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Acoustic signals of the bushcrickets of tribe Barbitistini (Orthoptera: Tettigoniidae: Phaneropterinae) from eastern Europe and Caucasus. I. *Poecilimon* Fisch., *Isoimon* B.-Bienko

Акустические сигналы кузнечиков трибы Barbitistini (Orthoptera: Tettigoniidae: Phaneropterinae) восточной Европы и Кавказа. I. *Poecilimon* Fisch., *Isoimon* B.-Bienko

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KEY WORDS. Tettigoniidae, Barbitistini, *Poecilimon*, *Isoimon*, sound signals.
КЛЮЧЕВЫЕ СЛОВА. Tettigoniidae, Barbitistini, *Poecilimon*, *Isoimon*, звуковые сигналы.

ABSTRACT. Temporal pattern and frequency spectra of the songs and stridulatory files of 15 species belonging to genera of *Poecilimon* and *Isoimon* of phaneropterine bushcrickets of the tribe Barbitistini from eastern Europe and Caucasus are given. Acoustic signals of eastern European and Caucasian species with other European species of *Poecilimon* are compared. Species status of *P. ukrainicus* and *P. tereckensis* are reinstated.

РЕЗЮМЕ. Приводятся данные об амплитудно-временных и частотных характеристиках звуковых сигналов и стридуляционных жилках 15 видов листовых кузнечиков трибы Barbitistini из родов *Poecilimon* и *Isoimon* из Восточной Европы и с Кавказа. Проводится сравнение их сигналов со звуками других европейских видов *Poecilimon.* Восстановлен видовой статус *P. ukrainicus* и *P. tereckensis.*

Phaneropterinae is the largest subfamily of Tettigoniidae. According to Orthoptera Species File [Otte et al., 2004] it includes more than 2000 species from 14 tribes. Most of species are distributed in the Palaearctic. The high biodiversity of these bushcrickets is observed in the Mediterranean region. Males of all known Phaneropterinae species produce calling songs and females in many species are capable to respond with sounds. The results of the first investigations of acoustic communication of the palaearctic species were published in 1977–1981 [Zhantiev & Dubrovin, 1977; Zhantiev, 1981]. Since this time acoustic signals of many western European species are carefully studied [Heller, 1984, 1988, 1990; Willemse & Heller, 1992; Ragge & Reynolds, 1998; Heller et al., 2004], but songs of species from the South of the eastern Europe, Caucasus and Transcaucasia are less known. Sound signals of only a few phaneropterine bushcrickets are described [cit. op.; Zhantiev & Korsunovskaya, 1986, 1990]. Songs of two sibling genera *Poecilimon* and *Isoimon* from the tribe Barbitistini are the subject of our study presented here.

Material and methods

Tape-recordings of the songs of captured insects in the laboratory were made with use 1/4 *inch* Bruel & Kjaer 4135 or MK 301 RFT microphones with linear characteristics in the range 0.02–100 kHz, microphone ampliphier 2604 Bruel & Kjaer or 00 017 RFT and modified tape recorder "Yupiter-202 Stereo" with linear characteristic in the range 0.063–70 kHz. In this tape recorder the slowest standard tape speed of 9 cm/s was replaced by speed of 38 cm/s. Recordings of the song of *P. beybienkoi* were made without tape-recorder (direct connection of microphone amplifier with oscilloscope equipped by oscilloscopic camera FOR-2 with light sensitive film). Sometimes for the recording and storage of sound signals the computer with A-D converter card L-305 (L-card) connected with microphone amplifier was used. Most of songs were stored on magnetic tape and then were digitazed (sampling rate 30.3; 58.8 or 142.8 kHz) and analyzed using the computer program TurboLab. All power spectra were obtained with linear amplitude scale.

All laboratory experiments were made in anechoic chamber in darkness at 20–26 °C. Microphone without defensive grid was positioned at 8–10 cm of singing male.

Electronnograms of *pars stridens* were obtained by use of scanning electron microscope Hitachi S-405A.

TERMINOLOGY. In our paper we have used following terms:

pulse — sound produced by closing wing-strokes at stridulation;

series (=echemes of Ragge & Reynolds [1998]) — the first order assemblage of pulses;

series sequences — the second order assemblages of pulses and the first order assemblages of series;
click — very fast sound impulse sometimes following pulse. In some species it is the obligatory second component of the song.
tooth-impact — fast sound impulse arising during contact of single tooth of stridulatory file (*pars stridens*) with *plectrum.*

Results

Genus ***Poecilimon*** **Fischer, 1853**

This genus includes more than 90 species. Similarity and variability of morphological characters make difficult to recognize many separate species. Thus investigation of acoustic signals of *Poecilimon* males could be useful for species discrimination. Songs of the specimens collected in eastern part of species distribution range could give additional material for analysis of geographical variability of sound signals.

Poecilimon affinis (Frivaldsky, 1867)

This species is distributed in the great part of Balkan (Albania, Romania, Bulgaria, Greece, former Yugoslavia), songs of specimens from Macedonien, Kosovo and Greek populations was described by Heller [1988]. In the eastern Europe is known from Kanev (Ukraine) only.

Locality: Ukraine, Kanev, VI.1996.

Song. During calling song male produces single pulses with gradually increasing thooth-impacts amplitude (Figs 1–3). They repeat with intervals of 200 *ms* to 10 *s.* Pulse duration at 21°C is *ca* 180 *ms.* Tooth-impacts rate differs during pulses and achieves maximum at the middle part of them. Besides calling sounds males produce protest sounds. The last ones are some shorter than pulses of the calling song.

The most frequency components of calling song lay in the range of 7–40 kHz (Fig. 46). The frequency spectrum contains main peak near 14–18 kHz. Frequency content of the protest sounds is similar to that of calling song.

Poecilimon similis Retowski, 1889

Locality: N Caucasus, N Ossetia, Tsey reserve, VIII. 1985, VI.1986; Armenia, near Goris, 21.VII.2000.

Song. Males produce regular and irregular single pulses or groups of two (rare three) pulses. At 25°C pulse duration is about 350 ms, pauses between pulses in the group are near 250–300 ms, between groups of pulses during regular singing — about two seconds. Male from N Ossetia produced pulses with rather high pulse rate — *ca* 1 s^{-1} (Figs 4, 5) Amplitude and frequency of tooth-impacts gradually increase to the middle of pulse and slightly decrease to the end of it (Fig. 6).

Song of Ossetian specimens differs from that of specimens from the rest localities by temporal pattern. It is a sequence of regular repeating single pulses (Fig. 4). Besides them in power spectrum there are main peaks at 15–20 and 25 kHz (Fig. 47).

Stridulatory file (Fig. 60) is weakly curved. Teeth are more densily arranged at medial part of file.

Poecilimon tereckensis Stshelkanovtsev, 1910

This species was described as subspecies of *P.similis.* Later it was considered as species [Ramme, 1939] or as synonym of previous species [Stshelkanovtsev, 1911; Bey-Bienko, 1954]. The properties of its sounds and structure of *pars stridens* indicate that it is separate species.

Locality: N.Caucasus, Tersky ridge near Grozny.

