



Aquatic Empididae (Diptera: Hemerodromiinae and Clinocerinae) of the Sierra Nevada, Spain, with the description of five new species

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Abstract

In total 24 species of aquatic Empididae (Clinocerinae and Hemerodromiinae) are known from the Sierra Nevada Mountains of Spain, including five new species (*Hemerodromia planti* Ivković & Sinclair **sp. nov.**, *Kowarzia nevadensis* Sinclair & Ivković **sp. nov.**, *Wiedemannia darioi* Sinclair & Ivković **sp. nov.**, *W. horvati* Ivković & Sinclair **sp. nov.** and *W. vedranae* Ivković & Sinclair **sp. nov.**). The new species are described, illustrated and distribution of all species listed. *Wiedemannia (Philolutra) angelieri* Vaillant and *W. (Roederella) ouedorum* Vaillant are newly recorded in Sierra Nevada and nine species are endemic to this region. A key to all 24 species of aquatic empidids is presented.

Key words: Clinocerinae, Hemerodromiinae, Empididae, Diptera, new species, Sierra Nevada, Spain

Introduction

The high mountain systems of Europe (e.g., Alps, Pyrenees) have greatly influenced the evolution of species during the cyclic climatic changes (Schmitt 2009). The mountains have acted both as barriers and refugia contributing to allopatric speciation of species endemic to these ranges. The Alps have been studied most extensively and shelter the highest number of endemics (Schmitt 2009). The highest number of endemic plants in Europe and also vast numbers of endemic invertebrates are confined to the Sierra Nevada range (Gonzalez-Megias *et al.* 2008). Although Europe has been relatively well studied in comparison to other parts of the world, some mountain ranges, including the Sierra Nevada remain poorly known with regard to aquatic Empididae (Diptera).

The Sierra Nevada Mountains are situated in the southern region of Andalusia, Spain and have Mediterranean high mountain ecosystems that are mostly protected by a national park. This mountain range is less than 2000 km², about 100 km in length and includes more than 20 peaks higher than 3000 m a.s.l. It is the highest mountain chain in the Iberian Peninsula and the second highest in Western Europe after the Alps. Its axis is orientated in a south-west to north-east direction, and the centre of the chain forms an elongated and depressed arch, constituting a series of rounded hillsides on southern slopes, and a clear glacial geomorphology with cirques and headwalls on the northern slopes. The peripheral zones of the Sierra Nevada, although of lower altitudes, present a radically different aspect with abrupt drops, steep slopes, and deep canyons (Martín *et al.* 2008). Due to its combination of alpine elevation and rather low latitude (at least in comparison to other European high mountains), the Sierra Nevada range is characterized by hard snowy winters and extremely warm summers with drought periods that result in some streams and rivers drying up and disappearing. Since 1986 the Sierra Nevada has been designated a Mountain Biosphere Reserve by UNESCO (MBRs) for studying the consequences of climate change (UNESCO 2014).

Thirty-four streams and rivers were surveyed for aquatic Empididae (Clinocerinae and Hemerodromiinae) in

Discussion

In total 24 species of aquatic dance flies are found on Sierra Nevada. In this research we collected 14 species, five of which are described here and *Wiedemannia (Philolutra) angelieri* and *W. (Roederella) ouedorum* are newly recorded in Sierra Nevada. Nine species (or 37% of aquatic empidid species) are endemic and currently found only in these mountains. On the data set gathered in this research and from prior sporadic research (see Ventura (2013) and above references), Sierra Nevada is possibly one of the richest regions of Europe for endemism of aquatic dance flies. Numerous endemic species of vascular flora (Fernández-Calzado *et al.* 2013), terrestrial invertebrates (González-Megías *et al.* 2008; López-Villalta 2011), stoneflies (Tierno de Figueroa *et al.* 2013), and caddisflies (Sáinz-Bariain *et al.* 2013) are also known from this mountain range. The endemism of the Sierra Nevada is likely due to many factors, including its range in altitude and its position in the Mediterranean area, isolated from other high mountain ranges creating barriers to species dispersal and promoting allopatric speciation (Schmitt 2009).

In a recent survey of the biodiversity of aquatic families in mountainous Spanish national parks, surprisingly no Empididae were listed (Guareschii *et al.* 2012). The apparent absence of aquatic Empididae was likely due to the sampling protocol where localities were surveyed once using kick-nets. In contrast, the present study was based on the collection of adult specimens using sweep nets and hand collecting.

