

Research article

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Ignored for 150 years: distribution, song description, habitat, and threat of *Cicadetta albipennis* (Fieber, 1876) – mysterious tiny cicada species from Sicily (Italy) (Cicadidae: Cicadettinae)

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Abstract

Cicadetta albipennis was described 150 years ago, yet no data on its ecology, acoustic behaviour, distribution and conservation have been published. This cicada species, notable for its distinct morphology, is among the smallest in Europe. We investigated the taxon within its presumed endemic range in Sicily and present the first data on its habitat preferences, acoustic behaviour and current distribution. Additionally, we provide the first photographs of live males and females. *Cicadetta albipennis* is an early-emerging species, active at least from mid-late May to the beginning of June. Its song consists of a monotonous series of short, purring echemes characterized by a supposedly very slow syllable rate and one of the highest frequency ranges among European cicadas. The species was found scattered in southern Sicily, although specimens from the north of the island (labelled — maybe erroneously — “Palermo” and “Messina”) exist in historical collections. The species is associated with grassland habitats shaped by herbivores. We discuss habitat availability across prehistoric and historic times, and suggest that *C. albipennis* is threatened by the disappearance of large wild herbivores and the decline of traditional, extensive grazing practices.

Key words: bioacoustics, biogeography, endemism, grassland biome, megaherbivore theory, smallest cicadas, ultrasound, transhumance.

Introduction

In tropical regions, many species remain undescribed, and numerous taxa become extinct due to habitat destructions before they are ever discovered (Reid 1992). Other taxa are described on poor or limited data, and subsequently fall into oblivion. This happens not only in those regions exceptionally rich in diversity, but it also affects regions with comparatively lower species richness. A case in point is *Cicadetta albipennis* (Fieber, 1876). This very tiny cicada species was originally described from Sicily and Greece on the basis of museum material, but it is likely endemic to the Italian island, as it was later never found in Greece (pers. comm. T. Trilar). After the formal description, the species was just mentioned in species lists (e.g. Nast 1987; Guglielmino et al. 2021) and has never been studied again except by Kartal (2007) who described and illustrated the genitalia after two vouchers from the Forschungsinsti-

tut und Naturmuseum Senckenberg (SMF; Frankfurt am Main, Germany) [labels: “Messina” and “Syracus” (sic!)]. A lectotype designated by Michel Boulard is kept in the Naturhistorisches Museum, Vienna, Austria (NHMW) with imprecise label “Sicily” among nine vouchers.

In cicadas, sexual attraction, mate selection and reproduction is highly dependent on male calling songs (e.g. Paterson 1985; Sueur & Aubin 2003). As a result, knowledge of their acoustic signals is often equally, or even more important than morphological characters, as it allows the identification of these well-camouflaged insects directly in the wild, and facilitates the detection of cryptic species (Gogala et al. 2008; Puissant & Sueur 2010; Hertach 2021a). For Europe, songs of approximately 90% of the known species are available on the website www.cicada-song.eu (Gogala 2025). *Cicadetta albipennis* belongs to the small minority of species for which the song has never been described. Its habitat requirements are also unknown.

During two field expeditions conducted by the first author in late June and the first half of July in northern Sicily, with focus on mountainous habitats and on species of the *Cicadetta montana* (Scopoli, 1772) group (Hertach 2011; Hertach et al. 2015), not a single population of *C. albipennis* was found as a by-product (around 200 absence points). These results led to the planning of a targeted survey to fill the above mentioned knowledge gaps. Based on relatively detailed labels from two museum vouchers — indicating the locations “Sortino” (Siracusa province) (private collection of Vera d’Urso, Catania) and “Palagonia” (Catania province; Muséum National d’Histoire Naturelle, Paris, France; MNHN), two villages in the south-east of the Island (Hyblaean Mountains, Monti Iblei) — we hypothesized that *C. albipennis* is active earlier in the season (late May) and occurs in the south of the island. One of these specimens was collected in 2007, suggesting that populations might still exist in the area.

Here, we present the first field data on the habitat preferences and acoustic behaviour of *Cicadetta albipennis*, along with the first photographs of live individuals in their natural habitat (Fig. 1). We also provide a preliminary assessment of its distribution and conservation status.

Materials and Methods

Field work

We conducted our targeted expedition from May 23 to 31, 2023, and on June 12, 2023. Since the habitat preferences of *C. albipennis* were unclear, we surveyed different habitat types, with a particular focus on grassland for two main reasons: i) Grasslands are typical and widespread in the Hyblaean Mountains region, and ii) the species’ very pale colouration of the wing venation might be an adaptation for camouflage in dry, desiccated grassland environments.

Detection of calling songs is the most effective way for assessing the presence of many cicada species. Individuals were localized by using ultrasonic detectors Peterson D 200, which are particularly effective for spotting calls in high-frequency domains (> 12 kHz) (Popov et al. 1997).

Song recordings were made with a Tascam DR-44WL connected to an ultrasonic detector (Pettersen D 200) and the microphone fitted into a small parabola (diameter: 16 cm; device 1), a Sennheiser K6/ME62 microphone combined with a Zoom H2n recorder (device 2) and a Sennheiser MKE600 mounted on a Canon 90D (device 3).

Habitat structure and some dominating plants were noted for each population. Some voucher specimens were collected for later morphological and molecular analyses and preserved either dry or in alcohol. Other individuals were photographed using a Panasonic Lumix DMC-TZ81 and a Panasonic Lumix DMC-TZ80.

Song analyses

Songs were analysed and sonograms generated using Raven Pro 1.4 (Cornell Lab of Ornithology). Song structure was interpreted hierarchically and comprises “pulses” (basic signal related to each timbal movement), “syllables” (one group of in-and-out buckling of both timbals) and “echemes” (main unit characterized by the duration of timbal activity), according to the definitions in Hertach et al. (2015). Pauses between echemes are named “inter-echemes”, while those between pulse groups “interpulses”. To properly test and differentiate pulses and syllables, one timbal should be artificially inactivated. This method allows to study the single timbal movements in comparison with normal activity (Fonseca 1991; Sueur & Aubin 2003). As we only recorded the activity of both tymbals together, our fine temporal definitions (see Figs 3 b-d) are provisional.

For the frequency domain, we executed on the base of echemes the Raven Pro functions “Maximum Frequency” and “Centre Frequency”, the latter indicating the frequency at which 50% of the signal’s energy lies below and 50% above the measured value. The -20 dB range was subtracted from the local maximum frequency level in a Hamming window with 1024 samples and an overlap of 98%. This procedure was also applied to the songs of other high-pitched cicada species (five song segments of approximately 2 s duration per individual) to compare values.

The temperature of perch surfaces where recorded singing individuals were sitting was measured with a TFA ScanTemp 410 infrared thermometer. However, the temperature range was narrow (29 to 32°C), so a relationship between song duration and temperature (Fonseca & Revez 2002; Hertach et al. 2015) could not be assessed.

Additional methods

The distribution map of *C. albipennis* (Fig. 2) was generated using QGIS 3.16 and edited with GIMP 2.10.8.

To assess whether *C. albipennis* is the smallest cicada, specimens of tiny European cicada species were measured for the length of the body and the length of the fore wing with vernier callipers and Wild M3Z or KERN OZS 574 stereo microscopes.

