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Two new species of the *Polysphincta* genus-group (Hymenoptera: Ichneumonidae: Pimplinae) reared from their spider (Araneae) hosts in Europe

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Abstract

Flacopimpla barathrica **sp. n.** and *Zatypota flamma* **sp. n.**, belonging to the *Polysphincta* genus-group, are described, the former from Fennoscandia and the latter from Hungary. Like other species of this group for which the natural history is known, the new species are koinobiont ectoparasitoids of spiders. They have been reared from the theridiid spiders *Thymoites bellissimus* (L. Koch) and *Parasteatoda* sp. Archer respectively. The host records support the hypothesis of *Flacopimpla* being parasitoids of the spider family Theridiidae. The results also indicate that *F. barathrica* sp. n. has a very narrow host range consisting of a single species in Fennoscandia. The genus *Flacopimpla* was previously only known from the New World, and *F. barathrica* sp. n. is thus the first species of its genus in the Palaearctic. It is also the first troglophilic species of the *Polysphincta* genus-group. *Zatypota albicoxa* (Walker) is reported as new to Hungary.

Key words: *Zatypota*, *Flacopimpla*, koinobiont, ectoparasitoid, Theridiidae, *Thymoites bellissimus*, *Parasteatoda*, new distribution, Palaearctic, Finland, Sweden, Norway, Hungary.

Introduction

The *Polysphincta* genus-group is a monophyletic linage of Pimplinae (Gauld & Dubois 2006) comprising 22 genera (Yu *et al*. 2012). As far as is known, all species of the genus-group are koinobiont ectoparasitoids of spiders. In a cladistic analysis of the *Polysphincta* genus-group (Gauld & Dubois 2006) the genera *Flacopimpla* Gauld and *Zatypota* Foerster (among several others) were not clearly delimited. However, after the reorganisation of some species both genera appeared monophyletic.

The genus *Flacopimpla* was described as monotypic from the Neotropics (Gauld 1991), but later another species was described from Brazil (Graf & Kumagai 1998) and three of the North and Central American species of *Zatypota* were transferred to the genus (Gauld & Dubois 2006). A new species from Mexico was recently described in *Flacopimpla*, now comprising six species but still considered a New World genus (Khalaim & Ruíz-Cancino 2011). *Zatypota* is a large cosmopolitan genus, comprising about 50 described species (Yu *et al*. 2012). Many undescribed species occur in museum collections (Gauld & Dubois 2006) and recently, ten new species have been described from the Palaearctic (Fritzén 2010; Matsumoto & Takasuka 2010).

Flacopimpla and *Zatypota* are similar in their general appearance with the metasomal tergites 2–3 possessing a more or less clearly defined rhombic raised area centrally. The two genera can be distinguished based on the presence of a longitudinal glabrous furrow on the inner side of the hind tibia (in females) and a slender and upcurved upper tooth of the mandible in *Flacopimpla*. In addition the labial palp of *Flacopimpla* is 4-segmented whereas it is 3-segmented in *Zatypota* (Gauld 1991; Gauld & Dubois 2006; Palacio *et al*. 2007).

Flacopimpla and *Zatypota* belong to the *Eruga*/*Acrodactyla*/*Zatypota* genus complex (Gauld & Dubois 2006), which includes *Pterinopus* Townes, *Megaetaira* Gauld & Dubois, *Eruga* Townes, *Acrodactyla* Haliday, *Longitibia* He & Ye and *Eriostethus* Morley, and also *Lamnatibia* Palacio & Sääksjärvi (Palacio *et al*. 2007). According to Gauld & Dubois (2006), this genus complex is defined by two unambiguous characters: the fore wing with 2*rs-m* obliterated and the hind wing with basal abscissa of *M* + *Cu* basally straight and quite abruptly bowed in distal 0.3 or 0.4.

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With a few exceptions, the species of *Zatypota* are parasitoids of the spider family Theridiidae (Shaw 1994; Zwakhals 2006; Matsumoto & Takasuka 2010). The biology of *Flacopimpla* is still very poorly known. The only host record of the genus is of *F. parva* (Cresson, 1870), which has been reared from *Theridion punctipes* Emerton (Theridiidae) (Cushman 1926). Old single host records should, however, be treated with some caution (Shaw 1994).

The main aim of this paper is to describe two new species of the *Polysphincta* genus-group from Europe based on extensive rearing data and to describe their natural history. One of the species belongs to *Zatypota* and the other one is the first species of *Flacopimpla* outside the New World.

Materials and methods

In the course of my study of the *Polysphincta* genus-group, since 2003 I have collected over 2000 parasitised spiders and successfully reared a parasitoid wasp from more than half of them. The material has mainly been collected in Finland, focusing on forests dominated by Norway spruce (*Picea abies*). To a lesser extent, parasitised spiders have also been collected by me or my colleagues in other northern and Central European countries. The spiders have been collected by beating branches of trees, with a sweeping net or sought by hand. Spiders carrying a parasitoid larva were mainly reared indoors in small plastic vials (7.5 x 3.5 cm) and fed with *Drosophila* flies from laboratory cultures. The developmental data therefore differs from what it would be under natural conditions, and the size of some specimens may have been negatively affected due to starvation of the host. For rearing methods see Shaw (1990). In addition to my reared material of the *Polysphincta* genus-group and the material listed under "Taxonomy", I have studied a large number of specimens collected by The Swedish Malaise Trap Project (SMTP) (see Karlsson *et al*. 2005) as well as material in several large institutional and private collections (e.g. NRM, BMNH and the private collection of Reijo Jussila).

