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A review of *Paroplitis* (Braconidae, Microgastrinae), and description of a new genus from New Zealand, *Shireplitis,* with convergent morphological traits

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Abstract

A new genus of Microgastrinae, *Shireplitis* Fernández-Triana and Ward, is described as endemic from New Zealand. *Shireplitis* resembles the Holarctic genus *Paroplitis* Mason, although morphological and molecular data reveal they are not likely to be closely related but are an example of convergent evolution. *Shireplitis* comprises species mostly found in moss, litter, or tussock grasslands, usually at moderate altitude on several New Zealand mountain ranges. Keys to all species from both genera are provided. Seven new species are described: *Paroplitis vietnamensis* van Achterberg and Fernández-Triana, and six *Shireplitis* species authored by Fernández-Triana and Ward: *S. bilboi*, *S. frodoi*, *S. meriadoci*, *S. peregrini*, *S. samwisei* and *S. tolkieni*.

Key words: Microgastrinae, *Paroplitis*, *Shireplitis*, Holarctic, New Zealand, Vietnam

Introduction

The genus *Paroplitis* was named by Mason (1981) to accommodate three Holarctic species which superficially resemble small specimens of *Microplitis* –although they are not closely related with the latter genus. *Paroplitis* can be easily recognized by its relatively small size, short and robust legs, short antenna (in females with a single rank of placodes per segment), mostly smooth metasomal terga, and propodeum usually with median and transverse carinae. Since Mason (1981), only one other species has been described (Papp 1991), but the distribution of known species has broadened across Europe (summarized in Yu *et al*. 2012) and North America (Fernández-Triana 2010).

As a result of studies being carried out by the authors on the Microgastrinae fauna of New Zealand (DW and JFT) and the Oriental region (CvA and JFT), new material representing one additional species of *Paroplitis* was discovered in Vietnam. Specimens of what at first seemed to be additional species from New Zealand were later found to represent a different genus, which is described below.

Methods

This study is based on the examination of material housed in the Canadian National Collection of Insects (CNC), Ottawa, Canada; the New Zealand Arthropod Collection (NZAC), Landcare Research, Auckland, New Zealand; the Entomological Research Museum (LUNZ), Lincoln University, Lincoln, New Zealand; Naturalis Biodiversity Center (RMNH), Leiden, the Netherlands; and Institute of Ecology & Biological Resources (IEBR), Vietnamese Academy of Science & Technology, 18 Hoang Quoc Viet Road, Cau Giay, Ha Noi, Vietnam.

Morphological terms and measurements of structures are mostly as used by Mason (1981), Huber & Sharkey (1993), Whitfield (1997), and Karlsson & Ronquist (2012). "Body length" refers to the anatomical line that is median and extends between the anteriormost point of the head and the posteriormost point of the metasoma (excluding ovipositor and ovipositor sheaths); and "fore wing length" refers to the anatomical line that extends between the median margin of the first axillary sclerite and the distalmost point of the wing blade. Throughout the keys the acronyms T1 and T2 are used for morphological terms mediotergite 1, and mediotergite 2.

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Non-morphological characters are also provided in the key whenever available (e.g., geographical distribution, altitude, and microhabitat). Those features are included in brackets at the end of the corresponding couplet and are intended as supplementary information that can help with identification. The new species descriptions are based on the holotype female, with other specimens studied (when available) for intraspecific variation.

Lucid 3.5.4 (http://www.lucidcentral.com/) software was used to generate automatic descriptions of the *Shireplitis* species and to prepare Lucid identification keys. A dataset of 14 characters and 77 character-states was used to provide uniform descriptions for all species treated. Description format includes one sentence per character, with the character mentioned first and the character-state following after a colon, e.g., "Body length: 1.8 mm". For measurements, we provide range and mean (between parentheses), e.g., "Body length: 1.8–2.0 mm (X=1.9 mm)".

Photos were taken either with a Keyence VHX-1000 Digital Microscope, using a lens with a range of 13–130X, or a Nikon DS-Ri1 digital camera mounted on a Leica M205A stereomicroscope. Multiple images through the focal plane were taken of a structure and these were combined, using the software associated with the Keyence System or Helicon Focus v5.3 and NIS Elements v4.0, to produce a single, focused image.

DNA barcodes were obtained using DNA extracts prepared from single legs using a glass fibre protocol (Ivanova *et al*. 2006). Extracts were re-suspended in 30 µl of dH2O, and a 658-bp region near the 5' terminus of the COI gene was amplified using standard primers (LepF1–LepR1) following established protocols (Smith *et al*. 2006, 2007, 2008). If the initial 658 bp amplification was not successful composite sequences were generated using internal primers. Primer information for individual sequences can be retrieved from the Barcode of Life Data System (BOLD) (Ratnasingham & Hebert 2007). Collection information and accessions (BOLD and GenBank) for all sequences were already published in a previous paper (Smith *et al*. 2013), and are summarized in Table 1.

For phylogenetic analyses, DNA barcode sequences from 3 *Shireplitis* species, 4 *Paroplitis* specimens, and 29 other Microgastrinae genera were downloaded from BOLD and imported in Geneious Pro 6.1 (Drummond et al. 2011) and aligned using the default settings for MUSCLE. All sequences were over 608 bp long except for *Shireplitis peregrini* (339 bp) and one specimen of *Paroplitis wesmaeli* (407 bp). The first 38 nucleotide positions of the aligned dataset were deleted to reduce the amount of missing data. The final aligned dataset contained 620 characters. The dataset was partitioned into two partitions, the first containing first and second codon positions and the second containing third codon positions. Model testing done in JModelTest v.2.1.1 (Darriba *et al.* 2012) using the Bayesian Information Criterion selected the GTR+I+G model for the first partition and the HKY+G model for the second partition. Two independent Bayesian analyses with 4 chains each were run in MrBayes v.3.2.1 (Ronquist and Huelsenbeck 2003) for 100 million generations each. Trace files of all parameters were examined in Tracer v.1.5 (Rambaut and Drummond 2009) to verify that the runs had converged on the same stationary distribution, and to select the percentage of samples to remove as burn-in. A 10% burn-in was removed from both tree files which were then combined and resampled at 10%. A Maximum Clade Credibility Tree (MCCT) was made from the combined resampled tree file in TreeAnotator v.1.7.5 (Rambaut and Drummond 2013). Two independent Bayesian analyses of the dataset with 3rd codon positions removed were also run in MrBayes.

In the taxonomic treatment of species, "Material Examined" presents the specimen's information in the following format: "Number of females/males, acronym of the storing institution between parenthesis, COUNTRY: State/Province, city, other locality details, coordinates (in Decimal Degrees), date, collector name, other data".

Maps with distribution of all species were generated using SimpleMappr (Shorthouse 2010).

Results

Including the new species described below, *Paroplitis* comprises five species, mostly distributed in Europe and North America, above 40° N (Fig. 1). Two species have been found further south (between 12–16° N), in northern Vietnam and northern Philippines; in both cases at moderately high altitude (1700–2400 m), and near the boundary between the Palaearctic and the Oriental regions. Palaearctic genera of ants (Hymenoptera, Formicidae) have been found to extend southward down to 22° N in northern Vietnam (e.g., Fellowes 2006); and Palaearctic elements of Collembola have been found in Vietnam as south as 12° N (e.g., Deharveng & Bedos 2000). Thus, we consider that *Paroplitis* is essentially a Holarctic genus, occasionally reaching the northern limits of the Oriental region.

TABLE 1. Taxa used in the molecular analysis, along with the source country, institution storing the specimens, codes (Process ID and Sample ID) to retrieve sequence data from BOLD (Barcode of Life Data System), and length of the COI sequences (in base pairs).

Species	Country	Institution Storing	BOLD Process ID	BOLD Sample ID	COI Sequence length
Apanteles carpatus	New Zealand	NAZC	NZMG198-11	NZAC04044445	622
Apanteles ensiger	Canada	CNC	CNCHX802-09	WMIC 0517	658
Apanteles galleriae	New Zealand	NAZC	NZMG201-11	NZAC04044347	625
Apanteles milleri	Canada	CNC	ASSR018-09	MIC 000206	606
Apanteles subandinus	New Zealand	NAZC	NZMG206-11	NZAC04044142	611
Choeras consimilis	Canada	CNC	HYCNE082-11	CNCHYM 00272	609
Cotesia plutellae	New Zealand	NAZC	NZMG254-11	NZAC04045448	620
Cotesia ruficrus	New Zealand	CNC	CNCBA937-10	WAM 0387	658
Cotesia urabae	New Zealand	NAZC	NZHYM611-10	NZAC04036566	658
Cotesia vanessae	Spain	CNC	WOMIA143-11	WAM 0448	658
Diolcogaster auripes	Canada	CNC	CNCHZ1166-09	CAM0546	657
Diolcogaster facetosa	Canada	CNC	CNCHZ814-09	MIC 000622	655
Diolcogaster perniciosa	New Zealand	CNC	CNCHX294-09	WMIC 0294	657
Dolichogenidea eucalypti	New Zealand	NAZC	NZMG278-11	NZAC04045145	624
Dolichogenidea renaulti	Canada	CNC	ASSR066-09	MIC 000254	628
Hygroplitis sp.	Canada	CNC	CNCHZ654-09	CAM0464	657
Microgaster canadensis	Canada	CNC	TTHYW990-09	08BBHYM-0861	657
Microgaster deductor	Canada	CNC	WOMIA301-11	GOU 0531	658
Microplitis alaskensis	Canada	CNC	HYCNE1521-11	CNCHYM 01706	631
Microplitis croceipes	New Zealand	NAZC	NZMG264-11	NZAC04044359	621
Microplitis plutellae	Canada	CNC	CNCHX192-09	WMIC 0192	658
Paroplitis wesmaeli	France	CNC	WOMIA107-11	WAM 0412	658
Paroplitis wesmaeli	France	CNC	WOMIA106-11	WAM 0411	658
Paroplitis wesmaeli	Sweden	CNC	CNCBR592-09	CNCH1717	632
Paroplitis wesmaeli	Netherlands	CNC	HYCNE1762-11	CNCHYM 01946	407
Pholetesor bedelliae	Canada	CNC	CNCHY059-07	HYM00000331	657
Pholetesor viminetorum	Canada	BIO	BBHYE128-10	09BBEHY-1128	658
Protapanteles alaskensis	Canada	BIO	BBHYE390-10	09BBEHY-1390	658
Rasivalva sp.	New Zealand	CNC	CNCBA920-10	WAM 0370	658
Sathon neomexicanus	Canada	CNC	CNCHY278-07	HYM00000550	583
Shireplitis frodoi	New Zealand	CNC	CNCBA863-10	WAM 0313	658
Shireplitis peregrini	New Zealand	NAZC	NZMG013-11	NZAC04044350	339
Shireplitis tolkieni	New Zealand	CNC	CNCBA901-10	WAM 0351	658
Venanides sp.	New Zealand	CNC	WOMIA201-11	WAM 0506	658
Venanides sp.	New Zealand	CNC	WOMIC672-10	WAM 0122	658
Venanus heberti	Canada	CNC	CNCHZ666-09	MIC 000474	657

