

Phalacrotophora beuki (Diptera: Phoridae), a parasitoid of ladybird pupae (Coleoptera: Coccinellidae)

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Abstract. In the years 1998–2000, parasitization of the pupae of various ladybird species by scuttle flies of the genus *Phalacrotophora* was studied in central Poland. Altogether, 12 ladybird species were found to be parasitized by these flies, and one of them, *Anatis ocellata* (L.), proved to be a host of *P. beuki* Disney, a species whose biology had not previously been described. Our studies showed that *P. beuki* can limit the numbers of *A. ocellata*. In its typical habitat, i.e. Scots pine forests, 35–40% of this ladybird were parasitized by *P. beuki*. In other habitats, however, where *A. ocellata* occurred sporadically, *P. beuki* was not recorded from *A. ocellata* or other ladybird pupae. *P. beuki* was described from a single female collected in Holland. The present paper describes the hitherto unknown male, which is very similar to the males of *P. berolinensis* Schmitz and *P. delageae* Disney. The feature that reliably separates the males of these three species (a detail of the hypopygium) is described. This feature enabled the recognition in the collection of the Cambridge University Museum of Zoology of a male of *P. beuki* from Germany, previously assigned to *P. berolinensis*.

INTRODUCTION

Seven species of *Phalacrotophora* Enderlein are reported from Europe. While the biology of most of them is unknown, the three species, *P. fasciata* (Fallén), *P. berolinensis* Schmitz and *P. delageae* Disney, are parasitoids of ladybird pupae (Disney & Beuk, 1997). Most is known about the life cycles of *P. fasciata* and *P. berolinensis*. Mating in these species occurs on, or nearby, ladybird prepupa. After copulation the male moves away from the female, which remains with the prepupa, and parasitizes it when it begins to pupate. Usually several eggs are laid on the ventral thoracic region of the pupa. Egg-larval development of the parasitoid lasts 7–12 days and then the larvae leave the dead host pupa and pupate in the soil. Adult flies may emerge after 15–25 days or overwinter and emerge next season (Disney et al., 1994; Ceryngier & Hodek, 1996). *P. fasciata* and *P. berolinensis* overwinter as fully formed adults within the puparia (Disney, 1994).

In this paper the life cycle of *Phalacrotophora beuki* Disney, a species only recently described from a single female caught in Holland (Disney & Beuk, 1997), is described. The hitherto unknown male is described and the character distinguishing it from the morphologically very similar males of *P. berolinensis* and *P. delageae* is illustrated.

MATERIAL AND METHODS

Most of material for this study was obtained in 1998–2000 in central Poland (around the village Dziekanów Leśny, some 15 km NW of Warsaw) during investigations of the parasitoids of ladybird juvenile stages (Ceryngier & Durska, in prep.). Pupae of various ladybird species were collected in various habitats and transferred to the laboratory, where they were kept singly in Petri dishes until adult or parasitoid emergence. Larvae of scuttle flies that emerged from host pupae were left in the dishes, where their further development (pupariation, pupation, emergence of adults) took place. The puparia, from which flies

did not emerge after at least one year, were dissected. Adults found within the puparia were gently removed. Additionally, several *Phalacrotophora* females were observed attending ladybird prepupae or pupae in the field. These flies were collected together with their hosts.

Male specimens obtained in this study and assigned to *P. beuki* are very similar to those of *P. berolinensis* and *P. delageae*. The males of these three species are reliably separated by details of the hypopygium (see Results). Indeed males of this species group previously not collected with their distinctive females need to be checked in the light of this newly discovered feature. *Phalacrotophora* males from the collection of the Cambridge University Museum of Zoology were re-examined and one male *P. beuki* found.

RESULTS

Field studies in Poland

In a study of the parasitoids of ladybird juvenile stages (Ceryngier & Durska, in prep.), pupae of 12 ladybird species were found to be hosts of parasitic scuttle flies. For 11 host species, their scuttle fly parasitoids were easily obtained because most of their larvae left these hosts, pupated and subsequently emerged as adults. All 11 ladybird species were parasitized by *Phalacrotophora fasciata*, 5 by *P. berolinensis* and 4 by *P. delageae*. However, after the first year of the study it was realised that the specific status of the scuttle flies parasitizing the twelfth ladybird, *Anatis ocellata* (L.), was uncertain. Although in its typical habitat, pine forests, *A. ocellata* was frequently parasitized, not one adult fly emerged from the relatively large, thick-walled puparia formed by larvae after leaving the pupae of this ladybird (Table 1). In contrast, scuttle fly larvae emerging from the pupae of other ladybirds collected from pines [*Myzia oblongoguttata* (L.), *Harmonia quadripunctata* (Pontoppidan), *Coccinella magnifica* (Redtenbacher), *Exochomus quadripustu-*

TABLE 1. Parasitization by scuttle flies of *Anatis ocellata* pupae collected on Scots pine (*Pinus sylvestris* L.)