Morphological terminology in this paper follows Gauld (1991). The measurements were made using an ocular micrometer. Abbreviations used in the text: **coll**. refers to the date of collecting of the host or as a cocoon, **coc**. refers to the date of finishing the construction of the cocoon; **em**. to the date of emergence. The figures 3–5 were made using a JEOL JSM-5200 scanning electron microscope at the Zoological Museum, University of Turku. Figure 2 was made using an Olympus E-3 DSLR attached to an Olympus SZX16 stereomicroscope and composed using Helicon Focus image stacking software, and the outlines of the mandible were enhanced in Adobe Photoshop. The close-up photographs (7–10, 12) were made by the author with Olympus E-3 DSLR with TF-22 twin flash, apart from Figs 13–14 taken with Olympus E-400 DSLR by the collector. The illustrations (Figs 1, 11) were made by Ika Österblad, utilizing digital drawing and painting techniques. The outlines of the wasp were traced from photographs of the holotypes, details and exact measurements obtained by carefully checking the specimen. Based on the drawings, colour images were painted using Adobe Photoshop.

Acronyms for depositories:

BMNH The Natural History Museum, London, UK
NMS National Museums of Scotland, Edinburgh, UK
NRF Private collection of the author, Vasa, FI
NRM Swedish Museum of Natural History, Stockholm, SE
ZMUT Zoological Museum, University of Turku, FI
ZISP Zoological Institute of the Russian Academy of Sciences, St. Petersburg, RU

Taxonomy

Flacopimpla Gauld, 1991

Type species: *Flacopimpla varelae* Gauld, 1991, by original designation.

***Flacopimpla varelae* Gauld, 1991**

MATERIAL EXAMINED. **COSTA RICA** (BMNH): Paratypes 2♀, Gste Pv., Guanacaste NP, 560 m, Est Mariza Vn Orosi, v–viii.1989 (Gauld); 1♀, Gste Pv., Guanacaste NP, 560 m, Est Mariza Vn Orosi, iii.1990 (Gauld & Michell) (det. I.D. Gauld, 1991).

***Flacopimpla gerardoi* (Gauld, Ugalde & Hanson, 1998)**

MATERIAL EXAMINED. **COSTA RICA** (BMNH): Paratypes 2♀ San José Prov., Cerro Muerte, 6 km N San Gerardo, 2800 m, i.1993 (Hanson & Godoy); 1♀ Puntarenas Prov., Cota Brus, Las Alturas, 2000 m, i–iii.1995 (Quirós).

***Flacopimpla nigriceps* (Walsh, 1873)**

MATERIAL EXAMINED. **CANADA** (BMNH): 1♂1♀ Quebec, Gatineau County, Lake Duncan, vii–viii.1979 (A.C. Pont); **USA** (BMNH): 1♀ Maine, Dryden, 5.viii.1959 (B.M.1961-239) (G.H. Heinrich); Michigan, Hiawatha N.P., viii.76 (Gauld) (det. R. Matsumoto 2007).

***Flacopimpla parva* (Cresson, 1870)**

MATERIAL EXAMINED. **USA** (BMNH): 1♂ Maine, Dryden. 23.viii.1959, G. H. Heinrich, B.M.1961-239 (det. G. Broad 2008); 1♀ the same data except date: 8.ix.1959; 1♂, Michigan, Gun Lake, viii.76 (Gld) (det. R. Matsumoto 2008); 1♀, Michigan, Ann Arbor, vi.76 (Gld) (det. M.G. Fitton 1984); 1♀, Michigan, Ann Arbor, 3–16.ix.1975 (M.G. Fitton) (det. R. Matsumoto 2007); 1♀, Michigan, Ann Arbor, viii.76 (Gld) (det. M.G. Fitton); 1♀ USA, Michigan, Ann Arbor, 17.ix–2.x.1975 (M.G. Fitton) (det. R. Matsumoto 2007).

***Flacopimpla barathrica* Fritzén, sp. n.**
Figs 1–10.

MATERIAL EXAMINED. **FINLAND**: **Holotype** ♀ (ZMUT), Sb, Kuopio, Kangasmäki, Pirunpesä, 62° 50.27'N; 27° 59.87'E, inside a small cave in a small ravine, ex adult ♀ *Thymoites bellissimus* coll. 18.vi.2011, coc. 25.vi.2011, em. 3.vii.2011 (N.R. Fritzén). **Paratypes**: **1**♂ (NRF) **2**♀ (BMNH, NRF), Ks, Kuusamo, Kiutaköngäs (Oulanka National Park), in clefts and crevices on rock wall in gully of Oulankajoki river, 66° 22.05'N; 29° 19.68'E, coll. as cocoon 15.vi.2011, em. 18– 24.vi.2011 (N.R. Fritzén); **2**♀ **(**NRF), Ks, Kuusamo, Kiutaköngäs (Oulanka National Park), 66° 22.09'N; 29° 19.75'E, on boulder and on rock wall with crevices in or near gully of Oulankajoki river, coll. as cocoon 19.vi.2011, em. 24–26.vi.2011 (I. Österblad); **2**♂ (NRF), Tb, Jyväskylä, Veijo, 61° 56.95'N; 25° 41.75'E, in hollows between boulders beneath rock wall, ex subadult *Thymoites bellissimus* coll. 10.v.2012, coc. 17–18.v.2012, em. 25–26.v.2012 (N.R. Fritzén); **3**♀ **1**♂ (1♀ NMS, 2♀1♂ NRF), Oa, Korsholm, Södra Vallgrund, Sommarö, 63° 09.81'N; 21° 18.32'E, in old concrete garden cellar, ex subadult and adult *Thymoites bellissimus* coll. 25–27.ix.2012, coc. 14–17.x.2012, em. 25–27.x.2012 (N.R. Fritzén); **4**♀ **3**♂ (1♀ ZISP, 1♂ ZMUT, 3♀ 2♂ NRF), Oa, Vasa, Östmelmo, 63° 04.77'N; 21° 41.72'E, beneath boulders in mixed forest dominated by pine, ex adult and subadult *Thymoites bellissimus* coll. 17.ix.2013, coc. 3–15.x.2013, em. 9–24.x.2013 (N.R. Fritzén); **1**♂ (NRF), the same data except dates, coll. 29.xii.2013, coc. 11.i.2014, em. 22.i.2014 (N.R. Fritzén); **NORWAY**: **1**♀ (NRF), Nord-Fron, Steinåa, 61° 32.01'N; 09° 58.89'E, steep stream canyon, under overhanging moss, ex *Thymoites bellissimus* coll. 10.v.2013, coc. 20.v.2013, em. 30.v.2013 (A. Fjellberg); **SWEDEN**: **1**♂ **2**♀ (1♀ NRM, 1♂ 1♀ NRF), Vb, Vindeln, Krycklan, 64° 13.02'N; 19° 50.15'E (~350 meters upstream from Krycklan Nature Reserve), beaten from beneath overhanging moss at edge of the stream, ex 2 ad. ♀ and 1 subad. ♂ *Thymoites bellissimus* coll. 7.ix.2013, coc. 12–16.x.2013, em. 21–25.x.2013 (N.R. Fritzén). **Other**

