

Research Article

A hotspot for Mediterranean cicadas (Insecta: Hemiptera: Cicadidae): new genera, species and songs from southern Spain

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Southern Spain exhibits high diversity and endemism. Based on a long-term field study, a review of nine regional cicada species hitherto placed in the genus *Tettigetta* is provided. According to morphological characters previously defined by Lee, none of these species belongs to the genus *Tettigetta*; they are placed instead in four new genera: *Tettigettalna* Puissant gen. nov., *Tettigettula* Puissant gen. nov., *Tettigettacula* Puissant gen. nov., and *Pseudotettigetta* Puissant gen. nov. *Tettigetta parvula* (Fieber, 1876) and *Tettigetta carayoni* Boulard (1982) are transferred to *Cicadivetta* Boulard, 1982, as *Cicadivetta parvula* (Fieber, 1876), comb. nov. and *Cicadivetta carayoni* (Boulard, 1982), comb. nov. *Tettigetta manuely* Boulard, 2000 is considered a synonym of *Tettigettalna helianthemi helianthemi* (Rambur, 1840), comb. nov., syn. nov. Three new endemics, *Tettigettalna bouldardi* Puissant sp. nov., *Tettigettalna armandi* Puissant sp. nov., and *Tettigettalna defaulti* Puissant sp. nov., are described. A new subspecies, *Tettigettalna helianthemi galantei* Puissant ssp. nov., is also reported. All species are described with information on their distribution, habitat selection, and acoustic behaviour. The high diversity of cicadas in southern Spain is discussed in terms of local geography and mating behaviour.

Key words: acoustic behaviour, Baetic ranges, Cicadidae, endemism, Hemiptera, Mediterranean basin, new taxa

Introduction

The Mediterranean basin has long been recognized as a biodiversity hotspot (Blondel & Aronson, 1999; Médail & Quézel, 1997, 1999; Myers *et al.*, 2000). Within this region, the Iberian Peninsula, which includes Spain, the Balearic Islands and Portugal, has been identified as an area of high diversity and endemism (De Jong, 1998; García-Barros *et al.*, 2002). Several analyses have sought to define local areas of endemism within Iberia (Médail & Quézel, 1997, 1999; Moreno Saiz *et al.*, 1998; García-Barros *et al.*, 2002; Mota *et al.*, 2002). Based on the geographical distributions of endemic plant species, they all point to southern Spain and, in particular, to the Baetic ranges. This major tectonic unit in the western Mediterranean also seems to be a centre of endemism for insects (De Jong, 1998; Ribera, 2000), as well as amphibians and fishes (Vargas *et al.*, 1998).

Cicadas are well-known for the sound they produce during courtship. Mainly based on acoustics, inventories of cicada species have been made in France (Puissant, 2006), southern Switzerland (Hertach, 2007), northern Italy (Trilar & Hertach, 2008), Slovenia (Gogala & Gogala,

1999), Macedonia (Gogala *et al.*, 2005), and Portugal (Boulard, 1982a; Sueur *et al.*, 2004).

Surprisingly, the cicada fauna of Spain has been neglected. Some older references describe or report species from Spain (Herrich-Schäffer, 1835; Waltl, 1837; Rambur, 1840; Amyot, 1847; Rosenhauer, 1856), but there are few recent works. Linnavuori (1956) published a list of species from Spanish Morocco. Gomez-Menor Ortega (1957) produced an identification key for Spanish cicadas. However, it appears that some species listed by Gomez-Menor Ortega do not belong to the Spanish fauna, and the nomenclature is now out of date. Kartal (1999) detailed the genital morphology of four species. Boulard (2000a) described four new species belonging to *Tettigetta* based on the analysis of voucher specimens only. An acoustic analysis led Sueur & Puissant (2003) to consider *Tibicina baetica* (Rambur, 1840) as a junior synonym of *Tibicina tomentosa* (Olivier, 1790). Puissant (2005) studied in detail the taxonomy, distribution and acoustic behaviour of *Hilaphura varipes* (as *Melampsalta varipes* (Waltl, 1837)), *Melampsalta* Amyot, 1847 being unavailable following ICNZ (Opinion 2165, 2006). Pinto-Juma *et al.* (2008a, 2008b, 2009) and Seabra *et al.* (2009) included some Spanish specimens in large-scale geographical studies regarding both genetic and

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acoustic population variability of *Cicada orni* Linné, 1758, and *Cicada barbara* (Stål, 1866).

Not a single new cicada taxon was described from Spain throughout the 20th century until four new species were named by Boulard (2000a). Knowing the high level of diversity and endemism in Spain and more specifically in the Baetic ranges, we expect that many species remain to be discovered. This seems particularly likely for the genus *Tettigetta* Kolenati, 1857, which includes four species in Portugal (Sueur *et al.*, 2004) and 12 in North Africa (Boulard, 1980, 1981a, 1982b, 1987). As with other cicadas, the diversity of this genus is thought to be driven by the divergence of acoustic signals leading to the evolution of cryptic species (Sueur, 2006). Based on a long-term field study including the recording and analysis of male sound behaviour, three new species and a new sub-species are described, and a new status and a new synonymy are established. Referring to morphological characters defined by Lee (2008), these species do not belong to *Tettigetta* but to four new genera currently known only from the western European region, one being endemic to southern Spain. As a result, cicada diversity and endemism are considerably increased for this part of the Mediterranean basin.

Materials and methods

Taxonomy and morphology

The taxonomy and morphological terminology are based on Moulds (2005). *Tettigetta* and the new genera described all belong to the Cicadidae Latreille, 1802, subfamily Cicadettinae Buckton, 1889, tribe Cicadettini. Morphometric measurements used for formal descriptions are as follows (with precision indicated in parentheses): FL: forewing length (0.1 mm), FW: forewing width (0.1 mm), YW: eye width (0.02 mm), VW: vertex width (0.03 mm), BL: body length (0.1 mm), PL: pronotum length (0.02 mm), PW: pronotum width (0.05 mm). Results are given as mean $\pm$ standard deviation (minimum–maximum).

Habitat and vegetation

The cicadas studied here do not select specific host plants. Habitats for each species were defined using categories based on the physical structure of the vegetation (vegetation height and ligneous plant percentage rather than floral composition). This habitat classification was successfully used in previous studies on the West-European cicada fauna (Puissant & Sueur, 2002; Sueur & Puissant, 2002; Sueur *et al.*, 2004). Habitat classes differ from vegetation classes because they do not account for any climatic features. As already established for French species (Puissant, 2006), vegetation classes are defined according to Defaut (1994, 1996) and Rivas-Martínez (1987), with A2-3: xeric arid class, warm to temperate sub-class; SA2-3: xeric semi-

arid class, warm to temperate sub-class; SH2: xeric sub-humid class, warm sub-class; SH3: xeric sub-humid class, temperate sub-class; SX3: sub-axeric class, temperate sub-class; SX4: sub-axeric class, cool sub-class; Cb and Cc: colinus class; and BM: boreal montane class.

Acoustics

Male calling songs were recorded in the field during spring 2002–2004. Recordings were made with an omnidirectional Telinga Pro4PiP microphone (Tobo, Sweden, frequency response 0.04–18 kHz $\pm$ 1 dB) connected to a Sony TCD-D7 digital audio tape recorder (DAT sampling frequency 44.1 kHz, frequency response flat within range 0.02–22 kHz $\pm$ 1 dB). Recordings were made from 10:00–18:00 hours, corresponding to the maximum activity of cicadas. The microphone was placed above and about 50 cm from calling males. Shade temperature was monitored for each recording session using an external thermometer with precision of $\pm$ 1°C. Signals were digitized from the analogue output of the DAT recorder at a sampling rate of 44.1 kHz and analysed using Soundruler (Gridi-Papp, 2003–2007) and Avisoft Light (Specht, 2004) analytical packages.

The temporal structure of calling songs was defined as following: (1) pulses are produced by the buckling of one tymbal rib, (2) groups of pulses are produced by the activation of one or both tymbals, (3) echemes are the main unit of calling song comparable to birdsong notes, and (4) phrases group a series of echemes following a specific rhythm. The following temporal parameters were measured with 10⁻³ s precision: number of echemes in a phrase, duration of echemes, duration of the silence between echemes, and number of groups of pulses per echeme. However, acoustic homology between parts constituting calling songs could not be established between all taxa recorded. This was due to a significant diversity in temporal pattern. This leads to temporal measurements specific to each taxon.

In the frequency domain, as no harmonic structure could be detected, only the dominant frequency (DF) was measured using a fast Fourier transform (FFT) with 43.1 Hz precision. For spectrogram representations, and if necessary, a 3 kHz high-pass frequency filter was applied to the signal to remove incidental background noise due to singing birds.

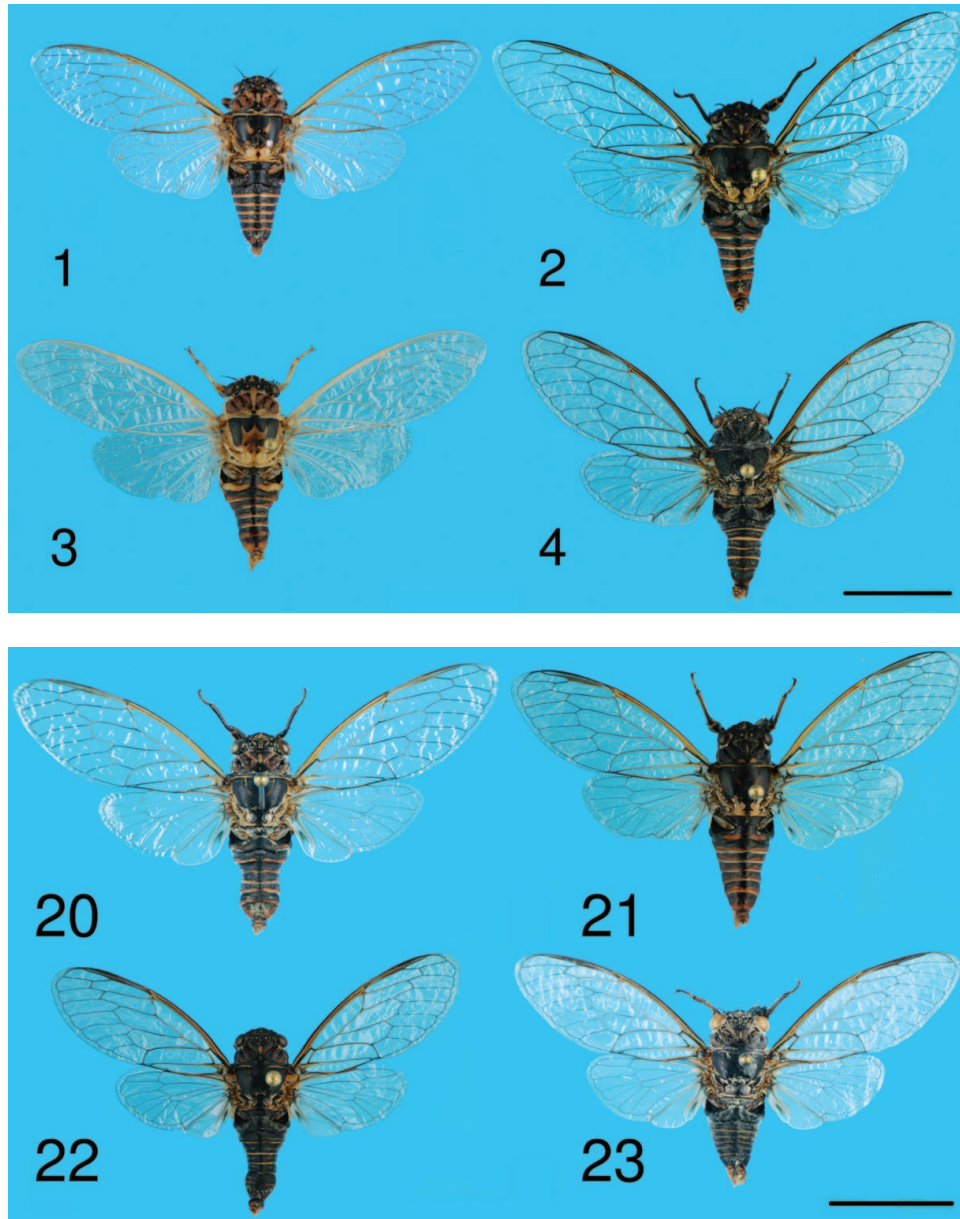
All results are given as mean $\pm$ standard deviation (minimum–maximum, *n* = sample size). The number of males recorded is specified for each species.

Results

Taxonomy of the genus *Tettigetta* Kolenati, 1857

Tettigetta Kolenati, 1857: 422–425. Type species, by subsequent designation (Boulard, 1980: 313):

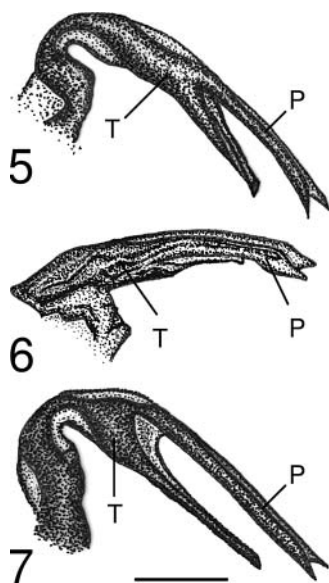
Cicada prasina Pallas, 1773. Boulard (1988a, 1998) and Boulard & Weiner (2001) provide a detailed discussion of



Figs 1–4. *Tettigettalna* gen. nov. Habitus: (1) *T. argentata*; (2, 3) *T. helianthemi* (Rambur, 1840) comb. nov.: dark and clear morphs; (4) *Tettigettalna helianthemi galantei* Puissant ssp. nov. Scale bar: 10 mm. **Figs 20–23.** *Tettigettalna* gen. nov. Habitus. (20) *Tettigettalna aneabi* (Boulard, 2000) comb. nov.; (21) *T. bouldardi* Puissant sp. nov.; (22) *T. armandi* Puissant sp. nov.; (23) *T. defauti* Puissant sp. nov. Scale bar: 10 mm.

the nomenclatural status of *Tettigetta* Kolenati, 1857, and explain why the type species of *Tettigetta* is considered to be *Cicada prasina* Pallas, 1776. Boulard (1980, 1981a) considered *Tettigetta* Amyot, 1847, to be a *nomen dubium* and that only Kolenati (1857) defined *Tettigetta* unambiguously when he designated *Cicada prasina* as the type. A summary of the nomenclatural issues regarding this genus are given in Appendix 1 (see supplementary material which is available on the Supplementary tab of the article's Informaworld page at <http://dx.doi.org/10.1080/14772000.2010.532832>).

