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Article

NEW UNEXPECTED SPECIES OF *ACHETA* (ORTHOPTERA, GRYLLIDAE) FROM THE ITALIAN VOLCANIC ISLAND OF PANTELLERIA

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Abstract: In late April 2022, during the hearing of the audio files from an unsupervised bioacoustic assessment of the shearwater populations (Aves, Procellariiformes) on the coast of Pantelleria island (Italy, Sicily), a cricket song of unknown attribution was heard. The first bioacoustic analyses, including FFT-based spectrograms and sound pressure envelopes, confirmed that it could not be attributed to the known sound of any Italian nor Mediterranean species of cricket. In the ensuing weeks, field research made on purpose in the original station and in further localities in the southern coast of Pantelleria provided photographs, living specimens and further audio records. As soon as the photos were shared among the authors, it became clear that the species belonged to the genus *Acheta*. Further bioacoustic analyses and morphological comparison with type specimens of Mediterranean and North-African congenerics in relevant collections and in the scientific literature were conducted: they confirmed that the findings could only be attributed to a still undescribed species, that escaped detection due to its impervious and unfrequented habitat. *Acheta pantescus* n. sp. is apparently restricted to the effusive coastal cliffs of the island of Pantelleria, a habitat whose scant extension and vulnerability require environmental protection actions such as the inclusion in a special Red List by the IUCN Italian Committee.

Keywords: new species, Biogeography, Mediterranean, Red List, Bioacoustics

1. Introduction

On the night of 27th April 2022, during a survey aimed at the assessment of the presence of the pelagic birds Scopoli's shearwater *Calonectris diomedea* and Yelkouan shearwater *Puffinus yelkouan* (Aves, Procellariiformes) on the island of Pantelleria (Italy, Sicily), BM and CC placed a Wildlife Acoustics sound recorder, set in unsupervised mode from sunset to dawn, near the cliffs of Punta Limarsi on the south-eastern coast of the island. After retrieving the recorder, they examined the content of the SD card and noticed an Orthopteran song with Gryllinae affinities, that by the unaided ear seemed not to match any species reported from Pantelleria or other Italian areas.

The recording was shared the same day with the other authors; considering that the sound pressure envelope of the song didn't match the pattern of any species recorded in Italy [1], it became clear that its source was a previously unreported species of cricket, a conclusion that promoted immediate and fruitless researches both in bibliography and in sound archives.

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After the serendipitous recording, during a subsequent expedition to Pantelleria island, on 14th-15th May, BM, CC and PF carried out further audio takes. They were respectively obtained at the cliffs of Punta Limarsi lighthouse and two kilometers north-east, at the cliff of Martingana. During the same visit the capture of three living specimens (respectively, female nymph and adult male near the lighthouse of Punta Limarsi, and adult female at Martingana; Fig. 1). The elytron venations visible in the photographs showed a striking similarity with those of the known species of the genus *Acheta* Fabricius, 1775 as illustrated by Gorochov [2].

On 5th-6th July 2022, further researches by BM and CC resulted in higher quality recordings, but couldn't provide any further specimens, as the insects sang from deep crevices on the cliff faces. The presence of the new species seemed more widespread than previously estimated, but apparently ecologically constrained to the cliffs, with no observation nor recording obtained in other environments.

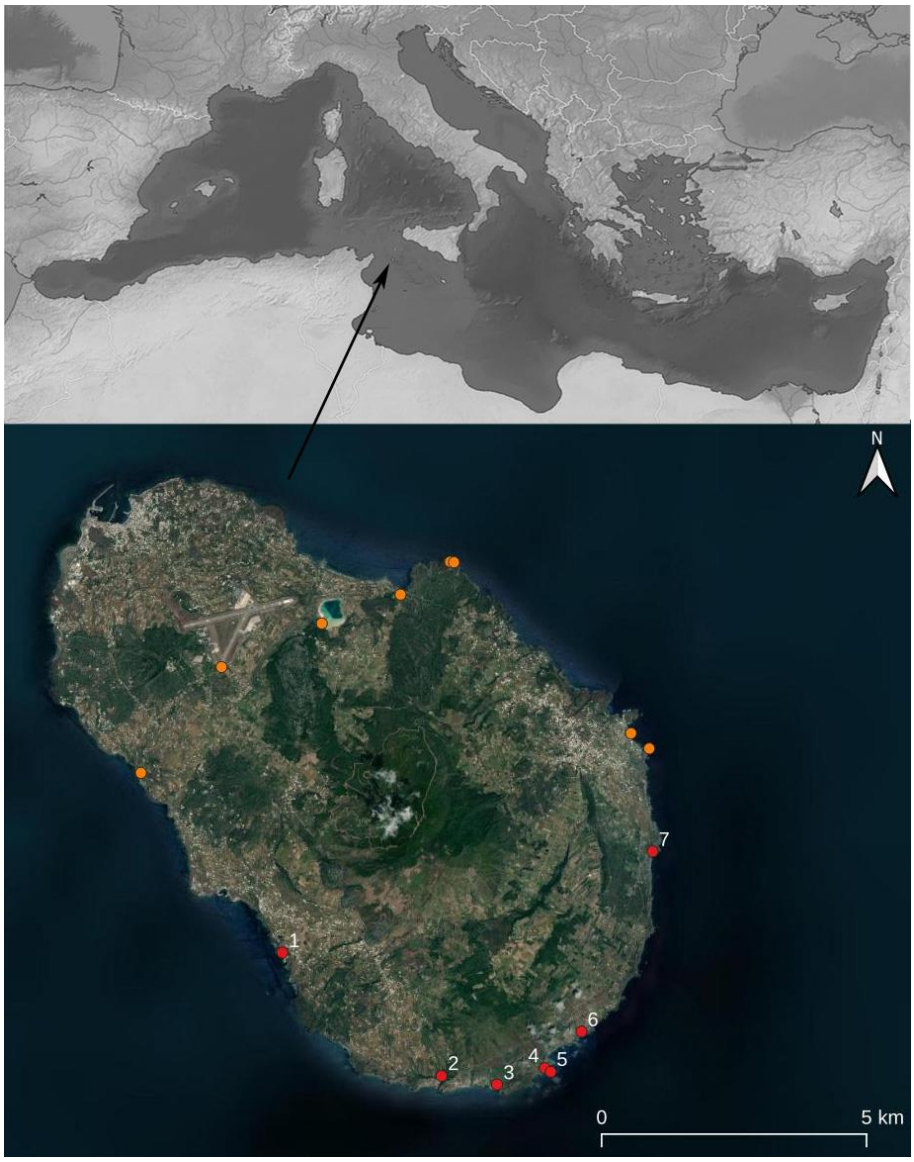

Figure 1. Above: Geographical position of the Island of Pantelleria in the Mediterranean. Below: localities of Pantelleria where night recording have been carried out. Red Dots mark stations where the new species was recorded, orange dots where was not recorded. See legend in Table 1.

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2. Materials and Methods

2.1. Discovery of the cricket

As reported in the Introduction, this new species of *Acheta* was discovered by chance, while listening the recording obtained from a Wildlife Acoustics sound recorder placed in the night of 27th April 2022 near the lighthouse of Punta Limarsi of Pantelleria (Fig. 1). Later, during the nights of 14th-15th May it was possible to discover a second site, in the locality Martingana, where many individuals of the cricket were singing. In the same days a male and a female adults were collected at the Punta Limarsi lighthouse and Martingana, respectively. Finally, during the night of 5th-6th July 2022 the use of Wildlife Acoustics sound recorders allowed to discover the presence of the same cricket in the localities Cimitero di Scauri, Salto della Vecchia, Punta Limarsi and Punta del Formaggio. In the same night at the lighthouse of Punta Limarsi and Martingana it was possible to observe the habitat of the crickets, which were singing from the crevices of volcanic rocks just a few meters above sea level, and in one case from a drystone wall behind a big *Juniperus turbinata* tree. Due to the shyness of the cricket, it was not possible to collect other specimens, but we successfully recorded its song with an Edirol R09 recorder.

During the survey to detect the presence of seabirds on Pantelleria, recorders were placed in further sites of the island coast, but the presence of the cricket was confirmed only in those marked by a red dot in Fig. 1. The peculiar song of the new species have been never listened in the inland part of the island during several entomological researches carried out by PF during 2021 and the early 2022.

2.2. Morphological analysis

We examined specimens of different species of the genus *Acheta* preserved in the museums of Genoa and Madrid and in the private collection of the first author. Collected specimens and their parts were photographed with a Nikon Coolpix 4500 digital camera, mounted on a Wild M3 Stereomicroscope and with an Olympus Stylus TG-5 Tough (cf. [3]). Photographs were integrated using the freeware CombineZP [4]. Mounted specimens were measured with a digital caliper (precision 0.01 mm); the following measurements were taken (in mm): Body length: dorsal length from the head to the apex of the abdomen; Pronotum length; Tegmina length; Hind femora length; Ovipositor: maximum length, subgenital plate included.

2.3. Abbreviations for collections and museums

BMPC: Bruno Massa personal collection, Palermo, Italy
MNCN: Museo Nacional Ciencias Naturales, Madrid, Spain
MSNG: Museo Civico di Storia Naturale 'G. Doria', Genoa, Italy
MSNR: Museo Civico di Storia Naturale, Rovereto (Trento), Italy

2.4. Recording and audio analysis equipment

Table 1 summarizes the audio samples considered in this study.

Table 1. List of localities cited in the text, with dates and kind of evidence collected.

