



## A NEW STONEFLY FROM LEBANON, *PERLODES THOMASI* SP. N. (PLECOPTERA: PERLODIDAE)

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### ABSTRACT

A new *Perlodes* species from Lebanon, *Perlodes thomasi*, is described and compared with its closely related species *P. floridus floridus* Kovács & Vinçon 2012 from the Balkan Peninsula and *P. floridus peloponnesiacus* Kovács & Vinçon 2012 from the Greek Peloponnes. These taxa differ from all the previously described *Perlodes* species primarily in the exceptional shape of the egg and the attachment disc. *P. thomasi* sp. n. is a cold stenothermal species occurring in the close surrounding of rheocene karstic springs on the Western slope of Mount Lebanon. The list of the 16 stoneflies known from Lebanon so far is updated and discussed.

**Keywords:** Plecoptera, Stoneflies, *Perlodes thomasi* sp. n., *P. floridus*, *P. floridus peloponnesiacus*, new species, Lebanon

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### INTRODUCTION

The knowledge of Lebanese stoneflies dates back to Navás (1909) with the description of *Marthamea beraudi*. Our knowledge improved progressively during the last 60 years with the important contributions of Aubert (1964), Zwick (1978), Berthélemy & Dia (1982), Alouf (1992) and Sivec & Dia (2001). The first specimens of *Perlodes thomasi* sp. n. were collected by Aref Dia in 1995 but remained undescribed until now due to a lack of a revision of the genus *Perlodes*. The present work is a sequel to the description of *Perlodes floridus floridus* and *P. floridus*

*peloponnesiacus* (Kovács et al. 2012).

### INTERSPECIFIC CRITERIA OF THE GENUS *PERLODES*

According to the observations of Berthélemy (1964), the identification of *Perlodes* adults is difficult because of the absence of reliable specific sexual characters. The usual distinctive criteria (wing length, head width, head coloration and patterns, shape of the female subgenital plate) are too variable to be used for reliable identification, except sometimes in a special geographical context. On the other hand, he

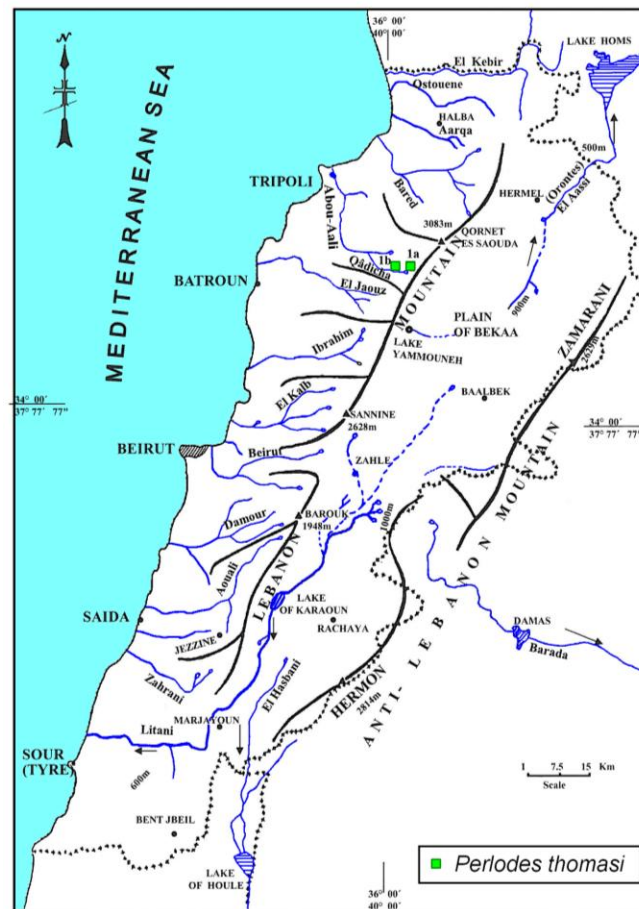


Fig. 1. Map of Lebanon, with the two collecting sites for *Perlodes thomasi* sp. n.

pointed out the great importance of egg characteristics for the identification of *Perlodes*.

