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The complex of parasitoids of *Asphondylia* spp. (Diptera Cecidomyiidae), flower gall midges of Lamiaceae, with description of a new species of *Baryscapus* (Hymenoptera Eulophidae)

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Abstract

During 2014-2019 the complex of parasitoids of *Asphondylia* spp. causing flower galls on Lamiaceae was investigated, mostly in locations of Southern Italy. Samples of flower galls caused by *Asphondylia hornigi* Wachtl on *Origanum vulgare*, *Asphondylia nepetae* Viggiani on *Clinopodium nepeta*, *Asphondylia serpylli* Kieffer on *Thymus vulgaris*, *Asphondylia* sp. 1 on *Clinopodium vulgare* and *Asphondylia* sp. 2 on *Micromeria graeca*, subsp. *graeca*, subsp. *fruticulosa*, subsp. *tenuifolia* and also subsp. *consentina*, were collected in several periods of each year and maintained in Petri dishes or in microdishes until the emergence of parasitoids. Some galls were kept singly isolated. Observations on the larval behaviour of the parasitoids and their association with the host were made dissecting the flower galls. The identified parasitoids were: *Aprostocetus westwoodii* (Fonscolombe), *Eurytoma dentata* Mayr, *Mesopolobus* sp., *Pseudocatolaccus nitescens* (Walker), *Sigmophora brevicornis* (Panzer), *Systasis encyrtoides* Walker, *Torymus thymi* Ruschka. A species of *Baryscapus* recognized as a new taxon was reared from pupae of *S. brevicornis* and is here described. The relative abundance of the parasitoids in the complex associated with the single species of gall midge was analysed and illustrated. Biological notes on the parasitoids are given.

Key words: *Aprostocetus*, *Baryscapus*, *Eurytoma*, *Pseudocatolaccus*, *Sigmophora*, *Systasis*, *Torymus*, hyperparasitoids, *Baryscapus hyperasphondyliae* sp. nov.

Introduction

Species of the genus *Asphondylia* (Diptera Cecidomyiidae) are recorded as hosts of 185 species of parasitoids (Hymenoptera Chalcidoidea), belonging to the families Torymidae, Ormyridae, Eurytomidae, Pteromalidae, Eupelmidae, Eulophidae and Trichogrammatidae (Noyes, 2019). In general, the most abundant species belong to the Eulophidae. Records concerning parasitoids of *Asphondylia* causing flower galls on Lamiaceae are reported by Ruschka (1921), by Malagaris (2011) for *Asphondylia coridothymi* Skuhrava on *Coridothymus capitatus*, Zimowska *et al*. (2017) for *Asphondylia serpylli* Kieffer on *Thymus vulgaris*, Bernardo *et al*. (2018) for *Asphondylia nepetae* Viggiani on *Clinopodium nepeta* and Viggiani and Stinca (2018) for *Asphondylia hornigi* Wachtl on *Origanum vulgare.* These papers mostly refer to one host species, the parasitoid records are marginal and in some cases the identifications are incomplete or need confirmation.

In the framework of an integrative project on the gall midges of the genus *Asphondylia* associated with flowers of Lamiaceae, started in 2014, the study of their parasitoid complex was one of the main focus. It was progressively extended to all studied host species in order to clarify the identification and bionomic of the species involved in each complex, acquire data on their abundance and variation in space and time. The results of this work are presented in this paper.

Materials and methods

Since 2014 research was carried out on the following species of *Asphondylia* infesting flowers of Lamiaceae: *A. hornigi* on *O. vulgare*, *A. nepetae* on *C. nepeta*, *A. serpylli* on *T. vulgaris*, *Asphondylia* sp. 1 on *Clinopodium vulgare* and *Asphondylia* sp. 2 on *Micromeria graeca*, and precisely subsp. *graeca*, subsp. *fruticulosa*, subsp. *tenuifolia* and also subsp. *consentina*. *Asphondylia* sp. 1 and *Asphondylia* sp. 2 will be described as new species in another paper (unpublished data). Flower galls of *Asphondylia* were collected at several locations and times of each year. Most of the flower galls were kept at room temperature in Petri dishes or in microdishes of 2 cm in diameter; some were dissected to study the young stages of the parasitoids and their relationship with the host. Some samples of flower galls on *C. nepeta*, caused by *A. nepetae*, were dissected to record the percentage of them marked by activity of parasitoids. The parasitoids emerged from the flower galls were mounted on pins and slides. They were identified according to keys of Graham (1987; 1991), Graham and Gijswijt (1998) and Zerova and Seryogina (2006). The specimens of *Torymus* sp. emerged from the flower galls of *A. nepetae* have been compared with the lectotype and 3 paralectotypes of *Torymus thymi* Ruschka, on loan from the Natural History Museum of Vienna.

All parasitoids mounted on pins and slides are preserved at the entomological collection of the Dipartimento di Agraria dell'Università degli Studi "Federico II", Portici (NA), Italy.

Results

Species identification and parasitoids abundance

From all flower galls collected a total of 917 specimens of parasitoids emerged. Details on the complex community of each gall midge hosts are given below.

