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**Autor:** Errochdi, Sanae / Vinçon, Gilles / El Alami, Majida

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## Contribution to the knowledge of the stoneflies (Plecoptera) of the Moroccan Rif

SANAE ERROCHDI<sup>1</sup>, GILLES VINÇON<sup>2</sup> & MAJIDA EL ALAMI<sup>3</sup>

<sup>1</sup> Université Abdelmalek Essaadi, Faculté des Sciences de Tétouan, Laboratoire Diversité et Conservation des systèmes biologiques (LDICOSYB), BP. 2121, 93000 Tétouan, Maroc.  
errochdi\_sanae@yahoo.fr

<sup>2</sup> 55 Bd J. Vallier, F-38100 Grenoble, France. vincon@kls-logistic.fr

<sup>3</sup> Université Abdelmalek Essaadi, Faculté des Sciences de Tétouan, Laboratoire Diversité et Conservation des systèmes biologiques (LDICOSYB), BP. 2121, 93000 Tétouan, Maroc.  
majidae@hotmail.com

*Amphinemura yasriarum* sp. n., endemic to the Moroccan Rif, is described and compared to its closest relative *A. chiffensis* Aubert, 1956. The two species are separable in both sexes. *A. chiffensis* is only known from the Moroccan High-Atlas and we assume that it is an endemic of this mountain range where it lives at high altitudes. New faunistic data are given for 19 stonefly species occurring in the Rif. *Nemoura fulviceps* Klapálek, 1902 is new for Morocco. New distinctive characters between *Nemoura lacustris* Pictet, 1865 and *N. rifensis* Aubert, 1961 are presented; both species are assigned to a distinct group in the *Nemoura* genus (*lacustris* group). The faunistic list of the 23 Rifan stoneflies is updated.

Keywords: *Amphinemura*, *A. chiffensis*, *A. yasriarum*, *N. fulviceps*, systematics, taxonomy, zoogeography, Morocco, Rif.

### INTRODUCTION

The Rifan arc is a wide Moroccan cordillera extending northward along the Mediterranean Sea, from Tanger to Saïdia (close to the Algerian border). It is separated from the Middle-Atlas westward by the Sébaou Valley up to the Touahar Pass near Taza, and eastward by the Moulouya Valley down to Saïdia.

The first major contribution to the knowledge of the Rifan stonefly fauna was by Aubert (1961), with a detailed list of 12 species. Giudicelli & Dakki (1984) mentioned four species in five Rifan springs. Azzouz & Sánchez-Ortega (1992, 1994) and Sánchez-Ortega & Azzouz (1997) added three species to the Rifan fauna. Then a two years survey of 19 Rifan localities, carried out by Sánchez-Ortega & Azzouz (1998), added 7 new records for the Rif. A new Rifan species was described by Vinçon & Sánchez-Ortega (1999). Another in-depth contribution by Errochdi & El Alami (2008) reported 18 stonefly species from the Laou catchment area, near Chefchaouen (N.W. Rif). Lastly, the compilation of the North African *Protonemura corsicana* species group by Vinçon & Murányi (2009) included two Rifan species.

This present study is based on six collecting trips performed in February 1996, January 2006, June 2006, April 2013, June 2013 and November 2013, inducing the discovery of *Amphinemura yasriarum* sp. n., already present in the Aubert collection but confused with *A. chiffensis* (Aubert 1961, specimens from the Moroccan Rif).

According to the allopatric distribution of *A. chiffensis* (High-Atlas), *A. berthelemyi* Vinçon, Yasri & Lounaci, 2013 (Algeria and Tunisia) and *A. yasriarum* sp. n. (Rif), the two last species could be considered as geographic subspecies of *A. chiffensis*, nevertheless the differences between them are conspicuous, concerning epiproct, paraprocts and female genitalia, justifying to consider them as distinct species. Moreover, in the Moroccan Middle Atlas, also occurs another new *Amphine-mura* species, clearly distinct from *A. berthelemyi*, *A. chiffensis* and *A. yasriarum* sp. n. (Vinçon, El Alami & Errochdi 2014, in press). Such a high level of micro-endemism is also observed in other stonefly genera in the Maghreb, for instance, 3 closely related *Protonemura* species have allopatric geographical areas: *Protonemura algerica* (Aubert, 1956) (Algeria and Tunisia), *P. berberica* Vinçon & Sánchez-Ortega, 1999 (Moroccan Rif) and *P. dakkii* Vinçon & Murányi, 2009 (Moroccan Middle and High Atlas).

#### MATERIAL AND METHODS

The material is preserved in alcohol. Type specimens are deposited in the Museum of Zoology, Lausanne, Switzerland (MZL). Other specimens are stored in the Aubert, 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: <> = in direction, > = above, < = below, b. = brook, r. = river, spr. = spring, t. = torrent, ex. = exuviae, E. = East, N. = North, S. = South, W. = West, v. = village, AUB = Aubert coll., VIN = Vinçon coll., ERR = Errochdi coll., m = m a.s.l.

Terminology of the terminalia follows Baumann (1975).

#### *Isoperla* cf. *kir* Fochetti & Vinçon, 1993

*Material.* Rif: S. Ketama, <> Taounate, 1400 m, b., 4.06.2006, 1 ♀ + 2 ex. (VIN); > Azila, Jbel Tidirhine, 1500 m, 7.06.2013, 1 ♂, 2 ♀♀ (VIN).

*Distribution.* According to Sánchez-Ortega & Azzouz (1998) this species is closely related to *I. kir* Fochetti & Vinçon, 1993, but needs further studies to confirm its taxonomic rank and geographical area, since few characters differ from *I. kir*.

*Ecology.* In the Rif, it occurs in mountain brooks and brooklets (300–2000 m) and mainly flies in late spring (V–VI) (Aubert 1961, Sánchez-Ortega & Azzouz 1998, Errochdi & El Alami 2008).

#### *Hemimelaena flaviventris* (Pictet, 1841)

The occurrence of *H. flaviventris* in the Maghreb outside the Moroccan mountain ranges is doubtful and should be confirmed, since there are old records of this species in Tunisia and Algeria that correspond to *Afroperlodes lecerfi* (Navás, 1929) (Berthélemy 1973, also reported in Lounaci & Vinçon 2005). Nevertheless the Rifan specimens are well identified (Aubert 1961, Sánchez-Ortega & Azzouz 1998, Errochdi & El Alami 2008).