Following the method outlined by Berthélemy, *P. jurassicus* Aubert, 1946 and *P. intricatus* (Pictet, 1841) were separable by the shape of their eggs (Knispel et al. 2002). In recent taxonomic compilations, the distinction of *Perlodes* species has been mainly based on egg features (Tierno de Figueroa et al. 2003, Fochetti & Tierno de Figueroa 2008, Kovács & Murányi 2008, Teslenko & Zhiltzova 2009). More recently, egg studies have also been used to reinstate *P. mortoni* (Klapálek 1906) and to remove it from synonymy with *P. microcephalus* (Pictet 1833) (Zwick 2011). Nevertheless, Zwick considers that the wing length is also a good criterion for some species like *P. dispar* (Rambur 1842) though it is useless for others like *P. microcephalus* (Zwick 2011).

The most reliable feature for the identification of adult males is the shape of the paraproctal sclerite. It was firstly illustrated by Kis for *P. microcephalus* (Kis 1974, Figs 129 b, c); and later by Marten (1991, Fig. 10) for *P. microcephalus* and *P. dispar*. It was not studied in the recent studies except in Fauna Helvetica where comparative illustrations are given for *P. intricatus*, *P. jurassicus*, *P. dispar* and *P. microcephalus* (Lubini et al. 2012, Figs 212-215).

## MATERIAL AND METHODS

SEM images were made using a Philips XL30 (BYU) and a Hitachi S-2600N scanning electron microscope (Hungarian Natural History Museum). Specimens for SEM study were critical point dried and sputter coated with gold-palladium. The adult and larval photos were made using two USB Digital

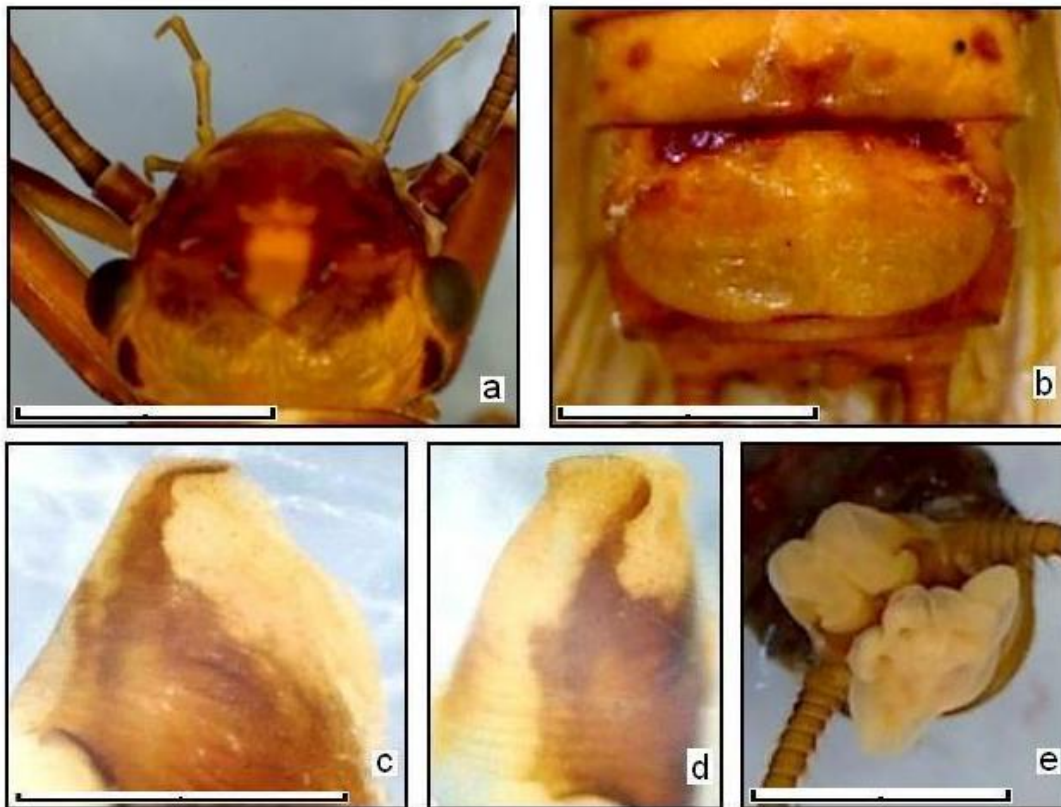


Fig. 2. *P. thomasi* sp. n. a: male head (2 mm), b: female subgenital plate (2 mm), c: male paraproc in  $\frac{3}{4}$  view (0.5 mm), d: male paraproc in side view (same scale), e: male everted penis (2 mm).