Results

Distribution and population size

Among the 39 locations we visited between May and June, 2023, we found thirteen populations of the species (Fig. 2 and Appendix 1). Five were classified as large (> 30 singing males), five as medium (6 to 30 singing males) and three as small (< 6 singing males). These populations are situated in the provinces of Agrigento (6), Siracusa (4), Trapani (2) and Ragusa (1). The village Salemi (Trapani province) marks the currently known distribution limit in

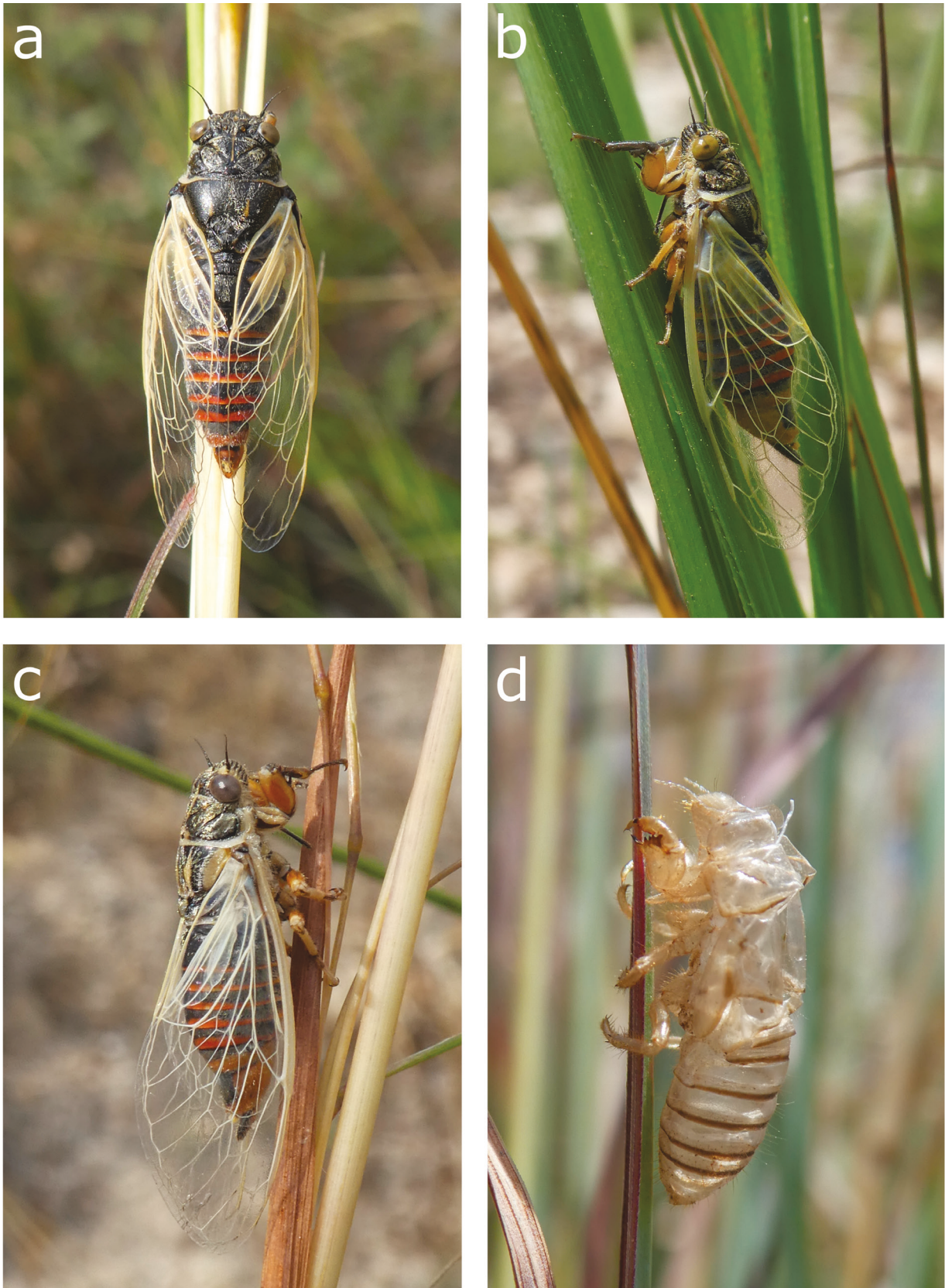


Fig. 1 – First photographs of *Cicadetta albipennis* (Fieber, 1876) in its natural habitats. **a**, male in cymbalization posture from Montallegro, 26 May 2023 and **b**, female from Chiramonte Gulfi, 29 May 2023. **c**, female from Montallegro, 26 May 2023 with perfect camouflage on dry grass thanks to the wing venations. **d**, exuvia from Monte d’Oro, Avola, 30 May 2023.

the West, Noto (Siracusa province) in the Southeast and Palagonia (Catania province) in the Northeast.

We also found 14 museum vouchers. Only two of them provide reliable locality data, i.e. Palagonia (year 1969) and Sortino (year 2007), which are in the same distribution range of our field data. Three additional vouchers are labelled “Syracus” (sic!), “Palermo” and “Messina”, with no further details about the location. As these labels refer not only to big towns but also to large provinces which cover more than one third of Sicily, we consider these records uncertain.

The average altitude of the 15 referenced populations of *C. albipennis* is 230 meters, with the highest recorded at 576 m (Chiaramonte Gulfi) and the lowest at 28 m (Torre Salsa Reserve). The species primarily inhabits hilly landscapes near the coast, and it seems not to colonize the more humid, forested mountainous regions.

Song pattern

Song patterns are described based on the analysis of 20 specimens from seven different populations (Appendix 1). The song of *Cicadetta albipennis* consists of a monotonous series of short echemes (ED = 0.1475 ± 0.0155 s), separated by interecheme pauses of 0.4886 ± 0.1356 s (IED; n_{ind}

= 18; Table 1; Fig. 3 a). The interecheme-to-echeme rate is 3.3 ± 1.0 , with individual means ranging from 2.1 to 5.2, probably varying in function of the stimulation. The echemes are formed by rather constant numbers of syllables (7.6 ± 1.0), resulting in long syllable periods (0.0216 ± 0.0030 s) comparatively to other species. This is due to pauses between syllables (interpulses; $IP_{1,2}$, $IP_{2,1}$). These pauses are perceptible to the human ear in a way that the echeme appears more as a purring or a soft rattling than a clear sound. The first and last pulse groups within an echeme are sometimes shorter and fainter than central pulse groups, but an obvious rule is not present (Fig. 3 f). Echeme power also varies, with males appearing to accentuate echemes in irregular series (Fig. 3 e).

Based on very clean recordings, mainly from device 2, the fine temporal structure of the song can be described as follows (Figs 3 b-d): We assume that the two timbals normally operate in exact synchrony, and each syllable consists of two distinct signals. In rare cases — often in the last or the first syllable of an echeme (but regularly in the specimen “Salemi-male1”) — the movements become slightly asynchronous, making the four pulses composing a syllable more clearly visible. The two timbals seem to produce one pulse group of high amplitude (PG_1) when