Lee (2008) gave a detailed description of *Tettigetta* with accurate diagnostic characters noting, in particular, that the genital claspers are hooked anterolaterad. However, species from the extreme west Palaearctic hitherto placed in *Tettigetta* lack this diagnostic feature. In conjunction with other characters, we propose new genera for these taxa, described below. Species still placed in *Tettigetta* include *Tettigetta prasina* (Pallas, 1773), *T. isshikii* (Kato, 1926; see Lee, 2008); and *T. golestani* Gogala & Schedl, 2008. However, we were unable to check all species currently placed



Figs 5–7. Aedeagus: (5) *Tettigettalna helianthemii* comb. nov.; (6) *Tettigettula pygmaea* (Olivier, 1790) comb. nov.; (7) *Pseudotettigetta melanophrys leunani* (Boulard, 2000) comb. nov., stat. nov. Scale bar: 0.25 mm. T = theca, P = thecal pseudoparameres.

in *Tettigetta*, which needs to be re-assessed using the diagnostic characters of Lee (2008). Based on genital and wing morphology, *Cicadetta parvula* Fieber, 1876, placed in *Tettigetta* by Schedl (1999), should be placed in *Cicadivetta* Boulard, 1982, as *Cicadivetta parvula* (Fieber, 1876), comb. nov. Similarly, *Tettigetta carayoni* Boulard (1982) should be considered as *Cicadivetta carayoni* (Boulard, 1985), comb. nov.

***Tettigettalna* Puissant gen. nov.**
(Figs 1–5, 8–36)

DIAGNOSIS. (Figs 1–4, 5) Small-sized species (body length 14–21 mm); abdomen cylindrical, not keeled mid-dorsally; median length of sternite VIII as long as or slightly shorter than sternite VII; lateral part of pronotal collar slightly to well expanded, with a ‘tooth’ usually more or less developed, sometimes absent; lateral angle of pronotal collar ampliate; operculum roundish, more or less confluent with distal margin of tympanal cavity; veins M and CuA of forewing always fused at base; forewing with eight apical cells, hindwing with six apical cells; dorsal beak of pygofer slightly rounded or sharp; anal styles moderately developed; claspers elongate, not hooked, sometimes slightly curved; uncus small and flat; thecal pseudoparameres filiform with apical part sharp (Fig. 5).

TYPE SPECIES. *Cicada argentata* Olivier, 1790, here designated.

ETYMOLOGY. Association of *Tettigetta* with an arbitrary combination of letters. Gender feminine.

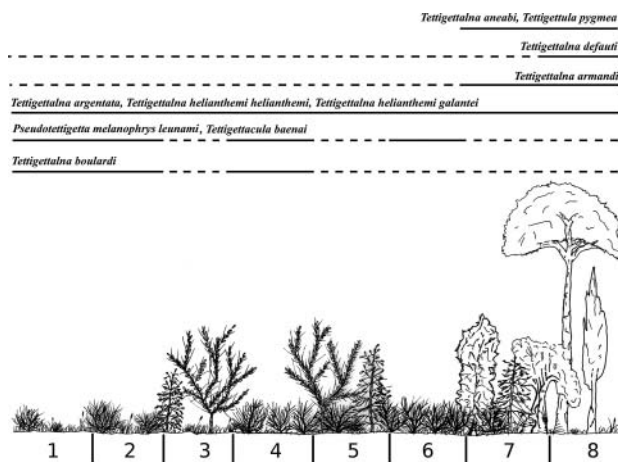


Fig. 8. Habitat occasionally (dotted line) or mainly (plain line) used by cicadas. Definitions of habitat classes refer to percentage of ligneous plants and vegetation height. 1: grassland (<20%, <0.5 m); 2: short moor (20–40%, <0.5 m); 3: high moor (20–40%, 0.5–2 m); 4: open short shrubland (40–60%, <0.5 m); 5: open high shrubland (40–60%, 0.5–2 m); 6: closed short shrubland (>60%, <0.5 m); 7: closed high shrubland (>60%, 0.5–2 m); 8: woodland (>40%, >2 m).

***Tettigettalna argentata* (Olivier, 1790) comb. nov.**
(Figs 1, 8–11)

Cicada argentata Olivier, 1790: 759. Holotype ♂, France: around ‘Brive’ in the ‘Bas-Limousin’ (Pierre-André Latreille) [not examined, probably lost or destroyed].

According to Michel Boulard (pers. comm.) the holotype is not in the MNHN, and is considered lost. Boulard (2000b) designated a neotype from Montagnac, Hérault, France (Puissant, 2006). However, Boulard (2000b) does not satisfy the publication criteria of Article 8.1.1 (ICZN, 1999), and cannot be considered a published work within the meaning of the Code. Moreover, Boulard’s work does not contain any evidence that the neotype came as nearly as practicable from the original type locality (Article 75.3.6), and we consider the neotype to be incorrectly designated. A primary type is not required, as the taxonomic status and original type locality are currently unambiguous.

MORPHOLOGY. (Fig. 1) Lateral part of pronotal collar slightly to well expanded with a ‘tooth’ absent or present, sometimes well developed in a ‘shark-tooth’ shape. Aedeagus similar to *T. helianthemii helianthemii* (Fig. 5). Size for 23 males: FL = 18.79 ± 1.04 (16.5–20.5), FW = 7.49 ± 0.41 (6.6–8.1), YW = 1.16 ± 0.06 (1.02–1.28), VW = 2.56 ± 0.15 (2.21–2.97). For additional measurements see Boulard & Mondon (1996: 67, as *Tettigetta argentata*).

HABITAT. (Fig. 8) In grassland, scrub, garrigue and open wood. Habitat classes: 1–8 (Puissant, 2006). Vegetation classes: mainly in SH3 but also found SA2-3, SH2, SX3, SX4, Cc, Cb and BM.

DISTRIBUTION. France (Olivier, 1790; Boulard, 1995; Puissant, 2006), widely distributed in Spain except the extreme South-East (Gomez-Menor Ortega, 1957; Nast, 1972, 1987; S.P. unpublished data), Portugal (Quartau *et al.*, 1999; Sueur *et al.*, 2004), Switzerland (Hertach, 2008), Italy (Servadei, 1967; Schedl, 2000; Hertach, 2008) and Slovenia (Gogala & Gogala, 1999).

ACOUSTIC BEHAVIOUR. (Figs 9–11) The calling song is made by the repetition of short echemes. The signal has been repeatedly described (Boulard, 1995; Quartau *et al.*, 1999; Fonseca & Allen Revez, 2002; Gogala, 2002; Sueur *et al.*, 2004; Fonseca *et al.*, 2008; Hertach, 2008). No alarm call reported.

***Tettigettalna helianthemi* (Rambur, 1840) comb. nov.**

Cicada helianthemi Rambur, 1840: 203. Lectotype ♂, Spain: 'Granada' (Fig. 12) (Webb, 1979) in Rambur's Hemiptera collection, British Museum (Natural History) [examined].

***Tettigettalna helianthemi helianthemi* (Rambur, 1840)
(Figs 2, 3, 8, 12–16)**

[*Cicadatra atra* (Olivier): Servadei (1967) (in part), Nast (1972) (in part). Misidentifications.]

[*Cicadatra concinna* (Germar): Schumacher (1922a, 1922b) (in part). Misidentifications.]

[*Tettigetta argentata* (Olivier): Puton (1874) in part; Gomez-Menor Ortega (1957) in part; Webb (1979) in part; Duffels & van der Laan (1985) in part; Nast (1987) in part; Puissant (2006) in part, *non* Olivier (1790). Misidentifications.]

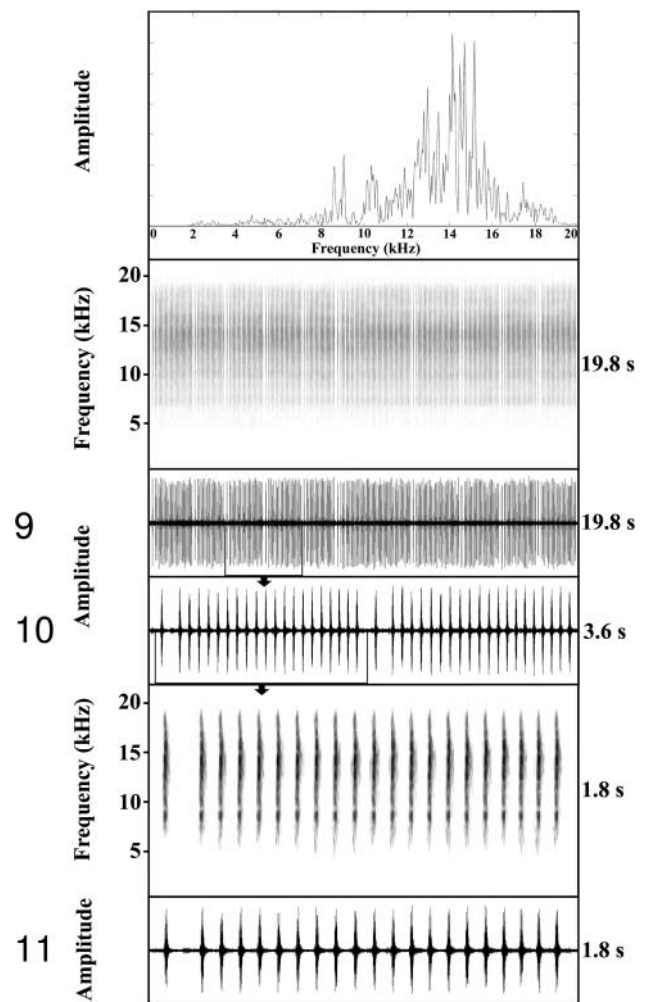
Tettigetta argentata? Fieber (1872, 1876); Distant (1906).

Tettigetta manuely Boulard, 2000a: 137. Holotype ♂, Spain: Granada, Baza, Barranco del Espartal.

Deposited in the Muséum national d'Histoire naturelle (MNHN, Paris, France) [examined] syn. nov.

T. helianthemi is highly variable in colouration (Figs 2, 3). However, this is the only cicada inhabiting Granada province that sometimes has yellowish fasciae on the pronotum, and these can be seen in the lectotype (Fig. 12). All other closely related taxa from this geographical area (Granada and Almeria) (Fig. 13) are darker and lack yellowish pronotal fasciae. *Tettigetta manuely*, described by Boulard (2000a: 137) from the same area, has similar pronotal fasciae, and is placed here as a junior synonym. The aedeagus illustrated by Kartal (1999: 102) as '*Cicadetta helianthemi*' represents *Pseudotettigetta melanophrys leunami* (Boulard, 2000), comb.nov., stat. nov. (see *Pseudotettigetta* Puissant, below).

MORPHOLOGY. (Figs 2, 3, 5, 12) See also Boulard (2000a: 137, as *Tettigetta manuely*). Very similar to *T. argentata*, highly variable in colouration, and difficult to identify with confidence without a description of the calling song (see Acoustic behaviour below). Lateral part of



Figs 9–11. *Tettigettalna argentata* comb. nov. Calling song. (9) mean frequency spectrum, spectrogram and oscillogram (from top to bottom) of ten sequences; (10) detailed oscillogram of two sequences; (11) detailed spectrogram and oscillogram of a single sequence. Saint-Antonin-Noble-Val, Tarn-et-Garonne (82), France, 27°C.

pronotal collar well expanded with a 'tooth' always present but variably developed. Aedeagus very similar to *T. argentata*: thecal pseudoparameres originating closer to theca than its base, much longer than theca (Fig. 5). Size for ten males: FL = 18.95 ± 0.50 (18.0–19.6), FW = 7.38 ± 0.33 (6.7–7.7), YW = 1.25 ± 0.18 (1.03–1.70), VW = 2.49 ± 0.07 (2.41–2.64). Additional measurements can be found in Boulard (2000a: 139).

HABITAT. (Fig. 8) Habitat classes similar to *T. argentata*. Vegetation classes inhabited: A2-3 and SA2-3, i.e. in the driest Mediterranean habitats.

DISTRIBUTION. (Fig. 13) South of Spain, in Andalusia and Murcia.

