https://www.biodiversityjournal.com - Edizioni Danaus
Biodiversity Journal, 2024, 15 (2): 347–353 - **Monograph**
https://doi.org/10.31396/Biodiv.Jour.2024.15.2.347.353

Biodiversity Journal
ISSN 2039-0394 (Print Edition)
ISSN 2039-0408 (Online Edition)

Brachytrupes membranaceus (Drury, 1773) and *B. megacephalus* (Lefebvre, 1827) (Orthoptera Gryllidae): two species compared

Alfredo Petralia[1], Marcello Artioli[2], Alberto Petralia[3] & Toni Puma[4]

[1]Ente Fauna Siciliana ETR, Via Angelo Cavarra 184, 96017 Noto, Siracusa, Italy; e-mail: alfredo.petralia@yahoo.it
[2]ENEA Centro Ricerche Bologna, Via Martiri di Monte Sole, 4, 40129 Bologna, Italy
[3]ENEA Centro Ricerche Frascati, Via Enrico Fermi, 45, 00044 Frascati, Roma, Italy
[4]Toni Puma Nature&Photography, Via Taormina 36, 97015 Modica, Ragusa, Italy

ABSTRACT The authors compare the stridulations of *Brachytupes membranaceus* (Drury, 1773) and *Brachytupes megacephalus* (Lefebvre, 1827) (Orthoptera Gryllidae), two burrowing sabulicolous crickets which coexist in the contiguous areas of their respective ranges and which, although easily distinguishable morphologically, show remarkable eco-ethological similarities. The sound spectrograms of the two species are here analysed and it is highlighted how the stridulations produced by the males to recall the females do not seem species-specific as they are mutually accepted as a signal of recall for the partner. It is hypothesized that the forms morphologically described in the literature as intermediate between the two species may be hybrids. This work was presented in 6th International Congress on Biodiversity "Biodiversity and the new scenarios on alien species, climate, environment and energy" held at the University Territorial Center of Trapani (Italy, Sicily) (2–3 September 2022).

KEY WORDS Stridulations; spectrogram; Marina di Modica; Kuiseb River; Gobabeb; Sicily, Namibia.

Received 19.08.2023; accepted 11.10.2023; published online 30.06.2024
Proceedings of 6th International Congress on Biodiversity "*Biodiversity and the new scenarios on alien species, climate, environment and energy*" - Trapani (Italy, Sicily) 2–3 September 2022

INTRODUCTION

The interests on the two species *Brachytupes membranaceus* (Drury, 1773) (Fig. 1) and *Brachytupes megacephalus* (Lefebvre, 1827) (Fig. 2) (Orthoptera Gryllidae) converge mainly on three aspects: as species harmful to crops (Ballard, 1914; Zanardi, 1964); as food resource for humans (Scortecci, 1960; Chopard, 1962); as protected species or subject of scientific investigation (Costa et al., 1987; Conti et al., 2012).

Many similarities can be observed in the two species. In particular some of them are: comparable morphology and conspicuous dimensions within the Gryllidae family (Chopard, 1943); digging activity to realize tunnels in sandy soil, digging by means of the jaws and removal of the material resulting from the excavation by the large head with a "bulldozer" technique; swimming ability with "transversal symmetry locomotion" quite different from the walking one (Caltabiano et al., 1979); vegetarian diet with transportation of the food inside the tunnels; activity outside the tunnels mainly limited to around sunset; mating periods of both species that overlap between the second half of February and the first half of March; spawning and hatching of the eggs inside the tunnels; subsequent postembryonic development during the arid period of the year and surface activity suspension in winter (Caltabiano et al., 1982; Bunzli & Buttiker, 1955). Among the differences (in addition to the morphological ones, including a significantly larger head in *B. megacephalus*) we note only in *B. membranaceus* an overlap between the previous generation and the new one which is observed for a short period before the adults die (Costa & Petralia, 1990).

