US Army Corps of Engineers

AQUATIC PLANT CONTROL RESEARCH PROGRAM

TECHNICAL REPORT A-88-6

A SURVEY OF THE FAUNA ASSOCIATED WITH *PISTIA STRATIOTES* L. (WATERLETTUCE) IN FLORIDA

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April 1988

Final Report

Approved For Public Release; Distribution Unlimited

Prepared for DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

and US Army Engineer District, Jacksonville
PO Box 4970, Jacksonville, Florida 32232-0019

Monitored by Environmental Laboratory
US Army Engineer Waterways Experiment Station
PO Box 631, Vicksburg, Mississippi 39180-0631

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) Technical Report A-88-6
6a. NAME OF PERFORMING ORGANIZATION See reverse. 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION USAEWES Environmental Laboratory
6c. ADDRESS (City, State, and ZIP Code) See reverse.	7b. ADDRESS (City, State, and ZIP Code) PO Box 631 Vicksburg, MS 39180-0631
8a. NAME OF FUNDING/SPONSORING ORGANIZATION See reverse. 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) See reverse.	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
A Survey of the Fauna Associated with *Pistia stratiotes* L. (Waterlettuce) in Florida

12. PERSONAL AUTHOR(S)
See reverse.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final report	FROM ______ TO ______	April 1988	36

16. SUPPLEMENTARY NOTATION
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Aquatic plants; Insects; Biological control; Waterlettuce

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Increasing waterlettuce populations in Florida appear to be associated with concurrently declining waterhyacinth populations. Waterhyacinth is competitively superior to waterlettuce and probably supplanted the vast waterlettuce mats observed by explorers in Florida during the mid-1700s. For these reasons, it is believed that waterlettuce may reach severe nuisance population levels as waterhyacinth abundance continues to decline. To prevent this, a project was initiated to introduce into the United States biological agents that have successfully controlled waterlettuce in Australia and portions of Asia.

The first phase of this project involved conducting a survey of the fauna, particularly plant-feeding insects, associated with waterlettuce in Florida. The objectives of the survey were to ensure proposed biocontrol agents were not in Florida, identify native

(Continued)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code) / 22c. OFFICE SYMBOL

DD Form 1473, JUN 86 Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

6a. NAME OF PERFORMING ORGANIZATION (Continued).

University of Florida, Institute
of Food and Agricultural Sciences;
US Department of Agriculture, Agriculture
Research Service, South Atlantic Region

6c. ADDRESS (Continued).

Gainesville, FL 32601;
Fort Lauderdale, FL 33314

8a. NAME OF FUNDING/SPONSORING ORGANIZATION (Continued).

US Army Corps of Engineers;
USAED, Jacksonville

8c. ADDRESS (Continued).

Washington, DC 20314-1000;
PO Box 4970, Jacksonville, FL 32232-0019

12. PERSONAL AUTHORS (Continued).

Dray, F. Allen, Jr.; Thompson, Catherine R.; Habeck, Dale H.;
Balciunas, Joseph K.; Center, Ted D.

19. ABSTRACT (Continued).

herbivores that stress the plants, and develop a preliminary understanding of dynamics of the faunal community associated with waterlettuce.

A minimum of 20 plants were collected at each of 61 water bodies (July 1985-June 1986). The fauna on these plants included 98 insect taxa and 11 other invertebrate taxa. Thirteen herbivorous species were collected from these plants, but only six (the moths *Samea multiplicalis*, *Petrophila drumalis*, and *Synclita obliteralis*, the leafhopper *Draeculacephala inscripta*, the aphid *Rhopalosiphum nymphaeae*, and an unidentified mealybug) feed on the living plant tissues. This is a depauperate herbivorous fauna compared to South America or Asia. In South America, for example, nine species of weevils (several of which are host specific) feed on waterlettuce. None of the Floridian herbivores are known to be host specific, which strengthens arguments that waterlettuce is not native to the United States. Finally, neither of the proposed biocontrol agents (*Neohydronomus pulchellus* and *Athetis pectinicornis*) was present in Florida.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

Preface

This research was sponsored by the US Army Engineer District, Jacksonville, Jacksonville, Fla., and the Office, Chief of Engineers (OCE), US Army, through the Aquatic Plant Control Research Program (APCRP) at the US Army Engineer Waterways Experiment Station (WES). The OCE Technical Monitor was Mr. E. Carl Brown.

The research described in this report was conducted through Specific Cooperative Agreement No. 58-7B30-3-586 between the US Department of Agriculture (USDA), Agriculture Research Service (ARS), South Atlantic Region (SAR), and the University of Florida (UF), Institute of Food and Agricultural Sciences (IFAS). The report was prepared by Mr. F. Allen Dray, Jr., UF, IFAS, Fort Lauderdale Research and Education Center (FLREC). Principal investigator for the USDA was Dr. Ted D. Center, USDA, ARS, SAR, Aquatic Plant Management Laboratory. Principal investigators for the UF, IFAS, were Dr. Joseph K. Balciunas, FLREC, and Dr. Dale H. Habeck, Department of Entomology and Nematology.

The field research and data analyses were performed by Mr. Dray, Dr. Center, Dr. Habeck, and Dr. Catherine R. Thompson, UF, IFAS, Department of Entomology and Nematology. Assistance with field collections and laboratory processing was provided by Messrs. Mike Bouhadana, Jim Grocki, Roger Stewart, Oleg Maslund, and Al Vargas, FLREC; Ms. Judy Gillmore, IFAS, Department of Entomology and Nematology; and Mr. Willey Durden, USDA, ARS, SAR, Aquatic Plant Management Laboratory. Special assistance with boats was provided to Drs. Habeck and Thompson by Ms. Margaret Glenn, UF, IFAS, Center for Aquatic Weeds. The report was edited by Ms. Jessica S. Ruff of the WES Information Technology Laboratory.

This research was monitored at WES by Dr. Alfred F. Cofrancesco, Jr., of the Environmental Laboratory (EL), Environmental Resources Division (ERD), Aquatic Habitat Group (AHG). The study was conducted under the general supervision of Dr. John Harrison, Chief, EL, and Dr. Conrad J. Kirby, Chief, ERD, and under the direct supervision of Mr. Edwin A. Theriot, Chief, AHG. Mr. J. Lewis Decell was Manager of the APCRP.

COL Dwayne G. Lee, CE, was the Commander and Director of WES. Technical Director was Dr. Robert W. Whalin.

This report should be cited as follows:

Dray, F. Allen, Jr., Thompson, Catherine R., Habeck, Dale H., Balciunas, Joseph K., and Center, Ted D. 1988. "A Survey of the Fauna Associated with *Pistia stratiotes* L. (Waterlettuce) in Florida," Technical Report A-88-6, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Contents

A SURVEY OF THE FAUNA ASSOCIATED WITH *PISTIA STRATIOTES* L. (WATERLETTUCE) IN FLORIDA

Introduction

Background

1. The use of water bodies for recreation and navigation is often severely restricted by nuisance aquatic weeds. These plants clog irrigation and drainage canals, impede hydroelectric operations, decrease property values, hinder mosquito control operations, and cause other problems that adversely impact the general populace. Species such as alligatorweed (*Alternanthera philoxeroides* (Mart.) Griesb.), waterhyacinth (*Eichhornia crassipes* (Mart.) Solms), hydrilla (*Hydrilla verticillata* L. fil.), and Eurasian watermilfoil (*Myriophyllum spicatum* L.) have been the subjects of extensive research efforts investigating a variety of control methodologies. These studies have led to the successful introduction of foreign insects as biological control agents on both alligatorweed and waterhyacinth. Resultant declines in host plant abundances have left open waterways that were once clogged by these weeds.

