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Interaction of *Chrysolina quadrigemina* and *Hypericum* spp. in California

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Abstract

Three insects introduced to control *Hypericum perforatum* (St. John's wort) in California, *Chrysolina quadrigemina, Agrilus hyperici,* and *Zeuxidiplosis giardi,* are now reproducing on the North American native *H. concinnum.* Although defoliation by *Chrysolina* seemingly reduces the plant size of *H. concinnum,* the beetle's impact has been difficult to separate from effects of the crown- and root-boring *A. hyperici. Chrysolina* also reproduces on two other native *Hypericum* spp. in the laboratory but has not been recorded from these plants in nature. None of the native plants studied are recognized as having economic value. The introduced and now widely cultivated ornamental *H. calcyinum* also serves as a host for *Chrysolina* and occasionally has suffered severe defoliation. At the time *Chrysolina* was introduced to North America (1946), the beetle showed no predisposition to feed or develop on this plant outside of experimental studies. Research is continuing to determine the significance of the presence of *Chrysolina* and *Agrilus* on the *Hypericum* spp.

Interaction Entre les Insectes du Millepertuis Perforé et les Espèces de *Hypericum* d'Amérique du Nord

Trois insectes introduits en vue de lutter contre le millepertuis perforé se reproduisent actuellement sur l'espèce indigène d'Amérique du Nord, *Hypericum concinnum,* en Californie. *Chrysolina quadrigemina* se reproduit sur deux autres espèces de *Hypericum* en laboratoire, ce qui n'a pas été constaté sur le terrain. La forme et l'habitat des plantes semblent être à l'origine des observations différentes en laboratoire et sur le terrain. *Agrilus hyperici* infeste *H. concinnum* en plusieurs sites et a entraîné la mort de la plante. Avant l'introduction, les facteurs dont il faut tenir compte au cours de l'évaluation des risques d'effets préjudiciables de l'agent biologique sur les plantes indigènes non visées sont: (1) le degré de sympatrie entre la plante indigène et la plante nuisible; (2) l'abondance de la plante indigène et la diversité de ses habitats; et (3) la relation qui existe entre l'hôte et la plante nuisible. Dans le choix des organismes candidats, il faut tenir compte entre autres des éléments suivants: (1) type de dommage à l'hôte; (2) synchronisation entre l'organisme et la plante indigène; (3) exigences en matière d'habitat; (4) capacité de dispersion; et (5) comportement de l'insecte en quête d'un hôte.

Introduction

In 1945, *Chrysolina hyperici* Forster (Coleoptera: Chrysomelidae) and in 1946 *C. quadrigemina* Suffrian were introduced into California for the biological control of St. John's wort, *Hypericum perforatum* L. (Clusiaceae), *Chrysolina varians* Schall, *Zeuxidiplosis giardi* Kieffer (Diptera: Cecidomyiidae), and *Agrilus hyperici* Cruetzer (Coleoptera: Buprestidae) were released in 1950, but by that time the dramatic increase and spread of *C. quadrigemina* had already resulted in control at many sites (Holloway

and Huffaker 1951). Despite occasional upsurges of the weed following wet winters, control has remained excellent, primarily due to *C. quadrigemina*.

About 1975, we began to receive reports that *C. quadrigemina* was showing up on *H. calycinum* L., an introduced ornamental now widely used for landscaping in urban areas and along highways. At first not much attention was assigned to these sightings, but by 1978, records of beetle damage spanned 11 counties in the northern half of California. A number of these reports were from CALTRANS, the agency responsible for building and maintaining California highways, and involved roadside plantings of *H. calycinum* through the central part of the State. Severe defoliation of the plant was observed in some instances. Although the beetle can still be commonly found reproducing on this plant, the reports of damage have lessened (Andres and Seeno, unpubl. records).

