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New Muscidae (Diptera) hosts of *Stylogaster* Macquart (Diptera: Conopidae) from the Afrotropical Region

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ABSTRACT

An extensive collection of Muscidae, amassed through recent expeditions to Burundi, the Democratic Republic of the Congo, Kenya, Namibia and South Africa, is now deposited at the National Museum, Bloemfontein, South Africa. Twenty-five specimens of 14 species impaled with the eggs of *Stylogaster* Macquart (Diptera: Conopidae) were discovered among this material. New records of *Stylogaster* eggs are presented for four muscid genera: *Afromydaea* Malloch, 1930, *Coenosia* Meigen, 1826, *Hebecnema* Schnabl, 1889 and *Pseudohelina* Vockeroth, 1972, and for eight species: *Afromydaea debilis* (Stein, 1913), *Coenosia ruwenzorica* (Emden, 1940), *Hebecnema semiflava* Stein, 1913, *Limnophora obsignata* (Rondani, 1866), *Pseudohelina nigrirtarsis* (Jaenicke, 1867), *Pseudohelina phaeoxantha* (Emden, 1951), *Pyrellina abdominalis* Zielke, 1971 and *Pyrellina versatilis* (Villeneuve, 1916). A brief discussion of these associations is presented.

KEY WORDS: Afrotropical, Diptera, Conopidae, *Stylogaster*, Muscidae, dart-eggs, hosts, parasites, thick-headed flies.

INTRODUCTION

Stylogaster Macquart, 1835 is a very peculiar genus of thick-headed flies, with an interesting and unique biology. The larvae are internal parasites and adult females have characteristic elongated ovipositors that are used to flick the eggs like darts into the host's cuticle. Hosts are predominantly cockroaches, crickets and calyprate Diptera, and *Stylogaster* flies often target hosts attempting to escape columns of army ants (Hymenoptera: Dorylinae). Although commonly referred to as "hosts", it is believed that calyprate flies are not the usual larval hosts, as larvae are infrequently found internally (Stuke 2012). Stuckenberg (1963) also questioned whether impaled flies are the final hosts or whether they transport eggs to their true hosts phoretically.

Information on the biology of *Stylogaster* is outlined by Rettenmeyer (1961), Stuckenberg (1963), Smith (1967), and Kotrba (1997).

Stylogaster occurs in the New World, the Afrotropical Region (including Madagascar), parts of Asia, the Philippines, New Guinea, Eastern Australia, Tasmania and New Caledonia, but mainly in the Neotropical and Afrotropical regions (Smith 1967; Schneider 2010; Stuke 2012).

Afrotropical species were recently revised by Stuke (2012), who added 21 new species, making a total of 34 valid species in the Afrotropical Region. Stuke also presented new faunistic records for nine previously described species, an identification key to Afrotropical species and a checklist with the revised and currently known distributions.

TABLE 1

African Muscidae (Diptera), hosts of *Stylogaster* Macquart (Diptera: Conopidae) newly recorded from Burundi, Kenya and South Africa. New records are marked with asterisks.