Song. Males produce single or pairs of pulses with duration 340–430 ms (22°C). Pauses between two-pulsed series last 3–7.5 s, pulse period in the series 620–775 ms (Figs 7, 8). Frequency of tooth-impacts during pulse changes as in *P. similis* (Fig. 9).

Frequency spectra are rather narrow and occupy range between 0.5–40 kHz, dominant frequencies are at 23–28 kHz (Fig. 48) , that is dominant components are displaced in the high frequency range *vs* thats in *P. similis*.

Stridulatory file is shown in Fig. 59.

Poecilimon boldyrevi Miram, 1938

Locality: S Crimea, near Yalta, riv. Uchan-Su, left coast, 8.VII.1981, 20VI.1996.

Preliminary description of the song was published earlier [Zhantiev, 1981; Zhantiev & Korsunovskaya, 1986] Here is given complete description of the calling signal. That is the sequence of irregular groups of two-three pulses. Sometimes males produce more or less regularly repeating single pulses (Figs 10, 11). Pulse duration is 320–350 ms, intervals between them in the groups are about 600 ms. Frequency spectrum contains two high amplitude peaks at 14–17 and 20–25 kHz in the range 0.5–45 kHz (Fig. 49).

Stridulatory file is shown in the Fig. 61. Teeth are evenly spaced in the lateral and middle parts of file and become very closely spaced and decrease in size at the proximal part of the file.

Poecilimon scythicus Stshelkanovtsev, 1911

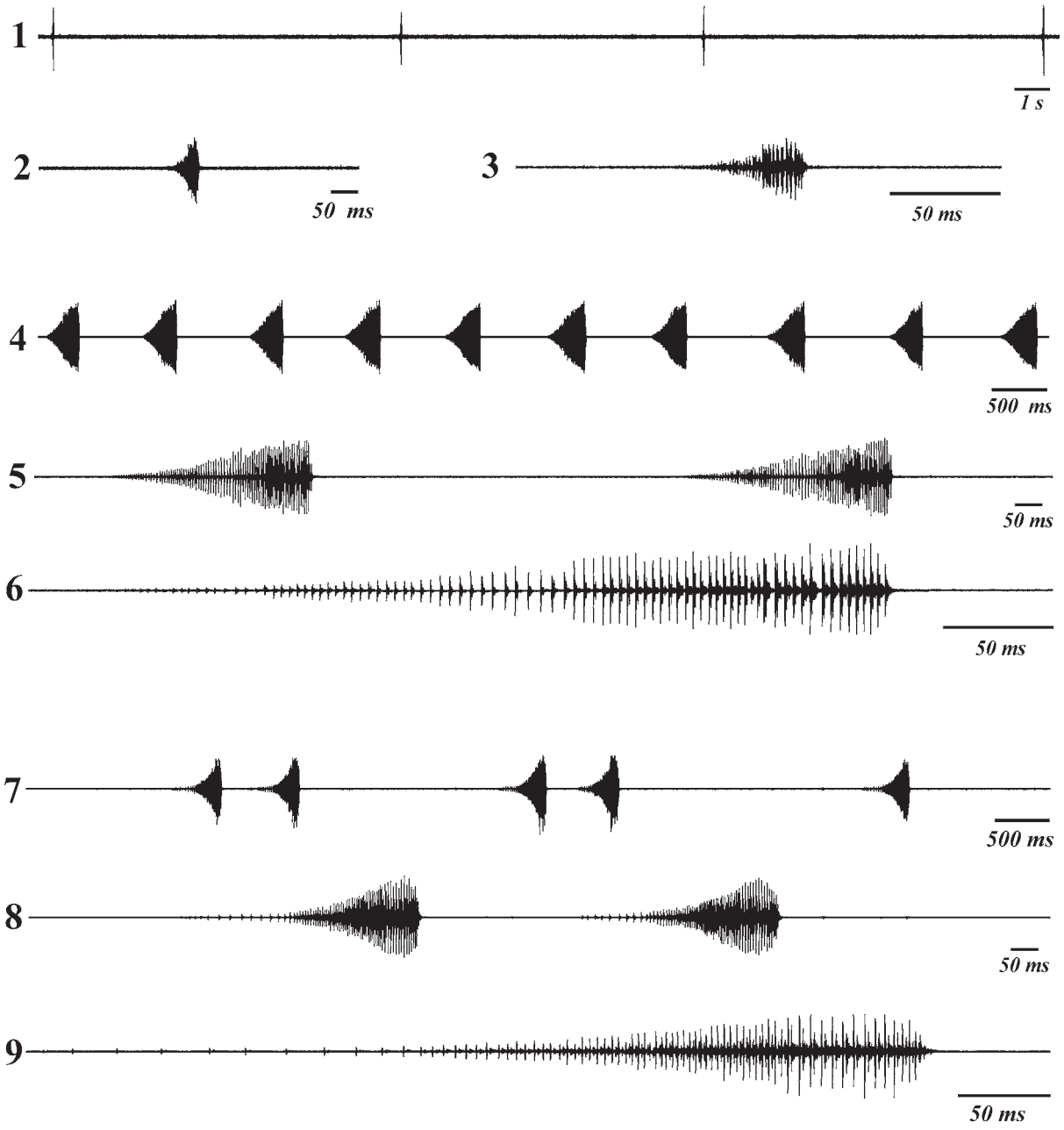
This species distributed in the eastern Ukraine, central and south-eastern Russia to Volga river, western and central Caucasus.

Localities: Ukraine, Lugansk res., VII.1996; Ciscaucasia, Krasnodar distr., 13.VII.1982; N.Caucasus, Teberda res., VIII. 1994

Song. Calling *song* preliminary described in Zhantiev & Korsunovskaya [1986] consists of repeating groups of two-three pulses (Figs 12–13). At 18°C these groups are devided by pauses of 1.5–2 s. Each pulse lasts about 500 ms and consists of tooth-impacts following with near equal frequency (*ca* 125 s^{-1}) (Fig. 14) or slightly decreasing rate to the end of closing tegmina movement.

Frequency spectrum occupies range 0–40 kHz with one peak at 27 kHz (Fig. 50)

Pars stridens is weakly curved with evenly spaced teeth in the distal and middle parts. Distal teeth are smaller and more densely arranged (Fig. 62).



Figs 1–9. Oscillograms of calling songs of *Poecilimon* spp. at different velocities: 1–3 — *P. affinis* (21°C), 4–6 — *P. similis* (26°C), 7–9 — *P. tereckensis* (22°C). Below time scales.

Рис. 1–9. Осциллограммы призывных сигналов *Poecilimon* spp. при разных скоростях развертки: 1–3 — *P. affinis* (21°C), 4–6 — *P. similis* (26°C), 7–9 — *P. tereckensis* (22°C). Внизу — отметки времени.

Poecilimon tauricus Retowski, 1888

This species is very close to *P. scythicus*. It differs by more or less stright of posterior serrata margin of cercal apex. In *P.scythicus* it forms slightly concave arc.

