



CONTRIBUTION TO THE KNOWLEDGE OF THE MOROCCAN HIGH AND MIDDLE ATLAS STONEFLIES (PLECOPTERA, INSECTA)

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ABSTRACT

Amphinemura tiernodefigueroai sp. n., endemic of the Moroccan Middle-Atlas, and *Capnioneura atlasica* sp. n., endemic of the Moroccan High-Atlas, are described and illustrated. The two new species are reliably separable in both sexes. Comparative descriptions are given for *Amphinemura berthelemyi* Vinçon, Yasri & Lounaci 2013 and *Capnioneura petitpierreae* Aubert 1961. Five species are new for the Middle Atlas: *Nemoura lacustris* Pictet 1865, *Capnopsis schilleri schilleri* (Rostock 1892), *Leuctra franzi paenibaetica* Sánchez-Ortega & Roperro-Montero, 1993, *L. ketamensis* Sánchez-Ortega & Azzouz 1997 and *Tyrrhenoleuctra tangerina* (Navás 1922) and three are new for the High-Atlas: *Brachyptera algirica* Aubert 1956, *Protonemura dakkii* Vinçon & Murányi 2009 and *Capnopsis schilleri schilleri* (Rostock 1892). The faunistic list of the 23 Atlas stoneflies is updated and discussed.

Keywords: *Amphinemura tiernodefigueroai* sp. n., *Amphinemura berthelemyi*, *Capnioneura atlasica* sp. n., *Capnioneura petitpierreae*, taxonomy, zoogeography, Middle-Atlas, High-Atlas, Morocco

INTRODUCTION

High and Middle Atlas stoneflies were studied for the first time in detail by Aubert (1956, 1961), with a list of 12 species occurring in the High-Atlas and 4 in the Middle-Atlas (Table I). Numerous faunistic works have followed: Miron (1972), 6 species in the High-Atlas from Toubkal; Pihan & Mohati (1983), 5 species from the High-Atlas of Marrakech; Giudicelli & Dakki (1984), 5 species in the Middle-Atlas; Dakki (1987), 10 species from the high Sebou watershed in the Middle-Atlas; Ajakane (1988), 8 species from N'fis

in the High-Atlas; Bouzidi (1989), 9 species from Oued Reghaya in the High-Atlas; Badri (1993), 5 species in the High-Atlas; Ouahsine (1993), 5 species from Tiferguine in the High-Atlas; Bouzidi & Giudicelli (1994), 8 species from the High-Atlas; Vinçon & Murányi (2009), description of *P. dakkii*, an endemic species from the Middle-Atlas.

This study is based on six collecting trips performed in February 1996, January 2006, June 2006, April 2013, June 2013 and November 2013. It follows a revision of the Rifan stoneflies (Errochdi *et al.* 2014).

Table 1: Atlas stoneflies, with biogeographical features

Abbreviations: HA = High Atlas, MA = Middle Atlas, Alg. = Algeria, Mor. = Morocco, Tun = Tunisia, Andal. = Andalucía; Circum Med. = Circum Mediterranean, Eur. = Europe, Ibe. = Iberian Peninsula, N. Afr. = North Africa, Pyr. = Pyrenees, W. Med. = West Mediterranean

♣ = Moroccan endemic species, ◻ = new citation, * = old citation, ? = doubtful citation. 1: Aubert 1956, 1961 (only the reports from the Middle and High Atlas); 2: Miron 1972; 3: Miron & Zwick 1972; 4: Pihan & Mohati 1983; 5: Giudicelli & Dakki 1984; 6: Dakki 1987; 7: Ajakane 1988; 8: Bouzidi 1989; 9: Ouahsine 1993; 10: Badri 1993; 11: Bouzidi & Giudicelli 1994; 12: Vinçon & Murányi 2009; 13: current work.

	Middle Atlas	High Atlas	Biogeographical pattern	Mentions
PERLODIDAE				
<i>Hemimelaena flaviventris</i> (Pictet)	*	*	Mor, Ibe.	1,6,13
<i>Afroperlodes lecerfi</i> (Navás)		*	N. Afr.	1,3,7,8,10,11,13
PERLIDAE				
<i>Eoperla ochracea</i> Illies	*		Circum Med.	1,5,6
<i>Perla cf pallida</i> Guerin	*	*	N. Afr., E. Eur.?	1,2,4,5,6,7,8,9,10,11,13
<i>Perla bipunctata</i> Pictet		*	Mor, Alg, Tun, Eur	1,2,7,8,10
CHLOROPERLIDAE				
<i>Siphonoperla lepineyi</i> (Navás)	*♣	*♣	Mor	1,2,4,5,6,7,8,9,11,13
TAENIOPTERYGIDAE				
<i>Brachyptera algirica</i> Aubert	*	◻	N. Afr.	1,6,13
<i>B. auberti</i> Consiglio		*	W. Med.	1,7
NEMOURIDAE				
<i>Amphinemura chiffensis</i> Aubert		*♣	HA	1,2,4,8,9,10,11,13
<i>Amphinemura tiernodefigueroai</i> sp. n.	◻♣		MA	13
<i>Protonemura dakkii</i> Vin. & Mur.	*♣	◻♣	HA, MA	5?,6?,12,13
<i>Protonemura talboti</i> (Navás)	*	*	Mor., E. Alg.	1,2,4,5,6,7,8,9,10,11,12,13
<i>Nemoura lacustris</i> Pictet	◻		W. Med	1,13
CAPNIIDAE				
<i>Capnia nigra</i> (Pictet)		*	Palaearctic	1, 8
<i>Capnioneura atlasica</i> sp. n.		◻♣	High Atlas	11,13
<i>C. petitpierreae</i> Aubert	*		Andal., N. Afr.	1,6,8,13
<i>Capnopsis schilleri schilleri</i> (Rostock)	◻	◻	N. Afr., Eur.	1,13
LEUCTRIDAE				
<i>Leuctra franzi paenibaetica</i> Sán. & Rop.	◻		S. Ibe., N. Mor.	13
<i>Leuctra geniculata</i> (Stephens)		*	N. Afr., W.Eur.	1,2,7,13
<i>Leuctra ketamensis</i> Sán. & Azz.	◻♣		N. Mor.	13
<i>Leuctra maroccana</i> Aubert		*	Mor., Ibe., Pyr.	1,4,8,11,13
<i>Leuctra vaillanti</i> Aubert		*	N. Afr.	1,9,13
<i>Tyrrhenoleuctra tangerina</i> (Navás)	◻		N. Afr., Ibe	1,13
Total species	14	16		
Total Moroccan endemic species	4	4		