Hosts caterpillars are only known for the European species *Paroplitis wesmaeli* (Ruthe), and include four families of Lepidoptera (Yu *et al*. 2012). Larvae of the host species *Scoparia basistrigalis* Knaggs, 1866 (Crambidae), feed on moss (Heckford & Sterling 2005); and larvae of the host species *Bryotropha umbrosella* (Zeller, 1839) (Gelechiidae), also feed on various mosses and grasses while living in a silken tube or tent (http://www.hantsmoths.org.uk/species/0778.php). We could not find any information about the feeding habits of larvae for the other two hosts species, *Hypotia corticalis* (Denis & Schiffermüller, 1775) (Pyralidae), and *Xestia collina* (Boisduval, 1840) (Noctuidae).

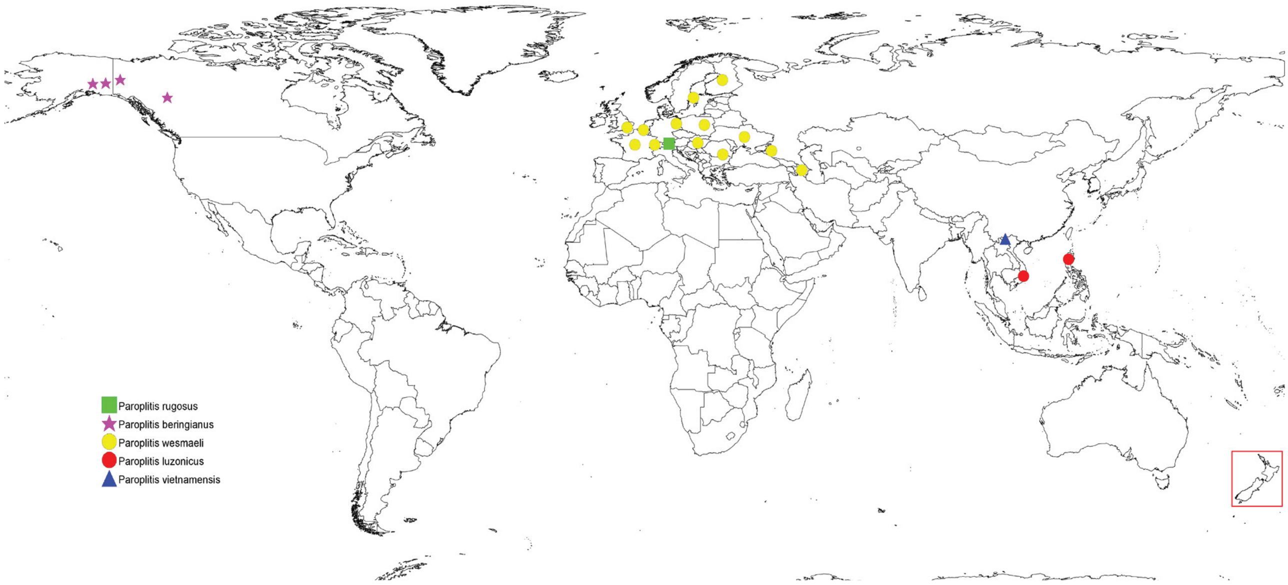


FIGURE 1. Distribution map of world species of *Paroplitis*. Species are individually color coded. The red open rectangle superimposed on New Zealand indicates the distribution of *Shireplitis* (which is detailed in Figure 2).

The new genus, *Shireplitis*, is restricted to New Zealand, mostly the South Island (Fig. 2), and comprises six species collected in moss, litter, or tussock grasslands, mostly on moist conditions, and at moderate altitude on several mountain ranges (usually 800–1800 m, with a few records from 300–500 m, and a single record at 50 m). No host is known for the genus; however, based on the information available, we speculate that *Shireplitis* may parasitize Lepidoptera with detritivorous larvae feeding on moss, leaf-litter, dead wood or fungi. The fauna of New Zealand is distinctive in having the highest proportion of detritivorous Lepidoptera (19 % of species) in the world (Dugdale 1996).

Paroplitis and *Shireplitis* are morphologically similar, at least superficially (Figs 4–42). The most remarkable shared features are the short size, dark color (brown to black), short but robust legs, and short antenna (which in females only has a single rank of placodes per segment). We speculate that these traits have evolved independently in both genera, and are related to the habitat (moss, litter or grasses) and characteristics of the host caterpillars. A robust body and legs, and shortened antennae would be beneficial for moving within the litter environment whilst searching for hosts.

However, *Paroplitis* and *Shireplitis* differ in a number of important morphological traits (see key below), the most important being the different carination patterns of the propodeum, the areolet in the fore wing, and the hypopygium type. Furthermore, they have unrelated and disparate geographical distributions, and most likely differ in the Lepidoptera families that they parasitize. Molecular data also suggest that the two genera are not closely related (Fig. 3), although posterior probabilities (shown on tree) of several branches separating the two genera are low, and the evidence from one gene cannot be considered conclusive. All available information suggests that *Paroplitis* and *Shireplitis* are an example of convergent evolution within Microgastrinae.

Key to separate the genera *Paroplitis* and *Shireplitis*

1 Fore wing of normal proportions, its length around 3.0 x its maximum width; fore wing with closed areolet (Figs 5, 10, 12, 17); propodeum rarely entirely sculptured, almost always with a median longitudinal carina (visible at least on anterior 0.5), and sometimes also with complete or partial transverse carina (Figs 7, 8, 15, 19); T2 almost always smooth (Figs 8, 15, 19), rarely partially and slightly sculptured; hypopygium fully sclerotized (Figs 6, 9, 13, 18) although usually sharply folded medially [Holarctic species, usually North of 40° N (Fig. 1); two species, found in Oriental region at high elevation, represent southern-most range of the genus (12–16° N)] . . . . **_Paroplitis_** Mason 1981

\- Fore wing clearly narrower, its length around 4.0 x its maximum width; fore wing without areolet (Figs 21, 24, 27, 31, 36, 39); propodeum entirely sculptured, without median or transverse carina, but with areola defined on posterior 0.5 of propodeum by two lateral carinae (Figs 22, 25, 28, 33, 34, 37, 42); T2 fully sculptured with longitudinal striation (Figs 22, 25, 28, 33, 37, 42);

hypopygium with a translucid median fold where several pleats are clearly visible (Figs 23, 32, 40) [Species restricted to New Zealand (Fig. 2), South of 39° S] .... ***Shireplitis*** Fernández-Triana and Ward, **new genus**

Taxonomic treatment of species and genera, in alphabetical order

Paroplitis Mason, 1981: 68.

Comments. Based on the known distribution of the genus (Fig. 1) it is noteworthy that no species has been found yet in the Eastern Palaearctic, and records for the Nearctic species are just restricted to northwestern North America. It is likely that more collecting would reveal a few additional species of *Paroplitis*.

Key to world species of *Paroplitis*

1 T2 partially and slightly sculptured; propodeum evenly rugose on its entire surface, without distinctive carination [western Palaearctic region: Austria (Tirol, 2400m)] .... ***Paroplitis rugosus*** Papp, 1991

- T2 mostly smooth and shiny (Figs 8, 15, 19); propodeum only partially rugose, with median carina visible on at least anterior 0.5, and sometimes with complete or partial transverse carina (Figs 7, 8, 15, 19) 2

2(1) Fore wing areolet quadrangular and relatively large, its maximum height 1.1 x vein r length (Fig 5); fore wing with vein 2CUa tubular on its anterior 0.3–0.5 [Nearctic region: Canada (British Columbia, Yukon) and United States (Alaska)] .... ***Paroplitis beringianus*** Mason, 1981

- Fore wing with areolet triangular and relatively small, its maximum height at most 0.7 x vein r length, usually much less (Figs 10, 12, 17); fore wing with vein 2CUa entirely nebulous [western Palaearctic or Oriental regions] 3

3(2) Propodeum usually without trace of transverse carina (Fig. 19); fore wing with areolet very small, its maximum height 0.2 x vein r length, its maximum width 0.2 x vein r length (Fig. 17) [western Palaearctic region: Azerbaijan, Belgium, Finland, France, Germany, Hungary, Poland, Romania, Russia (Krasnodar Kray), Sweden, Switzerland, Ukraine, United Kingdom] ... . ***Paroplitis wesmaeli*** (Ruther, 1860)

- Propodeum with a more or less complete and defined transverse carina (Fig 15); fore wing with areolet larger, its maximum height 0.5–0.7 x vein r length, its maximum width 0.6–0.7 x vein r length (Figs 10, 12) [Oriental region, between 1700–2400 m] 4

4(3) Scape, tegula, humeral complex, and legs entirely yellow (except for anterior 0.5–0.7 of metacoxa which is brown) (Fig. 9); fore wing with vein R1 as long as or longer than pterostigma length, and much longer than distance delimited between end of vein R1 and end of vein 3RSb (Fig. 10) [Oriental region: Philippines (Luzon Island) and southern Vietnam (Lam Dong)] .... ***Paroplitis luzonicus*** Mason, 1981

- Scape, tegula, humeral complex, and most of legs entirely brown to dark brown (Figs 11–15); fore wing with vein R1 shorter than pterostigma length and same length (at most slightly larger) than distance delimited between end of vein R1 and end of vein 3RSb (Fig. 12) [Oriental region: northern Vietnam (Tonkin)] .... ***Paroplitis vietnamensis*** van Achterberg and Fernández-Triana **new species**

Paroplitis beringianus Mason, 1981. Nearctic: Canada (British Columbia, Yukon), United States (Alaska).

