Sphenoptera foveola (Buprestidae) as a potential agent for biological control of skeletonweed, *Chondrilla juncea*

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Summary

Skeletonweed, *Chondrilla juncea* L. is an important invasive weed in the USA, Australia, and Argentina. With the aim of finding new potential agents for biological control of this weed, surveys were carried out in 2004 to 2005 in its native range in Southern Russia and Kazakhstan, where the bronze skeleton weed root borer, *Sphenoptera foveola* (Gebler) (Coleoptera: Buprestidae) was repeatedly collected from different *Chondrilla* species. According to the literature and our survey, this buprestid is widely distributed in sandy deserts of Southern Russia and Kazakhstan. Locally, it could be rather abundant. Observations suggest that both larvae and adults of *S. foveola* feed exclusively on plants of the genus *Chondrilla.* Adults feed on green stems, larvae feed externally (within latex case) on roots and, at high population density, can cause significant damage to attacked plants. We conclude that *S. foveola* should be considered as a potential agent for biological control of skeleton weed, although further studies (particularly, host-specificity tests) are necessary to prove this hypothesis. *Sphenoptera (Deudora) clarescens* Kerremans, another sphenopteran species attacking *Chondrilla* in Iran and Turkey, may have a different root-feeding strategy and invites further investigations to evaluate it as a potential agent for biological control of skeleton weed.

Keywords: bronze skeleton weed root borer, surveys, taxonomy, distribution, biology, host range, impact.

Introduction

Chondrilla juncea L. (Asteraceae), skeletonweed, is an important invasive weed in the western USA, Australia, and Argentina. With the aim of finding potential agents for biological control of this weed, extensive surveys have been carried out in 2004 and 2005 in its native range in Southern Russia and Kazakhstan. Among other phytophagous insects, the bronze skeleton weed root borer, *Sphenoptera foveola* (Gebler, 1825) (Coleoptera: Buprestidae) was repeatedly collected from different *Chondrilla* species. In an earlier programme this buprestid had been considered as a potential candidate for biological control (Caresche, 1970; Wapshere, 1973, 1974). However, no attempts were made to test this species. Another root boring buprestid, *Sphenoptera (Deudora) clarescens* Kerremans, 1909 distributed in Iran and Turkey was considered and tested, but dropped as a potential biological control candidate (Hasan, 1978). From a biological aspect *S. foveola* is one of the best studied species of *Sphenoptera* due to the ability of its larvae to induce latex secretion from *Chondrilla* roots. In the 1930s, an ambitious project was conducted in the former Soviet Union to use native Central Asian latex-producing plants (mainly *Scorzonera*, *Chondrilla*, and *Taraxacum*) for rubber production. This project resulted in extensive investigations of selected plants and associated insects including *S. foveola* (Emelianova *et al*., 1932).

To evaluate the potential perspectives of *S. foveola* as a candidate for biological control of *C. juncea*, field collections and biological observations were made in 2004 to 2005 in Kazakhstan and Russia.

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Methods and materials

The first trip to Kazakhstan was made between June 23 and July 15, 2004 and included two 6-day field trips and several 1-day visits. Total extent of the route covered was 4230 km, in which 41 sites were surveyed and *S. foveola* was found at eight. The second trip from May 10 to May 22, 2005 included one 7-day field trip and two short daily visits; total distance covered was approximately 1500 km with 18 sites being visited at which *S. foveola* was found at four. These trips covered mainly low land and foothill desert areas (elevation, 400–1385 m) between Ili River on the west, the artificial Qapshagay Lake on the south and Balqash Lake on the north (Figure 1). Numerous species of *Chondrilla* were abundant in the study area. Adults of *S. foveola* were collected by hand from *Chondrilla* plants or from the soil under the plants where they were apparently ovipositing. To collect preimaginal stages, the roots of different *Chondrilla* species were excavated, examined and if necessary, dissected.