Year	Date of collection	No. of pupae collected	Parasitization by scuttle flies	
			No. parasitized	% parasitized
1998	11 June	5	3	
	18 June	8	4	
	24 June	10	3	
	25 June	1	–	
	6 July	1	–	
	total	25	10	40.0
1999	9 June	8	5	
	14 June	12	5	
	17 June	2	–	
	18 June	7	2	
	21 June	17	8	
	24 June	12	6	
	26 June	2	1	
	5 July	4	–	
	7 July	1	–	
total	65	27	41.5	
2000	25 May	1	–	
	29 May	6	1	
	2 June	34	12	
	8 June	10	6	
	9 June	6	2	
	16 June	2	–	
total	59	21	35.6	

latus (L.)] usually developed into adults of either *P. fasciata* or *P. berolinensis*.

To obtain adults of the species parasitizing *A. ocellata* the flies attending prepupae or pupae of this ladybird in the field were collected and the unhatched fly puparia that came from *A. ocellata* pupae were checked for adult flies.

Altogether, in 1999 and 2000, 5 female flies that had either just laid eggs on freshly moulted *A. ocellata* pupae, or were attending *A. ocellata* prepupae waiting for them to pupate, were collected. These females were put with their hosts in the labora-

TABLE 3. Parasitization of *Anatis ocellata* pupae from plants other than Scots pine.

Plant	Date of collection	No. of pupae collected	No. of parasitized pupae
<i>Hippophaë rhamnoides</i> L.	7.06.1999	1	–
<i>Juglans regia</i> L.	17.06.1999	3	–
<i>Acer pseudoplatanus</i> L.	12.05.2000	1	–
	15.05.2000	2	–
	17.05.2000	2	–
	22.05.2000	2	1*
	2.06.2000	4	–
	6.06.2000	1	–
<i>Salix</i> sp.	21.06.2000	1	–
	total	17	1*

*parasitized by *Oomyzus scaposus* (Thomson) (Hymenoptera: Eulophidae)

TABLE 2. Scuttle flies found in the puparia that originated from *Anatis ocellata* pupae.

Number of host pupa	Date of collection	No. puparia	<i>P. beuki</i>		Undetermined individuals*
			females	males	
1	11.06.1998	7	1	3	3
2	11.06.1998	8	1	1	6
3	11.06.1998	7		1	6
4	18.06.1998	7	1	1	5
5	18.06.1998	7	7		
6	18.06.1998	4	1	1	2
7	18.06.1998	5	2		3
8	24.06.1998	3		1	2
9	24.06.1998	7	4	1	2
10	29.05.2000	6	1	1	4
11	2.06.2000	6			6
12	2.06.2000	6	2	3	1
13	2.06.2000	6	2		4
14	2.06.2000	5	1	2	2
15	2.06.2000	5	2		3
16	2.06.2000	10	1	1	8
17	2.06.2000	6	1		5
18	2.06.2000	4	1		3
19	2.06.2000	7	3	2	2
20	2.06.2000	5			5
21	2.06.2000	7	1		6
22	2.06.2000	4	1	1	2
23	8.06.2000	6		3	3
24	8.06.2000	6			6
25	8.06.2000	5			5
26	8.06.2000	6	1	2	3
27	8.06.2000	7	2	3	2
28	8.06.2000	7	1		6
29	9.06.2000	5			5
30	9.06.2000	5			5
	total	179	37	27	115

*larva or pupa within puparium

tory. From each of these hosts parasitoid larvae emerged and subsequently pupated but failed to give rise to adult flies. However, all the adult flies so collected proved to be *Phalacrotophora beuki*.

