

European parasitoids of *Lilioceris lili* (Coleoptera: Chrysomelidae)

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The lily leaf beetle, *Lilioceris lili* Scopoli, was first found in North America near Montreal, Canada, in 1943 (LeSage 1992). It was recovered in Boston, Massachusetts, in 1992 (Livingston 1996), and now occurs throughout all of the New England states and in the Canadian provinces of Quebec, Ontario, Nova Scotia, and Manitoba. It is a serious pest of native and cultivated lilies (Liliaceae) (Livingston 1996). This univoltine insect overwinters as an adult and after initiating feeding in the spring, oviposits in rows on the undersides of lily leaves. Larvae, which carry a fecal shield, pass through four instars before pupating in the soil. In North America, larval feeding often results in complete plant defoliation. *Lilioceris lili* apparently originated in Asia (Berti and Rapilly 1976), and now exists throughout Eurasia from Siberia to Morocco and from the United Kingdom to China (Labeyrie 1963; Lu and Casagrande 1998). Based on its Eurasian distribution, *L. lili* will likely increase its distribution in North America.

The large genus *Lilioceris* Reitter comprises 142 species, with the largest concentration (60 species) found in China (Berti and Rapilly 1976), and at least 6 species found in Europe (Livingston 1996). *Lilioceris lili*, the most widely distributed insect in this genus, is the only insect of this genus found in North America. To date, no natural enemies of *L. lili* have been reported in North America. Three other insects from the same subfamily (Criocerinae) have become serious pests after accidental introduction into North America: the cereal leaf beetle, *Oulema melanopus* (L.), the common asparagus beetle, *Crioceris asparagii* (L.), and the spotted asparagus beetle, *Crioceris duodecimpunctata* (L.). A complex of European parasitoids of the cereal leaf beetle has been established in North America, including *Tetrastichus julis* (Walker), *Lemophagus curtus* Townes, *Diaparsis temporalis* Horstman, and *Anaphes flavipes* (Foerster) (Haynes and Gage 1981). The asparagus beetles have related European parasitoids, including *Tetrastichus asparagi* Crawford and *Lemophagus crioceritor* Aubert, which have been released in North America to control *C. asparagi*, and *Tetrastichus crioceridis* Graham and *Diaparsis truncatus* (Gravenhorst), which have been released in North America to control *C. duodecimpunctata* (Hendrickson *et al.* 1991).

There are no named parasitoids of *L. lili* in the literature, although Lataste (1932) mentioned a gregarious larval parasitoid of *L. lili* in France and Fox-Wilson (1942) referred to a larval parasitoid in England. This paper reports on a survey conducted in Europe to identify the parasitoids of *L. lili* as a basis for a program of classical biological control. This information will be compared with parasitoid complexes of other exotic North American criocerids.

Collections of larvae, eggs, and adults of *L. lili* were made in France from 22 to 29 May 1996, near Saint-Malo, Angers, Bordeaux, Toulouse, and Montpellier. During the last week of May 1997 and 1998, we collected within 20 km of Angers in 11 home

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gardens and in the lily fields of seven small commercial lily bulb growers. In 1998, we also collected *L. lili* from a garden in Blotzheim, France, and in northwestern Switzerland. Adults, larvae, and eggs were collected on cultivated lilies in Delémont between 19 July and 2 September, and on wild lilies (*Lilium martagon*) in the Jura mountains near Grenchen from 22 June to 21 July and at Weissenstein on 5 July 1998.

Adults were held in the laboratory for several weeks in 1.3-L ventilated plastic containers with lily foliage to check for parasitoid emergence. Eggs collected on leaves were kept in petri dishes until eclosion. Field-collected larvae were fed lily leaves while held in 200-mL or 1.3-L ventilated plastic containers with vermiculite for pupation. Pupae were held at room temperature until 2 months after adult emergence had ended and were chilled at 7–8°C for a minimum of 2 months before returning to room temperature for parasitoid emergence. In addition to examining emerged parasitoids, we dissected all remaining intact cocoons and, when possible, identified immature or adult parasitoids.

