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Contribution to the knowledge of genus *Dociostaurus* Fieber, 1853 in the Iberian Peninsula, with special reference to its sound production (Orthoptera: Acridoidea)

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Resumen

Contribución al conocimiento del género Dociostaurus *Fieber, 1853 en la Península Ibérica, con especial referencia a sus manifestaciones acústicas (Orthoptera, Acridoidea).*

Se presenta una revisión de las especies del género *Dociostaurus* Fieber, 1853 que habitan en la Península Ibérica. Se propone la sinonimia de *Dociostaurus monserrati* García & Presa, 1984 con *Dociostaurus jagoi occidentalis* Soltani, 1978. Se aportan datos y figuras de aspectos anatómicos, como las filas estriduladoras, de machos y de hembras. Se hace especial referencia a la producción de sonido de las distintas especies. Se describen por vez primera los cantos producidos por *Dociostaurus crassiusculus* (Pantel, 1886) y *Dociostaurus genei genei* (Ocskay, 1832) y se presentan los primeros datos acerca de las características espectrales de todos los sonidos. Se presenta clave de identificación para las especies consideradas.

Palabras clave: *Dociostaurus*, Península Ibérica, Nueva sinonimia, Claves de identificación, Morfología, Producción de sonido.

Summary

A review of the species of genus *Dociostaurus* Fieber, 1853 inhabiting the Iberian Peninsula has been made. The synonymy of *Dociostaurus monserrati* García & Presa, 1984 with *Dociostaurus jagoi occidentalis* Soltani, 1978 is proposed. Data and figures of some anatomical aspects, such as the stridulatory files of males and females, are presented. A special reference to the sound production of the species is made. The respective songs produced by *Dociostaurus crassiusculus* (Pantel, 1886) and *Dociostaurus genei genei* (Ocskay, 1832) are described for the first time, along with data on the spectral characteristics of all the songs. A key for identifying the considered species is presented.

Key words: *Dociostaurus*, Iberian Peninsula, New synonymy, Identification key, Morphology, Sound production.

Introduction

The genus *Dociostaurus* Fieber, 1853 has been known since ancient times in the Iberian Peninsula because it includes the orthopteran species considered as one of the most important agricultural pests in many areas, *Dociostaurus maroccanus* (Thunberg, 1815), commonly known as Moroccan locust. Although several references from the VI-VII centuries can be found, the first reference to the genus that can be considered

official is that made by Charpentier (1825), who gave "Lusitania" as locus tipico of *Gryllus cruciatus*. The first reference for Spain is due to Rambur, who described *Gryllus crucigerus* Rambur, 1838 from Málaga.

Our knowledge of the biology of the different species of the genus in the Iberian Peninsula is quite unequal. In some cases, such as that of *D. maroccanus*, it is abundant as a result of economic effects; for the rest of the species knowledge is very limited, due to the lows number of captures and that, in some cases, the real taxonomical status has been established comparatively recently: *Dociostaurus genei genei* (Ocskay, 1832) and *Dociostaurus jagoi occidentalis* Soltani, 1978, for example. For this reason, the known data about them cannot be assigned to one or another with any certainty prior to Soltani (1978).

However, the morphology of the genus, the synonymies and its global distribution have been extensively studied; of special note in this respect are the studies of Bolívar (1898), Morales Agacino (1941), Mischenko (1974a, 1974b) and Soltani (1978).

As regards our knowledge of its sound production, the review made for Western Europe by Ragge & Reynolds (1998) should be cited because it includes the descriptions of calling songs of *D. maroccanus*, *Dociostaurus jagoi* Soltani, 1978 and *Dociostaurus hispanicus* (Bolívar, 1898), as well as a summary of all the references from the literature in relation to the sound.

Materials and Methods

The first question to be considered concerns the subgenus to be assigned the different taxa as well as their status as species or subspecies. In this respect there are many different opinions (Mishchenko, 1974a and b; Harz, 1975; Soltani, 1978; Défaut, 1987 and Latchininsky & Launois-Luong, 1992, among others), with which we may agree partly or completely, according to the taxonomical category considered. But, for practical purposes, we have decided to follow the taxonomy of the Orthoptera Species File (OSF) on line (http://140.247.119.145/Orthoptera/) (Eades, 2001), because this has become the world reference for this insect group. Accordingly, in the Iberian Peninsula six species are known to date: *D. (D.) maroccanus; D. (Stauronotulus) crassiusculus crassiusculus* (Pantel, 1886)*; Dociostaurus (Kazakia) monserrati* García & Presa, 1984; *D. (K.) genei genei, D. (D.) hispanicus* and *D. (D.) jagoi occidentalis*.

The morphology of each species has been studied but, in order to avoid repetition, we have decided to show only the most appropriate references from the literature. However, we present a description of the stridulatory file because it is a scarcely studied structure and because of its close relation with sound production.

A study of the stridulatory file was made, when possible, on the right hind femur, using for the biometrical study and peg survey a stereoscopic microscope Olympus SZH provided with 10X eyepieces, 0.66-4X-zoom object lens, and 2X lens and micrometer eyepiece. Femora length was measured as proposed by Jago (1963).

To study the shape and arrangement of pegs the scanning microscopy technique was used. The samples, after cleaning as proposed by Clemente *et al.* (1989), were prepared on rotatory bases and coated by sputtering with pure gold.

A JEOL 6100 scanning microscope was used. This provides secondary electron images (SEI) and works with an accelerating voltage of 0.3 to 30 kV, providing a magnification of 10-300,000X, with an automatic magnification compensation device. The samples were observed, with variable magnification, at 21 mm working distance by selecting a 15 kV accelerating voltage. Images were captured with the LINK ISIS program.

For this study the shape of the file and pegs have been taken into account, as well as the number of pegs in the file, femur length, file length, peg density in the file and file length / femur length ratio. The specimens studied are summarized in Table 1. Measurements are expressed in mm (Table 2).

For each species, data referring to phenology, altitudinal distribution and relationship with vegetation have been elaborated from the literature and from a study of specimens collected by the authors throughout the Iberian Peninsula between 1985 and 2004. Specimens are kept in the collection of the Zoology Department of the University of Murcia.

The geographical distribution for each species is based on the specimens studied by the authors, either from own captures or those kept in other collections. To these data, those from the literature referring to provinces from which no specimens could were studied, have been added. Among the literature references, only the most recent are included; they appear in bracket after the name of the province.

The sound study is based on 135 different songs of the studied *Dociostaurus* species. The songs are included in 21 different recordings (Table 3). Songs were recorded with two analogical tape recorders, Uher 4000 and Uher 6000, at tape speeds of 19.05 and 9.5 cm/s, respectively, with a Ni-Cd battery or electric power, and UHER M-655 or UHER M-518A dynamic

Table 1. Summarized data of the specimens used to study the stridulatory file.
Tabla 1. Datos de los ejemplares empleados para el estudio de la fila estriduladora.

Species/number of specimens	Collecting locality	Collecting date	Collector
D. maroccanus			
3 males	- Campo de Tiro (AB)	10-VII-92	R.Gómez
1 male	- Segóbriga (CU)	28-VI-2001	E.Larrosa
1 male	- Uclés (CU)	18-VI-2001	E.Larrosa
3 males	- Santiago de la Espada (J)	21-VI-2002	M.D.García
1 male	- Don Simón (AB)	11-VII-88	R.Gómez
1 male	- La Sagra (GR)	21-VI-2002	M.D.García
1 female	- Puerto de la Losa (GR)	21-VI-2002	M.García
1 female	- La Puebla de Don Fadrique (GR)	20-VI-2002	J.J.Presa
3 females	- Aroca Sierra Segura (J)	18-VI-86	M.D.García
3 females	- Campo de Tiro (AB)	10-VII-92	R.Gómez
D. crassiusculus			
5 males	- El Bonillo (AB)	9-VII-92	R.Gómez
6 females	- El Bonillo (AB)	9-VII-92	J.J.Presa
2 females	- El Bonillo (AB)	26-VI-89	R.Gómez
D. genei			
2 males	- Santa María Alameda (M)	6-IX-93	M.D.García
2 males	- Morenos (AB)	26-VII-89/23-IX-89	R.Gómez
1 male	- Reserva Biológica Doñana	21-VII-02	M.D.García
1 male	- Monterrubio de la Serena (BA)	27-IX-01	M.D.García
1 male	- Cacabelos (LE)	24-VII-90	E.Clemente
1 male	- Cerca de Palancar. Higuera Real (BA)	20-IX-89	M.D.García
1 male	- La Cabrera (M)	17-VII-92	M.D.García
1 male	- Puerto Canencia (M)	11-IX-91	E.Clemente
2 females	- Santa María Alameda (M)	6-IX-93	M.D.García
3 females	- Morenos (AB)	26-VII-89/23-IX-89	R.Gómez
1 female	- Cacabelos (LE)	24-VII-90	E.Clemente
1 female	- Burbia-Montico (LE)	21-VII-90	M.D.García
1 female	- Sierra de Albarracín (TE)	30-VII-86	J.J.Presa
D. jagoi occidentalis			
3 males	- Puerto Las Cabras (AB)	26-VII-87/28-VIII-89	R.Gómez
1 male	- F. Carnina (AB)	21-VII-87	R.Gómez
5 males	- Sierra Espuña (MU)	15-VII-82/27-VII-82/ 30-VIII-82	M.D.García
1 male	- El Sabinar (MU)	23-VII-79	J.J.Presa
2 females	- Sierra Espuña (MU)	21-VII-81/3-X-80	M.D.García
1 female	- Puerto Las Cabras (AB)	25-VIII-88	R.Gómez
2 females	- Cortijo los Bartolos S^{a}Filabres (AL)	24-VII-91	J.J.Presa
1 female	- Rambla de Tabernas (AL)	24-VII-91	E.Clemente
1 female	- Beniarrés Sierra Aitana (A)	8-IX-92	E.Clemente
1 female	- Los Poyos (AB)	11-IX-92	J.J.Presa
D. hispanicus			
4 males	- Sierra Arroyo. Las Batuecas (SA)	21-VII-88	M.D.García
3 males	- La Cabrera (M)	17-VII-92	J.J.Presa
1 male	- Escurial de la S^{a}. Peña de Francia (SA)	20-VII-88	M.D.García
2 females	- Sierra Arroyo. Las Batuecas (SA)	21-VIII-88	M.D.García
6 females	- La Cabrera (M)	17-VII-92	J.J.Presa

Table 2. Data and measurements referring to the stridulatory file of the studied species of genus *Dociostaurus*.
Tabla 2. Datos de la fila estriduladora.

Dociostaurus species	Number of specimens	Number of pegs	File length (mm)	Hind femur length (mm)	Peg density (number of pegs/ mm)	File length x100 /hind femur length
***D.maroccanus* Males**	10	73 (68-80)	6,36 (5,5-7,5)	13,36 (11,8-15)	11,51 (9,6-12,9)	47,54 (42,85-50)
***D.maroccanus* Females**	8	61 (57-65)	6,15 (5,5-7)	16,05 (15-17,1)	10,02 (9,19-10,83)	38,36 (33,33-42,50)
***D.crassiusculus* Males**	5	31 (27-35)	4,02 (3,5-4,3)	10,38 (10-10,7)	7,77 (6,42-8,42)	38,75 (32-41,74)
***D.crassiusculus* Females**	8	30 (26-34)	4,33 (3,3-5,5)	13,43 (12,5-14,8)	7,14 (5,20-9,09)	32,13 (25-40)
***D.genei* Males**	10	28 (21-33)	2,24 (1,8-2,4)	8,32 (7,4-9)	12,33 (9,13-15)	27,02 (21,17-31)
***D.genei* Females**	8	22 (17-26)	1,98 (1,4-2,5)	10,89 (10,5-11)	11,37 (10-13,33)	18,15 (12,73-22,73)
***D.jagoi* Males**	10	52 (44-58)	2,92 (2,7-3,2)	8,05 (7,3-8,6)	17,7 (14,66-20,37)	36,33 (33,73-41)
***D.jagoi* Females**	8	43 (37-49)	2,41 (2-2,8)	11,70 (11-12,6)	17,95 (14,07-21,36)	20,59 (18,02-23,73)
***D.hispanicus* Males**	8	76 (70-86)	3,77 (3,5-4)	9,76 (9-10)	20,22 (17-22,26)	38,67 (35,71-41,2)
***D.hispanicuss* Females**	8	80 (73-88)	4,64 (4-5,3)	12,79 (11,8-14)	17,63 (14,62-20,75)	36,03 (31,75-39,37)

microphones. Recordings and behaviour observations were made in the field or in the laboratory of the Zoology Department of the University of Murcia.

When sound was recorded in the field, specimens were kept in a well ventilated plastic recipient, held under natural light and temperature conditions and provided with plants from the environment. In the laboratory the specimens were kept in wooden cages with mesh top and glass front, exposed to artificial light provided by a 25 W bulb for 12 hours per day.

Sounds were studied with a Mingograph 420 System attached to a digital Tektronix 2211 oscilloscope. A Krohn-Hite 3550 filter (band-pass filter 2Hz-200 kHz) was used to obtain a clear image of the sound through the Mingograph, in order to make a metrical study and cut out the lowest noise frequencies when digitalizing the signal. The sound was then digitalized with a Sound Blaster AWE64 Gold (Creative technology Ltd, Iveragh Road, Killorglin, Co Kerry, Ireland), using a sampling frequency of 44 kHz and a sample size of 8 bits, and analysed with the Avisoft SAS Lab Pro 3.0 PC for MS-Windows (Sound Analysis and Synthesis Laboratory, Raimund Specht, Hauptstr. 52, D-13158 Berlin, Germany)

Several types of song have been taken into account: calling song and courtship song (Ragge & Reynolds, 1998), disturbance song (García et al., 2003), chorus song (Ewing, 1989) and song of a male when trying to mate with a female. Table 3 summarizes data referred to the specimens and recordings used in this study. To describe the songs the terminology proposed by Ragge & Reynolds (1998), Ewing (1989) and García et al. (2003) has been followed.

Results

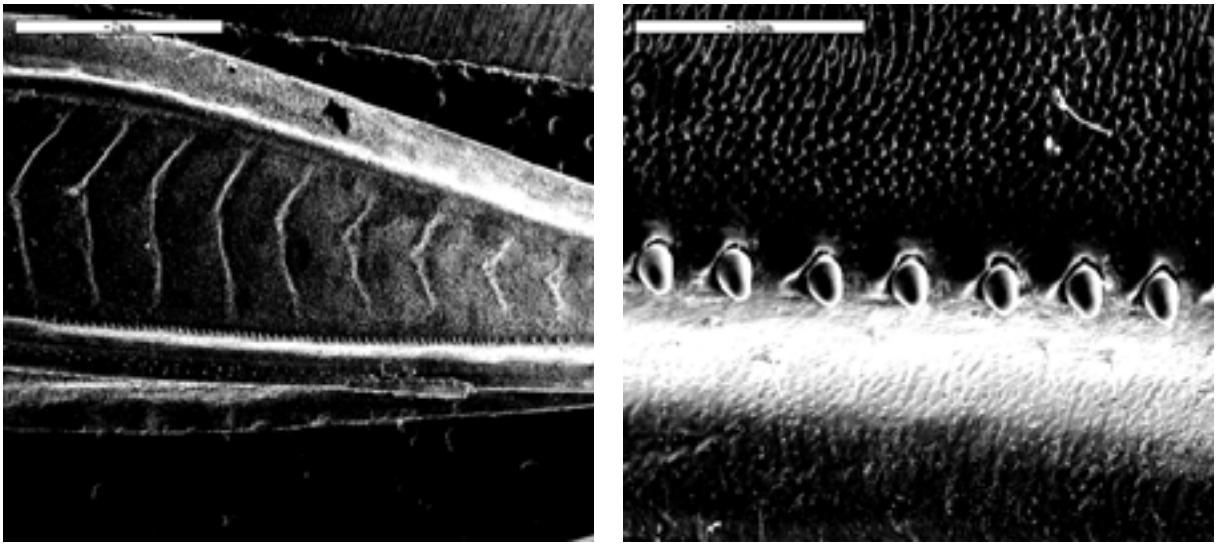
Dociostaurus maroccanus (Thunberg, 1815)

Thunberg. 1815. Mem. Acad. Imp. Sci. St. Peterburg. 5:211-301 as *Gryllus maroccanus*

- *Gryllus cruciatus* Charpentier, 1825. Horae entomologicae, adjectis tabulis novem coloratis. 4, 16: 137

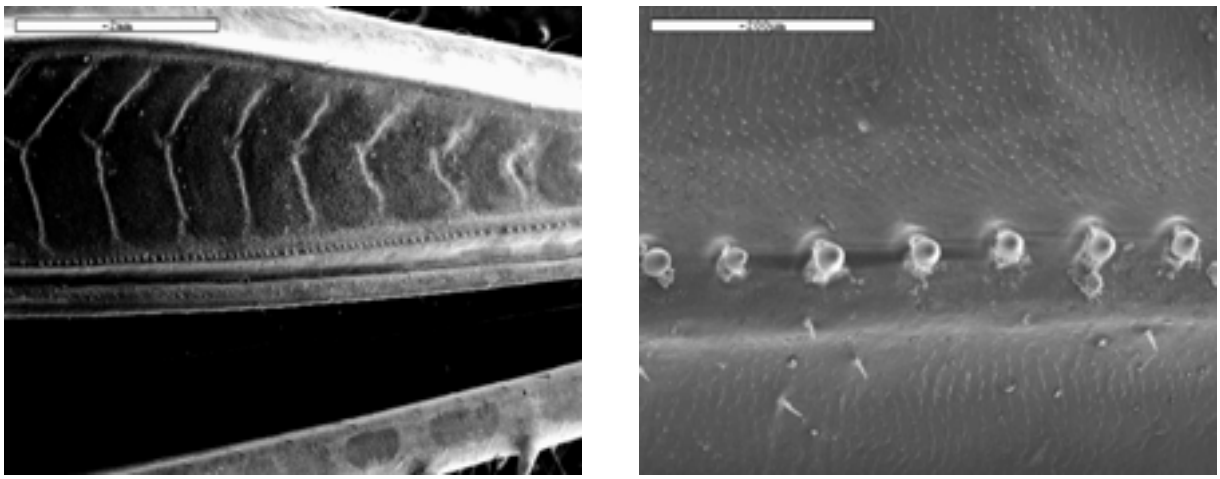
Table 3. Summarized data of the specimens and recordings used in the study.
Tabla 3. Datos de los ejemplares y registros de sonido empleados.

