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WEEVILS VERSUS NO WEEVILS: A COMPARISON OF *SALVINIA MINIMA* POPULATIONS IN FLORIDA AND LOUISIANA

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Cyrtobagous salviniae Calder and Sands (Coleoptera: Curculionidae) is a successful biological control agent of aquatic weeds suppressing species like giant salvinia, *Salvinia molesta* D.Mitch. (Salviniales: Salviniaceae), in at least 15 countries over 3 continents (Julien et al. 2002). There are at least 2 ecotypes of this insect; the smaller Florida ecotype found on common salvinia, *S. minima* Baker, throughout Florida, and the larger Brazil ecotype, which has been used extensively against *S. molesta* (Jacono 2001). Despite initial questions about the identity of the Florida ecotype (Goolsby et al. 2000), molecular work has confirmed that the 2 ecotypes represent a single species (Madeira et al. 2006). Although *S. minima* causes significant problems in Louisiana, it rarely forms persistent mats in Florida (Tipping et al. 2012). This regional difference may be caused by herbivory by the Florida weevil ecotype, which was first reported in Florida in 1962 (Kissinger 1966). The goal of this study was to compare population variables of *S. minima* between freshwater swamp forest habitats located in different states where one (Louisiana) lacks *C. salviniae*. Generalist herbivores like *Synclita oblteralis* (Walker) (Lepidoptera: Crambidae) and *Samea multiplicalis* Guenée (Lepidoptera: Crambidae) are present on *S. minima* in both states (Munroe 1972; Knopf and Habeck 1976).

Environmental, plant, and insect variables were compared between 4 field sites in Florida and 5 in Louisiana during 11 dates between 2002 through 2004. Florida sites were located near Immokalee, West Palm Beach, and LaBelle while Louisiana sites were located within the Barataria preserve south of New Orleans. In Florida,