Species	Locality	Sex	Body part(s) impaled	No of eggs
<i>Afromydaea debilis</i> (Stein)*	South Africa	♀	eye, frons, katatergite	3
<i>Coenosia ruwenzorica</i> (Emden)*	Burundi	♂	anepisternum	1
<i>Dichaetomyia</i> (<i>Panaga</i>) sp. 1	Burundi	♂	eye	1
<i>Dichaetomyia</i> (<i>Panaga</i>) sp. 2	South Africa	♀	postpronotum	1
<i>Dimorphia tristis</i> (Wiedemann)	South Africa	♀	scutum	1
<i>Dimorphia tristis</i> (Wiedemann)	South Africa	♀	base of wing, anepimeron, abdominal tergite 3	3
<i>Hebecnema semiflava</i> Stein*	Burundi	♀	abdominal tergite 5	1
<i>Helina</i> sp.	South Africa	♂	abdominal syntergite 1+2	1
<i>Limnophora obsignata</i> (Rondani)*	Burundi	♀	prescutum, abdominal syntergite 1+2	2
<i>Pseudohelina nigratarsis</i> (Jaenicke)*	Burundi	♀	anepisternum	1
<i>Pseudohelina nigratarsis</i> (Jaenicke)*	Burundi	♀	anepisternum	1
<i>Pseudohelina phaeoxantha</i> (Emden)*	Burundi	♀	scutum	1
<i>Pseudohelina</i> sp. 1	Burundi	♀	anepisternum	
<i>Pseudohelina</i> sp. 2	Kenya	♀	eye, between calypters	2
<i>Pyrellina abdominalis</i> Zielke*	Burundi	♀	postalar callus	1
<i>Pyrellina abdominalis</i> Zielke*	Burundi	♀	anepisternum	1
<i>Pyrellina abdominalis</i> Zielke*	Burundi	♀	suture between prescutum and scutum	1
<i>Pyrellina abdominalis</i> Zielke*	Burundi	♀	anepisternum, katepisternum	2
<i>Pyrellina abdominalis</i> Zielke*	Burundi	♀	notopleuron	1
<i>Pyrellina abdominalis</i> Zielke*	Burundi	♀	postpronotum, anterior spiracle	2
<i>Pyrellina abdominalis</i> Zielke*	Burundi	♀	abdominal tergites 3 and 4	2
<i>Pyrellina abdominalis</i> Zielke*	Burundi	♀	postpronotum	2
<i>Pyrellina abdominalis</i> Zielke*	Burundi	♀	suture between postpronotum and notopleuron	1
<i>Pyrellina versatilis</i> (Villeneuve)*	Burundi	♀	abdominal tergite 5	1
<i>Pyrellina versatilis</i> (Villeneuve)*	Burundi	♀	eye	1

Muscid flies (Diptera: Muscidae) have been recorded as frequent *Stylogaster* hosts and this association in the Afrotropical Region has been recently treated. Couri and Pont (2006) studied material from “*An Arthropod Survey of Madagascar’s Protected Areas (1998–2009)*” (housed in the California Academy of Sciences, San Francisco, USA) and recorded seven additional Madagascan muscid hosts, two for the first time. Couri and Barros (2010) recorded 15 specimens of Muscidae impaled with *Stylogaster* eggs, 14 from Madagascar and one from South Africa, belonging to 10 species, three of which were new records. These authors summarised records of *Stylogaster* Diptera hosts in Africa.

The aim of the current paper is to record new African muscid hosts of *Stylogaster* with a brief discussion of this association.

MATERIAL AND METHODS

All material included in this study was sampled during recent expeditions to Burundi (2010), Kenya (2011) and three provinces of South Africa (2009–2012) and is deposited at the National Museum (BMSA), Bloemfontein, South Africa.

Eggs were extracted from one specimen from Burundi (*Pyrellina abdominalis*), one from South Africa (*Dimorphia tristis*) and one from Kenya (*Pseudohelina* sp. 2). Infested flies were relaxed in a moist chamber for 24 hours, after which the egg was removed using entomological pins. It was macerated in 10% potassium hydroxide for 24 hours, rinsed, dehydrated in alcohol and was stored in a microvial of glycerol pinned beneath the specimen.

Colour images were captured using Syncroscopy Auto-Montage with Leica MZ16 optical microscope.

New genus and species records are indicated with an asterisk (*), new species records alone with two asterisks (**).

RESULTS

Twenty-five specimens in 14 species impaled with *Stylogaster* eggs were discovered in the material (Table 1), from about 6,550 specimens examined in total. Four new generic records and eight new species records are noted.

Some eggs were situated in unusual body parts, difficult to access, such as the ventral part of the abdomen and between the two calypters (Figs 5–7).

Stylogaster muscid hosts

Afromydaea debilis (Stein, 1913)*

Material examined: SOUTH AFRICA: *Eastern Cape*: 1 ♀ Hogsback, Hobbiton, 32°35.798'S 26°57.506'E, 6–8.iv.2010, 1186 m, A.H. Kirk-Spriggs & V.R. Swart, Malaise trap, indigenous Afromontane forest, BMSA(D)22515, three eggs present: in right eye (Fig. 1), in right frons (immediately adjacent to antenna) (Fig. 1) and in katatergite.

Coenosia ruwenzorica (Emden, 1940)*

Material examined: BURUNDI: *Kayanza*: 1 ♂ Parc National de la Kibira, Rwegura Sector, 02°55.320'S 29°30.067'E, 21–26.xi.2010, 2237 m, A.H. Kirk-Spriggs, Malaise trap, indigenous Afromontane forest, BMSA(D)13046, one egg in inferior part of left anepisternum (Fig. 2).

