Tettigoniidae (Orthoptera) ovipositing in old galls of *Dryocosmus kuriphilus* (Hymenoptera: Cynipidae)

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**Abstract.** This paper presents biological notes on two species of Orthoptera: Tettigoniidae that emerged from old spongy-woody galls of *Dryocosmus kuriphilus* Yasumatsu, 1951 collected in Sicily (Italy) in April 2015: *Leptophyes sicula* Kleukers, Odé et Fontana, 2010 (Phaneropterinae) and *Cyrtaspis scutata* (Charpentier, 1825) (Meconematinae). Between the end of April and the first few days of May a total of 30 neanids emerged from the galls, were reared and their life-cycle recorded. While *L. sicula* laid eggs in groups, *C. scutata* laid single eggs inside the galls; both species in a few years have adapted to exploiting this new shelter for egg laying. No interaction with the gall inducing insect was noted.

**INTRODUCTION**

Galls are induced by physical-chemical interactions between plants and organisms, such as insects, mites, nematodes, fungi, bacteria and viruses (Sugiura & Yamazaki, 2009). Galls are adaptive in that they provide the inducers with nutritious tissues and sometimes shelter from natural enemies (Price et al., 1987). Gall-inducers are referred to as “ecosystem engineers” because the physical-chemical alterations they induce in plant organs in the form of galls are habitats or resources for other organisms (Sugiura & Yamazaki, 2009). Galls indeed are important resources not only for the gall-inducers, but also for other organisms, generally classified as either: parasitoids, hyperparasitoids, inquilines, cecidophages, predators, successors or symbionts (Sugiura & Yamazaki, 2009).

Galls induced by *Dryocosmus kuriphilus* Yasumatsu, 1951 on *Castanea sativa* Miller, 1768 remain on the plant for months, sometimes years (Torrente-Pérez & Fernández-López, 2015) after the emergence of the gall-inducer, parasitoids and inquilines, and provide other insects with shelter and vital space. Successors are secondary users of galls (Mani, 1964) and include spiders, pseudo-scorpions, millipedes, beetles, ants, etc. (Cussigh, 1992; Sugiura & Yamazaki, 2009), which use the gall as shelter or for laying eggs, among which there are also grasshoppers (Fischer, 1853; Fitsch, 1880; Chopard, 1938; Harz, 1957, 1984; Kleukers et al., 1997; Fontana et al., 2002; Blommers, 2008; Massa et al., 2012). As there are few publications on this sort of association involving grasshoppers this paper presents a description of the life cycles of two species of Orthoptera that were recorded emerging from old galls of *D. kuriphilus*.

**MATERIALS AND METHODS**

Table 1 lists localities and the dates on which *D. kuriphilus* galls were collected from three sites in Sicily. Only the old spongy-woody galls induced by Cynipidae were collected (Fig. 1E) over a period of two years. Overall, ca. 1000 galls were collected. These galls were kept at room temperature in a laboratory at the University of Palermo and the parasitoids and other insects that emerged were collected. Most of the insects were preserved and mounted, but the Orthoptera were transferred to small plastic containers covered by tulle (Fig. 1A and C). A small plug of wet cotton wool was glued to the inside top of the container to provide the insects with water; water was added when necessary by means of a syringe (Fig. 1B and D). Food provided was young chestnut *Castanea sativa* leaves, leaves of *Sonchus oleraceus* L., lettuce, young leaves of summer squash, apple peelings, and crumbled corn flakes and fish food.

As one of the successor species was thought to be insectivorous it was provided with prey, by placing them inside the containers; prey consisted of larvae and adults of moths, Hymenopteran parasitoids and Cynipidae. Every 4–5 days the containers were cleaned and all remnants of food removed to guarantee hygiene and prevent buildup of mould.