Parasitoids of *A. hornigi*

Specimens emerged from the following samples collected in September-November 2017: Italy, Castellammare di Stabia (NA), 25.ix.2017; 25-27.xi.2017. Poland, Lublin, ix.2017. On 52 specimens collected the most common species was *Eurytoma dentata* Mayr (Eurytomidae), followed by *Aprostocetus westwoodii* (Fonscolombe) and *Sigmophora brevicornis* (Panzer) (Eulophidae). Rare species were *Baryscapus* sp. nov. (Eulophidae) and *T. thymi* (Torymidae) (table 1).

Parasitoids of *A. nepetae*

Specimens emerged from the following samples: Italy, Bari, 31.iii.2015; Bracciano (RM), 26.ix.2014; Corbara (SA), 21.iv.2016, Desenzano sul Garda (BS), 10.ix.2015; Matera, 16.xi.2016; Napoli-Camaldoli, 3.xii.2014; Napoli-Soccavo, 3.xii.2014, xi.2015; Palma Campania (NA), 16.i.2014; Paola (CS), 29.ix.2014; Portici (NA), 11.i.2016, 12.i.2016, 14.i.2016, 16.i.2016; Pozzuoli (NA)-Astroni, ix.2014; 25.x.2014, xi.2014, 25.x.2015, xi.2015, 8.xi.2015; Pozzuoli-lago d'Averno, xi.2014, 8.xii.2015; Rivello (PZ), 30.vi.2014, 2.vii.2014, 8.vii.2014, 29.vii.2014, 1.ix.2014, 8.ix.2014, 23.x.2014, 21.xi.2014, 27.xi.2014, 21.ii.2015, 2.iii.2015, 16.iii.2015, 30.iii.2015, 30.iv.2015, 28.ix.2015, x.2015, 3.x.2015, 13.x.2015, 20.x.2015, 29.x.2015, 13.xi.2015, 15.xii.2015, 29.xi.2015, 14.xii.2015, 11.i.2016, 23.i.2016, 11.ii.2016, 22.ii.2016, 29.iii.2016, 9.v.2016, 23.xi.2016, 18.ii.2017, 28-29.ii.2017, 9.iv.2017, 15.i.2018, 19.ii.2018; San Giorgio a Cremano (NA), 16.i.2014, 25.vi.2014, 8.vii.2014, 16.ix.2014, 1.x.2014, 5.xi.2014, xii.2014, 8.xi.2015, 18.xi.2015, 25.vi.2015, 28.xii.2015, 4.ii.2016; Terni, 21-26.ix.2014. The flower galls of *A. nepetae* were collected during 2014-2018, at almost any time of the year and at several Italian locations. A total of 378 parasitoids emerged. The dominant species was *S. brevicornis*, followed by *A. westwoodii* and *Baryscapus* sp. nov. the latter more common in spring and late autumn. Only in some locations *E. dentata* was found. *Pseudocatolaccus nitescens* (Walker) and *Systasis encyrtoides* Walker (Pteromalidae) were rare. The species *T. thymi* was obtained only in two locations. A *Baryscapus* sp. nov. reared from pupae of *S. brevicornis* was recognized as a new species and here described (see below). Relative abundance of parasitoids is summarized in table 1. From the dissection of flower galls of *A. nepetae* emerged that the percentage of galls with activity of parasitoids varies markedly, from a minimum of 10% to a maximum of 85% (figure 1).

Parasitoids of *A. serpylli*

From the limited sampling of *A. serpylli* flower galls in Poland (Lublin, x.2016, xi.2016) only 51 specimens of parasitoids emerged. As in most of the *Asphondylia* associated with Lamiaceae, the dominant species were *S. brevicornis* and *A. westwoodii*. A *Mesopolobus* sp. was recorded only in this parasitoid complex. (table 1).

Parasitoids of *Asphondylia* sp. 1

Specimens emerged from the following samples: Italy, Lagonegro-Serino (PZ), 30.vii.2017, Pietraroja (BN), 4.viii.2018; Rivello, 14.xii.2015, 14.ii.2016, 19.vi.2017, 25.vi.2018, 5.xii.2018, 15.xii.2018, 2.i.2019. A total of 32 parasitoids emerged from flower galls of *Asphondylia* on *Clinopodium vulgare*, and among them the most abundand species were *P. nitescens* and *S. encyrtoides* (table 1).

Parasitoids of *Asphondylia* sp. 2

Specimens emerged from the following samples of flower galls on *Micromeria graeca*: Italy, Capo d'Orso (SA), 21.iv.2016; Capri (NA), 9.iv.2017, 2.v.2017; Orria (SA), 4.x.2016; Palma Campania, 20.iv.2016, 30.iv.2016, 9.iv.2017; Pisciotta (SA), 20.x.2016; Portici, 11.v.2016, 22.v.2016, 22.vi.2016, 30.ix.2016, 27.i.2017, 2.v.2017, 10.v.2017, 17.v.2017, 8.vi.2017, 9.vi.2017, 8.vi.2018; Pozzuoli-Astroni, 2.v.2017, 13.vi.2017, 29.iii.2018; Procida (NA)-Vivara, 20.v.2017. Rivello, 9.iv.2017, 5.vi.2017, 1.xii.2017. v.2018; Salerno, 31.v.2016; Torre del Greco-Vesuvio (NA), 30.v.2017, Trecchina (PZ), 29.x.2016; Vallo della Lucania-Paco (SA), 28.vi.2016; Vico Equense (NA), 26.vi.2017. A total of 404 specimens of parasitoids emerged. The dominant species

Table 1. Species identification and abundance of parasitoids.

