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Effects of *Bellura obliqua* on *Typha latifolia* Productivity

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ABSTRACT

The noctuid moth *Bellura obliqua* Walk. is a potential pest of cultivated cattail (*Typha* spp.) in Minnesota. Transplanted cattails were grown in a greenhouse and artificially infested with *Bellura* larvae. Insect damage reduced aboveground, belowground, and total growth of infested primary ramets by ca. 60, 45, and 55%, respectively. Insect damage to the primary ramets had no effect on the total biomass of secondary ramets. Damaged primary ramets, however, produced secondary ramets with significanly more aboveground biomass and less belowground biomass than those of controls The number of rhizomes or secondary ramets produced was not affected by insect damage.

Key words: herbivory, plant-insect interactions, wetland ecology, stem-borer, bio-energy, biomass.

INTRODUCTION

The potential cultivation of cattails (*Typha* spp.) as a bio-energy crop is under study in Minnesota[4]. Productive stands have been established on peat and/or mineral soils by planting seed, seedlings, or young shoots (Andrews *et al.* 1981),[5,6] where yields of up to 18 mt/ha after the initial growing season and 22 mt/ha after a second growing season have been obtained. Planted stands are occasionally subject to infestation by larvae of the noctuid moth *Bellura obliqua* Walk. (Andrews *et al.* 1981)[7,8] and infestations appear to be most severe in small planted stands during the initial growing season when 40% of shoots can be damaged (pers. obs.).

B. obliqua has heen widely reported to utilize cattails in North America and its life history has been described in detail by Claassen (1921) and Penko.[9] In Minnesota, egg masses are deposited on cattail leaves in June and July. First instar larvae are leaf miners, instars feed on leaves in the lower shoot (or "stem") or on sheath leaves. Although infested shoots are not usually killed, they may be heavily damaged. Frequently, the central leaves of a plant are completely severed by larvae burrowing in the stem. The severed leaves soon yellow, and damaged shoots are readily apparent in the field (Claassen 1921). Larvae also usually damage the basally located meristimatic region, and thus preclude the growth of additional leaves. Larvae do not bore into rhizomes, however. Although second and third instars may be gregarious, latter instars are usually solitary. Mature larvae overwinter in damaged shoots or in drier upland locations and pupate in the spring.

This study was conducted to evaluate the effect of *Bellura obliqua* on the productivity, offshoot production, and biomass allocation pattern of *Typha latifolia,* the most widely distributed cattail species in North America (Smith 1967), and a common hostplant for *B. obliqua* in natural stands.

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[4]D. C. Pratt *et al.* Wetland biomass production: emergent aquatic management options and evaluations. Final technical report to the Solar Energy Research Institute. NTIS No. DE84013022. 1984.

[5]D. C. Pratt *et al.* Emergent aquatics: stand establishment, management, and species screening. Report to the Solar Energy Research Institute. NTIS No. DE83004697. 1982. (Section 2.0).

[6]D. C. Pratt *et al. op. cit.* 1984 (Section 4.0).

[7]D. C. Pratt *et al. op. cit.* 1982. (p. 17).

[8]J. M. Penko. Ecological studies of *Typha* in Minnesota: *Typha*-insect interactions and the productivity of floating stands. M.S. Thesis. University of Minnesota, Minneapolis. 1985.

[9]*Ibid.*

MATERIALS AND METHODS

Seventy-five young cattail shoots were collected in the spring from paddies maintained at the University of Minnesota (St. Paul). Shoots were weighed and planted individually in 19 one-liter plastic pails. In order to estimate the dry weight of planting material, additional shoots were weighed and dried at 60C for determination of a dry/wet weight ratio. Pails were filled with soil, fertilized with 3.4 g (56 g/m^2) of 6-24-34 fertilizer, and water depth was maintained at approximately 5 cm above the substrate. Plants were sprayed periodically with Pentac (Bix(pentachlors-2,4-Cyclo pentadiene-1-yl)) to control mites, and Pirimer (5,6-dimethyl-2-dimethyl amino 4-pyrimidinyl-dimethyl carbamate) to control aphids. Neither of these insecticides is toxic to lepidopterans. On 27 June sixty healthy plants (mean height 151 cm) were selected for use in the experiment. An average of 0.7 (±SE 0.3) offshoots (secondary ramets) had been produced by the selected shoots. The plants were assigned on the basis of shoot height to ten blocks arranged randomly along a single greenhouse bench.

B. obliqua larvae were obtained from egg cases collected near Aitkin, Minnesota on 17 June. Larvae hatched within a few days and were fed fresh cattail leaves until 27 June. Individual larvae were placed onto three randomly selected primary shoots in each block.