An important similarity between the two species concerns the pattern of courtship and mating which ends with the transfer of an ampolliform spermatophore from male to female. The male creates a sort of widening at the mouth of the tunnel (not present in the females' dens) where they place themselves to produce strong stridulations (generated by the stridulatory structures of the tegminae) for attracting female; this latter, once reached the male, enters the tunnel with him with him inside the tunnel. Here normally the mating takes place: the female, moving back slightly, offers to the male the rear end of the body making it swing sideways; she invites him to mount her on the back, which is followed by the application of the male's spermatophore to the female genital tract. After mating, the mouth of the tunnel is closed with sand (Fig. 3) which is pushed out by the male. This operation leads to the formation of typical little sand mound which easily allows to locate and map the presence of animals (Caltabiano et al., 1982; Costa et al., 1987; Petralia et al., 2015; Petralia et al., 2019).

Brachytrupes megacephalus dwells from Saharan Africa to Sicily and southern Sardinia while the

Figure 1. *Brachytrupes membranaceus*.

Figure 2. *Brachytrupes megacephalus*.

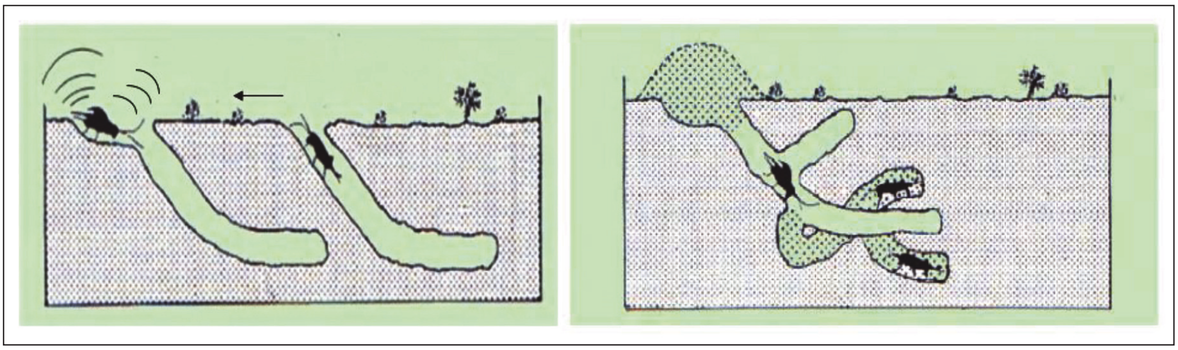


Figure 3. Left: male's stridulation at the mouth of the den to call the partner. Right: female (or females) is received (and therefore segregated in branches of the main tunnel) in the male's den which closes the mouth producing a typical mound by expelling sand from inside (see Conti et al., 2012). This behavioural pattern is observable in both species.