2. *Pistia stratiotes* L. (waterlettuce) is a hydrophyte that often invades waterways previously covered by waterhyacinth (T. D. Center, personal observation). Reports by John and William Bartram (Stuckey and Les 1984) indicate that extensive mats of waterlettuce existed in Florida during the late 1700s. The competitively superior waterhyacinth (El Seed 1978) apparently replaced these mats when the former was introduced at the beginning of the 20th century. However, recent estimates based on the Florida Department of Natural Resources' annual aquatic plant surveys (Schardt 1984, 1985, 1986) indicate waterhyacinth acreage decreased significantly from 1982 to 1985 while waterlettuce populations nearly quadrupled. The rapid expansion of waterlettuce into waterways opened by the decline of waterhyacinth, together with the Bartrams' observations, indicates waterlettuce has the potential to become a severe nuisance in Florida. This plant is already considered an important weed in Africa, Australia, India, and Southeast Asia (Cook et al. 1974, Holm et al. 1977, Harley et al. 1984). Waterlettuce could also become a nuisance

in much of the southern United States since Muenscher (1944) records waterlettuce from all of the Gulf Coast States, Georgia, and Arizona.

3. *Pistia stratiotes* L. is a free-floating aquatic weed having densely hairy, obovate-cuneate leaves arranged as a rosette. Leaves have parallel veins and are deeply grooved on the underside. The basal regions of the leaves are often quite swollen with spongy parenchyma (Ito 1899), which provides buoyancy to the plant. A cluster of plumose adventitious roots originates from the base of each leaf and remains attached to the short underwater rhizome following loss of the leaf. The flowers occur singly in the center of the plant and are composed of a small whitish spathe that is constricted near the middle. Two cavities are thus formed: the upper contains a whorl of three to eight stamens having fused filaments; the lower contains the pistil (Muenscher 1944).

4. Reproduction in the United States appears to be exclusively vegetative since viable seeds have not been observed (Weldon, Blackburn, and Harrison 1969; Godfrey and Wooten 1979). Pieterse, DeLange, and Verhagen (1981), studying the potential for this weed to sexually reproduce in the Netherlands, found that *Pistia* seeds germinate at temperatures from 20° to 30° C and pH values between 5 and 8 whether submersed or not. Seeds remained viable for up to 7 months and withstood freezing for several weeks. Since conditions optimal to seed germination (pH 6.5 to 7.5 and temperatures of 22.5° to 25° C) are common in Florida, the absence of sexual reproduction in the United States is presumably due to limited seed production (Weldon, Blackburn, and Harrison 1969), probably resulting from a paucity of suitable pollinators (Godfrey and Wooten 1979).

5. Geographical origins of waterlettuce have been difficult to determine. John and William Bartram often encountered waterlettuce during their explorations of Florida in the mid-1700s (Stuckey and Les 1984) leading some workers to consider it a species native to North America. Cordo, DeLoach, and Ferrer (1981) suggest a South American origin based on the abundance of insects associated with *P. stratiotes* on that continent. The antiquity of African populations is attested to in the writings of Pliney the Elder (A.D. 77) where he reports its use as a medicinal agent in Egypt (Stuckey and Les 1984). An African origin for waterlettuce is supported by evidence that African plants set seed readily, while North American plants rarely do so (Holm et al. 1977). The apparently widespread medicinal use of waterlettuce

during such ancient times argues strongly against introduction into the Old World from the New World. Arguments for an Old World origin are further strengthened by the presence of a fossil species, *Pistia sibirica* Dorofeev, in Oligocene and Miocene deposits from western Siberia (Dorofeev 1955, 1958, 1963) and in Miocene deposits from the German Democratic Republic (East Germany) (Mai and Walther 1983) and Denmark (Friis 1985).

Purpose and objectives

6. This report details the results of a survey of the fauna associated with *Pistia stratiotes* L. in Florida. The survey is part of the first phase of a project aimed at bringing waterlettuce populations under control in Florida using biological agents. The primary objective of the survey was to ensure that the prospective biocontrol agents *Neohydronomus pulchellus* Hustache (a weevil) and *Athetis (Namangana) pectinicornis* Hampson (a noctuid moth) were not present in Florida. A secondary objective was to identify any native herbivores that already adversely impact waterlettuce. The final objective was to develop a preliminary understanding of the trophic relationships and dynamics of the organisms that will be interacting with the proposed biocontrol agents once they are released on waterlettuce.

Methods

7. Florida water bodies, including lakes, ponds, rivers, streams, canals, and sloughs, in both north and south Florida were examined for waterlettuce populations during the period June 1985 through May 1986. A sample of at least 20 plants was collected from each population. Replicate samples were collected at some heavily infested sites. Several sites were visited quarterly to permit seasonal comparisons of faunas.

8. Invertebrates associated with waterlettuce were removed from the plants by a submergence sorting technique. In this technique, plants were immersed in a container of water for a period of time sufficient to force air-breathing insects to the water surface where they were easily removed. Preliminary tests indicated that if the plants were submerged for a period of 4 hr, over 95 percent of the air-breathing insects could be removed. This included moth and fly larvae that are known to tunnel in the plant leaves and stems. At the end of the 4 hr, the plants were shaken vigorously over the submergence chamber. The water from the container was then poured through a sieve. The materials retained on the sieve were hand sorted using a sugar-flotation technique (Anderson 1959), and the animals were removed and stored

in 70-percent isopropanol. Specimens were identified using standard taxonomic references (Byers 1930; Young 1954; Carpenter and LaCasse 1955; Arnett 1968, 1985; Borror and DeLong 1971; Usinger 1971; Needham and Westfall 1975; Pennak 1978; Simpson and Bode 1980; Brigham, Brigham, and Gnilka 1982; Merritt and Cummins 1984).

Results and Discussion

9. Sixty-one Florida water bodies (Table 1, Figure 1) were examined for *Pistia* populations during the course of this study. Seventeen of these were visited on a quarterly basis; the remainder, opportunistically. A total of 201 samples were collected (108 in north Florida, 93 in south Florida), 135 of which have been examined to date. Approximately 47,000 faunal specimens from 109 taxa have been identified (Table 2).

10. The 34,000 specimens of *Hyallela azteca* collected during the survey made this amphipod the most abundant invertebrate associated with waterlettuce in Florida. These omnivorous scavengers were present at virtually all sites, opportunistically feeding upon the algae, dead animals, organic debris, and microrganisms associated with the submersed portions of the plant. Although Haag, Habeck, and Buckingham (1986) reported that this amphipod may occasionally feed on living plant tissues, it is unlikely that *H. azteca* causes any substantive damage to waterlettuce plants.

11. Fly larvae are often the most numerous insects in aquatic communities, and dipteran abundances during the survey followed this trend. Unidentified midges (Chironomidae and Ceratopogonidae) were the most abundant dipterans (3,700 and 3,400 specimens, respectively) in the samples, but soldier flies (Stratiomyidae) from the *Odontomyia-Heterodiscus* complex (1,500 total) were encountered at more sites. Additionally, 25 percent of the waterlettuce populations that were sampled hosted mosquitos (Culicidae). This may be a conservative estimate because these insects anchor themselves by implanting a respiratory siphon in plant tissues to obtain oxygen. Such behavior might reduce the number of specimens collected by the methods employed in this survey. Chironomids, mosquitos, and soldier flies on waterlettuce probably graze periphyton or detritus from roots and submersed leaf surfaces. The ceratopogonids are generally predaceous (Merritt and Cummins 1984), feeding on other insects living among the roots of aquatic macrophytes.