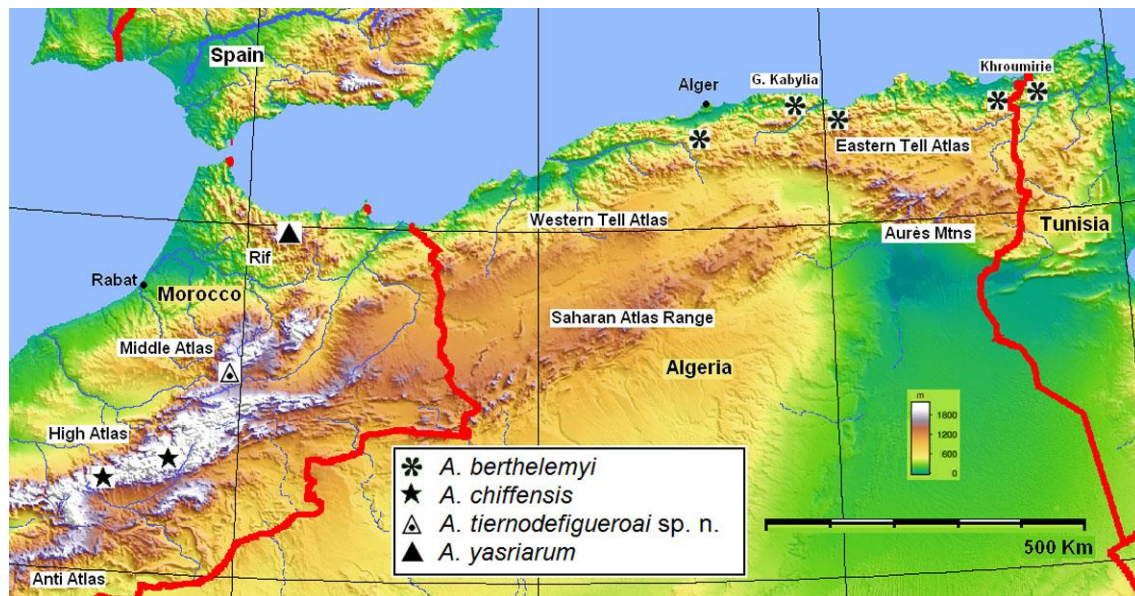


Fig. 1. Distribution of *Amphinemura berthelemyi*, *A. chiffensis*, *A. tiernodefigueroai* sp. n. and *A. yasriarum*.

MATERIAL AND METHODS

The material is preserved in alcohol. Type specimens are deposited in the Zoological Museum of Lausanne, Switzerland (ZML). Additional specimens are stored in the Aubert (Lausanne Museum), Errochdi or Vinçon collections. The drawings were made using two USB Digital Microscopes (Veho Microcapture 40x-200x and Veho Microcapture 20x-400x V1.3). Abbreviations: E. = East, N. = North, S. = South, W. = West, AUB = Aubert coll., VIN = Vinçon coll., ERR = Errochdi coll.

Terminology of the terminalia follows Baumann (1975).

RESULTS AND DISCUSSION

Hemimelaena flaviventris (Pictet 1841)

Material examined. Middle-Atlas: Taza, SW Tazzeka Mount, below Bab Taka Pass, Oued el Abod tributary, 1500-1700 m, brook, 6.06.2013, 6 ♂, 9 ♀ + 1 larva (VIN).

Distribution. It occurs in the Iberian Peninsula and Morocco. Previous records from Tunisia and Algeria (Berthélemy 1973, Lounaci & Vinçon 2005) relate to

Afroperlodes lecerfi (Navás 1929).

Ecology. A characteristic element of the temporary streams in the Iberian Peninsula (Aubert 1963). In the Moroccan Middle-Atlas, it occurs in high mountain streams of various sizes (torrents, brooks and brooklets) (1200-1400 m). The adults were found in late spring (VI).

Afroperlodes lecerfi (Navás 1929)

Material examined. High-Atlas: Ourika Valley, Ait El Kake, below Oukaimeden, torrent, 2150 m, 3.06.2006, 4 ♂, 5 ♀ (VIN); 15.11.2013, 1 exuviae (VIN).

Distribution. A North African endemic species which occurs in Morocco, Algeria (Lounaci & Vinçon 2005) and Tunisia (Berthélemy 1973 sub. nom. *Hemimelaena flaviventris*).

Ecology. An orophilic species which occurs in mountain brooks and torrents between 450 and 2150 m. The adults emerge during spring (V-VI).

Perla sp. (cf. *P. pallida* Guérin 1838)

Perla marginata (Sánchez-Ortega & Azzouz 1998 p. 452 and Errochdi & El Alami 2008 p. 40)

Material examined. High-Atlas: Ourika Valley, Ait El Kake, below Oukaimeden, 2150 m, 3.06.2006, 1♂, 1♀ + 2 exuviae; below Oukaimeden, confluence of two torrents, 2500 m, 3.06.2006, 2♂, 3♀ + 1 exuvia; below Oukaimeden, large brook with slow speed, 2620 m, 3.06.2006, 18♂, 14♀ + 4 exuviae (VIN).

Distribution. The *Perla* specimens occurring in the Middle-Atlas are assigned to a species closely related to *P. pallida* Guérin, 1838 (Sivec & Stark 2002, p. 24). The specimens from the Rif and High-Atlas probably belong to the same species.

Ecology. In the High-Atlas, this species occurs in high mountain brooks and torrents (2150 m - 2620 m). The adults emerge in late spring and summer (VI-VIII).

Siphonoperla lepineyi (Navás 1935)

Material examined. High-Atlas: Ourika Valley, above Oukaimeden ski station, brook and spring, 2800 m, 3.06.2006, 19♂, 15♀ (VIN).

Distribution. Moroccan endemic species occurring in the Rif, Middle-Atlas and High-Atlas.

Ecology. A strongly orophilic species which occurs mainly in the highest points of the Moroccan mountain ranges, up to 1800 m in the Rif (Errochdi *et al.* 2014), 2150 m in the Middle-Atlas (Giudicelli & Dakki 1984) and 3300 m in the High-Atlas (Aubert 1956). The flight period extends between May and July, according to the altitude.

Brachyptera algerica Aubert 1956

Material examined. Middle-Atlas: Taza, SW Tazzeke Mount, below Bab Taka Pass, brook, Oued el Abod tributary, 1500-1700 m, 13.04.2013, 2♀ (VIN), 1♀ (ERR). High-Atlas: N. slope of Tizi n'Test Pass, 22 Km above Ijoukak, Idni Forest House, Oued Nfiss tributary, 1430 m, 22.01.2006, 2♂ + 7 larva + 2 exuviae (VIN). N. slope below Tizi n'Test Pass, brook, 1900 m, 24.02.1996, 1♀ (VIN). S. slope below Tizi n'Test Pass, brook 1600 m, 22.01.2006, 1 larva. SW Chichaoua, Imi n'Tanoute Pass, brook, 22.01.2006, 2♂, 6♀ (VIN).