	Abundance of parasitoids (%)							
Host species	*Aprostocetus westwoodii*	*Baryscapus* sp. nov. hyperparasitoid	*Eurytoma dentata*	*Mesopolobus* sp.	*Pseudocatolaccus nitescens*	*Sigmophora brevicornis*	*Systasis encyrtoides*	*Torymus thymi*
Asphondylia hornigi	26.9	1.9	36.5	0	0	32.6	0	1.9
Asphondylia nepetae	35.1	10.8	5	0	0.5	46.2	0.26	1.8
Asphondylia serpylli	35.2	0	0	1	0	58.8	5.8	0
Asphondylia sp. 1	18.7	9.3	0	0	37.5	3.1	31.2	0
Asphondylia sp. 2	48.7	6.4	4.7	0	7.1	31.6	1.2	0

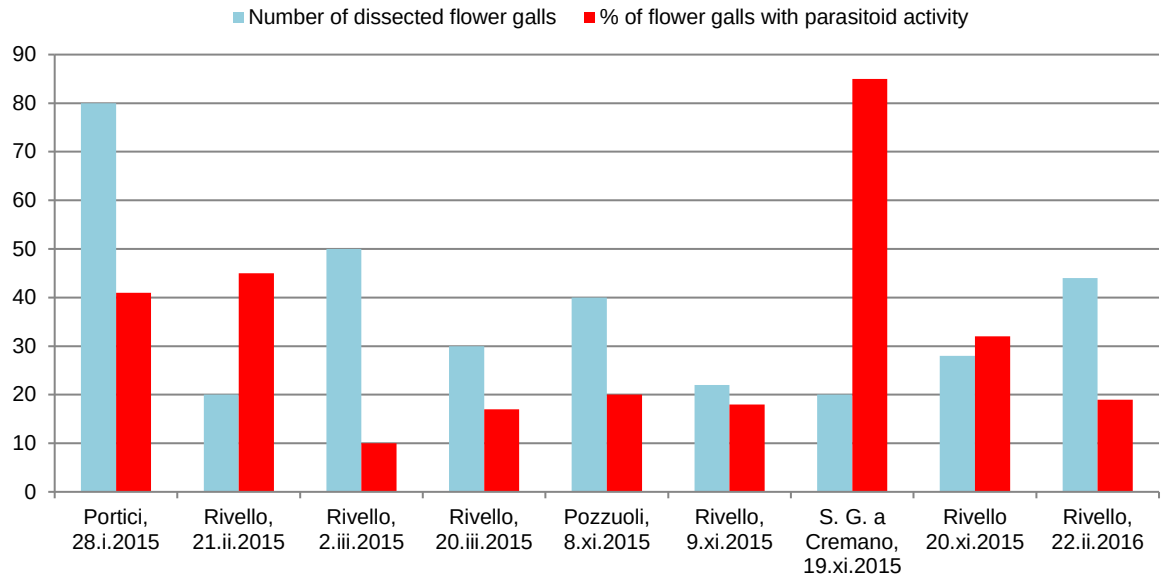

Figure 1. Samples of flower galls, caused by *A. nepetae* on *C. nepeta*, dissected.

were *A. westwoodii* and *S. brevicornis*, while *P. nitescens*, *E. dentata* and *S. encyrtoides* were less abundant. The hyperparasitoid *Baryscapus* sp. was also represented in the complex (table 1).

Taxonomic and biological notes on the parasitoids

A. westwoodii (figure 2a)

The species belongs to the *epicharmus*-group, characterized by antennae of males having a ventral plaque placed in the upper half of the scape (Graham, 1987). Recorded as parasitoid of *Asphondylia melanopus* Kieffer and probably of *Asphondylia verbasci* (Vallot) (Graham, 1987). Recently this parasitoid has been obtained from *A. serpylli* on *T. vulgaris* in Poland (Zimowska *et al*., 2017). The biology of *A. westwoodii* was unknown, but it was here observed that the species behaves as solitary endoparasitoid of larvae and pupae of *Asphondylia*. The parasitoid mature larva emerges from the host larval stage and pupate in the midge flower gall or in the host pupa (figure 2b). Adults of the first annual generation have been obtained in March-April; subsequently the eulophid completes several overlapping generations until late autumn. The species overwinters in quiescence as mature larva in the flower galls.

