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NORTH PYRENEAN POPULATIONS OF *MEGABUNUS DIADEMA* (FABRICIUS, 1779) (ARACHNIDA: OPILIONES) ARE CHARACTERIZED BY HIGHLY MALE-BIASED SEX RATIOS

Las poblaciones Nor-pirenaicas de Megabunus diadema *(Fabricius, 1779) (Aracnidos: Opiliones) se caracterizan por una proporción de machos altamente sesgada*

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ABSTRACT: *Megabunus diadema* (Fabricius, 1779) is an Atlantic and European harvestman species characterized by a discontinuous distribution from Scandinavia to the Iberian Peninsula. With very few male individuals ever observed in the field until now, the biological uniqueness of the species lies in its reproduction mode, hitherto regarded as asexual, facultative parthenogenesis.
Based on a large sample of 741 sexed individuals, the study indicates a sex ratio much higher than what was formerly known, equal to 65.58% of males. Locally varying from 0 to 100% (median 75.5% of males), the sex ratio depends indeed on the altitude and the phenological cycle: the proportion of males decreases with increasing altitude and increases gradually during the spring to reach a plateau in summer. By describing populations locally dominated by male individuals and providing new information on the spatial and temporal patterns of tertiary sex ratio, we question the currently admitted reproduction mode of the species which could be normally sexual, at least locally, rather than asexual.
A distribution map of the species on the northern slope of the Pyrenees is provided for the first time. Our study also complements the distribution for the southern slopes of the Pyrenees and the rest of the Iberian Peninsula published recently by Merino-Sáinz *et al.* (2013).

KEYWORDS: Tertiary sex ratio; parthenogenesis; altitude; Pyrenees.

RESUMEN: *Megabunus diadema* (Fabricius 1779) es una especie de opilión Atlántica y Europea, caracterizada por una distribución discontinua desde Escandinavia a la Península Ibérica. La singularidad biológica de la especie se encuentra en el modo de reproducción, la partenogénesis facultativa, hasta ahora considerada como asexual. De hecho, hasta el momento se han observado muy pocos individuos masculinos en el campo.
Los resultados de este estudio muestran, sobre una amplia muestra (741 individuos sexuados), que la proporción de sexo masculino es muy superior a lo conocido hasta ahora (65%). Localmente este porcentaje puede variar entre 0 y 100% (mediana del 75,5% para los machos). Los resultados muestran que la proporción de sexos depende de la altitud

y del ciclo fenológico: la proporción de machos disminuye con la altitud y aumenta gradualmente durante la primavera hasta llegar a una meseta en verano. Para describir las poblaciones dominadas localmente por individuos masculinos y proporcionar nueva información sobre los patrones espaciales y temporales de la proporción de sexos en poblaciones adultas, cuestionamos el modo de reproducción actualmente admitido de la especie que podría ser normalmente sexual, al menos localmente, en lugar de asexual.
Se proporciona, por primera vez, un mapa de distribución de la especie en la vertiente norte de los Pirineos. Nuestro estudio también complementa el estudio publicado recientemente por Merino-Sáinz et al. (2013) sobre su distribución en la vertiente sur de los Pirineos y en el resto de la Península Ibérica.

PALABRAS CLAVE: Ratio sexual; partenogénesis; altitud; Pirineos.

1. Introduction

Described for the first time under the binominal name *Phalangium diadema* by Fabricius (1779), the nomenclature of the species was complicated with its subsequent description under two different species names: Meade (1855) recognized a different species from British and Irish individuals under the name of *Megabunus insignis* while Simon (1881) described then *Megabunus grouvellei* from an individual from Hautes-Pyrénées (cirque of Troumouse). Both species were later synonymised (Thorell, 1876; Martens 1978). *Megabunus diadema* (Fabricius, 1779) is indeed an unmistakable species, easily identified from its crown of spines on the ocularium (D'Amico, 2015), both in the male and in the female, at any age. Observed both in coastal environment and in mountain woodland, this species astonishes by its eurytopy: in Iceland for example, the species is found near the sea (where individuals are mostly observed on wet cliffs) and also further inland (where they are found mostly on mosses and debris) (Agnarsson, 1998); moreover, it is rather a woodland species (in particular mountain woodlands but not exclusively), where the species is found on the ground, on rocks or tree trunks (Curtis & Morton 1974). Its distribution is typically Atlantic European (Martens, 1978; Rambla, 1985, 1998; Stol, 2005), discontinuous from Scandinavia to the Iberian Peninsula (Simon, 1879; Martens 1978; Stol, 2005, 2007; Muranyi, 2008; Agnarsson, 1998; Kauri, 1980; Feliú, 1981; Rambla, 1980, 1985, 1998; D'Amico, 1988; D'Amico & Besson, 1995, Fain & D'Amico, 1997; Cawley, 2002; Iorio, 2003; Delfosse, 2004; Delfosse & Iorio, 2009; Hillyard, 2005). Recently its distribution in Spain has been updated by Merino-Sáinz *et al.* (2013) who stated the species might even reach Portugal.