Map ref. no.	Location	Dates of visit	Audio Recording	Specimen collected
1	Cimitero Scauri	5-6.VII.2022	☑	☐
2	Salto la Vecchia	5-6.VII.2022	☑	☐
4	Punta Limarsi lighthouse	27.IV.2022 - 14-15.V.2022 - 5-6.VII.2022	☑	☑
5	Punta Limarsi	27.IV.2022 - 14-15.V.2022 - 5-6.VII.2022	☑	☐
6	Cala Rotonda -	14-15.V.2022	☑	☑

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7	Martingana Punta del Formaggio	5-6.VII.2022	☑	☐

Even though the recordings obtained with different devices and settings are not strictly comparable, some of the types of song observed (spring calling/advertising; summer calling/advertising; "type 2") were recorded by just one kind of device. Consequently, bioacoustic analyses include all the audio material available, regardless of the recording technique, to ensure a description as exhaustive as possible of the different songs observed from late April to the first week of July.

The April recordings (PCM WAV files) were obtained by a Wildlife Acoustics "Song Meter Micro" digital weatherproof recorder with built-in microphone, set at its default sampling frequency of 22050Hz. The device was optimized for long duration, medium quality soundscape recordings, for supervised playback aimed at the detection of bird songs, and could not provide audio files suitable for in-depth bioacoustic analyses; nevertheless, it allowed to exclude the attribution of the song to any known Italian Gryllidae.

On 14-15th May, in Martingana, also a Samsung SM-A750SN Smartphone was used as an audio recorder, via its built-in application, and provided recordings (lossy, compressed m4a format) hard-limited to around 16 kHz, that were converted to mp3 for the acoustic analyses. Higher quality recordings (PCM WAV files) where obtained on 5-6th July 2022, using an Edirol R09 digital recorder with built-in stereo microphones, at a sampling frequency of 44.1 kHz.

Sound description includes pressure envelopes (relative pressure in dB full scale), time/frequency spectrograms and frequency/sound pressure analysis diagrams, generated on an ASUS EeePC 1225B Netbook (for the July recordings, on a Gigabyte Brix desktop computer) by Adobe Audition 1.0 software running under Windows 10 64bit operating system. The same software was used to apply a 1700Hz high-pass software filter to exclude the background noise (wind, sea waves, anthropogenic sounds) from the April and May recordings. This intervention preserved all the sound components attributable to the new species.

Frequency resolution of FFT-based analyses is directly proportional to FFT size (e.g., see [5] and [6]): considering the expected size of the pictures in this article, an FFT size of 8192 byte was chosen as the best compromise between detail and smoothness of the picture. Frequency analyses were generated with Blackman-Harris method, by scanning a continuous interval of the audio samples as per Table 2.

Table 2. Details about the audio samples used for the analyses.

DEVICE	Record Date	Sampling frequency (recorded band)	Locality	Duration	Song Type	Interval analysed for frequency / sound pressure
Song Meter Micro	27.IV.2022	22.05kHz (0÷11025Hz)	Punta Limarsi	30'00".000	Calling	2 seconds
Song Meter Micro	27.IV.2022	22.05kHz (0÷11025Hz)	Punta Limarsi	1'52".676	Calling	2 seconds
Song Meter Micro	27.IV.2022	22.05kHz (0÷11025Hz)	Punta Limarsi	2'53".493	Calling	2 seconds
Samsung SM-A750SN	15.V.2022	unascertained (0÷16000Hz)	Martingana	1'30".958	Type 2	2 seconds
Edirol R09	06.VII.2022	44.1kHz (0÷22050Hz)	Martingana	1'46".701	Calling	10 seconds

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Bioacoustic illustrations are based on Adobe Audition screenshots, post-produced with Adobe Photoshop Elements, as needed to ensure optimal contrast. Contrast enhancement was also applied to photographs of the tegmina and of the genitalia to generate line drawing-like images. MS-Paint was used to draw custom horizontal/vertical reference rulers. Visual improvements did not alter the data nor the analysis results.

The whole frequency range available in each recording was thoroughly analyzed but, to optimize informativeness, the frequency/pressure observation window was customized in each picture: sound pressure axes are limited at the top by the highest volume observed, and at the bottom by the bottom noise at any frequency. Frequency axes are limited at the top by the actual useful frequency range, and at the bottom frequency by the lowest components attributable to the singing specimen.

3. Results

3.1. Choice of the new species name

As soon as it became evident that the population of *Acheta* living on the coasts of the island belonged to an undescribed species, an opinion poll was launched by the Parco Nazionale di Pantelleria both on the website of the Park and on Instagram, as well as on the Forum entomologiitaliani.net, offering the opportunity to choose the name of the newly discovered species among four alternatives:

1. *pantescus*, adjective indicating the inhabitants of Pantelleria;
2. *marinus*, indicating the peculiar eco-ethology of the species, linked to the rocks on the sea level;
3. *petrosus*, as alternative to the previous one;
4. *phantasma*, as a noun in apposition, indicating the difficult to observe this cricket, whose song was recorded only by chance.

In order of preference, the total 700 ballots, almost entirely collected on the website and Instagram pages of the Parco Nazionale di Pantelleria, were divided as follows:

- *pantescus*, 396 votes (56,6%);
- *phantasma*, 146 votes (20,8%);
- *petrosus*, 136 votes (19,4%);
- *marinus*, 22 votes (3,1%).

3.2. Description of Acheta pantescus *n. sp. (Figs. 2-6)*

3.2.1. Material examined

Italy, Sicily, Pantelleria Is., Lighthouse of Punta Limarsi 14.V.2022, C. Cusimano, P. Fontana, B. Massa (♂ holotypus) (BMPC); Italy, Sicily, Pantelleria Is., Lighthouse of Punta Limarsi 14.V.2022, C. Cusimano, P. Fontana, B. Massa (♀ nymph, reared to adult paratype in alcohol) (MSNR); Italy, Sicily, Pantelleria Is., Martingana 15.V.2022, C. Cusimano, P. Fontana, B. Massa (♀ paratypus) (BMPC).

3.2.2. Other species examined

Acheta turcomanoides Gorochov, 1993. Algeria, Sahara, Hoggar (1♂) (MNCN); United Arab Emirates, Sharjah x Khor Kalba, 31.V-7.VI.2006 (2♂♂, 1♀) (BMPC); *Acheta confalonierii* (Capra, 1929). Libya, Cyrenaica, Porto Bardia IV.1927 (♂ holotypus) (MSNG); United Arab Emirates, Wadi Shawkah 31.X-27.XI.2006 (1♂, 2♀♀) (BMPC); *Acheta hispanicus* Rambur, 1838. Spain, Siviglia 16.IX.1983, T. La Mantia (1♂, 1♀) (BMPC); *Acheta rufopictus* Uvarov, 1957. Yemen, Socotra, Wadi Ayev 10.IV.2008, B. Massa (1♀) (BMPC); *Acheta domesticus* (Linnaeus, 1758). Italy, Sicily, Pantelleria Is. Loc. Mursia 18.IX.1993 (1♀), 9.IX.1994 (1♂); Italy, Lombardy, Piacenza 24.VI.1989, B. Massa (1♀); Greece, Rodes, River Lutani 28.VII.1993, B.Massa (1♂); France, Corsica, Porto Vecchio 30.VIII.1995, B. Massa

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(1♂, 1♀) (BMPC); *Acheta meridionalis* (Uvarov, 1921) (photos of ♂ and ♀ from Canary Is. provided by A. Hochkirch).

3.2.3. Diagnosis

Small-sized, brachypterous with second wings atrophic, brown-reddish.

3.2.4. Description

Figure 2. Live male specimen of *Acheta pantescus* n. sp. as photographed at the lighthouse of Punta Limarsi on 14th May 2022.

Male. Small-sized for the genus. Color brown-reddish (Figs. 2-3). Head round, uniformly brown, darker vertex with a transverse oval whitish spot between antennae, width of antennal cavity as large as the distance between these cavities (Figs. 3b, 3c). Palpi pale brown, apically brown (Fig. 3b), antennae pale brown. Pronotum weakly narrowed anteriorly, brown with a paler transversal band (Fig. 3c). Elytra straw colored but with mostly dark veins, exceeding the apex of the 6th abdominal tergite, rather narrow, pale brown with a dark spot at the base of dorsal part and a band along upper edge of lateral field (Figs. 3a, 3d). Stridulatory vein short, three oblique veins, three transversal veins on the left of tegmen (Figs. 3d, 5a, arrows), mirror transverse, medium-sized, apical field of tegmina short. Posterior wings atrophic. Macropterous individuals unknown. Legs uniformly pale brown, anterior tibiae with a large outer and a small inner tympanum. Last tergite with posterior margin straight (Fig. 3e), cerci as long as body (Figs. 2, 3a, 3f). Genitalia: posterior edge of epiphallus in dorsal and lateral views as in Figs. 3g, 3h, 6a, 6b.