Species/number of specimens	Collecting date / locality	Recording date / locality	Recording conditions	Recording number
D. maroccanus 2 males 1 female	Campo de Tiro (AB) 10-VI-92	Laboratory 25-26-VI-92/8-10-VII-92	Wooden cage Light bulb 25W 20ºC	1/92/6000 2/92/4000 2/92/6000 3/92/6000
D. crassiusculus 3 males	El Bonillo (AB) 9-VII-92	Laboratory 10-VII-92	Wooden cage Light bulb 25 w 28ºC	1/92/4000 (1-11) 4/92/6000 (1-18) 5/89/4000
D. genei 1 male	Puerto de Canencia Sierra de Guadarrama (M) 12-IX-91	Puerto de Cotos Sierra Guadarrama (M) 12-IX-91	Plastic recipient 25ºC	7/91/6000 (1-9)
		Santa María de la Alameda. Sierra Guadarrama (M) 6-IX-93	Plastic recipient 30ºC	1/93/6000
4 males	Santa María de la Alameda. Sierra Guadarrama (M) 6-IX-93	Laboratory 7-IX-93 Estación Valdesquí Sª Guadarrama (M) 6-IX-93	Plastic recipient Light bulb 25 w Plastic recipient 25ºC	2/93/6000 (1-14) 11/93/4000
4 males, 3 females	Morenos.Nerpio (AB)18-VII-2000	Laboratory 24-VII-2000	Wooden cage Light bulb 25W 28ºC	1/2000/6000 (1-10) 2/2000/6000
D.jagoi occidentalis 2 males	Sierra Filabres (AL) 24-VII-91	Sierra Filabres (AL) 25-VII-91	Plastic recipient 25ºC	23/91/4000
5 males	Sierra Espuña (MU) 25-IX-91	Laboratory 26-IX-91/X-91	Wooden cage Light bulb 25W 31ºC	30/91/1601 53/91/4000
2 males	Cava Coloma. Font-Roja (A) 26-X-95	Laboratory 27-X-95	Wooden cage Light bulb 25W 20ºC	11/95/6000
2 males	Más de Tetuán Font-Roja (A) 26-X-95	Laboratory 31-X-95	Wooden cage Light bulb 25W 22ºC	14/95/6000 16/95/6000
4 males	Sierra Espuña (MU)12-VII-96	Laboratory 17-18-VII-96	Wooden cage Light bulb 25W 25ºC	20A/96/6000
2 males	Sierra Espuña (MU)9-IX-99	Laboratory 5-X-99	Wooden cage Light bulb 25W 25ºC	17/99/6000
D. hispanicus 3 males	La Cabrera. Sierra de Guadarrama (M) 17-VII.92	La Cabrera Sª de Guadarrama (M) 17-VII-92	Plastic recipient 35 ºC Natural conditions	8/92/4000 (1-9)



a b

Figure 1. *Dociostaurus maroccanus* male: a.- general appearance of the stridulatory file; b.- detail of the middle zone.
Figura 1. *Dociostaurus maroccanus* macho: a.- aspecto general de la fila estriduladora; b.- detalle de la zona media.



a b

Figura 2

Figure 2. *Dociostaurus maroccanus* female: a.- general appearance of the stridulatory file; b.- detail of the middle zone.
Figura 2. *Dociostaurus maroccanus* hembra: a.- aspecto general de la fila estriduladora; b.- detalle de la zona media.

- *degeneratus* Baranov, 1925 Poljopriverede Ogledna Kontrol Sta. Topichider. Phyto-Ent. Odesk. 3:14, 21
- *Epacromia oceanica* Walker, F., 1870 Catalogue of the Specimens of Dermaptera Saltatoria in the Collection of the British Museum. (4), i-v: 605-801
- *Oedaleus pendulus* Steinmann, 1965 Annls. hist. Nat. Mus. Natn. Hungarici. 57:223
- *Oedipoda vastator* Fischer-Waldheim, 1833 Bull. Soc. Nat. Moscou. 6:384
- *xanthocnema* Tarbinsky, 1932 Bull. Leningrad Inst. Contr. Farm and Forest Pests. 2:201

Morphology

Latchininski & Launois-Luong (1992); Morales-Agacino (1941); Barranco & Pascual (1995)

In the male the stridulatory file is long respect to femur length. It is composed of a large number of pegs (68-80) but at a low density (Table 2). Pegs are uniformly arranged all along the file except at the two ends, where they are more irregularly arranged, more separate, as usual among Gomphocerinae (Pitkin 1976, Clemente et al. 1989). Pegs are subconical in shape, with a very rounded tip; they are inserted in alveoli with clearly defined edges. (Figures 1a and b)

The females have a lower file length / femur length ratio, with a high number of pegs (57-65), subconical in shape with very rounded tips, some irregularly disposed along the file, especially near the ends. Peg density is low. (Table 2) (Figures 2a and b)

Biology

At first sight, data on this species are very abundant. Nevertheless, closer analysis shows that our knowledge is slanted towards the gregarious form. For example, for areas of the Iberian Peninsula where it is gregarious, it is possible to find a vast bibliography in Barranco (1992). On the other hand, scarce data are available on the solitary form. For example, Morales Agacino (1941) only gives two references to the solitary form from Spain. Hence, the data presented below solely refer to the solitary form.

It has been collected between June and September, at different altitudes between sea level and 2000 m in Huesca, always in dry pastures, where species of the genera *Poa*, *Bromus*, *Nardus, Festuca, Carex, Plantago,* etc. are also found.

As regards its geographical distribution, if we exclude the provinces where its reserve areas are found, that is, Albacete, Almería, Badajoz, Cáceres, Córdoba, Ciudad Real, Huesca, Navarra and Zaragoza in Spain and Alentejo and Beira Alta in Portugal, the resulting distribution is: Baleares (Lopez Seoane, 1878), Cuenca, Gerona (Olmo i Vidal, 2002), Granada, Guadalajara (Pardo & Gómez, 1995), Huelva (Herrera, 1982), Jaén, Lérida (Olmo i Vidal, 2002), Madrid, Málaga, Murcia (Herrera, 1982), Salamanca (González García, 1981), Segovia (Herrera, 1982) Sevilla (Medina, 1890), Teruel (Herrera, 1982), Toledo (Pardo & Gómez, 1995) and Valladolid (Gutiérrez Martín, 1904). References from Portugal come from Batalha (Vargas, 1930), Coimbra (Aires & Menano, 1916), Condeixa (Vargas, 1930), Coruche (Aires & Menano, 1916), Leiria (Vargas, 1930), Lisboa (Vargas, 1930), Mora (Aires & Menano, 1916) and Serra da Estrêlha (Vargas, 1930).

Sound

We have never observed captive isolated specimens or couples singing. However, sound has been observed and recorded when several specimens were together in the same cage, independently of the sex ratio. Under these conditions, it is a very noisy species, both males and females, the males producing sound even when walking. The songs of females have always been recorded as an answer to contact actions or a male's sound. Males sing indistinctly with one or both hind legs, in an apparently synchronous movement. Females' songs are shorter and more irregular than those of males, and are produced just with one hind leg.

The male's song has been recorded in three quite different situations, which we have grouped as follows:

Calling song: produced by a male far away from other individuals. It consists of echemes of a mean length of 5.250 s (0.800-11.200) composed of 4-18 syllables separated by very irregular gaps (Figure 3a). Syllables are 0.060 s (0.045-0.081) in length and emitted at a rate of 2.02 syl./s (0.95-3.35). Every syllable is composed of 4-6 sounds clearly separated one from another (Figure 3b). All these data agree with the possible variations suggested by Ragge & Reynolds (1998) for the species.

The frequency spectrum occupies a band 6500 Hz wide, with a lower frequency towards 6000 Hz and a higher one towards 13000 Hz. The main peak appears around 8500 Hz. Other more or less notable peaks can appear at 11-12000 Hz. The lower quartil (25% of the total energy) is near 7500 Hz; the medium quartil (50% of the energy) near 8700 Hz and the upper quartil (75% of the energy) near 11000 Hz. (Figure 4)

Disturbance song: produced by individuals when there is contact with other individuals, and is not related to sex. The sound is produced with one hind leg, while with the other leg the insect tries to kick the other individual. The sound is brief, 0.04 s (0.03-0.048) in mean length. (Figure 5).

The frequency spectrum occupies a broad band of 8000 Hz, the lowest frequency being at 4500 Hz and the upper one at 12500 Hz. There are several peaks of variable intensity, at 6000, 7500 and 9000 Hz; those at the extremes can be absent. The lower quartil is near 6000 Hz; the medium quartil at 8000 Hz and the upper quartil near 10000-12000 Hz. (Figure 6)

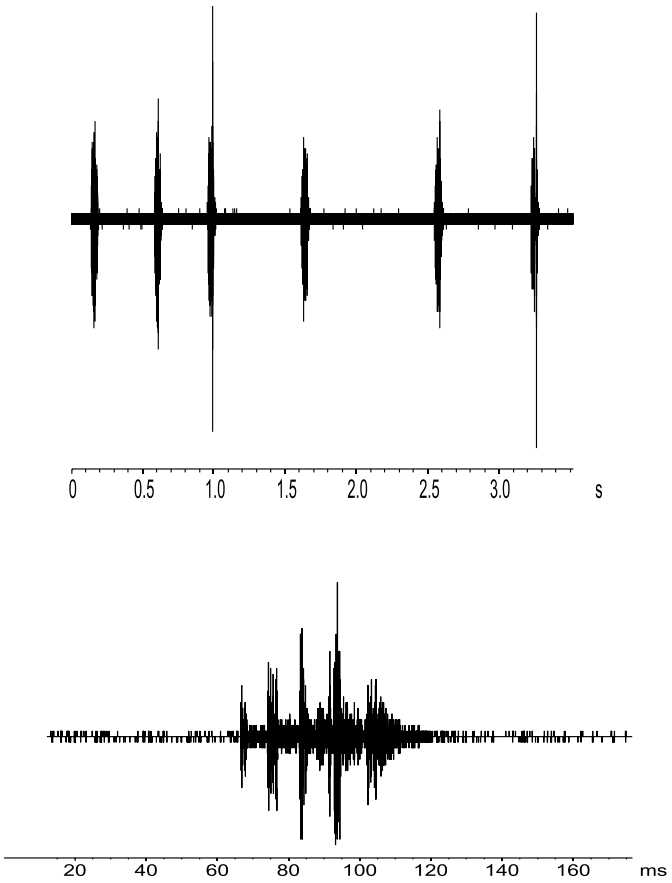


Figure 3. Calling song of *Dociostaurus maroccanus*: a.- echeme; b.- detail of a syllable.
Figura 3. Canto de proclamación de *Dociostaurus maroccanus*: a.- equema; b.- detalle de una sílaba.

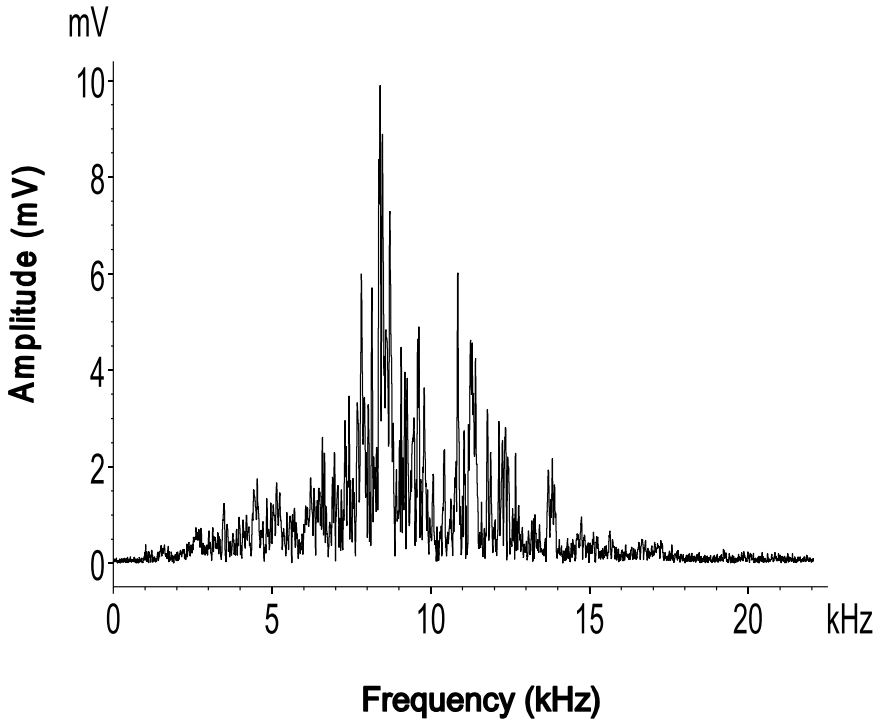


Figure 4. Frequency spectrum of *Dociostaurus maroccanus* calling song.
Figura 4. Espectro de frecuencia del canto de proclamación de *Dociostaurus maroccanus*.

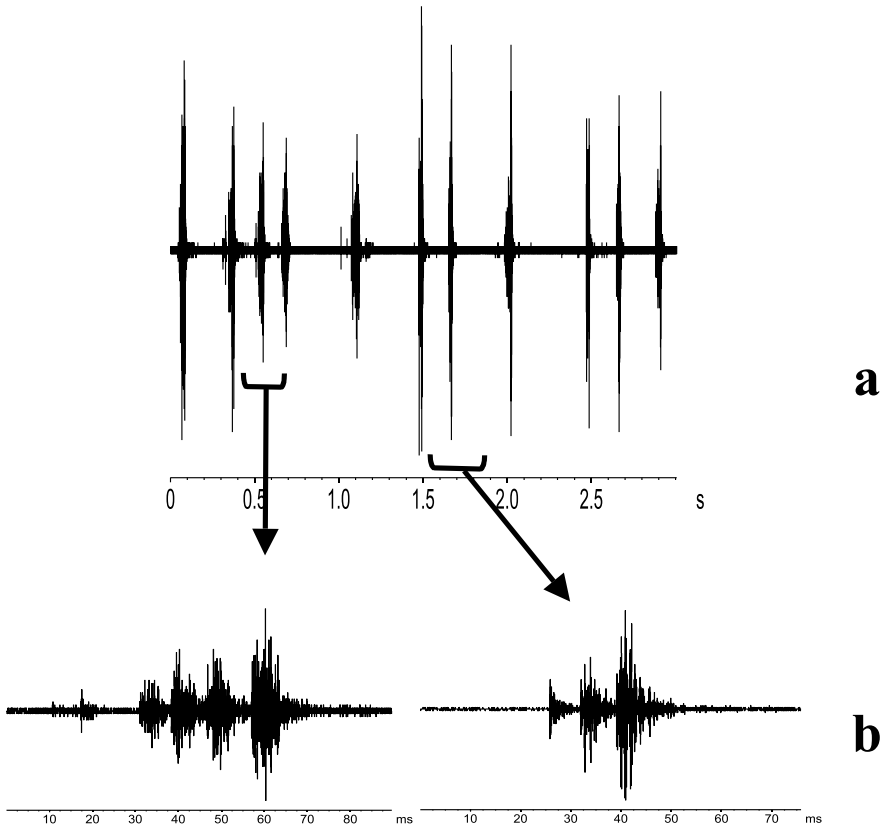


Figure 5. Disturbance song of *Dociostaurus maroccanus*: a.- sequence; b.- detail of a syllable.
Figura 5. Canto de molestia de *Dociostaurus maroccanus*: a.- secuencia; b.- detalle de una sílaba.

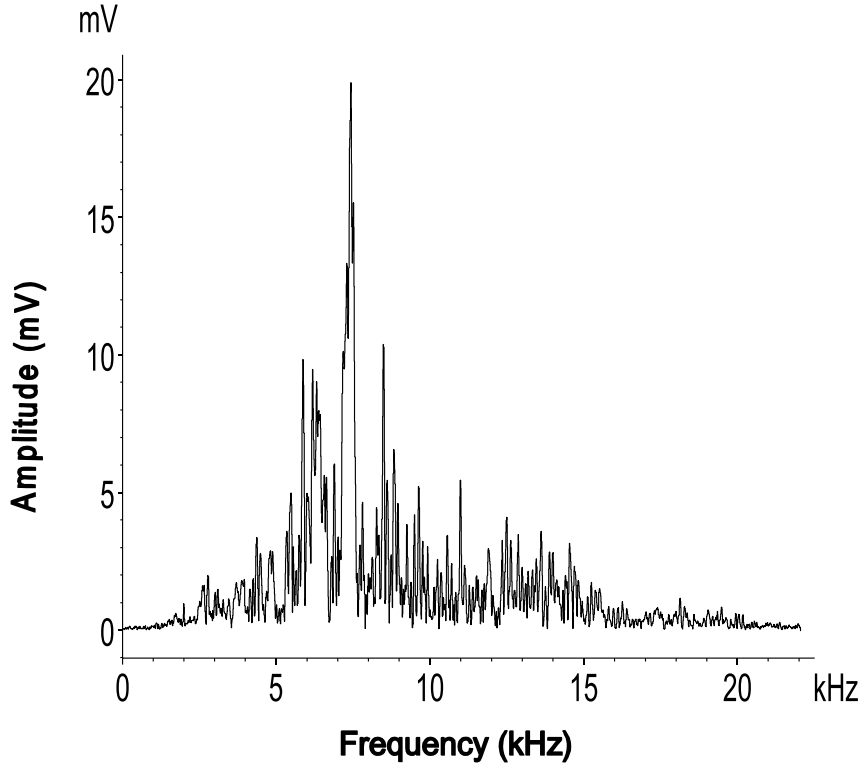


Figure 6. Frequency spectrum of *Dociostaurus maroccanus* disturbance song.
Figura 6. Espectro de frecuencia del canto de molestia de *Dociostaurus maroccanus*.