#### *Perla* sp. (cf. *pallida* Guérin, 1838)

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

*Material.* Rif: Ketama, > Azila, Tidirhine Mount, 1600–1800 m, b., 4.06.2006, 2 ♂♂, 3 ex. (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: 24). The specimens from the Rif and High-Atlas probably belong to the same species, but this identification needs confirmation by further studies.

*Ecology.* In the Rif, this species occurs in mountain brooks 140–1800 m (Sánchez-Ortega & Azzouz 1998, Errochdi & El Alami 2008).

### ***Siphonoperla lepineyi* (Navás, 1935)**

*Material.* Rif: Ketama, > Azila, Tidirhine Mount, 1600–1800 m, b., 4.06.2006, 10 ♂♂ (VIN); 1500 m, t., 7.06.2013, 6 ♀♀ (VIN); 1800–2000 m, 7.06.2013, 3 ♀♀ (VIN). Bab-Berred <> Bab-Bessen, W. Issaguen, spr., 1600m, 7.06.2013, 11 ♂♂, 4 ♀♀ (VIN).

*Distribution.* This species is a Moroccan endemic occurring in the Rif, Middle-Atlas and High-Atlas.

*Ecology.* In the Rif, this species widely occurs in the whole mountain range from nearly sea level (20 m) up to 1800 m (Aubert 1961, Sánchez-Ortega & Azzouz 1998, Errochdi & El Alami 2008). In the Middle-Atlas it is recorded at 2150 m (Giudicelli & Dakki 1984); in the High-Atlas our specimens were collected at 2800 m and it is reported up to 3000 m in the Toubkal Massif (Aubert 1956). In the Rif, it inhabits different types of water courses being more frequent at high altitudes. The flight period is in late spring (V–VI) and extends to July in the highest localities of the High-Atlas (Aubert 1956).

### ***Brachyptera algerica* Aubert, 1956**

*Material.* Rif: > Bab-Taza, Oued Bouhalla, t., 1000 m, 22.02.1996, 6 ♂♂, 2 ♀♀ (VIN); b. Bab-Berred <> Bab-Besen, near crossroad Tamarote – El Jebha, 1400 m, 22.02.1996, 2 ♂♂, 2 ♀♀ (VIN); Bab-Besen <> Ketama, 1600 m, *Cedrus* forest, b., 23.01.2006, 1 ♀ (VIN); Bab-Taza <> Bab-Berred, > Sefliane, El Anasser, b., 22.02.1996, 1 ♂, 3 ♀♀ (VIN).

*Distribution.* North African species occurring in the Maghreb from Tunisia to Morocco.

*Ecology.* In the Rif, it occurs in high mountain brooks and torrents (900–1600 m) (Sánchez-Ortega & Azzouz 1998, Errochdi & El Alami 2008). The emergence period is mainly in winter and spring (I–VI).

### ***Brachyptera auberti* Consiglio, 1957**

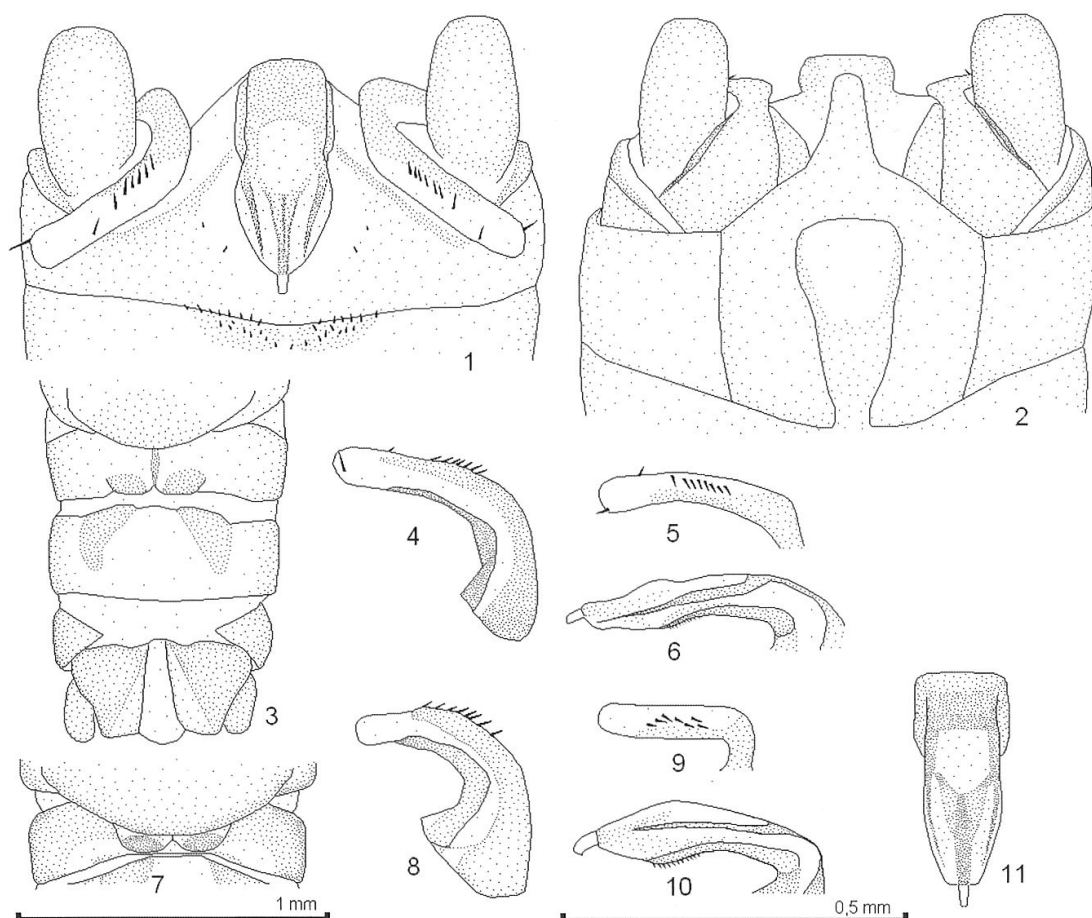
*Brachyptera mussardi* (Aubert 1961 p 215)

*Material.* Rif: Ketama, b. > Azila, Tidirhine Mount, 1500 m, 12.04.2013, 1 ♂, 1 ♀ (VIN); 7.06.2013, 1 ♀; 1600–1800 m, b., 4.06.2006, 4 ♀♀ (VIN); 12.04.2013, 1 ♂ (ERR), 1 ♂ (VIN).

*Distribution.* West Mediterranean species occurring in the Maghreb from Morocco to Tunisia.