ACOUSTIC BEHAVIOUR. (Figs 14–16) Calling males are static. During sound production the abdomen is raised and the wings are slightly lifted above the body. The calling



Fig. 12. *Tettigettalna helianthemii helianthemii* (Rambur, 1840) comb. nov. Dorsal and ventral view of lectotype. Image by Michael Webb, Natural History Museum, London.

songs of five males were analysed at 27–29°C. The calling song is made of a single phrase with two types of echemes. The phrase starts with the repetition of 4.22 ± 1.31 (1–7, $n = 50$) short echemes and finishes with a long one. The latter was omitted in 4% and repeated in 2% of the 50 recorded phrases. The short echeme has a duration of 0.09 ± 0.02 s (0.04–0.19, $n = 214$) and is composed of 20.39 ± 4.43 groups of pulses (12–44, $n = 204$). The long terminal echeme has a duration of 0.43 ± 0.08 s (0.31–0.56, $n = 49$)

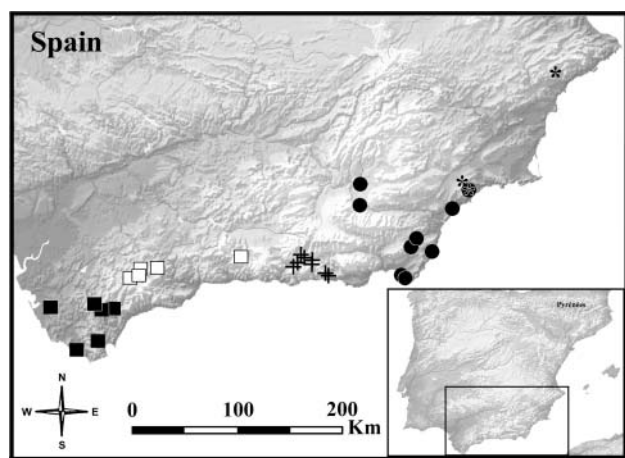
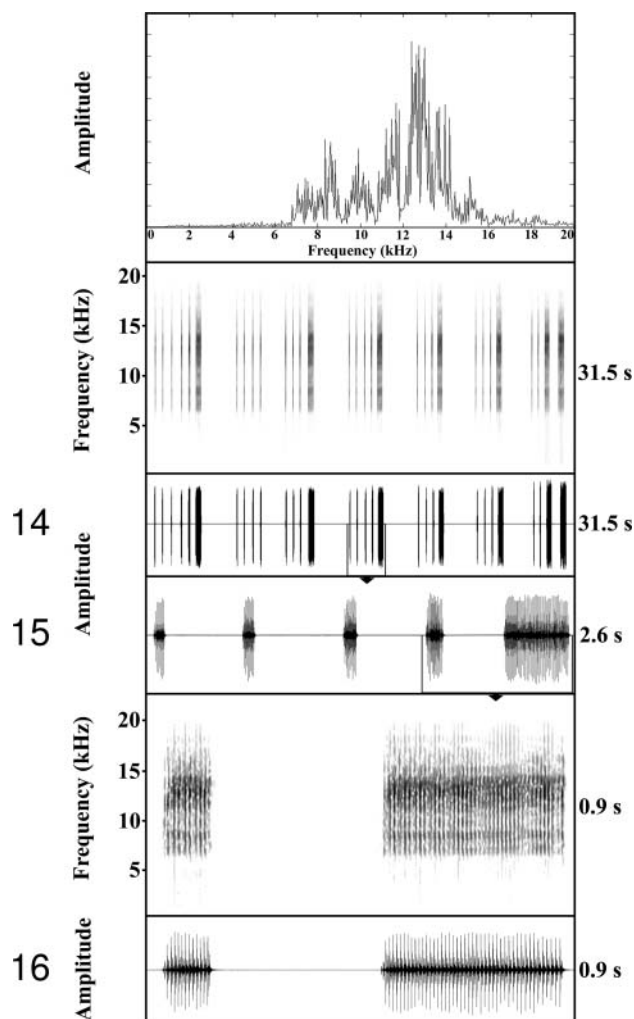


Fig. 13. *Tettigettalna* gen. nov. Distribution in Spain. Black square: *Tettigettalna armandi* Puissant sp. nov.; white square: *T. defauti* Puissant sp. nov.; black cross: *T. helianthemii galantei* Puissant ssp. nov.; black circle: *T. helianthemii helianthemii* comb. nov.; black star: *T. bouldardi* Puissant sp. nov.



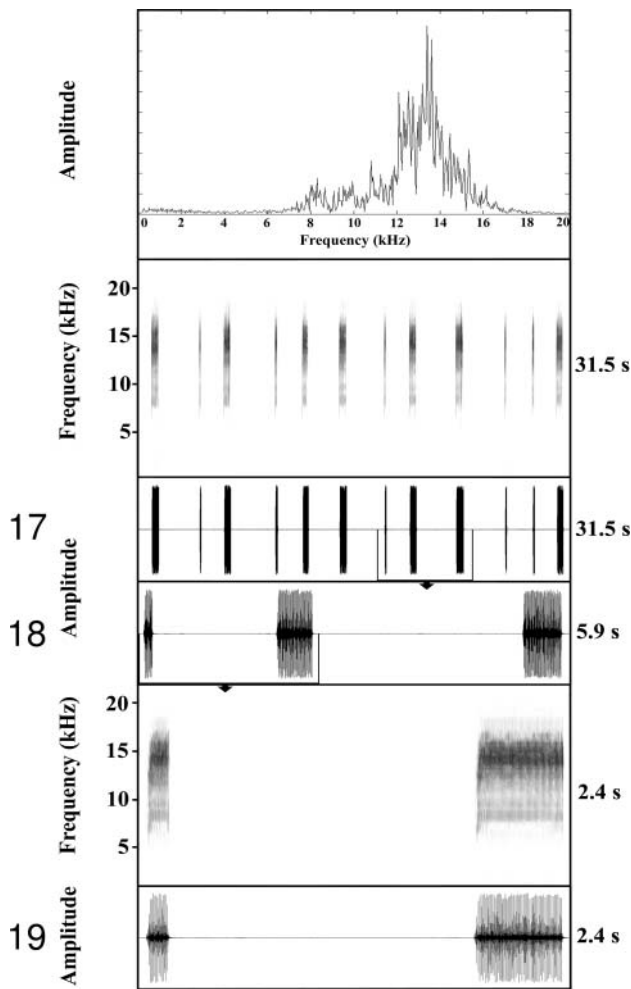
Figs 14–16. *Tettigettalna helianthemii helianthemii* (Rambur, 1840) comb. nov. Calling song. (14) mean frequency spectrum, spectrogram and oscillogram (from top to bottom) of seven sequences; (15) detailed oscillogram of one sequence with four short echemes and one long terminal echeme; (16) detailed spectrogram and oscillogram of one short echeme and one long terminal echeme. Close to Caniles, Baza, Spain, 28°C.

and is composed of 96.21 ± 9.87 groups of pulses (74–114, $n = 47$). The silence duration between the echemes is 0.48 ± 0.11 s (0.22–1.00, $n = 203$). In the frequency domain, there is no stable resonant frequency. The frequency spectral band is large, starting at 6 kHz and reaching the limit of our recording equipment (18 kHz). The dominant frequency is at 12.37 ± 0.88 kHz (9.99–14.00, $n = 254$). No alarm call.

Tettigettalna helianthemii galantei Puissant ssp. nov.
(Figs 4, 8, 13, 17–19)

[*Tettigettalna argentata*: Rosenhauer (1856), non Olivier (1790). Misidentification.]

Rosenhauer (1856: 405) reported that specimens collected in the Sierra Nevada (Andalusia) have a lateral part of the pronotal collar large and well developed in a ‘shark-tooth’



Figs 17–19. *Tettigetta helianthemii galantei* Puissant ssp. nov. Calling song. (17) mean frequency spectrum, spectrogram and oscillogram (from top to bottom) of five sequences; (18) detailed oscillogram of one sequence with one short echeme and two long terminal echemes; (19) detailed spectrogram and oscillogram of one short echeme and one long terminal echeme. Close to Berchules, Granada, Spain, 27–28°C.

shape. This new subspecies is thus morphologically distinct and geographically separate.

MORPHOLOGY. (Fig. 4) Very similar to nominate *T. h. helianthemii* but never with yellowish fasciae on pronotum. Pronotum blackish, sometimes slightly brownish. Scutum blackish. Lateral part of pronotal collar always large and well developed, in a ‘shark-tooth’ shape. Forewing very large. Aedeagus as in the nominate subspecies (Fig. 5). Size for 5 males: FL = 19.76 ± 1.30 (18.0–21.4), FW = 8.04 ± 0.64 (7.2–8.9), YW = 1.22 ± 0.11 (1.07–1.38), VW = 2.65 ± 0.21 (2.38–2.90), BL = 17.32 ± 1.09 (15.4–18.0), PL = 2.57 ± 0.21 (2.24–2.76), PW = 6.02 ± 0.62 (5.05–6.60).

HABITAT. (Fig. 8) Habitat classes as *T. argentata*. Vegetation classes inhabited: SH2, SH3, SX3 and SX4 but it is in the SH2 class that this cicada is most common.

DISTRIBUTION. (Fig. 13) Southern part of the Sierra Nevada, Andalusia, Spain.

ACOUSTIC BEHAVIOUR. (Figs 17–19) Same behaviour as *T. h. helianthemii*, but with a different calling song. The calling song of three males was recorded at 27–28°C. The structure is similar but the repetition rate of the short echeme is lower with a mean value of 1.73 ± 1.44 (1–9, $n = 48$) and the silence between the echemes is longer with a mean value of 1.52 ± 0.52 s (0.2–2.87, $n = 203$). The calling rhythm and tempo seem to be slower as the number of short and long echemes per calling song is similar. Echeme durations are similar, 0.13 ± 0.02 s (0.1–0.19, $n = 84$) for the short echeme and 0.43 ± 0.09 s (0.23–0.6, $n = 70$) for the long echeme. The number of groups of pulses is also similar, 29.20 ± 4.87 groups (22–44, $n = 83$) for the short echeme, and 98.97 ± 19.34 groups (58–114, $n = 47$) for the long echeme. The dominant frequency is higher, with a mean value at 13.58 ± 0.5 kHz (12.14–14.64, $n = 131$). No alarm call.

MATERIAL EXAMINED. 4♂

Holotype ♂, Spain: ‘Bérchules (Lanjarón), Prov. de Granada’ [label rectangular, white, with black margin, manuscript], ‘7-VI-2003, Espagne, S. Puissant leg.’ [label rectangular, white, with black margin, manuscript] and ‘Holotype ♂, *Tettigetta helianthemii galantei* ssp. nov, S. Puissant [label rectangular, red, manuscript and printed]. MNHN, Paris.

Paratypes (3♂). 1♂, data as holotype. 1♂, ‘Orgiva, (vers Lanjarón), Prov. de Granada’, ‘8-VI-2003, Espagne, S. Puissant leg.’, ‘Paratype ♂, *Tettigetta helianthemii galantei* ssp. nov, S. Puissant’. 1♂, ‘Espagne, Granada, Sierra Nevada, 2300 m, Rte de Capileira-Veleta, 30-VII-1991, D. Morin leg.’, ‘Paratype ♂, *Tettigetta helianthemii galantei* ssp. nov, S. Puissant’. All in MNHN, Paris.

ETYMOLOGY. Named in honour of Eduardo Galante, Professor at the University of Alicante.

***Tettigetta aneabi* (Boulard, 2000) comb. nov.**
(Figs 8, 20, 24–27)

Tettigetta aneabi Boulard, 2000a: 135. Holotype ♂, Spain: Córdoba, Las Lagunillas, Puerto Mahina. Deposited in the Muséum national d’Histoire naturelle (MNHN, Paris, France) [examined].
Tettigetta aneabi Boulard, 2000a: 140, 142. Lapsus calami.

Following Boulard (2000a), this species is similar to *Tettigetta argentata* (Olivier, 1790), but slightly larger and without marks in 3rd anal cell (or jugum). No biological data were reported by Boulard (2000a).

MORPHOLOGY. (Fig. 20) See Boulard (2000a: 135). Very close to *Tettigetta argentata* and difficult to identify without the calling song (see Acoustic behaviour section). Aedeagus as in *T. helianthemii* (Fig. 5). Size for 2 males: FL = 17.75 ± 0.21 (17.6–17.9), FW = 6.75 ± 0.21 (6.6–6.9), YW = 1.09 ± 0.08 (1.03–1.15), VW = $2.42 \pm$

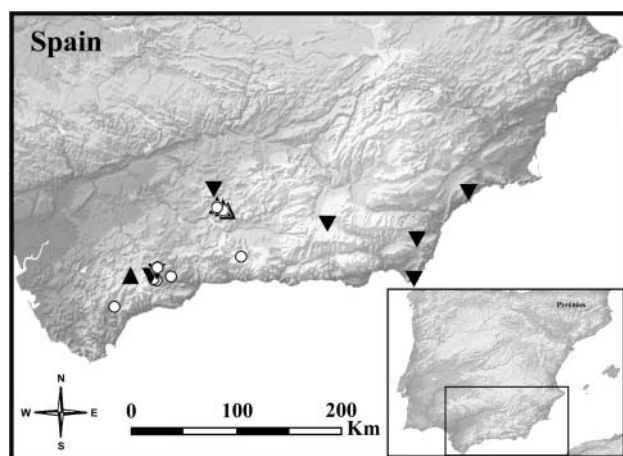


Fig. 24. *Tettigettalna* Puissant gen. nov., *Pseudotettigetta* Puissant gen. nov. and *Tettigettacula* Puissant gen. nov. Distribution in Spain. Black triangle: *Tettigettalna aneabi* (Boulard, 2000) comb. nov.; reversed black triangle: *Pseudotettigetta melanophrys leunami* (Boulard, 2000) comb. nov., stat. nov.; white circle: *Tettigettacula baenai* Puissant sp. nov.

0.06 (2.38–2.47). Additional measurements can be found in Boulard (2000a: 137).

HABITAT. (Fig. 8) Mainly in open wood. Habitat classes: 7–8. Vegetation classes inhabited: SH3, i.e. in the least warm Mediterranean class.

DISTRIBUTION. (Fig. 24) South of Spain, in Andalusia.