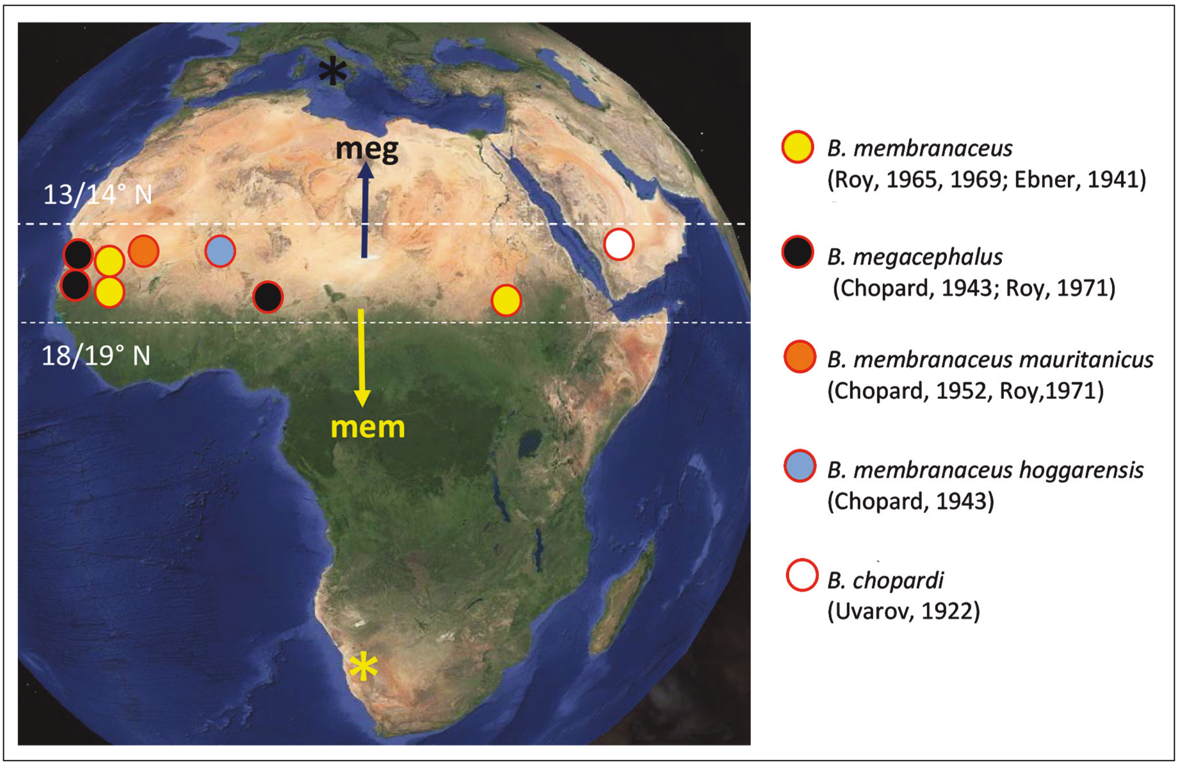


Figure 4. Overlapping band of *B. megacephalus* and *B. membranaceus* whose respective areas extend north to southern Sardinia and south to southern Africa. In the figure are also marked the once reported as subspecies of *B. membranaceus* and that described as intermediate forms between the two species. The asterisks indicate the position where the recordings of stridulations of the two species were made (north: Marina di Modica, Sicily, Italy; south: Gobabeb, Namibia) and compared in this study.

distribution of *B. membranaceus* extends to all Africa south of the Sahara: in the range between about 13°-19° north latitude there is probably an overlap of the two species' range, where they coexist. In that range, morphologically intermediate forms or described as subspecies of *B. membranaceus* are reported (Fig. 4).

Starting from these premises, we wondered if there were real isolation mechanisms between the two species on an acoustic basis and in this perspective we analyzed the properties of the stridulations produced by males (while females are silent) of both species to compare their characteristics and verify their possible specificity.

Stridulations analysis

Thirty-six years ago one of this article's author together with other researchers (Caltabiano et al., 1987) reported that a female of *B. membranaceus* collected in the sands of the Kuiseb River bed (Gobabeb, Namibia) was transferred to the dune system of Capo Isola delle Correnti (extreme south of Sicily). The female was released about six meters from the mouth of a tunnel in which a male *B. megacephalus* was screeching and she was immediately attracted by the call. Having reached the male, the female was welcomed into the latter's den with the typical pattern of the species. The closure of the den then took place and the typical small mound of sand was formed as usual. After the test, the female of *B. membranaceus* (and the sand excavated for the capture) was removed to prevent the risk of alien introduction.

Conversely, in laboratory three females of *B. megacephalus* were exposed individually to the stridulations of *B. membranaceus* previously recorded in nature on tape (in the Gobabeb habitat by means of a Superscope Professional Cassette Recorder CD 320 equipped with a directional microphone). The females were immediately attracted directly towards the source of the stridulations from various distances, up to ten meters (the largest width of the room).