Microscopes (Veho Microcapture 40x-200x and Veho Microcapture 20x-400x V1.3).

The specimens were preserved in 70% ethanol. The holotype and one female (paratype) are deposited in the collection of the Lausanne Museum of Zoology (Switzerland). Other paratypes: one female and one male are stored in the Gilles Vinçon Collection; other specimens are kept in the Aref Dia Coll.

## RESULTS AND DISCUSSION

*Perlodes thomasi* Vinçon, Dia & Kovács sp. n.  
(Figs. 2a-e, 3a-d, 4a-d, 5 right)

**Material examined.** Holotype male: northern Lebanon, western slope of Lebanon Mount, Ouâdi Qâdîcha torrent, 1500 m a.s.l., about 500 m above the village of Bcherré, Abou Aali water basin, 18.05.1996,

deposited in the Zoology Museum of Lausanne (ZML) (Fig. 1, station 1b). One female paratype, same location and date, in the ZML. One larva, 24.04.1996, same location, also in the ZML. Other material from the same locality: 1♂, 1♀, 30.05.1995, 1 larva, 24.04.1996 (in the collection of G. Vinçon); 25 larvae, 24.4.1996; 18♂, 7♀, 8 larvae, 2 exuviae, 18.05.1996; 2♂, 6♀, 15 larvae, 6.05.1999; 7♂, 5♀, 30.05.1999. Qâdîcha spring, resurgence of the Abou Aali stream, 1760 m a.s.l. (Fig. 1, station 1a), 8♀, 30.05.1995; 10♀, 15.06.1996; 4♀, 9.07.1995.

**Description.** Medium sized *Perlodes* species: ♂ body length 1.5-1.6 cm, ♀ 2.0-2.2 cm. ♂ micropterous with relative wing length (RWL) between 1.1 and 1.3 (RWL = wing length / head width at the position of eyes). ♀ normal winged (wing length: 2.4-2.6 cm). General colour brown. Head dark brown except yellowish occiput and oval yellow spot in the ocellar



Fig. 3. *P. thomasi* sp. n. larva. a: head (5 mm), b: maxilla (1 mm), c: paraprocts (1 mm).

triangle (Fig. 2a); two dark spots on each side of the occiput, behind the compound eyes. Antennae dark brown. Median part of pro- and mesonotum with lateral dark brown patterns and contrasting median yellowish strip. Legs brownish.

**Male genitalia.** The paraprocts are nearly pyramidal, mostly membranous on their inner side and protected by a wide outer sclerite that narrows progressively towards the tip of the paraproct. This expansion of the sclerite ends in a thin blade, extending around the tip of the paraproct; it is more visible in  $\frac{3}{4}$  view (Fig. 2c) than in lateral view (Fig. 2d). The membranous part of the paraprocts is of very variable size, from hardly turgescient (Figs. 2c-d) to strongly turgescient (Fig. 2e: male with everted penis). The penis is often not visible since it is retracted in the abdomen; in some specimens it could be reverted (perhaps during mating or due to finger pressure of the collector); it is fully membranous and of complicated structure comprising two wide lateral lobes extending on each side of the abdomen tip, two upper lobes with a median depression and two less developed posterior lobes (Fig. 2e).

**Female genitalia.** Subgenital plate wide, semi-circular, with rounded edges and shallow median depression on the outer edge. The plate sides nearly reach the lateral edges of the abdomen. Two lateral

dark spots occur near the anterior edge of the plate (Fig. 2b).

**Larva** (Figs. 3a-c). Head brownish, with a wide yellow marking covering the occiput and an oval median yellow spot between the three ocelli (Fig. 3a). M-line yellowish, sinuous and poorly visible. The lacinia is typical of the genus *Perlodes*, with a very strong outer tooth, gently curved over its length, and one inner tooth which is about twice as long as the smaller. Two strong bristles are visible, one on the inner edge of the lacinia, proximally to the smaller tooth, and the other between the two teeth (Fig. 3b). Paraprocts triangular, well sclerotized, and covered with only few scattered short spine-like bristles (Fig. 3c).