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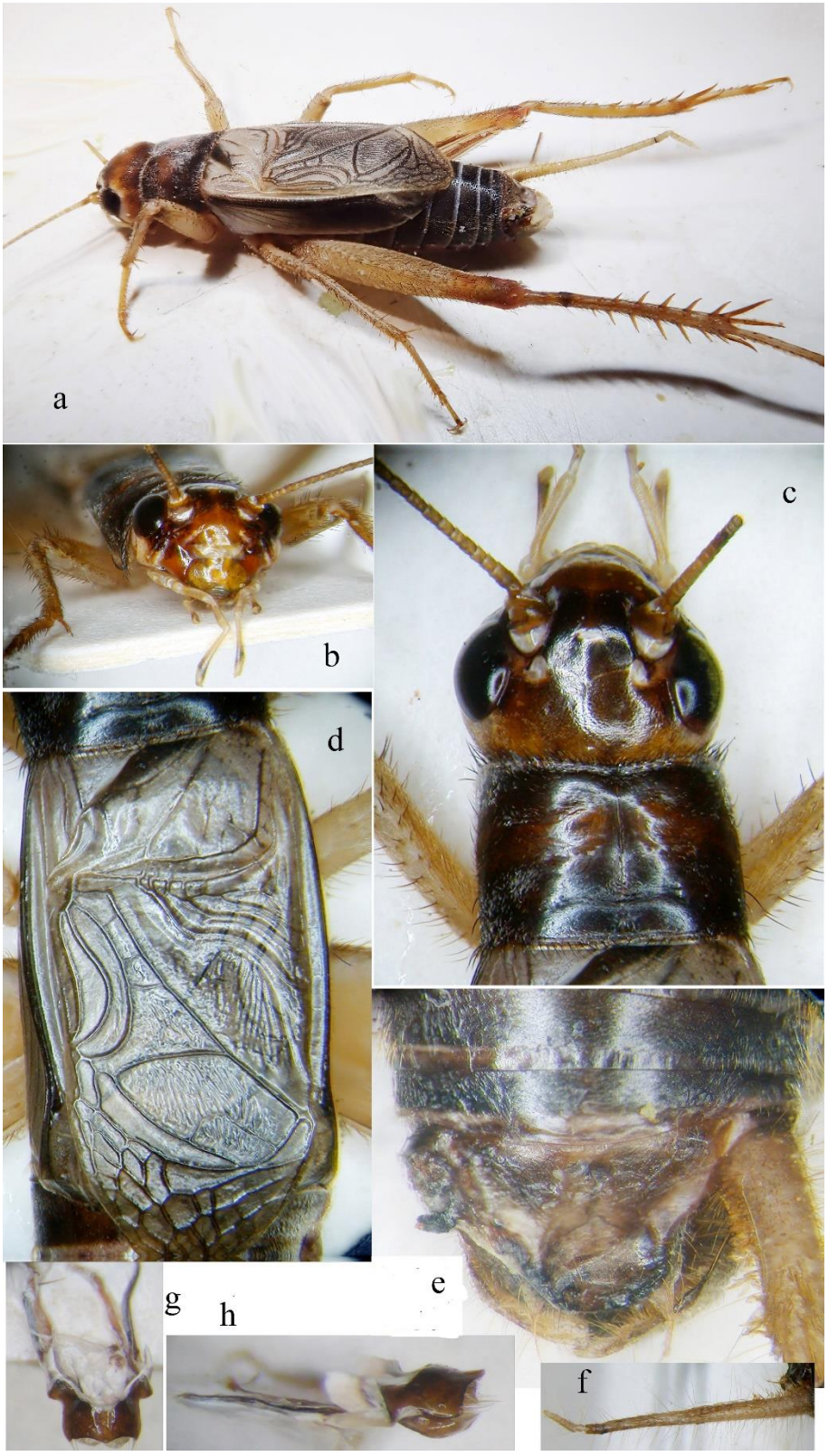

Figure 3. *Acheta pantescus* n. sp. male adult from the lighthouse of Punta Limarsi, Pantelleria. a) lateral view; b) head in frontal view; c) head and pronotum in dorsal view; d) detail of male right tegmen; e) last tergite; f) cercus; g-h) genitalia.

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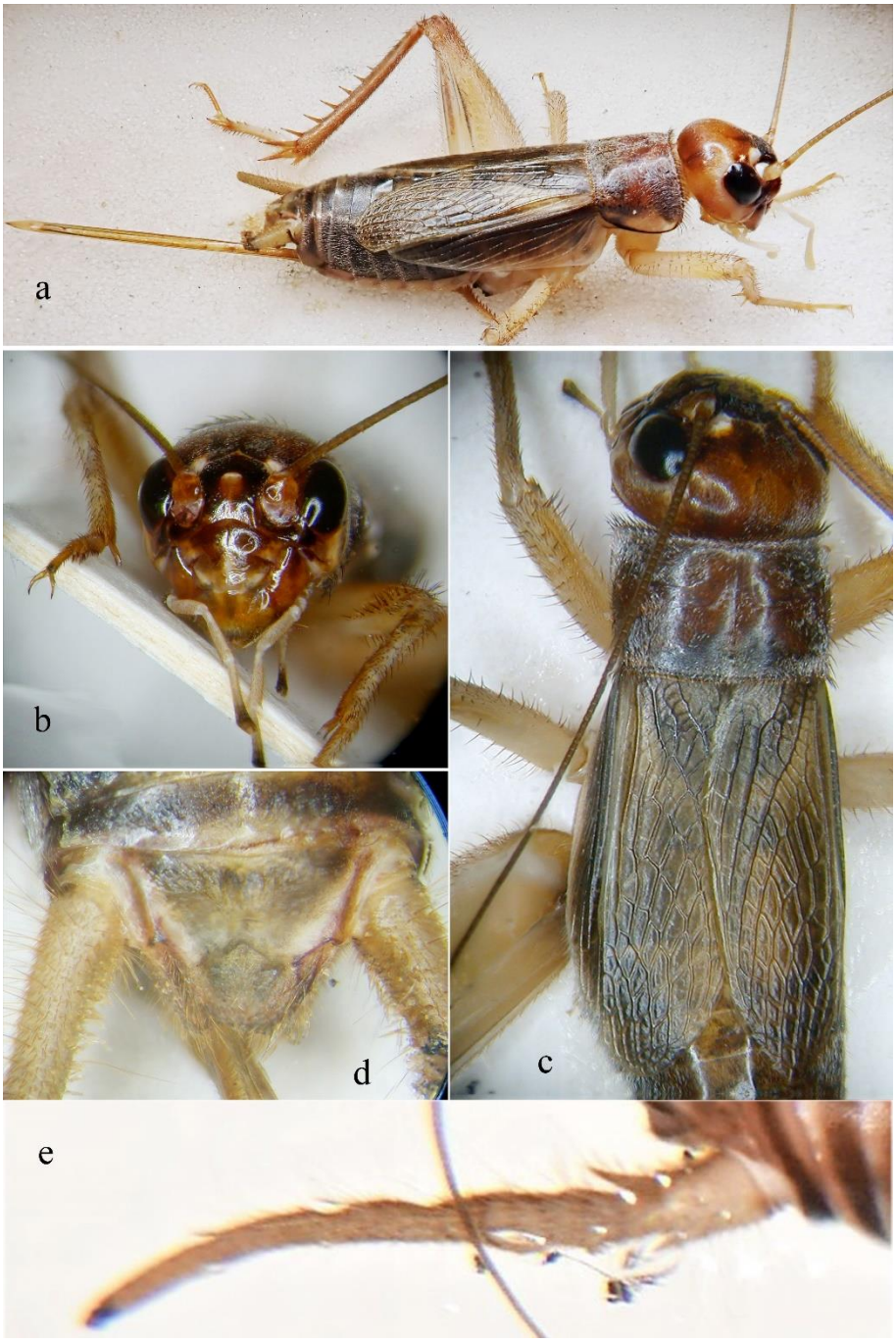

Figure 4. Adult female characters of *Acheta pantescus* n. sp.. a) lateral view; b) head in frontal view; c) dorsal view of head, pronotum and tegmina; d) last tergite; e) incomplete right cercus of the specimen collected as a nymph.

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Female. Same characters of the male, with the following differences (Figs. 4a-4d). Wide paler transversal band on pronotum. Tegmina just exceeding the 6th abdominal tergite (Figs. 4a, 4c), dorsal part of tegmina pale brown. Ovipositor slender (Fig. 4a). Cerci are incomplete in both specimens.

3.2.5. Measurements

Length of the body: 18.2 (♂), 18.3 (♀); length of pronotum: 2.5 (♂), 2.5 (♀); length of tegmina: 9.2 (♂), 8.0 (♀); length of hind femora: 9.7 (♂), 10.2 (♀); ovipositor: 12.2.

3.2.6. Etymology

The specific name *pantescus* is derived from the Latinization of the Italian adjective "pantesco", from the Sicilian language "pantisku", a clipping of "pantiddarisku", based on the island name, "Pantiddaria" – itself a derivation from the Arabic "Daughter of the winds", usually transliterated as *Bint al-riyāḥ*.

3.2.7. Affinities

A shortlist of related species was selected for comparison: *Acheta domesticus* (Linnaeus, 1758), widespread in the Palaearctic and North America; *Acheta gossypii* (Costa, 1855), presently known only from south Italy; *Acheta hispanicus* Rambur, 1839, known from Iberian peninsula, south Italy and North Africa; *Acheta meridionalis* (Uvarov, 1921), known from Sudan, North Africa to Iran and Canary Islands; *Acheta turcomanoides* Gorochov, 1993 from Saudi Arabia; *Acheta confalonierii* (Capra, 1929) from Libya and Arabian peninsula; *Acheta arabicus* Gorochov, 1993 from Saudi Arabia; *Acheta angustiusculus* Gorochov, 1993 from Saudi Arabia; *Acheta latiusculus* Gorochov, 1993 from Saudi Arabia; *Acheta rufopictus* Uvarov, 1957 from Socotra.