Distribution. First records from the High-Atlas. A North African species which occurs in the Maghreb from Tunisia to Morocco.

Ecology. It occurs in high mountain brooks and torrents (1200-1900 m) in the High and Middle Atlas. The emergence period is mainly during winter and

early spring (I-IV).

Brachyptera auberti Consiglio 1957

Brachyptera mussardi (Aubert 1961 p. 215)

Material examined. High-Atlas: Ourika Valley, Ait El Kake, below Oukaimeden, torrent, 2150 m, 3.06.2006, 1♀ + 2♂ exuviae (VIN).

Distribution. A west Mediterranean species which occurs in the Maghreb from Morocco to Tunisia.

Ecology. An orophilic species which occurs in mountain brooks and torrents between 170 and 1800 m in the Rif (Errochdi *et al.* 2014), up to 2150 m in the High-Atlas. The adults emerge during winter and spring (II-VI).

Amphinemura chiffensis Aubert 1956

Amphinemura chiffensis Aubert 1956 (partim): p. 428 (only the records from the Moroccan High Atlas).

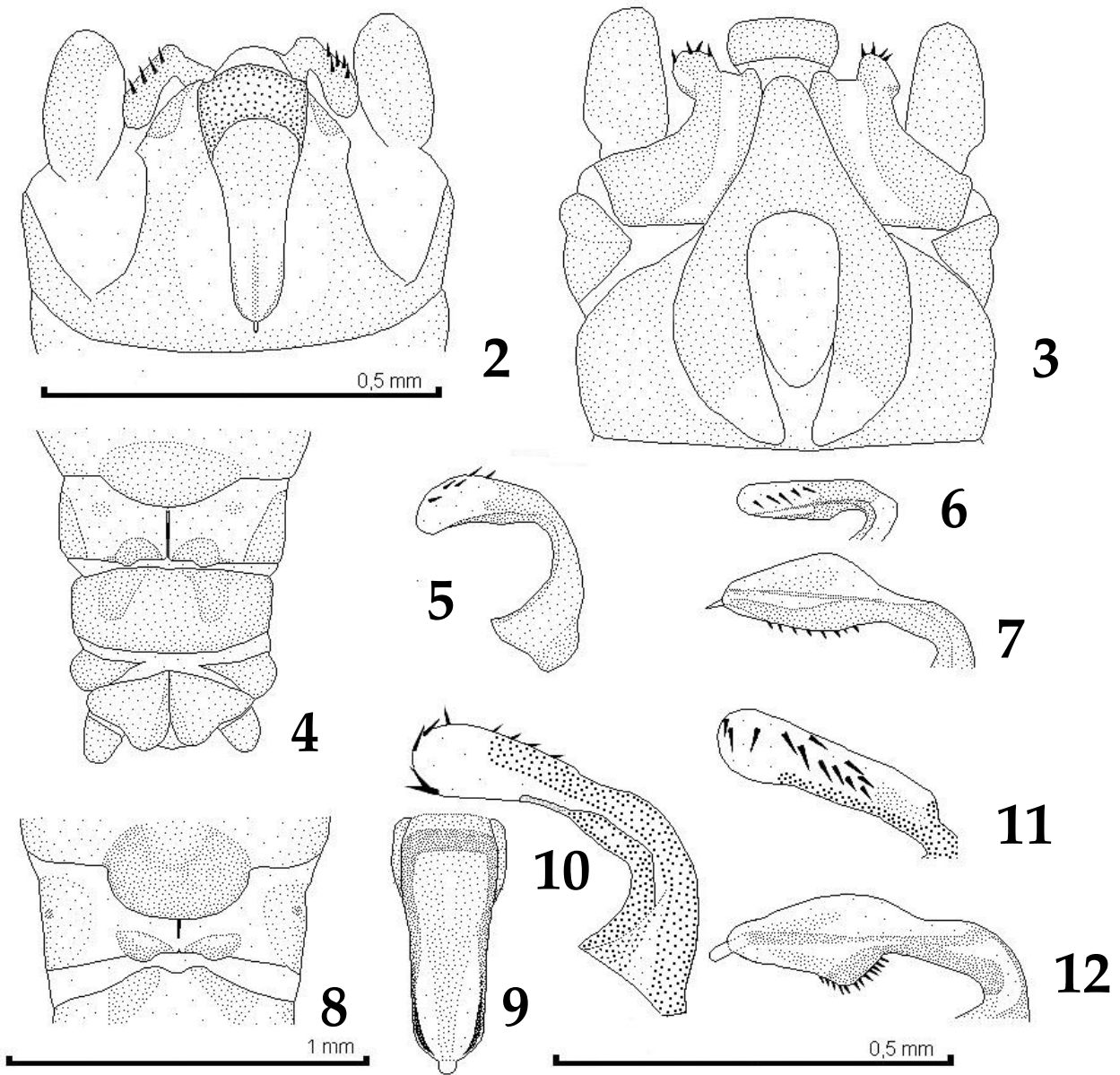
Material examined. High-Atlas: Ourika Valley, above Oukaimeden ski station, large brook with low speed, 2620 m, 3.06.2006, 3♀; brook and spring, 2800 m, 3.06.2006, 1♂ (VIN).

Distribution. A High-Atlas micro-endemic species (Fig. 1). The records from Tunisia (Béjaoui *et al.* 2003, Béjaoui & Boumaiza 2004) and Algeria (Aubert 1956, Lounaci & Vinçon 2005, Yasri *et al.* 2013) belong to *A. berthelemyi* Vinçon, Yasri & Lounaci, 2013 (Fig. 1), and those from the Moroccan Rif belong to *A. yasriarum* Vinçon, 2014.

Ecology. A strongly crenophilic and orophilic species which occurs mainly in springs, brooks and small rivers, between 2500 and 2800 m (Aubert 1956, 1961, Miron 1972, Pihan & Mohati 1983, Bouzidi 1989). It also occurs exceptionally in lower reaches (Tichka, 1350 m, Sánchez-Ortega coll.). Flight period VI-VIII.

Amphinemura tiernodefigueroai Vinçon sp. n. (Figs 2-3, 5-7)

Material examined. Holotype male: Morocco, Middle-Atlas, SE Khenifra, Sidi Yahia Ousaad, Oued Oum er Rbia tributary, lateral spring, 15.04.2013, deposited in the Zoological Museum of Lausanne, Switzerland (ZML). Paratypes: 3♂, 3♀, same locality



Figs 2-7. *Amphinemura tiernodefigueroai* sp. n. 2: male abdomen in dorsal view; 3: male abdomen in ventral view; 4: female abdomen in ventral view; 5: paraproct in lateral view (outer lobe on the left and median lobe on the right); 6: median lobe of the paraproct in dorsal view; 7: epiproct in lateral view.

