Genetic and behavioral variability in the ovary-feeding Nitidulid Brachypterolus pulicarius collected from Dalmatian and yellow toadflax
by Kelly Lynn Hering

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

Abstract:
Braychypteroluspulicarius is an ovary-feeding beetle in the family Nitidulidae. The species is found on Dalmatian and yellow toadflax, two non-native, invasive weeds. The beetle is native to Eurasia and is considered an important natural enemy and biological control agent for toadflax. Because B. pulicarius is found, at varying densities, on both yellow toadflax and Dalmatian toadflax, questions have been raised about the potential existence of host races in the species. Amplified fragment length polymorphism (AFLP) molecular genetic techniques are commonly used in studies of population genetics. Because it is a relatively easy and reliable method that does not require previous knowledge about the beetles' genome, the AFLP technique was utilized to examine the patterns of variability of populations ofB. pulicarius. Patterns of observed variability that corresponded with commonality of host plant could serve as evidence for host races in B. pulicarius. Insects were collected from both yellow and Dalmatian toadflax at a total of 12 locations in the northwestern US, British Columbia, and Europe. Volatile collections were made from host plants to characterize their chemical emissions and to look for species-specific plant differences. Behavioral assays were attempted to determine if beetles showed a preference for the species of host plant from which they were collected. Volatile collections revealed variability in volatile production within and between host plant species. Behavioral trials were highly variable and preference results were not obtained. AFLP analyses revealed variation that did not correspond to host plant commonality. Overall, the study revealed the dynamic nature and a high level of uncertainty surrounding the fundamental knowledge of this biological system. No evidence was found for host race existence in B. pulicarius. Alternative explanations for the observed variabilities are discussed.

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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, citation, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Signature Kelly L Hing

Date 11/6/02

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ABSTRACT

Braychypterolus pulicarius is an ovary-feeding beetle in the family Nitidulidae. The species is found on Dalmatian and yellow toadflax, two non-native, invasive weeds. The beetle is native to Eurasia and is considered an important natural enemy and biological control agent for toadflax. Because *B. pulicarius* is found, at varying densities, on both yellow toadflax and Dalmatian toadflax, questions have been raised about the potential existence of host races in the species. Amplified fragment length polymorphism (AFLP) molecular genetic techniques are commonly used in studies of population genetics. Because it is a relatively easy and reliable method that does not require previous knowledge about the beetles' genome, the AFLP technique was utilized to examine the patterns of variability of populations of *B. pulicarius*. Patterns of observed variability that corresponded with commonality of host plant could serve as evidence for host races in *B. pulicarius*. Insects were collected from both yellow and Dalmatian toadflax at a total of 12 locations in the northwestern US, British Columbia, and Europe. Volatile collections were made from host plants to characterize their chemical emissions and to look for species-specific plant differences. Behavioral assays were attempted to determine if beetles showed a preference for the species of host plant from which they were collected. Volatile collections revealed variability in volatile production within and between host plant species. Behavioral trials were highly variable and preference results were not obtained. AFLP analyses revealed variation that did not correspond to host plant commonality. Overall, the study revealed the dynamic nature and a high level of uncertainty surrounding the fundamental knowledge of this biological system. No evidence was found for host race existence in *B. pulicarius*. Alternative explanations for the observed variabilities are discussed.

CHAPTER 1

INTRODUCTION

Weeds

General Characteristics

Dalmatian and yellow toadflax are two common weeds in Montana and throughout the Western US and Canada (Coombs et al. 1996, Vujnovic and Wein 1996). Weeds, such as toadflaxes, are commonly defined as "any plant growing where it is not wanted (Hill 1977)" or an "unwanted or undesirable plant which interferes with the utilization of land and water resources and thus adversely affects human welfare (Rao 2000)." This broad definition allows for the classification of any plant as a weed under the particular circumstances that it is growing "out of place." Legally, noxious weeds are defined as "any plant designated by a particular federal, state, or county government to be injurous to public health, agriculture, recreation, wildlife, or any public or private property (Sheley et al. 1999)." In the United States and Canada, legislation has designated over 500 species of plants as noxious weeds (Lacey and Olson 1991).

If one considers the ecological characteristics of commonly occurring weed species, it becomes evident that weedy plants tend to share a variety of traits. Weeds are often "pioneer species" that commonly first colonize disturbed habitats (Taylor 1990). Weedy species tend to have rapid plant growth, with seed production beginning relatively early in the life cycle. Seed production continues over the entire duration of plant

growth, resulting in a large total output of seeds (Hill 1977). Often seed germination can occur in a wide variety of ecological conditions, and seeds remain viable in the soil over a long period of time. Generally, weedy species tend to be strong competitors for water and/or nutrients. Frequently in the United States the most invasive weeds are natives of Europe or Asia. Many were introduced intentionally, often as ornamentals. Others were brought to North America accidentally (Taylor 1990).

