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Recognizing taxonomic units in the field—The case of the crickets *Oecanthus dulcisonans* Gorochov 1993, and *O. pellucens* (Scopoli, 1763) (Orthoptera: Gryllidae): implications for their distribution and conservation in Southern Europe

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Abstract

Recognizing taxonomic units in the field complement classical museum taxonomy. It contributes to geographical distribution assessment making possible the recognition of conservation status of conflictive and similar species. In this paper, we provide unambiguous field characters distinguishing two similar species of *Oecanthus* in Southern Europe: *Oecanthus dulcisonans* Gorochov and *O. pellucens (*Scopoli*)* that are frequently misidentified. Whereas *O. dulcisonans* is a southern rare species with an uncertain status and distribution, *O. pellucens* is common and widely distributed in the Palaearctic. Song is the easiest way to distinguish between the two species in the field being continuous in the former and with regular schemes in the latter. Further, *O. dulcisonans* is larger, with relatively longer inner wings protruding more apically from tegmen, and with a more slender sternum, morphological traits that are detected simply with a hand magnifier.

Key words: Species identification, taxonomy, Spain, Tunisia

Introduction

One important task of researchers on conservation and biodiversity of invertebrates is the attempt to put together taxonomy and field studies. Linking both expertises would provide us a better understanding and knowledge of the real list and distribution of species of difficult identification in a given geographical area. This can facilitate the establishment of the real status of the taxa involved in particular faunas which would enhance future decision making on conservation and management. In this respect, there are many invertebrate species described from museum specimens only based on internal features like genitalia structure while additional information on field identification characters, ecology and distribution is lacking or badly known. For this reason, these species are often misidentified or rarely found in fauna lists. One typical example on this respect is ***Oecanthus dulcisonans***. The status of ***O. dulcisonans*** in Southern Europe is uncertain and it has been only identified in rare occasions and in very few localities (Gorochov 1993; Schmidth 1996; Gorochov and Llorente 2001). ***O. dulcisonans*** has a European sibling species, ***O. pellucens*** that, by contrast, is a common and well known species widely distributed all over the South Palearctic region. Both species are frequently misidentified in the literature, in museum collections and specialised internet forums. ***O. dulcisonans*** was described on the basis of museum specimens (Gorochov 1993) with holotype collected from Tenerife (Canary Islands, Spain) (Bland 2001). ***O. dulcisonans*** has been also cited in Arabian Peninsula,

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Palestine an Cyprus (Gorochov 1993); Yemen (Ingrisch 1999); Greece and Italy (Schmidth 1996); Southern Spain (Gorochov and Llorente 2001); Near East (Asian Turkey, Caucasian Russian republics, Georgia, Armenia, Azerbaidjan, Lebanon, Syria, Israel, Jordan, Egypt, Iran and Iraq) and Sardinia (Fauna Europaea 2007). The main feature differentiating ***O. dulcisonans*** and ***O. pellucens*** was genitalia and size, with ***O. dulcisonans*** being a bit larger (Gorochov 1993; Gorochov and Llorente 2001) (Figure 1). However, body size may vary within cricket species and identification of ***O. dulcisonans*** by genitalia dissection analysis is time consuming and not always feasible.

In this paper we provide new morphological and behavioural (calling song) traits to unambiguously discriminate *in situ* between both species in the field without requiring tedious genitalia analyses, simply with the aid of a hand magnifier, or alternatively, by hearing its song, even without actually capturing the specimens. Such easy diagnosis can facilitate the establishment of a more precise picture on the distribution of ***O. dulcisonans*** in South Europe which can also help to determine its current status and ecological relationship with its sibling species ***O. pellucens*** in possible areas of contact.

Material and methods

We examined all four ***O. dulcisonans*** specimens currently deposited in the Museo Nacional de Ciencias Naturales of Madrid (MNCN) (3 males and 1 female) and 3 own captures of this species (all males) picked up by song (Almería, Spain and Monastir, Tunisia). We also studied five ***O. pellucens*** from the MNCN museum (3 males and 2 females) and 13 individuals (8 males and 5 females) from own collection (Table 1). Field and lab observations were also taken from both species with final diagnoses of genitalic analyses according to Gorochov (1993) and Gorochov and Llorente (2001) (Figure 1). Song was recorded by using a digital portable audio recorder Tascam HD-P2 with a K6-M66 Sennheiser microphone and recording spectrum between 40 and 20,000 Hz. This device allows us to perform a single analogical/digital (A/D) conversion preventing possible signal degradation when several conversions A/D or D/A are made. Oscillograms were analysed with Pro Tools 7.4 LE and sonograms with “RTAS” plug-in iZotopeRX hosted by Pro Tools 7.4. We obtained several recordings of individuals in the field and from both captive male species at different temperatures in the lab. Here, we depict spectrograms and sonograms for comparison of neat recordings of both species under identical housing conditions and temperature (21ºC).