Then, in 1976, *C. quadrigemina* was recorded from *H. concinnum* Benth. in Marin County (E.I. Schlinger, Entomology Dept. of Univ. of Calif., Berkeley, pers. comm.). This plant is indigenous to California and is listed as occurring on dry brushy slopes, below 1000 m (3000 ft) in chaparral and yellow pine forests of the Sierra Nevada and North Coast ranges (Munz and Keck 1959).

Robbins *et al.* (1941) list *H. concinnum* as a weed (gold wire) although, in my opinion, it does not have the aggressive characteristics common to most weeds. Gold wire is sympatric with *H. perforatum* over much of the latter's California range. The extent of *Chrysolina* attack on *H. concinnum* is unknown, although we have observed the beetle at sites in Marin, Napa, Mendocino, Butte and El Dorado counties.

The appearance of *Chrysolina* on plants in the genus *Hypericum*, other than *H. perforatum*, comes as no surprise in light of pre-release studies demonstrating its ability to feed and reproduce on several *Hypericum* spp., including *H. calycinum* (Wilson 1943; Smith 1958). Damage to a planting of *H. calycinum* adjacent to one of the early *Chrysolina* release sites in northern California was reported, but following the reduction of the weedy host, the beetle population on *H. calycinum* collapsed and was no longer a problem (Holloway 1964). *H. calycinum* was not extensively planted around the State when *Chrysolina* was first released but, due to its drought-resistant, fire-retardant characteristics, it is now quite common. It is difficult to explain the upsurge of beetle sightings and damage to *H. calycinum* in 1978. It may have been connected with the 1977–78 drought which seemed to bring the plant growth into closer synchrony with beetle feeding and ovipositional activity.

The presence of *Chrysolina* on *H. concinnum* is of some interest because of the public's increased concern over environmental matters and the preservation of native plants. Since arthropods introduced for the biological control of weeds will continue to show up on non-target native plants, I felt that a retrospective look at the *Chrysolina–Hypericum* relationship might enable us to better assess the propensity of future control agents to expand their list of host species.

Limited observations were made on the behaviour of *C. quadrigemina* in relation to *H. perforatum* and related *Hypericum* species and on the impact of the beetle on *H. concinnum*. The following is a narrative summary of the findings to date. The actual studies will be presented elsewhere when completed.

Behavioral and Developmental Studies

Several replicated and non-replicated tests were conducted on: (a) beetle feeding rates and fecundity; (b) larval developmental rates and percent adult emergence; and (c) adult host finding and ovipositional behavior under field and garden conditions.

Fecundity and Feeding

In non-replicated studies *Chrysolina* females laid markedly fewer eggs on *H. calycinum* than on *H. perforatum* or *H. concinnum*. Replicated studies on these and other *Hypericum* spp. are underway.

Rate of Larval Development and Percent Adult Emergence

Chrysolina eggs were collected from field populations of *H. perforatum*, *H. concinnum*, and *H. calycinum*. Thirty newly hatched larvae were placed on plants of *H. perforatum*, *H. calycinum*, *H. concinnum*, *H. formosum* HBK. var. *Scouleri* (Hook) Coult. and *H. anagalloides* Cham. & Schlecht, in the laboratory (the latter three species are all native to California) and checked regularly for weight gain and completion of development. A magnitude of 2 to 3 times more larvae from the *Chrysolina* population ex. *H. calycinum* completed their development and emerged as adults when reared on *H. calycinum* and *H. anagalloides* than the larvae from the beetle populations ex. *H. perforatum* and *H. concinnum* when reared on the same plants. This suggests that the population on *H. calycinum* has changed to some extent from the population on *H. perforatum*. Adult emergence from the larvae reared on *H. formosum H. concinnum*, and *H. perforatum* test plants was essentially the same no matter from which population and host plants the beetles originated. There appeared to be no significant difference between the three populations in the rate of larval development and the weight of the emerging adults on the five species of test plants.