**Egg** (Figs. 4a-d). Exceptionally large (about 0.5 mm length and 0.4 mm width), bullet-shaped. The ridges of the egg are clearly visible, rather thick and bulged (not flat). The hatching line is strong, bulged, well delimiting the operculum. The attachment disc is flanked by several concentric rows of peripheral cells similar to the petals of a flower. These cells are placed on the anterior surface of the attachment disc (surface of the disc connected to the base of the egg). Therefore, the cells are more visible in lateral view (Fig. 4a) than in basal view (Fig. 4b). The cells of the inner rows are rounded and smaller than those of the



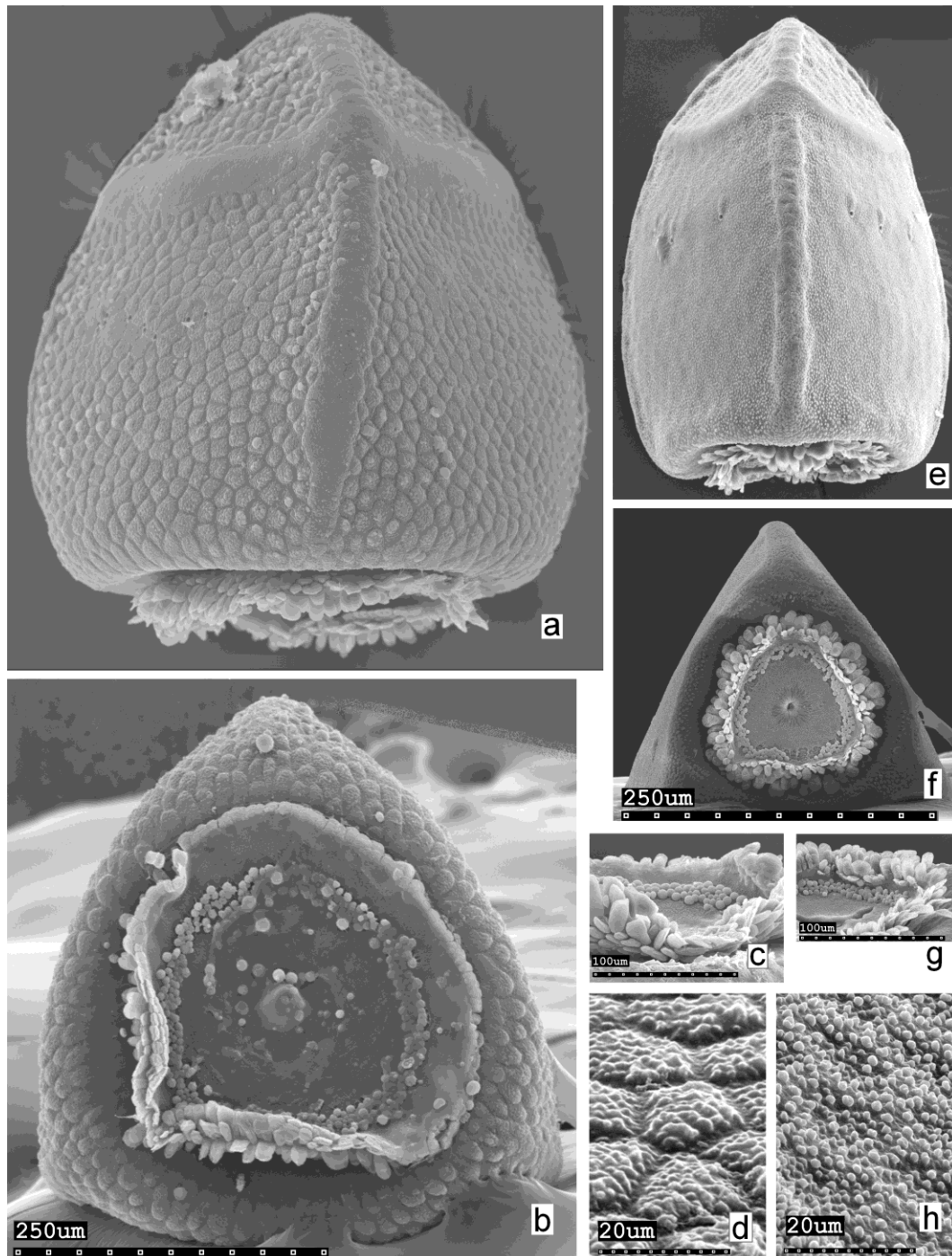


Fig. 4. Comparison of the eggs of *P. thomasi* sp. n. (a-d) and *P. floridus* (e-h). a, e: egg in side view; b, f: attachment disc; c, g: peripheral cells of the attachment disc; d, h: chorion ornamentation; a, b, f, e same scale.

