

THE HYPERPARASITOID *MESOCHORUS LILIOCERIPHILUS* (HYMENOPTERA: ICHNEUMONIDAE), AN ADDITION TO THE PARASITOID COMPLEX OF THE LILY BEETLE IN BRITAIN

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ABSTRACT

The hyperparasitoid *Mesochorus lilioceriphilus* Schwenke is reported new to Britain as a result of investigations into the parasitoid complex of the lily beetle, *Lilioceris lili* (Scopoli). Notes are given on *M. lilioceriphilus* and the other parasitoids of *L. lili* found in the UK.

INTRODUCTION

The lily beetle *Lilioceris lili* (Scopoli) (Coleoptera: Chrysomelidae) is found throughout much of the northern temperate zone. It is a pest of lilies and fritillaries (*Lilium* and *Fritillaria*: Liliaceae) in parts of mainland Europe and an introduced pest in the UK and North America (Rämert *et al.*, 2009). The parasitoid complex of lily beetle in Europe has been studied as part of a biological control programme which resulted in three species being released in the USA (Haye & Kenis, 2004; Casagrande & Tewksbury, 2007). The complex consists of four hymenopteran larval parasitoids, one hyperparasitoid, one egg parasitoid and some generalist tachinid (Diptera) parasitoids (Table 1).

Two of the hymenopteran parasitoids, *Lemophagus errabundus* (Gravenhorst) (Ichneumonidae) and *Tetrastichus setifer* Thompson (Eulophidae), have previously been reported as being present in the UK (Cox, 2001; Salisbury, 2003). In 2003 and 2004 *L. lili* larvae were collected from the Royal Horticultural Society Garden, Wisley, Surrey (TQ0659) and reared to collect adult parasitoids. In the spring after collection three species of parasitoid emerged, *T. setifer*, *L. errabundus* and *Mesochorus lilioceriphilus* Schwenke (Hymenoptera: Ichneumonidae). This is the first time that *M. lilioceriphilus* has been reported in the UK. Observations on this species and the other parasitoids of *L. lili* in the UK are presented.

METHODS: PARASITOID COLLECTION AND REARING

Using methods described in Salisbury (2003), *L. lili* larvae were collected weekly from *Lilium* at the RHS Garden, Wisley, Surrey (TQ0659) and reared in the laboratory during the spring and summer of 2003 and 2004. In 2003, 616 larvae were collected and 372 in 2004. The larvae were reared singly in ventilated glass tubes (75mm × 25mm), filled with a 1:1 coarse sand/ peat mix; leaves of *Lilium regale* Wilson were provided as a food source, replenished as necessary. This was carried out in the laboratory where temperatures were 24°C ± 5°C and a natural daylight cycle. Beetle larvae that died were dissected to establish whether parasitoid larvae were present. All of the hymenopteran parasitoids of lily beetle larvae overwinter in their host's pupal chambers (Gold *et al.*, 2001), thus tubes from which an adult *L. lili* had not emerged by the end of October of each year were emptied and pupal cells

Table 1. Characteristics of the parasitoid complex of the lily beetle *Lilioceris lili* in Europe.

Taxonomy	European distribution	Life cycle*	Hosts**
Hymenoptera: Ichneumonidae			
<i>Lemophagus errabundus</i> (Gravenhorst)	Widespread, UK	Univoltine, solitary May–June.	<i>Lilioceris</i> spp.
<i>Lemophagus pulcher</i> (Szépligeti)	Widespread (not UK)	Partly bivoltine, solitary July–August	Chrysomelidae: Criocerinae
<i>Diaparsis jucunda</i> (Holmgren)	Widespread (not UK)	Univoltine July	<i>Lilioceris</i> spp.
<i>Mesochorus lilioceriphilus</i> Schwenke	Widespread, UK	Partly bivoltine, solitary June–August	<i>Lemophagus</i> spp.
Eulophidae			
<i>Tetrastichus setifer</i> Thomson	Widespread, UK	Univoltine May–August. Gregarious	<i>Lilioceris</i> spp.
Mymaridae			
<i>Anaphes</i> sp. (undescribed)	France, Switzerland	Egg parasitoid. Plurivoltine, gregarious	Unknown alternate hosts
Diptera: Tachinidae			
<i>Meigenia</i> species	Widespread		Chrysomelidae

After Haye & Kenis, 2000; Haye, 2000; Gold *et al.*, 2001; Kenis *et al.*, 2002; Gold, 2003; Haye & Kenis, 2004; Rämert *et al.*, 2009. *Times of larval infestation **Host tests for biological control programme under laboratory conditions.

placed in a Petri dish in an incubator at 4–6°C for six months, to overwinter. The tubes were brought up to room temperature (22°C) at the beginning of April 2004 or 2005 and examined daily. After four weeks any pupal cells remaining from which no parasitoid had emerged were dissected to determine if parasitism had taken place.