Plants were harvested during the second week of September. After washing, the primary and secondary ramet(s) of each genet were separated (Figure 1) and di-

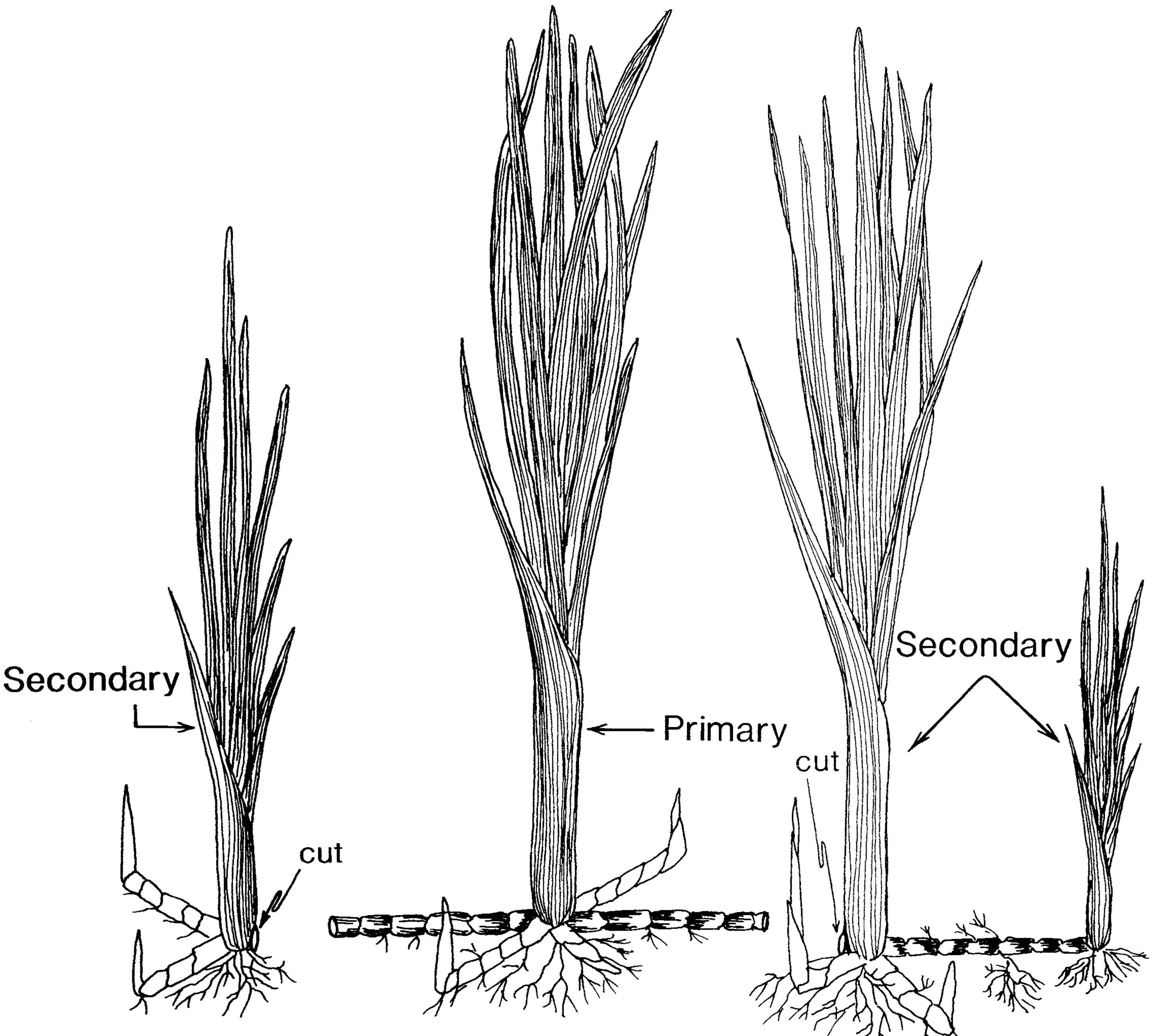

Figure 1. Primary and secondary ramets of a typical *Typha latifolia* genet at end of the experiment.

vided into belowground and aboveground fractions. Roots were discarded, and the remaining material was dried at 60C.

Data concerning plant yield were analysed by multiple regression using MULTREG (Weisberg 1982) where all dependent variables are transformed to the $\log_{10}$ scale in order to satisfy the assumptions of analysis of variance. The weight of planting material, shoot height, and number of offshoots produced on 27 June were included in the analysis as covariates. Offshoot production was analysed using the normality approximation of the Wilcoxon rank-sum test (Lehmann and D'Abrera 1975).