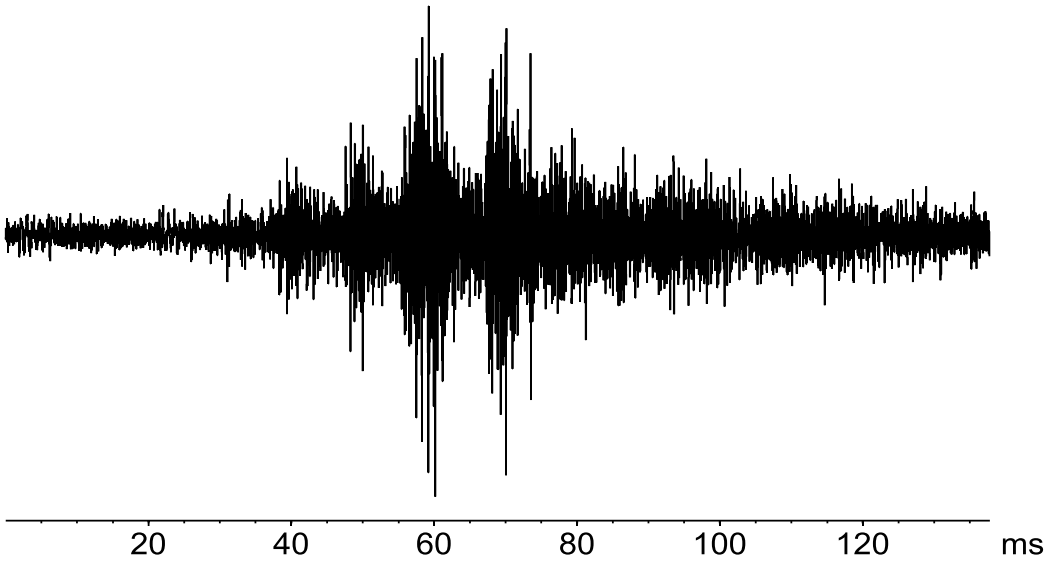


Figure 7. Syllable of *Dociostaurus maroccanus* female's song.
Figura 7. Sílaba del canto de la hembra de *Dociostaurus maroccanus*.

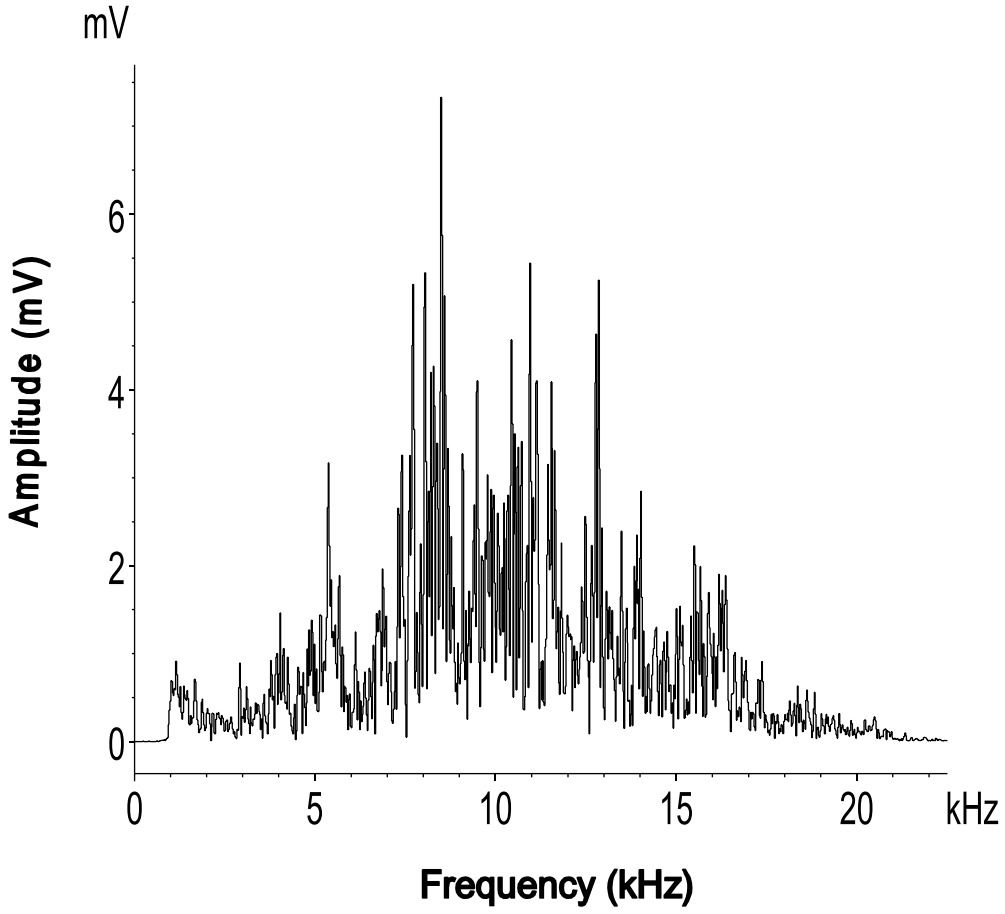


Figure 8. Frequency spectrum of *Dociostaurus maroccanus* female's song.
Figura 8. Espectro de frecuencia del canto de la hembra de*Dociostaurus maroccanus*.

Male's song when trying to mate: it has been recorded four times, when a male climbed on a female and tried to mate with her. The sound is composed of a variable number of syllables (5-10) that are 0.096 s (0.063-0.124) in length. The structure of the syllables and frequency spectrum are similar to that of the calling song.

Females's song: in different situations, when a male tries to mate, or other individual comes close to her, the female produces a sound, which can be intercalated with that of the male. The sound is made up of isolated syllables (Figure 7), which can be repeated or not, with a mean length 0.080 s (0.067-0.095). The frequency spectrum shows a broad band, of 9000 Hz, the lowest frequency being at 5200 Hz and the higher one at 14200 Hz. There are several peaks, with the main one at around 9000 Hz. Other peaks, of lower relative intensity, occur towards 10500 and 12700 Hz. Other weaker peaks can appear near the ends of the band. (Figure 8). The lower quartil is near 7700 Hz; the medium quartil at 10150 Hz and the upper quartil near 13000 Hz.

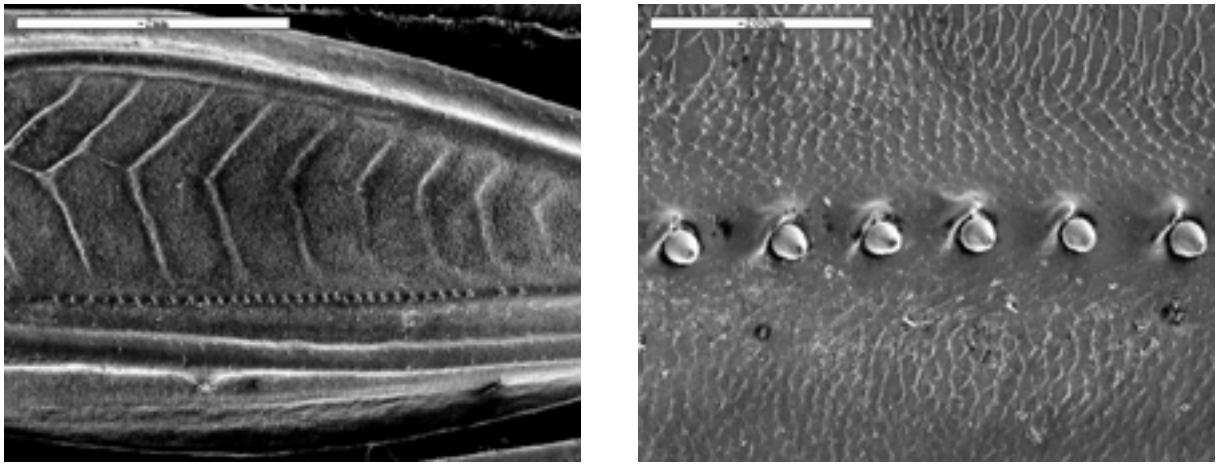


Figure 9. *Dociostaurus crassiusculus* male: a.- general appearance of the stridulatory file; b.- detail of the middle zone.
Figura 9. *Dociostaurus crassiusculus* macho: a.- aspecto general de la fila estriduladora; b.- detalle de la zona media.

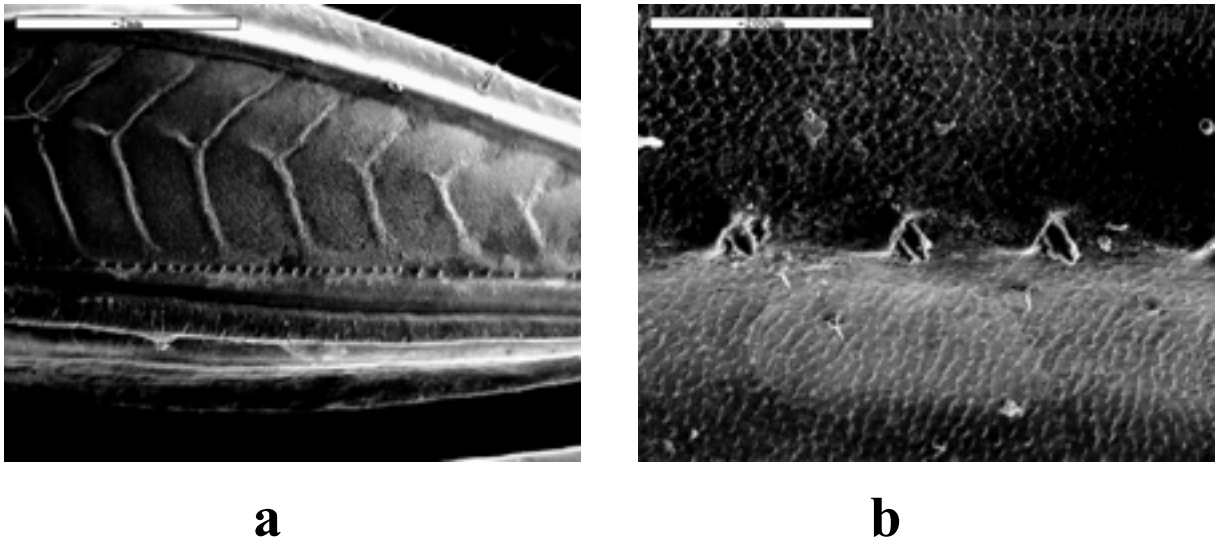


Figure 10. *Dociostaurus crassiusculus* female: a.- general appearance of the stridulatory file; b.- detail of the middle zone.
Figura 10. *Dociostaurus crassiusculus* hembra: a.- aspecto general de la fila estriduladora; b.- detalle de la zona media.

Dociostaurus crassiusculus crassiusculus (Pantel, 1886)

Pantel, 1886. An. Soc. Españ. Hist. Nat. 15:237 as *Stauronotus crassiusculus*

Morphology

Morales-Agacino (1941); Soltani (1978).

The male has a stridulatory file which is straight and very long in relation to the femur length. It is composed of few pegs (27-35) and the peg density is very low (Table 2). The number of pegs is similar to that (30-40) given by Soltani (1978) for the subspecies. The pegs are conical in shape, with pointed tips, inserted in an alveolus with one lateral border. At the ends of the file the pegs are slightly more separated (Figures 9a and b). Females have a stridulatory file straight and long, but almost vestigial. It has few pegs (26-34), and the density is, also, low. Pegs are well spaced. They are slender and long, with a pointed tip. (Table 2) (Figures 10a and b).

Biology

Because known captures of this species are scarce, data referring to its biology are limited. The species has been collected between June and August, in dry, steppe, saline and gypsum sites, with a scarce and low scrub of rock rose and lavender and low dry land pasture. Its altitudinal range runs from 600 to 1200 m.

Despite the limited knowledge of its biology its chromosomes (Santos et al., 1983) are known.

Distribution

It is an Iberian endemism, known from Albacete, Ciudad Real (Pardo & Gómez, 1995), Cuenca, Madrid and Toledo (Pardo & Gómez, 1995).

Sound

In the literature there is only the reference from Pantel (1886), who indicates *"it should be a bad singer, although I have not listened, because it just has 13 pegs in its stridulatory file"* (sic).

Only the sound produced by males has been recorded. The sound produced is almost inaudible, although they are very noisy animals, which produce sound almost continuously and in many situations, whether the individuals are separated or whether they are close to each other, whether of the same sex or the opposite. They sing when chasing females and in conflict or interaction situations.

The male sings moving only one or both hind legs almost synchronously regardless of the situation. In a same song both kinds of sound production can be found.

After analysing the structure and duration of sounds produced in the different situations, and studying their spectral characteristics, no clear differences could be established between them; so that we consider that *D. crassiusculus* produces only one kind of song, a calling song, which is composed of sequences of echemes formed by a variable number of syllables (1-7) (Figure 11a). Syllables have a very uniform general structure. They start louder and their intensity decreases progressively (Figure 11b). This characteristic makes them unmistakable, since it is unique among the studied species of the genus. The mean whole echeme length is 1.917 s (0.536-3.207) and that of the syllables 0.113 s (0.058-0.134). Syllables are emitted at a rate of 2.26 syl./s (1.120-3.73).

The frequency spectrum occupies a broad band, of about 7500 Hz, with the lowest frequency towards 3700 Hz and the highest towards 11000 Hz. There is a main peak at around 8000 Hz, and another weaker peak between 3000 and 4000 Hz. In some interaction situations this last peak is replaced by another, around 6500 Hz, which sometimes becomes the main peak. The lower quartil is near 5000 Hz; the medium quartil at 8000 Hz and the upper quartil near 10000Hz. (Figure 12).

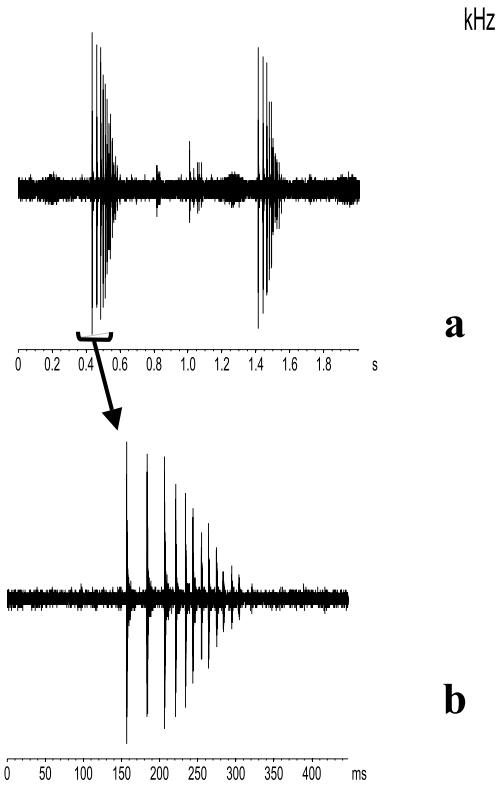


Figure 11. Song of *Dociostaurus crassiusculus*: a.- echeme; b.- detail of a syllable.
Figura 11. Canto de *Dociostaurus crassiusculus*: a.- equema; b.- detalle de una sílaba.

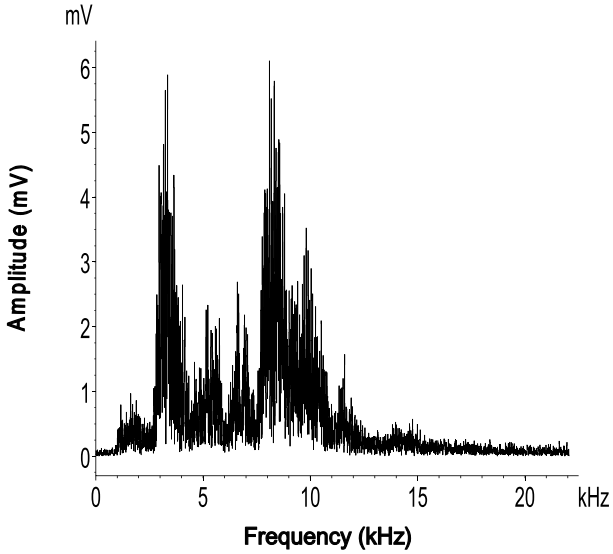


Figure 12. Frequency spectrum of *Dociostaurus crassiusculus* song.
Figura 12. Espectro de frecuencia del canto de *Dociostaurus crassiusculus*.