E. dentata (figure 2c)

Known as solitary and polyphagous ectoparasitoid of several *Asphondylia* spp. and other gall midges (Noyes, 2019). This species was reared from flower galls of *A. hornigi* on *O. vulgare*, *A. nepetae* on *C. nepeta* and *Asphondylia* sp. 2 on *M. graeca*. Details on the morphology of the immature stages of the species are given by Parnell (1964), except the egg. The same author reports that the ectoparasitoid larvae may attack both larvae and pupae of the *Asphondylia* host, and also act as hyperparasitoid of *S. brevicornis*. Dissecting a female emerged (5.ii.2018) in the laboratory condition from an overwintering *A. hornigi* flower gall, only 3 mature oocytes were found in the ovaries; probably the species is weakly synovigenic. The deposited egg found in the flower gall (figure 2d) shows an anterior peduncle 0.12-0.15 mm in length, an ovoid body long and short posterior peduncle (long of 0.25-0.30 mm and 0.020-0.025 mm respectively). The chorion surface shows a net of around 10 rows of longitudinal cells on one side, delimited by small denticles.

Mesopolobus sp.

The biology of this species is unknown.

P. nitescens (figure 2e)

Recorded as solitary ectoparasitoid of several *Asphondylia* spp. and other hosts (Parnell, 1964; Noyes, 2019). This species was rather common on *Asphondylia* sp. 1 and *Asphondylia* sp. 2. Adults emerged from flower galls collected in April, May and September.

S. brevicornis (figure 2f)

The genus *Sigmophora* Rondani includes 20 species and is worldwide distributed (Noyes, 2019). It was resurrected by Graham (1987) and revised by Ikeda (1999). It includes ectophagous parasitoids of Cecidomyiidae (Diptera), mostly *Asphondylia* spp. (Graham, 1987; Ikeda, 1999; Noyes, 2019). According to Graham (1987) *S. brevicornis* is a gregarious parasitoid of larvae and pupae of Cecidomyiidae. Here parasitization of host pupae was not observed. According to Parker and Thompson (1928) the gregarious larvae in a gall develop completely as ectoparasitoids of the single *Asphondylia* larva. Parnell (1964), who studied this species as parasitoid of *Asphondylia sarothamni* (Loew) and described in details its young stages, pointed out that the eulophid larvae start their development by feeding on the single larva of *Asphondylia* inhabiting the gall, but they complete it by feeding on the fungal mycelium and on the tissues of the gall, as the *Asphondylia* larva is