Figs 8-12. *Amphinemura berthemyi* 8: detail of female abdomen in ventral view; 9: epiproct in dorsal view; 10: paraproct in lateral view (outer lobe on the left and median lobe on the right); 11: median lobe of the paraproct in dorsal view; 12: epiproct in lateral view (♂ Figs 2-3, 5-7, 9-12: scale = 0,5 mm, ♀ Figs 4, 8: scale = 1 mm).

and date, deposited in the ZML. Other specimens, same locality, 15.04.2013, 17♂, 17♀; 8.06.2013, 5♂, 11♀, are held in the Vinçon collection.

Description. Medium sized species: body length: male 4.6-5.6 mm, female 4.8-6.5 mm. Macropterous, wing length: male 5.8-7.0 mm, female 6.4-7.2 mm.

General colour brownish. Head brown with dark granulation on lateral parts of occiput; light brown spot between the three ocelli. Antennae dark brown covered with short thin hairs. Pronotum brown with two lateral dark patterns. Femora brownish, slightly darker in their distal part. Abdomen light brown. Body and legs covered with short pilosity.

Male genitalia (Figs 2-7). Paraprocts: Inner lobe long and closely connected to median lobe; its base partly hidden beneath expansion of the hypoproct (Fig. 3). Median lobe with rounded base and finger-shaped expansion bending dorsally between base of the epiproct and cercus (Figs 2, 3); this expansion is covered with thin hairs and a distal row of 5-6 strong spines (Figs 2, 5, 6). Outer lobe narrow, strongly bent dorsally, and nearly parallel to outer side of median lobe (Figs 5, 6). Cercus sub-cylindrical, hardly narrowing toward its tip, about twice as long as wide and covered with long thin hairs. Epiproct elongate, with dorso-medial bulge and rounded apex in lateral view (Fig. 7), and regularly narrowing toward its tip, ending in rounded apex in dorsal view (Fig. 2). Transparent filament very short, triangularly shaped, bent downward, with acute tip (Figs 2, 7). Dorsal sclerite of epiproct very narrow, nearly rectilinear, extending medially between base and tip of epiproct (Fig. 7). Ventral sclerite hardly bulged, covered with several scattered spines (Fig. 7). Tergite IX sclerotized, slightly raised upward on outer edge, without median notch, covered with thin hairs, without spines. Other tergites membranous, without spines along outer edge. Sternite IX (Fig. 3): Hypoproct with rounded base and triangular expansion reaching base of epiproct. Ventral vesicle racket-shaped and membranous except its sclerotized rod.

Female genitalia (Fig. 4). Sternite VII: Pregenital plate wider than half segment's width, slightly projecting backward on sternite VIII. Sternite VIII with two small rounded lobes rising from posterior margin and separated by a notch wider than the width of one of them. A narrow median sclerotized strip separates the tergite into two parts (Fig. 4). Sternite IX with two dark triangular spots near anterior margin, laterally. Paraprocts more or less triangular with rounded tip. Cercus rounded, nearly as long as wide and covered with long thin hairs.

Affinities. *A. tiernodefigueroai* sp. n. is closely related

to *A. berthelemyi* from which it differs by the following features. ♂: median lobe of paraprocts nearly as long as wide, forming half a circle (Figs 5, 6); while in *A. berthelemyi*, the finger-shaped spiny dorsal projection is much longer and carries more spines (Figs 10, 11); epiproct narrowing more toward its tip in *A. tiernodefigueroai* sp. n. (Figs 2, 9); ventral spiny bulge less prominent in *A. tiernodefigueroai* sp. n. than in *A. berthelemyi* (Figs 7, 12); terminal filament ending in sharp point in *A. tiernodefigueroai* sp. n. (Fig. 7) but more bluntly in *A. berthelemyi* (Fig. 12). ♀ sternite VII: pre-genital plate projecting less backward and less convex in *A. tiernodefigueroai* sp. n. than in *A. berthelemyi* (Figs 4, 8).

Distribution. Micro-endemic species of the Moroccan Middle-Atlas, only known from three small springs of the same brook (Figs 13, 14), on the southern slope of the Middle-Atlas (southward Khenifra, Fig. 1).

Ecology. A cold stenothermic, crenophilic species. The adults emerge in spring (IV-VI).

Etymology. Dedicated to the Spanish entomologist José Manuel Tierno de Figueroa, for his major contributions to the knowledge of the Mediterranean and European stoneflies.

Protonemura algirica (Aubert 1956)?

The occurrence of *P. algirica* in Morocco is doubtful and should be confirmed by new studies (Errochdi *et al.* 2014). The Middle-Atlas specimens reported by Aubert (1961) belong to *P. dakkii* and those reported from the High-Atlas also probably belong to *P. dakkii* (lost specimens).

Protonemura dakkii Vinçon & Murányi 2009

Protonemura algirica pro parte (Aubert 1961, specimens from Moroccan Middle-Atlas)

Material examined. Middle-Atlas: SE Khenifra, Sidi Yahia Ousaad, Oued Oum er Rbia tributary, lateral spring, 15.04.2013, 1♂, 2♀; 8.06.2013, 13♂, 3♀, normal winged (VIN); 14.11.2013, 1♂ (VIN). High-Atlas: Midelt, spring above Tattiouine village, Moulouya tributary., 1700 m, 15.04.2013, 1♀ apterous (VIN).

Distribution. First records from the High-Atlas. A Moroccan endemic species which occurs in the High and Middle-Atlas.



Figs. 13-14. Middle-Atlas, SE Khenifra, Sidi Yahia Ousaad brook, tributary of Oum er Rbia River. 13: main brook and lateral springs on the left side, 14: detail of one lateral spring. In the lateral springs both *Amphinemura tiernodefigueroai* sp. n. and *Protonemura dakkii* occur.

Ecology. A crenophilic species which mainly occurs in karstic springs (Vinçon & Murányi 2009). In the Sidi Yahia Ousaad watershed, the adults were not found in the main brook but exclusively in the three lateral springs marked by the dark green color of the grass (Fig. 13, left side of the photo). These very small springs are covered with dense vegetation (Fig. 14). In the High-Atlas, it is only known from a large rheocene spring above Tattiouine (Figs 15, 16). The adults mainly emerge in spring and early summer (IV-VII), but one male was also catch in autumn (XI).