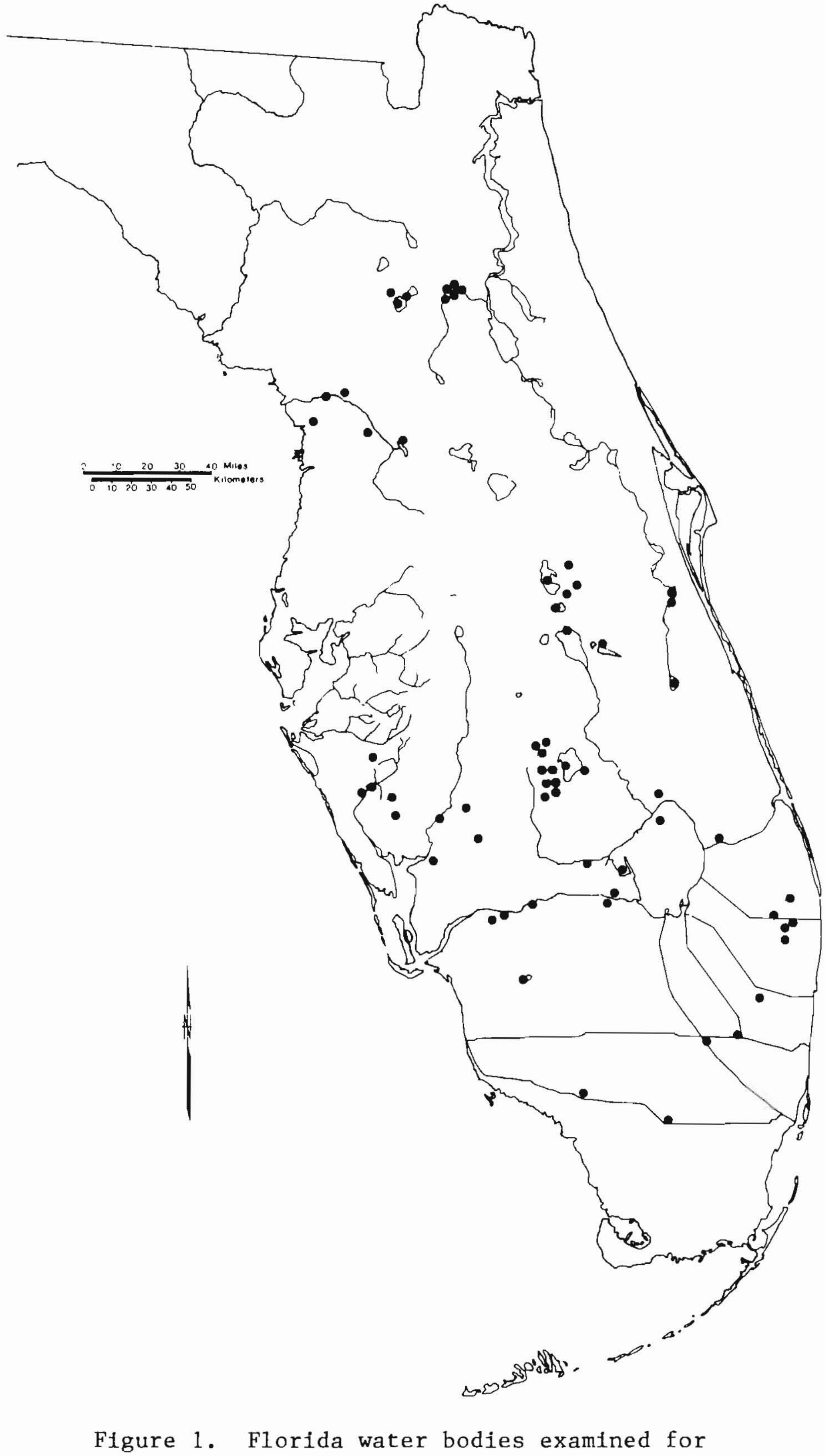


Figure 1. Florida water bodies examined for waterlettuce, June 1985-May 1986

The mosquitos were mostly *Mansonia titillans*, a vector for equine encephalitis and filariasis (Carpenter and LaCasse 1955). Larval mosquitos were very abundant in south Florida during autumn (Table 3), but February samples yielded few immatures. This suggests adults emerged early in the dry season. Larval chironomids were also most abundant during the autumn, but the majority of specimens were collected from one site. Thus, no clear pattern can be extrapolated from these data. Unlike midges and mosquitos, stratiomyids did not become abundant until early spring, when they were present at every site. Adults probably emerged during spring and early summer.

12. Several predatory bugs, including hebrids and naucorids, were moderately frequent though abundances were lower than for dipterans. *Hebrus* sp. was most abundant during winter, which is not surprising since members of this genus overwinter as adults (Brigham, Brigham, and Gnilka 1982). *Merragata brunnea* was most prevalent during spring, possibly in conjunction with the more abundant aphids upon which they may feed (Brigham, Brigham, and Gnilka 1982). The naucorid *Pelocoris femoratis* was more abundant during winter than during other seasons.

13. Predatory dragonfly nymphs were neither frequent nor abundant, but *Enallagma* damselfly nymphs were associated with almost half the sites (201 specimens). These nymphs and another coenagrionid, *Nehalennia* spp., became most abundant during south Florida's rainy season (summer and autumn). Both adults and nymphs of these genera feed on midges and mosquitos, and female *Enallagma* sp. may deposit their eggs in small punctures on waterlettuce leaves.

14. Nineteen beetle families were represented in the collections, but most were quite rare. Specimens from families such as the Buprestidae and Phalacridae were undoubtedly incidental catches, illustrating that many plants are utilized in an ephemeral manner (as resting sites) by animals not closely associated with them. Another group of beetles whose occurrence on *P. stratiotes* was incidental was the curculionid weevils, including *Neochetina bruchi* and *Neochetina eichhorniae*. These two host-specific herbivores were released as biological control agents on waterhyacinth during the 1970s. The duckweed weevil, *Tanysphyrus* sp., was also present, undoubtedly because duckweed was frequently intermingled with waterlettuce at the study sites. The most common water beetles were the noterids *Notomicrus* sp. (497 specimens) and *Suphisellus* sp. (456), which were abundant year-round. The larvae and

adults of these beetles live among the roots of *P. stratiotes* and other aquatic macrophytes, preying upon other animals associated with these plants. Dytiscid beetles, whose habits are similar to noterids, were infrequent and encountered only during the rainy season.

15. Three moth species were captured in the samples. *Samea multiplicalis* (Figure 2) was the most abundant (1,500 specimens) and most frequent (78 percent) herbivore inhabiting waterlettuce infestations. The seasonal comparisons from south Florida collections (Table 3) indicate that this moth was present year-round at most sites. Larval feeding damage to waterlettuce is often extensive (Figure 3) (DeLoach, DeLoach, and Cordo 1979), and researchers from the Division of Entomology, Commonwealth Scientific and Industrial Research Organization, have released this moth in Australia as a biocontrol agent (Sands and Kassulke 1984) on both *P. stratiotes* and *Salvinia molesta*. Larvae of a second moth, *Petrophila drumalis* (Figure 4), have not been associated with the adults prior to this survey and are atypical of the genus. These larvae weave lateral rootlets into "huts" from which they forage by clipping other lateral rootlets at their junctures with the roots. These clippings are then consumed. This species was not as common as *S. multiplicalis* but did occur at about 30 percent of the study sites during late summer and autumn. The last species, *Synclita obliteralis*, was rarely collected (two specimens) in south Florida. This was surprising since D. H. Habeck (personal observation) has found the larvae (Figure 5) to be quite abundant on *Pistia* at various times in north Florida. This highly polyphagous species attacks more than 40 plant species (Habeck, Haag, and Buckingham 1986) and usually builds larval cases from leaf clippings.