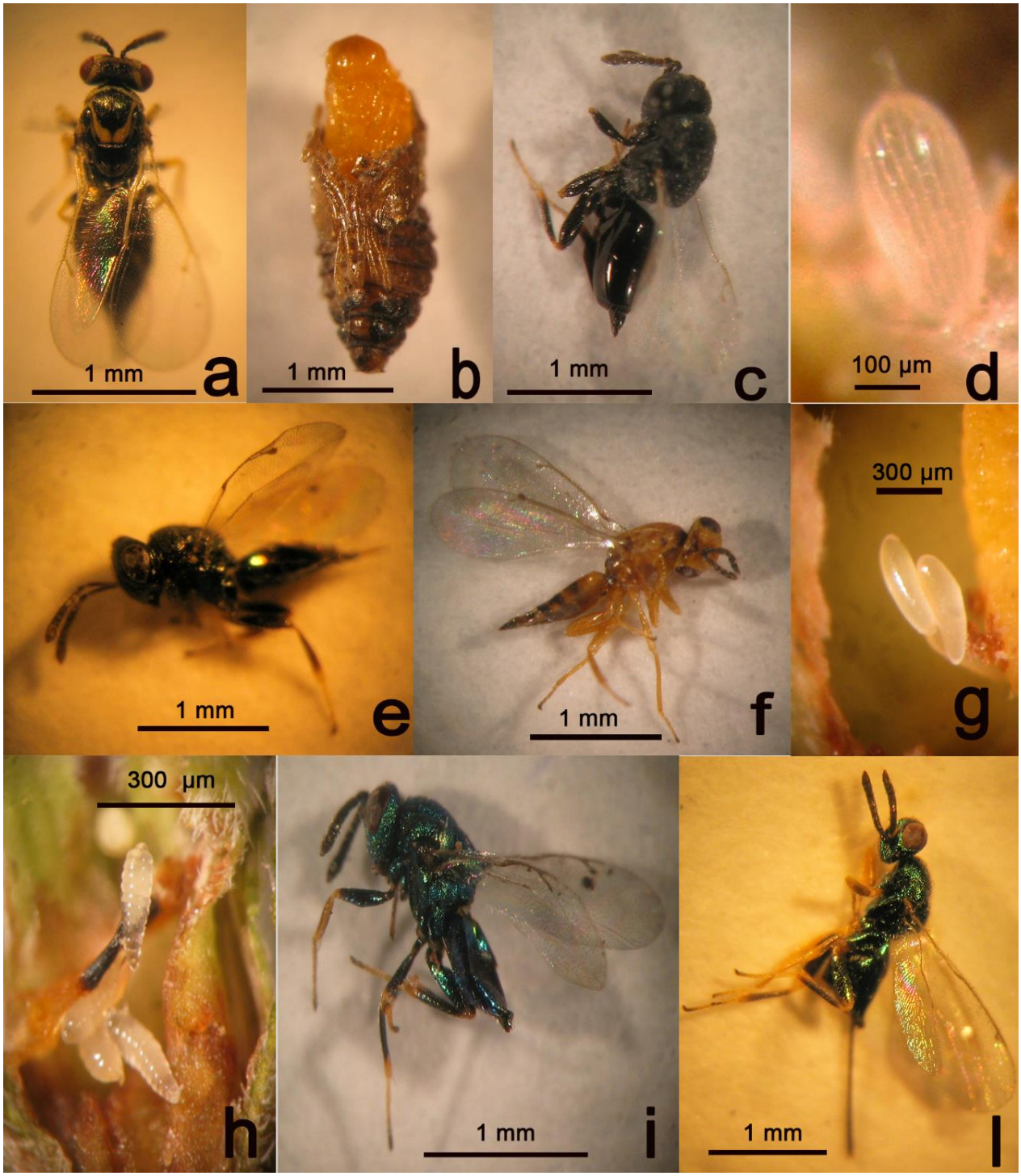

Figure 2. a. *Aprostocetus westwoodii*, female; **b.** Pupa of *Asphondylia* parasited by an endoparasitoid; **c.** *Eurytoma dentata*, female; **d.** Egg of *E. dentata*; **e.** *Pseudocatolaccus nitescens*, female; **f.** *Sigmophora brevicornis*, female; **g.** *S. brevicornis*, eggs; **h.** *S. brevicornis*, larvae in a gall; **i.** *Systasis encyrtoides*, female; **l.** *Torymus thymi*, female.

soon consumed. My observations on some larvae confirm Parnell's view on this trait. Eggs of *S. brevicornis* (figure 2g) have been found in flower galls with or, sometimes, without larva of *Asphondylia*. Their number in a single flower gall varied from 1 to 4, as those of the developed larvae and pupae (figure 2h). Females and males (ratio 1:1) can emerge from a single gall. From overwintering *Asphondylia* flower galls collected during January-March in several localities, no adults of *S. brevicornis* emerged. In other dissected flower galls any young stage of the parasitoid was detected. Most probably, as previously reported by Parnell (1964), the eulophid overwinters as adult. The first annual generation starts late March-April, when the parasitoid can find the new annual flower, and it is completed in April-May. Several overlapping generations follow until late autumn.

S. encyrtoides (figure 2i)

Solitary ectophagous parasitoid of several Cecidomyiidae and other hosts (Noyes, 2019). This species emerged from flower galls of *A. nepetae* on *C. nepeta*, *A. serpylli* on *T. vulgaris*, *Asphondylia* sp. 1 on *C. vulgare* and *Asphondylia* sp. 2 on *M. graeca* subsp. *tenuifolia*. The specimens emerged mostly from overwintering *Asphondylia* flower galls on *C. vulgare* and *M. graeca* enclosing quiescent full mature larvae of the parasitoid.

T. thymi (figure 2l)

It is the only species from *Asphondylia* on Lamiaceae, with an unknown biology.

Baryscapus hyperasphondyliae sp. nov.

Female (figure 3a)

Body length: 1.3 mm (average), (min. 1, max. 1.5, n = 20). Body black with strong metallic blue green reflections. Head green metallic, antenna brown, legs with coxa and femur (except the pale yellow distal end), fore tibia pale yellow, middle tibia brown in distal half, hind tibia mostly brown, fore tarsi brown yellow, middle and hind tarsi with brown distal one-two tarsomeres. Wings hyaline with light brown venation. Head in dorsal view 2.0-2.2× as wide as long, malar space about 0.7× eye length, post-ocellar distance 3× ocell-ocular distance, malar sulcus clearly curved without a fovea, clypeus with two distal rounded teeth. Antenna (figure 3b) inserted just above the level of the lower eye margin, with subquadrate radicle, scape rather narrow, 3.6× as long as wide, not reaching the vertex, 0.6× length of eye, pedicel 0.4× as long as scape and about one-third longer than F1, one normal transverse anellus and other two vestigial; funicle 3-segmented, with subequal segments, each slightly longer than wide (20:18), with 2-3 linear sensilla and setae, the longest, slightly longer than the related segments, pedicel and funicle combined 0.75× as long as mesosoma width; club slightly shorter than funicle (55:60) and wider, 2× as long as wide, C1 cup-shaped, C2 as long as C1, slightly wider than long (13:10), C3 conical, shorter than C2 (15:20), with a terminal spine 1/3 of the segment and the related apical seta slightly shorter, each club segment with 3-4 linear sensilla. Mesosoma slightly wider than head, 1.1× as long as wide, mid lobe of mesoscutum (figure 3c) about as wide as long, with distinct median line, surface with very fine engraved reticulation with most areoles longer than wide, a row of 3-4 adnotaular setae; scutellum moderately convex 1.1-1.2× as wide as long, with subparallel submedian lines, slightly nearer to sublateral lines than to each other, enclosing a space about 2.2× as long as wide, first pair of setae inserted at level of distal third and the second one near the hind scutellar margin, between and at same level of the setae insertion a pair of sensorial pores are present; propodeum medially as long as dorsellum, with spiracles rather wide, just below the anterior propodeum margin, callus with 3 setae. Fore wing (figure 3d) 2× as long as wide, submarginal vein 2.3× as long as the premarginal vein, marginal vein 3× as long as the premarginal vein, postmarginal vein very short, stigmal vein 0.4× as long as marginal vein, submarginal vein with 2-3 dorsal setae, cubital line of setae reaching straightforward the basal vein, speculum of moderate size, disc with rather dense and uniform ciliation, discal fringe with longest setae 1/7 of the discal width. Legs normal with tarsomeres subequal, not more than 2.5-3× as long as wide, with basitarsomere slightly smaller and distal tarsomere longer. Hind wing with uniform ciliation on the blade and fringe longest setae 1/2 of the discal width. Gaster (figure 3e) lanceolate, 1.3× as long as head and mesosoma combined, 1.4-1.8× longer than mesosoma, 2× as long as wide; VIII tergite transverse, last tergite subtriangular, about as long as wide, cercoid with 3 setae and one longer than others; hypopygium three-lobed (figure 3f) reaching 0.5× of gaster; ovipositor inserted at base of gaster and slightly exerted, 2.2× as long as hind tibia, third valvulae as long as 0.27× the length of the ovipositor.