RESULTS

B. obliqua larvae became established on 27 of 30 host plants. These plants exhibited damage typical of infested plants; several inner leaves were severed and died, while at least some outer leaves remained alive. At the end of the experiment, 14 mature larvae were found in damaged primary shoots and two others in secondary shoots. Data from five genets were deleted from the following analysis, either because larvae failed to become established on the primary shoot (three cases) or because secondary shoots were damaged by wandering larvae (two cases).

B. obliqua larvae had a slightly significant negative effect on the aboveground and belowground productivity of the primary ramet (Table 1). Insect damage reduced total productivity by 55%. *Bellura* also had a significant effect on the distribution of biomass in the primary ramet as damaged ramets had a higher ratio of belowground to aboveground biomass than undamaged ramets. The number of secondary ramets produced by a primary ramet was not affected by insect damage, and although the number of additional rhizomes produced was reduced the differences were not significant. Damaged primary ramets produced secondary ramets with significantly more aboveground biomass and less belowground biomass than those of controls, however, there was no significant effect on the total biomass (Table 2). Even though the overall productivity of secondary ramets was unaffected, the productivity of genets with a damaged primary ramet was reduced by 21% (Table 3) and the damaged genets had relatively less belowground biomass.

DISCUSSION

Biomass allocation in plants is not fixed; as demonstrated in this study, plants respond to herbivory or defoliation by allocating a greater proportion of their resource to the production of new photosynthetic tissue at the expense of belowround growth (see also Archer and Tieszen 1980; Gifford and Marshall 1973; Hartnett and Abrahamson 1979; Jameson 1963). It is likely that increased shoot growth results, at least in part, because *Bellura* damage to the basal cattail meristem releases apical dominance. It is also possible that insect produced growth regulators may have elicited increased shoot development (i.e. Detling and Dyer 1981; see also McNaughton 1983).

There is some evidence that stem borer damage in natural cattail stands stimulates the growth of new shoots. Stands of cattails with heavy damage due to *Archanara oblonga* Gr. seem to have a higher rate of midsummer shoot emergence than is typical of stands without damage (pers. obs.). Heavily damaged stands, however, also tend to have more open canopies, so new shoot growth may be related to higher light levels (i.e. Grace and Wetzel 1981; Phillips 1975). Below/aboveground biomass ratios vary widely in natural cattail stands and it is possible that part of this variability may be related to herbivory.

Although insect damage altered the allocation of resources within daughter ramets, the number and total biomass of daughter ramets were unaffected. This may

TABLE 1. EFFECT OF *BELLURA OBLIQUA* DAMAGE ON GROWTH OF THE PRIMARY CATTAIL RAMET.

Biomass component	Ramet yield[a] with damage	Ramet yield[a] control	Relative yield percentage[b]
Aboveground*	13.5 (1.095)	31.8 (1.489)	41.4
Belowground*	8.0 (0.865)	14.6 (1.125)	55.0
Total*	21.5 (1.300)	46.4 (1.649)	44.7
Ratio*[c]	0.60	0.45	—

[a]Unadjusted mean biomass in g, and $\log_{10}$ g adjusted for covariance.
[b]Yield of plants with insect damage expressed as a percentage of yield of control plants (adjusted for covariance).
[c]Ratio of belowground to aboveground biomass (adjusted for covariance).
*Significantly different at $p < 0.001$.

TABLE 2. EFFECT OF *BELLURA OBLIQUA* DAMAGE TO THE PRIMARY RAMET ON THE GROWTH OF SECONDARY RAMETS.

Biomass component	Ramet yield[a] with damage	Ramet yield[a] control	Relative yield percentage[b]
Aboveground*	54.8 (1.731)	48.1 (1.657)	118.6
Belowground*	32.3 (1.498)	42.6 (1.592)	80.5
Total	87.1 (1.934)	90.7 (1.931)	100.7
Ratio*[c]	0.605	0.899	—

[a]Unadjusted mean biomass in g, and $\log_{10}$ g adjusted for covariance.
[b]Yield of secondary ramets in damaged genets expressed as a percentage of those in control genets (adjusted for covariance).
[c]Ratio of belowground to aboveground biomass (adjusted for covariance).
*Significantly different at $p < 0.025$.

TABLE 3. EFFECT OF *BELLURA OBLIQUA* ON GROWTH OF THE CATTAIL GENET.