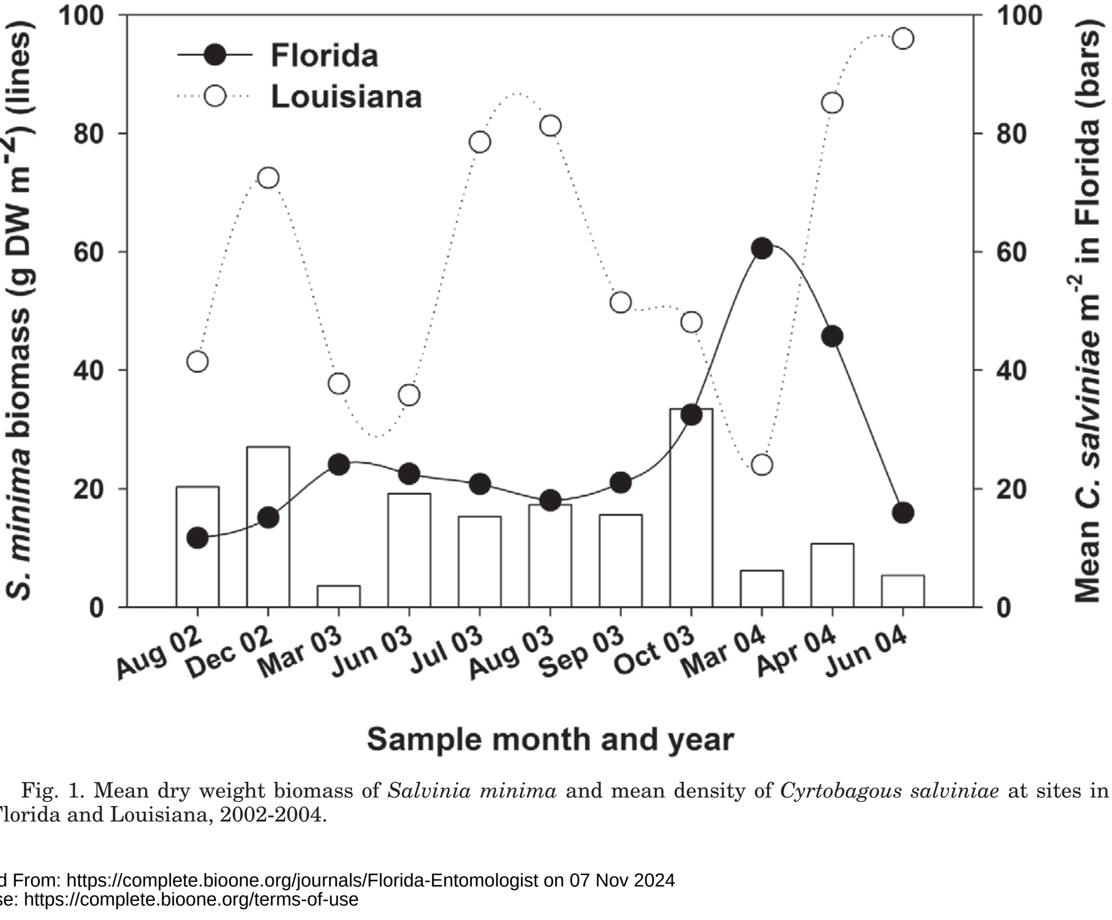

Fig. 1. Mean dry weight biomass of *Salvinia minima* and mean density of *Cyrtobagous salviniae* at sites in Florida and Louisiana, 2002-2004.

TABLE 1. GRAND MEANS (+SE) OF ABIOTIC AND BIOTIC VARIABLES IN FLORIDA AND LOUISIANA ALONG WITH ANALYSIS OF COVARIANCE TESTS FOR THE EFFECTS OF STATE AND YEAR[1].

	Grand means		State				Year			
Variable	Florida	Louisiana	N df	D df	*F*	*P*	N df	D df	*F*	*P*
S. minima biomass (g DW m^{-2})	27.8 + 2.2	56.2 + 2.3	9	67.4	3.21	0.003	2	67.6	0.10	0.9
Percent cover (m^{-2})	49.1 + 2.5	85.1 + 1.9	9	53.4	1.91	0.06	2	12.6	1.95	0.18
Percent green (m^{-2})	73.7 + 1.4	83.1 + 0.9	9	71	5.62	0.0001	2	71	2.39	0.09
Air temperature (°C)	24.1 + 0.3	26.9 + 0.2	9	56	3.08	0.004	2	56	4.65	0.06
Water temperature (°C)	23.4 + 0.3	23.9 + 0.3	9	58	0.91	0.52	2	45.3	32.15	0.0001
CN ratio	17.0 + 0.3	17.8 + 0.3	9	59.3	3.42	0.001	2	44.7	2.31	0.11
No. *C. salviniae* m^{-2}	15.7 + 2.7	0.0 + 0.0	9	48.5	2.02	0.05	2	10.2	0.98	0.41
pH	6.3 + 0.04	5.3 + 0.1	9	46	1.65	0.12	2	46	15.49	0.0001
DO (mg L^{-1})	1.5 + 0.1	1.6 + 0.1	9	53	0.54	0.84	2	53	0.50	0.61

[1] Presented are the grand means for each dependent variable in each state, the degrees of freedom for the numerator (*N* df), denominator (*D* df), *F*-statistic, and *P* values for analysis of the covariance structure of the state and year variables. There was a significant state*year interaction only with the CN ratio. The Kenward-Roger correction was applied to standard errors, *F*-statistics, and degrees of freedom in order to reduce Type 1 error rates (Kenward & Roger 1997). Sample sites were nested within states for this analysis.

3 samples were taken from each of 4 permanent transects within each site, whereas in Louisiana 4 samples were collected in cardinal directions around a permanent point within each site. Thus, the experimental units at Florida sites were transects, while sites were the experimental units in Louisiana.

Sampling of plant cover and biomass was conducted using 0.1 m^2 floating polyvinyl chloride (pvc) frames placed haphazardly within transects (Florida) or near points (Louisiana). Plant coverage within the sample frames was estimated visually to the nearest 10% independently by 2 observers. Brown coloration of *S. minima* mats has been associated with insect-damaged and weakened plants (plant condition) as with *S. molesta* (Room et al. 1981), so a visual estimate was also made of the percentage of the *S. minima* mat that appeared green vs. brown, estimated to the nearest 25% within the ranges of 0, 1-24, 25-49, 50-74, 75-99, and 100%. Dry weight plant biomass of *S. minima* was estimated by collecting all the plants therein, removing excess water via compression, and recording the fresh weight biomass. Tissue moisture was estimated to be 96% based on our earlier trials when plants were dried to a constant weight. In lieu of direct measurement of nutrients in the water column, carbon and nitrogen concentrations in whole plant tissues were determined with a CHN analyzer and presented as CN ratios. Air temperature, pH, water temperature, and DO were recorded using a variety of hand-held meters.

