

GEOGRAPHIC VARIATION IN THE CALLING SONG OF *CICADA ORNI* L. (HEMIPTERA: CICADIDAE) IN THE MEDITERRANEAN AREA

J. A. QUARTAU¹, G. ANDRÉ¹, G. PINTO-JUMA¹, S. G. SEABRA¹ & P. C. SIMÕES¹

With 1 figure

ABSTRACT. Several acoustic recordings of the calling song produced by males of *C. orni* L. were carried out in selected localities of the Mediterranean area. These were analysed in time and frequency domains, and there was some tendency for songs from southeastern Europe (Greece and Turkey) to group apart from those of Western Europe (Iberian Peninsula and France). This is not concordant with the prediction by Paterson that specific mate recognition systems should be invariant within the same species. The inter-echeme interval duration was the variable that contributed most to this separation. Yet, echeme duration proved to be quite constant across the geographic range investigated. As such, echeme duration is probably one of the most important parameters encoding species-specific information for species recognition and pair formation. On the other hand, the distinctiveness of the Greek populations may be the result of repeated events of geographic isolation among populations present in southern refugia during Pleistocene climatic cycles.

RESUMO. Vários registos acústicos do “som-de-chamamento” de *C. orni* Linnaeus foram realizados em localidades seleccionadas da área mediterrânea. Estes sinais foram analisados nos domínios temporal e de frequência, tendo-se verificado que os sons da parte oriental (Grécia e Turquia) se afastam dos da parte ocidental (Península Ibérica e França), uma diferenciação acústica intra-específica que não está de acordo com a previsão do conceito de reconhecimento de espécie de PATERSON, que considera que tais sinais seriam praticamente

¹ Centro de Biologia Ambiental & Departamento de Biologia Animal, Faculdade de Ciências de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal, E-mail: jaquartau@fc.ul.pt

invariantes dentro da mesma espécie. O intervalo entre equemas foi a variável que mais contribuiu para este afastamento, tendo-se, porém, revelado praticamente constante o equema através de toda a área investigada. Nestas circunstâncias, pensa-se que são os equemas que conterão mais informação útil no que se refere ao processo do reconhecimento específico durante a reprodução. Por outro lado, a divergência acústica das populações gregas deverá ter tido origem no isolamento geográfico de populações presentes em pequenos refúgios que terão persistido durante os ciclos de glaciações do pliocénico.

INTRODUCTION

Cicada orni Linnaeus is the commonest species of a complex belonging to the family Cicadidae (Hemiptera), which is mostly distributed around the Mediterranean basin and has been studied in terms of morphometrics, ecology, acoustics and genetics (e.g., QUARTAU, 1988, QUARTAU *et al.*, 1999, QUARTAU *et al.*, 2001, SUEUR *et al.*, 2004 and PINTO-JUMA *et al.*, 2005). Males produce acoustic signals using a tymbal mechanism and the calling song, which is the most usual type of sound produced, is species-specific and is involved in mate attraction. Since the other sibling species (e.g., *C. barbara* (Stål) and *C. mordoganensis* Boulard) are morphologically very similar but differ to a lesser or higher degree in the calling songs that males produce, the study of these acoustic signals is very important in the understanding of the speciation process among these cicadas. According to the PATERSON'S recognition concept of species, the calling song constitutes a distinct specific-mate recognition system (SMRS) that would be maintained relatively constant by stabilizing selection across the distribution range of the species (PATERSON, 1985). The present extended abstract presents some results on the structure of the calling song in *C. orni* over a wide distribution range in the Mediterranean area in order to understand the pattern of its geographic variation as well as to test PATERSON'S assumption

MATERIAL AND METHODS

Males of *C. orni* were recorded in several localities in the Mediterranean region, including the Iberian Peninsula, France, Corsica, Greece and Turkey. As equipment, Sony DAT recorders (TCD-D10 ProII and TCD-D8), coupled with either a dynamic Sony F-780 microphone or a Telinga Pro4PiP microphone, and a UHER 4200 Report Monitor recorder connected to an AKG D202 dynamic microphone were used. Sound analyses were performed through the software Avisoft-SASLab Pro (SPECHT, 2002), with the sampling rate of 44.1 kHz and a resolution of 16 bits and analysed in time and frequency domains.

RESULTS AND DISCUSSION

The calling song showed some variation among regions of the Mediterranean (Fig.1). Overall, echemes have 0.08 ± 0.03 (average \pm standard deviation) seconds of duration and are separated by intervals of 0.15 ± 0.07 seconds. The peak frequency is at 4825 ± 486 Hz, and the bandwidth (at -20dB) is 7233 ± 1437 Hz (PINTO-JUMA *et al.*, 2005). However, the eastern specimens (Greece and Turkey) showed longer inter-echeme intervals, while the echeme duration did not differ between eastern and western cicadas (PINTO-JUMA *et al.*, 2005). As such, echeme duration might encode significant species-specific information for species recognition and pair formation since it is quite constant in *C. orni*, while differing greatly from other closely related species (e.g., *C. mordoganensis*, a closely related species present also in south-eastern Europe) (SIMÕES *et al.*, 2000). In contrast, inter-echeme interval is probably not very important in species recognition since it shows pronounced variation along the distribution area of *C. orni*. The Greek populations were acoustically the most differentiated, a result which is in agreement with genetic analyses (QUARTAU *et al.*, 2001; PINTO-JUMA *et al.*, in prep.; SEABRA *et al.*, in prep.). Finally, there is evidence that this differentiation might have been the result of geographic isolation among populations present in Aegean refugia during Pleistocene climatic cycles.