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References

- Cobo, F. & Carreira, O. (2003) *Hemerodromia wagneri* sp. n., a new aquatic empidid (Diptera, Empididae: Hemerodromiinae) from Spain. *Aquatic Insects*, 25, 277–280.
<http://dx.doi.org/10.1076/aqin.25.4.277.26215>
- Collin, J.E. (1927) Notes on the Empididae (Diptera), with additions and corrections to the British list. *The Entomologist's Monthly Magazine*, 63, 93–98.
- Collin, J.E. (1961) Empididae. In: *British flies*. Vol. 6. University Press, Cambridge, UK, pp. 1–782.
- Cumming, J.M. & Wood, D.M. (2009) Adult morphology and terminology [Chapter] 2. In: Brown, B.V., Borkent, A., Cumming, J.M., Wood, D.M., Woodley, N.E. & Zumbado, M.A. (Eds.), *Manual of Central American Diptera*. Vol. 1. NRC Research Press, Ottawa, Ontario, Canada, pp. 9–50.
- Fernández-Calzado, F., Ghosn, D., Gottfried, M., Kazakis, G., Molero Mesa, J., Pauli, H. & Merzouki, A. (2013) Patterns of endemism along an elevation gradient in Sierra Nevada (Spain) and Lefka Ori (Crete, Greece). *Pirineos: Revista de Ecología de Montaña*, 168, 7–24.
<http://dx.doi.org/10.3989/pirineos.2013.168001>
- González-Megías, A., Gómez, J.M. & Sánchez-Piñero, F. (2008) Factors determining beetle richness and composition along an altitudinal gradient in the high mountains of the Sierra Nevada National Park (Spain). *Ecoscience*, 15, 429–441.
<http://dx.doi.org/10.2980/15-4-3105>
- Guareschi, S., Gutiérrez-Cánovas, C., Picazo, F., Sánchez-Fernández, D., Abellán, P., Velasco, J. & Millán, A. (2012) Aquatic macroinvertebrate biodiversity: patterns and surrogates in mountainous Spanish national parks. *Aquatic Conservation*, 22, 598–615.
<http://dx.doi.org/10.1002/aqc.2256>
- Haliday, A.H. (1833) Catalogue of Diptera occurring about Holywood in Downshire. *The Entomologist's Monthly Magazine*, 1, 147–180.
- Ivković, M., Plant, A. & Horvat, B. (2012) A new species of *Wiedemannia* (Diptera: Empididae: Clinocerinae) from Balkan Peninsula. *Zootaxa*, 3478, 581–585.
- Ivković, M., Mihaljević, Z., Miliša, M. & Previšić, A. (2013) Aquatic dance flies fauna (Diptera, Empididae: Clinocerinae and Hemerodromiinae) of Montenegro. *Natura Croatica*, 22, 243–252.
- Loew, H. (1869) *Beschreibungen europäischer Dipteren*. *Systematische Beschreibung der bekannten europäischen zweiflügeligen Insecten*. Von Johann Wilhelm Meigen. Achter Theil oder zweiter Supplementband. *Beschreibungen europäischer Dipteren*. Erster Band. H.W. Schmidt, Halle, xvi + 310 + [1] pp