Protonemura talboti (Navás 1929)

Material examined. Middle-Atlas: Taza, SW Tazzeka Mount, above Bab Hzhar, brook, Oued el Abod tributary, 1000 m, 6.06.2013, 6♂, 9♀ (VIN); Near Ifrane, river flowing from a lake, 14.11.2013, 1♂, 1♀ (VIN); between Skoura and Boulemane, below Taghrout village, brook, 14.04.2013, 33♂, 11♀ (VIN); SE Khenifra, Sidi Yahia Ousaad village, Oued Oum er Rbia tributary, brook, 15.04.2013, 22♂, 25♀; 8.06.2013, 2♂, 1♀; lateral spring, 9♂, 8♀; 8.06.2013 (VIN); 14.11.2013, 1♂, 1♀ (VIN). High-Atlas: Midelt, large spring, Moulouya tributary above Tattiouine village, 15.04.2013, 2♀; 8.06.2013, 25♂, 33♀; Tattiouine river, above Tattiouine, 8.06.2013, 15♂, 21♀ (VIN); 14.11.2013, 1♂ (VIN). Ourika Valley, below

Oukaimeden, cascade and brook, 2000 m, 3.06.2006, 5♂, 10♀; Ait El Kake, below Oukaimeden, torrent, 2150 m, 3.06.2006, 5♂, 10♀; above Oukaimeden ski station, spring and brook, 2800 m, 3.06.2006, 5♂, 4♀ (VIN). N. slope of Tizi n'Test Pass, Iguer, brook, 16.11.2013, 11♂, 7♀ (VIN). N. slope of Tizi n'Test Pass, 22 Km above Ijoukak, Idni Forest House, Oued Nfiss tributary, 1430 m, 24.02.1996, 3♂; N. slope of Tizi n'Test Pass, 31 Km between Asni and Ijoukak, brook, 16.11.2013, 2♂, 3♀ (VIN). S. slope below Tizi n'Test Pass, rheocene spring on calcareous substratum, 1900 m, 22.01.2006, 9♂, 5♀; near Imdersen Restaurant, brook, 1700 m, 22.01.2006, 2♂, 2♀ (VIN), 16.11.2013, 7♂, 5♀ (VIN).

Distribution. A west Maghreb species which occurs in the Rif, Middle and High-Atlas, and Tlemcen Mountains in western Algeria.

Ecology. It occurs in various mountain brooks and springs of the Middle and High-Atlas, up to 2900 m. Emergence period very wide XI-VIII.

Nemoura lacustris Pictet 1865

Material examined. Middle-Atlas: Taza, SW Tazzeka Mount, below Bab Taka Pass, brook, Oued el Abod tributary, 1500-1700 m, 13.04.2013, 6♂, 7♀; 6.06.2013, 6♂, 1♀ (VIN).

Distribution. First records from the Middle-Atlas. A

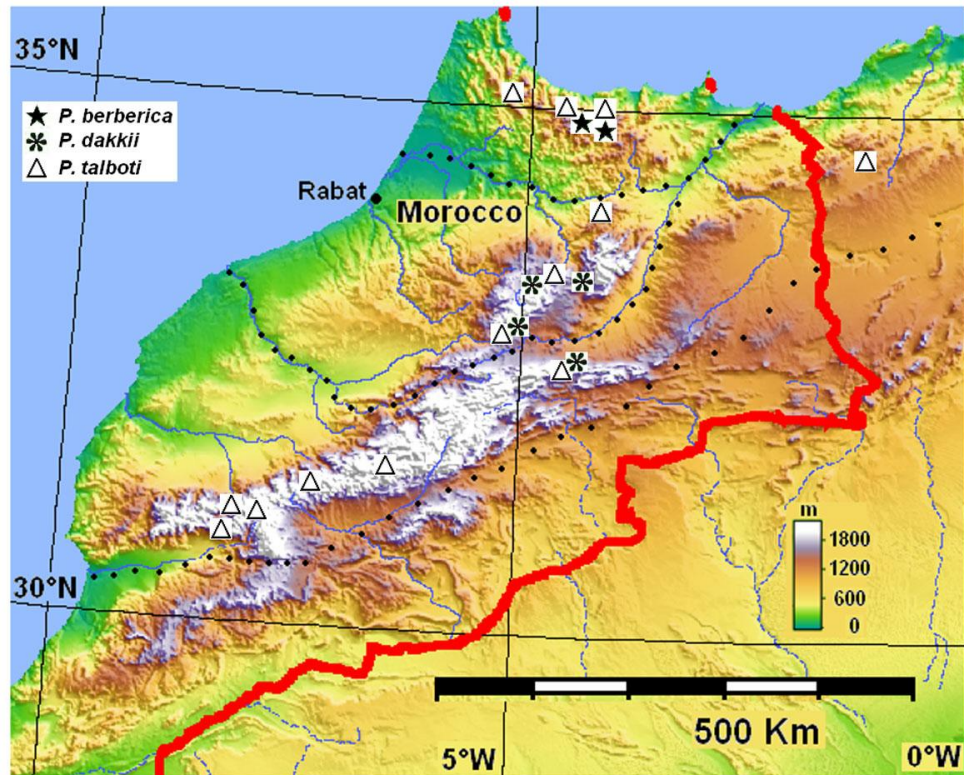


Fig. 15. Distribution of *Protonemura berberica*, *P. dakkii* and *P. talboti*.



Fig. 16. High-Atlas, Middel, Tattouine spring where occurs *Protonemura dakkii* and *P. talboti*.

west Mediterranean species which covers France, Spain, Portugal and extends in the Moroccan mountain ranges through the Rif and up to the northern edge of the Middle-Atlas (Tierno de Figueroa *et al.* 2003, Le Doaré & Vinçon 2006, Errochdi *et al.* 2014).

Ecology. In the Rif and Middle-Atlas, it is a cold stenothermic, crenophilic species which only occurs in high altitude brooks and springs (1200-1800 m). Flight period (I-VI).

Capnia nigra (Pictet 1833)

The only mention of this species in the High-Atlas refers to Aubert 1961.

The report of *C. bifrons* from the High-Atlas (Bouzidi 1989) is very doubtful since it is based on larval identifications not confirmed by adult specimens; therefore, we assigned them to *C. nigra*.

Capnionaura atlasica Vinçon sp. n.

(Figs. 17-20, 23)

Material examined. Types. Holotype male: Morocco, High-Atlas, N. slope of Tizi n'Test Pass, 22 Km above Ijoukak, Idni Forest House, Oued Nfiss tributary, 1430 m, 22.01.2006, deposited in the Zoological Museum of Lausanne, Switzerland (ZML). Paratypes: 3♂, 3♀, same locality and date, deposited in the ZML. Other specimens, same locality, 22.01.2006, 18♂, 6 larvae, 24.02.1996, 2♂, 4♀, are held in the Vinçon collection. N. slope of Tizi n'Test Pass, Goundafa Kasbah, above Ijoukak village, 24.02.1996, 6♀; Oued Agoundiss at Ijoukak, 1200 m, 22.01.2006, 1♀. S. slope below Tizi n'Test Pass, near Imdersen Restaurant, brook, 1700 m, 22.01.2006, 16♂, 14♀, 3 larvae (VIN). S.W. Chichaoua, Imi n'Tanoute Pass, brook, 22.01.2006, 3♀; above Irchalen below Zaouïa Tamaroute village, brook, 1700 m, 22.01.2006, 1♂, 1♀ (VIN). The specimens reported from the High-Atlas (Bouzidi & Giudicelli 1994) are also assigned to *C. atlasica* sp. n. since they most probably also belong to this species.

