The Biological Control of Russian Knapweed with a Nematode
by
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INTRODUCTION
Russian knapweed (Acroptilon repens (L.) DC. = Centaurea repens L.) was introduced into North America with the seed Turkestan alfalfa around 1900 (Groh, 1940). A. repens is a persistent perennial that is difficult to control by cultural and chemical methods. The purpose of this investigation was to determine the potential of a nematode, Paranguina picridis Kirjanova and Ivanova, as a biological control agent of Russian knapweed.

BIOLOGY OF ACROPTILON REPENS
A. repens forms dense infestations in cultivated fields, grain and alfalfa fields, pastures and waste places. The weed is widely distributed in western Canada (Moore and Frankton, 1974) and is widespread in the western and central regions of the United States (Reed and Hughes, 1970). The native distribution of the weed includes Mongolia, Western Turkestan, Iran, Turkish Armenia and Asia Minor (Moore and Frankton, 1974).

Russian knapweed reproduces by seeds and by vegetative means with creeping horizontal roots producing stem buds that develop into leafy shoots. One plant may produce up to 1200 seeds which may remain viable for two to three years (Ivanova, 1966). However, A. repens propagates mainly vegetatively and does not reproduce extensively from seed. Very few viable seeds are formed in Canadian populations of the weed.

Dense infestations of A. repens suppress other plant growth and establish essentially single species stands. Patches of A. repens may have up to 300 shoots per m² (Ivanova, 1966). A. repens is also poisonous to livestock (Young et al., 1970).

PARASITES OF ACROPTILON REPENS
In North America, A. repens is apparently free of specialized parasites and is not extensively attacked by polyphagous feeders, but is extensively damaged by specialized organisms attacking the weed in its native range. Prospective biocontrol agents of A. repens which are reported to be host specific and damage the weed include:

- Aceria acropiitoni (V. Shev and Kov.)
- Urophora maura Frfld.
- Dasyneura spp.
- Aulacida acropiitonica Beliz.
- Puccinia acropiiti Syd.

Paranguina picridis Kirjanova and Ivanova Since A. repens populations in Canada do not reproduce extensively from seed, the importation of agents that attack the seed head, such as A. acropiitoni, U. maura and Dasyneura spp. is not warranted.

Puccinia acropiiti and Paranguina picridis were imported into Canada to be studied. However, the teliospores of the rust would not germinate and, therefore, the study was confined to the nematode.

BIOLOGY OF PARANGUINA PICRIDIS (after Ivanova, 1966)
Populations of A. repens in southeastern U.S.S.R. are attacked by P. picridis. The nematode incites galls on the stems, leaves and root-collars of infected plants. Infected plants were reported to be severely distorted with growth and reproduction greatly reduced.

Infactive second stage larvae in the soil penetrate the emerging knapweed shoots in April-May. On the third or fourth day after penetration a gall is formed at the site of penetration. Larvae continue to feed and mature within the gall. Numerous eggs are laid and two generations are completed. As the host plant matures, the second stage larvae become dormant. The nematodes overwinter in this dormant state within the gall. The galled portions of the plant decay during the winter and early spring. The larvae are revived by moisture and migrate out of the decayed galls into the soil in search of emerging knapweed shoots.

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HOST RECORDS OF
PARANGUINA PICRDIS

The only host plant is A. repens (Ivanova, 1966; Kirjanova and Ivanova, 1969). Ivanova (1966) investigated the host specificity of P. picridis and found that seedlings of sunflower, cotton, wheat, barley and corn were penetrated by the nematode. These plants appeared healthy and no nematodes were recovered 15 days after inoculation. The nematodes were unable to initiate galls on these plants and either perished within the plants or egressed.

EFFECT OF PARANGUINA PICRDIS
ON ACROPTILON REPENS

Experiments in the U.S.S.R. have demonstrated that up to 100 per cent of the knapweed was infected with 20 per cent destroyed and 30 per cent severely damaged (Ivanova, 1966). Water suspensions of the nematode have been utilized as a “biological herbicide” for the control of A. repens in the U.S.S.R. (Kovalev et al., 1973).