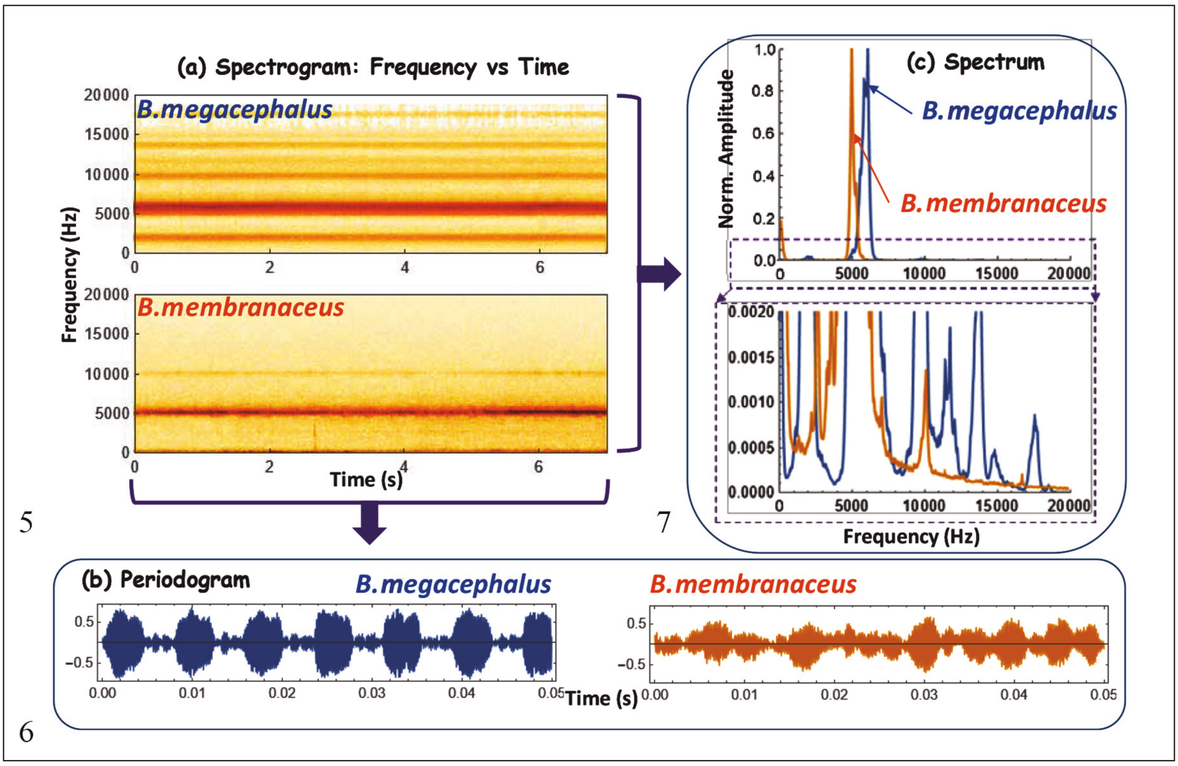
For the present study we compared the original recording of *B. membranaceus'* stridulation with a similar field recording of an *B. megacephalus* specimen realised in the dunes of Marina di Modica, southern Sicily (by means of a full-HD Panasonic G6 camera with Sennheiser MKE 400 external microphone). The results of this analysis are summarized in Figs. 5–7 and Figs. 8–10.

The two samples were analyzed by comparing the respective:

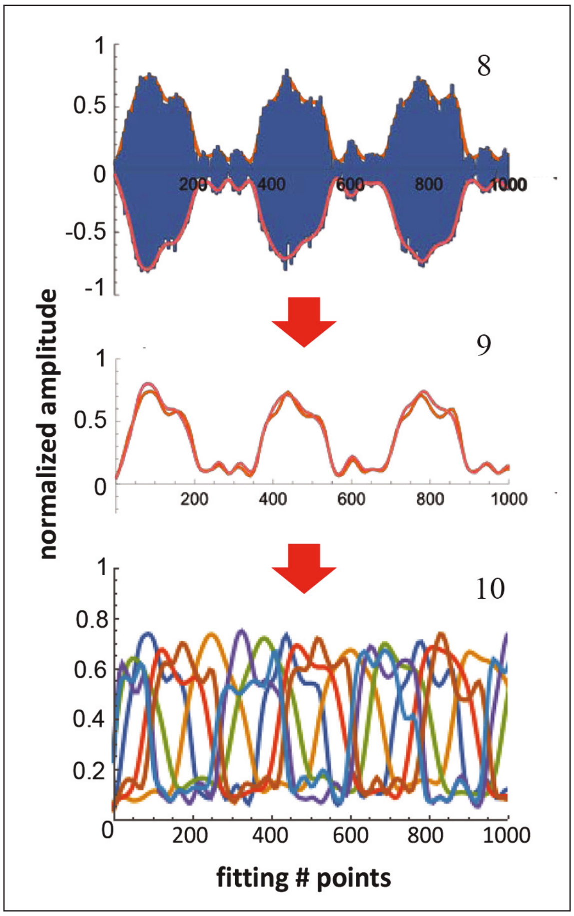
- spectrograms (as a graphical representation of the intensity of the emitted sounds in the time-frequency domain, Fig. 5),
- periodograms (waveforms, Fig. 6),
- spectra (obtained through the Fast Fourier Transform (FFT) of the waveforms, Fig. 7).

Finally, the spectra of the envelope were also studied, namely the macro periodicities of waveforms in time (Figs. 8–10 and Figs. 11, 12).

Comparing the two periodograms, in both cases we notice a periodicity of the sound wave even much defined for *B. megacephalus*. For both crickets, in addition to a high-frequency oscillation, some lobes are evident with a periodicity that indicates the presence of one or more amplitude modulations of the main frequency component. Looking at the spectrogram, for both sounds it is evident a dominant frequency around 5-6 kHz and other secondary peaks, more evident for *B. megacephalus* but also present in the *B. membranaceus'* sound. It is to be noticed also that the frequency has no chirp, so it does not vary over time. Observ-



Figures 5–7. Spectrogram (Fig. 5) of the screeching of *B. megacephalus* (in agreement with the previous analysis by Brizio, 2018), and of *B. membranaceus*. A comparison is made between the wave-form (Fig. 6) of the emitted sound and the related spectra (Fig. 7) with normalized amplitude. The main frequencies of emission are both centred around 5–6 kHz, differing for the two species less than 16%. It is also evident the presence of other lines in the spectrum, whose values indicate the presence of an high-frequency amplitude modulation. The modulating frequencies are evaluated by comparing the spectral lines position with the theoretical modulation pattern. The resulting values are 4 kHz for *B. megacephalus* and 2.2 kHz for *B. membranaceus*.



Figures 8-10. Fitting procedure of the envelope waveform. To increase the statistics, the starting audio sample is first divided to obtain 7 fragments, each 1 second long. Then one fitting is done on each sub-sample for both the "upper" and "lower" part of the wave envelope (Fig. 8), being the two very similar (Fig. 9), to have the envelope profile for all the selected samples (Fig. 10).

ing the spectrum, we note for the sounds of both animals the presence of the main frequency and a pattern of lines that correspond to that given by a high-frequency amplitude modulation. For both species, other lines are also present in the initial part of the spectrum at low frequencies. As described in Figs. 11, 12, these lines are consistent with a low-frequency amplitude modulation which defines the shape of the envelope of the waveform in time.

From the investigation on the spectral properties of the stridulations of the two species, several indications of similarity emerge. A similar structure is found both in the spectrogram and in the spectral.

CONCLUSIONS

Females of the two species do not discriminate between the calls of conspecific and non-conspecific males, since any differences are not relevant as they are contained in a range that in any case ensures the usability of the signal triggering the attraction of the two sexes. It is also interesting to highlight that animals also respond to human imitations of stridulation as reported by Scortecci (1945), which suggests that an extremely characterized stridulation is not necessary for the recognition of the sexes.