Host Finding and Ovipositional Behavior

H. concinnum, *H. perforatum*, *H. anagalloides* and *H. calycinum* plants were transplanted among a field population of *H. perforatum* plants infested with *Chrysolina* to rate their relative acceptability for oviposition under 'natural' conditions. Only 4 out of 30 plants of the transplanted *H. calycinum* were oviposited on *vs.* 20 to 27 out of 30 plants of each of the other three transplanted test species. One percent of the total eggs oviposited were found on *H. calycinum*.

A similar transplant study was conducted at the Albany laboratory garden, only in this instance it was necessary to field-collect adult beetles from *H. perforatum* and release them throughout the plot. No eggs were oviposited on the 30 *H. calycinum* plants, whereas eggs were present on 11 to 20 of the 30 plants of the other three test plant species. *H. perforatum* appeared to be slightly favored for oviposition based on the number of eggs laid.

Impact Study

Whether *Chrysolina* is impacting on *H. concinnum* is probably of greater importance than the fact that the beetles feed and reproduce on this native. Larval feeding proved quite damaging and reduced plant size in a study comparing sprayed (malathion) *vs.* non-sprayed *H. concinnum* plants. An unanticipated high rate of attack by the naturalized *A. hyperici* prevented us from determining whether *Chrysolina* alone can kill the plants. *Agrilus* larval feeding in the crown and root probably contributes to reduced plant size and either kills the plant outright or otherwise shortens the life span of this otherwise perennial plant. Further studies are underway.

During the impact study it was noted that *Z. giardi*, the gall midge, was also reproducing on *H. concinnum* in El Dorado County, but in low numbers.

Discussion

Despite the fact that *C. quadrigemina* showed a very low preference for *H. calycinum* in the laboratory (e.g. less feeding, oviposition and larval survival than on *H. perforatum*), it is interesting that a population of this beetle has apparently adapted to live on this plant. This is not quite what we might have expected and signals the need for caution when discussing the plant preferences of candidate biological control arthropods and its significance in relation to post-release behavior.

Chrysolina fed, oviposited and reproduced on all the *Hypericum* species tested in the laboratory, yet it has not been reported attacking *H. anagalloides* and *H. formosum* in the field. Both of these native species are present throughout portions of the naturalized range of *H. perforatum* and quite likely have been exposed to the beetles, although both plants are present more in 'wet meadows, springy places and along streams' than *H. perforatum* (Abrams 1951). This difference in habitat may account for the absence of field records and points up the limitations of predicting insect behavior in nature from laboratory and even field experiments. Whether this can be corrected by increasing our pre-release observations on the natural field behavior of candidate biological control agents in their native range is uncertain. Certainly studies of this nature have been lacking more often than not, and would help us evaluate the role of habitat in determining post-release host range and behavior.

Conclusions

H. concinnum is sympatric with the naturalized *H. perforatum* which has often placed it in direct exposure to *C. quadrigemina* attack over the past 30 yrs. Despite severe damage and varying impact depending on prevailing conditions at the observation sites, the plant is still a common element in those Californian communities to which it is native. I attribute the beetle's limited effect to be due to one or more of the following factors: (1) The form of the plant. *Chrysolina* adults and larvae spend most of their time in the shelter provided by the rosette foliage of *H. perforatum*. The limited basal foliage of *H. concinnum* does not afford such shelter; (2) The plant's phenology. The basal foliage which appears on *H. concinnum* in response to fall rains sometimes appears later than the foliage of *H. perforatum*, again making *H. concinnum* less attractive to the beetles. Both of these factors limit the number of beetles on the plant; and (3) The plant's ability to regenerate from its trailing root system. This factor makes it difficult to kill the plant outright. Once the *H. concinnum* 'mother' plants have been damaged by *Chrysolina*, 'daughter' plants appear along the roots, permitting some plant recovery.

Conceivably, the resiliency shown by *H. concinnum* to attack by *Chrysolina* is more the rule than the exception in describing the response of a native plant attacked by naturalized arthropods. More field studies are needed to document whether this is correct. In the meanwhile, we should proceed with new introductions of new weed control candidates in as responsible a manner as possible.

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