*Ecology.* In the Rif, this species occurs in mountain brooks and torrents (170–1800 m) (Aubert 1961, Sánchez-Ortega & Azzouz 1998, Errochdi & El Alami 2008). The adults fly in winter and spring (II–VI).





Figs 1–11. — 1–6: *Amphinemura yasriarum* sp. n. 1: male abdomen in dorsal view; 2: male abdomen in ventral view; 3: female abdomen in ventral view; 4: paraproct in lateral view (outer lobe on the left and median lobe on the right); 5: median lobe of the paraproct in dorsal view; 6: epiproct in lateral view — 7–11: *Amphinemura chiffensis* 7: detail of female abdomen in ventral view; 8: paraproct in lateral view (outer lobe on the left and median lobe on the right); 9: median lobe of the paraproct in dorsal view; 10: epiproct in lateral view; 11: epiproct in dorsal view (♂ Figs 1–2, 4–6, 8–11: scale = 0,5 mm, ♀ Figs 3, 7: scale = 1 mm).

***Amphinemura yasriarum* Vinçon sp. n.**

(Figs 1–6, 12, 13–15)

*Amphinemura chiffensis* auctt., nec Aubert 1956:

Aubert 1961 (partim): 219 (records from the Moroccan Rif).

Lounaci & Vinçon 2005: 117 (records from the Moroccan Rif).

*Types.* Holotype male: Morocco, Rif, Azib de Ketama, Tidirhine (Tidiguin) Mount, t., 1400 m a.s.l., 24.04.1960 (AUB) and 1 ♀ paratype, same date and locality, deposited in the Museum of Zoology, Lausanne (MZL). Other paratypes: Rif, > Ketama, > Azila, 1700–1800 m, 4 ♀♀, 4.06.2006 (VIN), held in the Vinçon collection.

*Description.* Medium sized species: body length: male 7.0 mm, female 7.5–8.3 mm. Macropterous, wing length: male 7.9–8.5 mm, female 8.1–8.8 mm. General

colour brownish. Head brown with dark granulation on lateral parts of occiput; light brown spot on front and median part of occiput. Antennae dark brown covered with short thin hairs. Pronotum brown with two lateral dark markings. Femora light brown with three longitudinal dark brown bands extending all along femora except shorter median one. Abdomen light brown. Body and legs covered with short thin setae.

Male genitalia. Paraprocts: Inner lobe long, cylindrical, narrowing towards tip and closely connected to median lobe (Fig. 2). Median lobe sub-triangular (Fig. 2), extending in narrow finger shaped expansion bending dorsally and slightly turning around cercus (Fig. 1); dorsal expansion covered with thin hairs and median row of 6–7 strong spines followed by one isolated spine before apex and one last very strong spine rising from lobe's tip (Figs 1, 4, 5). Outer lobe narrow, long, strongly bent dorsally, and nearly parallel to outer side of median lobe (Fig. 4). Cercus sub-cylindrical, hardly narrowing toward tip, about twice longer than wide, covered with long thin hairs. Epiproct elongate, with dorso-medial bulge and truncate apex in lateral view (Fig. 6). In dorsal view (Fig. 1), first half of epiproct nearly rectilinear; widening after mid-length, then regularly narrowing and ending in rounded apex. Transparent filament short and apparently not open at tip, extending inside epiproct, less and less visible by transparency (Figs 1, 6). Dorsal sclerite of epiproct nearly rectilinear, extending from epiproct's base near to tip (Fig. 6). Ventral sclerite hardly bulged, covered with one row of tiny spines along bulgy part (Fig. 6). Tergite IX with 2 wide bulges of spines strongly raised upward and separated by shallow median notch. Other tergites without any spines along outer edge. Sternite IX (Fig. 2): Hypoproct nearly pentagonal, ending in finger shaped expansion reaching base of epiproct. Ventral vesicle racket-shaped and membranous except sclerotized rod.

Female genitalia (Fig. 3). Sternite VII: Pregenital plate wide, nearly extending up to segment edges, slightly projecting backward, covering a fourth of sternite VIII, and not reaching base of vaginal lobes. Sternite VIII with 2 sub-rectangular sclerotized vaginal lobes separated by shallow notch prolonged frontward by narrow sclerotized strip meeting outer edge of tergite (Fig. 3). Sternite IX with 2 dark triangular spots near anterior margin, laterally. Paraprocts about triangular with rounded tip. Cercus cylindrical, nearly twice as long as wide, and covered with long thin hairs.

*Affinities.* *A. yasriarum* sp. n. is closely related to *A. chiffensis* from which it differs by the following features. ♂: median lobe of the paraprocts carrying a strong apical spine that is absent in *A. chiffensis*; paraprocts with longer rectilinear apex in *A. yasriarum* sp. n. (Figs 4–5, 8–9); epiproct more widening near mid-length in *A. yasriarum* sp. n. (Figs 1, 11) and with a median dorsal bulge that is absent in *A. chiffensis* (Figs 6, 10); terminal filament without distal hook in *A. yasriarum* sp. n. ♀ sternite VII: pre-genital plate projecting more backwards and reaching the base of the vaginal lobes in *A. chiffensis*, while it is less prominent in *A. yasriarum* sp. n., not reaching the two lobes (Figs 3, 7) (character not linked to abdomen contraction since it is constant in both species). The other Maghrebin *Amphinemura*, *A. berthelemyi* Vinçon, Yasri & Lounaci, 2013, from Algeria and Tunisia, clearly differs by the shape of the male and female genitalia (Yasri *et al.* 2013).