Some of the previous species may have macropterous and micropterous forms, others (e.g., *A. gossypii*) are known only from micropterous form and only from the original description.

Figs. 5a-5i show the male tegmina of the most closely related *Acheta* species. Differences are evident between *Acheta pantescus* n. sp. (Fig. 5a), *A. turcomanoides* (Fig. 5f), *A. arabicus* (Fig. 5g) and *A. meridionalis* (Fig. 5i), which have four oblique veins [7]. *A. meridionalis* is brachypterous, especially the female (as *Acheta pantescus* n. sp.), is blackish with a frontal yellow line on the head (specimens from Pantelleria were compared with two photographs of *A. meridionalis* from Canary Is. provided by A. Hochkirch). *A. angustiusculus* (Fig. 5c) and *A. confalonierii* (Figs. 5d, 5e) have three oblique veins, but lack transversal veinlets on the left area of tegmen. *A. gossypii* (Fig. 5b), as schematized by Costa (1853)[8], has only two oblique veins and lacks transversal veinlets. *Acheta domesticus* and *A. hispanicus* may be excluded, other than by right tegmen veinlets, also by the different song ([1], [9]; see below).

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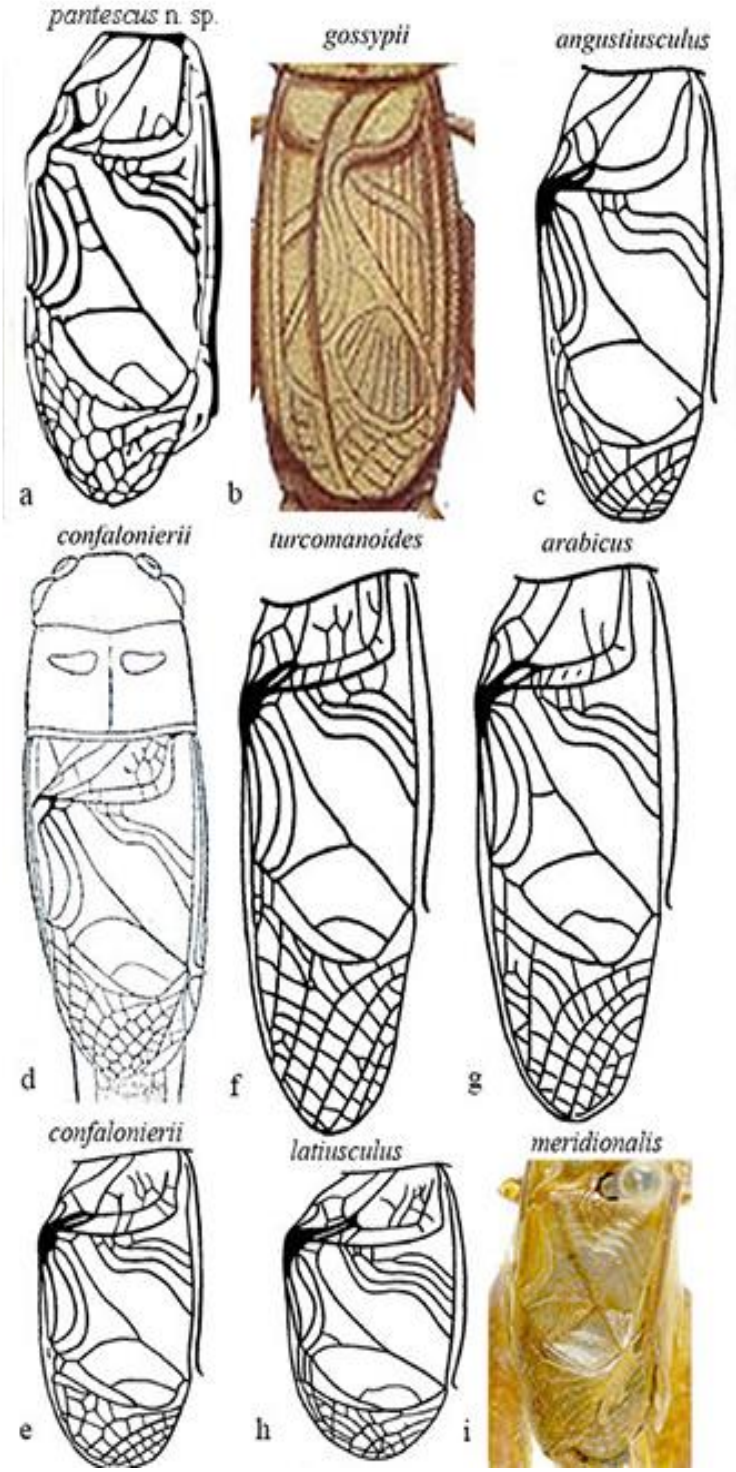

Figure 5. Right tegmen of eight species of Mediterranean *Acheta*. a) *Acheta pantescus* n. sp., contrast-enhanced image; b) *A. gossypii* (after Costa [8]); c) *A. angustiusculus* (after Gorochov [2]); d) *A. confalonierii* (after Capra [14]); e) *A. confalonierii* (after Gorochov [2]); f) *A. turcomanoides* (after Gorochov [2]); g) *A. arabicus* (after Gorochov [2]); h) *A. latiusculus* (after Gorochov [2]); i) *A. meridionalis* (holotypus of its synonym *A. canariensis*, after OSF online [9]).

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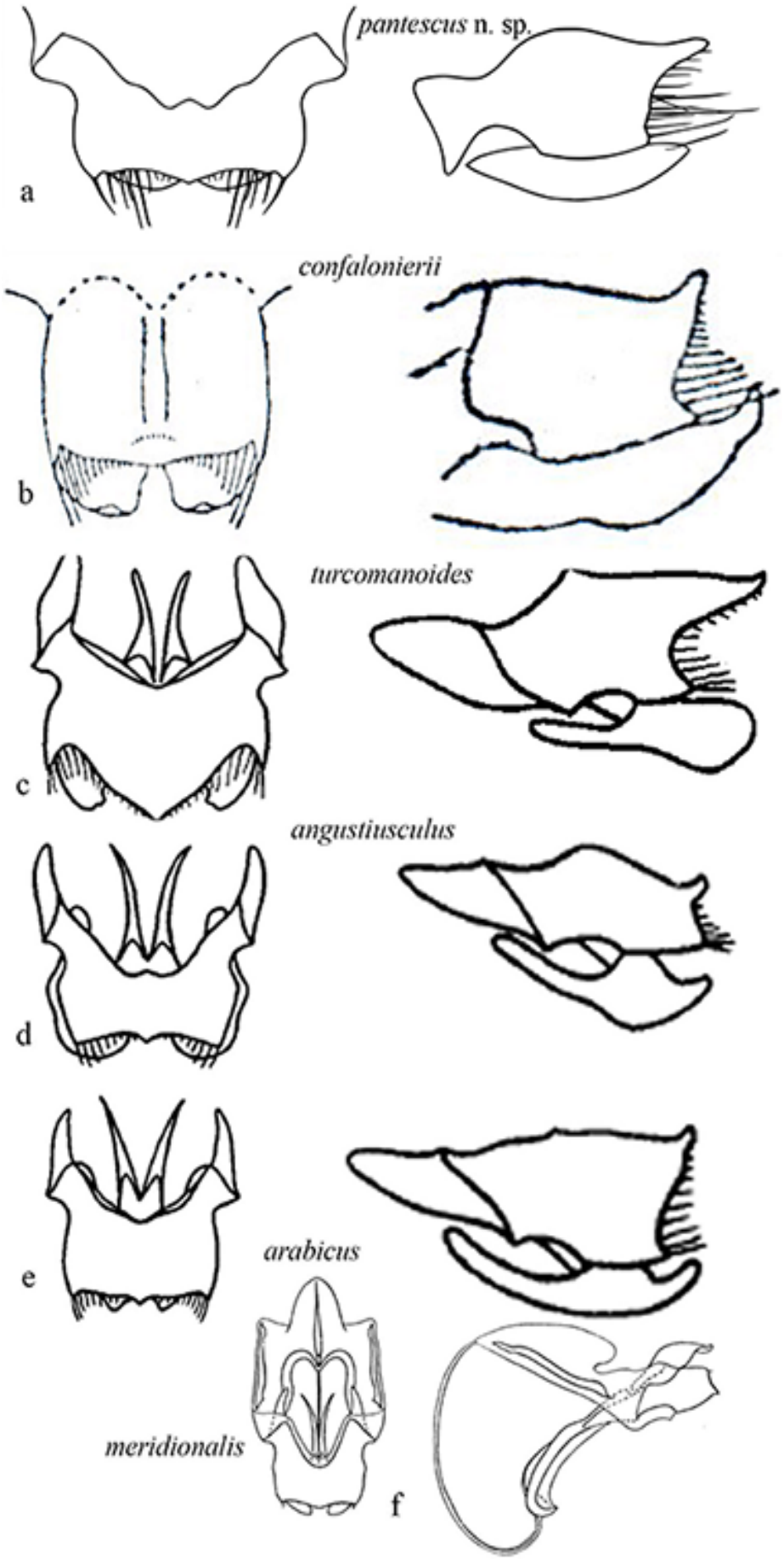

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Figure 6. Genitalia of some Mediterranean species of *Acheta*. On the left epiphallus and ectoparameres from above, on the right in lateral view: a) *Acheta pantescus* n. sp.; b) *A. confalonierii* (after Capra [14]); c) *A. turcomanoides* (after Gorochov [2]); d) *A. angustiusculus* (after Gorochov [2]); e) *A. arabicus* (after Gorochov [2]); f) *A. meridionalis* (after Gorochov & Llorente [27]).