Dichaetomyia (*Panaga*) sp. 1

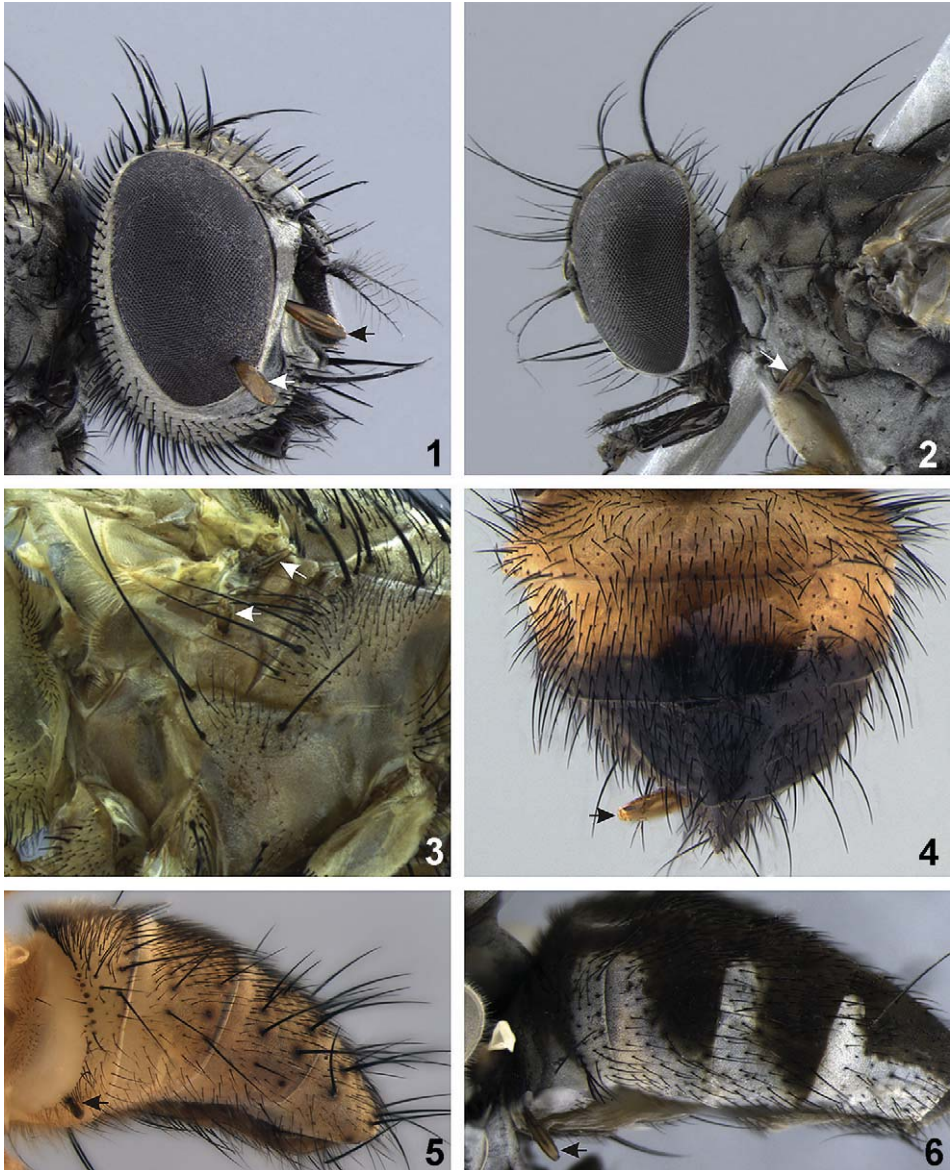
Material examined: BURUNDI: *Kayanza*: 1 ♂ Parc National de la Kibira, Rwegura Sector, 02°55.320'S 29°30.067'E, 21–26.xi.2010, 2237 m, A.H. Kirk-Spriggs, Malaise trap, indigenous Afromontane forest, BMSA(D)24760, one egg in left eye.