Comments. Description and images of the species in Mason (1981), additional images (Figs 4–8). One male specimen from CNC is the first record for the Yukon, with labels data: 1. CANADA, YT, Top of the world Hwy, Km 82, 19.vii.2006, 64°05.411'N 140°57.048'W, sweeping clover along road, Goulet & Boudreault, 2006, # 16. 2. HYM00000543. That specimen was sampled for COI, but no DNA could be recovered.

Paroplitis rugosus Papp, 1991. Western Palaearctic: Austria.

Comments. Description and images of the species in Papp (1991). Only known from the female holotype. Its distribution seems to overlap with that of *P. wesmaeli*, although *P. rugosus* was collected at relatively high altitude, 2400 m, in the Alps.

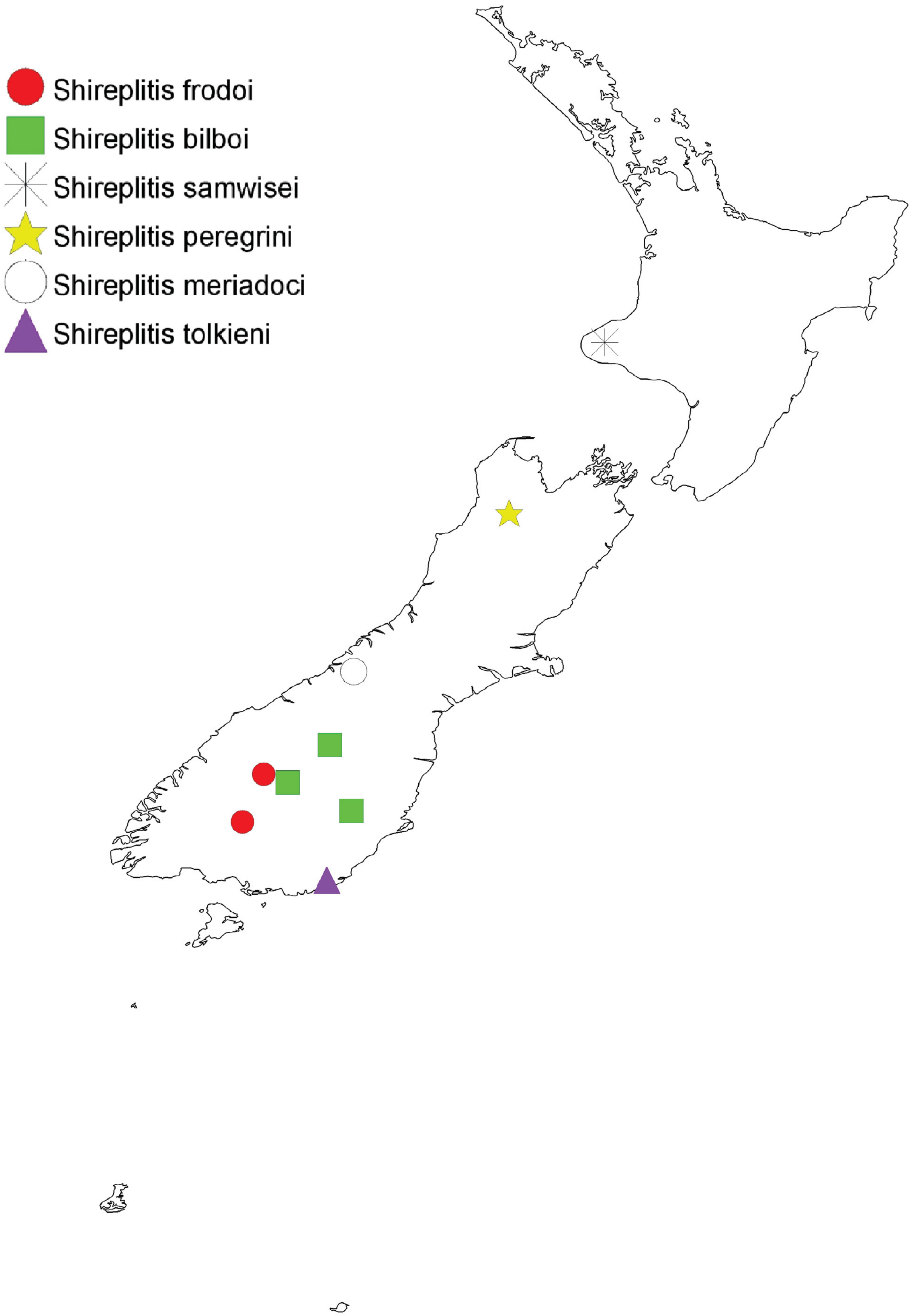


FIGURE 2. Distribution map of *Shireplits* species in New Zealand. Species are individually color coded.

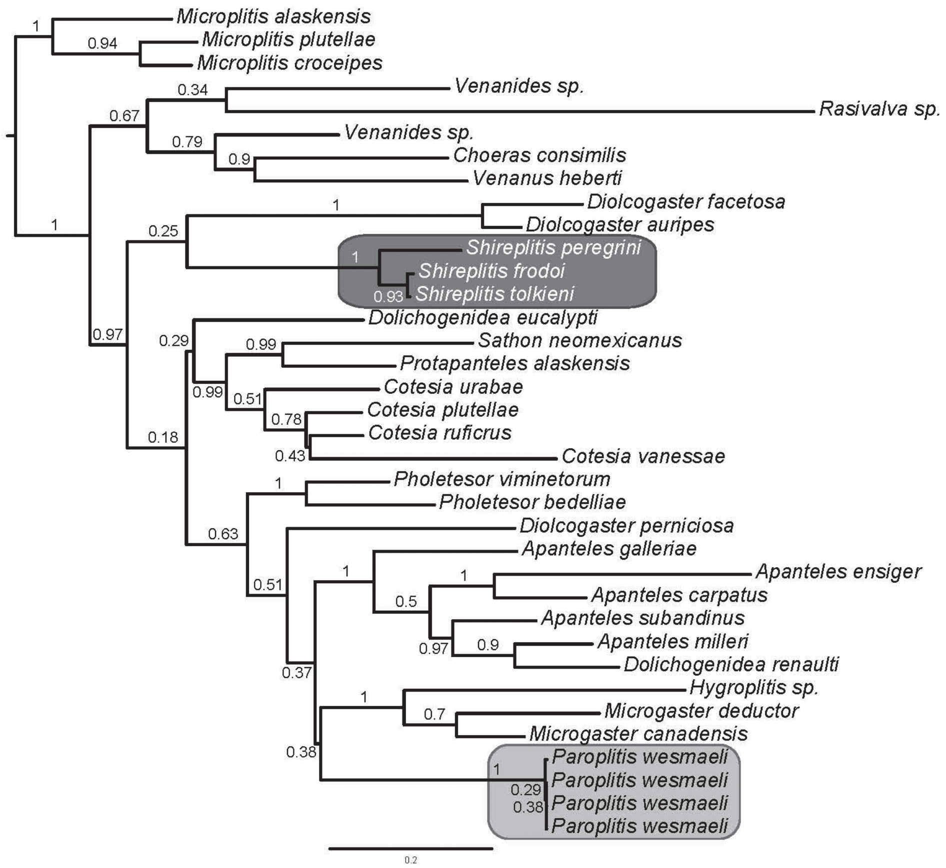


FIGURE 3. Bayesian Maximum Clade Credibility Tree based on the COI barcoding region of various genera of Microgatrinae. *Shireplitis* (shaded in dark grey) and *Paroplitis* (shaded in light grey) do not appear to be closely related, though posterior probabilities (shown on tree) of several branches separating the two genera are low.

Paroplitis luzonicus Mason, 1981. Oriental: Philippines, Vietnam.

Comments. Description in Mason (1981), images (Figs 9–10). One female specimen from NCB represents the first record of the species for Vietnam, with label data: Southern Vietnam, Lam Dong, Bidoup Nuiba N.P., nr Da Lat, Mal. Trap 1–12, 1650–1700 m, 11–19.x.2005, C.v.Achterberg & R. de Vries, RMNH'05.

Paroplitis vietnamensis van Achterberg and Fernández-Triana **new species**
(Figs 11–15)

Type locality. VIETNAM: Tonkin, Lao Cai Province. Hoang Lien N.R., 15 km W Sa Pa.

Holotype. Female, NCB. Holotype labels: 1. NW Vietnam: Tonkin. Hoang Lien N.R., 15 km W Sa Pa, c. 1900 m, 15–21.x.1999, Malaise traps, C.v.Achterberg, RMNH'99.

Paratypes. 1 ♀ (CNC) and 1 ♀ (IEBR), same labels as holotype.