To study the geographic distribution of *S. foveola,* the buprestid collection of Laboratory of Insect Taxonomy, Zoological Institute, Russian Academy of Sciences, St. Petersbourg, Russia (ZIN) was examined, all collecting data were studied and collecting localities mapped (Figure 1). Confirmation of identification was performed by comparison with syntype from ZIN collection using a dissecting microscope. *Chondrilla* species collected were identified by botanists from Botanical Institute, Russian Academy of Sciences, St. Petersbourg, Russia, and A. Popov, Volgograd, Russia.

Results and discussion

Taxonomy

Taxonomical position of this buprestid is as follows: Coleoptera: Buprestidae: Chrysochroinae: Sphenopterini (Volkovitsh and Kalashian, 2006).

Sphenoptera (Sphenoptera) foveola Gebler, 1825: 46 (as *Buprestis*). 1 Syntype: Steppe Kirgiz., Gebler (Zoological Museum, Helsinki University, Finland); 1 syntype: the same label (ZIN).

Synonym: *strandi* Obenberger, 1920: 113. 2 syntypes: Tarbagatai, Siberia [Tarbagatai Mts., Kazakhstan] (National Museum, Praha, Czech Republic).

Synonym: *foveola* var. *usta* Obenberger, 1927: 51. 1 syntype (female): Astrakhan (National Museum, Praha, Czech Republic).