If the outlines of its overall biogeographic area are better known, there are still some gaps about the ecological envelope of the species, especially at the meso- and microhabitat scales. For example, the limits of its altitudinal distribution are still imprecise and ecological versatility is yet to be characterized. The biggest gaps and contradictions concern the reproduction of the species. Many authors have already pointed out that *Megabunus diadema* is a facultative parthenogenetic species (Phillipson, 1959; Feliú, 1981; Stol, 2005). The majority of the information provided in the literature as well as, marginally, in discussion forums (webography not supplied) report mostly female individuals sightings. For example, in England, Phillipson (1959) found a single male individual versus 406 females during his survey. In Norway, the proportion provided by Stol (2005) is comparable, 3 males to 261 females. In Spain, the tendency to over-representation of females is also reported by Merino-Sáinz *et al.* (2013), although the proportion of males is slightly higher than elsewhere (8 males to 51 females) but they recognize possible local variation of this proportion, namely in the Huesca region where the largest number of males was found (7 males off the total of eight found). By contrast, D'Amico & Besson (1995) already described an overrepresentation of males in the population monitored in the Ossau Valley, on the northern slope of the Pyrenees.

Based on current knowledge, *Megabunus diadema* appears to be a species with highly biased sex ratio in favour of females throughout its range, with the exception of the Pyrenean populations. The main objective of this work is to quantify for the first time this variation in the sex ratio of the north-Pyrenean populations by examining the patterns of variation in spatial dimensions (focusing here on altitude) and temporal dimension (here adult development period).

This work is also used to update the distribution of the species on the northern slope of the Pyrenees and to specify the limits of its altitudinal distribution.

2. Methods

Data were collected between 1988 and 2014 (see also D'Amico, 1988; D'Amico & Besson 1995) by sight sampling, methodically searching for individuals of the species on favorable substrates (rocks, trunks ...). These original presence data (see Annex), combined with historical data (Simon, 1881), and other published data (Evenou, undated; Ledoux & Emerit, 2006), allow to establish the distribution map of the species on the northern side of the Pyrenees. Data published by Merino-Sáinz *et al.* (2013) for the south side are not taken into account.

The characterization of the sex ratio and its spatial and temporal variation was made from a subset of this data set, putting as strong conditions a reliable identification of males and females and a minimum number of 3 individuals in the sample. In accordance with the definitions proposed by West (2009), the sex ratio is the proportion of males in a population. Although the term sex ratio