Dissections of the puparia from parasitized *A. ocellata* in 1998 and 2000 (material from 1999 was lost) showed that they mostly contained early developmental stages (larvae or pupae) of the flies. However, in 64 puparia from 24 hosts adult flies were present. All females found in these puparia were *P. beuki* and the males were assumed to be males of this species (Table 2).

Dissections of unhatched puparia obtained from other ladybirds revealed adults of *P. fasciata*, *P. delageae* and *P. berolinensis*, but not *P. beuki*.

So *P. beuki* was only recorded as a parasitoid of *A. ocellata* in pine forests. *A. ocellata* pupae collected from untypical habitats for this species: deciduous trees and shrubs, were not parasitized by *P. beuki* or any other scuttle flies (Table 3). Data presented in Table 3 should be treated with caution as the numbers of pupae collected were low due to the rarity of *A. ocellata* on deciduous plants. It should be mentioned, however, that the pupae of other ladybirds [*Adalia bipunctata* (L.), *A. decempunctata* (L.), *Calvia quatuordecimguttata* (L.)] collected in these habitats at the same time were frequently parasitized by *P. fasciata* and *P. delageae*.

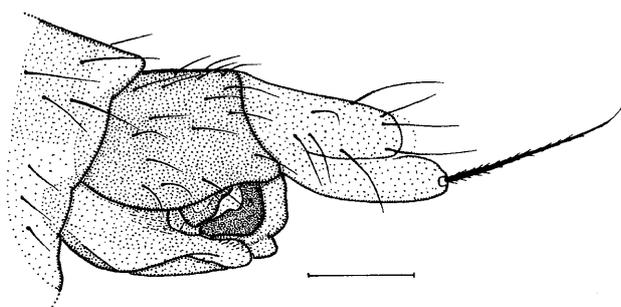


Fig. 1. *Phalacrotophora beuki* male, left side of hypopygium. Scale bar = 0.1 mm.

Re-examination of *Phalacrotophora* males in an insect collection

Comparison of *Phalacrotophora* males from the collection in the Cambridge University Museum of Zoology with the *P. beuki* males from Poland revealed that one male in the Cambridge collection, which had been assigned to *P. berlinensis*, belonged to *P. beuki*. This specimen was collected in Germany (N. Bavaria, nr Schweinfurt, 19 June 1983, W. Büchs). As the males from Poland are all teneral, this German specimen was used to obtain the colours and wing measurements for the description of the male of *P. beuki*.

Phalacrotophora beuki Disney, in Disney & Beuk, 1997: 185. (Figs 1 and 4)

Male

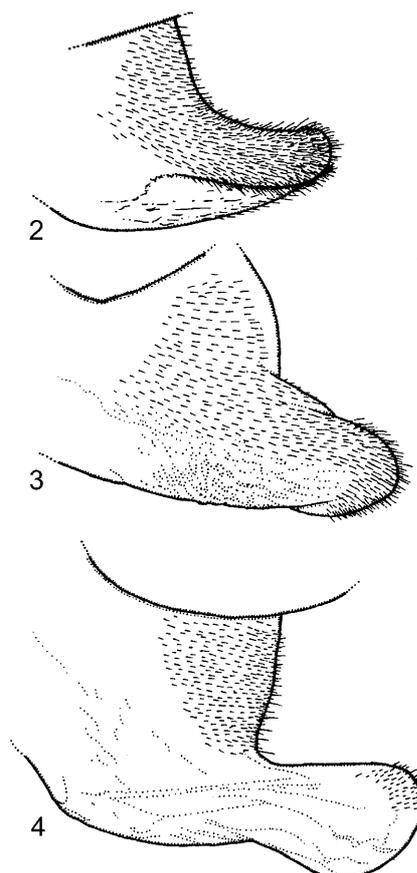
Frons similar to female but not obviously narrowing below (anteriorly). Supra-antennal bristles more strongly differentiated from the more numerous adjacent frontal hairs than in female. Antennae and palps similar to those in female. Labrum pale straw yellow and only about 0.8× as broad as postpedicel (third antennal segment). Labella a little broader than in female. Abdominal tergites 1, 2 and 6 entirely, or largely, orange yellow. T5 with at least anterolateral brown patches. T3 and T4 largely brown in outer thirds but variably orange yellow in middle thirds. Venter straw yellow with hairs restricted to segment 6. Hypopygium as in Fig. 1, with the epandrium orange brown and the anal tube light brown. The left lobe of the hypandrium as in Fig. 4, with the microsetae restricted to a patch on the posterolateral extremity. The right lobe is as in *P. berlinensis* (see Fig. 6 in Disney & Beuk, 1997). Legs similar to those of female. Wing 2.25 mm long. Costal index 0.43. Costal ratios 4.6 : 2.1 : 1. Costal cilia 0.10–0.15 mm long. With three axillary bristles, otherwise it and haltere as in female.