Importance

Weeds negatively impact humans' activities in a variety of ways. Infestations of weeds have large impacts on agriculture. They can decrease crop yield, lower land value, limit a producers' choices of which crops to grow, and decrease the quality of agricultural products. Weeds can also increase producers' control costs for pests that utilize the plants as secondary hosts. Weed infestations can clog waterways (Rao 2000). Some weeds are poisonous or harmful to livestock, or may simply taste bad, causing them to rarely be consumed. Often, weeds have undesirable physical traits – such as the existence of spines or thorns (Hill 1977). Due to all of their negative attributes, weed infestations can reduce the grazing capacity of rangeland by up to 75% (Sheley et al. 1999). Of total annual losses in agricultural production, weeds account for the largest percentage - roughly 45%, while insects account for 30%, diseases 20%, and other pests for the remaining 5% (Rao 2000).

Weed infestations also impact humans in other ways. Some plants cause allergies and can be poisonous if consumed (Rao 2000). Weeds have ecological impacts, often excluding native plants (Taylor 1990) and decreasing biodiversity (Lacey and Olson

1991). Invasive weed species can alter hydrologic, fire, and nutrient cycles, increase run-off and sedimentation, and change soil chemistry as well as displace important forages for wildlife (Cronk and Fuler 1995).

Through their many negative impacts, weedy species depreciate wildlife habitat, cropland, and rangeland. The combined effects of weed infestations are estimated to cost the United States at least $20 billion annually (Rao 2000).

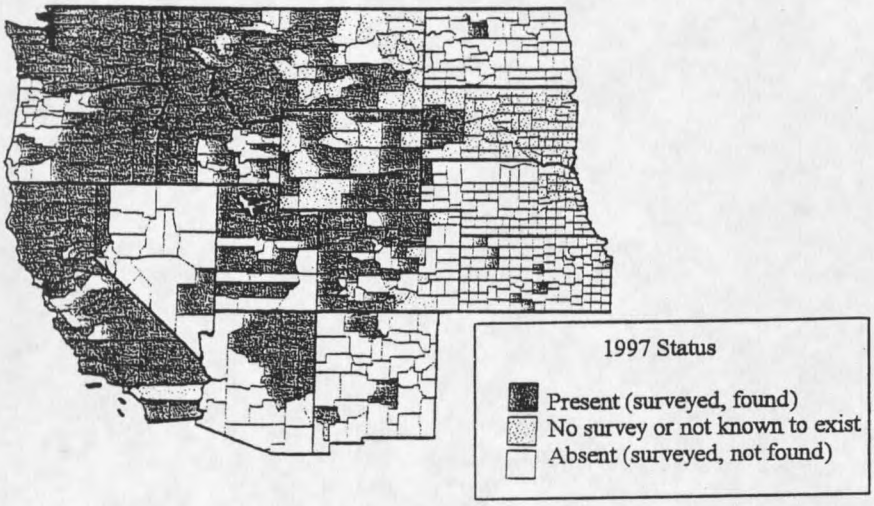
Dalmatian Toadflax

History & Biology

Linaria genistifolia ssp. *dalmatica* (L.) Maire & Petitmengin, commonly called Dalmatian toadflax or broad-leaved toadflax is considered an invasive weed in North America. The species is native to Mediterranean Europe and western Asia and has been cultivated there for over 400 years (Lajeunesse et al. 1993). Dalmatian toadflax originally came to North America in the late 1800's as an ornamental (Alex 1962, Nowierski 1996a, Lajeunesse 1999). However, over time the plant escaped cultivation and began to demonstrate its weedy characteristics throughout Canada and the United States (Alex 1962). As of the 1960's, Dalmatian toadflax was present in at least six Canadian provinces and 15 states in the US (Alex 1962). Currently, the heaviest infestations occur in the northwestern United States (Figure 1) and Canada (Lajeunesse 1999). In the provinces of Alberta and British Columbia, Dalmatian toadflax is considered a noxious weed (Vujnovic and Wein 1996). In the United States, Dalmatian

toadflax occurs much more commonly than its close relative, yellow toadflax, *Linaria vulgaris* Mill. (Lajeunesse 1999).