RESULTS

Three species of parasitoid emerged from lily beetle collected in 2003 and 2004 (Table 2). One of these parasitoids had not previously been identified from Britain; this was confirmed as the hyperparasitoid of *Lemophagus* species, *Mesochorus lilioceriphilus*, by comparison with paratypes by Dr Klaus Horstmann (Universitaet Wuerzburg) (Plate 8, Fig. 1). Specimens of this species have been retained by K. Horstmann, and deposited with the Natural History Museum, London, and the RHS insect reference collection at Wisley. Nineteen specimens emerged, 15 males and 4 females.

Over the two years, 21% of *L. lili* larvae were parasitised (204 parasitised larvae from 988 collected). *Tetrastichus setifer* occurrence peaked in May with 8 (6%) larvae affected, and only 1 (<1%) larva collected in June; less than 1% (9) of larvae collected over both years. *Lemophagus errabundus* parasitised 56 (41%) larvae collected in May and 118 (31%) in June, or 18% (178) of all larvae collected. *Mesochorus lilioceriphilus* occurred in 19 (5%) larvae collected in June, 2% of all larvae collected. Only one parasitised larva was collected in July (which produced *L. errabundus*); no parasitoids were found in larvae collected in August or September.

Table 2. Monthly summary of results of lily beetle larvae collected and reared at Wisley Garden, Surrey in 2003 and 2004. Bracketed figures represent percent values

2003	May	Jun	Jul	Aug	Sep	Total
Number collected	76	238	168	114	20	616
No. died (no parasitoids)	24 (32)	45 (19)	40 (24)	33 (29)	2 (10)	144 (23)
No. adults emerged	15 (20)	105 (44)	128 (76)	81 (71)	18 (90)	347 (56)
<i>Tetrastichus setifer</i>	6 (8)	1 (<1)	0	0	0	7 (1)
<i>Lemophagus errabundus</i>	31 (41)	71 (30)	0	0	0	102 (17)
<i>Mesochorus lilioceriphilus</i>	0	17 (7)	0	0	0	17 (3)
2004	May	Jun	Jul	Aug	Sep	Total
Number collected	63	138	105	61	5	372
No. died (no parasitoids)	28 (44)	60 (43)	31 (30)	27 (44)	3 (60)	149 (40)
No. adult emerged	6 (10)	29 (21)	73 (70)	34 (56)	2 (40)	144 (39)
<i>Tetrastichus setifer</i>	2 (3)	0	0	0	0	2 (<1)
<i>Lemophagus errabundus</i>	26 (41)	47 (34)	1 (<1)	0	0	74 (20)
<i>Mesochorus lilioceriphilus</i>	0	2 (1)	0	0	0	2 (<1)

DISCUSSION

Mesochorus lilioceriphilus

Mesochorus lilioceriphilus (Plate 8) is an obligate solitary hyperparasitoid of *Lemophagus* parasitoids of *Lilioceris lili* and *L. meridigera* (L.) (Haye, 2000). The primary host of *M. lilioceriphilus* is reported to be *Lemophagus pulcher* (Haye, 2000); however this species has not yet been recorded in the UK and its host in England is presumably *L. errabundus*. The low rate of hyperparasitism (< 1%) is similar to that found in mainland Europe (Haye, 2000). The lifecycle of *M. lilioceriphilus* is presumed to be similar to that of its *Lemophagus* hosts, overwintering as adults within *L. lili* cocoons, but with adults emerging slightly later than the primary parasitoid (Haye, 2000). When the primary parasitoid is bivoltine (*L. pulcher* (Szépligeti)) a second generation of *M. lilioceriphilus* can occur (Haye, 2000). However, the primary parasitoid in the UK (*L. errabundus*) is univoltine and so it can be assumed that *M. lilioceriphilus* is *de facto* univoltine in the UK.

The genus *Mesochorus* is easily recognised amongst the British ichneumonid fauna by the following combination of characters: fore wing areolet large and diamond-shaped; hind wing lacking second abscissa of *Cu* (nervellus not intercepted); face not separated from clypeus, forming uniform, slightly convex surface; female with ovipositor needle-like, sheaths stiff and glabrous; male with parameres elongate and thin. These features are illustrated in an online identification key to British subfamilies of Ichneumonidae (http://www.nhm.ac.uk/resources-rx/files/ich-key-2_11-reduced-95113.pdf).