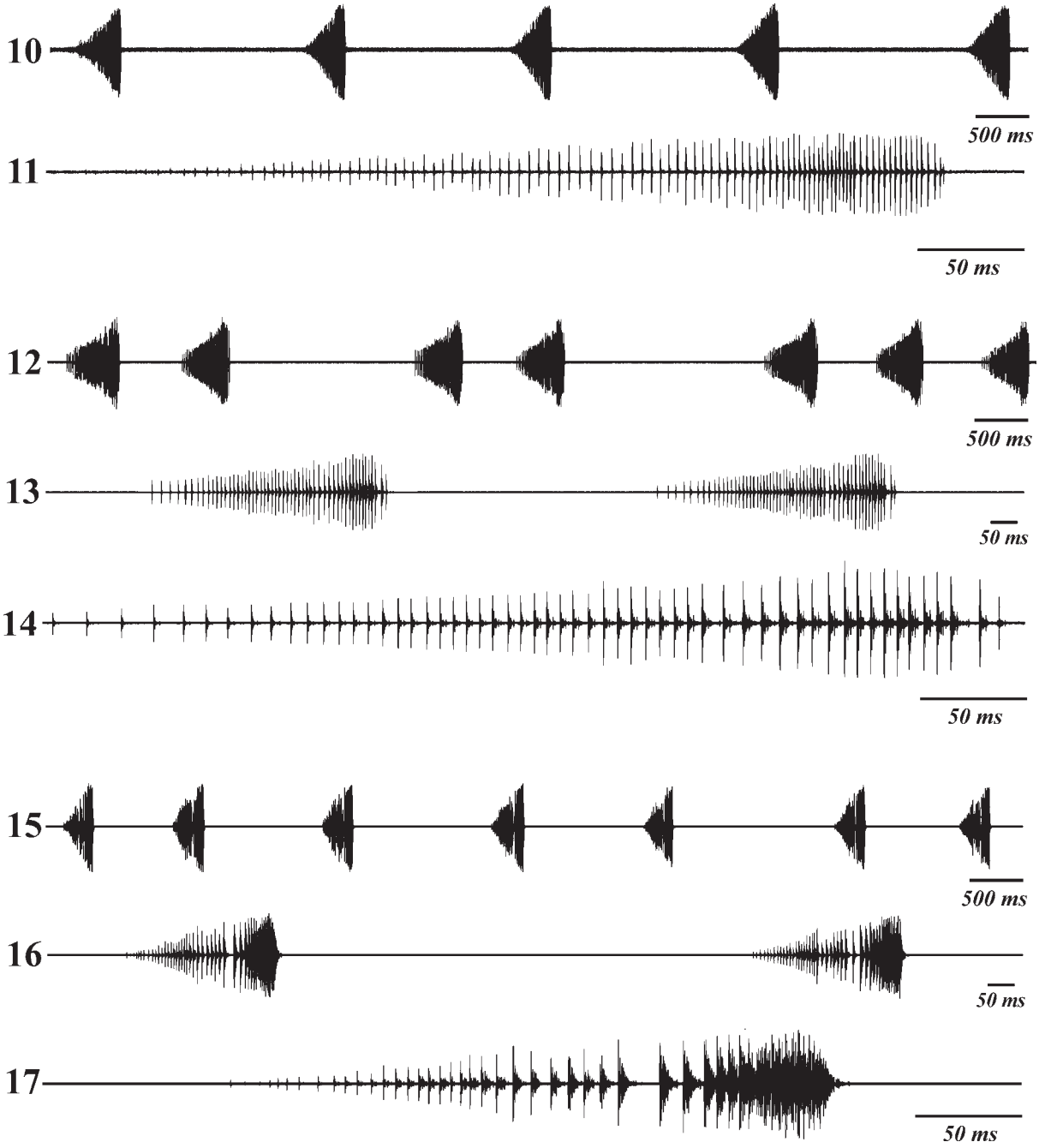
P. tauricus occurs in the southern and eastern Crimea only.

Locality: E.Crimea, vill. Kurortnoe, VII 1985.

Song. Males produce single pulses with considerably high rate: about 7 s^{-1} at 24 °C (Fig. 15). Strong alternation in the singing occurs. Pulses of recorded specimens are characterized by fast increasing of amplitude and different tooth-impact rate during pulse. It is minimal at the middle of pulse — about 120 s^{-1}. In the end of pulse it achieves more than 300 s^{-1}. Pulse duration is about 300 ms, pauses between them last 1–1.5 s (Figs 16–17).

Frequency range of stridulation in this species is the same as in *P. scythicus*, and frequency components of the great amplitude occupy band between 20 and 25 kHz (Fig. 51).

Stridulatory file is very similar to that in *P. scythicus* (Fig. 63).



Figs 10–17. Oscillograms of calling signals of *Poecilimon* spp. at different velocities: 10–11 — *P. boldyrevi* (23°C), 12–14 — *P. scythicus* (Teberda reserve, 18°C), 15–17 –*P. tauricus* (24°C). Below time scales.

Рис. 10–17. Осциллограммы призывных сигналов *Poecilimon spp* при разных скоростях развертки: 10–11 — *P. boldyrevi* (23°C), 12–14 — *P. scythicus* (Тебердинский заповедник, при 18°C), 15–17 — *P. tauricus* (24°C). Внизу — отметки времени.

Poecilimon pliginskii Miram, 1929

Endemic of southern Crimea.

Locality: S.Crimea, near Alushta, vill. Verkhnaya Kutuzovka, 30.VI.1993.

Song. Males produce single pulses or two–three pulsed series with pauses of several seconds (Fig. 18). Pulse duration is near 400 ms (at 21°C). Tooth-impact frequency is about 400 s^{-1} in the initial part of pulse and decreases almost twice in the final third (Figs 19–20).