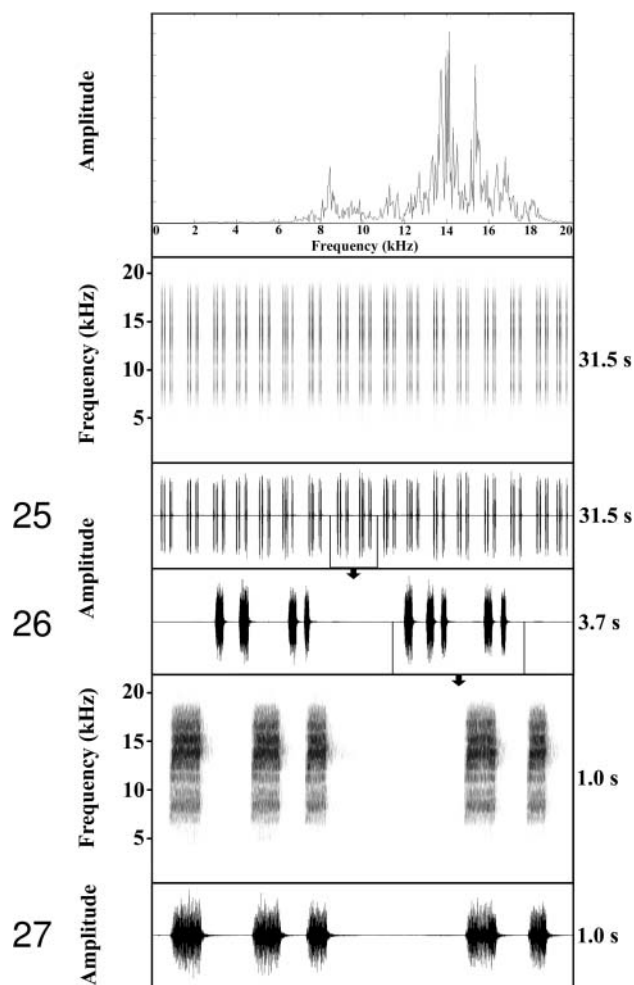
ACOUSTIC BEHAVIOUR. (Figs 25–27) Males do not adopt any particular calling posture. The calling songs of four males were recorded at 25°C. The song has two rapid phrases with echemes of similar structure. The first phrase includes 2.25 ± 0.49 echemes (1–3, $n = 111$) and the second phrase includes 1.50 ± 0.50 echemes (1–2, $n = 108$). Echeme duration is 0.09 ± 0.02 s (0.05–0.17, $n = 238$). Silence duration within phrases is 0.10 ± 0.03 s (0.04–0.17, $n = 152$) and the silence duration between phrases is 0.38 ± 0.05 s (0.30–0.50, $n = 105$). The frequency spectral band is large, starting at 6 kHz and reaching the limit of our recording equipment (18 kHz). The dominant frequency is at 14.13 ± 0.94 kHz (12.49–16.06, $n = 166$). No alarm call.

***Tettigettalna bouldardi* Puissant sp. nov.**

(Figs 8, 13, 21, 28–30)

Similar to *T. armandi* sp. nov. (below), but distinct calling song.

MORPHOLOGY. (Fig. 21) Head: slightly broader than mesonotum; black except epicranial suture, base of median postclypeal fissure, and lateral margins of postclypeus, which are yellowish. Anteclypeus blackish except median part more or less widely yellowish. Rostrum with labrum and mentum brownish or yellowish, labium brownish with its apical part black. Apex of rostrum reaching middle of mid trochanter. Gena and lorum black with dense, long silvery hairs. Prominent brownish compound eyes, wider than long. Ocelli reddish, distance between lateral ocelli shorter



Figs 25–27. *Tettigettalna aneabi* (Boulard, 2000) comb. nov. Calling song. (25) mean frequency spectrum, spectrogram and oscillogram (from top to bottom) of 16 sequences; (26) detailed oscillogram of two sequences; (27) detailed spectrogram and oscillogram of one sequence including a first phrase with three echemes and a second phrase with two echemes. Between Algarinejo and Las Lagunillas, Granada, Spain, 25°C.

or equal to distance between each lateral ocellus and nearest eye. Antennae and supra-antennal plate black except anterior part of latter more or less widely brownish or yellowish; scape brownish.

Thorax: pronotum blackish to brownish with an interrupted yellowish median line, lateral angle of pronotal collar and pronotal collar black except the basal border more or less yellowish, lateral part of pronotal collar slightly expanded with a little 'tooth' absent or present. Mesonotum black, scutum with pair of brownish fasciae of elongated triangular shape, lateral and submedian sigilla black. Metanotum yellowish except median part black, cruciform elevation with posterior and anterior branches yellowish except median part black, mesonotal scutellar cords yellowish, wing groove brownish. Opercula separated, yellowish,

well developed, more or less confluent with distal margin of tympanal cavity.

Wings: forewing hyaline with eight apical cells. Veins brownish. Median and cubital anterior vein meeting basal cell with their stems completely fused. Hindwing with six apical cells. Venation brownish, ambient vein brownish, vannus hyaline, plaga and anterior margin of jugum talc-like.

Legs: yellowish-brown and black. Forelegs with coxa yellowish with longitudinal bands brownish; trochanter yellowish with brownish fasciae medially; femur with anterior side blackish and yellowish longitudinal band more or less expanded, posterior side yellowish with a brownish longitudinal band more or less expanded; three black spines, sometimes a little fourth accessory spine, the primary spine strong and oblique, isolated from the other two, secondary sharp and oblique, apical spine short and triangular; tibia brownish; tarsus brownish with pretarsal claw blackish. Midlegs brownish except the femur anterior side blackish and median longitudinal part of coxa blackish; trochanter yellow with a small black spot; tibia yellowish to brownish; tarsus yellowish with claw blackish. Hindlegs similar to midlegs or lighter in colour.

Abdomen: tergites black with posterior margins ochraceous, black auditory capsules sub-circular, convex. Tymbal bearing a series of three long ribs, alternating with two or three very short ribs, the three long ribs connected by a dorsal bar and running dorsoventrally to the tymbal plate. Sternites orange.

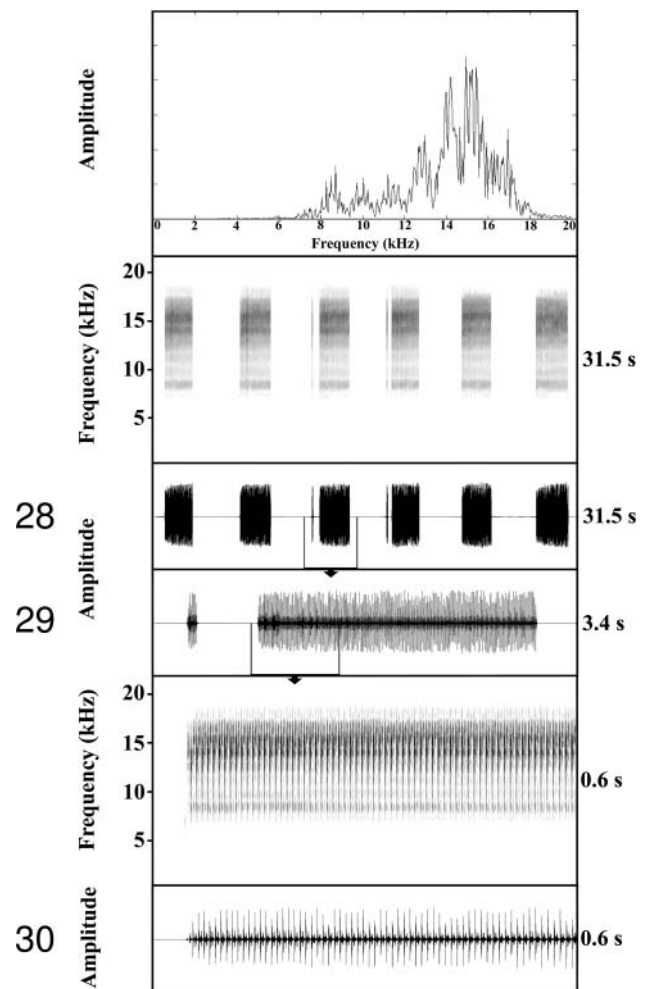
Genitalia: pygofer basal lobe moderately developed, tending to be rounded in lateral view; upper lobe moderately developed, distant from dorsal beak; dorsal beak sharp. Uncus small and flat, not dominant; clasper closely aligned, small to medium size. Aedeagus as in *T. helianthemis helianthemis* (Fig. 5) but smaller, thecal pseudoparameres originating closer to theca than its base, much longer than theca.

Size for 3 males: FL = 16.97 ± 0.50 (16.5–17.5), FW = 6.73 ± 0.15 (6.6–6.9), YW = 1.06 ± 0.03 (1.04–1.09), YW = 2.21 ± 0.03 (2.18–2.24), BL = 15.87 ± 0.32 (15.5–16.1), PL = 2.13 ± 0.08 (2.07–2.22), PW = 4.60 ± 0.17 (4.50–4.80).

HABITAT. (Fig. 8) Mainly in low vegetation mixed with small bushes and herbaceous plants, sometimes on trees. Habitat classes: 1–8. Vegetation classes inhabited: A2–3 and SA2–3, i.e. in the driest Mediterranean domains.

DISTRIBUTION. (Fig. 13) South-east of Spain, in Murcia and Valencia.

ACOUSTIC BEHAVIOUR. (Figs 28–30) Similar to *T. helianthemis helianthemis* but short echemes are rarely emitted and the duration of long echemes is particularly long. Males are static singers. They raise their abdomen and lift up their wings when calling. The calling songs of four males were recorded at 34°C. The calling song has a single sequence with two types of echeme. The first type is short,



Figs 28–30. *Tettigettalna boulandi* Puissant sp. nov. Calling song. (28) mean frequency spectrum, spectrogram and oscillogram (from top to bottom) of 6 sequences; (29) detailed oscillogram of one sequence with a short and a long echeme; (30) detailed spectrogram and oscillogram of the beginning of a long echeme. Campico de los Lopez, Murcia, Spain, 34°C.

lasting 0.20 ± 0.11 s (0.08–0.46, $n = 14$). In 21.6% of the phrases recorded, it immediately precedes a second, longer echeme lasting 2.17 ± 0.30 s (1.3–2.78, $n = 53$). In these cases it can be repeated up to three times 1.27 ± 0.65 (1–3, $n = 11$). The silence duration between successive phrases is 3.27 ± 0.68 s (2.17–5.12, $n = 48$). Short echemes have 45.86 ± 26.39 groups of pulses (20–106, $n = 14$) and long echemes 471.58 ± 63.81 groups of pulses (288–588, $n = 53$). The frequency spectral band starts at 7 kHz and reaches the limit of our recording equipment (18 kHz). The dominant frequency is at 14.92 ± 0.48 kHz (14.04–15.59, $n = 109$). No alarm call.

MATERIAL EXAMINED. 2 ♂

Holotype ♂, Spain: 'Campico de los Lopez, Prov. De Murcia' [Label rectangular, white, with black margins, manuscript], '26-VI-2004, Spain, S. Puissant leg.' [Label

rectangular, white, with black margins, manuscript] and 'Holotype ♂, *Tettigettalna bouldardi* n.sp., S. Puissant' [label rectangular, red, manuscript and printed]. MNHN, Paris. Paratype. 1 ♂, data as holotype, labelled accordingly. MNHN, Paris.

ETYMOLOGY. Named in honour of Michel Boulard, world expert on the Cicadidae.

***Tettigettalna armandi* Puissant sp. nov.**

(Figs 8, 13, 22, 31–33)

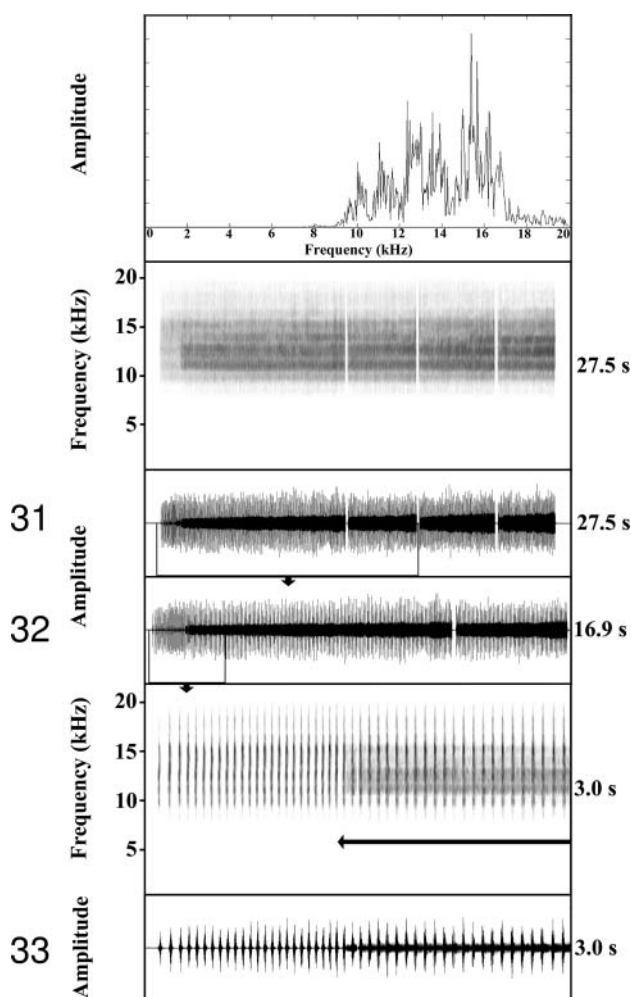
Similar to *T. bouldardi* sp. nov. (above) but with distinct calling song.

MORPHOLOGY. (Fig. 22) Very similar in size and colour to *T. bouldardi* except lateral part of pronotal collar is always expanded with a 'tooth', and the dorsal beak of the pygofer sometimes has the apex slightly rounded. Aedeagus as in *T. helianthemis helianthemis* (Fig. 5). This species is difficult to identify without the calling song (see Acoustic behaviour section). Size for 5 males: FL = 16.62 ± 0.54 (16.0–17.3), FW = 6.68 ± 0.13 (6.5–6.8), YW = 1.09 ± 0.05 (1.01–1.15), VW = 2.31 ± 0.10 (2.14–2.41), BL = 15.92 ± 0.28 (15.5–16.2), PL = 2.31 ± 0.14 (2.12–2.46), PW = 4.88 ± 0.28 (4.45–5.20).