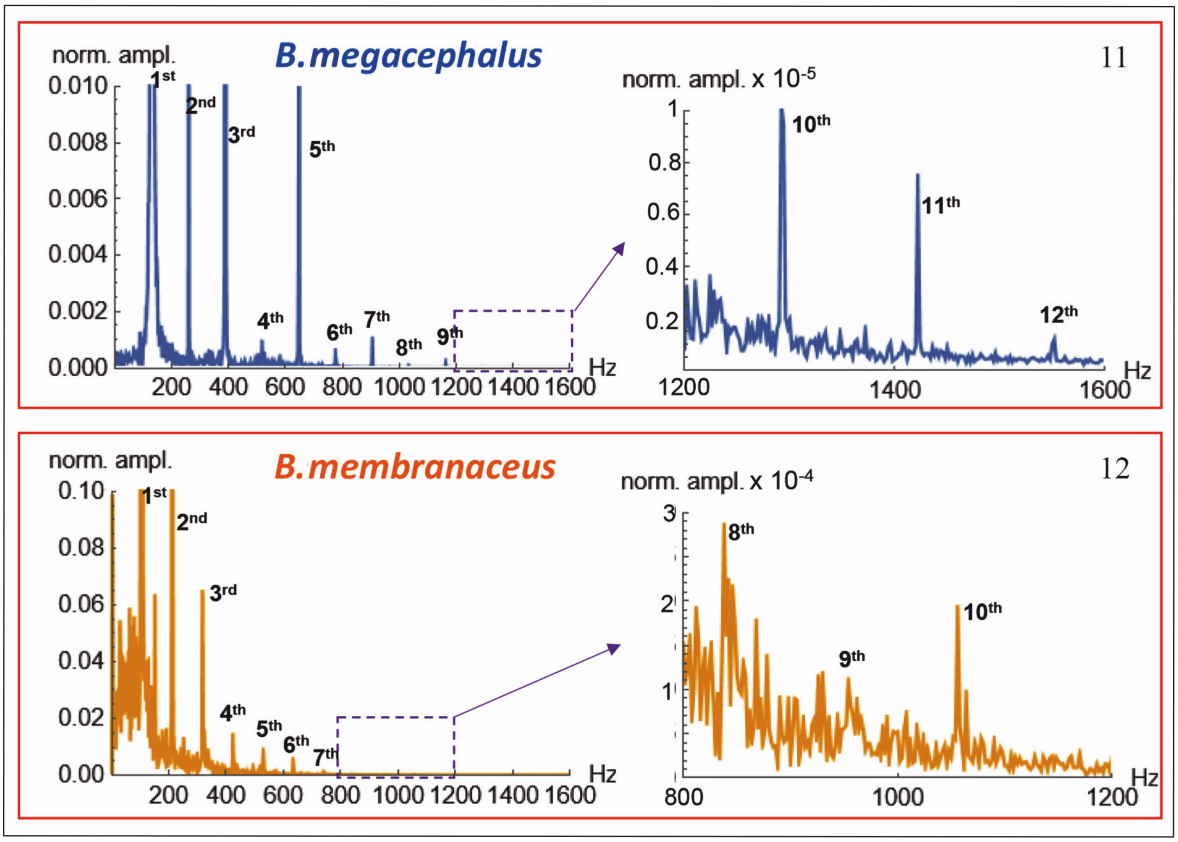
In general, it is believed that the sounds produced by closely related species are often very similar but with some species-specific differences still allowing discrimination acting as a reproductive barrier (Robinson & Hall, 2002; Massa, 2013). In our case it can reasonably be supposed that the differences are not relevant and that different levels of the ecological and ethological reproductive barriers, including the acoustic once, can be overcome. This allows us to hypothesize that the subspecies of *B. membranaceus* mentioned, as well as the intermediate forms described by the cited authors, could be hybrids between the two species we are dealing with. Furthermore, since there is currently no evidence on the possible fecundity of the supposed hybrids, it would be necessary to direct the research on further levels of mechanical, gametic or postzygotic reproductive isolation.

