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Preliminary Results on the Phytophagous Insect Fauna on *Onopordum acanthium* (Asteraceae) in Bulgaria

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SUMMARY

The Scotch thistle, *Onopordum acanthium* (Asteraceae) has the Eurasian origin and represents an invasive weed in the USA and Australia. It is a serious problem in pastures, along roadsides, rangeland, etc. The weed is very common in Bulgaria and in 2009-2010 several sites with large populations of *O. acanthium* have been located. The weekly surveys of some of the sites, mainly in the region of Plovdiv, revealed a significant diversity of phytophagous insect species, some of which had very high population density. More than 30 species have already been identified and observations on the phenology and biology of some of them have been conducted. For some of the species, such as endophagous *Larinus latus, Lixus cardui, Eublemma amoena, Trichosirocalus briesei,* or ectophagous *Cassida rubiginosa* etc. found during our surveys, there are reports in the literature describing them as having been already introduced as successful biocontrol agents in Australia. Endophagous species like lepidopteran *Myelois circumvoluta* and *Pyroderces argyrogrammos* which feed on the stems and the head, and the tephritid flies *Tephritis postica* and *Chaetostomella cylindrica* which feed on the capitula, seem quite destructive for the weed, but need to be further studied regarding host specificity. Species like *Vanessa cardui* and *Brachycaudus cardui* were found regularly, but in low population density, mainly due to the high rate of parasitism.

Keywords: Weeds; Scotch thistle; Biological control agents

INTRODUCTION

The Scotch thistle, *Onopordum acanthium,* is a widespread weed, found in nearly 50 countries (CAB International, 2004). It is a major problem in North America as well. Its presence has been recorded in 37 states of the US (USDA-NRCS, 2006) and five provinces in Canada (Moor and Frankton, 1974). In the United States, the weed is most problematic in the arid parts of the Northwest, California and Nevada. Since the late 1970s, there has been an exponential expansion in the number of states in the Northwest that have been infested by this weed (Rice, 2006). It belongs to the sunflower family (Asteraceae) and it is also known as cotton thistle, heraldic thistle, Scotch cotton thistle, and woolly thistle. It is native to Europe and Asia (Cargill et al., 1998) and has been introduced to temperate climates elsewhere, including much of North America (Taylor, 1990) and Australia (Briese et al., 2002). In North America *Onopordum acanthium* causes significant economic losses to ranchers. It occurs in agricultural areas, range/grassland, riparian zones, disturbed scrubs/shrublands. Infestations of *O. acanthium* reduce forage production and prohibit land utilization for livestock. Dense stands of large, spiny plants constitute a barrier to livestock movement, almost totally excluding animals from grazing and access to water (Hooper et al., 1970; Sindel, 1991). It is easily transmitted to new locations by livestock and floating vegetation or debris, or when used for ornamental purposes. Seeds are dispersed locally by wind or by livestock and wildlife (Piper, 1984).

Physical and chemical management has partial effect on the thistle. Australia was the first country to initiate a biological control effort especially targeting Scotch thistle by surveying the insect fauna on *Onopordum* spp. thistles in Europe and the Mediterranean region (Balciunas, 2007). Briese et al. (1994) identified 129 insect species that fed on *Onopordum* spp. in Europe. Eventually, seven insect species were released in Australia (Briese et al., 2002; Swirepik and Smyth, 2002). Several biocontrol agents have been introduced in the United States for the biological control of Musk thistle (*Carduus nutans*) from the same family, including *Rhinocillus conicus, Trichosirocalus horridus* and *Psylliodes chalcomera* in 1969, 1974, and 1997, respectively (Gassman and Kok, 2002). In 2007, the BBCA started field surveys in several countries in Europe and Eastern Asia (Turkey, Kazakhstan) for the selection of new biocontrol agents with the aim to introduce them in the United States (Cristofaro, 2008). Numerous associated organisms were found and three of them were preliminary selected - *Trichosirocalus briesei*, *Larinus latus*, and *Psylliodes chalcomerus*. The last two have already past preliminary host range tests in quarantine facilities in the USA (Cristofaro, 2008). Recently, Bulgaria has been included on the list of surveyed countries and the objective of the current study was to establish the native insect fauna associated with *O. acanthium*.