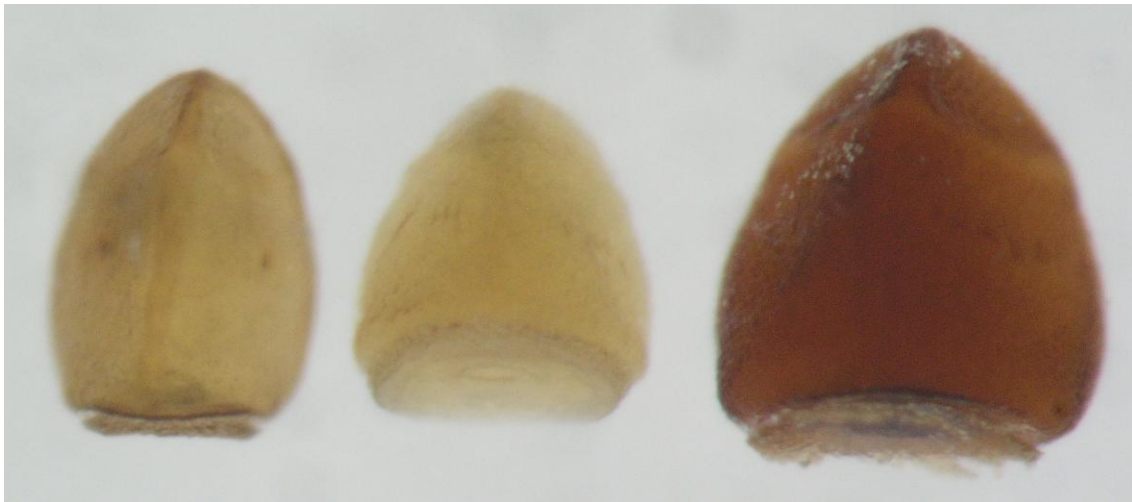


Fig. 5. *Perlodes* eggs, from left to right: *P. floridus floridus*, *P. floridus peloponnesiacus* and *P. thomasi* sp. n.

outer rows that are more oval or even quadrangular (Figs. 4c). Numerous mushroom-like globules are gathered on the surface of the attachment disc near its outer edge (Fig. 4b-c). The chorionic surface is covered by a conspicuous polygonal network of follicular cell impressions (FCIs) (Figs. 4a, d). The surface of each polygon is covered by several rounded granulations (Fig. 4d).

**Affinities.** In the genus *Perlodes*, *P. thomasi* sp. n. shares a very distinct position together with *P. floridus floridus* from the Balkan Peninsula and *P. floridus peloponnesiacus* from the Greek Peloponnes. Both species have bullet-shaped eggs with a distinctive flower-like attachment disc (Figs. 4b-c, 4f-g). Nevertheless, the eggs of *P. thomasi* sp. n. are about one third wider and longer than those of *P. floridus floridus* and *P. floridus peloponnesiacus* (Figs 4a, 4e, 5). The chorion is covered by a network of conspicuous convex polygonal cells FCIs (Fig. 4d), while that of *P. floridus floridus* just shows hardly visible depressions and is densely covered with numerous rounded globules (Fig. 4h). In *P. floridus peloponnesiacus* the polygonal cells of the chorion are concave instead of convex (Kovács et al. 2012, Figs 12, 13, 15). The male paraproctal sclerite is also different: in *P. thomasi* the sclerite expansion is short, narrowing quickly toward the tip (Fig. 2c), while in *P.*

*floridus* it is more elongated and slender (Kovács et al. 2012, Fig. 3a). In both species the apex of the sclerite of the paraproct turns around the tip of the paraproct, just as in *P. jurassicus* and to a lesser degree for *P. intricatus* (Lubini et al. 2012, Vinçon, Murányi & Kovács in prep.). In *P. microcephalus* the sclerite of the paraproct ends in a rather long thin expansion that is just slightly curved at the tip, and in *P. dispar* the sclerite of the paraproct is very short with a rounded apex (Marten 1991, Lubini et al. 2012).

**Etymology.** This species is named in honor of Prof. Alain Thomas (Toulouse) for his important contributions to the knowledge of Mediterranean aquatic Insects, especially Ephemeroptera.