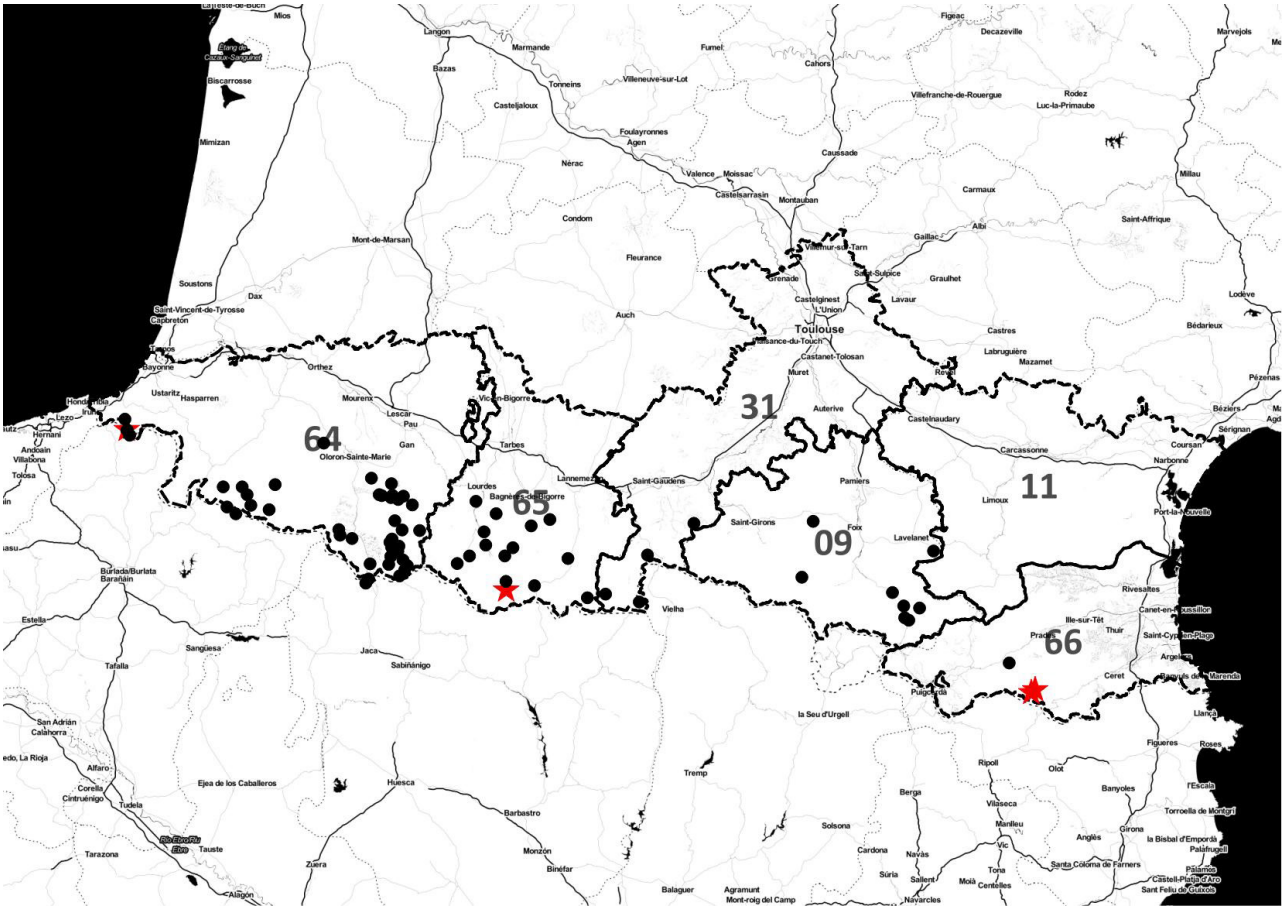

Figure 1: Updated distribution of *Megabunus diadema* on the northern slope of the Pyrenees, from original data (• black dots / mainly F. D'Amico & S. Danflous, see also contributors in the section «Acknowledgements») and the sparse historical data (☆ red stars). Dark lines delineate the administrative boundaries of Département Pyrénées-Atlantiques (64), Hautes-Pyrénées (65), Haute-Garonne (31), Ariège (09), Aude (11) and Pyrénées-Orientales (66).

Figura 1: Distribución actualizada de Megabunus diadema *en la vertiente norte de los Pirineos, a partir de datos originales (• puntos negros: principalmente, F. D'Amico y S. Danflous, ver también colaboradores en la sección «Agradecimientos») y los datos históricos escasos (☆ estrellas rojas). Las líneas oscuras delinean los límites administrativos de los departamentos de los Pirineos Atlánticos (64), Altos Pirineos (65), Haute-Garonne (31), Ariège (09), Aude (11) y Pirineos Orientales (66).*

is used indiscriminately throughout this paper, figures provided in this study relate only to the tertiary sex ratio, defined as the ratio for mature organisms (adults). Primary sex ratio (ratio at the time of conception) and secondary sex ratio (ratio at birth) are not evaluated in this work.

The patterns of spatial and temporal variation in the sex ratio are analysed in a descriptive manner using multiple boxplots built with the commands "geom_boxplot» and «geom_jitter" of ggplot2 package for the free software R (R Core Team, 2012). These commands of the package ggplot2 (Wickham, 2009) allow to superimpose all raw data as points to the conventional box plots. In boxes presented here, the horizontal line represents the median and the upper and lower "hinges" correspond to the first and third quartiles (the 25th and 75th percentiles).

3. Results

3.1. Geographic distribution

The species has a wide distribution over the whole French Pyrenees (Figure 1), with an apparent under-representation in the easternmost part. Indeed, we provide the first records of this species in the departments of Haute-Garonne and Ariège. To date, no record of the species has been made in the department of Aude. The species was already cited from the Pyrénées-Atlantiques (Simon, 1879; D'Amico, 1988) and Hautes-Pyrénées (Simon, 1881) whilst its presence was first recorded recently (Ledoux & Emerit, 2006) in the Pyrénées-Orientales from two close locations.

3.2. Altitudinal distribution

The altitudinal distribution profile for *Megabunus diadema* in the Pyrenees is established from an original dataset of 82 records. The species is found between 220 and 1920 m, with a mean altitudinal value of 1143 m (median value 1182 m).

3.3. Sex-ratio

The characteristics of the sex ratio are based on a sample of 54 records, with an average of 13.7 individuals per record (range: 3-37 individuals). In total, 741 individuals were sexed during the study, 486 males and 255 females, corresponding to a total value of sex ratio equal to 65.58%. In statistical terms, for the entire dataset, the sex-ratio varies between 0 and 100%, with an average of 64.0% and a median of 75.5%.

The great variability in the sex ratio results in a decrease in the proportion of males as altitude increases (Figure 2): high (ca 80%) between 400 and 1200 m, it recedes quickly in its upper altitudinal range to a median value of around 30%.

The sex ratio shows a well marked pattern in temporal variation, indicated by a gradual increase during the spring and a plateau in the summer (Figure 3). Lower than 50% in May, when adults appear, it reaches a median value of around 90% in July and August.

4. Discussion

A distribution map of the species on the northern slope of the Pyrenees is provided for the first time, with mostly new records from all the french Pyrenees. Apparent under-representation in the easternmost part (namely departement of Ariège and Aude) is probably an artifact, resulting from a relative lower field survey pressure in this area. Our study complements the one recently compiled by Merino-Sáinz *et al.* (2013) for the southern side of the Pyrenees and the rest of the Iberian Peninsula. Our work provides new and original information on the variability of the tertiary sex ratio of this species whose notable originality lies in its reproduction mode: considered until now as facultative parthenogenesis, with very few male individuals observed in the nature, our study (involving 741 individuals in total, the largest number of