Description. Small sized species: body length: ♂ 4.2 – 6.0 mm, ♀ 5.5 – 7.8 mm. ♂ slightly brachypterous: anterior wing 2.6 – 3.6 mm. ♀ normally winged: anterior wing 6.3 – 7.3 mm. Body brown; head with dark brown granulations on the occiput, dark

marking between lateral ocellus, compound eye and base of antenna. Antenna dark brown. Pronotum with dark markings. Legs brownish with longitudinal darker strips.

Male (Figs 17-20). Tergite VII-VIII with rounded posterior membranous field and strong anterior sclerotized strip. Tergite IX similar but with narrower anterior sclerotized strip. Tergite X: wide anterior sclerotized strip getting narrower medially; heart-shaped median membranous field (Fig. 17). Epiproct strongly raised upwards; with rounded base and long slightly curved expansion; apex rounded with triangular anterior tooth (Fig. 19). Paraproct shaft long, blade-shaped, getting thinner toward its sharp apex (Fig. 18, 19). Specillum hook-shaped, ending in sharp point (Fig. 18). Cercus with thick base and strong tooth on inner side (Figs 17, 19).

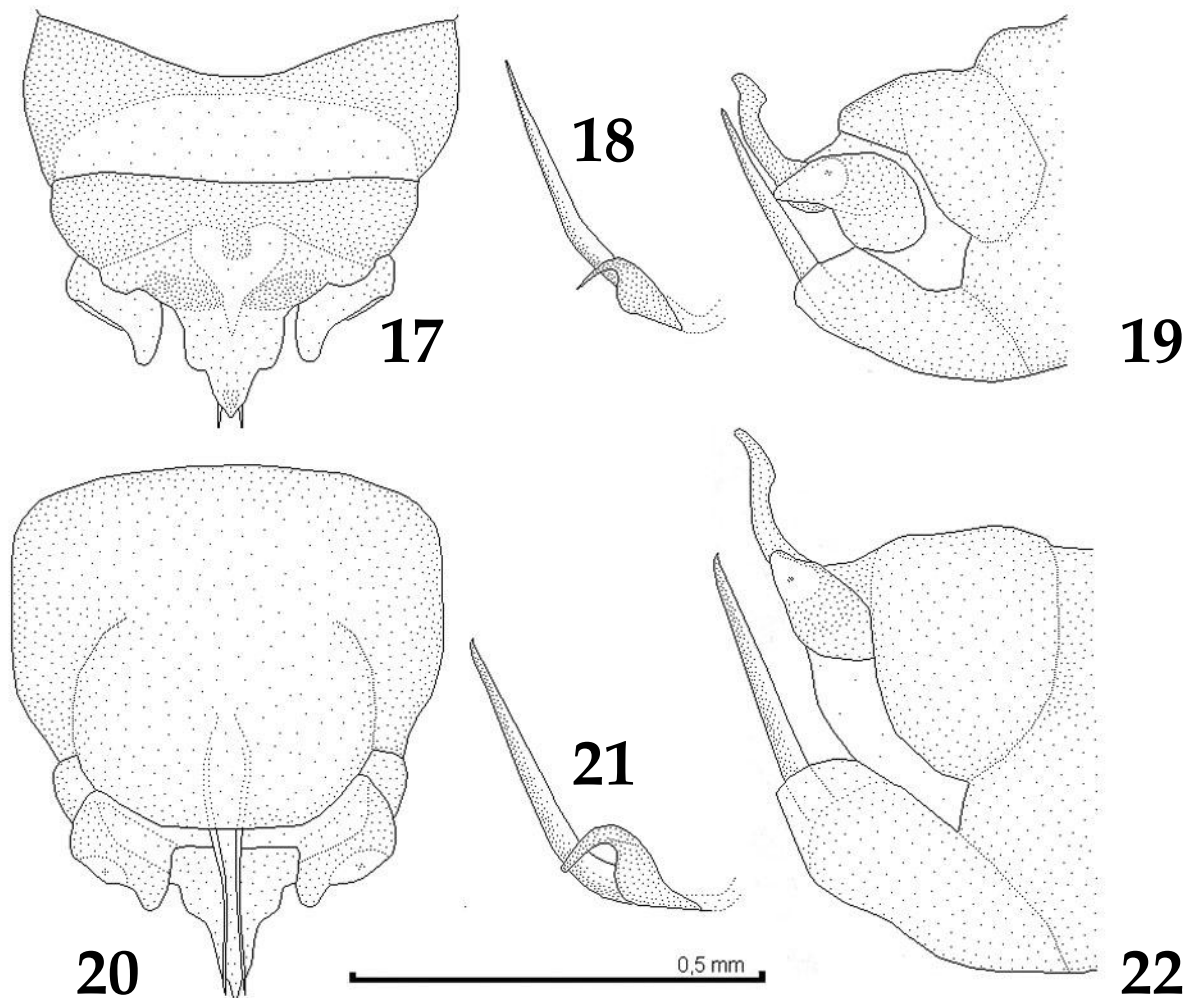
Female (Fig. 23). Tergite I-VIII with wide median membranous area. Tergite IX-X fully sclerotized. Sternite VII: wide sclerotized plate with sub-triangular posterior expansion that nearly reaches the middle part of sternite VIII. Sternite VIII with median membranous area, partly crossed by the projection of sternite VII; two anterior dark spots on inner edge of lateral plates. Sternite IX with median sub-triangular sclerite flanked by two lateral dark expansions. Tergite X: paraprocts nearly triangular; cerci very short and rounded.

Affinities. Male closely related to *C. petitpierreae* by the shape of specillum, paraproct blades and epiproct; nevertheless, epiproct with short apical expansion in lateral view (Fig. 19) instead of long gently curved expansion in *C. petitpierreae* (Fig. 22). The paraproct shaft ends in rectilinear apex (Figs 18, 19) while it is slightly curved frontward at tip in *C. petitpierreae* (Figs 21, 22). Apex of specillum sharper in *C. atlasica* than in *C. petitpierreae* (Figs 18, 21). The female genitalia of *C. atlasica* are conspicuously different from those of *C. petitpierreae*, especially the shape of the sclerotized plate on sternite VII (Figs 23, 24).

Distribution. A micro-endemic species which is restricted to the western extremity of the Moroccan High-Atlas (Fig. 25).

Ecology. A cold stenothermic, crenophilic species. The adults were collected in winter (I-II).

Etymology. The name of *C. atlasica* sp. n. refers to the Atlas, the wonderful mountain range where it occurs.