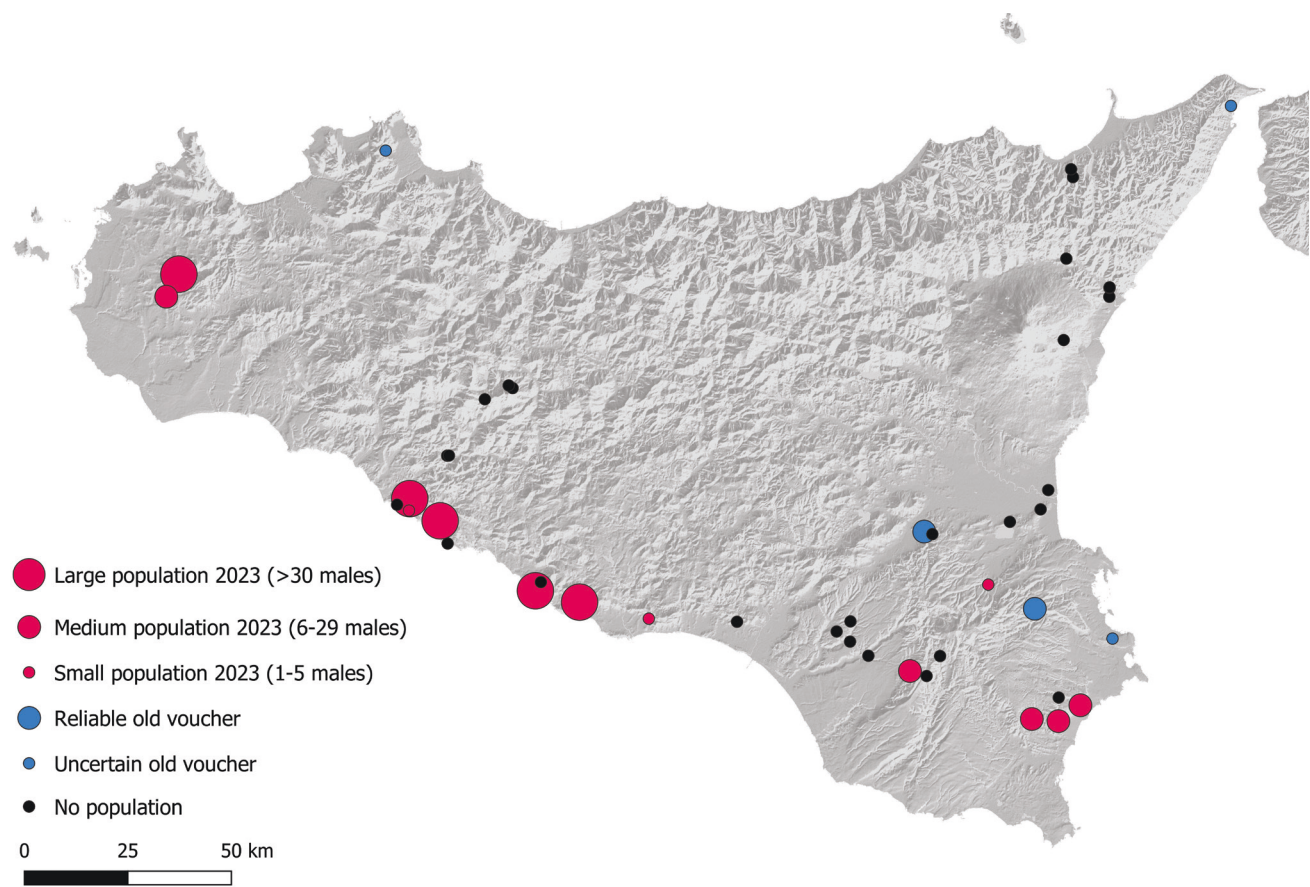


Fig. 2 – Distribution map of *Cicadetta albipennis*. Populations detected during our field trips in 2023 (magenta). Some vouchers found in collections (blue, small dots when labels seem inaccurately). Locations with absence data are reproduced when season and weather conditions were suitable (black).

buckling inwards, and a second pulse group of very low amplitude (PG₂) when returning to the relaxed position. The difference in power between these two movement types is about 12.6 ± 2.5 dB ($n_{\text{ind}} = 10$).

The carrier frequency of the *Cicadetta albipennis* song is very high (Figs 3 a-b). Our equipment was not sufficient to measure the whole range, especially not device 2 whose results are not reproduced here ($n_{\text{ind}} = 10$). Regarding the maximal frequency, we can conclude that in 50% of the males it was probably above 22 kHz and in 50% probably below 22 kHz. On average, the maximum frequency is certainly above 20.0 kHz. Consequently, the centre frequency is even more hypothetical, but it must be above 19.0 kHz. The upper -20-dB-limit is in average clearly above 22 kHz. The frequency range is very broad, the lower -20-dB-limit is around 11.2 kHz. This allowed us to hear the song of *C. albipennis* by ear up to a distance of 9 meters. According to the signal on the ultrasonic detectors, the song propagates up to 35 m.

Habitat requirements and behaviour

Cicadetta albipennis is a habitat specialist (Fig. 4). All populations were found exclusively in grassland environments characterized by dry and hot conditions. Vegetation cover is optimally around 50-70%, with 30-50% bare ground. Seventy percent of the populations are located on slopes faced from Southeast to Southwest. Male and female cicadas live in herbaceous vegetation, clinging to the culms of grasses and sometimes also to other plants (e.g. *Ferula communis* L., 1753). Dominant grasses are most often *Hyparrhenia sinaica* (Delile) Llaurodó ex G. López, 1994 and perhaps *H. hirta* (L.) Stapf, 1919, but also *Ampelodesmos mauritanicus* (Poir.) T. Durand & Schinz, 1894 on flatter areas. These plants likely are the main hosts of the cicada. A low density of small bushes with the dwarf palm *Chamaerops humilis* L., 1753 grows on rocky xerothermophilous slopes (e.g. Montallegro station). However, *C. albipennis* was never observed on ligneous plants.

Individuals of *C. albipennis* do not seem to stray far from their breeding sites. Sometimes they congregate in large numbers on small plots characterised by flatter terraces with deeper soils and slightly higher grass. The discovery of numerous exuviae in these microhabitats indicates that also egg-laying and nymphal development occur in the same spots (Fig. 4 d). The last moult and hatching take place at the base of the grass tufts, between 5 and 30 cm above the ground.

Our observations suggest that extensive pasturing is crucial for the persistence of *C. albipennis* populations. While the species was also found on temporarily abandoned land, it became very rare at sites with no evident herbivore activity for many years, even in the absence of upcoming shrubs.

Discussion

Distribution and biogeographical aspects

Knowledge of the distribution of *Cicadetta albipennis* is incomplete. While the species appears to be mainly distributed in the southern half of Sicily, older specimens labelled “Palermo” and “Messina” suggest that populations may also be present in the northern part of the island. We consider the species to be a Sicilian endemic. It does not occur in Greece as originally stated by Fieber (1876) (see many works of M. Gogala, T. Trilar and S. Drosopoulos in recent years, e.g. Gogala et al. 2008, 2012; Gogala & Trilar 2014) and has never been found in Calabria or other Italian regions (Guglielmino et al. 2021, personal data T. Hertach, F. Sanna).

According to the unique shape of the male genitalia (Kartal 2007; S. Puissant pers. comm.), *C. albipennis* must have undergone an ancient speciation event and a long-lasting reproductive isolation, supposedly in a small, isolated distribution range including Sicily. No closely related species are currently known. Calabria and Sicily repeatedly formed an archipelago due to intense tectonic activity in the Plio- and Early Pleistocene (> 0.8 million years BP), and the Strait of Messina was only one of several barriers to dispersal. The step-by-step immigration from the Italian peninsula to Sicily was limited in many animals like amphibians, mammals and arthropods — including cicadas — and shaped genetics, subspecies and species (Canestrelli et al. 2007; Marra 2013; Hertach et al. 2015). An African origin of the *C. albipennis* ancestors cannot be excluded either, with the last land bridges between Northern Africa and Sicily existed during the Messinian Salinity Crises (5.6 to 5.3 Mya), when the Mediterranean Sea almost desiccated (Krijgsman et al. 1999; Marra 2013). After that late Miocene time frame, a migration crossing the Mediterranean Sea from West and South is almost impossible for a small cicada, as these insects are generally unable to fly long distances due to the low endurance of their wing muscles (but see Arensburger et al. 2004).

Song behaviour

Calling songs of small cicadas normally have higher carrier frequency ranges than those of larger species (Bennet-Clark & Young 1994; Gogala et al. 2017). This can be explained by differences in abdominal volumes, which function as a resonating chamber. However, notable exceptions to this general rule exist, such as *Pagiphora annulata* (Brullé, 1832) — one of the tiniest European species — which exhibits an unusually low frequency range (Gogala & Trilar 2000). Table 2 lists the smallest known species, with *Tettigetacula baenai* (Boulard, 2000) and *Oligoglana sakisi* (Gogala & Trilar, 2017) at the top. *Cicadetta albipennis* fits well into the norm: with a body length of 12.9 ± 0.6 mm in males ($n = 21$) and 13.3 ± 0.6 mm in females ($n = 19$) and a wing

