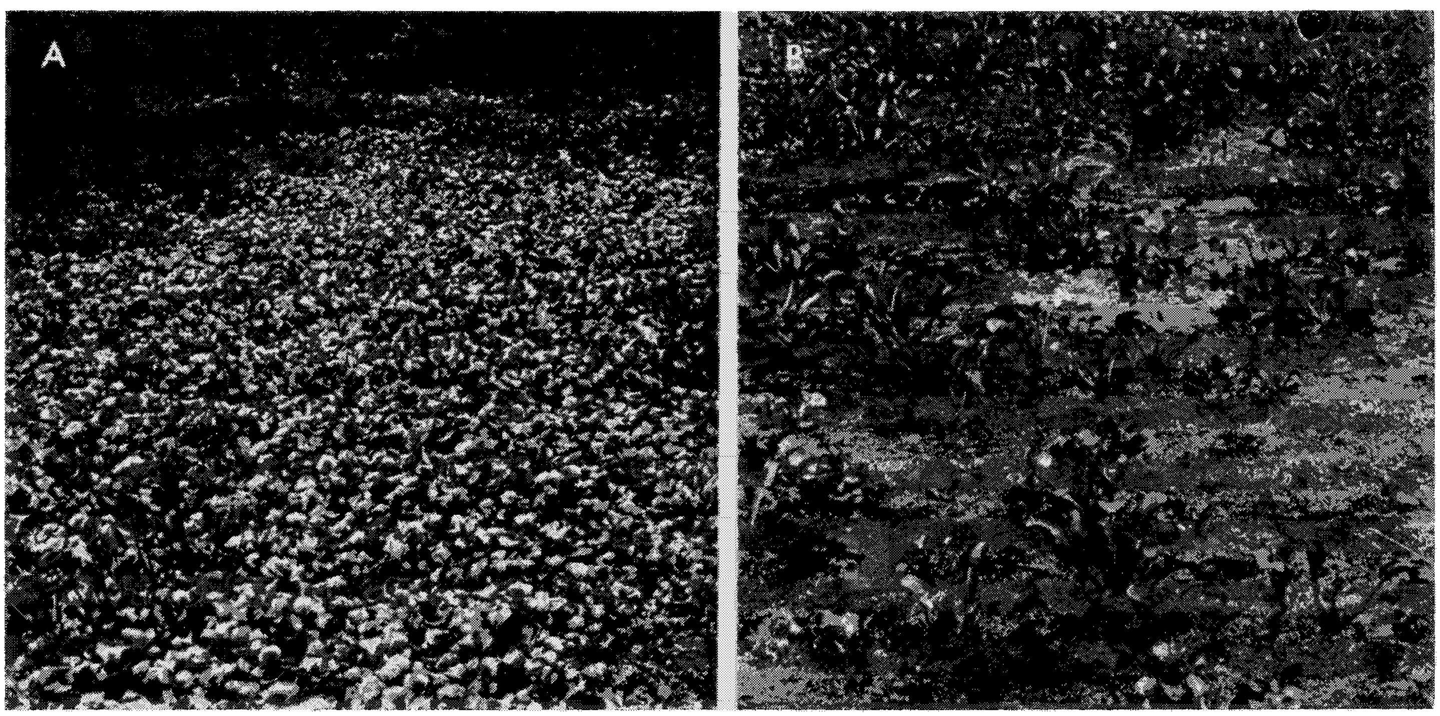

Figure 2. Waterhyacinth mat at Morgan City. A=June 1979, B=August 1980.

species of *Ludwigia*. Two aquatic weeds were also identified: alligatorweed (*Alternanthera philoxeroides* [Mart.] Griseb.) and duckweed (*Lemna minor* L.).

It is hypothesized that as the decaying waterhyacinth mat sinks, the semi-aquatic weeds living on it will not be able to survive, and open water would result. However, this open water will then be susceptible to invasion by other aquatic weeds, or waterhyacinth may reinfest this area as noted at the Whitehall site. A cyclic situation may develop wherein high weevil populations and resultant low plant populations alternate. This has been further indicated by visual examination of these plots throughout 1981 and 1982.

LITERATURE CITED

1. Foret, J. A., J. R. Barry and E. A. Theriot. 1980. Biological control agents on waterhyacinth at nineteen locations in Louisiana. Miscellaneous Paper A-80-4, U.S. Army Corps of Engineers, Waterways Exp. Sta., Vicksburg, MS. 8 pp.
2. Forno, I. W. 1981. Effects of *Neochetina eichhorniae* on the growh of waterhyacinth. J. Aquat. Plant Manage. 19:27-31.
3. Goyer, R. A. and J. D. Stark. 1981. Suppressing waterhyacinth with an imported weevil. La. Agric. 24(4):4-5.
4. Manning, J. H. 1979. Establishment of waterhyacinth weevil populations in Louisiana. J. Aquat. Plant. Manage. 17:39-41.
5. Perkins, B. D. 1973. Potential for waterhyacinth management with biological agents. Proc. Tall Timbers Conf. Ecol. Anim. Control Habitat Manage. 4:53-64.
6. Stark, J. D. 1981. The biology and life cycle of *Neochetina eichhorniae* Warner (Coleoptera:Curculionidae) and its impact on waterhyacinth in southern Louisiana. M.S. Thesis, La. State Univ., Baton Rouge. 69 pp.