Figs. 17-20. *Capnioneuratlasica* sp. n. 17: male abdominal tip in dorsal view, 18: paraproct shaft and specillum, 19: male abdominal tip in lateral view, 20: male abdominal tip in ventral view.

Figs. 21-22. *Capnioneurapetitpierreae*. 21: paraproct shaft and specillum, 22: male abdominal tip in lateral view.

***Capnioneurapetitpierreae* Aubert 1961**

The report of *C. petitpierreae* from the High-Atlas (Bouzidi & Giudicelli 1994) is assigned to *C. atlasica* sp. n.

Material examined. Middle-Atlas: Taza, SW Tazzeke Mount, below Bab Taka Pass, Oued el Abod tributary, brook, 1500-1700 m, 13.04.2013, 5♀ (VIN).

Distribution. A Baetic-Maghrebin species with wide distribution in the Maghreb from northern Morocco to Tunisia and extending in Andalucía.

Ecology. It is only reported from high altitude brooks and torrents (1500-1700 m) in the Middle-Atlas, but in the remaining parts of the Maghreb, it is more eurytopic and even present in lower reaches (Sánchez-Ortega & Azzouz 1998, Errochdi & El Alami 2008). The emergence period extends from autumn to spring (XI-IV).

***Capnopsis schilleri schilleri* (Rostock 1892)**

Material examined. Middle-Atlas: Taza, above Bab

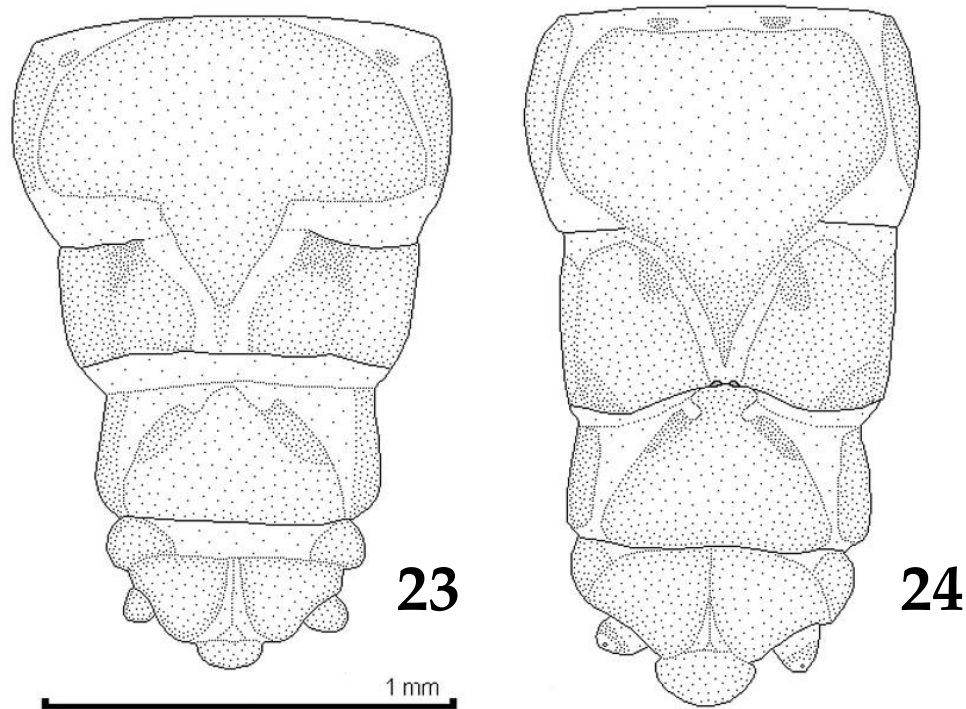


Fig. 23. *Capnioneura atlasica* sp. n.: female abdominal tip in ventral view.

Fig. 24. *Capnioneura petitpierreae*: female abdominal tip in ventral view.

Hzhar, brook and spring, Oued el Abod tributary, 1000 m, 13.04.2013, 1♂, 1♀; Taza, SW Tazzeka Mount, below Bab Taka Pass, Oued el Abod tributary, brook, 1500-1700 m, 13.04.2013, 8♂, 25♀ (VIN). High-Atlas: N. slope of Tizi n'Test Pass, Goundafa Kasbah, above Ijoukak village, 24.02.1996, 6♂, 6♀; SW Chichaoua, Imi n'Tanoute Pass, brook, 22.01.2006, 12♂, 66♀; above Irchalen below Zaouïa Tamaroute village, brook, 1700 m, 22.01.2006, 3♂, 4♀ (VIN).

Distribution. First records from the Middle and High-Atlas. *C. schilleri schilleri* has a wide distribution in Europe and North-Africa (Zwick 1984). In the Maghreb, it is reported from Tunisia (Berthélemy 1973) and Algeria (Lounaci & Vinçon 2005). In Morocco it covers the Rif (Sánchez-Ortega & Azzouz 1998, Errochdi *et al.* 2014), Middle-Atlas and High-Atlas.

Ecology. In the Middle and High-Atlas, it occurs in mountain brooks and torrents (1000-1700 m). The adults fly in winter and early spring (I-IV).

***Leuctra franzi paenibaetica* Sánchez-Ortega & Ropero-Montero 1993**

Material examined. Middle-Atlas: Taza, SW Tazzeka Mount, below Bab Taka Pass, Oued el Abod tributary, brook, 1400 m, 13.11.2013, 4♂, 10♀ (VIN).

Distribution. First records from the Middle-Atlas. A Baetic-Rifan subspecies, slightly extending in the northern part of the Middle-Atlas.

Ecology. In the Rif and Middle-Atlas, it occurs in high altitude water courses of different size (springs, brooks and torrents) (1400-1700 m). The adults fly in autumn (X-XI).

***Leuctra geniculata* Stephens 1836**

Material examined. High-Atlas: Ourika Valley, Ait El Kake, below Oukaimeden, torrent, 2150 m, 15.11.2013, 47♂, 29♀ (VIN).