material: **SWEDEN**: **1**♀ (NRM), Vb, Vindelns kommun, Svartbergets försökspark, Åheden, Svartberget, 64° 13.831'N; 19° 47.106'E, (=TrapID 61), 23.vii–05.viii.2004 (=coll. event ID 1302) (Malaise trap in glade in pine forest) (SMTP).

Diagnosis. The new species may be separated from the five known North and Central American species of *Flacopimpla* by the combination of the following characters: 1) smooth, polished and more or less glabrous mesoscutum, 2) complete submetapleural carina, 3) more or less uniformly dark brown mesosoma, 3) the ovipositor with only a very weak swelling at the extreme base and with its thin apical part relatively long and 4) mid trochanter unmodified.

Description. Holotype ♀, length of body 5.0 mm, of fore wing 4.2 mm.

FIGURE 1. *Flacopimpla barathrica* sp. n.: Holotype in lateral view (slightly straightened) and head in anterior view.

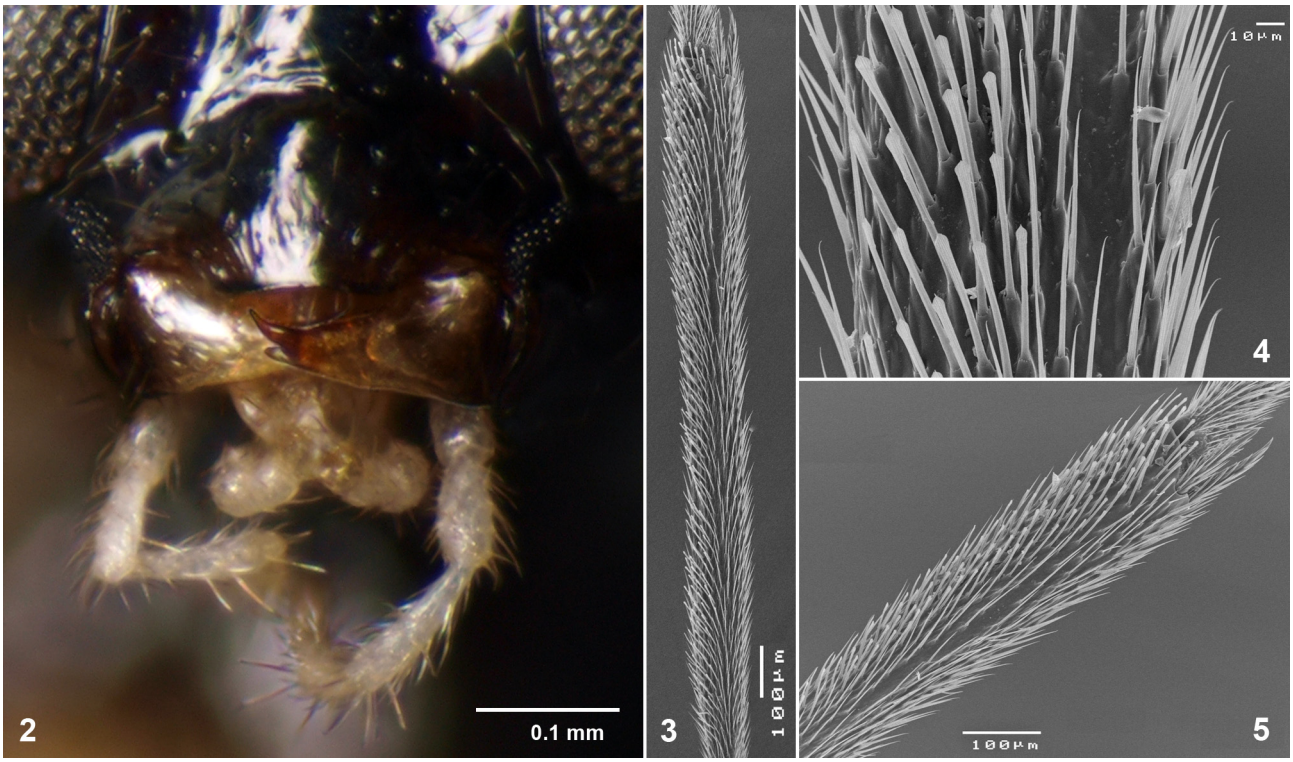

FIGURE 2–5. *Flacopimpla barathrica* sp. n.: 2—Mandible of a paratype ♀ showing the slender and upcurved upper tooth, 3–5—SEM-images of the inner side of the hind tibia of a paratype ♀ showing the longitudinal glabrous furrow in different magnifications.

Head. Malar space 1.1x basal mandibular width, without subocular sulcus but with band of coriaceous sculpture. Mandible with upper tooth slender, upcurved and distinctly longer than lower tooth (Fig. 2). Face 0.9x as wide as medially high, polished, with coarse sparse setae. Apex of clypeus relatively long and narrow, about 0.35x width of face. Eyes from anterior view of head conspicuously protruding. Antenna with 21 flagellomeres, length-to-width ratio of first flagellomere 7.2, of second 4.0. Palpal formula 5:4. Head, in dorsal view, with gena strongly receding and weakly rounded; posterior ocellus separated from eye by 1.2x its own maximum diameter; occipital carina mediodorsally complete.