Dichaetomyia (*Panaga*) sp. 2

Material examined: SOUTH AFRICA: *Free State*: 1 ♀ Harrismith Dist., Mooihoekkop, 28°10'50.0"S 29°10'51.1"E, 14–16.ix.2009, ca 1800 m, A.H. Kirk-Spriggs, Malaise trap, *Leucosedea*-dominated scrub, BMSA(D)09236, one egg in superior part of left postpronotum.

Dimorphia tristis (Wiedemann, 1819)

Material examined: SOUTH AFRICA: *Free State*: 1 ♀ Harrismith Dist., Scotland farm, 27°58'59.5"S 29°37'09.8"E, 26–29.iii.2012, A.H. Kirk-Spriggs, Malaise trap, dense *Leucosedea*-dominated scrub,



Figs 1–6. Muscidae hosts impaled by *Stylogaster* (Conopidae) eggs: (1) *Afromydaea debilis* (Stein); (2) *Coenosia ruwenzorica* (Emden); (3) *Dimorphia tristis* (Wiedemann); (4) *Hebecnema semiflava* Stein; (5) *Helina* sp.; (6) *Linnophora obsignata* (Rondani). Arrows indicate *Stylogaster* eggs.

BMSA(D)35137, one egg in anterolateral part of right scutum; 1♀ same data, BMSA(D)35161, three eggs inserted in left side of body: immediately below wing base (Fig. 3), in anepimeron and in tergite 3.

Hebecnema semiflava Stein, 1913*

Material examined: BURUNDI: *Kayanza*: 1♀ Parc National de la Kibira, Rwegura Sector, 02°55.320'S 29°30.067'E, 21–26.xi.2010, 2237 m, A.H. Kirk-Spriggs, Malaise trap, indigenous Afromontane forest, BMSA(D)26798, one egg in left side of tergite 5 (Fig. 4).

Helina sp.

Material examined: SOUTH AFRICA: *Western Cape*: 1♂ Keurbos forest, 33°54.435'S 23°43.714'E, 28–30.iii.2009, 500 m, A.H. Kirk-Spriggs & S. Otto, MV-light trap, BMSA(D)07026, one egg in left ventral part of syntergite 1+2 (Fig. 5).

Limnophora obsignata (Rondani, 1866)**

Material examined: BURUNDI: *Kayanza*: 1♀ Parc National de la Kibira, Rwegura Sector, 02°55.320'S 29°30.067'E, 21–26.xi.2010, 2237 m, A.H. Kirk-Spriggs, Malaise trap, indigenous Afromontane forest, BMSA(D)25803, two eggs present: in prescutum and in left ventral side of syntergite 1+2 (adjacent to sternite 1) (Fig. 6).

Pseudohelina nigratarsis (Jaenicke, 1867)*

Material examined: BURUNDI: *Kayanza*: 1♀ Parc National de la Kibira, Rwegura Sector, 02°55.320'S 29°30.067'E, 21–26.xi.2010, 2237 m, A.H. Kirk-Spriggs, Malaise trap, indigenous Afromontane forest, BMSA(D)24707, one egg in superior part of left anepisternum (adjacent to notopleuron); 1♀ same data but 22–24.xi.2010, hanging trap, baited fermenting fruit, BMSA(D)28297, one egg in medial part of left anepisternum.

Pseudohelina phaeoxantha (Emden, 1951)**

Material examined: BURUNDI: *Kayanza*: 1♀ Parc National de la Kibira, Rwegura Sector, 02°55.320'S 29°30.067'E, 21–26.xi.2010, 2237 m, A.H. Kirk-Spriggs, Malaise trap, indigenous Afromontane forest, BMSA(D)24727, one egg in median part of scutum (adjacent to suture).

Pseudohelina sp. 1

Material examined: BURUNDI: *Kayanza*: 1♀ Parc National de la Kibira, Rwegura Sector, 02°55.320'S 29°30.067'E, 21–26.xi.2010, 2237 m, A.H. Kirk-Spriggs, Malaise trap, indigenous Afromontane forest, BMSA(D)24725, one egg in inferior part of right anepisternum.

Pseudohelina sp. 2

Material examined: KENYA: *Eastern Prov.*: 1♀ Njuki-Ini Forest station, 00.51660°S 37.41843°E, 19–20.iv.2011, 1455 m, A.H. & M.K. Kirk-Spriggs, Malaise trap, remnant indigenous upland forest, BMSA(D)32693, two eggs inserted in left side of body: in eye and between two calypters.