*Geographical distribution and ecology.* *A. yasriarum* sp. n. is a cold stenothermal, micro-endemic species of the Moroccan Rif. It occurs in the highest part



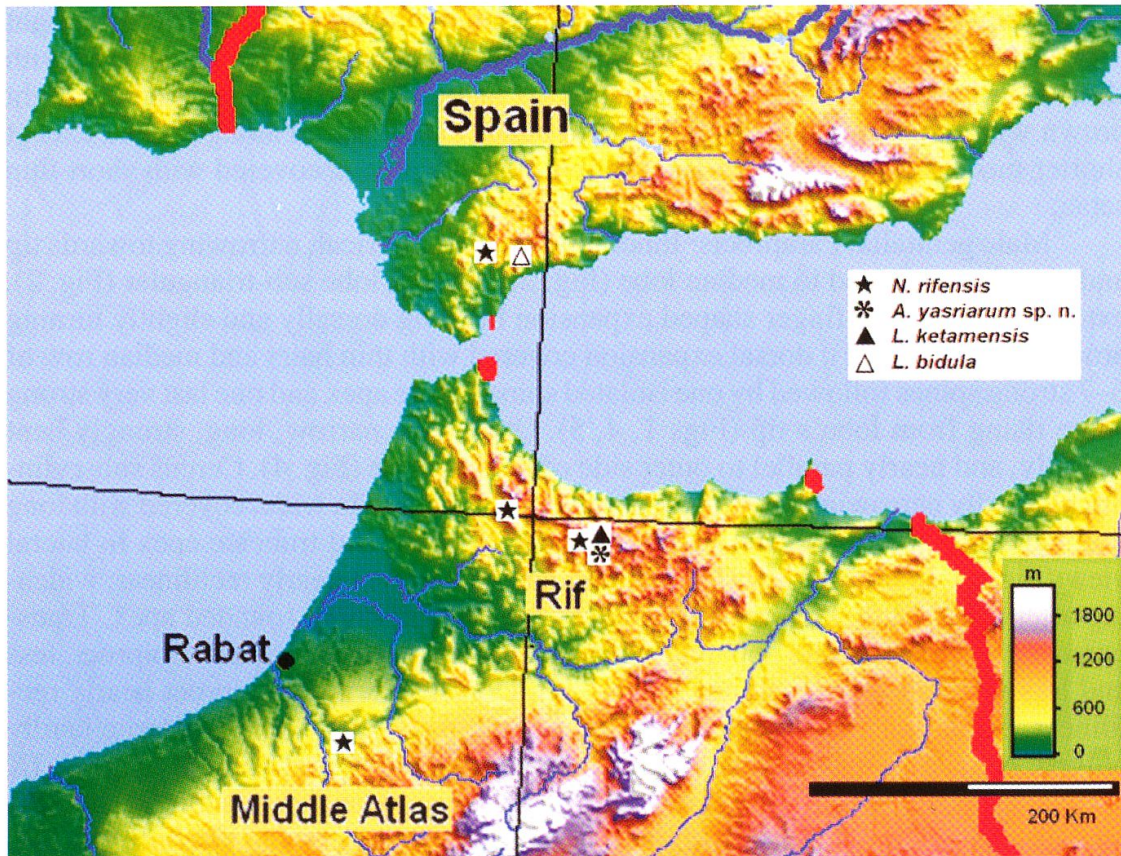


Fig. 12. Distribution of the three most endangered species occurring in the Rif, *Amphinemura yasriarum* sp. n., *Nemoura rifensis* and *Leuctra ketamensis*, and distribution of *L. bidula*, baetic species closely related to *L. ketamensis*.

of this long coastal mountain range, between 1400–1800 m a.s.l., in the surroundings of Ketama, on the northern slope of the Tidirhine mount (2448 m), highest point of the Rif (Fig. 12). It lives in brooks and torrents of various size (Figs 13–15), tributaries of Oued Sra <> Oued Ouerrha <> Oued Sebou flowing into the Atlantic Ocean at Kénitra. The adults fly in spring (IV–VI).

*Etymology.* This species is dedicated to the Algerian entomologist Nabila Yasri and to her family.

#### *Protonemura algerica* (Aubert, 1956)

The occurrence of *P. algerica* in Morocco is highly doubtful and needs to be confirmed (Vinçon & Muranyi 2009). In fact the Rifan specimens mentioned by Aubert (1961), Giudicelli & Dakki (1984), Sánchez-Ortega & Azzouz (1998) and Tierno de Figueroa *et al.* 1998, belong to *P. berberica* or *P. talboti*, and specimens from the Middle-Atlas (Aubert 1961, Giudicelli & Dakki 1984) belong to *P. talboti* or *P. dakkii* Vinçon & Muranyi, 2009.

#### *Protonemura berberica* Vinçon & Sánchez-Ortega, 1999

*Material.* Rif: Bab-Berred <> Bab-Besen, W. Issaguen, 1600 m, spr., 12.04.2013, 2 ♀♀; 7.06.2013, 2 ♂♂, 1 ♀, 1 larva (VIN); Ketama, > Azila, Tidi-

rhine Mount, 1500 m, t., 7.06.2013, 1 ♂, 1 ♀ (VIN); 1700 m, 7.06.2013, 1 ♂, 2 ♀♀ (VIN); 1800–2000 m, 7.06.2013, 2 ♂♂ (VIN); 1700 m, 13.11.2013, 5 ♂♂, 5 ♀♀ (VIN). The distribution of *P. berberica* in the Rif is detailed in Vinçon & Muranyi (2009).

*Distribution.* Morocco, Rifan micro-endemic species.

*Ecology.* Crenophilic, mainly occurring in springs and brooklets: 300–2100 m a.s.l. (Figs 13–15). The emergence period covers the cold season from autumn to spring but mainly in spring (XI–VII).

### ***Protonemura talboti* (Navás, 1929)**

*Material.* Rif: N.E. BabTaza, <> Beni Mahmed, Jbel Bouhalla, Forest House, 1200 m, 11.04.2013, 2 ♂♂ (ERR), 1 ♀ (VIN). Bab-Berred <> Bab-Besen, 1600 m, spr., 12.04.2013, 1 ♂ (ERR), 2 ♀♀ (VIN). Ketama, > Azila, Tidirhine Mount, 1500 m, t., 12.04.2013, 1 ♂; 1600 m, b., 12.04.2013, 1 ♂, 3 ♀♀ (ERR), 3 ♀♀ (VIN).

*Distribution.* West Maghreb species occurring in the Rif, Middle and High Atlas, and Tlemcen Mountains in western Algeria.

*Ecology.* Species occurring in various mountain brooks and springs: 85–2900 m a.s.l. The emergence period is in winter and spring (I–VI).

### ***Nemoura fulviceps* Klapálek, 1902**

First record for Morocco.

*Material.* Rif: Bab-Berred <> Bab-Besen, W. Issaguen, 1600 m, spr., 12.04.2013, 2 ♀♀. Ketama, > Azila, Tidirhine Mount, 1600–1800 m, brooklet, 12.04.2013, 1 ♂ (VIN); 1700 m, 7.06.2013, 1 ♀ (VIN).

*Distribution.* West Mediterranean species occurring in the Iberian Peninsula, Sicilia and Maghreb from the Moroccan Rif to the Djurdjura massif in central Algeria (Lounaci & Vinçon 2005). It could have originated in the Iberian Peninsula where it is very common.