16. The leafhopper *Draeculacephala inscripta* (Figure 6) and the aphid *Rhopalosiphum nymphaeae* (Figure 7) were also frequently collected (55 and 36 percent, respectively) from waterlettuce populations. Both of these species have been recorded from numerous species of (mainly aquatic) plants (Haag, Habeck, and Buckingham 1986). Leafhoppers were abundant during winter, while aphids were abundant in spring. These herbivores are of particular interest because they are known to act as vectors for some plant viruses (Pettet and Pettet 1970, Borror and DeLong 1971). Yellowed, necrotic plants, which were apparently diseased, were often observed during the study.

17. Caddisflies (trichopterans) were quite abundant (2,848 specimens) in north Florida but were not observed in south Florida. The most striking

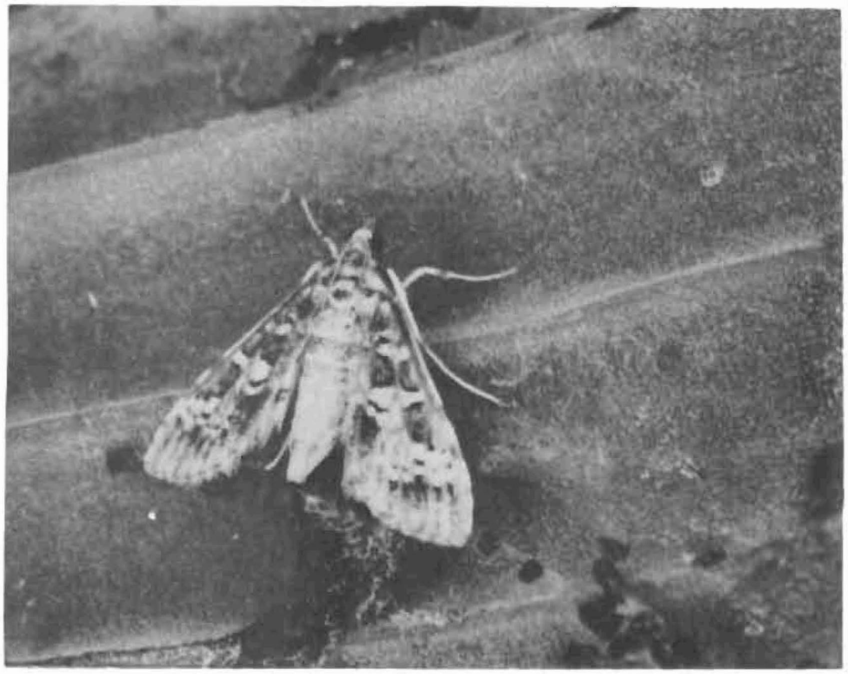
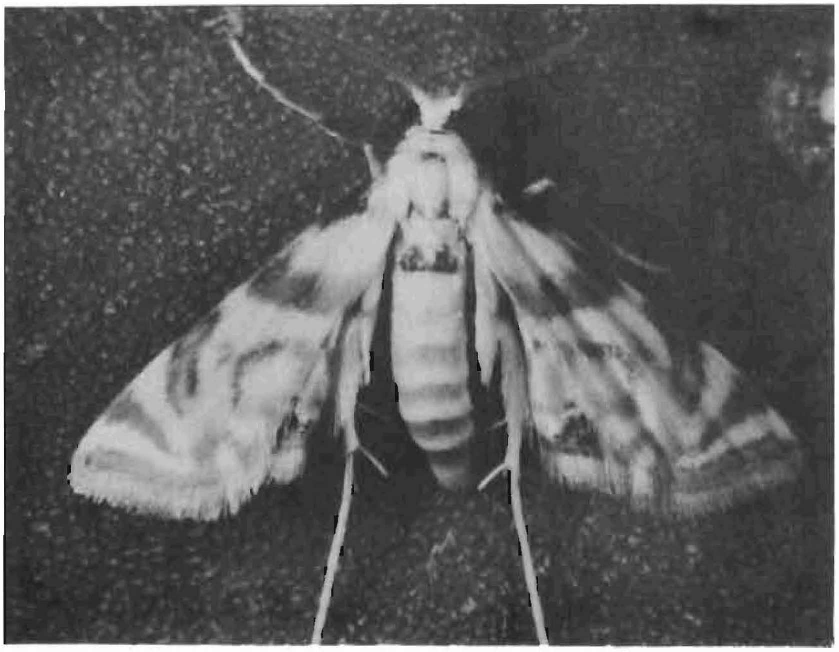