MATERIAL AND METHODS

Immature and mature phytophagous insects were collected from *O. acanthium* at several locations in the central part of southern Bulgaria – Chernichevo, Stamboliyski, Karadzovo, Plovdiv, Poroyna. The plants were examined once a week from May to mid-November for insect-caused injuries during their early and late vegetative, flowering, fruiting and senescing stages. The leaves, stems, and capitula of at least 20 plants per site were examined *in situ* and ectophagous insects were collected by hand or by aspiration. The leaves and stems of 10-15 plants were dissected on-site in search of endophagous insects. Larvae and nymphs of unidentified species were collected together with the damaged plant parts and placed in plastic containers in laboratory, for emergence of adults and identification. Relative frequency of insect occurrence was recorded as: rare (found at less than 15% of the sample sites); occasional (found at 15-50% of the sites); and common (found at more than 50% of the sites) (Watts and Piper, 2000). The adults were identified using the identification keys for different species.

For studying the insect fauna in the flower and seed heads, 50 capitula were collected from a location near Karadzovo (42°05,45 N, and 024°54,35 E) in June. At the time of collection, some of the capitula were still in the bud stage, while some in the same cluster had ripening seeds. Each capitula was placed separately in a 300 ml plastic container covered by muslin on the top. The containers were checked several times later and the emerged adults were recorded. The ratio of the adults of different species was calculated.

RESULTS AND DISCUSSION

A total of 42 insect species was detected, feeding on different plant parts of *Onopordum acanthium* in the central part of Southern Bulgaria (Table 1), four of

which were not identified at all and five – identified only to genus. Inclusion in the table was based on direct observation of feeding-caused damage. The insect fauna was represented by five orders and 28 families. The most abundant were the species from Coleoptera and Lepidoptera.

The number of coleopteran species feeding on Scotch thistle was 15, some of them found in very high population density, like Onopordum capitulum weevil *Larinus latus*, the stem-boring weevil *Lixus cardui*, the green thistle beetle *Cassida rubiginosa,* the flea beetle *Psylliodes chalcomerus,* and the cigarette beetle *Lasioderma serricorne*. The first two are specialized and already introduced for biological control of *Onopordum* spp. thistles in Australia (Briese et al., 2002; Briese et al., 2004, Swirepik et al., 2008). The green thistle beetle *C. rubiginosa* was found suitable for introduction in New Zealand (Goulray and Hill, 2006) as potential control agent for Californian thistle (*Cirsium arvense*). After laboratory and field tests it was concluded that it is unlikely the beetle would attack any plant species outside the tribe Cardueae. *C. rubiginosa* is widely distributed in Europe, North America and northern Asia, and according to Zwölfer and Eichhorn (1966), it is one of the most common insects on thistles in Europe. It has been present in North America for over 100 years and is now commonly found in the Western United States and neighbouring parts of Canada (Ward and Pienkowski, 1978). The flea beetle *P. chalcomerus* was evaluated as prospective control agent for Yellow starthistle, *Centaurea solstitialis* (Cristofaro, 2004). Several biological forms of this species were collected on different host plants, including *Onopordum,* and the studies suggest that each of the established forms is closely connected with the specific plant.

Lasioderma serricorne though very common and in high population density is polyphagous and is considered a pest of stored products like tobacco (Ashworth, 1993). The specialized *Rhinocyllus conicus* and *Ceratapion onopordi* were rarely found. The rest of the coleopteran species were polyphagous (8 species) and without influence on the survival of the plants.

From 9 lepidopteran species only *Eublemma amoena* is specialized, the rest being non-specialized or with unknown specialization. The most common were *Myelois circumvoluta* (Figure 1 and 2) and *Pyroderces argyrogrammos* (Figure 3 and 4), the larvae of which were feeding in the stems and the capitula. There is information that the larvae of *M. circumvoluta* are oligophagous, feeding on different thistles – *Arctium lappa, Cirsium eriophorum* and *C. vulgare* (Fitter and Peat, 1994) although no host specificity tests have been performed for either of the two species so far. Six dipteran species were found to feed on *Onopordum acanthium*: three from family Tephritidae, one from Agromyzidae, one from Anthomyiidae (Figure 5 and 6), and one from Cecidomyiidae (Figure 7), the last three being unidentified yet. The agromyzid fly from genus *Melanagromyza* was quite common, together with the tephritid fly *Tephritis postica*. *Acanthiophilus helianthi* was found only on one occasion, and *Chaetostomella cylindrica* – on two. *A. helianthi* is a generalist fly, attacking the flower heads of more than 50 plants (Knio et al., 2002), some of which with economic importance and for this reason it is not considered suitable as biocontrol agent. *Tephritis postica* is related to one genus only – *Onopordum* (Knio et al., 2002). It is spread in Europe, Western Asia and Northern Africa (Neuenschwander and Freidberg, 1983; Foote, 1984; Freidberg and Kugnel, 1989). It has been included in the strategy for the control of *Onopordum* spp. thistles in Australia (Briese et al., 2002). Recent studies by Knio et al. (2007) on the host-race formation in *C. cylindrica* revealed that the fly is most probably a complex of cryptic and reproductively isolated species and one of them is the *Onopordum* host race. The species from order Hemiptera found during the survey were polyphagous or in low population density, causing insignificant damage. Psyllid nymphs (Figure 8), which were not identified, were found at one of the sites in Karadzovo.