*Ecology.* Species occurring in various mountain brooks and springs: 160–1600 m a.s.l. in Andalucía (Tierno de Figueroa *et al.* 2003). In the Rif, it only occurs in high altitude biotopes 1600–1800 m (Fig. 15). The adults fly in spring (IV).

### *Nemoura lacustris* group

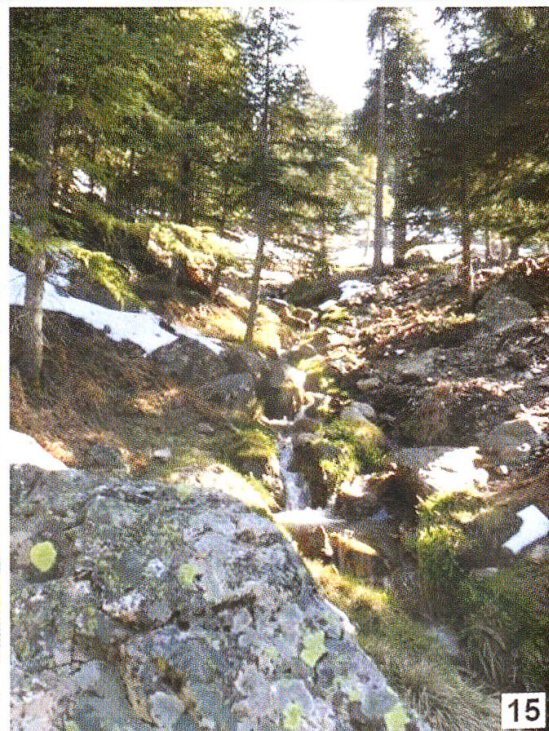
*Nemoura lacustris* Pictet, 1865 and *N. rifensis* Aubert, 1960 are rather exceptional in the *Nemoura* genus. We separate them in a distinct group called the *lacustris* group that is characterized by the asymmetric epiproct ending in a long, thin apical expansion with two hook-shaped spines rising medially. This group occurs in the West Mediterranean region from Morocco to France and could have originated in Spain. A complementary description is given for *N. lacustris*.

### ***Nemoura lacustris* Pictet, 1865**

(Figs 16–18)

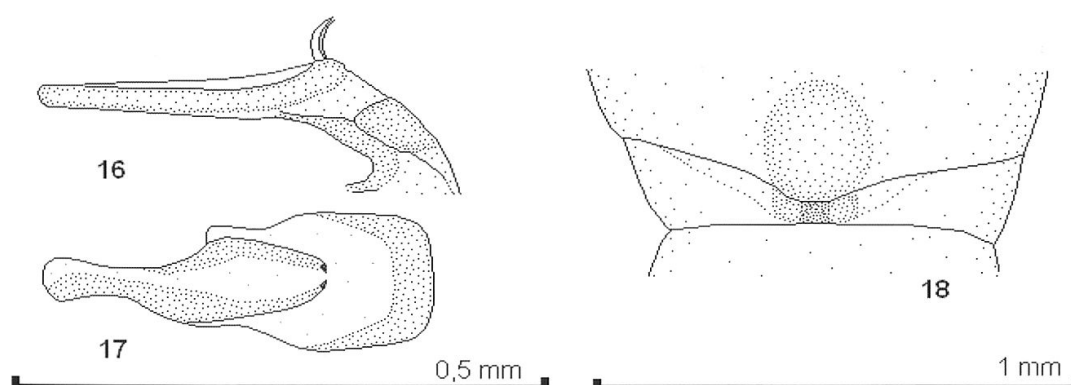
*Material.* Rif: Bab-Berred <> Bab-Besen, W. Issaguen, 1600 m, spr., 12.04.2013, 5 ♂♂, 2 ♀♀; 7.06.2013, 1 ♂, 2 ♀♀ (VIN), 2 ♂♂ (ERR). Ketama, > Azila, Tidirhine Mount, 1800–2000 m, b., 4.06.2006, 1 ♀; 12.04.2013, 1 ♂ (VIN);





Figs 13–15: Different kinds of torrents and brooks flowing from the Tidhirine Mount, highest point of the Rif.





Figs 16–18: *Nemoura lacustris*: male epiproct in lateral view (Fig. 16) and dorsal view (Fig. 17). Female sternite VII with subgenital and pregenital plates (Fig. 18).

7.06.2013, 21 ♂♂, 18 ♀♀ (VIN); 1700 m, 7.06.2013, 19 ♂♂, 24 ♀♀ (VIN); 1500 m, 7.06.2013, 2 ♂♂, 3 ♀♀ (VIN).

*Complementary description.* Males: epiproct with short base, long gutter-shaped expansion, and 2 small horn-shaped appendices projecting upwards medially (Fig. 16). The distal expansion could correspond to the arms of the ventral sclerite of the epiproct, usually forming a sclerotized ring in other *Nemoura* species (Murañyi *in litt.*). In dorsal view, distal expansion with an apical widening and 2 asymmetric lateral sclerites; left one much longer than right one (Fig. 17). Females: sternite VIII with sclerotized subgenital plate partly hidden under rounded sclerotized pregenital plate of sternite VII; its median part darker than lateral edges. Subgenital plate more or less visible according to abdominal contraction (Fig. 18).

*Affinities.* *N. lacustris* mainly differs from *N. rifensis*, in the male, by the nearly two times longer cercus and by the expansion of epiproct which is rectilinear in side view (Fig. 16) while strongly bent downward in *N. rifensis* (Aubert 1961, Fig. 18). In dorsal view, it is also bent at the tip in *N. rifensis* (Aubert 1961, Fig. 17) and nearly rectilinear with two asymmetrical longitudinal sclerites in *N. lacustris* (Fig. 17). Females: pregenital plate less wide in *N. lacustris* (Fig. 18) than in *N. rifensis*.

*Distribution.* West Mediterranean species covering the Rif, the Iberian Peninsula and France (Tierno de Figueroa *et al.* 2003, Le Doaré & Vinçon 2006).

*Ecology.* In the Rif, it is a cold stenothermic, crenophilic species only occurring in high altitude brooks and springs (1200–1800 m a.s.l.) (Aubert 1961, Errochdi & El Alami 2008) (Figs 13–15). In the Iberian Peninsula, it is more eurytopic, occurring even in low altitude water courses (150–1600 m); in septentrional localities (France), it only occurs in the foothills. The adults fly from January to June but mainly in spring (IV–V).

