Age-specific life table studies of potential strains or host races of Calophasia lunula (Lepidoptera: Noctuidae) (Hufn.) reared on Dalmation toadflax, Linaria genistifolia ssp. dalmatica (L.) Maire and Petitmengen, or yellow toadflax, Linaria vulgaris (Mill.)
by Todd Alan Breitenfeldt

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Entomology
Montana State University

Abstract:
Although the possible existence of host races in phytophagous biological control agents has only recently come under general consideration when screening and releasing these agents, the implications for successful establishment and impact on the target weed, and for minimizing impacts on nontarget plant species are enormous.

The issues of potential host races and strain differences were investigated for different populations of the defoliating moth, Caloohasia lunula, which attacks Dalmatian toadflax, Linaria genistifolia ssp. dalmatica (L.) Maire and Petitmengen, and yellow toadflax, Linaria vulgaris (Mill'.), using age-specific life table studies. Life table studies of the three Calophasia populations (one obtained from Europe on Yellow toadflax, another obtained from yellow toadflax in Europe and established on Dalmatian toadflax in Montana, and the third obtained from Dalmatian toadflax from Yugoslavia) were tested on both Dalmatian toadflax and yellow toadflax.

Little evidence of host races was evident. Caloohasia lunula rates of development and weight gain, survivorship, and fecundity occurred at the same rate or pattern on both plants of interest. This supports the previous starch gel electrophoretic studies by McDermott and Nowierski (unpub. data).

Some strain differences were apparent. Analysis of life table data showed significant difference in mean duration of life stages between strains, mean weight between strains, and differences in lower developmental thresholds, intrinsic rates of increase (rm), population doubling times (PDT), mean generation times (MGT), and net reproductive rates (Ro) . Little evidence of strain differences were found in the analysis of survivorship, fecundity, mean rates of development, and mean rates of weight gain.

It is probable that strains of C. lunula exist, but more research needs to be conducted to further clarify these relationships. .

Strategies for mass rearing C. lunula and improving the chances for establishment on Dalmatian toadflax are discussed.

AGE-SPECIFIC LIFE TABLE STUDIES OF POTENTIAL STRAINS OR HOST RACES OF *CALOPHASIA LUNULA* (LEPIDOPTERA: NOCTUIDAE)(HUFN.) REARED ON DALMATIAN TOADFLAX, *LINARIA GENISTIFOLIA* SSP. *DALMATICA* (L.) MAIRE AND PETITMENGEN, OR YELLOW TOADFLAX, *LINARIA VULGARIS* (MILL.)

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APPROVAL

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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GLOSSARY OF TERMS

CD- Calophasia lunula collected from L. g. dalmatica in Yugoslavia, imported into Canada in 1991 and obtained from Alec McClay, Agriculture Canada, Vegerville, Canada.

CD-D- The CD strain of C. lunula reared on L. g. dalmatica toadflax.

CD-Y- The CD strain of C. lunula reared on L. vulgaris toadflax.

CY- Calophasia lunula collected in Canada on L. vulgaris toadflax and previously imported from Europe where they were collected on L. vulgaris toadflax.

CY-D- The CY strain of C. lunula reared on L. g. dalmatica toadflax.

CY-Y- The CY strain of C. lunula reared on L. vulgaris toadflax.

Host Race- Insect host races are groups of insects that show genetic polymorphism in host use with reduced interbreeding between genotypes that produces pronounced genotypic differences.

MD- Calophasia lunula collected near Missoula, MT on L. g. dalmatica in 1989-92. Imported from Canada where they were collected from L. vulgaris toadflax, and before that, Europe where they were collected from L. vulgaris toadflax (see Calophasia history below).

MD-D- MD strain of C. lunula reared on L. g. dalmatica.

MD-Y- MD strain of C. lunula reared on L. vulgaris toadflax.

MGT- Mean generation time.

PDT- Population doubling time.

r_m- Intrinsic rate of increase.

R_0- Net reproductive rate.

GLOSSARY OF TERMS--Continued

Strain- A strain is defined as a group of insects of presumed common ancestry with clear-cut physiological but usually not morphological distinctions; broadly: a specified infraspecific group or biotype.

ABSTRACT

Although the possible existence of host races in phytophagous biological control agents has only recently come under general consideration when screening and releasing these agents, the implications for successful establishment and impact on the target weed, and for minimizing impacts on nontarget plant species are enormous.