Variable means were calculated for each date and analyzed using a first order autoregressive Toeplitz model which accounted for the time dependent covariance structure of the data, thereby permitting statistical inferences to be made on the effects of state, year, and their interactions on variables of interest (Freud & Wilson 1998). The equation of the general autoregressive model was:

$$Y_t = -a_1 Y_{t-1} + \varepsilon_t$$

Where Y is the response at time *t*, a is the autoregressive coefficient, and ε is the regression residual at time *t*. Another first-order autoregressive model was constructed to examine the roles of air and water temperatures, herbivory, and nutrients on the biomass of *S. minima* (SAS Institute 2004). Both of these models relate the residuals of period *t* to those of the previous periods to estimate a set of autoregressive parameters, whose coefficients were then used to perform the appropriate generalized least squares analysis (Freund & Littell 2003).

The Louisiana sites contained more *S. minima* biomass as their Florida counterparts regardless of the year (Table 1). There were also differences in coverage ($P = 0.06$) and condition (% green). Although air temperature was different between states, water temperature, perhaps a better predictor of growing conditions for a small floating

TABLE 2. ESTIMATES, STANDARD ERRORS, AND STATISTICS FOR AUTOREGRESSIVE PARAMETERS OF THE MODEL VARIABLES USED TO PREDICT *SALVINIA MINIMA* DRY WEIGHT BIOMASS, PERCENT COVER, AND CONDITION IN FLORIDA AND LOUISIANA.

Dependent	r^2	Independent	Estimate	SE	*t*	*P*
S. minima biomass (g DW m^{-2})	0.48	air temperature	1.6	1.3	1.64	0.101
		water temperature	-0.47	1.2	-0.37	0.71
		CN ratio	2.52	0.69	3.62	0.0004
		C. salviniae	0.36	0.05	6.96	<0.0001
% Cover (m^{-2})	0.59	air temperature	-1.31	1.18	-1.11	0.26
		water temperature	1.71	1.12	1.52	0.13
		CN ratio	1.59	0.61	2.63	0.0091
		C. salviniae	0.22	0.04	5.09	<0.0001
% Green (m^{-2})	0.45	air temperature	0.82	0.65	1.27	0.21
		water temperature	-0.007	0.62	-0.01	0.99
		CN ratio	-0.05	0.33	-0.17	0.86
		C. salviniae	-0.06	0.02	-2.41	0.01

plant like *S. minima,* was not. Both plant nutrition, based on CN ratios, and herbivory, based on densities of *C. salviniae*, differed between states (Table 1). Environmental variables like DO and pH are often influenced by *Salvinia* sp. biomass and coverage (Nichols et al. 2000; Tipping et al. 2008) so any differences between states were likely influenced by the presence of the plant, not the other way around (Table 1). Analysis of abiotic and biotic variables indicated that neither air nor water temperatures were important predictors of *S. minima* characters (Table 2). Instead, plant nutrition and especially herbivory by *C. salviniae* played significant roles in predicting the biomass, coverage, and condition of *S. minima* (Table 2).

Population patterns of *S. minima* between states were conspicuously different with Louisiana populations exhibiting regular cycles with peaks during warmer months while Florida populations lacked any distinct cycles (Fig. 1). Considering that a grand mean of 15.7 *C. salviniae* was recorded per square meter in Florida versus none in Louisiana, and that *C. salviniae* reduced the relative growth rate of *S. minima* up to 58.6% without interspecific plant competition, and extirpated it when plant competition was present (Tipping et al. 2009; Tipping et al. 2010), we submit that its absence in Louisiana likely explains the differences in *S. minima* population parameters compared to Florida. We submit also that these differences fully justify attempts to establish *C. salviniae* in Louisiana.

SUMMARY

Although the range of *S. minima* in the U.S. includes Florida and Louisiana, the plant behaves differently between states, most notably in Louisiana where it is considered a significant aquatic weed. Plant and insect populations were sampled 11 times in both states over consecutive weeks during 2002 through 2004. Mean *S. minima* biomass was more than twice as great in Louisiana as compared with Florida. Plant coverage was also greater and plants were healthier in Louisiana. The most unequivocal difference between states was the absence of *Cyrtobagous salviniae* in Louisiana. This specialist herbivore has repeatedly demonstrated its ability to suppress *S. minima* and probably accounts for its differential weed status between states.