Dociostaurus genei genei (Ocskay, 1832)

Ocskay. 1832. Nova Acta Phys.-Med. Acad. Leop. Car. 16(2):961 as *Gryllus genei*

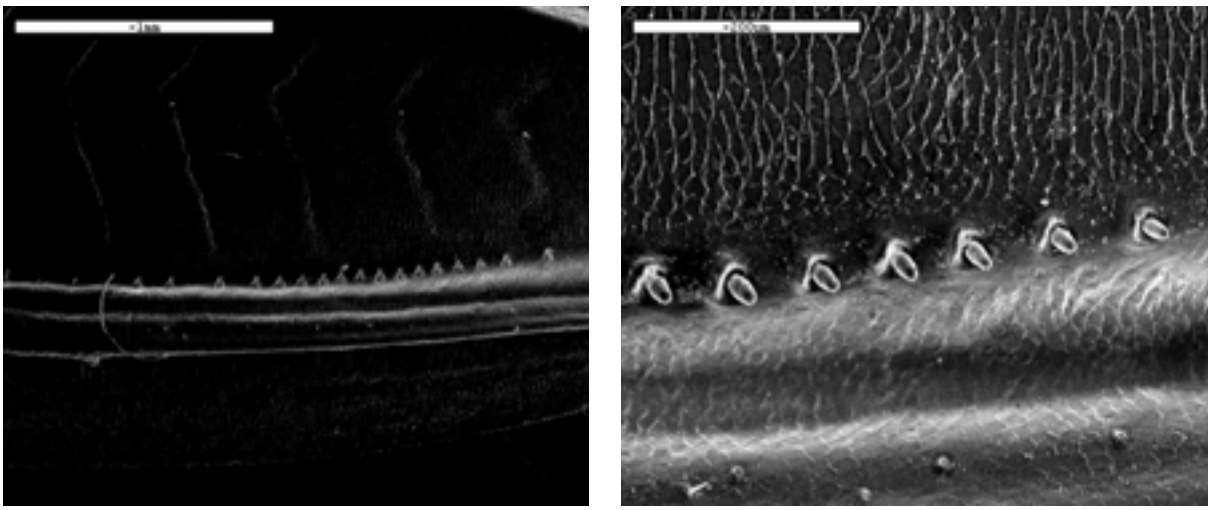
• *Gryllus crucigerus* Rambur, 1838 Fauna Andalous. 2:86

• *Acridium pygmaeum* Fischer-Waldheim, 1853 Bull. Soc. Nat. Moscou. 6:353

Morphology

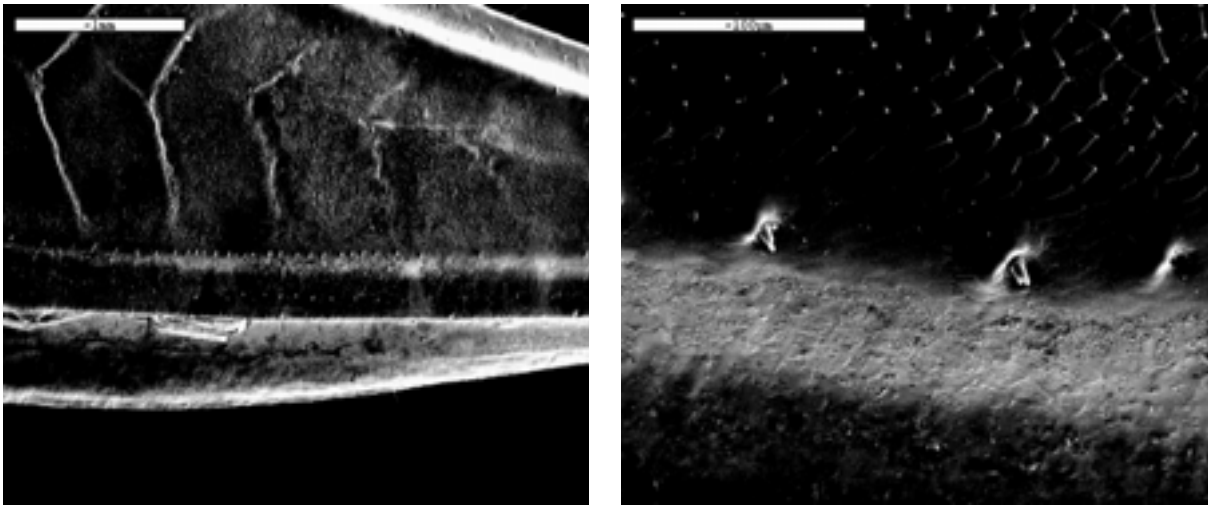
Soltani (1978).

The male has a stridulatory file, very short with respect to the femur length; it is somewhat curved and situated in the inner fore half of the hind femur. It is composed of a very low number of pegs (21-33), well



a b

Figure 13. *Dociostaurus genei* male: a.- general appearance of the stridulatory file; b.- detail of the middle zone.
Figura 13. *Dociostaurus genei* macho: a.- aspecto general de la fila estriduladora; b.- detalle de la zona media.



a Figura 14 b

Figure 14. *Dociostaurus genei* female: a.- general appearance of the stridulatory file; b.- detail of the middle zone.
Figura 14. *Dociostaurus genei* hembra: a.- aspecto general de la fila estriduladora; b.- detalle de la zona media.

spaced, mainly at the ends of the file. The number of pegs is similar to that given by Soltani (1978) (22-35) for the subspecies. Peg density is average. (Table 2). Pegs are pointed and very slender, resembling thorns at the file ends (Figure 13a and b).

Females have a stridulatory file almost vestigial, very short, difficult to see and composed of a very low number of pegs (17-26) irregularly arranged all along the file. The pegs, which are inserted in alveoli of clearly defined edges, hardly project outside these structures. They are poorly differentiated, like thorns or spatulas, like hairs or bristles at the ends of the file. (Table 2) (Figure 14a and b)

Biology

We think that the data from Soltani (1978) and those from Llorente (1980) are the first clearly referring to this species as different from *D. jagoi occidentalis*.

It lives from June to November, having a maximum for both sexes in August. Its altitudinal range runs from sea level, in Doñana (Huelva), to 2500 m in Sierra de Guadarrama. It occupies arid areas. Where it has been studied in detail, it prefers open scrub and grass dry land pastures, of *Thymo cistetum* var. *cistisum, Helichriso serotini- Thymetum mastichinae, Trifolium fragiferi-Cynodontetum dactylonis,...*types. It is graminivorous (Aguirre et al., 1987). Rodríguez Iñigo et al. (1993) have studied its chromosomes.

Distribution

As in the case of *D. jagoi occidentalis*, we consider Llorente (1980) as the starting reference for its distribution in the Iberian Peninsula. We do not take into consideration Herrera (1982) because the author does not examine the references critically, and awards to *D. genei* all the previous references from the literature, not taking into account that they could correspond to *D. jagoi occidentalis*, as later revealed to be the case (Gangwere & Llorente, 1992; Llorente & Pinedo, 1988, etc...).

As a consequence, this species is, to date, known from Albacete, Badajoz, Burgos, Córdoba, Cuenca (Pardo & Gómez, 1995), Ciudad Real (Pardo & Gómez, 1995), Guadalajara (Pardo & Gómez, 1995), Granada (Beiro et al., 1998), Huelva, Jaén (Soltani, 1978), León, Madrid, Orense (Soltani, 1978), Salamanca (Aguirre-Segura et al., 1995), Segovia (Soltani, 1978), Teruel and Toledo (Pardo & Gómez, 1995).

Sound

In the literature only the reference from Chopard (1951) referred to by Luquet (1978) has been found.

The specimens sing both in isolation and when with other individuals. They are not very noisy. When singing, the males move their two hind legs very rapidly and slightly asynchronously, raising them very with little respect to the resting position. On few occasions we have observed the males producing mute movements of the hind legs, like those described by García et al. (1994) for *D. jagoi occidentalis*.

The males sing when alone or far from of other individuals, in the presence of females and close to them, when close to other males and when fighting with them. The females sing occasionally when disturbed by other individuals, males or females.

Analysis of all the sounds and the differences between leads us to suggest the following kind of songs.

Calling song: made up of echemes of average duration 1.98 s (0.632-3.379), composed of 5 syllables (2-8). Syllabes are 0.090 s (0.033-0.154) in length and emitted at a rate of 2.47 syl./s (1.17-4.22). (Figure 15)

The frequency spectrum occupies a 13000 Hz-wide band, with the lower frequency around 7000 Hz and the higher one around 20000 Hz. There are two peaks, of variable relative intensity, one around 8500 Hz and the other around 12000 Hz. The lower quartil is close to 9000 Hz, the mean quartil around 11500 Hz and the upper quartil close to 14500 Hz. (Figure 16)

Courtship song: made up of echemes of mean duration 1,84 s (0.329– 5.785), composed of 5 syllables (2-8) of 0.100 s (0.025- 0.212) in length. They are emitted at a rate of 3.39 syl./s (1.38-6). (Figure 17)

The frequency spectrum occupies a 15500 Hz-wide band, with the lower frequency at 2000 Hz and the higher one at 17500 Hz. There are three peaks of variable relative intensity, at 6000, 8000 and 10000 Hz. The lower quartil is close to 6500 Hz, the mean quartil at 9300 Hz and the upper quartil close to 14000 Hz. (Figure 18)

Disturbance song: the males produce syllables of 0.050 s (0.025-0.075) in length, single in structure (Figure 19). The frequency spectrum occupies a broad band, 13500 Hz wide, with the lower frequency at 4000 Hz and the higher one at 17500 Hz. There is a main peak at around 8500 Hz and another peak at around 11000 Hz. The lower quartil is close to 8500 Hz; the mean quartil around 11000 Hz and the upper quartil close to 14000 Hz. These data make the song similar to the calling song. (Figure 20)

The females produce isolated and irregular syllables, of varying structure and duration. They are 0.110 s (0.018-0.230) in length (Figure 21). The frequency spectrum occupies a band of 12000 Hz; the lower frequency is around 4000 Hz and higher one at 16000 Hz as a mean. The main peak is around 9000 Hz. There may be another peak at around 13000 Hz. The lower quartil is close to 8000 Hz; the mean quartil around 11000 Hz and the upper quartil close to 14000 Hz. (Figure 22)

The structures of the calling and courtship songs are similar. They show an amplitude progressively increasing from the beginning, as well as in every syllable, as in *D.jagoi* (Ragge & Reynolds, 1998) and in the courtship song of *D. genei littoralis* (Blondheim, 1990). Nevertheless, some variations can be observed in syllables length and the emission rate; the syllables are longer and the emission rate is higher in courtship than in calling song. Although the frequency band is

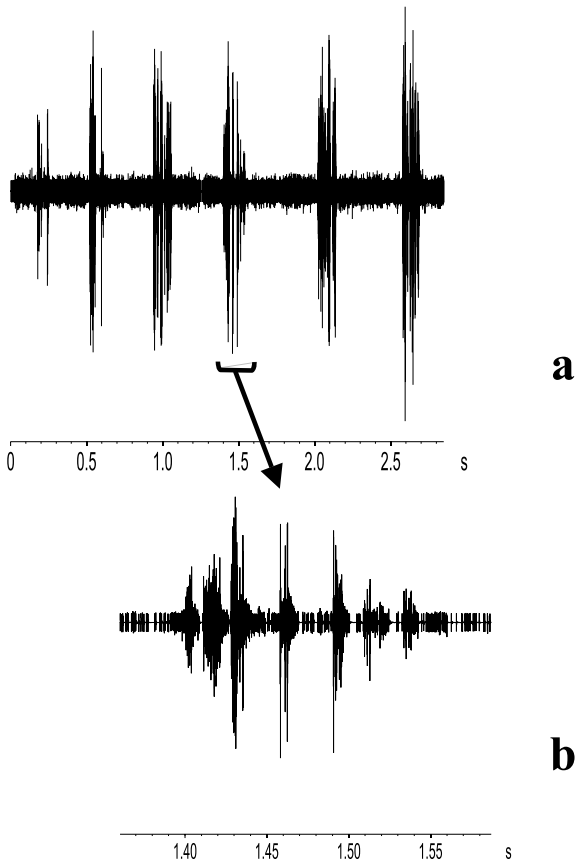


Figure 15. Calling song of *Dociostaurus genei*: a.- echeme; b.- detail of a syllable.
Figura 15. Canto de proclamación de *Dociostaurus genei*: a.- equema; b.- detalle de una sílaba.

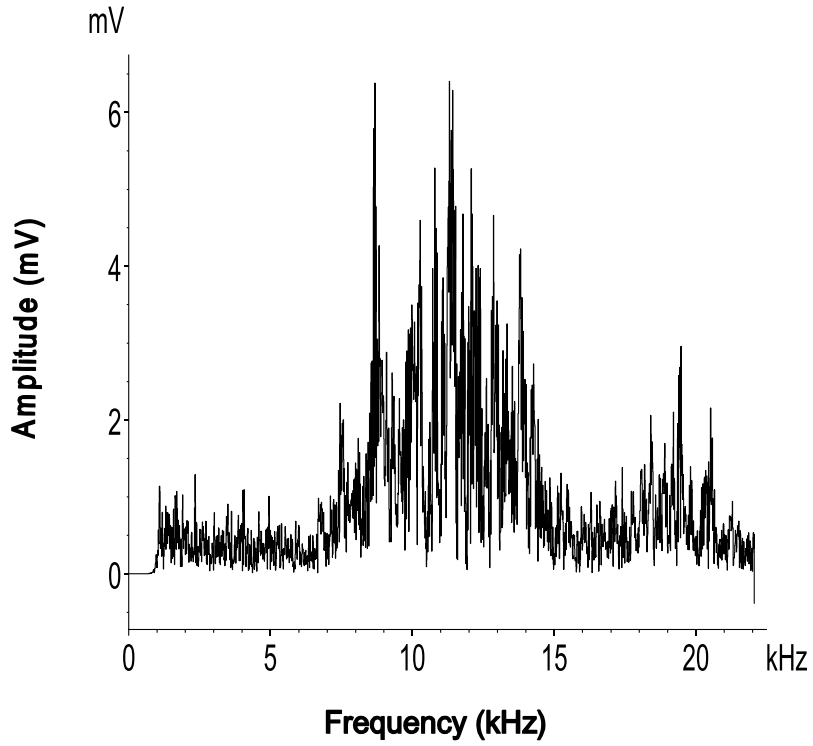


Figure 16. Frequency spectrum of *Dociostaurus genei* calling song.
Figura 16. Espectro de frecuencia del canto de proclamación de *Dociostaurus genei*.

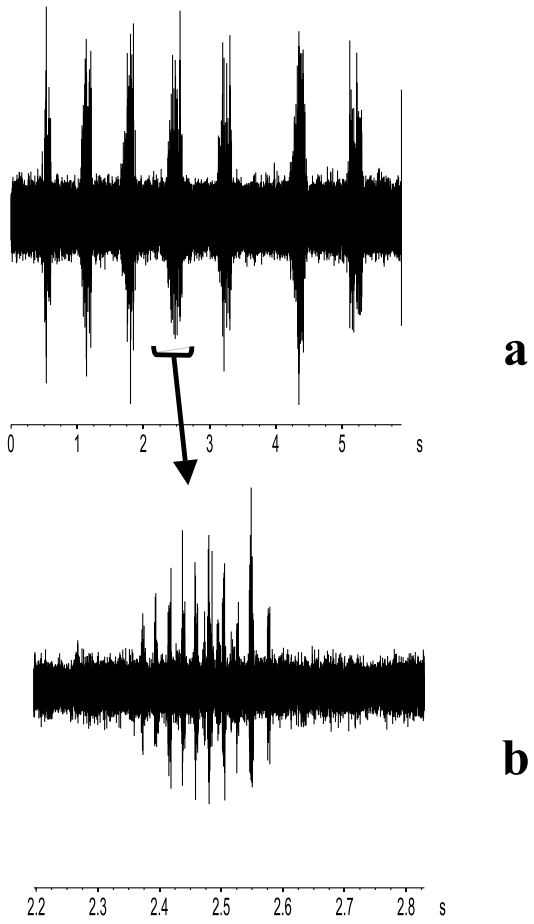


Figure 17. Courtship song of *Dociostaurus genei*: a.- echeme; b.- detail of a syllable.
Figura 17. Canto de cortejo *Dociostaurus genei*: a.- equema; b.- detalle de una sílaba.

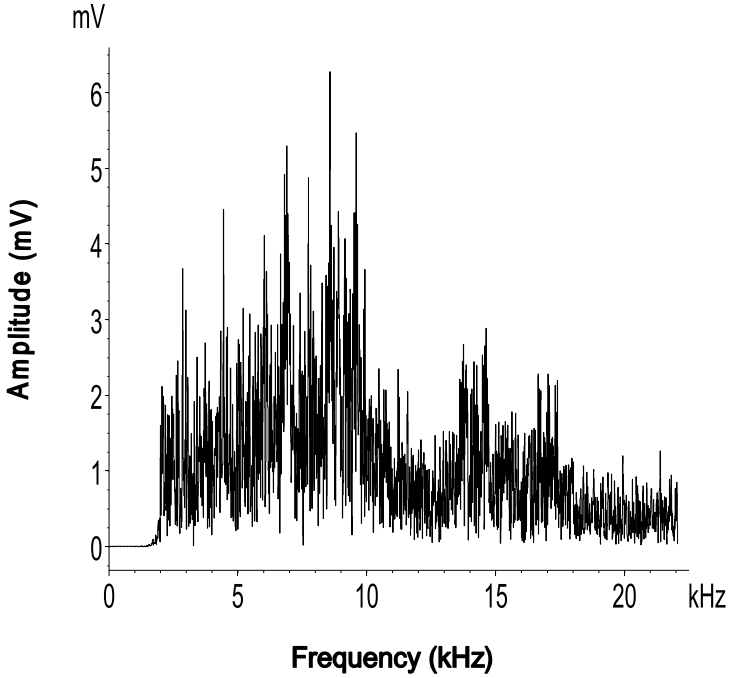


Figure 18. Frequency spectrum of *Dociostaurus genei* courtship song.
Figura 18. Espectro de frecuencia del canto de cortejo de *Dociostaurus genei*.