**Table 1.** List of localities and dates on which the galls of *Dryocosmus kuriphilus* were collected.

| Location (Province) | GPS coordinates | Date of collection |
|---------------------|-----------------|--------------------|
| Camaro (Messina)    | 38°11’57.41”N, 15°29’40.60”E | 21.iv.2015 |
| Favarella (Messina) | 38°11’54.51”N, 15°28’22.31”E | 21.iv.2015 |
| Musolino (Messina)  | 38°11’32.50”N, 15°29’4.02”E | 21.iv.2015 |

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Fig. 1. Details of the cages in which the galls of Dryocosmus kuriphilus containing eggs of the successors Leptophyes sicula and Cyrtaspis scutata were kept (A, C). Rearing containers (B, D) showing top cover of container and the plug of cotton wool injected with water using a syringe. (E) Old spongy-woody galls of D. kuriphilus. (F) Eggs of L. sicula laid in crevices in the walls of old galls. (G–H) Eggs of L. sicula laid on the cotton wool attached to the cover of the container. (I) Details of the eggs extracted from the cotton wool. (J–K) Comparison of the eggs of L. sicula laid in the container (J) and those obtained from galls (K). (L) Side of an egg laid inside a gall. (M) Eggs of C. scutata individually laid inside the larval chamber of D. kuriphilus. (N, P) Silken pupal remains indicating an emerging C. scutata. (N, Q) Sections of galls showing the egg of C. scutata. (O) Larval chamber of C. scutata. (R–S) Egg of C. scutata extracted from a gall magnified to show its reticulate surface. (S) Side view of same egg.
Fig. 2. Nymphal instars of Leptophyes sicula. A–B: 10th May 2015 (first-instar nymph); C–D: 6th June 2015; E–G: 20th June 2015 (adult female and details of ovipositor); H–I: 6th June 2015 (adult male and details of cerci).
All the specimens were examined under a Wild-Heerbrugg M8 stereomicroscope. Some specimens (both galls and insects) were photographed using a Canon 7D digital camera provided with a macro lens Canon MP-E 65 mm and photographs were integrated using the freeware CombineZP (Hadley, 2011). In addition, we measured the length and breadth of the ovipositor of Orthoptera that emerged from galls, using specimens preserved in museum collections. Measurements were taken using the soft-
ware Optika Vision Pro. Samples are preserved in the collections of the Department of Agriculture and Forest Sciences, University of Palermo.

RESULTS AND DISCUSSION

The insects that emerged from the galls were mainly Coleoptera Anobiidae of the genus Dryophilus Chevrolet, 1832; in addition, ca. 30 neanids of Orthoptera Ensifera belonging to two species emerged between the 27th April and 2nd May 2015.

One of them was Leptophyes sicala Kleukers, Odé et Fontana, 2010 (Tettigonidae: Phaneropterinae). The adult laid groups of eggs in crevices inside the gall (Fig. 1F). The neanid emerged from an opening in the side of an egg (Fig. 1F). The neanid emerged from an opening in the side of an egg (Fig. 1F). The neanid emerged from an opening in the side of an egg (Fig. 1F). The neanid emerged from an opening in the side of an egg (Fig. 1F).

The other species that emerged from eggs laid inside galls of Dryocosmus kuriphilus was Cyrtaspius scutata (Charpentier, 1825) (Tettigonidae: Mecronematinae). It laid single eggs that occupied the entire empty larval chamber of the Cynipid (Fig. 1Q). The eggs were elliptical, light brown with a very flat (0.2 mm) (Fig. 1I and J), those found inside the galls of Dryocosmus kuriphilus were clearer and not so flat (0.7 mm) (Fig. 1K and L), probably due to the growth of the embryo. Eggs inside galls cannot be seen from outside, so it was necessary to open the galls.

Fig. 2 shows some nymphal instars of this insect, whose diagnostic characteristics are small black spots all over the body; in this instar these spots are few and there are some markings in one or two lines on each tergite (Fig. 2A and B), later the markings are smaller and closer. Males and females of L. sicula reared in the same containers did not eat or attack one another. This is a phytophagous species, endemic to Sicily and discovered only recently (Kleukers et al., 2010), but previously considered as L. punctatissima (Bosc, 1791), a widespread European species associated with broadleaved trees and small bushes. It has a spring-summer phenology (Massa et al., 2012).

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