Of all the species detected in our study, the specialized feeders represent 24% and for 19% the host specialization is not known, or additional host specificity tests are needed (Table 1). In a survey carried out in the United States, Watts and Piper (2000) encountered no specialist insects; as suggested by Goeden and Ricker (1986), the absence of *Onopordum* endophages there may be attributed to the lack of congeneric thistle species in the region, which would provide to the pre-adapted specialist feeders an opportunity to cross over to the weed.

The percentage of internal feeders found in Southern Bulgaria was quite high - 45% of all species, compared to 5% in Australia (Briese, 1989), and no internal feeders in a survey in south-eastern Washington and north-western Idaho (Watts and Piper, 2000). In the latter case, according to Briese et al. (1994), all endophagous feeding niches are open for exploitation by non-indigenous specialist insects.

Table 1. Phytophagous insect species feeding on *Onopordum acanthium* in Southern Bulgaria

No	Genus, Species	Order, Family	Host specialization	Plant part damaged	Internal /external feeder	Relative frequency
1	2	3	4	5	6	7
1	*Melanagromyza* sp.	Dipt., Agromyzidae	U	St	L-I	C
2	*Tephritis postica* (Loew 1844)	Dipt.,Tephritidae	S	Cp	L-I	C
3	*Chaetostomella cylindrica* (Robineau-Desvoidy 1830)	Dipt., Tephritidae	S	Cp	L-I	O
4	*Acanthiophilus helianthi* Rossi 1794	Dipt., Tephritidae	NS	Cp	L-I	O
5	*Pegomyia* sp.	Dipt., Antomyiidae	U	St, Cp	L-I	R
6	Unidentified gall midge	Dipt., Cecidomyiidae	U	St, Cp	L-I	R
7	*Cassida rubiginosa* O.F. Müller 1776	Coleopt., Chrysomelidae	S	Lf	L,A-E	C
8	*Psylliodes chalcomerus* (Illiger 1807)	Coleopt. Chrysomelidae	S	St, Lf	L-I, A-E	C
9	*Lixus (Epimeces) cardui* Olivier 1807	Coleopt., Curculionidae	S	St	L-I, A-E	C
10	*Larinus (Larinus) latus* (Herbst 1783)	Coleopt., Curculionidae	S	St, Cp	L-I , A-E	C
11	*Trichosirocalus briesei* Alonso-Zarazaga & Sánchez-Ruiz 2002	Coleopt. Curculionidae	S	R, Lf	L-I , A-E	C
12	*Rhinocyllus conicus* (Froelich 1792)	Coleopt. Curculionidae	S	R, Lf	L-I, A-E	R
13	*Ceratapion onopordi* (W. Kirby 1808)	Coleopt., Apionidae	S	St, Lf	L-I, A-E	R
14	*Protaetia cuprea* (Fabricius 1775)	Coleopt., Cetoniidae	NS	Cp	A-E	R
15	*Polyphylla fullo* (Linnaeus 1758)	Coleopt., Scarabaeidae	NS	Lf	A-E	O
16	*Anoxia villosa* (Fabricius 1781)	Coleopt., Scarabaeidae	NS	Lf	A-E	C
17	*Oxythyrea funesta* (Poda 1861)	Coleopt., Scarabaeidae	NS	Cp	A-E	C
18	*Tropinota hirta*(Poda 1861)	Coleopt., Scarabaeidae	NS	Cp	A-E	C
19	*Agapanthia* sp.	Coleopt., Cerambycidae	NS	St, Lf	L-I, A-E	C
20	*Lasioderma serricorne* (Fabricius 1792)	Coleopt., Anobiidae	NS	Cp	L,A-I	C
21	*Mylabris variabilis* (Pallas, 1782)	Coleopt., Meloidae	NS	Cp	A-E	R
22	*Myelois circumvoluta* (Fourcroy 1785)	Lepidoptera, Pyralidae	U	St, Cp	L-I	C
23	*Eublemma amoena* (Hübner 1803)	Lep., Noctuidae	S	R, St	L-I	C
24	*Chrysodeixis chalcites* (Esper 1789)	Lep., Noctuidae	NS	Lf	L-E	O
25	*Pyroderces argyrogrammos* (Zeller 1847)	Lep., Cosmopterigidae	U	St, Cp	L-I	C
26	*Vanessa cardui* Linnaeus 1758	Lep., Nymphalidae	NS	Lf	L-E	C
27	*Melitaea didyma* (Esper 1778)	Lep., Nymphalidae	NS	Lf	L-E	R
28	*Cochylis hybridella* Hübner 1813	Lep., Tortricidae	NS	Cp	L-I	O
29	Unidentified green larva	Lep., Tortricidae	U	Lf	L-E	O
30	*Pontia* sp.	Lep., Pieridae	NS	Lf	L-E	O
31	*Brachicaudus cardui* (Linnaeus 1758)	Hem., Aphidiidae	NS	St, Lf	L,A-E	C
32	*Philaenus spumarius* (Linnaeus 1758)	Hem., Cercopidae	NS	Lf	N, A-E	C
33	*Aphrophora almi* (Fallen 1805)	Hem., Cercopidae	NS	Lf	N, A-E	C
34	Unidentified nymphs and adults	Hem., Flatidae	U	Lf	N,A-E	C