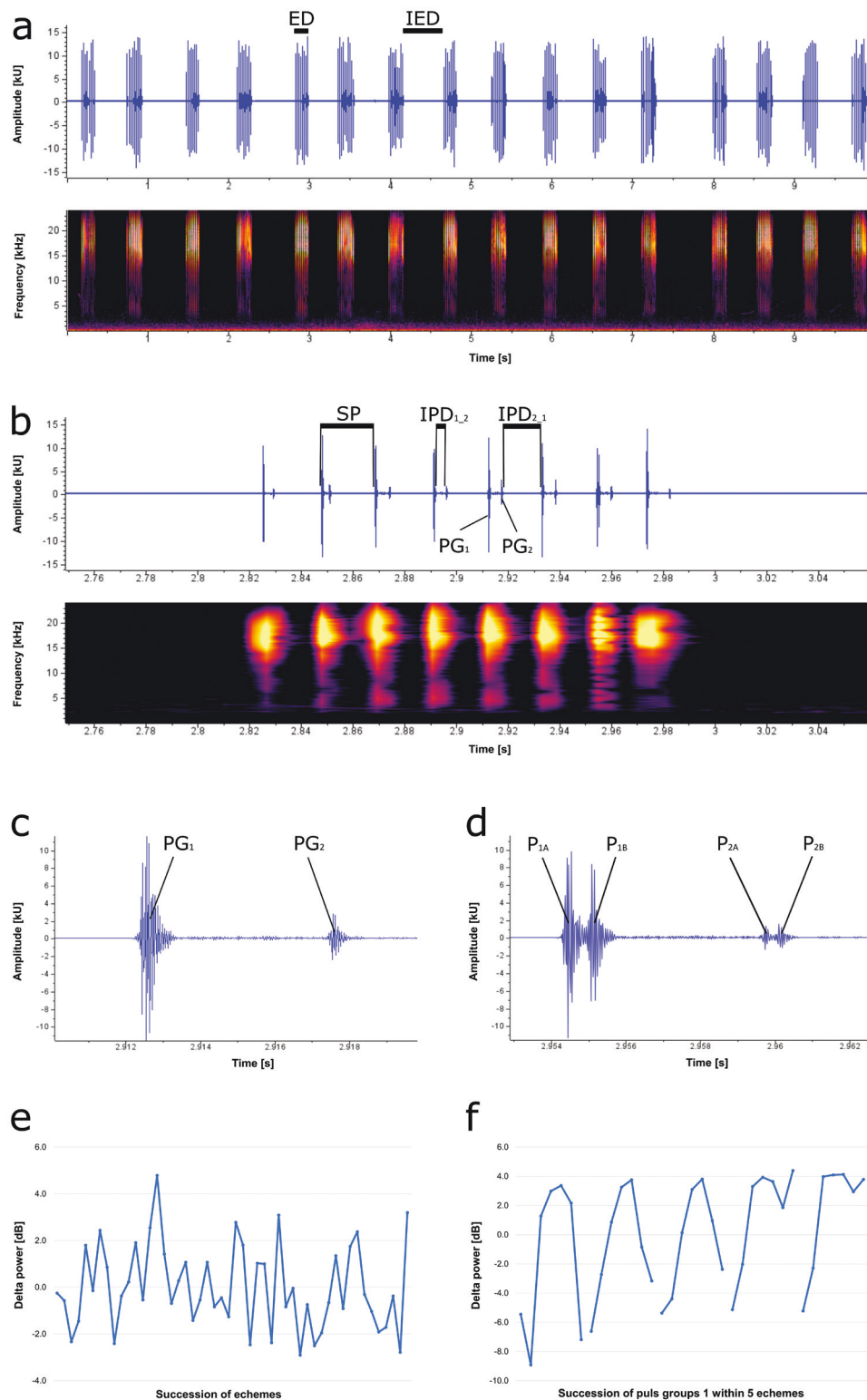


Fig. 3 – Calling song of *Cicadetta albipennis*. **a**, 10 s sonogram with 16 echeme-interechemes sequences, oscillogram above and spectrogram below. **b**, detailed 0.3 s view of one echeme with 8 putative syllables respectively 16 pulse groups. Further enlarged time scale (ca. 10 ms): **c**, oscillogram of one pulse group with normal synchronic and **d**, exceptionally asynchronous signals. **a-d**, male from Palma di Montechiaro. Song characters are defined as follows: ED = echeme duration, IED = interecheme duration, SP = syllable period, PG₁ = pulse group 1 (resp. PGD₁ = pulse group 1 duration), PG₂ = pulse group 2 (ditto PGD₂), IPD_{1,2} = interpulse 1 to 2 duration, IPD_{2,1} = interpulse 2 to 1 duration, P_{1A} = pulse 1A (ditto P_{1B}, P_{2A}, P_{2B}), P_{1A} + P_{1B} = PG₁ (ditto PG₂). **e**, variable power levels in a 50 echemes succession (values relative to the medium power level; male from Siculiana). **f**, within echeme power variability of the pulse groups 1 (PG₁) (values relative to the mean; five echemes; male from Montallegro).

span of 29.6 ± 1.9 mm in males and 30.5 ± 1.9 mm in females, it is among the smallest European cicadas and produces one of the highest-pitched calling songs (Table 2). The highest, well-described European cicada song is currently known for the Greek endemic *Oligoglena goumenissa* (Gogala, Drosopoulos & Trilar, 2012) (Gogala et al. 2012; Gogala 2025).

The *C. albipennis* song pattern is rather simple (Fig. 3), exhibiting a low variability and static characters for species-specific information (compare Gerhardt 1991). This is best demonstrated by the low coefficients of variation (CV; Table 1): Echeme duration (ED), syllables per echeme (S/E), but also the fine temporal characters syllable period (SP) and pulse group 1 duration (PGD1) are the key parameters for intraspecific communication.

A notable characteristic of the acoustic behaviour of *C. albipennis* is the very long syllable period, which makes the song sound like a purring (Figs 3 b-d). Syllable periods have rarely been published for European cicadas, so that a comparison is limited (e.g. Popov 1975). However, they

are an important character to distinguish *Tibicina* species (Sueur & Aubin 2003; Hertach 2021a) and helped resolving taxonomic issues in the very difficult *Cicadetta montana* complex (Hertach et al. 2015). While syllable periods are strongly temperature dependent and around 5 to 9 ms in *Cicadetta sibillae* Hertach & Trilar, 2016 and *Cicadetta anapaistica* Hertach, 2011, they range from 6.6 ± 0.5 ms (*T. picta* (Fabricius, 1794) = *T. tomentosa* (Olivier, 1790)) to 19.6 ± 0.6 ms (*T. longisyllaba* Hertach, 2021) in *Tibicina* and are more robust against temperature in these larger species. *Cicadetta albipennis* surpasses this record with 21.6 ± 3.0 ms and medium values up to 29.3 ms for one male.

We based the interpretation of the fine temporal structure of the *C. albipennis* song on studies in which one timbal was artificially inactivated (Popov 1975; Fonseca 1991; Hertach et al. 2015). These studies show that Cicadettinae typically produce four pulses per syllable, with the timbals operating synchronously, half-synchronously or alternately (2, 3 or 4 pulses visible) sometimes even within the same species, population and individual. In the *Cicadetta montana* species