Pyrellina abdominalis Zielke, 1971**

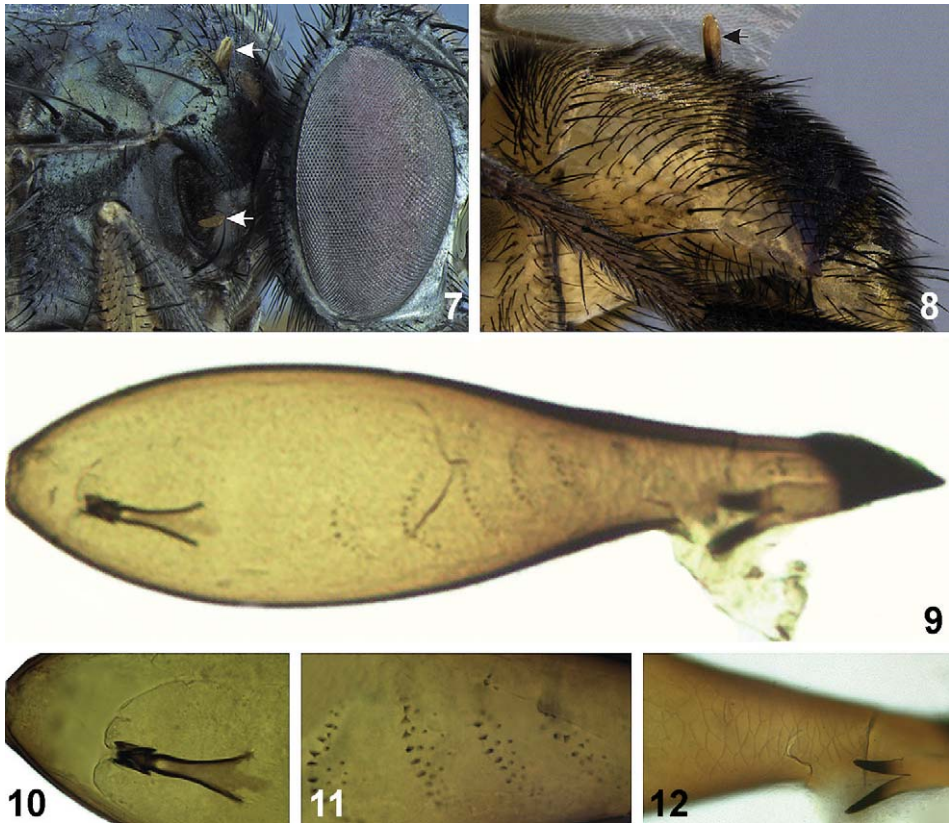
Material examined: BURUNDI: *Kayanza*: 1♀ Parc National de la Kibira, Rwegura Sector, 02°55.320'S 29°30.067'E, 21–26.xi.2010, 2237 m, A.H. Kirk-Spriggs, Malaise trap, indigenous Afromontane forest, BMSA(D)28302, one egg in left postalar callus; 1♀ same data, BMSA(D)24731, one egg in dorsal part of right anepisternum; 1♀ same data, BMSA(D)24724, one egg in left side, at suture between prescutum and scutum; 1♀ same data, BMSA(D)24739, two eggs present: in dorsal part of right anepisternum and in inferior part of left anepisternum; 1♀ same data but 22–24.xi.2010, hanging trap, baited fermenting fruit, BMSA(D)24722, one egg in anterior part of left notopleuron; 1♀ same data, BMSA(D)28307, two eggs inserted in right side: in dorsal part of postpronotum and in right anterior spiracle (Fig. 7); 1♀ same data, BMSA(D)28310, two eggs present: medially in abdominal tergite 3 and in left ventral part of tergite 4 (Fig. 8); 1♀ same data, BMSA(D)28222, two eggs in right postpronotum; 1♀ same data, BMSA(D)24721, one egg in right suture (between postpronotum and notopleuron).

Pyrellina versatilis (Villemeuve, 1916)**

Material examined: BURUNDI: *Kayanza*: 1♀ Parc National de la Kibira, Rwegura Sector, 02°55.320'S 29°30.067'E, 21–26.xi.2010, 2237 m, A.H. Kirk-Spriggs, Malaise trap, indigenous Afromontane forest, BMSA(D)28285, one egg in left side of tergite 5; 1♀ same data but 22–24.xi.2010, hanging trap, baited fermenting fruit, BMSA(D)24754, one egg inserted in left eye.