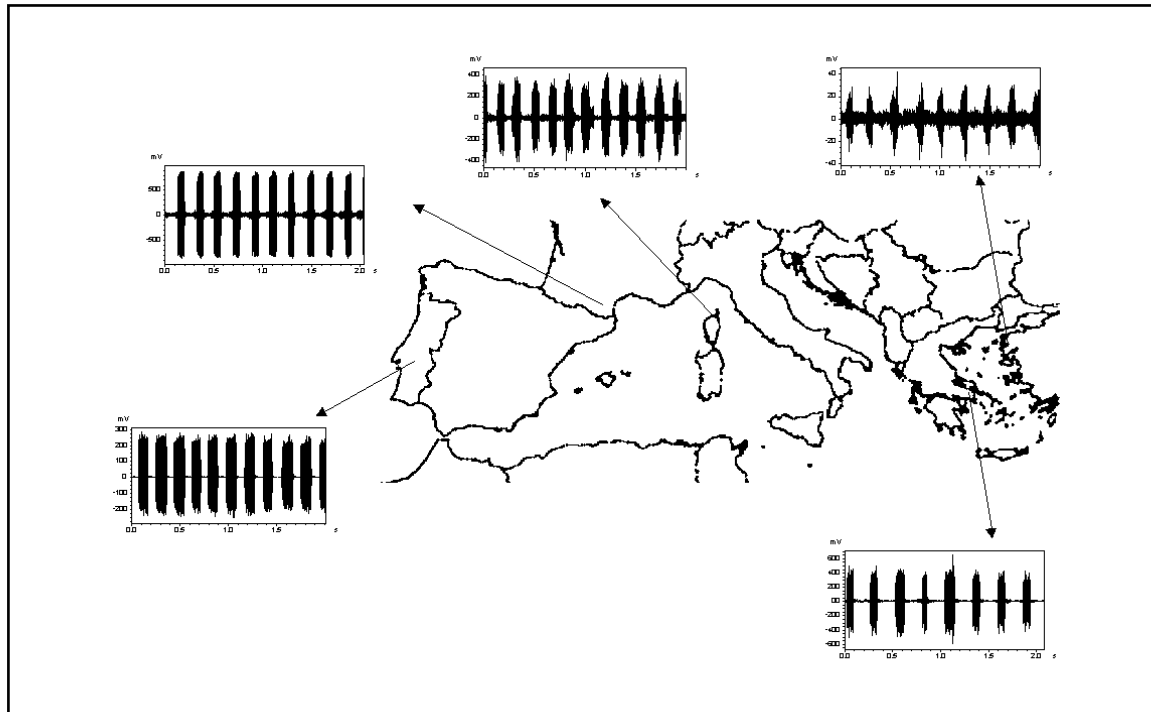


Fig. 1 - Oscillograms (amplitude vs. time) of calling songs of *C. orni* L. indicating some of the localities investigated in the following geographical areas: Iberian Peninsula, France, Corsica, Greece and Turkey.

REFERENCES

PATERSON, H. E. H.:

1985. The recognition concept of species. In: *Species and speciation* (ed. E. S. Vrba), pp. 21-29. Transvaal Museum Monograph no 4, Pretoria.

PINTO-JUMA, G., P. C. SIMÕES, S. G. SEABRA & J. A. QUARTAU:

- (2005). Calling song structure and geographic variation in *Cicada orni* Linnaeus (Hemiptera: Cicadidae). *Zoological Studies*, **44** (1): 81-94.

QUARTAU, J. A.:

1988. A numerical taxonomic analysis of interspecific morphological differences in two closely related species of *Cicada* (Homoptera, Cicadidae) in Portugal. *Great Basin Naturalist Memoirs*, **12**: 171-181.

QUARTAU, J.A., M.T. REBELO, P.C. SIMÕES, T.M. FERNANDES, M.F. CLARIDGE, S. DROSOPOULOS & J.C. MORGAN:

1999. Acoustic signals of populations of *Cicada orni* L. in Portugal and Greece (Homoptera: Auchenorrhyncha: Cicadomorpha: Cicadidae). *Reichenbachia*, **33**: 7-80.

QUARTAU, J. A., M. RIBEIRO, P. C. SIMÕES & M. M. COELHO:

2001. Genetic divergence among populations of two closely related species of *Cicada* Linnaeus (Hemiptera: Cicadoidea) in Portugal. *Insect Systematics & Evolution*, **32**: 99-106.

SIMÕES, P. C., M. M. BOULARD, M. T. REBELO, S. DROSOPOULOS, M. F. CLARIDGE, J. C. MORGAN & J. A. QUARTAU:

2000. Differences in the male calling songs of two sibling species of *Cicada* (Hemiptera: Cicadoidea) in Greece. *European Journal of Entomology*, **97**: 437-440.

SPECHT, R.:

2002. *Avisoft-SASLab Pro- Sound analysis and synthesis laboratory*. Version 4.1d, Berlin.

SUEUR, J., S. PUISSANT, P. C. SIMÕES, S. SEABRA, M. BOULARD & J. A. QUARTAU:

2004. Cicadas from Portugal: revised list of species with eco-ethological data (Hemiptera: Cicadidae). *Insect Systematics and Evolution*, **35** (2): 177- 187.