Mesosoma. Pronotum laterally glabrous, smooth and polished with very weak reticulation; anteriodorsal margin reflexed and produced into a backwardly directed mediodorsal blunt tooth with backwardly directed incomplete longitudinal crest not reaching hind margin of pronotum; hind margin of pronotum mediodorsally with distinct forwardly directed protrusion; epomia more or less straight, reaching dorsal margin of but not continuing across pronotal collar. Mesoscutum smooth and highly polished, almost bare with sparse setae laterally on lateral lobes and anteriolaterally on median lobe; notauli relatively weakly impressed. Mesopleuron smooth and highly polished, dorsally, ventrally and anteriorly pubescent; epicnemial carina extending dorsally beyond ventral corner of pronotum. Mesosternum pubescent. Metapleuron convex, polished and moderately smooth, central area hirsute, dorsal and ventral border glabrous; submetapleural carina strong and complete. Propodeum subpolished, area spiracularis and area lateralis hirsute and weakly rugulose, elsewhere coriaceous; area petiolaris not D-shaped nor any other area completely enclosed by strong carinae, transverse carinae only as vestiges, lateromedian longitudinal carinae indicated by faint ridges only, with shallow longitudinal trough between them, lateral longitudinal carinae short, reaching forwards 0.3 to spiracle, area petiolaris with similarly short but strong median crest; pleural carina complete but weak. Fore wing with 2*rs-m* short, about as long as broad, base of 1*m-cu* separated from *Cu*1*a* by distance equal to length of *Cu*1*b*, *cu-a* postfurcal and separated from *Rs&M* by distance 0.5x its length. Hind wing with distal abscissa of *Cu*1 present but relatively weak, joining *cu-a* closer to 1*A* than to *M*, at distance of 0.37 from 1*A* towards *M*. Mid trochanter unmodified. Length of hind femur 5.6x breadth. Hind tibia with inner surface with more or less glabrous longitudinal relatively weak furrow (Figs 3–5).

FIGURES 6–10. *Flacopimpla barathrica* sp. n.: 6—type locality at the Pirunpesä ravine in Kuopio, Finland, 7—an adult ♀ of the host *Thymoites bellissimus* with the larva of the holotype, 8—a subadult ♂ of the same host species infested with both the larva of a paratype and an *Iphidosoma physogastris* mite, 9—a cocoon with pupa *in situ* (Oulanka National Park), attached to the upper rock surface in the web of the host and 10—the newly emerged holotype *in vitro*, still resting on the cocoon. Scale bars 1 mm.

Metasoma. Tergite 1 of metasoma 1.3x as long as posteriorly broad, coriaceous, with lateromedian carinae extending 0.45 of length of segment, continuing posteriad as dull ridges to 0.8 of length of segment; tergite 2 0.9x as long as posteriorly broad; tergite 3 0.7x as long as posteriorly broad; tergites 2–3 each with moderately defined raised rhombic coriaceous/trans-strigose central area. Ovipositor 0.5x as long as hind tibia, projecting beyond apex of metasoma by 0.22x length of hind tibia, almost straight, with only weak swelling and no distinct bending at extreme base, with moderately strong swelling before middle with maximum at 0.39x length at upper valve and 0.31x at lower valve, after which tapering into long fine tip.

Colour. Head dark brown; clypeus and orbits concolorous with rest of head; mandibles fulvous; palpi whitish, antenna brownish with scape and first flagellomere ventrally pallid. Mesosoma more or less uniformly dark brown except for fulvous to fuscous mesepimeron, subalar prominence, scutellum and thin longitudinal stripe on collar of pronotum; tegula whitish. Metasoma more or less uniformly brown. Front and middle legs fulvous, with coxae, trochanters and trochantelli whitish; hind leg fuscous with trochanter and trochantellum fulvous, and coxa and distal third and dorsal fleck at 0.25 from base of tibia darker brown. Wings hyaline; pterostigma brown.

Paratypes. Resemble holotype in colouration and structure. Fore wing with 2*rs-m* slightly longer than in holotype in some specimens. Hind wing with distal abscissa of *Cu*1 present in all specimens, but in some specimens faint and near base of 1*A*. Females: Body length 3.6–4.9 mm. Fore wing length 3.1–4.2 mm. Antennal flagellomeres 21–23. Ovipositor from slightly bent upwards to slightly decurved (probably as a result of air-drying). Males: Body length 3.0–4.5 mm. Fore wing length 2.8–3.8 mm. Antennal flagellomeres 21–22. Metasoma on average narrower than in females. Lack glabrous longitudinal furrow on inner surface of hind tibia.

Other material. The colouration and structure of the single specimen fall within the variation of the holotype and paratype females, except for the presence of two distinct pronotal swellings on both sides running from the base of the fore wing downwards to the pronotal collar and anteriad along the lower margin of the mesoscutum, respectively.

Type locality. A small ravine called Pirunpesä (En. Devils nest) in the eastern part of the Kangasmäki Hill in the village of Suojärvi in Kuopio, in the fauna province of *Savonia borealis* in the central part of Finland, N62° 50.27' E 27° 59.87', altitude ca. 150 m. The Pirunpesä-ravine is about 100 m long with 4–8 m high rock walls with small fissure caves (Fig. 6). The Kangasmäki Hill is classified as locally significant cliffs/rocky hills for the North Savo region (Husa *et al*. 2001).

Distribution. Boreal forest zone of Fennoscandia.

Etymology. The specific name refers to the troglophilic habits of the species but is particularly associated with the name of the type locality (Barathrum = chasm, abyss, hell; in ancient Greece a pit at Athens into which criminals were cast).