### *Nemoura rifensis* Aubert, 1961

(Fig. 12)

*Material.* Rif: Ketama, > Azila, Tidirhine Mount, 1600–1800 m, b., 4.06.2006, 1 ♀ (VIN).

*Distribution.* Endemic species occurring in the Baetic-Rifan complex (Fig. 12). It is only known from five localities, two in Spain (Aubert 1963, Tierno de Figueroa & López-Rodríguez 2011), two in the Rif (Aubert 1961, Errochdi & El Alami 2008) and one in the surroundings of Rabat (Dakki 2009).

*Ecology.* Cold stenothermic, crenophilic species occurring in mountain brooks and springs (850 m in Andalucía and 1020–1800 m in the Rif). The adults fly in spring (IV–VI).

*Affinities.* Closely related to *N. lacustris* (differences between the two species given previously).

### ***Capnia nigra* (Pictet, 1833)**

*Material.* Rif: Ketama, > Azila, Tidirhine Mount, 1400 m, t., 12.04.2013, 2 ♀♀ (VIN), 1 ♀ (ERR); 1500 m, 12.04.2013, 2 ♂♂, 2 ♀♀ (ERR), 5 ♂♂, 11 ♀♀ (VIN); 1600 m, b., 12.04.2013, 1 ♀ (ERR), 1 ♂, 3 ♀♀ (VIN).

*Distribution.* Palearctic species.

*Ecology.* In the Rif, it only occurs in high altitude brooks (1400–1600 m a.s.l.) of different size. The flight period is mainly in winter and extends slightly into spring.

### ***Capnioneura petitpierreae* Aubert, 1961**

*Material.* Rif: Tétouan <> Chefchaouen, Oued Hajera, 22.02.1996, 1 ♂, 3 ♀♀ (VIN); Douar Kajjeen, 4 km Chefchaouen <> Bab-Taza, 23.01.2006, 1 ♂, 2 ♀♀ (VIN); > Bab-Taza, Oued Bouhalla, t., 1000 m, 22.02.1996, 5 ♂♂, 5 ♀♀ (VIN); N.E. BabTaza, <> Beni Mahmed, Jbel Bouhalla, Forest House, 1200 m, 11.04.2013, 1 ♀ (VIN). Bab-Taza <> Bab-Berred, > Sefliane, El Anasser, b., 22.02.1996, 3 ♀♀ (VIN); Bab-Berred <> Bab-Besen, near Tamarote – El Jebha crossroad, b., 1400 m, 22.02.1996, 9 ♂♂, 8 ♀♀ (VIN); 23.01.2006, 1 ♂ (VIN); Bab-Besen <> Ketama, 1600 m, Cedrus forest, b., 23.01.2006, 4 ♂♂, 4 ♀♀ (VIN). > Azila, Tidirhine Mount, 1400 m, t., 12.04.2013, 2 ♂♂, 1 ♀ (ERR), 1 ♂ (VIN); 13.11.2013, 24 ♂♂, 18 ♀♀ (VIN); 1500 m, 12.04.2013, 4 ♂♂, 10 ♀♀ (ERR), 22 ♂♂, 21 ♀♀ (VIN); 7.06.2013, 1 ♀ (VIN); 1600 m, b., 12.04.2013, 8 ♂♂, 7 ♀♀ (ERR), 12 ♂♂, 17 ♀♀ (VIN), 13.11.2013, 20 ♂♂, 26 ♀♀ (VIN); 1700–1800 m, 13.11.2013, 6 ♂♂, 18 ♀♀ (VIN).

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

*Ecology.* In the Rif, *C. petitpierreae* occurs in various kinds of brooks and torrents (10–1700 m) but more frequently in low altitude water courses (Sánchez-Ortega & Azzouz 1998, Errochdi & El Alami 2008). The emergence period covers the cold season from autumn to spring (XI–IV).

### ***Capnopsis schilleri schilleri* (Rostock, 1892)**

*Material.* Rif: Tétouan <> Chefchaouen, Oued Hajera, 22.02.1996, 2 ♀♀ (VIN); Douar Kajjeen, 4 km Chefchaouen <> Bab-Taza, 23.01.2006, 4 ♂♂, 6 ♀♀ (VIN); > Bab-Taza, Oued Bouhalla, t., 1000 m, 22.02.1996, 11 ♂♂, 16 ♀♀ (VIN); Bab-Taza <> Bab-Berred, > Sefliane, El Anasser, b., 22.02.1996, 1 ♂ (VIN); Bab-Berred <> Bab-Besen, near Tamarote – El Jebha crossroad, b., 1400 m, 22.02.1996,



7 ♂♂, 13 ♀♀ (VIN); 23.01.2006, 3 ♂♂, 6 ♀♀ (VIN); Bab-Besen <> Ketama, 1600 m, *Cedrus* forest, b., 23.01.2006, 21 ♂♂, 5 ♀♀ (VIN).

*Distribution.* *C. schilleri schilleri* has a wide distribution in Europe and North-Africa (Zwick 1984). In the Maghreb, it is mentioned in Tunisia (Berthélemy 1973), Algeria (Lounaci & Vinçon 2005) and Morocco (Sánchez-Ortega & Azzouz 1998).

*Ecology.* In the Rif, it occurs in mountain brooks and torrents (900–1600 m a.s.l.). The adults fly in winter (I–III).

***Leuctra franzi paenibaetica* Sánchez-Ortega & Roperro-Montero, 1993**

*Material.* Rif: Ketama, > Azila, Tidirhine Mount, 1400 m, t., 13.11.2013, 1 ♂ (VIN); 1500 m, 13.11.2013, 2 ♂♂, 5 ♀♀ (VIN); 1600 m, 13.11.2013, 6 ♂♂, 5 ♀♀ (VIN); 1700 m, 13.11.2013, 5 ♂♂, 7 ♀♀ (VIN).

*Distribution.* Baetic-Rifan species, also occurring in the Middle-Atlas (not yet published).

*Ecology.* In the Rif, it occurs in high altitude water courses of different size (springs, brooks and torrents) (1400–1700 m a.s.l.). The adults fly in autumn (X–XI).

***Leuctra geniculata* Stephens, 1836**

*Material.* Rif: Ketama, > Azila, Tidirhine Mount, 1400 m, t., 13.11.2013, 2 ♂♂, 5 ♀♀ (VIN).

*Distribution.* Central and west European species, also occurring 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 a.s.l. (Sánchez-Ortega & Azzouz 1998, Errochdi & El Alami 2008, Yasri-Cheboubi *et al.* 2013). This species is more eurytopic and orophilic than in the rest of Europe. The adults mainly emerge in autumn (VIII–XI).