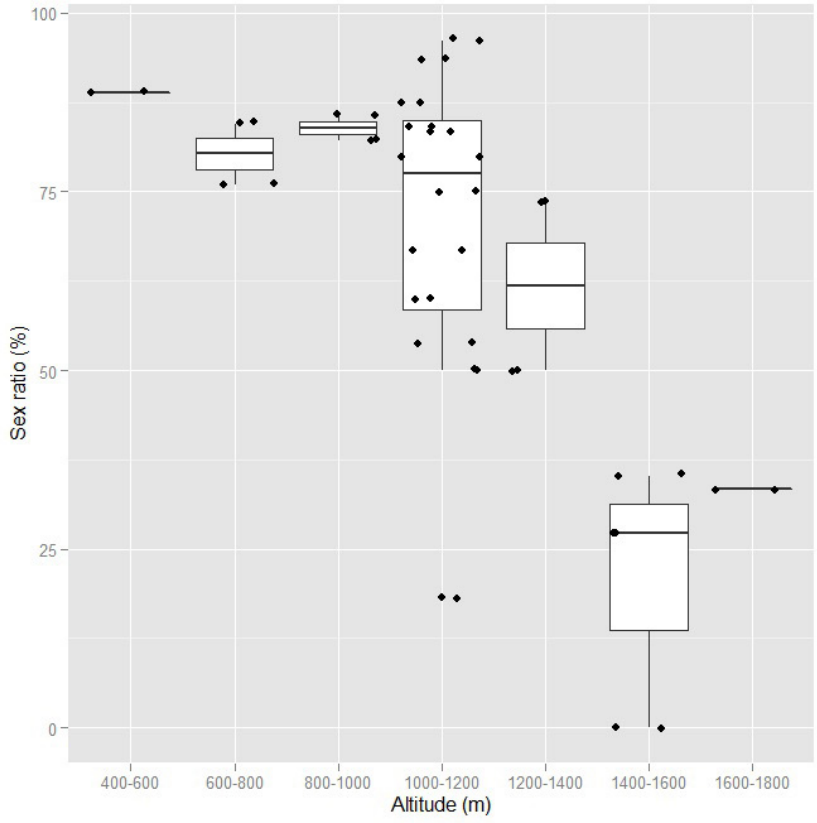

Figure 2: Variation of sex ratio in *Megabunus diadema* on the northern slope of the Pyrenees (n = 53 observations), according to altitude, split into 7 blocks from 400 m to 1800 m.
Figura 2: Variación de la proporción de sexos en Megabunus diadema en la vertiente norte de los Pirineos (observaciones n = 53), de acuerdo con la altitud, dividida en 7 bloques de 400 m. a 1.800 m.

individuals ever studied in this species) leads to an opposite conclusion, at least in the northern Pyrenees, and emphasizes for the first time the possibility for this species to be a sexually reproducing one.

4.1. Distribution

In his review on mountain harvestmen, Beron (2002) indicates that many species can live or survive at high altitude. In Europe, he cites at least 47 species reaching or exceeding 2200 m; they belong to 6 families (Phalangidae, Sclerosomatidae, Ischyropsalididae, Trogulidae, Sabaconidae and Nemastomatidae). Of these, only 14 species are observed at 2500 m and only 3 reach 3500 m (corresponding to the so-called "nival" vegetation belt). The *Megabunus* genus belongs to this tiny assemblage of high altitude species, with altitudinal records of 3200 m for *Megabunus armatus* (Kulczynski, 1887) and 3000 m for *Megabunus rhinoceros* (Canestrini, 1872) in the Alps (Beron, 2002). On the northern side of the Pyrenees (Figure 1), *Megabunus diadema* has a wide altitudinal range (220 - 1920 m) with a likely preference for the "montane" vegetation belt (dominated by beech and fir woodland in particular; see D'Amico & Besson, 1995), given that the mean elevation is 1143 m (median value: 1188 m). With a maximum altitude of 1920 m recorded in this study, *Megabunus diadema* does not reach the highest peaks of the Pyrenees (culminating at 3404 m, Pico de Aneto).

However, a deficit of field surveying beyond the tree line is not discarded. These values are narrower than those published by Merino-Sáinz *et al.* (2013) for geographically close populations on the southern slope of the Pyrenees (mean elevation: 1298 m; range: 800 to 2150 m) and in the Cantabrian Mountains (mean elevation: 561 m; range: 2 to 1450 m). The climatic contrast between the southern side and northern side of the Pyrenees explains this difference, through the well-known increase in vegetation belts of vegetation on the southern side (Gruber, 1978; Rameau *et al.,* 1993) compared to the northern side.

4.2. Sex-ratio

The sex ratio of a population, or a set of several local populations (whether connected or not), is a key structural variable of their natural history, as it underpins the