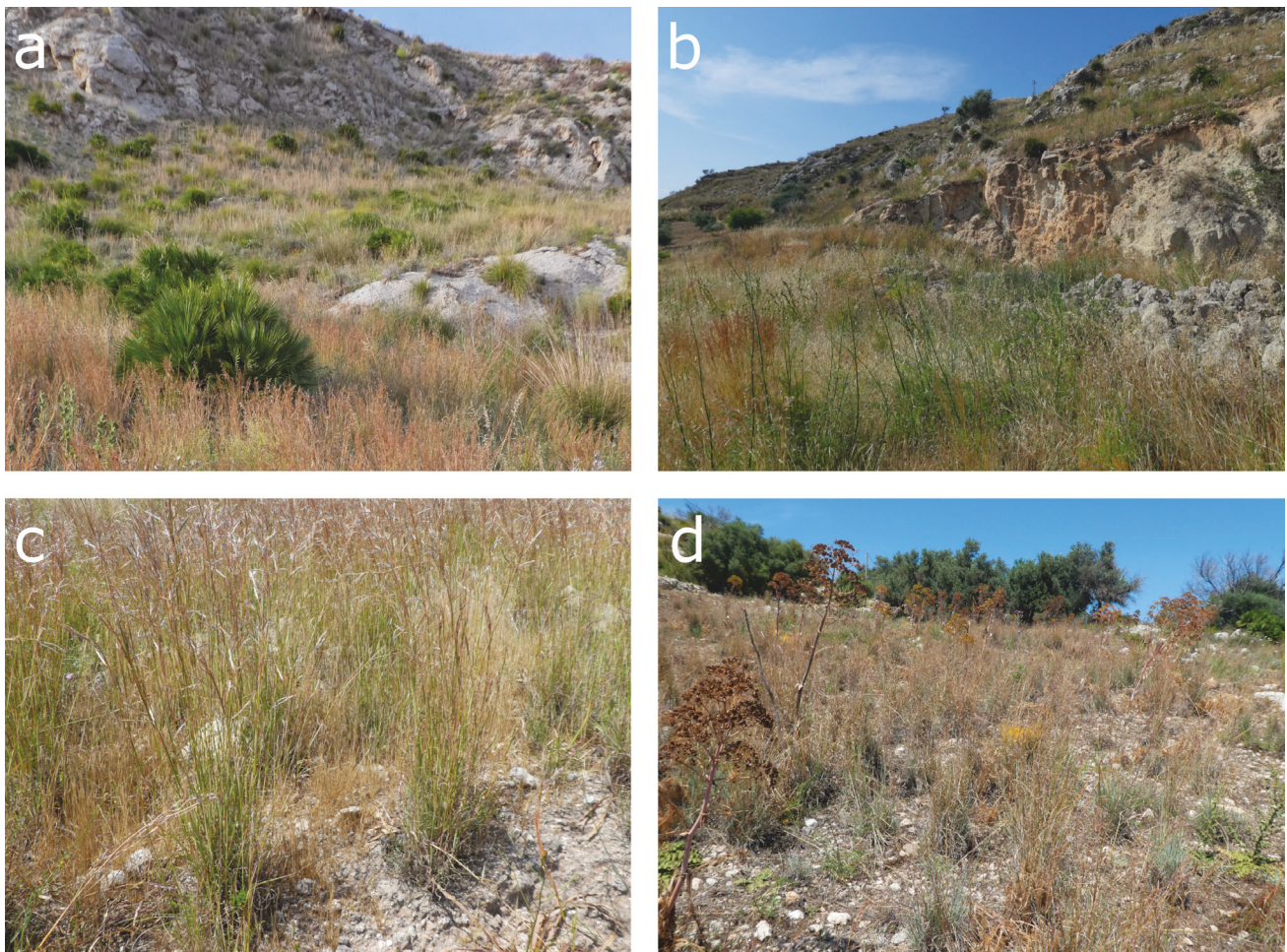


Fig. 4 – Typical grassland habitats of *Cicadetta albipennis* in Sicily. **a**, rocky habitats of large populations in Montallegro and **b**, in Palma di Montechiaro; **c**, typical plant composition with dominance of *Hyparrhenia* cf. *sinaica* (Palma di Montechiaro); **d**, place of reproduction with record of many exuviae (Monte d'Oro, Avola). The photos below show the important bare ground portions.

Table 1 – Temporal song characters in *Cicadetta albipennis*. Measured averages per specimen from 50 echemes (columns 1 to 3) and 30 syllables (columns 4 to 8). Avola, Francofonte, Montallegro, Noto, Palma di Montechiaro, Siculiana are the locations of recorded specimens in alphabetic order. Total average, standard deviation (SD) and coefficient of variation (CV = standard deviation/mean) over 18 specimens. S/E = syllables per echeme. For other definitions of song variables see Figure 3.

| Specimen | No. | Temporal characters [ms] | | | | | | |
|-------------------|------|--------------------------|-------|-------|------------------|--------------------|------------------|--------------------|
| | S/E | ED | IED | SP | PGD ₁ | IPD _{1,2} | PGD ₂ | IPD _{2,1} |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Avola-Male1 | 6.98 | 124.5 | 340.0 | 19.75 | 0.83 | 3.89 | 0.49 | 14.41 |
| Avola-Male2 | 7.58 | 134.8 | 485.1 | 18.71 | 0.72 | 4.21 | 0.78 | 12.87 |
| Francofonte-Male2 | 7.46 | 123.2 | 434.8 | 18.08 | 0.60 | | | |
| Montallegro-Male1 | 7.32 | 134.1 | 475.9 | 20.91 | 0.68 | | | |
| Montallegro-Male2 | 6.76 | 156.3 | 777.4 | 25.17 | 0.79 | 4.53 | 0.48 | 19.44 |
| Montallegro-Male3 | 5.64 | 144.8 | 753.2 | 29.34 | 0.88 | 6.19 | 0.42 | 22.14 |
| Noto-Male2 | 9.30 | 173.4 | 471.8 | 19.55 | 0.67 | | | |
| Noto-Male4 | 8.02 | 158.1 | 379.3 | 22.87 | 0.75 | | | |
| Palma di M.-Male1 | 7.60 | 136.1 | 502.1 | 20.68 | 0.77 | | | |
| Palma di M.-Male2 | 7.01 | 141.8 | 661.3 | 21.69 | 0.86 | 4.70 | 0.47 | 15.85 |
| Palma di M.-Male3 | 7.92 | 160.7 | 411.0 | 22.00 | 0.78 | 4.84 | 0.52 | 16.10 |
| Palma di M.-Male4 | 9.52 | 179.1 | 409.3 | 20.13 | 0.80 | 3.53 | 0.67 | 15.27 |
| Siculiana-Male1 | 7.92 | 135.7 | 338.3 | 18.92 | 0.66 | | | |
| Siculiana-Male2 | 8.14 | 155.8 | 529.4 | 20.99 | 0.76 | 5.23 | 0.41 | 14.56 |
| Siculiana-Male3 | 6.04 | 138.2 | 522.2 | 26.77 | 0.61 | | | |
| Siculiana-Male4 | 7.70 | 154.5 | 364.9 | 22.81 | 0.68 | | | |
| Siculiana-Male5 | 7.60 | 149.0 | 607.0 | 20.75 | 0.64 | 3.77 | 0.62 | 15.64 |
| Siculiana-Male6 | 8.66 | 155.9 | 331.0 | 19.11 | 0.60 | 5.49 | 0.60 | 12.22 |
| | | | | | | | | |
| Average | 7.62 | 147.5 | 488.6 | 21.57 | 0.73 | 4.64 | 0.55 | 15.85 |
| SD | 0.98 | 15.5 | 135.6 | 2.96 | 0.09 | 0.83 | 0.12 | 2.95 |
| CV | 0.13 | 0.10 | 0.28 | 0.14 | 0.12 | 0.18 | 0.22 | 0.19 |

complex, the amplitude of the timbal buckling inwards and outwards is almost similar (Hertach et al. 2015). However, Popov (1975), Fonseca & Revez (2002) and Fonseca et al. (2008) present cases where the return of the timbal to the relaxed position produces a much fainter sound than the inward movement (e.g. *Tettigetta josei* (Boulard, 1982)). It seems that *C. albipennis* acts the same, with timbals normally moved synchronously.

Habitats, their history, and conservation

Grassland species are clearly underrepresented in European cicadas. Besides *C. albipennis*, only *Cicadetta mediterranea* Fieber, 1876 and *Tibicina corsica* s. l. (Rambur, 1840) are exclusively or predominantly living in these habitats among Italian species (Hertach 2021a). In contrast, many cicadas live in ecotones — transitions between forest and grassland — or in savanna-like mosaics, singing and feeding on ligneous plants (Puissant, 2006; Hertach, 2021b). Since *C. albipennis* is perfectly adapted to grassland habitats (Fig. 1; colouration, behaviour) and stenoe-

cious with respect to its requirements, it gives evidence for the continuous existence of naturally open grassland habitats in Sicily over hundreds of thousands of years. This habitat type has probably been shaped by drought, fire, and especially wild herbivores. In fact, despite its insular position, Sicily was rich of large herbivores such as bovines (*Bos primigenius*, *Bison priscus siciliae*), elephants (*Palaeoloxodon falconeri*, *P. mnaidriensis*), and horses (*Equus hydruntinus*, *E. ferus*) in the Pleistocene, some of which were endemic (Bonfiglio et al. 2002; Marra 2013). The ecological impact of these wild herbivores seems still underestimated in the discussion of natural habitat formations in general, and for Sicily in particular (Barbera & Cullotta 2012; Michelangeli et al. 2022). Their populations were numerous enough to feed several carnivore top-predators (Marra 2013), suggesting that these key-species were capable to play a major role in maintaining open or semi-open steppe and savanna-like habitats dominated by grassland, avoiding the forest succession on nutrient-poor soils at a large

scale. A recent study for temperate Europe estimates 17% open vegetation, 63% light woodland and only 21% closed forest, with weak climate correlations and low human impacts for the Last Interglacial (Pearce et al. 2025). In dry-summer zones like Sicily, areas with open and semi-open vegetation may have been even more dominant.