#### ECOLOGICAL NOTES

*P. thomasi* sp. n. is a micro-endemic, cold stenothermal species confined to a karstic rheocrene spring and torrent on the Western slope of Mount Lebanon (Fig. 1). This karstic spring (named Qâdîcha spring), is the resurgence of a high discharge subterranean river crossing the Cenomanian limestone. It constitutes one of the headwater tributaries of the Abou Aali stream (catchment area: 484 km<sup>2</sup>, length: 42 km). The amplitude of water temperature is narrow, ranging from 6-8°C at the resurgence (1760 m a.s.l.) to 6-10°C downstream





Fig. 6. a: Cascade downstream of the Qâdîcha resurgence (1760 m a.s.l.), b-c: Ouâdi Qâdîcha, near the Bcherré village (1500 m a.s.l.).

(Abou Aali torrent at 1500 m a.s.l.). At the resurgence, the stream is 2 m wide and 5 - 40 cm deep, and downstream at 1500 m a.s.l. it is 4 m wide and 10 - 40 cm deep.

*P. thomasi* sp. n. occurs between the resurgence (1760 m a.s.l.) (Fig. 6a) down to the Bcherré village (1500 m a.s.l.) (Figs 6b-c). The immature stages are confined to areas that exhibit a large diversity of

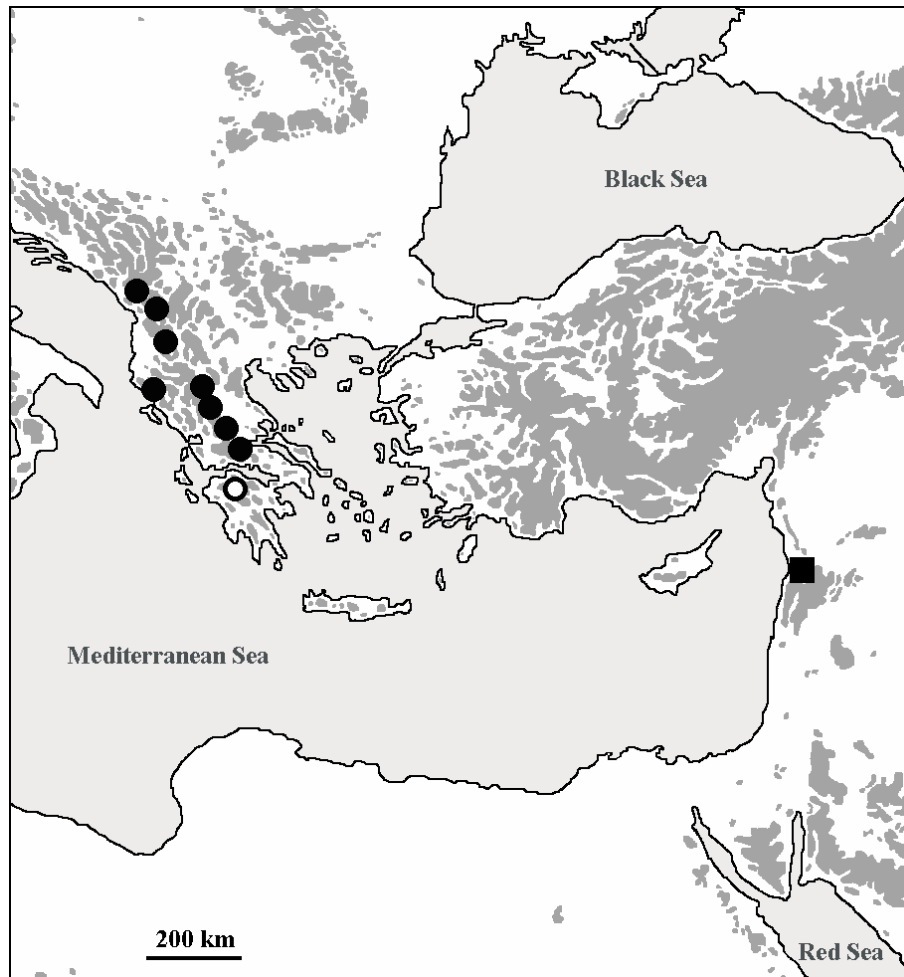


Fig. 7. Distribution area of *P. floridus floridus* (black dot: Montenegro, Albania and Greece), *P. floridus peloponnesiacus* (black and white circle: Greek Peloponnes) and *Perlodes thomasi* sp. n. (black square: Lebanon) (mountainous areas in grey).

substrates: medium rubble, small boulders, cobbles, gravels and rocks partially covered with mosses (*Rhynchostegium riparioides*), sand, leaf litter detritus, and filaments of green algae encrusting the substrate. The flight period extends from May to July.