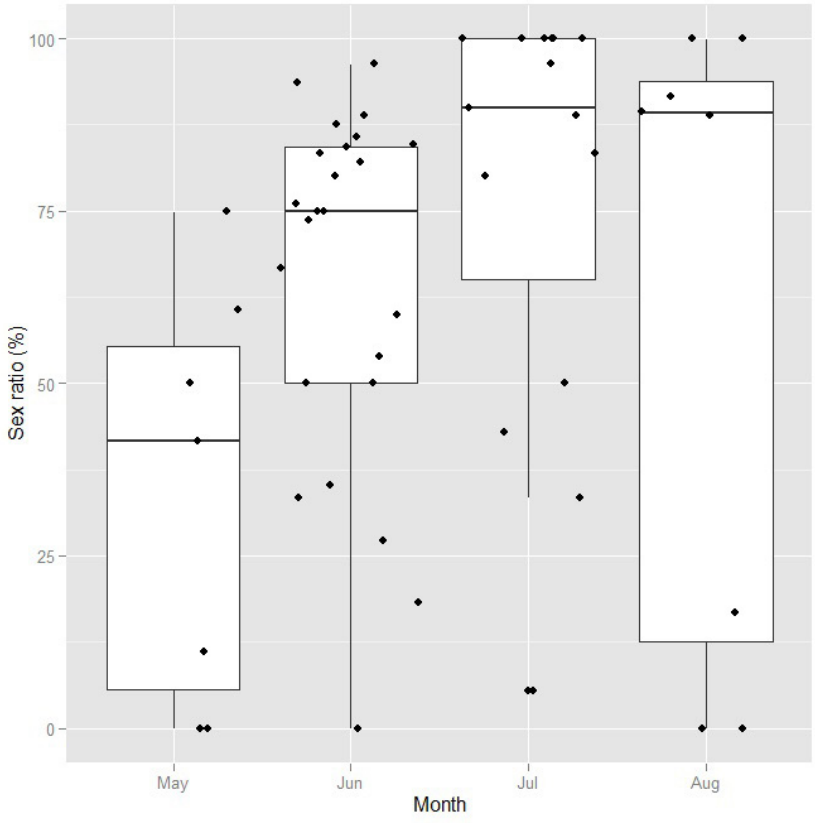

Figure 3: Monthly variation of sex ratio in *Megabunus diadema* on the northern slope of the Pyrenees (n = 53 observations), from May to August.
Figura 3: Variación mensual del índice de masculinidad en Megabunus diadema *en la vertiente norte de los Pirineos (observaciones n = 53), de mayo a agosto.*

behaviour, the social structure and the dynamics of the reproductive system (Charnov, 1982; Edwards, 1998; Frank, 1998; Hardy, 2002; West, 2009). As a result, understanding what generates sex ratio variations, is an important element to model the future growth of the population, sustainability and its vulnerability to extinction, especially when the sex ratio is asymmetrical (i.e. strongly biased in favour of one sex).

Many arachnids [including spiders - see for instance Vollrath & Parker (1992) and Aviles *et al.* (2000) and harvestmen - see for example Tsurusaki (1986)] show a remarkable variety of reproductive phenotypes, such as parthenogenesis, and a very strong asymmetry of the sex ratio. *Megabunus diadema* is an outstanding example, although available knowledge so far published mix parthenogenesis and asymmetrical sex ratio, concluding (without demonstration yet) that this limited number of males necessarily induce parthenogenesis, may this parthenogenesis be facultative. As already pointed, Philipson (1959) had described the species as parthenogenetic in England from a tertiary sex ratio of 0.25% (1 single male observed among 407 individuals), as did Stol (2005) who observed 3 males among 264 individuals (raising thus a tertiary sex ratio of 1.13 %). In the Iberian Peninsula, the recent study by Merino-Sáinz *et al.* (2013) reached the same finding, a highly skewed sex ratio in favour of females with a tertiary sex ratio of 13.5% (8 males observed among 59 individuals). Our study contrasts sharply with those three published studies, to the extent that we observe a skewed sex ratio in favour of males, with a tertiary sex ratio of 65.6% (486 males observed among 741 individuals). The fact that we have a higher number of individuals in the sample [741 for this study, versus 407, 264 and 59 for previously published studies: Philipson (1959), Stol (2005) and Merino-Sáinz *et al.* (2013) respectively] cannot alone explain the contrast. If existing, a possible bias is to be searched in the spatial and temporal variability that we characterize here for the first time, for which we describe the specific patterns. The comparison of total tertiary sex ratio (i.e. for the entire sample) as we have done for 4 populations (England, Norway, Iberian Peninsula vs northern Pyrenees) may conceal some possibly unobserved intra-populational variability and does not include the effects of altitude, time, and more importantly the interaction between altitude and time. Despite Merino-Sáinz *et al.* (2013) noticed that sex-ratio may locally reach a value of 30% (in the region of Huesca where 3 males and 27 females were found), our work is the only one published to date that describes the subtlety of these altitudinal and temporal variations, preventing yet further comparison.

Since the study populations in our study and that of Merino-Sáinz *et al.* (2013) are geographically very close, and given that the period of study is contemporary in both cases (hence excluding the possibility for any historical change in sex ratio), we advocate further studies in the whole Pyrenees mountain to understand the remarkable contrast in sex-ratios, especially in the light of recent findings. Among Arachnids, as has recently been shown for the spider *Oedothorax retusus* (Westring, 1851), one of the potential causes of variation in sex ratio is the level and patterns of infection by bacteria endosymbionts of maternal origin that can alter the sex ratio of offspring of a mother in order to increase their own physical condition (Vanthournout *et al*., 2014)

The existence of altitudinal and temporal variation in the sex ratio of *Megabunus diadema* had never been described. This even appears to be the first documented case in harvestmen. Moreover, we show that these variations follow clear patterns: the proportion of male decreases with altitude and increases during adult development period (spring and summer). The existence of a relationship between sex ratio and altitude has already been established in other arachnids, particularly the spider *Myro kerguelenensis* (O. Pickard-Cambridge, 1876) in which the proportion of females increases with altitude (Lee *et al.,* 2011). In such a case, the explanations are related to resource limitation and an increase in the prevalence of sexual cannibalism with altitude.