Figure 6 shows the genitalia in dorsal and lateral view, respectively of *Acheta pantescus* n. sp. (Fig. 6a), *A. confalonierii* (Fig. 6b), *A. turcomanoides* (Fig. 6c), *A. angustiusculus* (Fig. 6d), *A. arabicus* (Fig. 6e) and *A. meridionalis* (Fig. 6f). Consulting the paper by Gorochov [2], in particular comparing the genitalia (Fig. 6), the most closely related species seems *A. confalonierii* from Libya, found also in the Arabic peninsula, which is bigger and macropterous. However, there are two or three species of *Acheta* very similar to *A. confalonierii* in North Africa and Arabian peninsula, differing only in the male genitalia ([2], A. Gorochov, V. Llorente, pers. comm.).

3.2.8. Distribution and Conservation Assessment

Acheta pantescus n. sp. is present in the Italian territory, and it's currently reported from a few stations on the Island of Pantelleria (Fig. 1).

The intrinsic vulnerability of insular habitats under increasing anthropic pressure requires some form of conservation initiative, such as its inclusion in a special Red List by the IUCN Italian Committee, aimed at ensuring the survival of this newly-reported, unique and elusive species of cricket. Presently *Acheta pantescus* n. sp. has the following distribution criteria that allow to include it within a critically endangered (CR) species: B1 Extent of occurrence EOO: less than 100 km^2; B2 Area of occupancy AOO: less than 10 km^2.

3.2.9. Habitat on Pantelleria island

Acheta pantescus n. sp. has been found only on the south and south-west coasts of Pantelleria, between the localities of Scauri and Punta del Formaggio (Fig. 1), consisting of steep and indented cliffs. Their typical lithology is volcanic, consisting of various overlapped lava layers, attributed to the "pre-Green Tuff lavas and tephra" (as clarified in the Discussion). The cliffs are subject to frequent collapses and landslides, and vary in height reaching altitudes of up to 200-300m overlooking the sea. This coastal area, from the point of view of bioclimatic levels, falls between the semi-arid infra-Mediterranean level and the dry Mediterranean thermal level [10]. On the coastal cliffs, in the lower parts most exposed to storm surges, a more or less sparse halo-rupicolous coenosis is found in *Limonietum cosyrensis*, while moving to the higher parts, sheltered from the sea, but not from the salt, a pioneer vegetation is represented by coenosis of subalophilic chamaephites *Matthiolo pulchellae-Helichrysetum errerae* and *Silenus sedoidis-Bellietum minuti*. On the plateau developing on the top of the cliffs, a vegetation of rocky substrates and sub-coastal areas of high scrub (*Periploco angustifoliae-Juniperetum turbinatae*) and low scrub (*Periploco angustifoliae-Euphorbietum dendroidis* and *Genisto aspalathoidis-Rosmaniretum officinalis*) can be observed, with fragmentary aspects of *Opuntia ficus-indica*, the latter introduced in the past by man as an agricultural crop.

Acheta pantescus n. sp. lives mainly among the fractures of the lava rocks a few meters above sea level and in the steep sandy sides, from which, well hidden, at night the males emit their song. Figs. 7-9 show some habitat types where the cricket has been found.

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Figure 7. Above: Cala Rotonda, Martingana; the arrows indicates the area inhabited by *Acheta pantescus* n. sp.; in the inset a volcanic rock photographed in the night; the cricket sang inside the crevise (see arrow). Below: *Juniperus turbinata*; the cricket in the night of 6th July 2022 was singing behind this plant and its recovery was the dry stone wall.

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Figure 8. Habitat of *Acheta pantescus* n. sp. in the locality Punta Limarsi, next to the lighthouse.

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Figure 9. Two aspects from the sea of Punta Limarsi (Pantelleria Is., Sicily), where the newly discovered *Acheta* lives.

3.3. Song description

3.3.1. Calling/advertising song

The song is emitted at night, at a pulse rate of up to 10 syllables/sec. Syllable duration ranges between 30 and 50 msec. Echemes vary in duration and number of syllables, and tend to merge in continuous, uniform trills with a duration up to 20 or more seconds, made by regular syllables of subequal volume. Prolonged trills may begin in a slight crescendo involving 1–5 syllables and end abruptly, as well as with one or two feebler final syllables. Besides the trills, the song may unorderly include shorter groups of syllables, the first two-four in crescendo.

Fig. 10 covers the recordings obtained in the open field in April and May: each syllable in a trill includes a very short final pulse, lasting around 5msec, with a volume around 60% lower than the syllable's maximum. Impact count is around 150 for the main

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syllable body, around 30 for the final pulse, and sometimes a feeble tail consisting of 10-15 impacts is observed.

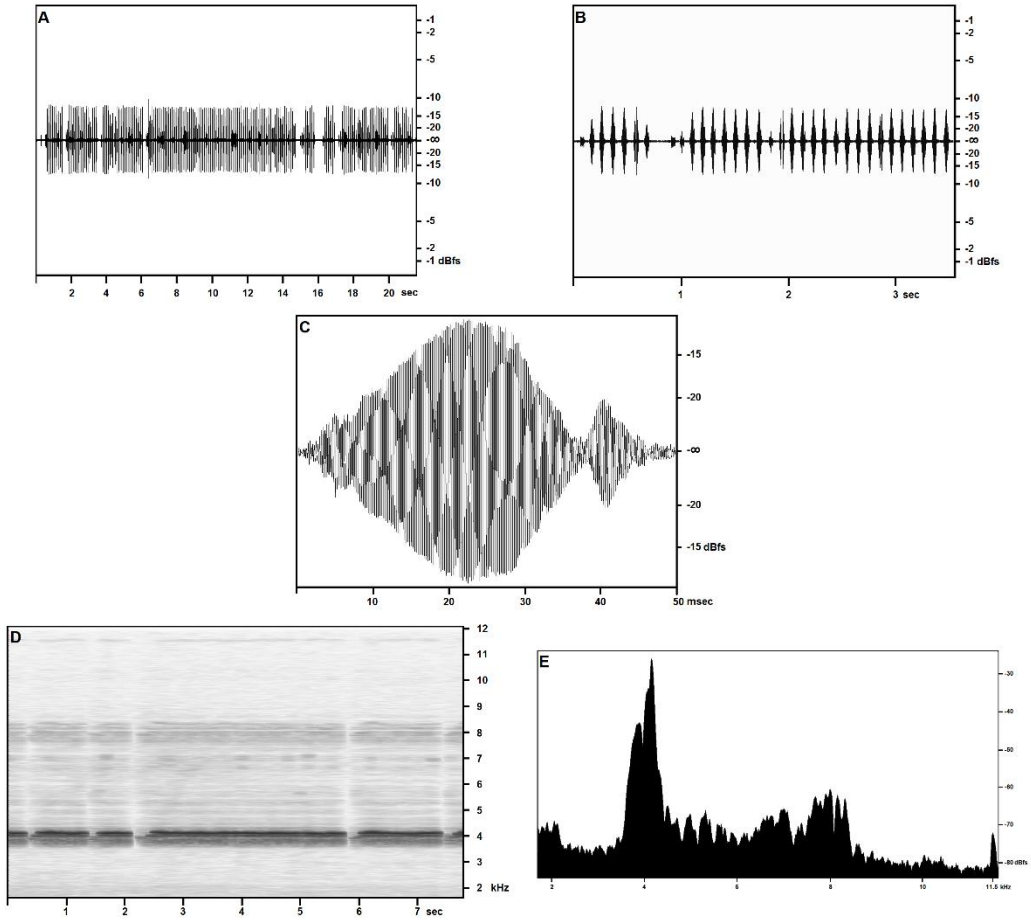

Figure 10. *Acheta pantescus* n. sp., calling/advertising Song – A, Sound Pressure Envelope, 21.5 seconds; B, Sound Pressure Envelope, 3.5 seconds; C, Impact count, one syllable; D, Time/Frequency Spectrogram, 7.7 seconds; E, Frequency/ Sound Pressure analysis, scan on two seconds.

The opening and closing syllables in each trill may show a different structure, consisting of up to three distinct pulses of subequal duration, the middle pulse loudest, or of two sub-syllables respectively longer and louder, and shorter and feebler. Trills may occasionally include lower volume syllables and structured syllables as described above.

Time-frequency spectrogram shows a well-defined fundamental band with peak pressure concentrated at around 4100Hz with a secondary, wider peak centered at around 4000Hz and a slightly lower pressure band between around 3750Hz and 3900 Hz. The first harmonic band reproduces the same structure in a more feeble and less distinct way, at double the frequencies reported for the fundamental. A narrow band may be observed near the cut-off frequency and should be considered a technogenic artefact.

The frequency/acoustic pressure analysis based on the full scan of 2 seconds (around 20 syllables) of calling song by a single individual confirms the presence of the three-peaked band as per time/frequency spectrogram. The same analysis performed on a single syllable provides a single-peaked fundamental, demonstrating a slight inconsistence in the fundamental frequency in adjacent syllables emitted by the same individual.