#### FAUNISTICS OF THE MOUNT LEBANON

In the arid Mediterranean surrounding, the Mount Lebanon (3083 m a.s.l.), highest point of the Middle East, is a large mountain range extending over 170 km along the Mediterranean coast.

This cordillera, directly exposed to Mediterranean precipitation (especially on its western slope where the amount of snow averages 4 meters depth), constitutes an exceptional refuge for the aquatic fauna. Within the stoneflies, two micro-endemic species are strictly restricted to the western slope of the Lebanon Mount: *Perlodes thomasi* sp. n. and *Protonemura phoenicia* Sivec & Dia 2001. Their isolation is favored by the exceptional hydrological context, with a high discharge of cold water flowing throughout the year from main calcareous resurgences such as the Qâdîcha spring.



## BIOGEOGRAPHICAL ASPECTS OF THE LEBANESE STONEFLIES

Among the 16 stonefly species occurring in Lebanon, 10 (62%) are Lebanese endemics (Table 1); 4 others slightly extend into neighboring countries: *Protonemura libanocypria* Zwick 1978 on Cyprus, *Protonemura zernyi* Aubert 1964 in northern Israel (Zwick 1972), *Siphonoperla libanica* Alouf 1992 and *Leuctra fusca latior* Berthélemy & Dia 1982 in Anatolia (Alouf 1992, Vinçon & Sivec 2001). One, *Leuctra kopetdaghi* Zhiltzova 1972, extends to Central Asia, while *Leuctra hippopus* Kempny 1899 has a wide Euro-Siberian distribution.

Except for *L. kopetdaghi*, Lebanese stoneflies probably have a European origin, mostly expanding their range across Anatolia and Syria as already

supposed by Berthélemy & Dia (1982). The presence of *Siphonoperla libanica* and *Leuctra fusca latior* in Anatolia and Lebanon supports this hypothesis (Berthélemy & Dia 1982, Alouf 1992).

Nevertheless, the widely disjointed distribution area of *Perlodes thomasi* sp. n. and of its close relatives *P. floridus floridus* and *P. floridus peloponnesiacus* (Fig. 7) could hardly be explained by a trans-Anatolian migration since both species seem to be absent from Anatolia where only *P. microcephalus* is reported (Kazanci 1982). More probably their ancestor could have an East Mediterranean origin as already presumed for four Lebanese *Protonemura* of the *corsicana* group: *P. libanica*, *P. pectinata*, *P. phoenicia* and *P. zernyi* (Vinçon & Murányi 2009).

**Table I. List of stoneflies known from Lebanon**

	Geographical Distribution	Endemic
<b>Perlodidae</b>		
<i>Perlodes thomasi</i> sp. n.	Lebanon	*
<i>Isoperla berthelemyi</i> Sivec & Dia 2001	Lebanon	*
<i>Isoperla libanica</i> Aubert 1964	Lebanon	*
<b>Perlidae</b>		
<i>Marthamea beraudi</i> (Navás 1909)	Lebanon	*
<b>Chloroperlidae</b>		
<i>Siphonoperla libanica</i> Alouf 1992	Lebanon, Anatolia	
<b>Taeniopterygidae</b>		
<i>Brachyptera galeata</i> Koponen & Brinck 1949	Lebanon	*
<b>Nemouridae</b>		
<i>Protonemura libanica</i> Aubert 1964	Lebanon	*
<i>Protonemura libanocypria</i> Zwick 1978	Lebanon, Cyprus	
<i>Protonemura pectinata</i> Berthélemy & Dia 1982	Lebanon	*
<i>Protonemura phoenicia</i> Sivec & Dia 2001	Lebanon	*
<i>Protonemura zernyi</i> Aubert 1964	Lebanon, Israel	
<b>Capniidae</b>		
<i>Capnia bicornata</i> Alouf 1992	Lebanon	*
<i>Capnia turkestanica brevicula</i> Berthélemy & Dia 1982	Lebanon	*
<b>Leuctridae</b>		
<i>Leuctra fusca latior</i> Berthélemy & Dia 1982	Lebanon, Anatolia	
<i>Leuctra hippopus</i> Kempny 1899	Euro Siberian	
<i>Leuctra kopetdaghi</i> Zhiltzova 1972	Middle Asia	

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