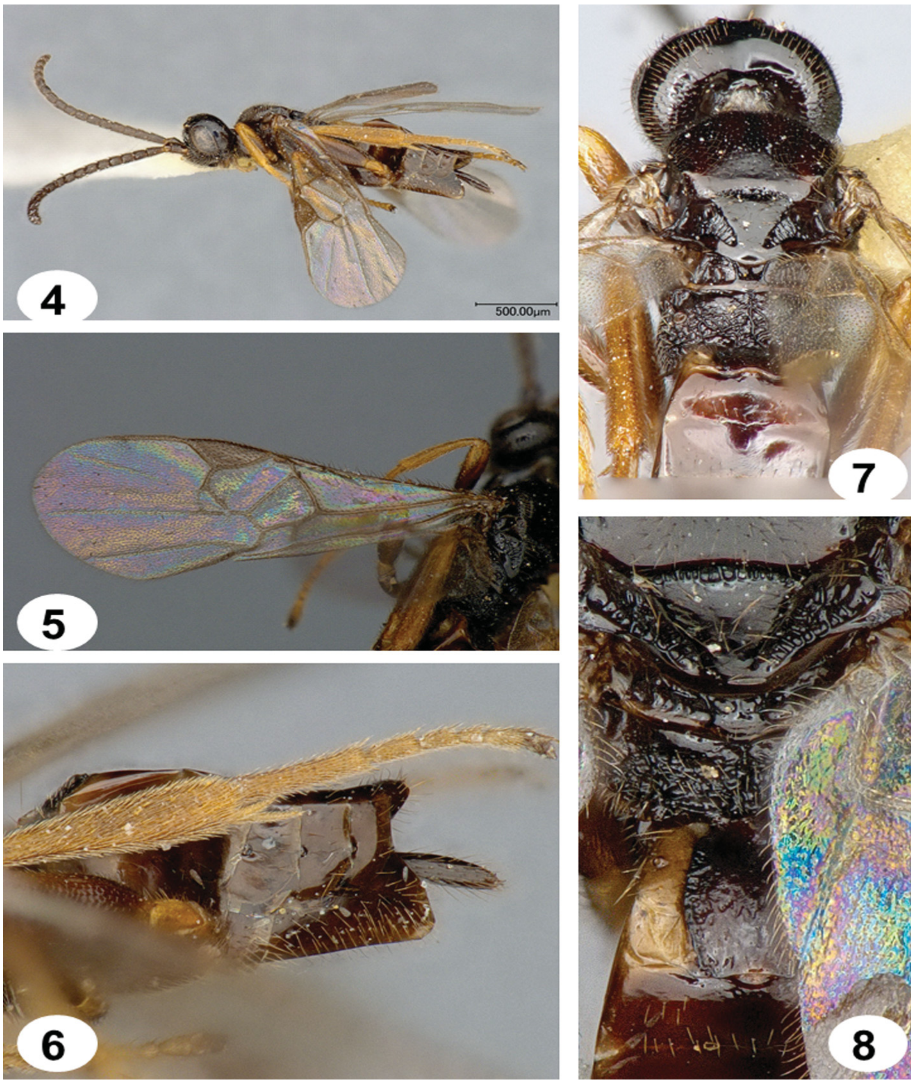
Description. Female. Body length: 2.1–2.3 mm. Fore wing length: 2.2–2.4 mm. Scape, tegula, humeral complex, and most of legs entirely brown to dark brown. Flagellomerus 2 length/width: 1.5–1.6 x. Flagellomerus 14 length/width: 1.2–1.3 x. Flagellomerus 2 length/flagellomerus 14 length: 1.5–1.6 x. Ocular–ocellar line/posterior ocellus diameter: 2.5 x. Interocellar distance/posterior ocellus diameter: 1.7 x. Fore wing with vein 2CUa entirely nebulous; and vein R1 shorter than pterostigma length and same length (at most slightly larger) than distance delimited between end of vein R1 and end of vein 3RSb. Fore wing with areolet triangular and relatively small, its maximum height 0.5 x vein r length, its maximum width 0.7 x vein r length. Propodeum mostly smooth and shiny, with some striation near transverse carina; median longitudinal and transverse carinae complete.

Metafemur length/width: 2.5–2.6 x. Mediotergite 1 and 2 mostly smooth; T1 1.9 x as long as wide at posterior margin; T2 2.0 x as wide at posterior margin as long. Metatibia length: 0.68–0.71 mm. Metatibia length/ovipositor sheaths length: 2.2–2.4 x. Ovipositor sheaths length: 0.28–0.32 mm.

Male. Unknown.

Distribution. Oriental: northern Vietnam.

Etymology. The name refers to the country where the species is found.



FIGURES 4–8. *Paroplitis beringianus*. 4- Habitus. 5- Fore wing. 6- Hypopygium. 7- Dorsal view of mesosoma and part of metasoma. 8- Details of mesoscutellar disc, propodeum and meditergites 1-2.

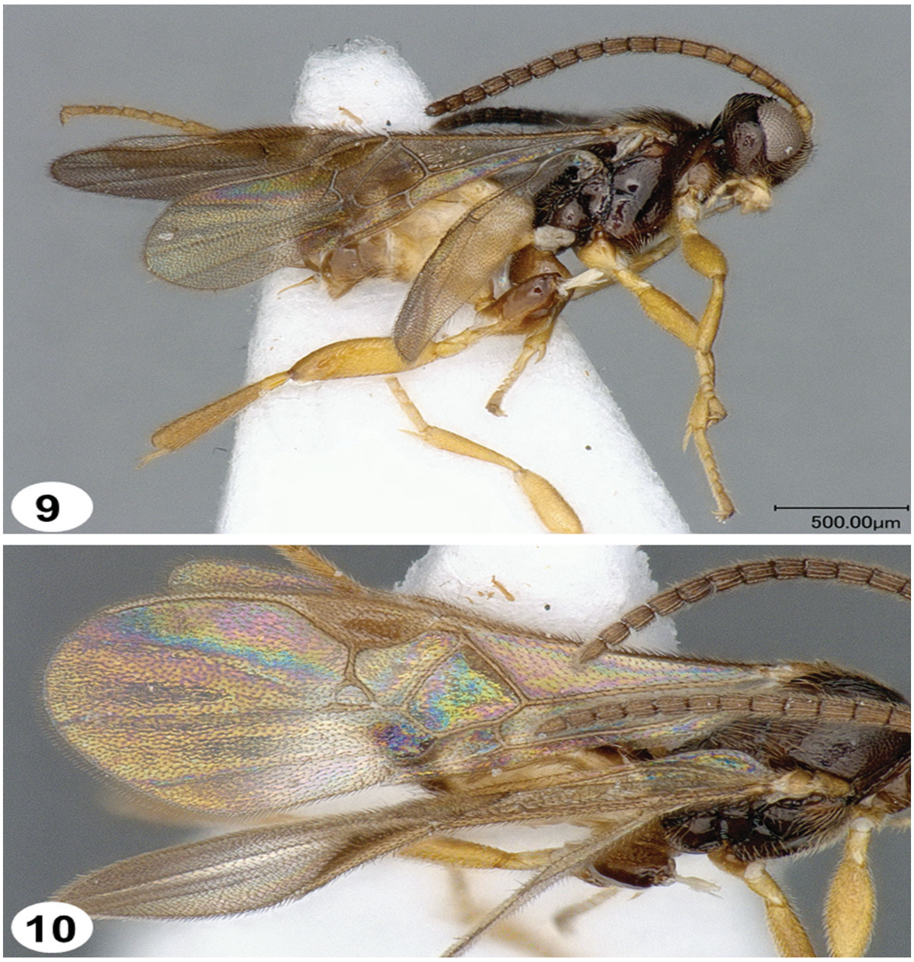
Paroplitis wesmaeli (Ruther, 1860). Western Palaearctic: Azerbaijan, Belgium, Finland, France, Germany, Hungary, Poland, Romania, Russia, Sweden, Switzerland, Ukraine, United Kingdom.

Comments. Description and images of the species in Papp (1991), additional images (Figs 16–19). This is the only species of *Paroplitis* where DNA barcodes are available (Fig. 3), and host data are known. It also seems to be the most widespread of all known species.

Shireplitis Fernández-Triana and Ward **new genus**

Type species. ***Shireplitis bilboi*** Fernández-Triana and Ward, by present designation.

Description. Body length 1.8–2.4 mm. Fore wing distinctly narrow (4.0 x as long as maximum width), and 0.1–0.3 mm shorter than body length. Body colour brown to black. Females with reduced length of antennal segments, which only have a single rank of placodes. Legs short and robust, with metafemur usually less than 3.0 x as long as wide. Fore wing without areolet. Propodeum entirely sculptured and with areola defined by carinae on posterior 0.5. Ovipositor sheaths 0.4–0.5 x as long as metatibia. Hypopygium with translucid median fold where several pleats are clearly visible.



FIGURES 9–10. *Paroplitis luzonicus*. 9- Habitus. 10- Fore wing.

Distribution. Endemic to New Zealand, where is distributed mostly in mountain ranges of the South Island, with one species found in the southern third of the North Island (latitudinal range: 39–46° S).

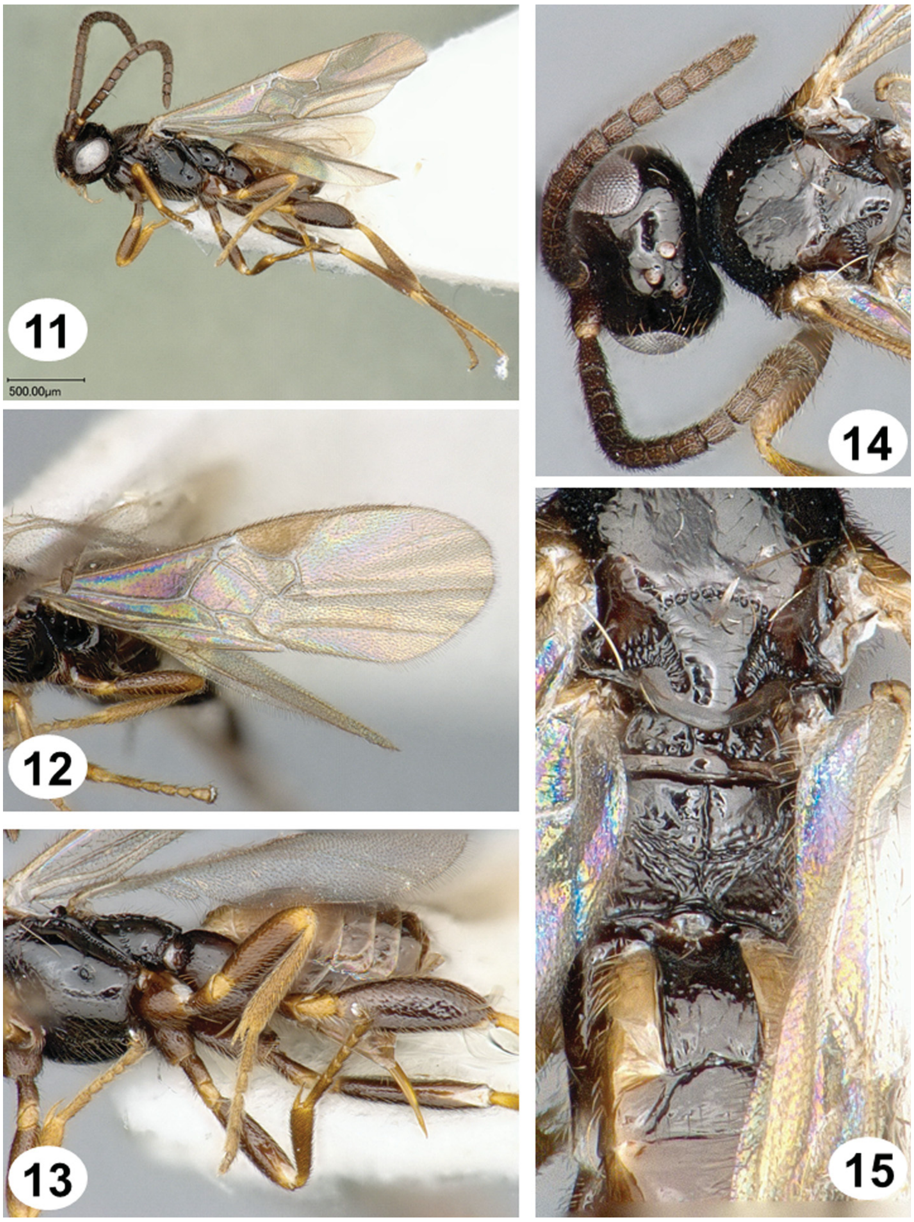
Biology. Unknown. Most of the species have been collected in moist areas with moss, litter and/or grasses; it is suspected that its hosts are detritivorous Lepidoptera.