Figure 2. Adult *Samea multiplicalis* collected from waterlettuce

Figure 3. Feeding damage to waterlettuce caused by larval *Samea multiplicalis*



a. Adult

b. Larval stage feeding on waterlettuce roots.
Note the clipped lateral roots

Figure 4. *Petrophila drumalis*

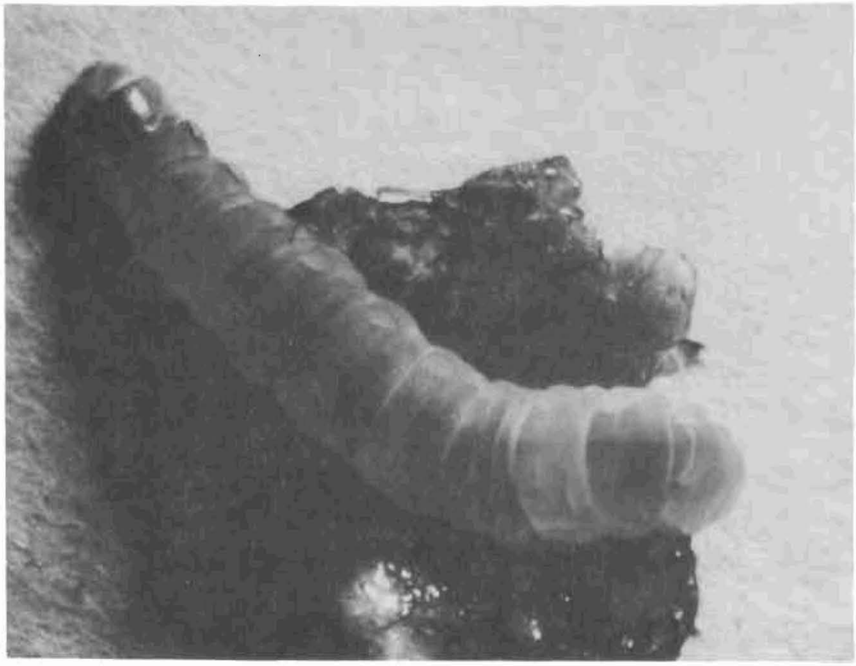


Figure 5. Larval *Synclita obliteralis* collected from waterlettuce

Figure 6. Adult *Draeculacephala inscripta* on a watterlettuce leaf

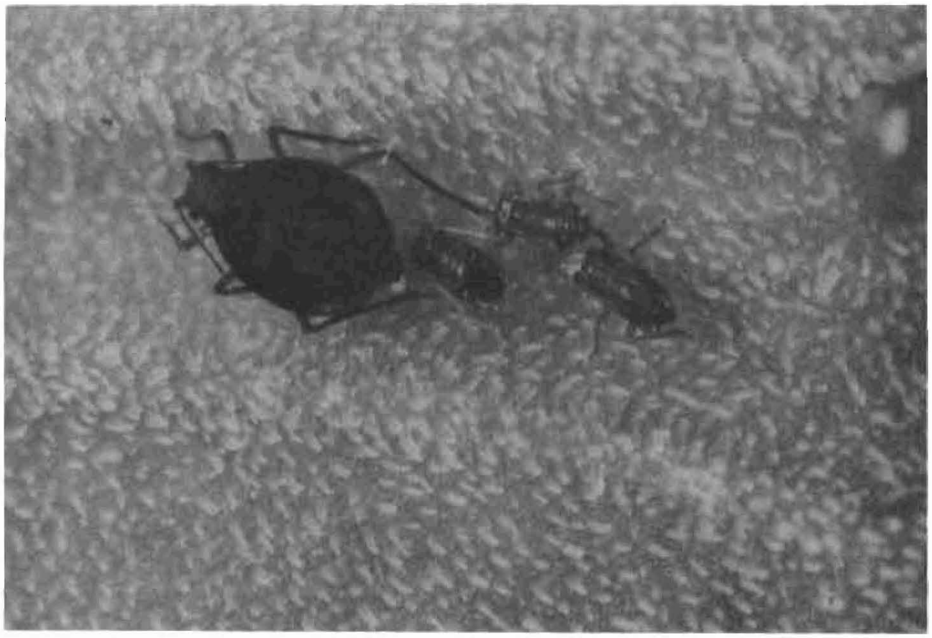


Figure 7. Adult and nymphal *Rhopalosiphum nymphaeae* on a waterlettuce leaf

aspect of caddisfly biology is the diversity of larval cases they build. These may be portable or stationary, constructed of sand grains or plant materials held together by silk, or they may be constructed entirely of silk. There are several phytophagous species, but it is likely that these insects have little effect on waterlettuce population dynamics throughout Florida since over 70 percent of the specimens came from one sample.

18. Parasites and predators can reduce the effectiveness of biological control agents. Thus, a brief discussion of these groups is here included. Several parasitic hymenopterous adults were collected, albeit rarely, during this survey. *Trichopria* is a diapriid wasp whose larvae parasitize the pupae of some flies and beetles (Merritt and Cummins 1984). The specimen in our collections probably belongs to the species that attacks *Hydrellia* fly pupae since this was the only diapriid host in these samples. Species from a second family of parasitic wasps represented in the study collections, the Braconidae, attack all immature forms of *Hydrellia* (Merritt and Cummins 1984). Mymarid wasps, the third parasite collected, specialize by attacking eggs of beetles, bugs, and dragonflies (Merritt and Cummins 1984), all of which were collected during this survey. Samples collected during this study generally

contained numerous spiders, many of which were observed capturing and devouring moth larvae and leafhopper nymphs. Other predators, i.e., birds and minnows, may also prove important to biocontrol efforts, but were not within the scope of this investigation.

19. Table 4 lists the phytophages collected during this investigation and the herbivores reported from waterlettuce in other countries. The South American fauna on *P. stratiotes* has been extensively studied (Neiff and Poi de Neiff 1978, Poi de Neiff 1983), and Bennett (1975) includes additional records from Central America and the Caribbean. Reports on faunas from other regions of the world are often restricted to species that have a severe impact on the plants (e.g., Mangoendihardjo and Nasroh 1976, Gonzalez 1978, Joy 1978). Although this makes comparison of regional faunas difficult, such comparison may still prove insightful.

20. The most striking feature in Table 4 is the restricted phytophagous fauna on waterlettuce in Florida (and presumably in North America) as contrasted with the extensive fauna reported from South America. Florida waterlettuce populations support only half of the number of herbivores found in South America, and none of these species are restricted in diet to *P. stratiotes* (with the possible exception of *Petrophila drumalis*). The abundance of South American phytophages on waterlettuce was the basis for the suggestion by Cordo, DeLoach, and Ferrer (1981) that waterlettuce originated on that continent. The paucity of North American phytophages certainly supports their contention by substantially weakening the argument for a North American origin of the plant. The absence of host-specific herbivores on waterlettuce in Florida compared to those reported from other regions of the world virtually eliminates the possibility of a North American origin for this aquatic weed, since host-specific herbivores would most likelv evolve in the original range of a plant prior to evolving in the adventive range (Wapshere 1974).

21. Distributions of two of the most abundant herbivores in the survey are not limited to Florida. *Samea multiplicalis* is apparently established throughout the New World and has been introduced into Australia. *Rhopalosiphum nymphaeae* is cosmopolitan, with records from four continents. The hydrophilid beetles are well represented throughout the Americas, and while Merritt and Cummins (1984) report that some species may be plant-feeders, it is doubtful that they cause much damage to *Pistia*. The Scirtidae (=Helodidae), also reported to contain herbivores (Merritt and Cummins 1984), are equally

unlikely to cause extensive damage to waterlettuce though present on the plant in both North and South America. The moth *Synclita obliteralis* is apparently limited to the eastern United States and feeds on several aquatic plants, but may occasionally cause severe damage to waterlettuce populations. Little can be said about the chironomid and ephydrid larvae except that both families have worldwide distributions and contain species that can be voracious phytophages.

22. One group of herbivores conspicuously absent from the Floridian fauna on waterlettuce was the weevils. While *Neochetina bruchi*, *N. eichhorniae*, and *Tanysphyrus* sp. were collected from waterlettuce, these are all known to feed exclusively on plants other than *Pistia*. Central and South America, however, present an array of weevils that feed on waterlettuce, including three species of *Argentinorhynchus*, two of *Neohydronomus*, and one each of *Ochetina* and *Onychylis*. This is very fortuitous because weevils as a group are usually host specific. Thus, should the two currently proposed biological agents prove unsuccessful at controlling *Pistia* populations in Florida, several additional waterlettuce herbivores are available for study.

Conclusions

23. This investigation revealed that the community of organisms currently associated with waterlettuce in Florida includes many species of aquatic and semiaquatic invertebrates. Other organisms were infrequent visitors to this community. Regular inhabitants included representatives from all trophic levels, the most important of which, in regard to this project, are the phytophages.

24. From the data it was not possible to extract patterns that suggest that one trophic group or higher taxon dominated the waterlettuce community during a given season, because apparent trends in seasonal faunas can be misleading when drawn from data collected on a quarterly basis. This factor is complicated by the relatively limited number of aquatic and semiaquatic invertebrates for which detailed life histories have been described. However, the data do imply that omnivorous scavengers (e.g., *Hyallela azteca*) are numerically dominant throughout the year. Samples collected in south Florida show evidence of the wet/dry seasonality generally expected in tropical and subtropical climatic regions. The fauna associated with *P. stratiotes* seems

richer and more abundant during the rainy season (summer and autumn) than during the dry season (winter and spring).

25. Results from this survey indicate that the phytophagous fauna associated with waterlettuce in Florida (and presumably the United States) is depauperate when compared to faunas of other continents. Furthermore, this fauna does not include the proposed biological agents *Neohydronomus pulchellus* and *Athetis (Namangana) pestinicornis*. Phytophages currently present in Florida are either not host specific or do not effectively control waterlettuce in this country, although they do, at times, severely stress the plants. It is assumed that native pathogens, parasites, and/or predators limit the effectiveness of waterlettuce phytophages native to this country. Successful introduction of the moth *Samea multiplicalis* to Australia as a biocontrol agent following removal of its native parasites and pathogens (Sands and Kassulke 1984) supports this assumption. Biocontrol agents imported to the United States and similarly freed of closely associated pathogens and parasites from their native ranges should prove highly effective.