Since the females of *B. megacephalus* and *B. membraceus* accept the stridulations of the males of both species, it would be interesting to verify whether this occurs among all the species of the genus (see the work of Simeu-Noutchom et al., 2024). It would be interesting to ascertain whether the acoustic signal is genus-specific rather than species-specific, tolerating more or less large variations with respect to the frequency around 5000 Hz considered as the basic value. This would help the understanding of which reproductive isolation mechanisms are potentially decisive or not among *Brachytrupes* species.

REFERENCES

Ballard E., 1914. A list of the more important insect peste of crops in the Nyasaland Protectorate. Bulletin of entomological Research, 4: 347–351.

Brizio C., 2018. Bioacoustic evidence of two uncommon



Figures 11, 12. Envelope spectrum, given by the Fast Fourier Transform (FFT) of the acoustic wave envelope, for *B. megacephalus* (Fig. 11) and *B. membranaceus* (Fig. 12). Similarities arise from the comparison of the two spectra. It is evident a large harmonic content up to high order for both species. This corresponds to an amplitude modulation at low frequency with high order components, even those with a small relative intensity. The values of the modulating (low) frequency result to be 130 Hz and 108 Hz for respectively *B. megacephalus* and *B. membraneceus*, the difference is than less than 20% for the two stridulations.

crickets from SW Sardinia, including an analysis of the song of *Brachytrupes megacephalus* (Lefèvre, 1827) (Orthoptera Gryllidae) in the ultrasonic range. Biodiversity Journal, 9: 135–142.

Bunzli G.H. & Buttiker W.W., 1955. The control of the tobacco cricket (*Brachytrupes membranaceus* Drury) in Southern Rhodesia. Acta tropica, 12: 252–260.

Caltabiano A.M., Costa G. & Petralia A., 1979. Ricerche sulla locomozione negli Insetti. IV. Deambulazione, nuoto e scavo di *Brachytrupes megacephalus* (Lef.) (Orthoptera, Gryllidae). Animalia, Catania, 6: 71–79.

Caltabiano A.M., Costa G. & Petralia A., 1982. Ricerche eco-etologiche sulla fauna delle dune costiere di Portopalo (Siracusa). Biologia comportamentale di *Brachytrupes megacephalus* (Lef.) (Orthoptera Gryllidae). Animalia, 9: 269–292.

Caltabiano A.M., Costa G., Leonardi M.-E. & Petralia A., 1987. *Brachytrupes membranaceus* and *Brachytrupes megacephalus*: which isolating mechanisms prevent their interbreeding? Abstracts International Ethological Conference XX, 7 August 1987, Madison, Wisconsin: 28.

Chopard L., 1943. Orthoptéroïdes de l'Afrique du Nord. Faune de l'Empire français, Librairie Larose, Paris, 1: [4] + 450 pp., 658 figs.

Chopard L., 1952. Contribution a l'etude du peuplement de la Mauritanie. Orthoptéroïdes. Bulletin de l'Institut français d'Afrique Noire, 14: 457-478.

Chopard L., 1962. Orthopters Gryllidae et Gryllacrididae del l'Angola. Publicações Culturais da Companhia de Diamantes de Angola, 56: 13–69.

Chopard L. 1967. Gryllides. In: Orthopterorum Catalogus. Ed. M. Beier. Uitgeverij Dr. W. Junk, Gravenhace, pp. 40–44.

Conti E., Costa G., Petralia A. & Petralia E., 2012. Ecoethology of *Brachytrupes megacephalus* (Orthoptera, Gryllidae), protected species in EU. Atti e Memorie dell'Ente Fauna Siciliana, 11: 51–56.