Mesochorus is by far the largest genus of Mesochorinae, with 66 species currently recorded from Britain and Ireland (Broad, 2011). Schwenke (1999) revised the European fauna of Mesochorinae and described *M. lilioceriphilus* in a supplementary paper (Schwenke, 2000). However, these publications are of limited use when attempting to identify *Mesochorus* species in general and *M. lilioceriphilus* in particular. For example, despite what Schwenke (2000) says, *M. lilioceriphilus* will not key to *M. slawicus* Schwenke in his 1999 key to species as the temples of

M. lilioceriphilus are clearly shorter than the eye width (see Plate 8, Figs 2–3). *Mesochorus* species seem to have narrow host ranges (Horstmann, 2006) so any reared from *Lilioceris* / *Lemophagus* species are likely to be *M. lilioceriphilus*. Here we illustrate a male (Plate 8, Fig. 1) and a female (Plate 8, Figs 2–4) to aid recognition of this species when reared from *Lilioceris* larvae.

Parasitism

Combined parasitoids of the lily beetle have been found to parasitise 25% to 94% of *L. lili* larvae in mainland Europe (Haye & Kenis 2000; 2004; Rämert *et al.*, 2009). With 21% of larvae producing parasitoids in this investigation and 27% reported in Salisbury (2003) it appears that parasitism rates are currently towards the lower end of the European range in the UK. This may be due to the UK currently having fewer species of parasitoid than mainland Europe. The dominant parasitoid in most of Northern and Western Europe is *Lemophagus errabundus* (Haye & Kenis 2000, 2004, Rämert *et al.*, 2009). From the results presented here it is apparent that this species is also the dominant parasitoid of *L. lili* in at least part of the UK. *Tetrastichus setifer* is dominant in Germany and *Diaparsis jucunda* (Holmgren) (Hymenoptera: Ichneumonidae) (a species not yet found in the UK), is dominant in Southern Europe (Haye & Kenis, 2000; 2004).

In mainland Europe the parasitoids differ in phenology: *T. setifer* attacking larvae throughout the summer and *L. errabundus* attacking larvae in the spring and early summer; *L. pulcher* and *D. jucunda* parasitise larvae primarily in July (Kenis *et al.*, 2002; Haye & Kenis, 2004). However, in the UK it appears that both *T. setifer* and *L. errabundus* are early season parasitoids, being found in May and June.

The first confirmed report of *T. setifer* in the UK was from East Kent in 1997 (Cox, 2001). This species has since been recorded from Essex, Surrey, Sussex, Kent, Middlesex, Suffolk, Cambridgeshire and East Yorkshire (Cox, 2001; Salisbury, 2003; 2008). It is possible therefore that *Tetrastichus setifer* is as widely distributed as its host as it is present in areas where *L. lili* has become established relatively recently (Salisbury, 2003). *Lemophagus errabundus* was reared from *L. lili* larvae collected from Essex in 1998, and has since been recorded in Surrey, Sussex and Middlesex (Salisbury, 2003; 2008). The hyperparasitoid *Mesochorus lilioceriphilus* has only been recorded from Wisley Garden, Surrey; however, it may be more widely distributed as no investigations have been made at other locations.

None of these parasitoids seem likely to be native to the UK as extensive host testing as part of a biological control programme has shown that they are specific to the genus *Lilioceris* (Gold *et al.*, 2001; Kenis *et al.*, 2002) or, in the case of *M. lilioceriphilus*, the *Lemophagus* parasitoids of the genus *Lilioceris* (Haye, 2000). *Lilioceris lili* is the only representative of the genus in the UK and is an established alien (Salisbury, 2003). It is unknown how these parasitoids became established in the UK, or how long they have been here. As well as inadvertent introduction, another possibility is that these parasitoids arrived in the UK as a result of natural range expansion following an increase in the geographical range of their host, as has been found for parasitoids of newly arrived leafmining Lepidoptera (Godfray *et al.*, 1995). It is possible that *L. pulcher* and *D. jucunda*, which are widespread in Europe, may be accidentally introduced into the UK in the future.

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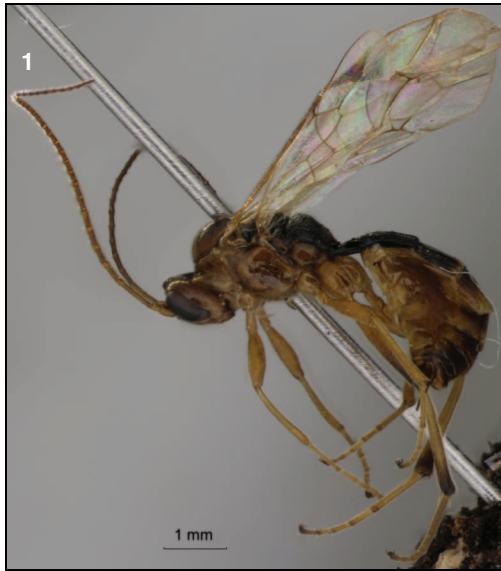


PLATE 8. Figs 1–4. *Mesochorus lilloceriphilus*. Male – 1: adult; Female – 2: head, showing face not separated from clypeus; 3: vertex; 4: abdomen with ovipositor.