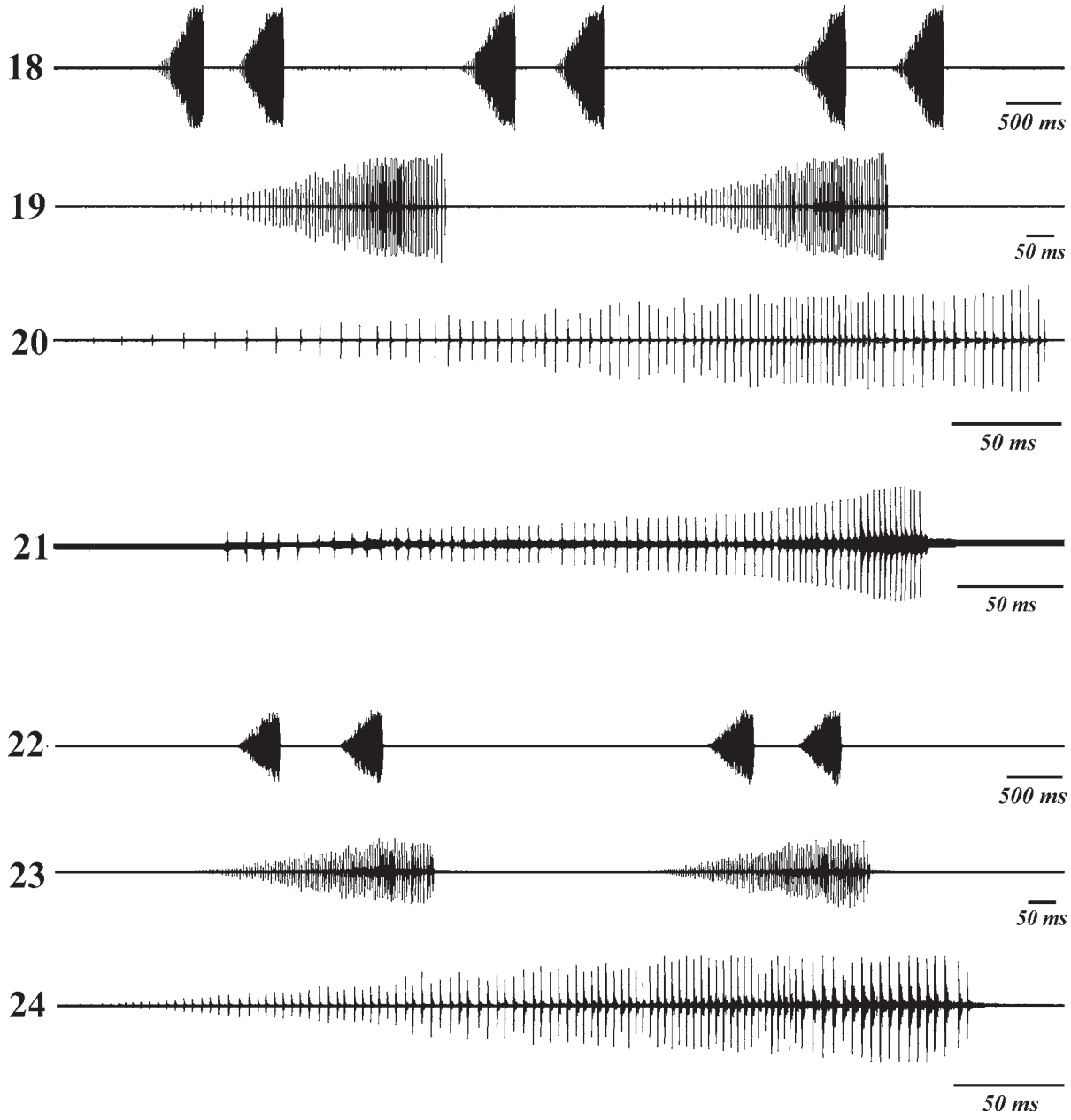
Frequency spectrum contains many peaks in the range 17–35 kHz. More high amplitude peaks occure at 20 and 23 kHz. Whole spectrum occupies band 0–55 kHz (Fig. 52).

Stridulatory file (Fig. 64) as in *P. boldyrevi.*

Poecilimon beybienkoi Tarbinsky, 1932

Endemic of southern Crimea.

Locality: S.Crimea, Grushevaya Polyana near Yalta, VI.1980 Uch-Kosh, 8.VII.1981.



Figs 18–24. Oscillograms of calling signals of *Poecilimon* spp. at different velocities: 18–20 — *P. pliginskii* (21°C), 21 — *P. beybienkoi* (24°C), 22–24 — *P. kuznezovi* (27°C). Below time scales.

Рис. 18–24. Осциллограммы призывных сигналов *Poecilimon spp* при разных скоростях развертки: 18–20 — *P. pliginskii* (21°C), 21 — *P. beybienkoi* (24°C), 22–24 — *P. kuznezovi* (27°C). Внизу — отметки времени.

Song. Was preliminary described earlier [Zhantiev, 1981; Zhantiev & Korsunovskaya, 1986]. Here additional material is given. Calling signal is the sequence of two-pulsed series devided by intervals of several seconds. Pulse duration is near 400 ms, pauses between pulses in the series last about 1.7 s. Amplitude and frequency of tooth-impacts gradually increases to the end of pulse (Fig. 21).

Males stridulate very silent for human ear because most of frequency components of their song occupy ultrasound range (25–35 kHz with maximum at 30 kHz).

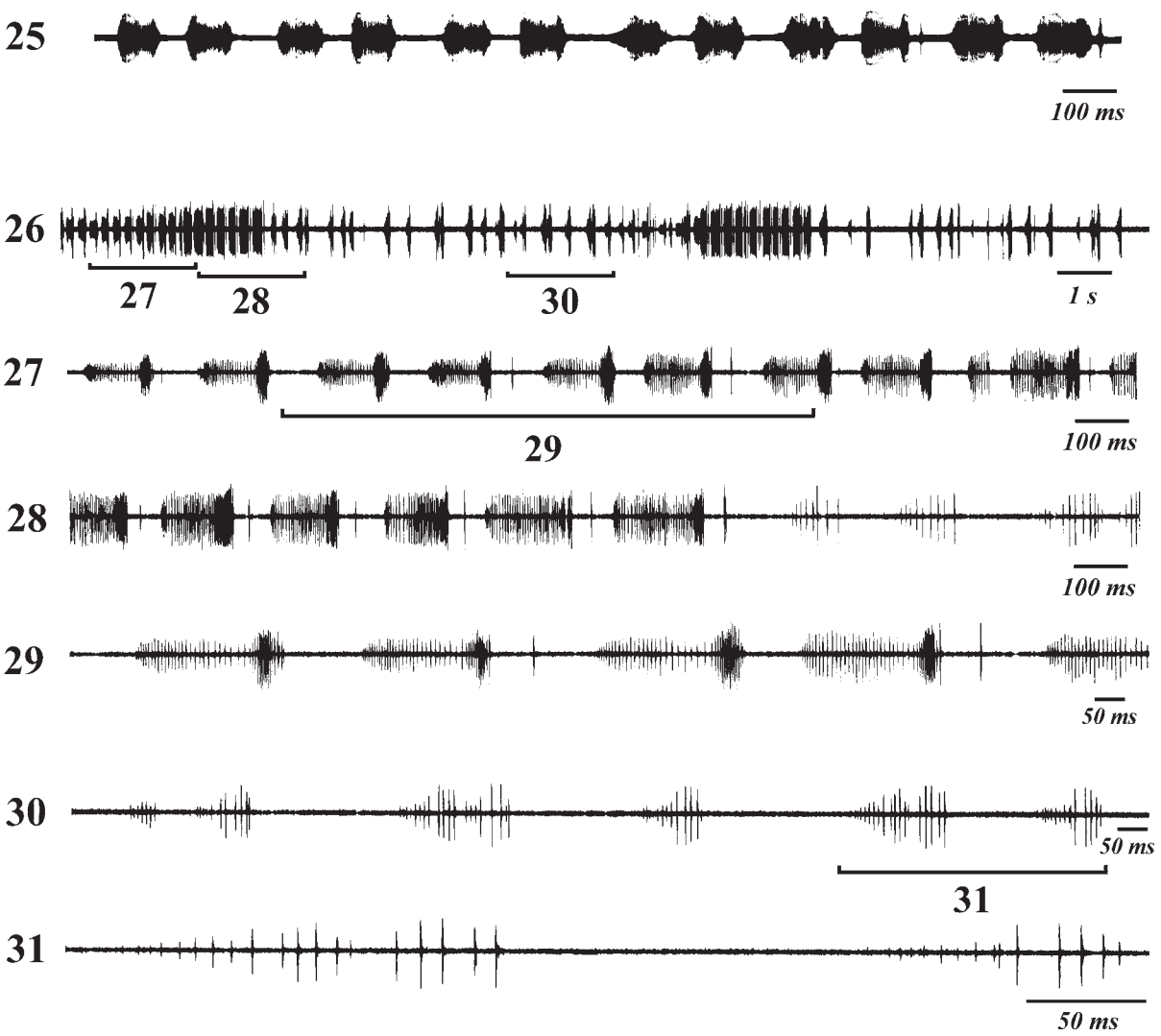
Stridulatory file (Fig. 65) is very similar to the one of *P. boldyrevi*, *P. pliginskii* and *P. kuznezovi* (Figs 61, 64, 66).