HABITAT. (Fig. 8) Mainly in open wood and high shrub land, sometimes in low vegetation mixed with small bushes and herbaceous plants. Habitat classes: 1–8. Vegetation classes: SA2–3, SH2, SH3 more common in SH2 class.

DISTRIBUTION. (Fig. 13) South of Spain, in the vicinity of the Gibraltar Strait in Andalusia.

ACOUSTIC BEHAVIOUR. (Figs 31–33) Males raise their abdomen and lift up their wings when calling. They are mobile and seem to maintain a distance between them of at least 20 m. The calling songs of four males were recorded at 30°C. The song involves repetition of sequences with two types of echemes. The first echeme type, which introduces the phrase, lasts 12.95 ± 3.43 s (9.31–18.65, $n = 6$). It starts with a train of 29 ± 10.70 (20–50, $n = 6$) of separated groups of pulses produced at high amplitude. There is then a second sound component with a continuous low-amplitude structure that is added to the train of isolated groups of pulses. This generates a two-sound effect with 106.14 ± 54.23 groups of pulses (42–200, $n = 7$). The second echeme type only differs from the first by the omission of the starting part, having the groups of pulses only, the two-sound effect being continuously produced. The second type echeme is repeated 2.33 ± 0.82 times (1–3, $n = 6$) until the end of the phrase. It is shorter in duration lasting 4.16 ± 0.92 s (3.05–5.62, $n = 13$) and is made of 54.85 ± 11.42 groups of pulses (41–69, $n = 13$). The silence duration between the echemes lasts 0.16 ± 0.02 s (0.13–0.18, $n = 14$). In the frequency domain, most of the energy is produced by the high amplitude groups of pulses with a dominant frequency of 15.41 ± 1.05 kHz (12.83–17.23, $n = 153$). The frequency spectral band starts at 8 kHz and reaches the limit of our recording equipment (18 kHz). The low amplitude sound



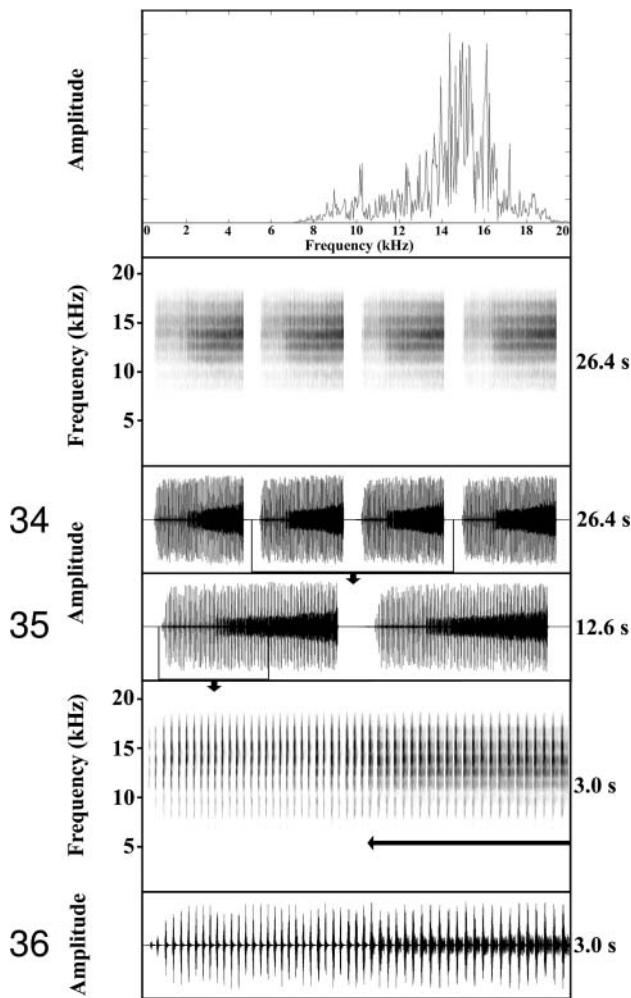
Figs 31–33. *Tettigettalna armandi* Puissant sp. nov. Calling song. (31) mean frequency spectrum, spectrogram and oscillogram (from top to bottom) of two sequences alternating two types of echemes; (32) detailed oscillogram of one phrase including the two types of echemes; (33) detailed spectrogram and oscillogram of the beginning of the first echeme illustrating the 'two-sound' effect (horizontal arrow). West of Punta Paloma, Tarifa, Spain, 30°C.

generates a second frequency band between 12 kHz and 14 kHz. No alarm call.

MATERIAL EXAMINED. 2 ♂

Holotype. ♂, Spain: 'Los Barrios (Algeciras), Prov. de Cadix' [label rectangular, white, with black margin, manuscript], '10-VI-2003, Espagne, S. Puissant leg' [label rectangular, white, with black margin, manuscript] and 'Holotype ♂, *Tettigettalna armandi* n. sp., S. Puissant' [label rectangular, red, manuscript and printed]. MNHN, Paris. Paratype. 1 ♂, Spain: 'Tarifa (Algeciras), A l'ouest de la Punta Paloma', '10-VI-2003, Espagne, S. Puissant leg.', 'Paratype ♂, *Tettigettalna armandi* n. sp., S. Puissant'. MNHN, Paris.

ETYMOLOGY. Named in memory of Armand Puissant, father of one of the authors.



Figs 34–36. *Tettigettalna defauti* Puissant sp. nov. Calling song. (34) mean frequency spectrum, spectrogram and oscillogram (from top to bottom) of four sequences; (35) detailed oscillogram of two types of sequences; (36) detailed spectrogram and oscillogram of the beginning of one sequence illustrating the 'two-sound' effect (horizontal arrow). Puerto del Viento, Ronda, Spain, 30°C.

***Tettigettalna defauti* Puissant sp. nov.**

(Figs 8, 13, 23, 34–36)

Very similar in size and colour to *T. armandi* Puissant sp. nov., but with distinct calling song.

MORPHOLOGY. (Fig. 23) Close in size and colour to *T. armandi* except: scutum always completely black; lateral part of pronotal collar expanded with a 'tooth' absent or present; dorsal beak of pygofer sharp; claspers sometimes slightly curved. Aedeagus as in *T. helianthemis helianthemis* (Fig. 5). This is another species difficult to identify without the calling song (see Acoustic behaviour section). Size for 5 males: FL = 17.98 ± 1.29 (16.8–20.0), FW = 6.96 ± 0.62 (6.3–7.9), YW = 1.17 ± 0.06 (1.07–1.23), VW = 2.45 ± 0.14 (2.24–2.61), BL = 15.22 ± 1.45 (14.0–16.9), PL = 2.32 ± 0.06 (2.24–2.39), PW = 5.01 ± 0.34 (4.65–5.50).

HABITAT. (Fig. 8) Mainly in open woodland, sometimes in low vegetation mixed with small bushes and herbaceous plants. Habitat classes: 1–8. Vegetation classes inhabited: SH3, i.e. in the least warm Mediterranean domain.

DISTRIBUTION. (Fig. 13) South of Spain, in Andalusia.

ACOUSTIC BEHAVIOUR. (Figs 34–36) Males are static singers without particular calling posture. The calling songs of seven males were recorded at 25–27°C. Similar to *T. armandi* but with a single type of echeme lasting 3.92 ± 1.45 s (1.87–10.34, $n = 112$) and separated by silent pauses of 1.77 ± 0.49 s (0.22–3.1, $n = 105$). The echeme starts with a train of 47.56 ± 18.44 (5–95, $n = 102$) separate groups of pulses produced at high amplitude. There is then a second sound component with a continuous low-amplitude structure that is added to the train of isolated groups of pulses. This generates a two-sound effect with 33.71 ± 14.93 (12–67, $n = 59$) groups of pulses repeated at a rate of 15.20 ± 1.80 per second (12–18, $n = 75$). In the frequency domain, most of the energy is produced by the high amplitude groups of pulses with a dominant frequency of 14.10 ± 0.91 kHz (11.80–16.19, $n = 237$). The frequency spectral band starts at 8 kHz and reaches the limit of our recording equipment (18 kHz). The low amplitude sound generates a second frequency band between 11 kHz and 16 kHz. No alarm call.

MATERIAL EXAMINED. 5♂, 1♀

Holotype. ♂, Spain: 'Puerto del Viento, Prov. de Malaga, Alt. ≈ 1200 m' [label rectangular, white, with black margin, manuscript], '22-VI-2004, Spain, S. Puissant leg.' [label rectangular, white, with black margin, manuscript] and 'Holotype ♂, *Tettigettalna defauti* n. sp., S. Puissant' [label rectangular, red, manuscript and printed]. MNHN, Paris.

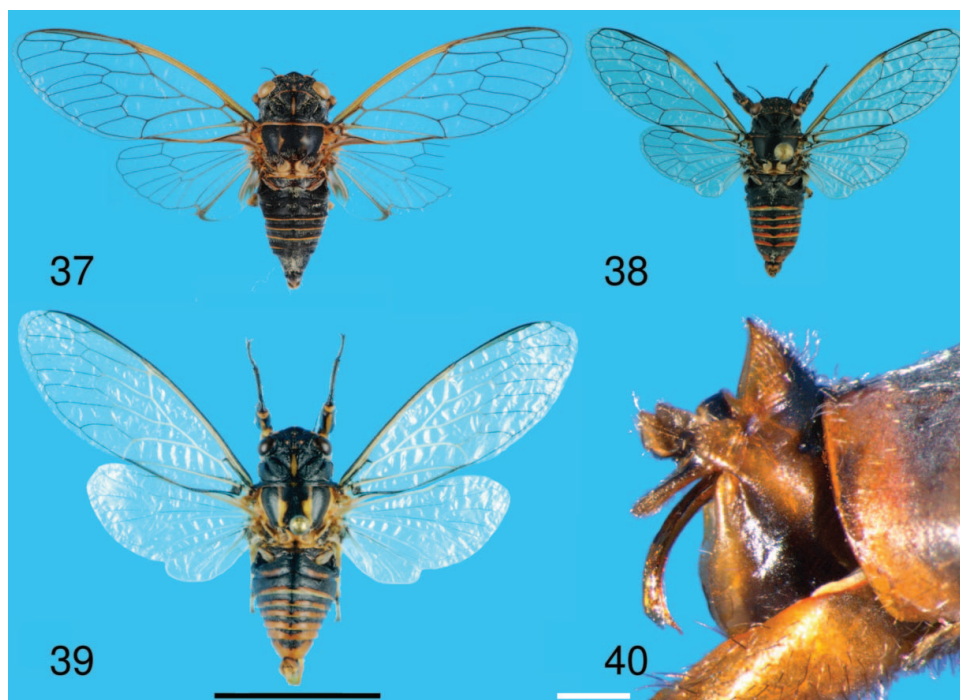
Paratypes. (4♂, 1♀). 1♂, data as holotype. 3♂, 'Vantas de Zafarraya, Prov. de Grenade', '6-VI-2003, Espagne, S. Puissant leg.', 'Paratype ♂, *Tettigettalna defauti* n. sp., S. Puissant'. 1♀, 'Pto. del Viento, Ronda (MA), 11-VII-84, J.M. Vela leg.', '*Tettigetta atra* (G.M.), Michel Boulard det. 1991', 'Paratype ♀, *Tettigettalna defauti* n. sp., S. Puissant'. All MNHN, Paris.

ETYMOLOGY. Named in honour of Bernard Defaut, specialist on Orthoptera.

Other taxa assigned to the genus

Tettigettalna

Tettigettalna estrellae (Boulard, 1982) comb. nov., recorded in Portugal by Boulard (1982a), Quartau & Fonseca (1988) and Sueur *et al.* (2004); *Tettigettalna josei* (Boulard, 1982) comb. nov., recorded in Portugal by Boulard (1982a), Quartau & Fonseca (1988) and Sueur *et al.* (2004); *Tettigettalna mariae* (Quartau & Boulard, 1995) comb. nov., recorded in Portugal by Quartau & Boulard (1995) and Sueur *et al.* (2004).



Figs 37–40. *Tettigettula* Puissant gen. nov., *Tettigettacula* Puissant gen. nov., and *Pseudotettigetta* Puissant gen. nov. Habitus. (37) *Tettigettula pygmea* comb. nov. (specimen incorrectly designed neallotype by Boulard, 1981b); (38) *Tettigettacula baenai* Puissant sp. nov.; (39) *Pseudotettigetta melanophrys leunami* (Boulard, 2000) comb. nov., stat. nov.; (40) *Tettigettacula baenai* Puissant sp. nov., genitalia, right lateral view. Scale bars—Figs 37–39: 10 mm, Fig. 40, 0.5 mm.

***Tettigettula* Puissant gen. nov.**
(Figs 6, 8, 37, 41–43)

DIAGNOSIS. Small-sized species (body length 12–16 mm); abdomen cylindrical, not keeled mid-dorsally; median length of sternite VIII as long as sternite VII; lateral part of pronotal collar slightly expanded to expanded, without ‘tooth’; lateral angle of pronotal collar ampliate; operculum roundish, more or less confluent with distal margin of tympanal cavity; veins M and CuA of forewing always fused at base; forewing with eight apical cells; hindwing with six apical cells; dorsal beak of pygofer slightly rounded; anal styles moderately developed; claspers curved posterolaterad with their base straight, sometimes elongate and totally straight; uncus slightly elongate and flat; thecal pseudoparameres in lateral position of theca, dorsally fused almost to their apices, pseudoparameres with apical part flat (Fig. 6).

TYPE SPECIES. *Cicada pygmea* Olivier, 1790, here designated.

ETYMOLOGY. Small *Tettigetta* by addition of the Latin suffix *ula*. Gender feminine.