HOST SPECIFICITY STUDIES
ON PARANGUINA PICRDIS

Most plant species tested were penetrated, but it was extremely difficult to obtain gall formation on A. repens under laboratory conditions. Numerous tests were made conducted and consistent gall formations on A. repens occurred when plants were grown under cool (10 to 15°C), moist (R.H. > 90%) conditions in vermiculite and received Hoagland’s solution modified to 10.5 ppm N. This represented the first time that these nematodes have been cultured under laboratory conditions.

Extensive host specificity studies involving 61 species in 18 families were conducted. Contrary to the literature, P. picridis is not host specific. In addition to gall formation on A. repens, one or more galls developed on the following plants: Centaurea diffusa Lam., Centaurea maculosa Lam., Centaurea x pratensis Thuill., Carduus nutans L., Cirsium floridanum (Ryd.) Arthur, Cynarea scolymus L., Onopordum acanthium L., Echinops ritro, and Gerbera jamesonii Bolus. Eggs were observed in dissected galls from all the above plants with the exception of E. ritro and G. jamesonii. Therefore, in addition to the reported host, A. repens, seven closely related species were found to be suitable hosts for P. picridis.

HISTOLOGICAL STUDIES

The galls that formed on the different laboratory hosts were dissimilar and histological investigations were conducted to determine the hosts' cellular responses to the nematode attack.

The nematode was capable of initiating an extensive feeding site in the form of a large nutritive layer of non-vacuolated cells with dense cytoplasm in A. repens and C. diffusa. Cell necrosis was extensive in the C. diffusa galls and probably limited the reproduction of the nematode. Substantially reduced feeding sites were observed in the galls on C. scolymus and O. acanthium which were associated with an increase in cell necrosis. Feeding sites failed to be established in the galls on the other hosts and limited reproduction of the nematode was observed. Extensive cell necrosis was observed in the galls on C. x pratensis and G. jamesonii, and granular inclusions were common in C. x pratensis galls.

A. repens is the best host of P. picridis and was severely damaged by the nematode. P. picridis was capable of initiating an elaborate gall on A. repens which was well supplied with nutritive cells. The other laboratory hosts of P. picridis ranged from intolerant (C. diffusa) to resistant (E. ritro and G. jamesonii). Nutritive cells declined in number or were absent and extensive necrosis developed in some of the galls producing a barrier between the developing nematodes and the nutritive regions of the galls. This restricted or prevented development and reproduction of the nematodes.

STATUS OF CYNAREA SCOLYMUS
AS A HOST OF P. PICRDIS

The development of galls and subsequent reproduction on C. scolymus may preclude the use of P. picridis as a biological control agent of A. repens in North America. However, it is most unlikely that P. picridis will become a pest of C. scolymus if the nematode is released in North America. A total of 70 C. scolymus plants were inoculated with approximately 1500 larvae per plant which represents an input of over 100,000 nematodes. Only three of the 70 plants had a small gall form on a leaf. These galls did not damage the infected plants and only 500 to 1000 larvae were recovered from these galls. This initial decrease suggests that the nematode would have difficulty in maintaining a population on C. scolymus. In addition, the cultivation and cropping practices associated with the production of globe artichoke in Cali-
fornia do not favor the development of the nematode.

CONCLUSIONS
As a result of this study, the host range of *P. picridis* was extended, but restricted, to some species of the Centaureinae and Carduininae subtribes of the Cynareae tribe of the Compositae family with relatively slow growth that maintained their apical meristems at or near the soil surface for an extended period of time. *A. repens* was the only host plant susceptible to *P. picridis*. The galls on *A. repens* developed an extensive layer of nutritive cells with very little necrosis. In the galls on the other hosts the nutritive layer or feeding site was not established or was poorly developed and extensive necrosis was present in many of the galls. The inability of the nematode to produce sufficient feeding areas in hosts, other than *A. repens*, resulted in poor development and low reproductive capacity of *P. picridis*.

*A. repens* is a serious problem in many areas and present control methods are not adequate. The nematode has a great potential for controlling *A. repens* in North America and there is little risk involved. Globe artichoke was occasionally attacked in the laboratory tests, but all available evidence suggests that *P. picridis* will not become a pest of *C. scolymus* in California. Therefore, it is concluded that *P. picridis* is a suitable biological control agent of *A. repens*, and permission to release the nematode in North America has been requested.

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REFERENCES