Putatives autopomorphies. Reduced length of antennal segments in females, both sexes with short and robust legs, propodeum entirely sculptured, with areola defined posteriorly by carinae, and hypopygium with translucid median fold with pleats.

Molecular data. DNA barcodes were available for three species (from one specimen each). *Shireplitis* is recovered as monophyletic, and clearly separate from *Paroplitis* (Fig. 3). Based on those sequences, *Shireplitis peregrini* is very distinctive from the other two *Shireplitis* species, but *S. frodoi* and *S. tolkieni* only differ in 7 base pairs (1.1 %).

Comments. Morphologically similar to the genus *Paroplitis*, it can be separated from the latter by the key provided above.

Etymology. The first part of the name "Shire" refers to The Shire, the region exclusively inhabited by Hobbits in J. R. R. Tolkien's fictional universe setting of Middle-earth (the genus is endemic to New Zealand, where a human replicate of The Shire is built). The second part of the name "plitis" refers to the superficial morphological similarities with the genus *Paroplitis*.



FIGURES 11–15. *Paroplitis vietnamensis*. 11- Habitus. 12- Fore wing. 13- Hypopygium, legs, and latero-ventral side of mesosoma (partially). 14- Head, antennae, and anteromesoscutum. 15- Anteromesoscutum, propodeum and mediotergites 1–3.

Key to species of *Shireplitis*

1 Smaller species, fore wing length 1.6–1.7 mm (rarely up to 1.8 mm), body length 1.8–2.0 mm, metatibia 0.52–0.63 mm, ovipositor sheaths 0.24–0.29 mm; metafemur relatively thick, its length 2.3–2.5 x its maximum width (rarely up to 2.6 x) 2

\- Larger species, fore wing length 2.0–2.3 mm, body length 2.1–2.4 mm (usually over 2.2 mm), metatibia 0.70–0.80 mm (very rarely 0.63 mm), ovipositor sheaths 0.30–0.40 mm (***if***, very rarely, 0.27 mm ***then*** metafemur 2.9 x as long as wide); metafemur relatively thin, its length 2.6–2.9 x its maximum width 3

2(1) Metafemur 0.39–0.48 mm; ocular-ocellar line 3.4–4.3 x posterior ocellus diameter (very rarely 3.2 x); first discal cell relatively transverse, its maximum width 1.6–1.8 x its height (Fig. 21) [Carrick, Dunstan, and Rock and Pillar Ranges, CO; between 820–1560 m; collected either on *Sphagnum* bog, or tussock grassland] . . . . ***Shireplitis bilboi*** Fernández-Triana and Ward, **new species**

\- Metafemur 0.51 mm; ocular-ocellar line 3.1 x posterior ocellus diameter; first discal cell less transverse, its maximum width 1.4 x its height (Fig. 39) [Catlins State forest park, Catlins River, SL; around 50 m] . . . . ***Shireplitis tolkieni*** Fernández-Triana and Ward, **new species**

3(2) Body length 2.1 mm, ***and*** ovipositor sheaths 0.27 mm; metafemur 3.0 x as long as wide; legs and metasoma light brown (Fig 26, 28, 29) [Mount Cook, MK; 850 m; collected on moss] . . . ***Shireplitis meriadoci*** Fernández-Triana and Ward, **new species**

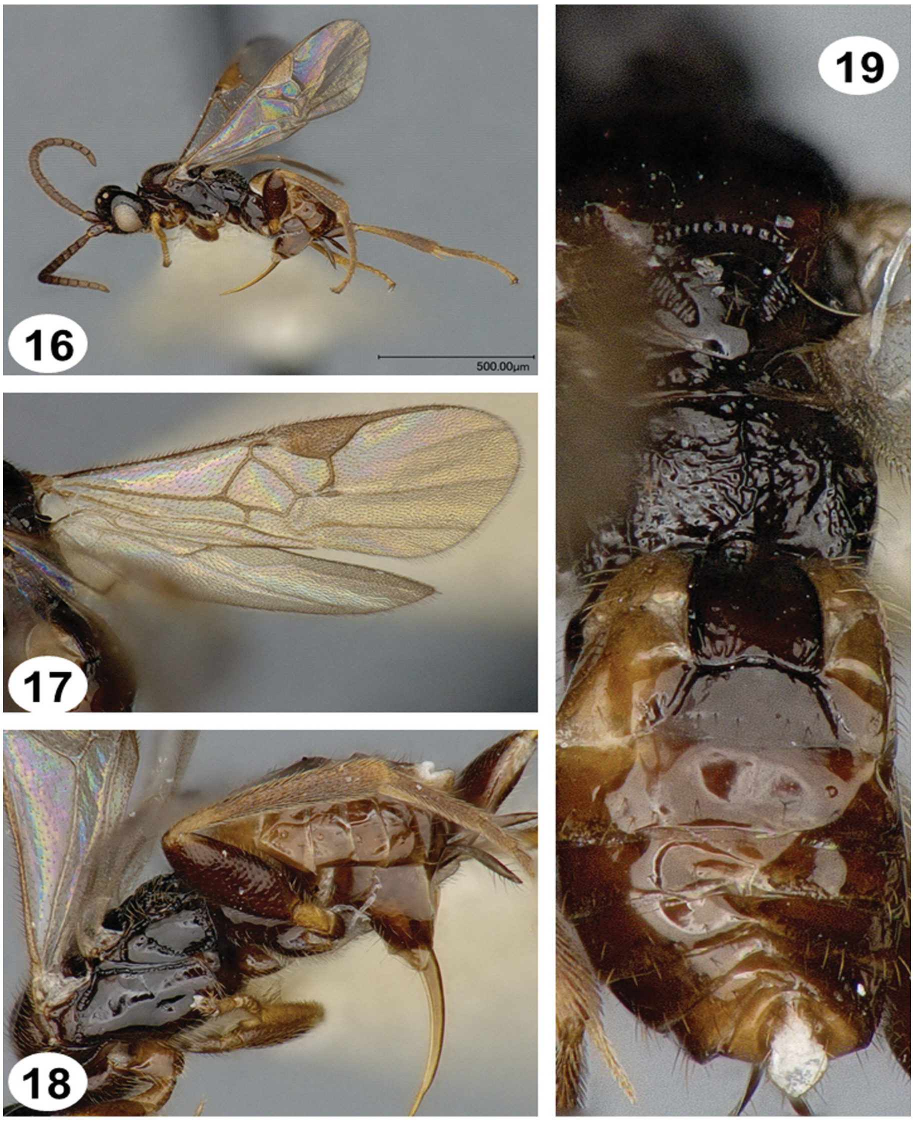
\- Body length 2.3–2.4 mm, ***if*** 2.1 mm ***then*** ovipositor sheaths 0.40 mm (ovipositor sheaths otherwise 0.30–0.36 mm); metafemur 2.5–2.9 x as long as wide; body colour dark brown to black (Figs 23–25, 30–37). 4

4(3) Antennal segments relatively short (Fig 23), flagellomerus 2 1.2 x as long as wide, and flagellomerus 14 0.8–0.9 x as long as wide; ovipositor sheaths 0.30–0.32 mm; metatibia 0.69–0.73 mm, and metafemur 0.52–0.57 mm; metafemur 2.5–2.7 x as long as wide; [Distributed in the southermost third of South Island: Coronet Peak, Cromel Stream, OL; between 340–1450 m] . . . . ***Shireplitis frodoi*** Fernández-Triana and Ward, **new species**

\- Antennal segments relatively long (Figs 30, 35), flagellomerus 2 1.4–1.5 x as long as wide, and flagellomerus 14 1.2–1.5 x as long as wide; ovipositor sheaths 0.34–0.40 mm (very rarely 0.32 mm); metatibia 0.74–0.83 mm, and metafemur 0.57–0.63 mm; metafemur 2.8–2.9 x as long as wide [Distributed either on North Island or northernmost third of South Island] 5

5(4) Body length 2.1 mm; flagellomerus 2 1.6 x as long as flagellomerus 14; relatively small eyes, ocular-ocellar line 3.8 x as long as posterior ocellus diameter, and interocellar distance 2.0 x as long as posterior ocellus diameter; first discal cell less transverse, its maximum width 1.5 x its height; metatibia 1.9 x as long as ovipositor sheaths [Mount Arthur summit, NN; at 1826 m] . . . . ***Shireplitis peregrini*** Fernández-Triana and Ward, **new species**

\- Body length 2.2–2.4 mm; flagellomerus 2 1.3–1.5 x as long as flagellomerus 14; relatively large eyes, ocular-ocellar line 2.8–3.5 x as long as posterior ocellus diameter, and interocellar distance 1.8 x as long as posterior ocellus diameter; first discal cell relatively transverse, its maximum width 1.6–1.7 x its height; metatibia 2.1–2.5 x as long as ovipositor sheaths [Pouakai Saddle, TK; 1220 m; collected either on litter or *Poa colensoi* swards]. . . . . ***Shireplitis samwisei*** Fernández-Triana and Ward, **new species**



FIGURES 16–19. *Paroplitis wesmaeli*. 16- Habitus. 17- Fore wing. 18- Lateral side of meso and metasoma, including hypopygium. 19- Dorsal view of scutellar disc, propodeum, and mediotergites.

FIGURES 20–22. *Shireplitis bilboi*. 20- Habitus. 21- Fore wing. 22- Dorsal view of scutellar disc, propodeum, and mediotergites.