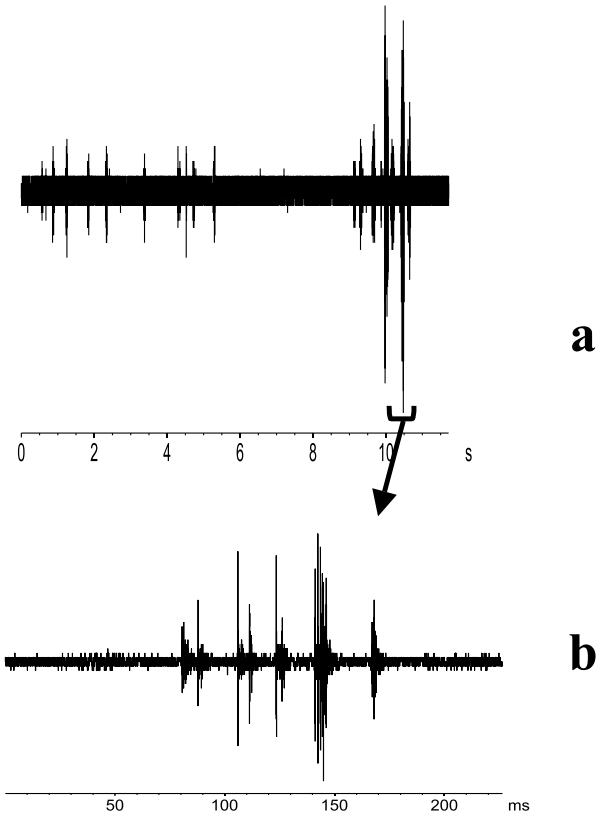


Figure 19. Disturbance song of *Dociostaurus genei*: a.- sequence; b.- detail of a syllable.
Figura 19. Canto de molestia de *Dociostaurus genei*: a.- secuencia; b.- detalle de una sílaba.

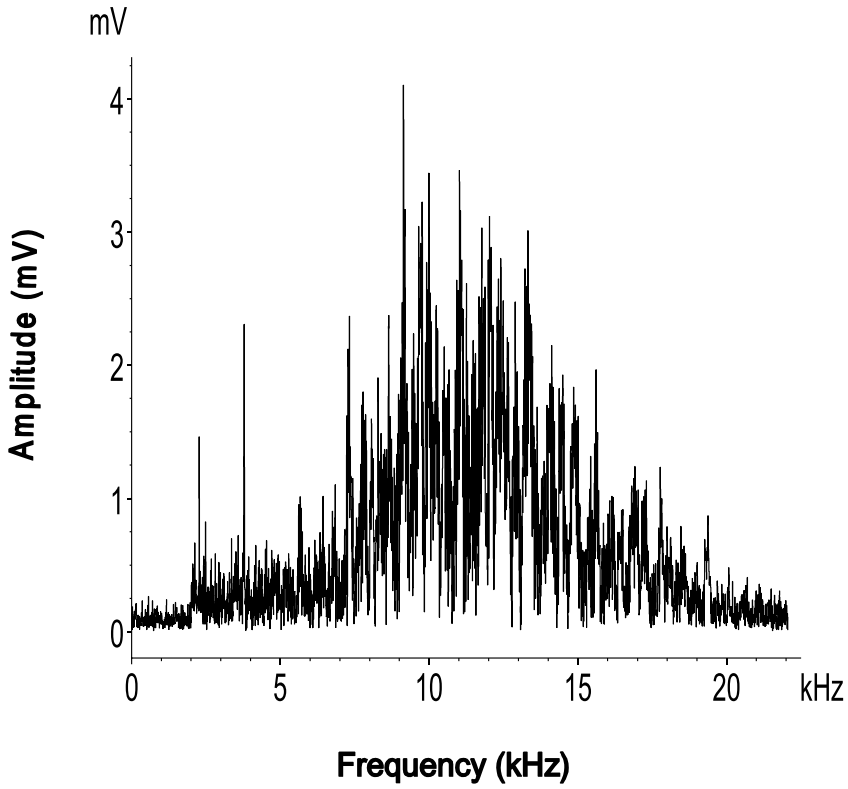


Figure 20. Frequency spectrum of *Dociostaurus genei* disturbance song
Figura 20. Espectro de frecuencia del canto de molestia de *Dociostaurus genei*.

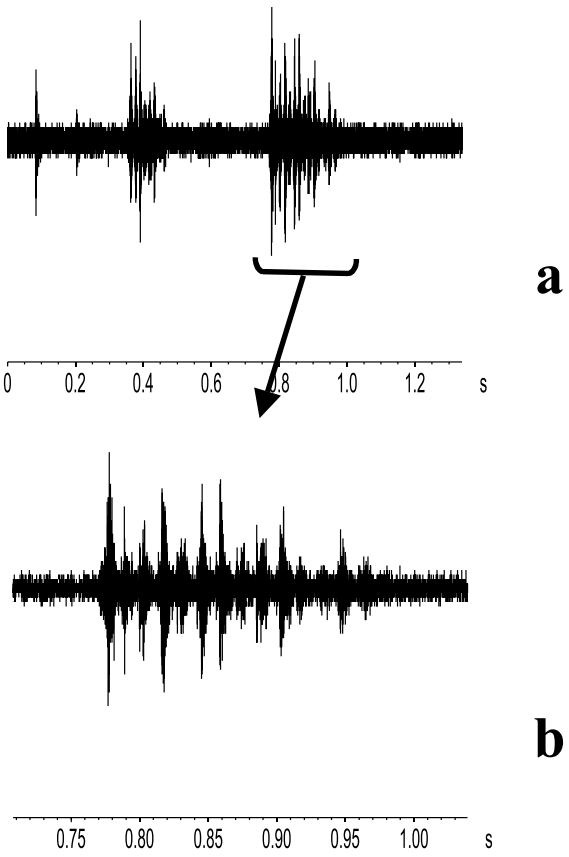


Figure 21. *Dociostaurus genei* female's song: a.- two syllables; b: detail of a syllable.
Figura 21. Canto de la hembra de *Dociostaurus genei*: a.- dos sílabas; b: detalle de una sílaba.

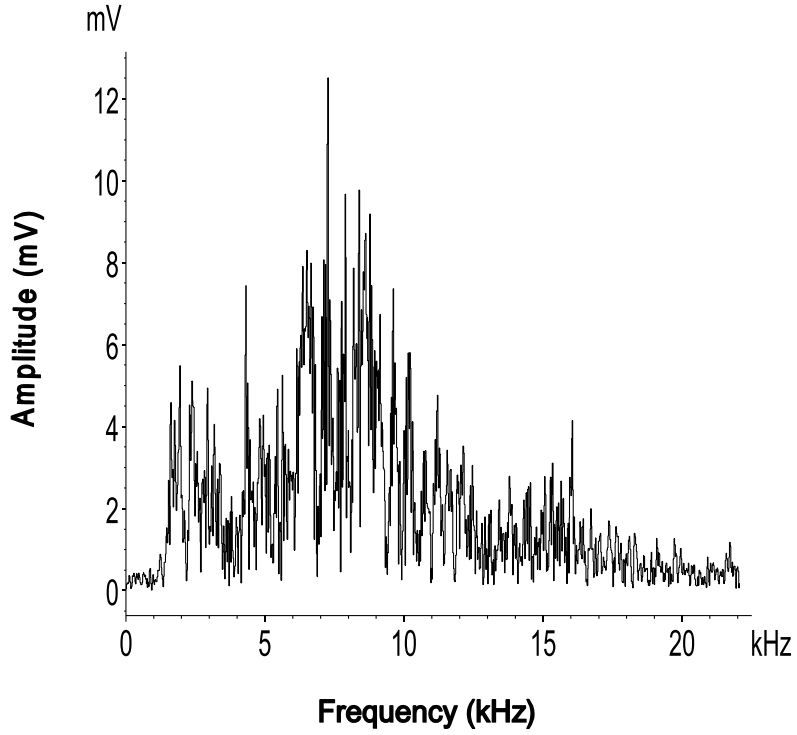
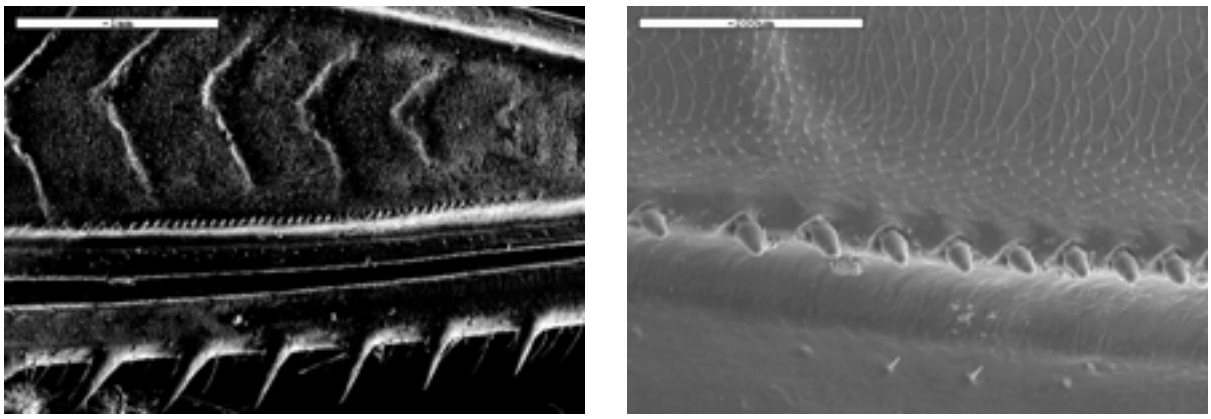
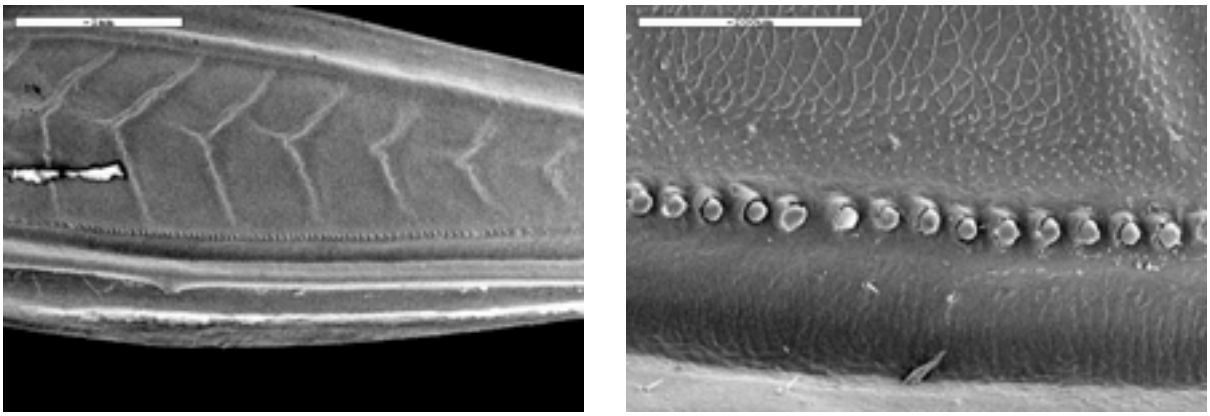


Figure 22. Frequency spectrum of *Dociostaurus genei* female's song.
Figura 22. Espectro de frecuencia del canto de la hembra de *Dociostaurus genei*.



a b

Figure 23. *Dociostaurus jagoi occidentalis* male: a.- general appearance of the stridulatory file; b.- detail of the middle zone.
Figura 23. *Dociostaurus jagoi occidentalis* macho: a.- aspecto general de la fila estridulador; b.- detalle de la zona media.



a b

Figure 24. *Dociostaurus jagoi occidentalis* female: a.- general appearance of the stridulatory file; b.- detail of the middle zone.
Figura 24. *Dociostaurus jagoi occidentalis* hembra: a.- aspecto general de la fila estridulador; b.- detalle de la zona media.

the same in both kinds of song, that of the courtship song tends towards lower frequencies.

Dociostaurus jagoi occidentalis Soltani 1978

Soltani. 1978. J. Entomol. Soc. Iran. Suppl. 2:29

• *Dociostaurus monserrati* García & Presa, 1984. Bol. Asoc. Esp. Entomol. 8:21

García & Presa (1984) described *D. monserrati* on the basis of 8 specimens collected in Sierra Espuña (Murcia). This species was very close to *D. jagoi occidentalis*, with which it was sympatric, and to *D. gene*i. It could be differentiated from them by the epiphallus and penis basal valves structure, although the last character was considered with certain reservations because could be due to specimen immaturity. Défaut (1987) doubts the validity of the species because he considers that the characters used to differentiate it are of little validity due to their variability, while the rest of the characters are sufficient valid to consider the specimens as belonging to the other two species. Gómez et al. (1992) cited the species from three localities of Sierra del Taibilla (Albacete), as collected between 1987 and 1989. Pardo et al. (1995) cited it from two new localities of the Sierras of Alcaraz and Segura (Albacete), collected in 1989. In both cases it was found sharing habitat with *D. jagoi occidentalis.* Unfortunately, not all these specimens could be studied; we have only been able to study three speci-

mens from Sierra del Taibilla, none of which presented characters of *D. monserrati*. Despite the numerous samplings we have made in the last fifteen years, it has not been collected, either in the locus typicus or in Albacete province; in all these localities only *D. jagoi occidentalis* has been collected.

Taking into account the previous considerations, we have decided to propose the synonymy of *D. monserrati* with *D. jagoi occidentalis*, because we consider that the typical specimens used to describe *D. monserrati* were really immature specimens of *D. jagoi occidentalis*.

Morphology

Soltani, 1978. García & Presa, 1984.

The stridulatory file of the male is straight and long in relation to the femur length. Peg number (44-58) and density are high (Table 2). The pegs are conical in shape, with pointed tips. They are inserted through a long peduncle in alveoli of poorly defined borders. At the file ends, the pegs are more irregularly arranged (Figures 23a and b). The number of pegs falls into the range given by Soltani (1978) (39-76) for the species.

Females have a stridulatory shorter and more irregular file than males, and a lower number of pegs (37-49). The peg density is high. Pegs are subconical in shape, with rounded tips; they do not present a peduncle and are inserted in alveoli of marked borders. (Table 2) (Figures 24a and b)

Biology

This species is present in almost all more or less dry areas of the Iberian Peninsula. It presents just one generation, from June to November, with a maximum in August for both sexes. Pulido García (1993) cited a male collected in April, which suggests the posibility of adult overwintering. The species has been collected from sea level (Llorente, 1980; Soltani, 1978) to 2100 m (in Albacete), in very diverse habitats. It prefers low dry land pastures and clear scrubs, but always related to grasses, which seems to be its preferred food (Gangwere & Morales Agacino, 1973; Gangwere & Llorente, 1992; Gangwere & Spiller 1995). Rodríguez Iñigo et al. (1993) have studied its chromosomes.

Distribution

This species is widely distributed in the Iberian Peninsula, and in Spain it is known from: Albacete, Alicante, Almería, Ávila, Badajoz, Baleares, Barcelona (Lluciá Pomares, 2002), Cádiz, Castellón (Pinedo & Llorente, 1987), Ciudad Real, Córdoba, Cuenca, Gerona, Granada, Guadalajara (Pardo & Gómez, 1995), Huelva, Huesca, Jaén (Soltani, 1978), Lérida, Málaga, Madrid, Murcia, Navarra, Palencia, Pontevedra, Segovia, Sevilla, Tarragona, Teruel, Toledo (Pardo & Gómez, 1995), Valladolid, Zamora and Zaragoza. From Portugal it is known from Tapado da Ajuda (Soltani, 1978), Mafra (Soltani, 1978), Sierra de Monchique; Vilar Formoso and Bussaco.

Sound

In general, specimens are very active and noisy; nevertheless, when a male is isolated or in presence of a female it does not sing; they only sing when several males are together in a cage.

The male behaviour is similar to that of the males of *D.genei*. They sing alone from several places in a cage and, sometimes, other males far away answer as if in a chorus. Males sing very close to females and when surrounded by other males and close to them, or when fighting with other males or interacting with them.

It has been repeatedly observed that, when one male starts singing, several other males in the same cage sing, usually alternately. This, according to Ragge & Reynolds (1998), could be considered rivalry song. After studying the different recordings, we have grouped the songs into the following categories.

Calling song: composed of echemes with a mean duration of 2.630 s (1.569-3.417). They are made up of 5-12 syllables of mean length 0.084 s (0.045-0.122), emitted at a rate of 3.48 syl./s (2.9-5.29). (Figure 25)

The frequency spectrum occupies an 8000 Hz-wide band, with the lower frequency at 4500 Hz and the higher one at 11500 Hz. The main peak is around 10000 Hz; other peaks of variable intensity appear at 6000, 7000 and 9000 Hz. The lower quartil is close to 6500 Hz; the mean quartil at 9500 Hz and the upper quartil close to 12000 Hz. (Figure 26).

The song of males together (chorus) did not differ from the calling song.

A progressive increase in amplitude can be observed from the beginning to the end of the echeme, as well as in every syllable, a characteristic already mentioned by Blondheim (1990) and Ragge & Reynolds (1998). No diplosyllables were observed, despite the assertion of García et al. (1994). When the recordings used by these authors were studied again, it seems that they confused intermingled calling songs (choruses) and an isolated calling song.

