

**NOTE****New North American records of Chalcidoid parasitoids of the introduced knapweed gall fly (*Urophora jaceana*)**

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Black Knapweed, *Centaurea nigra* L. (Asteraceae) is a perennial plant that grows in disturbed areas along roadsides and pastures. Its native range is Western Europe, including Britain, from Spain to Norway, east to Germany and Switzerland. It was introduced from Europe and is now widespread in Atlantic Canada, Ontario, British Columbia and the eastern United States (Hoebeke and Wheeler 1996). *Urophora jaceana* (Hering, 1935) (Diptera: Tephritidae) is the common knapweed gall fly that attacks *Centaurea nigra* in Europe (Varley 1947). It was first recorded in North America in Kentville, Nova Scotia in 1923, and later in St. John's, Newfoundland in 1949 by Shewell (1961), but he indicated that this gall fly was noted many years before its official introduction date and suggested that it was likely introduced along with its host plant. Notes on the biology of the *Urophora jaceana* were given by Wadsworth (1914), Varley (1937) and Varley (1947). Cooper (1981) suggested that *Centaurea nigra* was introduced to Newfoundland, Canada, centuries ago during the migratory fishery when southwest English soil ballast was deposited on the shores of the oldest communities on the Avalon Peninsula. This mechanism of introduction for plants and animals was outlined by Lindroth (1957). Additionally, archaeobotanical analysis of samples taken from a latrine at Ferryland, dated from 1621-1673, contained remains of *Centaurea* sp. (Bain and Prévost 2010). I surveyed black knapweed seed-heads in eastern Newfoundland to determine which, if any, parasitoids may be attacking *Urophora jaceana*. *Centaurea nigra* seed-heads containing galls were sampled on two occasions during December 2013 and December 2014 at three localities in eastern Newfoundland (Carbonear-Boardwalk 47°44'12.3"N, 53°13'51.9"W; Carbonear-Lilly Pond 47°44'52.9"N, 53°13'45.7"W; and St. John's-Majors Path 47°36'21.8"N, 52°44'01.9"W). The collected seed-heads were frozen at -20°C to arrest the development of the contents of the galls. In 2013, 20 — 40 seed-heads were sampled from each of the sites, while in 2014, 30 seed-heads were sampled from each site. In April 2014 and April 2015, the number of galls present in each seed-head was determined. Each gall was then carefully dissected to examine its contents. Verification of the identification of parasitoids was by third party specialists (see below). Voucher specimens of the gall fly and its associated parasitoids are housed in the insect collection at the College of the North Atlantic, Carbonear campus and in the Newfoundland Collection at the Canadian Forest Service, Edmonton, Alberta.

All of the galls sampled were initiated by knapweed gall flies (*Urophora jaceana*). Within the sample years, there was little difference between the sites in the number of galls per seed-head. However, there seemed to be a higher number of galls per seed-head between the two years studied (14.2 galls/seed-head in 2015 versus 6.9 galls/seed-head in 2014) (Table 1). Insects collected from galls at each of the sites are presented in Table 1. The data shown represent the proportions of the galls containing gall fly larvae and various parasitoids. In addition, several galls contained dead gall fly larvae or were empty. These were grouped together under "other mortality". I did not attempt to identify the sources of the mortality. These unknown sources of mortality produced empty galls, gall fly larvae with fungal growth on them or larvae that were dried and shrivelled. It was unclear why some of the galls were empty but I assumed that the initial gall fly larvae were killed by parasitoids during the previous summer or autumn, and that these parasitoids completed their development and had exited the galls.

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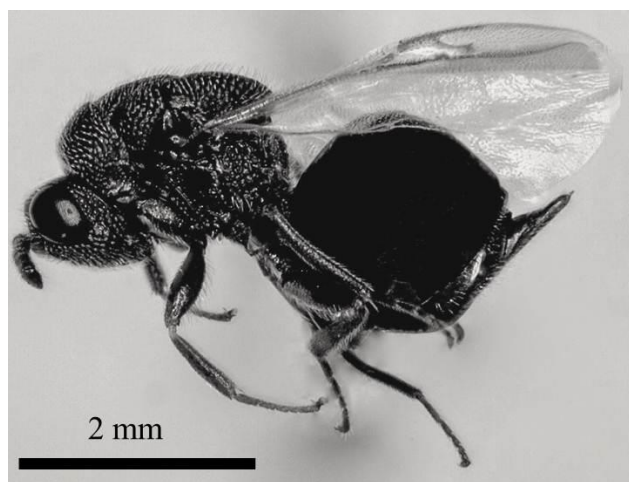
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The galls contained the following insects:

***Eurytoma compressa* (Fabricius, 1794) (Hymenoptera: Chalcidoidea: Eurytomidae)**

This is a common, black endoparasite of the larvae of *Urophora jaceana* (Figure 1). It was the most abundant parasitoid of *Urophora jaceana* larvae I collected (level of parasitism in 2014 = 18.1%; 2015 = 24.8%). *Eurytoma compressa* is the senior synonym of *Eurytoma curta* (Boucek and Delvare 1992). *Eurytoma compressa* was erroneously identified as occurring in Mexico in 1935 but Bugbee (1975) re-examined the specimen and determined it was misidentified. With the occurrence of *Eurytoma compressa* in Newfoundland, it represents the first record of this wasp in North America. Verification of the identification was by G. Delvare (CIRAD-Amis, Montpellier, France). Varley (1947) described the natural history of *Eurytoma compressa* (as *Eurytoma curta*). When galls are cut open during the winter, the presence of gall fly puparia indicates that it is parasitized by *Eurytoma compressa*. The gall fly is normally in the larval stage at this time of the year. However, *Eurytoma compressa* advances the pupation of the gall fly before killing it. I dissected each puparium to verify if an *Eurytoma compressa* larva was present inside.

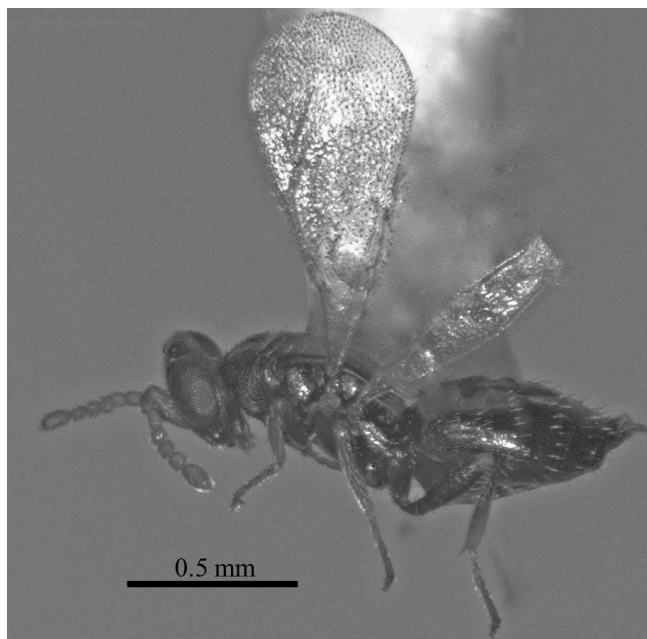
Figure 1. Lateral view of *Eurytoma compressa* Walker (Hymenoptera; Chalcidoidea: Eurytomidae).



***Baryscapus gradwelli* Graham, 1991 (Hymenoptera: Chalcidoidea: Eulophidae)**

This was the smallest wasp species observed (~ 1 mm length), which was collected in 2015 only (Figure 2). C. Hansson (Museum of Biology, Lund, Sweden) verified the identification of this species. The adults are metallic

Figure 2. Lateral view of *Baryscapus gradwelli* Graham (Hymenoptera: Chalcidoidea: Eulophidae).



green with brown legs. Varley (1947) identified a eulophid parasitoid from *Urophora jaceana* as *Tetrastichus* "sp.B" but this wasp was reclassified as *Baryscapus gradwelli* by Graham (1991). The current collections (Table 1) represent the first records of this species in North America. *Baryscapus gradwelli* larvae are endoparasites of *Urophora jaceana* (Graham 1991). Askew and Shaw (2005) suggest that *Baryscapus* species are often relatively polyphagous as was seen by this species parasitism of *Eurytoma compressa* and *Pteromalus elevatus* (Walker, 1834) (Eulophidae) by Varley (1947). Generally, members of the genus may have up to three generations per year. Adults that emerge in autumn attack host larvae and overwinter inside the host body. In addition, they are gregarious, where 3 — 20 larvae may feed on a single host (Varley 1947). I observed 2 — 37 (median = 10; N = 27) *Baryscapus gradwelli* larvae located in *Urophora jaceana* larvae parasitized by this wasp. It is interesting to note that Varley (1947) indicated that *Eurytoma compressa* was sometimes parasitized by *Baryscapus gradwelli* but the ability of *Eurytoma compressa* to cause the gall fly to pupate prematurely, reduced the chances of multiparasitism by this eulophid wasp. Varley (1947) suggested that the puparium exoskeleton was tough and difficult for *Baryscapus gradwelli* to penetrate with its small ovipositor, enabling *Eurytoma compressa* to survive possible attacks from this parasitoid. I observed several puparia containing *Baryscapus gradwelli* larvae, indicating

Table 1. The contents of galls produced by the knapweed gall fly, *Urophora jaceana*, on black knapweed, *Centaurea nigra*, during winters 2014 and 2015 from Newfoundland, Canada. The values are mean proportions of the population with their standard deviations in brackets.