Biomass component	Yield[a] with damage	Yield[a] control	Relative yield percentage[b]
Aboveground*	68.3 (1.826)	79.9 (1.898)	84.7
Belowground*	40.3 (1.592)	57.2 (1.740)	71.1
Total*	108.6 (2.028)	137.1 (2.131)	78.9
Ratio*[c]	0.598	0.714	—

[a]Unadjusted mean biomass in g, and $\log_{10}$ g adjusted for covariance.
[b]Yield of genets with damaged primary ramet expressed as a percentage of yield of control genets (adjusted for covariance).
[c]Ratio of belowground to aboveground biomass (adjusted for covariance).
*Significantly different at $p < 0.0025$.

indicate that translocation from the main ramet to daughter ramets was minimal by the time the main shoots were heavily damaged by *B. obliqua* larvae. In other plants, young shoots may soon lose their dependence on the main shoot for translocated materials (Ashmun et al. 1982; Gifford and Marshall 1973). The smaller number of additional rhizomes produced by damaged main ramets may be due to reduced availability of photosynthate later in the growing season when shoots were more heavily damaged. Further studies, using $^{14}CO_2$, are needed to compare the fate of photoassimilate in damaged and undamaged genets.

Results of this study indicate that *B. obliqua* can considerably reduce the productivity of cattails. Extrapolation of these results to field studies[10] indicates that the yield of plots planted with rhizomes may have been reduced by 8 to 15%. Lepidopteran stem borers, including *B. obliqua*, are also the most common and most damaging phytophagous insects that utilize cattail in natural Minnesota stands. On average ca. 10% of cattail shoots have stem damage (Penko and Pratt, unpublished), so according to this study shoot productivity would be reduced by about 5%.

Conclusions drawn from controlled greenhouse studies should, of course, be viewed cautiously. Plants growing under relatively confined conditions may respond very differently from those growing in the field. Growth of damaged plants in the field may be further reduced by factors such as weather and opportunistic pathogens and insects. *B. obliqua* larvae may switch host plants and some shoots in the field are probaby damaged relatively late in the growing season. Because the growth of older, larger plants is probably affected less by larvae than that of younger shoots, extrapolations from this study may overestimate the effect of insect damage in field plots.

In addition to a direct reduction in yield, insect damage to perennial plants may have an indirect effect on productivity in subsequent growing seasons (i.e. Hartnett and Abrahamson 1979; Jameson 1963). In cattail, reduced allocation of resources to rhizomes might contribute to increased overwintering mortality of young shoots and/or slow canopy development in the spring. Rapid expansion of leaf area in spring is thought to be among the factors responsible for the high productivity of natural cattail stands[11] (see also McNaughton 1974). Even moderate infestations over a number of years could have a considerable cumulative effect on stand productivity and community composition.

[10]D. C. Pratt *et al. op. cit.* 1982.

[11]T. D. Gustafson. Production, photosynthesis, and the storage and utitization of reserves in a natural stand of *Typha latifolia* L. Dissertation. University of Wisconsin, Madison. 1976.

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LITERATURE CITED

Andrews, N. J., M. Penko, M. D. Mattson, D. C. Pratt. 1981. The establishment of cattails on a northern Minnesota peatland. Minnesota Department of Natural Resources.

Archer, S., L. L. Tieszen. 1980. Growth and physiological responses of tundra plants to defoliation. Arctic and Alpine Res. 12:531-552.

Ashmun, J. W., R. J. Thomas, L. F. Pitelka. 1982. Translocation of photoassimilates between sister ramets in two rhizomatous forest herbs. Annals of Botany 49:403-415.

Claassen, P. W. 1921. *Typha* insects: their ecological relationships. Cornell Univ. Agr. Exp. Sta. Mem. 47:457-531.

Detling, J. K., M. I. Dyer. 1981. Evidence for potential plant growth regulators in grasshoppers. Ecology 62:485-488.

Gifford, R. M., C. Marshall. 1973. Photosynthesis and assimiate distribution in *Lolium multiflorum* Lam following differential tiller defoliation. Aust. J. Biol. Sci. 26:517-526.

Grace, J. B., R. G. Wetzel. 1981. Effects of size and growth rate on vegetative reproduction in *Typha.* Oecologia (Berl.) 50:158-161.

Hartnett, D. C., W. G. Abrahamson. 1979. The effects of stem gall insects on life history patterns in *Solidago canadensis.* Ecology 60:910-917.

Jameson, D. A. 1963. Responses of individual plants to harvesting. Bot. Rev. 29:532-594.

Lehmann, E. L., H. J. M. D'Abrera. 1975. Nonparametrics. Statistical methods based on ranks. San Francisco, CA: Holden-Day, Inc. and McGraw Hill.

McNaughton, S. J. 1974. Developmental control of net productivity in *Typha latifolia* ecotypes. Ecology 55:864-869.

McNaughton, S. J. 1983. Compensatory plant growth as a response to herbivory. Oikos 40:329-336.

Phillips, I. D. J. 1975. Apical dominance. Ann. Rev. Plant Physiol. 26:341-367.

Smith, S. G. 1967. Experimental and natural hybrids in North American Typha (*Typhaceae*) Amer. Mid. Nat. 78:257-287.

Weisberg, S. 1982. Multreg users manual (version 4.2). Minneapolis, MN: School of Statistics, University of Minnesota.