From the Neolithic onwards, with the extinction of Sicily's megafauna — at least partly driven by human hunting pressure —, domesticated cattle assumed a similar ecological role. Later, transhumance with sheep became a central aspect of traditional Sicilian livestock farming. The life of Sicilian shepherds was characterized by continuous mobility: in September-October, pastures in the hill areas were grazed; in November-December, the flocks were led to the coast; in March they returned to the hills, and in late spring they were moved to the mountain areas until August (Mannia 2022).

Since the years following World War II, traditional transhumance is in decline, or it is nowadays often characterized by shorter displacements and transports organized with trucks (Russo et al. 2014, Mannia 2022). Moreover, as farmers settled down, some grasslands were intensified with the use of fertilisers, longer grazing periods and higher livestock numbers (Russo et al. 2014; Barbera & Cullotta 2012). Due to this, the ancient trails along migration routes and the associated seasonal

disturbances to the grassland systems — many of them which are rather unproductive, rocky and steep — are disappearing, with these areas increasingly transitioning into shrub-dominated landscapes. So, grassland habitats with traditionally extensive managements are more threatened on Sicily now than they have been for thousands of years.

In such situation of land abandonment, the driest habitats tend to remain the most stable ones. However, our observations show that *C. albipennis* not only prefers dry grassland, but specifically sparse grassland with patches of open soil. These microstructures require regular disturbance by trampling herbivores (or fire) for their maintenance. When such land use practices cease, populations of *C. albipennis* eventually decline and disappear. Notably, the vast majority (85%) of the known stations of *C. albipennis* is outside the Natura 2000 protected areas network (<https://natura2000.eea.europa.eu/>), reflecting the low importance dedicated to grassland habitats in politics. We conclude that *C. albipennis* is a species endangered to extinction.

To conserve the species, extensive, low-impact and large-scale pasturing should be preserved or re-established, and financially supported by policy incentives. These models should be carefully designed, respecting biodiversity. Importantly, pasturing should remain extensive rather than intensive, as high livestock density

Table 2 – Smallest European cicada species, highest-pitched songs: *Cicadetta albipennis* in comparison to provisional record holders according to a literature survey and own analyses (Boulard 2000; Puissant & Sueur 2010; Gogala et al. 2012; Gogala et al. 2017; pers. comm. S. Puissant and T. Trilar). Genera not well investigated like *Euryphara* Horváth, 1912 are excluded from the list. All recording devices used by us (20 resp. 22 kHz) or cited from literature (18 resp. 24 kHz) are not capable of detecting the putative complete frequency spectra and conclusions are provisionally. + female is larger, = female is about the same size (but vouchers are often scarce).

| Smallest males | | | |
|---------------------------------|---------------------------|---------------------------|--------------------------------|
| Species | n_{ind} | Body length [mm] | Fore wing length [mm] |
| <i>Oligoglana sakisi</i> + | 12 | 11.6 ± 0.7 | 12.7 ± 0.9 |
| <i>Tettigettacula baenai</i> | 9 | 12.1 ± 0.5 | 12.2 ± 0.4 |
| <i>Cicadetta mediterranea</i> = | 13 | 13.1 ± 0.7 | 12.9 ± 0.4 |
| <i>Oligoglana tibialis</i> + | 15 | 12.7 ± 0.5 | 14.0 ± 0.6 |
| <i>Cicadetta albipennis</i> = | 19 | 12.9 ± 0.7 | 14.3 ± 0.8 |
| <i>Tettigettula pygmaea</i> + | 14 | 13.0 ± 0.6 | 15.3 ± 0.5 |
| Highest-pitched songs | | | |
| Species | n_{ind} | -20 dB range [kHz] | Maximal frequency [kHz] |
| <i>Oligoglana goumenissa</i> | NA (Gogala et al. 2012) | 13.6 – 22.9 | 19.5 ± 0.2 |
| <i>Cicadetta albipennis</i> | 10 | ≈ 11.2 – >22.0 | > 20.0 |
| <i>Tettigettula pygmaea</i> | 9 | 13.2 – 22.3 | 17.9 ± 1.1 |
| <i>Oligoglana sakisi</i> | 10 | 13.9 – >22.5 | 17.4 ± 1.1 |
| <i>Oligoglana iphigenia</i> | 1 | ≈ 12.8 – 23.8 | 17.5 |
| <i>Tettigettacula baenai</i> | 2 (Puissant & Sueur 2010) | ≈ 12 – >18 | 16.8 ± 0.8 |

over prolonged periods significantly increases mortality rates of the last-instar subterranean nymphs due to trampling (Pinchen & Ward 2002; Hertach 2021b). We suggest two different systems: First, the traditional practice of transhumance, with livestock wandering from place to place and therefore influencing grassland for short timeframes, should be maintained or reactivated. Bindi (2022) and Mannia (2022) observe a “new ruralist” movement with a growing interest in transhumance, which is also increasingly becoming a sustainable tourist attraction. Local initiatives and the nomination for the UNESCO Intangible Cultural Heritage (2023) pushed by other South Italian regions give hope. Nevertheless, it is questionable whether these initiatives create a sustainable impact on the whole Sicilian grassland biome. Secondly, consideration should be given to grazing large, year-round pastures of 50 ha or more at very low densities and with multiple species. The choice of herbivores should orientate on ungulate groups originally native to Sicily or their domesticated substitutes (bovines, equids, deer). This management simulates the permanent original interactions between plants, large wild ungulates, and other animals on ecosystems over millions of years. For Central European and Western European ecosystems, it has been proven that these models create a high level of biodiversity (Vera 2000; Nickel et al. 2016; Bunzel-Drücke et al. 2019; Tree 2022). Habitats result in mosaics from low grazed patches to higher herbaceous vegetation, bushy zones and sparse woods. The pastures are full of small ecological niches like bare soil, and gradients in vegetation structure are omnipresent.

Conclusions

Cicadetta albipennis still persists in its Sicilian habitats, and this species would appear to be endemic to the

southern and eastern portions of the Island. It is active early in the year (at least compared to most other cicada species) and emits a very high-pitched song. Its presumed long reproductive isolation and its specialisation on grassland habitats suggest the continuous presence of naturally open areas for hundreds of thousands of years. However, with the extinction of wild megaherbivores and the ongoing decline of traditional extensive grazing, these grassland ecosystems are increasingly at risk. Greater awareness at the policy level and consistent, targeted conservation efforts on the ground are urgently needed to preserve these unique biomes with their rich biodiversity.