No parasitoids of adults or eggs of *L. lili* were found at any site during any of the three seasons. We identified four larval parasitoids from our 1996 to 1998 collections (Table 1). None of these parasitoids had been previously reported from this host.

Tetrastichus setifer Thomson was the most abundant parasitoid in gardens and commercial lily fields in France and Switzerland, but it was not found in larvae on wild *L. martagon* in Switzerland. *Tetrastichus setifer*, a gregarious species, averaged 8.8 parasitoid larvae per host (range = 2–17). It is univoltine and mature larvae overwinter in the host cocoon in the soil. This parasitoid was described in 1878 and is known from the Czech Republic/Slovakia, France, Yugoslavia, and Sweden (Graham 1991). It is likely that *T. setifer* was the parasitoid found by Lataste (1932) in France. We could not determine overall parasitism by *T. setifer* because they decomposed before our cocoon dissections.

Lemophagus errabundus Gravenhorst, 1829 was described from Germany and was reported to attack *Lilioceris merdiger* (L.) in France (Elliott and Morley 1911). It is common near Angers, where 10.6% of *L. lili* larvae from 1997 were parasitized, but we did not find it elsewhere. *Lemophagus pulcher* (Szepligeti), first described from Hungary, and *Diaparsis jucunda* Holmgren, reported by Horstmann (1971) from Sweden, Finland, Denmark, Germany, and the Czech Republic, were common in *L. lili* found on native lilies in Switzerland. *Diaparsis jucunda* was also found across the border in Blotzheim, France. Overall, ichneumonids parasitized up to 44% of the *L. lili* found on the wild populations of native lilies. The three ichneumonid species are solitary parasitoids that overwinter in cocoons built within the host cocoon in the soil. They appear to be mainly univoltine, although some *L. pulcher* have a second generation.

The parasitoid complex of *L. lili* is similar to that of the cereal leaf beetle and asparagus beetles, with species in the genera *Tetrastichus*, *Lemophagus*, and *Diaparsis*. The asparagus beetles have fewer European parasitoid species; however, asparagus originated in the eastern Mediterranean, not in Europe (Yamaguchi 1983). Species of *Tetrastichus* are the most successful of the parasitoids released to control the asparagus beetles in North America (Hendrickson *et al.* 1991), and *T. julis* is also widespread and important in controlling the cereal leaf beetle (Barbosa *et al.* 1993). Hence, *T. setifer* is getting special emphasis in our current research on host specificity, distribution, phenology, and competition among the four parasitoids of *L. lili*. Voucher specimens of all *L. lili* parasitoids are maintained in the University of Rhode Island Biological Control Laboratory.

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TABLE 1. Parasitoids either reared to adult or dissected from larvae of *Lilioceris lili* collected in Europe.

Year	Date	Site	Coordinates	Altitude (m)	No. of <i>L. lili</i> larvae	No. of instars	Identity of parasitoids recovered from	
							rearing	dissection
1996	23 May	Angers	47°23.1N, 0°39.7W	50	68	1–4	—	<i>T. setifer</i> (5)
	24 May	Bordeaux	44°42.7N, 0°43.7W	50	68	1–4	—	<i>T. setifer</i> (19)
1997	8–30 May	Angers	47°23.1N, 0°39.7W	50	443	1–4	<i>T. setifer</i> (11), <i>L. errabundus</i> (2)	<i>T. setifer</i> (19), <i>L. errabundus</i> (9), undetermined ichneumonid (34)
1998	29–31 May	Angers	47°23.1N, 0°39.7W	50	180	4	<i>T. setifer</i> (97), <i>L. errabundus</i> (2)	<i>L. errabundus</i> (31), undetermined ichneumonid (24)
	7 July	Grenchen	47°14.0N, 7°26.2E	1000–4000	156	4	<i>L. pulcher</i> (4), <i>D. jucunda</i> (14)	Undetermined ichneumonid (49)
	19 July	Delémont	47°22.4N, 7°19.5E	400	11	4	<i>T. setifer</i> (6)	
	5 July	Weissenstein	47°15.2N, 7°30.2E	1300	38	1–4	—	Undetermined ichneumonid (15)

NOTE: Values in parentheses are the number of parasitoids recovered from rearing or dissection.

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