However, the interaction between the effect of altitude and time remains to be described because it may obscure the patterns of variation. We cannot exclude the existence of other spatially-related effects (for example a possible East/West gradient). Undoubtedly, these relationships may also be affected by differences in habitat use by females and males, as has been shown for other arachnids. These aspects deserve further investigations, especially because environmental changes quickly alter habitats and drive rapid adaptive responses by species (Bowden *et al.,* 2015).

Revealing a preponderance of males never suspected before in this species and describing extreme variability of tertiary sex ratio values within the population (or populations) on the northern slope of the Pyrenees, we feed the debate on the mode of reproduction of the species (is *Megabunus diadema* really an asexual, parthenogenetic species?), and put forward the interest of this species as a model to study the underlying mechanisms in populations with a strong distortion of sex ratio.

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ANNEX

New distribution data of *Megabunus diadema* in the French Pyrenees
Distribución de nuevos datos de Megabunus diadema *en los Pirineos franceses*

Code	Date	Collection	Identification	Commune	Department	Latitude	Longitude	Altitude	Depositary
64-1	06/08/1986	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°50'47.6"	W 0°27'47.0"	1590	D'Amico F.
64-2	12/08/1986	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°53'18.5"	W 0°25'01.9"	1140	D'Amico F.
64-3	19/08/1986	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°53'56.2"	W 0°25'14.6"	1190	D'Amico F.
64-4	21/08/1986	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°53'02.5"	W 0°25'33.6"	1150	D'Amico F.
64-5	29/05/1988	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°51'08.0"	W 0°27'44.2"	1540	D'Amico F.
64-6	14/06/1988	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°52'40.8"	W 0°24'38.8"	1545	D'Amico F.
64-7	29/06/1988	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°49'36.0"	W 0°23'29.8"	1460	D'Amico F.
64-8	06/07/1988	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°51'32.3"	W 0°26'21.1"	1750	D'Amico F.
64-9	05/06/1989	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°52'09.6"	W 0°27'21.2"	1380	D'Amico F.
64-10	18/06/1989	D'Amico F.	D'Amico F.	Bilheres	Pyrénées-Atlantiques (64)	N 43°04'05.7"	W 0°27'01.6"	955	D'Amico F.
64-11	19/06/1989	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°51'30.8"	W 0°23'44.0"	1400	D'Amico F.
64-12	19/06/1989	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°51'25.7"	W 0°24'02.5"	1580	D'Amico F.
64-13	22/04/1994	D'Amico F.	D'Amico F.	Sare	Pyrénées-Atlantiques (64)	N 43°15'43.5"	W 1°37'08.0"	425	D'Amico F.
64-14	26/04/1994	D'Amico F.	D'Amico F.	Eaux-Bonnes	Pyrénées-Atlantiques (64)	N 42°56'11.4"	W 0°26'21.1"	995	D'Amico F.
64-15	08/06/1994	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°55'48.9"	W 0°26'58.7"	770	D'Amico F.
64-16	16/0/1994	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°59'07.0"	W 0°26'20.5"	730	D'Amico F.
64-17	16/0/1995	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°58'54.7"	W 0°27'06.1"	1090	D'Amico F.
64-18	26/04/1997	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°53'52.9"	W 0°26'13.0"	1190	D'Amico F.
64-19	10/05/1997	D'Amico F.	D'Amico F.	Accous	Pyrénées-Atlantiques (64)	N 42°55'40.9"	W 0°37'36.1"	780	D'Amico F.
64-20	27/06/1997	D'Amico F.	D'Amico F.	Arudy	Pyrénées-Atlantiques (64)	N 43°06'02.3"	W 0°27'11.4"	450	D'Amico F.
64-21	29/06/1997	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°55'47.2"	W 0°27'02.0 "	900	D'Amico F.
64-22	17/08/1997	D'Amico F.	D'Amico F.	Eaux-Bonnes	Pyrénées-Atlantiques (64)	N 42°57'09.1"	W 0°19'33.4"	1470	D'Amico F.
64-23	20/06/1998	D'Amico F.	D'Amico F.	Lées-Athas	Pyrénées-Atlantiques (64)	N 42°57'26.1"	W 0°41'04.4"	1459	D'Amico F.

ANNEX (cont.)