The calling/advertising song was recorded in higher quality in July (Fig. 11) from specimens singing from crevices in the cliff: song structure was higher-pitched, smoother, and didn't include the structured syllables nor the final pulse observed in the spring

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songs. Frequency/acoustic pressure analysis based on a 10-second scan of three subsequent trills, confirms the presence of a two-peaked fundamental band, with a primary narrow spike at around 5154Hz (-23.51 dBfs), and a secondary spike at 5028Hz (-28.46 dBfs). Primary and secondary fundamental repeat at regular harmonic intervals, respectively in very narrow spikes, with exceptional consistency (less than 0.4% frequency variance if compared with the natural arithmetical multiples of the fundamental) and in progressively blunter humps (the highest variance is shown by the fourth harmonic, and the third secondary harmonic equal in volume to the third primary harmonic). Numerical data are provided in Table 3.

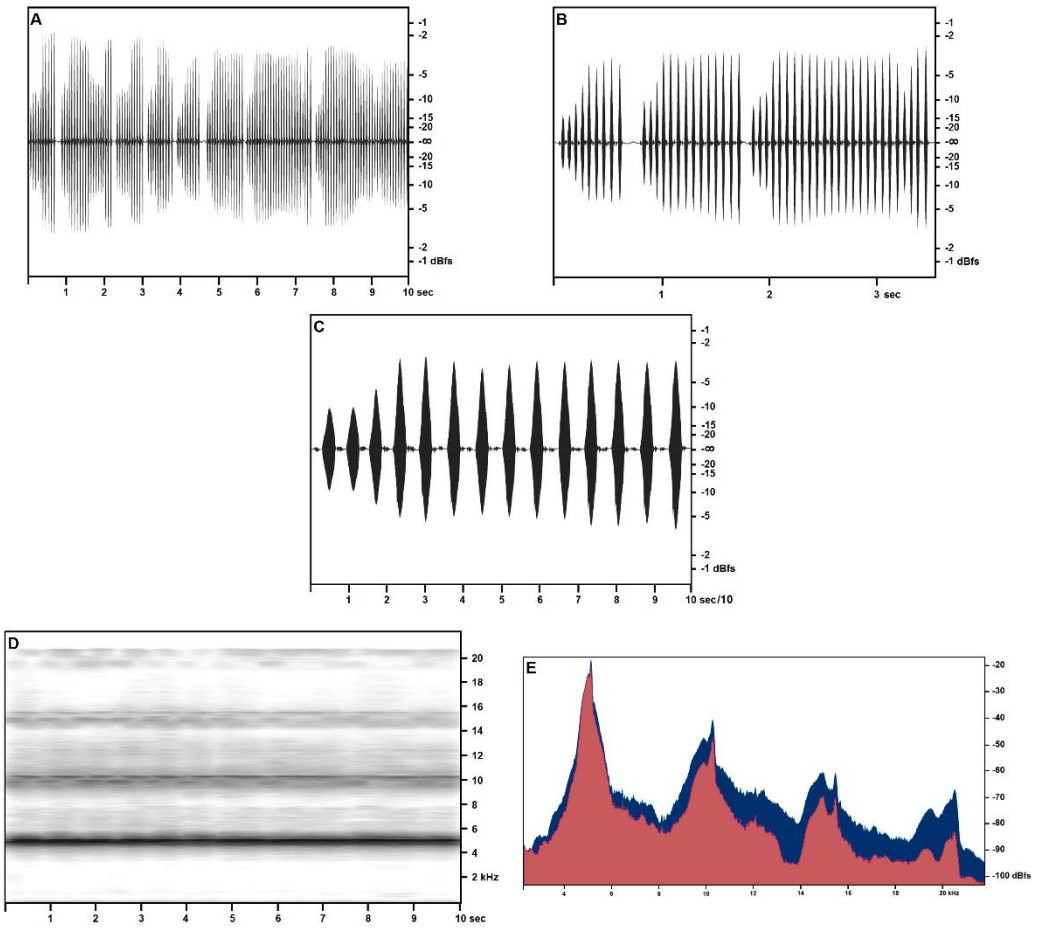

Figure 11. *Acheta pantescus* n. sp., calling/advertising Song, 44.1kHz sampling frequency stereo recording –A, Right Channel – Sound Pressure Envelope (10 seconds); B, Right Channel – Sound Pressure Envelope (3 seconds); C, Right Channel – Sound Pressure Envelope, 1-second trill; D, Time/Frequency Spectrogram, 10 seconds; E, Frequency / Sound Pressure analysis, scan on ten seconds, Right Channel in the foreground (red).

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Table 3. Harmonic structure of the July calling/advertising song of *Acheta pantescus* n. sp. in the stereo high quality recordings.

Element		Frequency (Hz)	Theoretical value	Δ	Pressure (dBfs)
Fundamental	Harmonic				
Primary	I	5154	--	--	-23.51
	II	10270	10308	+ 0.37%	-45.37
	III	15440	15462	+ 0.14%	-65.44
	IV	20540	20616	+ 0.37%	-70.39
Secondary	I	5028	--	--	-28.46
	II	9894	10056	+ 1.61%	-51.8
	III	14960	15084	+ 0.83%	-64.02
	IV	19500	20118	+ 3.14%	-76.92

3.3.2. "Type 2" song

The "type 2" song, reported from the cliff face of Martingana and illustrated in Fig. 12 shows short echemes of 6-12 syllables arranged in a crescendo up to 60% of the maximum volume, followed by two or three subequal syllables at maximum volume. Echemes are emitted in close sequence, and two or more echemes may merge, still preserving the cycle of crescendo and maximum volume syllables.

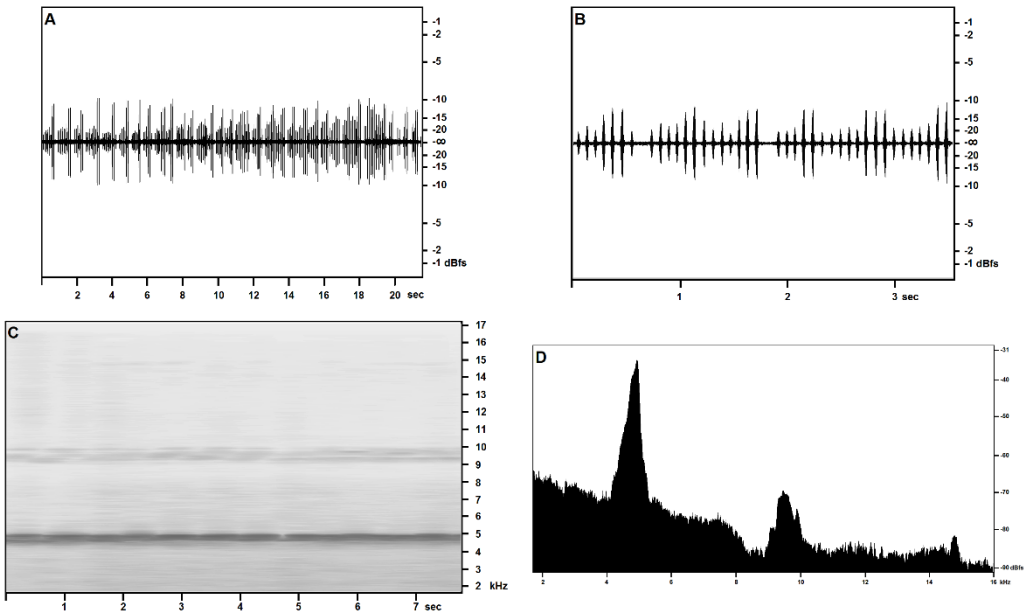

Figure 12. *Acheta pantescus* n. sp., "type 2" Song – A, Sound Pressure Envelope, 21.5 seconds; B, Sound Pressure Envelope, 3.5 seconds; C, Time/Frequency Spectrogram; D, Frequency/ Sound Pressure analysis, scan on two seconds.

The song, although surely attributable to the same species, shows an entirely different pattern than the calling/advertising song, a difference that – pending further investigation - may be reasonably attributed to a different function such as courtship, an hypothesis that may be supported by the disappearance of this type of song in the July recordings from the same locations.

Both the time-frequency spectrogram of around 8 seconds of song, and the frequency analysis of two seconds of the same song, confirm a fundamental frequency of around 4800-4900Hz, much nearer to the fundamental observed in the July call-

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ing/advertising song: this frequency peak slopes gently towards the lower frequencies, and more abruptly towards the higher range.

The first harmonic band is well recognizable and more blunt, with a clear spike at around 10kHz. The narrow second harmonic band appears at around 14.9kHz, in good accord with the fundamental.

3.3.3. Generalities and bioacoustic comparison with other *Acheta* songs

The song is decidedly High-Q ([11], [12]). The higher-pitched songs ("Type 2" and July calling/advertising) were recorded from narrow crevices in the cliff front. Those fissures may both provide a thermal conditions different from those in the open field, and spatial constraints that may result in an alteration ("sound box effect") of the song, with selective amplification and damping of specific frequency bands as reported by Brizio et al. [13] in the case of *Eumodicogryllus bordigalensis* (Latreille, 1804) singing from close cavities.

Judging from the clarity of the harmonic structure and the volume of the 4th harmonic frequency, wider band recordings (e.g., at a sampling frequency of 96 or more kHz) may reveal high-order harmonic bands well above the audible range [13].

Initial attempts to identify song affinities from bioacoustic evidence only were unfocused and fruitless. The attribution to genus *Acheta* emerged only after the first pictures became available: subsequently, similarities with congeneric songs were investigated, starting with the species reported for the Italian territory.