Costa G., Leonardi M.-E. & Petralia A., 1987. Reproductive behaviour of the sand cricket *Brachytrupes membranaceus* (Drury) in the Namib. Madoqua, 15: 217–228.

Costa G. & Petralia A., 1990. Nuove ricerche sulla biologia comportamentale di *Brachytrupes membranaceus* (Drury) vivente nel Namib Desert nell'area di Gobabed (Namibia). Bollettino dell'Accademia Gioenia di scienze naturali in Catania, 23: 293–316.

Ebner R., 1941. Wissenschaftliche Ergebnissedermit Unterstutzung der Akademie der Wissenschaften in Wienausder Erbschaft Treitl Von Franz Werner Unternommenen Zoologischen Expedition nachdem Anglo-Ägyptischen Sudan (Kordofan). XXIX. Orthoptera (Gryllidae et Tettigoniidae). Holder Pichler Tempsky Staats Drukerei, Wien: 4.

Massa B., 2013. Importanza della bioacustica nella sistematica degli Ortotteri. Atti Accademia Nazionale Italiana di Entomologia Anno, 61: 33–41.

Petralia A., Petralia E., Sabella G., Brogna F. & Bianca C., 2015. Presence'smapping of *Brachytrupes megacephalus* (Lefebvre, 1827) (Orthoptera Gryllidae) within the Natural Reserve of Vendicari (Noto, Siracusa, Italy). Biodiversity Journal, 6: 323–326.

Petralia A., Fiandaca P., Petralia E., Sabella G., Torrisi G., Bianca C., Lamanna F. & Dima C., 2021. On the presence and localization of *Brachytrupes megacephalus* (Lefebvre, 1827) (Orthoptera Gryllidae) in the "Oriented Natural Reserve Simeto Oasis" (Sicily, Italy). Biodiversity Journal, 12: 977–992. https://doi.org/10.31396/Biodiv.Jour.2021.12.4.977.992

Robinson D.J. & Hall M.J., 2002. Sound Signalling in Orthoptera. In: Evans P. (Ed.), Advances in Insect Physiology, Volume 29. Elsevier: Kidlington, UK, pp. 151–278.

Roy R., 1965. Contribution a l'étude de la faune de la bassa Casamence (Sénégal). XV Orthoptères Gryllodea. Bulletin de l'I.F.A.N., 27: 910.

Roy R., 1969. Le Park National du Niokolo-Koba (Sénégal). Fascicule III. IX Orthoptera Grylloidea et Glyllotalpoidea. Memoires de l'Institut Fondamental d'Afrique Noire, 84: 181.

Roy R., 1971. Contribution a l'étude biologique du Sénegal septentrional. VII. Orthoptères Ensifères (Tettigonioidea et Grylloides). Bulletin de l'Institut Francais d'Afrique Noire (I.F.A.N.), 33: 92.

Roy R., 1971. Contribution a l'étude biologique du Sénegal septentrional. VII. Orthoptères Ensifères (Tettigonioidea et Grylloides). Bulletin de l'Institut Francais d'Afrique Noire (I.F.A.N.), 33: 398.

Scortecci G. 1945. Sahara. Editore Ulrico Hoepli, Milano, 424 pp.

Scortecci G., 1966. Animali. Insetti I. Edizioni Bolis, Bergamo, 879 pp.

Simeu-Noutchom A., Heller K.-G., Aude Um Nyobe P. C. & Kekeunou S., 2024. Taxonomy review of the genus *Brachytrupes* (Orthoptera: Gryllidae) with the description of a new species and key to the species. Zootaxa, 5336 (3): 373–388 https://doi.org/10.11646/zootaxa.5336.3.4

Uvarov B.P., 1922. Description of Orthoptera from S.W. Asia. Journal Bombay Natural History Society, 28: 736–737.

Zanardi D., 1964. Un singolare insetto dannoso a vigneti e orti in Sardegna. Il *Brachytruypes megacephalus* Lefeb. Il Coltivatore e Giornale Vinicolo Italiano, 110: 370–375.