64-24	20/06/1998	D'Amico F.	D'Amico F.	Lurbe St-Christau	Pyrénées-Atlantiques (64)	N 43°07'20.0"	W 0°32'25.2"	430	D'Amico F.
64-25	25/06/1998	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°48'28.8"	W 0°24'47.4"	1920	D'Amico F.
64-26	03/07/1999	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°50'22.5"	W 0°22'38.3"	1510	D'Amico F.
64-27	03/07/1999	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°51'33.1"	W 0°23'19.0"	1400	D'Amico F.
64-28	05/07/1999	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°55'06.9"	W 0°28'38.7"	1645	D'Amico F.
64-29	16/05/2000	D'Amico F.	D'Amico F.	Borce	Pyrénées-Atlantiques (64)	N 42°47'13.1"	W 0°33'54.7"	1450	D'Amico F.
64-30	08/06/2000	D'Amico F.	D'Amico F.	Urdos	Pyrénées-Atlantiques (64)	N 42°47'44.2"	W 0°33'22.4"	1340	D'Amico F.
64-31	22/06/2000	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°54'52.1"	W 0°27'37.8"	1450	D'Amico F.
64-32	06/08/2000	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°53'52.9"	W 0°26'13.0"	1190	D'Amico F.
64-33	02/05/2001	D'Amico F.	D'Amico F.	Estérencuby	Pyrénées-Atlantiques (64)	N 43°06'43.9"	W 1°12'25,5"	250	D'Amico F.
64-34	31/07/2001	D'Amico F.	D'Amico F.	Borce	Pyrénées-Atlantiques (64)	N 42°46'56.0"	W 0°34'02.0"	1675	D'Amico F.
64-35	16/06/2002	D'Amico F.	D'Amico F.	Eaux-Bonnes	Pyrénées-Atlantiques (64)	N 42°57'42,6"	W 0°24'06.8"	1420	D'Amico F.
64-36	16/06/2002	D'Amico F.	D'Amico F.	Eaux-Bonnes	Pyrénées-Atlantiques (64)	N 42°57'57.9"	W 0°23'39.7"	1150	D'Amico F.
64-37	12/07/2003	D'Amico F.	D'Amico F.	Bilheres	Pyrénées-Atlantiques (64)	N 43°03'34.7"	W 0°29'30.9"	1014	D'Amico F.
64-38	13/07/2003	D'Amico F.	D'Amico F.	Gourette	Pyrénées-Atlantiques (64)	N 42°57'11.2"	W 0°19'32.1"	1463	D'Amico F.
64-39	NA	D'Amico F.	D'Amico F.	Saint-Goin	Pyrénées-Atlantiques (64)	N 43°13'22.0"	W 0°44'28.0"	220	D'Amico F.
64-40	17/07/2012	D'Amico F.	D'Amico F.	Urdos	Pyrénées-Atlantiques (64)	N 42°50'44.0"	W 0°32'45.7"	1040	D'Amico F.
64-41	24/07/2012	D'Amico F.	D'Amico F.	Laruns	Pyrénées-Atlantiques (64)	N 42°54'02.4"	W 0°26'59.3"	1590	D'Amico F.
64-42	18/05/2014	D'Amico F.	D'Amico F.	Sare	Pyrénées-Atlantiques (64)	N 43°16'41.5"	W 01°37'273"	364	D'Amico F.
64-43	18/05/2003	D'Amico F.	D'Amico F.	Lescun	Pyrénées-Atlantiques (64)	N 42°56'34.60"	W 0°40'42.26"	1100	D'Amico F.
64-44	18/05/2003	D'Amico F.	D'Amico F.	Lescun	Pyrénées-Atlantiques (64)	N 42°56'24.88"	W 0°41'48.53"	1500	D'Amico F.
64-45	25/04/2010	D'Amico F.	D'Amico F.	Bilheres	Pyrénées-Atlantiques (64)	N 43°03'36"	W 0°27'16"	762	D'Amico F.
64-46	30/05/2010	D'Amico F.	D'Amico F.	Bilheres	Pyrénées-Atlantiques (64)	N 43°04'00"	W 0°29'43"	951	D'Amico F.
64-47	20/06/2010	D'Amico F.	D'Amico F.	Bilheres	Pyrénées-Atlantiques (64)	N 43°04'08"	W 0°30'23"	1080	D'Amico F.

ANNEX (cont.)