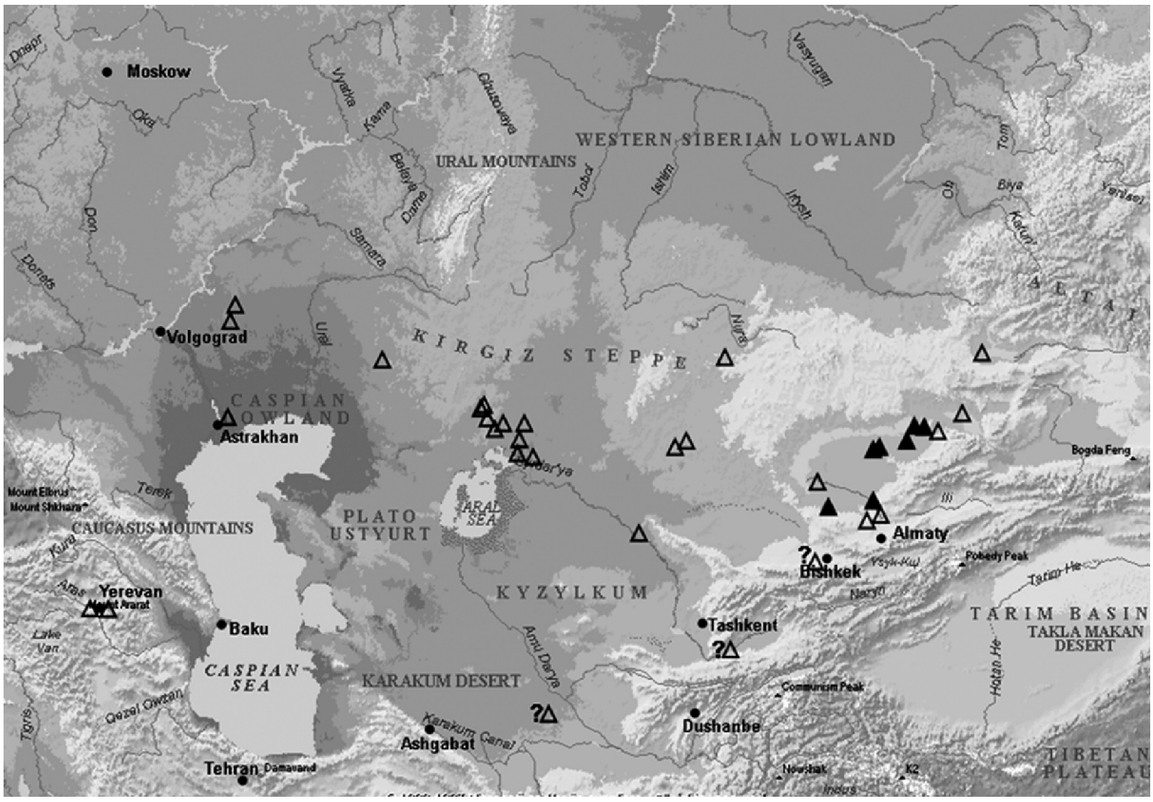

Figure 1. The distributional map of bronze skeleton weed root borer, *Sphenoptera foveola*. *Closed triangles* refer to our field collections in 2004 to 2005; *open triangles* refer to the data from the insect collection of Zoological Institute, St.Petersburg, Russia.

Larva: Alexeev *et al*., 1990 (detailed morphological description).

We looked for but did not find another sphenopteran species, *S.* (*Deudora*) *clarescens* Kerr., reported by Hasan (1978), to be found in Iran and Turkey by Kashefi (2002) and C. Tronci (unpublished communication). This species tunnels inside the roots of *C. juncea* which is different from that of *S. foveola* which feed externally on the roots. *S. clarescens,* according to Hasan (1978), also has a very wide host range among non-*Chondrilla* genera of plants which would make it an unsuitable biological control agent. We did not find evidence of a *Sphenoptera* that fit the description of *S. clarescens* in our surveys in either Kazakhstan or southern Russia or find evidence in museum collection of it having been collected in any former USSR countries.

Geographical distribution

According to the literature, *S. foveola* has been found in southeastern European Russia (Astrakhan prov.), Armenia, Kazakhstan, Kyrgyzstan, Uzbekistan, Turkmenistan (Alexeev *et al*. 1990, Kadyrbekov and Tleppaeva 2004, Volkovitsh and Kalashian 2006). The great majority (28 specimens examined) were from east of the Caspian Sea or the Volga River (Figure 1). We did not find any specimens from the coastal sandy semi-desert areas around the west side of the Caspian Sea but we suspect that it would be found in this area as well as in the semi-desert and desert habitats along the valleys of the Kura and Arax rivers in the Armenian Mountains. This is based upon the finding of two specimens of *S. foveola* in the ZIN collection from Armenia, the only two specimens from west of the Caspian Sea.

Biology

Our field observations and the literature (Emelianova *et al*., 1932) suggested that adult *S. foveola* are present in the field from mid-April to mid-October, where they feed on growing *Chondrilla* plants in hilly, sandy deserts (Figures 2, 3a). In the hottest part of the day we found adult beetles usually sitting, head down on the stems of *Chondrilla* plants or in the plant's shadow on the ground probably to protect themselves from overheating. Under laboratory conditions, oviposition was observed from mid-May until the beginning of October. In the field, eggs were laid in the sand near the crown or directly on the crown of the plant. In the laboratory, oviposition of an individual female lasted 10 to 50 days during which she laid 11 to 135 eggs. In the field, peak oviposition activity appeared to occur in June and July. The eggs take 12 to 14 days to develop in July but more than 30 days in September. Mortality of eggs laid both in the laboratory and collected in the field was approximately 25%. By the end of the summer, 70% of the plants examined had been attacked but in some sites this could reach 90% to 97% ($n > 50$).