Figure 1. Distribution of *L. genistifolia* ssp. *dalmatica* in the Western US (from Lajeunesse 1999).



Dalmatian toadflax (Figure 2) is a "robust perennial herb with attractive yellow flowers and glaucous green foliage (Alex 1962)." It is a member of the family Scrophulariacae. Stems grow to 0.6-0.9 meters (2-3 feet) or taller (Lajeunesse 1999). Leaves are broad and heart-shaped and tend to wrap around the stem (Nowierski 1996a). The weed tolerates a variety of climatic ranges and soil types (Vujnovic and Wein 1996), but is usually found growing in xeric, open sites with sandy or rocky soils. It can also grow in loam soils and has even been observed growing, under cultivation, in heavy clay soil (Alex 1962). Dalmatian toadflax reproduces both by seed, with a single plant producing up to 400-500,000 seeds in a single growing season, and by vegetative root buds (Lange 1958, Nowierski 1996a). Flowers are bright yellow with an orange center, and are often referred to as resembling the blossoms of snapdragons (Lajeunesse 1999).

The blossoms are produced from May or June through September or October, with seed dispersal beginning as early as June and lasting through the winter (Lajeunesse et al. 1993).

Figure 2. *Linaria genistifolia* ssp. *dalmatica* (L.) Maire & Petitmengin. 1. Habit; 2. flower; 3. capsule; 4. seeds (from Vujnovic & Wein 1996).

Impacts

While many types of land are impacted by Dalmatian toadflax, the weed has its greatest impacts on rangeland and wildlife habitat (Lajeunesse 1999). Seedlings are poor competitors for water and nutrients, but once the plant is established it successfully outcompetes native plants and other more desirable forages (Nowierski 1996a). This often results in the loss of that forage's associated animal life as well (Lajeunesse 1999). Infestations of Dalmatian toadflax grow slowly but steadily over time (Lange 1958) and a single patch can easily persist up to 13 years (Lajeunesse et al. 1993). The plant contains chemicals including a glucoside antirrhinoside, a quinoline alkaloid, and penganin that reportedly make it toxic to livestock (Nowierski 1996a) and most grazing animals do not readily consume Dalmatian toadflax (Lange 1958). Infestations of the weed reduce the cattle carrying capacity of rangeland (Lajeunesse 1999) and decrease its overall productivity. An extensive root system and waxy leaves result in inconsistent efficacy of herbicide treatments (Lange 1958), making chemical control of Dalmatian toadflax very difficult (Nowierski 1996a).

Yellow Toadflax

History & Biology

Linaria vulgaris Mill., another member of the family Scrophulariacae, is commonly called yellow toadflax, common toadflax, or butter-and-eggs (McClay 1992, Nowierski 1996b). The plant is native to south central Eurasia and was introduced into New England in the late 1600's as an ornamental and folk remedy (Lajeunesse 1999). By

the late 1700's it was already being referred to as a weed by settlers (Mitich 1993). Yellow toadflax (Figure 3) is a herbaceous perennial and is widely dispersed in North America (McClay 1992). It occurs most commonly in the northeastern United States and southeastern Canada, and is localized in other parts of North America – especially Western Canada (Figure 4) (Lajeunesse 1999). It is said to now occur "throughout the continental United States" and in every Canadian province and territory (Saner et al. 1995). Because of its attractive snapdragon-like yellow and orange flowers yellow toadflax is still sold as an ornamental throughout the U.S. by gardening companies (Lajeunesse et al. 1993). The biology of yellow toadflax is similar to that of Dalmatian toadflax. Its morphology is different, though, with leaves that are narrow, pale green, alternating, and pointed at the end. Yellow toadflax has bright yellow and orange flowers, like those produced by Dalmatian toadflax (Lajeunesse 1999). Plants generally produce them from May until October (Lajeunesse et al. 1993). Yellow toadflax can occur in a wide variety of habitats and plant communities, but prefers mesic sites (Saner et al. 1995, Nowierski 1996b). The weed tends to have a very well-developed root system (Nowierski 1996b) and reproduces both by seed and vegetatively (McClay 1992, Nadeau et al. 1992). Seed production is highly variable (Saner et al. 1995), with a single plant producing up to 35,000 seeds per season (Nowierski 1996b). Germination rates, however, can be quite low (Nadeau and King 1991), often with rates less than 10% (Saner et al. 1995). Seedlings are considered to be poor competitors (Lajeunesse et al. 1993, Saner et al. 1995). Because of these factors, vegetative propagation is considered a key factor in yellow toadflax's ability to persist and spread locally (Bakshi and Coupland