- *Acheta domesticus* (Linnaeus, 1758). The following observations are based on Massa et al. [1] and on the accompanying DVD. Its song consists of a series of melodious "kre"-sounds (echemes), repeated more or less regularly at the rate of about 1-3/s. Echemes vary in the number of syllables they contain, between 2 and 4. Males produce a courtship song in the vicinity of a female. It consists of a continuous rustling mixed with loud, high-pitched ticks. Both the fundamental frequency, in the range of 4700/4800Hz, the perceived timbre and the harmonic structure of *A. domesticus* songs, with evenly spaced and well-structured harmonic bands, bear resemblance with the song of the n. sp., but the song structure is radically different, both in the calling/advertising song and in the courtship song.
- *Acheta gossypii* (Costa, 1855). In Italy, the actual presence of this species is under scrutiny, for the lack of type material and of reliable reports since the original description. No bioacoustic description of this species exists.
- *Acheta hispanicus* Rambur, 1838. In Italy, the species is reported from Calabria and Sicily. No song recordings from the Italian territory are available; the following observations are based on an audio sample from OSF [9], based on a laboratory recording from India (Uttar Pradesh, Aligarh). Song of *A. hispanicus* is made by very irregular bouts of 3-4 syllables echemes, reminiscent of the calling song of *Gryllus bimaculatus*, that are emitted at a rate of 1-6/s. Observed fundamental is at around 4500Hz, the first harmonic band at around 9000Hz is almost unnoticeable in the spectrogram and in the frequency/sound pressure analysis, while the second harmonic is relevant at 14.5kHz. The song of *Acheta pantescus* n. sp. is radically different both from the structural and from the harmonic point of view.
- *Acheta meridionalis* (Uvarov, 1921). Search for audio files attributed to this unusually widespread species (whose range spans from Macaronesia to Sudan) was fruitless, and promoted a direct contact with Axel Hochkirch, who studied *A. meridionalis* at the Canary Islands. After receiving our recordings and after comparing them with his own unpublished audio of *A. meridionalis* and of *A. hispanicus*, A. Hochkirch (pers. comm.) confirmed that the song from Pantelleria didn't match either.

Also other candidate species with Mediterranean and North African distribution were considered: *Acheta angustiusculus* Gorochov, 1993; *Acheta arabicus* Gorochov, 1993;

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Acheta confalonierii (Capra, 1929); *Acheta latiusculus* Gorochov, 1993; *Acheta rufopictus* Uvarov, 1957; *Acheta turcomanoides* Gorochov, 1993.

Unfortunately, neither Capra [14] nor Uvarov [15], Uvarov & Popov [16], and Gorochov [2] did include any bioacoustic description of these species, and present authors could not locate relevant audio samples in the online repositories.

4. Discussion

In accordance with Massa [18], the presence at Pantelleria of phytophagous species strictly linked to allochthonous plants, imported to the island in the last decades, is certainly the proof of a speedy immigration of insects, at least concerning small and light species driven by the winds. However, the present fauna and flora of Pantelleria are more related to their Italian than to their North African counterparts ([17], [18], [19], [20], [21],[1]).

Presently 12 species of Grylloidea are known from Pantelleria ([18], [22]): *Gryllus bimaculatus* De Geer, 1773; *Acheta domesticus* (Linnaeus, 1758); *Eumodicogryllus bordigalensis* (Latreille, 1804); *Arachnocephalus vestitus* Costa, 1855; *Trigonidium cicindeloides* Rambur, 1838; *Pseudomogoplistes squamiger* (Fischer, 1853); *Myrmecophilus baronii* Baccetti, 1966; *Myrmecophilus ochraceus* Fischer, 1853; *Oecanthus pellucens* (Scopoli, 1763); *Gryllotalpa cossyrensis* Baccetti & Capra, 1978. To them we add also *Gryllomorpha dalmatina* (Ocskay, 1832) (C. Bucolo, F. Fonseca, M. Zapparoli, pers. comm.) and *Oecanthus dulcisonans* Gorochov, 1993 (B. Massa, pers. obs.). All the previous species are generally widespread in the Mediterranean.

Acheta pantescus n. sp. is an unexpected taxon not only for Pantelleria, but also for the Mediterranean area, which is well explored and studied from the orthopterological point of view. This unreported species escaped detection despite its peculiar song because of the unfrequented and impervious terrain where it lives: rocks and steep slopes only a few meters above the sea level on the volcanic island of Pantelleria. Very likely palaeogeographical dynamics influenced the degree of connectivity in the Mediterranean during the Pleistocene, when fluctuating eustatic sea levels, a result of the alternation of glacial and interglacial phases, led to intermittent but prolonged isolation of species as islands formed during sea level highstands and, conversely, allowed species influxes across previously submerged regions as natural land bridges formed terrestrial linkages during lowstands [23]. The most recent period of Quaternary glaciation or Last Glacial Period (between approximately 115,000 to 11,700 BP, peaking during the Last Glacial Maximum (LGM) between 26,500 and 15–18,000 years ago) was one such significant event thought to have facilitated the exchange of flora and fauna between Sicily and Malta ([24],[25]). Pantelleria was theatre of a Plinian eruption 45,000 years ago, with the deposition of the strongly peralkaline air-fall Green Tuff; thus, it is usually believed that no fauna and flora remained in the island (Silvio Rotolo, pers.comm.). Anyway, it should be noted that the observed distribution of *Acheta pantescus* n. sp. seems to concentrate, or to be restricted to, "pre-Green Tuff lavas and tephra" cliff faces (see the maps in [26],[27]), not covered by the Green Tuff deposition: in line of principle, those cliffs could have provided refugia from the Plinian eruption in case of an ingression of the new species earlier than 45,000 years ago. However, according to Lodolo & Ben-Avraham [28], during the LGM, the Adventure Plateau was part of the former Sicily mainland, forming a peninsula (the Adventure Peninsula); Lodolo & Ben-Avraham believe that most likely the ancient inhabitants of the Adventure Peninsula came from Sicily, with which a direct terrestrial connection existed throughout the LGM, as indicated by morphological reconstructions of paleo-shorelines (Fig. 13). The provenance from North Africa would have been more difficult because of a nearly 50 km wide seaway between the Peninsula and the former Tunisian shore.

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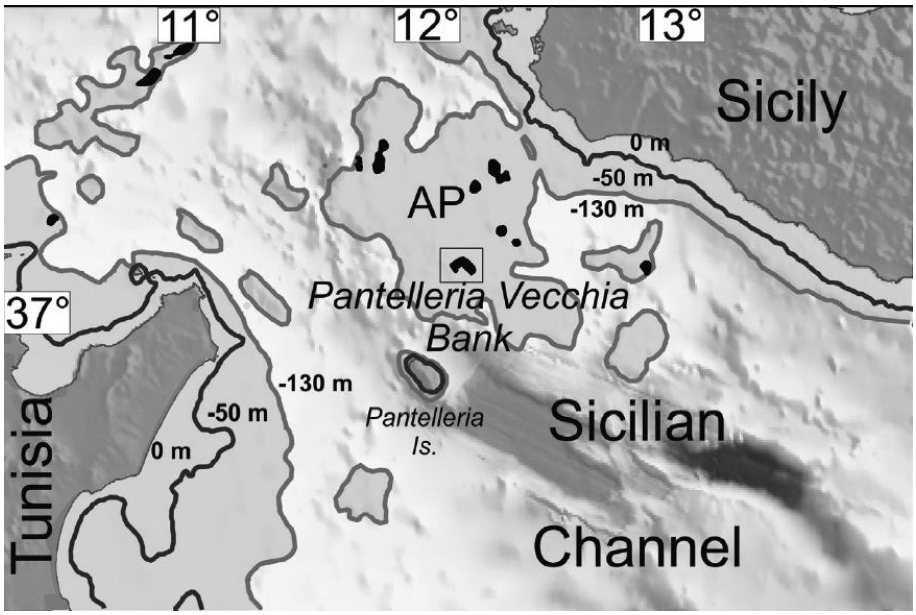

Figure 13. Adventure Plateau dominated by north-west trending, linked to Sicily during the LGM and few km away from the island of Pantelleria (after Lodolo & Ben-Avraham 2015[28]).

One of the widespread species of the genus is *Acheta domesticus*, a medium-sized light fulvous or testaceous cricket, whose pronotum is adorned with two large brown spots and whose lateral lobes are testaceous with a brown band in the superior part. This species, geographically widespread and accidentally introduced in many countries, often synanthropic and today widely bred as live food for various animals, is generally macropterous and has 4-5 oblique veins on the right tegmen. When Costa described *Gryllus gossypii* [8], which infested cotton cultivations in the area of Otranto (Apulia, south Italy), he highlighted the possibility that it was a brachypterous form of *A. domesticus*; regrettably we were not able to find the types which had to be preserved in the Museum of Zoology of Naples University, and *A. gossypii* was no more collected since its description; indeed the female, identified as *A. gossypii*, collected in Murcia (Spain) is very probably belonging to another species [29]. Concerning this species, Chopard [30] reported it also from Kenya, but this record has not been supported by specimen collection.

Thus, we may propose three hypotheses. The first is that the newly discovered *Acheta* from Pantelleria arrived from Europe (Sicily during the LGM was only a few km away from Pantelleria [28]); in this case the only possible colonization was passive, that is the spread of propagules by possible means, such as floating logs or even the wind. These propagules likely settled along the coast, in a very peculiar habitat, where they lost their second pair of wings, became brachypterous, lost the ability to fly and underwent size reduction, becoming endemic to the island. This may have happened during the last 15-26,500 years. Colonizers very likely remained linked to the coasts of Pantelleria.