Natural history. *Flacopimpla barathrica* sp. n. is a koinobiont ectoparasitoid of *Thymoites bellissimus* (Theridiidae). All specimens of the type series (n = 24) were found as larva on *T. bellissimus* or as cocoon in or close to webs with this spider species. They were all found in caves, clefts and other cavities on rock walls, in hollows between boulders or in a similar habitat of antropochorous origin, or in other partly subterranean places like under overhanging moss on river banks. It overwinters as a minute larva on its host within these concealed sites. The larval placement varies from dorsolateral to almost lateral and from the posterior to the anterior part of the host's abdomen (Figs 7–8). Based on all the parasitised specimens of *T. bellissimus* collected (some of which not successfully reared) the head of the larva usually (n = 28) points towards the posterior part of the host abdomen, but rarely (n = 3) the head points anterioventrally, but only when the larva is at the anterior extreme of the host abdomen. The cocoon is subcylindrical, diaphanous with springy and loosely woven whorls of yellowish white colour (Figs 9–10) with a distinct caudal orifice. It is built vertically with its anterior apex usually attached to the upper substrate, in the case of all cocoons collected in the field (n = 14) or empty ones seen, they have been attached to the upper rock surface (Fig. 9). Among the other European species of the *Polysphincta* genus-group, the cocoon could be confused with those of *Z. bohemani* (Holmgren, 1860), *Z. percontatoria* (Müller, 1776), *Z. discolor* (Holmgren, 1860) and *Z. anomala* (Holmgren, 1860), at least the first two of which can be found on rock walls. Of the 13 cocoons with pupae, tentatively belonging to *F. barathrica* sp. n, collected at one site in the Oulanka National Park, eight (~60%) were infested by pseudohyperparasitoids of the ichneumonid genus *Gelis* Thunberg. Based on the collection data of the cocoons, the single imago and unhatched eggs found on the hosts as late as on September 7 and 17, the flight period begins in late June and continues to at least mid September. One larva presumably belonging to the new species (due to the presence of parasitised *T. bellissimus* at this site in combination with absence of other possible hosts) was seen building its cocoon on September 25, indicating an

even longer flight period. Due to the sensitive life stage the larva was not collected and two days later when re-checked it had disappeared.

Remarks. The new species is classified as a *Flacopimpla* since most of its diagnostic characters correspond better to the expanded *Flacopimpla* (see Gauld & Dubois 2006) than to *Zatypota*: a rather slender mandible with upper tooth upcurved (Fig. 2), palp formula 5:4, hind tibia with a hairless longitudinal groove internally (Figs 3–5), propodeum dorsally without areas closed by carinae, propodeum dorsally and the central area of tergites 2–3 coriaceous-strigose and distal abscissa of *Cu*1 of hind wing present.

Flacopimpla barathrica sp. n. is morphologically highly similar to the Nearctic *F. parva*. In its brownish colouration it is, however, rather different from the more colourful *F. parva. F. parva* has a distinct swelling at the extreme base of the ovipositor. The basal swelling is inconspicuous in *F. barathrica* sp. n., whose ovipositor is also longer, especially the thin apical part. In the new species, the propodeal carinae seem to be slightly more developed and the propodeum more strongly sculptured than in *F. parva*. In addition, there are, on average, fewer flagellomeres in *F. barathrica* sp. n. than in *F. parva*, the latter of which has 24–25 in females (n=4) and 24 in males (n=2).

Zatypota Foerster, 1969

Type species: *Ichneumon percontatorius* Müller, 1776, by subsequent designation (Viereck 1914).

Zatypota elegans Matsumoto, 2010

MATERIAL EXAMINED. **JAPAN**: Paratypes: 1♀ (BMNH), Honshu [Nara] Yamato–koriyama c., Yatachô, 34-39-51N/135-44-18E, 29.Apr.2009 (cocoon) (R. Matsumoto); 1♂ (BMNH), the same data except date: 22.X.2009.

Zatypota maculata Matsumoto, 2010

MATERIAL EXAMINED. **JAPAN**: Paratypes: 1♀ (BMNH), Honshu, [Osaka]/Ikeda c., Satsukiyama 30-50-03N/135-25-50E, 7 Sep. 2006 (cocoon) (R. Matsumoto); 1♀ (BMNH), Honshu, [Nara] Ikoma c., Tawaraguchi-chô 34-42-06N/135-40-47E, 28. Feb. 2007 (R. Matsumoto); 2♂ (BMNH), Honshu, [Osaka] Osaka c., Utsubo Park, 34-41-08N/135-29-41E, 27.Sep. 2006 (cocoon) (R. Matsumoto).

Zatypota flamma Fritzén, sp. n.

Figs 11–14.

MATERIAL EXAMINED. **HUNGARY**: **Holotype** ♀ (ZMUT), Sopron, Brennbergbánya, 47° 39.04'N; 16° 29.36'E, SW-slope of forest with *Abies alba*, *Quercus* sp. and *Fagus sylvatica*, beaten from tree branch, ex juv. *Parasteatoda* ?*lunata* coll. 18.vi.2010, coc. 24.vi.2010, em. ~6.vii.2010 (I. Österblad).

Diagnosis. *Zatypota flamma* sp. n. can be distinguished from all Palaearctic and North and Central American species of *Zatypota* by the combination of the following characters: 1) mesoscutum, propodeum and metasomal tergites smooth and highly polished without any trace of microsculpture, 2) ovipositor straight, 3) palp formula 4:3, 4) malar space without subocular sulcus but with a coriaceous band, 5) middle part of the face brownish but cheeks and orbital stripes yellow, the latter reaching the hind margin of the posterior ocelli but not continuing beyond them, and 6) more or less straight submetapleural carina without any projection anteriorly.

Description. Holotype ♀, length of body 3.7 mm, of fore wing 3.2 mm.

Head. Malar space 1.1x basal mandibular width, without subocular sulcus but with band of coriaceous sculpture. Mandible with upper tooth straight and longer than lower tooth. Face as wide as medially high, polished, with sparse setae. Antenna with 21 flagellomeres, length-to-width ratio of first flagellomere 4.9, of second 3.3. Palpal formula 4:3. Head, in dorsal view, with gena strongly receding but rounded, in lateral view with vertex rather flat; posterior ocellus separated from eye by 1.1x its own maximum diameter; occipital carina strong and mediodorsally complete.