Poecilimon kuznezovi Miram, 1929

Known from S.Crimea only.

Locality: S.Crimea, near Yalta, 20.VI.1996.

Calling *song* consists of irregularly repeating pairs of pulses (Figs 22–24). Duration of pulses is *ca* 400 ms, interpulse intervals — about 500 ms. Tooth-impact frequency is more or less equal in the initial and final parts of pulses.



Figs 25–31. Oscillograms of calling song of *Poecilimon* spp.: 25 — *P. brunneri* (25°C) 26–31 — different parts of calling song of *P. ukrainicus* at different velocities (25°C). Below time scales and fragments of oscillograms with faster velocities given separately.

Рис. 25–31. Осциллограммы призывного сигнала *Poecilimon* spp.: 25 — *P. brunneri* (25°C) 26–31 — разные фрагменты призывного сигнала *P. ukrainicus* при разных скоростях развертки (25°C). Внизу — отметки времени и фрагменты осциллограмм при большей скорости развертки, приведенные отдельно.

The main frequencies of the song are in the narrow range between 10–30 kHz with maximum at 17 kHz and additional peak near 21 kHz (Fig. 53).

Stridulatory file (Fig. 66) as in *P. boldyrevi.*

Poecilimon brunneri (Frivaldsky, 1867)

Distribution range of this species includes Balkan (from Macedonia (former Yugoslavia) to NO Greece), Romania, Bulgaria, Moldavia and steppes of southern Ukraine.

Locality: Moldavia, near Kutuzov, VI.1987, ex larva.

Song. Known for specimens from Macedonia (former Yugoslavia) and Greece [Heller, 1988]. We obtain only very short fragment of the calling song of one specimen (Fig. 25). Male has produced the sequence of series containing two pulses. Sometimes pulse is followed by fast click. At 25 °C pulse duration is between 90–110 (avrg. 96±3) ms. Pauses between pulses are 45–65 (avrg. 52±3) ms, series are divided by intervals of 80–110 (avrg. 94±5) ms.

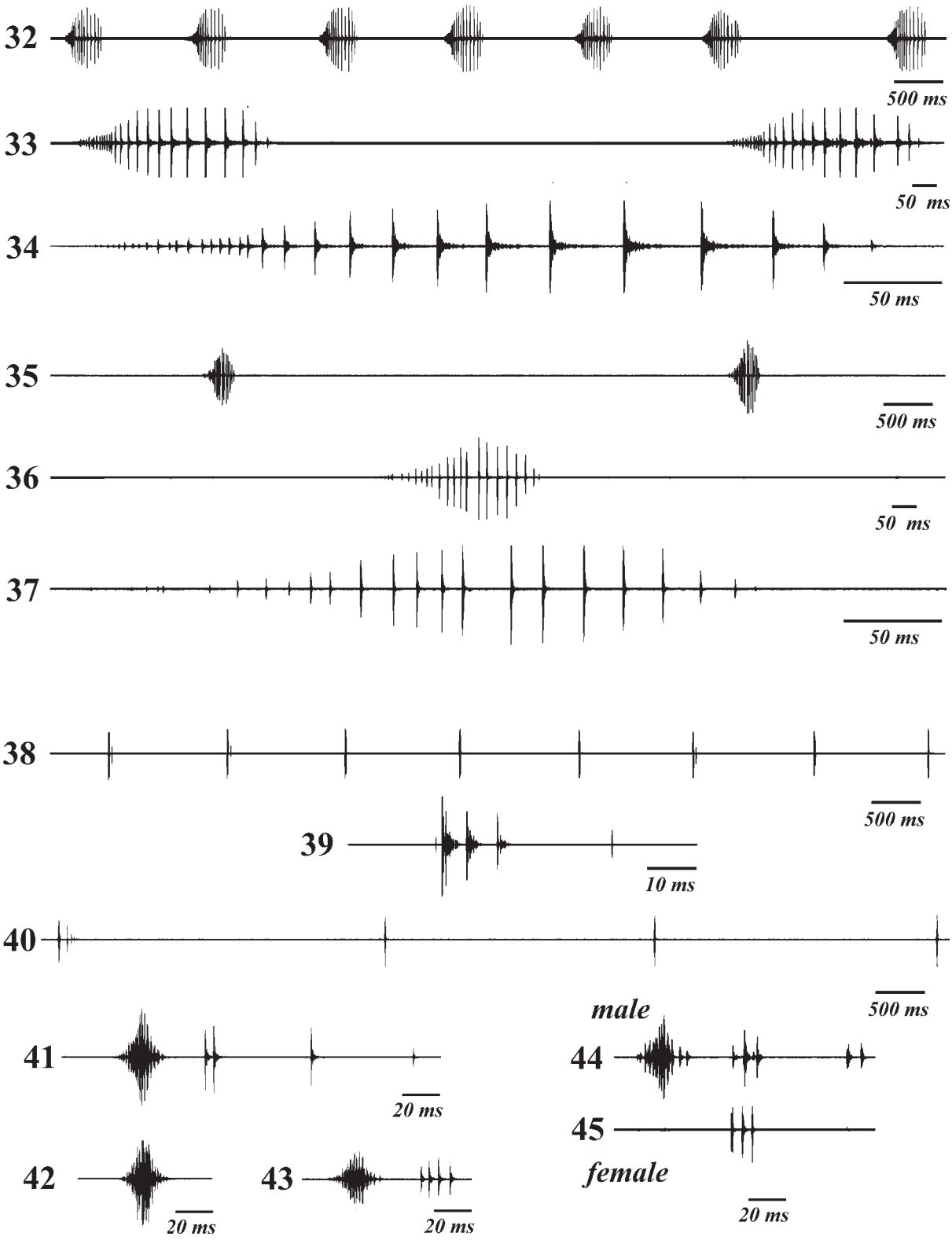
Stridulatory file (Fig. 67) is more or less straight and contains tooths of different size and density. Maximum size of them is observed at the middle part of pars stridens. These teeth are placed on the convexity. File of western European specimen is of the same structure [Heller, 1988].

Poecilimon ukrainicus Bey-Bienko, 1951

This species is distributed in southern Ukraine and Moldavia. It is very close to *P. fussi* Br.-W. and was synonymized by Harz [1965] with this species.