The second hypothesis is that the propagules arrived from North Africa, which during the LGM remained at least 50 km away from Pantelleria. However, according to Thiel & Gutow [31] Orthoptera are not in the list of rafting organisms, like Coleoptera, Hymenoptera, Diptera etc. Thus, the colonization from Sicily looks more probable than from North Africa. An interesting similar case concerns *Stenostoma cossyrense* Bologna, 1995 (Coleoptera: Oedemeridae), which, however, has a much related species living in Malta and Sicily (*S. melitense*, M. Bologna, pers. comm.).

A third hypothesis could be that of a transport by the first ancient human populations who have visited Pantelleria since prehistoric times, both as a stop for navigation in the Sicilian Channel and for the precious deposits of Obsidian. According to Rapisarda [32], the exploitation of the obsidian deposits of Pantelleria could also have begun in the Paleolithic, starting from 18,000 years ago, when the level of the Mediterranean was

lower than 110 m and therefore navigation from North Africa to Sicily was really practicable. *Acheta pantescus* n. sp. could therefore also be a species transported by man (for example with artifacts, foodstuffs or live plants) and then extinct or never found again in its place of origin or a species that evolved from a small number of individuals accidentally introduced on the island. All the three hypotheses match the patterns described by Kenyeres et al. [33] with reference to the endemisms of the islands in the Mediterranean Sea.

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Conflicts of Interest: The authors declare no conflict of interest.

References

1. Massa, B.; Fontana P.; Buzzetti F.M.; Kleukers, R.; Odé, B. Fauna d'Italia. Orthoptera Edizioni Calderini de Il Sole 24 Ore, Italy, 2012; Volume XLVIII, pp.1-563.
2. Gorochov, A.V. Grylloidea (Orthoptera) of Saudi Arabia and Adjacent Countries. Fauna of Saudi Arabia 1993, 13, 79-97.
3. Mertens, J.E.J.; Van Roje, M.; Merckx, J.; Dekoninck, W. The use of low cost compact cameras with focus stacking functionality in entomological digitization projects. Zookeys 2017, 712, 141–154. DOI: https://doi.org/10.3897/zookeys.712.20505
4. Hadley, A. Combine Z. Available online: www.hadleyweb.pwp.blueyonder.co.uk (accessed on 15 February 2009).
5. Welch, T.B.; Wright Cameron, H.G.; Morrow, M.G. Real-Time Digital Signal Processing from MATLAB to C with the TMS320C6x DSPs. Second Edition, CRC Press, Boca Raton, USA, 2012.
6. National Instruments Corporation, White Paper 4278 (2018) - The Fundamentals of FFT-Based Signal Analysis and Measurement in LabVIEW and LabWindows/CVI. Available online: http://www.ni.com/white-paper/4278/en/ (accessed on 10 June 2022).
7. Massa, B.; Buzzetti, F.M.; Fontana P. Order Orthoptera. Arthropod fauna of the UAE 2010, 3, 70–112.
8. Costa, O.G. Ortotteri Nevrotteri. Fauna del Regno di Napoli 1855, 5.
9. Cigliano, M.M.; Braun, H.; Eades, D.C.; Otte, D. Orthoptera Species File Online. Version 2.0/4.0 (2022). Available online: http://Orthoptera.SpeciesFile.org (accessed on 15 June 2022).
10. Gianguzzi, L. Il paesaggio vegetale dell'Isola di Pantelleria. Contributo alla conoscenza della flora, della vegetazione e delle serie di vegetazione. Collana Sicilia Foreste, Azienda Foreste Demaniali della Regione Siciliana, Palermo, Italy, 2000; pp. 1-192.
11. Elsner, N.; Popov, A.V. Neuroethology of acoustic communication. Advances Insect Physiology 1978, 13, 229-355. DOI: https://doi.org/10.1016/S0065-2806(08)60267-2
12. Montealegre-Z, F.; Morris, G.K. Songs and Systematics of Some Tettigoniidae from Colombia and Ecuador I. Pseudophyllinae (Orthoptera). Journal of Orthoptera Research 1999, 8, 162-236. DOI: https://doi.org/10.2307/3503439

13. Brizio, C.; Buzzetti, F.M.; Pavan, G. Beyond the audible: wide band (0-125 kHz) field investigation on Italian Orthoptera (Insecta) songs. Biodiversity Journal 2020, 11 (2), 443–496. DOI: https://doi.org/10.31396/Biodiv.Jour.2020.11.2.443.496
14. Capra, A.V. Grylloidea (Orthoptera) of Saudi Arabia and Adjacent Countries. Annali del Museo Civico di Storia Naturale Giacomo Doria 1929, 53, 122-159.
15. Uvarov, B.P. On the native country of the common house-cricket (*Gryllus domesticus* L.). The Entomologist's Monthly Magazine 1921, 57, 138–140.
16. Uvarov, B.P.; Popov, G.B. The saltatorial Orthoptera of Socotra. Zoological Journal Linnean Society 1957, 43, 359-389.
17. Chopard, L. Orthoptéroides de l'Afrique du Nord. Faune de l'Empire Français. Librairie Larose, Paris, France, 1943; Volume I, pp.1-450.
18. Massa, B. (ed.) Arthropoda di Lampedusa, Linosa e Pantelleria. Il Naturalista siciliano 1995, 19 (suppl.), 3-910. DOI: https://doi.org/10.1080/11250009609356130
19. Massa B. Annotated check-list of Orthoptera of Libya. Journal of Orthoptera Research 2009, 18, 75-93. DOI: http://dx.doi.org/10.1665/034.018.0109
20. Sahnoun, A.M.; Doumandji, S.E.; Desutter-Grandcolas, L. A check-list of Ensifera from Algeria (Insecta: Orthoptera). Zootaxa 2010, 2432, 1–44. DOI: https://doi.org/10.5281/zenodo.294257
21. Orthoptères Acridomorpha de l'Afrique du Nord-Ouest. Available online: http://acrinwafrica.mnhn.fr/SiteAcri/accueil.html (accessed on 20 June 2022).
22. Cassar, L.F.; Ebejer, M.J.; Massa, B. Annotated checklist of Orthoptera of the Maltese Islands. Zootaxa 2020, 4885 (1), 107-124. DOI: https://doi.org/10.11646/zootaxa.4885.1.7
23. Hunt, C.O. Quaternary deposits in the Maltese Islands: a microcosm of environmental change in the Mediterranean lands. Geojournal 1997, 41(2), 101–109. DOI: https://doi.org/10.1023/A:1006824605544
24. Hunt, C.O.; Schembri, P.J. Quaternary environments and biogeography of the Maltese Islands. Pp. 41–75 in: Mifsud, A. & Savona Ventura, C. (eds.), Facets of Maltese prehistory. The Prehistoric Society of Malta, Malta, 1999, Volume VII, pp.1-243. DOI: https://doi.org/10.1023/A:1006824605544
25. Prampolini, M.; Foglini, F.; Biolchi, S.; Devoto, S.; Angelini, S.; Soldati, M. Geomorphological mapping of terrestrial and marine areas, northern Malta and Comino (central Mediterranean Sea). Journal of Maps2017, 13, 457–469. DOI: https://doi.org/10.1080/17445647.2017.1327507
26. Civetta, L.; Cornette, Y.; Gillot, P.Y.; Orsi, G. The eruptive history of Pantelleria (Sicily channel) in the last 50 ka. Bulletin of Volcanology 1988, 50, 47–57. DOI: https://doi.org/10.1007/BF01047508
27. Romano, P.; White, J.C.; Ciulla, A.; Di Carlo, I.; D'Oriano, C.; Landi, P.; Rotolo, S.G. Volatiles and trace element contents in melt inclusions from the zoned Green Tuff ignimbrite (Pantelleria, Sicily): petrological inferences. Annals of Geophysics 2019, 61, 1-18. DOI: https://doi.org/10.4401/ag-7671
28. Lodolo, E.; Ben-Avraham, Z. A submerged monolith in the Sicilian Channel (central Mediterranean Sea): Evidence for Mesolithic human activity. Journal of Archaeological Science Reports 2015, 3, 398-407. DOI: http://dx.doi.org/10.1016/j.jasrep.2015.07.003
29. Gorochov, A.; Llorente, V. Estudio taxónomico preliminar de los Grylloidea de España (Insecta, Orthoptera). Graellsia 2001, 57, 95-139. DOI: https://doi.org/10.3989/graellsia.2001.v57.i2.281
30. Chopard, L. Gryllides. Fam. Gryllidae; Subfam. Gryllinae (Trib. Grymnogryllini, Gryllini, Gryllomorphini, Nemobiini). In: Beier (ed.), Orthopterorum Catalogus 1967, 10: pp. 1-213.
31. Thiel, M.; Gutow, L. The Ecology of the Rafting in the Marine Environment. II. The Rafting Organisms and Community. In: Gibson, R.N.; Atkinson, R.J.A.; Gordon J.D.M. (eds.), Oceanography and Marine Biology: An Annual Review 2005, 43, 279-418. DOI: https://doi.org/10.1201/9780429026379
32. Rapisarda, M. L'età dell'ossidiana di Pantelleria. Atti dell'Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali 2007, 13, 1-21. DOI: https://doi.org/10.1478/C1C0702001
33. Kenyeres, Z.; Rácz, I. A.; Varga Z. Endemism hot spots, core areas and disjunctions in European Orthoptera. Acta zoologica cracoviensia 2009, 52B (1-2): 189-211. DOI: https://doi.org/10.3409/azc.52b_1-2.189-211