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Appendix 1: Database of the records of *Cicadetta albipennis*.

| SPECIES | LOCATION | ALT. | LAT. | LONG. | NAME | FIRST NAME | YEAR | MONTH | DAY | POP. SIZE | DATA SOURCE |
|-----------------------------|--------------------------------------|-------|---------|---------|----------------|--------------|------|-------|-----|-----------|-------------------|
| <i>Cicadetta albipennis</i> | Syracus (sic !) | | | | | | | | | | Collection sample |
| <i>Cicadetta albipennis</i> | Palermo | | | | Blanchon | M. | | | | | Collection sample |
| <i>Cicadetta albipennis</i> | Messina | | | | | | | | | | Collection sample |
| <i>Cicadetta albipennis</i> | Palagonia (Catania) | | | | Ronsisvalle | | 1969 | 5 | 30 | | Collection sample |
| <i>Cicadetta albipennis</i> | Sortino, Monti Iblei | 380 m | | | Marchese | Giovanni | 2007 | 5 | 26 | | Collection sample |
| <i>Cicadetta albipennis</i> | SE Francofonte | 190 m | 37.212N | 14.904E | Hertach/Gurcel | Thomas/Kevin | 2023 | 5 | 24 | Small | Field observation |
| <i>Cicadetta albipennis</i> | Torre Salsa, Monte di Eremita | 28 m | 37.371N | 13.341E | Hertach/Gurcel | Thomas/Kevin | 2023 | 5 | 27 | Small | Field observation |
| <i>Cicadetta albipennis</i> | NE Licata | 111 m | 37.138N | 13.988E | Hertach/Gurcel | Thomas/Kevin | 2023 | 5 | 28 | Small | Field observation |
| <i>Cicadetta albipennis</i> | Chiaramonte Gulfi | 576 m | 37.026N | 14.693E | Hertach/Gurcel | Thomas/Kevin | 2023 | 5 | 29 | Medium | Field observation |
| <i>Cicadetta albipennis</i> | NE Noto | 179 m | 36.917N | 15.093E | Hertach/Gurcel | Thomas/Kevin | 2023 | 5 | 30 | Medium | Field observation |
| <i>Cicadetta albipennis</i> | Serra di Vento, Noto | 393 m | 36.922N | 15.021E | Hertach/Gurcel | Thomas/Kevin | 2023 | 5 | 30 | Medium | Field observation |
| <i>Cicadetta albipennis</i> | Monte d’Oro, Avola | 233 m | 36.952N | 15.153E | Hertach/Gurcel | Thomas/Kevin | 2023 | 5 | 30 | Medium | Field observation |
| <i>Cicadetta albipennis</i> | Ricalcata, W Salemi | 230 m | 37.828N | 12.685E | Sanna | Francesco | 2023 | 6 | 12 | Medium | Field observation |
| <i>Cicadetta albipennis</i> | Montallegro | 163 m | 37.396N | 13.343E | Hertach/Gurcel | Thomas/Kevin | 2023 | 5 | 26 | Large | Field observation |
| <i>Cicadetta albipennis</i> | Siculiana | 194 m | 37.349N | 13.425E | Hertach/Gurcel | Thomas/Kevin | 2023 | 5 | 27 | Large | Field observation |
| <i>Cicadetta albipennis</i> | E Palma di Montechiaro | 153 m | 37.174N | 13.801E | Hertach/Gurcel | Thomas/Kevin | 2023 | 5 | 28 | Large | Field observation |
| <i>Cicadetta albipennis</i> | Monte Grande, W Palma di Montechiaro | 227 m | 37.198N | 13.682E | Hertach/Gurcel | Thomas/Kevin | 2023 | 5 | 28 | Large | Field observation |
| <i>Cicadetta albipennis</i> | Lago Rubino, NW Salemi | 180 m | 37.876N | 12.720E | Sanna | Francesco | 2023 | 6 | 12 | Large | Field observation |

References

- Arensburger P., Simon C., Holsinger K.E. 2004. Evolution and phylogeny of the New Zealand cicada genus *Kikihia* Dugdale (Homoptera: Auchenorrhyncha: Cicadidae) with special reference to the origin of the Kermadec and Norfolk Islands' species. *Journal of Biogeography*, 31(11): 1769–1783. Doi: <https://doi.org/10.1111/j.1365-2699.2004.01098.x>
- Barbera G., Cullotta S. 2012. An inventory approach to the assessment of main traditional landscapes in Sicily (Central Mediterranean Basin). *Landscape Research*, 37(5): 539–569. Doi: <https://doi.org/10.1080/01426397.2011.607925>
- Bennet-Clark H., Young D. 1994. The scaling of song frequency in cicadas. *Journal of Experimental Biology*, 191(1): 291–294. Doi: <https://doi.org/10.1242/jeb.191.1.291>
- Bindi L. 2022. Transhumance is the new black: fragile rangelands and local regeneration, pp. 149–173. In: Bindi L. (ed), *Grazing communities: pastoralism on the move and biocultural heritage frictions*. Environmental Anthropology and Ethnobiology 29 (1st Edition). Berghahn Books, New York and Oxford. Doi: <https://doi.org/10.1515/9781800736672-010>
- Bonfiglio A., Marra A.C., Masini F., Pavia M., Petruso D. 2002. Pleistocene fauna of Sicily: a review, pp. 428–436. In: Waldren W.H., Ensenyat J.A. (eds), *World islands in prehistory, international insular investigations*, V Deia international conference of prehistory. BAR International Series 1095, Oxford.
- Boulard M. 2000. Description de quatre *Tettigetta* ibériques nouvelles. *École Pratique des Hautes Études, Travaux du Laboratoire Biologie et Evolution des Insectes Hemipteroidea*, 13: 133–143.
- Bunzel-Drüke M., Reisinger E., Böhm C., Buse J., Ellwanger G., Finck P., Freese J., Grell H., Hauswirth L., Herrmann A., Idel A., Jedicke E., Joest R., Kämmer G., Kapfer A., Köhler M., Kolligs D., Krawczynski R., Lorenz A., Luick R., Mann S., Nickel H., Raths U., Riecken U., Röder N., Rössling H., Rupp M., Schoof N., Schulze-Hagen K., Sollmann R., Ssymank A., Thomsen K., Tillmann J.E., Tischew S., Vierhaus H., Vogel C., Wagner H.G., Zimball O. 2019. Naturnahe Beweidung und NATURA 2000 – Ganzjahresbeweidung im Management von Lebensraumtypen und Arten im europäischen Schutzgebietssystem NATURA 2000. 2. Überarbeitete und erweiterte Auflage. Arbeitsgemeinschaft Biologischer Umweltschutz im Kreis Soest e.V., Bad Sassendorf-Lohne, 411 pp.
- Canestrelli D., Cimmaruta R., Nascetti G. 2007. Phylogeography and historical demography of the Italian treefrog, *Hyla intermedia*, reveals multiple refugia, population expansions and secondary contacts within peninsular Italy. *Molecular Ecology*, 16(22): 4808–4821. Doi: <https://doi.org/10.1111/j.1365-294X.2007.03534.x>
- Fieber F.X. 1876. Les Cicadines d'Europe d'après les originaux et les publications les plus récentes. Deuxième partie: Descriptions des espèces. *Revue et Magasin de Zoologie pure et appliquée*, 4(3): 11–268.
- Fonseca P.J. 1991. Characteristics of the acoustic signals in nine species of cicadas (Homoptera, Cicadidae). *Bioacoustics*, 3(3): 173–182. Doi: <https://doi.org/10.1080/09524622.1991.9753178>
- Fonseca P.J., Revez M.A. 2002. Temperature dependence of cicada songs (Homoptera, Cicadoidea). *Journal of Comparative Physiology A*, 187: 971–976. Doi: <https://doi.org/10.1007/s00359-001-0267-5>
- Fonseca P.J., Serrão E.A., Pina-Martins F., Silva P., Mirra S., Quartau J.A., Paulo O.S., Cancela L. 2008. The evolution of cicada songs contrasted with the relationships inferred from mitochondrial DNA (Insecta, Hemiptera). *The International Journal of Animal Sound and its Recording*, 18(1): 17–34. Doi: <https://doi.org/10.1080/09524622.2008.9753588>
- Gerhardt H.C. 1991. Female choice in treefrogs: static and dynamic acoustic criteria. *Animal Behaviour*, 42(4): 615–635. Doi: [https://doi.org/10.1016/S0003-3472\(05\)80245-3](https://doi.org/10.1016/S0003-3472(05)80245-3)
- GIMP.org. 2025. GNU Image Manipulation Program. Available at <https://www.gimp.org/>
- Gogala M. (ed) 2025. Songs of European singing cicadas. Available at <https://www.cicadasong.eu>
- Gogala M., Drosopoulos S., Trilar T. 2008. *Cicadetta montana* complex (Hemiptera, Cicadidae) in Greece – a new species and new records based on bioacoustics. *Deutsche Entomologische Zeitschrift*, 55(1): 91–100. Doi: <https://doi.org/10.1002/mmnd.200800006>
- Gogala M., Drosopoulos S., Trilar T. 2012. *Cicadivetta goumenissa*, a new cicada species from Peloponesos, Greece (Hemiptera: Cicadidae). *Acta Entomologica Slovenica*, 20: 5–16.
- Gogala M., Puissant S., Trilar T. 2017. Revision and resurrection of the genus name *Mezammira* Fieber, 1876 (Hemiptera: Cicadidae) with special focus on its species from Greece and the description of two new species. *Acta Entomologica Slovenica*, 25(1): 5–64.
- Gogala M., Trilar T. 2000. Sound emissions of *Pagiphora annulata* (Homoptera: Cicadoidea: Tibicinidae) – a preliminary report. *Acta Entomologica Slovenica*, 8(1): 21–26.
- Gogala M., Trilar T. 2014. Distribution of endemic cicadas (Hemiptera: Cicadidae) on Evia and adjacent islands in Greece. *Acta Entomologica Slovenica*, 22(1): 45–58.
- Guglielmino A., Bückle C., Hertach T., D'Urso V. 2021. Insecta Hemiptera Auchenorrhyncha. In: Bologna M.A., Zapparoli M., Oliverio M., Minelli A., Bonato L., Cianferoni F., Stoch F. (eds), *Checklist of the Italian Fauna*. Version 1.0. Last update: 2021-05-31. Available at <https://www.lifewatchitaly.eu/en/initiatives/checklist-fauna-italia-en/checklist/>
- Hertach T. 2011. Spectacular song pattern from the Sicilian Mountains: The new cicada species *Cicadetta anapaistica* sp. n. (Hemiptera: Cicadidae). *Zootaxa*, 2771(1): 25–40. Doi: <https://doi.org/10.11646/zootaxa.2771.1.3>
- Hertach T. 2021a. Look closely and listen carefully: unexpected cicada diversity in northern Sardinia, with the description of a new species (Cicadidae: *Tibicina*). *Zoological Journal of the Linnean Society*, 191(3): 823–845. Doi: <https://doi.org/10.1093/zoolinnean/zlaa047>
- Hertach T. 2021b. Rote Liste der Singzikaden. Gefährdete Arten der Schweiz. Bundesamt für Umwelt, Umwelt-Vollzug 2111, Bern, 63 pp.
- Hertach T., Trilar T., Wade E.J., Simon C., Nagel P. 2015. Songs,