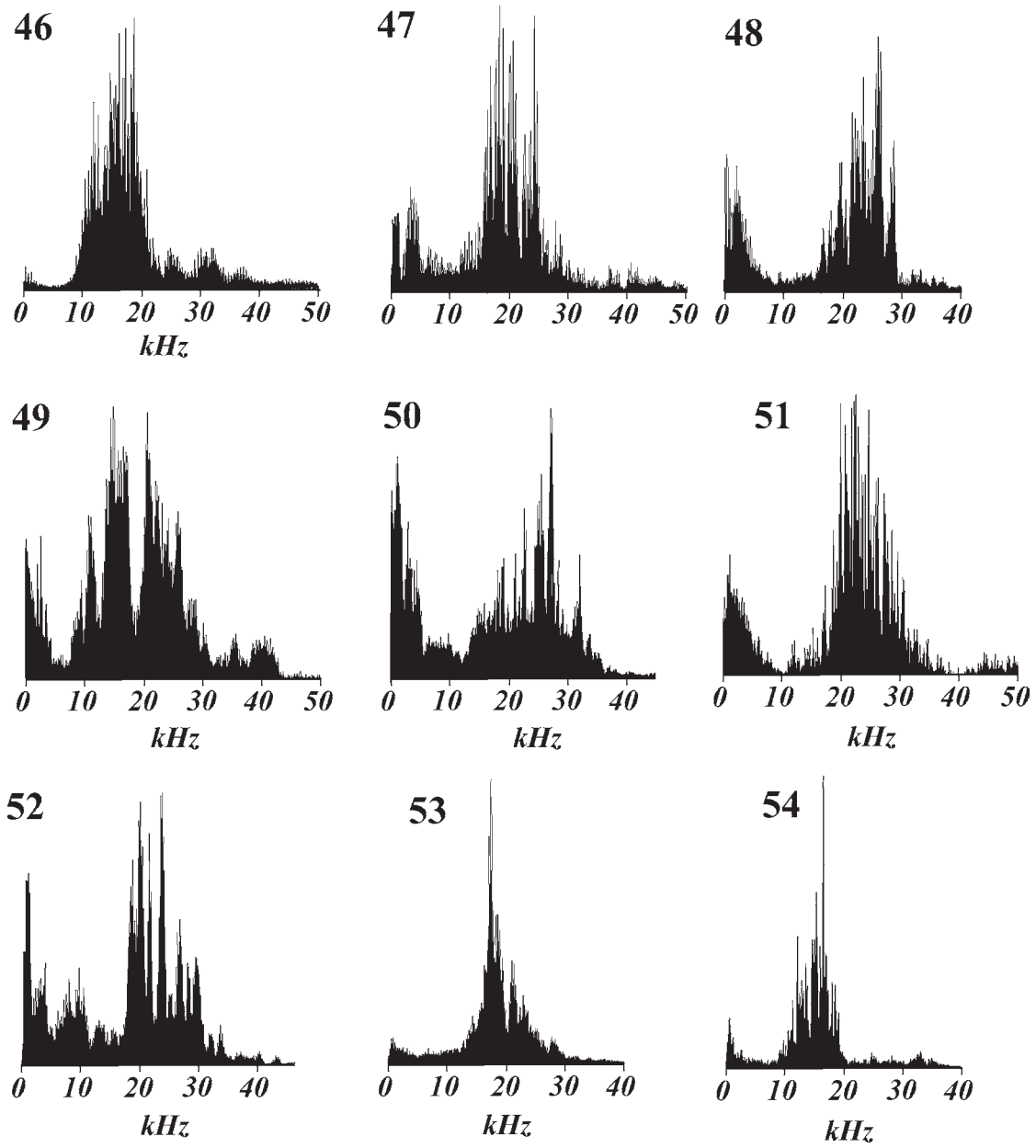
Locality: Ukraine, Kanev, VI.1996.

Song. Males produce very complicated calling sounds (Figs 26–31). That divides into two different alternating fragments. The first fragment is the sequence of the fast



Figs 32–45. Oscillograms of male calling (32–44) and female response (45) songs of *Poecilimon* spp. and *Isoimon riabovi* at different velocities: 32–34 — *P. heroicus* (Lugansk reserve, 22°C), 35–37 — *Poecilimon* sp. cf *heroicus* (26°C), 38–39 — *P. schmidtii* (Abkhasia, Avadhara, 26°C), 40–45 — *I. riabovi* (26°C). Below time scales.

Рис. 32–45. Осциллограммы призывного сигнала самца (32–44) и ответного сигнала самки (45) *Poecilimon* spp. и *Isoimon riabovi* при разных скоростях развертки: 32–34 — *P. heroicus* (Луганский заповедник), 22°C., 35–37 — *Poecilimon* sp. cf *heroicus* (26°C), 38–39 — *P. schmidtii* (Абхазия, Авадхара) при 26°C, 40–45 — *I.riabovi* (26°C). Внизу — отметки времени.

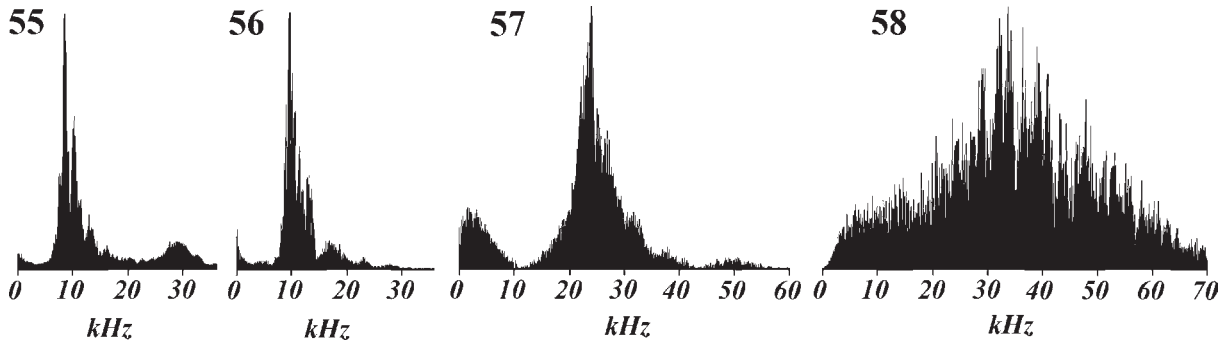


Figs 46–54. Frequency spectra in linear scale of calling songs of *Poecilimon* spp. and *Isoimon riabovi*: 46 — *P. affinis*, 47 — *P. similis*, 48 — *P. tereckensis*, 49 — *P. boldyrevi*, 50 — *P. scythicus* (Lugansk reserve), 51 — *P. tauricus*, 52 — *P. pliginskii*, 53 — *P. kuznezovi*, 54 — *I. riabovi*.