For all individuals we measured tegmen, femur, tibia, pronotum to the nearest 0.1 mm using the software LAS version 2.8.1 from a stereoscopic microscope Leica S8 APO. We also checked for any possible external morphological differences which could allow an efficient diagnosis between both species, particularly a prospective analysis focusing differences on tegmen venation in dorsal view, spurs of the legs and sternum in ventral view. Here we only deal with those characters relevant for identification. Averages are expressed in means ± S.E. and levels of significance of $\alpha = 0.05$.

Results and discussion

Measurements

Up to now, the first suspicious external trait for specific diagnostic in males of these two species was size. Accordingly, here we have obtained that *O. dulcisonans* is significantly larger than *O. pellucens* particularly in tegmen (*dulcisonans* = 14.01 ± 0.26; *pellucens* = 10.80 ± 0.14) ($t_{15} = 12.05$; $P < 0.0001$) (Figure 2) but also in femur (*dulcisonans* = 8.60 ± 0.14; *pellucens* = 7.60 ± 0.17) ($t_{14} = 4.06$; $P < 0.001$) or tibia and pronotum (data not shown). It is particularly interesting that difference in the median value of tegmen is around 4 mm larger in *dulcisonans* with no overlapping. However, aside from possible population variations, length is not always an easy trait to perceive with a simple inspection or measurements based on field rulers to the nearest mm, particularly when we lack information on biometrics of these species from different populations.

Notwithstanding, differences in tegmen length are distinctive of species' identification. Also, *O. dulcisonans* has a relatively longer inner wing than *O. pellucens*. This is traduced on the part of the inner wings protruding from tegmen observed easily eye inspection. In male *O. dulcisonans* this protruding part of the inner wing is much longer (3.57±0.20 mm) than in male *O. pellucens* (0.42±0.10 mm) ($t_{15} = 15.83$, $P < 0.0001$), which is most evident on fresh or living specimens (Figure 3A). This wing difference is correlated with more frequent flying behaviour displayed by *O. dulcisonans* with respect to *O. pellucens*. Except for the ovipositor (*O. dulcisonans* female, *n* =1, Table 1), all other measurements were longer in *O. dulcisonans* than in any *O. pellucens* specimen studied, although these differences were not significant.

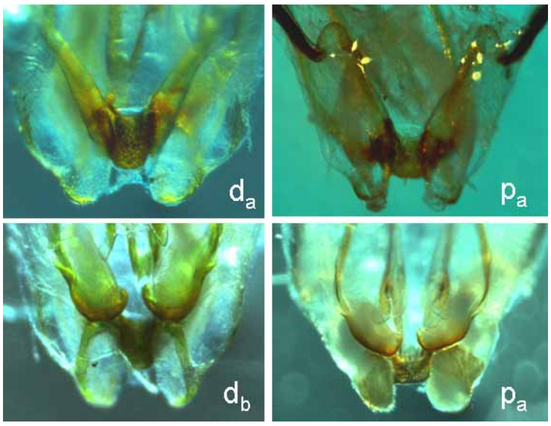

FIGURE 1. Epiphallus of *Oecanthus dulcisonans* from Almería, Spain (d_a, above; d_b, below) and *O. pellucens* from Toledo, Spain (p_a, above; p_b, below).

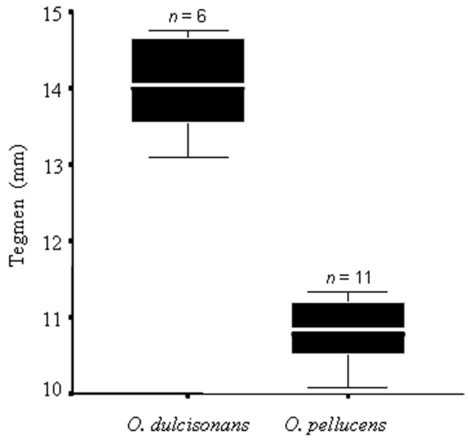

FIGURE 2. Differences in tegmen length between *O. dulcisonans* and *O. pellucens*. Line in box representing the median, extreme of the boxes, quartile ranges and bars are the extreme values.