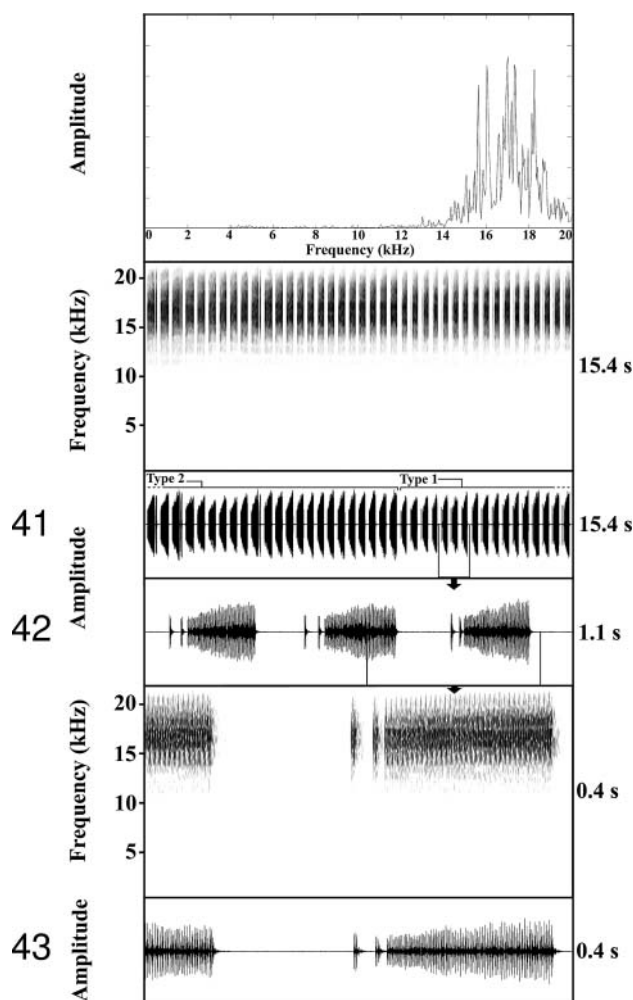
***Tettigettula pygmea* (Olivier, 1790) comb. nov.**

Cicada pygmea Olivier, 1790: 760. Type material, France: ‘Provence’ and ‘Languedoc’ [not examined, probably lost]. *Cicadetta brullei* Fieber, 1876: 99. Type material,

southern France, close to Montpellier; Italy close to Trieste and Corfou [not examined].

Neglected for many years (e.g. Distant, 1906, placed *Cicada pygmea* as ‘*Species incerti loci systematici*’), the taxonomic status of this species was fixed by Boulard (1973, 1974). However, the type designation needs to be clarified. Olivier (1790: 760) described *Cicada pygmea* from specimens collected in ‘Provence’ and ‘Languedoc’, in the south of France. As the specimens were not found in the MNHN they were considered to be lost by Boulard (1981b), who designated a neotype male. Unfortunately, Boulard (1981b) did not provide locality data, and thus his designation does not satisfy Article 75.3.6 (ICZN, 1999), requiring ‘evidence that the neotype came as nearly as practicable from the original type locality’. Furthermore, this designation does not satisfy Article 75.3.3 as the data and description do not permit recognition of the specimen designated. A primary type is not in fact required, as the taxonomic status and original type locality are currently unambiguous.

Fieber (1876) established a nominal species very similar to *T. pygmea* under the name *Cicadetta brullei*, but described it as having only five apical cells on the hindwings, whereas *T. pygmea* typically has six. It is highly probable that this wing pattern reported by Fieber (1876) is an exception. Popov *et al.* (1997) described in detail the calling song of *Tettigetta brullei* (Fieber, 1876). There are



Figs 41–43. *Tettigettula pygmea* comb. nov. Calling song. (41) mean frequency spectrum, spectrogram and oscillogram (from top to bottom) of 23 phrases of type 2 followed by 17 phrases of type 1; (42) detailed oscillogram of three phrases of type 2; (43) detailed spectrogram and oscillogram of the type 2 phrase. Castelnau-de-Montmiral, Tarn (81), France. 27°C.

no significant differences among the calling songs of *T. pygmea* from the south of France. In particular, all include two types of phrases (Figs 41–43). Thus *Tettigetia brullei* (Fieber, 1876) is accepted here as a junior subjective synonym of *T. pygmea*, as proposed by Boulard & Mondon (1996).

MORPHOLOGY. (Fig. 37) Lateral part of pronotal collar slightly expanded to expanded, without 'tooth'. Thecal pseudoparameres in lateral position of theca, dorsally fused almost to their apices, pseudoparameres with apical part flat (Fig. 6). Size of four males: FL = 15.2 ± 0.55 (14.5–15.8), FW = 5.92 ± 0.21 (5.7–6.1), YW = 1.09 ± 0.05 (1.02–1.14), VW = 2.10 ± 0.06 (2.05–2.18). Additional measurements can be found in Boulard & Mondon (1996: 67, as *Tettigetia pygmea*).

HABITAT. (Fig. 8) Habitat classes as *T. aneabi*. Vegetation classes inhabited: SH3, SX3, SX4, but this cicada is particularly common in the SH3 domain (see Puissant, 2006, for more details).

DISTRIBUTION. France (Olivier, 1790; Boulard, 1973, 1974, 1995; Puissant, 2006), Greece (Fieber, 1876; Nast, 1972), Italia (Fieber, 1876; Servadei, 1967), Istria (Schedl, 1986), Slovenia (Popov *et al.*, 1997; Gogala & Gogala, 1999); Austria (Schedl, 2004), Macedonia (Gogala *et al.*, 2005), Romania (Trilar *et al.*, 2006). *T. pygmea* is mentioned from Spain by Duffels & van der Laan (1985) and Nast (1972, 1987). However, this species has not been found in Spain and has probably been misidentified with *Tettigetacula baenai* (Boulard, 2000) comb. nov. (see below).

ACOUSTIC BEHAVIOUR. (Figs 41–43) Calling song already described by Boulard (1995), Popov *et al.* (1997) and Gogala (2002). Two types of phrases, as in Popov *et al.* (1997). The low frequency content at 7–10 kHz reported by Popov *et al.* (1997) and Gogala (2002) was never detected by us. These low frequencies could have been generated by using high-frequency recording equipment but a too low digitization sampling rate (aliasing effect). No alarm call.

***Tettigetacula* Puissant gen. nov.**
(Figs 8, 24, 38, 40, 44–48)

DIAGNOSIS. Very small species (body length 11–14 mm); abdomen cylindrical, sometimes slightly keeled mid-dorsally; median length of sternite VIII as long as sternite VII; lateral part of pronotal collar slightly expanded to expanded, without 'tooth'; lateral angle of pronotal collar ampliate; operculum roundish, more or less confluent with distal margin of tympanal cavity; veins M and CuA of forewing always fused at base; forewing with eight apical cells, hindwing with six apical cells; dorsal beak of pygofer slightly rounded; anal styles moderately developed; claspers short and straight, sometimes slightly curved; uncus small or slightly elongate, flat; thecal pseudoparameres entirely lateral of theca, very long and flat with apical part triangular, almost as long as theca (Fig. 40).

TYPE SPECIES. *Tettigetia baenai* Boulard, 2000.

ETYMOLOGY. Very small *Tettigetia* by addition of the Latin suffix *cula*. Gender feminine.

***Tettigetacula baenai* (Boulard, 2000) comb. nov.**

Tettigetia baenai Boulard, 2000a: 134. Holotype ♂, 2 paratypes ♂, Spain: Córdoba, Las Lagunillas, Puerto Mahina. Deposited in the Muséum national d'Histoire naturelle (MNHN, Paris, France) [examined]. ?*Tettigetia brullei*: Duffels & van der Laan (1985) in part; Nast (1972, 1987) in part; *non* Fieber (1876). Probable misidentifications.

?*Tettigetia pygmea*: Nast (1987) in part; *non* Olivier (1790). Probable misidentification.



Figs 44–45. *Tettigettacula baenai* comb. nov. (A) calling male head upwards; (B) female laying eggs in a plant, head downwards.

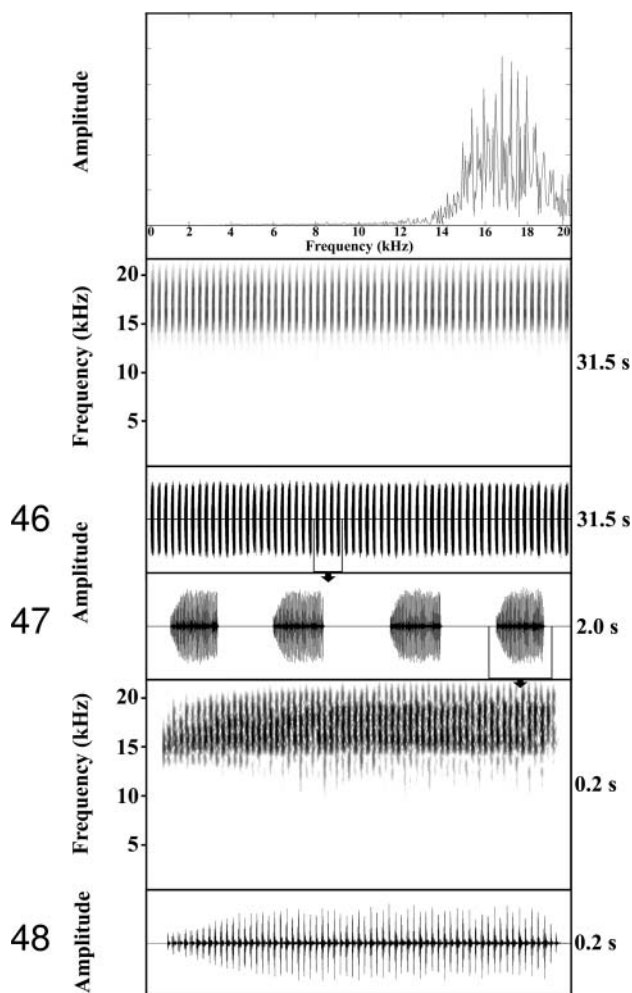
Tettigettacula baenai was described by Boulard (2000a) on the basis of three males and a female from a single locality (Puerto, Mahina, Las Lagunillas, Provincia de Córdoba). Considered by Boulard (2000a) to be morphologically similar to *Tettigetta josei* Boulard, 1982 (now *Tettigettalna josei*), but differentiated by the rounded head, larger hindwings, long fusion of the median (M) and cubital anterior (CuA) veins, and the red and yellow stripe along the posterior edge of the abdominal tergites. No biological data were reported. This taxon was probably misidentified under the name *Tettigetta pygmaea* (= *brullei*) by Duffels & van der Laan (1985) and Nast (1972, 1987).

MORPHOLOGY. (Figs 38, 40) Lateral part of pronotal collar slightly expanded to expanded, without 'tooth'. Thecal pseudoparameres entirely lateral of theca, very long and flat with apical part triangular, about as long as theca. Size for eight males: FL = 12.19 ± 0.56 (11.5–12.9), FW = 4.85 ± 0.24 (4.5–5.2), YW = 0.75 ± 0.04 (0.68–0.80), VW = 1.82 ± 0.08 (1.72–1.95). Additional measurements can be found in Boulard (2000a: 135).

HABITAT. (Fig. 8) Mainly in low vegetation mixed with small bushes and herbaceous plants, sometimes on trees. Habitat classes: 1–8. Vegetation classes: SH2, mainly in SH3.

DISTRIBUTION. Southern Spain, in Andalusia (Fig. 24).

ACOUSTIC BEHAVIOUR. (Figs 44, 46–48) Males raise their abdomen and lift up their wings when calling. They are mobile and can produce song during flight. The calling songs of two males were recorded at 26–27°C. Song continuous, involving the regular repetition of a single echeme. Echeme duration is 0.24 ± 0.02 s (0.17–0.28, $n = 100$), and silence between successive echemes is 0.35 ± 0.09 s (0.21–0.71, $n = 100$). Echemes comprise 72.49 ± 7.46 groups of pulses (49–89, $n = 90$). The frequency spectral band starts at 12 kHz and reaches the limit of our recording equipment (18 kHz). The dominant frequency is at 16.76 ± 0.80 kHz (15.59–18.86, $n = 96$). No alarm call.



Figs 46–48. *Tettigettacula baenai* comb. nov. Calling song. (46) mean frequency spectrum, spectrogram and oscillogram (from top to bottom) of 60 echemes; (47) detailed oscillogram of four echemes; (48) detailed spectrogram and oscillogram of a single echeme. Close to Alhama de Granada, Vantas de Zafarraya, Spain, 26–27°C.

Female behaviour (Fig. 45). The female deposits her eggs facing head downwards, as in *Tettigettula pygmaea*.

Other taxa assigned to the genus

Tettigettacula

Tettigettacula bergevini (Boulard, 1980), comb. nov., recorded in Algeria by Boulard (1980); *Tettigettacula sedlami* (Boulard, 1981), comb. nov., recorded in Algeria by Boulard (1981a); *Tettigettacula floreae* (Boulard, 1987), comb. nov., recorded in Morocco by Boulard (1987); *Tettigettacula linarsae* (Boulard, 1987), comb. nov., recorded in Algeria by Boulard (1987).

Pseudotettigetta Puissant gen. nov.

(Figs 7, 8, 24, 39, 49–52)

DIAGNOSIS. Small species (body length 14–20 mm); abdomen cylindrical, not keeled mid-dorsally; median

length of sternite VIII as long as sternite VII; lateral part of pronotal collar well expanded, mainly anteriorly, sometimes with a median 'tooth'; lateral angle of pronotal collar ampliate; operculum roundish, more or less confluent with distal margin of tympanal cavity; veins M and CuA of forewing always fused at base; forewing with eight apical cells, hindwing with six apical cells; dorsal beak of pygofer slightly rounded or sharp; anal styles moderately developed; claspers elongate, not hooked, sometimes slightly curved; uncus small and flat; thecal pseudoparameres in dorsal position of theca, originating near thecal base, much longer than theca, pseudoparameres flat with apical part triangular (Fig. 7).