Newly eclosed, first instar larvae migrate down the outside of the taproot working their way down between the grains of sand to a depth of two to three centimeters where they chew into the cortex on the *Chondrilla* roots. Their attack provokes an extreme secretion of latex which when mixed with sand forms a small, porous case one to one and one-half cm long in which the larvae develop. As the larvae grow, they move spirally down the outside of the root, further damaging the cortex and releasing more latex which increases the size of the case, which can now surround the root (Figures 3b, c). A single case can be up to 30 cm long and often when several larvae attack the same plant and their combined cases fusing forming congealed latex/sand lump that can be as big as 225 grams. It was noticed that plants growing in loose stands have both a higher rate of attack and larger than in plants growing in compact, hardened sand. The cases contain hollow chambers in which the larvae move freely and extend from near the surface to over 30 cm deep. At the deepest points, they probably experience a constant temperature of 20°C to 25°C which may be optimal for larval development. In the field, larvae usually eclose in May or June, feed during the summer, over-winter as larvae inside the case, and pupate the following spring. Adults emerge from the pupae at the beginning of summer, usually June and July. Larvae that hatch from eggs laid in midsummer over-winter and continue to feed in the following season. However, larvae from the first eggs laid in spring may complete their development and produce adults by the end of the summer which then may over-winter.

Host range

According to our field observations,*S. foveola* fed and developed mainly on *Chondrilla ambigua* Fisch. ex Kar. et Kir., and, occasionally, on *C. canescens* Kar.

Figure 2. Typical collection site for the bronze skeleton weed root borer, *Sphenoptera foveola*, in hilly desert. Kazakhstan, Site KZ04-08, Almaty Region, Qumbasy sandy desert, 69 km NNW of Qapshagay, 28.06.2004.

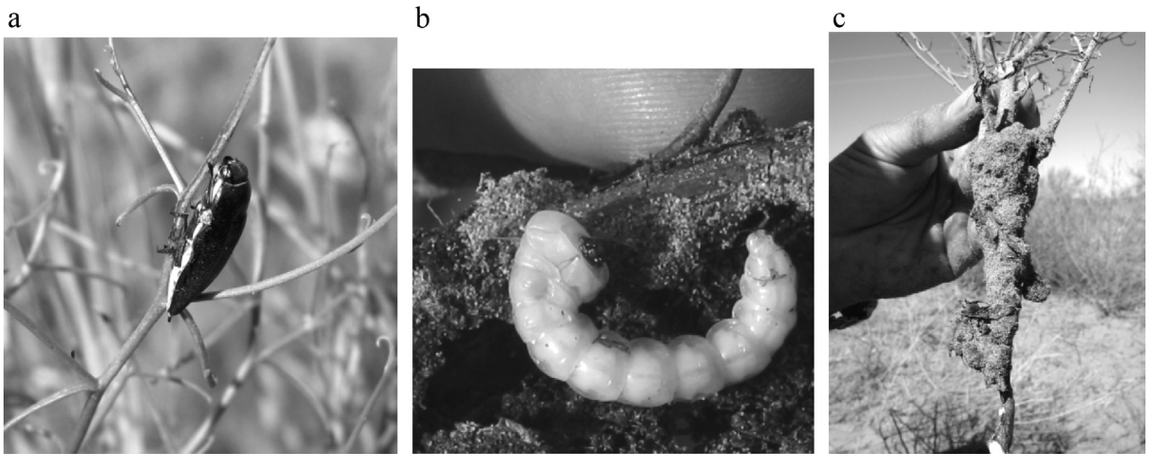

Figure 3. The bronze skeleton weed root borer, *Sphenoptera foveola*: (a) the adult; (b) mature larva; and (c) latex and sand cases of the mature larvae. The insect was feeding on *Chondrilla ambigua*, Almaty Region, Kazakhstan.

et Kir. Additionally, *S. foveola* was reported from the literature to have been found feeding on *C. pauciflora* Ldb. and more rarely on *C. brevirostris* Fisch. et Mey. (singularly) (Emelianova *et al*., 1932), but not on *C. juncea*. The genus *Chondrilla*, is taxonomically divided into several divisions, section *Brachyrhynchus* contains *C. ambigua* and *C. pauciflora.* Section *Euchondrilla* contains *C. brevirostris* and *C. canescens* which also contains *C. juncea* L. (Iljin, 1930, Flora SSSR, 1964).