- genetics, and morphology: revealing the taxonomic units in the European *Cicadetta cerdaniensis* cicada group, with a description of new taxa (Hemiptera: Cicadidae). *Zoological Journal of the Linnean Society*, 173(2): 320–351. Doi: <https://doi.org/10.1111/zoj.12212>
- Kartal V. 2007. Genital morphology of *Cicadetta albipennis* Fieber, 1876 and *Euryphara cantans* (Fabricius, 1794) (Hemiptera: Auchenorrhyncha: Cicadidae). *Russian Entomological Journal*, 15(3): 279–280.
- Krijgsman W., Hilgen F.J., Raf I., Sierro F.J., Wilson D.S. 1999. Chronology, causes and progression of the Messinian salinity crisis. *Nature*, 400: 652–655. Doi: <https://doi.org/10.1038/23231>
- Mannia S. 2022. Wandering shepherds: new and old transhumances in Sardinia and Sicily, pp. 259–279. In: Bindi L. (ed), *Grazing communities: pastoralism on the move and biocultural heritage frictions*. Environmental Anthropology and Ethnobiology 29 (1st Edition). Berghahn Books, New York and Oxford.
- Marra A.C. 2013. Evolution of endemic species, ecological interactions and geographical changes in an insular environment: a case study of Quaternary mammals of Sicily (Italy, EU). *Geosciences*, 3(1): 114–139. Doi: <https://doi.org/10.3390/geosciences3010114>
- Michelangeli F., Di Rita F., Celant A., Tisnérat-Laborde N., Lirer F., Magri D. 2022. Three millennia of vegetation, land-use, and climate change in SE Sicily. *Forests*, 13(1): 102. Doi: <https://doi.org/10.3390/f13010102>
- Nast J. 1987. The Auchenorrhyncha (Homoptera) of Europe. *Annales Zoologici Warszawa*, 40(15): 355–661.
- Nickel H., Reisinger E., Sollmann R., Unger C. 2016. Aussergewöhnliche Erfolge des zoologischen Artenschutzes durch extensive Ganzjahresbeweidung mit Rindern und Pferden – Ergebnisse zweier Pilotstudien an Zikaden in Thüringen, mit weiteren Ergebnissen zu Vögeln, Reptilien und Amphibien. *Landschaftspflege und Naturschutz in Thüringen*, 53(1): 5–20.
- Paterson H.E.H. 1985. The recognition concept of species, pp. 21–29. In: Vrba E.S. (ed), *Species and speciation*, Monograph No. 4. Transvaal Museum, Pretoria.
- Pearce E.A., Mazier F., Davison C.W., Baines O., Czyżewski S., Fyfe R., Bińka K., Boreham S., de Beaulieu J.L., Gao C., Granoszewski W., Hrynowiecka A., Malkiewicz M., Mighall T., Noryskiewicz B., Pidek I.A., Strahl J., Winter H., Svenning J.C. 2025. Beyond the closed-forest paradigm: cross-scale vegetation structure in temperate Europe before the late-Quaternary megafauna extinctions. *Earth History and Biodiversity*, 3: 100022. Doi: <https://doi.org/10.1016/j.hisbio.2025.100022>
- Pinchen B.J., Ward L.K. 2002. The history, ecology and conservation of the New Forest Cicada. *British Wildlife*, 13: 258–266.
- Popov A.A. 1975. The structure of the tymbals and the characteristics of the sound signals in singing cicadas (Homoptera, Cicadidae) in the southern regions of the USSR. *Entomological Review*, 54(2): 7–35.
- Popov A., Beganovic A., Gogala M. 1997. Bioacoustics of singing cicadas on the Western Palaearctic: *Tettigetia brullei* (Fieber 1876) (Cicadoidea: Tibicinidae). *Acta Entomologica Slovenica*, 5: 89–101.
- Puissant S. 2006. Contribution à la connaissance des cigales de France: Géonémie et écologie des populations (Hemiptera, Cicadidae). Association pour la Caractérisation et l'Etude des Entomocénoses, Bédéilhac/Aynat, 193 pp.
- Puissant S., Sueur J. 2010. A hotspot for Mediterranean cicadas (Insecta: Hemiptera: Cicadidae): new genera, species and songs from southern Spain. *Systematics and Biodiversity*, 8(4): 555–574. Doi: <https://doi.org/10.1080/14772000.2010.532832>
- QGIS.org 2025. QGIS Geographic Information System. QGIS Association. <http://www.qgis.org>
- Reid W.V. 1992. How many species will there be?, pp. 55–73. In: Whitmore T.C., Sayer J.A. (eds), *Tropical deforestation and species extinction*. Chapman and Hall, New York.
- Russo P., Riguccio L., Carullo L., Tomaselli G. 2014. Parametric analysis of the changes a landscape previously used for transhumance in a nature reserve in Sicily. *Natural Resources*, 5(5): 213–224. Doi: <https://doi.org/10.4236/nr.2014.55020>
- Sueur J., Aubin T. 2003. Specificity of cicada calling songs in the genus *Tibicina* (Hemiptera, Cicadidae). *Systematic Entomology*, 28(4): 481–492. Doi: <https://doi.org/10.1046/j.1365-3113.2003.00222.x>
- Tree I. 2022. *Wildes Land – Die Rückkehr der Natur auf unser Landgut*. Erste Auflage. DuMont Buchverlag, Köln, 416 pp.
- UNESCO Intangible Cultural Heritage 2023. Transhumance, the seasonal droving of livestock. <https://ich.unesco.org/en/RL/transhumance-the-seasonal-droving-of-livestock-01964>
- Vera F.W.M. 2000. *Grazing ecology and forest history*. CABI Publishing, Wallingford, 506 pp.