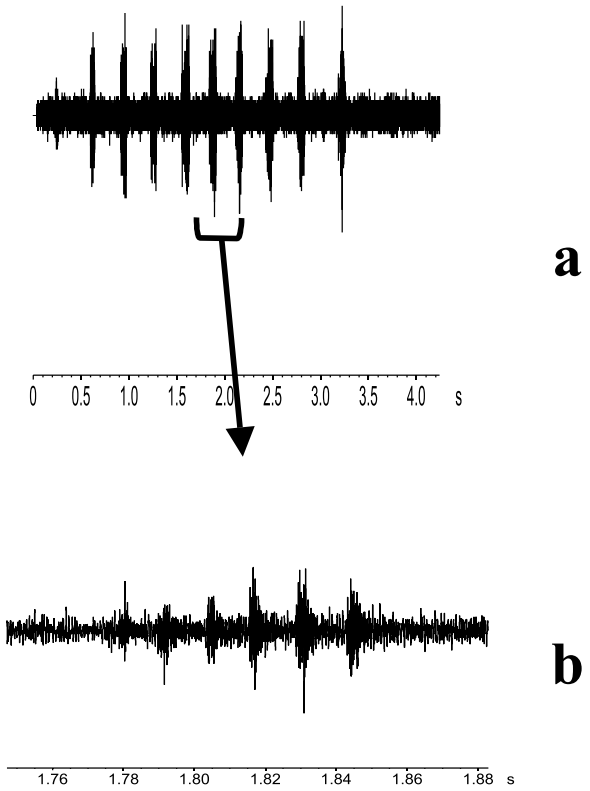


Figure 25. Calling song of *Dociostaurus jagoi occidentalis*: a.- echeme; b.- detail of a syllable.
Figura 25. Canto de proclamación de *Dociostaurus jagoi occidentalis*: a.- equema; b.- detalle de una sílaba.

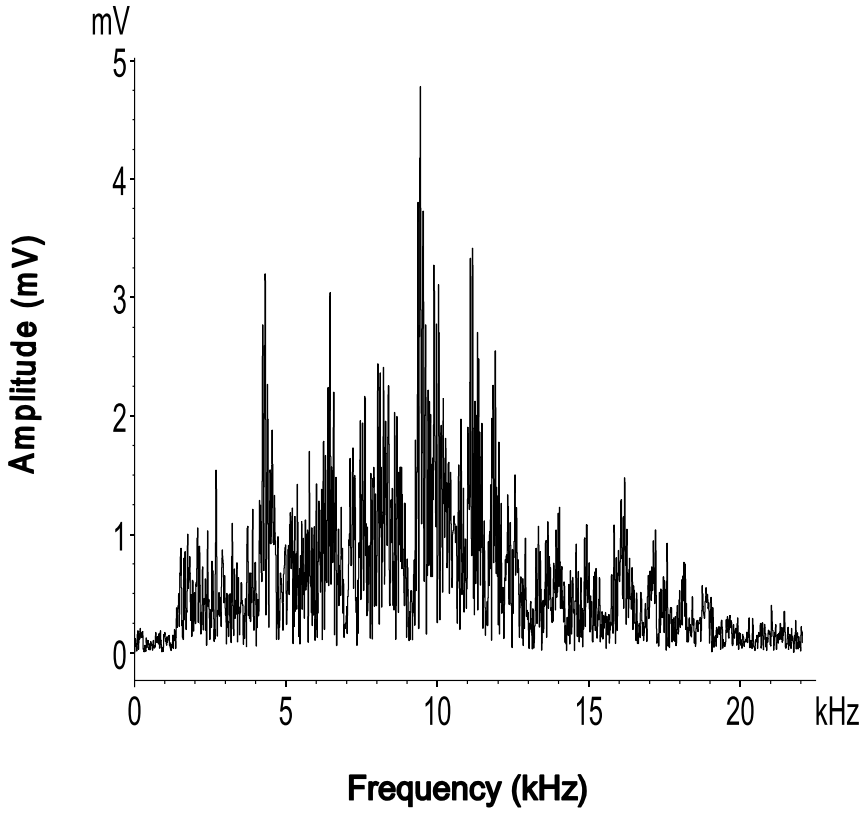


Figure 26. Frequency spectrum of *Dociostaurus jagoi occidentalis* calling song.
Figura 26. Espectro de frecuencia del canto de proclamación de *Dociostaurus jagoi occidentalis*.

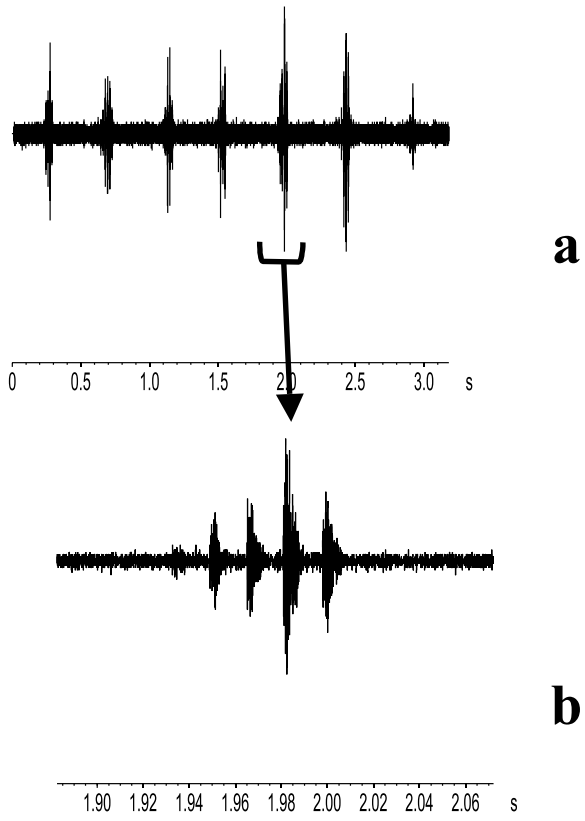


Figure 27. Courtship song of *Dociostaurus jagoi occidentalis*: a.- echeme; b.- detail of a syllable.
Figura 27. Canto de cortejo de *Dociostaurus jagoi occidentalis*: a.- equema; b.- detalle de una sílaba.

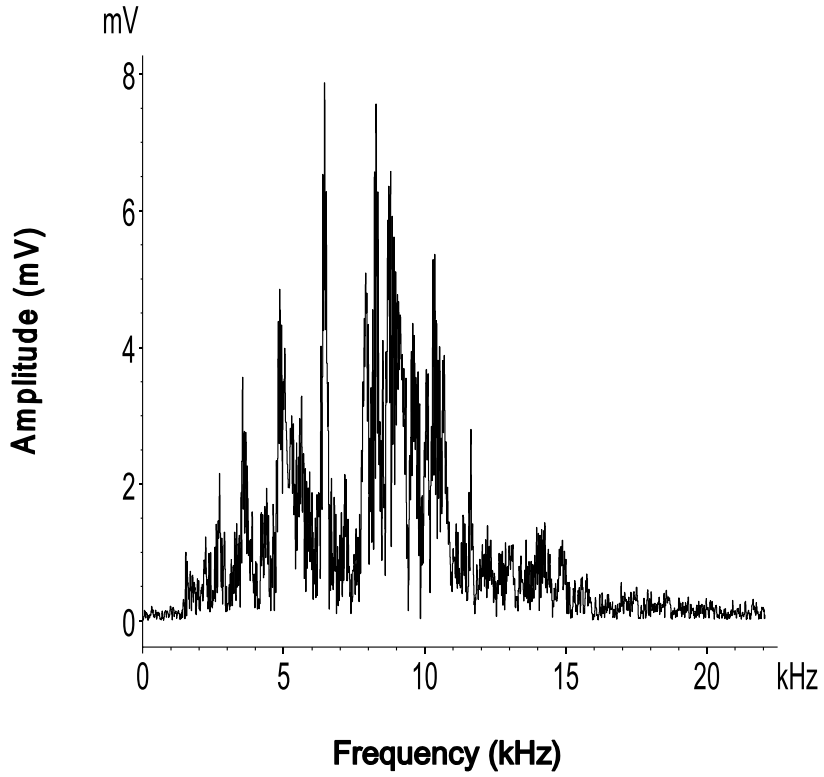


Figure 28. Frequency spectrum of *Dociostaurus jagoi occidentalis* courtship song.
Figura 28. Espectro de frecuencia del canto de cortejo de *Dociostaurus jagoi occidentalis*.

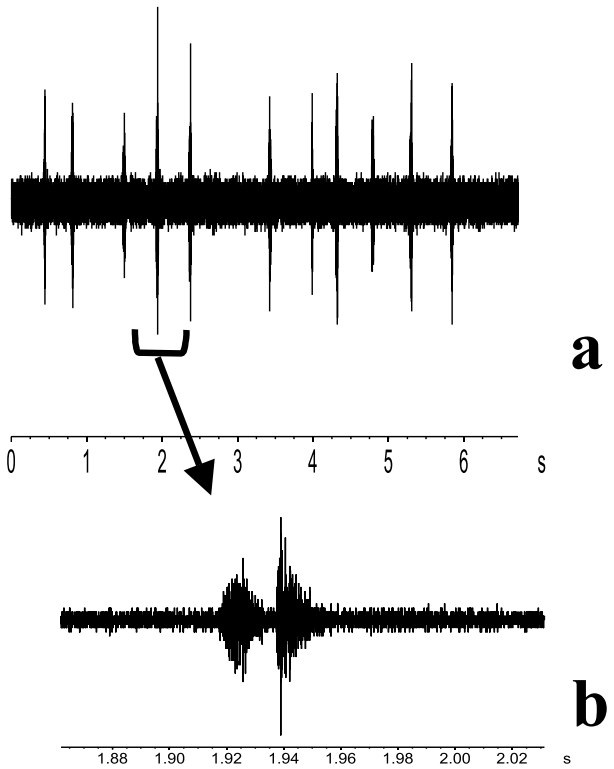


Figure 29. Disturbance song of *Dociostaurus jagoi occidentalis*: a.- sequence; b.- detail of a syllable.
Figura 29. Canto de molestia de *Dociostaurus jagoi occidentalis*: a.- secuencia; b.- detalle de una sílaba.

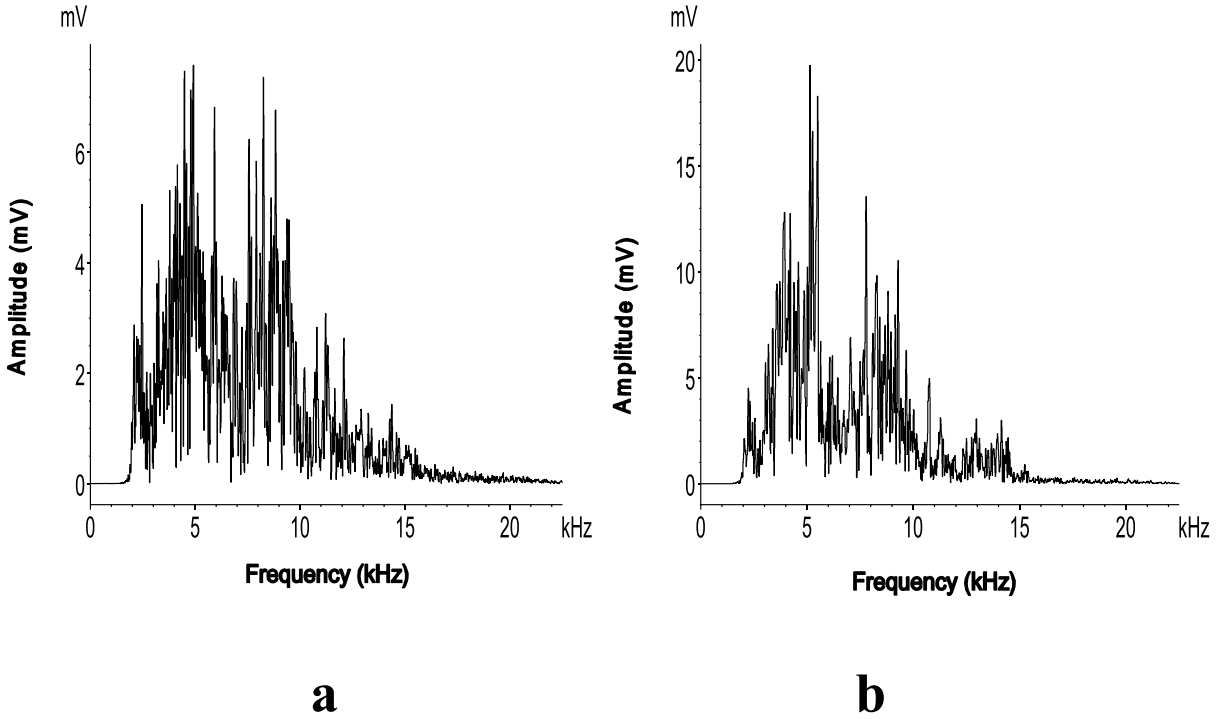


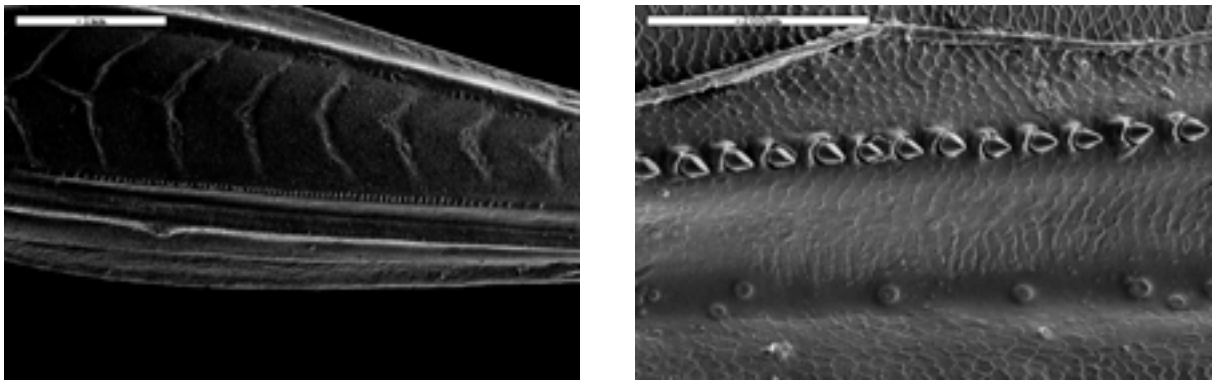
Figure 30. Frequency spectrum of *Dociostaurus jagoi occidentalis* disturbance song: a.- two peaks of similar amplitude; b.- first peak the main.
Figura 30. Espectro de frecuencia del canto de molestia de *Dociostaurus jagoi occidentalis*: a.- los dos picos con amplitud similar; b.- el primer pico el principal.

Courtship song: is composed of echemes of a mean length of 2.685 s (1.40-4.70), made up of 4-11 syllables, 0.093 s (0.064-0.138) in length, emitted at a rate of 2.62 syl./s (2.34-3.57). (Figure 27)

The frequency spectrum occupies a band 5500 Hz wide with the lower frequency at 4500 Hz and the higher one at 10000 Hz. There are two peaks, of variable relative intensity, at around 6500 Hz and 9000 Hz. The lower quartil is close to 6000 Hz; the mean quartil at 8500 Hz and the upper quartil close to 10500 Hz. (Figure 28)

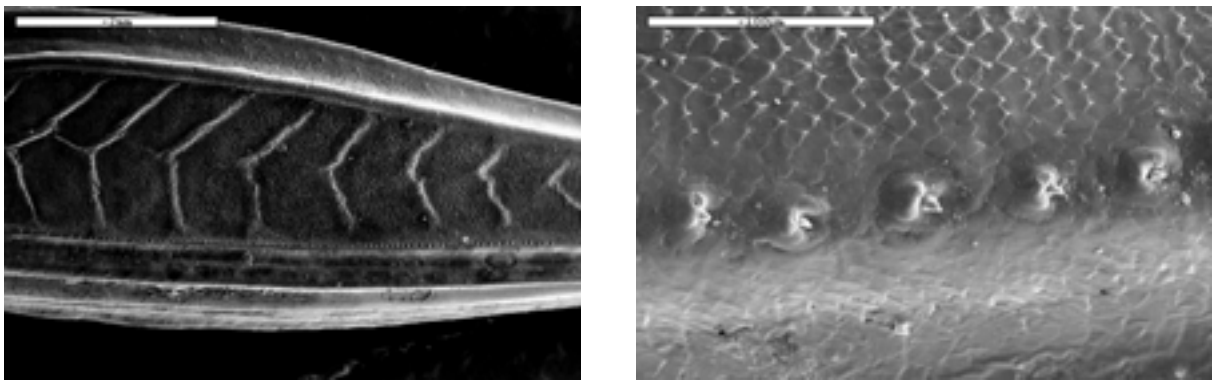
The structure of the calling song is similar to that of the courtship song, as occurs in *D.jagoi jagoi* (Blondheim, 1990). However, they can be differentiated by the emission rate and the syllable duration, which are longer in the courtship song. Differences in frequency bands, as well as the main peaks of both songs are also observed. The courtship song has a quite narrower band and the main peak is at a lower frequency than in the calling song.

Disturbance song: consists of alternate syllables, which are clearly shorter than the syllables of calling songs. The disturbance song was described by García et al. (1994) as rivalry (Figure 29). It is composed of short syllables, of a mean duration of 0.020 s (0.002 s-0.047 s), emitted alternately by two or more individuals when fighting. The frequency spectrum occupies a band 6000 Hz wide, its lower frequency being at 3300 Hz and the higher one around 9600 Hz. There are two peaks, one around 5000 Hz and other around 8000 Hz (Figure 30). Their relative intensity is variable, although the first is usually the main one



a b

Figure 31. *Dociostaurus hispanicus* male: a.- general appearance of the stridulatory file; b.- detail of the middle zone.
Figura 31. *Dociostaurus hispanicus* macho: a.- aspecto general de la fila estriduladora; b.- detalle de la zona media.



a b

Figure 32. *Dociostaurus hispanicus* female: a.- general appearance of the stridulatory file; b.- detail of the middle zone.
Figura 32. *Dociostaurus hispanicus* hembra: a.- aspecto general de la fila estriduladora; b.- detalle de la zona media.