1	2	3	4	5	6	7
35	*Eurygaster testudinaria* (Geoffroy 1785)	Hem., Scutelleridae	NS	Lf, Cp	N,A-E	R
36	*Psacasta exanthematica* (Scopoli 1763)	Hem., Scutelleridae	NS	Lf	N, A-E	R
37	*Eurydema ornata* (Linnaeus 1758)	Hem., Pentatomidae	NS	Lf, Cp	N,A-E	C
38	*Cymus* sp.	Hem., Lygaeidae	NS	Cp	N,A-I	C
39	*Centrocoris variegatus* Kolenati 1845	Hem., Coreidae	NS	Cp	A-E	R
40	*Dolycoris baccarum* Linnaeus 1758	Hem., Pentatomidae	NS	Lf, Cp	N,A-E	R
41	Unidentified psyllid nymphs	Hem., Psyllidae	U	St, Lf	N-E	R
42	*Tettigonia viridissima* (Linnaeus 1758)	Orthoptera, Tettigoniidae	NS	Lf	N,A-E	R

Host specialization: S – specialized; NS – non-specialized; U – unknown
Plant part damaged: Lf – leaf, St – stem, Cp – capitulum, Rt – root
Internal feeder – I; External feeder – E
Insect stages: L – larva, N – nymph, A – adult
Relative frequency: C – common; R – rare; O – occasional

Figure 1. Larva of *Myelois circumvoluta*

Figure 2. Mating adults of *M. circuvoluta*

Figure 3. Larva of *Pyroderces argirogrammos*

Figure 4. Adult of *P. argirogrammos*

Figure 5. Larvae of *Pegomyia* sp.

Figure 6. Damage by the larvae of *Pegomyia* sp.

Figure 7. Unidentified cecidomyiid larva

Figure 8. Unidentified psyllid nymphs

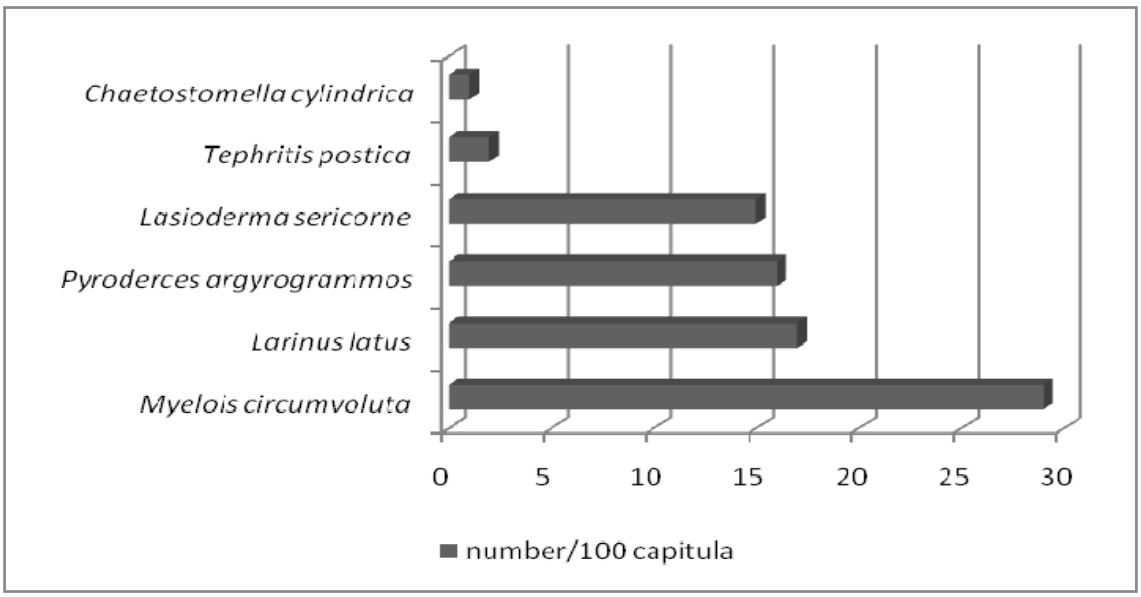

Figure 9. The ratio between insect species feeding on capitula, collected in the region of Plovdiv in June-July 2009