64-48	06/05/2011	D'Amico F.	D'Amico F.	Bielle	Pyrénées-Atlantiques (64)	N 43°03'14"	W 0°25'20"	437	D'Amico F.
64-49	20/07/2011	D'Amico F.	D'Amico F.	Arudy	Pyrénées-Atlantiques (64)	N 43°06'19"	W 0°27'07"	421	D'Amico F.
64-50	25/07/2013	D'Amico F.	D'Amico F.	Castet	Pyrénées-Atlantiques (64)	N 43°02'13"	W 0°21'35"	1345	D'Amico F.
64-51	10/08/2013	D'Amico F.	D'Amico F.	Bilheres	Pyrénées-Atlantiques (64)	N 43°04'06"	W 0°27'03"	965	D'Amico F.
64-52	NA	D'Amico F.	D'Amico F.	Aussurucq	Pyrénées-Atlantiques (64)	N 43°06'8.72"	W 0°58'1.24"	739	D'Amico F.
64-53	04/06/2014	D'Amico F.	D'Amico F.	Castet	Pyrénées-Atlantiques (64)	N 43° 3'54.07"	W 0°23'58.07"	524	D'Amico F.
64-54	24/06/2014	D'Amico F.	D'Amico F.	Lecumberry	Pyrénées-Atlantiques (64)	N 43° 0'28.40"	W 1° 8'28.18"	850	D'Amico F.
64-55	24/06/2014	D'Amico F.	D'Amico F.	Estérencuby	Pyrénées-Atlantiques (64)	N 43° 1'47.81"	W 1°10'48.14"	940	D'Amico F.
64-56	02/07/2014	D'Amico F.	D'Amico F.	Mendive	Pyrénées-Atlantiques (64)	N 43° 5'41.86"	W 1° 6'46.68"	550	D'Amico F.
64-57	02/07/2014	D'Amico F.	D'Amico F.	Lecumberry	Pyrénées-Atlantiques (64)	N 43° 4'11.33"	W 1° 5'28.24"	1045	D'Amico F.
64-58	02/07/2014	D'Amico F.	D'Amico F.	Mendive	Pyrénées-Atlantiques (64)	N 43° 2'7.65"	W 1° 4'28.46"	980	D'Amico F.
64-59	02/07/2014	D'Amico F.	D'Amico F.	Larrau	Pyrénées-Atlantiques (64)	N 43° 1'16.45"	W 0°59'37.45"	612	D'Amico F.
65-1	01/04/2007	Bergès C.	Danflous S.	Campan	Hautes-Pyrénées (65)	N 42° 59' 23"	W 0° 14' 57"	1400	Danflous S.
65-2	25/09/2012	Blanc F.	Danflous S.	Campan	Hautes-Pyrénées (65)	N 42° 58' 59"	W 0° 10' 21"	1420	Danflous S.
65-3	12/07/2012	Déjean S.	Danflous S.	Betpouey	Hautes-Pyrénées (65)	N 42°52'25"	E 0°02'57"	1300	Danflous S.
65-4	04/06/2008	Déjean S.	Déjean S.	Villelongue	Hautes-Pyrénées (65)	N 42° 56' 12"	W 0° 02' 53"	500	Déjean S.
65-5	15/07/2008	Déjean S.	Déjean S.	Barèges	Hautes-Pyrénées (65)	N 42° 53' 34"	E 0° 04' 32"	1500	Déjean S.
65-6	29/07/2009	Déjean S.	Déjean S.	Cauterets	Hautes-Pyrénées (65)	N 42° 50' 3"	W 0° 10' 12"	1720	Déjean S.
65-7	11/07/2008	Déjean S.	Déjean S.	Gèdre	Hautes-Pyrénées (65)	N 42° 47' 17.9"	E 0° 03' 28.8"	1630	Déjean S.
65-8	16/07/2002	D'Amico F.	D'Amico F.	Cauterets	Hautes-Pyrénées (65)	N 42°52'15,0"	W 0°06'24,8"	1130	D'Amico F.
65-9	14/08/2000	D'Amico F.	D'Amico F.	Loudenvielle	Hautes-Pyrénées (65)	N 42°44'51,0"	E 0°24'41.5"	1560	D'Amico F.
65-10	13/07/2001	D'Amico F.	D'Amico F.	Loudenvielle	Hautes-Pyrénées (65)	N 42°44'11.5"	E 0°24'45.1"	1560	D'Amico F.
65-11	09/05/2003	D'Amico F.	D'Amico F.	Luz	Hautes-Pyrénées (65)	N 42°54'50.2"	W 0°02'12.5"	640	D'Amico F.
31-1	15/07/2008	Valladarès L.	Danflous S.	Marignac	Haute-Garonne (31)	N 42° 52' 34"	E 0° 40' 54"	NA	Danflous S.

ANNEX (cont.)

31-2	16/05/2010	Danflous S.	Danflous S.	Herran	Haute-Garonne (31)	N 42° 58' 39"	E 0° 52' 59"	900	Danflous S.
31-3	18/06/2012	Déjean S.	Déjean S.	Bagnères-de-Luchon	Haute-Garonne (31)	N 42° 43' 15"	E 0° 38' 11"	NA	Déjean S.
31-4	14/08/2000	D'Amico F.	D'Amico F.	Bagnères-de-Luchon	Haute-Garonne (31)	N 42°43'02,6"	E 0°39'02,8"	1450	D'Amico F.
31-5	15/07/2001	D'Amico F.	D'Amico F.	Bagnères-de-Luchon	Haute-Garonne (31)	N 42°44'51,0"	E 0°29'30,3"	1560	D'Amico F.
09-1	22/06/2011	D'Amico, F.	D'Amico, F.	Belesta	Ariège (09)	N 42°52'30.0"	E 1°57'56.6"	850	D'Amico, F.
09-2	09/06/2010	Danflous S.	Danflous S.	Port	Ariège (09)	N 42° 48' 15"	E 1° 21' 53"	1600	Danflous S.
09-3	20/06/2009	Danflous S.	Danflous S.	Port	Ariège (09)	N 42° 48' 15"	E 1° 21' 53"	1600	Danflous S.
09-4	21/01/2012	Déjean S.	Déjean S.	Alzen	Ariège (09)	N 42° 59' 9"	E 1° 25' 11"	540	Déjean S.
09-5	10/07/2013	Déjean S.	Danflous S.	Perles-et-Castelet	Ariège (09)	N 42° 43'00.2"	E 1° 48'19.3"	1380	Danflous S.
09-7	20/05/2014	Déjean S.	Déjean S.	Mérens-les-Vals	Ariège (09)	N 42°39'46.09"	E 1°50'15.12"	1427	Déjean S.
09-9	27/06/2014	Gouix N. & Déjean S.	Déjean S.	Ax-les-Thermes	Ariège (09)	N 42°40'14.98"	E 1°49'10.11"	1425	Déjean S.
09-10	02/07/2014	Déjean S. & Blanc F.	Danflous S.	Luzenac	Ariège (09)	N 42°45'9.93"	E 1°45'54.92"	1174	Danflous S.
09-11	19/07/2014	Danflous S. & Cally S.	Danflous S.	Orlu	Ariège (09)	N 42°42'8.52"	E 1°53'7.22"	1170	Danflous S.
66-0	23/05/2004	Evenou Y.	Evenou Y.	Nyer	Pyrénées-Orientales (66)	UTM WGS84: "31T 0441330 4707468"		NA	Evenou Y.