(Figure 30b). The lower quartil is close to 4500 Hz; the mean quartil at 6500 Hz and the upper quartil close to 9000 Hz.

Dociostaurus hispanicus (Bolívar, 1898)

Bolívar, I. 1898 Catálogo sinóptico de los Ortópteros de la fauna Ibérica. Annaes de Ciencias Naturaes de Porto. 5.p. 14 como *Stauronotus brevicollis var. Hispanicus*

Morphology

Morales Agacino (1941) (as *D. crucigerus crucigerus* and *D. c. hispanicus*); Uvarov (1948); Mishchenko (1974a y b).

The stridulatory file of the male is straight and long in relation to the femur length. It has many pegs (70 – 86), with a high density (Table 2). Soltani (1978) gave a range of 58-90 for the species *D. brevicollis* (Eversmann, 1848) in which he considered this species. The number given here, although falling within the range, is quite different. The pegs are disposed very uniformly along the file except at the ends, where they are irregular and more separated. They are subconical and inserted into alveolus with clearly marked borders. Their size and shape are similar except at the file ends, where they are more pointed. (Figure 31)

Females have a stridulatory file straight, longer than in males, with more pegs (73-88). These are very small, almost invisible and translucent, very slender and pointed and arranged irregularly all along the file. Pegs are inserted in alveoli with marked borders. (Table 2) (Figure 32)

Biology

Available data cannot be generalised. In Sierra de Guadarrama the species has a single generation, from June to August, with a maximum in July. In Dehesa of Salamanca it has been collected in June and July, and in Toledo from May to July. Morales Agacino (1941) cited it as adult from April to September and, even, October. The species has been collected between 500 and 1300 m, always in xerophilic vegetation, mainly dry land pastures and low and sparse shrubs. Santos et al. (1983) studied its chromosomes.

Distribution

Ciudad Real (Navás, 1924), Cuenca, Jaén (Navás, 1924), Madrid, Salamanca, Toledo (Pena, 1980), Valladolid (Gutiérrez Martín, 1904). It is an Iberian endemism because the references from France, besides being very doubtful according to the known distribution, have been rejected by Uvarov (1948), who corrected his own error, which had been maintained in the literature since Uvarov (1921).

Sound

Only the data from Ragge & Reynolds (1998) are known about the calling song.

Like other species of the genus, it is noisy and produces audible sound in several circumstances. All the studied recordings were made when several specimens were in the same cage.

Sound production has been recorded in the following situations: males far from other individuals, male close to a female, male trying to mate with a female and individuals interacting and disturbing. Thus, the following types of song can be identified.

Calling song: This is composed of sequences lasting 0.189 s (0.126-0.281) of 1-4 echemes of mean duration 0.189 s (0.126-0.281), irregularly emitted. The echemes consist of 4-10 syllables of a mean duration of 0.016 s (0.006-0.025), emitted at a rate of 38 syl./s (31.74-47.81) (Figure 33). These values are lightly lower than those from Ragge & Reynolds (1998) but fall into the variability range.

The frequency spectrum occupies an 8500 Hz wide band, with its lower frequency at 3000 Hz and the higher one at 11500 Hz. There are two peaks, of variable intensity, one just below 5000 Hz and other at 8000 Hz. Their relative intensity is variable, although the first is usually the main one (Figure 34a). Sometimes there is another peak around 6500 Hz, in which case the spectrum seems to be displaced towards higher frequencies (Figure 34b). The lower quartil is close to 5000 Hz; the mean quartil at 7000 Hz and the upper quartil close to 10000 Hz

Echemes start very gently and achieve their maximum intensity in the second half. The final syllables are double, as mentioned by Ragge & Reynolds (1998). (Figure 33)

The males produce this type of song moving one hind leg or both two hind legs almost synchronously.

Courtship song: This is formed by sequences of 1-3 echemes lasting a mean 0.170 s (0.126-0.209). Echemes consist of 5-8 syllables of mean duration 0.020 s (0.008-0.027), emitted at a rate of 38.82 syl./s (36.26-43.01). (Figure 35)

The frequency spectrum occupies a 5500 Hz-wide band, its lower frequency being around 4400 Hz and the higher at 10000 Hz. There are two main peaks,

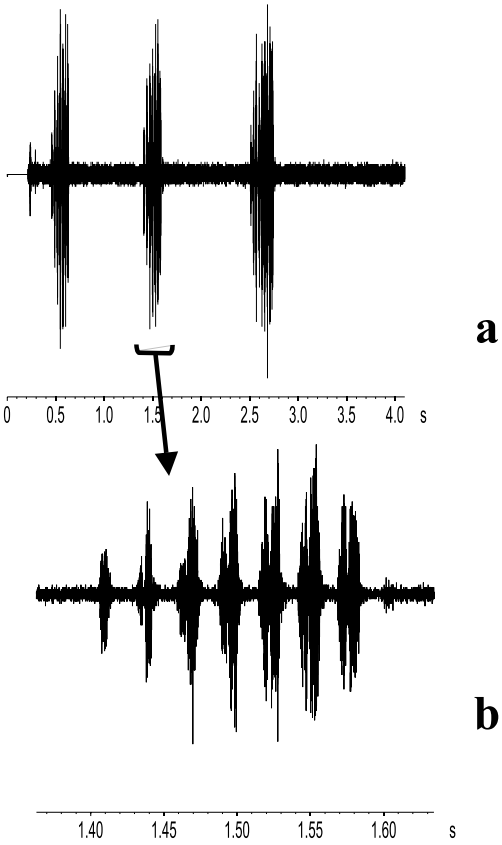


Figure 33. Calling song of *Dociostaurus hispanicus*: a.- echeme; b.- detail of a syllable.
Figura 33. Canto de proclamación de *Dociostaurus hispanicus*: a.- equema; b.- detalle de una sílaba.

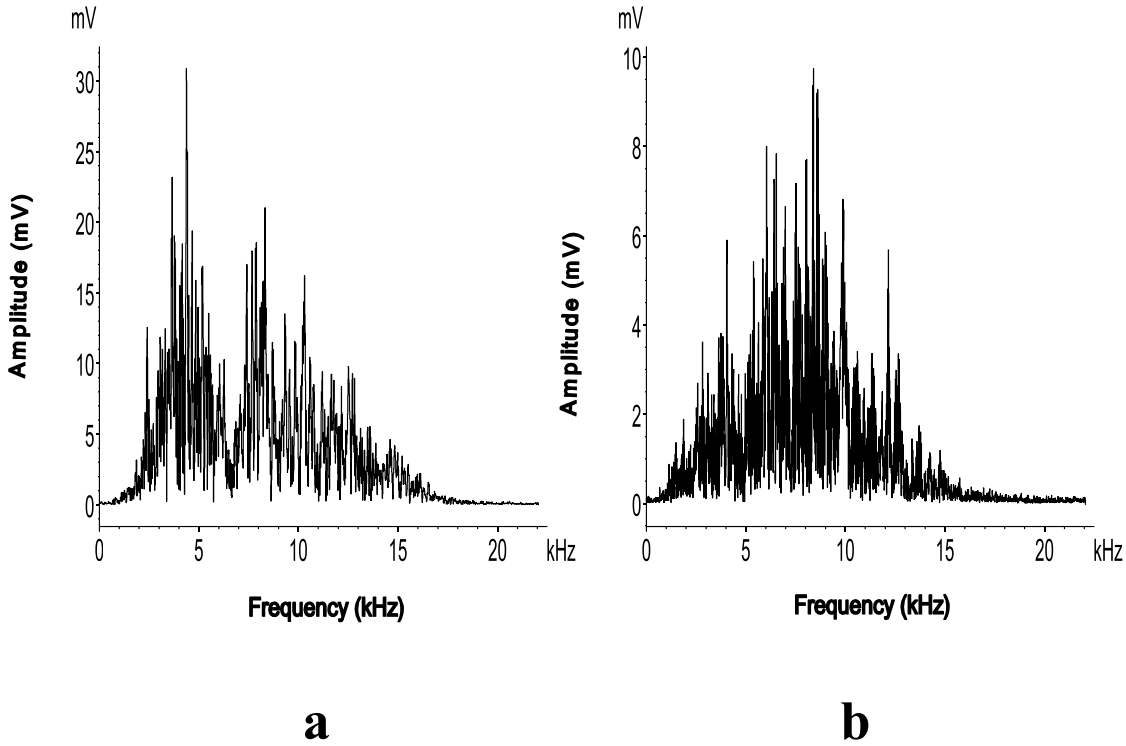


Figure 34. Frequency spectrum of *Dociostaurus hispanicus* calling song: a.- first peak the main; b.-third peak present.
Figura 34. Espectro de frecuencia del canto de proclamación de *Dociostaurus hispanicus*: a.- el primer pico el principal; b.- tercer pico presente.

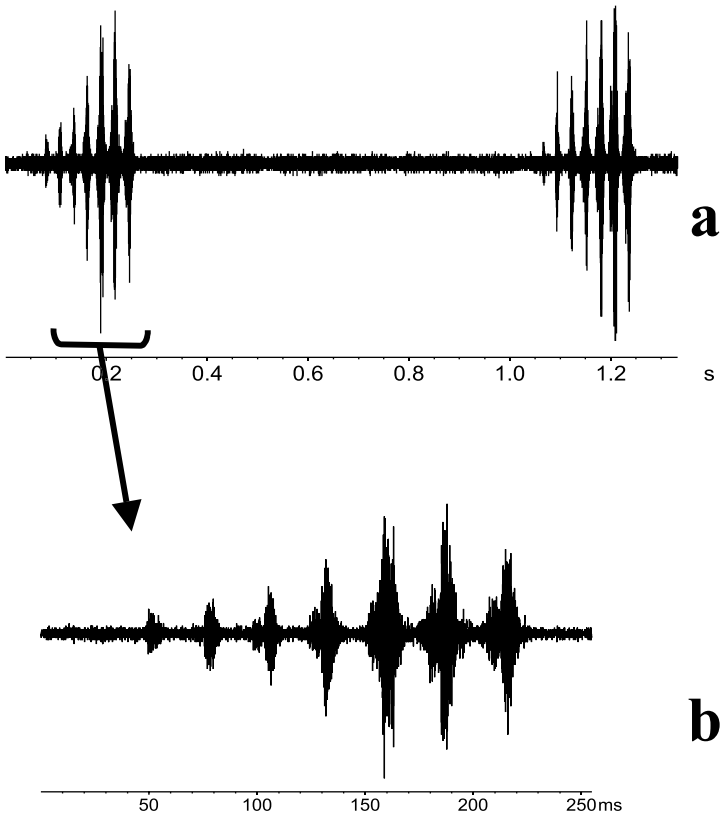


Figure 35. Courtship song of *Dociostaurus hispanicus*: a.- echeme; b.- detail of a syllable.
Figura 35. Canto de cortejo de *Dociostaurus hispanicus*: a.- equema; b.- detalle de una sílaba.

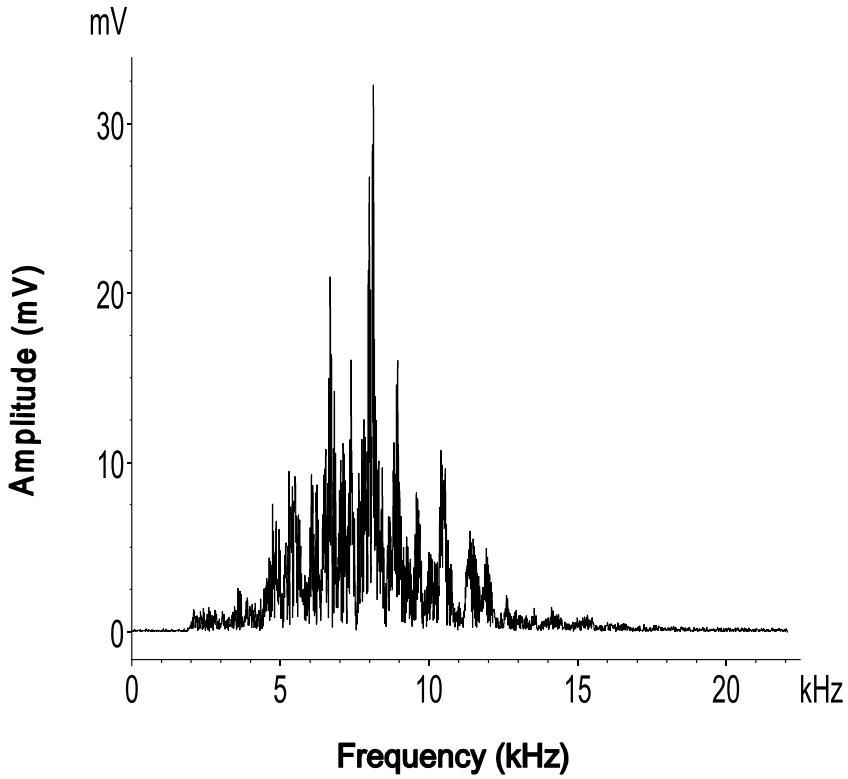


Figure 36. Frequency spectrum of *Dociostaurus hispanicus* courtship song.
Figura 36. Espectro de frecuencia del canto de cortejo de *Dociostaurus hispanicus*.

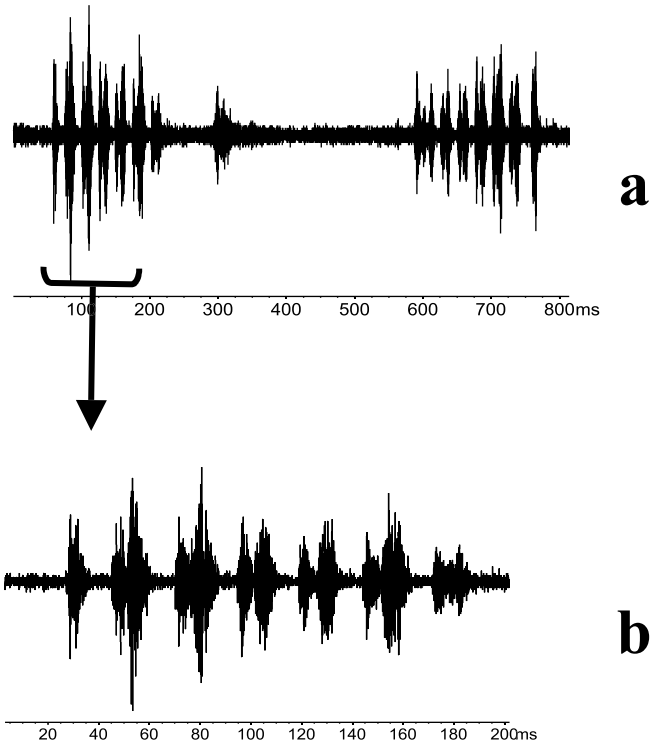


Figure 37. Song of a *Dociostaurus hispanicus* male trying to mate: a.- two syllables; b.- detail of a syllable.
Figura 37. Canto de un macho de *Dociostaurus hispanicus* tratando de copular: a.- dos sílabas; b.- detalle de una sílaba.

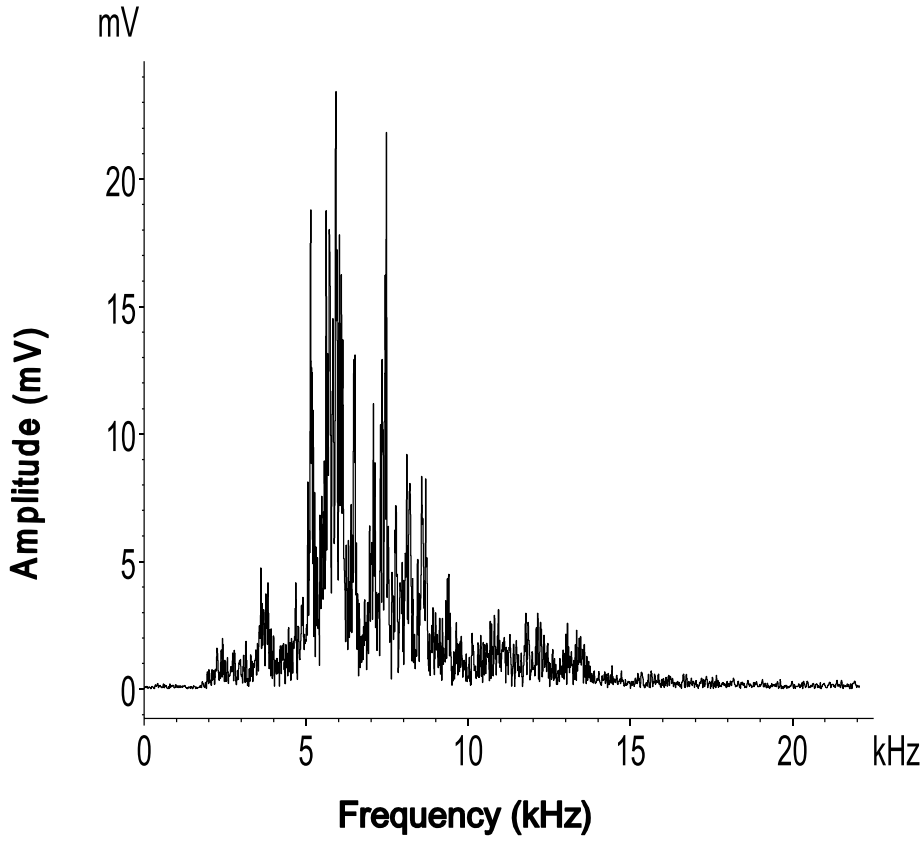


Figure 38. Frequency spectrum of the song of a *Dociostaurus hispanicus* male trying to mate.
Figura 38. Espectro de frecuencia del canto de un macho de *Dociostaurus hispanicus* tratando de copular.

quite close to each other, the first being around 7000 Hz and the second just above 8500 Hz, the latter frequently being the main peak. The lower quartil is close to 5500 Hz; the mean quartil at 7500 Hz and the upper quartil close to 9000 Hz. (Figure 36)

As in the calling song, the echemes start very silently, reaching a maximum intensity after the middle. Final syllables are double. Sound is produced with an almost synchronous movement of both hind legs.