Male

Body length: 1.0 mm (average) (min. 0.9, max. 1.2, n = 10). Similar to the female, but antenna (figure 3g) with scape 3× as long as wide, with ventral plaque placed mostly on its basal half and slightly shorter than 0.5 of its length; funicle 4-segmented with subequal segments, at most one-third longer than wide, F1 the smallest, as long as pedicel, with a not compact subbasal whorl of setae, the setae at maximum as long as the segment bearing them, each funicular segment with 3-4 linear sensilla; club as long as the last two funicular segments combined and slightly wider. Gaster oblong-ovate. Genitalia (figure 3h) with phallobase 3.3× as long as wide, 0.25 mm in length, with antero-dorsal aperture 0.4× of its length, parameres with a terminal spine a little longer than the single digital spine, aedeagus with apodemes as long as its body.

Material examined

Holotype. ♀, on pin card, Rivello, 2.iii.2015, laboratory emergence 20.iii.2015, ex pupa *S. brevicornis* in flower gall of *A. nepetae*, coll. G. Viggiani.

Allotype. ♂, on pin card, Rivello, 28.ii.2017, laboratory emergence iii.2017, ex flower gall of *A. nepetae*, coll. G. Viggiani.

Paratypes. On slide, 1♀, Bari, 31.iii.2015, ex flower gall of *A. nepetae*, coll. U. Bernardo and G. Viggiani; 1♀, Portici, 12.i.2015, ex flower gall of *A. nepetae*, coll. G. Viggiani; 1♀, San Giorgio a Cremano, 1.x.2014, ex flower gall of *A. nepetae*, coll. R. Sasso; 2♂, San Giorgio a Cremano, 1.x.2014, ex flower gall of *A. nepetae*, coll. R. Sasso. On pin card: 1♂, 28.ii.2017, laboratory emergence iii.2017, ex flower gall of *A. nepetae*, coll. G. Viggiani. Additional material. 1♀, Bari, 31.iii.2015, ex flower galls of *A. nepetae*, coll. U. Bernardo and G. Viggiani; Matera, 16.iii.2016, laboratory emergence iii.2017; 2♀, Napoli-Camaldoli, 3.xii.2014, coll. R. Nicoletti; 3♂, Palma Campania 16.1.2016, laboratory emergence 24.iii.2016; 2♀, 1♂, Portici,11.i.2016, 1♂, 11.xi.2016; 1♂, Rivello, 21.ii.2015 coll. G. Viggiani, 3♀, 2.iii.2015, laboratory emergence 20.iii.2015, ex pupae *S. brevicornis*, 1♂, 21.ii.2015, 2♂,16.iii.2015, 1♀, 1♂, 30.iii.2015, 4♀, 2♂, 23.i.2016, laboratory emergence 24.iii.2016, ex pupae *S. brevicornis*; 1♀, 22.ii.2016; 2♀, 7♂, San Giorgio a Cremano, 1.x.2014,