Рис. 46–54. Амплитудно-частотные спектры в линейном масштабе призывных сигналов *Poecilimon* spp. и *Isoimon riabovi*: 46 — *P. affinis*, 47 — *P. similis*, 48– *P. tereckensis*, 49 — *P. boldyrevi*, 50 — *P. scythicus* (Луганский заповедник), 51 — *P. tauricus*, 52 — *P. pliginskii*, 53 — *P. kuznezovi*, 54 — *I. riabovi*.

pulses. They follow with irregular rate and have duration differing sometimes twice. Some pulses consist of two parts (Figs 30–31). The second song fragment lasts about 3–4 s and consists of pulses with repetition rate *ca* 4.5 s^{-1} (Figs 27, 29). In the initial 2–3 s of this song phase a amplitude of the toouth-impacts increases up to twice in the final part of each pulse. Then amplitude of initial 2/3 pulse becomes approximately identical. The rate of tooth-impacts achieves the maximum in the final part of pulse. To the end of the second song fragment each pulse is followed by single short click with duration about 1–2 ms (Figs 27–29). It divided from pulse by pause of 40–50 ms. Frequency spectra of pulses of two song fragments lay in the range 30–50 kHz (Fig. 58) with mean peak at 34–39 kHz (longer pulses with loud final part and clicks) and 33 kHz (shorter pulses).

Temporal pattern of this song is very similar to that of *P. fussi* described from Hungarian and Transylvanian populations [Orci, 2001, 2002]: calling signal of *P. fussi* consists of two phases too and the pulses are of the same structure. However pulses in both phases as well as inside of each phase have approximately equal



Figs 55–58. Frequency spectra in linear scale of calling songs of *Poecilimon* spp.: 55 — *P. heroicus* (Lugansk reserve), 56 — *P.* sp. cf *heroicus*, 57 — *P. schmidtii*, 58 — *P. ukrainicus*.

Рис. 55–58. Амплитудно-частотные спектры в линейном масштабе призывных сигналов *Poecilimon* spp.: 55 — *P. heroicus* (Луганский заповедник), 56 — *Poecilimon* sp. cf *heroicus*, 57 — *P. schmidtii*, 58 –*P. ukrainicus*.

duration and in the first part of the song they have very regular repetition rate.

Taking into account results of comparison of songs of two species and distinctions in their morphological characters we consider that *P. ukrainicus* is very close to *P. fussi* yet they are two separate species.

Weakly curved stridulatory file is shown in Fig. 68. In distal third of file teeth are more thick, in proximal half of file they are arranged more densely.

Poecilimon heroicus Stshelkanovtsev, 1911

Distributed in steppes of southern Russia and eastern Ukraine up to Voronezh district; eastern part of species range includes Ciscaucasia and northern Caucasus (Teberda, Daghestan).

Localities: Ukraine, Lugansk reserve, 12.VI.1996; N.Caucasus, Tersky ridge near Grozny, VI.1986.

Song. Males produce sequence of single pulses (Fig. 32) with pulse rate about 0.7 s^{-1} (at 22 °C). Each pulse consists of separate tooth-impacts with amplitude increasing to the middle part and decreasing to the end of pulse. Tooth-impact frequency decreases to the final part of pulse. Duration of the pulses is about 500 *ms* (Figs 33–34). Females in this species are mute.

The main frequencies of calling song are in the audible range with maxima at 9–12 (the main one) and 25–30 (the additional one) kHz. In the Fig. 55 is shown spectrum of the calling sounds of specimen collected near Lugansk. There is some frequency modulation during the pulse. Its beginning is more high-frequency than the middle and the final parts.

Stridulatory file with thick, peg-like teeth, more densely arranged at medial part. Above medial end of *pars stridens* there is specific area with wide lamelliform teeth. Their function is unclear but perhaps they are part of tegminal closing apparatus (Fig. 69).

Poecilimon sp. cf *heroicus* Stshelkanovtzev, 1911

The single male was found near Pyatigorsk (VII. 1989). It differs from *P. heroicus* in the structure of pars stridens (Fig. 70), dark colour of hind half of pronotum and dorsal surface of hind femora. It is necessary to obtain additional material for final determination of taxonomic status of this form.

Song. Male song of this species is similar to that in *P. heroicus*. It consists of single pulses (Fig. 35) repeating with considerably long intervals (*ca* 5 s at 26 °C). Tooth-impacts period in the middle part of pulse is about twice shorter than that in the calling song of *P. heroicus*. Pulses are significantly shorter too (Figs 36, 37). As in *P. heroicus* frequency spectrum occupies band between 7 and 30 kHz, with dominant components near 10 kHz, but additional high-frequency peak lies at 17–18 kHz vs 30 kHz in *P. heroicus* (Fig. 56)

Stridulatory file differs from that of *P. heroicus* in thick and more densely arranged teeth (Fig. 70).

Poecilimon schmidtii (Fieber, 1853)

Wide distributed Mediterranean species.

Localities: E Crimea, near Sudak, 9.VI.1979; N.Caucasus, near Tuapse, 20.IX.1994; Abkhasia, near lake Ritsa, Avadhara, 5.IX.1985.

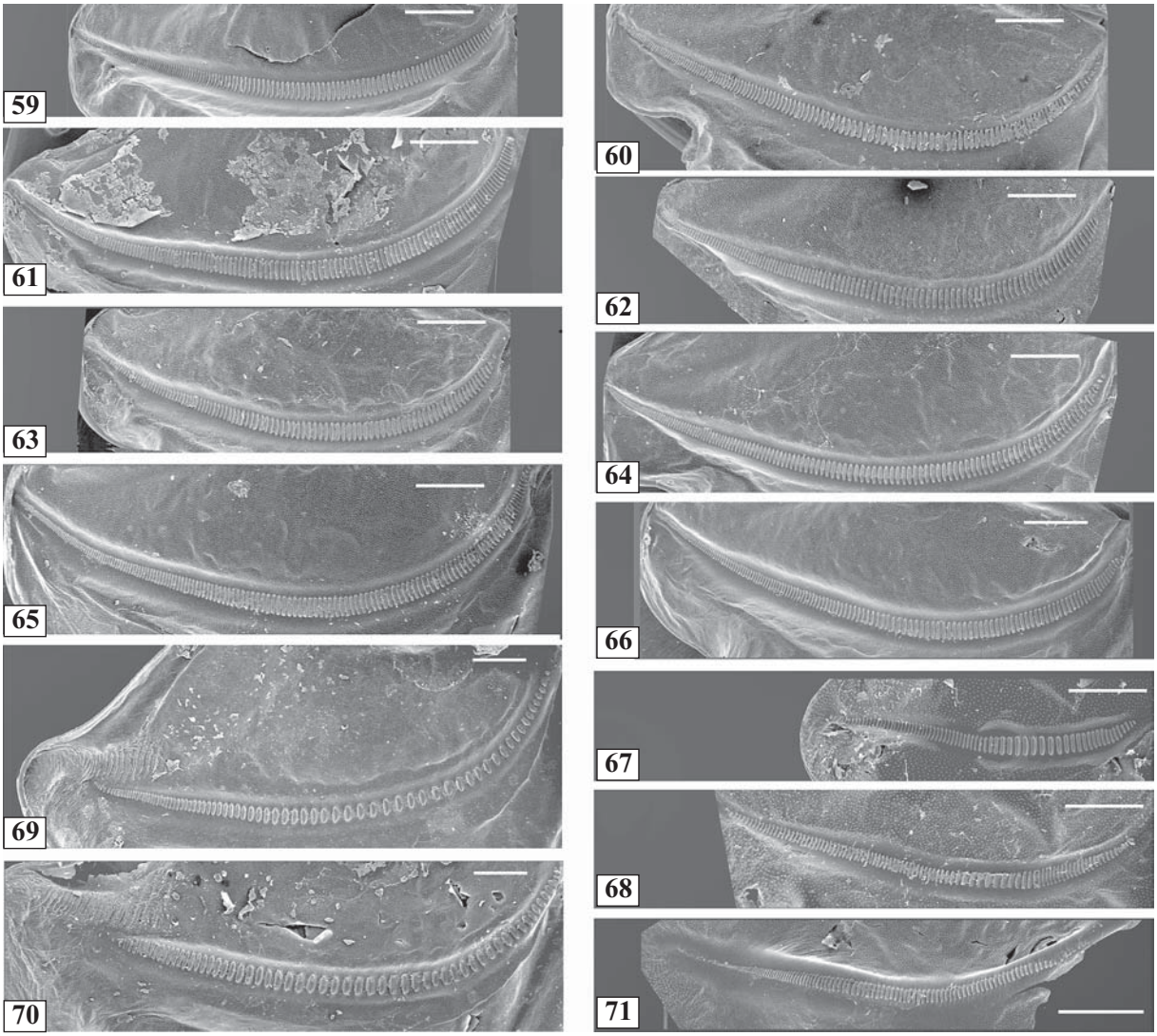
Song of Crimean and Macedonian specimens was described earlier [Zhantiev & Korsunovskaya, 1986; Heller, 1988]. Here is given a description of the song of male from Caucasian populations. Male produces sequence of very short single pulses containing two to four tooth-impacts. At 26°C pulse duration is *ca* 10 ms, interval between pulses — near 1 *s*. Most of pulses are followed by single click with interval about 20 *ms* (Fig. 39). Females of this species respond to male calling sounds by one to several clicks with delay of 32–46 (avrg 36±1, n=12, 20°C) *ms*. Ethological experiments with calling song models of different duration showed that delay of female sound response is triggered by the beginning of the male pulse.