Meso- and metasternum

There are obvious visual differences in the shape of the mesosternite and metasternite plates of both of these species of *Oecanthus* (Figure 3A, B). The mesosternite plate is hexagonal in both but it is longer than wide in *O. dulcisonans*. This difference is partly at expenses of the pleural (lateral) sides that are longer than the upper (cranial) side of the plate. On the contrary, the mesosternite is more compact and quadrangular in *O. pellucens*. The metasternal sclerotic plate is also hexagonal in both species. However, in *O. dulcisonans* the sides in contact with the second pair of coxae (the medial coxae sides, upper-lateral) are wider than the abdominal (lower) side of the plate resulting in a more slender calyx-shaped structure in *O. dulcisonans*. On the other hand, the reverse is found and the lower (abdominal) side is wider than the medial coxae sides of the matesternal plate in *O. pellucens* (Figure 3 B).

Although these meso- and metasternal patterns are very easy to recognise in fresh or live specimens with the simple aid of a hand magnifier, desiccation of tissues and position of the entomological pin in dead specimens make difficult the recognition of the original shape of these sternal plates. For these reasons, the mesosternite is often distorted in prepared specimens although the metasternite plate is usually preserved, even in old museum specimens. The metasternite was visible in almost all museum samples and could be used as a diagnosis trait together with tegmen size. We suggest that sternum could also have a taxonomic value in other similar species of the genus *Oecanthus*, and thus we recommend that entomological pins should be avoided in the pronotum area.

TABLE 1. Specimens of *Oecanthus dulcisonans* (d) and *O. pellucens* (p) studied from the Museo Nacional de Ciencias Naturales of Madrid (MNCN) and own captures with sex (0= female, 1= male), locality, date and collector or person who identified it. LV= Llorente, V.; PJC= P.J. Cordero.

Oecanthus	specimen	sex	locality	date	collector/identif
d	MNCN 1	1	San Roque, Cádiz	1996/10/19	J Ramirez
d	MNCN-2	1	Málaga?	?	M Candela
d	MNCN-3	1	Pinar del Fraile, Doñana	1968/09/28	AV Gorochov
d	MNCN-4	0	San Roque, Cádiz	1996/08/11	J Ramirez
d	AL-1	1	El Retamar, Almería	2008/09/21	PJC
d	AL-2	1	El Retamar, Almería	2008/09/21	PJC
d	Tunisia-1	1	Sahaline, Monastir (Tunisia)	2009/06/14	PJC
p	MNCN-1	1	Colmenar Viejo, Madrid	1982/08/18	VL
p	MNCN-2	0	Cazorla, Jaén	1956/07/00	E Morales
p	MNCN-3	0	Azañón, Guadalajara	1956/07/00	J Abajo
p	MNCN-4	1	Voto, Cantabria	2001/08/30	C Rey
p	MNCN-5	1	Sigüenza, Guadalajara	?	M Escalera
p	Pontón Se-1	0	Pontón, Segovia	2007/08/00	PJC
p	Tala-2	1	Talavera, Toledo	2007/10/08	PJC
p	Peñahueca-1	1	Villacañas, Toledo	2007/11/19	PJC
p	MontesTo-1	1	San Pablo, Toledo	2007/10/06	PJC
p	MontesTo-1b	1	San Pablo, Toledo	2008/08/26	PJC
p	MontesTo-2	1	San Pablo, Toledo	2007/10/06	PJC
p	MontesTo-2b	0	San Pablo, Toledo	2008/08/26	PJC
p	CR-1	0	Ciudad Real	2008/10/20	PJC
p	CR-2	1	Ciudad Real	2008/10/20	PJC
p	CR-3	1	Ciudad Real	2008/10/20	PJC
p	CR-4	0	Ciudad Real	2008/10/20	PJC
p	CR-5	1	Ciudad Real	2008/10/20	PJC
p	Fresneda-1	0	Viso del Marqués, Ciudad Real	2008/08/18	PJC

Song

To the human ear, the sound uttered by these two species is very similar. However, song by *O. dulcisonans* is continuous, without pauses whereas scheme sequences are uniformly repetitive in *O. pellucens* (687.42 ± 10.77 ms) separated by constant pauses of shorter length (315 ± 8.26 ms) (Figure 4 A–D). Furthermore, syllables of both species differ: syllables are fairly homogeneous in *O. dulcisonans* (average duration of 22.74 ± 0.12 ms) while in *O. pellucens* syllables are more complex and longer although also quite constant in shape (average duration of 30.96 ± 0.20 ms) (Figure 4 E–H). Main audible frequency in *O. pellucens* is 3000 Hz with secondary harmonics of 6400, 9000, 12000 Hz. In *O. dulcisonans*, main audible frequency is 3200 Hz with secondary harmonics of 6400, 9600 Hz.