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

*Material.* Rif: Ketama, > Azila, Tidirhine Mount, 1600 m, b., 13.11.2013, 1 ♀ (VIN).

*Distribution.* North Moroccan micro-endemic species. This very scarce species was only known from one male and five females collected in the Rif (Sánchez-Ortega & Azzouz 1997). It also occurs in the Middle-Atlas (not yet published).

*Ecology.* Crenophilic species restricted to the highest points of the Rif (1250–1600 m a.s.l.). The adults emerge in autumn (X–XI).

***Leuctra maroccana* Aubert, 1956**

*Material.* Rif: Chefchaouen, N.E. BabTaza, <> Beni Mahmed, Jbel Bouhalla, Forest House, 1200 m, 11.04.2013, 15 ♂♂, 19 ♀♀ (VIN), 10 ♂♂, 7 ♀♀ (ERR). Bab-Berred <> Bab-Besen, 1600 m, spr., 11.04.2013, 5 ♂♂, 15 ♀♀. Ketama, > Azila, Tidirhine Mount, 1400 m, 13.11.2013, 5 ♂♂, 1 ♀ (VIN); 1500 m, 12.04.2013, 1 ♂, 1 ♀, 13.11.2013, 2 ♂♂, 4 ♀♀ (VIN); 1600 m, b., 12.04.2013, 1 ♂, 2 ♀♀ (ERR), 21 ♂♂, 34 ♀♀ (VIN), 13.11.2013, 26 ♂♂, 11 ♀♀ (VIN); 1700–1800 m, 13.11.2013, 5 ♂♂, 15 ♀♀ (VIN).

*Distribution.* West Mediterranean species extending from the Moroccan High-Atlas to the foothills of the Atlantic Pyrenees, and widely distributed within the Iberian Peninsula (Tierno de Figueroa *et al.* 2003).

*Ecology.* It is a cold stenothermic, crenophilic species. In the Moroccan mountains, as in the southern Iberian Peninsula, it mainly occurs in high altitude biotopes (1400–2600 m). The emergence period covers the cold season from autumn to spring (XI–IV).

### *Tyrrhenoleuctra tangerina* (Navás, 1922)

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

*Material.* Rif: > Bab-Taza, Oued Bouhalla, t., 1000 m, 22.02.1996, 1 ♂ (VIN).

*Distribution.* This species widely covers North-Africa, from the Moroccan Rif (Aubert 1961, Sánchez-Ortega & Azzouz 1998), to Algeria (Lounaci *et al.* 2000, Lounaci & Vinçon 2005) and Tunisia (Berthélemy 1973), and the southern extremity of the Iberian Peninsula near Algeciras (Fochetti *et al.* 2009).

*Ecology.* It occurs in brooks and brooklets of moderate altitude (100–1400 m), that often dry up in summer and autumn. According to Aubert (1963), this species is a characteristic element of temporary streams «thermophile association». The adults fly in the cold season (II–V), but more frequently in winter (II–III).

#### RIFAN STONELIES DISTRIBUTION PATTERNS (TAB. 1)

The following list of Rifan stoneflies refers to the 6 main compilations (1 = Aubert 1961, 2 = Giudicelli & Dakki 1984, 3 = Sánchez-Ortega & Azzouz 1998, 4 = Errochdi & El Alami 2008, 5 = Vinçon & Murányi 2009 and 6 = current work).

From a biogeographical point of view, the 23 Rifan stonefly species belong to the Palearctic Fauna. We separate them into the following sets of species, according to the size of their distribution area:

#### *Species with a wide distribution (7 species)*

*C. nigra* has the widest geographical area in Europe, North Africa and Asia (up to Mongolia).

*C. schilleri schilleri* widely covers Europe and North Africa.

*E. ochracea* occurs all around the Mediterranean Sea.

*B. auberti*, *N. fulviceps*, *N. lacustris* and *L. geniculata* extend more or less in the western part of the Mediterranean region.

#### *Species covering a large part of the Iberian Peninsula and North Africa (4)*

This set of species is separated in two subgroups:

- *T. tangerina* and *C. petitpierreae* have a wide distribution in North Africa and partly extend into the southern Iberian Peninsula
- *L. maroccana* and *H. flaviventris*, in contrast, have a wide distribution in the Iberian Peninsula and extend only into the western part of Maghreb.

Tab. 1: Rif stoneflies, with ecological and biogeographical features (+ = Vulnerable species, ++ = Endangered species). Abbreviations: Alg. = Algeria, Andal. = Andalucía; Circum Med. = Circum Mediterranean, Eur. = Europe, Fr. = France, Ibe. = Iberian Peninsula, Mor. = Morocco, N. Afr. = North Africa, Pyr. = Pyrenees, W. Med. = West Mediterranean.

	Altitudinal range in the Rif	Flight period	Biogeographical pattern	Vulnerable / endangered	Records
PERLODIDAE					
<i>Hemimelaena flaviventris</i> (Pictet)	320-1500	IV-VI	Mor., Ibe.		1, 3, 4
<i>Afroperlodes lecerfi</i> (Navás)	400-1700	VI	N. Afr.		3
<i>Isoperla cf. kir</i> Foc. & Vin.	300-2000	V-VI	Rif	++	1, 3, 4, 6
PERLIDAE					
<i>Eoperla ochracea</i> Illies	140-1460	IV-VII	Circum Med.		3, 4
<i>Perla cf. pallida</i> Guerin	140-1800	VI	N. Afr., E. Eur.?		2, 3, 4, 6
CHLOROPERLIDAE					
<i>Siphonoperla lepineyi</i> (Navás)	20-1800	V-VII	Morocco		1, 3, 4, 6
TAENIOPTERYGIDAE					
<i>Brachyptera algerica</i> Aubert	900-1600	I-VI	N. Afr.		3, 4, 6
<i>Brachyptera auberti</i> Consiglio	170-1800	II-VI	W. Med.		1, 3, 4, 6
NEMOURIDAE					
<i>Amphinemura yasriarum</i> sp. n.	1400-1800	IV-VI	Rif	++	6
<i>Protonemura berberica</i> Vin. & Sán.	300-2100	XI-VII	Rif	+	5, 6
<i>Protonemura talboti</i> (Navás)	85-1400	XII-VI	Mor., E. Alg.		4, 5, 6
<i>Nemoura fulviceps</i> Klapalek	1020-1800	IV-VI	W. Med.		6
<i>Nemoura lacustris</i> Pictet	1200-2000	IV-V	Rif, Ibe., Fr.		1, 3, 6
<i>Nemoura rifensis</i> Aubert	1020-1800	IV-VI	Baetic-Rifan	++	1, 4, 6
CAPNIIDAE					
<i>Capnia nigra</i> (Pictet)	1000-1800	XI-VI	Palaearctic		1, 3, 4, 6
<i>Capnioneura petitpierreae</i> Aubert	10-1700	XI-IV	N. Afr., Andal.		1, 3, 4, 6
<i>Capnopsis schilleri schilleri</i> (Rostock)	900-1600	I-III	N. Afr., Eur.		3, 6
LEUCTRIDAE					
<i>Leuctra franzi paenibaetica</i> Sán. & Rop.	1400-1700	X-XI	Baetic-Rifan	+	3, 6
<i>Leuctra geniculata</i> Stephens	50-1520	VIII-XI	N. Afr., W. Eur.		3, 4, 6
<i>Leuctra ketamensis</i> Sán. & Azzouz	1210-1600	X-XI	Rif	++	3, 6
<i>Leuctra maroccana</i> Aubert	20-1700	XI-IV	Mor., Ibe., Pyr.		1, 2, 3, 4, 6
<i>Leuctra vaillanti</i> Aubert	1210-1400	X-I	N. Afr.		3
<i>Tyrhenoleuctra tangerina</i> (Navás)	360-900	II-V	N. Afr., Andal.		1, 3, 6