S. foveola feeding on a non-*Chondrilla* species, *Scorzonera tau-saghyz* Lipschiz et Bosse, was reported by Alexeev *et al*. (1990) although they give no data to support this claim. This doubtful host use was repeated by Tleppaeva (1999), Kadyrbekov and Tleppaeva (2004), and Tleppaeva and Ishkov (2004) but without any additional substantiating data. Our field observations agree with Emelianova *et al*. (1932) who suggested that only *Chondrilla* species are suitable for *S. foveola* larval development, with feeding primarily concentrated on species of the *Brachyrhynchus* section with fewer records from *Chondrilla* in the *Euchondrilla* section.

Impact on the host plant

Chewing by adults on *Chondrilla* shoots often kills small branches which break off when dry. However, most of the damage is done by larvae feeding on the roots. The damage from a single small larva is usually not fatal but damage by mid-sized larva particularly if there are several, often kills the above ground portion of smaller plants and some times larger stems of bigger plants. The copious flow of latex exuded by the wounded roots represents a major loss of nutrients and energy. This loss of latex if does not kill the plant, must stress it, which should result in reduced growth, flowering, and general loss of competitiveness. Also, increased stress from the loss of latex probably would weaken the plants making them more susceptible to the three existing biological control agents already established in many parts of *Chondrilla juncea*'s introduced range (Julien and Griffiths, 1998).

Discussion

S. foveola's natural range, at least where it is most abundant, seems to extend from the Volga River and Caspian Sea eastward through the deserts of Kazakhstan, possibly northern most parts of Turkmenistan and Uzbekistan, as well as the southern most part of Russia adjacent to Kazakhstan. This area is probably the centre of origin for the genus *Chondrilla* since it contains approximately 18 of the 21 known species of this plant (Flora SSSR, 1964). By contrast, the target weed, *C. juncea* is one of the few species not found in this area. *C. juncea*'s range extends eastward across Europe from Spain, along the borders of the Mediterranean Sea (Wapshere *et al*., 1974). It is also found in the Balkans, Turkey and Iran and along the north shore of the Black Sea (Wapshere *et al*., 1976). The recorded eastern edge of its range ends approximately at the edge of the Caspian Sea and the Volga River (our review of herbarium species). It is therefore unfortunate that the range of *S. foveola* does not naturally extend westward far enough for it to overlap that of *C. juncea*.

The wide range of other species of *Chondrilla* which *S. foveola* can attack including the very closely related species *C. brevirostris* and *C. canescens* make us suspect that under the right climate conditions, *S. foveola* will probably also attack *C. juncea*. We are presently planning feeding studies to determine the suitability of *C. juncea* as a new association host for *S. foveola*. The fact that *S. foveola* can attack a number of different species of *Chondrilla* should not prohibit it from being considered as a biological control agent. In all parts of the introduced range of *C. juncea* there are no native or introduced species of *Chondrilla* which might be

at risk from this attack. Its potential for attacking species other than in the genus *Chondrilla*, we feel is also low since we found the only record in the literature being *Scorzonera tau-saghyz* reported by Alexeev *et al*., (1990). We hope to address the question of its potential for non-*Chondrilla* host attack in future host testing. We are also planning to find and compare *S. foveola* with the related species of *Sphenoptera clarescens* reported attacking *Chondrilla* in Turkey and Iran.

Acknowledgements

We would like to thank Alexander Popov (Volgograd), botanist and our guide in Lower Volga and Don Basins (Southern-East Russia); Dr Roman Yashchenko, President of Tethys Scientific Society (Almaty, Kazakhstan) for the great assistance in arranging our trips to Kazakhstan. The major sources of funding for this study are the Idaho Rush Skeletonweed Task Force, the Idaho Department of Agriculture and the Forest Service, Rocky Mountain Research Station. We also gratefully acknowledge the help and support of the USDA ARS foreign program office in Beltsville, MD, and Dr Walker Jones, Director of EBCL, Montpellier, France.

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