FIGURE 11. *Zatypota flamma* sp. n.: Holotype in lateral view (slightly straightened) and head in anterior view.

FIGURES 12–14. Holotype of *Zatypota flamma* sp. n.: 11—the cocoon and 12–13—the larva on its host *Parasteatoda* ?*lunata*. Scale bars 1 mm.

Mesosoma. Pronotum laterally glabrous, highly polished and smooth; mediodorsally with longitudinal crest (partly hidden by head and not properly seen); epomia more or less straight and continuing across pronotal collar. Mesoscutum glabrous, smooth and highly polished; notauli strongly impressed. Mesopleuron smooth and highly polished, ventrally and anteriodorsally with few setae; epicnemial carina extending dorsally beyond ventral corner of pronotum. Mesosternum pubescent. Metapleuron convex, evenly hirsute, polished, anterior part smooth, posterior part with weak rugosities. Propodeum polished, area spiracularis and area lateralis hirsute and weakly rugulose, elsewhere smooth and glabrous except for anterior part with some setae; D-shaped area petiolaris enclosed by strong carinae, lateromedian longitudinal carinae complete anteriorly of D-shaped area petiolaris but medially weak, lateral longitudinal carinae reaching forwards almost to spiracle; pleural carina moderately strong and complete. Fore wing with 2*rs-m* short, about as long as broad, radius distally slightly bent towards front edge of fore wing, base of 1*m-cu* separated from *Cu*1*a* at distance slightly less than length of *Cu*1*b*. Hind wing with distal abscissa of *Cu*1 entirely absent. Length of hind femur 4.2x its width. Hind tibia with inner surface without any trace of longitudinal furrow.

Metasoma. Tergite 1 of metasoma 1.3x as long as posteriorly broad, polished, with lateromedian carinae extending 0.4 of length of segment; tergite 2 0.7x as long as posteriorly broad; tergites 2–5 each with clearly defined and smooth and polished raised rhombic to triangular central area, surrounding furrows polished but with strong trans-striae on tergites 2–4. Ovipositor 0.6x as long as hind tibia, projecting beyond apex of metasoma by 0.4x length of hind tibia, more or less straight, with distinct swelling at about middle (base of ovipositor hidden).

Colour. Head blackish brown; clypeus, cheeks, mandibles yellowish; facial to vertical orbits yellowish, broadening inwards below antennal sockets, reaching hind margin of posterior ocelli where turning inwards almost touching ocelli; palps whitish; antenna brownish with scape ventrally pallid. Mesosoma blackish brown apart from collar of pronotum yellowish, posterior part of pronotum fuscous, rest of pronotum fulvous, anterior part of propleuron fuscous, lower corner of propleuron fulvous, anteriolateral parts of mesoscutum yellowish, anterior part of middle lobe and area between lateral lobes fuscous, rest of mesoscutum fulvous, mesopleuron fuscous, mesepimeron, tegula, subalar prominence, scutellum and postscutellum yellowish. Metasoma fuscous; central area on tergite 2 fulvous, of tergites 3–5 yellowish. Front and middle legs fulvous, with coxae, trochanters and trochantelli whitish, tibia of middle leg with proximal tip brown; hind leg fulvous with middle part of femur slightly darker, proximal and distal third of tibia fuscous, middle part whitish. Wings hyaline; pterostigma brown but diaphanous.

Type locality. A forest with *Abies alba*, *Quercus* sp. and *Fagus sylvatica* in Sopron, Brennbergbánya in North-West Hungary N47° 39.04' E16° 29.36' near the Austrian border, altitude ca 420 m.

Distribution. So far only known from the type locality.

Etymology. The specific name refers to the colouration of the species.

Natural history. Koinobiont ectoparasitoid of *Parasteatoda* ?*lunata* (Clerck) (Theridiidae), the larva situated dorsolaterally on the anterior part of the host's abdomen (Figs 13–14). Based on the holotype, the species seems to

be arboreal in mixed forests. The cocoon is brownish, subcylindrical and densely spun (Fig. 12) with a distinct caudal orifice. Based on the cocoon remains, the adult parasitoid emerges from it by nicely chewing off a circular cap from the apex of it. The cocoon resembles the ones of *Z. picticollis* (Thomson, 1888), *Z. albicoxa* (Walker, 1876), *Sinarachna pallipes* (Holmgren, 1860) and *S. nigricornis* (Holmgren, 1860) in Europe.

Remarks. The male of *Z. flamma* sp. n. is unknown.

Among the European species of *Zatypota* the combination of straight ovipositor as well as glabrous, smooth and polished mesoscutum and smooth and polished gastral tergites is found only in *Z. picticollis* (Zwakhals 2006) and *Zatypota kerstinae* Fritzén, 2010. *Zatypota picticollis* has a malar space with distinct subocular sulcus, orbits similarly coloured as the head and the palpal formula is 5:3. In *Z. kerstinae*, the orbital stripes hardly extend to the hind margin of the anterior ocellus. Furthermore, the cheeks are blackish brown in *Z. kerstinae*. *Zatypota albicoxa* (Walker), which the new species also superficially resembles and with which it also shares host species, is generally a larger species, has a very different ovipositor (thin and evenly tapered with no distinct middle swelling and with an upcurved apex), orbital stripes not reaching the front margin of the posterior ocelli, cheeks similarly coloured as the rest of the head, palpal formula 5:3 (or when seemingly reduced to 4:3 with the distal palpomere of the maxillary palp long and undivided), and radius of fore wing distally bent away from the front the edge of the fore wing.