| Year, Location | n | # galls/ seedhead | % <i>Urophora jaceana</i> | % <i>Eurytoma compressa</i> | % <i>Pteromalus elevatus</i> | % <i>Baryscapus gradwelli</i> | % other mortality |
|-------------------------|-----------|-------------------|---------------------------|-----------------------------|------------------------------|-------------------------------|--------------------|
| 2014 | | | | | | | |
| Carbonear, Boardwalk | 20 | 6.6 (4.8) | 85.8 (18.2) | 0.0 (0.0) | 8.3 (14.6) | - | 6.0 (14.4) |
| Carbonear, Lily Pond | 40 | 7.9 (5.5) | 46.6 (25.6) | 23.1 (23.8) | 11.5 (19.4) | - | 18.8 (22.8) |
| St. John's, Majors Path | 25 | 5.8 (3.8) | 54.3 (32.2) | 24.6 (27.2) | 0.7 (3.3) | - | 20.5 (28.3) |
| 2014 means | 85 | 6.9 (4.9) | 58.1 (30.4) | 18.1 (24.0) | 7.6 (15.7) | - | 16.2 (23.5) |
| 2015 | | | | | | | |
| Carbonear, Boardwalk | 30 | 13.8 (5.4) | 70.0 (23.0) | 7.2 (10.5) | 5.6 (7.6) | 0.9 (2.7) | 16.4 (15.3) |
| Carbonear, Lily Pond | 30 | 15.6 (5.2) | 28.3 (18.0) | 31.6 (16.2) | 4.7 (7.0) | 1.1 (2.7) | 34.3 (16.1) |
| St. John's, Majors Path | 30 | 13.2 (4.7) | 30.2 (13.0) | 35.5 (16.9) | 1.7 (3.8) | 0.4 (1.4) | 32.2 (13.8) |
| 2015 means | 90 | 14.2 (5.1) | 42.8 (25.7) | 24.8 (19.3) | 4.0 (6.5) | 1.6 (5.4) | 27.6 (17.0) |

that these wasps can hyperparasitize *Eurytoma compressa* inside the puparium. In one case, an empty puparium was observed with the remains of some *Baryscapus gradwelli* adults inside. *Baryscapus gradwelli* is known to have several generations per summer. It is possible that *Baryscapus gradwelli* adults may have encountered puparia containing *Eurytoma compressa* larvae during the autumn, laid eggs within the *Eurytoma compressa* larvae, and had sufficient time to develop into adults in the same autumn. This may be one of the contributing factors for the number of empty galls that we also encountered.

***Pteromalus elevatus* (Walker, 1834) (Hymenoptera: Chalcidoidea: Pteromalidae)**

This wasp was recorded in North America (Newfoundland) by Graham (1969). Hoebeke and Wheeler (1996) outlined the taxonomy of the species and gave additional records of its occurrence in New Brunswick, Nova Scotia and Newfoundland. Verification of the identification of this wasp inside *Urophora jaceana* galls collected in Newfoundland for the present study was by E.R. Hoebeke (University of Georgia, Athens, GA, USA). Varley (1947) indicated that the normal host for *Pteromalus elevatus* (as *Habrocytus tryptetae*) in knapweed was the gall fly, but he also suggested that other parasitoids like *Eurytoma compressa* were attacked by *Pteromalus elevatus*. Developing *Pteromalus elevatus* consume the entire *Urophora jaceana* larva and overwinter inside the gall. This ectoparasitoid larva was easily distinguishable in the dissected galls. The levels of parasitism of *Urophora jaceana* by *Pteromalus elevatus* were 7.6% in 2014, and 4.0% in 2015.

Eurytoma compressa was the most abundant parasitoid of *Urophora jaceana* in the present Newfoundland survey, found in 18 — 25% of galls collected. Carbonear-Boardwalk showed a larger number in the surviving gall flies and a lower level of parasitism by *Eurytoma compressa* than the other two sites sampled. The flower density (although not measured directly) appeared lower at Carbonear-Boardwalk compared to the other sites sampled. Varley (1947) suggested that cool weather during 1936 negatively affected the area of discovery of *Eurytoma compressa* and thus a lower rate of parasitism was recorded for that year. Carbonear-Boardwalk is directly adjacent to the ocean and experiences considerable amount of fog and cool temperatures during June and July. This occurs at the time when the *Eurytoma compressa* adults have emerged and are searching for hosts. It is possible that a combination of lower flower density and poor weather may have affected the parasitoids ability to locate its host at this location. This may have resulted in the higher percentage survival of *Urophora jaceana* larvae and lower parasitism by *Eurytoma compressa* that was observed at the Carbonear-Boardwalk site for both years. The rates of parasitism for *Pteromalus elevatus* and *Baryscapus gradwelli* at Carbonear-Lilly Pond and Carbonear-Boardwalk were similar and probably not affected by the poor weather because these wasps are actively seeking hosts later in the summer when the weather conditions improve.

This is the first record of *Eurytoma compressa* and *Baryscapus gradwelli* in North America. While the exact mechanism of introduction of the knapweed gall fly and its associated parasitoids is unknown, it has been suggested their introduction was by the same soil-ballast mechanism described by Lindroth (1957) for the introduction of the host plant (Hoebeke and Wheeler 1996).

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