Among the internal feeders in Australia 16% damaged the stem, 32% - the capitulum, 26% - the stem and the capitulum, 16% - the stem and the leaves, 5% - the root and the stem, and 11% - the root and the leaves (Briese, 1989). Among the external feeders, only the green thistle beetle *Cassida rubiginosa* was of significance. As for the European endophagous fauna, 21% were feeding on the capitula, 9% were stem and root feeders, and 8% stem and leaf feeders (Briese, 1989).

A guild of capitulum feeders could be of great importance in the regulation of *O. acanthium*, as the effective occupation of this niche could significantly affect plant reproduction and survival (Briese et al., 1994). In our study, the most abundant in the capitula were larvae of *M. circumvoluta, L. latus* and *P. argyrogrammos* (Figure 9). The larvae of *C. cylindrica* and *T. postica* were found in less than 3% of the capitula. A great number of parasitoid species emerged in the containers, which is one possible reason for the low population density if the capitulum feeders at the place of collection.

Host-specificity testing of several candidate European natural enemies of *O. acanthium* is being carried out at the Exotic and Invasive Weed Research Unit, USDA-ARS, Albany, CA. Two culculionids (*Lixus cardui* Olivier and *Lixus* sp.) ware examined in 1996–1997 by Balciunas (2007) and according to him *L. cardui* feeds and completes development on several indigenous thistles (*Cirsium* spp.). The root-infesting weevil *Trichosirocalus* sp. is still in the process of evaluation. It is hoped that the beetle or other yet- to- be-tested insects will be host-specific enough to be approved for release against Scotch thistle in the Western United States (Watts and Piper, 2000). *Botanophila spinosa* was identified among four species of *Onopordum* (Briese et al., 1994) and failed to develop on members of other carduinae thistle genera that were tested.

Among the species damaging the capitula (Figure 9), the most numerous were *M. circumvoluta*, *L. latus* and *P. argyrogrammos*. Besides *L. latus,* neither of the other two species has been studied. Obviously, HS testing will be necessary for evaluating them as possible biocontrol agents.

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Preliminarni rezultati ispitivanja fitofagne faune insekata na *Onopordum acanthium* (Asteraceae) u Bugarskoj

REZIME

Čkalj, *Onopordum acanthium* (Asteraceae), vodi poreklo iz Evrope i Azije i u SAD i Australiji se smatra invazivnom korovskom vrstom. Predstavlja veliki problem na livadama, pored puteva, na pašnjacima, itd. Ovaj korov je vrlo zastupljen u Bugarskoj i u 2009. i 2010. zabeležena je pojava brojnih populacija *O. acanthium* na nekoliko lokacija. Nedeljnim osmatranjem na nekim lokacijama, uglavnom u regionu Plovdiva, utvrđeno je prisustvo velikog broja različitih vrsta fitofagnih insekata, od kojih su neke imale brojnu populaciju. Identifikovano je više od 30 vrsta i izvršeno je ispitivanje fenologije i biologije nekih od njih. Za neke od vrsta koje su identifikovane, kao što su endofagne *Larinus latus, Lixus cardui*, *Eublemma amoena, Trichosirocalus briesei*, ili ektofagne *Cassida rubiginosa*, itd., postoje podaci u literaturi da su u Australiji s uspehom primenjene kao agensi biološke kontrole. Endofagne vrste insekata iz reda Lepidoptera, *Myelois circumvoluta* i *Pyroderces argyrogrammos*, koje se hrane stabljikama i cvetom, kao i mušice *Tephritis postica* i *Chaetostomella cylindrica* koje se hrane cvetom, deluju prilično destruktivno na korov, ali je potrebno sprovesti dodatna ispitivanja kako bi se izvršila specifikacija domaćina. Vrste kao što su *Vanessa cardui* i *Brachycaudus cardui* nađene su na svim lokalitetima, ali u malom broju, uglavnom zbog značajnog prisustva parazitizma.

Ključne reči: Korovi; čkalj; biološka kontrola