26. The effects of predatory spiders and birds on larvae of *Neohydrononomus pulchellus* should be limited since these are endophages (i.e., they feed inside the tissues of their host plants), making them inaccessible to predation. Early instar larvae of *Athetis (Namangana) pectinicornis* should also be inaccessible because of endophagy, but later instars are exophages and may be fed upon heavily by the predators that currently attack *S. multiplicalis*. Adult weevils and moths will be more susceptible than the larvae to predation by birds, and adult moths will also be susceptible to predaceous dragonflies. However, similar predators exist in Australia and Thailand where these biocontrol agents have been very successful, so there is every reason to believe these predators will not significantly impair the effectiveness of these biocontrol agents in Florida.

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Table 1

A List of Florida Water Bodies Investigated During the Survey from July 1985 to June 1986*

County	Water Body Investigated
Alachua	Cross Creek [1]; Orange Lake [5]; River Styx [1]
Brevard	Lake Washington (at Tom's Canal) [3]; Lake Hellen Blazes [1]
Broward	Andytown Loop Canal [4]; Alligator Alley Canal [2]; Conservation Area 2A [4]
Charlotte	Shell Creek [1]; Trout Creek [1]
Citrus	Crystal River [3]; Tsala Apopka Lake [1]
Collier	Lake Trafford [4]; Tamiami Canal (at Ochopee) [1]
Dade	Fortymile Bend Side Canal [3]
De Soto	Joshua Creek [1]; Peace River [1]; Prairie Creek [1]
Glades	Caloosahatchee Canal [1]; Fisheating Creek [4]; Lake Hicpochee [1]; Lake Okeechobee [1]; West Ave. Canal (in Moor Haven) [4]
Hendry	Caloosahatchee River (at La Belle) [1]
Highlands	County Rd. 621 Canal [1]; Dinner Lake [1]; Grassy Lake [1]; Lake Clay [1]; Lake Huntley [1]; Lake Istokpoga [1]; Lake Jackson [1]; Lake Josephine [1]; Lake June in Winter [1]; Lake Placid [1]; Lake Sebring [1]
Indian River	Blue Cypress Lake [1]
Lee	Caloosahatchee River (at Avon) [1]; Hickey Creek [1];
Manatee	Bud Slough (at Gill Rd.) [1]; Lake Manatee [1];
Marion	Lake Rousseau [3]; Withlacooches River [1]
Martin	Saint Lucie Canal (at Indiantown) [1];
Okeechobee	Lake Okeechobee (at Horse Island) [4]; Taylor Creek [1]

(Continued)

* Number in parentheses indicates the times the site was visited during the course of the survey.

Table 1 (Concluded)

County	Water Body Investigated
Osceola	Alligator Lake [1]; Cypress Lake [1]; East Lake Tohopekaliga [1]; Lake Gentry [1]; Lake Kissimmee (at Sturm Island) [1]; Lake Marian [1]; Lake Tohopekaliga [1]
Palm Beach	Canal M [3]; D Road Canal (in Loxahatchee) [3]; Forest Hills Rd. Canal [3]; Pierson Rd. Canal [4]; West Palm Beach Canal (at S.R.7/S.R.80 intersection) [1]
Putnam	Rodman Reservoir (at Deep Creek) [3]; Cross Florida Canal [2]; Palm Point [1]; Swimming Hole [3]
Sarasota	Myakka River [1]; Lake Myakka [1]
Sumter	Lake Panasoffkee [3]

Table 2

Listing of Fauna Collected from *Pistia stratiotes* L., July 1985-June 1986

Arachnoidae
  Hydracarina (water mites)
    Pionidae
      Tiphys sp. (A,400,27%)*
  Araneae (spiders) (A,I,1661,87%)

Chilopoda
  Lithobiomorpha
    Lithobiidae (centipedes) (A,1,2%)

Crustacea
  Amphipoda (scuds)
    Talitridae
      Hyalella azteca (A,I,33840,100%)
  Decapoda
    Cambaridae (crayfish) (A,I,15,6%)
    Palaemonidae (crayfish)
      Palaemonetes paludosus (A,9,8%)
    Isopoda (pillbugs)
    Asellidae
      Lirceus sp. (A,5,5%)
  Ostracoda (seed shrimp)
    Cypridae (A, undetermined)

Diplopoda (millipedes) (A,11,5%)
Hirudinea (leaches)
  Pharyngobdellida
    Erpobdellidae (A?,41,11%)
  Rhynchobdellida
    Glossiphoniidae
      Helobdella stagnalis (A?,63,11%)

Insecta
  Coleoptera (beetles)
    Buprestidae (metallic wood-boring beetles) (A,2,2%)
    Carabidae (ground beetles)
      Bembidion sp. (A,16,10%) *Brachinus* sp. (A,1,2%)
    Chrysomelidae (leaf beetles)
      c.f. *Altica* sp. (A,2,3%)
    Coccinellidae (ladybird beetles) (A,8,5%)

(Continued)

* Each taxon is followed by the lifestages (A = adults, I = immatures), number of specimens collected, and percentage of episodes during which that taxon was collected. Each episode represents a single site sampled on one date.

Curculioniade (weevils)
  Neochetina sp. (A,25,15%) *Rhynchophorus* sp. (A,1,2%)
  Tanysphyrus sp. (A,208,22%)
Dytiscidae (predacious diving beetles)
  Celina sp. (A,I,15,9%) *Copelatus* sp. (A,27,4%)
  Cybister sp. (I,6,8%) *Laccodytes* sp. (A,10,6%)
  Laccophilus sp. (I,2,4%) *Oreodytes* sp. (I,8,6%)
  Rhantus sp. (A,6,2%) Unidentified Bidessini (I,57,28%)
  Unidentified (?,291,10%)
Elateridae (click beetles) (A,10,8%)
Haliplidae (crawling water beetles)
  Peltodytes sp. (A,1,2%) Unidentified (?,1,2%)
Histeridae (clown beetles) (A,1,2%)
Hydrophilidae (water scavenger beetles)
  Berosus sp. (A,14,4%) *Cercyon* sp. (A,1,2%)
  Dactylosternum sp. (A,1,2%) *Enochrus* sp. (A,5,6%)
  Helochares sp. (A,1,2%) *Hydrobius* sp. (A,4,2%)
  Phaenonotum sp. (A,1,2%) *Tropisternus* sp. (I,22,13%)
  Unidentified (?,90,8%)
Lampyridae (firefly beetles) (I,2,3%)
Noteridae (burrowing water beetles)
  Hydrocanthus sp. (A,I,97,34%) *Notomicrus* sp. (A,497,45%)
  Pronoterus sp. (A,22,8%) *Suphis inflatus* (A,32,8%)
  Suphisellus sp. (A,456,38%) Unidentified (?,41,6%)
Orthoperidae (minute fungus beetles) (A,2,3%)
Phalacridae (shining flower beetles) (A,1,2%)
Pselaphidae (antloving beetles) (A,1,2%)
Scarabaeidae (lamellicorn beetles)
  Lichnanthe sp. (A,3,2%) Unidentified (?,18,8%)
Scirtidae (Helodidae) (marsh beetles)
  Cyphon sp. (I,2,3%) *Scirtes* sp. (A,I,56,9%)
Staphylinidae (rove beetles) (A,25,15%)
Tenebrionidae (darkling beetles) (A,2,3%)
Collembola (springtails)
  Isotomidae
    Isotomurus sp. (A,I,28,6%)
  Unidentified (?,53,13%)
Dictyoptera (mantids and cockroaches)
  Blattidae (American cockroach) (I,1,2%)
Diptera (flies)
  Ceratopogonidae (biting midges) (A,I,3355,18%)
  Chamaemyiidae (A,1,2%)
  Chironomidae (midges)
    Larsia sp. (I,2,2%) *Paratanytarsus* sp. (I,1,2%)
    Unidentified (I,3727,22%)
  Culicidae (mosquitos)
    Mansonia titillans (I,325,25%)