Among the East-Palearctic species not occuring in Europe (see Matsumoto & Takasuka 2010), the combination of straight ovipositor, smooth and polished mesoscutum and smooth and polished metasomal tergites, malar space with a coriaceous band and orbital stripes reaching the posterior ocelli is found only in *Z. maculata* and *Z. elegans*. The submetapleural carina of *Z. maculata* has a small projection at the anterior end and the propodeum and tergite 1 are dorsally and laterally finely coriaceous. The frontal orbital whitish stripe in *Z. maculata* and *Z. elegans* extends backwards far behind the posterior ocelli. The antenna is also longer in *Z. maculata* (24–28 flagellomeres) than in *Z. flamma* (21 flagellomeres). Viewed from in front the shape of the head of *Z. maculata* is also distinctly more triangular than in *Z. flamma* sp. n. The face and clypeus of *Z. elegans* is characteristic in being entirely white. Additionally the face is as long as wide in *Z. flamma* while it is distinctly longer (1.3–1.4x) than wide in *Z. elegans*.

The North and Central American species resembling *Z. flamma* sp. n. in having long orbital stripes are *Z. crassipes* Townes, 1960 and *Z. alborhombarta* (Davis, 1895), *Z. fonsecai* Gauld, 1991 and *Z. solanoi* Gauld , 1991 (Townes & Townes 1960; Gauld 1991). From the latter three species, *Z. flamma* sp. n. is easily distinguished by the lack of a strong subocular sulcus. Townes & Townes (1960) do not say whether *Z. crassipes* has a strong subocular sulcus or a coriaceous band as in the new species. However, it differs from *Z. flamma* sp. n. at least in the black colour of the median rhombic area of T2–5 and in having longer orbital stripes, continuing back behind hind ocelli.

Discussion

On taxonomy

Flacopimpla barathrica sp. n. is the only known species of the genus outside the New World. This species from the Western Palaearctic completely changes the conception of the distribution range of the genus. *Flacopimpla barathrica* sp. n. differs from the type species of the genus in a few characters. According to the original description of *F. varelae*, the pronotum lacks a mediodorsal longitudinal crest, which is present in *Zatypota* (cf. Fig. 354 in Gauld 1991), but also as a backwardly directed incomplete longitudinal crest in *F. barathrica* sp. n., which also has a more well developed epomia than *F. varelae.* Since the original description of *Flacopimpla* (Gauld 1991), several new species have been described and some former *Zatypota* have been transferred to *Flacopimpla.* Also these differ in some respects from the characters originally thought to distinguish *Flacopimpla* from *Zatypota*.

The rather slenderly built *Zatypota percontatoria*, with polished and glabrous mesoscutum and coriaceous rhombic central area on the tergites, superficially resembles *F. barathrica* sp. n. However, the lack of strong carinae on the propodeum, the longitudinal furrow of the inner surface of the hind tibia, the upcurved upper tooth of the mandible, the shape of the head and the bulging eyes, the shape of the ovipositor and the longer flagellomeres 1–2 are characters that easily separate the new species from *Z. percontatoria*. In addition, in *F. barathrica* sp. n. the distal abscissa of *Cu*1 is present. Among the Palaearctic species of *Zatypota* (Fitton *et al.* 1988; Zwakhals 2006; Fritzén 2010; Matsumoto & Takasuka 2010; Šedivý 1971), the distal abscissa of *Cu*1 is present in *Z. bohemani*

only, whose mesoscutum is matt, coriaceous and evenly covered with setae. The examination of reared Finnish specimens of *Z. bohemani* revealed that, contrary to what is stated in Gauld & Dubois (2006), a glabrous furrow is also present on the inner side of the hind tibia in females of this species. Also the weak carinae of the propodeum and its mandibles indicate that it would better fit in *Flacopimpla* than in *Zatypota*. However, *Z. bohemani* has a rather unusual ovipositor and because of its matt and setiferous mesoscutum it is different from the other species placed in *Flacopimpla*. The only other species with a matt mesoscutum (but not setiferous) placed in *Flacopimpla* is *F. nigriceps*. Except for the weak propodeal carinae, the examination of the specimens of *F. nigriceps* in BMNH (which fully fit the description of the species in Townes & Townes (1960) and I therefore consider correctly identified) did not offer many clues to why the species was transferred to *Flacopimpla* by Gauld & Dubois (2006). I could not see any trace of a glabrous furrow on the inner side of the hind tibia, the palp formula was 5:3 and the mandibles did not have a slender and upcurved upper tooth. In addition, the midtrochanter of *F. nigriceps* is ventroretrolaterally distinctly triangularly produced with a sharp edge resembling an axe-blade. Contrary to what is often indicated (cf. Gauld & Dubois 2006; Khalaim & Ruíz-Cancino 2011), this character or any trace of it in the form of a ventral swelling seems to be lacking in all other species of *Flacopimpla*.

The key to the Nearctic species of *Zatypota* in Townes & Townes (1960) and the redescriptions and descriptions of new species in this work indicate that further species than *F. parva* could in fact belong in *Flacopimpla,* especially when, in the descriptions of several species, it is often referred to "structure otherwise as described for *Z. parva*". This seems obvious for e.g. *Z. patellata* Townes, 1960 by the additional statement "this species is closely related to *Z. parva* and seems to be its western counterpart". *Zatypota patellata* occurs in California not far from the Mexican border. The possibility of this species belonging in *Flacopimpla* was apparently not taken into account when describing the Mexican *Flacopimpla kasparyani*, which, based on the description, is very similar to *F. parva* (cf. Khalaim & Ruíz-Cancino 2011).

Based on the key to *Zatypota* in Townes & Townes (1960), *F. barathrica* sp. n. mostly resembles *Z. exilis* Townes, a species only known from Quebec in Canada and New Hampshire in the USA, but seems to differ from it at least in the proportions of the third tergite. The description of *Z. exilis* is very short and I have not examined any specimens of it and I can therefore not fully exclude the possibility that it could be conspecific with *F. barathrica* sp. n. However, due to their disjunct distributions I find this scenario rather unlikely.

From the discussion above it seems obvious that the limits of *Zatypota* and *Flacopimpla* are still not fully understood and that the two genera are in need of a worldwide revision. Any nomenclatural changes of *Z. bohemani, F. nigriceps* or other species are therefore beyond the scope of this paper.