The only recorded song of a male trying to mate with a female consisted of a sequence of echemes formed by 7 syllables, whose the duration and structure are almost identical to those of previously described songs. (Figure 37). Its frequency spectrum occupies a broad band, 8000 Hz wide. The lower frequency is at 5000 Hz, and the higher is close to 13000 Hz. There are two, very close, main peaks, one at 6000 Hz and the other around 8000 Hz. The lower quartil is close to 6000 Hz; the mean quartil at 7500 Hz and the upper quartil close to 9500 Hz. (Figure 38)

As can be seen in Figures 36 and 38, the frequency spectrum of this song is very similar to that of the courtship song, although the peaks, especially the lower, are slightly displaced.

Similar to the two previous songs, the echemes start very gently, reaching maximum intensity after the middle. The final syllables are also double. The male moves one hind leg to produce the sound, the other hind leg being used to disturb the female.

Disturbance song: Two males emit alternate sounds, which may sometimes overlap. The structure and duration of these sounds are similar to those of the syllables corresponding to the calling song.

A comparison of the different sounds produced by this species point to slight differences in the duration and emission rate of the sound produced by a male trying to mate. There is no difference as regards frequency. For this reason, we consider that, similar to the cases of *D. crassiusculus* and probably *D. maroccanus*, individuals of this species produce just one type of song. This song is used in different situations, and is modified following the stress situation.

Identification key

1(6) Tips of folded tegminae never reaching tips of folded hind femora. Hind tibiae reddish or coral red, never bluish. (Figures 39a and 40a)

2(3) Pronotum cylindrical, disc of pronotum somewhat prominent, robust and not constricted in the middle (Figure 39b). Lateral carinae weakly present in prozone (Figure 39c). Dorsal yellow bands interrupted by a wide space, so they are only distinguishable by the fore edge and in metazone (Figure 39c). Triangular light band on inner side of lateral carinae in metazone (Figure 39c). Hind femora short, large and enlarged at the base (Figure 39a). Temporal foveolae trapezoidal, longer than wide, narrowed near the front (Figure 39d). .....*D. crassiusculus*

3(2) Pronotum clearly constricted in the middle (Figure 40b). Dorsal yellow bands of pronotum angular and not interrupted except by a short space. Fusiform light band on inner side of lateral carinae in metazone (Figure 40b). Hind femora narrow, slightly enlarged at the base (Figure 40a). Temporal foveolae longer than wide, almost rectangular (Figure 40c) *D. hispanicus*

4(1) Tips of folded tegminae reaching or even surpassing the tips of folded hind femora. (Figures 41a, 42a and 43a). Hind tibia red, bluish or concolor.

5(6) Large animals (when compared with the other species) (male: 16.5-28.5 mm; female: 20.5-38 mm). Hind tibiae red. Temporal foveolae trapezoidal, wider near the eyes (Figure 41b). Male subgenital plate truncated (Figure 41c).....*D. maroccanus*

6(5) Little animals (male: 11.3-16.5 mm; female: 15-22 mm). Hind tibiae whitish, yellowish, dun or light blue. Head prominent. Male subgenital plate pointed.

7(8) Genicular lobes of hind femora black (Figure 42b). Hind tibiae bluish, with a white ring close to its proximal end. Apical penis valves elongate with pointed apices (Figure 42c).....*D. genei*

8(7) Genicular lobes of hind femora of variable colour, never black (Figures 43a and b). Hind tibiae hardly ever bluish. Apical penis valves short and thick (Figure 43c) .....*D. jagoi occidentalis*

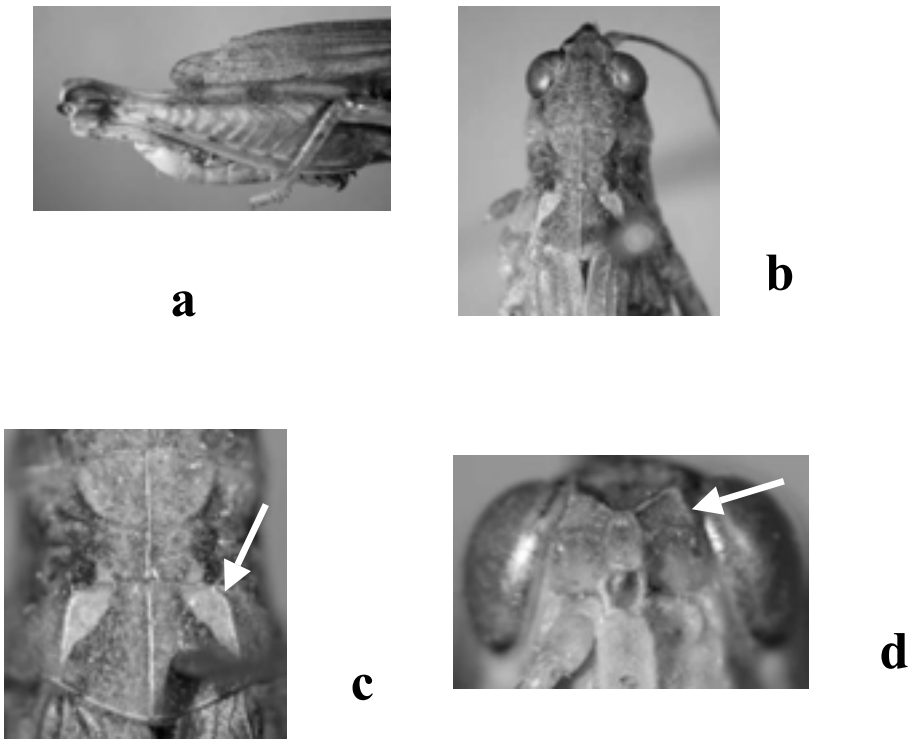


Figure 39. *Dociostaurus crassiusculus* male: a.- body tip; b.- head and pronotum in dorsal view; c.- pronotum in dorsal view; d.- frontal view of foveolae.
Figura 39. *Dociostaurus crassiusculus* macho: a.- extremo del cuerpo; b.- cabeza y pronoto en vista dorsal; c.- pronoto en vista dorsal; d.- visión frontal de las foveolas temporales.

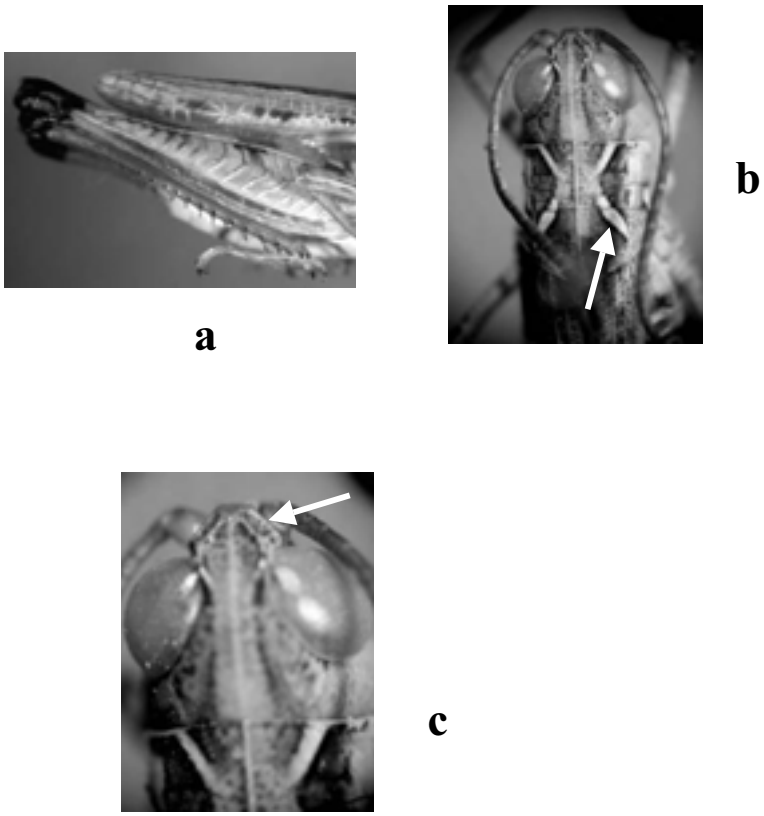


Figure 40. *Dociostaurus hispanicus* male: a.- body tip; b.- head and pronotum in dorsal view; c.- head in dorsal view.
Figura 40. *Dociostaurus hispanicus* macho: a.- extremo del cuerpo; b.- cabeza y pronoto en vista dorsal; c.- cabeza en vista dorsal.

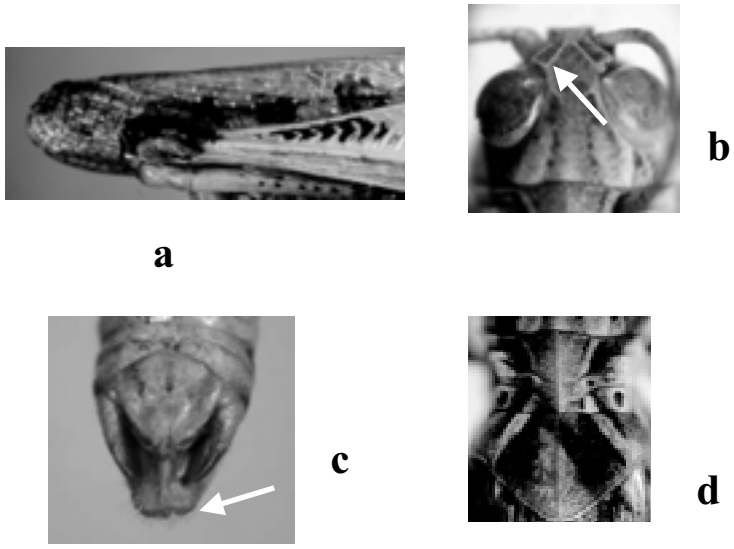


Figure 41. *Dociostaurus maroccanus* male: a.- body tip; b.- frontal view of foveolae; c.- apex of abdomen in dorsal view; d.- pronotum in dorsal view.
Figura 41. *Dociostaurus maroccanus* macho: a.- extremo del cuerpo; b.- visión frontal de las foveolas temporales; c.- ápice del abdomen en vista dorsal; d.- pronoto en vista dorsal.

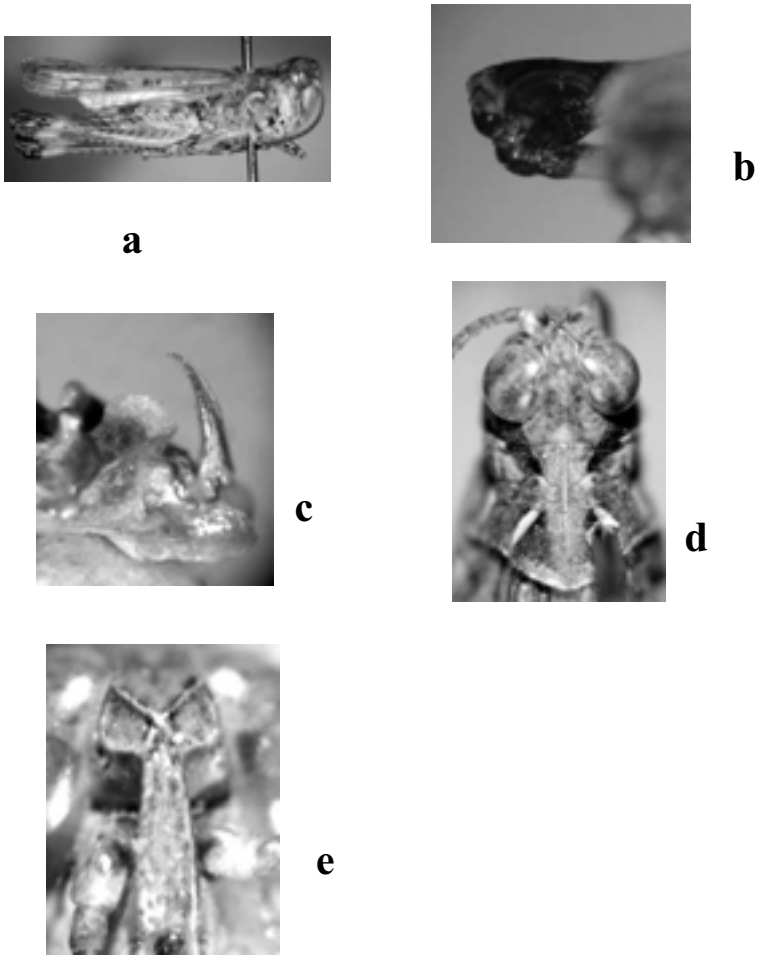


Figure 42. *Dociostaurus genei* male: a.- lateral view; b.- internal view of hind knee; c.- lateral view of penis valves; d.- head and pronotum in dorsal view; e.- frontal view of foveolae.
Figura 42. *Dociostaurus genei* macho: a.- vista lateral; b.- aspecto interno de la rodilla posterior; c.- vista lateral de las valvas del pene; d.- cabeza y pronoto en vista dorsal; e.- visión frontal de las foveolas temporales.

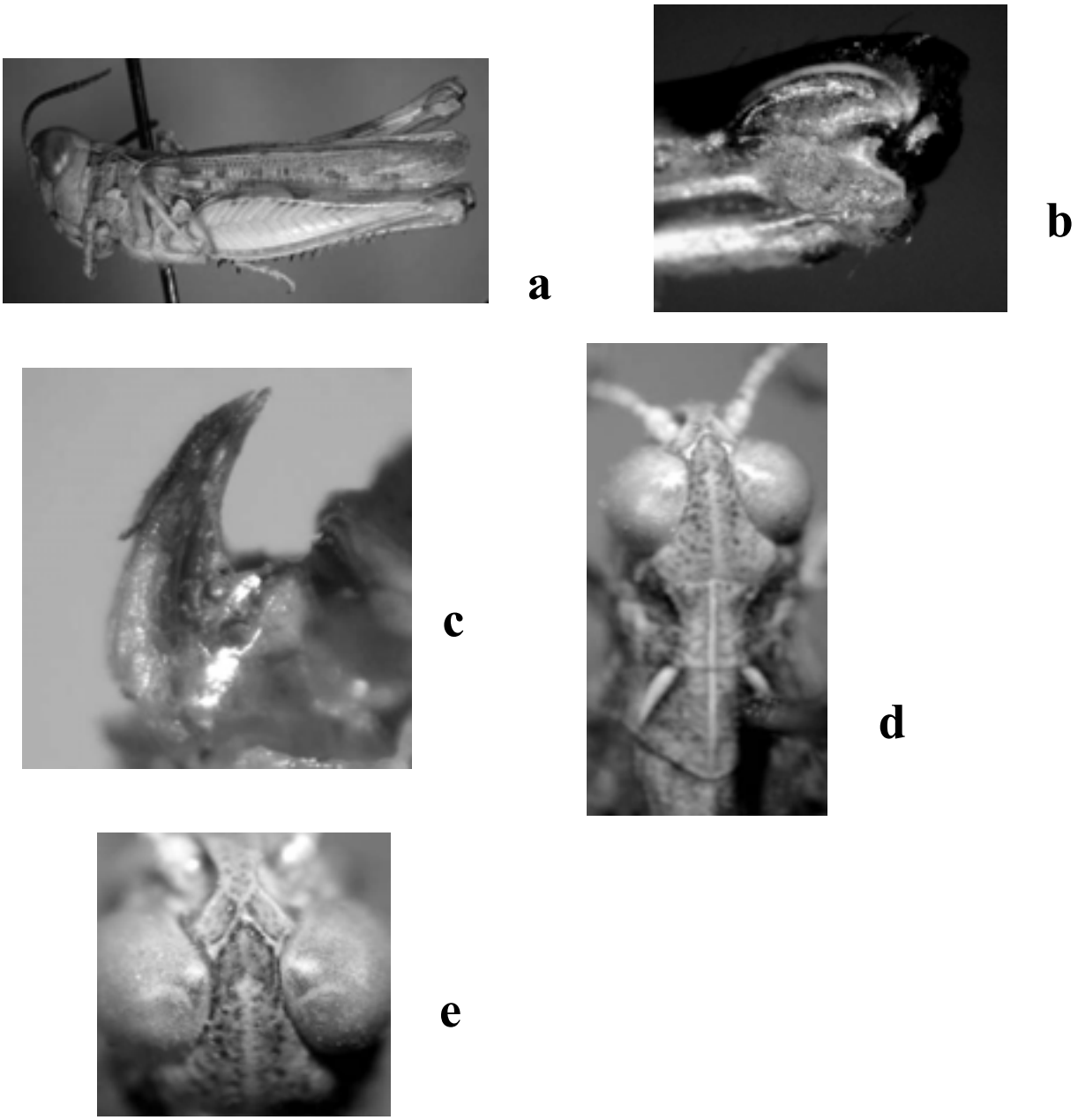


Figure 43. *Dociostaurus jagoi occidentalis* male: a.- lateral view; b.- internal view of hind knee; c.- lateral view of penis valves; d.- head and pronotum in dorsal view; e.- dorsal view of foveolae.
Figura 43. *Dociostaurus jagoi occidentalis* macho: a.- vista lateral; b.- aspecto interno de la rodilla posterior; c.- vista lateral de las valvas del pene; d.- cabeza y pronoto en vista dorsal; e.- visión dorsal de las foveolas temporales.

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