(Continued)

- Ephydridae (shore flies)
  - *Hydrellia* sp. (A,I,17,5%)
- Stratiomyidae (soldier flies)
  - *Odontomyia-Hedriodiscus* complex (I,1507,63%)
- Tipulidae (crane flies) (I,4,5%)

Ephemeroptera (mayflies)
- Baetidae
  - *Centroptilum* sp. (I,2,4%)
- Caenidae
  - *Caenis* sp. (I,21,15%)
- Unidentified (?,85,3%)

Hemiptera (true bugs)
- Belostomatidae (giant water bugs)
  - *Belostoma* sp. (A,I,19,19%) *Lethocerus* sp. (I,6,2%)
  - Unidentified (?,21,10%)
- Corixidae (water boatsmen)
  - *Trichocorixa* sp. (A,5,5%)
- Hebridae (velvet water bugs)
  - *Hebrus* sp. (A,I,573,33%) *Merragata brunnea* (A,I,69,25%)
- Hydrometridae (water measurers)
  - *Hydrometra* sp. (A,6,8%)
- Lygaeidae (A,1,2%)
- Mesoveliidae (water treaders)
  - *Mesolvelia* sp. (A,I,178,31%)
- Naucoridae (creeping water bugs)
  - *Ambrysus* sp. (I,1,2%) *Pelocoris balius* (I,7.4%)
  - *Pelocoris femoratis* (A,I,108,55%) Unidentified (?,87,16%)
- Nepidae (water scorpions) (A,1,2%)
- Ochteridae (A,1,2%)
- Pentatomidae (A,1,2%)
- Pleidae (pigmy backswimmers)
  - *Paraplea* sp. (A,10,8%)
- Veliidae (borad-shouldered water striders)
  - *Paraveliai* sp. (I,8,8%) Unidentified (?,17,5%)

Homoptera
- Aphididae (aphids)
  - *Rhopalosiphum nymphaeae* (A,I,165,36%)
- Cicadellidae (leafhoppers)
  - *Draeculacephala inscripta* (A,I,423,55%)
- Pseudococcidae (mealybugs) (A,4,5%)

Hymenoptera
- Braconidae (wasps) (A,3,2%)
- Diapriidae (wasps)
  - *Trichopria* sp. (A,1,2%)
- Formicidae (ants) (A,47,30%)
- Mymaridae (fairyflies) (A,1,2%)

(Continued)

Lepidoptera
  Pyralidae (moths)
    Petrophila drumalis (A,I,59,28%)
    Samea multiplicalis (A,I,1498,78%)
    Synclita obliteralis (A,I,2,3%)
  Odonata
    Aeshnidae (darner dragonflies)
      Aeshan sp. (I,1,2%)
    Coenagrionidae (damselflies)
      Argia sp. (I,17,9%) *Enallagma* sp. (I,201,49%)
      Ischnura sp. (I,25,19%) *Nehalennia* sp. (I,134,28%)
      Telebasis sp. (I,1,2%)
    Libellulidae (dragonflies)
      Erythemis sp. (I,24,30%) *Lepthemis* sp. (I,1,2%)
      Miathyria sp. (I,8,10%) *Pachydiplax longipennis* (I,21,19%)
      Perithemis sp. (I,2,3%)
  Orthoptera
    Gryllotalpidae (mole crickets)
      Gryllotalpa sp. (A,1,2%)
  Neuroptera (dobsonflies) (?,7,2%)
  Plecoptera (stoneflies) (I,5,2%)
  Strepsiptera (twisted-winged parasites) (?,1,2%)
  Trichoptera (caddisflies) (?,2848,9%)

Nemerta
  Hoplonemertini
      Prostoma sp. (?,32,6%)
Turbellaria
  Tricladia
    Planariidae
      Dugesia sp. (?,undet.)

Table 3

Comparison of Seasonal Faunas at Seven South Florida Sites*,**

Taxa	1985 Summer No.	1985 Summer %	1985 Autumn No.	1985 Autumn %	1986 Winter No.	1986 Winter %	1986 Spring No.	1986 Spring %
Arachnoidea								
Hydracarina								
Pionidae								
Tiphys sp.	30	14	0	0	0	0	7	29
Araneae	227	71	350	86	114	71	96	57
Crustacea								
Amphipoda								
Talitridae								
Hyalella azteca	2109	100	1428	86	616	71	489	86
Decapoda								
Cambaridae	0	0	0	0	1	14	0	0
Palaemonidae								
Palaemonetes paludosus	0	0	0	0	1	14	0	0
Isopoda								
Asellidae								
Lirceus sp.	0	0	0	0	1	14	0	0
Diplopoda	0	0	0	0	7	14	1	14
Insecta								
Coloeptera								
Carabidae								
Bembidion sp.	10	14	2	29	3	43	0	0
Brachinus sp.	1	14	0	0	0	0	0	0
Chrysomelidae								
c.f. *Alitca* sp.	0	0	0	0	0	0	1	14
Coccinellidae	1	14	0	0	0	0	1	14
Curculionidae								
Neochetina bruchi	0	0	0	0	0	0	1	14
Neochetina eichhorniae	0	0	0	0	1	14	0	0
Tanysphyrus sp.	6	29	0	0	5	43	7	29
Dytiscidae								
Celina sp.	7	29	5	14	0	0	0	0

(Continued)

* South Florida sites included: Andytown Loop Canal, Conservation Area 2A, Lake Trafford, Fisheating Creek, West Avenue Canal, Horse Island, and Pierson Road Canal.

** Data include number of individuals and percentage of sites at which that species was collected.

Table 3 (Continued)

Taxa	1985				1986			
	Summer		Autumn		Winter		Spring	
	No.	%	No.	%	No.	%	No.	%
Copelatus sp.	1	14	26	14	0	0	0	0
Cybister sp.	4	29	0	0	0	0	0	0
Laccodytes sp.	0	0	8	29	0	0	0	0
Laccophilus sp.	1	14	0	0	0	0	0	0
Rhantus sp.	0	0	6	14	0	0	0	0
Unident. Bidessini	25	43	22	29	0	0	5	14
Elateridae	3	14	0	0	0	0	0	0
Hydrophilidae								
Berosus sp.	2	14	0	0	0	0	0	0
Cercyon sp.	0	0	0	0	0	0	0	0
Dactylosternum sp.	1	14	0	0	0	0	0	0
Enochrus sp.	0	0	0	0	1	14	3	14
Phaenonotum sp.	1	14	0	0	0	0	0	0
Tropisternus sp.	0	0	2	29	4	14	9	14
Lampyridae	0	0	1	14	1	14	0	0
Noteridae								
Hydrocanthus sp.	9	57	46	43	8	29	5	29
Notomicrus sp.	127	71	107	71	80	71	103	86
Pronoterus sp.	0	0	18	43	4	43	0	0
Suphis inflatus	8	14	7	29	0	0	0	0
Suphisellus sp.	133	71	147	86	20	43	70	71
Orthoperidae	2	29	0	0	0	0	0	0
Phalacridae	4	14	0	0	0	0	0	0
Pselaphidae	1	14	0	0	0	0	0	0
Scarabaeidae								
Lichnanthe sp.	0	0	2	14	1	14	0	0
Scirtidae (Helodidae)								
Cyphon sp.	0	0	0	0	1	14	0	0
Scirtes sp.	52	43	2	14	1	14	1	14
Staphylinidae	8	29	0	0	1	14	2	14
Collembola								
Isotomidae								
Isotomurus sp.	0	0	0	0	9	14	18	14
Diptera								
Ceratopogonidae	1	14	0	0	0	0	0	0
Chironomidae	0	0	101	29	5	14	7	29
Culicidae								
Mansonia titillans	47	71	188	71	4	14	0	0
Ephydridae								
Hydrellia sp.	0	0	0	0	0	0	1	14
Stratiomyidae								
Odontomyia								
Hedriodiscus complex	15	57	40	57	17	71	259	100
Tipulidae	0	0	0	0	0	0	2	14