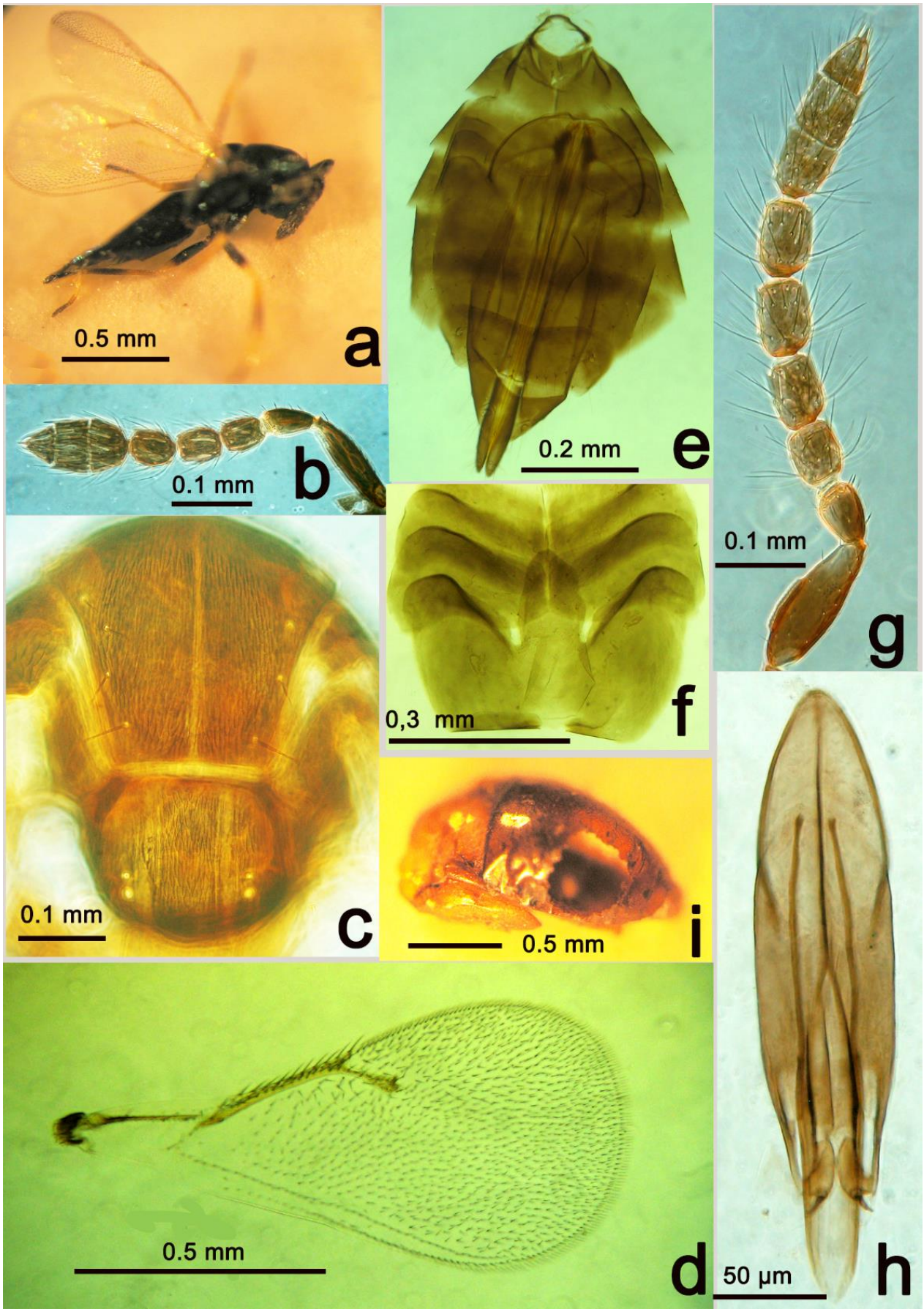

Figure 3. a. *Baryscapus hyperasphondyliae*, female; **b.** Antenna; **c.** Mesoscutum; **d.** Fore wing; **e.** Gaster; **f.** Last gastral sternites; **g.** Antenna of the male; **h.** Genitalia; **i.** Pupal case of *Sigmophora brevicornis* with the exit hole of *B. hyperasphondyliae*.

coll. R. Sasso, 2♀, 1♂, 16.ix.2015, 2♀, 1♂, 8.xi.2015, 2♀, 18.xi.2015, laboratory emergence 9.xii.2015; 1♂, Castellammare, 25.ix.2017, laboratory emergence 13.x.2017, ex flower gall of *A. hornigi*, coll. A. Stinca; 2♀, Rivello, 2.i.2019, laboratory emergence ii.2019, ex pupae of *S. brevicornis* in a single flower gall of *Asphondylia* on *C. vulgare*, coll. G. Viggiani; 1♀, 7♂, Palma Campania, 30.iv.2016, laboratory emergence 1-21.v.2016, ex flower galls of *Asphondylia* on *M. graeca*, coll. G. Viggiani; 4♀, 2♂, Portici, 2.vi.2016, laboratory emergence 26.vi-7.vii.2016, 2♀, 1♂, 8.vi.2017, 2♀, 3♂, 9.vi.2017, ex flower galls of *Asphondylia* on *M. graeca*, coll. G. Viggiani.

Holotype, allotype, 4 paratypes and all additional material will be deposited at the entomological collection of the Dipartimento di Agraria dell'Università degli Studi "Federico II", Portici, Napoli, Italy. Two paratypes will be deposited at the Natural History Museum, London.

E t y m o l o g y

Named after the combination of hyperparasitoid and *Asphondylia*.