Shireplitis bilboi Fernández-Triana and Ward, **new species**
(Figs 20–22)

Type locality. NEW ZEALAND: CO, Dunstan Range, 1560 m.

Holotype. Female, NZAC. Holotype labels: 1. New Zealand, CO, Dunstan Range, 1560 m, 13 Jan 1971, JS Dugdale. 2. Moss 71/2, 2. NZAC04045187.

Paratypes. 1 ♀ (CNC), New Zealand, CO, Dunstan Range, 1560 m, 13 Jan 1971, JS Dugdale coll., on moss; 7 ♀, 1 ♂ (LUNZ), New Zealand, CO, Great Moss Swamp, Howell Hut, 820 m, 9–12/2/1986, JW Early coll., yellow trap or pitfall trap in *Sphagnum* bog; 2 ♀ (LUNZ), CO, Carrick Range, Watts Rk, 1300 m, 5–8/2/1986, JW Early coll., yellow pan trap in tussock grassland; 1 ♀ (LUNZ), CO, Howells Hut, 12/2/1986, RM Emberson coll., pitfall trap in *Sphagnum* bog; 6 ♀, 4 ♂ (NZAC), New Zealand, CO, Dunstan Range, 1560 m, 13 Jan 1971, JS Dugdale coll., on moss.

Description. Female. Body length: 1.8–2.0 mm (X=1.9 mm). Body color: legs and metasoma dark brown to black. Fore wing length: 1.6–1.8 mm (X=1.7 mm). Fore wing discal cell maximum width/height: 1.6–1.8 x. Ocular–ocellar line/posterior ocellus diameter: 3.2–4.3 x (X=3.7 x). Interocellar distance/posterior ocellus diameter: 1.7–2.0 x, rarely 1.5–1.6 x (X=1.8 x). Flagellomerus 2 length/width: 1.1–1.3 x, rarely 1.4 x (X=1.2 x).

Flagellomerus 14 length/width: 0.8–1.1 x (X=0.9 x). Flagellomerus 2 length/flagellomerus 14 length: 1.3–1.5 x, rarely 1.6 x (X=1.4 x). Metafemur length/width: 2.3–2.6 x (X=2.4 x). Metafemur length: 0.39–0.48 mm (X=0.43 mm). Metatibia length: 0.52–0.60 mm (X=0.56 mm). Metatibia length/ovipositor sheaths length: 2.1–2.2 x, rarely 2.0 x or 2.4 x (X=2.2 x). Ovipositor sheaths length: 0.24–0.27 mm (X=0.26 mm).

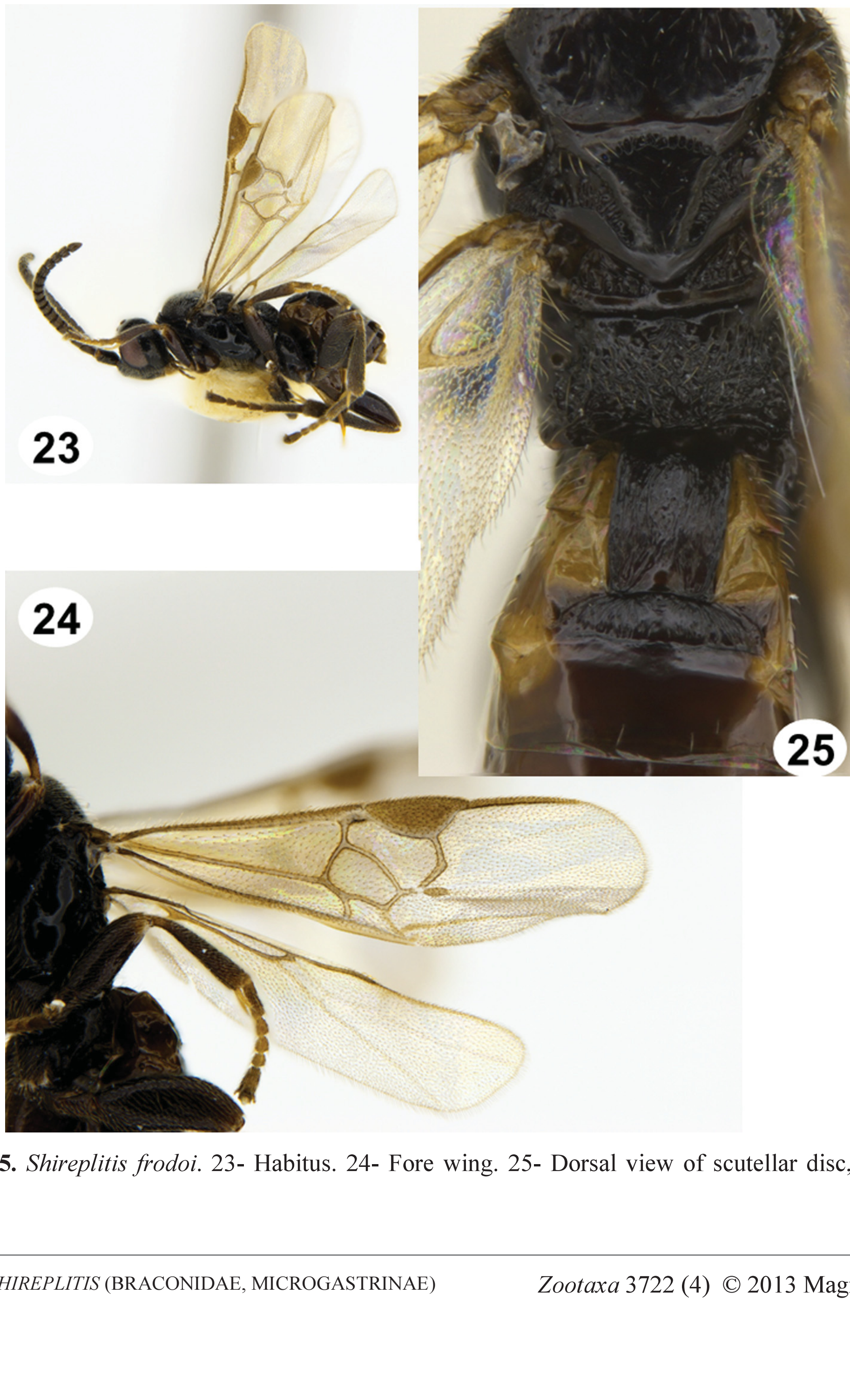
Male. Same as females.

Etymology. Named after Bilbo Baggins, the title character of the famous novel The Hobbit, written by J. R. R. Tolkien.

Shireplitis frodoi Fernández-Triana and Ward, **new species**
(Figs 23–25)

Type locality. NEW ZEALAND: OL, Coronet Peak, 1450 m.

Holotype. Female, NZAC. Holotype labels: 1. New Zealand, OL, Coronet Peak, 1450 m, 27 Jan 1996, BIP Barratt, Malaise trap, 2. NZAC04048842.



FIGURES 23–25. *Shireplitis frodoi*. 23- Habitus. 24- Fore wing. 25- Dorsal view of scutellar disc, propodeum, and mediotergites.

Paratypes. 1 ♀ (CNC), New Zealand, OL, Cromel Stream 340 m, 45.576°S, 168.373°E, 8.iii.2010, L. Masner coll., screen sweeping (DNA barcoding code: WAM 0313); 3 ♀, 12 ♂, (LUNZ), New Zealand, CO, Great Moss Swamp, Howell Hut, 820 m, 9–12/2/1986, JW Early coll., yellow trap in *Sphagnum* bog; 10 ♀, 1 ♂ (NZAC), New Zealand, OL, Coronet Peak, between 450 and 1450 m, various dates between: 16 Dec 1995 to 10 Feb 1996, BIP Barratt coll., Malaise trap.

Description. Female. Body length: 2.3–2.4 mm (X=2.4 mm). Body color: legs and metasoma dark brown to black. Fore wing length: 2.0–2.1 mm (X=2.0 mm). Fore wing discal cell maximum width/height: 1.6–1.7 x. Ocular–ocellar line/posterior ocellus diameter: 2.6–2.7 x, rarely 3.0–3.1 x (X=2.8 x). Interocellar distance/posterior ocellus diameter: 1.5–1.8 x, rarely 1.9–2.0 x (X=1.8 x). Flagellomerus 2 length/width: 1.2 x. Flagellomerus 14 length/width: 0.8–0.9 x, rarely 1.0–1.1 x (0.9 x). Flagellomerus 2 length/flagellomerus 14 length: 1.4–1.6 x (X=1.6 x). Metafemur length/width: 2.5–2.8 x (2.6 x). Metafemur length: 0.52–0.57 mm (0.55 mm). Metatibia length: 0.68–0.73 mm (X=0.70 mm). Metatibia length/ovipositor sheaths length: 2.1–2.3 x (X=2.2 x). Ovipositor sheaths length: 0.30–0.32 mm (X=0.31 mm).

Male. As female, with legs and mediotergite 1 slightly slender.

Etymology. Named after the hobbit Frodo Baggins, one of the primary characters of The Lord of the Rings, J. R. R. Tolkien's masterpiece.

Shireplitis meriadoci Fernández-Triana and Ward, **new species**
(Figs 26–29)

Type locality. NEW ZEALAND: MK, Mount Cook tr. Tokea Point, 850 m.

Holotype. Female, NZAC. Holotype labels: 1. NEW ZEALAND, MK, Mt Cook, 850m, Tr. Tokea Point, 7 Jan 1966, J. I. Townsend. 2. Moss 66/2. 3. NZ Arthropod Collection, Private Bag 92170, Auckland, New Zealand, NZAC04045142.

Description. Female. Body length: 2.1 mm. Body color: legs and metasoma mostly light brown. Fore wing length: 2.0 mm. Fore wing discal cell maximum width/height: 1.7 x. Ocular–ocellar line/posterior ocellus diameter: 3.3 x. Interocellar distance/posterior ocellus diameter: 1.8 x. Flagellomerus 2 length/width: 1.4 x. Flagellomerus 14 length/width: 1.3 x. Flagellomerus 2 length/flagellomerus 14 length: 1.4 x. Metafemur length/width: 3.0 x. Metafemur length: 0.55 mm. Metatibia length: 0.69 mm. Metatibia length/ovipositor sheaths length: 2.6 x. Ovipositor sheaths length: 0.27 mm.

Male. Unknown.