TYPE SPECIES. *Cicadetta melanophrys* Horváth, 1907.

ETYMOLOGY. False *Tettigetta* by addition of the Greek prefix *pseudo* derived from *pseudēs*. Gender feminine.

***Pseudotettigetta melanophrys* (Horváth, 1907) comb. nov.**

Cicadetta melanophrys Horváth, 1907: 319. Two syntypes from the Hungarian Natural History Museum of Budapest examined by Boulard in 1976 (David Redei pers. comm., Natural History Museum of Budapest). Material examined under the name '*melanophrys*' in MNHN identified by Boulard.

Pseudotettigetta melanophrys melanophrys
(Horváth, 1907)

Pseudotettigetta melanophrys melanophrys occurs in Algeria and Tunisia (Horváth, 1907; Nast, 1972). Similar in morphology to *P. m. leunami* (see below).

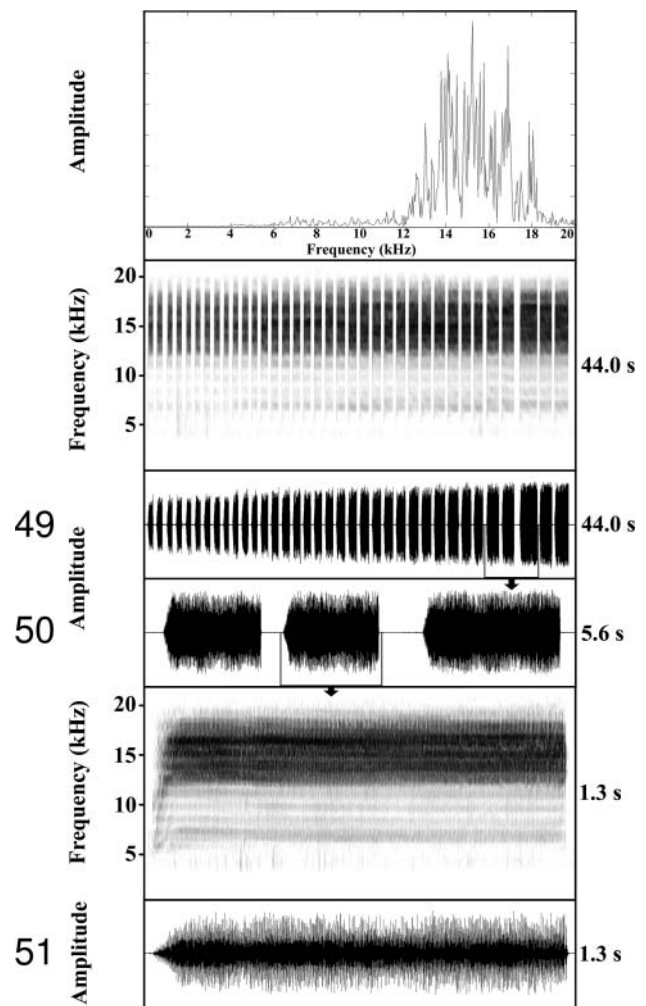
***Pseudotettigetta melanophrys leunami* (Boulard, 2000)**
comb. nov., stat. nov.

Tettigetta helianthemis: Kartal (1999), *non* Rambur (1840). Misidentification. *Tettigetta leunami* Boulard, 2000a: 139. Holotype ♂. Spain: Cordoba, Luque, Cerro de la Cruz. Deposited in the Muséum national d'Histoire naturelle (MNHN, Paris, France) [examined].

T. leunami was described by Boulard (2000a) from a single specimen from Cerro de la Cruz. The diagnostic character given was the presence of pale orange marks on the head and thorax. No biological data were reported.

Tettigetta leunami Boulard, 2000, is morphologically similar to *Pseudotettigetta melanophrys* (Horváth, 1907), including the aedeagus. However, the calling song of nominate *P. melanophrys* from Algeria is unknown and may be different. The conservative rank of subspecies is adopted here for the Spanish taxon. The aedeagus figured by Kartal (1999: 102, as *Cicadetta helianthemis*) represents *P. melanophrys leunami*.

MORPHOLOGY. (Figs 7, 39) Lateral part of pronotal collar well expanded, mainly anteriorly, sometimes with a little median 'tooth'; thecal pseudoparameres in dorsal position of theca, originating near thecal base, much longer



Figs 49–51. *Pseudotettigetta melanophrys leunami* (Boulard, 2000) comb. nov., stat. nov. Calling song. (49) mean frequency spectrum, spectrogram and oscillogram (from top to bottom) of a sequence made of 36 echemes; (50) detailed oscillogram of two echemes; (51) detailed spectrogram and oscillogram of a single echeme. El Coyote, San José, Spain, 28°C.

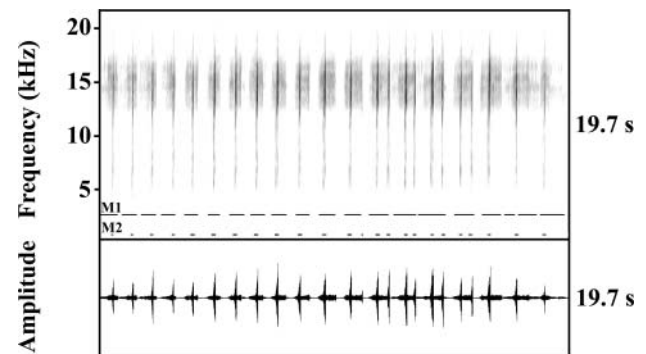


Fig. 52. *Pseudotettigetta melanophrys leunami* (Boulard, 2000) comb. nov., stat. nov. Rivalry song. One male producing a rivalry song in the foreground and a second male emitting a calling song in the background. El Coyote, San José, Spain, 28°C.

than theca, pseudoparameres flat with apical part triangular (Fig. 7). Size for ten males: FL = 16.39 ± 0.68 (15.2–17.3), FW = 5.8 ± 0.26 (5.5–6.2), YW = 1.09 ± 0.04 (1.03–1.15), VW = 2.19 ± 0.07 (2.05–2.28). Additional measurements can be found in Boulard (2000a: 140) and, for the nominate subspecies, Horváth (1907: 320).

HABITAT. (Fig. 8) Mainly in low vegetation mixed with small bushes and herbaceous plants, sometimes on trees. Habitat classes: 1–8. Vegetation classes: A2–3, SA2–3, SH2, SH3.

DISTRIBUTION. (Fig. 24) Only southern Spain, where it is widely distributed in Andalusia.

ACOUSTIC BEHAVIOUR. (Figs 49–52) Males do not show any particular calling posture and are able to produce sound during flight. Males gather in groups of four or five and then disperse. They are particularly mobile. They actively search for females by flying from place to place. The calling songs of seven males were recorded at 28°C. The song has a single phrase with a single type of echeme. The amplitude and duration of the echemes increase from beginning to end, and most of the phrases (71%) finish with a group of 4.00 ± 3.16 (1–9, $n = 5$) isolated echemes. The duration of the non-isolated echemes is 0.50 ± 0.24 s (0.16–1.91, $n = 499$) and that of the isolated echemes is 1.00 ± 0.56 s (0.49–2.36, $n = 20$). Silence between echemes lasts 0.36 ± 0.05 s (0.21–0.58, $n = 505$), while the silence that precedes the terminal group of isolated echemes lasts 0.74 ± 0.29 s (0.51–1.25, $n = 5$). In the frequency domain, there is no stable resonant frequency. The frequency spectral band is large, starting at 6 kHz and reaching the limit of our recording equipment (18 kHz). The dominant frequency is at 15.21 ± 0.97 kHz (12.53–17.53, $n = 484$). Males also produce a courtship song that we were unable to record. When two males are in proximity, a rivalry signal is produced with a repetition of short echemes (<0.15 s) (Fig. 52). No alarm call.

A genus identification key based on morphological characters, including the new combinations *Euryphara virens* (Herrich-Schäfer, 1835), comb. nov. and *Euryphara dubia* (Rambur, 1840), comb. nov. is proposed in Appendix 2 (see supplementary material which is available online). A species identification key based on acoustic characters is also provided in Appendix 3 (see supplementary material which is available online).

Discussion

As expected, southern Spain is an area of high diversity for cicadas. Focusing on a single taxon, nine species and one subspecies belonging to four new genera have been found, including eight taxa that can be considered endemic. *Tettigetia* was until now a genus with a very broad Palaearctic distribution, extending from North Africa to East Asia. The new genera described here give a new status to the species found in the western part of the Palaearctic domain.

Other new genera might occur in the eastern part of the domain as well. The validity of these new genera is based on morphological characters. However they are also supported by preliminary molecular analyses. Moreover, these former *Tettigetia* do not form a monophyletic group. The new genera are more closely related to other cicadettine genera, several of which are also in need of revision (Kathy Hill, David Marshall, Max Moulds and Chris Simon, pers. comm.). *Tettigetia* is probably not the only cicada genus that should be split into several taxa. Other genera that include small, dull-coloured species with widespread distributions might likewise need to be revised. This is clearly the case for *Cicadetta* Kolenati, 1857.

The cicada diversity observed in southern Spain is particularly high when compared to the four *Tettigetialna* species reported for all Portugal (Sueur *et al.*, 2004). This underlines the high level of diversity found in this part of Spain where four micro-endemic areas were defined previously (García-Barros *et al.*, 2002). The cicadas' distribution approximately fits into these local areas that go from South to North along the coast and south of a line joining Cádiz to Valencia. The Western Baetic area includes *Tettigetialna armandi*, *Tettigetialna defaulti*, *Tettigetialna aneabi* and *Tettigetiacula baenai*. The Eastern Baetic area is occupied by *Tettigetialna helianthemii galantei*. The Coastal Mediterranean area includes *Tettigetialna bouldardi* and *Tettigetialna h. helianthemii*. *Tettigetialna argentata* and *Pseudotettigetia melanophrys leunani* are found in all these areas. Unfortunately, there are as yet no phylogeographic data to explain such a distribution pattern. However, some biogeographic ideas can be discussed. First, the Baetic area is known for the high diversity and endemism of its flora (Mota *et al.*, 2002), and a direct link between plant and cicada diversity could be expected. However, as already illustrated for Portugal (Sueur *et al.*, 2004) and France (Puissant, 2006), there is no obvious association between cicadas and flora. Whereas plant association has been illustrated for South African (Price *et al.*, 2007) and Australian cicadas (Popple *et al.*, 2008), the species here studied do not show any host specialization. They are observed calling, feeding and laying their eggs on a wide diversity of plants. Second, the Baetic ranges are characterized by the occurrence of siliceous and calcareous high mountains with disjunct highland areas that could act as 'islands' (Mota *et al.*, 2002). The current distribution of cicadas does not seem to show any pattern linked to the topography but we cannot rule out the possibility that local geographic barriers played a role in past species diversification. Southern Spain is known to have had several Pleistocene refugia that played a role in speciation of several groups (Blondel & Aronson, 1991; Ribera & Vogler, 2004). Again, information regarding phylogeny and speciation dates is absolutely necessary but we can assume that cicada populations might have been isolated long enough during the Pleistocene to speciate. Eventually, cicada diversity might be related to

the diversity of vegetation classes observed in the region. These classes, based on vegetation and climatic factors, are numerous and those covering most of the region (SA2–3, SH2, SH3) are particularly favourable for cicada diversity.

This study confirms the major role that acoustics can play in the taxonomy of cicadas. Sound, through sexual selection processes, might be important in speciation. The diagnosis of cicada species and genera has been based for a long time on morphological characters only. These characters might be obvious and well defined but can also be both hard to delimit and render identification difficult. This is particularly the case for characters describing the shape of the male genitalia or wing topology in which aberrant venation patterns are not uncommon. Acoustic characters can complement morphological characters, if not replace them. Thanks to the new availability of low-priced but high-quality recording systems, recent field studies have shown that an important part of cicada species diversity has been overlooked. By analysing the calling and courtship songs, acoustics has allowed a direct access to species-specific characters. Male calling songs play an important role in mating and, as such, often represent species-specific characters offering reliable diagnostic characters for taxonomy. Acoustic cryptic species in cicadas have been known for 20 years (Boulard, 1988b), and several new cryptic species have been discovered recently by acoustic analysis (Sueur & Puissant, 2007; Gogala *et al.* 2008; Lee, 2008; Cole, 2008). Here the definition of several species (e.g. *Tettigettalna helianthemi*, *Tettigettalna aneabi*, *Tettigettalna armandi*, *Tettigettalna defauti*) is mainly supported by acoustic analyses. Cicadas constitute a good model for inclusion in the current effort to survey cryptic species (Bickford *et al.*, 2007; Pfenninger & Schwenk, 2007; Trontelj & Fišer, 2009).

The occurrence of acoustic cryptic species suggests that sound communication might have played a special or key role in speciation. Even if historical information is absolutely necessary to infer the importance of sound in species emergence, acoustic analysis alone can give some clues. All the species reported on here produce sound over a very wide frequency spectrum, from about 10–19 kHz, and probably extending to the ultrasound domain. No true resonance peak was ever detected, the dominant frequency being variable as shown by the high standard deviations of about 1 kHz. *Tettigettacula baenai* and *Tettigettalna pygmea* produce higher frequencies. These frequency features might be linked to morphology. All the species described here are small, which constrains the frequency content of their songs to high values (Bennet-Clark, 1998). *Tettigettua baenai* and *Tettigettalna pygmea* are the smallest species and generate the highest frequency signals. None of these species has a hollow abdomen that could act as a Helmholtz resonator to sharpen the output around a single dominant frequency (Bennet-Clark, 1999). The morphology seems to constrain frequency variation very strongly. This is counterbalanced

by a high variability in the time/amplitude pattern of the calling songs. Each species can be recognized with temporal parameters only. The differences between species are so great that it has proved almost impossible to establish clear acoustic homologies between the different song elements. It is then highly probable that species-specific information is encoded in the time characteristics of the songs. This also seems to be true for other small cicada species which lack a resonating abdomen, as illustrated by the *Cicadetta montana* complex (Gogala *et al.*, 2008).