D i a g n o s t i c t r a i t s

In Graham's key to genera of Tetrastichinae (1991) the new species runs to *Baryscapus* Foerster. This genus includes 128 species (Noyes, 2019), about 60 of which are known from Europe and Mediterranean countries (Cassar *et al*., 2018). In the key to the European species-groups, the new species runs to the *evonymellae* species-group and in couplet 44 in the key to the included species, near *Baryscapus euphorbiae* Graham (Graham, 1991). This species, known only for the female is compared with *Baryscapus endemus* (Walker). *B. euphorbiae* differs from *B. hyperasphondyliae* for having scape 0.75-0.8× length of eye (in *B. hyperasphondyliae* 0.6× length of eye), funicular segments increasing in width and F3 quadrate (in *B. hyperasphondyliae* funicular segments not increasing in width and F3 not quadrate), antennal pedicel as long as F1 (in *B. hyperasphondyliae* pedicel one-third longer than F1), submarginal vein with 3-5 dorsal setae (in *B. hyperasphondyliae* 2-3). From *B. endemus* the new species differs for having female antenna with pedicel not or hardly longer than F1 and male antenna with longer funicular segments bearing a compact subbasal whorl of dark setae. *B. euphorbiae*, at present known only from Netherlands, seems likely to be a hyperparasitoid associated probably to *Bayeria capitigena* (Bremi) (Diptera Cecidomyiidae) on *Euphorbia* sp. (Graham, 1991). Also *B. endemus*, reared from several hosts, seems to have hyperparasitic behaviour (Graham, 1991). After Graham's revision (1991) additional 20 species of *Baryscapus* were described (Noyes, 2019), of which only 10 specifically compared by the authors with species belonging to the same group of the new species. Many of them were described without accurate details to be properly compared with allied species and others show characters very distinct from this new species. Recently (Cassar *et al*., 2018) the new species *Baryscapus ecballii* Cassar, Askew et Mifsud was described as belonging to the species-group *evonymellae*. This species, a gregarious parasitoid of Coccinellidae, appears rather near *B. hyperasphondyliae*, but in addition to the different biology, the female can be distinguished by having F1 as long as pedicel, F2 slightly shorter than F1, club markedly longer than funicle and marginal vein with 3-4 dorsal setae; the male shows longer scape, with ventral plaque 0.8× its length.

B i o l o g y

The species, an endophagous hyperparasitoid, has been obtained from isolated pupae of *S. brevicornis*. The adult emerges from the the host through a rather wide exit hole (figure 3i). Several specimens have been obtained from parasitized pupae of *S. brevicornis* found in overwintering galls of *A. nepetae*; the hyperparasitoid larva or pupa remains in quiescence until the end of winter. Probably the hyperparasitoid may have other hosts among the primary parasitoids of *Asphondylia*.

Concluding remarks

The parasitoid complex associated with *Asphondylia* species causing flower galls on Lamiaceae is represented by several families of the Hymenopteran superfamily Chalcidoidea. It appears composed by several common species across gall midges, with active parasitization from early spring to late autumn. Most of the species depend on the host mature larva in the gall. The latter has a simple and uniform shape, not dissimilar to that of the old flower (calyx) containing fruits and without specific differences (Viggiani, 2017). Contrary to *Asphondylia* hosts, which show a common period of quiescence in the flower galls from late autumn to spring, the parasitoids overwinter differently as adult or young instars (mostly mature larva). They are polyphagous or oligophagous and start the annual reproduction, as on *Asphondylia* causing flower galls on *M. graeca*, in early spring and then can also shift on other *Asphondylia* associated with host plants flowering later. Among the ectophagous parasitoids the most common is *S. brevicornis*, a solitary and gregarious species. Solitary ectophagous are *E. dentata*, *P. nitescens* and *S. encyrtoides*. Their larvae develop in flower galls containing not only the single stage of *Asphondylia* but also an abundant mycelium of the fungus *Botryosphaeria dothidea*, the basic symbiont of the gall midges, on Lamiaceae and many other plant species (Zimowska *et al*., 2017; Bernardo *et al*., 2018). Although it was not experimentally proven, observations suggest that the larvae of some parasitoids, as those of *S. brevicornis*, may complete their development, feeding directly on the fungus or on the modified gall tissues. This seems particularly possible for *S. brevicornis*, as commonly 2-4 larvae can develop in a gall on a single larva of the gall midge. The dimensions of this larva (long 2-4 and wide 0.9-1.5 mm) compared with those of all parasitoid larvae (each full larva long 2-3 and wide 0.5-0.7 mm) to be nourished support the aforementioned view that this parasitoid likely uses also other sources of nutrients. In addition it is to be stressed that the ectoparasitic larvae of *S. brevicornis* in a gall are very mobile, not strictly linked to the

host larva. The complex of the endophagous species is represented by *A. westwoodii*, and possibly other species of the same genus, which attack larvae but also pupae of *Asphondylia*. Inside this parasitoid complex a secondary level is represented by the hyperparasitoid *B. hyperasphondyliae*. As here shown, the abundance of the single parasitoid species varies, in several cases markedly, in space and time.

The only possible comparison of the data presented here, with other studies including the complex of parasitoids attacking *Asphondylia* in flowers of Lamiaceae, concerns *A. coridothymi* (Malagaris, 2011). In this study the parasitoid complex is represented by 8 species, but only one, *S. encyrtoides*, is identified at specific level. This species was the most abundant parasitoid, causing the 30.76% of larval parasitization.

The role of the parasitoids of *Asphondylia* as vectors of the fungi associated with the flower galls remains to be investigated.

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