Etymology. Named after Meriadoc (Merry) Brandybuck, friend and companion of Frodo in the novel The Lord of the Rings.

Shireplitis peregrini Fernández-Triana and Ward, **new species**
(Figs 30–34)

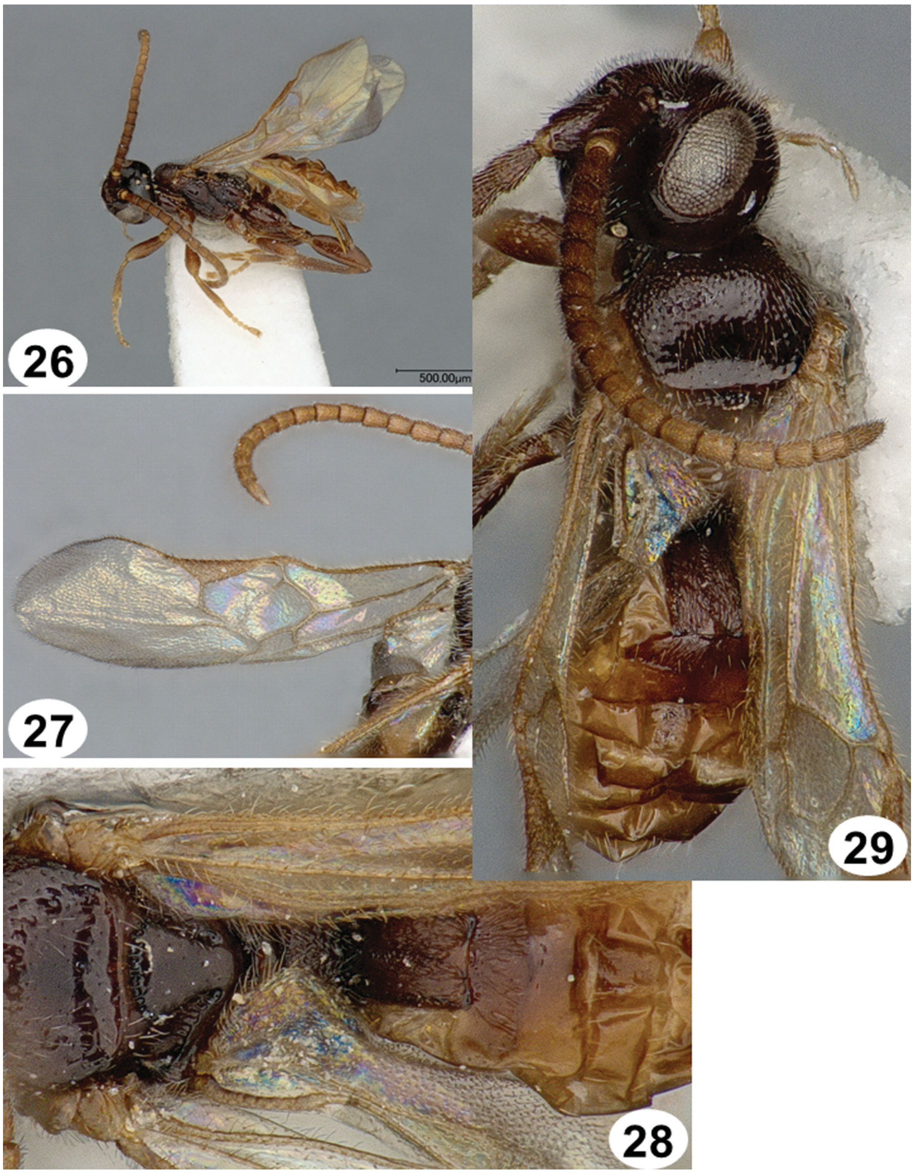
Type locality. NEW ZEALAND: NN, Mount Arthur, 1826m.

Holotype. Female, NZAC. Holotype labels: 1. NEW ZEALAND, NN, Mt. Arthur, 1826m, 4 Jan 88. 2. A.K. Walker, on summit, snow. 3. NZ Arthropod Collection, Private Bag 92170, Auckland, New Zealand, NZAC04044350.

Description. Female. Body length: 2.1 mm. Body color: legs and metasoma dark brown to black. Fore wing length: 2.1 mm. Fore wing discal cell maximum width/height: 1.5 x. Ocular–ocellar line/posterior ocellus diameter: 3.8 x. Interocellar distance/posterior ocellus diameter: 2.0 x. Flagellomerus 2 length/width: 1.4 x. Flagellomerus 14 length/width: 1.1 x. Flagellomerus 2 length/flagellomerus 14 length: 1.6 x. Metafemur length/width: 2.9 x. Metafemur length: 0.62 mm. Metatibia length: 0.74 mm. Metatibia length/ovipositor sheaths length: 1.9 x. Ovipositor sheaths length: 0.40 mm.

Male. Unknown.

Etymology. Named after Peregrin (Pippin) Took, friend and companion of Frodo in the novel The Lord of the Rings.



FIGURES 26–29. *Shireplitis meriadoci*. 26- Habitus. 27- Fore wing. 28- Dorsal view of scutellar disc, propodeum (partially), and mediotergites 1-5. 29- Body dorsal view.

Shireplitis samwisei Fernández-Triana and Ward, **new species**
(Figs 35–37)

Type locality. NEW ZEALAND: TK, Pouakai Range, W edge of Hump Plateau.

Holotype. Female, NZAC. Holotype labels: New Zealand, TK, Pouakai Ra. W edge of Hump Plateau, 2 Dec 1975, 2. JS Dugdale, swards & mosses, 75/200, 3. NZAC04048822.

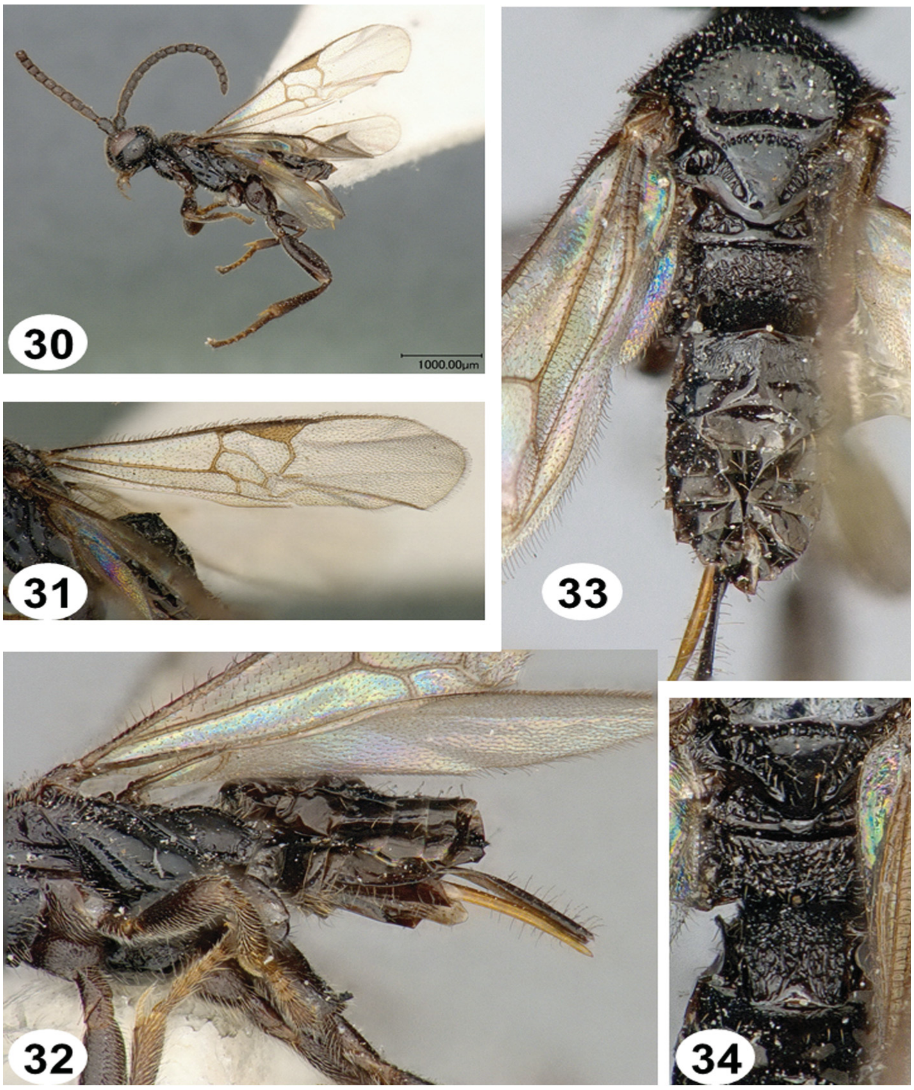
Paratypes. 1 ♀ (CNC), 8 ♀ (NZAC), New Zealand, TK, Pouakai Sdle, 1220m, 3 Dec 1975, JS Dugdale coll., on litter, sward & mosses, or *Poa colensoi* swards.

Description. Female. Body length: 2.2–2.4 mm (X=2.3 mm). Body color: legs and metasoma dark brown to black. Fore wing length: 2.0–2.1 mm, rarely 2.3 mm (X=2.1 mm). Fore wing discal cell maximum width/height: 1.6–1.7 x. Ocular–ocellar line/posterior ocellus diameter: 2.8–3.3 x, rarely 3.4–3.5 x (X=3.1 x). Interocellar distance/posterior ocellus diameter: 1.7–1.8 x (X=1.8 x). Flagellomerus 2 length/width: 1.4–1.5 x (1.5 x). Flagellomerus 14 length/width: 1.2–1.5 x (X=1.4 x). Flagellomerus 2 length/flagellomerus 14 length: 1.3–1.4 x, rarely 1.5 x (X=1.4 x). Metafemur length/width: 2.8–2.9 x (X= 2.9 x). Metafemur length: 0.57–0.62 mm (X=0.61

mm). Metatibia length: 0.75–0.83 mm (X=0.79 mm). Metatibia length/ovipositor sheaths length: 2.1–2.4 x, rarely 2.5 x (X=2.3 x). Ovipositor sheaths length: 0.32–0.36 mm (X=0.34 mm).

Male. Unknown.

Etymology. Named after Samwise (Sam) Gamgee, sidekick of Frodo and one of the main characters in the novel The Lord of the Rings.