Distribution. A central and west European species

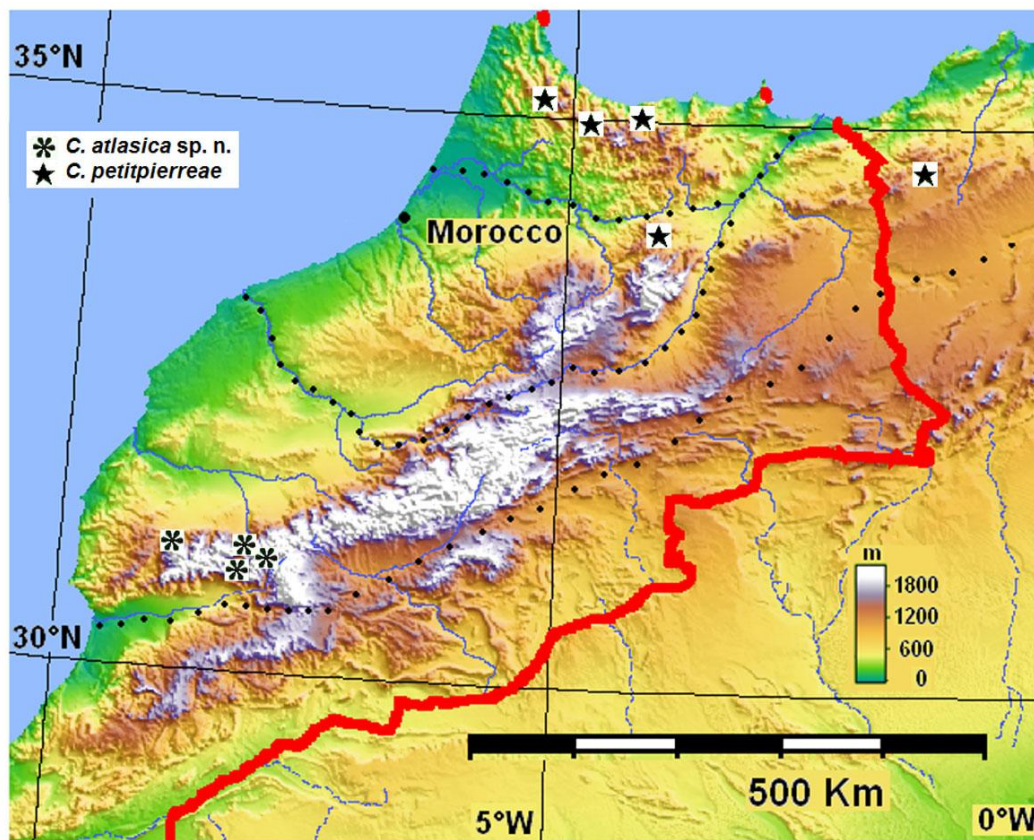


Fig. 25. Distribution of *Capnioneura atlasica* sp. n. and *C. petitpierree* in western Maghreb.

which also occurs in the British Isles and the Maghreb.

Ecology. In Europe, it occurs more frequently in large rivers and streams of lowland regions (metarhithral-epipotamal) while in the Moroccan Rif, it widely occurs between 50-1520 m (Errochdi *et al.* 2014) and in the High-Atlas, up to 2150 m. The adults mainly emerge in autumn (VIII-XI).

***Leuctra ketamensis* Sánchez-Ortega & Azzouz 1997**

Material. Middle-Atlas: Taza, SW Tazzeke Mount, below Bab Taka Pass, Oued el Abod tributary, brook, 1400 m, 13.11.2013, 1♂ (VIN).

Distribution. First record from the Middle-Atlas. A north Moroccan micro-endemic species. This very scarce species was only known from one male and six females collected in the Rif (Sánchez-Ortega & Azzouz 1997, Errochdi *et al.* 2014).

Ecology. A crenophilic species which is restricted to the highest points of the Rif and to the northern part of the Middle-Atlas (Taza National Park) (1250-1600 m). The adults emerge in autumn (X-XI).

***Leuctra maroccana* Aubert 1956**

Material examined. High-Atlas: Ourika Valley, Ait El Kake, below Oukaimeden, torrent, 2150 m, 15.11.2013, 9♂, 5♀ (VIN). N. Oukaimeden, before Tassalt n Tizi Pass, after Ait Amer, spring, 16.11.2013, 2♂, 2♀ (VIN).

Distribution. A west Mediterranean species which extends from the Moroccan High Atlas to the foothills of the Atlantic Pyrenees, and which is widely distributed within the Iberian Peninsula (Tierno de Figueroa *et al.* 2003).

Ecology. It is a cold stenothermic, crenophilic species. In the Moroccan mountains it mainly occurs in high

altitude biotopes (1400-2600 m). The emergence period covers the cold season from autumn to spring (XI-IV).

Leuctra vaillanti Aubert 1956

Material. High-Atlas: Ourika Valley, Ait El Kake, below Oukaimeden, 2150 m, 3.06.2006, 1♀ (VIN). N. slope of Tizi n'Test Pass, Iguer, brook, 16.11.2013, 21♂, 19♀ (VIN); N. slope of Tizi n'Test Pass, 22 Km above Ijoukak, Idni Forest House, Oued Nfiss tributary, 1430 m, 24.02.1996, 1♂, 2♀ (VIN); N. slope of Tizi n'Test Pass, 31 Km between Asni and Ijoukak, brook, 16.11.2013, 5♂, 2♀ (VIN). S. slope below Tizi n'Test Pass, near Imdersen Restaurant, brook, 1700 m, 22.01.2006, 1♂, 1♀ (VIN); 16.11.2013, 6♂, 5♀ (VIN).

Distribution. A maghrebin endemic species which is known from Tunisia (Vinçon & Pardo 1998) to Morocco (Aubert 1956).

Ecology. A cold stenothermic, orophilic species which mainly occurs in high altitude biotopes (1400-2150 m). The flight period covers the cold season from autumn to spring (XI-VI).

Tyrrhenoleuctra tangerina (Navás 1922)

All the Maghrebin *Tyrrhenoleuctra* are considered to belong to the same species, *T. tangerina* (Yasri-Cheboubi *et al.* 2013).

Material examined. Middle-Atlas: Taza, above Bab Hzhar, 1000 m, brook and spring, Oued el Abod tributary, 13.04.2013, 4♂, 9♀; 6.06.2013, 14♀ (VIN), 1♀ (ERR).

Distribution. First records for the Middle-Atlas. *T. tangerina* occurs in central and western Maghreb, from Morocco to Tunisia, and in southern Spain (Yasri-Cheboubi *et al.* 2013, Errochdi *et al.* 2014).

Ecology. It mainly occurs in small temporary streams at moderate altitude (100-1400 m) that often dry in summer and autumn corresponding to the "thermophile association" (Aubert 1963). Flight period II-VI, but more frequently in winter (II-III).

STONEFLIES OF THE ATLAS MOUNTAINS

The list of the 23 Atlas stoneflies is given in Table 1. It compiles the main records concerning the two

mountain ranges of Moroccan Atlas (Middle-Atlas and High-Atlas).

The biogeography of Atlas stoneflies, the comparative richness of the different mountainous regions in Morocco and the human impact will be studied in a follow-up study of Moroccan stoneflies.

ACKNOWLEDGEMENTS

We thank very much our colleagues José Manuel Tierno de Figueroa (Granada) and Jean Luc Gattolliat (Lausanne) for their loan of comparative material. We are grateful to Dr. John Brittain and Dr. Jean-Paul Reding for kindly revising our English text.

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Received 14 January 2014, Accepted 10 April 2014, Published 9 June 2014