On biology

Facultative cave dwellers that may complete their life cycles in subterranean habitats but can also survive in more epigeic habitats are called troglophiles (Chapman 1982). *Flacopimpla barathrica* sp. n. is the first troglophilic species in the *Polysphincta* genus-group. However, it has no distinct morphological adaptations to the subterranean habitats and it is probably a threshold troglophile, occurring mainly near the entrances of subterranean habitats. The sites where *F. barathrica* sp. n. has been found differ in their microclimate from the outside climatic conditions to various degrees. This variation most likely affects the phenology of the species both at the population and the individual level, more than in species completing their life cycles in exposed habitats. This is indicated by the holotype still being a minute larva and presumably the overwintered one (Fig. 7) when collected on June 18, in a small cold cave with ice still on the floor, whereas a few days earlier about 400 km further north, less concealed in crevices on rock walls in Oulanka National Park, no larvae could be found on hosts since they had already reached advanced pupal stages.

Only a single specimen of *F. barathrica* sp. n. is known as having been collected as an imago, and no specimens of the species are known from before 2004. After the host of this species was finally revealed in 2011, I found it in several places within 5 km of my home. This indicates that the adult wasp rarely disperses from its rather small and concealed habitat and has therefore been overlooked, even if it seems to be not uncommon in places where its host is abundant.

The single imago of *F. barathrica* sp. n. caught in a Malaise trap outside its typical habitat in a young pine forest without any suitable habitat in the nearest vicinity differs in one morphological character from the type series. This specimen has two distinct pronotal swellings on both sides running from the base of the fore wing downwards to the pronotal collar and anteriad along the lower margin of the mesoscutum, respectively. The latter

one makes the dorsolateral parts of the pronotum distinctly broader than the mesoscutum when viewed from above. In all other specimens the pronotum is smoothly concave and the mesoscutum and the pronotum are equally broad viewed from above. Three normal specimens of the species were later collected as larvae on their hosts 2.9 km away from the location of the aberrant specimen. Interestingly, one specimen of *F. parva* in BMNH has identical pronotal swellings. For the time being, the swellings remain a conundrum.

At least in Fennoscandia, the host *Thymoites bellissimus* lives a concealed life in the habitats listed for *F. barathrica*. It represents the only species of *Thymoites* within the known distribution (Finland, Sweden, Norway) of its parasitoid. During this or other projects, no other species of the *Polysphincta* genus-group has been reared from *T. bellissimus* or from any other species of this theridiid genus (Yu *et al*. 2012). This and the unusual habitat of the species suggest that *F. barathrica* sp. n. has an extremely narrow realised host range (cf. Shaw 1994) to which only *T. bellissimus* belongs. However, *T. bellissimus* has a wide Trans-Palaearctic boreal range (Marusik *et al*. 2000), and since *F. barathrica* sp. n. has been found in Oulanka National Park less than 15 km from the Russian border the species presumably also occurs in at least the parts of Russia adjacent to Finland.

Parasteatoda spp. are hosts for several species of the *Polysphincta* genus-group. *Zatypota albicoxa* is known to be a parasitoid of both *P. lunata* and *P. simulans* (Thorell) in Europe (Fitton *et al*. 1988) and of several other *Parasteatoda* spp. in Japan (Matsumoto & Takasuka 2010). In addition, the Japanese *Z. maculata* parasitises *P. japonica* (Bösenberg & Strand) (Matsumoto & Takasuka 2010). Some species of the *Polysphincta* genus-group seem to have a rather determined larval position on its host (cf. Matsumoto & Konishi 2007). The egg of *Z. albicoxa* is usually located apically on the opisthosoma of the host, at a rather low position near the pedicel, and the larva is growing dorsally over the opisthosoma (personal unpubl. observations, but see also Matsumoto & Takasuka (2010)). When collected, the half-grown larva of *Z. flamma* sp. n. was positioned more dorsally (Figs 13–14) and this could be a diagnostic position or at least a clue for *Z. flamma* sp. n. when collecting parasitised *Parasteatoda* spp. in Central Europe. However, to support this suggested difference in larval position more material of the new species is required. The rather small size of the holotype of *Z. flamma* sp. n. is not likely to be a result of rearing conditions. When the parasitised host was collected, the larva was already rapidly growing and had killed the host and built a cocoon six days later.

In September 2010, I visited the type locality where *Z. flamma* sp. n. was collected three months earlier. *Parasteatoda lunata* was very common in the forest and hence this species was most likely the host of the holotype. Nonetheless, I found a single female of the sometimes very similar *P. simulans* a few kilometres away, so this species cannot be completely ruled out as the host of the holotype of *Z. flamma*. I found only three parasitised specimens of *Parasteatoda* in trees at the type locality, one of which was successfully reared to an adult male *Z. albicoxa.* The low position of the larva on the other two spider specimens also indicates *Z. albicoxa*. As *Z. albicoxa* was previously not reported from Hungary (see N. Bajári 1960; Yu *et al*. 2012), it is hereby reported as new to the country.

As far as is known, the genus *Oxyrrhexis* Foerster, also belonging to the *Polysphincta* genus-group, is specialised exclusively on hosts of the spider family Theridiidae (Fritzén & Fjellberg 2014), as are most species of *Zatypota* (Shaw 1994; Zwakhals 2006; Matsumoto & Takasuka 2010). The two genera seem restricted to hosts of a part of this spider family only. The theridiid hosts of *Zatypota* are mainly in the subfamily Theridiinae, whereas the hosts of *Oxyrrhexis* are in Asageninae and Enoplognathinae (Fritzén & Fjellberg 2014). The reared specimens of *F. barathrica* sp. n. support the hypothesis that *Flacopimpla* is a third genus of the *Polysphincta* genus-group specialised on theridiid hosts, and, like *Zatypota*, perhaps mainly or exclusively of the subfamily Theridiinae.

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