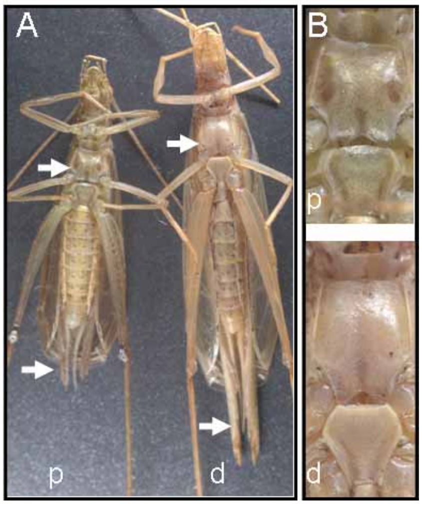

FIGURE 3. A, ventral view of *Oecanthus pellucens* (p) and *O. dulcisonans* (d). B, details of the sternum of both species (p) and (d).

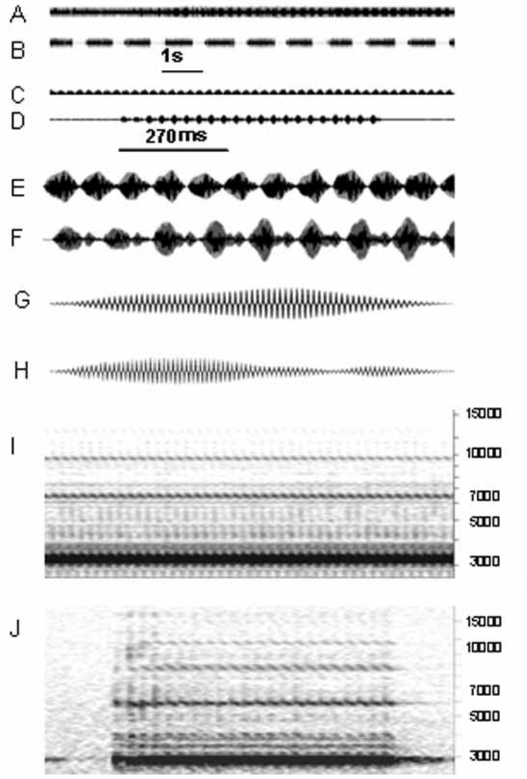

FIGURE 4. Oscillograms and sonograms of *Oecanthus dulcisonans* (A,C,E,G,I) and *O. pellucens* (B,D,F,H,J). AB, oscillograms of 10 seconds of calling song at 21ºC in identical housing conditions. CD, one second oscillogram including a full echeme of *O. pellucens* in the middle. EF, 270 ms of syllables. GH, details of single syllables. IJ, sonograms showing the audible frequencies of the calling songs ranking from 2000 to 15000 Hz.

Calling song is the easiest way to detect and distinguish *O. dulcisonans* from *O. pellucens* in the field. The song of both species cannot be confounded with any other arthropod song in the Palearctic Region although from distance and because of the continuous trill, *O. dulcisonans* could be confused with a *Gryllotalpa* species. However, at short distance, a lower intensity and the particular location of singing individuals in long grasses, shrubs or even trees (often palm trees) excludes confusion with any Palearctic *Gryllotalpa* species.

In sum, and though genitalia is a valid character for species identification (Gorochov 1993), in this paper we provide unambiguous external traits to recognize museum and field specimens of the two *Oecanthus* species living in Western Europe. The most important trait for field identification is song, but also we provide new morphological traits as the shape of meso and meta-sternum together with length of tegmen and protruding distal part of the inner wing traits also useful for revising specimens from museum collections. In this study, we conclude that song allows the recognition of taxonomic units which clearly help to overcome the taxonomic impediment due to our scanty knowledge on certain insect faunas as it occurs with other species of Orthoptera (Riede 1998). Once songs are properly identified to the species, it can be a useful tool for estimating population densities and determining species distribution, habitat quality assessment and guiding conservation strategies (Cordero & Llorente 2008).

Acknowledgements

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