### Baetic-rifan species (2)

The Gibraltar Arc is composed northward by the Baetic System (Andalucía) and southward by the Rif (Fig. 12). These two ranges of mountains, separated by the Gibraltar Strait, were before the Miocene epoch a single mountainous unit characterized by its own flora and fauna. Relicts of this event are called baetic-rifan species. In the stoneflies, two species can characterize this geographical unit: *L. franzi paenibaetica* and *N. rifensis*, though they slightly extend into the northern part of the Middle-Atlas.

Moreover, the case of *L. ketamensis* is also significant since this North Moroccan micro-endemic species with exceptional features in the genus *Leuctra* is related to *L. bidula* Aubert, 1962, a micro-endemic species of the Sierra Bermeja at the southern extremity of the Baetic System (Fig. 12). Therefore both species probably have a common baetic-rifan ancestor.

### North African endemic elements (9)

*Afroperlodes lecerfi*, *Isoperla cf. kir*, *Siphonoperla lepineyi*, *Brachyptera algerica*, *Amphinemura yasriarum* sp. n., *Protonemura berberica*, *P. talboti*, *Leuctra ketamensis* and *L. vaillanti*.

Four of them are North Moroccan micro-endemic species: *I. cf. kir*, *A. yasriarum* sp. n., *P. berberica* and *L. ketamensis*.

This set of 9 species represents 39 % of the total number of stoneflies reported from the Rif (23), a level of endemism less than that of the Iberian Peninsula (> 50 %, Sánchez-Ortega & Tierno 1996).

#### HUMAN IMPACT AND DANGER OF EXTINCTION

In a biodiversity protection plan, there is an urgent need to identify the sectors of great biodiversity that are the most endangered. To this purpose, the defining of «hot-spots» is necessary, especially in the Mediterranean region where micro-endemic species are very isolated and in danger of extinction (Sánchez-Ortega & Tierno 1996, Tierno de Figueroa & López-Rodríguez 2011: red list of Iberian stoneflies).

Climate change (global warming) also increases the risk of extinction for the aquatic fauna, especially in the Mediterranean surroundings exposed to severe droughts and increasing human influence. This impact, already studied in southern European Trichoptera (Hering *et al.* 2009), and Plecoptera (Tierno de Figueroa *et al.* 2010), should be extended to the North African aquatic fauna. According to Giudicelli & Dakki (1984), some Rifan endemic species (Trichoptera, Plecoptera) occurring in the crenal zone are relict elements in great danger of extinction since the cold refuges where they occur are becoming more and more isolated and threatened by human activities and global warming.

The High and Middle Atlas mountains and the Baetic-Rifan complex are already considered as endangered «hot-spots», both for the plant biodiversity (Medail & Quezel 1997) and the aquatic fauna (Dakki 2009).

From the point of view of conservation biology, the most endangered species in the Rif can be separated in two groups according to their scarcity and risk of extinction. The scarcity is evaluated just according to the number of known collecting places, without taking into account other criteria (Table 1):

#### *Vulnerable species (+)*

This first group concerns 3 species known from less than 10 localities in their whole distribution area.

*Isoperla cf. kir* and *Protonemura berberica* are Rifan endemic species with wide altitudinal range (300–2100 m) but more frequent in high mountain biotopes (> 1000 m), exposed both to human pressure and global warming.

*Leuctra franzi paenibaetica* is a baetic-rifan species already considered as vulnerable by Sánchez-Ortega & Tierno (1996).

#### *Endangered species (++)*

This group comprises 3 species only known from 5 localities or less (Fig. 12): *Amphinemura yasriarum* sp. n., *Nemoura rifensis* and *Leuctra ketamensis*.

They are all occurring in the crenal zone, more frequently in high altitude biotopes (cold stenotherm species), exposed to human impact or global warming.

The red list of Iberian stoneflies (Sánchez-Ortega & Tierno 1996), already considers one of them, *Nemoura rifensis*, as an endangered species and its risk of extinction was upgraded in 2011 (Tierno de Figueroa & López-Rodríguez 2011).

To prevent these patrimonial species from extinction, a biodiversity survey in the highest part of the Rif should be done.

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#### RÉSUMÉ

*Amphinemura yasriarum* sp. n., endémique du Rif Marocain, est décrite et comparée à l'espèce la plus proche *A. chiffensis* Aubert, 1956. Les deux espèces se distinguent dans les deux sexes. *A. chiffensis* n'est connue que du Haut-Atlas Marocain et nous supposons qu'elle est endémique de cette chaîne de montagnes où elle vit en haute altitude. De nouvelles données faunistiques sont présentées pour 19 espèces de Plécoptères du Rif. *Nemoura fulviceps* Klapálek, 1902 est nouvelle pour le Maroc. De nouveaux caractères distinctifs sont présentés pour *Nemoura lacustris* Pictet, 1865 et *N. rifensis* Aubert, 1961; les deux espèces sont associées à un groupe distinct dans le genre *Nemoura* (groupe *lacustris*). La liste faunistique des 23 plécoptères Rifains est mise à jour.

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