REFERENCES CITED

FREUND, R. J., AND LITTELL, R. C. 2003. SAS System for Regression, Third Edition. SAS Institute and Wiley, Cary, NC. 236 pp.

FREUND, R. J., AND WILSON, W. J. 1998. Regression Analysis. Statistical Modeling of a Response Variable. Academic Press, San Diego, CA. 444 pp.

GOOLSBY, J. A., TIPPING, P. W., CENTER, T. D., AND DRIVER, F. 2000. Evidence of a new *Cyrtobagous* species (Coleoptera: Curculionidae) on *Salvinia minima* Baker in Florida. Southwest. Entomol. 25: 299-301.

JACONO, C. C., DAVERN, T. R., AND CENTER, T. D. 2001. The adventive status of *Salvinia minima* and *S. molesta* in the southern United States and the related distribution of the weevil *Cyrtobagous salviniae*. Castanea 66: 214-226.

JULIEN, M. H., CENTER, T. D., AND TIPPING, P. W. 2002. Floating fern (salvinia), pp. 17-32 *In* R. Van Driesch, B. Blossey, M. Hoddle, S. Lyon and R. Reardon [eds.], Biological Control of Invasive Plants in the Eastern United States. USDA Forest Service Publ. FHTET-2002-04. 413 pp.

KENWARD, M. G., AND ROGER, J. H. 1997. Small sample inference for fixed effects from restricted maximum likelihood. Biometrics: 53: 983-997.

KISSINGER, D. G. 1966. *Cyrtobagous* Hustache, a genus of weevils new to the United States fauna (Coleoptera: Curculionidae: Bagoini). Coleopt. Bull. 20: 125-127.

KNOPF, K. W., AND HABECK, D. H. 1976. Life history and biology of *Samea multiplicalis*. Environ. Entomol. 5: 539-542.

MADEIRA, P. T., TIPPING, P. W., GANDOLFO, D. E., CENTER, T. D., VAN, T. K., AND O'BRIEN, C. W. 2006. Molecular and morphological examination of *Cyrtobagous* sp.

collected from Argentina, Paraguay, Brazil, Australia, and Florida. Biocontrol 51: 679-701.

Munroe, E. G. 1972. Pyraloidae Pyralidae (Part) *In* R. B. Dominick [ed.], The Moths of America North of Mexico, Fasc. 13.1A E. W. Classey and R. B. D. Publications, Inc. London. 134 pp.

Nichols, P. B., Couch, J. D., and Al-Hamdani, S. H. 2000. Selected physiological responses of *Salvinia minima* to different chromium concentrations. Aq. Bot. 68: 313-319.

Tipping, P. W., Martin, M. R. Center, T. D., and Davern, T. M. 2008. Suppression *of Salvinia molesta* Mitchell in Texas and Louisiana by *Cyrtobagous salviniae* Calder and Sands. Aquat. Bot. 88: 196-202.

Tipping, P. W., Bauer, L., Martin, M. R., and Center, T. D. 2009. Competition between *Salvinia minima* and *Spirodela polyrhiza* mediated by nutrient levels and herbivory. Aquat. Bot. 90: 231-234.

Tipping, P. W., Martin, M. R., Bauer, L., Pokorny, E., and Center, T. D. 2010. Asymmetric impacts of two herbivore ecotypes on similar host plants. Ecol. Entomol. 35: 469-476.

Tipping, P. W., Martin, M. R., Bauer, L., Pierce, R. M., and Center, T. D. 2012. Ecology of common salvinia, *Salvinia minima* Baker, in southern Florida. Aquat. Bot. 102: 23-27 http://dx.doi.org/10.1016/j.aquabot.2012.04.005.

Room, P. M., Harley, K. L. S., Forno, I. W., and Sands, D. P. A. 1981. Successful biological control of the floating weed *salvinia*. Nature 294: 78-80.

SAS Institute. 2004. The SAS/STAT 9.1 User's Guide. Vol. 1-7. SAS Institute, Cary, NC. 5180 pp.