Affinities

In the key to European species in Disney & Beuk (1997) the male of *P. beuki* runs to couplet 5, to *P. berlinensis* and *P. delageae*, whose separation from each other is far from satisfactory. However, in the present study a better character was found to distinguish all three species. The left lobe of the hypandrium is entirely covered in dense microsetae in *P. berlinensis* (Fig. 2). In *P. delageae* the microsetae only occur on the outer half along the entire length and only extend onto the inner half at the tip (Fig. 3). In *P. beuki* the microsetae are restricted to a patch on the posterolateral extremity (Fig. 4).

DISCUSSION

Parasitic *Phalacrotophora*, especially *P. fasciata* and *P. berlinensis*, are rather catholic in their choice of host species. They can parasitize many species of ladybirds belonging to the sub-families Coccinellinae and Chilocorinae (Disney, 1994; Disney



Figs 2–4. *Phalacrotophora* males, left lobes of hypandrium. 2 – *P. berlinensis* (with right lobe visible below lower margin of left lobe); 3 – *P. delageae*; 4 – *P. beuki*. Scale bar = 0.1 mm.

et al., 1994; Ceryngier & Hodek, 1996). *P. fasciata* is even reported to parasitize a non-ladybird host, the chrysomelid *Oulema gallaeciana* (Heyden) (Miczulski, 1978).

Our studies in central Poland seem to indicate that, in contrast to *P. fasciata* and *P. berlinensis*, *P. beuki* is restricted to one host, the largest European ladybird, *Anatis ocellata*. However, the previous record of *P. beuki* may suggest a broader host range for this species. Dr Matthias Buck (*in litt.*) reports that in June 1992 he collected a female of *P. beuki* sitting on a pupa of *Coccinella septempunctata* in Germany. This does not prove that this encounter would have resulted in parasitization.

There are many reports in the literature of *A. ocellata* parasitized by *P. fasciata* (Marriner, 1932; van Emden, 1950; Parmenter, 1965; Filatova, 1974; Kuznetsov, 1987; Majerus & Kearns, 1989) and *P. berlinensis* (Klausnitzer, 1969, 1976; Majerus & Kearns, 1989). In our survey *A. ocellata* was not parasitized by these species, although in the habitats where the pupae of *A. ocellata* were collected both fly species frequently parasitized other ladybirds. During this study *A. ocellata* was only parasitized by *P. beuki*. The identity of scuttle flies bred from *A. ocellata* ought to be checked, especially where the identification was based only on males.

P. beuki seems to be an uncommon species. It was described in 1997 from a single female, but material in collections from before this date need checking for misidentifications, especially as our study suggests that *P. beuki* could be a quite frequent parasitoid of ladybirds in coniferous forests, a habitat widespread in Europe. Why did *P. beuki* remain undiscovered for

such a long time? *A. ocellata*, the main host species of this scuttle fly, is widely distributed in Europe and other parts of the Palearctic Region (Iablokoff-Khinzorian, 1982). Maybe, the "cryptic nature" of *P. beuki* can be partly explained by the specific requirements for its development. The laboratory conditions used by us, and perhaps other workers, for rearing scuttle flies are suitable for some species but not *P. beuki*. In natural conditions, the larvae of this species probably pupate in the soil, i.e. in a humid environment. Thus for the successful development of *P. beuki* pupae it is important they are kept at a relatively high humidity. In our study the humidity was not controlled but fluctuated with the external conditions. Some other physical factors, however, might also be involved. For example, the flies might require particular temperature conditions for diapause completion.

The premature mortality of *P. beuki* may also be related to the unsuitability of *A. ocellata* as a host, although, in our opinion, this is unlikely. It is known that parasitoids sometimes parasitize unsuitable hosts (e.g. Vinson, 1976), but the regular parasitization of more than one third of quite an abundant but unsuitable ladybird is highly maladaptive.

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