Morphology of the eggs

Stylogaster eggs are yellow, elongate, with the anterior tip pointed, and possess one or two pairs of projecting barb-like spines. Some eggs have an eversible sac-like structure at the pointed apex, which is highly variable in shape and length among species



Figs 7–12. (7, 8) Muscidae hosts impaled by *Stylogaster* (Conopidae) eggs (arrowed): (7) *Pyrellina abdominalis* Zielke, (8) same; (9–12) egg of *Stylogaster* sp. (host: *Dimorphia tristis* (Wiedemann), South Africa): (9) habitus, lateral; (10) details of posterior end, with cephalopharyngeal skeleton of larva; (11) details of cuticular spines of larva; (12) details of anterior end, illustrating barbs and surface sculpture.

(Stuckenberg 1963). All dissected eggs exhibited the same general morphology, with two pairs of short and closely-approximated lateral barbs (the dorsal a little shorter than the ventral), a short sculptured area behind the pointed apex and a short eversible sac (Figs 9–12). These are very similar to structures illustrated for an unidentified species of *Stylogaster* ex. *Dichaetomyia* sp. (Smith 1967: fig. 17). Larvae may be observed in two of the dissected eggs.

DISCUSSION

Much remains to be discovered regarding the morphology of eggs and their associations with adult flies, a topic treated in a few papers, such as Stuckenberg (1963) and Smith (1967). Recently, the egg of *S. hauseri* Stuke, 2012, a Madagascan endemic, has been described (Stuke 2012).

Couri and Barros (2010) attempted to identify eggs found in some muscid hosts by removing these from impaled pinned adults, but were unsuccessful, given that available

information in the literature was insufficient and the key for identifying eggs (Smith 1967) only partial.

Stuke (2012) noted that Afrotropical *Stylogaster* represent 30% of the world fauna of this genus, with 68% apparently restricted to Madagascar.

As far as the countries treated here are concerned, Stuke (2012) recorded the following *Stylogaster* species:

SOUTH AFRICA: *S. complexa* Bigot, 1859; *S. kirkspriggsi* Stuke, 2012; *S. leonum* Westwood, 1851; *S. nitens* Brunetti, 1925; and *S. westwoodi* Smith, 1967.

KENYA: *S. copelandi* Stuke, 2012; *S. kakamegensis* Stuke, 2012; *S. kenyensis* Stuke, 2012; and *S. westwoodi* Smith, 1967.

BURUNDI: *S. obscurinotum* Kröber, 1936.

Of these species, only eggs of *Stylogaster leonum*, *S. nitens*, and *S. westwoodi* are known (Smith 1967).

A brief discussion of the speculation on the association between muscid flies, *Stylogaster* and army ants was provided by Couri and Pont (2006). Since army ants are not found in some parts of Africa and Madagascar, it is clear that at least some species of *Stylogaster* are not associated with them (Stuckenberg 1963; Couri & Pont 2006).

As most of the muscid specimens attacked are females (72.6%) (Couri and Barros 2010) and represent species attracted to faeces, it has been suggested that *Stylogaster* spp. may actively seek hosts in the vicinity of dung, where female flies are less active due to feeding or oviposition behaviour (Stuckenberg 1963; Smith 1969; Couri & Pont 2006). The current study confirms sex preference, with 88% of attacked flies being female.

As regards the biology of the genera newly recorded here, *Coenosia* adults prey on other insects, both at the larval and adult stages; *Pseudohelina* larvae occur in decaying vegetables and fruit, in which they are predaceous feeders; *Hebecnema* larvae are predators in ungulate dung (Skidmore 1985). Nothing is known about the biology of *Afromydaea* or *Limnophora obsignata*, although the larva of the latter probably occurs in dung.

It is intriguing to find eggs on the ventral parts of the host's body. It could be suggested that *Stylogaster* females hover below muscids while in flight and flick their eggs directly into the cuticle from beneath. This appears improbable, however, at least in the case of *L. obsignata*, which is a poor flier, occurring in the vicinity of streams and generally flying from stone to stone.

Here, as recorded earlier by Couri and Pont (2006), the maximum number of eggs per specimen is three. Stuckenberg (1963) recorded a maximum of four and Smith (1967) five.

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