This study reveals the potential for a significant number of new cicada genera and species to be described from Spain. Other areas known for their endemism should be investigated, such as the central and Cantabro-Galaic mountains. At a larger biogeographical scale the fauna and flora of southern Spain is often associated with those of the Rif and Tell Atlas mountain chains in Morocco and Algeria, respectively (Médail & Quezel, 1999). It would be particularly interesting to know whether the genera and species here described are truly endemic to the Iberian Peninsula, or also occur in North Africa. The diversity of Mediterranean cicadas is far from exhaustively known and we can expect many new taxa to be discovered in future.

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SUPPLEMENTARY MATERIAL for 'A hotspot for Mediterranean cicadas (Insecta: Hemiptera: Cicadidae): new genera, species and songs from southern Spain'

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Appendix 1. Nomenclatural issues regarding the genus *Tettigetta* Kolenati, 1857

Amyot (1847: 156–157) was the first author to introduce the generic name *Tettigetta*, when he referred to two cicada species, “*pygmea* Ol.?” and “*aestuans* Fabr.”. *Cicada pygmea* Ol.? is not a valid designation under Article 67.5.3 (ICZN, 1999), but “*aestuans* Fabr.” would be (Article 12.2.5). Consequently, *Cicada aestuans* Fabricius is the only unambiguous species-group taxon listed under *Tettigetta* Amyot, and would become the type species by monotypy (Article 68.3). This potential type fixation has been overlooked. Unfortunately, it cannot be accepted since ICNZ has placed the work of Amyot (1845–1847) on the Official Index of Rejected and Invalid Works in Zoological Nomenclature (Opinion 2165, 2006). Thus *Tettigetta* Amyot, 1847, has no availability or validity.

The second author to use *Tettigetta* was Kolenati (1857: 422–425), who applied the name as a subgenus of *Cicada* Linné, 1758, to include *Cicada prasina* Pallas, 1773, and *Tettigonia tibialis* Panzer, 1798 (now *Cicadivetta tibialis*). However, Kolenati (1857) did not fix either as the type species.

The first author to designate one of the originally included nominal species was Boulard (1980: 313), who fixed *Cicada prasina* Pallas, 1773, as the type species. *C. prasina* is therefore the type by subsequent designation (Article 69.1), not by original designation as later stated by Boulard (1988a, 1998) and Boulard & Weiner (2001).

Appendix 2. Morphological identification key to genera of west European Cicadettini

In this key to genera of west European Cicadettini Buckton, 1889, neither *Cicadetta albipennis* Fieber, 1876, nor *Cicadetta mediterranea* Fieber, 1876, have been taken into account as it was not possible to place these nominal species with confidence in any of the currently recognised genera. These species probably belong to new genera but additional information is required for formal genera description.

(1a) Uncus small, not dominant, duck-bill shaped. Smaller cicadas → 2

(1b) Uncus large and dominant with short lateral lobes. Black and yellowish large cicadas → *Hilaphura* Webb, 1979, including the following species:

- *Hilaphura varipes* (Waltl, 1837)

(2a) Claspers hooked anterolaterad → 3

(2b) Claspers not hooked anterolaterad but curved posterolaterad with their base straight, or sometimes elongate and totally straight → 4

(3a) Sternite VIII very large and long, about 1.5 times as long as sternite VII. Forewing veins M and CuA meeting at basal cell with vein aligned, or not, after basal cell but not fused. Pygopher basal lobe in ventral view without inner tooth. Hindwing usually with 6 apical cells → *Cicadetta* Kolenati, 1857, including the following species:

- *Cicadetta montana* (Scopoli, 1772)

- *Cicadetta brevipennis* Fieber, 1876

- *Cicadetta fangoana* Boulard, 1976

- *Cicadetta cerdaniensis* Puissant & Boulard, 2000

- *Cicadetta cantilatrix* Sueur & Puissant, 2007

(3b) Sternite VIII as long as or slightly shorter than sternite VII. Forewing veins M and CuA meeting basal cell with their stems completely fused. Pygopher basal lobe in ventral view showing inner tooth present. Hindwing usually with 5 apical cells → *Cicadivetta* Boulard, 1982, including the following species:

- *Cicadivetta tibialis* (Panzer, 1798)

- *Cicadivetta flaveola* (Brull 1832) **comb. nov.**, erroneously mentioned from Spain and Portugal (e.g. Gomez-Menor Ortega, 1957; Nast, 1972): misidentified by Gomez-Menor Ortega (1957) with a species of the genus *Euryphara* (see below).

- *Cicadivetta carayoni* (Boulard, 1982) **comb. nov.**

(4a) Pygofer dorsal beak well developed, sharp or slightly rounded. Abdomen gradually narrowed caudad. Hindwing usually with 6 apical cells. Forewing veins M and CuA meeting at basal cell or meeting basal cell with their stems completely fused → 5

(4b) Pygofer dorsal beak not developed, rounded. Abdomen elongated, not gradually narrowed caudad. Hindwing usually with 5 apical cells but aberrations with 4 or 6 apical cells not rare.

Forewing veins M and CuA meeting basal cell with their stems completely fused → *Tympanistalna* Boulard, 1982 including the following species:

- *Tympanistalna distincta* (Rambur, 1840)
- *Tympanistalna gastrica* (Stål, 1854)

(5a) Forewing veins M and CuA meeting basal cell with their stems completely fused → 6

(5b) Forewing veins M and CuA meeting at basal cell with veins aligned or not after basal cell → *Euryphara* Horvath, 1912 including the following species:

- *Euryphara virens* (Herrich-Schäfer, 1835) **comb. nov.**
- *Euryphara undulata* (Waltl, 1837)
- *Euryphara dubia* (Rambur, 1840) **comb. nov.**
= *Cicadetta euphorbiae* Fieber, 1876.
- *Euryphara contentei* Boulard, 1982

(6a.) Thecal pseudoparameres in dorsal position → 7

(6b) Thecal pseudoparameres in lateral position → 8

(7a) Thecal pseudoparameres originating closer to theca than its base. Lateral part of pronotal collar slightly expanded to well expanded in the median part → *Tettigettalna* Puissant **gen. nov.** including the following species:

- *Tettigettalna argentata* (Olivier, 1790) **comb. nov.**
- *Tettigettalna helianthemi helianthemi* (Rambur, 1840) **comb. nov.**
- *Tettigettalna helianthemi galantei* Puissant **ssp. nov.**
- *Tettigettalna estrellae* (Boulard, 1982) **comb. nov.**
- *Tettigettalna josei* (Boulard, 1982) **comb. nov.**
- *Tettigettalna mariae* (Quartau & Boulard, 1995) **comb. nov.**
- *Tettigettalna aneabi* (Boulard, 2000) **comb. nov.**
- *Tettigettalna bouldardi* Puissant **sp. nov.**
- *Tettigettalna armandi* Puissant **sp. nov.**
- *Tettigettalna defauti* Puissant **sp. nov.**

(7b) Thecal pseudoparameres originating near thecal base. Lateral part of pronotal collar well expanded in the anterior part → *Pseudottettigetia* Puissant **gen. nov.** including the following

species:

- *Pseudotettigetta melanophrys* (Horváth, 1907) **comb. nov.** ssp *leunami* Boulard, 2000 **stat. nov.**

(8a) Thecal pseudoparameres dorsally fused to near their apices → *Tettigettula* Puissant **gen. Nov.**

Including the following species:

- *Tettigettula pygmea* (Olivier, 1790) **comb. nov.**
= *Tettigetta brullei* (Fieber, 1876).

(8b) Thecal pseudoparameres entirely lateral of theca, very long and flat → *Tettigettacula* Puissant **g. nov.** including the following species:

- *Tettigettacula baenai* (Boulard, 2000) **comb. nov.**

Appendix 3. Acoustic identification key to species of west European Cicadettini

The songs of *Euryphara virens* (Herrich-Schäfer, 1835) **comb. nov.**, *Euryphara undulata* (Waltl, 1837), *Euryphara dubia* (Rambur, 1840) **comb. nov.**, *Tympanistalna distincta* (Rambur, 1840) have not been reported and could not be included in the key. A literature reference is specified for each song that is not described in the present work.

(1a) Continuous sound → 2

(1b) Rhythmic sound → 5

(2a) With a final short echeme → 3

(2b) No final short echeme → 4

(3a) Starts with a slow amplitude increase → *Cicadetta brevipennis* Fieber, 1876 (see Gogala & Trilar (2004) for a description)

(3b) Starts with a succession of short echemes → *Cicadetta fangoana* Boulard, 1976 (see Boulard, 1995, for description)

(4a) Very long sequence (> 10 s) ending with a sharp decrease in amplitude → *Cicadetta montana* (Scopoli, 1772) (see Gogala & Trilar, 2004, for description)

(4b) Short sequence (< 10 s) ending with a deep amplitude modulation → *Tettigettalna josei* (Boulard, 1982) **comb. nov.** (see Fonseca, 1991, for description)

(5a) Production of a 'two-sound' effect → 6

(5b) No production of a 'two-sound' effect → 7

(6a) 'Two-sound' effect dominant throughout the echeme. First echeme with a longer duration → *Tettigettalna armandi* Puissant **sp. nov.**

(6b) 'Two-sound' effect only produced in the second half of the echeme, or sometimes not produced at all. All echemes with a similar duration → *Tettigettalna defaulti* Puissant **sp. nov.**

(7a) Calling song made up of a regular repetition of a single main echeme → 8

(7b) Calling song not made of the regular repetition of a single echeme but organized in sequences → 10

(8a) High pitched song (dominant frequency > 10 kHz) → 9

(8b) Low pitched song (dominant frequency < 10 kHz) → *Hilaphura varipes* (Waltl, 1837) (see

Puissant, 2005, for description, as *Melampsalta varipes*).

(9a) Main echeme duration > 0.15 s $\rightarrow$ *Tettigettula pygmea* (Olivier, 1790) **comb. nov.**

(9b) Main echeme duration < 0.15 s $\rightarrow$ *Tettigettacula baenai* (Boulard, 2000) **comb. nov.**

(10a) A single type of echeme $\rightarrow$ 11

(10b) More than one type of echeme $\rightarrow$ 13

(11a) Short echemes (< 0.1 s) with similar duration throughout the sequence $\rightarrow$ 12

(11b) Long echemes (> 0.1 s) regularly increasing in duration throughout the sequence $\rightarrow$

Pseudotettigetta melanophrys (Horváth, 1907) **comb. nov.** ssp. *leunami* Boulard, 2000 **stat. nov.**

(12a) Sequence with a long sustained part $\rightarrow$ *Euryphara contentei* Boulard, 1982 (see Sueur *et al.*, 2004, for a description).

(12b) Rhythmic sequence without any sustained part $\rightarrow$ *Tettigettalna argentata* (Olivier, 1790) **comb. nov.**

(13a) Two types of echeme $\rightarrow$ 14

(13b) Three types of echeme $\rightarrow$ *Cicadetta cerdaniensis* Puissant & Boulard, 2000 (see Puissant & Boulard (2000) and Sueur & Puissant (2007) for a description).

(14a) Important amplitude modulation affecting all echemes $\rightarrow$ 15

(14b) No important amplitude modulation affecting the echeme $\rightarrow$ 16

(15a) Amplitude modulation at the end of all echeme types $\rightarrow$ *Cicadetta cantilatrix* Sueur & Puissant, 2007 (see Sueur & Puissant (2007) for a description).

(15b) Amplitude modulation at the beginning of one echeme type $\rightarrow$ *Tympanistalna gastrica* (Stål, 1854) (see Fonseca (1991) for a description).

(16a) Duration of all echemes almost the same $\rightarrow$ 17

(16b) Duration of echemes significantly different $\rightarrow$ 18

(17a) Long echeme duration (> 0.3 s), slow rythm $\rightarrow$ *Tettigettalna estrellae* (Boulard, 1982) **comb. nov.** (see Boulard (1995) and Sueur *et al.* (2004) for a description).

(17b) Very short duration (< 0.3 s), fast rythm $\rightarrow$ *Tettigettalna aneabi* (Boulard, 2000) **comb. nov.**

(18a) Duration of the longest echeme < 1 s $\rightarrow$ 19

(18b) Duration of the longest echeme $> 1\text{ s}$ $\rightarrow$ *Tettigettalna bouldardi* Puissant **sp. nov.**

(19a) Duration of the silence between successive echemes $< 0.2\text{ s}$ $\rightarrow$ 20

(19b) Duration of the silence between successive echemes $> 0.2\text{ s}$ $\rightarrow$ 21

(20a) Longest echeme duration $> 0.2\text{ s}$ $\rightarrow$ *Cicadivetta tibialis* (Panzer, 1798) (see Gogala *et al.*, 1996; Sueur & Puissant, 2000, for descriptions).

(20b) Longest echeme duration $< 0.2\text{ s}$ $\rightarrow$ *Cicadivetta flaveola* (Brull 1832) **comb. nov.** (see Gogala & Drosopoulos, 2006, for a description).

(21a) Echeme duration increasing throughout the sequence $\rightarrow$ 22

(21b) Echeme duration decreasing throughout the sequence $\rightarrow$ *Tettigettalna mariae* (Quartau & Boulard, 1995) **comb. nov.** (see Quartau & Boulard, 1995, and Fonseca, 1991, as *Tettigetta* sp., for descriptions).

(22a) Rythmic sequence, always with more short echemes than long $\rightarrow$ *Tettigettalna helianthemi helianthemi* (Rambur, 1840) **comb. nov.**

(22b) Sequence arhythmic, with an irregular number of short echemes $\rightarrow$ *Tettigettalna helianthemi galantei* Puissant **ssp. nov.**

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