The issues of potential host races and strain differences were investigated for different populations of the defoliating moth, Calophasia lunula, which attacks Dalmatian toadflax, Linaria genistifolia ssp. dalmatica (L.) Maire and Petitmengen, and yellow toadflax, Linaria vulgaris (Mill.), using age-specific life table studies. Life table studies of the three Calophasia populations (one obtained from Europe on Yellow toadflax, another obtained from yellow toadflax in Europe and established on Dalmatian toadflax in Montana, and the third obtained from Dalmatian toadflax from Yugoslavia) were tested on both Dalmatian toadflax and yellow toadflax.

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It is probable that strains of C. lunula exist, but more research needs to be conducted to further clarify these relationships.

Strategies for mass rearing C. lunula and improving the chances for establishment on Dalmatian toadflax are discussed.

1. INTRODUCTION

A Description of the Toadflax Weed Problem

Many plants when introduced into habitats where they are not native become invasive, quite vigorous, and competitive (Baker 1974). These plants, often called noxious weeds, significantly impact native flora and fauna and cost farmers and ranchers millions of dollars each year in crop/forage losses and control measures (Cranston 1984, Lacey et al. 1985, Nowierski et al. 1987, Lacey 1989).

These introduced plants often fit many of the 'ideal weed characteristics' as given by Baker (1974). For instance, the seeds of these weeds show great longevity, discontinuous germination, and the ability to germinate in many environments. They show rapid growth through the vegetative phase of flowering, are self-compatible but not completely autogamous or apomictic. Unspecialized pollinators or wind are used for cross- pollination. Seed output is high and continuous for as long as favorable conditions permit, and is achieved in a wide range of environments. These weeds have adaptations for long- and short-distance seed dispersal. If perennial, they have brittleness, so are not easily drawn from the ground, have vigorous vegetative reproduction and/or regenerate from fragments. They can compete interspecifically by some special adaptation such- as a basal rosette or allelochemics, and are tolerant to a wide range of

environmental conditions (Baker 1974).

These weeds also fit the 'ideal colonizer model' as described by Saner (1991). Their 'species specific factors' usually include high rates of growth and reproduction, persistence, dispersal, adaptability, phenotypic and/or genetic variability, and nondependence upon specific abiotic resources, specific pollinators, mycorrhizae or other mutualists. They are strong competitors and are resistant to or tolerant of predation by herbivores. 'Founder event factors' often include: founder populations large enough to exclude negative genetic effects and random extinctions, the introduction of the proper biotypes to fit the environment, favorable selection, and a large number of founder events. These weeds are usually helped by 'factors which determine the suitability of the new environment.' These include a growing season well synchronized with the founder population, a large, readily available suitable habitat, and similar or less restrictive biotic and abiotic factors to the native habitat (Saner 1991).

Of the approximately 17 species of Linaria (Scrophulariaceae) that have been introduced into North America, and the nine that have become naturalized, two species, L. genistifolia ssp. dalmatica (L.) Maire and Petitmengen (Dalmatian toadflax or broad-leaved toadflax) and L. vulgaris Mill. (yellow toadflax, common toadflax or butter and eggs) have become widespread and have attained

the status of noxious weeds in some parts of the North American continent (Saner 1991)(Figure 1). In the state of Montana, L. g. dalmatica and L. vulgaris have been classified as a Category I Noxious Weed by the Montana State Department of Agriculture. These two species have been the subject of many control measures in both Canada and the United States (Harris 1963, Harris and Carder 1971, Lajeunesse et al. 1993, and Nowierski 1995).

In the State of Montana, conventional measures used to control these weeds include the use of herbicides and cultivation. However, control of these weeds with herbicides has proven inconsistent particularly in the coarse, sandy to gravelly soils that these two weed species typically frequent (Nowierski 1995). Because of the lack of effectiveness of conventional control measures, the widespread nature of these weeds, and the fact that both toadflax species often occur on rangeland where expensive or intensive conventional controls are not economically feasible or are physically impossible to implement, more practical and cost-effective methods need to be developed. One such method called 'classic biological control' uses host specific natural enemies of the target weed, collected and imported from the plant's native range, to decrease the competitiveness of the weed and lower it's density to