FIGURES 30–34. *Shireplitis peregrini*. 30- Habitus. 31- Fore wing. 32- Lateral side of meso and metasoma, including hypopygium. 33- Dorsal view of scutellar disc, propodeum, and mediotergites. 34- Details of propodeum, mediotergite 1 and 2.

Shireplitis tolkieni Fernández-Triana and Ward, **new species**
(Figs 38–42)

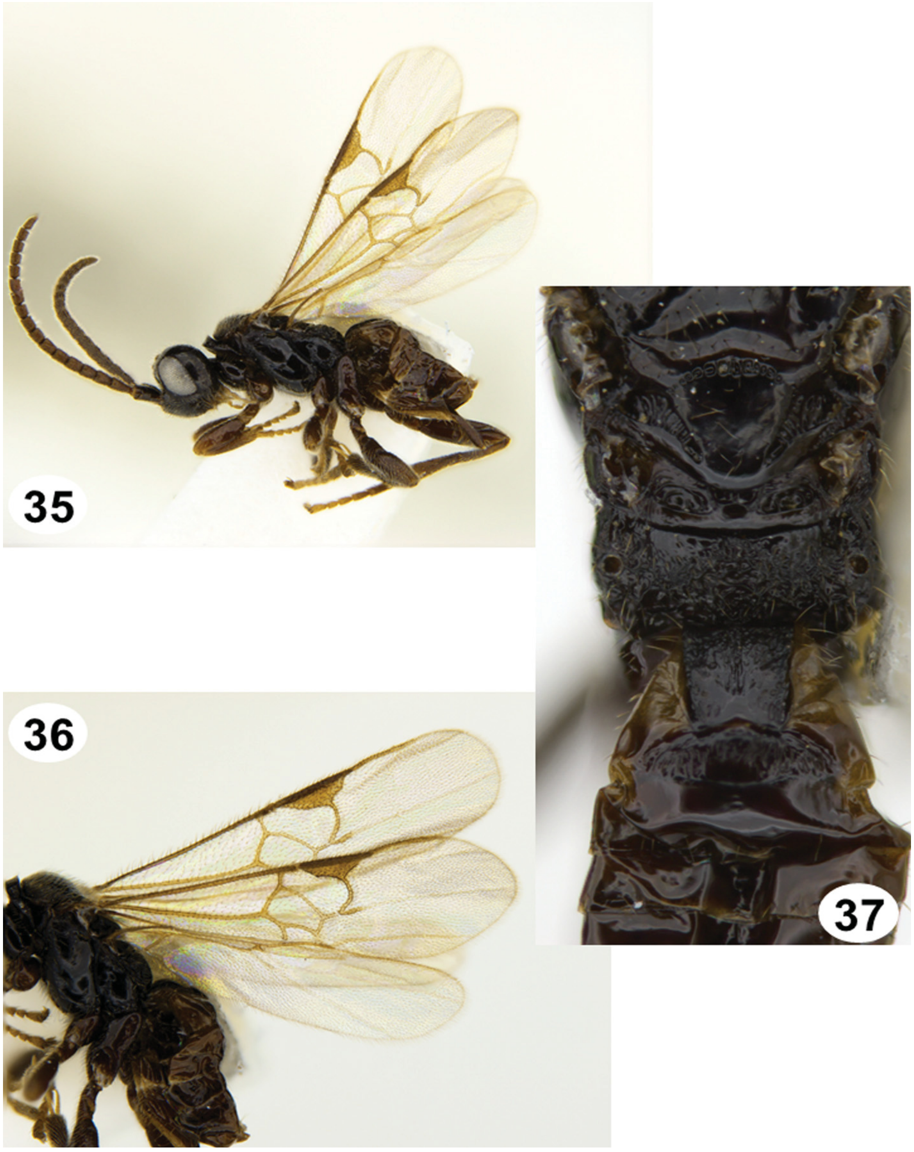
Type locality. NEW ZEALAND: SL, Catlins, State Forest Park, Shaw Road.

Holotype. Female, NZAC. Holotype labels: 1. NEW ZEALAND: SI, Catlins, State forest Park, Shaw Road, 13.i.1999, Sweeping various herbs along road, L. Le Sage, NZ-15. 2. WAM 0351. 3. NZAC04049517.

Description. Female. Body length: 2.0 mm. Body color: legs and metasoma dark brown to black. Fore wing length: 1.8 mm. Fore wing discal cell maximum width/height: 1.5 x. Ocular–ocellar line/posterior ocellus diameter: 3.1 x. Interocellar distance/posterior ocellus diameter: 2.1 x. Flagellomerus 2 length/width: 1.4 x. Flagellomerus 14 length/width: 0.9 x. Flagellomerus 2 length/flagellomerus 14 length: 1.6 x. Metafemur length/width: 2.6 x. Metafemur length: 0.51 mm. Metatibia length: 0.63 mm. Metatibia length/ovipositor sheaths length: 2.2 x. Ovipositor sheaths length: 0.29 mm.

Male. Unknown.

Etymology. Named after John Ronald Reuel Tolkien, as a humble homage to his extraordinary literary works.



FIGURES 35–37. *Shireplitis samwisei*. 35- Habitus. 36- Fore wing. 37- Dorsal view of scutellar disc, propodeum, and mediotergites 1-4.

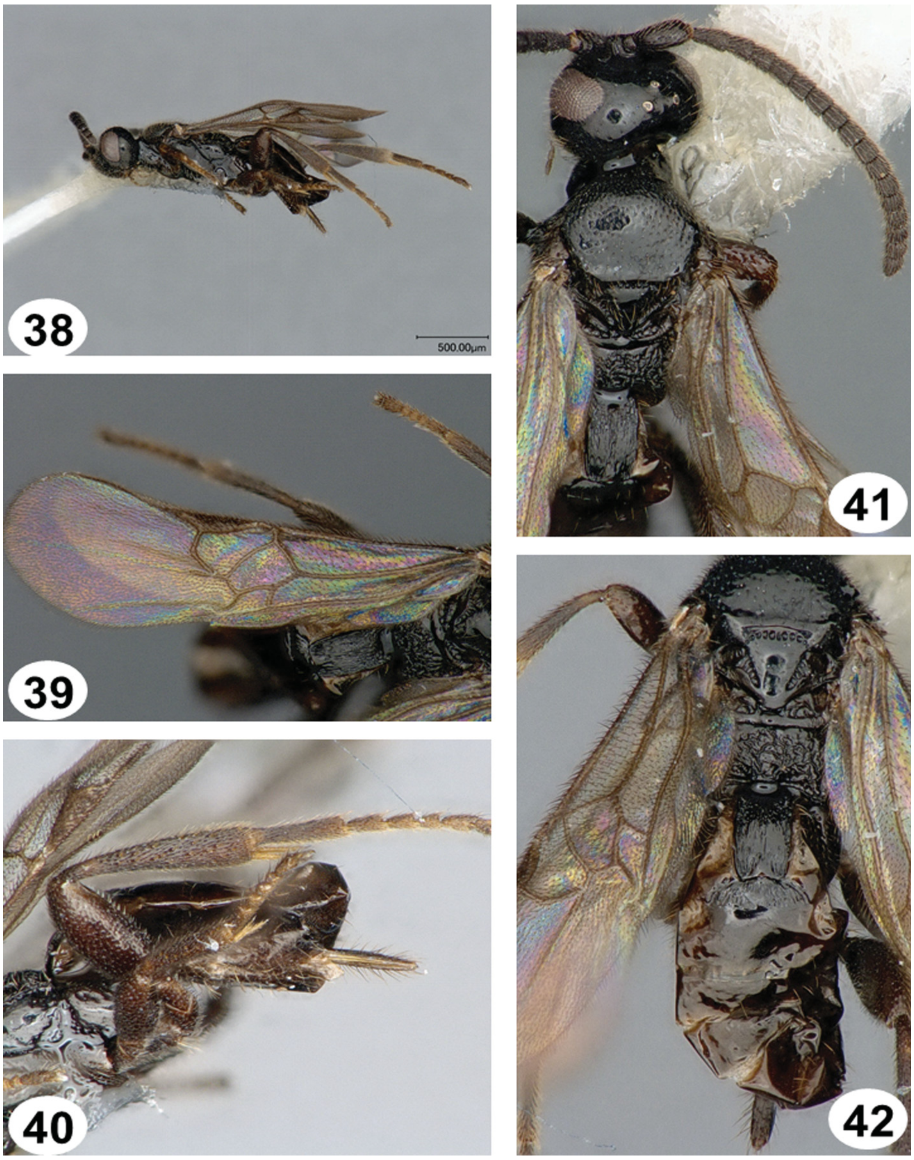
Discussion

The microgastrine of New Zealand have received very little attention, with the known fauna predominantly composed of species purposefully introduced for biological control of lepidopterous pests in agriculture or horticulture (Cameron *et al*. 1989; Valentine & Walker 1991). It is expected that the native diversity is far greater than is currently known, particularly when considering the under-collecting of Hymenoptera from several regions and habitats (Ward 2012), the number of potential lepidopteran hosts available in New Zealand (estimated at over 2000 species, Dugdale 1988), and the ratios of Lepidoptera to Microgastrinae species (Rodriguez *et al*. 2013).

New Zealand also has some unusual species of Microgastrinae. For example, the genus *Kiwigaster* is unique among all known microgastrines in not having a fixed number of 16 flagellomeres, but different numbers in females (17) and males (18) (Fernandez-Triana *et al*. 2011).

Species of *Shireplitis* appear to be uncommonly collected, the 62 specimens mentioned here are part of a microgastrinae collection of >10,000 specimens (NZAC). This is despite the extensive litter collecting during the

1960–1970s from throughout New Zealand. Currently there is only one species of Microgastrinae on the threatened species list of New Zealand Hymenoptera (Ward *et al*. 2012), *Glyptapanteles aucklandensis* (Cameron, 1909), which is found only on Auckland Island in the Subantarctic region. However, all species of *Shireplitis* deserve threatened status because species are either found at only one location or are apparently range restricted.



FIGURES 38–42. *Shireplitis tolkieni*. 38- Habitus. 39- Fore wing. 40- Lateral side of meso and metasoma, including hypopygium. 41- Dorsal view of head, mesosoma and mediotergites 1-2. 42- Dorsal view of meso and metasoma.

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