- Loew, H. (1873) *Diptera nova*, in Pannoniâ inferiori et in confinibus Daciae regionsibus a Ferd. Kowarzio capta. *Berliner Entomologische Zeitschrift*, 17, 33–52.
- López-Villalta, J.S. (2011) Why mountain passes are higher... for endemic snails. *Zoologica Baetica*, 22, 87–97.
- Martín, J.M., Braga, J.C. & Gómez, M.T. (2008) *Itinerarios geológicos por Sierra Nevada. Guía de campo por el Parque Nacional y Parque Natural de Sierra Nevada*. Consejería de Medio Ambiente, Junta de Andalucía, Granada, 267 pp.
- McAlpine, J.F. (1981) Morphology and terminology—adults. In: McAlpine, J.F., Peterson, B.V., Shewell, G.E., Teskey, H.J., Vockeroth, J.R. & Wood, D.M. (Coordinators), *Manual of Nearctic Diptera*. Vol. 1. *Agriculture Canada Monograph*, 27, 9–63.
- Meigen, J.W. (1804) *Klassifikation und Beschreibung der europäischen zweiflügeligen Insecten (Diptera Linn.)*. Erster Band. Reichard, Braunschweig, Abt. I. xxviii + pp. 1–152, Abt. II. vi + pp. 153–295; 298–314..
- Mik, J. (1880) Beschreibung neuer Dipteren. I. Elf neue europäische *Clinocera*-Arten. *Verhandlungen der Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien*, 30, 347–358.
- Ruano, F., Tierno de Figueroa, M. & Tinaut, A. (2013) *Los insectos de Sierra Nevada. 200 años de historia*. Vol. 1. & 2. Asociación Española de Entomología. 542+528 pp.
- Saigusa, T. (2006) *Homology of wing venation of Diptera*. Privately published handout distributed at the 6th International Congress of Dipterology, Fukuoka, Japan, 26 pp.
- Sáinz-Bariáin, M., Zamora-Muñoz, C. & González, M.A. (2013) Los Tricópteros. In: Ruano, F., Tierno de Figueroa, M. & Tinaut, A. (Eds.), *Los insectos de Sierra Nevada. 200 años de historia*. Vol. 2. Asociación española de Entomología, pp. 202–230.
- Schiner, J.R. (1862) *Fauna Austriaca. Die Fliegen (Diptera)*, 1. Wien, LXXX + 672 pp.
- Schmitt, T. (2009) Biogeographical and evolutionary importance of the European high mountain systems. *Frontiers in Zoology*, 6, 1–10.
<http://dx.doi.org/10.1186/1742-9994-6-9>
- Sinclair, B.J. (1995) Generic revision of the Clinocerinae (Empididae), and description and phylogenetic relationships of the Trichopezinae, new status (Diptera: Empidoidea). *The Canadian Entomologist*, 127, 665–752.
<http://dx.doi.org/10.4039/ent127665-5>
- Sinclair, B.J. (1999) Review of the Holarctic *Clinocera appendiculata* complex (Diptera: Empididae: Clinocerinae). *The Entomologist's Monthly Magazine*, 135, 223–232.
- Strobl, G. (1899) Spanische Dipteren, II. Theil & III. Theil. *Wiener Entomologische Zeitung*, 18, 12–27, 77–83.
- Strobl, G. (1909) Bombyliidae, Therevidae, Empididae. In: Czerny, L. & Strobl, G. (Eds.), *Spanische Dipteren*. III. Beitrag. *Verhandlungen der Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien*, 59, 121–301.
- Stuckenberg, B.R. (1999) Antennal evolution in the Brachycera (Diptera), with a reassessment of terminology relating to the flagellum. *Studia Dipterologica*, 6, 33–48.
- Tierno de Figueroa, J.M., López-Rodríguez, M.J. & Luzón-Ortega, J.M. (2013) Los Plecópteros. In: Ruano, F., Tierno de Figueroa, M. & Tinaut, A. (Eds.), *Los insectos de Sierra Nevada. 200 años de historia*. Vol. 1. Asociación española de Entomología, pp. 126–138.
- UNESCO (2014) Ecological sciences for sustainable development: global change in mountain regions (GLOCHAMORE). Available from: <http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/specific-ecosystems/mountains/glochamore/> (accessed 20 January 2014)
- Vaillant, F. (1950) Contribution à l'étude des Empididae Atalantinae des Alpes françaises. *Travaux du Laboratoire d'Hydrobiologie et de Pisciculture de l'Université de Grenoble*, 41–42, 49–57.
- Vaillant, F. (1952) Un Empidide destructeur de simulies. *Bulletin de la Société Zoologique de France*, 76, 371–379.
- Vaillant, F. (1965) Revision des Empididae Hemerodromiinae de France, d'Espagne et d'Afrique du Nord [Dipt.]. *Annales de la Société Entomologique de France*, 133 (1964), 143–173.
- Vaillant, F. (1967) La repartition des *Wiedemannia* dans les cours d'eau et leur utilisation comme indicateurs de zones écologiques (Diptera, Empididae). *Annales de Limnologie*, 3, 267–293.
<http://dx.doi.org/10.1051/limn/1967016>
- Vaillant, F. & Chvála, M. (1973) Empididae Hemerodromiinae from Spain (Insecta, Diptera). *Stenstrupia*, 3, 57–64.
- Ventura-Pérez, D. (2013) Los Empídidos. In: Ruano, F., Tierno de Figueroa, M. & Tinaut, A. (Eds.), *Los insectos de Sierra Nevada. 200 años de historia*. Vol. 2. Asociación Española de Entomología, pp. 300–311.
- Wahlberg, P.F. (1844) Nya Diptera från Norrbotten och Luleå Lappmark. *Öfversigt af K Vetenskapsakademins förhandlingar*, 1, 106–110.
- Wagner, R. (1990) Neue *Wiedemannia*-Arten aus der *rhynchops*-Gruppe (Diptera, Empididae, Clinocerinae). *Entomofauna*, 11, 229–237.
- Wagner, R. (1995) Empididen aus dem Mittelmeerraum (Diptera, Empididae: Hemerodromiinae und Clinocerinae). *Acta Entomologica Slovenica*, 3, 5–23.
- Walker, F. (1851) *Insecta Britannica. Diptera*. Vol. 1. Reeve & Benham, London, pp. vi + 314, pls. I–X.
- Yang, D., Zhang, K.-Y., Yao, G. & Zhang, J.-H. (2007) *World catalog of Empididae (Insecta: Diptera)*. China Agricultural University Press, Beijing, 599 pp.
- Zetterstedt, J.W. (1838) Sectio tertia. Diptera. Dipterologis scandinaviae. amicis et popularibus carissimus. In: *Insecta Lapponica*. Lipsiae (= Leipzig), pp. 477–868.