(Continued)

Table 3 (Continued)

Taxa	1985 Summer No.	1985 Summer %	1985 Autumn No.	1985 Autumn %	1986 Winter No.	1986 Winter %	1986 Spring No.	1986 Spring %
Ephemeroptera								
Baetidae								
Centroptilum sp.	0	0	1	14	0	0	1	14
Caenidae								
Caenis sp.	0	0	41	14	0	0	3	29
Hemiptera								
Belostomatidae								
Belostoma sp.	4	43	1	14	0	0	0	0
Lethocerus sp.	6	14	0	0	0	0	0	0
Corixidae								
Trichocorixa sp.	0	0	1	14	0	0	3	14
Hebridae								
Hebrus sp.	4	29	36	43	15	14	7	29
Merragata brunnea	4	29	8	43	12	43	27	57
Hydrometridae								
Hydrometra sp.	0	0	4	43	1	14	1	14
Lygaeidae	1	14	0	0	0	0	0	0
Mesoveliidae								
Mesovelia sp.	1	14	6	29	5	29	5	57
Naucoridae								
Ambrysus sp.	2	14	0	0	0	0	0	0
Pelocoris balius	3	14	0	0	0	0	0	0
Pelocoris femoratis	40	57	27	71	8	71	8	43
Pentatomidae	1	14	0	0	0	0	0	0
Pleidae								
Paraplea sp.	1	14	1	14	0	0	0	0
Veliidae								
Paravelia sp.	0	0	1	14	0	0	0	0
Homoptera								
Aphididae								
Rhopalosiphum nymphaeae	22	71	2	14	15	43	73	71
Cicadellidae								
Draeculacephala inscripta	12	43	45	71	85	57	36	57
Pseudococcidae	3	29	0	0	1	14	0	0
Hymenoptera								
Formicidae	28	43	4	29	1	14	5	29
Lepidoptera								
Pyralidae								
Petrophila drumalis	15	71	24	57	1	14	7	29
Samea multiplicalis	133	86	109	100	120	71	128	71

(Continued)

Table 3 (Concluded)

Taxa	1985				1986			
	Summer		Autumn		Winter		Spring	
	No.	%	No.	%	No.	%	No.	%
Odonata								
Aeshnidae								
Aeshna sp.	0	0	0	0	0	0	1	14
Coenagrionidae								
Enallagma sp.	50	43	65	86	11	43	17	29
Ischnura sp.	5	14	0	0	2	29	2	29
Nehalennia sp.	103	71	1	14	7	29	4	29
Libellulidae								
Erythemis sp.	5	57	4	57	2	14	1	14
Miathyria sp.	1	14	2	29	1	14	0	0
Pachydiplax longipennis	5	29	3	29	6	43	1	14

Table 4

Herbivores Collected from Waterlettuce (*Pistia stratiotes*)*

Taxon	Distribution*	Feeding Observed	Literature Cited**
Acari			
Homocaligidae			
Annerosella knorri n. sp.	SEA	+	7
Coleoptera			
Curculionidae			
Argentinorhynchus breyeri Hustache	SA	+	1,3,4,13
Argentinorhynchus bruchi Hustache	SA	+	3,4,5,13
Argentinorhynchus squamosus Hustache	SA	+	1,3,4
Neohydronomus pulchellus Hustache	SA,AUS	+	1,3,4,5,12,13
Neohydronomus n. sp.	SA,CA,CAR	+	1
Ochetina bruchi Hustache	SA,CA	+	1,3
Onychylis cretatus Champion	SA,CA	+	1,3
Photinus sp.	SA		12
Hydrophilidae			
Berosus sp.	SA,FL		12,13
Enochrus sp.	SA,FL		12,13
Hydrochus sp.	SA		12,13
Tropisternus sp.	SA,FL		12,13
Scirtidae (Helodidae)			
Scirtes sp.	SA,FL		13
Diptera			
Chironomidae			
sp. undet.	SA,FL		12,13
Ephydridae			
sp. undet.	SA,FL		12,13
Hemiptera			
Lygaeidae			
Lipostemmata humeralis	SA		12,13
Valtissius sp.	SA	+	1
Homoptera			
Aphididae			
Rhopalosiphum nymphaeae L.	SA,FL,CAR,AFR	+	1,12,13

(Continued)

Note: Partially adapted from a list compiled by G. Buckingham (unpublished).

* SEA = Southeast Asia, SA = South America, AUS = Australia, CA = Central America, CAR = Caribbean, FL = Florida, AFR = Africa, IND = India, IDO = Indonesia.

** (1) Bennett 1975; (2) Chaudhuri and Ram 1975; (3) Cordo, DeLoach, and Ferrer 1981; (4) Cordo et al. 1978; (5) DeLoach, DeLoach, and Carlo 1979; (6) George 1963; (7) Gonzalez 1978, (8) Habeck, Haag, and Buckingham 1986; (9) Joy 1978; (10) Mangoendihardjo and Nasroh 1976; (11) Mangoendhardjo and Soerjani 1978; (12) Neiff and Poi de Neiff 1978; (13) Poi de Neiff 1983; (14) Sands and Kassulke 1984; (15) Suasa-Ard 1976. Unless otherwise noted, Florida records are from this study.

Table 4 (Concluded)

Taxon	Distribution	Feeding Observed	Literature Cited
Homoptera (Cont.)			
Coccidae			
Planococcus citri	CAR	+	1
Cicadellidae			
Draeculacephala inscripta Van Duzee	FL	+	
Delphacidae			
sp. undet.	CAR	+	1
Menoplidae			
Nisia atrovenosa Lethierry	IND	+	9
Pseudococcidae			
sp. undet.	FL		
Lepidoptera			
Noctuidae			
Erastroides curvifascia Hampson	IND	+	2
Namangana pectinicornis Hampson	SEA,IDO	+	6,15
Proxenus sp.	IDO	+	10
Proxenus hennia Swinhoe	IND	+	11
Spodoptera litura F.	IND	+	11
Spodoptera mauritia Bids.	IND	+	11
Pyralidae			
Nymphula responsalis Walker	IND	+	11
Samea multiplicalis Guenee	SA,CA,FL,CAR,AUS	+	1,8,13,14
Synclita obliteralis Walker	FL	+	8
Petrophila drumalis	FL	+	
Orthoptera			
Acridae			
Paulinia acuminata DeGeer	SA,CAR	+	4
Gryllidae			
sp. undet.	SA,FL		13
Trichoptera			
Leptoceridae			
Oxyethira sp.	SA		13