Calling sounds are almost inaudible for a human ear. The main peak is in the frequency range 10–55 kHz at 23–24 kHz (Fig. 57). Dominant frequencies in the spectrum of female response lay near 20 kHz.

The songs and stridulatory files of Caucasian and Crimean specimens are the same as thats of specimens from Macedonian population described by Heller [1988].

Genus ***Isoimon* Bey-Bienko, 1954**

This genus is very similar to *Poecilimon* but differs from it in following morphological characters: pronotum and visible part of tegmina similar in both sexes,



Figs 59–71. Stridulatory files of *Poecilimon* spp. and *Isoimon riabovi*:: 59 — *P. tereckensis*, 60 — *P. similis*, 61 — *P. boldyrevi*, 62 — *P. scythicus*, 63 — *P. tauricus*, 64 — *P. pliginskii*, 65 — *P. beybienkoi*, 66 — *P. kuznezovi*, 66 — *P. kuznezovi*, 67 — *P. brunneri*, 68 — *P. ukrainicus*, 69 — *P. heroicus*, 70 — *Poecilimon* sp. cf *heroicus*, 71 — *I. riabovi*. Scales 500 and 300 (figs 67, 68) mkm.

Рис. 59–71. Стридуляционные жилки *Poecilimon* spp. и *Isoimon riabovi*: 59 — *P. tereckensis*, 60 — *P. similis*, 61 — *P. boldyrevi*, 62 — *P. scythicus*, 63 — *P. tauricus*, 64 — *P. pliginskii*, 65 — *P.beybienkoi*, 66 — *P. kuznezovi*, 67 — *P. brunneri*, 68 — *P. ukrainicus*, 69 — *P. heroicus*, 70 — *Poecilimon* sp. cf *heroicus*, 71 — *I. riabovi*. Масштаб 500 и 300 (рис. 67, 68) мкм.

female pronotum concave dorsally, tegmina of female bulging, protruding, mesosternum with two small lateral denticles.

Only one species in the genus is known. It occurs in northern Caucasus (Daghestan, near Derbent), Transcaucasia (SE Azerbaidjan) and northern Iran (Gorgan).

Isoimon riabovi (Uvarov, 1927)

Locality: Azerbaidjan, Lenkoran, 29.VII.1987.

Song. The calling song is a sequence of short pulses with rate 0,4 s^{-1}(at 26°C). Sometimes pulses lasting 20–32 ms are followed by several very short clicks. Duration of the last ones is 1–5 ms (Figs 40–44).

Females respond to the first more long pulse of calling song usually with some tooth-impakts (Fig. 45). Temporal delay of this response concerning a beginning of the first pulse is 32–50 ms (avrg. 46±2 ms, n=10, 26°C).

Males stridulate in the audible range with dominant frequency at 16–17 kHz. There is additional maximum near 12 kHz (Fig. 54). Frequency spectrum of females clicks differs from the male one in more low dominant frequency (near 14–15 kHz)

Male stridulatory file with teeth uniform in thickness, evenly spaced, narrowing towards proximal and distal ends (Fig. 71).

Discussion

The songs of *Poecilimon* and *Isoimon* described in this paper may be devided into main groups with following features:

1. Pulses consist of numerous tooth-impacts. Their frequency changes more or less gradually slowly during most part of pulse (sounds of 1st–9th species in this article).

According to temporal pattern acoustic signals of this group may be divided into three subgroups:

i) repeating single pulses;

ii) repeating two-pulses series;

iii) more or less complicated trills.

2. Frequency of tooth-impacts sharply increases in the final part of pulse (*P. ukrainicus, P. brunneri*). Similar form have pulses of *P. tauricus* but in this case final part of pulse is result of junction of very long tooth-impacts.

3. Pulses consist of very rare tooth-impacts with frequency ca 30–40 or 60 s^{-1} in the middle part of pulse (*P. heroicus, P.* sp. cf *heroicus*).

4. Pulses have minimal duration and consist of 3–4 common tooth-impacts (*P. schmidtii*) or several very short almost adjoining ones (*I. riabovi*).

Great part of temporal pattern modifications is caused by changes in neuromuscular program of tegmina movements namely their amplitude, velocity and forces. The pulse pattern depends also on the *pars stridens* structure. At more or less uniform movements of tegmina tooth-impacts frequency usually correlates with teeth density. Thus minimal levels of both these parameters are observed in the 3rd group and maximal — in the 1st group. In the pulses of species belonging to the 2nd group we can see two phases in tegmina movements: slow in the beginning and fast in the final part of pulse. In their *pars stridens* also there are two visible zones with different teeth density (Fig. 67, 68). Species of the 4th group producing extremely short pulses apparently use only part of *pars stridens* (*I. riabovi*) or special tubercle in its beginning (*P. schmidtii*) [Heller, 1988].

Comparison of our data with song classification of Mediterranean *Poecilimon* species [Heller, 1990] shows that the song pattern of eastern European and Caucasian species demonstrates the same tendencies. So the 1st and 2nd groups of signals correspond to Heller's group A, the 4th group — to the group B [Heller, 1990]. As for signals of the 3rd group their pulse structure differs by extremely low tooth-impacts rate (intervals between them achieve 20–24 ms) and there are no analogous in known *Poecilimon* songs.

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